Effects of steel fibers and Silica fume on Compressive and flexural Strength of pavement Concrete.

Submitted in partial fulfilment of the requirements

of the degree of

MASTER OF TECHNOLOGY

in

CIVIL ENGINEERING

by

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School of Civil Engineering

LOVELY PROFESSIONAL UNIVERSITY, PHAGWARA

2017

DECLARATION

I, Faisal Farooq (11207362), hereby declare that this thesis report entitled **"Effects of steel fibers and Silica fume on Compressive and flexural Strength of pavement Concrete."** submitted in the partial fulfilment of the requirements for the award of degree of Master of Civil Engineering, in the School of Civil Engineering, Lovely Professional University, Phagwara, is my own work. This matter embodied in this report has not been submitted in part or full to any other university or institute for the award of any degree.

Date: FAISAL FAROOQ

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CERTIFICATE

Certified that this project report entitled "**Effects of steel fibers and Silica fume on Compressive and flexural Strength of pavement Concrete.** " submitted individually by student of School of Civil Engineering, Lovely Professional University, Phagwara , carried out the work under my supervision for the Award of Degree. This report has not been submitted to any other university or institution for the award of any degree.

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ACKNOWLEDGEMENT

This project consumed a huge amount of work, research and dedication. Still, finalization would not have been possible if I did not have a support of many individuals and fellow colleagues. Therefore I would like to extend our sincere gratitude to all of them.

First and foremost I would like to thank my parents for their kind co-operation, encouragement and supporting me morally and financially all through the project.

I would like to thank and express my deepest gratitude to the following people:
Mrs Niharika Gupta, School of Civil Engineering. Lovely Professional University.
Ms.Ambika Thakur, Assistant Professor, Civil Engineering Department, Lovely Professional University.
Mr.Sanjay Verma, Laboratory Assistant, Civil Engineering Department Lovely Professional University.

I would like to give my special thanks and gratitude to my mentor and advisor:
Mr. Nitin Bhardwaj, Assistant Professor, Civil Engineering Department, Lovely Professional University for his guidance, for giving me the opportunity to do research and providing invaluable guidance throughout this research. His dynamism, vision, sincerity and motivation have deeply inspired me. He taught me the methodology to carry out the research and to present the research works as clearly as possible. It was a great privilege and honor to work and study under his guidance.

Signature of Student

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ABSTRACT

Due to high strength, durability, economy and better serviceability there is a growing interest in the construction of concrete pavement. The main concentration nowadays is towards the production of thinner and green pavements of good quality which can sustain much heavier loads. High strength steel fibre concrete with partial replacement of cement with silica fume is a concrete that possesses strength greater than 50 MPa and is made of hydraulic cement, silica fume, fine and coarse aggregates and unconnected, discontinuous, randomly distributed steel fibres which allows it to attain noteworthy compressive as well as flexural strength. The aim of this study was to develop high strength steel fiber reinforced pavement quality control mixture including silica fumes as a partial replacement to cement.

For this research, 54 cubes with dimensions 150x 150x 150mm were casted to test the compressive strength with varying steel fiber and silica fume percentage after 7, 28 and 56 days. To test the flexural strength 36 concrete beams (15cm x 15cm x 75cm) were casted using varying percentages of silica fumes and steel fibers using twisted end undulated steel fibres in the concrete. The flexural strength test was done after 7 and 28 days of curing.

From the studies it was found that there is almost 25.15% increase in the compressive strength of concrete with 10% silica fumes with 1% steel fibers after 28 days of curing against plain concrete without silica fumes and fibers.

There was a 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. Hence 10% silica fumes with 1% steel fibers is the optimum percentage recommended for achieving maximum compressive as well as flexural strength.

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CA	Coarse aggregates
FA	Fine aggregates
FRP	Fibre reinforced polymer
GFRP	Glass fibre reinforced polymer
CFRP	Carbon fibre reinforced polymer
PPC	Pozzolana Portland cement
Min	Minutes
mm	Millimetre
Sec	Second
^oC	Degree Celsius
ml	Millilitre
kg	Kilogram
%	Percent
Cum	cubic metres
kg/m^3	Kilogram per metre cube
MPa	Mega-pascal
$V_f\%$	Steel Fiber percentage

CHAPTER 1

INTRODUCTION

1.1 General

During the last decade there has been an exponential increase in the number of vehicles plying on the roads. With the increase in the population as well as with technological advancements, more and more vehicles are added to the current stream of traffic which contribute to high loads on the pavements. Flexible pavements have a low design life.

On the other hand, rigid pavements play an important role in the modern high density traffic as it has a longer design life. The loads which are transferred to the rigid pavements are distributed evenly, hence they last long and need lesser maintenance as compared to flexible pavements.

In rigid pavement due to the cost of reinforcements as well as the construction method, it is costlier\than the flexible pavements.

In rigid pavements the basic fault is seen as the cracking due to the compressive loads which eventually deepens. These cracks widen and result in the failure of the pavement. So in order to deal with these faults, significant research has been done to increase the compressive and flexural strength of the pavement quality concrete.

Fibers are added into the concrete to reduce this cracking and improve the flexural as well as tensile strength of concrete. Silica fumes are added to act as a finer substrate which increases the density by decreasing the pores in the finer aggregates. And hence eventually increases the compressive strength of concrete. Steel fibers incorporated in the concrete tends to fasten the cracks that are induced in the pavement concrete. It holds to the concrete matrix and thus prevents the cracks to spread into the pavement. These steel fibers added during the mixing of concrete gets distributed in all directions and hence increase the flexural strength of the concrete significantly.

Rigid pavements have a greater significance in the areas where there is high loading such as airports, docks, and bus stands etc

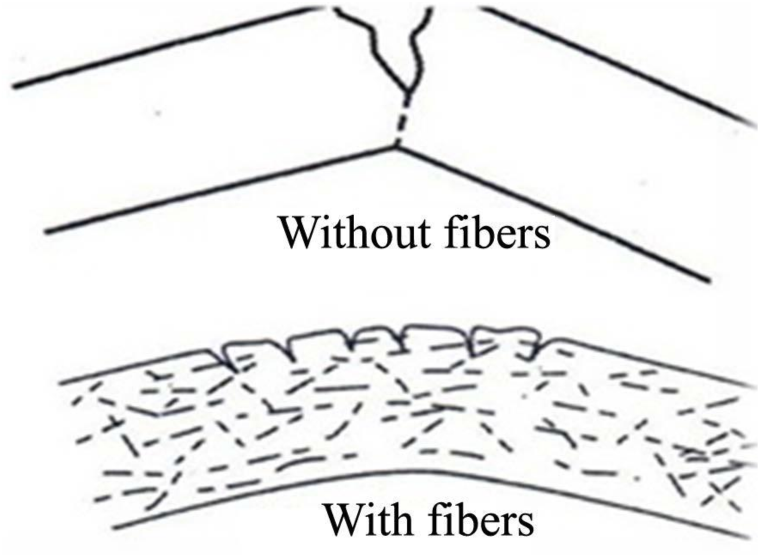


Figure 1.1: Failure mechanism of pavement and the "effect of fibers".

Steel fibers are considered to be the wastes from steel manufacturing industries. Arranging mechanical waste materials is one of the best natural challenges. Significant innovation can offer a few applications in the re-use of some of the wasted mechanical wastes. Since the light-weight forged aggregates (LWAs) usually bring down the strength of the distinctive aggregates, concrete, including the LWA with the mechanical waster such as steel fibers may increase the mechanical properties compared to the normal mix.

In such cases, to enhance the mechanical property of concrete containing some used aggregates(recycled concrete), some mineral mixtures can be used at the same rate to maintain the strength.

For example, silica fume noticeably changes both the strength and mechanical properties of concrete. It is known today silica fume as a result of all of the silicon metal and alloy industry, a combination of iron and silicon, rather than waste component, and increased use in concrete innovation lately. It has acquired the major use of silica fumes and nano silica in the concrete for the year 1952 by the norwegian Scientist. It was just in the late 1970s that the silica fume began to be used as an adhesive in the supplementary concrete in Scandinavia. It was not until the mid-1980s they began to be used as part of the length of these lines in North America.

Turned the use of silica fumes in the creation of high-strength concrete (HSC) is mandatory in the case, because of the significant improvements achieved in the interface area of the cement paste aggregate. Extracting fume from silica (<1 LM) is very fine particles and increases the strength of the glue bond between the cement and the total area by making interfaces more thick. Presumably in addition to a vital part of the expansion of the mechanical strength of the concrete in the light of the existence pozzolonic movement. Specifically, not a replacement of cement. Moreover super softness to it. In this way, silica fume is for the most part used in addition with a super plasticizer to control the workability. Silica fume permits high-strength concrete, however, it causes the concrete has a structure more fragile. In this way, enhance the usability of the concrete turns into a noteworthy case of high-strength concrete. Fiber used as part of the concrete to increase the maximum absorption of vital concrete and to give more flexibility for the concrete structure especially for the rigid pavements.

It can be seen as a fundamental property of steel fibers for concrete after the network mesh formed inside the concrete mix. Steel fibers circulating in the arbitrary directions in the concrete matrix act as inhibitors to the cracks that are developed at the surface

These types of materials are useful if you need to retain many of the reduction is vital to reduce the disappointment fragile. Fiber type, and the proportion of angle (length / width), and the division of the size and tensile strength of the fibers, the withdrawal of the resistance and the introduction of fiber in the very framework as the impact of the network implementation SFRC force. SFRC has a wide range of bands to use, for example, and sidewalks and overlay, modern flooring prefabricated elements, pressure-driven marine structures, Since a large concrete changes on their property, and kept silica fumes to be the most profitable metal mixture commonly used among Buz materials and utensils in innovation concrete and cement. Then again, the advantage of steel fiber has incredibly concrete by enhancing its flexibility commitment. Along these lines, it was noted unequivocally that both silica fume and steel fiber is a material that can not be avoided to be used for more high-strength concrete flexible..

1.2 Silica Fume in Concrete

Silica (also known as silicon dioxide, small) is one of the side effects of quartz and silicon reduce coal, iron and silicon composite material, when the peak electric heater flawlessly. Given the extraordinary precision and a high proportion of silica

Silica is a material viable unusual ash. Silicon is used as part of the gray concrete to improve its performance, such as compressive strength, adhesive strength and scratch resistance area, and the reduction of the porosity, along these lines, and also helps to protect the rebar consumption.

1.3 Utilization of Steel Fiber in Concrete

It is important to build up the concrete of unique properties. Portland Pozzolona cement concrete has a low tensile strength, constrained pliability and little imperviousness to splitting. Inward smaller scale breaks are characteristically present in the concrete and its poor tensile strength is because of spread of such miniaturized scale breaks, prompting to fragile disappointment of concrete.

Promote the need to meet the needs of ordinary concrete. With the increase in the strength of concrete, it increases the fragility of the concrete. This is to reduce the vulnerability and fragility through the inclusion of steel fibers in concrete mixture. These fibers help in the exchange of breaks for small internal loads, this is known as fiber-reinforced concrete. Received a steel reinforced concrete (SFRC) a variety of applications, in particular, the mechanical floors, connected by decks, sidewalks, water and marine installations, prefabricated elements, and the reform of the atomic containers and restoration project, recognized the impact structures. Add to that the steel fiber concrete concrete construction properties, such as tensile strength, compressive strength, impact strength, flexibility and durability.

Increase strength, elastic modulus high, flexibility, softness sufficient basic prerequisite steel fiber security Association large and complex and the strength of reinforced concrete at the intersection of mechanical properties of the fibers ratios transparent measurement of the intensity of the network method, the size, shape, and examples of fiber preparation, as well as the overall dimensions.

1.4 Need of the Study

As far as the rigid pavements are considered, their utilization is increasing day by day due to the vast field of applications, like harbours air strips, bus stands and other heavily traffic loaded areas. Various experiments have been done in this regard to increase the compressive as well as the flexural strength of the pavement quality concrete.

This study is essential in the way so as to study the effective strength of concrete with the addition of silica fumes with the introduction of steel fibers. Silica fumes is known to increase the density and hence the compressive strength of concrete. On the other hand steel fibers intend to increase the flexural strength, this reduces the tension in the pavement concrete, and hence the cracks developed in the cracks under the heavy loading. Hence this study intends to solve the major problem of cracking in the concrete pavements as well as increasing the overall strength of concrete.

CHAPTER 2

LITERATURE REVIEW

2.1 Recent studies

The accompanying conclusions can be attracted understanding with the test comes about exhibited:

(Gesogulu et al. 2012) The generation of concretes made with ice-strengthened units fly slag having appropriate mechanical properties over the fact that it was possible by the addition of silica fume and steel fibers. Using the SF as a substitute material provides improved mechanical properties when contrasted with plain concrete for any w/c ratio. The most striking quality of the quality of compression was measured as 49.2 and 34.3 MPa for w/c ratio of 0.35 and 0.75.

Adding steel fibers exhibited an exceptional change in the conduct and stiffness within the concretes investigated. Steel fibers with a higher length / promising proportions contributed further change in the conduct and limits rigidity than the one with lower proportions. However, when considering the quality of the compression it was only slight contrast between the upper and lower steel fibers proportion of fused concrete. This difference in behavior of steel reinforced concrete can be attributed to scattering and introduction of steel fibers.
The addition of 0.7% of the volume of steel fiber concrete was much more mobile than the 0.2% strength additive, rather than relying on the steel fibers and joining SF. Measurable study found that the w / w proportions, sort and measure the steel fibers and the consolidation of all components of the SF-grounded at different levels on the mechanical properties of concrete. In particular, for proper adherence and flexural quality measure steel fibers have better effect. Moreover, joining SF was measurable ultimately be conclusive on the mechanical properties of concretes.

(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.

At steady rate of fiber =1%, it is seen that the flexural quality is increased 85% when contrasted with plain concrete quality. The consistent rate of steel fiber (1% arbitrarily blend) is tried against various rate of silica fume (5%, 10%, and 15%), the flexure quality is increases when we indicate 5% of silica fume past that flexure quality abatements.

The consistent rate of steel fiber (1% at specific profundity) is tried against various rate of silica fume (5%, 10%, and 15%), the flexure quality is increases when we mean 5% of silica fume past that flexure quality abatements.

The asphalt thickness is discovered utilizing IRC-58, the 75% lessening in thickness of asphalt utilizing steel fibers.

(H.M.Somase kharaiah et al. 2015): In this review led on asphalt quality concrete, It is watched that at 10% replacement of cement by silica fume flexural quality increases more than 0% silica fume . Additionally increase in silica fume by 20% the flexural quality reduction more than 0% silica fume . Subsequently the greatest replacement of cement by admixture silica fume is 10%. As W/B proportion increases the flexural quality reductions. It is watched that the 28 days flexural quality increases with increase in composite fibers.

10% silica fume can be taken as Optimum measurements, which can be utilized as a fractional replacement to cement for giving most extreme conceivable compressive quality at any age for composite fibers (steel and polypropylene) reinforced superior concrete.

Addition of composite fibers (steel and polypropylene) enhances the pressure solidifying impact significantly and this increase the bond strength of reinforced bars in composite fiber reinforced concrete than in plane concrete.

1.25% composite fiber volume can be taken as the ideal dose which can be utilized for giving greatest conceivable compressive quality at any age for steel fiber reinforced elite concrete. Composite fibers increase the compressive quality of concrete furthermore opposes the sudden crumple of the solidified concrete.

From trial comes about, the ideal rate suggested as 1.25% composite fiber volume with 10% silica fume for accomplishing greatest advantages in compressive quality, flexural quality and split rigidity.

(Handong Yan et al. 1999): Significant increase are achieved with cement replacement, marble dust with cement, which is therefore saving the future also. Maximum strength (bending, compressive and split tensile) quality marble pavement incorporating concrete steel fibers and dust, as is achieved with 10% marble dust

Replacement and 1% steel fibers. However, if the marble dust content increases to 20%, even at 1% steel fibers, then The increase is not very large.

In addition, it became possible to achieve economies of its cement replacement of marble dust and other fibers. This study also shows that, given the higher split tensile strength levels,

flexural strength, compressive strength, higher life span and higher load carrying capacity.

(Rafat Siddique et al. 2011): Addition of silica fume increases the 28-day compressive quality.

Silica fume does not have noteworthy impact on the splitting tensile quality of concrete. Silica fume appeared to pronouncedly affect flexural quality in correlation with splitting tensile quality.

(P. Ramadoss 2013): In view of the experimental review on high-quality steel fiber reinforced pavement concrete, the accompanying conclusions are drawn:

The normal rate picks up in the splitting tensile quality of silica fume concrete as for control were acquired as 9.4% and 18.9% at 5% and 10% SF replacement, separately.

The addition of steel fibers by 1.5% volume portion (RI=3.88) brings about an increase of 56% in the splitting tensile quality contrasted and concrete grid.

(Engin Yener et al. 2011) : The connection between 28-day splitting tensile quality and pressure quality of SFRC was created, and found to give great expectations with the test information of prior inquires about its strength characteristics.

The review has shown that more solid and stronger pavement concrete can be acquired with a reasonable blend of OPC, steel fibers and SF.

The experimental outcomes in the present test conditions have demonstrated that utilizing fly fiery remains just abatements while SF just marginally increases 28 days flexural quality.

Then again, utilizing SF and FA together shows generally more quality pick up. Among every one of those tried, greatest 28 days flexural quality of 4.53 MPa is gotten for the blend extents of 84% OPC + 10% FA and 5% SF+ 1% steel fibers.

(Aquib Sultan Mir 2016): Concrete blend with 10 percent marble clean as replacement of cement is the ideal level as it has been seen to demonstrate a noteworthy increase in compressive quality at 28 days when contrasted and ostensible blend. Concrete blends when reinforced with steel fiber demonstrate an increased compressive quality when contrasted with ostensible blend.

The split tensile quality likewise tends to increase with increase rates of steel fibers in the blend.

The flexure quality likewise tends to increase with the increase rates of steel fibers, a pattern like increase in split tensile quality and compressive quality.

(Toutanji 1999): Consequences of the experimental review on the properties of fiber reinforced silica fume extensive cement concrete FRSFEC were exhibited in this paper. The accompanying conclusions can be drawn:

Silica fume seemed to adversly affect the workability of fiber concrete.

The addition of 5% silica fume created a little decline in extension and a comparative increase in drying shrinkage. This impact was more affirmed with the addition of 10% silica fume.

The utilization of 5% silica fume brought about enhancing the security quality between the new sweeping cement concrete as a repair material to the old traditional concrete as a substrate

The rate of increase in security quality diminished with expanding silica fume content from 5 to 10%.

In view of the test outcomes exhibited in this paper, it was inferred that a blend outline with 5% silica fume and 0.30% fiber volume division was ideal in diminishing penetrability while keeping up a sufficient workability.

CHAPTER 3

RATIONALE AND SCOPE OF THE STUDY

Isolate investigates been performed for both of these materials for the change of strength of pavement concrete, yet this exploration was a hybrid research attempt to assess the powerful strength under the variable rates of these materials in pavement concrete. Various researches for the addition of admixtures like silica fume, fly slag, diverse fibers and so on in pavement concrete has been in advance since most recent two decades and research is as yet continuing attributable to the differed uses and addition of fresher materials and modern requirement of high strength concrete pavements.

This research was specifically intended to study the behaviour of improving both the flexural as well as compressive strength together which will significantly improve the overall lifetime of pavement and decrease the pavement thickness.

CHAPTER 4

OBJECTIVES OF THE STUDY

The objectives of the fundamental research project are as:

- To accomplish a more sturdy and higher strength concrete by a reasonable mix of Ordinary Portland Cement (OPC), SF and steel fiber.
- To determine a proper mix proportion with which workability will be maintained without compromising on the strength of comcrete.
- To increase the flexural strength of the concrete and which will diminish the splits in pavement and widening of pores in rigid pavements under high loads.
- To obtain an optimum dosage of silica fume and steel fibers upto which there will be significant increase in both the compressive and flexural strength.

CHAPTER 5

METHODOLOGY AND RESEARCH PROCESS

5.1 MATERIAL USED:

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

5.1.1 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.

5.1.2 Aggregates

The coarse aggregate where 12-20 mm in size brought from a local crusher plant in Phagwara Punjab and fine aggregate river sand bought from a local vendor from the same place with fineness modulus 2.389 confirming to Zone III.

5.1.3 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.

5.1.4 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.

5.1.5 Admixture

Auramix 200 high performance super plasticizer with low viscosity based on polycarboxyclic base was used in this project. This admixture has been developed for high pumpable concrete and SCC by Fosroc chemicals. It is light yellow coloured with PH of 6 .0 and 0 % chloride content. Reduces sensitivity to variations in moisture content in aggregates. Eliminate segregation and bleeding in mixes. Reduces pump pressure by decreasing plastic viscosity of concrete while keeping homogeneity and thereby reducing friction.

5.1.6 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.

5.2 METHODOLOGY:

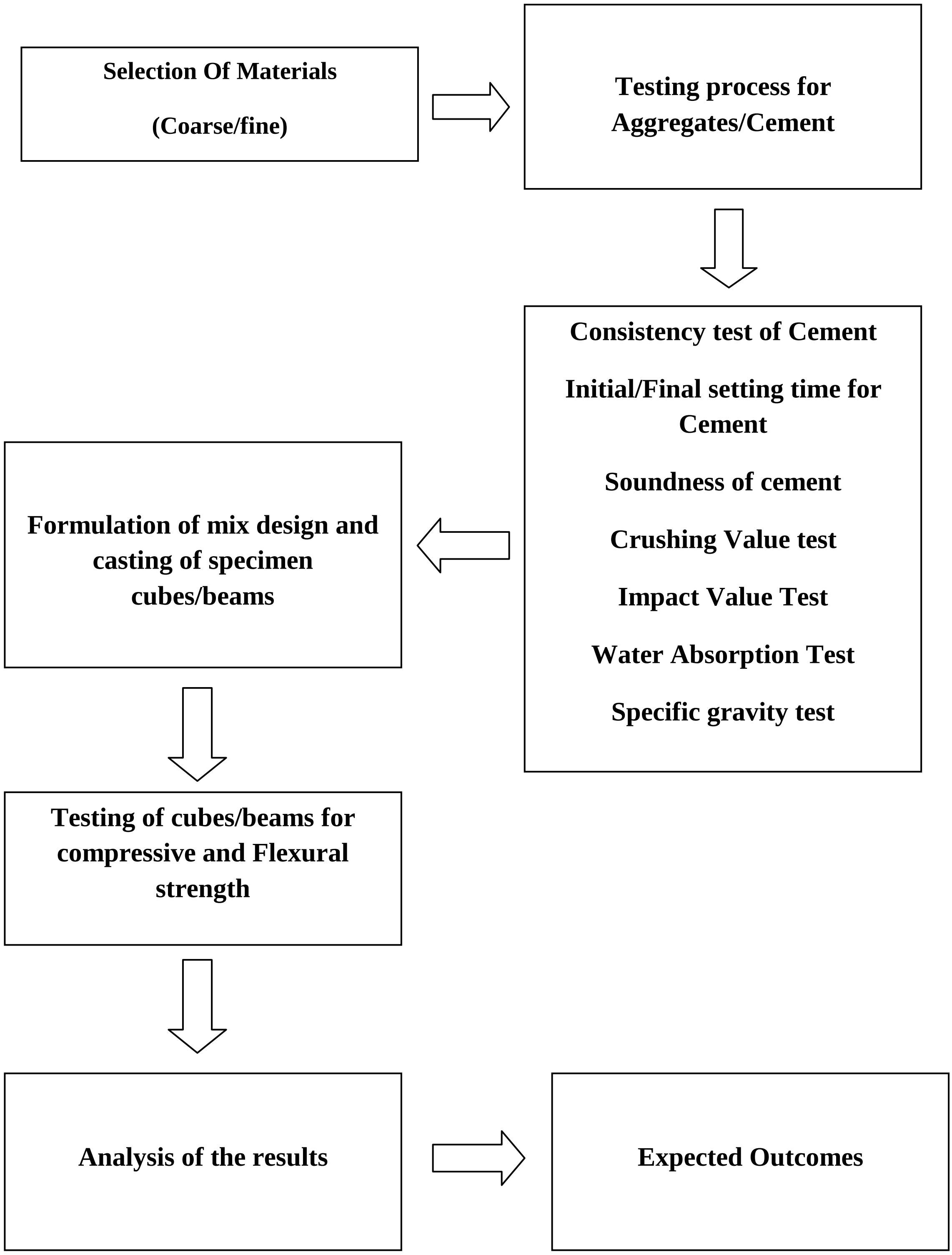


Fig 5.1: Flowchart for the overall testing process.

5.2.1 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 pavement 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 fibres 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 was distributed all over the concrete mix.

Figure 5.2: Specimen for compressive and flexural test.

For this research, 54 cubes with dimensions 150x 150x 150mm were casted to test the compressive strength with varying steel fiber and silica fume percentage after 7, 28 and 56 days. To test the flexural strength 36 concrete beams (15cm x 15cm x 75cm) were casted using varying percentages of silica fumes and steel fibers using twisted end undulated steel fibres in the concrete. For the flexural strength, to check the strength of the control mix, 3 beams without steel fibres and silica fumes were casted to compare our results with the silica fume with steel fibre reinforced concrete. This experiment required lot of trial work needed to find out the maximum strength at optimum quantity of steel fibres as well as optimal percentage of silica fumes. In order to determine that, the optimum quantity of steel fibres 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 and steel fibers will be varied accordingly. The cubes/beams will be casted for testing after curing for 7, 28 and 54 days.

5.2.2 Mix design:

Table 5.1: Mix Design Of M-30

S.No	Material	Kg/m^3
1.	Cement	435.89
2.	Coarse Aggregate(20mm)	761.74
3.	Coarse Aggregate(10mm)	400
4.	Fine aggregate	712.04
5.	Super Plasticizer	5.23
6.	Silica Fumes	Varied
7.	Steel Fiber	Varied
8.	Water	165.64

For any other type of concrete, depending on the specific mixing conditions SFRC along with silica fume it has to be designed so as to maintain the strength as well as the workability which is decreased by the addition of fibers and silica fumes both. There are several methods for determining the optimum fiber and silica fume content in SFRC, emphasizing on the subsequent target strength of the mix. Yes, because it may be, there exist some. In general, the higher the SFRC mixture contains cement material, and the ratio of fine to coarse ordinary concrete, containing a large proportion of the total, and is therefore suitable for conventional concrete mixing systems for the program may not all SFRC material. Periodically, in order to reduce the amount of cement, up to 35% of the cement replaced with fly pieces of a fire. Moreover for the higher amount of fibers in order to improve the workability of the mixture, the mixture often use less water, hence superplasticizers are used to improve the workability of the concrete by maintaining the water cement ratio.

Target strength = Compressive strength+1.65×ɠ(s)

ɠ(s)= 5(for M30 mix design)

So target strength = 30+ 1.65(5) = 38.25N/mm^2

Mix design properties:

Table 5.2: Different Mix Design Properties

Mix No.	W/(C+SF)	W (kg/m^3)	Cement (kg/m^3)	S.F (kg/m^3)	C.A (kg/m^3)	F.A (kg/m^3)	V_f%	V_f (kg/m^3)	Slump
1	0.38	165.64	435.84	0	1161.74	712.03	0.0	0	70
2	0.38	165.64	409.69	26.15	1155.93	712.03	0.5	5.8	56
3	0.38	165.64	400.97	34.87	1152.44	712.03	0.8	9.34	59
4	0.38	165.64	392.56	43.58	1150.10	712.03	1.0	11.61	43
5	0.38	165.64	383.54	52.30	1150.10	712.03	1.0	11.61	51
6	0.38	165.64	374.82	61.02	1150.10	712.03	1.0	11.61	45

Six design mixes were prepared having varying percentage of silica fime and steel fibers. Mix 1 is the control mix and is excluded of steel fibers and silica fumes. Water-cement ratio was maintained at 0.38.

V_f% represents the percentage of steel fibers which was varied from 0.5 to 1.0% for the compressive strength test.

5.2.3 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 3000 kN 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 and silica fumes were casted to compare our results with the steel fibre reinforced concrete. For this research, 54 cubes with dimensions 150x 150x 150mm were casted to test the compressive strength with varing steel fiber and silica fume percentage after 7, 28 and 56 days. To test the flexural strength 36 concrete beams (15cm x 15cm x 75cm) were casted using varying percentages of silica fumes 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 as well as optimal percentage of silica fumes. In order to determine that, the optimum quantity of steel fibres is tested against different percentages of silica fumes.

5.2.3.1 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. The results of compressive strength obtained in this project are shown in **Table 4**

5.2.3.2 Flexural Strength Test:

To determine the precise flexural strength an average of three samples were taken for every reading. The specimen size was fixed at 150*150*750 mm. The testing of specimens has been performed after curing period of 7 days and 28 days for both controlled as well as for beams with partial replacement of cement with fine aggregates with the addition of steel fibers. The results of flexural strength obtained in this project are shown in **Table 5**.

CHAPTER 6

RESULTS AND DISCUSSION

6.1 Slump Test of Specimen Mixes:

Slump test for the workability were performed on every mix design on fresh concrete and following readings were recorded:

Table 6.1: Slump cone Height

Mix No.	Silica fume (%)	Steel fibers (%)	Slump (in mm)
1	0	0	70
2	6	0.5	56
3	8	0.8	59
4	10	1.0	43
5	12	1.0	51
6	14	1.0	45

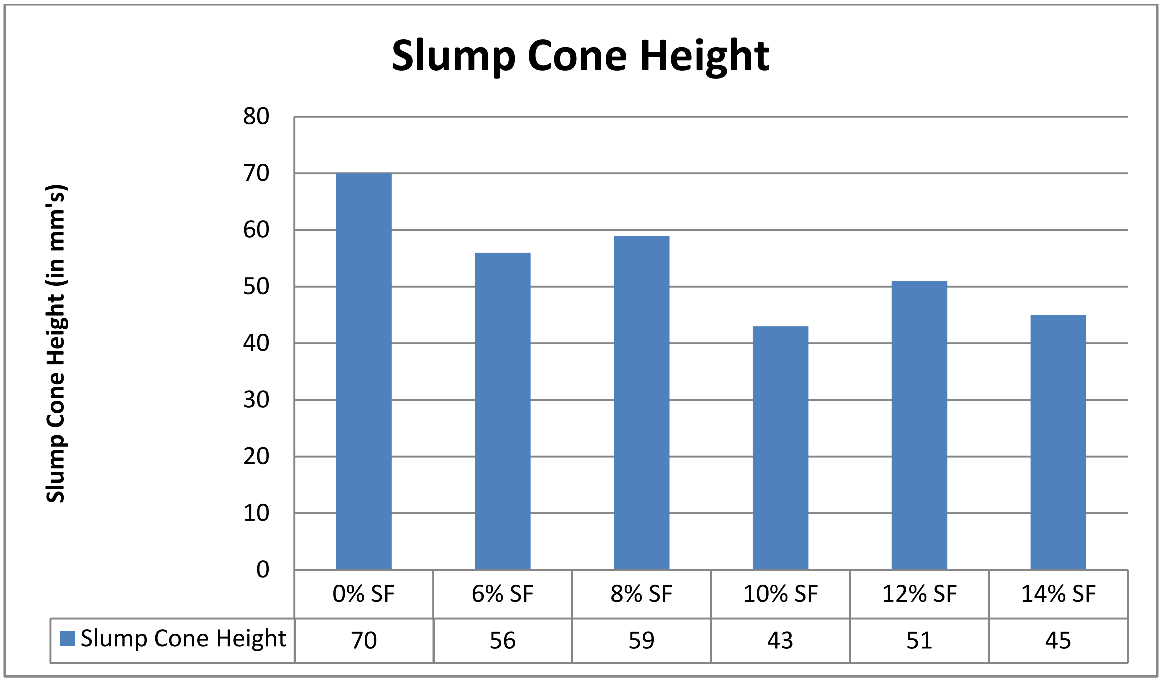


Figure 6.1: Slump Cone Height (in cm's) vs. Silica Fume %

The IRC recommended slump ranges from30-50mm. In the steel fiber reinforced concrete, as shown in the graph above, as we increase the percentage of steel fibers, the value of slump decreases as both the silica fume as well as steel fiber tend to decrease the workability of concrete. Super plasticizer was very effective in increasing the workability and maintaining the w/c ratio.

6.2 Compressive strength of sample cubes:

Calculations:

The readings for the compressive strength tests were as under:

Table 6.2: Compressive Strengths after 7, 28, 56 days of curing.

Mix No.	Silica fume (%)	7 Days(N/mm^2)	28 Days(N/mm^2)	56 Days(N/mm^2)
1	0	31.70	44.43	48.30
2	6	35.82	52.63	55.10
3	8	37.18	55.88	57.78
4	10	38.92	59.36	62.35
5	12	39.15	59.12	64.65
6	14	38.45	56.88	63.22

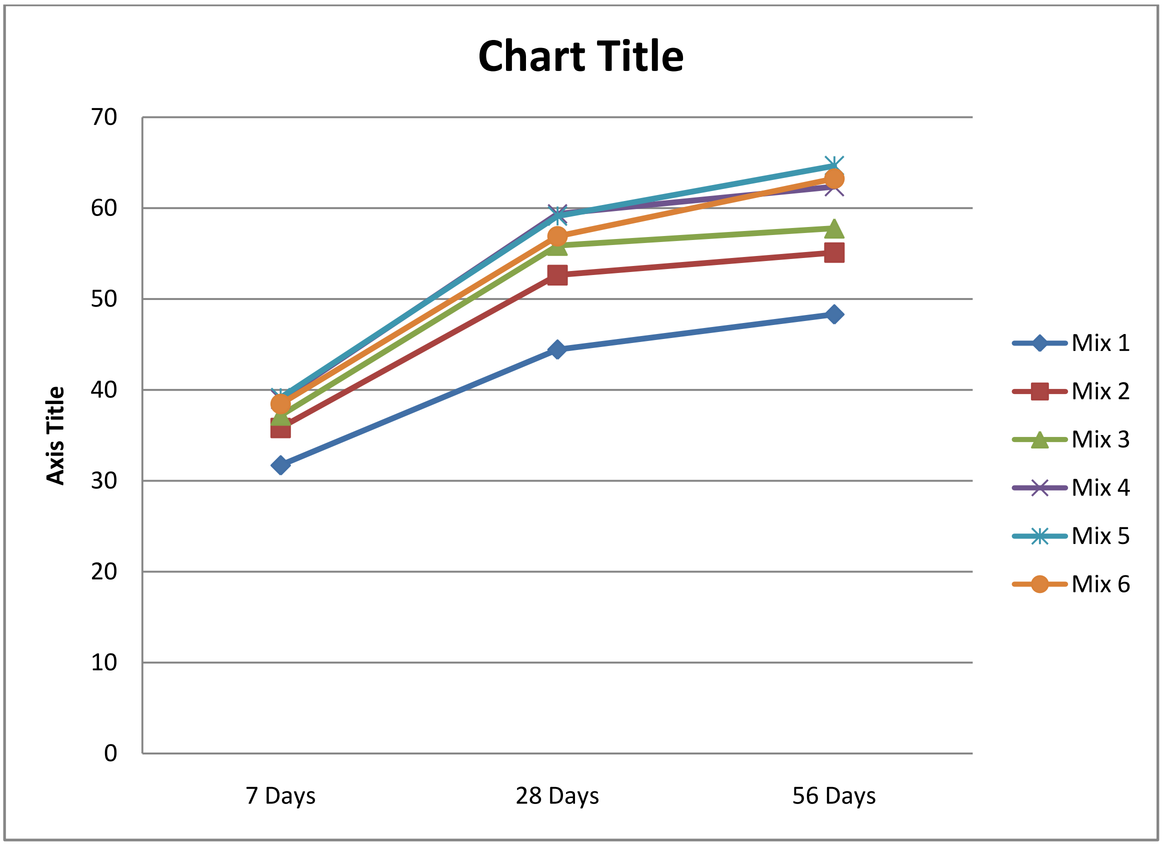


Figure 6.2: Compressive Strength vs. Days of Curing

The compressive tests were done for varying silica fume percentage as 6%, 8%, 10% 12% and 14 %. 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. From the study it is incited that there is almost 25.15% increase in the compressive strength of concrete with 10% silica fumes with 1% steel fibers after 28 days of curing against plain concrete without silica fumes and fibers.

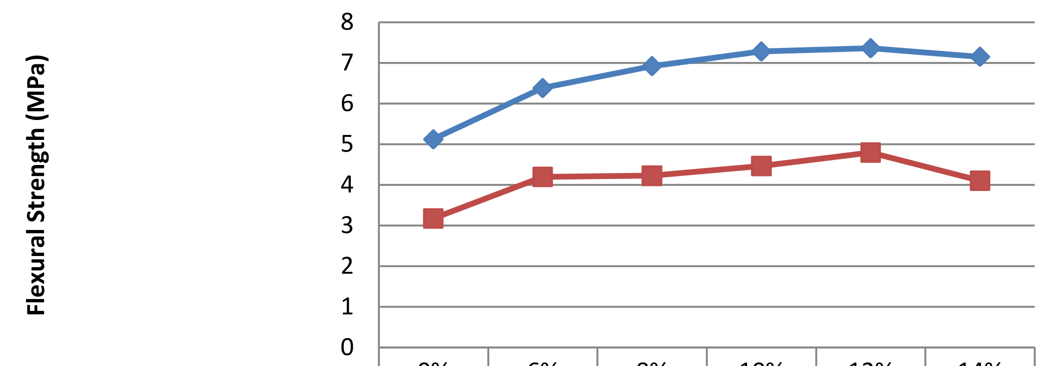
6.3 Flexural Strength of sample Beams:

The test to check the flexural strength was done with specimens with dimensions 150×150×750mm prismatic samples by using the two point beam testing machine as per ASTM C1018 standards.

Calculations:

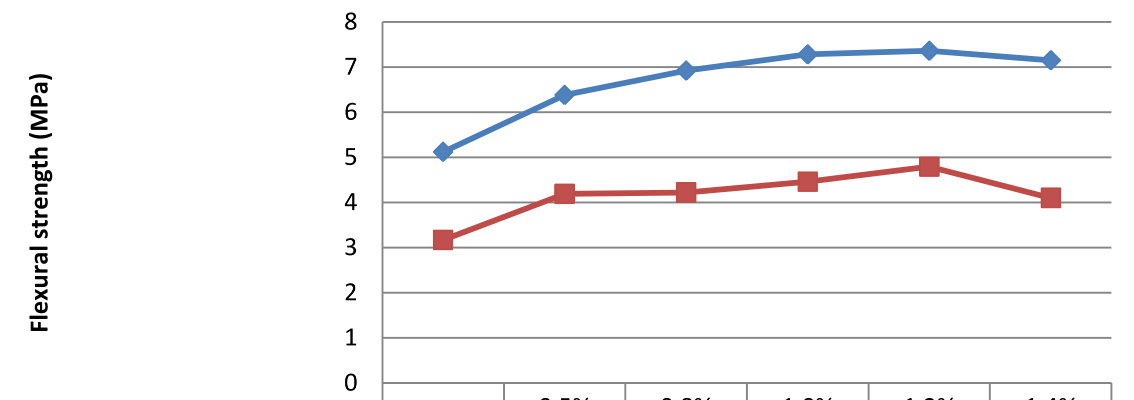
Table 6.3: Flexural Strength after 28 days

Mix No.	Silica Fume (%)	Steel Fiber (%)	Flexural Strength 7 Days (MPa)	Flexural Strength 28 Days (MPa)
1	0	0	3.17	5.12
2	6	0.5	4.19	6.28
3	8	0.8	4.22	6.73
4	10	1.0	4.46	7.18
5	12	1.2	4.79	7.23
6	14	1.4	4.10	7.05



	0% Silica fume	6% Silica fume	8% Silica fume	10% Silica fume	12% Silica Fume	14% Silica Fume
Flexural Strength after 28 days	5.12	6.38	6.92	7.28	7.36	7.15
Flexural Strength after 7 days	3.17	4.19	4.22	4.46	4.79	4.1

Figure 6.3: Flexural strength vs Silica Fume (%)



	0% Steel Fiber	0.5% Steel Fiber	0.8% Steel Fiber	1.0% Steel Fiber	1.2% Steel Fiber	1.4% Steel Fiber
Flexural Strength after 28 days	5.12	6.38	6.92	7.28	7.36	7.15
Flexural Strength after 7 days	3.17	4.19	4.22	4.46	4.79	4.1

Figure 6.4: Flexural Strength vs Steel Fiber Content(%)

There was a 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.

With 1% of steel fiber, the flexural strength was increased by about 29.18% after 28 days compared to plain concrete. With 1.2%, 1.4% there was no significant increase thereafter.

CHAPTER 7

CONCLUSIONS AND FUTURE SCOPE

For the rigid pavements the overall strength and the lifetime of a certain pavement depends on the flexural strength of the concrete and the resistance to the cracking developed due to surface loads over a period of time.

In this project both the flexural and compressive strength has been improved by the addition of silica fumes and steel fiber which will eventually result in the decrease of the pavement thickness as well as the lifetime of the pavement.

Following are the conclusions that can be drawn from this research:

1. The compressive tests were done for varying silica fume percentage as 6%, 8%, 10% 12% and 14 %. 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. Since 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. From the studies it was found that there is almost 25.15% increase in the compressive strength of concrete with 10% silica fumes with 1% steel fibers after 28 days of curing against plain concrete without silica fumes and fibers.
4. There was a 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. The increase in the compressive strength and flexural strength with addition of silica fumes and steel fibers together is considerably higher than the one containing only silica fumes or steel fibers.
6. 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 for fiber reinforced pavement concrete.

7. As silica fume was increased to 14% there was a decrease in compressive strength upto 4.17% against the optimum dosage at 10% of silica fume.
8. Hence 10% silica fumes with 1% steel fibers is the optimum percentage recommended for achieving maximum compressive as well as flexural strength.
9. With 1% of steel fiber, the flexural strength was increased by about 29.18% after 28 days compared to plain concrete. With 1.2%, 1.4% there was no significant increase thereafter.
10. With the addition of super plasticizer there was considerable increase in the workability of fiber reinforced concrete and reduced the w/c ratio with helped in attaining good compressive strength.

FUTURE SCOPE OF THE STUDY:

Further research can be done by studying the effect of steel fiber by placing at different depths in the concrete pavement.

Also by varying the aspect ratio as well as the diameter of the steel fibers tests can be done to see the effect of these characteristics on the flexural strength.

CHAPTER 8

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