Experimental Review on Replacement of Cement By Silica Fume With Steel Fiber And Carbon Fiber In Concrete And Comparitive Study

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I. INTRODUCTION

Infrastructure development for a country is a principle development and concrete plays a vital role. Concrete is the world's largest consuming material in the field of construction. From time immemorial research over concrete has been going on to enhance its performance and strength. Nowadays, most concrete mixture contains supplementary cementitious material (SCM) which forms part of the cementitious component. These materials are majority by-products from other processes. The main benefits of SCMs are their ability to replace certain amount of cement and still able to display cementitious property, thus reducing the cost of using Portland cement. The fast growth in industrialisation has resulted in tons and tons of by-product or waste materials, which can be used as SCMs such as silica fume, by adding steel fibers and carbon fibers etc. The use of these by-products not only helps to utilize these waste materials but also enhances the properties of concrete in fresh and hydrated states.

Micro silica or silica fumes, a very fine non-crystalline material is very good as filler material to provide good strength. In the present study, an attempt has been made to investigate the strength parameters of concrete made with partial replacement of cement by Silica Fumes and by adding steel fibers, carbon fibers. Here in the experiment an attempt has been made to increase the strength of concrete by replacing cement with 0%,5%,10%,15% and 20% of Micro silica fumes in a design mix of M20. The materials are taken from the locally available sources. Properties of hardened concrete viz Ultimate Compressive strength and Splitting Tensile strength has been determined for different mix combinations of materials and these values are compared with the corresponding values of conventional concrete. The compressive strengths are checked for the mentioned design mixes. It is found that an optimum replacement of 10% of Micro silica with 1%Steel Fiber and 1%Carbon Fiber to that of cement (by weight and Volume) increases the strength of concrete to 25% - 30%.Further addition of micro silica shows a decreasing trend with proportion to the steel fibers and carbon fibers.

II. LITERATURE REVIEW

The various literatures have been referred from journals, preceding, books etc to understand present status of project undertaken. From this literature data is summarized for work. These are explained below.

Kumar & Dhaka (2016) write a Review paper on partial replacement of cement with silica fume and its effects on concrete properties. The main parameter investigated in this study M-35 concrete mix with partial replacement by silica fume with varying 0, 5, 9, 12 and 15% by weight of cement The paper presents a detailed experimental study on compressive strength, flexural strength and split tensile strength for 7 days and 28 days respectively. The results of experimental investigation indicate that the use of silica fume in concrete has increased the strength and durability at all ages when compared with normal concrete

Hanumesh, Varun& Harish (2015) observes the Mechanical Properties of Concrete Incorporating Silica Fume as Partial Replacement of Cement. The main aim of this work is to study the mechanical properties of M20 grade control concrete and silicafume concrete with different percentages (5, 10, 15and 20%) of silica fume as a partial replacement of cement. The result showed that The compressive strength of concrete is increased by the use of silica fume up to 10% replacement of cement. From 10% there is a decrease in compressive strength and The split tensile strength of concrete is increased by the use of silica fume up to 10% replacement of cement. From 10% there is adecrease in split tensile strength. The optimum percentage of replacement of cement by silicafume is 10% for M20 grade of concrete

FuatKoksal (June 2007) The changes on some mechanical properties of concrete specimens produced by using silica fume and steel fiber were investigated. The main objective of this work is to obtain a more ductile high strength concrete produced by using both silica fume and steel fiber. Two types of steel fibers with aspect ratios (fiber length/fiber diameter) of 65 and 80 were used in the experiments and volume fractions of steel fiber were 0.5% and 1%. Additions of silica fume into the concrete were 0%, 5%, 10% and 15% by weight of cement content. Water/cement ratio was 0.38 and the reference slump was 120} 20 mm. Slump test for workability, air content and unit weight tests were performed on fresh concretes. Compressive strength, splitting tensile strength and flexural strength tests were made on hardened concrete specimens. Load–deflection curves and toughness of the specimens were also obtained by flexural test performed according to ASTM C1018 standards. Flexural tests on beam specimens was achieved using a closed loop deflection-controlled testing machine.

The use of silica fume increased both the mechanical strength and the modulus of elasticity of concrete. On the other hand, the addition of steel fiber into concrete improves toughness of high strength concrete significantly. As the steel fiber volume fraction increases, the toughness increases, and high values of aspect ratios give higher toughness. The toughness of high strength steel fiber concrete depends on silica fume content, the fiber volume fraction and the fiber aspect ratio.

(DebabrataPradhan, D. Dutta) The incorporation of silica fume into the normal concrete is a routine one in the present days to produce the tailor made high strength and high performance concrete. The design parameters are increasing with the incorporation of silica fume in conventional concrete and the mix proportioning is becoming complex. The main objective of this paper has been made to investigate the different mechanical properties like compressive strength, compacting factor, slump of concrete incorporating silica fume. In this present paper 5 (five) mix of concrete incorporating silica fume are cast to perform experiments. These experiments were carried out by replacing cement with different percentages of silica fume at a single constant water-cementitious materials ratio keeping other mix design variables constant. The silica fume was replaced by 0%, 5%, 10%, 15% and 20% for water-cementitious materials (w/cm) ratio for 0.40. For all mixes compressive strengths were determined at 24 hours, 7 and 28 days for 100 mm and 150 mm cubes. Other properties like compacting factor and slump were also determined for five mixes of concrete.

(**Vishal S. Ghutke)** Portland cement can be partially replaced by silica fume. Silica fume is non metallic and non hazardous waste of industries. It is suitable for concrete mix and improves properties of concrete i.e. compressive strength etc. The main objective of this research work is to determine the optimum replacement percentages which can be suitably used under the Indian conditions. To fulfill the objective various properties of concrete using silica fume have been evaluated. Further to determine the optimum replacement percentage comparison between the regular concrete and concrete containing silica fume is done .It has been seen that when cement is replaced by silica fume compressive strength increases up to certain percentage (10% replacement of cement by silica fume).But higher replacement of cement by silica fume gives lower strength. The effect of Silica fume on various other properties of Concrete has also been evaluated.

(Joe Paulson.A1*, John Wesly) The effect of optimum replacement of cement with silica fume on various methods of mix proportioning is discussed in this paper. The optimum extent of replacement of cement with silica fume as reported in the previous module of work was taken as 13%1. The extent of replacement was applied to various methods of mix proportioning like Indian Method, Pumpable Concrete Method, American Method and British Method. This work is done to study the pattern of cube compressive strength and cylinder tensile strength when optimum replacement is adopted. Cubes and cylinders are casted to find the compressive strength and tensile strength for 0% and 13% replacement for all methods of mix proportioning mentioned.

(Hanumesh B M) Silica fume is usually categorized as a supplementary cementitious material. These materials exhibit pozzolanic properties, cementitious properties and a combination of both properties. Due to these properties, it can affect the concrete behavior in many ways. In the present work, an attempt has been made to use silica fume as a supplementary material for cement and to evaluate the limit of replacement of cement for M20 grade concrete. The main aim of this work is to study the mechanical properties of M20 grade control concrete and silica fume concrete with different percentages (5, 10, 15 and 20%) of silica fume as a partial replacement of cement.

(C.G. Konapure, V.S Dasari) This experimental study deals with M50 grade of concrete having mix proportion 1:1.97:2.75 with w/c ratio 0.41 to study the properties of concrete like compressive strength and flexural strength. The concrete containing steel fiber of 1% volume fraction of hook end with 71 aspect ratio. silica fume used as a replacement of cement of about 5% by weight and also superplastisizer are added as per requirement for achieving desired workability of concrete. A relationship between workability, compressive strength and flexural tensile strength represented mathematically and graphically. In the present investigation, the combined effects of steel fiber and silica fume on concrete properties were experimentally assessed with control specimen.

(Sagri et al. 2015) With this review, it can be reason that the 1% ideal measurements of steel fiber is required to acquire the high flexural quality. The 1% steel fiber blended with various rates of silica fume then with 10% silica fume the flexure quality increase however more than 10% silica fume the flexure quality is abatements. Asphalt thickness is decreased up to 75% utilizing steel fiber which is exceptionally prudent from development perspective.

III. EXPERIMENTAL SETUP

For studying the compressive strength cubic samples with dimensions 150*150*150 mm were used. They were tested by loading after 7, 28 and 56 days. The load was applied perpendicular to the upper face of cube, and the loading speed of the compressive testing machine was 5 mm/min. The apparatus used to test had a loading capacity of about 3000KN Three specimens were casted for each mix design for 7, 28 and 54 days of testing.

For the flexural strength,3 beams without steel fibres, carbon fiber and silica fumes were casted to compare our results with the steel fibre and carbon fiber reinforced concrete. For this research, 36 cubes with dimensions 150x 150 x 150mm were casted to test the compressive strength with varying steel fiber, carbon fiber and silica fume percentage after 7, 28 and 56 days. To test the flexural strength 12 concrete beams (15cm x 23cm x 220cm) were casted using varying percentages of silica fumes, carbon fibers and steel fibers using twisted end undulated steel fibres in the concrete. This experiment required lot of trial work needed to find out the maximum strength at optimum quantity of steel fibres, carbon fibers as well as optimal percentage of silica fumes. In order to determine that, the optimum quantity of steel fibres and carbon fibers is tested against different percentages of silica fumes.

4.2.3.1 Compressive Strength Test:

To determine the precise compressive strength of cubes an average of three samples were taken for every reading. The testing of specimens has been performed after curing period of 7 days, 28 days and 56 days for both controlled as well as for cubes with partial replacement of cement with fine aggregates with the addition of steel fibers and carbon fibers.

4.2.3.3 Split Tensile Strength

The tensile strength of concretez is one of the basic and important properties. Splitting tensile strength test on concrete cylinder is a method to determine the tensile strength of concrete. The concrete is very weak in tension due to its brittle nature and is not expected to resist the direct tension. The concrete develops cracks when subjected to tensile forces. Thus, its necessary to determine the tensile strength of concrete to determine the load at which the concrete members may crack. To determine the split tensile of concrete

4.2.1 Detailed Methodology:

In steel fiber-reinforced concrete, steel fibers are distributed randomly all over the matrix. The fibers are present at all the depths with proper mixing. This results in the even strength attainment in all directions. And hence improves the overall properties of concrete in all directions.

As for the mix procedure, dry ingredients (coarse and fine aggregates, silica fume and cement) was rotated in the mixer for 45 seconds. After that, steel fibers, carbon fibers along with silica fumes and super plasticizer was eventually added. Then water was added gradually in and the mixing was continued until a uniform matrix was formed and steel fiber and carbon fibers was distributed all over the concrete mix.

Concrete cubes to be casted in the mold

For this research, 36 cubes with dimensions 150 x 150 x 150mm were casted to test the compressive strength with varying steel fiber, carbon fibers and silica fume percentage after 7, 28 and 56 days. To test the flexural strength 36 concrete beams (15cm x 23cm x 220cm) were casted using varying percentages of silica fumes, carbon fibers and steel fibers using twisted end undulated steel fibers in the concrete. For the flexural strength, to check the strength of the control mix, 3 beams without steel fibers, carbon fibers and silica fumes were casted to compare our results with the silica fume, carbon fibers with steel fiber reinforced concrete. This experiment required lot of trial work needed to find out the maximum strength at optimum quantity of steel fibers, carbon fibers as well as optimal percentage of silica fumes. In order to determine that, the optimum quantity of steel fibers, carbon fibers is tested against different percentages of silica fumes.

For each test, three specimen were casted and the average of those three was considered for the specific reading. The quantity of the silica fumes, carbon fibers and steel fibers will be varied accordingly. The cubes will be casted for testing after curing for 7, 28days

4.1 MATERIAL USED

For the casting process, various construction materials are used like cement, fine aggregates coarse aggregates, admixtures and water.

4.1.1 Cement

The cement used was taken from a local JAYPEE CEMENT Vendor and the cement used is OPC 43 grade with consistency (P) of 27% Initial setting time of 48 min and final setting time of 283 min with a specific gravity of 3.15.The cement has been checked for various properties and they have been accurately taken keeping in mind the limits specified by IS: 8112-1989.

4.1.2 Aggregates

For coarse aggregate, the maximum size of aggregate in between 20mmzto 4.75mm. The physical properties of both fine aggregate and coarse aggregate z are evaluated as per IS: 2386z(Part III)-1963 and given in Table and fine aggregate river sand bought from a local vendor from the same place with fineness modulus 2.389 confirming to Zone III.

S No	Property	Coarse aggregate
1	Specific Gravity	2.72
2	Bulk Density (kg/L)	1.408
3	Loose Bulk Density (kg/L)	1.25
4	Water Absorption (%)	4.469
5	Impact Value	26.910
6	Crushing Value	26.514
7	Fineness Modulus	3.38

Table 5.1. Properties of aggregates

4.1.3 Water

The water for the testing as well as for the curing was taken from local tap. The w/c ratio used in this project is kept constant at 0.38.

4.1.4 Silica fumes:

Silicon powder is a by-product as a result of reducing the high - purity quartz with coal or coke and the production of silicon metal chips and silicon alloys in an electric arc furnace. Silicon powder is known to improve the mechanical strength of the concrete has two sand. The fact that the filler, it is because the same manner adapted to the cement particles in the space between the soft sand or particles filling the space between the cement particles coarse aggregate concrete-filled space between the interior of sand most important physical effects of silica dust.

Steel Fibers

Steel fibers are made of shredded steel wire having low percentage of carbon (C) or also known a stainless steel mesh. The fibers can be flat, hooked or undulated. Undulated steel fibers are effective in a way that the concrete holds a better grip over the surface of the fibers. Hence undulated steel fibers were used in this research.

.**3.4 Mix design of concrete of river sand as fine aggregate:**

There are various methods of mix design. In the present work, Indian Standard method(IS: 10262 - 2009) is used for Concrete mix design of grade M20

III] Mix proportions:

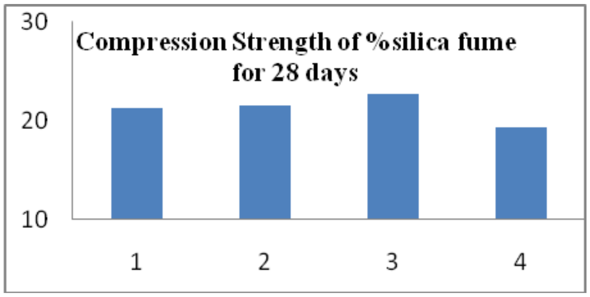
Cement = 311.12 kg/m^3
Water = 140 kg/m^3
Fine aggregate = 868 kg/m^3
Coarse aggregate = 1150 kg/m^3
Water-cement ratio = 0.45

3.5 Schedule of Casting

Table 3.5 Casting details of cube

SR NO	**Type of Specimen**		**No. of Specimen**	**No. of Specimen**
	M20 Standard Cube	M20	3	3
1	Silica fume Cube	5% A1	3	3
2		10% A2	3	3
3		15% A3	3	3
4	Silica Fumes + Steel Fiber's (SF 10% +	A 10% + 0.9% B1	3	3
5		A 10% + 1% B2	3	3

6	ST F)	A 10% + 1.2% B3	3	3
7	Silica Fumes + Carbon Fiber's (SF 10% + C. F)	A 10% + 0.9% C1	3	3
8		A 10% + 1% C2	3	3
9		A 10% + 1.2% C3	3	3
Total no of specimen			**30**	**30**



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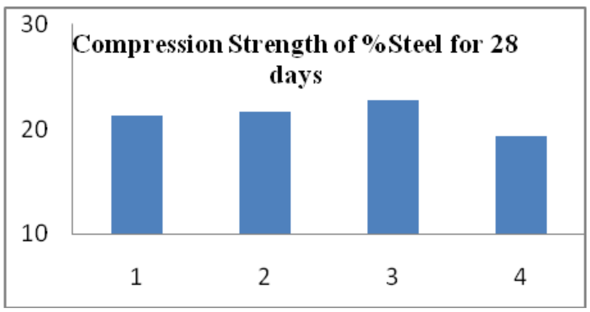
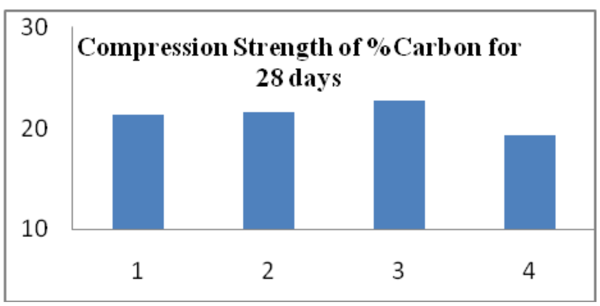
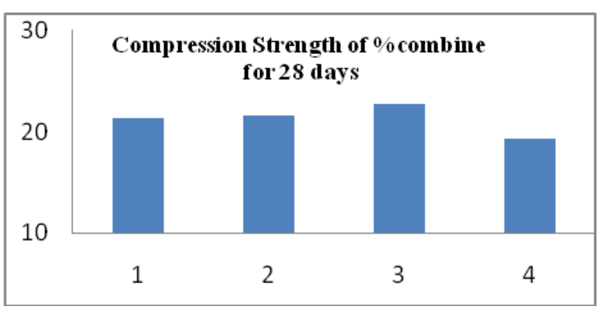


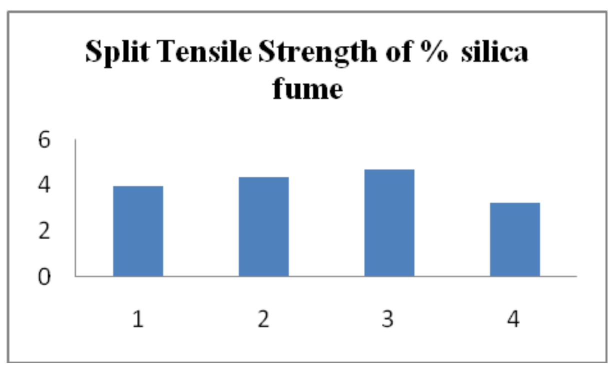


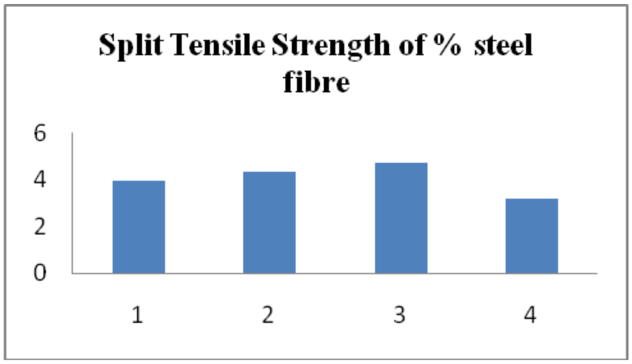


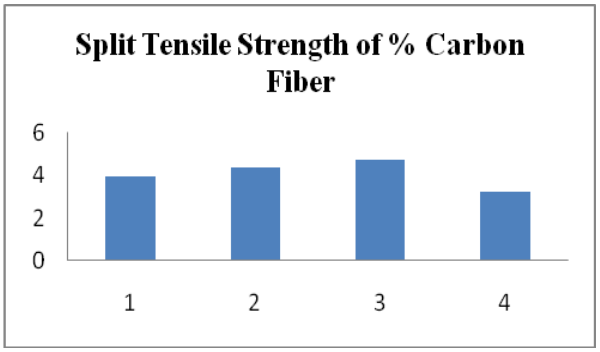
SR NO	Type of Specimen	Percentage of Content	No if Specimen
1	Silica Fumes + Steel Fiber's+CarbonFiber's (SF 10%+ST F 1%+ CF 1%)	A10%+ 1%B+1%	3

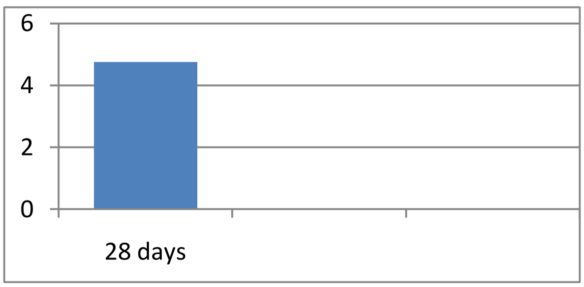
Table 3.5 Casting details of Cylinder

S R N O	Type of Specimen		No of Specimen
	M20 Standard Cylinder	M20	3
1	Silica fume Cylinder	5% A1	3
2		10% A2	3
3		15% A3	3
4	Silica Fumes + Steel Fiber's (SF 10% + ST F)	A 10% + 0.9% B1	3
5		A 10% + 1% B2	3
6		A 10% + 1.2% B3	3
	Silica Fumes + Carbon Fiber's (SF 10% + C. F)	A 10% + 0.9% C1	3
8		A 10% + 1% C2	3
9		A 10% + 1.2% C3	3
		Total	30









V. CONCLUSION

In this project both the flexural and compressive strength has been improved by the addition of silica fumes, carbon fibers and steel fiber.

1. based on research compressive tests are carried for varying silica fume percentage as 5%, 10%, 15% and 20 %. There was a gradual increase in the compressive strength with increase in the percentage of silica fumes in the beginning but after 10% there was almost negligible increase in the compressive strength. Hence 10% can be attributed as the optimum dosage of silica fume that can be added as a partial replacement of cement for maximum compressive strength.
2. Steel fiber as well as silica fumes decreases the workability of the concrete hence super plasticizer is required to maintain the w/c ratio.
3. Based on finding of 25% to 30% increase in the compressive strength of concrete with 10% silica fumes with 1% steel fibers and 1% carbon fibers after 28 days of curing against plain concrete without silica fumes and fibers.
4. Based on research, considerable increase in the flexural strength of the concrete beams with the addition of steel fibers at percentages of 0.5%, 0.8%, 1.0% at 28 days curing in the beginning as compared to plane concrete beams. But as soon as the fibers were increased upto 1.2%, 1.4%, there was a decrease in the flexural strength of the beams. So with silica fumes as partial replacement of cement, 1% steel fiber was optimum percentage for maximum flexural strength.
5. Based on finding, the increase in the compressive strength and flexural strength with addition of silica fumes, carbon fibers and steel fibers together is considerably higher than the one containing only silica fumes or steel fibers.
6. Based on research, 10% silica fume can be taken as the optimum percentage which can be used to achieve maximum possible compressive strength at 28 days of curing for any percentage of steel fiber, carbon fibers for fiber reinforced concrete

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