As per UGC guidelines an electronic bar code is provided to secure your paper

International Journal for Modern Trends in Science and Technology
Volume 11, Issue 07, pages 102-108
ISSN: 2455-3778 online
Available online at: http://www.ijmtst.com/vol11issue07.html
DOI: https://doi.org/10.46501/ijmtst.017.v11.i07

Mechanical Properties on Self Compacting Concrete Replacement with Fly Ash, Silica Fume in Cement and Addition with Fibres

Peela Sravya[1], S Pavani[2]

[1]*PG Scholar, Baba Institute of Technology and Sciences, India.*
[2]*Assistant Professor, Baba Institute of Technology and Sciences, India.*

To Cite this Article
Peela Sravya & S Pavani (2025). Mechanical Properties on Self Compacting Concrete Replacement with Fly Ash, Silica Fume in Cement and Addition with Fibres. International Journal for Modern Trends in Science and Technology, 11(07), 102-108. https://doi.org/10.46501/ijmtst.017.v11.i07

Article Info
Received: 09 June 2025; Accepted: 09 July 2025.; Published: 11 July 2025.

KEYWORDS

Self-compacting concrete, silica fume, European Federation of National Associations Representing for Concrete, compressive strength, split tensile strength.

ABSTRACT

Self-compacting concrete has high workability and flow ability than normal compacted concrete. With its segregation resistance and fluidity, it offers a solution to problems in construction field like lack of skilled labour, inadequate compaction, over compaction, segregation etc. This study includes designing a self-compacting concrete mix which is standardized using its fresh properties with respect to EFNARC (European Federation of National Associations Representing for Concrete) standards. In this study, fly ash is used as partial replacement for cement in concrete. The mix design for M30 grade self-compacting concrete is done as per EFNARC standards. Then various properties of different mixes of M30 grade with 0%, 10%, 20%, 30%, 40% & 50%and 5% of silica fume as partial replacements of cement were compared, and the optimum percentage replacement is obtained at 30% replacement (SCC 30). On determining the optimum percentage replacement of fly ash in cement for M30 grade SCC as SCC 30, various properties such as weight loss and compressive strength and flexural strength of SCC 30 with normal SCC 30 are compared and then finally basalt fibres were added to cement content to asses the performance of concrete with fly ash and fibres as partial replacements of cement. It is found that the there is loss in weight as well as compressive strength and flexural strength of specimen due to adding fly ash and basalt fibres.

1. INTRODUCTION

Self-compacting concrete is highly flow able type of concrete that spreads in to the form work without the need of mechanical vibration. In Self-compacting concrete there will not be any segregation. Self-compacting concrete (SCC) being different from conventionally compacted concrete has high workability and flow ability to reach every corner of formwork. Though SCC was developed in late 1980's world adopted it in rapid phase, which raised the need for more study towards the affordable SCC. This study focuses on producing concrete of acceptable strength with crushed waste ceramic tiles as partial replacement for coarse aggregate and fly ash as partial replacement for cement. On using fly ash and Broken tiles as partial replacements for cement and coarse aggregate, we can reduce the environmental hazards and also we can partially overcome waste disposal crisis. Cost of fly ash as compared to that of cement will be very less. Broken tiles are procured from construction and demolition waste. Hence the overall cost of concrete with fly ash and broken tiles as partial replacements for cement and coarse aggregates will by very much less as compared to normal SCC. Partial replacement of coarse aggregate by waste ceramic tile increases the strength and durability where as partial replacement of cement by fly ash increases the strength of concrete. In the current study both fly ash & broken tiles are used as partial replacement for cement and coarse aggregate respectively.

EFNARC STANDARDS FOR SCC: The European Federation of Specialist Construction Chemicals and Concrete Systems also known as EFNARC, formed the European Guidelines for Self-Compacting Concrete in January 2004. It formed various guidelines for self-compacting concrete such as testing procedures and standard ranges to design a SCC. It also provides standards for the associated constituent materials used in the production of SCC. It proposed a generalized mix design method which consists of trial and error method depending on tests on fresh concrete.

NECESSARY TO ADD FIBERS WITH CONCRETE: By adding the glass fibers to concrete, it is possible to improve the compressive and tensile strength of the concrete. Reinforcing glass fibers can improve the durability of the concrete matrix by increasing the ductility and absorbing energy when subjected to impact loads and external vibrations. When mixing the glass fibers into the concrete mixture, the fibers will form clusters and the uniform distribution cannot be achieved. Clusters of fibers often trap considerable amount of air, which has an adverse effect on the mechanical properties of the fiber-reinforced concrete. Therefore, researchers have adopted several chemical treatment processes to increase its surface energy.

2. LITERATURE REVIEW

Nipat Puthipad et.al [1] conducted experimental study on the enhancement of self-compacting ability in fresh concrete with high volume fly ash and the stability in terms of volume of entrained air bubbles was analysed. In this paper, the authors considered the lower water retention, ball- bearing effect of fly ash and entrained air bubbles which affect the self-compact ability of fresh concrete. The concrete test results suggested that the ball-bearing effect of fly ash significantly enhanced the self- compact ability of fresh concrete and reduced the required dosage of superplasticiser. The ball-bearing effect of entrained air bubbles, with certain type of air-entraining agent (AEA), was also found to further enhance the self-compact ability of fresh concrete with fly ash. The author's results suggest the potential of the combination between the ball- bearing effect of fly ash and entrained air bubbles for reducing the cost and increasing the sustainability of SCC.

Hakan Elci [2] investigated about the possibility of using the tile waste as aggregates in concrete production to decrease the production cost and also to minimize the environmental impact of tile wastes. The authors compared the properties of tile concretes with the properties of the concrete made using the limestone aggregates. From the authors study it is found that the thickness of the tile is limiting factor for concrete aggregate when used greater than 14mm size due to increasing amount of the flat and elongated particles. The flexural strength results of the WTC is found to be better than the FTC and LSC. From the test results the authors found that the concrete made using the crushed floor tile aggregates have similar mechanical properties as that of the limestone concrete, on the other hand the concretes made with the wall tile aggregates have given lower mechanical properties than the limestone concrete.

Paul O. Awoyera et al [3] research focuses on the mechanical characterization of waste ceramic wall and floor tiles aggregate concrete. Ceramic tiles were sieved into fine and coarse aggregates in line with standards and they were compared to other materials that were used like gravel, river sand, cement and potable water. Workability of the fresh concrete was checked through slump test, and concrete cubes of 150 mm dimensions and cylinders of 100 mm - 200 mm were cast in 7 the laboratory. After 24 h of casting, the concrete samples were demoulded and were cured by immersion in curing tank at temperature of 22^{0}C. The authors conducted compressive and split- tensile strengths tests on the hardened concrete samples. The strengths were determined after curing them for 3, 7, 14 and 28 days. Test results showed that both the compressive strength and split tensile strengths increased appreciably with the curing age than the conventional concrete. From the author study it is found that within the limited scope of the experiments carried out in author investigation, concrete made with CWA (Ceramic waste aggregate) as a replacement for part of the natural aggregates can be considered a suitable alternative for normal concrete. Finally, the authors conclude that the highest compressive strength and split tensile strength were achieved by replacing 100% of the natural aggregate with CCA (Ceramic coarse aggregate) and ceramic fine aggregate (CFA) individually.

Ivana Milicevic et.al [4] study is to demonstrate that it is possible to make precast concrete floor blocks with more than 50% replacement of natural aggregate with recycled aggregate made with crushed clay bricks and roof tiles. In first phase of the author's study, the physico-mechanical properties of concrete with recycled and with natural aggregate were tested and in the second phase they explored the properties of precast concrete floor blocks (i.e. geometrical, mechanical, thermal and acoustic properties were determined). Crushed brick and tile aggregate concrete density is about 15% less than that of natural aggregate concrete. Based on author experimental study, it is possible to make precast concrete floor blocks with recycled aggregate with the fulfilled thermal, cost and environmental requirements.

Huizhao et.al [5] investigated the fresh properties and mechanical properties of self-compacting concrete. The study was carried out by partially replacing Fly ash and GGBFS at the rate 20%, 30% and 40% in cement. The results owed that presence of Fly ash and GGBFS increased the loss of slump flow, wet density of SCC and prolonged the setting times considerably. Results also showed that Fly ash, GGBFS SCC exhibited a higher carbonation depth than the control SCC but the concrete was effective on resisting the chloride ion penetration and drying shrinkage.

3. PRELIMINARY INVESTIGATION

Physical Properties of ordinary Portland cement.

S.NO	Characteristics	Values obtained	Values as per Is Code
1	Specific gravity of Cement	3.136	3.15
2	Fineness of cement	7.2%	10% residue on 90 micro sieve
3	Standard consistency	33%	Minimum 23% as per present code
4	Initial setting time	35	Not less than 30 minutes
5	Final setting time	330	Not greater than 600minutes
6	Compressive strength of cement (MPa) 3days 7days 28 days	28.4 36.9 54.2	23 37 53
Brand of cement – OPC 53 grade (KCP) **Result** – The properties of the cement tested lie within the Indian standard limits and are considered to be of standard quality.			

Physical Properties of Fine aggregates

S. No	Property	Test Results	Standard Limits	IS Standard Testing Code
1	Specific gravity (Fine aggregate) Zone II Sand	2.5019	> 2.5	963] Part III
2	Fineness modulus of Fine aggregates	**2.58**	2.6-3.2 (Coarse Sand)	963 Part III
3	Bulk Densityin Fineaggregates	**1.49**	1.5 ~ 1.7	IS 2386-1963 Part III
4	Water absorption	**0.47**	(0.5- 1) %	IS 2386-1963 Part III

Type ofFineaggregates- Natural riversand
Result – The properties of the fine aggregates tested lie within the Indian standard limits and are considered to be suitable for production of concrete since the properties come under
ZONE II category

Physical Properties of natural coarse aggregates

S.No	Property	Test Results	Permissible Limit	IS Standard Testing Code
1	specific gravity	For 20mm-2.80 For 10mm-2.68	2.5 to 3.0	IS 2383-1986
2	Water Absorption	For 20 mm-0.3 For 10 mm-0.60	Not more than 0.6 %	IS 2383-1986
3	Bulk density (kg/m 3)	1738	1520 to 1680 kg/m3	IS 2383-1986
4	Flakiness Index %	11.3%	Not more than 15 %	IS 2383-1963 Part 1
5	ngation Index	18.9%	Not more than 15 %	IS 2383-1963 Part 1
6	Aggregate Impact Value	28.6%	Not more than 30%	IS 2383-1963 Part 1
7	Aggregate Crushing Value	26.459%	Not more than 30%	IS 2383-1963 Part 1
8	Fineness modulus	6.27	-	IS 2383-1963 Part 1

4. PRELIMINARY INVESTIGATION

SELF-COMPACTING CONCRETE: Self-compacting Concrete is a concrete mix which flows under its own weight and completely fill the formwork, even in the presence of dense reinforcement, without the need of any mechanical vibration. Self- compacting concrete consists of water, fine aggregate (conforming to zone- 2), coarse aggregate (size upto 20mm) and Portland cement. The characteristics of materials such as cement, fine aggregate and coarse aggregate are tested as per Indian Standards. To investigate the mix proportions, cube casting and tests of concrete presented in this chapter.

FLY ASH: In India, due to globalization, increase in technology and increase in population, the demand for electricity is increasing day by day. Most of the electricity generated in India is from thermal power plants. Fly ash is a by-product from thermal power plants. As the production of electricity from thermal power plants is increasing, the generation of fly ash is also increasing. The chemical composition of fly ash makes it much like cement hence it can be considered as partial replacement. On using fly ash as supplementary cementitious material, its adverse effects on environment can be decreased.

Results for specific gravity of fly ash

Weight of empty specific gravity bottle (w1)	36 gm
Weight of the bottle with fly ash (w2)	63 gm
Weight of the bottle with fly ash and kerosene (w3)	109 gm
Weight of the bottle with kerosene (w4)	93 gm
Specific gravity of fly ash= w2-w1/(w2-w1)-(w3-w4) x 0.79	1.93

SILICA FUME: Silica fume is a by-product of producing silicon metal or ferrosilicon 43 alloys. One of the most beneficial uses for silica fume is in concrete. Because of its chemical and physical properties, it is a very reactive pozzolanic. Concrete containing silica fume can have very high strength and can be very durable.

Chemical properties of silica fume

S.No	Chemical compositions	Silica fume
1	Silica Dioxide (SiO_2)	85%
2	Moisture content	3%
3	Cao content	< 1%
4	Alkalis as Na2O	1.50%
5	Loss on ignition	4.00%

Results for the tests on fresh self-compacting concrete

Property	Test method	Measured value	Results	Limits
Viscosity/ Flowability	T500	Flow time	4 sec	2sec-5sec
	V funnel	Flow time	11 sec	8sec-12sec
	Slump flow	Flow distance	680 mm	650mm-800mm
Passing ability	L box	Passing ratio	0.9	0.8-1.0

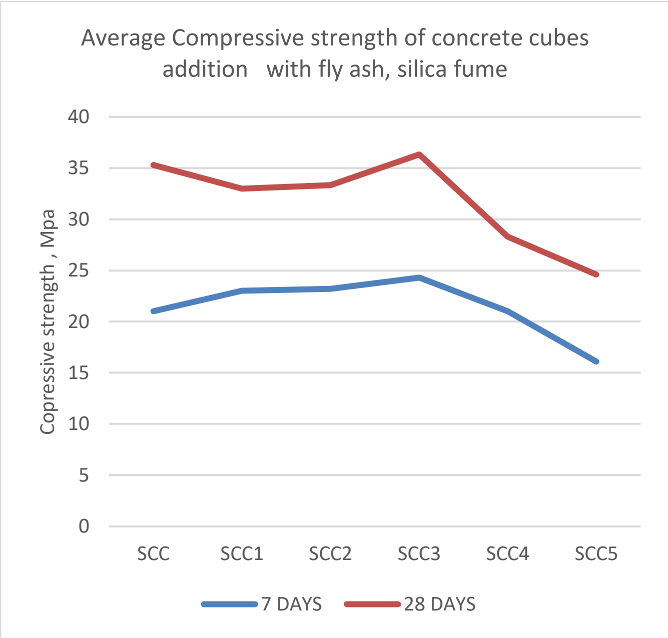
5. RESULTS AND DISCUSSIONS

GENERAL

In this chapter the compressive, tensile and flexural strengths of self- compacting concrete at the ages of 7 days, 28 days and 90 days are discussed. The constituents of SCC are partially replaced by 10%, 20%, 30%, 40% and 50%.

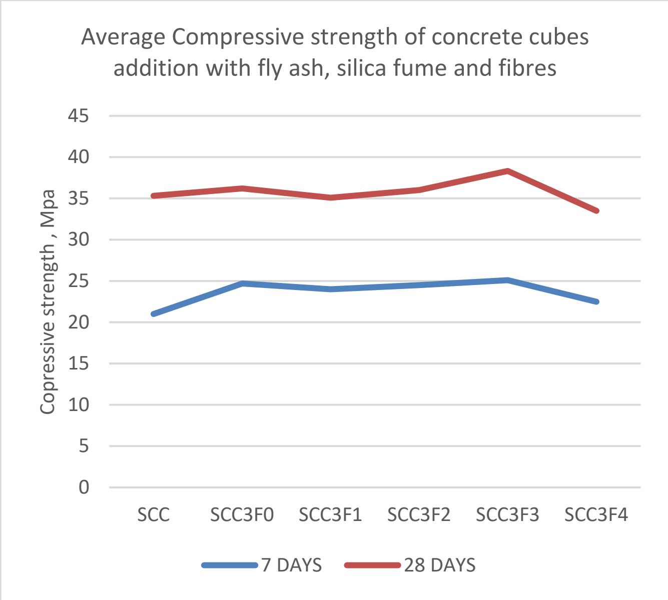
AVERAGE COMPRESSIVE STRENGTH OF CONCRETE CUBES ADDITION WITH FLY ASH, SILICA FUME

S.No	Mix designation	Compressive strength (MPa)	
		7 days	28 days
1	SCC	21.00	35.30
2	SCC1	23.00	33.00
3	SCC2	23.20	33.33
4	**SCC3**	**24.30**	**36.33**
5	SCC4	21.03	28.30
6	SCC5	16.10	24.60



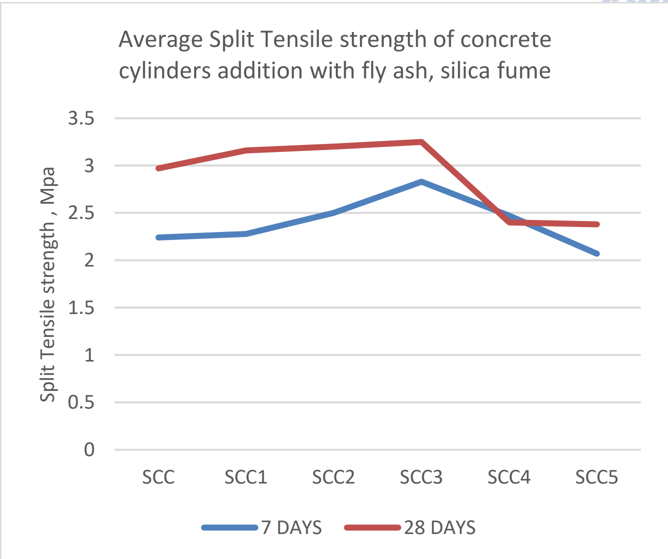
AVERAGE COMPRESSIVE STRENGTH OF CONCRETE CUBES ADDITION WITH FLY ASH, SILICA FUME AND FIBRES

S.No	Mix designation	Compressive strength (MPa)	
		7 days	28 days
1	SCC	21.00	35.30
2	SCC3F0	24.70	36.22
3	SCC3F1	24.00	35.10
4	SCC3F2	24.50	36.00
5	**SCC3F3**	**25.10**	**38.33**
6	SCC3F4	22.50	33.50



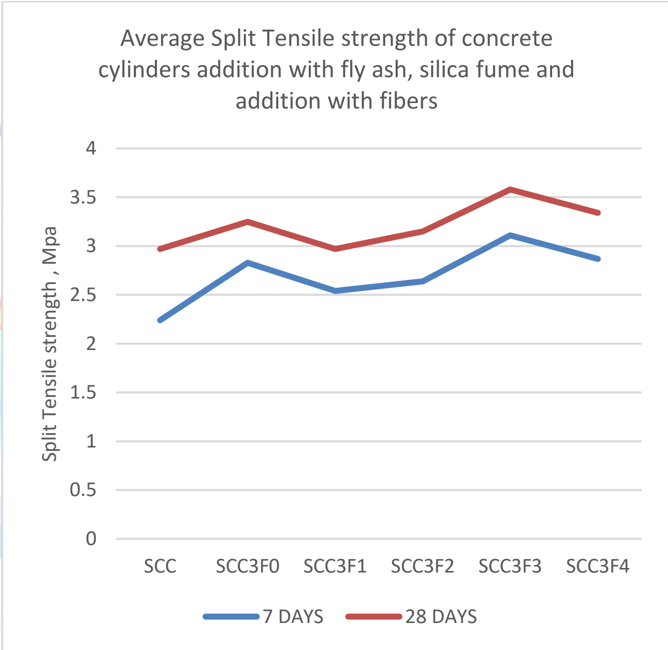
AVERAGE SPLIT TENSILE STRENGTH OF CONCRETE CYLINDERS ADDITION WITH FLY ASH, SILICA FUME

S.No	Mix Designation	Split Tensile strength (MPa)	
		7 days	28 days
1	SCC	2.24	2.97
2	SCC1	2.28	3.16
3	SCC2	2.5	3.20
4	**SCC3**	**2.83**	**3.25**
5	SCC4	2.47	2.40
6	SCC5	2.07	2.38



AVERAGE SPLIT TENSILE OF CONCRETE CYLINDERS ADDITION WITH FLY ASH, SILICA FUME AND FIBRES

S.No	Mix Designation	Split Tensile strength (MPa)	
		7 days	28 days
1	SCC	2.24	2.97
2	SCC3F0	2.83	3.25
3	SCC3F1	2.54	2.97
4	SCC3F2	2.64	3.15
5	**SCC3F3**	**3.11**	**3.58**
6	SCC3F4	2.87	3.34



6. SUMMERY AND CONCLUSIONS

The results from a wide experimental campaign carried out for evaluating the most important physical and mechanical properties like compressive strength of M30 with and without pozzolanic materials for different replacements. The main test variables of concrete have been produced by replacing (0%, 5%, 10%and 15%) given amounts of fly ash with Cement and silica fume at 5% concrete and by adding Silica fume and fly ash in partial replacement of Cement.

1. For compressive strength, the optimum percentage replacement of SCC is obtained at SCC3.

2. For Split tensile strength, the optimum percentage replacement of SCC is obtained at SCC3.

3. Compressive strength of basalt fibre reinforced concrete specimens were higher than cement concrete specimens at all the ages.

4. Split tensile strength for concrete specimens containing basalt fibres it is observed that there is increase in split tensile strength when compared to control concrete specimen.

5. Compressive strength increases by adding fly ash and silica fume at the mix SCC3 of in the specimens when compared to cement concrete.

6. Split Tensile strength increases by adding fly ash and silica fume at the mix SCC3 of in the specimens when compared to cement concrete.

Conflict of interest statement

Authors declare that they do not have any conflict of interest.

References

[1] M. Nili, A. Ehsani and K. Shabani, "Influence of Nano-SiO2 and Micro silica on Concrete Performance", Second International Conference on Sustainable Construction materials and Technologies , 2010.

[2] Dr. D. V. Prasada Rao, U. Anil Kumar "An experimental investigation on strength properties of concrete containing micro-silica and nano- silica", IJCIET, Volume 5, Issue 8, pp. 89-97 , August 2014.

[3] Fathima Irine I .A, "Strength Aspects of Basalt Fiber Reinforced Concrete", International Journal of Innovative Research in Advanced Engineering (IJIRAE), Volume 1, Issue 8, September 2014 .

[4] Sangamesh upasi, Sunil kumar .H.S, Manjunatha. H, Dr.K.B.Prakash, "An Investigation on Strength characteristics of basalt fibre reinforced concrete", International journal of Engineering Research-Online, Vol.2., Issue.5, 2014.

[5] Parvez Imraan Ansari, Rajiv Chandak, "Strength of Concrete Containing Basalt Fibre" , Parvez Imraan Ansari Int. Journal of Engineering Research and Applications, Vol. 5, Issue 4, (Part -6), pp.13- 17, April 2015.

[6] Urkhanova Larisaa, Lkhasaranov Solbona, Buiantuev Sergeib, "Fiber- reinforced concrete with mineral fibers and nanosilica", 18th International Conference on Rehabilitation and Reconstruction of Buildings 2016, CRRB 2016,

[7] A.Ranjani, K.Keerthana, N.K.Amudhavalli, "Study on effect of micro silica and nano silica in polyester fibre reinforced concrete", IRJET volume 3, issue 4, April -2016.

[8] Maria Wlodarczyka, Igor Jedrzejewskia, "Concrete slabs strengthened with basalt fibres – experimental tests results", XXV Polish – Russian – Slovak Seminar on Theoretical Foundation of Civil Engineering, 2016.

[9] Mr.Gore ketan R, Prof. Suhasini M.Kulkarni, "The Performance of basalt fibre in high strength concrete", Journal of information, knowledge and research in civil engineering, Volume 2, Issue2, pp-117- 124, 2013.

[10] Joshi A. A., Dr. Rangari S. M., and Shitole A. D, "The use of Basalt Fibers to improve the Flexural Strength of Concrete Beam", International Journal of Innovative Science, Engineering & Technology (IJISET), Vol. 1 Issue 10, pp-612-614, December 2014.

[11] Nipat Puthipad, Masahiro Ouchi, Sovannsathya Rath, Anuwat Attachaiyawut., Enhancement in self-compactability and stability in volume of entrained air in self- compacting concrete with high volume fly ash, Construction and Building Materials, 128, 2016, pp. 349-360.