International Journal of Science and Research (IJSR)
ISSN (Online): 2319-7064
Impact Factor (2012): 3.358

Strength Analysis of Concrete by Using Iron Slag as a Partial Replacement of Normal Aggregate (Coarse) in Concrete

Khalid Raza[1], Apoorv Singh[2], R. D. Patel[3]

[1,2]P.G. Scholar, Department of Civil Engineering, M.M.M.U.T. Gorakhpur, India

Abstract: ***Iron slag is an industrial waste by-product of steel industry. The demand for aggregate in construction industry is increasing rapidly and so is the demand for concrete. In this study the coarse aggregate (CA) were partially replaced with iron slag aggregate (ISA) at different proportions of 0%, 10%, 20%, 30% 40% and 50%. Compressive strength and Flexural strength on M40 grade of concrete with 0.45 water/cement ratio were investigated. In which to determine and check out the compressive strength, Flexural strength, and split tensile strength of concrete with various percentages of iron Slag Aggregate. The result has been found from the various tests which were compared with conventional concrete. Thus the use of iron slag in concrete could enhance the strength in concrete.***

Keywords: Natural coarse aggregate, Iron slag, Iron slag aggregate, concrete, cement

1. Introduction

Iron slag is a by-product of the iron and steel making process. Steel cannot be prepared in the Basic Oxygen Furnace (BOF) or in an Electric Arc Furnace (EAF) without making its by-product, steel slag [1]. The use of Iron slag aggregate in concrete by replacing coarse aggregate is a most promising concept [2].The iron slag present in concrete Satisfy physical properties which slow down the hydration of blended cement due to morphology and low calcium silicate content [3]. Thus Iron slag can be used in conventional concrete to improve its mechanical, chemical and physical properties. The only potential problem with Iron slag aggregate is its expansive characteristics and undesirable reactions between slag and components of concrete. The only potential problem with Iron slag aggregate is its expansive characteristics and undesirable reactions between slag and components of concrete. Studies and tests are being conducted on ways to use this iron slag as an aggregate in concrete.

2. Material Characterisation

Cement: The cement used for this work is OPC of 43 grades. The specific gravity of cement was tested as per IS: 8112 and was found to be 3.15.In this research cement used OPC 43 grade confirming to IS: 8112. The physical properties of the cement obtained on conducting appropriate are IS: 10262-2009. A cementations material is one that has the adhesive and cohesive properties necessary to proper bond inert aggregates into a solid mass adequate strength and durability.

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. Pure water is not good use with ordinary Portland cement. This can be used with high alumina cement. If impurities in the water may affect the setting time of cement, strength of concrete, and may cause corrosion of the reinforcement.

Super plasticizer: To improve the workability of fresh concrete sulphonated naphthalene based super plasticizer i.e., Conplast SP 430 was used supplied by FOSROC chemicals, 1.4% dosages was used to increase the workability of concrete. Use of Super plasticizer permits the reduction of water to the extent up to 30% without reducing workability. Super plasticizer is a high range water reducer. The super plasticizer produces a homogeneous, cohesive concrete generally without tendency for segregation and bleeding. Super plasticizers are used to produce high- strength concrete with a very low W/C ratio and they are also used to produce flow able concrete at conventional W/C ratios. Chemical admixture like super plasticizer conforming to IS: 9103.

Coarse aggregates: The coarse aggregate used is crushed (angular) aggregate conforming to code IS 383:1970. The maximum size of aggregate considered is 20mm IS sieve passing and minimum size of aggregate considered is 12.5mm IS sieve passing. The results of sieve analysis conducted as per the specification of IS: 383-1970.The fineness modulus of coarse aggregate is 5.82. Soundness is also an important property of coarse aggregates. Specific gravity of coarse aggregate is 2.69. The normal maximum size is gradually 10-20 mm; however particle sizes up to 40 mm or more have been used in Self Compacting Concrete.

Fine aggregates: Locally available clean river sand passing through the IS-480 sieves have been used. The results of sieve analysis conducted as per the specification of code IS: 383 -1970.The fineness modulus of fine aggregate is 3.276.Fine aggregates like river sand , Moran are used in mix proportion of concrete.

Iron slag: Iron slag is an industrial waste material. It is a by-product of the iron and steel making process. Steel slag is obtained from conversion of iron to steel in a Basic Oxygen Furnace (BOF) or by the melting of scrap to make steel in the Electric Arc Furnace (EAF). Steel slag is defined by the American Society for Testing and Materials (ASTM) as iron-metallic product, consisting essentially of

calcium silicates and ferrites combined with fused oxides of iron, aluminium, manganese, calcium.

3. Selection of Suitable Mix Proportion

Concrete mix design of M40 grade was designed conforming to code IS: 10262-2009. Cubes of standard size 150x150x150mm, Prisms of size150x150x700mm were casted at room temperature and were tested at 7, 14 and 28 days of curing.

Table 1: Design parameters per cubic metre

Cement	400kg
Fine Aggregate	660kg
Coarse Aggregate	1168kg
W/C Ratio	0.4
Super plasticizer	1%of weight of cement
Iron slag	150kg

4. Material Properties Investigate

Concrete mixes were checked for workability through slump test. With the help of slump test to know more about the workability and fresh concrete.

Max. Size of coarse aggregate	20mm
Slump Range	50-75mm IS:10262-2009
Specific Gravity of cement	3.15 IS :8112
Fineness modulus of F.A.	3.276 IS:383-1970
Fineness modulus of C.A.	5.82 IS:383-1970
Specific Gravity of F.A.	2.65
Specific gravity of C.A.	2.75
Specific gravity of Iron slag	2.67

Table 2: Materials Investigation

5. Experimental Program

Materials used in this research were OPC 43 Grade and cement confirming to code IS 8112 and fine aggregate or coarse aggregate confirming to IS 383-1970.

Designed concrete mix of M-40 grade having mix proportion 1:1.65:2.92 with water -cement ratio 0.45 at different percentages of iron slag 0%, 10%, 20%, 30%, 40% and 50% were used in concrete.
The concrete ingredients such as cement, steel slag, and coarse aggregate, fine

The experimental program included the following:

- Testing of properties of materials used for making concrete.
- Design mix (M40).
- Casting and curing of specimens.
- Tests to determine the compressive strength and Flexural strength of concrete

Aggregate were first mixed in the dry state and pure water was added at the last. The standard size of prisms is 700x150x150mm for compressive strength was casted.

In which we calculate the compressive strength of each sample after complete the 7days, 14 days and 28 days. All the samples of cube or prisms were cured for 7days, 14days and 28 days. After complete the 7, 14 and 28days to check the compressive
Strength or Flexural strength of all samples. The experimental investigation of effect of different percentages Replacement of coarse aggregate by steel slag.

6. Compressive Strength: (IS 516-1959)

Compressive strength was accounted by placing the cubes of size 150x150x150 mm on UTM (Universal testing machine). This machine was used as a set up for carrying out all tests on hardened concrete. This test was to be done to carry out for finding the Flexural strength and compressive strength.

Compressive strength calculated by the formula **fcu=P/A,** fcu=compressive strength of cube, MPa

A=area of loading at failure.

The compressive strength of cubes checked after complete the 7, 14and 28days. Compressive strength results are show in tables:

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

Sr. No.	*% of slag*	*Compressive strength in (N/mm^2) at 7 Days*	*Compressive strength in (N/mm^2) at 14 Days*	*Compressive strength in (N/mm^2) at 28 Days*
1	0%	36	39	41
2	10%	37	40	43
3	20%	42.22	44	46.63
4	30%	47.13	48.22	49.76
5	40%	38.22	39.73	42.22
6	50%	35.75	37.43	40

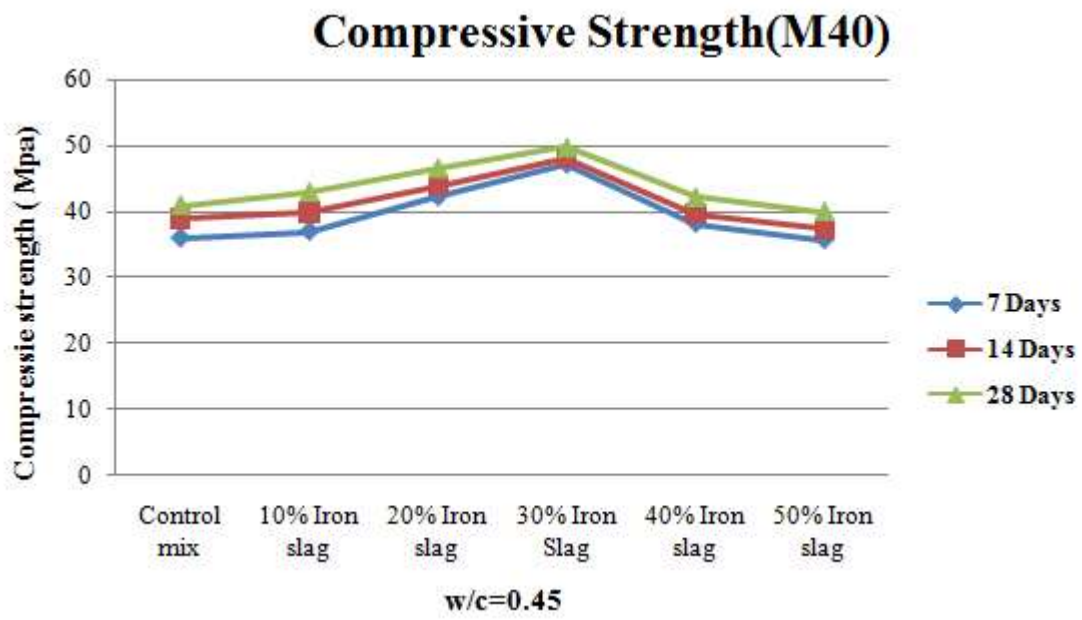

Figure 1: Compressive strength of iron slag concrete

7. Flexural Strength :(IS51-1959)

To determined the Flexural strength of each specimen of standard size 700x150x150mm was supported over a entire span of 600mm and a two point load was applied at the centre of span .The deflection of beam and prisms under the load condition was recorded up to the first crack.

Table 4: Flexural strength of concrete mixes of specimen size 150 × 150 × 700 with Iron slag

Sr. No.	*% of Iron slag*	*Flexural strength in (N/mm^2) at 7 Days*	*Flexural strength in (N/mm^2) at 14 Days*	*Flexural strength in (N/mm^2) at 28 Days*
1	0% (CM)	5.18	5.63	6.37
2	10%	5.54	5.85	6.94
3	20%	5.94	6.74	7.63
4	30%	5.03	5.48	5.63
5	40%	4.96	5.18	5.04
6	50%	4.05	4.74	4.40

The flexural strength is calculated by the formula. The maximum load applied to the specimens during the tests are recorded and used to calculate flexural strength of the concrete using the formula.

$$f_b = \frac{P \times l}{b \times d^2}$$

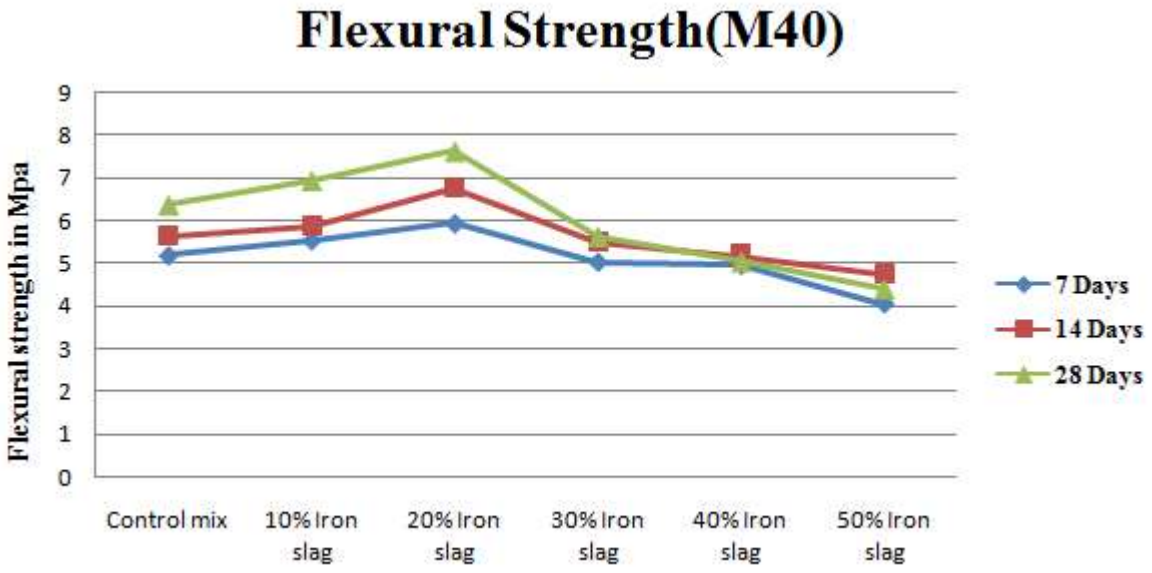

Figure 2: Flexural strength of iron slag concrete

8. Impact Test of Aggregates

Aggregates are passed through 13.2mm sieve and retained sample in 11mm sieve was tested.

Weight of empty cylinder=971.0gm
Weight of empty cylinder + Aggregate (w_1) =1313gm
w_2 =1313-1287=26gm
W2/w1 ×100=26/342×100=7.6 (impact value good quality)

9. Test Results and Discussion

Compressive Strength:

Results of the compressive strength test on concrete with varying proportions of iron slag replacement at the age of 7, 14 and 28 days are given in the Table 3. Compressive strength increases up to replace the 30% iron slag as compare to control mix to add the proportion of iron slag.

Flexural Strength:

The average flexural strength of Iron slag concrete at the different age of 7days , 14days and 24 days is show in Table 4 results show that at 28 days, with replacing percentage of Iron slag as 20% and we found that the increasing strength that of 0% replacement. The maximum flexural strength at 28 days is 7.63 N/mm^2 of 20% replacement of Iron slag. We conclude that the flexural strength at 20% is more than that of 0% replacement of iron slag.

Workability:

The workability of concrete in M40 grade of concrete it improved upto 30to 50% replacement level and later dropped at 100% replacement by about 8% in case of replacing coarse aggregate with slag. The workability improved in higher grade concrete (M40) due to potential availability of finer materials.

10. Conclusion

Following are the conclusions draw from the above research work.

1. After adding 10% iron slag in the mix, there is an increase of 2.7% after 7days, 2.56% increase after 14 days and 5% increase after 28 days as compared to the control mix. By adding 20%,30%,40% iron slag, there is large amount of increase in percentage i.e. 17.27%, 12.82%, 13.73% and 30%, 23.64%, 21.36% and 6.16%,1.87%,2.97% after 7, 14 and 28 days respectively as compared to the control mix design concrete at 0% replacement of coarse aggregate . After adding 50% Iron slag there is decreases in concrete. up to 50% replacement.
2. The Compressive strength tends to increase with increase percentages up to 30% of iron slag in the mix.
3. At 30% replacement of coarse aggregate with Iron slag aggregate gives desirable compressive strength.
4. At 20% of replacement of coarse aggregate with iron slag aggregate gives desirable flexural strength which can be can accounted for the construction practices.
5. After adding 30%, 40% and 50% iron slag in concrete there is decreases in hardened concrete.

Hence, it could be recommended that the Iron slag aggregate could be effectively utilized as coarse as coarse and fine aggregate in all concrete applications either as partial or full replacements of normal coarse and natural fine aggregate.

References

[1] ASTM C 33. (2003). “Standard Specification for Concrete Aggregates” ASTM International.
[2] IS: 10262-2009 (Reaffirmed 2004): Recommended guidelines for concrete mix design, Bureau of Indian Standard, New Delhi-2004.
[3] IS: 383-1970: Specification for Coarse and Fine Aggregates from Natural Sources for Concrete, Bureau of Indian Standard, And New Delhi- 197.
[4] IS: 4031 (Part 4, 5&6)-1988: Methods of Physical Tests for Hydraulic Cement, Bureau of Indian Standard, New Delhi-1988.
[5] Monshi A., Asgarani M.K. (1999). “Producing Portland cement from iron and steel slags and limestone.”Cement and Concrete Research Vol. 29 pp 1373-1377.
[6] IS: 4031 (Part 4, 5&6)-1988: Methods of Physical Tests for Hydraulic Cement, Bureau of Indian Standard, and New Delhi-1988
[7] IS 8112: 1989, Specification for 43 grade OPC, reaffirmed 1997.
[8] IS 10262: 1982 “Recommended guidelines for concrete mix design”, 1982