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Compressive and Split Tensile Strength Characteristics of Silica Fume Modified Fiber Reinforced Concrete

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ABSTRACT
The Cement mainly consumes approximately 10 -15 % of total industrial energy. This energy releases carbon dioxide co_2 emission to atmosphere as a result of burning fuels to produce energy needed for cement manufacturing process. The study project deals with the mechanical properties of concrete specimens as per mix design. The compressive strength, split tensile strength of concrete are calculated for 7, 14 and 28 days age with replacement of chemical admixtures with respect to the cement by weight. The project deals with different percentages of replacement of silica fumes so as 0, 5, 10 and 15 and polypropylene fibers of 0, 0.4, 0.8, 1 and 1.2. Comparison of results and discussion parameters of project and pros and cons of the experiment are determined. It states the safety usage and limitations of use of chemical admixtures up to an extent. Polypropylene fibers can increases the strength of a building by reducing internal cracking in beams and column sections. it is important to reduce the crack width and this can be achieved by adding polypropylene fibers to concrete. The bridging of cracks by the addition of polypropylene fibers to other materials.Fibre reinforced concrete is a concrete containing the fiberous material which can increases its structural integrity. In this project using fiber materials is initiated to control cracks. There are different types of structures where the concrete is the only solution. The project deals with designing the M40 grade concrete by replacing and addition of some admixtures like silica fumes and polypropylene fiber. My project specifies the strength characteristics and the maintenance of lifelong strength of concrete. The project explains how to overcome the problems of cracking in concrete and maintain stability for a lifetime period and not to harm the environment with a non-degradable waste from the industries. In future research the increase in polypropylene fibre content can increases the compressive strength results upto a maximum of 2 to 3 % addition in concrete. Polypropylene fiber reinforced concrete can increases strength for columns and slabs and controls the emission of waste gases entering into the buildings.

Keywords – Admixtures , Internal Cracking, M40 grade, , Polypropylene fibre, Silica fume.

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I. INTRODUCTION

The High-strength concrete has a compressive strength greater than 40 MPa. defines High strength concrete as concrete with a compressive strength greater than 40 MPa and below 60 MPa. High-strength concrete is made by lowering the water-cement (W/C) ratio to 0.38 or lower. Often silica fume is added to prevent the formation of free calcium hydroxide crystals in the cement matrix, which might reduce the strength at the cement-aggregate bond. Low W/C ratios and the use of silica fume make concrete mixes significantly less workable, which is particularly likely to be problem in high-strength concrete.

Addition of polypropylene fibers decreases the unit weight of concrete and increases its strength. Several fibre materials in various sizes and shapes have been developed for use in FRC. Among these fibers, the polypropylene has been one of the most successful commercial applications. The common forms of these fibers are smooth-monofilament and have triangular shape. Polypropylene fibers have some unique properties that make them suitable for reinforcement in concrete. The fibers have a low density, are chemically inert and non corrosive.

II. LITERATURE REVIEWS.

Slamet Widodo state that , This research conducted to evaluate the effects of polypropylene fiber addition on fresh state characteristics of Self-Consolidating Concrete (SCC)mixes, and investigate the effects of polypropylene fiber on some hardened properties of SCC. In this research, concrete mixes were added with polypropylene fiber of 0%, 0.05%,0.10%, and 0.15% volume fraction. Tests results indicate that polypropylene fibers tend to reduce the flow ability and passing ability but will increase viscosity and segregation resistance of SCC. Furthermore, it can be concluded that polypropylene fiber reduce deformability of SCC in the fresh state. After 28 days of curing, concrete specimens' tests indicate that polypropylene fiber addition up to 0.10% of volume fraction tend to improve the compressive strength, tensile strength, and impact resistance of hardened SCC. It also can be suggested that polypropylene fibers allowed to be added into SCC mixes up to 0.10% by volume of concrete

Roohollah Bagherzadeh, Abdol Hossein The influence of polypropylene fibers has been studied in different proportioning and fiber length to improve the performance characteristics of the lightweight cement composites. Fibers used in two different lengths (6mm and12mm) and fiber proportions (0.15% and 0.35%) by cement weight in the mixture design. Compared to unreinforced LWC, polypropylene (PP) reinforced Lightweight Cement Composites (LWC) with fiber proportioning 0.35% and 12mm fiber length, caused 30.1% increase in the flexural strength and 27% increase in the splitting tensile strength.

VahidAfroughsabet, TogayOzbakkaloglu This study investigates the effect of the addition of steel and polypropylene fibers on the mechanical properties of high-strength concrete (HSC). Hooked-end steel fibers with a 60-mm length were used at four different fiber volume fractions of 0.25%, 0.50%, 0.75%, and 1.0%. Polypropylene fibers with a 12-mm length were used at the content of 0.15%, 0.30%, and 0.45%. Some mixtures were produced with the combination of steel and polypropylene fibers at a total fiber volume fraction of 1.0% by volume of concrete, in order to study the effect of fiber hybridization. All the fiber-reinforced concretes contained 10% silica fume as a cement replacement. The compressive strength, splitting tensile strength, flexural strength, electrical resistivity, and water absorption of the concrete mixes were examined. Results of the experimental study indicate that addition of silica fume improves both mechanical and durability properties of plain concrete.

M Toutanji, S McNeil, Z Bayasi (1998) They conducted experiments on permeability and impact resistance of polypropylene fiber-reinforced concrete mixtures containing silica fume. They considered two fiber lengths 12.5 and 19mm with four volume fractions 0.1%, 0.3%, 0.5% and silica fume was used as a replacement by cement with 5% and 10% are used. They found that the adding of polypropylene fiber increases the permeability of conventional concrete of silica fume improved fiber dispersion in the cementitious matrix.

III. EXPERIMENTAL INVESTIGATION

In the present experimental investigation silica fume has been used as partial replacement of cement. The effect of adding different percentages of silica fume as additional material along with Recron 3s fibers to concrete mixes and their compressive strength is studied. To reduce the setting time we have used Conplast SP430 super plasticizer. A series of laboratory tests was conducted on polypropylene fibre reinforced concrete. Significant engineering properties such as compressive strength, spilt tensile strength of concrete were determined. The specimens were removed from the mould after 24hours and then cured under water for a period of 7, 14, and 28 days. The tests were conducted as per the relevant Indian Standard specifications (IS Code).

IV. TEST MATERIALS

1. Cement:[Is: 12269-2013]:

Ordinary Portland cement available in the local market of standard brand was used in the investigation. Care has been taken to see that the procurement made from a single batch is stored in air tight containers to prevent it from being effected by the atmospheric and monsoon moisture and humidity. The manufacture of OPC is decreasing all over the world in view of blended cement on account of lower energy consumption and environmental pollution.

S.no	Properties	Test Results	Requirements as per IS 12269-1987
1.	Normal consistency	30%	30-35%
2.	Initial setting time	50	Not less than 30
3.	Final setting time	180	Not more than 600
4.	Specific gravity	3.15	3.1 – 3.2
5.	Fineness	6%	Not less than 10%
6.	Soundness	1.30 mm	Not more than 10 mm
7.	Compressive strength of cement (28 days)	53 MPa	53 Mpa
8.	Specific Surface area	320 m2/kg	

Properties of Cement:

2. Micro Silica [Silica Fume]:

It is a very reactive and effective pozzolanic material due to its fine particle size and high purity of sio2 (99.5%) content. It enhances the mechanical properties, durability and constructability in concrete. It is used in the production of high-strength and high performance concrete. Micro silica or silica fume is the most commonly used mineral admixture in the high-strength concrete. High performance concrete and high-strength, low permeability concrete for use in bridges, marine environment and nuclear plants etc.

Silica Fume

3. Fine Aggregate: [Is: 383-1970] : The locally available river sand is used a fine aggregate in the present investigation. The sand is free from clay, silt and organic impurities. The fine aggregate used should conform to the standard specifications as per IS 2386-1963. The fine aggregate used is river sand confirming to zone-II. The specific gravity of fine aggregate is 2.60.

4. Coarse- Aggregate: [Is:383-1970]:

Machine crushed angular granite metal of 20 mm to 12.5 mm nominal size from the local source is used as coarse aggregate. It is well graded and its specific gravity is 2.8 and fineness modulus is 7.26. The material is of uniform color and has good angularity. The size of aggregates bigger than 4.75 mm is considered as coarse aggregates.

5. Water: [Is: 3025-1984]:

The locally available potable water accepted for local construction is used in the experimental investigation after testing. The pH value should not be less than 6. Water-cement ratio of 0.4. Sea water also contains small quantities of sodium and potassium salts. Sea water should not be used even for PPC if aggregates are known to be potentially alkali reactive.

6. Admixture: [Is:9103-1999]:

High range water reducing admixtures known as super plasticizers are used for improving or workability for decreased water-cement ratio without decreasing the compressive strength. Conplast SP430 is differentiated from conventional super plasticizers in that it is based on a unique carboxylic ether polymer with long lateral chains.. Conplast SP430 combines the properties of water reduction and workability retention. It allows the production of high performance concrete and/or concrete with high workability. As the water-cement ratio is very less, to achieve the repaired workability Conplast SP430 was used as a water reduce dosage of the chemical is 58.8 kg per cubic meters adopted for M40 grade of concrete in the experimental investigation.

7. POLYPROPYLENE FIBER (RECRON 3S)

Recron-3s is a discrete, discontinuous short fiber that can be used in concrete to control and arrest the cracks. It arrest shrinkage cracks in concrete and increase resistance to water penetration, abrasion and impact. It makes concrete homogenous and also improves the compressive strength and flexural strength together with improving the ability to absorb more energy .Use of uniformly dispersed Recron 3S fibers reduces segregation and bleeding and also results in a more homogenous mix of concrete. Benefits of using larger fibers include impact resistance, flexural and tensile strength. Polypropylene fibres are composed of crystalline and non- crystalline material. The degree of crystallinity of polypropylene fibre is generally between 50 to 65% depending on processing conditions. Polypropylene is a light fibre and its density is about 0.91 gm/cm3 is lowest of all other synthetic fibers. Recron 3S Polypropylene fiber has a specific gravity of 0.91 cm/m3.

Polypropylene Fibre (Recron 3s)Property Values

Cut length 6mm or 12mm

Shape of fiber special for improved holding of cement aggregates

Tensile strength 4000-6000 kg/cm2

8. SUPER PLASTICIZER SP430

Conplast SP430 (superplasticizer) is based on sulphonated naphthalene polymers and supplied as a brown liquid instantly dispersible in water. It has been specially formulated to give high water reductions upto 25% without loss of workability or to produce high quality concrete of reduced permeability. Conplast SP430complies with IS:9103:1999 and BS:5075 Part 3 and ASTM--C-494 Type ‘A’ and Type ‘G’ depending on the dosage of high range water reducing admixture and Type G at high dosage.

V. MIX PROPORTION

Table - 1 Material requirement for 1m3

	Cement	Fine aggregate	Coarse aggregate	Water
Kg/m3	380	828.67	1157.670	148
Proportion	1	2.180	3.046	0.39

VI. MIXING

Mixing of ingredients is done in pan mixer of required capacity. The cementitious materials thoroughly blended and then the aggregate is added and followed by gradual addition of water and mixing. Recron 3s and SP430 are also added carefully. Wet mixing is done until a mixture of uniform color and consistency is achieved which is then ready for casting.

Mixing of mineral admixtures

i. **Mixing of Recron 3s material in concrete**

It is added to the concrete mix in 900grms/m3 (maximum). Weigh recron and mix it with the required water for the concrete mix and stir very well and add some amount of mixed cement & sand material **.** When we add the recron to the concrete mix it absorbs the water in the concrete mix. After the completion of casting it releases the water slowly.

Mixing of recron 3S Polypropylene fiber in water

I. Casting Of Conventional Concrete

Take a sample of coarse aggregate which is retained on 10mm sieve and mix them by hand batching. Take a sample of fine aggregate and cement and mix them well. Later calculated the super plasticizer content and water content and mix them in coarse aggregate, fine aggregate, and cement mixture. Make a pond and pour the sp430 liquid and water mix the proportions well and take every material of 10% extra for shortage of concrete due to wastage. Now the sample is well mixed by machine mixing. After casting leave them for 24 hours and keep them in curing tanks for 7, 14, 28 days per our trails. Then take the samples and test them in testing machines and note the values. Calculate the average load. Also calculate the stress value. Check if the value is satisfied for 7 days i.e., the compressive strength must be 70% of the target mean strength. If satisfies the conventional concrete.

II. Mixing Of Recron 3s Material In Concrete

Recron 3s material is added to nominal mix concrete to obtain the target mean strength. Weigh Recron and mixed it with required quantity of water and stir very well. Then it is poured in to the sample of cement, fine aggregate, and coarse aggregate and mixed it very well. 10% of Recron 3s is taken. When Recron material material is not mixed well, the strength of the concrete mix is decreased. After the completion of casting it release the water slowly. After mixing the recron to the concrete mix take the sample for the slump cone test, pour the sample in to the slump cone, damp well, and remove the cone.

III. Curing Of Specimens

The specimens are left in the moulds undisturbed at room temperature for about 24 hrs of casting. The specimens are then removed from the moulds and immediately transferred to the curing pond containing clean and fresh water. The specimens are cured for required period and tested.

Curing of specimens

VII. TESTS CONDUCTED

Tests should be conducted by trial and error method for cement, fine aggregate, coarse aggregate, water and the remaining chemicals which we are using having the test results with the company.

7.1 **Compressive Strength Test For Concrete Specimens**

Compressive strength of the concrete specimens (100 mm × 100 mm × 100 mm) was determined according to the IS 516:1959. The bearing surfaces of the testing machine were wiped clean and the concrete cube specimen was placed in the machine in such a manner that the load applied on the opposite sides of the cubes as cast, and not on the top and bottom faces. The load was applied without any shock or vibration and increased continuously at a rate of 14 N/mm2 /min (approx.) until the specimen failed. The compressive strength of the cubes was determined at curing periods of 7 days, 14days and 28 days.

The compression testing machine used for testing the cubes specimens is of standard make. The capacity of testing machine is 2000KN. The machine has a facility to control the rate of loading with a control valve. The plates are cleaned and oil level is checked, and kept ready in all levels of testing. After the required period of curing, the cube specimens are removed from the curing tank and cleaned to wipe off the surface water.. A uniform rate of loading 140kg/sq.cm is maintained.

Compressive testing machine

7.2 **Split Tensile Strength Of Concrete Specimens:**

The split tensile strength of cylindrical specimens is 200 mm in height and 100 mm in diameter. The split tensile strength was also determined at the curing periods 7 days, 14 days and 28 days. Diametric lines on each end of cylinder were drawn and it was ensured that it was in the same axial plane one of the plywood strips along the centre of the lower bearing block was centered and the specimen was placed on the plywood strip was aligned so that the lines marked on the ends of the specimen were vertical and centered over the plywood strip. The second plywood strip was placed lengthwise on the cylinder and centered on line marked on the ends of the cylinder. The load was continuously applied at a constant rate within the range 0.7 MPa/min to 1.4 MPa/min until the specimen failed. The split tensile strength (T) was determined from the equation

$T = 2P/\pi ld$

Where, P is the failure load

Split tensile strength test

VIII. RESULTS AND DISCUSSIONS

1. RECRON 3S

Table - 2 Compressive strength Test Results of Cube Specimens On % Addition Of Recron 3s Fiber

S.no	Recron 3S (%)	7 days strength (MPa)	14 days strength (MPa)	28 days strength (MPa)
1	0	36.75	41.50	48.50
2	0.4	37.25	42.75	49.25
3	0.8	38	44.25	51.75
4	1	40	46.75	54.0
5	1.2	37.75	41.50	47.25

Table - 3 Compressive strength Test Results of concrete with % replacement of Cement With Silica fume

S.no	Silica fume (%)	7 days compressive strength(MPa)	14 days compressive strength (MPa)	28 days compressive strength (MPa)
1.	0	36.75	41.50	48.50
2.	5	37.25	42.0	49.25
3.	10	41.8	45.75	50
4.	15	34.5	39.75	44.5
5.	20	32.5	36.75	41.25

Table – 4 Split tensile strength Test Results of Cylindrical Specimens On % Addition Of Recron 3s Polypropylene Fiber

S.no	Recron 3S (%)	7 days strength(MPa)	14 days strength (MPa)	28 days strength (MPa)
1	0	2.260	2.398	2.673
2	0.4	2.514	2.620	2.833
3	0.8	2.641	2.811	3.151
4	1	2.992	3.214	3.740
5	1.2	2.705	2.917	3.342

Table - 5 Split tensile strength Test Results of concrete with % replacement of Cement with Silica fume

S.no	Silica fume(%)	7 days strength(MPa)	14 days strength (MPa)	28 days strength (MPa)
1.	0	2.260	2.398	2.673
2.	5	2.450	2.769	3.055
3.	10	2.832	3.055	3.246
4.	15	2.291	2.769	2.928
5.	20	2.228	2.450	2.801

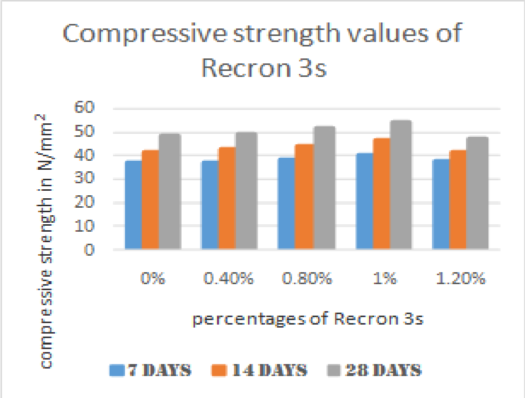
Table- 6 Compression And Split Tensile strength Test Results of Cubes And Cylindrical Specimens For 1% Recron 3s Fiber and 10% Replacement Of Silica fume

S.no.	Specimen	7 days(MPa)	14 days(MPa)	28 days(MPa)
1.	Cubes	40	44.75	50.50
2.	Cylinders	2.578	2.992	3.310

IX. GRAPH AND DISCUSSION

i. Recron 3s

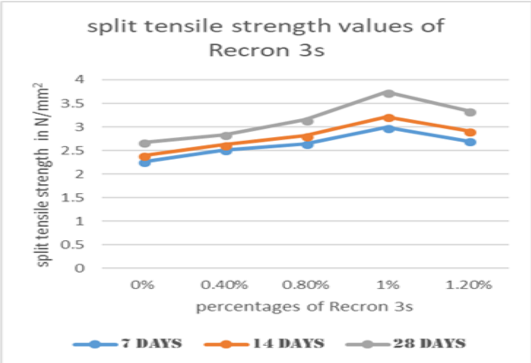
The graphical representation and discussions of obtained results are shown below



Graph - 1 Compressive strength Test Results of Cube Specimens On % Addition Of Recron 3s Fiber

The compressive strength values of concrete with varying percentages of Recron 3s at age of 7, 14, 28 days gives the optimum value at 1%.

GRAPH FOR REPRESENTINGSPLITTENSILE STRENGTH TEST

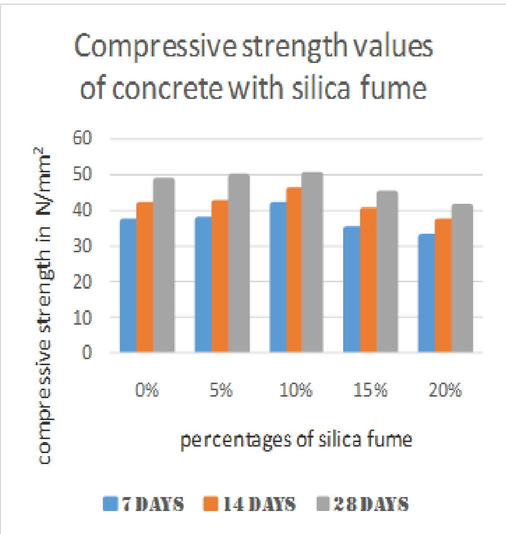


Graph - 2 Split tensile strength Test Results of Cylindrical Specimens On % Addition Of Recron 3s Polypropylene Fiber

The split tensile strength values of Recron 3s are plotted in graph.The split tensile strength values of concrete with varying percentages of Recron 3s at age of 7, 14, 28 days gives the optimum value at 1%.

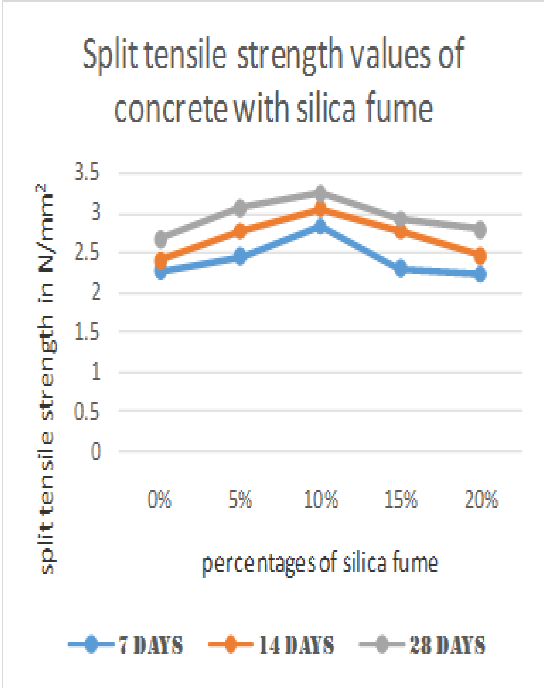
ii. SILICA FUME

The compressive strength values of silica fume are plotted in the graph.The compressive strength values of concrete with varying percentages of silica fume at age of 7,14, 28 days gives the optimum at 10%.



Graph - 3 Compressive strength Test Results of concrete with % replacement of Cement With Silica fume

Split tensile strength Graphical Representation



Graph - 4 Split tensile strength Test Results of concrete with % replacement of Cement with Silica fume

The split tensile strength values of silica fume are plotted in the graph.The split tensile strength values of concrete with varying percentages of silica fume at age of 7, 14, 28 days gives the optimum at 10%.

X. CONCLUSION

An experimental study was conducted on cubes and cylinders for compressive and split tensile strengths respectively by mixing of Recron 3s fiber and replacement of cement with silica fume. Based on the investigation the following conclusions were drawn. They are

1. From the result, it was found that the optimum replacement percentage of silica fume with cement is found at 10% when, Recron 3s fibers are not added.
2. The optimum percentage of Recron 3s is found at 1%, when silica fume is not added.
3. Usage of silica fume will maintain low permeability and usage of Recron 3s will reduce the cost maintenance by reducing micro cracks and permeability and hence the durability will increase. It is found that use of Recron 3s fiber reduce the segregation.
4. Optimum values obtained for split tensile strength, flexural strength and compressive strength of silica fume at 10% and Recron 3s at 1%.
5. In my thesis work I have observed that the polypropylene fibre strength had increased upto 1%

and reduced compression values at 1.2%. So I refers the optimum values at 1%.

XI. FUTURE SCOPE STUDY :

Usage of Recron 3s is satisfying the Flexural values and replacement of silica fume with respect to cement is giving good strength properties. By these materials the strength properties are increasing. Effectively flexural strength behavior is giving good strength properties. In construction of tanks and pavements gives best results in construction industry. Poly propylene fiber can be used as an addition material in concrete mix to increase the strength of buildings. In future investigations the strength characteristics of poly propylene fibre and silica fume can be increased if percentage range of recron fibre may vary upto 1.5 to 2%. There is increase in strength of compressive and split tensile values upto a optimum of 1.2 to 1.5%.

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