Global Scientific JOURNALS

GSJ: Volume 9, Issue 1, January 2021, Online: ISSN 2320-9186
www.globalscientificjournal.com

TO EVALUATE THE DURABILITY OF SELF COMPACTING CONCRETE BY USING STEEL SLAG AND MANUFACTURED SAND AS REPLACEMENT OF FINE AGGREGATE.

Ishfaq Khan[1], Syed Basit Ali[2]

[1]Author, Civil Engineering Department, CECOS University of IT and Emerging Science Peshawar.

[2]Co-Author, Civil Engineering Department, CECOS University of IT and Emerging Science Peshawar.

hk910457@gmail.com, engrbasitoffical@gmail.com

Abstract

The paper presents the durability characteristics of self-compacting concrete (SCC) of iron slags (IS). For this, a control sample was originally designed and then the small units (0, 10, 25, and 40%) were partially replaced with iron slages. Various studies have been performed on the properties, compressive strength, and durability of recent SCCs, such as rapid chloride permeability, water uptake, sulfate resistance, and ultrasonic heart rate for up to 365 days. SEM analyzes were also performed. The test result shows that SCC, including iron slag, offers greater strength and durability than the SCC control mixture and can be used correctly in SCC.

Keywords –*Self Compacting Concrete, Iron Slag, Strength, Permeability.*

1. INTRODUCTION

Concrete reinforced with concrete is essential and consistent for blowing trapped air. Hardening is a method of obtaining a good concrete with excellent strength and durability, but internal or external vibrations do not require self-compacting concrete (AC) to compress it, as it is hardened with its own permeability and filling capacity. Self-compacted concrete (CAA) tests were stronger every day. Various industrial products successfully used to produce permanent SCC, including fly ash, quartz smoke and granular slag in furnaces, steel slag and copper slag, etc. it is used to replace sand as concrete. Because iron slag is produced in large quantities, it is blown up in nearby areas, endangering living things. A good opening is to use iron slag to make concrete.

With the steady increase in the production of iron slag, it becomes necessary and appropriate to use it in concrete, rather than for disposal. Some researchers have focused on iron slag as an additional material instead of concrete sand. In SCC, the replacement of iron slag with sand provides soothing results in strength and microstructural properties. Despite these findings, a very limited literature on the durability properties of SCC containing fine iron as fine aggregates has been reported.

2. LITERATURE REVIEW

Sheen et al. it used stainless steel reduced slag (SSRS) for the first time and was found to give better flow values up to 20% SSRS, replaced by OPC after increasing the slag content, values decreasing by together, the technical requirements of V funnel time and box fillers are met until 50% SRSS are replaced, and the ultrasonic pulse frequency result shows excellent SCC quality with 30% replacement.

Ismail and Hashmi performed various tests to evaluate the quality of concrete with reuse of left over iron as sand in concrete up to 20% replacement and result enumerates that concrete formed with waste iron imparts had more compressive strengths than normal concrete. The results of iron concrete show that slump values decrease with an addition of the waste iron as sand, which is believed to be influenced by the shape of the waste grains. Even with decreased in the slump of concrete mixtures, they remain easy to consolidate.

Bilim et al. studied artificial neural networks (ANN) and check the compressive strength of concrete made with ground granulated blast furnace slag. Three different parameters of w/c ratios (0.3, 0.4, and 0.5) and 20–80% four partial slag replacement ratios with 20% increment were used. Compressive strength of cured concrete samples was checked up to 360 days. Taking all slag replacement ratios, at 7 days' age strength was found to be low. Whereas at 28 days of concrete strength with slag (20 and 40%) was higher than control concrete.

Chitra investigated on high strength concrete prepared from copper slag as fine aggregates at 40% and nano-silica up to 2% replacement. Results show that very low rapid chloride permeability values at 28 and 90 days. Water absorption values reduce with increment in copper slag content.

Deboucha believed that blast furnace slag improves the strength and durability properties of concrete mixtures.

Sheen et al. investigated the effect of using oxidizing and reducing slag obtained from stainless steel making as sand on the engineering concrete properties. Research concluded all engineering properties were comparable with control mix and it could save cost up to 43% with 100% substitution of stainless steel oxidizing slag as coarse aggregates and 30% part of stainless steel reducing slag substitutes to Portland cement in SCC.

Afshoon and Sharifi examined the consequences of ground copper slag as substitutes of cement on fresh properties of SCC. Seven mixes made with fix waterpowder ratio at replacements of 0–30% with 5% increment. They concluded that the utilization of GCS as cement replacement can be beneficial for fresh concrete properties in SCC.

Devi and Gnanavel evaluated that the part replaced of fine aggregates with steel slag upgrade the strength properties and penetrations of chloride ions in rapid chloride permeability values are low.

Law et al. examined the durability properties of alkali activated slag (AAS) concrete. Study concluded that with the increase of activator modulus reduced the conductivity and charge passed in rapid chloride permeability of the AAS concrete. The number of micro-cracks reduced as modulus increased and there was a large decline in sorptivity for AAS concrete comparable to control mix.

Khatib concluded that part replaced of cement with slag in concrete subjected to initial moist curing beneficial for low water absorption and water absorption coefficient.

Bakharev et al. conducted tests to find out resistance of alkali-activated slag (AAS) concrete to sulphate attack. These tests includes immersion in 5% MgSo4 and 5% Na2So4 solutions and observed that the strength reduction was up to 17% for alkali activated slag (AAS) concrete and up to 25% for ordinary Portland cement (OPC) concrete after 12 months exposure to sodium sulphate solution. After the same time of exposure to the MgSo4 solution, the compressive strength decline was more up to thirty-seven percent for OPC and twenty-three percent for alkali-activated slag (AAS).

Humam and Siddique checked compressive strength and permeability parameters of mortar incorporating iron slag as part replaced with sand and concluded that iron slag raises the compressive strength of the mortar and improve permeability at higher extent. The purpose of this investigation was to find the compressive strength, and durability properties such as rapid chloride permeability, water absorption, sulphate resistance and ultra-sonic pulse velocity of self-compacting concrete made from iron slag.

3. EXPERIMENTAL PROCEDURE

3.1. MATERIAL

3.1.1. Cement

Portland cement is used in this work, which conformed to BIS: 8112-1989.

3.1.2. Fine Aggregate

River sand was used as fine aggregate, and satisfied the requirements for grading zone-II of BIS: 383-1970. Its specific gravity and fineness modulus values were 2.57 and 2.64 respectively.

3.1.3. Coarse Aggregate

Locally available gravel of 12 mm size was used as coarse aggregate. Its specific gravity was 2.69 and fineness modulus was 6.87.

3.1.4. Iron Slag

Iron slag was collected from a local iron and steel rolling mills. It was black in color. The chemical composition of iron slag. Specific gravity and fineness modulus of iron slag is 2.49 and 2.72 respectively. Fineness modulus values of fine aggregate (2.64) and iron slag (2.72) indicate that they are almost similar in particle size.

3.2. Mix Proportion

The mixture proportion of SCC was picked on the basis of trials. The below table shows mixture proportion ratios. Control mixture was

Properties	BIS-8112-1989	Test Result
Compressive strength (N/mm2)		
7 day	22	33.2
28 day	33	44.8
Setting time (minutes)		
Final	600 Max	273
Specific gravity	–	3.09
Standard consistency (%)	–	34%
Soundness		
Le-chat expansion (mm)	10.0 Max	1.7

Table 1: Properties of Portland cement.

Chemical Compound	**Formula**	**%Age of chemical compound**
Iron Oxide	Fe2O3	66.88
Silicon dioxide (silica)	SiO2	6.98
Aluminum oxide (alumina)	Al2O3	2.94
Calcium oxide (lime)	CaO	0.8
Carbon dioxide	CO2	22.40

Table 2: Chemical composition of iron slag.

designed to achieve 30 MPa compressive strength at 28 days. Then river sand was replaced with 10, 25 and 40% iron slag. The control SCC mixture was designated as ‘‘SCC-CM”, and SCC mixtures with 10, 25 and 45% iron slag were designated as SCC-IS10, SCC-IS25 and SCC-IS40 respectively. All the mixtures also contained 10% of fly ash weight of cement and 1.2% of super plasticizer was added by weight of cement

4. MEHODOLOGY:

To achieve the study objectives, the following methodology is adopted.

Passing and filling abilities of fresh SCC were examined as per guidelines of EFNARC. Compressive strength test performed on 150 mm size cube, up to the age of 365 days as per BIS: 516- 1959. Water absorption test was performed on 150 mm size cube up to the age of 365 days as per ASTM C642-97. Rapid chloride permeability tests were conducted on circular specimen of diameter 100 mm and 50 mm length up to 365 days age as per ASTM C 1202-10. Sulphate resistance test performed on 150 mm size cubical specimen up to 365 days as per ASTM C1012-10. Ultra-sonic pulse velocity test was done on cylindrical specimen of 150 mm diameter and 300 mm length up to 365 days as per ASTM C 597-02. Guidelines of concrete quality

based on pulse velocity if the value of velocity more than 4000 m/s then it sounds very good to excellent quality and if velocity lies between 3500 and 4000 m/s then good to very good quality of concrete, 3000–3500 m/s satisfactory results but loss of integrity is suspected, less than 3000 m/s then poor quality of concrete.

5. RESULT AND DISCUSSION

The result of the study are summarized as:

5.1. Fresh concrete properties

Incorporation of iron slag in SCC mixture has changed the fresh properties. It was observed that incorporation of iron slag in SCC mixture reduced the workability. Fresh properties of SCC are in good quality comparison as per European procedure, ENFNARC. SCC was proved for fresh concrete properties. The water powder ratio was 0.44 and admixture was 1.2% by mass of powder.

5.2. Hardened concrete properties

5.2.1. Compressive strength

The replacement of iron slag leads to increase in compressive strength at any testing period. The strength increment is not only cause of rigidity of changing aggregates but in fact, it is a good quality of interfacial transition region over the aggregate. Compressive strength of control mixture of SCC without iron slag is 35.7 MPa, 38.5 MPa and 47.3 MPa at 28, 91 and 365 days respectively. Compressive strength at 28 days of SCC mixtures made with 10, 25 and 40% iron slag as fine aggregates gained 4, 13 respectively more compressive strengths in comparison with Control SCC (without iron slag). At the age of 91 days, SCC mixtures containing 10, 25 and 40% iron slag as fine aggregates gained 5%, 13% and 21% respectively more compressive strength as compared to 91 days SCC mixture without iron slag. At the age of 365 days, SCC mixtures containing 10, 25 and 40% iron slag as fine aggregates gained 5, 15 and 22% respectively more compressive strength as compared to 91 days SCC mixture without iron slag. On the curing age of 91 days and 365 days, the increment in compressive strength percentage of SCC mixtures containing iron slag is more than control mixes. Increase in compressive strength at all ages with increase in iron slag content exhibits that SCC with inclusion of iron slag got denser, resulting in improved strength.

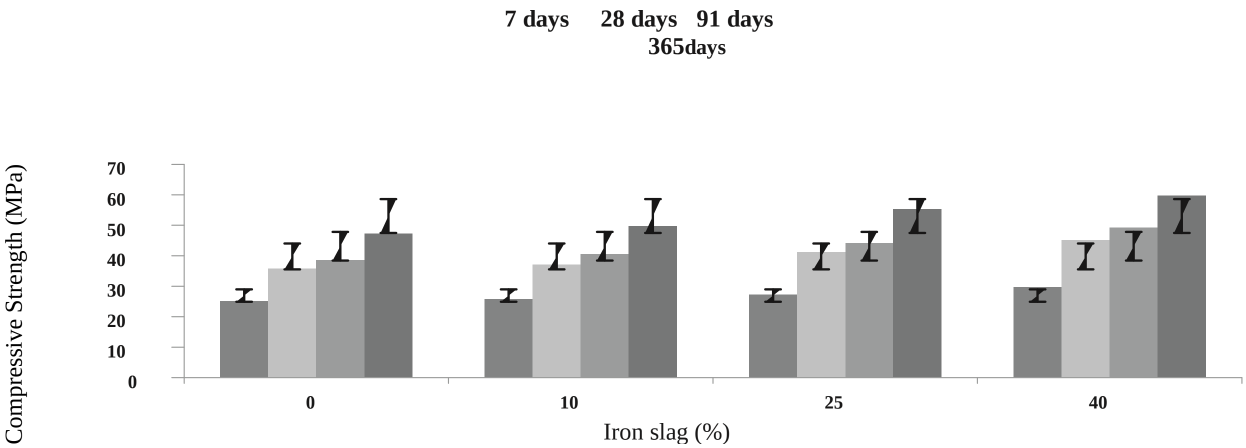


Fig. 1: Effect of iron slag on compressive strength

5.2.2. Water absorption

The durability of concrete mostly built upon the movement of water through it. Water absorption is a simple criterion to find a measure of concrete resistance to exposure in aggressive environments. Water absorption results of iron slag in SCC mixtures up to 365 days. Water absorption of SCC mixture without iron slag replacement with fine aggregates is 4.81%, 4.12% and 3.5% at 28, 91 and 365 days. Findings indicates that as the percentage of iron slag increases the percentage of water absorption decrease in all concrete mixtures and same in case of curing age due to increment in passage of time water absorption decreases. Curing age of 7 days, SCC mixtures containing 10, 25 and 40% iron slag as fine aggregates gained 1, 3, and 9% less absorption as compared to 7 days SCC mixture without iron slag. Curing age of 28 days, SCC mixtures incorporating 10, 25 and 40% iron slag as fine aggregates gained 1.5, 12, and 4% less absorption as compared to 28 days SCC mixture without iron slag. At 91 days, SCC mixtures consist of 10, 25 and 40% iron slag as fine aggregates gained 1, 1, and 8% less absorption as compared to 91 days SCC mixture without iron slag. Results of 365 days indicates that SCC mixtures containing 10, 25 and 40% iron slag as fine aggregates gained 5, 4, and 2% less absorption as compared to SCC mixture without iron slag at same age. Water absorption generally related to the structural pores (inter-layer C–S–H) and porous paste, aggregate interface zone, especially more at initial stage. Water absorption decreased with the increase of iron slag content, which indicates that concrete got denser because inclusion of iron.

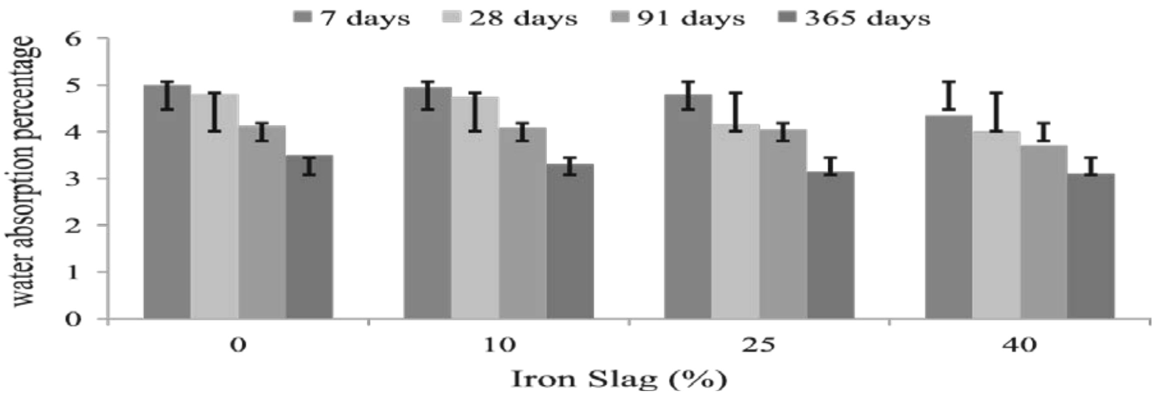
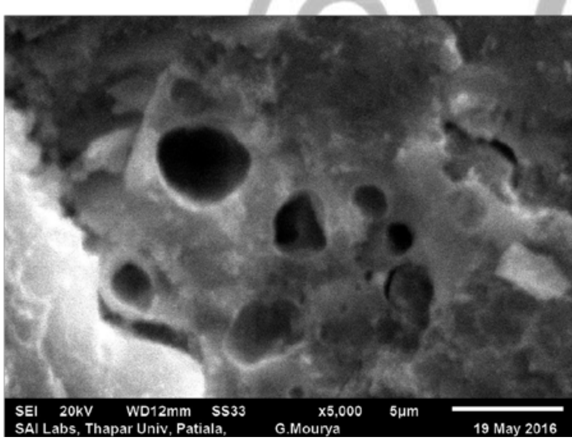


Fig. 2: Effect of iron slag on water absorption

5.3. SEM Analysis

Scanning electron micrographs of concrete mixture SCC-CM, SCC-IS10, SCC-IS25 and SCC-IS40 after 28 days. In this research, broken pieces of SCC were mounted on the SEM stub and images were collected by using SE image state. Broken pieces of SCC specimen were covered with thin sheet. The below images shows SCC mixture with considerable amount of iron slag it was clearly observed ettringites formation in void spaces and C–S–H gel in some areas.



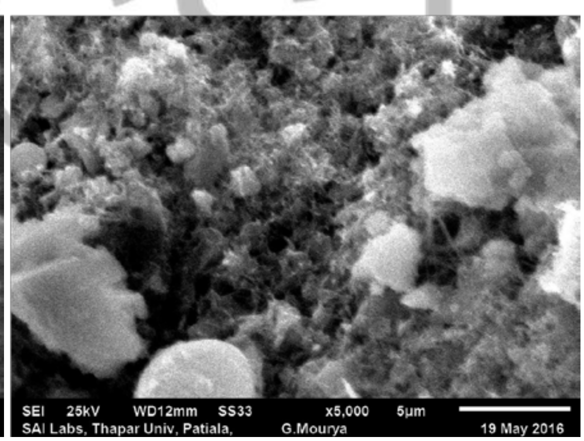


Fig. 3. SEM image of SCC (without iron slag) at 28 days. **Fig.4:** SEM image of SCC (with iron slag) at 365 days.

6. <u>CONCLUSION AND RECOMMENDATION:</u>

Based on the outcomes of the study it is strongly recommended to

- Slump flow, L-box and U-box values decrease with increase in with iron slag whereas there is increase in V-funnel time.

- Workability of SCC mixtures decreases due to increase of iron slag percentage cause may be multi-angle and rough in surface of iron slag aggregates. Increases friction between particles may responsible for the results.
- Compressive strength of SCC mixtures increases with iron slag content, and also with age. At 28 days, strength increases by 21% over control SCC.
- Water absorption of SCC mixtures with iron slag was lesser than control SCC mixtures at all curing ages.
- SCC mixtures without iron slag performed slightly better than SCC mixture with iron slag under external sulphate attack. There were only 10 and 16% loss in compressive strength at 7 and 28days after immersion in Mg_2SO_4.
- Iron slag SCC mixture gives good resistance to chloride ion penetration. The cumulative charge passed through iron slag mixtures was lesser than that passed through SCC mixture without iron slag.
- SEM images indicate that internal structure of concrete gets denser after the inclusion of iron slag.
-

7. REFRENCES

[1]. Y.N. Sheen, D.H. Le, T.H. Sun, Greener self-compacting concrete using stainless steel reducing slag, Constr. Build. Mater. 82 (2015) 341–350.
[2]. Z.Z. Ismail, E.A. AL-Hashmi, Reuse of waste iron as a partial replacement of sand in concrete, Waste Manage. 28 (2008) 2048–2053.
[3]. C. Bilim, C.D. Atis, H. Tanyildizi, O. Karahan, Predicting the compressive strength of ground granulated blast furnace slag concrete using artificial neural network, Adv. Eng. Softw. 40 (2008) 334–340.
[4]. S. Chithra, S.S.R. Kumar Senthil, The effect of colloidal nano-silica on workability, mechanical and durability properties of high performance concrete with copper slag as partial fine aggregates, Constr. Build. Mater. 113 (2016) 794–804.
[5]. W. Deboucha, M.N. Oudjit, A. Bouzid, L. Belagraa, Effect of incorporating blast furnace slag and natural pozzolana on compressive strength and capillary water absorption of concrete, Procedia Eng. 108 (2015) 254–261.
[6]. Y.N. Sheen, C.J. Huang, T.H. Sun, D.H. Le, Engineering properties of self compacting concrete containing stainless steel slags, Procedia Eng. 142 (2016) 79–86.
[7]. M. Afshoon, Y. Sharifi, Ground copper slag as a supplementary cementing material and its influence on fresh properties of self-consolidating concrete, IES J. Part A: Civ. Struct. Eng. 7 (4) (2014) 229–242.
[8]. V.S. Devi, B.K. Gnanavel, Properties of concrete manufactured using steel slag. 12th global congress on manufacturing and management, GCMM 2014, Procedia Eng. 97 (2014) 95–104.

[9]. D.W. Law, A.A. Adam, T.K. Molyneaux, I. Patnaikuni, Durability assessment of alkali activated slag (AAS) concrete, Min. Struct. 45 (2012) 1425–1437.

[10]. J.M. Khatib, Effect of initial curing on absorption and pore size distribution of paste and concrete containing slag, KSCE J. Eng. 18 (1) (2014) 264–272.

[11]. T. Bakharev, J.G. Sanjayan, Y.-B. Cheng, Sulfate attack on alkali-activated slag concrete, Cem. Concr. Res. 32 (2) (2002) 211–216.

[13]. T. Human, R. Siddique, Properties of mortar incorporating iron slag, Leonardo J. Sci. 23 (2013) 53–60.