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

V. Sri Ramya Lekhini[1] | Janardhan G[2]

[1]Postgraduate student, Visakha Technical Campus, Andhra Pradesh, India.
[2]Assistant professor, Visakha Technical Campus, Andhra Pradesh, India.

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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.

KEYWORDS:- *Self compacting concrete, silica fume, European Federation of National Associations Representing for Concrete, compressive strength, flexural strength.*

I. 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.

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.

Fly ash is a waste product generated by thermal power stations. It is usually much cheaper than cement in India. Fly ash is a burnt and powdery derivative of inorganic mineral matter that generates during the combustion of pulverized coal in thermal power plant.

REVIEW OF LITERATURE

NipatPuthipad 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 super plasticiser. 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**.**

Huizhao et.al [2] 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.

R. D. Padhye et.al [3] studied about the effects of Fly ash as partial replacement for cement in concrete and the optimum proportion of fly ash for different grades of concrete which is acceptable, applicable and economical. The variation in compressive strength of different grades of concrete at different percentages of fly ash and at different curing periodshas been studied. Different grades of concrete mixes with varying percentage of fly ash content were prepared and the effects of fly ash onmechanical properties of fresh and hardened concrete have beeninvestigated. From the results it is observed that percentage replacementwas varying from 15% to 25%. It is concluded that fly ash can be replaced8up to 40%. The compressive strength of concrete was measured at 7, 28and 45 days and compaction factor is taken as a measure of workability.

HalitYazıcı et.al [4] studied the durability properties self-compactingconcrete (SCC). Durability properties such as freezing and thawing andchloride penetration resistance have been investigated by replacing cementwith Class C fly ash (FA) in various proportions from 30% to 60% andwith the incorporation of 10% silica fume (SF) to the same mixtures. Theyobserved that FA replacement without SF decreased both early andultimate compressive strength whereas, 10% replacement of SF improvedcompressive strength for all FA contents at all ages. Also, heat of hydrationand shrinkage of these mixtures are lower than SCC mixtures made withPortland cement. They concluded that incorporation of FA and SF in SCCis very effective in the case of chloride penetration resistance.

P. R. Wankhede et.al [5] studied about the effect of fly ash on properties of concrete. By using of fly ash in concrete imparts several environmental benefits and thus it is eco-friendly. Fly ash is pozzolanic material & it improving the properties of concrete like compressive strength & Durability. The test results obtained from authors study state that the ultimate compressive strength of concrete goes on decreasing with increase in w/c ratio of concrete and slump loss of concrete goes on increasing with increase of quantity of fly ash. The author study concludes that the study on the effect of fly ash on the properties of concrete for nominal mix of M25 grade of concrete with 10% and 20% replacement of cement with fly ash shows good compressive strength for 28 days than normal concrete for 0.35 w/c ratio. But in the case of 30% replacement of cement with fly ash shows that ultimate compressive strength of concrete decreases.

Dina M. Sadek et.al [6] investigated about the possibility of using various types of waste powders, as mineral additives in self-compacting concrete (SCC) generated from marble and granite industry.

Fresh properties with Slump flow, V-funnel, and J-ring tests are conducted in self-compacting concrete. Hardened properties with compression, splitting tensile, flexural, water absorption and sulphate attack tests are conducted on SCC. SCC incorporating mixed powder showed the superior performance followed by granite powder mixes, while marble powder has a marginal effect on the performance of hardened concrete. However, Silica fume could be used for the enhancement of marble powder performance.

A.H. HASSAN et.al [7] studied about the paper briefly discusses about the mixture proportion of self-compacting concrete and the effects of addition of rice husk ash (RHA), fly ash (FA) and ground granulated blast furnace slag (GGBS) to fresh properties, compressive strength and durability performance of self- compacting concrete. M40 grade SCC containing 15%, 10%, 5% of FA, RHA and GGBS respectively was produced. It was concluded that RHA, GGBS and FA improve the long term strength of self-compacting concrete.

RakeshSoni et.al [8] studied about the compressive strength of fly ash cement concrete in a normal way as use to determine on construction site, which can utilize in road construction in rural areas. Replacement of Ordinary Portland Cement (OPC) with fly ash in various proportion like 10%, 20%, 30%, 40% and 50% Fly Ash by mass. High volume of Fly Ash in concrete reduces the water demand and improves the workability. Results shown that as amount of fly ash increased, as compressive strength decreased. Replacement of fly ash with cement in concrete up to 30% is safe to use in road construction to sustain its better quality.

EXPERIMENTAL WORK

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.

TESTS ON CEMENT

The cement used is ordinary Portland cement (OPC 53) confirming to IS: 12269-1987. The KCP OPC 53 grade is used in experimental work. The physical properties of the cement are tested in accordance with IS: 4031-1988.

S.No	Description of test	Test result	Permissible limits
1.	Specific Gravity	3.09	3.15
2.	Fineness	7.8%	Should not exceed 10% residue on 90 micron sieve(max)
3.	Standard consistency	33%	Minimum 23 % till obtaining viscous paste
4.	Initial Setting time	30 min	Should not be less than 30 minutes
5.	Final setting time	275 min	Maximum 600 minutes

TESTS ON FINEAGGREGATE

Fine aggregate should pass through I.S. sieve 4.75 mm. Standard coarse sand is to be from river origin. According to IS 383-1970, fine aggregate used in this present study confirms to zone – II classification**.**

S.No	Property	Test Results	Standard Limits	IS Standard Testing Code
1	S Specific gravity (Fine aggregate) Zone II Sand	2.5019	> 2.5	IS 2386-1963] Part III
2	Fineness modulus of Fine aggregates	2.58	2.6-3.2 (Coarse Sand)	IS 2386-1963 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

NATURAL COARSE AGGREGATES

Aggregate which retained on 4.75 mm sieve and the broken stone is generally used as a Coarse aggregates. The nature of work decides the maximum size of the coarse aggregates. Locally available coarse aggregates having the maximum size 20 mm and minimum size 10 mm was used in the present work.

Several laboratory testing will be carried out and compared to the standard requirements as per IS: 2386-1963 has grouped the test methods for aggregates into different parts

.No	Property	Test Results	Permissible Limit	IS Standard Testing Code
	Specific gravity	For 20mm-2.80 For 10mm-2.68	2.5 to 3.0	IS 2383-1986
	Water Absorption	For 20 mm-0.3 For 10 mm-0.60	Not more than 0.6 %	IS 2383-1986
	Bulk density (kg/m ^{3})	1738	1520 to 1680 kg/m^3	IS 2383-1986
	Flakiness Index %	11.3%	Not more than 15 %	IS 2383-1963 Part 1
	El Elongation Index	18.9%	Not more than 15 %	IS 2383-1963 Part 1
	Aggregate Impact Value	28.6%	Not more than 30%	IS 2383-1963 Part 1
	Aggregate Crushing Value	26.459%	Not more than 30%	IS 2383-1963 Part 1
	Fineness modulus	6.27	-	IS 2383-1963 Part 1

PHASE I

PERCENTAGE OF REPLACEMENTS

Mix designation		**SCC**	**SCC 1**	**SCC 2**	**SCC 3**	**SCC 4**	**SCC 5**	**Units**
Cement		100	85	75	65	55	45	%
Fly ash		0	10	20	30	40	50	%
Silica fume		0	5	5	5	5	5	
Fine aggregate		100	100	100	100	100	100	%
Coarse aggregate	20 mm	100	100	100	100	100	100	%
	10 mm	100	100	100	100	100	100	%
Normal water		100	0	100	0	100	0	%
Super plasticizer		100	100	100	100	100	100	%

PHASE II

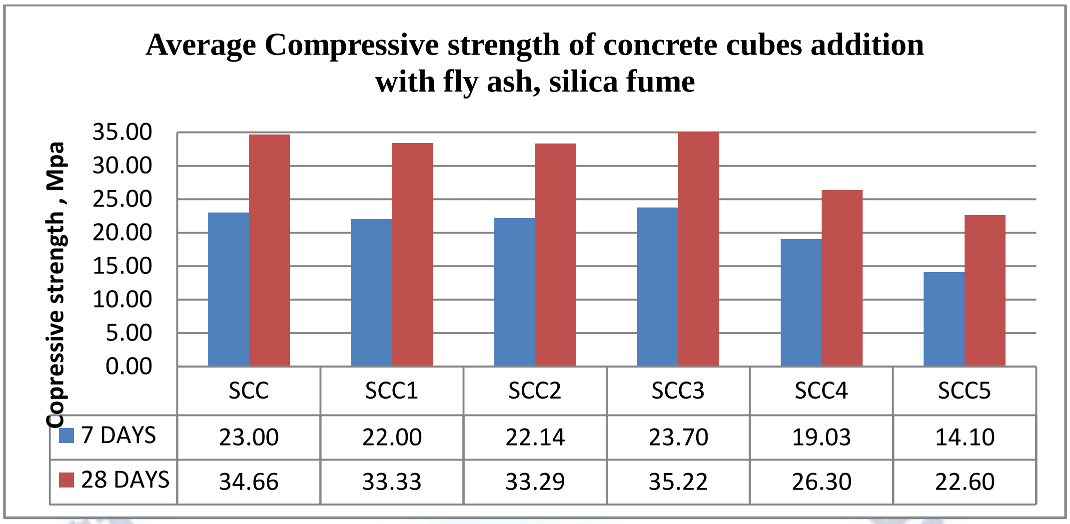
PERCENTAGE OF REPLACEMENTS

Mix designation		**SCC**	**SCC 3F1**	**SCC 3F2**	**SCC 3F3**	**SCC 3F4**	**SCC 3F5**	**Units**
Cement		100	85	75	65	55	45	%
Fly ash		0	10	20	30	40	50	%
Silica fume		0	5	5	5	5	5	
Basalt fibers		0	0.1	0.2	0.3	0.4	0.5	%
Fine aggregate		100	100	100	100	100	100	%
Coarse aggregate	20 mm	100	100	100	100	100	100	%
	10 mm	100	100	100	100	100	100	%
Normal water		100	0	100	0	100	0	%
Super plasticizer		100	100	100	100	100	100	%

RESULTS AND DISCUSSIONS

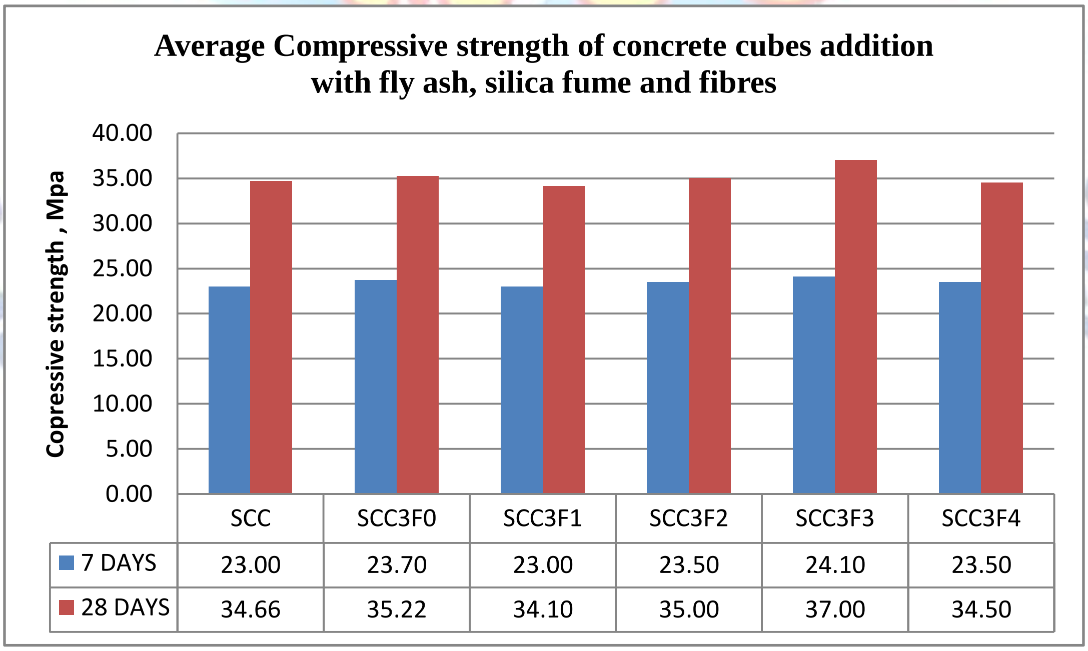
Average Compressive strength of concrete cubes addition with fly ash, silica fume

S.No	**Mix designation**	**Compressive strength (MPa)**	
		7 days	**28 days**
1	SCC	23.00	34.66
2	SCC1	22.00	33.33
3	SCC2	22.14	33.29
4	**SCC3**	**23.70**	**35.22**
5	SCC4	19.03	26.30
6	SCC5	14.10	22.60



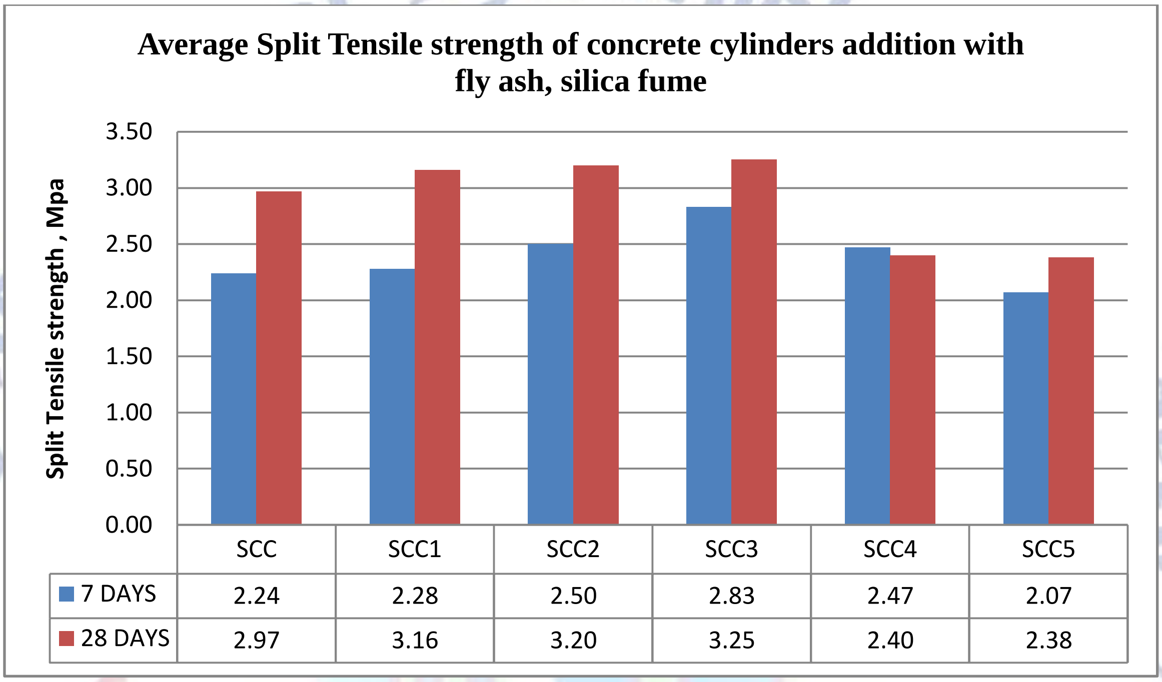
Average Compressive strength of concrete cubes addition with fly ash, silica fume And fibres

S.No	Mix designation	Compressive strength (MPa)	
		7 days	28 days
1	SCC	23.00	34.66
2	SCC3F0	23.70	35.22
3	SCC3F1	23.00	34.10
4	SCC3F2	23.50	35.00
5	**SCC3F3**	**24.10**	**37.00**
6	SCC3F4	23.50	34.50



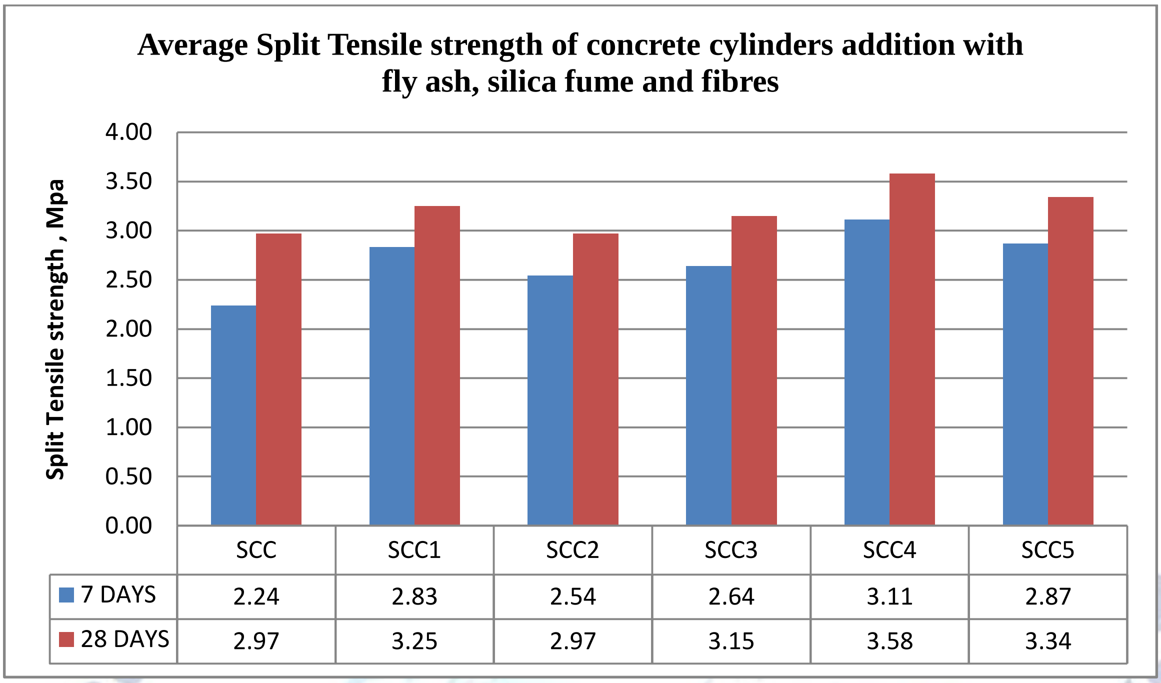
Average Split Tensile strength of concrete cylinders addition with fly ash, silica fume

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



CONCLUSIONS

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.

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