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EXPERIMENTAL INVESTIGATION ON PARTIAL REPLACEMENT OF CEMENT BY USING MICROSILICA FUME AND POLYPROPYLENE FIBER REINFORCED CONCRETE

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Abstract: In this study silica fume is used in replacement of the Ordinary Portland cement with various percentages of 5% and 10% in M30 grade mix concrete. The properties of fiber reinforced concrete with various percentages (0.4% and 0.8%) of fiber content incorporated with silica fume were made. Fiber reinforced concrete play better role in acting as a more ductile and versafite crack free or micro crack distributed materials. It is observed that the principal reason for incorporating fiber in to a cement matrix is to increase the toughness, tensile strength and to improve the cracking deformation characteristics of the resultant composite. This research revealed the properties of polypropylene fiber to which the commercial FRC'S are exposed along with partial replacement of cement by silica fume. The compressive and split tensile test are carried out and the result have are compared.
Keywords: Ductile, versafite crack, toughness, compressive strength, tensile strength, durability

I. INTRODUCTION

The concrete technology has made tremendous strides in past decade. Concrete is now no longer a material consisting of cement, aggregates, water and admixtures but it is an engineered material with several new constituents. The concrete today can take care of any specific requirements under most of different exposure conditions. The concrete today is tailor made for specific applications and it contains several different materials like GGBS, Micro Silica, Metakaolin, colloidal silica and several other Binder, Filler and Pozzolanic materials. The development of specifying the concretes as per its performance requirements rather than the constituents and ingredients in concrete has opened innumerable opportunities for producer and user of concrete to design concrete as per specific requirements.

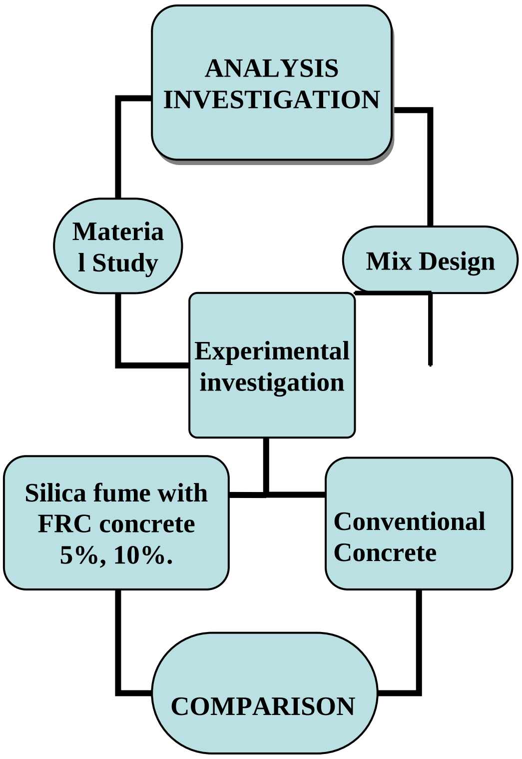
1.1 Polypropylene fiber

Civil structures made of steel reinforced concrete normally suffer from corrosion of steel by the salt, which results in the failure of those structures. Constant maintenance and repairing is needed to enhance the life cycle of those civil structures. There are many ways to minimize the failure of the concrete structures made of steel reinforcement concrete. The custom approach is to adhesively bond fiber polymer composite on to the structure. This helps to increase the toughness and tensile strength and improve the cracking and deformation characteristics of the resultant composite. But this method adds, another layer, which is prone to degradation. These fiber polymer composites have been shown to suffer from degradation when exposed to marine environment due to surface blistering. As a result, the adhesive bond strength is reduced, which results in the lamination of the composite. Another approach is to replace the bars in the steel with fiber reinforced concrete and this termed as FRC, Basically this method of reinforcing the concrete substantially alters the properties of non – reinforced cement – bases matrix which is brittle in nature, possess little tensile strength compared to the inherent compressive strength. The principal reason for incorporating fibers into a cement matrix is to increase the toughness and tensile strength, and improve the cracking deformation characteristics of the resultant composite. Only a few of the possible hundreds of fiber types have been found suitable for commercial applications. This project deals with the concrete reinforced with the "fibrillate polypropylene fiber". The objective of this research is to explore the properties of polypropylene fiber to which the commercial FRC's are exposed along with partial replacement of cement by silica fume.

1.2 silica fume

Silica fume, also known as micro silica, is a byproduct of the reduction of high-purity quartz with coal in electric furnaces in the production of silicon and ferrosilicon alloys. Silica fume is also collected as a byproduct of other silicon alloys such as ferrochromium, Ferro magnesium, and calcium silicon. Before the mid-1970's, nearly all silica fume was discharged in to the atmosphere. After environmental concerns necessitated the collection and land filling of silica fume, it became economically justified to use silica fume in various application. Silica fume has become one of the necessary ingredients for making high strength and high performance concrete. In India, silica fume has been used very rarely. Nuclear Power Corporation was one of the first to use silica fume concrete in their kanga and kola nuclear power projects. Silica fume is a highly effective pozzolanic material. Silica fume is used in concrete to improve its properties. It has been found that silica fume improves compressive strength, bond strength, and abrasion resistance; reduces permeability; and therefore helps in protecting reinforcing steel from corrosion. Silica fume was also used for one of the flyovers at Mumbai where, for the first time in India 75Mpa concrete was used (1999).Silica fume is also now specified for the construction of proposed Bandra - Woril sea link project at Mumbai. At present, India is not producing silica fume of right quality. Recently Steel Authority of India has provided necessary facilities to produce annually about 3000tons of silica fume. Twenty five years ago no one in the concrete industry could even imagine creating and placing concrete mixes that would achieve in place compressive strength as high as 120Mpa. The structures such as key Tower in cleave land with a design strength of 85Mpa and Wackier Tower in Chicago with specified concrete strength of 85Mpa, and two union square in Seattle with concrete that achieved 130Mpa strength are testaments to the benefits of silica fume technology in concrete construction.

II. METHODOLOGY



III. MATERIAL PROPERTIES

3.1.Materials

3.1.1 Cement
3.1.2 Fine aggregate
3.1.3 Coarse aggregate
3.1.4 Micro Silica fume(5%,10%)
3.1.5 Polypropylene fiber(0.4%,0.8%)
3.1.6 Water

3.1.1 Cement

Ordinary Portland cement (OPC-53 grade) is to be used for the entire investigations

Table:1 physical properties of cement

SL.NO	PHYSICALPROPERTIES OF CEMENT	RESULT
1	Specific gravity	3.15
2	Initial setting time	32 minutes
3	Standard Consistency	30%

3.1.2 Fine Aggregate

Locally available river sand confirming to zone II of IS; 383 (1970).River sand passing through IS sieve of size 1.18mm was used for this study the particle size Distribution of fine aggregate was determined from sieve analysis and the experimental results are carried out to find properties of fine aggregate .IS sieve ranging from 10mm to 150 micron were used to conduct the sieve analysis and finesses was found out.

Table 2:Physical Properties of fine Aggregate

SL.NO	PHYSICALPROPERTIES OF FINE AGGREGATE	RESULT
1	Zone	II
2	Fineness modules	2.83
3	Specific gravity	2.61

3.1.3 Coarse Aggregate

The coarse aggregate used was 20 mm size crushed granite stone supplied by the local quarry. crushed granite coarse aggregate of maximum size 20mm is used. The experimental are carried out to find the properties of coarse aggregate. The entire tests are carried out as per IS: 2386 – 1963. The properties of coarse aggregate are coarse aggregate

Table 3:Physical Properties of coarse Aggregate

SL.NO	PHYSICAL PROPERTIES OF COARSE AGGREGATE	RESULT
1	Angular size	20mm
2	Fineness modulus	2.68
3	Specific Gravity	2.62

3.1.4 Polyproylne Fiber

The polypropylene fiber of length 12mm used. Lowest thermal conductivity of any nature or synthetic fiber, the resistance to sunlight, bacteria and micro-organism

3.1.5 Micro Silica Fume

Table 4: Specification of silica fume (f90)

SL .NO	CHEMICAL SPECIFICATION	LIMITS
1	Form/colour	Powder/white/gra y
2	Sio_2,min	90%
3	H_2O(moisture),max	3.0%
4	Loss on ignition (LOI) @975^0	4.0%
5	Specific surface min	18 m^2/g
6	Coarse particles ;>45µm(325 mesh);max	7%
7	Pozzolanic active index	95%
8	Bulk density	600kg/m^3

3.1.6 Water

Ordinary potable water available in the laboratory was used for the experimental investigations and for curing purpose. Water is an important ingredient of concrete reaction with cement. Portable water available in a college premise is used for maxing and curing.

3.2 Mix proportioning

Mix design was done on IS 10262-1982.

Table 5: Mix Proportioning

SI.NO	MATERIAL	QUANTITY (kg/m³)
1	Cement	547.37
2	Fine aggregate	503.4
3	Coarse aggregate	1094.6
4	Water	191.58

Mix ratio: (1:0.919:1.99)

IV. RESULT AND DISCUSSIONS

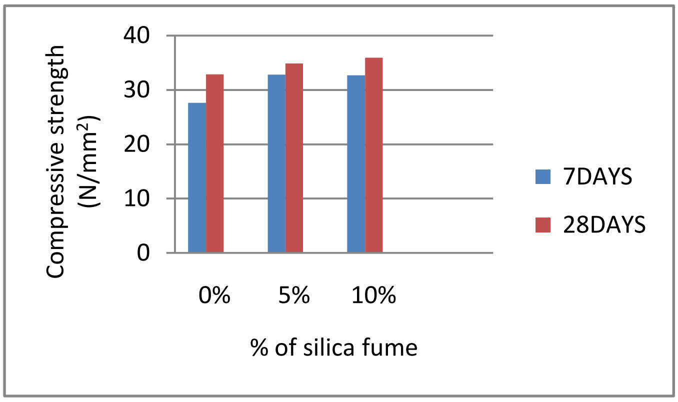
4.1 Compressive Strength

Compressive strength is one of the important properties of concrete. Concrete cube of 150 x 150 x 150mm were cast. After 24 hours the specimen were demoulded and subjected to water curing. After 7 and 28 days of curing of curing three cubes were taken and tested in compression testing machine. Compressive test is most common test conducted on hardened concrete, partly because it is an easy to perform, and partly because most of the desirable characteristic properties of concrete are qualitatively related to its compressive strength.The compressive test is carried out on specimens cubical or cylindrical in shape. Prism is also sometimes used, but it is not common in our country. Sometimes, the compressive strength of concrete is determined using parts of a beam is flexure and, because the beam is usually of square section, this part of the beam could be used to find out the compressive strength. The cube specimen is of the size 150mmX150mmX150mm. If the largest nominal size of the aggregate does not exceed 20mm, 100mm size cubes may also be used as an alternative. In our investigation we used 150mmX150mmX150mm size cube.

The compressive strength of concrete was found out for ordinary OPC then for 6mm to 20mm Polypropylene Fiber mixed concrete and then for Silica fumes mixed concrete. For 7^{th} day and 28^{th} day.

Table 6: Result of compressive strength

SI.NO	% OF SILICA FUME ADDED	COMPRESSIVE STRENGTH (N/mm^2)	
		7 days	28 days
1	0	27.6	32.9
2	5	32.8	34.85
3	10	32.67	35.95

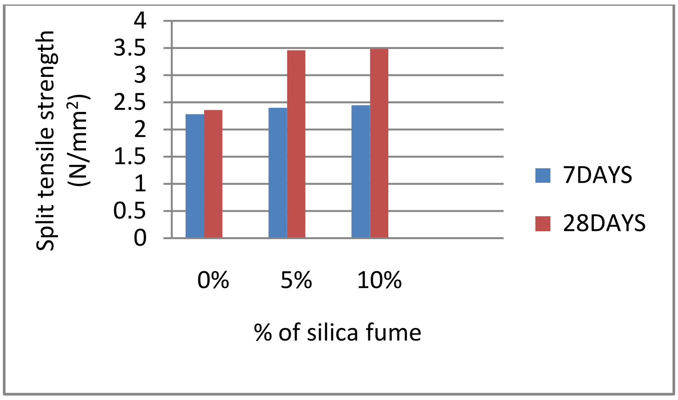


4.2 Split Tensile Strength

The split tensile strength tests of concrete can be broadly classified into direct and indirect methods. The first method suffers from a number of difficulties relating to placing or holding the specimen property in the testing machine without increasing the stress concentration and difficulties in applying axial load free of eccentricity on the specimen. Because of the difficulties involved in conducting the direct tension test, indirect test such as split tensile method has been used. Split tensile tests were conducted for various cylindrical specimens (150mm diax300mm height) at the age of 7 and 28 days in the compression testing machine of capacity 200 tons. Cylindrical splitting tension test is also sometimes referred as "Brazilian test" . this test was developed in brazil in 1943. At about the same time this independently developed in Japan.The test is carried out by placing a cylindrical specimen horizontally between the loading surfaces of a compression testing machine and the load is applied until failure of the cylinder along the vertical diameter. When the load is applied along the generator an element on the vertical diameter of the cylinder is subjected to a vertical compressive stress of The main advantages of this method is that the same type of specimen and the same testing machine as are used for the compressive test can be employed for this test. That is gaining popularity splitting test simple to perform and gives more uniform result than other tension tests. Strength determined in the splitting test is believed to be closer to that true tensile strength of concrete than the modules of rupture. Splitting strength gives about 5-12 % higher value than the direct tensile strength agreement with what is generally observed for conventional concrete. The presence of fibres again had little effects on the test results.

Table 7: Result of split tensile strength

SI.NO	% OF SILICA FUME ADDED	SPLIT TENSILE STRENGTH (N/mm2)	
		7 days	28 days
1	0	2.28	2.36
2	5	2.4	3.46
3	10	2.45	3.48



V. CONCLUSIONS

The conclusion are drawn as below,

- With the increasing of Silica Fume and Polypropylene Fiber percentage optimum moisture content goes on decreasing while maximum compressive strength goes on increasing.
- It was observed that the 28 days of compressive strength of M30 grade concrete increased in 32.9% to 35.95% and split tensile strength of concrete increased in 2.36% to 3.48%.
- Compared with polypropylene fibers, the small diameters of fibers ensures better and more uniform dispersions , efficient load transfer, and their greater surface area provide better ability to bridge cracks.
- By adding polypropylene fiber it gives sufficient strength to withstand micro cracks before they reach critical stage and giving maximum durability to the concrete structure.
- If Silica Fume and Polypropylene Fiber percentage increases Split tensile strength, compressive strength are also increased.

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