

# Design and Evaluation of M50 Grade Concrete (H.P.C & S.C.C) using Ferro Alloy Silicon Slag as Fine Aggregate

Mohammed Ibrahim Khan

Bachelor of Technology (Civil Engineering),  
Sri Indu College Of Engineering, JNTU (Hyd)  
Email: Ibrahim.khan9640@gmail.com

**Abstract** – Natural river sand is expensive due to excessive cost of transportation from natural sources. Also large-scale depletion of these sources creates environmental problems. In such a case non availability of natural fine aggregate and population growth rate in geometric progression has urged the present day engineering society to search an alternative for aggregates to fulfill the basic human need for a shelter. On the other hand Ferro Alloy Silicon Slag, the waste product during the manufacturing process of Ferro- alloys silicon requiring a vast land to be dumped and polluting the environment can be a better substitute for natural fine aggregate i.e natural river sand. Here the objective of the project is the application of slag as a replacement for natural fine aggregate and its effect on mechanical properties of high strength concrete and also self compacting concrete. The paper aims to design concrete with certain target mean strength and to compare the strength of concrete by replacing the natural fine aggregate.

**Keywords** – High Performance Concrete, Self Compacting Concrete, River Sand, Ferro Alloy Silicon Slag.

## I. INTRODUCTION

Currently India has taken a major initiative on developing the infrastructures such as express highways, power projects and industrial structures etc., to meet the requirements of globalization, in the construction of buildings and other structures concrete plays the rightful role and a large quantum of concrete is being utilized. River sand, which is one of the constituents used in the production of conventional concrete, has become highly expensive and also scarce. In the backdrop of such a bleak situation, there is large demand for alternative materials from industrial waste.

This paper presents the feasibility of the usage of Ferro Alloy Silicon slag as a substitute for conventional concretes. Tests were conducted on cubes to study the compressive strength.

## II. MATERIALS AND METHODS

### Cement

Ordinary Portland cement (53-grade) with 30% standard consistency conforming to IS-12269 – 1987 was used. The physical properties of cement obtained by testing the sample as per Indian standards are listed in table 1.

Table 1: Physical properties of OPC

S.No.	Property	Value
1	Fineness of cement	4.52%
2	Specific gravity	3.15
3	Normal consistency	25.0%
4	Setting time i) Initial setting time ii) Final setting time	145 mins 265 mins
5	Compressive strength at i) 3 days ii) 7 days iii) 28 days	32.0 Mpa 39.5 Mpa 59.5 Mpa

### Ferro alloy silicon slag

The slag obtained from local resource “Shri Hari Ferro Alloys” and was crushed at “V.K.A stone crusher”, Hyderabad. The physical properties of Ferro Alloy Silicon Slag as per Indian standards are listed in table 2.

Table 2: Properties of ferro alloy silica slag

S.No.	Property	Value
1	Specific Gravity	2.77
2	Fineness Modulus	3.77
3	Bulk Density i) Loose ii) compacted	1475.9 Kg/m <sup>3</sup> 1566.6 Kg/m <sup>3</sup>
4	Grading	Zone II
5	Water absorption	1.66

### Fine aggregate (natural river sand)

Natural river’s sand properties are shown in the table 3.

Table 3: Properties of natural river sand

S.No.	Property	Value
1	Specific gravity	2.5
2	Fineness modulus	3.77
3	Bulk density i) Loose ii) Compacted	1361.1 Kg/m <sup>3</sup> 1438.8 Kg/m <sup>3</sup>
4	Grading	Zone II

### Coarse Aggregate

Natural granite aggregate of 12.5 mm and 20mm has been used having density of 1521.6 Kg/m<sup>3</sup> and 1581.6 Kg/m<sup>3</sup> respectively. Water absorption was found to be 0.2% and specific gravity 2.64.

### Admixture

Commercially available super plasticizer has been used to enhance the workability of fresh concrete for selected proportion of ingredients.

### III. MIX DESIGN FOR HIGH PERFORMANCE CONCRETE USING FERRO SILICON SLAG AND NATURAL RIVER SAND SEPARATELY

Indian standards has been used for river sand as fine aggregate and as there is no standard method of designing concrete mixes incorporating ferro alloy silicon slag and hence the method is proposed by IS.

### IV. TEST SPECIMENS AND TEST PROCEDURES

The 150mm size concrete cubes were used as test specimens to determine the compressive strength. The specimens were cast for M50 grade and for coarse aggregates of 12.5mm and 20mm were used.

The workability of fresh concrete was measured in the terms of slump values and equivalent compacting factor super plasticizers (0.7% to 2.4% weight of the cement) were added. The properties of fresh concrete were measured according to IS: 1199-1959. The ingredients of concrete were thoroughly mixed in mixer machine till uniform consistency was achieved. The cubes were compacted on a vibrating table.

Table 4: Details of concrete mix, results of workability and strength test

Materials used as fine aggregate	Mix proportions C:FA:CA	w/c ratio	a/c ratio	Slump (mm)		Compressive strength (Mpa)	
				Initial	After 30 mins	7 days	28 days
Natural river sand	1:1.74:2.5	0.49	6.02	130	90	35	56.2
	1:1.76:2.4	0.33	4.2	140	100	40	54.7
	1:1.75:2.5	0.30	2.87	120	60	42	52.2
Ferro alloy silicon slag	1:1.64:2.5	0.46	3.28	130	90	40.2	58.6
	1:1.7:2.54	0.31	5.04	140	100	45	56.3
	1:1.60:2.52	0.37	6.02	150	80	42	55.7

### V. WATER ABSORPTION

Six cubes of size 150mm were cast for two different mixes. All specimens were removed 24 hours after casting and subsequently water cured for 28 days. Samples were removed from water and wiped out any traces of water with damp cloth and difference in weight was measured.

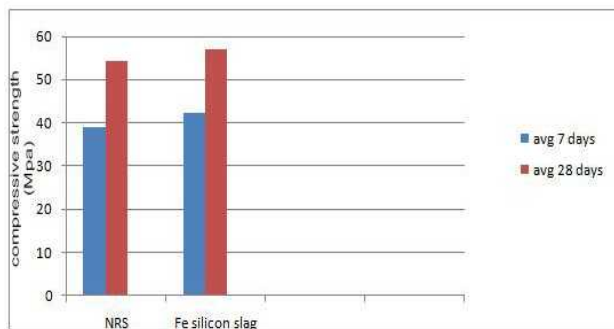


Fig.1. Comparative compression strength of NRS and FE silicon slag

### VI. RESULTS AND DISCUSSIONS

Natural river sand and Ferro Alloy Silicon slag have specific gravity and fineness modulus values are 2.55; 3.8 and 2.77; 3.7 respectively. Maximum size of the coarse aggregate was 20mm and minimum size of aggregate was 12.5mm. The specific gravity for 20mm was 2.64; impact value was 14% as per Indian standards. The increase in water cement ratio using Ferro Alloy Silicon slag had an overwhelming compressive strength when compare to natural river sand.

### VII. MIX DESIGN FOR SELF COMPACTING CONCRETE USING FERRO ALLOY SILICON SLAG AS FINE AGGREGATE

EFNARC specifications has been used for Ferro Alloy Silicon slag as fine aggregate and as there is no standard method of designing concrete mixes incorporating Ferro Alloy Silicon slag and hence the method is proposed by EFNARC.

### VIII. TEST SPECIMENS AND TEST PROCEDURES

The 150mm size concrete cubes were used as test specimens to determine the compressive strength. The specimens were cast for M50 grade and coarse aggregates of 12.5mm and 20mm were used.

The flow abilities of fresh concrete and blocking ratios was measured using slump cone test, V-Funnel flow time, U-Box test and L-box test and equivalent compacting factor super plasticizer (0.7% to 2.4% weight of the cement) were added and apart from super plasticizer Fly ash as a mineral admixture is also added. The ingredients of concrete were thoroughly mixed in mixer machine till uniform consistency has been achieved.

### IX. RESULTS AND DISCUSSION

Results of flow properties of concrete has been shown in table no.5

Table 5: Results of flow properties of SCC

Trial No.	Water cement ratio	Slump flow (mm)	Slump flow (sec)	V – Funnel flow time (sec)	U – Box filling ht (h1-h2)	L - Box		
						Blocking-ratio (h2/h1)	T20 (sec)	T40 (sec)
1	0.75	680	3.5	7.2	10	0.81	9.24	15.8
2	0.8	730	4.1	8.5	15	0.92	3.98	7.68
3	0.9	750	4.5	11	20	0.94	5.32	9.98

The slump flow test was used to evaluate the free deformability and flow ability of the SCC in the absence of any obstruction. A standard slump cone was used for the test and the concrete was poured in the cone without compaction. The slump flow value is represented by the mean diameter (measured in two perpendicular directions) of concrete after lifting the standard slump cone. The measurements were repeated 1 h after the initial mixing (During the 1 h rest period, the concrete mixture was not agitated, but the mixture was remixed for about 1 min using the initial mixing speed before the second slump test was performed) to evaluate the slump loss properties of the SCC mixtures.

The L-box test, u-box test and V-funnel test was performed in accordance with EFNARC standards. This test has been used to assess the flow ability and passing ability of concrete.

## X. CONCLUSION

The results of this investigation demonstrates a potential application of ferro alloy silica slag in both high performance concrete and self compacting concrete as a complete replacement of natural river sand. The test of these slag concrete mixes revealed that this method performed efficiently to improve most properties of the slag concrete mixes:

- The compressive strength of both HPC and SCC had seen to be more using slag when compare to sand.
- Both the fresh and dry densities values of slag concrete mixes at each curing stage tend to increase above their reference values.
- The slump values of mixes increased with an increasing content of the slag as a fine aggregate, which is believed to be influenced by the shape of the waste grains.
- The slump flow and blocking ratio of the SCC mixtures increased with increasing slag aggregate content. The initial slump flows of all the SCC mixtures prepared were at least 680mm and the blocking ratios varied from 0.81 to 0.94. The addition of slag resulted in an increase in slump flow and blocking ratio.

The study is exploratory, drawing attention to the potential for the use of ferro alloy silicon slag as a fine aggregate and requires further research and development.

## REFERENCES

- [1] CHAMPION, J.M and JOST, P, Self compacting concrete: Expanding the possibility of concrete design and placement, Concrete International, (Vol.22, No.4, pp. 158-178, June 1998)
- [2] EFNARC specification and guidelines for SCC.
- [3] IS 12269-1987 “Specification for 53 Grade Ordinary Portland Cement”, Bureau of Indian Standards, New Delhi.
- [4] IS 2386-1963 “Method of Test for Aggregate for Concrete”, Bureau of Indian Standards, New Delhi.
- [5] IS 456-2000 “Code of Practice for Plain and Reinforced Concrete”, Bureau of Indian Standards New Delhi.
- [6] IS 516-1959 “Method of Tests for Strength of Concrete”, Bureau of Indian Standards, New Delhi.
- [7] IS 383-1970 “Specifications for Coarse and fine Aggregate from Natural Source of concrete”, Bureau of Indian Standards, New Delhi.
- [8] IS 15388-2003 “Micro Silica – Specifications”, Bureau of Indian Standards, New Delhi.
- [9] IS 10262-1982 “Recommended Guidelines for Concrete Mix Design”, Bureau of Indian Standards, New Delhi.
- [10] IS 4031-1988 “Method of Physical Tests for Splitting Hydraulic Cement”, Bureau of Indian Standards, New Delhi.

## AUTHOR’S PROFILE



### Mohammed Ibrahim Khan

B.Tech (Civil Engineer)  
Sri Indu College of Engineering, JNTU (Hyderabad).  
Email: ibrahim.khan9640@gmail.com