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A Research on Effects of Polyester Fiber for Strengthening of Self Compacting Concrete

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Abstract
Self-Compacting Concrete (SCC) has the ability to flow under its own weight and completely fill the formwork, despite the presence of reinforcements, without compaction and while keeping the concrete's homogeneity. The use of SCC will eliminate the difficulties of compacting while casting and reduce the amount of personnel required. Concrete's tensile behavior will be improved by adding fibers. Polyester Fiber Reinforced Self Compacting Concrete was created by combining SCC with relatively discrete, short, and irregular polyester fibers (PFRSCC). In varied percentages, polyester fibers with a length of 12mm are added to the self-compacting mix. 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 fiber. Fibers evenly distributed throughout the matrix provide support to concrete in all directions. It also eliminates the issue of rusting. The primary goal of this investigation is to look at the workability and mechanical qualities of plain SCC and PFRSCC.
Keywords: *Self Compacting Concrete, Polyester Fiber, Workability, Concrete, Strength.*

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I. INTRODUCTION

Self-Compacting Concrete (SCC), which flows under its own weight and does not require external vibration for compaction, has revolutionised concrete placement. SCC is a highly workable concrete that can flow over confined areas under its own weight without segregation or bleeding. Such concrete should have a low yield value to ensure high flow ability, a moderate viscosity to resist segregation and bleeding, and maintain homogeneity during shipping, placement, and curing to achieve acceptable structural performance and long-term durability. Plane concrete has low tensile strength and easily splits under stressed and unstressed conditions. It is brittle, ductile, and has a low strain rate. Polyester fibre reinforced concrete was used to address these issues. These are randomly distributed fibres that must be reinforced in Portland cement concrete. Polyester increases the compressive and flexural strength of conventional concrete. It also increases abrasion resistance and resistance to alkaline conditions. This research presents a method for producing self-compacting concrete that was developed specifically for this purpose..

II. LITERATURE REVIEW

2.1 GENERAL

In recent years, several studies on self-compacting concrete and silica fume have been conducted. Various researchers' work has been studied and discussed below.

2.2 REVIEW OF LITERATURE

Heba et al. (2011) presented an experimental investigation on SCC with two cement concentrations, involving three types of mixes: the first used various percentages of fly ash, the second used various percentages of silica fumes, and the third utilized combinations of fly ash and silica fume. The higher the percentages of fly ash in the concrete, the higher the values of concrete compressive strength till 30% FA, although the higher values of concrete compressive strength are produced from mixes containing 15% FA.

Miao (2010) The development of an SCC with up to 80% cement substitution in all combinations, as well as its fresh qualities, was investigated. The findings show that fly ash acts as a lubricant; it does not react with the super plasticizer and produces a repulsive force, whereas the super plasticizer may only act on the cement. As a result, the more fly ash there is, the less super plasticizer is required.

E. A. Bobadilla-Sánchez1et al., (2009). Gamma irradiation of polyester fibres is used in this paper to investigate the mechanical behaviour of concrete. The compressive strength of polyester fibres decreases as the irradiation dose and percentage of polyester increase, but there is no information on how they behave when reinforced in concrete at high temperatures.The inclusion of glass fibers to the concrete mixture improves the compressive strength marginally after 28 days.

Khatib (2008) investigated the properties of fly ash-added self-compacting concrete (FA). FA was used as a Portland Cement replacement (PC). PC was replaced to the tune of 0-80% by fly ash. In all of the mixtures, the water binder ratio was kept constant at 0.36. This study looked into the material's workability, shrinkage, absorption, and ultrasonic pulse velocity. According to the findings, replacing 40% of the FA resulted in a strength of more than 65 N/mm2 after 56 days. Significant absorption values were obtained

Chin et al. (1997) When vinyl ester and polyester were exposed to water, salt water, and cement pore water at temperatures of 23°C, 60°C, and 90°C, the glass transition temperature changed little, but their tensile strengths changed significantly. Polyester resins' tensile strength changed so much that they couldn't be evaluated after 10 weeks at 90°C because they were damaged.

III. METHODOLOGY

3.1 METHODOLOGY

The methodology of the work begins with a review of the literature and the materials' qualities, as well as previous work based on the gathering of literature for review. Fundamental material tests, as well as fresh/hard concrete specimen tests A thorough investigation was carried out, and the results can be found in the current work's references section. The influence of polyester fibre improves bonding with crowded reinforcement and improves the mechanical and durability properties of self-compacting concrete., This study looked at the effect of polyester fibres in different volume fractions with varying percentages on the compressive strength, split tensile strength, and flexural strength of concrete. Standard sizes of cubes, cylinders, and prisms were cast and tested for compressive strength, flexural strength, and split tensile strength for each mix.

IV. MATERIAL AND METHODS

4.2 Cement

Cement is used as a binding material. In this study, ordinary Portland Cement, Grade 53, is used. Physical cement parameters include specific gravity, consistency, fineness modulus, and initial and final setting times.

Table 1. Properties of cement

SN.	Test	Result
1	Specific gravity	3.15
2	Normal Consistency	34%
3	Initial setting time (minutes)	34 mins
4	Final setting time (minutes)	598mins
5	Fineness modulus	5%

4.3 Coarse Aggregate

The coarse material in the current study is passed through a 20mm IS sieve and retained on a 12mm IS sieve. Special care is taken when selecting coarse aggregate to ensure that it is free of contaminants. Tests are used to determine the properties of coarse aggregate.

Table 2. Properties of coarse aggregate

SN.	Test	Result
1	Fineness	6.4%
2	Water absorption	0.5%
3	Specific Gravity	2.95

4.4 Fine Aggregate

The fine aggregate used in this experiment is locally available sand that has been thoroughly cleaned to remove contaminants and waste stones. The sand used is in accordance with IS: 383-1970 specifications. Fine aggregate is subjected to characteristic tests, and its properties are listed in the table below.

Table 3. Properties of fine aggregate

SN.	Test	Result
1	Specific gravity	2.9
2	Water absorption	1.6%
3	Fineness Modulus	2.83

4.5 Polyester Fiber

Polyester is a popular synthetic material. Polyester is a long-chain synthetic polymer that contains an ester. The physical properties of polyester fibre are critical. The fibre length used in this study is 12mm, the specific gravity is 1.36, and the diameter of the polyester fibre is 36 micron.

Table 4. Properties of polyester fiber

SN.	Test	Result
1	Fiber length	40mm
2	Effective Diameter	0.87mm
3	Young's modulus	11.3 kN/mm^2
4	Specific gravity	1.35
5	Tensile strength	680 Mpa
6	Melting point	253ºC
7	Aspect ratio	334

4.6 Mix Proportion

M30 grade of design mix according to IS 10262 was utilized in this research. The cement, fine aggregate, and coarse aggregate proportions in the concrete mix are 1: 2.05 : 3.49 by volume, with a water cement ratio of 0.45.

Table-1: Mix proportion

W/C Ratio	Cement	Fine Aggregate	Coarse Aggregate
0.40	1	2.85	2.25

4.7 Casting and Curing

Steel moulds are used to cast all concrete samples. Before casting, they were cleaned and oiled. The fresh concrete was compacted and placed inside the moulds in three equal layers. When a liquid material is poured into a mould with a hollow cavity of the desired shape and allowed to solidify. Mixes were kept separate as much as possible. The dimensions of the cubes are 150 x 150 x 150 mm, and a cylinder with a diameter of 150 mm and a height of 300 mm was casted. The specimen was left in the mould for more than 24 hours before being de-moulded. The de-moulded specimens are collected for curing.

Before being tested, cubes can be cured. After a 24-hour period, all of the specimens are de-moulded and allowed to cure. Ample space should be provided between the cubes and between the cubes and the sides of the curing tank to allow for adequate water circulation.

V. TEST PROCEDURE

5.1 Slump Cone Test

Initially, the base plate and the inside of the slump cone were moistened. The base plate was then placed on level, stable ground, and the slump cone was firmly secured in the centre of the base plate. After that, the cone was filled with concrete. There was no tamping. Any excess concrete around the cone's base was removed. Following that, the cone was raised vertically, allowing the concrete to flow freely.

The diameter of the concrete was measured in two perpendicular directions. The average of the two diameters measured was computed. This was measured as the slump flow in millimetres.

5.2 Compression Test

Cubes of 150 x 150 x 150 mm were cast and tested for compressive strength according to IS: 516-1959 on a compression testing equipment with a capacity of 2000 kN.

5.1.1 Procedure

The Compressive Strength Test is carried out according to the steps below.

1. Averaging perpendicular dimensions at least twice determines the size of the test specimen.
2. Center the specimen on the compression testing machine, and apply a constant and uniform load to the surface perpendicular to the tamping direction.
3. Increase the weight until the specimen fails, then record the highest load handled by each specimen during the test.

The following is how compressive stress was calculated:

Compressive strength = P/A x 1000

Where, P = Load in KN

A = Area of cube

5.3 Split Tensile Strength Test

For the splitting 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.

5.3.1 Procedure

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

1. Draw diametrical lines in the same axial plane on the two ends of the specimen.
2. Averaging the diameters of the specimen lying in the plane of pre-marked lines measured near the ends and the middle of the specimen will give you the diameter to the nearest 0.2 mm. By averaging the two lengths measured in the plane including pre-marked lines, the length of the specimen must also be taken to be within 0.2 mm.
3. Center one of the plywood strips in the lower platen's centre. Place the specimen on the plywood strip and orient it so that the lines on the specimen's end are vertical and centred.
4. The second plywood strip is centred on the lines marked on the cylinder's ends and placed lengthwise on the cylinder.
5. Apply the load without shock and gradually raise it until no further load can be sustained, resulting in a split tensile stress of roughly 1.4 to 2.1 N/mm2/min. Note the maximum load on the specimen. 6. The split tensile strength was calculated as follows:

Split tensile strength = 2P/πdL x 1000

Where, P = Load in KN = 3.142

d = Diameter of cylinder

L = Length of cylinder

5.4 Flexural Strength Test

For the 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.

5.4.1 Procedure

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

1. Clean the beam with a brush. Place the beam in the breaking machine on its side, facing away from the moulded position.
2. Align the bearing plates squarely with the beam and adjust the distance using the machine's guide plates.
3. To help distribute the load, place a strip of leather or similar material under the upper bearing plate.
4. Turn the screw in the plunger's end to bring the jack's plunger into contact with the ball on the bearing bar.
5. Once contact has been made and only strong finger pressure has been applied, set the dial gauge needle to "0." We're going to apply two point loading to the beam specimen, and we're going to keep going 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

5.5 L - Box Test

The L-box test apparatus, which consists of three smooth bars of 12 mm diameter with a gap of 41 mm, was placed on levelled firm ground to ensure that the sliding gate can be opened and closed freely. The inside of the apparatus had been moistened. The vertical section of the apparatus was filled with concrete and rested for 1 minute. The sliding gate was then raised, allowing the concrete to flow out into the horizontal section. The distances 'H1' and 'H2' were measured when the concrete stopped flowing. The blocking ratio was 'H2/H1.' The entire test took 5 minutes to complete.

5.6 V-Funnel Test

The V-funnel apparatus was firmly placed on a level surface and its inside surface was moistened. The 'trap door' was shut and a bucket was placed beneath it. Without compacting or tamping, the apparatus was completely filled with concrete. After 10 seconds of filling concrete, the trap door was opened and the concrete was allowed to drain naturally.

When the trap door was opened, a stopwatch was started, and the time it took for the discharge to complete was recorded. This was taken when light was seen shining through the funnel from above. The entire test took 5 minutes to complete.

VI. RESULT AND DISCUSSION

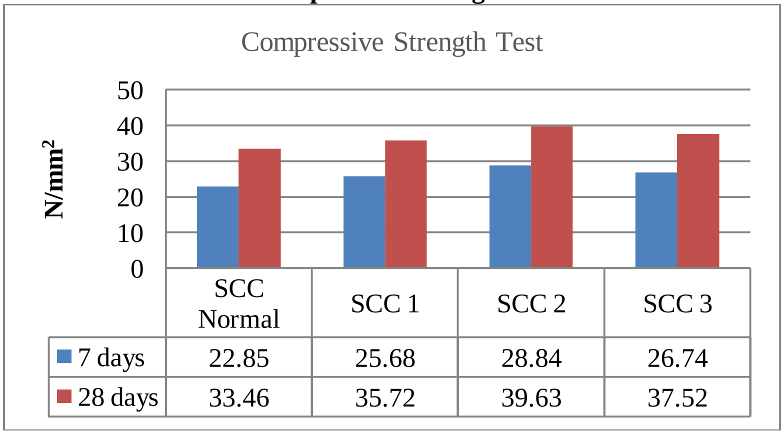
6.1 Compressive Strength Test

To investigate the use of polyester fiber for the strengthening of self compacting concrete, cube specimens were cast and tested. The results of the specimen test Compressive Strength for 7 and 28 days were reported in the table.

Table 6.1 Compressive Strength Test Result

S.No	Polyester Fiber (%)	Compressive Strength (N/mm^2)	
		7 Days	28 Days
SCC Normal	0	22.85	33.46
SCC 1	0.5	25.68	35.72
SCC 2	1	28.84	39.63
SCC 3	1.5	26.74	37.52

Chart 6.1 Compressive Strength Test Result



6.2 Split Tensile Strength Test

To investigate the use of polyester fiber for the strengthening of self compacting concrete, cylinder specimens were cast and tested. The results of the specimen test split tensile strength for 7 and 28 days were reported in the table.

Table 6.2 Split Tensile Strength Test Result

S.No	Polyester Fiber (%)	Split Tensile Strength (N/mm^2)	
		7 Days	28 Days
SCC Normal	0	1.5	4.15
SCC 1	0.5	1.6	6.48
SCC 2	1	2.05	7.18
SCC 3	1.5	1.9	6.95

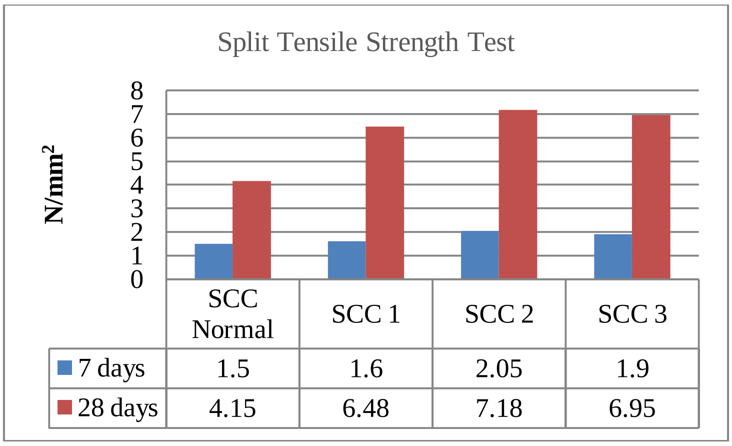


Chart 6.2 Split Tensile Strength Test Result

6.3 Flexural Strength Test

To investigate the use of polyester fiber for the strengthening of self compacting concrete, prism specimens were cast and tested. The results of the specimen test flexural strength for 7 and 28 days were reported in the table.

Table 6.3 Flexural Strength Test Result

S.No	Polyester Fiber (%)	Flexural Strength (N/mm^2)	
		7 Days	28 Days
SCC Normal	0	3.1	4.58
SCC 1	0.5	4.41	6.45
SCC 2	1	5	7.20
SCC 3	1.5	4.71	6.94

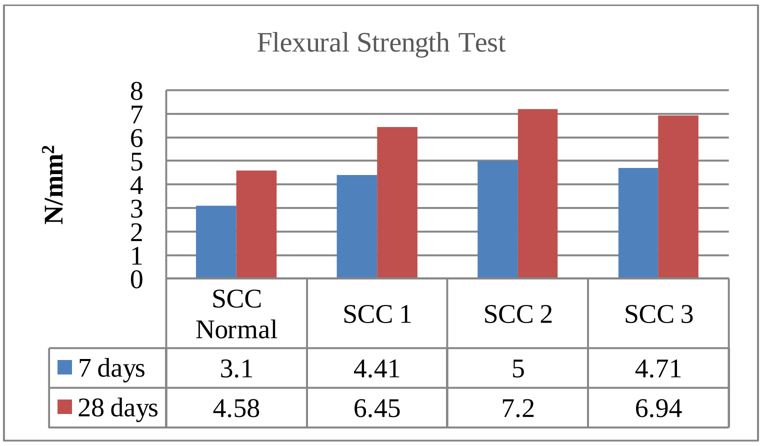


Chart 6.3 Flexural Strength Test Result

6.4 Test on Structural Specimen Beam

To investigate the use of polyester fiber for the strengthening of self compacting concrete, beam specimens were cast and tested. The results of the specimen test for 7 and 28 days were reported in the table. The load deflection data of the concrete beam is shown in the Table 6.4 Ultimate Load = 50 kN

Table 6.4 Result on Structural Specimen Testing for SCC 2 at 28 Days

S.NO	LOAD (kN)	DEFLECTION (mm)
1	0	0
2	2.5	0.78
3	5	1.44

4	7.5	2.64
5	10	3.30
6	12.5	4.58
7	15	5.97
8	17.5	7.00
9	20	8.10
10	22.5	9.64
11	25	10.25
12	27.5	11.59
13	30	12.98
14	32.5	3.85
15	35	14.23
16	37.5	15.45
17	40	16.68
18	42.5	17.41
19	45	18.72
20	47.5	19.23
21	50	20.98

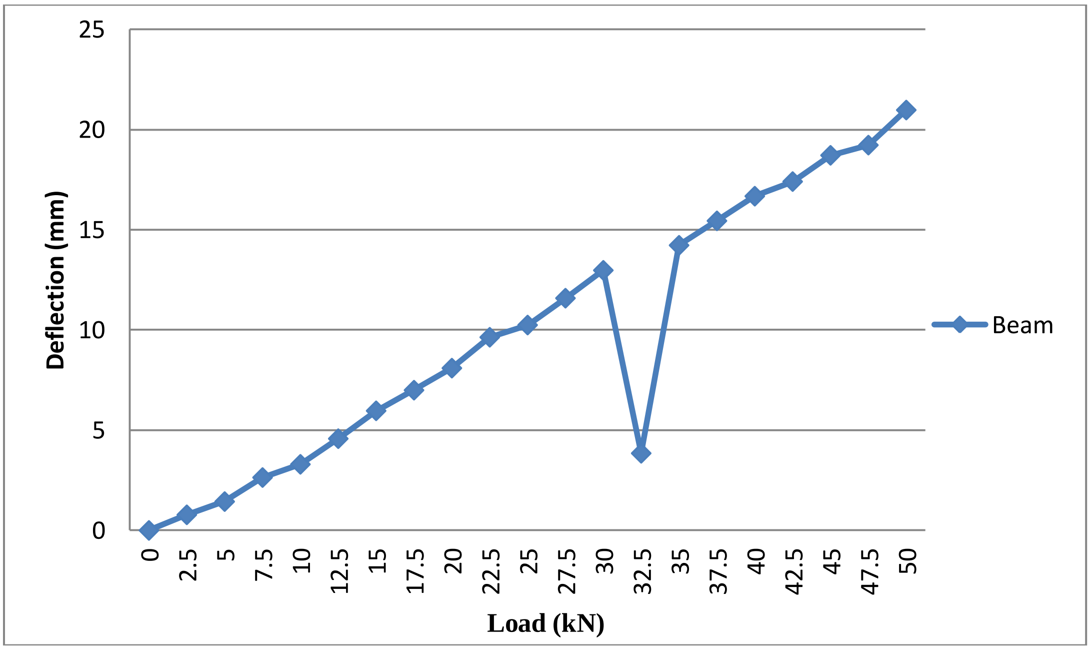


Chart 6.4 Structural Specimen M3 at 28 Days

VII.CONCLUSION

- When compared to conventional concrete, the addition of fibre content increases compressive strength, split tensile strength, flexural strength, and modulus of elasticity. By replacing cement with polyester dosage, the cement content in concrete is reduced.
- The slump value decreases as the percentage of polypropylene fibre increases.
- Polyester fibre can be used in conjunction with admixtures, plasticizers, and super plasticizers to increase the strength of concrete by partially replacing cement.
- It has been discovered that the workability of polyester fibre concrete decreases as the percentage of polyester fibre replaced increases.
- Optimum flexural strength was obtained when the fiber addition is at SCC2, When compared to the other mix.

- Optimum split tensile strength was obtained when the fiber addition is at SCC2, When compared to the other mix.
- Optimum compressive strength was obtained when the fiber addition is at SCC2, When compared to the other mix.

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