International Journal of Research in Engineering and Science (IJRES)
ISSN (Online): 2320-9364, ISSN (Print): 2320-9356
www.ijres.org Volume 10 Issue 5 ǁ 2022 ǁ PP. 01-08

Addition of Silica Fume in Polyester Fiber Reinforced Concrete

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Abstract
The compressive strength of concrete constructions is usually strong, but the tensile strength is low. Concrete qualities such as compressive strength, tensile strength, impact strength, and abrasion resistance are improved by using polyester fibre. Fibers support concrete in all directions because they are evenly dispersed throughout the matrix. It also eliminates the issue of rusting.. M30 is the concrete grade. By substituting 0 percent, 5%, 10%, and 15% of the cement weight with marble powder and adding 0 percent, 0.5 percent, 0.75 percent, and 1 percent of the concrete weight with polyester fibre, the compressive strength, split tensile strength, and flexural strength of concrete can be enhanced. In all concrete compositions, the water/cement ratio was kept at 0.45he compressive strength, split tensile strength, and flexural strength of the concrete mixtures were measured at 7, 14, and 28 days.

Keywords: *Polyester Fiber, Silica fume Powder, Compressive Strength, Split Tensile Strength, Flexural Strength*

Date of Submission: 08-05-2022 Date of acceptance: 23-05-2022

I. INTRODUCTION

Concrete has very low tensile strength and cause formation of cracks in stressed and unstressed states. It has low strain, brittle and has less ductility in nature. To modify these problems by using polyester fiber reinforced concrete. These fibers are randomly distributed fibers that need in Portland cement concrete reinforcement. Polyester in normal concrete improves the compressive and flexural strength of a concrete. It also improves the abrasion to resistance and resistance to alkaline condition. Silica fume is also known as micro silica or condensed silica fume. It is a material resulting from reduction of quartz with coal in an electric arc furnace in the manufacture of silicon or ferro-silicon alloy. Chemical composition of silica fume contains more than 90 percent silicon dioxide.

II. LITERATURE REVIEW

2.1 GENERAL

The journal published by several scholars around the world on polyester reinforced concrete with silica fume addition is described below.

2.2 REVIEW OF LITERATURE

Mebarkia.S Vipulanandan.C (1990)-This study investigates the influence of aggregates, polyster fibers and a coupling agent on the compressive and flexural (three-point and four-point bending) behavior of a polyester mortar. Particle size of fine aggregates (quartz and limestone) varied from 0.1 to 5 mm (0.004 to 0.2 inch) and the polyester fiber content was varied up to 6% by weight of mortar. A silane was introduced into the polyester mortar by pre-treating the aggregates and the polyster fibers. The mechanical properties of mortar were studied at room temperature. The test results indicate that the selection of aggregate type, size and distribution is very important. Silane treated aggregate systems showed more than 66% increase in compressive strength and 35% increase in flexural strength when compared to the untreated systems. Addition of polyster fibers enhances the strength and toughness of the polyester mortar, and silane treatment of polyster fibers helps to further enhance these properties. Flexural (three-point bending)-to-compressive strength ratio varied from 0.28 to 0.35 for unreinforced system and from 0.26 to 0.54 for the reinforced system. The mortar with only 14% polyester and 86% aggregates (by weight) and a coupling agent had a compressive strength of 103MPa (15,000 psi) which is 94% of the polyester polymer strength. A stress-strain relationship is proposed to represent the complete stress-strain response under compression and flexural loading. Also, a method is proposed to quantify the failure patterns.

Jain and Pawade (2015)- This reports on the physical properties of high quality silica seethe cements and their affectability to curing techniques were assessed and contrasted and reference Portland concrete cements, having either a similar solid substance as the silica smolder concrete or a similar water to cementitious materials ratio. The trial program involved six levels of silica-rage substance (as halfway substitution of bond by weight) at 0% (control blend), 5%, 10%, 15%, 20%, and 25%, with and without superplasticizer. It likewise included two blends with15% silica smolder added to bond in ordinary cement.

Amarkhail (2015)- This reports on Effects of Silica Fume on Properties of High Strength Concrete. He found that up to 10% bond might be supplanted by silica rage without hurting the solid workability. Concrete containing 10% silica seethe substitution accomplished the most noteworthy compressive quality took INTERNATIONAL JOURNAL OF INFORMATION AND COMPUTING SCIENCE Volume 5, Issue 4, April 2018 ISSN NO: 0972-1347 167 http://ijics.com/ 5 after by 15% silica rage supplanting with a little difference. Concrete with 15% silica rage content accomplished the most elevated flexural strength.10% and 15% silica smolder content as substitution of bond were observed to be the ideal sum for fundamentally upgrade of compressive quality and flexural quality individually.

Amudhavalli. N. K. Jeena Mathew (2012)-Silica fume is known in different names such as micro silica, silica dust, and condensed silica fume. When SF is used as an additive in cement concrete, a heat of hydration is observed resulting in the formation of pozzolanic material and calcium hydroxide. Due to large surface area silica fume gets densely packed in the paste of cement and aggregate reducing the wall effect in the transition zone between the paste and aggregate. Silica fume shows improvement in both strength and durability properties of concrete. The main physical effect of silica fume in concrete is that it act as a filler and because of its fineness, silica fume fit in to the space between the cement grains just as sand fill the space between particles of coarse aggregate or cement grains fill the space between the sand grains . Realizing the pozzolanic nature of the materials, this has been used successfully as an admixture in producing concrete. For the improvement of strength and durability of the concrete, the use of silica fume as a replacement of cement has been tried with success in concrete. The use of silica fume in concrete mix has engineering potential and economic advantage. The use of silica fume will not affect the weight of concrete. Silica fume will produce a much less permeable and high strength concrete.

Bobadilla-Sánchez1et al (2009)-In this paper the polyester fibers are subjected to gamma irradiation to study the mechanical behavior of concrete. The compressive strength decreases with higher dose of irradiation & percentage of polyester but, there are no details of behaviour of polyester fibers when reinforced in concrete subjected to elevated temperatures.

Chin et al. (1997)- Observed that when vinyl ester and polyester were exposed to water, salt water and cement pore water at temperatures 23°C, 60°C and 90°C there was not much change in the glass transition temperature but there was considerable change in their tensile strengths. The change in tensile strength of polyester resin was so much that they could not be tested after 10 weeks at 90°C as they were degraded.

III. METHODOLOGY

3.1GENERAL

This chapter proposes methodology for this investigation based on a survey of the literature.

3.2 METHODOLOGY

The work's technique begins with a review of the literature and the qualities of the materials, as well as previous work based on the gathering of books for review. Basic material tests, fresh/hard concrete specimen tests

Polyester Fiber: Polyester is a cutting-edge reinforcing material that is utilised in a number of applications such as automobile batteries, paper, filtration fabrics, asbestos cement sheets, cement-based pre-cast goods, and for increasing construction quality.

Silica fume, also known as micro silica, is an extremely fine pozzolanic substance made up of amorphous silica formed as a by-product of the manufacturing of elemental silicon or ferrosilicon alloys in electric arc.

IV. MATERIALS AND METHODS

4.1 GENERAL

This chapter covers the materials that will be used in the project.

4.2MATERIALS

In this study M30 concrete mix is prepared for 53 grade OPC. Cement, crushed natural stone as fine aggregate and coarse aggregate, silica fume, polyester fiber is used. Following tables shows the properties of materials**.**

4.1 Cement

The cement used in this study was ordinary Portland Cement (53 grade) with a specific gravity of 3.14. The trends of the experimental results showed no significant changes. As a result, common Portland cement of grade 53 was utilised in building.

Table 1. Properties of cement

SN.	Test	Result
1	Specific gravity	3.14
2	OPC grade of cement	53
3	Initial setting time (minutes)	32 mins
4	Final setting time (minutes)	594mins

4.3 Coarse Aggregate

Local quarries provided natural granite aggregate with a density of 1520 kg/m3 and a fineness modulus (FM) of 7.1. The aggregate passing through IS Sieve 20mm and retaining on IS Sieve 12.5mm was found to have a specific gravity of 2.71.

Table 2. Properties of coarse aggregate

SN.	Test	Result
1	Fineness	7%
2	Water absorption	0.5%
3	Specific Gravity	2.71

4.4 Fine Aggregate

Sand with a density of 1483 kg/m3 and a fineness modulus of 2.80 was used locally. The fine aggregate was determined to confirm to zone-II as per Is 383:1970, with a specific gravity of 2.67.

Table 3. Properties of fine aggregate

SN.	Test	Result
1	Specific gravity	2.67
2	Water absorption	2.6%
3	Fineness Modulus	2.80

4.5 Silica Fume Powder

Silica fume particles are exceedingly minute and form a greyish black powder with more than 95 percent of the particles finer than 1 m, with a specific area of roughly 20,000 cm2/g in this study. Silica fume has a specific gravity of 2.20. Silica fume's bulk density ranges from 130 to 430 kg/m3.

Table 5. Properties of silica fume

SN.	Test	Result
1	Specific gravity	2.2
2	colour	White colour
3	Mean grain size	0.15μm
4	Particle shape	spherical

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4.5 Polyester Fiber

Polyester is a type of polymer that has an ester functional group in its main chain. The polyester fibre used in this investigation has a length of 12mm, a specific gravity of 1.36, and a diameter of 36 microns. Polyesters include both naturally occurring compounds, such as those found in plant cuticles, and synthetics, such as polycarbonate, produced through stepgrowth polymerization. Natural polyesters and a few synthetic polyesters degrade naturally, but synthetic polyesters do not. Polyester can be thermoplastic or thermoset depending on its chemical structure; nevertheless, thermoplastic polyesters are the most frequent.

Table 4. Properties of polyester fiber

SN.	Test	Result
1	Fiber length	12mm
2	Diameter	36 micron
3	Young's modulus	4 Gpa
4	Specific gravity	1.36
5	Tensile strength	500 Mpa
6	Melting point	>250ºC
7	Aspect ratio	334

4.6 Mix Proportion

The design mix grade M30 according to IS 10262 was used in this study. In the concrete mix, the proportions of cement, fine aggregate, and coarse aggregate are 1: 1.49: 2.58 by volume, with a water cement ratio of 0.45.

Table-1: Mix proportion

W/C Ratio	Cement	Fine Aggregate	Coarse Aggregate
0.45	1	1.49	2.58

4.7 Casting and Curing

In 5 percent increments, silica fume powder was added to concrete (0 percent , 5 percent , 10 percent , 15 percent). In 0.5 percent increments, polyester fibre was added to concrete (0 percent , 0.5 percent , 0.75 percent , 1 percent). For each percent of Silica fume powder substituting Cement and addition of Polyester fibre, three cubes, three cylinders, and three prisms were cast for 7 and 28 days, respectively. The cube, cylinder, and beam were tested for final strength after 7 and 28 days of curing.

V. TEST PROCEDURE

5.1 Compression Test

On a compression testing apparatus with a capacity of 2000 kN, 150 x 150 x 150 mm cubes were cast and tested for compressive strength according to IS: 516-1959.

5.1.1 Procedure

The Compressive Strength Test is performed in the following order.

1. The size of the test specimen is determined by averaging perpendicular dimensions at least thrice.
2. Center the specimen on the compression testing equipment and apply a steady and uniform stress parallel to the tamping direction to the surface.
3. Increase the weight until the specimen breaks, then record the maximum load each specimen could handle throughout the test.The following is how compressive stress was calculated:

Compressive strength = $P/A \times 1000$

Where, P = Load in KN

A = Area of cube

5.2 Split Tensile Strength Test

Cylinders with a diameter of 150 mm and a length of 300 mm were cast and tested on a compression testing machine in accordance with IS: 5816-1999 for the splitting tensile strength test.

5.2.1 Procedure

The tensile strength test is carried out according to the steps below.

1. On both ends of the specimen, draw diametrical lines in the same axial plane.

2. To get the diameter to the nearest 0.2 mm, average the diameters of the specimen lying in the plane of pre-marked lines measured near the ends and the centre of the specimen. The length of the specimen must also be taken to be within 0.2 mm by averaging the two lengths measured in the plane incorporating pre-marked lines.
3. Place one of the plywood strips in the middle of the lower platen. Place the specimen on the plywood strip and align the lines on the specimen's end so that they are vertical and in the middle.
4. Center the second plywood strip on the lines drawn on the cylinder ends.
5. The split tensile strength was calculated as follows:

Split tensile strength = $2P/\pi dL$ x 1000
Where, P = Load in KN = 3.142
d = Diameter of cylinder
L = Length of cylinder

5.3 Flexural Strength Test
100 x 100 x 500 mm beams were cast and tested on a 400 mm effective span with two point loading according to IS: 516- 1959 for the flexural strength test.
5.3.1 Procedure
The flexural strength test is carried out according to the steps below.
1. Use a brush to clean the beam. Place the beam on its side in the breaking machine, away from the moulded position.
2. Align the bearing plates squarely with the beam and use the machine's guide plates to adjust the distance.
3. Place a strip of leather or similar material under the upper bearing plate to assist spread the load.
4. To bring the jack's plunger into contact with the ball on the bearing bar, turn the screw in the plunger's end.
5. Set the dial gauge needle to "0" once contact has been made and only forceful finger pressure has been applied. We'll apply two point loading to the beam specimen and continue until it breaks.. 6. The flexural strength was calculated as follows:

Flexural strength = PL/bd2 x 1000
Where, P = Load in KN
L = Effective length of prism
b = Width of the prism
d = Depth of the prism

VI. RESULT AND DISCUSSION

6.1 Compressive Strength Test
To study the polyester fiber addition of silica fume reinforced concrete, cubical specimen were casted and tested this results obtained for specimen test compressive strength for 7 & 28 days were reported in the table.
Optimum compressive strength was obtained when the fiber addition is at 0.5%.

Table 6.1 Compressive Strength Test Result

S.No	Polyester fiber (%)	Silica fume (%)	Compressive Strength (N/mm^2)	
			7 Days	28 Days
M1	0	0	21.04	35.07
M2	0.5	5	26.52	38.52
M3	0.75	10	25.18	33.78
M4	1	15	23.26	34.27

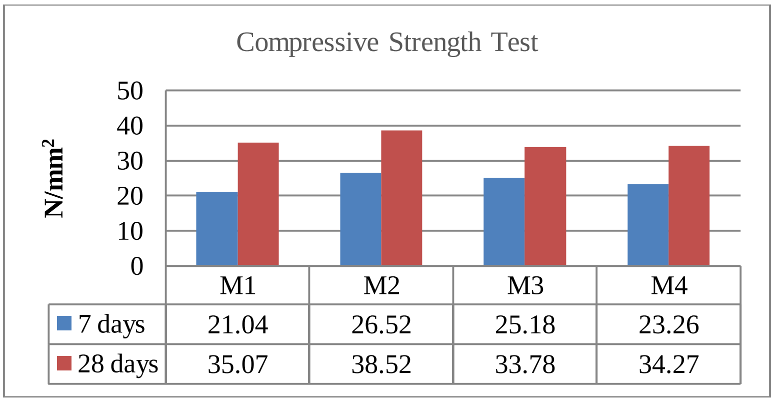

Chart 6.1 Compressive Strength Test Result

6.2 Split Tensile Strength Test

To study the polyester fiber addition of silica fume reinforced concrete, cylinder specimen were casted and tested this results obtained for specimen test split tensile strength for 7 & 28 days were reported in the table. Optimum split tensile strength was obtained when the fiber addition is at 0.75%.

Table 6.2 Split Tensile Strength Test Result

S.No	Polyester Fiber (%)	Silica fume (%)	Split Tensile Strength (N/mm^2)	
			7 Days	28 Days
M1	0	0	2.48	3.03
M2	0.5	5	2.64	3.36
M3	0.75	10	3.04	3.42
M4	1	15	2.99	3.34

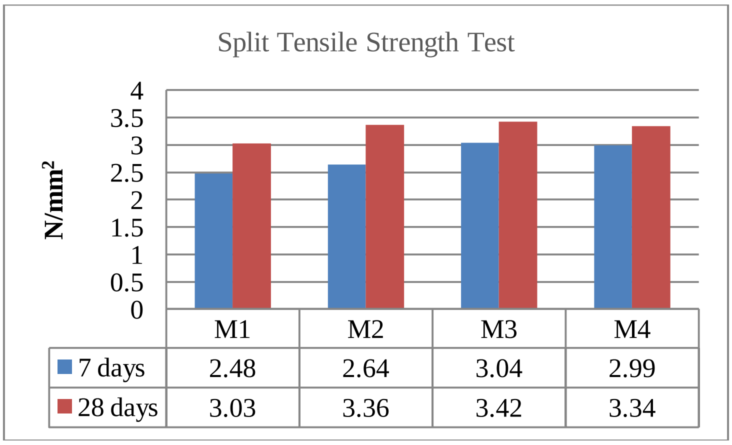

Chart 6.2 Split Tensile Strength Test Result

6.3 Flexural Strength Test

To study the polyester fiber addition of silica fume reinforced concrete, prism specimen were casted and tested this results obtained for specimen test flexural strength for 7 & 28 days were reported in the table. Optimum flexural strength was obtained when the fiber addition is at 0.5%

Table 6.3 Flexural Strength Test Result

S.No	Polyester Fiber (%)	Silica fume (%)	Flexural Strength (N/mm^2)	
			7 Days	28 Days
M1	0	0	3.92	4.66
M2	0.5	5	4.90	5.58
M3	0.75	10	4.71	5.25
M4	1	15	4.51	5.14

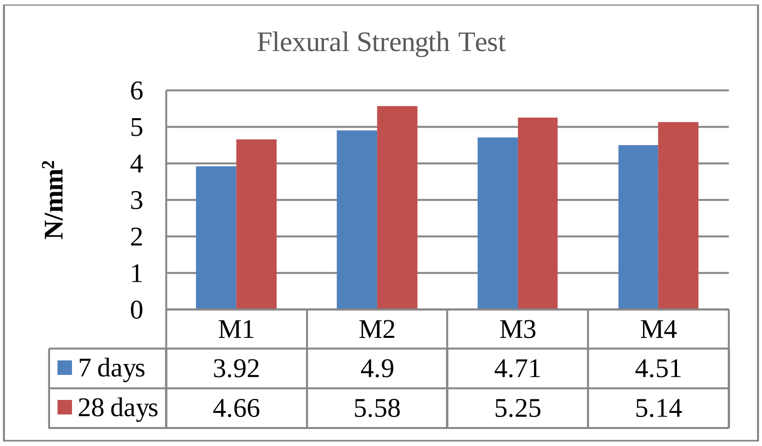

Chart 6.3 Flexural Strength Test Result

6.4 Test on Structural Specimen Beam

The compressive strength and split tensile strength of the beam were increased due to the substitution of Silica fume powder with cement and the inclusion of Polyester fibre. Table 6.4 shows the load deflection data for the concrete beam. Ultimate Load = 57 kN

Table 6.4 Result on Structural Specimen Testing for M2 at 28 Days

S.NO	LOAD (kN)	DEFLECTION (mm)
1	0	0
2	3	0.56
3	6	1.23
4	9	2.61
5	12	3.28
6	15	4.24
7	18	5.62
8	21	6.18
9	24	8.14
10	24	7.82
11	27	8.44
12	30	9.56
13	33	10.28
14	36	11.63
15	39	12.26
16	42	13.75
17	45	14.92
18	48	15.16
19	51	16.83
20	54	17.05
21	57	18.16

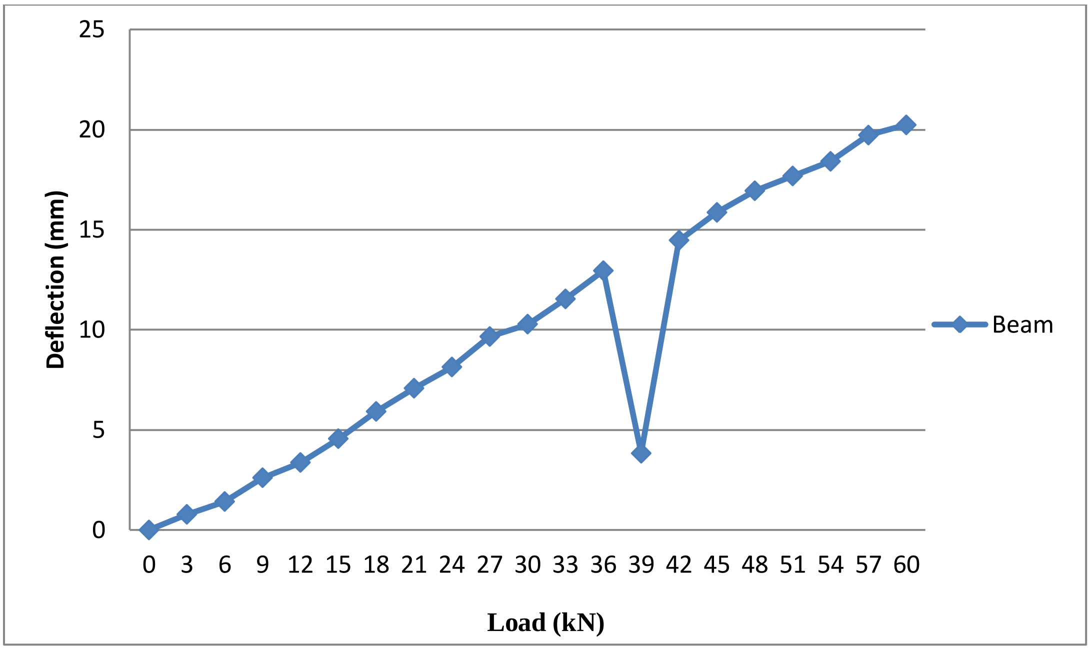

Chart 6.3 Structural Specimen M2 at 28 Days

VII.CONCLUSION

The compressive strength of the specimen tested, when polyester fibre was added at 0 percent, 0.5 percent, 0.75 percent, 1 percent, and silica fume was added at 0 percent, 5 percent, 10 percent, and 15 percent. The compressive strength of a mix containing 0.5 percent was raised after 28 days. When compared to the other mix. Optimum compressive strength was obtained when the fiber addition is at 0.5%.

The split tensile strength of the specimen tested , when polyester fibre was added at 0 percent, 0.5 percent, 0.75 percent, 1 percent, and silica fume was added at 0 percent, 5 percent, 10 percent, and 15 percent. At 28 days, the split tensile strength of a mix containing 0.75 percent was increased. When compared to the other mix. Optimum split tensile strength was obtained when the fiber addition is at 0.75%.

The inclusion of polyester fibre at 0 percent, 0.5 percent, 0.75 percent, 1 percent, and silica fume at 0 percent, 5 percent, 10 percent, and 15 percent increased the flexural strength of the specimen tested. The flexural strength of a mix containing 0.5 percent was raised after 28 days. When compared to the other mix. Optimum flexural strength was obtained when the fiber addition is at 0.5%

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