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Flexural Behavior on SCC Structures with Respect to Chloride Ion Penetration

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Abstract:--- Self-compacting concrete (SCC) is a high performance concrete which is having good segregation resistance, and also possess high strength. It is a special kind of concrete, which is having easy flow-able property, so that it can reach every corner of the mould easily when compared with conventional concrete. This concrete does not require any vibration or compaction while placing. The present investigation deals with the usage of both ground granulated blast furnace slag (GGBS) as a partial replacement material to cement with varying percentages such as (0%, 30%, 50%, 70%) and Silica Fume. Silica Fume is taken 2% by weight of GGBS and replaced partially to it. Auromix 300 plus is used as admixture with a dosage of 0.6% by weight of cement. It gives good workability and also acts as viscosity modifying agent. Usage of these materials resulted in high strength, durability and corrosion resistant. In this research, beams (150mm × 150mm × 1000 mm) were casted. Flexural strength was determined for 4 beams at an age of 28days, under four point beam bending test and remaining 4 beams were allowed for chloride penetration test after completion of 30days age which are left under NaCl curing. It is been observed from the research, blended self-compacted concrete has high strength and also high corrosion resistant.

Index Terms: Chloride penetration, Corrosion resistance Flexural strength, Self compacting concrete.

I. INTRODUCTION

Concrete plays main role in construction which is used mainly as a key material from low rise structures to high rise structures. As time passes, due to change in environmental conditions either by natural or artificial which is in terms of actions by living beings or by non living beings, high performance concrete structures are designed in order to meet the demands of high strength which is needed for infrastructural developing countries like India etc. Word wide concrete is not just a mixture of coarse aggregates, fine aggregates, cement etc. It also includes chemical admixtures which rise to good workability there by leads to high performance concrete. In conventional concrete structures highly compaction is required by labors, which results in wastage of time, money etc. To overcome this, self compacting concrete (SCC) is developed which itself have self flow-able property thereby eliminating compaction. Prof. Okamura from Ouchy University which is at Japan has developed SCC concept firstly in 1986. The aim of developing SCC is arosen of social problems from concrete structures like corrosion, voids etc in 1983.Scc gives flexibility to both the engineers as well as architects. In members like beams, columns, beam-column joints, when used with conventional concrete there is a chance of voids in the corners as it can't reach all corners fully as the members contains reinforcement. The present study deals with finding a mix proportion for self compacting concrete and its chloride saturation. For this, cement is replaced partially with binders such as GGBS and Silica Fume. *This partial replacement is also useful in reduction of more consumption of* co_2 *which is generated by cement. This binding material has good resistance over acids and also has less heat of hydration, less corrosion.* Therefore, flexural strength is determined as well as with chloride saturation for grade M40.

II. RESEARCH SIGNIFICANCE

The main aim of this research is to determine the flexural strength and chloride ion penetration in SCC by partial replacement of cement with GGBS and Silica Fume.

III. MATERIALS USED

A. Cement

Ordinary Portland Cement (OPC) of grade 53 was used. The physical properties obtained when compared with standard values are as follows:

a) Standard value for Specific Gravity of cement is 3.15 here obtained value is 3.14.
b) Standard value for initial setting of cement is 32minutes here obtained value is 30 minutes.
c) Standard value for final setting time of cement is 600 minutes; here obtained value is 355 minutes.
d) Standard value for normal consistency is 31% where as for fineness is 5.

B. GGBS

Ground Granulated Blast Furnace Slag is a binding material which is obtained from quenching molten iron slag and then glassy granular product formed is dried and crushed to be a fine powder. This acts as good binding material which results in less heat of hydration, less corrosion resistance, and also reduces environmental effects. Physical properties of GGBS are noted below in Table I.

Table I: Physical properties of GGBS

Size of particle	12µ
Color	White
Specific gravity	2.91
Bulk density	1

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Fig. 1: Appearance of GGBS

C. Silica Fume

Silica Fume gives high potency and also high long lasting. Specific gravity of silica fume is 2.25.

D. Fine aggregate

River sand from zone-2 is used in this study. Sand retained on 4.75mm sieve is neglected which is conformed from IS 383-1970 and passed sand is used. Specific gravity of fine aggregate which obtained is 2.603.

E. Coarse aggregate

Coarse aggregates of size 12.5mm size are used which are available in zone2. Specific gravity of coarse aggregate which obtained is 2.64.

F. Admixture

Auromix300 plus is used as admixture which gives good flow-able property to concrete as well as with workability. Specific Gravity of this is 1.18.

G. Water

Potable water which is available in structures laboratory at Koneru Lakshmaiah educational foundation (deemed to be University), Guntur district was used. pH value of this potable water is 7.

IV. METHODOLOGY

A. Mix Design

Using EFNARC guidelines and IS 10262-2017 code, mix proportion for self compacting concrete is designed for Water- cement ratio 0.4 of grade M40.

0% mix calculation*:* Dosage of admixture is taken as 0.4% by weight of cement. Mix proportion for 1m^3 concrete of grade M40 is in Table II.

Table II: Mix proportions for M40 grade concrete

S. No	Materials	Quantity in kg/m^3
1.	Cement	500
2.	Admixture	2
3.	Fine aggregate	866.66
4.	Coarse aggregate	839.86
5.	Water	200

30% mix calculation: GGBS is partially replaced i.e., 30% to cement .GGBS itself again is replaced partially with 2% silica fume. Dosage of admixture is taken as 0.5% by weight of cement. Therefore, mix calculation values for 1m^3 concrete as follows in Table III.

Table III: 30% Mix calculation values

S. No	Material	Quantity in kg/1m^3
1.	Cement	350
2.	GGBS	147
3.	Silica Fume	3
4.	Admixture	2.5
5.	Fine aggregate	866.67
6.	Coarse aggregate	827.08
7.	Water	200

50% mix calculation: GGBS is partially replaced i.e., 50% to cement .GGBS itself again is replaced partially with 2% silica fume. Dosage of admixture is taken as 0.6% by weight of cement. Therefore, mix calculation values for 1m^3 concrete as follows in Table IV.

Table IV: 50% Mix calculation values

S. No	Materials	Quantity in kg/m^3
1.	Cement	250
2.	GGBS	245
3.	Silica fume	5
4.	Admixture	3
5.	Fine aggregate	866.66
6.	Coarse aggregate	818.07
7.	Water	200

70% mix calculation: GGBS is partially replaced i.e., 70% to cement .GGBS itself again is replaced partially with 2% silica fume. Dosage of admixture is taken as 0.6% by weight of cement. Therefore, mix calculation values for 1m^3 concrete as follows in Table V.

Table V: 70% Mix calculation values

S. No	Materials	Quantity in kg/m^3
1.	Cement	350
2.	GGBS	343
3.	Silica fume	7
4.	Admixture	3
5.	Fine aggregate	866.66
6.	Coarse aggregate	818.07
7.	Water	200

B. Test Setup:

To determine compressive strength, cubes of dimension (150×150×150mm) are casted with different kinds of proportions and tested on Universal Testing Machine (UTM) as shown in fig.3 and also flexural strength tests are carried out for beam specimens (1000×150×150mm) in loading frame which is having capacity of 200 tones as shown in Fig.4.

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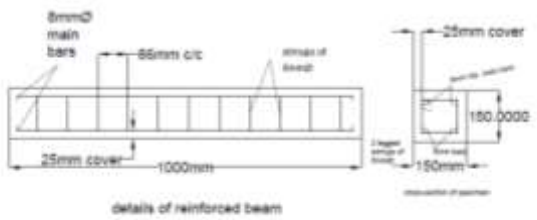

Fig. 2: Detailing of beam specimen in AUTOCAD software

Fig. 4: Test specimen of SCC

V. RESULTS AND DISCUSSION

A Basic SCC Tests and Their Results

As per guidelines of EFNARC and IS 10262-2017 code, concrete mix proportion of grade M40 designed should satisfy following tests within the range. Hence obtained values are mentioned below in Table VI.

Table VI: Fresh properties of SCC

Tests	**Limit range as per code**	**0%**	**30%**	**50%**	**70%**
Slump flow	500-700mm	674	645	636	600
V-funnel	6 -12 seconds	7	9	11	12
L-box (H_2/H_1)	0.8 -1	0.83	0.9	0.93	25
U-box (H_2-H_1)	0 -30 mm	12	15	18	23
T_{50}	2-6 seconds	3	4.53	5.51	6

Table VII: Compressive strength test results

Mix Proportions	Strength at 7days in MPa	Strength at 28 days in MPa
0%	26.32	46.53
30%	27.85	52.34
50%	25.28	43.78
70%	19.85	36.35

B. Results of RC beam specimens

By testing RC beam specimens, it has undergone through bending case. The following graphs show the relationship between load and displacement. Load is applied gradually and displacement is found out by connecting LVDT (linear variable differential transducer) to beam specimen. Hence crack width is found out and all curves from all proportions are plotted in to one graph which is shown in Fig. 5.

C. Flexural strength

This flexural strength is also useful in determining tensile strength .In this research beams of dimensions 1000mm ×150mm×150mm were tested by using loading frame under four point beam bending test, with one end fixed support and other end is roller support. In these specimens, 8mm diameter steel bars are used as main reinforcement and 6mm diameter bars are used as stirrups. Flexural strength can be determined by using formula are shown in Eq. 1.The flexural strength values is shown in Table VIII.

From Fig. 5 it is observed that the load versus deflection curve is higher for 50% replacement of GGBS and silica fume.

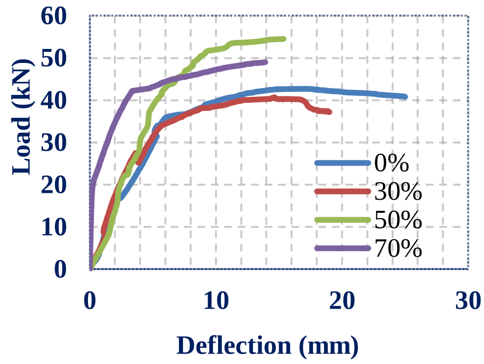

Fig. 5: Load- Deflection curves

$$f_{cr} = {}^{Pl}/_{bd^2} \quad (1)$$

Where,

P = Load at ultimate point in kN
L = length of specimen (beam) in mm
b = breadth of specimen in mm
d = depth of beam in mm
f_{cr} =flexural strength in N/mm^2

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Table VIII: Flexural strength results

S. No	0%	30%	50%	70%
Load in kN(P)	40.2	42.1	54.5	49
Length of specimen(l) in mm	1000	1000	1000	1000
Breadth Of specimen (b) in mm	150	150	150	150
Depth of specimen (d) in mm	150	150	150	150
F_{cr} in N/mm^2	11.91	12.47	16.15	14.52

D. Chloride saturation test:

Specimens are immersed under NaCl curing up to 30 days, after completion of 28 days curing with normal water. After curing, specimen surfaces are dried and then Powder samples from all sides are collected with the help of driller by choosing certain depths like 5, 10,15,20,25 mm etc. And then, by using this drilled powder chemical analysis is done by titrating with silver nitrate ($AgNo_3$) in order to determine chloride content. This is determined by using Eq.2. The chloride content Vs Depth graph is shown in Fig.6.

Chloride in percentage $= (K \times N \times V) / W$ (2)

Whereas,

K= Molecular weight of $AgNo_3$

N= Normality of silver nitrate i.e., (0.01)

V= Volume consumed when titrated with sample

W= weight of sample powder in grams i.e., 4grams

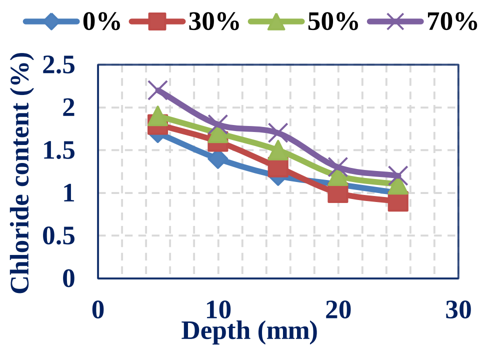

Fig. 6: Chloride content vs Depth for 30 days

VI. CONCLUSION

This research is done for prediction of flexural behavior and its chloride content.

- In this scenario, while using GGBS and Silica fume, it is observed that flexural strength increases when compared with conventional concrete.
- Chloride attack is minimum when these materials are used as binders when compared to conventional concrete.
- Blended concrete of 50% GGBS resulted in high flexural strength.
- From chemical analysis it is observed that as depth increases blended SCC of 30% has less chloride penetration as shown in Fig.6.

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