EXPERIMENTAL INVESTIGATION ON STRENGTH CHARACTERISTICS OF SILICA FUME BASED HIGH PERFORMANCE CONCRETE WITH STEEL FIBER AND POLYPROPYLENE FIBER

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Abstract

Cement is the most popular material used in construction, recent trend is in concrete cement is replaced by admixtures such as GGBS, fly ash, slag, silica fume and metakaolin to improve the characteristics of high performance of concrete in order to reduce the creep and shrinkage and to improve tensile strength, fibers are added. The scope of present investigation deals with the strength properties of high performance concrete, on the effect of partial replacement of cement by silica fume with different percentages viz 0%, 10% and 20% was used in the concrete mix containing composite fibers (steel and polypropylene) of different percentages viz 0%, 0.50%, 0.75% and 1% steel fibers and 0.25% polypropylene fiber constant for all silica fumeconcrete mixes on the properties of high performance concrete. An aggregate binder ratio of 2.5 and different water binder ratio viz 0.30, 0.35 and 0.40 with super plasticizer of 0.6% by weight of binder was used in this investigation. Each series consists prisms, cylinders and cubes as per IS standard. The tests are conducted to find out the flexural strength, split tensile strength and compressive strength at the age of 7 days and 28 days.

Key Words: *silica fume, steel fiber, polypropylene fiber, super plasticizer, strength properties.*

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1. INTRODUCTION

Cement is a very commonly used construction materials, it has ability to get cast in any form and shape in general and rigid pavement in particular. Also replaces old construction materials such as stone and brick masonry. A good concrete much possess high strength and low permeability. The strength of concrete can be changed by making appropriate changes in its ingredients like aggregate, water and cementitious material, also adding some special ingredients. However concrete has some deficiencies as low impact strength, low post cracking capacity, low tensile strength,
Incapable of accommodating large deformations, brittleness and low ductility. Limited fatigue life of certain mineral admixture are also added to concrete to improve their strength properties of concrete materials such as silica fume, which are usually very fine, may be finer than cement, when added to concrete in right proportion can improve the strength of concrete extremely and high strength and high performance concrete is received in this manner.
In order to improve the mechanical properties of concrete it is good to mix cement with fiber which have good tensile strength. Addition of polypropylene fibers decreases the unit weight of concrete and increases its strength.
Incorporation of composite materials (steel and polypropylene fibers) in concrete significantly improve its plastic settlement, strains and stress concentrations imposed by external restraints, bleeding, thermal and shrinkage.

[1] **Mr.Sabale Vishal Dhondiram Miss. BorgaveManali Deepak Mr.ShindeSurajDadasaheb Miss. Bhagwat MayuriDattatray.**The mineral admixture silica fume with 10% in concrete increases in compression resistance, ten-sile strength and bending stress. The investigation is made on M60 grade. Further Increase in silica fume decrease the strength. The workability decreases with increase in percentage of mineral admixtures

[2] **P. Vinayagam.** The mineral admixture silica fume used in 0%,2.5%,5%,7.5%,10%,12.5% and 15% in a mix of M60, M70 and M80. It is found that at replacement level 10%, the compression resistance, ten-sile strength and bending stress are maximum. Further increase in percentage of silica fume decreases the strength.

[3] **Venkatesh Babur and Krishnamurthy** (2005) studied that the silica fume concrete and cement replacement level of 10 percentage silica fume in concrete mixes showed a compressive strength of 61.28 Map at the age of 28 days and 81.5 MPa at the age of 90 days. When 15 percentage of silica fume used in concrete mixes, the compressive strength of concrete at 28 and 90 days decreased to a lower value.

[4] **S.K. Al-Oraimi*,** A.W. Hago, H.F. Hassan and R.Taha

.The cement is replaced by silica fume up to 30% which increases the compression resistance. Experimentally, observed that the compression resistance results, that the concrete which is prepared with mineral admixture like silica fume was less sensitive to air curing compared to the conventional concrete prepared without silica fume. In Experiment observe that the silica fume can be used up to range of 10-15% replacement of cement. Concrete with silica fume has a lower surface absorptive than concrete without silica fume.

[5] **T.Shanmugapriya ,Dr.R.N.Uma**,The silica fume is used in different percentage by 5%, 7.5%, 10% and 12.5% by weight of cement. It is observed that at 7.5% of replacement level. The compression resistance increases by 15% and ten-sile strength increases by 20% bending stress increases by 23%.Further increases in percentage of silica fume decreases the strength.

[6] **Krishnakumar S.1, Asif Abdul Vahab2, Akhil RajS.R.2, Jayasree S2 Job Thomas1** In this paper for M50 grade concrete the silica fume is used at 5%,7.5%,10% and 12.5 and test have been conducted to find its mechanical properties and resistance to chloride ion penetration. It is observed that cement replacement at 7.5% the compressive strength increases by 15.74%.Split tensile strength increases by 16.12%.Also it is found that addition of silica fume reduces the permeability and increases the durability of concrete

1.1 Materials

- Cement (OPC): Ultra tech cement 43 grade was used. Specific Gravity of Cement was 3.08.
- Coarse aggregate: - crushed granite metal with 60% passing 20 mm and retained on 12.5mm sieve and 40% passing 12.5mm and retained on 4.75mm sieve were used. The weight of coarse aggregate was 60% of the total aggregate and specific gravity of coarse aggregate was 2.70.
- Fine aggregate: - River sand from local sources was used as fine aggregate. Specific Gravity was 2.50.
- Water: Water used for both mixing and curing should be free from harmful amounts of harmful materials. In the present work drinkable tap water was mixed directly with concrete.
- silica fume: Silica fume is obtained from By-product from an Electric Arc Furnace used in manufacture of Silicon metal or Silicon alloy station was used in the investigation. The specific gravity is 2.3.
- Super plasticizer: To improve the workability of the mixes, a high range water reducing agent Fosrocconplast SP430 (SNF- Sulphonated Naphthalene Formaldehyde) is used.
- Steel fibers: Crimped steel fibres of 30mm length with a dia of 0.6mm and an aspect ratio of 50, density is 7840 Kg/m3 and specific gravity is 7.9 were used throughout the experimental program.
- Polypropylene fibers: RECRON 3S TYPE–CT 2012 polypropylene fibres of density 946 Kg/m3 are used in experimental program.

Figure: - 1 Specimens

2. METHODOLOGY

In this study the mixtures of silica fumein ratio of 0%, 10% and 20% was used in the concrete mix containing steel fiber of different dosage i.e. 0%, 0.5%, 0.75% and 1% and 0.25% polypropylene fiber constant was used for silica fume concrete mixes. An aggregate binder ratio of 2.5 and different water binder ratio viz 0.30, 0.35 and 0.40 with super plasticizer of 0.6% was used in this investigation. Each series consists prisms, cylinders and cubes as per IS standard. The tests are conducted to find out the flexural strength, split tensile strength and compressive strength at the age of 7 days and 28 days. The above said mixtures with silica fume containing composite fibers in different dosage with different water binder ratio were composed in this study. At the age 7 days and 28days of each mixture were tested and analysed in order to find out the best efficient mixture in following of strength characteristics of concrete mix.

Compressive Strength Test: Concrete cubes confirming to IS: 516-1964 of size 150x150x150 mm was cast for determination of compressive strength. After 24 hours the moulds were de moulded and subjected to water curing. Before testing, the cubes were air dried for 2 hours, crushing loads were noted and average compressive strength of 3 specimens is determined at 28 days.

Table-1: Compressive strength

Sl No	% of steel Fibre	% of ppf	Total % of composite fibres	Cube Compressive strength (MPa)		
				0% silica fume w/c Ratio		
				0.30	0.35	0.40
1	0	0	0	50.33	48.86	47.62
2	0.50	0.25	0.75	55.62	53.22	50.32
3	0.75	0.25	1.00	58.44	57.35	55.61
4	1.00	0.25	1.25	63.74	62.72	60.82

Table-2: Compressive strength

Sl No	% of steel fibre	% of ppf	Total % of composite fibres	Cube Compressive strength (MPa)		
				10% silica fume w/c Ratio		
				0.30	0.35	0.40
1	0	0	0	53.45	52.56	50.34
2	0.50	0.25	0.75	58.22	56.62	54.11
3	0.75	0.25	1.00	61.84	59.46	58.22
4	1.00	0.25	1.25	64.73	63.82	61.06

Table-3: Compressive strength

Sl No	% of steel fibre	% of ppf	Total % of composite fibres	Cube Compressive strength (MPa)		
				20% silica fume w/c Ratio		
				0.30	0.35	0.40
1	0	0	0	48.33	47.92	46.07
2	0.50	0.25	0.75	53.11	51.84	49.14
3	0.75	0.25	1.00	55.72	53.5	52.83
4	1.00	0.25	1.25	60.86	57.22	56.43

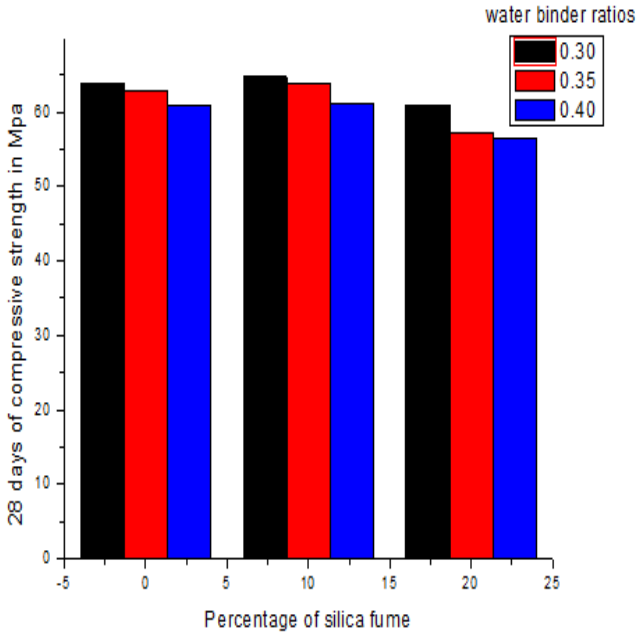

Chart -1: Variation of 28 days compressive strength with percentage of silica fume for different W/B ratio

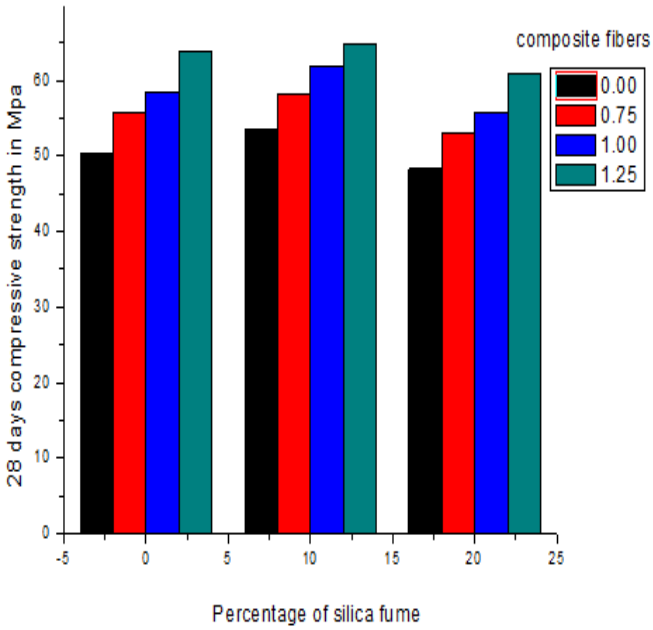

Chart -1: Variation of 28 days compressive strength on different percentage of silica fume for different percentage of composite fibers

It is observed that at 10% replacement of cement by silica fume compressive strength increases over 0% silica fume. Further increase in silica fume by 20% the compressive strength decrease over 0% silica fume. Hence the maximum replacement of cement by admixture silica fume is 10%. As W/B ratio increases the compressive strength decreases. It is observed that the 28 days compressive strength increases with increase in composite fibers.

Split tensile strength test: Tensile strength is one of the basic and important properties of concrete. Size of test sample of 15cm diameter, 30cm height and 0.3cm thick cylindrical mould is used. The cylinder is placed left and right between the two plates of the compressive testing machine and the load is applied. The load at which the sample in the end fails is noted and split tensile strength is calculated. The split tensile is calculated by using the formula.

Table-4: Split tensile strength

Sl No	% of steel Fibre	% of ppf	Total % of composite fibres	Split Tensile strength (MPa)		
				0% silica fume w/c Ratio		
				0.30	0.35	0.40
1	0	0	0	4.81	4.57	4.46
2	0.50	0.25	0.75	5.02	4.82	4.68
3	0.75	0.25	1.00	5.18	5.09	4.93
4	1.00	0.25	1.25	5.27	5.18	5.04

Table-5: Split tensile strength

Sl No	% of steel fibre	% of ppf	Total % of composite fibres	Split Tensile strength (MPa)		
				10% silica fume w/c Ratio		
				0.30	0.35	0.40
1	0	0	0	5.11	4.94	4.74
2	0.50	0.25	0.75	5.33	5.21	5.09
3	0.75	0.25	1.00	5.48	5.38	5.31
4	1.00	0.25	1.25	5.67	5.54	5.42

Table-6: Split tensile strength

Sl No	% of steel fibre	% of ppf	Total % of composite fibres	Split Tensile strength (MPa)		
				20% silica fume w/c Ratio		
				0.30	0.35	0.40
1	0	0	0	4.66	4.52	4.44
2	0.50	0.25	0.75	4.92	4.84	4.59
3	0.75	0.25	1.00	5.06	5.11	4.82
4	1.00	0.25	1.25	5.21	5.18	4.96

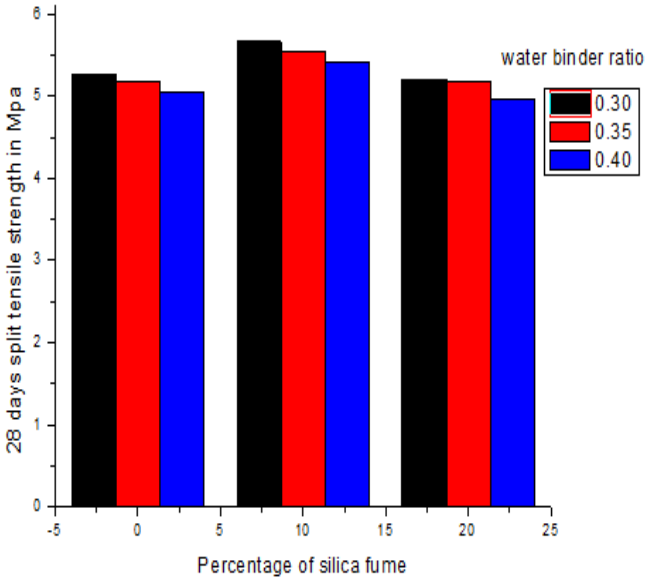

Chart -3: Variation of 28 days split tensile strength with percentage of silica fume for different W/B ratio

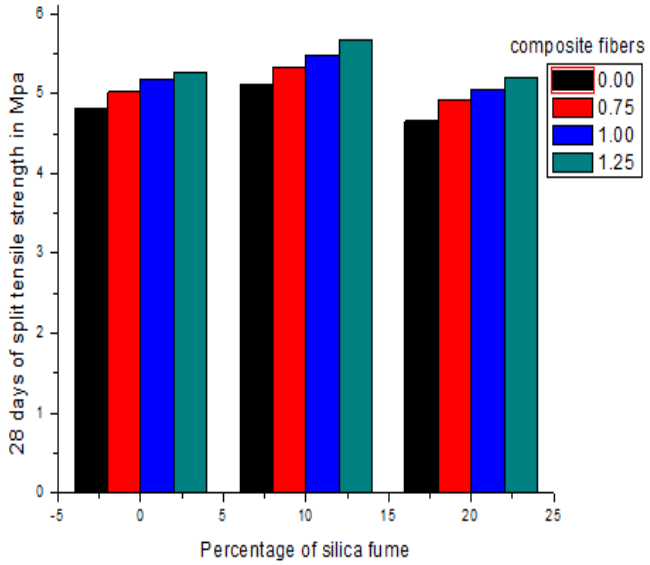

Chart -4: Variation of 28 days split tensile strength on different percentage of silica fume for different percentage of composite fibers

It is observed that at 10% replacement of cement by silica fume split tensile strength increases over 0% silica fume. Further increase in silica fume by 20% the split tensile strength decrease over 0% silica fume. Hence the maximum replacement of cement by admixture silica fume is 10%. As W/B ratio increases the split tensile strength decreases. It is observed that the 28 days split tensile strength increases with increase in composite fibers.

Flexural strength test: The prism is generally tested to identify the flexural behaviour of the hardened concrete. The test is carried in a universal testing machine of 60T load ability. Standard prism of size 10cm x 10cm x 50cm were tested under one point loading to study the flexural strength of concrete. The maximum tensile stress read at the failure of prism is called modulus of rupture and is calculated. The flexural strength is calculated by using formula.

Table-7: Flexural strength

Sl No	% of steel Fibre	% of ppf	Total % of composite fibres	flexural strength (MPa)		
				0% silica fume w/c Ratio		
				0.30	0.35	0.40
1	0	0	0	5.62	5.24	5.06
2	0.50	0.25	0.75	5.84	5.56	5.32
3	0.75	0.25	1.00	6.13	5.82	5.58
4	1.00	0.25	1.25	6.22	6.06	5.92

Table-8: Flexural strength

Sl No	% of steel Fibre	% of ppf	Total % of composite fibres	flexural strength (MPa) 10% silica fume w/c Ratio		
				0.30	0.35	0.40
1	0	0	0	5.88	5.61	5.42
2	0.50	0.25	0.75	6.12	5.94	5.66
3	0.75	0.25	1.00	6.26	6.22	5.96
4	1.00	0.25	1.25	6.48	6.34	6.24

Table-9: Flexural strength

Sl No	% of steel Fibre	% of ppf	Total % of composite fibres	flexural strength (MPa) 20% silica fume w/c Ratio		
				0.30	0.35	0.40
1	0	0	0	5.58	5.12	4.96
2	0.50	0.25	0.75	5.72	5.43	5.24
3	0.75	0.25	1.00	5.86	5.78	5.46
4	1.00	0.25	1.25	6.04	5.88	5.72

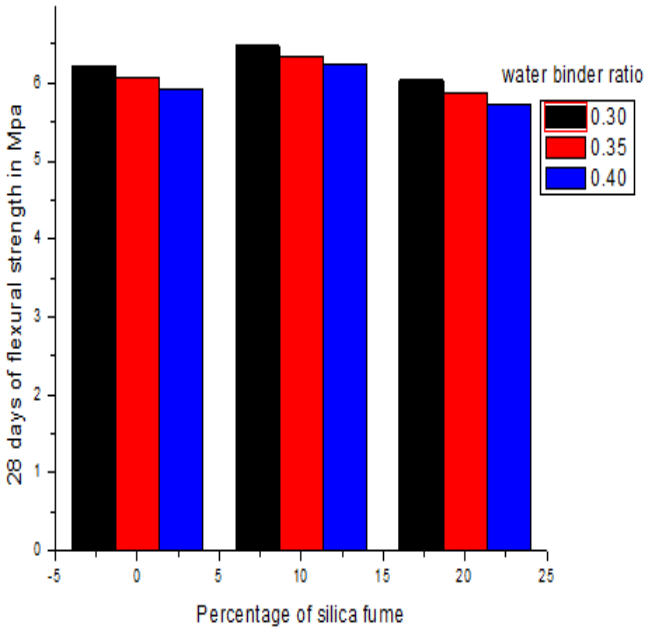

Chart -5: Variation of 28 days flexural strength with percentage of fly ash for different W/B ratio

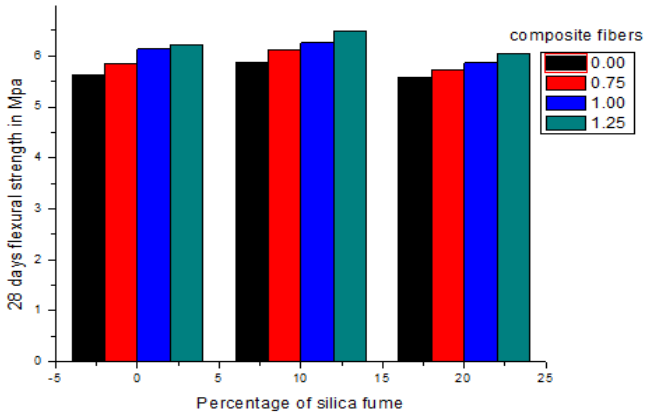

Chart -5: Variation of 28 days flexural strength on different percentage of fly ash for different percentage of composite fibers.

It is observed that at 10% replacement of cement by silica fume flexural strength increases over 0% silica fume . Further increase in silica fume by 20% the flexural strength decrease over 0% silica fume . Hence the maximum replacement of cement by admixture silica fume is 10%. As W/B ratio increases the flexural strength decreases. It is observed that the 28 days flexural strength increases with increase in composite fibers.

CONCLUSIONS

[1] 10% silica fume can be taken as Optimum dosage, which can be used as a partial replacement to cement for giving maximum possible compressive strength at any age for composite fibers (steel and polypropylene) reinforced high performance concrete.

[2] Addition of composite fibers (steel and polypropylene) improves the tension stiffening effect considerably and this increase the bond stress of reinforced bars in composite fiber reinforced concrete than in plane concrete.

[3] 1.25% composite fiber volume can be taken as the optimum dosage which can be used for giving maximum possible compressive strength at any age for steel fiber reinforced high performance concrete.

[4] Composite fibers increase the compressive strength of concrete and also resist the sudden collapse of the hardened concrete.

[5] From experimental results it has been observed that at 28days of 1.25% composite fiber (steel and polypropylene) volume with 10% silica fume concrete the increase in compressive strength is 28.61%, split tensile strength is 17.87% and flexural strength is 15.30% over plane concrete without fiber.

[6] From experimental results it has been observed that at 28days of 1.25% composite fiber (steel and polypropylene) volume with 20% silica fume concrete the decrease in compressive strength is 4.13%, split tensile strength is 3.21% and flexural strength is 0.91% over plane concrete without fiber.

[7] From experimental results, the optimum percentage recommended as 1.25% composite fiber volume with 10% silica fume for achieving maximum benefits in compressive strength, flexural strength and split tensile strength.

[8] Polypropylene fibers reduce the settlement, plastic, water permeability and shrinkage.

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[5]. American Journal of Engineering Research (AJER) e-ISSN : 2320-0847 p-ISSN : 2320-0936 Volume-2 pp-01-05 www.ajer.org. Effect of silica fume on the resistance to chloride ion penetration in high performance concrete Krishnakumar S.1, Asif Abdul Vahab2, Akhil RajS.R.2, Jayasree S2 Job Thomas1 1Division of Civil Engineering, School of Engineering, Cochin University of Science and Technology, Kochi-682022, Kerala, India 2Department of Civil Engineering, Mar Baselios College of Engineering And Technology, Mar IvaniosVidyanagar, Nalanchira P.O, Thiruvananthapuram,695015, Kerala, India

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