Journal of Civil Engineering and Environmental Technology
Print ISSN: 2349-8404; Online ISSN: 2349-879X; Volume 2, Number 6; April-June, 2015 pp. 510-513

http://www.krishisanskriti.org/jceet.html

Effect on Compressive Strength of Concrete with Partial Replacement of Sand using Iron Slag

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Abstract—*Now-a-days environment problems are very common in India due to generation of industrial byproducts. Due to increase in industrialization the waste products also increases and to utilize these waste products is a big concern. Iron slag is one of the industrial by-products from the iron and steel making industries. In this paper the effect on compressive strength with partial replacement of sand using iron slag is studied. Compressive strength tests are carried out on concrete cubes (150X150X150 mm) with sand replaced by iron slag at five levels (0, 15, 30, 45 and 60%). The results show that the iron slag added to the concrete has greater strength than the plain concrete.*

1. INTRODUCTION

Slag is a broad term covering all non-metallic co products resulting from the separation of a metal from its ore, its chemistry and morphology depends on the metal being produced and the solidification process used. Slags can be broadly categorized as ferrous (iron/steel) and non-ferrous (copper, lead/zinc) depending on the industry from which they come. Iron slag is a byproduct obtained in the manufacture of pig iron in the blast furnace and is produced by the blend of down-to-earth constituents of iron ore with limestone flux. While limestone may seem unrelated to the production of iron and steel, it actually is an essential auxiliary material that is added during the production process. During the process of reducing iron ore, it is necessary to remove the silica, alumina (Al_2O_3), and other non-ferrous components contained in iron ore. The added limestone fuses with these components and lowers their melting point, making it easier to separate them from the iron and recover them. This recovered substance is slag.

Aggregates have a significant influence on both rheological and mechanical properties of mortars and concrete, Neville [1]. Their specific gravity, particle size distribution, shape and surface texture influence markedly the properties of mortars and concrete in the fresh state. In India, natural river sand (fine aggregate) is traditionally used in mortars and concrete. However, growing environmental restrictions to the exploitation of sand from riverbeds have resulted in a search for alternative sand, particularly near the larger metropolitan areas. Thus artificial sand/fine aggregate appear as an attractive alternative to natural sand for concrete. The replacement of natural sand using iron slag in different proportion had been done by Pellegrino C et al. [2], M C Nataraja et al. [3], Chetan Khajuria et al. [4]. Siddique R et al. [5] studied the properties of concrete containing ground granulated blast furnace slag (GGBFS) at elevated temperatures.

Many steel industries in India are supplying GBFS as an alternative to sand. Various types of slag from copper and steel industry are being used in mortar and concrete Pundhir et al. [6], Khalifa et al. [7], Mohammed Nadeem et al. [8], Tamilarasan et al. [9]. The use of Granulated Blast-Furnace Slag (GBFS) as an aggregate in cement mortar and concrete provides environmental as well as economic benefits.

In addition there are many other alternative materials for aggregates derived from construction and demolition wastes, recycled aggregates and quarry wastes. These aggregates are successfully utilized in concrete production which can also help to conserve natural materials and to reduce the cost of waste treatment prior to disposal, Nataraja et al. [10].

2. MATERIALS

The various materials that are used in this research are as follow:-

Cement – Ordinary Portland Cement (OPC) of 43 Grade (Bangur Cement) is used that is locally available. The cement was free from lumps. The properties of the cement as determined from various test confirming to IS: 8112-1989 code [11] are listed in Table 1.

Fine Aggregate: Natural sand of grading Zone II confirming to IS:383-1970 code [12] is used that is available commercially. The specific gravity of the sand is calculated as 2.70.

Coarse Aggregate: Crushed angular coarse aggregates of 10mm and 20mm nominal sizes are used as per IS:383-1970. The specific gravity of the aggregate is 2.69.

Chemical Admixture: A concrete super plasticizer was used from Fosroc Chemicals (India) Pvt. Ltd. as shown in (Fig.1) to reduce the water Cement ratio.

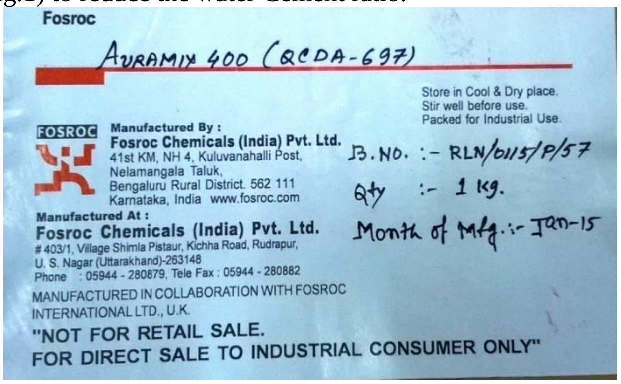

Fig. 1: Superplasticizer (Fosroc)

Iron Slag: The Iron Slag was obtained from the Shri Jaibalaji Steel Rolling Mills Ltd. located at Muzaffarnagar, (U.P.) as shown in (Fig.2). The Fineness Modulus of iron slag was 2.10 and was in black grey colour.

Fig. 2: Iron Slag

Table 1: Properties of OPC 43 Grade Concrete

S.NO.	Characteristics	Value Obtained Experimentally	Value Specified By IS 8112:1989
1	Specific Gravity	3.15	—
2	Standard Consistency, percent	30.5	No standard value
3	Initial Setting Time, minutes	135	Not less than 30
4	Final Setting Time, minutes	295	Not more than 600
5	Compressive Strength 3 days 7 days 28 days	27.5 39.6 49.8	23 N/mm^2(minimum) 33 N/mm^2(minimum) 43 N/mm^2(minimum)

3. EXPERIMENTAL PROCEDURE

3.1 Mixture Proportioning

The two types of mixes are prepared. Firstly, control mix composed according to IS:10262- 2009 code [13] as shown in Table 2. Secondly, concrete mix are prepared using iron slag replacing 15 %, 30 %, 45 % & 60% of fine aggregates with the same amount of cement, coarse aggregates and same water cement ratio as shown in (Fig. 3). The curing period of all the concrete mixes was 3, 7 and 28 days.

Table 2: Weight of component per m3 of concrete

Mix Proportion	Weight per m^3 (kg)
Cement	350
Fine aggregate	855.28
Coarse aggregate	1157.58
Water/Cement(w/c) ratio	0.40
Super plasticizer	1% by weight of cement

Fig. 3: Concrete Cubes made with different proportions of Iron Slag

3.2 Test Procedure and Results

Concrete cube of size 150 × 150 × 150 mm were prepared for testing the compressive strength. The concrete mixes with varying percentages (0%, 15%, 30%, 45% and 60%) of iron slag as partial replacement of fine aggregate (sand) were cast into cubes for testing. In this study, to make control mix, cement and fine aggregate were first mixed dry till uniform colour appeared and then coarse aggregate was added in the mixture of cement and fine aggregate. After that water was added along with superplasticizers and the whole mass mixed. The interior surface of the moulds and the base plate were oiled before concrete was placed. After 24 hours the specimens were removed from the moulds and placed in clean fresh water for curing. The specimens so cast were tested after 3, 7 and 28 days of curing measured from the time water is added to the dry mix. For testing in compression, the load was applied axially without shock till the specimen was crushed. The results of the compression testing with varying proportions of iron slag replacement at 3, 7, and 28 days are given in the Table 3. The compressive strength of concrete cubes is shown graphically in Fig. 4. The compressive strength increases as compared to control mix as the percentage of iron slag was increased upto 45% after that it was decreased. After adding 15% iron slag in the mix, there was an increase of 10.95% after 28 days as compared to the control mix. By adding 30% and 45% iron slag, there was large amount of increase in percentage i.e. 19.2%and 23.3%. By adding 60% of iron slag the increase in percentage decreased upto 5.95%.

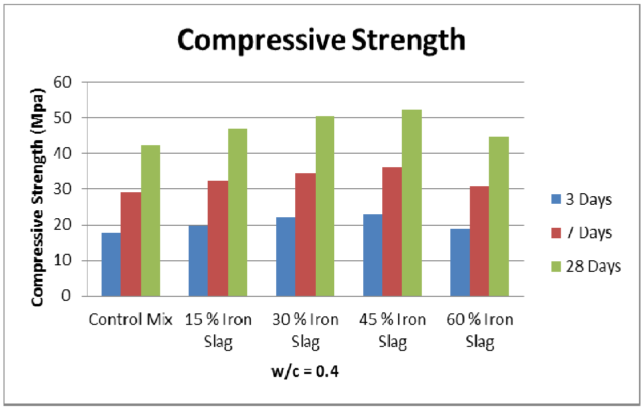

Fig. 4: Compressive strength of iron slag concrete

Table 3: Compressive strength of concrete mixes specimen size 150 × 150 × 150 with iron slag

Mix Proportion	Compressive Strength (N/mm2)		
Iron Slag By % of F.A.	**3 Days**	**7 Days**	**28 Days**
Control Mix	17.77	29.04	42.31
15%	19.71	32.15	46.94
30%	21.92	34.39	50.41
45%	23.08	36.03	52.13
60%	18.85	30.78	44.82

Fig. 4 shows the variation of percentage increase in compressive strength with different proportion of iron slag. The results also indicate that strength gain at early age for 3 and 7 days was higher when compared to the control mix if 45% of fine aggregate is replaced by iron slag.

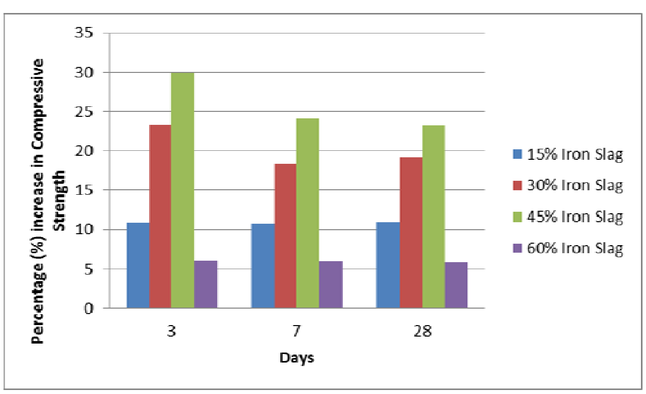

Fig. 5: Percentage (%) increase in compressive Strength of iron slag concrete

4. CONCLUSIONS

The compressive strength of concrete had been computed in the present work by replacing 15%, 30%, 45% and 60% iron slag with the sand. On the basis of testing, subsequent conclusions were drawn:

- ✓ After adding 15% iron slag in the mix, there was an increase of 10.92% after 28 days as compared to the control mix. By adding 30% and 45% iron slag, there was large amount of increase in percentage i.e. 19.2% and 23.3%. By adding 60% of iron slag the increase in percentage decreased upto 5.95%.
- ✓ With the increase of percentages of iron slag in the concrete mix, the compressive strength also increases upto 45% iron slag.
- ✓ Workability of concrete decreases with increase in percentage of iron slag.
- ✓ The early age strength gain is higher as compared to later ages, if 45% of fine aggregate is replaced by iron slag.

Fig. 6: Compressive strength test in progress

Fig. 7: Concrete cubes after compression testing

5. ACKNOWLEDGEMENT

First author is grateful to second author for helping him in this research who has been a constant source of inspiration throughout this work. The author also wishes to acknowledge Gautam Buddha University (Gr. Noida, U.P), Mr. Kapil Nagar (Globus Constructions Pvt. Ltd.) and Mr. Deepak Jain (Shri Jaibalaji Steel Rolling Mills Ltd.) for their invaluable contributions to this paper.

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