

SCIENCE | ENGINEERING | TECHNOLOGY

e-ISSN: 2319-8753 | p-ISSN: 2347-6710

EDIA

INTERNATIONAL JOURNAL OF INNOVATIVE RESEARCH

IN SCIENCE | ENGINEERING | TECHNOLOGY

Volume 10, Issue 9, September 2021

INTERNATIONAL STANDARD SERIAL NUMBER INDIA

Impact Factor: 7.569

9940 572 462

6381 907 438

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Volume 10, Issue 9, September 2021

DOI:10.15680/IJIRSET.2021.1009101

An Experimental Investigation on Behaviour of Fibre Reinforced Concrete with Silica Fume

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ABSTRACT: Now a day, civil engineering field growing very rapidly. High rise buildings, long span bridges, shear walls etc carry very heavy loads due to this high strength concrete is necessary for the construction hence many experiments are going on to produce high strength concrete using different admixtures. These admixtures added to concrete in a definite proportion to achieve max strength. Here in this experiment we used Silica fume as a partial replacement to cement and Steel fibres added to concrete. The concrete mix selected here was M30 and we kept quantity of steel fibre constant ie., 1% and vary the percentage of replacement of silica fume ie (5%, 10%, 15%, 20%) for the experimental investigation. After the test results obtained we concluded that the addition of silica fume and steel fibre enhances the strength properties of concrete as the high pozzolonic property of silica fume helps in binding the aggregate and filling the air voids provides greater strength and as steel fibres provide support in all direction will enhances the strength properties of concrete and also silica fume helps in gaining high early strength but reduction of workability will take place as the silica fume particles prevent the concrete flow steel fibres provide grip thus reduce concrete flow.

KEYWORDS: Silica fume, Steel fibre, Workability, Strength.

I. INTRODUCTION

Concrete is the most common civil engineering material which is being utilized in construction industry as it is a versatile material that can be casted into any required shape and size. Concrete is the mixture of cement, fine aggregate, coarse aggregate, water and admixtures. Cement is the most important constituent in the concrete as it binds the aggregate and helps to prevent decay of concrete from atmospheric action. Concrete is a product which is strong in compression but have very low strength in tension hence fibres are also being used in the production of concrete which will provide a 3D support / strength to concrete that is it will provide tensile strength to concrete. These are small fibres/thread like material of different sizes manufactured in industry and can be available from suppliers the fibres are of different sizes that is length and thickness. We can use these fibres in concrete as per our requirement.as these fibres provide grip in all direction the strength of concrete will increase considerably and also many experiments are going on to produce high strength concrete by using different materials alternative to cement and also many materials are incorporated in concrete to enhance the strength of concrete. Commonly silica fume is used as a partial replacement to cement to enhance the concrete properties.

II. LITERATURE REVIEW

R. Sri Ravindraraj et al (1984)^[13]

This investigation deals with the study of effect of steel fibres on the max strength of concrete beams. They concluded that the concrete containing both fibre reinforcement and conventional reinforcement at bottom is 25% stronger than fully reinforced Beam. The ultimate strength of Partially Fibre imposed concrete beams between plain concrete and Fibre concrete steel does not change appreciably if casting is delayed.

S. U. Balouch et al (2009) ^[15]

This paper explains about the study of the effect of corrosion of steel fibres in the SFRC. The test is carried out by placing the member in salt fog for 1 week and drying for 1 week if the corrosion takes place corrosion spots appear. They concluded that with water cement ratio=0.78 and all the Fibre less than 1mm are expected to give corrosion spots at the surface.



Volume 10, Issue 9, September 2021

| DOI:10.15680/IJIRSET.2021.1009101 |

Mohmoud Nili et al (2011)^[8]

This paper states that when silica fume is replaced to cement it enhances the effectiveness of steel Fibre used on the concrete properties. They used a different percentage of steel fibres 0%, 0.5% and 1% of vol of concrete. They kept Silica fume content constant i.e. 8% of weight of cement and they concluded that adding of silica fume and steel Fibre led to the highest long-term compression strength and lowest resistivity and also a decrease in water absorption is observed.

Jao Barros et al (2012)^[5]

In this paper they investigate about the fracture energy of SFRC. They carried out three point bending notched beam tests using displacement control. Amount of steel Fibre is used is very from Beam to beam they used 30 60 90 KG per cubic meter of steel. According to the test results, specimens containing 90 KG per cubic metre steel fibre required the most energy.

S. Syed Mohsin et al (2012)^[14]

The purpose of this study was to determine the feasibility of employing steel fibres to reduce the amount of conventional steel used without compromising the ductility and strength of concrete. According to the researchers, fibre has the ability to compensate for the loss of shear connection. When both fibres and links are used in the current task, the gain in strength will be greater.

R. Sri Ravindrarajah (2012)^[12]

This investigation deals with the study of influence of acid attacks on concrete which contain silica fume. They used 2 types of cement they are GP cement and GB cement with 35% slag cement. Silica fume is replaced to cement i.e.:-5%, 8% and 15% by weight. 3types of acids used are lactic acid, hydrochloric acid and Sulphuric acid. They concluded that Sulphuric acid is the most corrosive out of all other. When silica fume replaced to cement by 8% the weight loss by Sulphuric Acid attack from 5.8% to 11.9% in 35 days. The weight loss of concrete is around 3% for other 2 acids.

P. Vinayagam.(2012)^[10]

They used silica fume, super plasticizers for HPC and describes that the maximum replacing amount of silica fume for cement is 10% for more strength and elastic modulus. The concrete blends having silica fume indicated low pH when comparing with normal concrete. They also stated that the water absorption is more without using silica fume in HPC mix.

N. K. Amudhavalli et al. (2012)^[9]

They studied on influence of silica fume in the strength as well as durability parameters of concrete and noticed that due to fineness large surface area normal consistency rises up to 40% for 0% to 20% increment of silica fume. They also mentioned that for 10% - 15% replacement level, strength of the specimen is optimal.

M D Asif Ahmed et al (2014)^[7]

This work investigates the influence of silica fume on OPC in the absence as well as in the presence of steel fibres. They employed concrete mixes with 0%, 4%, 8%, and 12% silica fume and crimped steel fibres of 5mm diameter with an aspect ratio of 60 at varied percentages of 0%, 0.5%, 1%, and 1.5%, by volume of concrete. They concluded that replacing the cement in concrete by 8% of silica fume showed greater increase in strength properties and 1.5% steel Fibre usage is best for both economical and strength aspect.

R Rama Subramani et al (2014)^[11]

In this paper they investigated and evaluated the outcomes for M40 grade concrete with a mix proportion of 1:1.45:3.12 and a water cement ratio of 0.35 SFRC. Silica fume is used to substitute cement in 4%, 6%, 8%, and 10% volume fractions, and steel fibres are used in 2% and 2.5% volume fractions. Steel fibre with a 50 aspect ratio was used in this study. After 28 days of concrete curing, compressive strength and split tensile test data are taken. They discovered that a 10% silica fume replacement and a 2.5%, steel fibre replacement provided the optimum results.



Volume 10, Issue 9, September 2021

| DOI:10.15680/IJIRSET.2021.1009101 |

Ghutke and Bhandari (2014)^[4]

They investigated about the influence of silica fume on concrete. By observing the results, they said that silica fume is a good alternative or partial replacement of cement. They observed that the concrete will have high early strength and less workability if we used silica fume as a partial replacement to cement. They also observed that the optimum value of compressive strength is obtained at 10% replacement of cement with silica fume and at 15% replacement also as the strength of concrete is higher finally they concluded that the optimum dose for the replacement of cement with silica fume is between 10% and 15%.

Sudarsana Rao.Hunchate et al. (2014)^[17]

In present study, they prepare the mix design of HPC by introducing silica fume and superplasticizer and commented that with the addition of silica fume, the compressive strength increases up to 15% [HPC] and then reduces. Therefore, 15% replacement is ideal and they also specified that the workability goes on reducing with the increment of silica fume percentage.

Sabale V.D et al (2014) [16]

They investigated on the Outcome of Adding Silica Fume on HPC and describes that 10% replacement of cement with silica fume results in greater Strength properties of concrete. They also specified below 10% reduction in strength takes place for 28 days curing. They also mention workability goes on reducing with the increment of silica fume and hence the blender requires more water.

Lakhbir Singh et al. (2016)^[6]

They investigated about the influence of silica fume on the performance of the concrete. First they tested the properties of concrete with control mix here control that is the concrete which does not contain any admixtures and the results were studied. Then silica fume was used as a partial replacement to cement at varying percentage that is 5%, 10% and 15%. Compressive strength and split tensile strength of concrete was examined in this experiment. They concluded that the optimum dosage of silica fume is 10%, after which the strength starts to decrease.

Akshatha K. B. et al. (2018)^[1]

Author states that compressive strength of concrete becomes boosted when silica fume was used. The split tensile as well as flexural strength is also boosted when silica fume was replaced. There is no specific trend of change in elasticity modulous of conventional and silica fume blended concrete. Author also stated that workability will reduce with higher usage of silica fume and density of concrete remains same as ordinary concrete.

Amit et al (2019)^[3]

This work investigates the effects of silica fume and steel fibre on ordinary concrete. Experiments and analyses were done to analyse the flexural and compressive behaviour of composite concrete when different percentages of silica fume and steel fibre were added. They adapted with 0%, 5%, 10%, 15% and 20% replacement of cement with silica fume and stainless steel fibres of dia 0.5mm and length of 400 MM and aspect ratio 80 at different percentage ranging from 0% .4% 1.4% 2.4% and 3.4% by weight of concrete. They concluded that there is an enhancement in properties of concrete with the addition of steel fibre and silica fume but the workability gets reduced.

Amar kendre et al (2020)^[2]

This paper discusses the effectiveness of silica fume in concrete and conducts experiments on the properties of fresh and hardened concrete having various amounts of silica fume. The study focused on mixes of concrete with a constant total binder cement content of 412kG/m3 and a fixed w/c ratio of 0.35 with the addition of super plasticizer. The percentages of silica fume substituted in cement in this study were 5%, 10%, 15%, 20%. It had the highest compressive strength when 10% silica fume was substituted for cement.

III. MATERIALS USED AND METHODOLOGY

To carry out the tests we need to cast the concrete specimen following are the materials which are required to cast the concrete specimen:

International Journal of Innovative Research in Science, Engineering and Technology (IJIRSET)



| e-ISSN: 2319-8753, p-ISSN: 2347-6710| <u>www.ijirset.com</u> | Impact Factor: 7.569|

Volume 10, Issue 9, September 2021

| DOI:10.15680/IJIRSET.2021.1009101 |

CEMENT: As per IS 8112-1989, Ordinary Portland Cement (OPC43 grade cement) (Ultra Tech) was used in the present Experiment. The tests were conducted according to the code IS 4031(part-4)-1988.

FINE AGGREGATES: As the field of civil engineering is advancing rapidly, the scarce of river sand is a major issue and hence M-sand is used as substitute to river sand in civil industry. The M- sand is manufactures in plants by crushing coarse aggregates by using machines. The M-sand size taken here is less than 4.75mm size. The physical properties of M- sand were tested according to IS 383-1970 and IS 2386(part 3). Figure shows manufactured M-sand.

COARSE AGGREGATE: Nominal Max size of coarse aggregate used here was 20mm. Coarse aggregate should pass through 20mm sieve and retained in 10mm sieve. Basic properties of coarse aggregates were tested as per IS-2386:1963.

STEEL FIBRES: Steel fibres are the discrete fibres made of steel having specific dimension length and thickness having correct aspect ratio here we used hocked end steel fibres for the experiment.

SILICA FUME: Silica fume is a byproduct of produced while manufacturing of ferrosilicon alloys or silicon metal. Because of its physical and chemical belongings, it is widely used in concrete production. Concrete having silica fume have the property of high strength and more durability. These are very reactive pozzolona and also ultrafine material with spherical particles.

CHEMICAL ADMIXTURE: Chemical admixtures are the admixtures added to concrete to enhance the concrete properties. there are many types chemical admixtures they are accelerators, retarders, air-entraining agents, water-reducing agents, and plasticizers (Super plasticizers). Here we used super plasticizer to increase the workability/reduce the water content and also to reduce the air voids in present experiment.

METHODOLOGY

Different tests were conducted in this experimental program to study the effect of addition of Silica Fume and Steel Fibre as a percentage from cement in concrete mix design respectively. The 3 main groups of specimens were standard cubes and standard cylinders and beams. The first group of concrete tests performed to study the result of Silica Fume and Steel fibres in concrete compressive strength, where the second concrete investigation was concerned with studying the result of Silica Fume and Steel fibres in concrete fibres in concrete tensile strength. And third is to know the flexural strength of the concrete. In each case of study three different percentage of Silica Fume 5%, 10%, 15%, 20% and Steel Fibre were used 1%. Trial mix was prepared as per IS 10262 - 2019.

Mixes are prepared as per the procedure and these Mixes are named for convenience that are M1, M2, M3, M4, M5.

IV. EXPERIMENTAL RESULTS

The tests which are required for this experimental investigation were conducted as per procedure and the results obtained from the tests are shown in table and graphs below:

4.1 WORKABILITY

Table 4.1 Workability test				
Concrete Mix	Workability (mm)			
M1	110			
M2	85			
M3	75			
M4	70			
M5	65			

|| Volume 10, Issue 9, September 2021 ||

|DOI:10.15680/IJIRSET.2021.1009101|



Fig 4.1 Workability in mm

The workability of the M30 grade concrete in the present investigation is measured by slump test. The workability of the control specimen is high ie., the slump value of the specimen in 110mm, while that of the concrete mixes which have silica fume and steel fibre have less workability. The workability of concrete will reduce as the percentage of usage of silica fume is higher. Concrete mix M5 has the least workability (65mm) as shown in fig 4.1

4.2 COMPRESSIVE STRENGTH TEST AFTER 7 DAYS

Concrete Mix	Trial 1	Trial 2	Trial 3	Avg Compressive Strength (MPa)
M1	25.78	25.33	24.89	25.33
M2	33.33	34.67	33.78	33.93
M3	35.56	36.44	37.33	36.44
M4	35.11	33.78	34.67	34.52
M5	31.11	32	31.56	31.56

Table 4.2 Compressive Strength (MPa) After 7 days of curing for Cube



Fig 4.2 Compressive Strength (MPa) After 7 days of curing for Cube

In the present investigation, the compressive strength of M30 grade concrete is done with the help of CTM. 7th day compressive strength of control mix (M1) is low that is 25.33 MPa. The strength of concrete has increased after

International Journal of Innovative Research in Science, Engineering and Technology (IJIRSET)

L IJIRSET | e-ISSN: 2319-8753, p-ISSN: 2347-6710| <u>www.ijirset.com</u> | Impact Factor: 7.569|

|| Volume 10, Issue 9, September 2021 ||

DOI:10.15680/IJIRSET.2021.1009101

the addition of steel fibre and silica fume. The maximum strength is observed for concrete mix M3 that is 36.44 MPa. After which if the further increase in silica fume will leads to decrease in strength

4.3 COMPRESSIVE STRENGTH TEST AFTER 28 DAYS

Table 4.3 Compressive Strength (MPa) After 28 days of curing for Cube

Concrete Mix	Trial 1	Trial 2	Trial 3	Avg Compressive Strength (MPa)
M1	39.11	40	39.56	39.56
M2	46.67	47.11	46.22	46.67
M3	49.78	49.33	50.22	49.78
M4	48.44	47.56	48	48
M5	45.33	46.67	45.78	45.93



Fig 4.3 Compressive Strength (MPa) After 28 days of curing for Cube

In the present investigation, the compressive strength of M30 grade concrete is done with the help of CTM. 28th day compressive strength of control mix (M1) is low that is 39.56 MPa. The strength of concrete has increased after the addition of steel fibre and silica fume. The maximum strength is observed for concrete mix M3 that is 49.78 MPa. After which if the further increase in silica fume will leads to decrease in strength

4.4 SPLIT TENSILE STRENGTH TEST AFTER 28 DAYS

Concrete Mix	Trial 1	Trial 2	Trial 3	Avg Tensile Strength (MPa)
M1	3.54	3.82	3.68	3.68
M2	4.67	4.39	4.53	4.53
M3	4.81	4.53	4.95	4.76
M4	4.39	4.24	4.1	4.24
M5	3.96	3.82	4.24	4.01

Table 4.4 Split tensile strength after 28 days of curing



|| Volume 10, Issue 9, September 2021 ||

|DOI:10.15680/IJIRSET.2021.1009101|





In the present investigation, the tensile strength of M30 grade concrete is done with the help of CTM. 28th day tensile strength of control mix (M1) is low that is 3.68 MPa. The strength of concrete has increased after the addition of steel fibre and silica fume. The maximum strength is observed for concrete mix M3 that is 4.76 MPa. After which if the further increase in silica fume will leads to decrease in strength

4.5 FLEXURAL STRENGTH TEST AFTER 28 DAYS

	Table 4.5	Flexural	strength	after 2	28 days	of curing
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Concrete Mix	Trial 1	Trial 2	Trial 3	Avg Flexural Strength
M1	4.88	5.12	4.98	4.99
M2	5.82	5.88	5.94	5.88
M3	6.34	6.22	6.26	6.27
M4	5.94	5.9	5.86	5.9
M5	5.7	5.66	5.69	5.68



Fig 4.5 Flexural strength after 28 days of curing

In the present investigation, the flexural strength of M30 grade concrete is done with the help of UTM. 28th day flexural strength of control mix (M1) is low that is 4.99 MPa. The strength of concrete has increased after the addition of steel fibre and silica fume. The maximum strength is observed for concrete mix M3 that is 5.88 MPa. After which if the further increase in silica fume will leads to decrease in strength

International Journal of Innovative Research in Science, Engineering and Technology (IJIRSET)

| e-ISSN: 2319-8753, p-ISSN: 2347-6710| www.ijirset.com | Impact Factor: 7.569

Volume 10, Issue 9, September 2021

| DOI:10.15680/IJIRSET.2021.1009101 |

V. EXPERIMENTAL RESULTS

- Based on the results obtained by conducting tests for various mixes (M1, M2, M3, M4, M5.) following conclusions are obtained.
- Reduction in workability takes place if Silica fume is used as the partial replacement of cement because it prevents concrete flow due to micro particles and addition of Steel fibres affects the flow of concrete and thus reduces the workability.
- > As the silica fume is a highly pozzolonic material and as it fills air voids results in formation of dense concrete.
- As the steel fibres placed randomly it gives support in all direction to concrete and hence it enhances the strength properties of concrete.
- To achieve better strength properties, the optimum dosage of 10% of silica fume is recommended for SFRC which 1% of steel fibre by volume.
- By using the optimum dosage of Silica fume and 1% steel fibre in the concrete, the compressive strength of concrete will increase by 43.86% for 7 days of curing and 25.83% for 28 days of curing
- By using the optimum dosage of Silica fume and 1% steel fibre in the concrete, the Tensile strength of concrete will increase by 29.34% for 28 days of curing
- By using the optimum dosage of Silica fume and 1% steel fibre in the concrete, the Flexural strength of concrete will increase by 25.65% for 28 days of curing

SCOPE FOR FUTURE STUDY

- The present experimental investigation is done for M30 grade concrete. Hence, further study can be carried out using other grades of concrete.
- Percentage of variation of silica fume replacement can be reduced and check the exact optimum dosage for adjacent values to optimum dosage obtained.
- Durability tests such as acid attack sulphate attack tests can be carried out by using optimum dosage of silica fume obtained in the present experiment.
- ➢ By keeping the silica fume quantity constant (optimum dosage value obtained), steel fibres quantity can be varied and tests to be conducted to find the optimum dosage of steel fibre.
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Volume 10, Issue 9, September 2021

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