NATIONAL CONFERENCE ON RECENT RESEARCH IN ENGINEERING AND TECHNOLOGY (NCRRET-2015)
INTERNATIONAL JOURNAL OF ADVANCE ENGINEERING AND RESEARCH DEVELOPMENT (IJAERD)
E-ISSN: 2348 - 4470 , PRINT-ISSN:2348-6406

Effective study of various proportions of Fine and Coarse Aggregates on fresh and hardened properties of Self Compacting Concrete

Sabuwala Hasan K. [1], Dr. Pamnani Nanak J. [2], Dr. Sinha Deepa A. [3]

[1] Post graduate student of M.E. (Structural Engineering), BVM Engineering College, V.V. Nagar, Gujarat, India
[2] Associate Professor, Civil Engg. Dept., DJMIT, Mogar, Anand, Gujarat, India
[3] Associate Professor, Structural Engineering Dept, BVM Engineering College, V.V. Nagar, Gujarat, India

Abstract— In the present studies, results of an experimental investigation carried out to evaluate the fresh and hardened properties of various mixes with varying fine aggregate and coarse aggregate proportions is presented. The fresh properties for filling, passing and segregation resistance are monitored as per EFNARC guidelines while hardened properties namely the early age compressive strength development of various specimens for a selected refrence mix is evaluated. The mix proportion of self compacting concrete has a constant water-binder ratio of 0.31 and the super plasticizer dosage was kept 1.5 %. The total binder content is 585 kg/m^3. The concrete specimens are cured by normal moist curing under normal atmospheric temperature. Early age strength was determined at 7 days. The experiements were carried out varying the proportions of fine aggregates size particles between 600 micron to 2.36 mm and coarse aggregates of size 20mm and 10mm. The results show that there is considerable effect on the fresh properties and early age compressive strength of self compacted concrete, due to varaiation in proportions of fine and coarse aggregates.

Key words— Self compacting concrete, fresh properties, early age compressive strength, grading of aggregates, water-binder ratio

1 Introduction

In the last three decades, there have been significant improvements in concrete technology, and these improvements have led to the development of high-performing concrete, such as self compacting concrete (SCC). SCC is a highly workable, non segregating concrete that can easily reach remote corners, fill congested formworks and provide reinforcement without any vibration efforts. The use of SCC offers a more industrialised production. Not only does it reduce the unhealthy tasks for workers, it also reduces the technical costs of in situ cast concrete constructions, due to improved casting cycle, quality, durability, surface finish and reliability of concrete structures and eliminating some of the potential for human error. However, SCC is a sensitive mix, strongly dependent on the composition and the characteristics of its constituents. It has to possess the incompatible properties of high flow ability together with high segregation resistance. This balance is made possible by the dispersing effect of high-range water-reducing admixture (superplasticizer) combined with cohesiveness produced by a high concentration of fine particles in additional filler material.

SCC consists of the same components as conventional concrete (CC) cement, water, aggregates, admixtures and mineral additions but the final composition of the mixture and its fresh characteristics are different. Compared with CC, SCC contains larger quantities of mineral fillers such as finely crushed limestone or fly ash, as well as higher quantities of high-range water reducing admixture. These modifications in the composition of the mixture affect the properties of the concrete in its hardened state .Newly developed admixtures allow lowering the water/binder ratio to very low-levels without loss of workability. To produce SCC, the major work involves designing an appropriate mix proportion and evaluating the properties of the concrete thus obtained. In practice, SCC in its fresh state shows high fluidity, self-compacting ability and segregation resistance, all of which contribute to reducing the risk of honey combing of concrete.

In this research, fine aggregates were sieved through 600 micron sieve and the sand retained on 600 micron was further sieved through a sieve of 2.36 mm and 4.75 mm. Also coarse aggregate were utilized in varying percentages of 10 mm and 20 mm aggregates .Proportions of cement, fly ash, water/binder ratio and dosage of super plasticizer were kept constant. Quantity of fine aggregate and coarse aggregate were fixed and there particle sizes were varied in such a way that overall proportions of sand and aggregates remain the same.Various concrete cubes were caste for different proportioning and various mixes obtained were evaluated regarding flow characteristics, segregation, bleeding, passing ability, filling ability and early age compressive strength at 7 days.

2 Experimental Program

2.1 Material characterisation

2.1.1 Cement

Ordinary Portland cement (OPC) 53 grade conforming IS-12269-2013, manufactured by Hathi Cement Limited is used. Cement is tested as per above codes and properties are listed in table-1.

Table 1
Properties of 53 grade Ordinary Portland cement

Specific gravity of Cement	3.15
Consistency of cement	31%
Initial setting time	45 mins
Final setting time	260 mins
Compressive strength at 7 days	40 N/mm^2
Compressive strength at 28 days	58 N/mm^2
Fineness (% passing 90 micron IS sieve)	3%
Soundness of cement (mm)	1.3 mm

2.1.2 Water

Normal tap water is used for making concrete. The tap water did not contain any objectionable substances causing color or odor. The water was not tested to verify the acceptance criteria based on the physical tests assuming that the quality of potable water is acceptable for making concrete.

2.1.3 Fly ash

Fly ash (ASTM Class F) was obtained from Wanakbori thermal power station, kheda,Gujarat,India, having a specific gravity of 2.4 and fineness 280 m^2/kg .

2.1.4 Aggregates

(A) Coarse aggregates (20 mm and 10mm size) from local quarry have been used. The test results for the properties of aggregates are presented in Table-2, 3, and Table-4. The properties of grit indicates that it is suitable for use to produce the concretes. The bulk density, fineness modulus and specific gravity were within permissible limits specified by the Indian standards IS:2386- [1963].

Table 2
Sieve analysis of 10 mm size aggregates

Sr. No	IS Sieve No	Weight Retained (gm)	% Retained	% Finer	% Passing
1	40 mm	0.0	0.0	100	--
2	20 mm	0.0	0.0	100	--
3	10 mm	124	12.4	87.6	85-100
4	4.75 mm	696	82.0	18.0	0-20
5	Pan	180	100	0.0	0-5

Table 3
Sieve analysis of 20 mm size aggregates

Sr. No	IS Sieve No	Weight Retained (gm)	% Retained	% Finer	% Passing
1	40 mm	0.0	0.0	100	100
2	20 mm	128	12.8	87.2	85-100
3	10 mm	808	93.6	6.4	0-20
4	4.75 mm	64	100	0.0	0-5
5	Pan	0.0	100	0.0	--

Table 4
Properties of coarse aggregates

Type of coarse Agg.	Specific gravity	Void ratio
20 mm single size	2.78	42.89 %
10 mm single size	2.73	44.27 %

(B) Fine aggregates from local river have been used. The test results for the properties of F.A. are presented in Table 5 & 6. The bulk density of sand was 1776 kg/m^3. The results indicate F.A. of zone-II.

Table 5
Properties of fine aggregates

	Specific gravity	Void ratio
Fine Aggregate	2.64	29.19 %

Table 6
Sieve analysis of fine aggregates

IS Sieve No	Weight Retained (gm)	% Retained	% Finer	Grading Zone-II
4.75 mm	67	6.7	93.3	90-100
2.36 mm	56	12.3	87.7	75-100
1.18 mm	205	32.8	67.2	55-90
600 μ	248	57.6	42.4	35-59
300 μ	311	88.7	11.3	8-30
150 μ	84	97.1	2.9	0-10
Pan	29	100	0.0	--

2.1.5 Chemical admixtures

A new generation Poly-CarboxylicEther (PCE) based super-plasticizer was used. This super-plasticizer is available as a medium brown colored aqueoussolution.Its brand name is Glenium sky-784.Glenium sky-784 is free of chloride & has low alkali content. It is compatible with all types of cement.

2.2 Development of concrete mixes

After getting results from basic test of concrete ingredients like cement, fly ash, sand, coarse aggregate etc, a refernce mix design was finalized after several trials and errors.The basic ingredients constituting binder (cement and fly ash), sand, coarse aggregate and water were kept constant in the proportion (1:1.47:1.37:0.31) .The super plasticizer dosage was kept constant at 1.5%.

Table 7
Mix Proportion of reference SCC

Water to cement ratio	0.31
Cement	450 kg/m^3
Fly ash	135 kg/m^3
Fine Aggregate	860 kg/m^3
Coarse Aggregate	800 kg/m^3
Water	180 litres

Super Plasticizer	1.5% (by weight of binder)

Various mixes were prepared altering the fine and coarse aggregate contents as follows:-

Mix (A-1)
Mix with 50% of sand less then 600 micron and 50% between 600 micron to 2.36 mm. Coarse aggregate proportion as 75% - 10 mm and 25%-20 mm.

Mix (A-2)
Mix with 50% of sand less then 600 micron and 50% between 600 micron to 4.75 mm. Coarse aggregate proportion as 75%- 10 mm and 25%- 20 mm..

Mix (A-3)
Mix with 100% sand sieved through 4.75 mm IS sieve having coarse aggregate proportion as 75%-10 mm and 25%-20 mm.

Mix (B-1)
Mix with 100% sand sieved through 4.75 mm IS sieve having coarse aggregate proportion as 60%-10 mm and 40%-20 mm.

Mix (B-2)
Mix with 100% sand sieved through 4.75 mm IS sieve having coarse aggregate proportion as 40%-10 mm and 60%-20 mm.

Mix (B-3)
Mix with 100% sand sieved through 4.75 mm IS sieve having coarse aggregate proportion as 75%-10 mm and 25%-20 mm.

Mix (B-4)
Mix with 100% sand sieved through 4.75 mm IS sieve having coarse aggregate proportion as 25%-10 mm and 75%-20 mm.

2.3 Casting of cubes

For each mix of concrete, three concrete cube specimens were cast each of size 150mmx150mmx150mm. Burnt oil was applied on sides of moulds for easy de-molding of cubes. Electrically operated mixer was used for casting.To obtain a homogeneous mix, aggregates were mixed and binders (cement and Fly ash) were added to the system. After remixing water was added to the dry mix. Finally, super plasticizer was introduced to the wet mixture.

2.4 Curing

Each set of cubes were demoulded after 24 hrs of casting and placed in water curing tank for 7 days. Curing of concrete was at laboratory temperature. Cubes were taken out and kept in laboratory after 7 days curing period.

2.4 Testing of specimens

2.4.1Properties of fresh concrete

Conventional workability experiments are not sufficient for the evaluation of SCC. European guidelines (EFNARC, 2005) were referred to evaluate the properties of concrete mixes like passing ability, filling ability and resistance to segrega-

tio ... 's cone. Th

2.4

Co ... ith the hel ... testing ma

Grading of aggregates V-funnel test

L-Box test Slump flow

Curing Compression testing machine

3 Results

Table 8
Fresh properties of self compacting concrete

Mix Name	Slump flow (mm)		V-funnel time (sec)	L-Box H_2/H_1
	T 50 (sec)	Dia (mm)		
A-1	4.5	680	11	0.84
A-2	4.8	665	11.5	0.81
A-3	6	625	13.8	0.73
B-1	6.7	620	blocked	blocked
B-2	8.6	575	blocked	blocked
B-3	6	620	13.8	0.73
B-4	9.8	530	blocked	blocked

Table 9
7 days compressive strength in N/mm² for reference SCC

Mix Name	Compressive strength at 7 days (MPa)
A-1	42.32
A-2	39.76
A-3	34.51
B-1	33.07
B-2	27.61
B-3	34.51
B-4	22.79

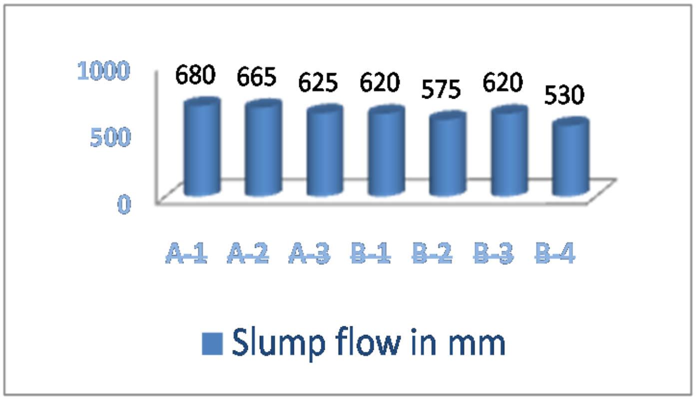
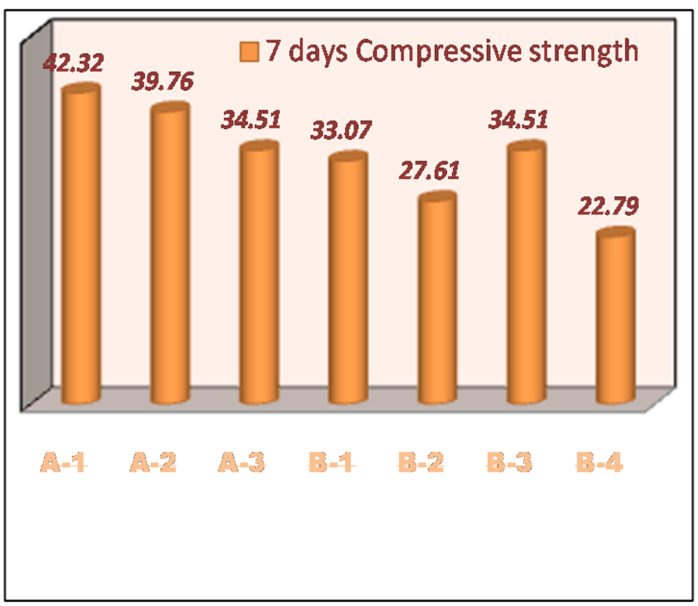


Figure 1: Slump flow in mm for various trial SCC mix



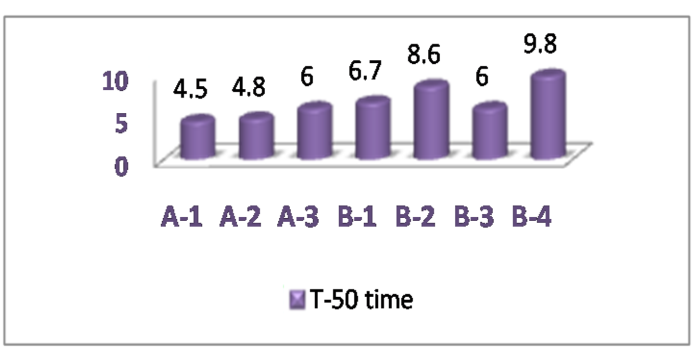


Figure 2: 7-days compressive strength for various SCC mix

Figure 3 T-50 time for various SCC mix

The results of tests conducted on fresh SCC are within the specified limits as suggested by EFNARC for A1, A2 & A3 mixes. It can be observed that the 7 days compressive strength is maximum for these samples. The increased flowability of mix may be due to increased viscocity due to presence of fines.

4 Conclusion

It is apparent that from the various concrete mixes developed mix having sand sieved through 600 micron sieve gives higher values of early age compressive strength along with appropriate values of slump flow, L-box and V-funnel. It can also be observed that self compacting concrete mixes develop segregation and bleeding as the percentage of larger size coarse aggregates (20 mm) increases in the mix. Slump flow value decreases from mix A-1 to A-3 as the size of finer fine aggregates decreases. Also slump value decreases with increase in percentage of 20 mm coarse aggregates .Thus it can be concluded from the above research that more the amount of finer particles in the mix better is the compressive strength and thus properties of self- compacting concrete like passing ability, filling ability and resistance to segregation improves. It can also be concluded that lesser the quantity of higher size aggregates (20 mm) in concrete mixes better is its ability to flow.

5 Refrences

[1] "Experimental Investigation on Ultra High Strength Concrete Containing Mineral Admixtures under Different Curing Conditions" Arunachalam. K1, Vigneshwari.M2

[2] "Indian Standard Plain And Reinforced Concrete - Code Of Practice". IS 456:2000, Bureau of Indian Standards, New Delhi

[3] IS:2386 (Part I)-1963, Methods of test for Aggregates for Concrete, Part I: Particle Size and Shape, Tenth Reprint March 1993, Bureau Of Indian Standards, New Delhi.)

[4] IS:516-1959, Methods of tests for Strength Of Concrete, Bureau Of Indian Standards, New Delhi

[5] Nan, Su; Kung –Chung, H; His – Wen, C; "A Simple Mix Design Method For Self Compacting Concrete." Cement And Concrete Research 31(2001)P.P. 1799-1807

[6] EFNARC (2005) "The European Guidelines for Self-Compacting Concrete,Specification, Production and Use." EFNARC, Farnham, UK.

[7] "Performance of concrete with different ingredients at elevated temperatures-An experimental study".Dr. ShaileshChoudhary,Dr. Ravi Saxena.IJTAE, Volume 4, Issue 5, May 2014.