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Experimental Study on Self-Compacting Concrete by Partial Replacement of Cement by Industrial Waste

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Abstract - *Self-compacting concrete (SCC) is a type of concrete which do not need external compaction, because it flows under its own weight. SCC is very much suitable in the situations where there is occurrence of congested reinforcement. SCC is gaining popularity as it offers many advantages over conventional concrete. In the present work SCC is studied using fly ash as industrial-waste by weight of Ordinary Portland cement and master Polyheed 8630 is used as plasticizer. Previously there was no code available for designing SCC. But recently the revised version of IS 10262 has been published which includes the mix design of SCC in 2019. Before carrying out the strength tests on SCC it must and should be checked for its workability. Workability of SCC is a critical concept as the concrete must be just accurate to be neither too loose nor too stiff. Workability test on SCC is carried out as per the guidelines of IS 1199 (Part 6) 2018 standards. Further the strength tests i.e. compression, split tensile and flexure are carried out for 7 and 28 days curing respectively. After testing all the workability and strength test for different dosage of fly ash that is 0, 10, 20, and 30%. It is concluded that 30% replacement of cement by industrial waste gave the desired flow and strength properties.*

Key Words: self-compacting, workability, fly ash, mix design, strength, EFNARC Standards

1. INTRODUCTION

Concrete is a man-made material which has the vastest utilization worldwide. The design and preparation of concrete plays a major role as it should be economic and should also be long lasting. The material used for concrete work should be "friendly with the environment". There is continuous rise in the performance of concrete in order to accomplish the needs of society.

SC concrete does not require external consolidation as it consolidates under its self-weight. It can be suitably placed in very difficult and congested reinforcement. It was first developed in Japan (1986). It has very good workability, strength, and resistance to segregation. The addition of super plasticizer further increases the slump height of concrete. But due to the addition of super plasticizer segregation may take place, in order to avoid this problem sand content is increased. Fly ash is blended so as to increase the cohesion in SCC and it also provides excellent workability to SCC.

The experimental work is carried out in present study to understand the behavior of fly ash on strength properties of SCC. Efforts are also made to cover the possible range of tests need to be carried out to know the workability of the SCC. This work will help reader to understand and gain knowledge on how to replace cement with fly ash and what will be the expected results. Strength properties of SCC are compared with conventional concrete.

1.1 Necessity of SCC

1. As per mix design, SCC should be able to flow and consolidate itself, without any vibration.
2. It should be capable to flow through very difficult and congested reinforcement under its own weight.
3. It should be homogeneous and there should not be any segregation.
4. The workability higher than that of high degree of workability mentioned in IS 456:2000
5. Self-compacting has following characteristics-
    a) Favorable to filling.
    b) Favorable to passing.
    c) Resistance to segregation.
    d) Viscosity.

2. MATERIALS

Ordinary Portland cement of specific gravity 2.88, confirming to IS 12269-1987, locally available river sand of zone II from IS 383-1970, having specific gravity of 2.52 was used. Locally available crushed aggregate of size 12.5 mm and 20 mm down size conforming to IS 383-1970 with specific gravity of 2.72 were used in the preparation of concrete. Potable water was used in the present investigation for both casting and curing of the concrete. Super plasticizer used is Master Polyheed 8630. Class F fly ash is used as replacement of cement.

3. MIX DESIGN

The concrete was designed for various percentages of the industrial waste replacing cement to know effect of it on behavior of SC concrete. The fly ash replaced cement by 0%,

10%, 20%, and 30%.The mix design provides clarity on proportioning different ingredients of concrete.
The mix design needs to be prepared are as follows-

1. The mix design for M30 grade SCC (0% fly ash).
2. The mix design for M30 grade SCC (10% fly ash).
3. The mix design for M30 grade SCC (20% fly ash).
4. The mix design for M30 grade SCC (30% fly ash).

3.1 The mix design for M30 grade SCC (10% fly ash)

Data
Grade = M30
Cement type = OPC
Max. size of aggregate = 20mm
Min. cement = 450 kg/cum
Exposure condition = Mild
Chemical admixture = Master Polyheed 8630
Mineral admixture type = Fly ash
Test data
Cement used = OPC
SG of cement = 2.88
SG of fly ash = 2.2
SG of:
Coarse agg. = 2.72
Fine agg. = 2.52
Calculation
Step 1 Desired mean strength $f'_{ck}= \{f_{ck}+ (1.65*) S\}$ = 38.25 N/mm^2 OR $f'_{ck}= \{f_{ck}+ X\}$ = 36.5 N/mm^2
Adopting higher value Target mean strength = 38.25 N/mm^2
Step 2 Approximate void content from table 3,
The approx. amount of void in % = 1
Step 3 Water-cement ratios
From fig 1,
Referring curve 2, w/c = 0.425
W/c ratio for reinforced concrete for mild condition = 0.55
0.425<0.55 Hence OK
Step 4 Proportioning for initial mix
4.1 Water and Cement/Fly ash Content Slump flow class = 750-850mm (SF3) Initially select, Water content = 190 kg/cum Super plasticizer = 0.6% of cement weight
W/c = 0.425
C = water / (w/c ratio)
C = 447.058 kg/cum
This is divided into OPC and fly ash as OPC percent = 90 % Fly ash percent = 10% Weight of OPC = 402 kg/cum Weight of fly ash = 44.7 kg/cum
4.2 Selection of admixture content
Dose of admixture = 0.6 % by weight of cementitious material = 2.682 kg/cum
4.3 Selection of Powder Content and Fine Aggregate Content
Powder content = OPC + fly ash + sand
Adopt powder content = 520 kg/cum
Sand = 10 %
Fines required to be contributed by fine aggregate = Powder-(fly ash + cement)
=72.941 kg/cum
The fine aggregate has 8 percent materials < 0.125 mm
The fine aggregate quantity = 911.764 kg/cum
4.4 Selection of CA Content
Let V_{ca} be volume of CA,
Assuming 1 m^3 of concrete,
V_{ca} = (1 - Air) - (water Vol. + cement Vol. + fly ash Vol. +admixture Vol. + fine agg Vol.) = 0.26 cum
Mass of coarse agg =V_{ca} x SG of coarse agg × 1000 = 777 kg/cum
4.5 Calculation of Powder Content
Powder Content vol. = OPC vol. + fly ash vol. + fine agg vol. (< 0.125mm) = 0.521 cum
Ratio of water to powder by volume= 0.36
Step 5 Mix proportioning trial Cement = 402 kg/cum Fly ash = 45 kg/cum Water = 190 kg/cum Fine aggregate = 912 kg/cum Coarse aggregate = 777 kg/cum Super plasticizer = 2.68 kg/cum W/C ratio = 0.425 Powder content = 0.52 kg/cum Water/powder ratio by volume = 0.36

Table-1: Mix features of SCC comprising (0, 10, 20, and 30) % of fly ash

Sl. No.	Ingredient Kg/cum	Fly ash percentage			
		0%	10%	20%	30%
1	Cement	447	402	358	313
2	Fly ash	0	45	89	134
3	Water	190	190	190	190
4	Fine agg.	912	912	912	912
5	Coarse agg.	790	777	764	751
6	SP	3	3	3	3
7	W/C ratio	0.425	0.425	0.425	0.425
8	Powder content	0.52	0.52	0.53	0.53
9	W/ P ratio by vol.	0.37	0.36	0.36	0.36

4. TESTS CONDUCTED ON SCC

4.1 Workability tests

It deals with workability property of SCC. The concrete must and should be tested for its workability before casting for strength. To check the workability of SCC, it should be checked for following tests as described in IS 1199 (part 6)-

A. Ability of filling (Flow ability)
B. Ability of Passing.
C. Resistance to Segregation and
D. Viscosity

Table-2: workability test results.

Sl. No.	Tests for workability	Concrete mix type				Acceptable range
		0%	10%	20%	30%	
1	Slump flow test	575	610	643	669	650-800mm
2	L-Box test	.95	.88	.85	.82	0.8-1.0
3	V-Funnel test	14	13	11	10	8-12sec
4	T_{50} slump flow test	6.4	5.7	4.3	3.2	2-5sec

5	J-Ring test	10	9	8	5	0-10mm
6	U-Box test	35	33	30	26	0-30mm

4.2 Strength tests

Here SC concrete of M30 grade with different percentage of fly ash as 0%, 10%, 20% and 30% is tested for three basic strength tests by casting 3 specimen for each type of concrete for 7 and 28 days respectively.

A. Compression strength test
B. Split tensile strength test
C. Flexural strength test

5. RESULTS

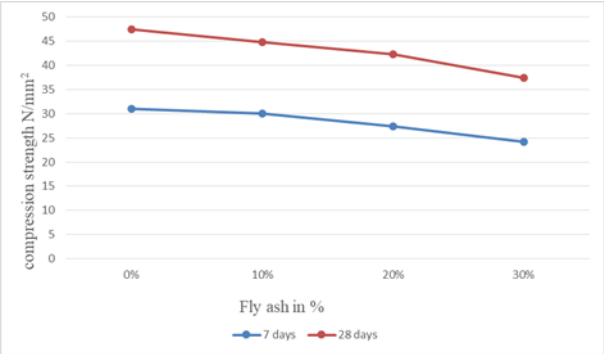

Fig-1: Graph representing compression strength of SCC

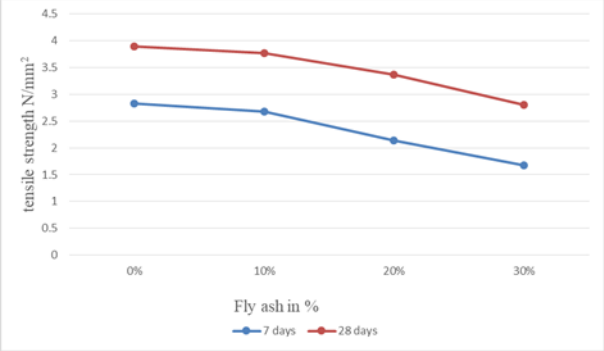

Fig-2: Graph representing split tensile strength of SCC

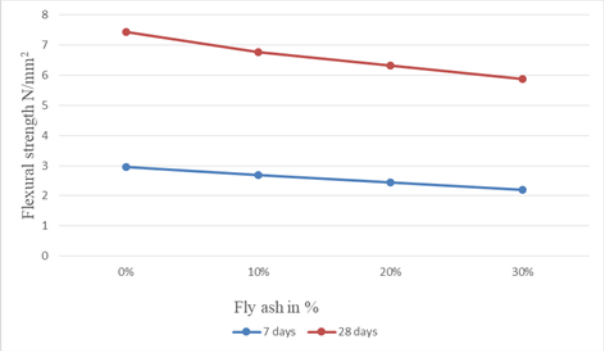

Fig-3: Graph representing flexural strength of SCC

6. OBSERVATIONS AND CONCLUSION

From table 2, we can observe that the desired value for workability is obtained for 30% replacement of fly ash. Thus we can conclude that 30% of fly ash is the optimum dosage for workability of SC concrete.

From figure 1, 2 and 3, we can observe that strength of both 7 and 28days of SCC is linearly decreasing with increase in fly ash content. But the desired strength is obtained for each dosage of fly ash.

The maximum strength is achieved for 0% of fly ash in SCC. But taking into account of flow properties 30% replacement satisfied both workability and strength properties.

REFERENCES

[1] Nan Su.et al. [2], "A simple mix design method for self-compacting concrete" (published in Cement and Concrete Research, 6 June 2001)

[2] Krishnamurthy .N. et al. [2], "Mix Design Procedure for Self Compacting Concrete" (published in IOSR Journal of Engineering (IOSRJEN), Volume 2, Issue 9, September 2012)

[3] Biswadeep Bharali. et al.[5], "Experimental study on self-compacting concrete (SCC) using GGBS and fly ash" (Published in International Journal Of Core Engineering & Management (IJCEM), Volume 2, Issue 6, September 2015)

[4] Prajapathi Krishnapal. et al.[6], "Strength Characteristics of Self Compacting Concrete Containing Fly ash" (Published in Research Journal of Engineering Sciences, Vol. 2(6), June 2013)

[5] Mallesh M. et al. [7], "Experimental Studies on M30 Grade Self Compacting Concrete" (Published in International Journal of Science, Engineering and Technology Research (IJSETR), Volume 4, Issue 9, September 2015)

[6] Mahalingam B. et al. [8], "Effect of processed fly ash on fresh and hardened properties of SCC" (Published in The International Journal of Earth Sciences and Engineering (IJEE), Volume 4, October 2011)

[7] Mr. Satish S, Mr. Keshavmurthy H, "Comparison of high strength concretes" (Published in JCIET, Volume 1, Issue 1, July-December 2013)

[8] Deepa Balakrishnan, Paulose K.C, "Workability and strength characteristics of SCC containing fly ash and dolomite powder" (Published in AJER, Volume 2)

[9] Reena K, Mallesh M, "Experimental studies on M20 self-compacting concrete" (Published in International Journal of Advanced Technology in Engineering and Science, Volume 2, Issue 9, September 2014)

[10] Hajime Okamura, Masahiro Ouchi, "self-compacting concrete" (Published in Journal of Advanced Concrete Technology, Volume 1, April 2003)

[11] Jagdish Vengala Sudershan M.S. and Ranganath R.V, "Experimental study for obtained self-compacting concrete" (Published in Indian Concrete Journal, 2003)

[12] Shriram H. Mahurel, Dr.V.M. Mohitkar, "Effect of Mineral Admixture on Fresh and Hardened Properties of SCC" (Published in International Journal of Innovative Research in Science, Engineering and Technology, Volume 2, Issue 10, October 2013)

[13] IS: 10262 2019, Indian Standards Code of Practice for Concrete mix proportioning-Guidelines, Second Revision (January 2019)

[14] IS 516 -1959, Method of tests for strength of concrete, Eighteenth reprint, (June 2006)

[15] IS 5816 -1999, Method of test splitting tensile strength of concrete, First revision, (July-1999)

[16] IS:1199-part 6-2018, Fresh concrete-Methods of sampling, testing and analysis, First revision (December 2018)

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