iJRASET
International Journal For Research in Applied Science and Engineering Technology



INTERNATIONAL JOURNAL FOR RESEARCH

IN APPLIED SCIENCE & ENGINEERING TECHNOLOGY

Volume: 10 **Issue:** III **Month of publication:** March 2022

DOI: https://doi.org/10.22214/ijraset.2022.41047

www.ijraset.com

Call: 08813907089 | E-mail ID: ijraset@gmail.com

International Journal for Research in Applied Science & Engineering Technology (IJRASET)
ISSN: 2321-9653; IC Value: 45.98; SJ Impact Factor: 7.538
Volume 10 Issue III Mar 2022- Available at www.ijraset.com

Development of Self-Compacting Concrete of Grades M25, M30 and M35 Using Composite Cement

C Praneeth Sudharsan[1], Sayantan Gosh[2], Dr. Hemant Sood[3]
[1, 2, 3]*Civil Engineering Department, NITTTR Chandigarh*

Abstract: ***Both fly ash and slag are industrial by-products and their disposal has become a serious environmental problem. Considering their excellent cementitious properties, their utilization in the cement industry becomes crucial. Because of the significant contribution to the environmental pollution, over dependency on cement has to be reduced. There is a need to economize the use of cement, thus, the concept of composite cement becomes necessary. In this study, Fly Ash (FA) and Ground Granulated Blast Furnace Slag (GGBFS) were used as partial replacement of cement to improve the properties of self-compacting concrete (SCC).***

Three SCC grades viz., M25, M30 and M35 were made in the laboratory. For all the three grades, two variations were considered. Case 1 included 65% Ordinary Portland Cement (OPC), 15% FA and 20% GGBFS while case 2 included 85% OPC and 15% FA. In order to improve the workability of SCC, certain amount of super-plasticizer was added in the design mix. V-funnel, L-box and slump flow tests were conducted on fresh SCC whereas compressive strength, flexural strength and split tensile tests were performed on hardened SCC.

The results showed that the optimum admixture content was used their respective grades and cases leading to negligible segregation. Moreover, all the design mixes satisfied the SCC workability conditions comfortably. It was concluded that by replacing cement partially with fly ash and GGBFS in percentages mentioned in cases 1 and 2, the tensile strength of SCC could improve. From the 28 days results obtained from the compressive strength test, it was inferred that 15% fly ash and 20% GGBFS could be partially replaced with cement for all the grades i.e., M25, M30 and M35. This, could help in reducing the reliance on cement, and utilizing the industrial by-products in a better way.

Keywords: Self-Compacting Concrete (SCC); Ordinary Portland cement (OPC); Fly Ash (FA); Ground Granulated Blast Furnace Slag (GGBFS); Workability; V-funnel; L-box; slump flow; compressive strength test; split tensile strength; flexural strength

I. INTRODUCTION

Both fly ash and iron slag are industrial by-products. Their disposal has become a very serious environmental problem. Considering their excellent cementitious properties, their utilisation in the cement industry becomes crucial. Secondly, cement is the backbone for infrastructural development, and its production leads to the emission of carbon dioxide which is a major greenhouse gas. Due to significant contribution to the environmental pollution, over dependency on cement has to be reduced. The need for economising the use of cement makes the concept of composite cement necessary.

A concrete mix can only be classified as self-compacting if it has the following characteristics: Filling ability; Passing ability and Viscosity. This concrete mix is highly workable facilitating faster placement of concrete.

When we look at ordinary concrete, it is a dense material when mixed and requires the use of vibration or other compacting techniques to remove air bubbles and honeycomb-like holes, especially at the surfaces, where air has been trapped during pouring. These air particles trapped on the concrete surface are not desired and weaken the concrete if left. Vibration is a laborious task and takes time to remove such particles. Improper or inadequate vibrations lead to undetected problems later. Additionally some complex forms cannot be easily vibrated. These problems aggravate during the construction of large structures with congested and isolated reinforcements. Thus, in such scenarios, the concept of Self-Compacting Concrete (SCC) comes in handy. When placed, due to its own weight, the concrete gets compacted easily without the help of any compacting media and without much segregation. For such seamless compaction, stricter monitoring and high precision measurements of SCC become necessary for large construction activities

©IJRASET: All Rights are Reserved

ISSN: 2321-9653; IC Value: 45.98; SJ Impact Factor: 7.538
Volume 10 Issue III Mar 2022- Available at www.ijraset.com

II. EXPERIMENTAL WORK

A. Materials

1) *Cement, fly ash and GGBFS:* The cement which was used in the experimentation work was Ordinary Portland Cement (OPC), 43 grade, of Ultratech conforming to BIS: 269 - 2015. Fly ash and GGBFS that were used for the thesis work conform to BIS: 3812 (Part 1) - 2013 and BIS: 12089 - 1987 respectively. The specific gravities of cement, fly ash and GGBFS were calculated to be 3.13, 2.2 and 2.88 respectively. The colour of fly ash was light grey while the colour of GGBFS was dark grey. Cement, fly ash and GGBFS were added together in the proportions as mentioned above i.e., case 1 and case 2. The composite cement thus obtained was mixed with water to form a composite cement paste. This paste was then tested for important parameters of Indian Standard Code.
2) *Coarse and fine aggregates:* 10 mm nominal size aggregates were considered for the mix design of SCC. They were naturally occurring with well-defined angular edges and rough planar surfaces. The specific gravity of coarse aggregates was calculated to be 2.68. Natural sand was used as fine aggregate. Its specific gravity was evaluated and was found to be 2.65. The percentage silt content of sand was observed to be 7.15 percent.
3) *Admixture:* The admixture used for the enhancing the workability of SCC was MasterEase 3504, a product of Master Builders Solutions. It is a super-plasticizer, which improves the rheological properties of SCC, significantly facilitating its pump-ability and placement. The colour of the liquid was reddish-brown and its specific gravity was found to be 1.08.

B. Replacement of Cement with Fly ash and GGBFS

The gradations of SCC viz. M25, M30 and M35 were designed with the help of Indian standards by replacing cement with composites in the following variations: case 1: (OPC – 65%, GGBFS – 25%, FA – 15%); case 2: (OPC – 85%, FA – 15%).

TABLE I
QUANTITIES OF MIXING MATERIALS PER M3 FOR CASE 1

Materials	M25 grade mix	M30 grade mix	M35 grade mix
Cement	308.75 Kg	352.85 Kg	390 Kg
Fly ash	71.25 Kg	81.43 Kg	90 Kg
GGBFS	95 Kg	108.57 Kg	120 Kg
Admixture	5.225 Kg	6.514 Kg	7.2 Kg
Fine aggregate	803.90 Kg	754.77 Kg	724.21 Kg
Coarse aggregate	880.75 Kg	860.76 Kg	848.78 Kg
Water	190 litres	190 litres	190 litres

TABLE II
QUANTITIES OF MIXING MATERIALS PER M3 FOR CASE 2

Materials	M25 grade mix	M30 grade mix	M35 grade mix
Cement	403.75	461.4	510
Fly ash	71.25	81.45	90
Admixture	5.7	7.33	8.1
Fine aggregate	805.18	758.14	721.76
Coarse aggregate	805.18	864.60	845.91
Water	190 litres	190 litres	190 litres

©IJRASET: All Rights are Reserved

III.RESULTS

A. Compression Test

Compressive strength test was done on cubical moulds, where the test specimen was subjected to a compressive force at a loading rate of 140 Kg/sq cm/min. The loading capacity of the compressive testing machine is 3000 KN. The code followed for this test was BIS: 516 - 1959. Higher compressive strength correspond to better durability of the specimen. This test was conducted for specimens having curing age of 7, 14, 28 and 56 days. A set of three cubes were tested for each mix and the average value was considered.

Table III
Compressive Test Results Of Three Grades For Both Cases

Curing Age (days)	Compressive strength of M25 (N/mm^2)		Compressive strength of M30 (N/mm^2)		Compressive strength of M35 (N/mm^2)	
	Case 1	Case 2	Case 1	Case 2	Case 1	Case 2
7	24	25.77	25.54	34.22	33.77	38.22
14	27.55	29.12	31.96	35.56	38.67	44
28	31.95	35.89	39.38	42.2	46.2	46.67
56	38.23	39.68	43.56	45.67	49.3	50.2

B. Flexural Test

Flexural strength test was done on beam moulds. In this case the specimens were removed after 3 and 7 days curing and were subjected to a symmetrical two point loading with a loading rate of 7 Kg/sq cm/min. It is important to know the tensile strength of concrete since it is weak in tension. Tensile strength determines the load under which the cracking would develop. The absence of cracking is of considerable importance in maintaining the durability of concrete. The code followed for this test was again BIS: 516 - 1959.

TABLE IV.
Flexural Strength Test Results Of Three Grades For Both Cases

Curing Age (days)	Flexural strength of M25 (N/mm^2)		Flexural strength of M30 (N/mm^2)		Flexural strength of M35 (N/mm^2)	
	Case 1	Case 2	Case 1	Case 2	Case 1	Case 2
3	5.61	5.72	5.69	5.71	6.34	6.39
7	6.74	7.31	6.235	7.6	7.97	8.06

C. Split Tensile Test

Split tensile strength test was done on cylindrical moulds. In this case the specimens were removed after 7, 14 and 28 days curing. Using a special gear consisting of steel loading pieces (as per the codal provisions), the split tensile testing was done. These loading pieces were placed in compressive testing machine. The loading rate for the testing was 140 Kg/sq cm/min. The reason for calculating split tensile strength is similar to flexural testing. BIS: 5816 - 1999 was referred for this test.

TABLE V.
Split Tensile Strength Test Results of Three Grades For Both Cases

Curing Age (days)	Split tensile strength of M25 (N/mm^2)		Split tensile strength of M30 (N/mm2)		Split tensile strength of M35 (N/mm2)	
	Case 1	Case 2	Case 1	Case 2	Case 1	Case 2
7	2.652	2.758	2.865	3.183	2.865	3.819
14	2.971	3.077	3.183	3.501	4.297	4.138
28	3.395	3.607	3.819	4.138	4.35	4.562

©IJRASET: All Rights are Reserved | SJ Impact Factor 7.538 | ISRA Journal Impact Factor 7.894 |

IV. CONCLUSIONS

The normal consistency of the composite cement paste for case 1 (OPC – 65%, Fly ash – 15% and GGBFS – 20%) had an increment of 6.45% as compared to case 2 (OPC – 85% and Fly ash – 15%). The initial setting time of case 1 was 5.88% more than case 2 and the final setting of case 2 was 3.37%. The reason for higher initial and final setting times for case 1 as compared to case 2 could be due to the presence of pozzolanic materials (35%).

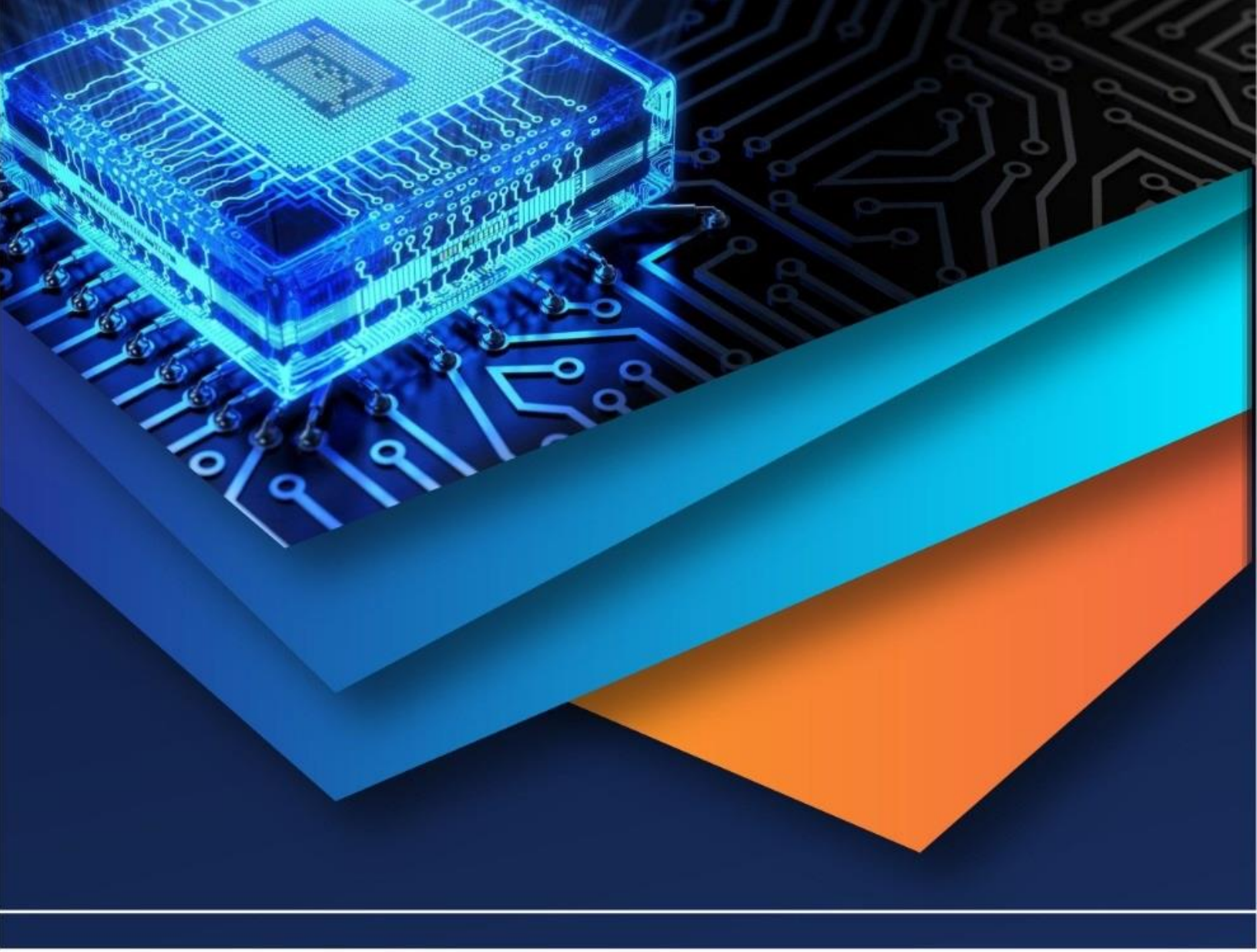
The admixture content used was optimum for their respective grades and cases. Not much segregation was observed in the SCC mixes. Since all the design mixes i.e., cases 1 and 2 of M25, M30 and M35, were categorized under V2 class for viscosity flow tests, from BIS: 10262 – 2019, it could be assumed that the mixes would be viscous with less segregation. As per the codal provisions for slump flow test, the concrete mixes were categorized under SF2 class. The code states that, these mixes could be used for normal concreting works.

After analyzing the results of flexural strength test and split tensile strength test, it can be concluded that, by replacing cement partially with fly ash and GGBFS in percentages mentioned in cases 1 and 2, the tensile strength of SCC could improve. From the 28 days results obtained from the compressive strength test, it can be inferred that cement can be partially replaced with 15% fly ash and 20% GGBFS for all the grades i.e., M25, M30 and M35. This, could help in reducing the dependency on cement, and utilizing the industrial by-products in a better way.

REFERENCES

[1] S. Kavitha and T. Felix Kala, “Evaluation of Strength Behaviour of Self-Compacting Concrete using Alccofine and GGBS as Partial Replacement of Cement”, Indian Journal of Science and Technology, Vol 9, pp 22, June 2016.
[2] Gurpreet Singh and Rafat Siddique Ph.D. , “Effect of iron slag as partial replacement of fine aggregates on the durability characteristics of self-compacting concrete”, Construction and Building Materials, Vol 128, pp 88-95, 15 December 2016.
[3] Paweł Niewiadomski, Damian Stefaniuk and Jerzy Hoła, “Microstructural Analysis of Self-compacting Concrete Modified with the Addition of Nanoparticles”, Procedia Engineering, Vol 172, pp 776-783, 2017.
[4] Nadine Hani, Omar Nawawy, Khaled S. Ragab and Mohamed Kohail, “The effect of different water/binder ratio and Nano-silica dosage on the fresh and hardened properties of self-compacting concrete”, Construction and Building Materials, Vol 165, pp 504-51, 20 March 2018.
[5] Kosmas K. Sideris, Ch. Tassos, A. Chatzopoulos and P. Manita, “Mechanical characteristics and durability of self-compacting concretes produced with ladle furnace slag”, Construction and Building Materials, Vol 170, pp 660-667, 10 May 2018.
[6] Yimmy Fernando Silva, David A. Lange and Silvio Delvasto, “Effect of incorporation of masonry residue on the properties of self-compacting concretes”, Construction and Building Materials, Vol 196, pp 277-283, 30 January 2019.
[7] Brabha Hari Nagaratnam, Muhammad Abdul Mannan, Muhammad Ekhlasur Rahman, Abdul Karim Mirasa, Alan Richardson and Omid Nabinejad, “Strength and microstructural characteristics of palm oil fuel ash and fly ash as binary and ternary blends in Self-Compacting concrete”, Construction and Building Materials, Vol 202, pp 103-120, 30 March 2019.
[8] Anurag Gupta, Sayantan Ghosh and Dr. Hemant Sood, “Experimental Investigations on Composite Cement using ash based Industrial By-Products”, Journal of Emerging Technologies and Innovative Research, Volume 6, Issue 6, June 2019.
[9] Hossein Sasanipour, Farhad Aslani and Javad Taherinezhad, “Effect of silica fume on durability of self-compacting concrete made with waste recycled concrete aggregates”, Construction and Building Materials, Vol 227, 10 December 2019.
[10] C. Thomas, J. Sainz-Aja, J. Setien, A. Cimentada and J. A. Polanco, “Resonance fatigue testing on high-strength self-compacting concrete”, Journal of Building Engineering, Vol 35, March 2021.

©IJRASET: All Rights are Reserved | SJ Impact Factor 7.538 | ISRA Journal Impact Factor 7.894 |



10.22214/IJRASET

45.98

IMPACT FACTOR: 7.129

IMPACT FACTOR: 7.429

INTERNATIONAL JOURNAL FOR RESEARCH

IN APPLIED SCIENCE & ENGINEERING TECHNOLOGY

Call : 08813907089 (24*7 Support on Whatsapp)