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Compressive Strength of Different Grades of SCC Mix Using Portland Slag Cement (70%) and GGBS (30%)

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Abstract – *The use of Self Compacting Concrete (SCC) is increasing day by day in India and many infrastructure projects are going in for SCC, the example being 'The Signature Bridge' on river Yamuna near New Delhi and the Bandra Worli sea link project, Mumbai The effect of Portland Slag Cement (70%) and GGBS (30%) on compressive strength of different grades of SCC Mix is not investigated as per the literature cited. The present investigation finds the effect of above proportion on compressive strength of SCC Mixes.*
The modified Nan-Su mix design for application to PSC concrete is used. The workability properties Slump Flow, J-Ring, V- Funnel and L Box values satisfy EFNARC Guidelines. For all grades compressive strength obtained is less than the target mean strength. For M35 and M40 grades compressive strength is less than the characteristic compressive strength of concrete.

Key Words: Self Compacting Concrete (SCC), GGBS, Portland Slag Cement, Nan-Su Mix Design, EFNARC Guidelines, Slump Flow Test, J-Ring Test, V-Funnel Test and L-Box Test.

1. INTRODUCTION

The use of Self Compacting Concrete (SCC) is increasing day by day in India and many infrastructure projects are going in for SCC, the example being 'The Signature Bridge' on river Yamuna near New Delhi and the Bandra-Worli sea link project, Mumbai.

The workability properties of SCC can be characterized by the three properties (EFNARC, 2002): filling ability, passing ability and segregation resistance.

The modified Nan-Su mix design for application to PSC concrete is used. Master Glenium SKY 8233 super plasticizer is used. Mix grades M20 to M40 are considered in investigation.

2. EXPERIMENTAL INVESTIGATION

2.1 Materials Used

The materials used in the SCC are

i. Portland Slag Cement (JSW company) (IS: 12089)
ii. GGBS
iii. Fine Aggregate
iv. Coarse Aggregate-12.5 mm(70%) and 20 mm(30%)
v. Master Glenium Sky 8233 (Super Plasticizer)

2.11 Materials Properties

The properties of materials are determined and are shown in Table 1, 2, & 3 . Table 4 shows the super plasticizer properties as given by the manufacturer.

2.21 Nan-Su Mix Design

The steps used in Nan-Su Mix Design for M40 Grade are given below.

Step 1: Calculation of Coarse and Fine aggregate contents:

$$W_{fa} = PF \times \Upsilon_{fa}\left(\frac{s}{a}\right) \quad = 853.507 \text{ kg/ m}^3 \qquad (1)$$

$$W_{ca} = PF \times \Upsilon_{ca}\left(1 - \frac{s}{a}\right) = 737.587 \text{ kg/ m}^3 \qquad (2)$$

Where,

W_{fa} : content of fine aggregates in SCC (kg/m^3),

W_{ca} : content of coarse aggregates in SCC (kg/m^3),

Υ_{fa} : unit volume weight of loosely piled saturated surface-dry fine aggregates in air (kg/m^3), = 1465.50 kg/ m^3

Table 1: Properties of Cementitious Materials

Cementitious Material	Specific Gravity Of Cement	Initial Setting Time	Final Setting Time	Standard Consistency	Soundness of Cement	Fineness of Cement
Portland Slag Cement (JSW Company)	2.935	2 hrs 22 min	8 hrs 10 min	38%	2 mm	4%
GGBS	2.840	> 600 min	-	34%	-	2%
PSC (70%) & GGBS (30%)	2.810	1 hrs 55 min	7 hrs 31 min	36%		3%
Ranges (For Cement)	3.00 – 3.15	> 30 min	< 10 hrs	-		< 10%

Table 2: Properties of Coarse Aggregate (IS: 383-2016)

Properties		Size		Standard range
		20 mm	12.5 mm	
Specific gravity of Coarse Aggregate		2.785	2.711	2.5-3.0
Bulk Density of Coarse Aggregate tightly packed (Kg/m^3)		1550.3	1518.5	-
Bulk Density of Coarse Aggregate loosely packed (Kg/m^3)		1385.2	1371.4	-
Crushing test		14.84%		
Shape Tests	a) Flakiness Test	13.87 %	16.80%	< 35%
	b) Elongation Test	14.56%	14.56%	< 40%
Impact Test		14.05 %		< 35%

Table 3: Properties of Fine Aggregate (IS: 383-2016)

Properties	Property Value	Standard range
Specific Gravity	2.75	2.5 to 3
Bulk Density, (kg/m^3) Loosely Packed	1465.5	-
Bulk Density, (kg/m^3) Tightly Packed	1561.5	-
Fineness Modulus	3.008 (Zone –I)	2.2 – 2.6 (Fine Sand)

Table 4: Master Glenium Sky 8233(Super Plasticizer)

Properties	Test Results of Manufacturer Catalogue
Appearance	Reddish Brown Liquid
pH Value	≥ 6
Solubility	Readily Soluble In Water
Relative Density	1.08 ± 0.02 at 25^{o}C

Chloride Content	0%
Solid	50±1%
Appearance	Reddish Brown Liquid

Υ_{ca} : unit volume weight of loosely piled saturated surface-dry coarse aggregates in air (kg/m³), =1372.00 kg/ m³

PF : packing factor, the ratio of mass of aggregates of tightly packed state in SCC to that of loosely packed state in air,= 1.12 (Assumed)

$\frac{s}{a}$: volume ratio of fine aggregates (sand) to total aggregates, which ranges from 50% to 57%. = 52% (Assumed)

Step 2: Calculation of Cement Content:

$$C = 1.5\frac{f_c^{'}}{20}(for\ PSC\ Cement) \quad =524.864\ kg/\ m^3 \qquad (3)$$

Where,

C= Cement content (kg/m³);

$f_c^{'}$ = designed compressive strength (psi). =6998 psi (48.25 MPa Target Mean Strength Obtained from IS: 10262-2019)

Step 3: Calculation of mixing water content required by cement:

$$W_{wc} = \frac{W}{C} \times C \qquad = 188.951\ kg/\ m^3 \qquad (4)$$

Where,

W_{wc} = content of mixing water content required by cement (kg/m³),

$\frac{W}{C}$= the water/cement ratio by weight = 0.36 (After Trial mixes)

Step 4: Calculation of SP dosage

Dosage of SP used W_{sp} = n% × W_C (5)

Where,

n% = Dosage of SP = 0.48 % (Assumed and fixed after trials)

W_c = Cement content in kg/m³

Amount of water in SP W_{wsp} = (1-m%)W_{sp} = 1.260 kg/m³ (6)

Where,

m% = Amount of binders and its solid content of SP taken as 50%.

Step 5: Calculation FA and GGBS contents:

$$V_{PF} + V_{PG} = \left[1 - \left(\frac{W_{ca}}{\Upsilon_W G_{ca}} + \frac{W_{fa}}{\Upsilon_W G_{fa}} + \frac{W_c}{\Upsilon_W G_c} + \frac{W_w}{\Upsilon_W G_w} + V_a\right)\right]$$

= 0.034 m³ (7)

Where, Υ_w = density of water,

G_{ca} = specific gravity of coarse aggregates,

G_{fa} = specific gravity of fine aggregates,

G_c = specific gravity of Cement,

G_w = specific gravity of water,

(W/F) =Water to Fly ash ratio(Assumed).

(W/G) = Water to GGBS ratio(Assumed).

V_a = air content in SCC (%).

As per Nansu Mix Design the formula for calculating W_{PM} is

$$V_{PF} + V_{PG} = \left[1 + \left(\frac{W}{F}\right)\right] \times A\% \times \frac{W_{PM}}{\Upsilon_W G_F} + \left[1 + \left(\frac{W}{G}\right)\right] \times B\% \times \frac{W_{PM}}{\Upsilon_W G_G} \qquad (8)$$

Where A% = percentage of Fly Ash (Weight basis) =0%

B% = percentage of GGBS (Weight basis) =100%

But, the modified formula[1] (8.a) for calculating W_{PM} is used.

$$V_{PF} + V_{PG} = \left[1 + \left(\frac{W}{F}\right)G_F\right] \times A\% \times \frac{W_{PM}}{\Upsilon_W G_F} + \left[1 + \left(\frac{W}{G}\right)G_G\right] \times B\% \times \frac{W_{PM}}{\Upsilon_W G_G} \qquad (8.a)$$

Where, G_G, G_F, are obtained from tests and $\frac{W}{F}$ =0.42 and $\frac{W}{G}$ = 0.42 are assumed, A% =0% and B% =100% are assumed and $V_{PF} + V_{PG}$ obtained from Eq.(7)

W_{PM} = 48.34 kg/m³

W_F = 0% × W_{PM} =0.0 kg/m³ (9)

W_G = 100% × W_{PM} =48.34 kg/m³ (10)

Mixing water content required for GGBS paste is obtained from Eq(12)

$$W_{WG} = \frac{W}{G} \times W_G \quad = 17.403 \text{ kg/m}^3 \quad (11)$$

Step 6: Calculation of mixing water content in SCC:

The mixing water content required by SCC is the total amount of water needed for cement, FA and GGBS in the mix. Therefore, it can be calculated from Eq. (14)

$$W_w = W_{wc} + W_{WG} - W_{wsp} \quad = 205.094 \text{ kg/m}^3 \quad (12)$$

Step 7: Calculation of total GGBS used SCC:

$$W_{TG} = 30\% \text{ x} W_C + W_G = 157.46 + 48.34 = 205.80 \text{ kg/m}^3 \quad (13)$$

3. MIX DESIGN

Concrete grades M20 to M40 is considered, and mixes are designed as per Nan-Su mix design. Target mean strength as per IS 10262:2019 is used for the mixes in Eq. 3 in place of f'_c. Based on trial mixes W/C ratio and SP dosage is fixed to satisfy EFNARC guidelines. The SCC mix proportions for different grades of concrete are shown in Table 5.

4. WORKABILITY TESTS

Slump flow test and then J-Ring test is conducted in order by using 6 litres of concrete. V funnel test is conducted by using 14 litres of concrete. L Box test is conducted by using 17 litres of concrete. Fresh properties are determined for the mixes. The results are as show in Table 6 and also in Fig. 1. All the test results are conforming to EFNARC guidelines for SCC.

Table 5: Mix Design of Different Brands of OPC 53 Grade Cement

Mixes	Grades	Compressive Strength (N/mm²)	W/C Ratio (as per NANSU)	W/P Ratio	SP Dosage(%)	SP Content (Kg/m³)	Water (kg/m³)	Cementitious Materials (Kg/m³)		Fine Aggregate (Kg/m³)	Coarse Aggregate (Kg/m³)		Packing Factor
								Cement (70%)	GGBS =(30%) Cement + Additional GGBS		12.5mm(70%)	20 mm(30%)	
M1	M20	20	0.42	0.418	0.6	1.736	221.050	202.54	332.99	853.507	516.311	221.276	1.12
M2	M25	25	0.405	0.403	0.57	1.959	216.367	240.62	296.06				
M3	M30	30	0.39	0.388	0.54	2.247	212.785	291.26	257.26				
M4	M35	35	0.375	0.373	0.51	2.399	208.990	329.33	231.21				
M5	M40	40	0.36	0.358	0.48	2.519	205.094	367.40	205.85				

Table 6: Workability Properties

S.NO	Different Grades of SCC	J Ring Test (mm)	L- Box Test	V- Funnel Test (sec)	T50 Slump Flow Test (sec)	Slump Flow Test (mm)
1	M20	6	0.833	6	4	675
2	M25	8	0.818	7	3	720
3	M30	8	0.863	8.9	2	730
4	M35	7	0.850	8	3	725
5	M40	6	0.800	9.3	3	727
EFNARC Guidelines		0-10	0.8-1.0	6-12	2-5	650-800

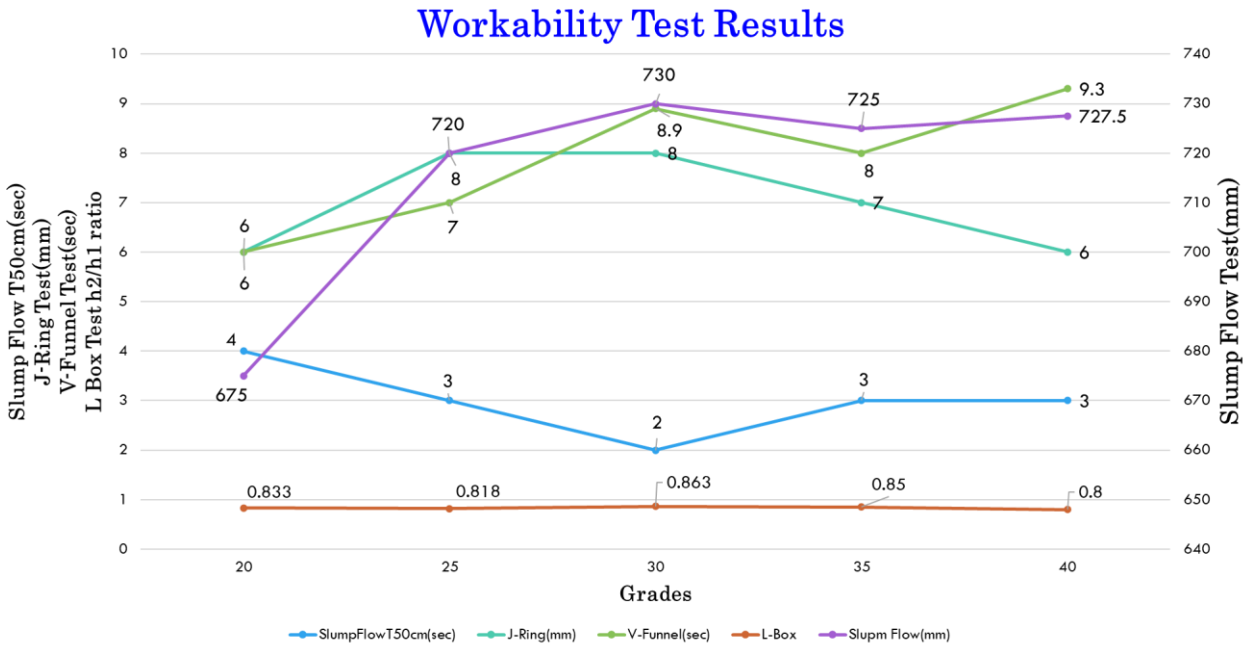

Fig. 1: Workability Properties of Different Brands of Cements

5. COMPRESSIVE STRENGTH OF MIXES

Cubes are casted for each mix to determine the 3,7 and 28 days compressive strength. The compressive strength of different grades of concrete for 3,7 and 28 days with normal curing is shown in Table 7 and the variation of compressive strength is shown in Fig 2. For all the grades target mean strength is not achieved. For grades M20, M25, M30 characteristic compressive strength is achieved.

Table 7: 3, 7 and 28 Days Compressive Strength of Different Grades of SCC

S.No	Different Grades of Concrete	Compressive Strength (N/mm²)		
		3 Days	7 Days	28 Days
1	M20	11.19	17.73	21.48
2	M25	13.29	19.75	26.20
3	M30	15.73	22.45	30.84
4	M35	17.38	25.27	28.02
5	M40	17.84	26.31	32.87

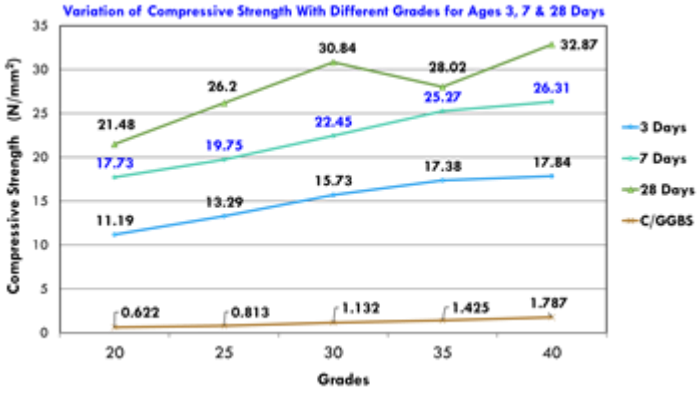

Fig 2. Variation of Compressive Strength with Different Grades of SCC for Ages 3, 7 & 28 days

6. CONCLUSIONS

1. For grades M20, M25, M30 characteristic compressive strength is achieved.
2. For all the grades target mean strength is not achieved (IS: 10262-2019).
3. All the workability test results are conforming to EFNARC guidelines for SCC.

REFERENCES

1. C. Krishnama Raju et. al. (2022) investigated on "*Compressive Strength of Different Grades of SCC Mix using Portland Slag Cement (75%), GGBS(25%) and Replacing 20% Fine Aggregate with Copper Slag*" , International Research Journal of Engineering and Technology(IRJET), Vol. 9, Issue 04, April 2022 pp: 3535-3539, p-ISSN:2397-0072.

2. G. Asif Hussain et.al (2020), "Properties of M60 High Performance Self Compacting Concrete by using Blends of Different Sizes of Coarse Aggregate", National Virtutal Conference on Recent Trends in Civil Engineering -2020 (RTCE'20),September 2020 pp 31-36, ISBN: 978-81-942685-2-9.

3. J. Vengadesh Marshall Raman et. al. (2017), "*Partial Replacement of Cement With GGBS in Self Compacting Concrete for Sustainable Construction*", SSRG International Journal of Civil Engineering,(SSRG-IJCE), Vol. 04, Issue.03, March 2017, ISSN: 2348-8352.

4. B. Chandraiah, et. al. (2017) "*Variation Of Compressive Strength And Split Tensile Strength Of M40 Self Compacting Concrete With Different Sizes Of Coarse Aggregate*", International Journal of Engineering Technology Science and Research (IJETSR), Vol. 4, Issue 8, August 2017, pp.279-285

5. Bhavani, et. al. (2016), " *Effect on Mechanical Properties of M25 SCC with Variation of Class - F Fly Ash & GGBS*". International Journal of ChemTech Research, Vol. 11, No. 07, 2018, pp. 70-77, DOI= http://dx.doi.org/10.20902/IJCTR.2018.110709

6. S. Venkateswara Rao, M.V. Seshagiri Rao, P. Rathish (2010), "Effect of Size of Aggregate and Fines on Standard and High Strength Self Compacting Concrete", Journal of Applied Sciences Research, pp. 433-442.

7. Nan Su, Kung-Chung Hsu and His-Wen Chai (2001) proposed a " *Simple Mix Design Method for Self Compacting Concrete*" Journal of Cement Concrete Research , Vol. 31, No. 12, pp. 1799-1807., Dec. 2001.

8. IS: 2386 (Part-i, Part-iii, Part-iv)-1963, "Methods of Test for Aggregate for Concrete".

9. IS: 383-2016, "Specifications for Fine aggregate and Coarse aggregate".

10. IS: 10262-2019, "Concrete Mix Proportioning - Guidelines".