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Investigations of Properties of self Compacting Concrete by Adding Iron Slag as Partial Replacement of Fine Aggregate

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Abstract: Self compacting concrete is the latest development in the concrete technology for better durability, high deformability and fluidity for construction industries. In this paper, mechanical properties of self-compacting concrete (SCC) made with iron slag (IS) are investigated. The possibility of using it as partial replacement of fine aggregates in concrete mix is studied and evaluated based upon the percentage of the partial replacement of fine aggregate with iron slag. In this research work, iron slag obtained from industry is replaced with fine aggregate accordingly in the reach of 0, 0.1, 0.2, & 0.3 by weight of M25 grade of concrete. Various tests were done for fresh SCC properties, compressive strength and split tensile strength. The experimental results showed that the iron slag replacement with fine aggregate content gives better strength than control mixture of self compacting concrete and can be suitably used in self compacting concrete.

Keywords: self compacting concrete, fly ash, iron slag, compressive strength, split tensile strength.

1. INTRODUCTION

Self-compacting concrete (SCC) can be defined as a fresh concrete which possesses superior flow ability under maintained stability (i.e. no segregation) thus allowing self-compaction that is, material consolidation without addition of energy. Self-compacting concrete is a fluid mixture suitable for placing in structures with Congested reinforcement without vibration and it helps in achieving higher quality of surface finishes. Self-compacting concrete (SCC), which flows under its own weight and doesn't require any external vibration for compaction, has revolutionized concrete placement. Such concrete should have relatively low yield value to ensure high flow ability, a moderate viscosity to resists segregation and bleeding and must maintain its homogeneity during transportation, placing and curing to ensure adequate structural performance and long term durability.

Self-Compacting Concrete also known as Self Consolidating Concrete or SCC is the one that consolidate under its own weight and has high flow ability. It does not need any mechanical consolidation as well as minimal separation of material constituents enables it to spread easily and fill the restricted as well as congested reinforcement sections of the structure. Prof. Okamura of Ouchi University, Japan developed and conceptualized the idea of SCC in 1986.

Characterized by parameters like high deformability, moderate viscosity and low yield stress ensures homogenous particle suspension during the processes like transportation and placement. It also gives a superior surface finish after the setting of concrete than conventional or normal concrete. Use of super plasticizers and high amounts of powdered material eliminates segregation and ensures high mobility. A mix design procedure was developed by Okamura and Ozawa for SCC which states that the contents of fine and coarse aggregates are to be kept constant whereas the super plasticizer dosage and water/powder ratio can be varied accordingly to achieve self-compatibility. SCC is considered to be an emerging class of concrete which offers increased rates of construction, reduced cost, labour and time. The first prototype of SCC was developed by Prof. Ozawa of University of Tokyo in 1989 although the concept of SCC was developed by Hajime Okamura in 1986. For SCC, it is generally necessary to use super plasticizers in order to obtain high mobility. Adding a large volume of powdered material or viscosity modifying admixture can eliminate segregation. The powdered materials that can be added are fly ash, silica fume, lime stone powder, glass filler and quartzite filler.

The three properties that characterize a concrete as self-compacting Concrete are:
- Flowing ability: The ability to completely fill all areas and corners of the formwork into which it is placed.
- Passing ability: The ability to pass through congested reinforcement without separation of the constituents or blocking.

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- Resistance to segregation: The ability to retain the coarse components of the mix in suspension in order to maintain a homogeneous material.

The objectives and scope of present study are:
- To find the optimum percentage of replacement of fine aggregate with iron slag at which maximum strength is obtained.
- To study the effect of use of iron slag on the properties of concrete.
- To compare the results of conventional and modified concrete with the given concrete mix.
- To provide economical construction material.

2. MATERIAL PROPERTIES

2.0 Cement
Ordinary Portland Cement of 43 grade manufactured by the JP Cement Company confirming to IS 8112:1989 was used in this study. The Properties of Cement are shown in Table 1.

Table 1: Physical properties of cement

S.No.	Test	Result	Specified by IS 8112:2013
1	Fineness of cement (kg/m^2)	245	225
2	Consistency of cement	36	30
3	Initial setting time (minutes)	75	30
4	Final setting time (minutes)	260	600
5	Specific gravity	3.12	2.5-3.5
6	Compressive strength (N/mm^2)	48.3	58
7	Soundness (mm)	3	10

2.1 Fine aggregate
Fine aggregate is used after sieving sand which passed through 4.75mm IS sieve . The fineness modulus of sand is 2.46 and specific gravity is 2.60. The water absorption capacity of sand is 1.15%. Bulk density values obtained are 1587 Kg/m^3 and the percentage of bulking is 33%.

2.2 Coarse aggregate
The Coarse aggregate are obtained from a local quarry. The coarse aggregate is used with maximum size of 12mm , having a specific gravity 2.65 and fineness modulus of 6.93. The bulk density of coarse aggregate obtained was 1538 Kg/m^3 and water absorption of 0.75%.

2.3 Fly ash
Fly ash is obtained in the process of combustion of coal. Nowadays, fly ash is commonly used as replacement (partial) for Portland cement in order to obtain concrete of higher strength and durability because fly ash reacts with the lime present in Portland cement to form a more durable binder. Class F fly ash was used. It was grey in color, particle size less than 35µm. Its specific gravity was 2.24.

Table 2: Physical properties of fly ash

S.No.	Parameters	Fly Ash
1	Bulk Density (gm/cc)	0.9-1.3
2	Specific Gravity	1.6-2.6
3	Plasticity	Lower or non-plastic
4	Shrinkage Limit	Higher
5	Clay	Negligible
6	Free Swell Index	Very low
7	Classification (Texture)	Sandy silt to silty loam
8	Water Holding Capacity	40%-60%
9	Porosity	30%-65%

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Table 3: Chemical properties of fly ash

S.No.	Compounds (%)	Fly Ash
1	SiO_2	38-63
2	$Al_2 O_3$	27-44
3	TiO_2	0.4-1.8
4	$Fe_2 O_3$	3.3-6.4
5	MgO	0.01-0.5
6	CaO	0.2-8
7	$K_2 O$	0.04-0.9
8	$Na_2 O$	0.07-0.43
9	LOI	0.2-5.0
	pH	6-8

2.4 Iron slag

Iron slag was collected from local iron industry. It was black in color. The specific gravity and fineness modulus of iron slag was 2.53 and 2.76 respectively. The fineness modulus of fine aggregate and iron slag shows that both materials are almost similar in particle size.

Table 4 Chemical composition of iron slag

S.No.	Chemical compound	Formula	Mass percentage
1	Calcium oxide	CaO	0.8
2	Aluminum oxide	$Al2O_3$	2.94
3	Silicon dioxide	SiO_2	6.98
4	Iron oxide	Fe_2O_3	66.88
5	Carbon dioxide	CO2	22.40

3. EXPERIMENTAL METHODOLOGY

The valuation of iron slag after replacement of fine aggregate starts with the concrete testing. The study is conducted to check the behaviour of concrete when the fine aggregate is replaced by iron slag. The experimental results are obtained after conducting compressive strength and tensile strength tests on concrete. The iron slag which obtained from industry replacement is kept at 0, 0.1, 0.2 and 0.3. In this research work total 12 cubes (150mm X 150mm X150mm) and 12 cylinders (150mm X 300mm) are developed and results are analyzed after curing of 7, 14 and 28 days of concrete. The Data obtained from the replacement of iron slag is compared with data obtained from a Conventional concrete.

4. EXPERIMENTAL PROGRAMME AND RESULTS

A mix M25 grade is designed as per IS 456: 2000 and the same was used to prepare the test samples. The concrete mix proportion (cement: fine aggregate: coarse aggregate) is 1: 1: 2 by volume and a water-cement ratio of 0.45 is used for the normal concrete . Designed mix was prepared for the conventional concrete. The details of replacement of iron slag by fine aggregate are shown in Table 5.

Table 5: Replacement of iron slag (by weight)

Sample no.	Cement + Fly ash	Iron slag	Fine aggregate	Course aggregate
1	1 + 0	0	1	1
2	0.95 + 0.05	0.1	0.9	1
3	0.9 + 0.1	0.2	0.8	1
4	0.85 + 0.15	0.3	0.7	1

4.1 Compressive strength

Compressive strength of concrete is tested on cubes at different percentage of iron slag content in concrete. The strength of concrete is tested on cubes at 7, 14 and 28 days curing. 7 days test is conducted to check the initial strength

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of concrete, 14 days test is conducted to check the median strength of concrete and 28 days test is conducted to check the final strength of concrete. Compression testing machine is used for testing the compressive strength of concrete. The samples of concrete with iron slag replacing by fine aggregate at 0, 0.1, 0.2 and 0.3 are tested after curing of 7, 14 and 28 days. The results obtained from the experiment are shown in Table 6.

Table 6 Compressive Strength Results

Cement + Fly ash	% of iron slag	Compressive strength at 7 days (N/mm^2)	Compressive strength at 14 days (N/mm^2)	Compressive strength at 28 days (N/mm^2)
1 + 0	0 (Conventional concrete)	20.81	26.8	32.56
0.95 + 0.05	0.1	21.81	28.8	33.56
0.9 + 0.1	0.2	28.05	34.15	35.85
0.85 + 0.15	0.3	19.42	22.37	24.21

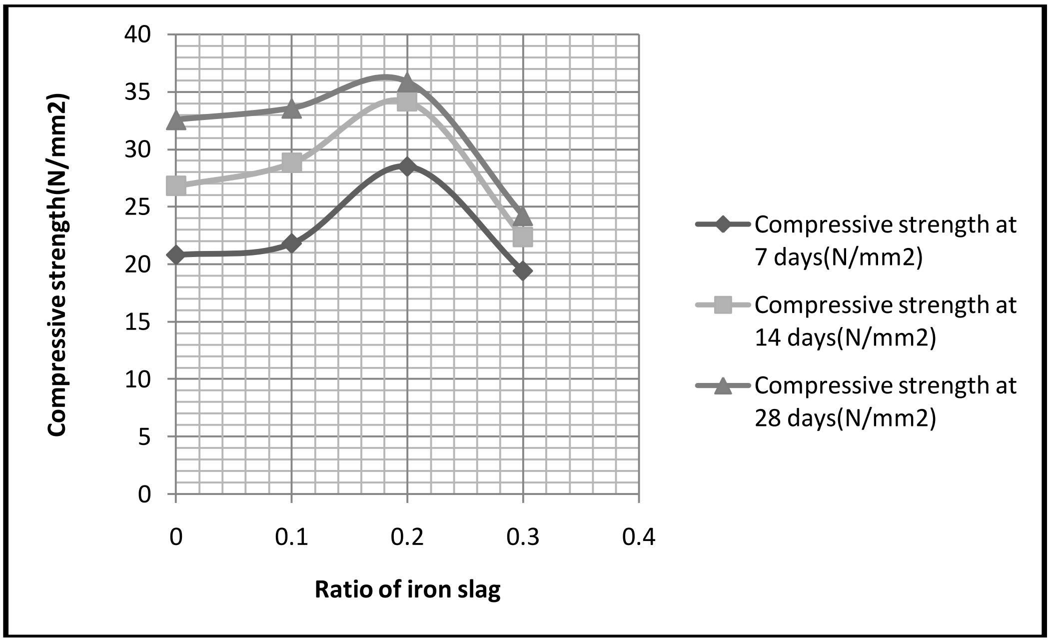

Figure 1 Compressive strength of concrete

4.2 Split tensile strength

Split tensile strength of concrete is tested on cylinders at different percentage of iron slag content in concrete. The split tensile strength of concrete is tested on cylinder at 7, 14 and 28 days of curing. 7 days test is conducted to check the initial strength of concrete, 14 days test is conducted to check the median strength of concrete and 28 days test is conducted to check the final strength of concrete. Compression testing machine is used for testing the split tensile strength test on concrete along with two wooden boards by changing the axis of sample. The samples of concrete with iron slag replacing the fine aggregate at 0, 0.1, 0.2 and 0.3 are tested after curing of 7, 14 and 28 days. The results obtained from the experiment are shown in Table 7.

Table 7 Split tensile strength results

Cement + Fly ash	% of iron slag	Split tensile strength at 7 days(N/mm^2)	Split tensile strength at 14 days(N/mm^2)	Split tensile strength at 28 days(N/mm^2)
1 + 0	0 (Conventional Concrete)	2.10	2.35	3.30
0.95 + 0.05	0.1	2.23	2.69	3.52
0.9 + 0.1	0.2	2.39	2.95	3.75
0.85 + 0.15	0.3	1.63	1.85	2.23

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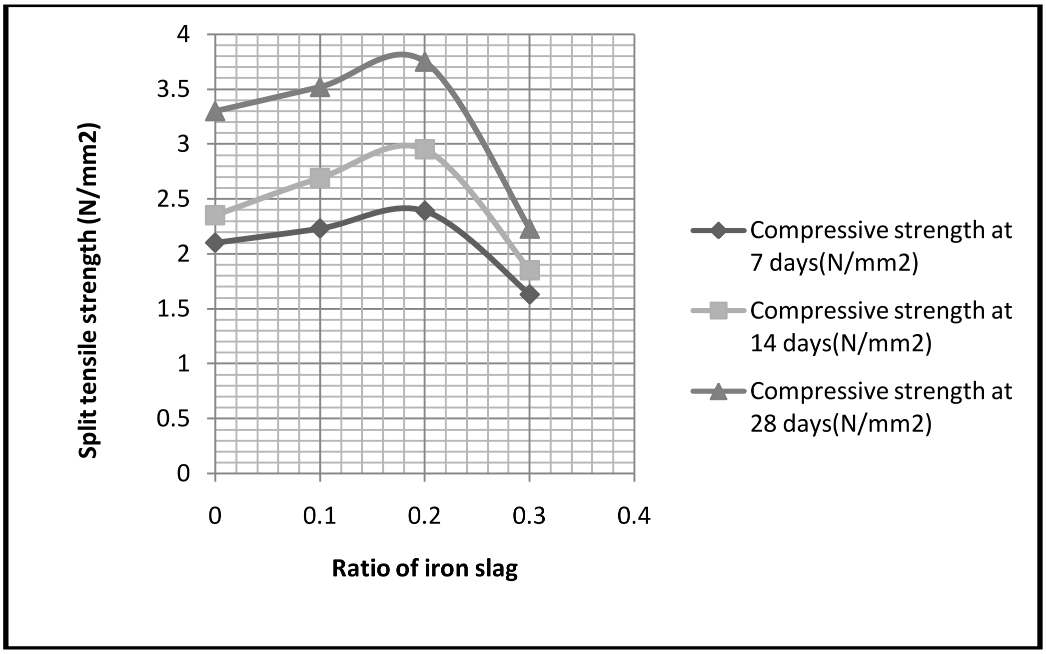

Figure 2 split tensile strength of concrete

5. CONCLUSIONS

From the results obtained from the experiments the following conclusions can be drawn:

- The paper investigated the compressive strength and split tensile strength of concrete containing iron slag at 0, 0.1, 0.2 and 0.3 percentage of fine aggregate and it is concluded that iron slag has a potential to provide an alternative to fine aggregate.
- Compressive strength and split tensile strength of concrete are increased with addition of iron slag up to 0.2 replacement by weight of fine aggregate and further any addition of iron slag reduced the compressive strength and split tensile strength of concrete.
- The result obtained for 28-day compressive strength and split tensile strength of concrete concludes that the optimal percentage for replacement of fine aggregate with iron slag is about 0.2.
- This paper concludes that the optimum percentage for replacement of iron slag with fine aggregate is almost 0.2 of the fine aggregate for both cubes and cylinders.
- The use of iron slag with fine aggregate which is available in the industries can minimize the cost for construction.

REFERENCES

[1] EFNARC, (2002). Specifications and Guidelines for Self-Compacting Concrete, EFNARC, UK.
[2] Hajime Okamura and Masahiro Ouchi “Self-Compacting Concrete” journal of advanced concrete technology Vol.1, No. 1.5-15, April 2003.
[3] Paratibha Aggarwal, Rafat Siddique, Yogesh Aggarwal, Surinder Gupta “Self-Compacting Concrete – Procedure for Mix Design” Leonardo electronic journal of practises and technologies, Issue 12, January-June 2008, p. 15-24.
[4] N R Gaywala, D B Raijiwala “SELF COMPACTING CONCRETE: A CONCRETE OF NEXT DECADE” journal of engineering research and studies.
[5] H.J.H. Brouwers, H.J. Radix “Self-Compacting Concrete : Theoretical and experimental study” cement and concrete research 35 (2005) 2116-2136
[6] Schutter, G.De, Bartos, P.J.M., Domone P.L.J., Gibbs, JC. (2008). Self-compacting concrete. Whittles publishing.
[7] Siddique, R. (2010). Properties of self-compacting concrete containing class F fly ash Materials and Design, vol: 32, pp.1501-1507
[8] Dr. Needhisadan Santhanam, Manoj Nallanathel, Monirupa Ananya “Self Compacting Concrete – A Boon To Construction Industry” global journal for research analysis, Vol-3, Issue-9, September-2014.
[9] IS 456-2000, Indian standard plain and reinforced concrete code of practice, 4th revision, 1st reprint Sep-2000.
[10] IS 516-1959, Methods of test of strength of concrete, 16th reprint, Jan-1976
[11] IS 1489 (PART-I Fly ash based) 1991, Specification for Portland-pozzolana cement, 3rd revision, BIS-1991
[12] IS 383-1970, Specification for coarse and fine aggregate for natural sources for concrete, second revision, 9th reprint

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