STUDY ON CHRACTERISTIC STRENGTH OF PAVEMENT QUALITY CONCRETE ON PARTIAL REPLACEMENT OF CEMENT WITH SILICAFUME AND ADDITION OF 1% STEEL FIBRES

Submitted in partial fulfillment of the requirements of the degree of

MASTER OF TECHNOLOGY
in

CIVIL ENGINEERING

By

GURPREET SINGH
(11200877)

Supervisior

MR. PARIJAT HASIJA

School of Civil Engineering

LOVELY PROFESSIONAL UNIVERSITY, PHAGWARA
2017

CERTIFICATE

It is certified that the work contained in this Dissertation entitled **'STUDY ON CHRACTERISTIC STRENGTH OF PAVEMENT QUALITY CONCRETE ON PARTIAL REPLACEMENT OF CEMENT WITH SILICAFUME AND ADDITION OF 1% STEEL FIBRES'** submitted by GURPREET SINGH, REGD. NO-11200877 for the award of M. Tech is absolutely based on his own work carried out under my supervision and that the work is not submitted elsewhere.

Mr. Parijat Hasija

Supervisor

Assistant Professor

ACKNOWLEDGEMENTS

I would like to express my sincere gratitude to **Mr. PARIJAT HASIJA**, Assistant professor in Civil Engineering department, Lovely Professional University, Punjab for his consistent support, guidance and understanding throughout the course of the project work. Without his innovative thought this research would not have been possible. I acknowledge him for their great serenity, and useful thoughts apart from the valuable guidance.

I would like to thank my parents for their support and encouragement. Due respect to my parents and friends who stood by me to make my quest for knowledge a reality.

Finally, I would like to thank almighty for his gracious blessings during the tenure of my project work.

Date: Department of Civil Engineering

Place: LPU Punjab

ABSTRACT

In this study, the changes on some properties of concrete produced by the replacement cement with the silica fume and on the addition of the steel fibers will be examined. Use of steel fiber increases the capability of concrete to elongate or we can say with the addition of steel fiber the elasticity of the concrete increases. Due to the temperature stresses, the plastic and dry shrinkage result in the cracking which can be controlled by the usage of steel fibers.

The aim of this experimental study is to obtained a superior strength and economical concrete by the use of silica fume and steel fibers. The steel fibers having aspect ratios (fiber length/fiber diameter) of 65 are used in the experiments and volume fractions of steel fiber will be 0.5% ,1% and 1.5%. Additions of silica fume into the concrete will be range 0%, 5%, 10% and 15% by weight of cement content. It is found that the desired strength with partial replacement of silica fume with cement and with the addition of steel fiber is obtained in optimum percentage by weight. The use of steel fibers in the concrete volume is often limited to 1% because over this the dosage will not be much effective.

CONTENTS

LIST OF TABLES

LIST OF FIGURES

CHAPTER 1

INTRODUCTION

1.1GENERAL

There is a growing interest in the construction of pavement with the use of Pavement quality concrete (PQC) due to its high strength, durability and resistance to the impact. The word impact means a great toughness which is the primary requirement of runways .Mostly, the bound base layers are used for the construction. According to the Indian specification some of the example of these base layer used in the construction are dry lean concrete (DLC), roller compacted concrete (RCC) (IRC:15-2002)

Pavement quality concrete has its application in runways, expressways, toll plaza where the life span requirement is more than 30 years. PQC is connected with the discontinuous joints .The joint may be contraction joint, expansion joint, construction joint or wrapping joint.

The contraction joints are generally provided in the transverse direction to withstand with the contraction of concrete due to the temperature stresses. Expansion joints are also given in the same direction to allow the moment due to temperature variation. Wrapping joints are provided in the longitudinal direction to resist the wrapping of the concrete which occur due to subgrade .All these joints are provided up to middle or the full depth of the slab. To hold these joints sometimes iron bars are provided which are known tie bars which are provided transversely to the joints, the bars provided longitudinally to the slabs are known as dowels. One of the earliest design approaches is CBR method (1928-29) according to which the thickness design charts are developed with reference to CBR value for the critical moisture condition. For the design of airfield this method was first adopted by the U.S corps of engineers in1940.

Bearing approach is also used in which it is investigated that the bearing capacity of the slab not exceeds the bearing stress. But at that time these values not involves the traffic parameters which are taken afterwards as a correction factor. Another design criteria is limiting recoverable deflection which suggests that failure is due the excess stress and strain. The making of concrete mix is not just the matter of mixing the ingredients to produce plastic mass. The mix should be such that it satisfies all the property of green stage (plastic) as well as hardened stage.

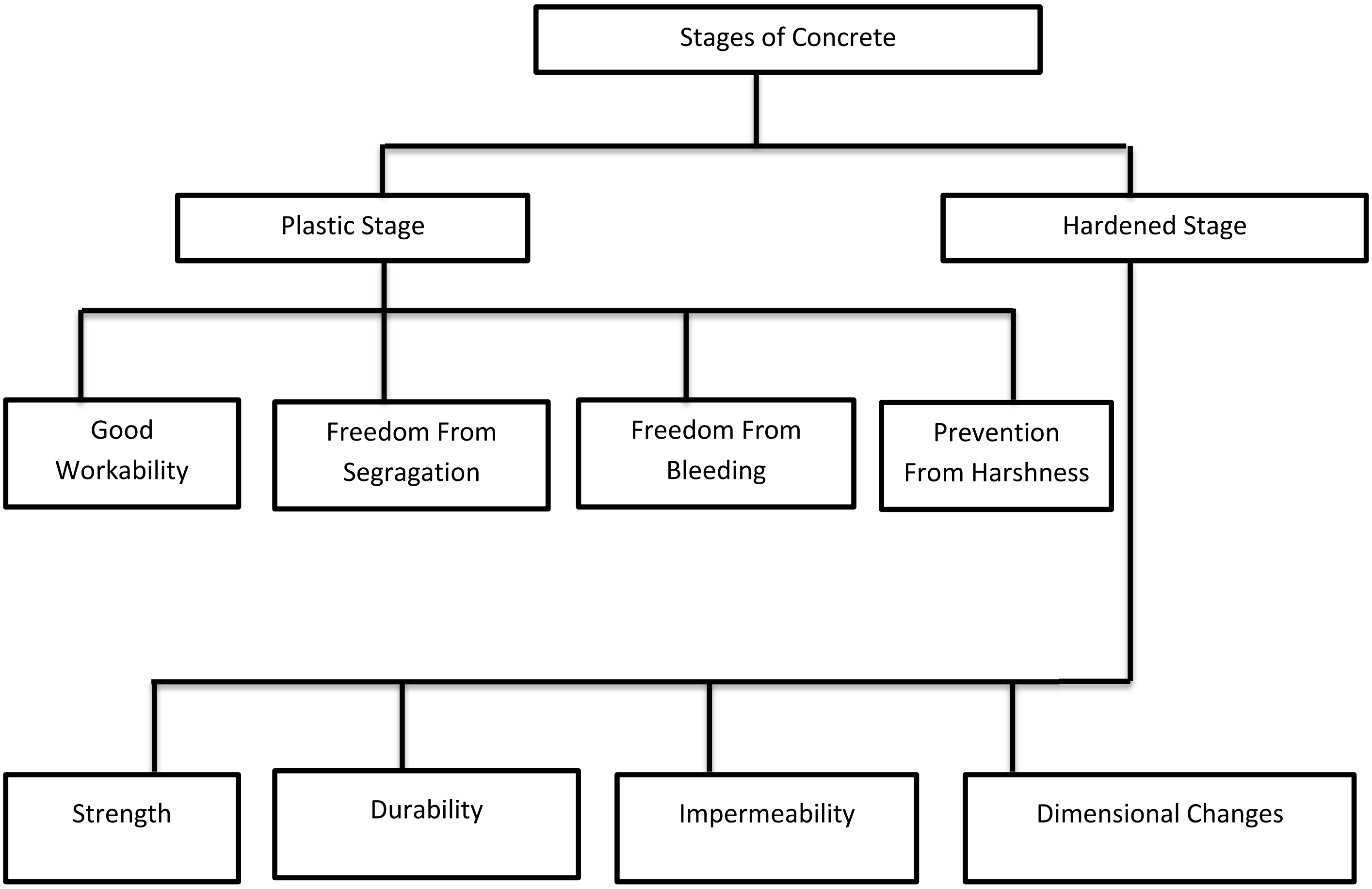


Fig. 1 Properties of concrete

1.2 Definition of High strength concrete

High strength concrete may be defined as specified characteristics strength of 60 to100 N/mm2. The producers of high strength concrete knows very well which factor effect the strength and how these factor can be manipulated to achieve the desired strength. The strength is obtained by varying the proportion of cement content and by optimizes the combination of materials.

1.3 Selection of material

The optimize selection should be done to obtain high strength concrete. To ensure the optimization, the concept of quality control was introduced which confirms that the concrete produced is of uniform quality and ensures that it is consistent with the standard specification. A controlled quality concrete is only obtained by good workmanship and strict supervision.

1.3.1 Cement

Cement is an extremely fine material having the cohesive and adhesive properties which act as binder for the discrete ingredients. The cement which generally used for construction is Portland cement. Its inventor Joseph Aspdin, English brick layer of Leeds, England, introduced in the year 1824. He named it Portland Cement because after hardening it looks like the stone quarried near Portland in England.

The generally used Portland cements are Portland Pozollona Cement (PPC) and Ordinary Portland Cement. For the manufacturing of OPC, two basic raw materials Calcareous and Argillaceous are used.

Calcareous materials containing calcium or lime as their major constituents, that is calcium carbonate in the form of lime stone or chalk, marl or oyster shells.

Argillaceous material containing alumina as their major constituents, these materials is in the forms of clay, shale's, slates and selected blast furnace. These raw materials should be proportion such that two parts of Calcareous materials and one part of Argillaceous material is mixed.

Table 1. Chemical Composition of Ordinary Portland Cement

S. No.	Chemical constituents	Range (in % age)	Commonly used proportion(in% age)
1.	Lime (CaO)	60-65	63
2.	Silica (SiO_2)	17-25	22
3.	Alumina(Al_2O_3)	3-8	6
4.	Iron Oxide(Fe_2O_3)	0.5-6	3
5.	Magnesium Oxide(MgO)	0.5-4	2.5
6.	Sulphur Trioxide(SO_3)	1-3	2
7.	Alkalies e.g. Soda and Potash (Na_2O+K_3O)	0.5-1	1

Calcium Sulphate (gypsum or plaster of Paris) and $CaSO_4$ is added to set the setting time. The gypsum is added 3% by the weight of clinkers formed during the grinding process.

1.3.2 Aggregates

Aggregates are the main constituents for making the concrete, which gives body to the concrete. Aggregates constitute 70-80% by volume of concrete, therefore it is important to choose significantly right type of aggregates at the site. Moreover, the concrete properties greatly commended by the aggregates such as water requirement, cohesiveness and workability of the concrete in green stage. Durability, permeability, density, surface finishes and strength are the properties influenced by the aggregates in hardened stages.

1.3.2.1 Coarse aggregates

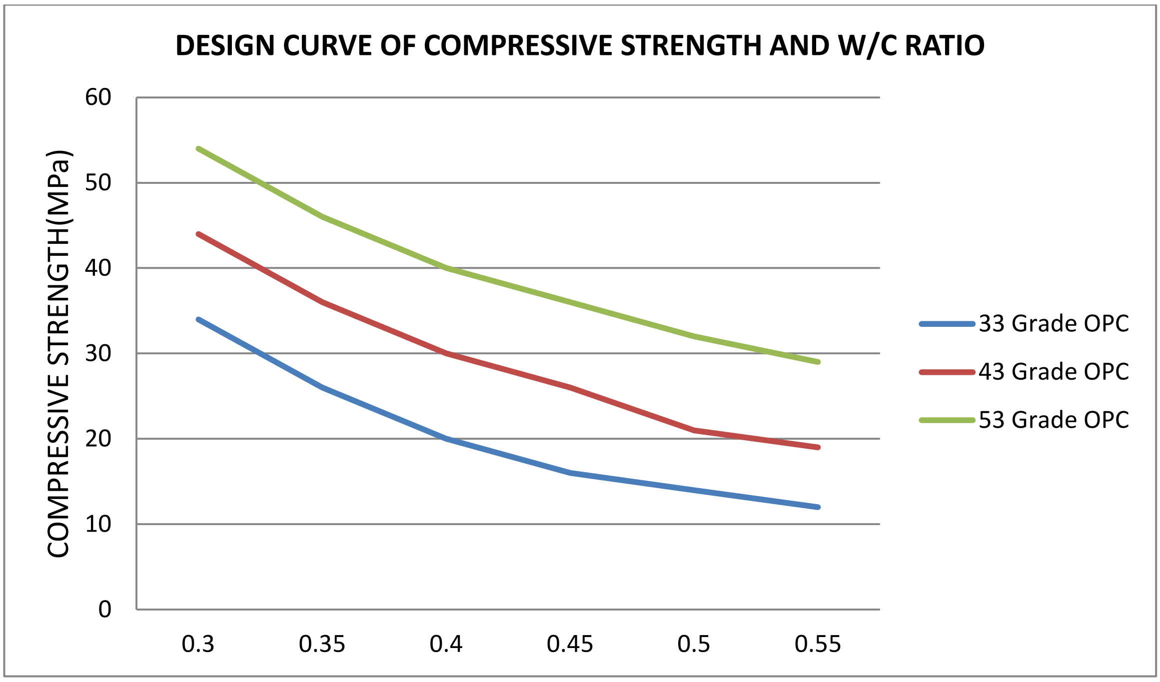
Coarse aggregates are defined, as most of which passes through the 75mm IS sieve and retained on the 4.75mm IS conforming sieve. Coarse aggregates may be crushed gravel, partially crushed or uncrushed gravels. The shape of the aggregates is important characteristics as it influence the green properties of the concrete. The size of the aggregates is totally depending on the reduction ratio and the crusher type. Reduction ratio is the original size of the materials and the size of the finished product.

1.3.2.2 Fine aggregates

The lower limit for the fine aggregates is 0.07mm.The aggregates passes through the 4.75mm sieve and retained on the 0.075 or 75 micron sieve are termed as fine aggregates. The particles having size lies between the 0.06 and 0.002mm are classified as silt particles and the soft deposit made by the sand, clay and silt particles is defined as loam. According to the IS: 383-1970, the fine aggregates are divided into four zones. These zones are progressively finer from grading zone I to zone IV.

1.3.3 Water

Water is the important ingredients in concrete. The reaction of cement is only started when the water gets added into it. It helps in the hydration of cement and act as a lubricant which increases the workability and makes the concrete workable. Concrete needs about 0.25 percent by weight of water for the reaction.



Graph 2: Relationship between compressive strength and water cement ratio of OPC

The proper ratio of water to cement is needed to make the uniform matrix. Water Cement ratio is the weight of water added in the concrete (except the water absorbed by the aggregates) to the weight of cement added. The strength of the concrete is directly influenced by the water-cement ratio, this relation of water cement ratio and strength is understood by the relation given by Duff Abrahm (1918). According to him, it is the water cement ratio that determines the strength of concrete not only the quantity of cement.

1.3.4 Admixtures

Admixtures are poured to the concrete to enhance or improve the properties of the concrete. These admixtures can be naturally obtained or waste material. Due to the pozzolonic characteristics these admixtures improves the properties of concrete mix.

Some of the minerals admixtures are:

1. Fly ash
2. Blast furnace slag
3. Rice husk ash
4. Silica fume

5. Marble dust

All these admixtures are used as addition or the replacement of the cement content.

1.3.5 Silica fumes

It is the byproduct of silica metal obtained when the high purity quartz reacted with coal in electric arc furnace. The product is condensed and collected when the gasses evolved are filtered. The silicon dioxide (Sio2) content in fumes generally varies from 85-98%. Silica fume is obtained in a very fine quality; its size is less than 0.001mm which is 100 times smaller than the particle size of cement content.

The constituents of silica fume are:

1. Sio2 - 85% minimum (and maximum up to 98%)
2. Al2O3 -0.1%
3. Fe2O3 - 0.6%
4. Carbon -12%

Uses of silica fumes as an admixtures are:

1. It resist the bleeding occur in the plastic stage
2. Modulus of elasticity improved
3. Resistance to freeze and thaw
4. Permeability of concrete mix improve by its usage
5. Resistance to the Sulphate attack

1.3.6 Plasticizers:

Plasticizers reduce the water demand in the mix and increase the workability as well enhances the strength of concrete. It reduces the water content at least 20% for the same workability. It basically facilitates good mix and good construction practices to achieve the desired specifications. Anionic surfactants (lignosulphonates) and Non-ionic surfactants (hydroxylated carboxylic acids) are the chemical compounds used as plasticizers.

1.4 Applications of high strength concrete

High strength concrete is of great interest now days. Due to its attractive properties every engineer, every developer explore the HSC. They are used in every superstructure where strength as well as durability is required

1. They are used in earth quake resistance buildings
2. Used in chimneys
3. Applications in runways, toll ways and concrete pads
4. The methodology of HSC is used in nuclear power plants
5. High rise buildings columns and its shear wall

1.5 Silica fume as replacement material

Supplementary material is added in concrete mixture to enhance the concrete properties such as to increase the strength, reduce the permeability, through hydraulic and pozzolonic activities it contributes its effect in the hardened concrete. Silica fume is also known as micro silica or condensed silica which is final residual of the elemental silicon or Ferro-silicon alloys which is carried through the furnace by exhaust gases.

1.6 Material required

For the construction of the pavement quality concrete, ordinary Portland cement of grade 53 is used refer to the IS 269 code. The maximum size of aggregates used the concrete mixture is not greater than 25mm.With the opc53 grade, it means that the compressive strength after 7 days should be between 350 to370 kg/sq.cm and after 28 days of curing it should be between 530 to 470kg/sq.cm according to the IS 12269 code. Based on the different grades of cement, different values of the water cement ratio are taken from the chart refer to the code IRC-44, IS10266

Aggregate which passes through 4.75mm sieve are fine aggregates .the workability is totally influenced by water content .Fine aggregates for the pavement quality concrete should be clean, natural sand from the river banas from location triveni 20km from LADPURA according to IS383

1.7 Proportioning of concrete

Pavement concrete should be such proportion that the characteristics strength after 28 days is 50MPA.

Water cement ratio should be kept 0.33, the increase in the ratio of water lead to the increase of workability but up to some limit ,beyond these limits the as the quantity of water increases its strength goes on decrease.

Chapter 2

SCOPE AND RATIONALE OF THE STUDY

2.1 Scope of the study

Pavement quality concrete (PQC), M40 grade is being used for experimental work. The cement is to be replaced (by weight) silica fume with the proportions of 0%, 5%, 10%and 15%, and steel fibers of aspect ratio 65 to get optimized results. The concrete pavement is generally consists of three subsequent layers i.e. base layer, subgrade layer and base slab. The concrete slab for the rigid pavement is generally M40 to M50 grade as per Indian specifications, and this slab is known as pavement quality concrete (PQC) (IRC:15-2002).The strain and stress values of slab is only can be determine when the elastic moduli, poisson's ratio and the thickness of the individuals layer is known. The several of mechanical properties in the specimen like compressive strength, split tensile strength and flexural strength for various mixes being examined for different proportions of the silica fume. Normal specimen means without the replacement of cement are also casted. The results are compared for the normal/standard (without replacement of silica fume) specimen and the experimented specimen (with replaced proportions of silica fume and steel fibers) are compared and the best result is used further for practical applications.

2.2 Objective of the study

Objective of the study is to evolved the high strength concrete for M50 grade of concrete with the variance in the proportion of cement with silica fume and steel fibers. The main project objectives are as follows: -

1. To evaluate effect on compressive strength of concrete by replacement of cement with silica fume and fibers for different proportions.

2. To study the effect on split tensile strength of concrete by replacement of cement with silica fume for different proportions.

3. To study the effect on concrete flexural strength by replacing the cement with silica fume and steel fibers for different proportions.

4. To examine the concrete flexural strength by replacing the cement with silica fume and steel fibers for Pavement Quality concrete as per MORTH specifications.

Chapter 3

Review of literature

The relevant works that carried out pertaining to the use of silica fume and the steel fibers in India and abroad has been reviewed and presented as under:

Ozgur Eren et.al (1997) study investigates the effects on performance of HSC(high strength concrete) of high strength concrete by the interchanging of cement and silica fume with the addition of steel fibers. The HSC (high strength concrete) shows brittle behavior that could be overcome by placement of fibers. The three different hooked end steel fibers with the aspect ratio 15, 75 and 83 and with the different volume percentages 0.5%,1%,2% by volume of concrete is used. The results revealed that there is a linear function developed between the tensile strength of the concrete and the amount of the steel fibers added. The different proportion of silica fume of volume 5% and 10% by the volume of cement is replaced. The replacement of silica fume with the cement has although some effects on the compressive strength but there is very little effect of fibers on the compressive strength.

Handong Yan et.al (1999) studies the experimental investigation of impact and fatigue performance of high strength concrete (HSC) made up of the steel fibers, silica fume under the dynamics loading. The mechanisms, how the steel fibers and silica fumes contributes in restraining the development of cracks. Silica fume makes effectively changes to improve the weakness of the interfacial zones, it boost the capability of the fibers to restrict the crack development and reduces the size of the crack. Moreover, the incorporation of the steel fibers and the silica fume to the concrete enhance the performance under the fatigue and the impact loadings.

M mazloom et.al (2004) worked on the concrete mixes with the water cement ratio of 0.35 and of total constant cement content of 500kg/m^3. The cement is replaced by the silica fume with the percentage of 0%,6%,10% and 15% of total volume, the workability of the concrete is investigated, apart from this the mechanical properties are evaluated such as compressive strength of concrete, modulus of elasticity, strain due to creep, moisture movement ,shrinkage and swelling. At the final the result indicate that with the increase in the content of silica fume the workability of the concrete decreases but all other mechanical properties after 28 days such as compressive strength and secant modulus, modulus of elasticity increased.

Fuat Ko¨ksal et.al (2007) did his experimental research work on plain concrete and investigate the changes on the mechanical possession of the concrete and his main objective was to increase the ductile strength of the concrete by the addition of silica fume and steel fibers as supplement materials. He uses steel fibers of the different aspect ratio (fiber length/fiber diameter) i.e. 65 and 80 and the usage of steel fiber was 0.5 to 1% of the total volume and addition of silica fume was 0%, 5%, 10% and 15% by the weight of cement content.

The concrete is made by the water to cement ratio of 0.38.

The slump value with the reference to his water cement ratio was 120mm, he concluded with the usage of steel fiber in the concrete the ductile strength of the concrete increases but beyond some limits these result goes to the negative side.

Mehmet Gesog˘lu et.al (2009) experimental study report was on change in mechanical strength of the concrete with the inclusion of steel fibers in both plain and silica fume concrete which is produced by the cold bonded artificial fly ash aggregates (AFA's)

He makes the concrete by using two ratios of water to cement i.e. 0.35 and 0.55 and the silica fume concrete was made by the incorporation of 10% replacement by the weight of cement. Two categories of hooked end steel fibers are used in the concrete with the aspect ratio of 60/80 and 30/40.AFA produced by the cold bonding pillarization of 90% class F fly ash and 10% of Portland cement is used. . The mechanical properties investigated were compressive strength, bonding strength between the rebar and concrete, modulus of rupture.

Bahar Demirel et.al (2010) studies the effect of elevated temperature on the mechanical as well physical properties of the concrete mix incorporates with the silica fume. The specimens are subjected to the elevated temperature of 400,600 and 800 degree Celsius in an electric furnace. The ultrasonic pulse velocity (UPV), compressive strength and weight loss results are analyzed. The additionally elevated temperature more than 600 results in the weight loss and affects the compressive strength of concrete.

Tehmina Ayub (2013) introduces the elastic moduli, creepened durability, shrinkage and thermal expansion in the pavement designing. High-performance fiber reinforced concrete (HPFRC), due to high release of heat during its setting there is problem of thermal contraction. The basalt fibers are used in experiment with the variation of 1%, 2% and 3%. Three mixes were made, one with the 100% cement and the others two with 10% replacement of cement with the silica fume as substitute. The result shows that the addition of fibers up to 2% with the addition of mineral admixture increases the compressive strength. The results show that at all volume of fibers there is improvement in strengths and impact resistance, but there is not much influence of the elastic modulus on the addition of steel fibers.

Juan Navarro et.al (2015) research based on the effect or contribution of the steel fibers in the concrete on the shear stress occur on the concrete, ten specimen of reinforced concrete(RF) and steel fiber reinforced concrete(SFRC) which were initially un cracked are tested. At the vicinity at which the shear plane occurs, the average of normal and transverse strain is measured by photogrammetry with the precise accuracy. Experimental study reveals that the concept of constant shear stress flow is adequate. The result shows that the specimen made up of steel fiber reinforcement concrete (SFRC) have more stiffness when compared to the plain reinforced concrete(RF), MOREOVER how effective is the usage of fiber in the concrete after diagonal cracking is totally depend on the crossing of reinforcement in shear.

Mahmoud nilli et.al(2010) studied investigated the resistance to the impact and corresponding mechanical properties of SFRC(steel fiber reinforcement concrete).he carried out his study without the incorporation of silica fume. The water cement ratio is kept 0.46 and 0.36, and the hooked type steel fibers are used with the length 60mm and the aspect ratio is kept 80mm and three volumes 0%, 0.5%and 1% were used as reinforcing material. The incorporation of steel fibers in the concrete increases the performance of the concrete particularly the tensile and the flexural strength of the concrete. The concrete is not good in tension but with the addition of steel fibers its tensile strength increases.

Adel Kaikea et.al (2014) did his experiment on High Performance Fiber Reinforced Concrete (HPFRC) and studies the influence on the properties with the addition of minerals admixtures and volume of steel fibers content. He did his experimental work on six (HPFRC) specimens and varied the admixtures content and proportion of steel fibers. The behavior of concrete to shrinkage, flexural tension and compression were analyzed to guide for the structural use. The results reflect that the addition of fibers to more volume content has improved the performance and is suitable for the use in practice.

M. Mastali et.al (2016) did his experimental work to investigate the changes in the mechanical properties of the self-compacted concrete on the replacement of cement with the silica fume and wasted steel fibers. His aim was actually to correlate the effect causes on mechanical properties and the impact resistance. He tested 144 specimens with different fibers volume i.e. 0.25%, 0.5%, and 0.75% and different proportion of the silica fume. The mechanical properties are characterized as compressive, splitting tensile and flexural strengths. An analytic analysis performed by regression analysis to check and correlation between the impact and mechanical properties of the SSC concrete. Moreover, a linear equation was also developed to correlates the properties. The result obtained revealed that the usage of silica fume and steel fibers in the concrete improved the mechanical and impact resistance of the concrete.

Farid Bouziadi et.al (2016) experimental study is carried out to investigate the influence of the type of curing, aspect ratio and types of steel fibers on the compressive strength, flexural strength, split tensile strength and total shrinkage of the high strength concrete. Steel fibers (SF), polypropylene (PF), hybrid fibers (HF) are used with the aspect ratio of 55 and 80. The specimens are cured at different isothermal temperatures of 20, 35 and 50 degree Celsius. Two dosages 0.1% and 0.2% for polypropylene (PF) and 0.5% to 1% steel fibers (SF) are used. The results revealed that there is total decrease in the shrinkage due to addition of the fibers, however hybrid fibers (HF) induces more decrease in shrinkage as compared to the steel fibers. Furthermore, the rising of curing temperature boost the rate of shrinkage. The usage of steel fibers increases the flexural strength.

Hasan Sahan Arel (2016) experimental study is carried out to know the influence on compressive strength and resistance of impact on the ultra-high-performance fiber-reinforced concrete (UHPFRC) due to the fineness of silica fume and with the different aspect ratio of steel fibers. The concrete mixtures are made by combining the variations in the fineness with the specific surface areas (17,200, 20,000, and 27,600 m2/kg) and hooked steel fibers with the different aspect ratios. The compressive strength of the specimens are calculated at -7,-14,-21,-28,-56 and 90 days. Different methods of curing were used specifically, standard curing, steam curing and hot water curing. The result revealed that the specimen with steam curing and with the fineness of surface area 27600 m2/kg gives the better result as compared to the others combinations.

Valeria Corinaldesi et.al (2016) did his experiment on twenty different composites of steel fibers reinforcement specimens in which he used the CaO expensive agent. He used five different types of fibers three were hooked metallic and two were plastic based fibers. The metallic fibers used are brass-coated, steel and zinc-coated. Corrugated polypropylene (PP) and hooked polyethylene-terephthalate (PET) are the plastic based fibers.

All the parameters of strength like flexural, dry shrinkage strains, fresh consistency and strength are determined. The result revealed that the combination of the CaO based agent with the brass-coated and zinc-coated fibers improved the flexural strength, this may be because of the formation of

Calcium hydroxide zincate (CHZ) crystal between the fibers and the cement which is promoted by the alkaline environment .The alkaline hydrolysis occurs due to the result of PET fibers degradation accerlated by the CaO agents, reduces the mechanical strength of the concrete. The addition of Ca0 based agents to the mixture overall reduces the drying shrinkage, no matter which type of fibers are used.

CHAPTER 4

MATERIALS AND RESEARCH METHODOLOGY

4.1 General

The main objective is to test the properties of the all materials used for testing. All the parameters associated with the materials used in the research works are first tested and the experimental implementation is done. The material used in the research works are Portland cement, coarse aggregate, fine aggregates, silica fumes and steel fibers. The material is used to check all the mechanical properties of the concrete mix.

4.2 Materials

4.2.1 Portland cement

Cement is important component of the concrete mix which acts as a binding material between the aggregates. All the properties of the cement are examined before it is applied to the experimental research i.e. consistency of cement, specific gravity, fineness modulus, initial setting, and final setting time. Prior to 1987 there was only one grade of cement available, conforming to IS: 269-1976. After 1987 higher grade of cement were introduced in India, which were classified as 33 grades, 43 grade, 53 grades. These grades of the cement are given according to the strength after 28days, the parameters of the cement tested are as under:

Table 2: Properties of OPC grade43 cement

S.NO	CHARACTERSTICS	VALUE OBTAINED EXPERIMENTALLY	VALUES SPECIFIED BY IS8112:1989
1	Specific gravity	3.15	3.1-3.25
2	Standard consistency	29.5%	-
3	Initial setting time	32 minutes	shouldn't be less than 30 minutes

4	Final setting time	4 hrs 38 minutes	Should not be greater than 600 minutes

4.2.2 Aggregates

Aggregates contribute about 75% bulk of the concrete mix, for the growth of the density of the concrete the aggregates should be mix in the different dimensions. The particles of the aggregates passes through the sieve of 4.75mm are fine aggregates and which retained on the sieve are coarse aggregates. The purpose of the fine aggregates is to create desire workability and uniformity in the mixture. If the dissimilar aggregates are used in the concrete mix, it exhibits the properties of both the type of aggregates. Creased aggregates have a habit of to recover the strength because of meshing of pointed particles, though curvy aggregates better the flow since of lower interior friction**.** The classifying zones become progressively finer from grading zone I to IV.

Aggregates have a great influence on the properties of the concrete/mortar such as workability, water requirement and adhesiveness in the plastic stage.

4.2.2.1 Fine aggregates

In this trial program, fine aggregates (stone dust) were collected from Jalandhar and compatible to grading zone II. It was coarse sand bright brown in color. The sieving of the sand was done to takeoff the particles having size more than 4.75mm. The particles having size 0.06 to 0.002 mm are categorized as silt particles and the particles having size less than 0.002 are known as clay , the mixture of the particles with the sand, clay and silt is known as loam. The fine modulus and the physical properties of the sand are tested according to the IS: 383-1970 code and the outcomes are given below:

The specific gravity of the sand is found to be 2.49.

Table3: Sieve Analysis of Fine aggregates

S.no	IS –sieve (mm)	Wt. retained (gram)	Cumulative Wt.	%Cumulative Wt.
1	4.75mm	6	6	0.3%
2	2.36mm	4.5	10.5	0.525%
3	1.18 mm	5	15.5	0.775%
4	600 mm	7	22.5	1.125%
5	300 mm	155	177.5	8.875%
6	150 mm	1720	1897.5	94.875%
7	90 mm	82.5	1980	99%
8	Pan	20	2000	**Total=205.475**

Fineness modulus=205.475/100

2.05475 < 2.2

It means very fine sand

4.2.2.2 Coarse aggregates

The aggregates size lies between the 4.75mm and 75mm or which are passes through the 75mm sieve and retained on the 4.75mm IS sieve are termed as coarse aggregates. The aggregates having the size greater than 75mm are boulders. The coarse aggregates may be crushed gravel, partially crushed or uncrushed gravels. Generally 10mm and 20mm particles are used in making the concrete. The combination of the aggregates is used for the 10mm and 20mm in 70:30 fractions.

Table 4: Properties of Coarse aggregate

Characteristics	**Description**
Color of aggregates	Grey
Shape of aggregates	Angular
Maximum Size of aggregates	20mm
Specific Gravity of coarse aggregates 20 mm	2.73
Specific Gravity of coarse aggregates 10 mm	2.71

Table 5: Sieve Analysis of Coarse Aggregates (10mm)

S.no	IS-Sieve size	Wt. retained (gram)	% age retained	Cumulative passing	Cumulative %retained
1	40	0	0	100	0
2	20	0	0	100	0
3	10	2002	66.73	33.27	66.73
4	4.75	948	31.6	1.67	98.33
5	pan	50	1.66	0.01	-

6	Total =3000gm	Sum=165.06
	Fineness modulus	(165.06+500)/100=6.65

Table 6: Sieve Analysis of Coarse Aggregates (20mm)

S.no	IS-Sieve size	Wt. retained (gram)	% age retained	Cumulative passing	Cumulative % retained
1	80	0	0	100	0
2	40	0	0	100	0
3	20	69.8	2.32	97.68	2.32
4	10	2902.6	96.75	0.93	99.07
5	4.75	5.5	0.18	0.75	99.25
6	Pan	3.00	0.1	0	-
7	Total=3000gm			Sum=(200.64+500)/100	
	Fineness modulus			7.006	

4.2.3 Water

The yardstick for the water that is suitable for the mixing of the concrete is that; if the water is pure as much that we can drink it, and then it is suitable for the concrete. The amount of the water and quality of the water in concrete mix plays significant role. The impurities present in the water influence the strength of the concrete. Prior studies revealed that the presence of salt in water reduces the compressive strength up to 10-30% as compared to the fresh concrete. Presence of silt decreases the bonding strength.

In the experiment the underground water is used for making the concrete and for the curing purposes the cubes are kept in the sack and then placed in the curing tank.

4.2.4 Superplasticizers

Superplasticizer “Sikament NS 2000” in the liquid form, to increase the workability is used for the experimental work. Plasticizers are the chemical compounds that decrease the amount of water and attain the same workability as on equal volume of water. It decreases at least 20% of the water for given workability. Moreover the use of plasticizer increases its slump value 25mm to 100mm.

The amount of plasticizer used is (0.5-2) % of the cementious material as per IS 10262-2009. It should be noted that most of the commercial plasticizers come with the water dissolved in it, so the extra addition of water should be account for the proportioning. The strength of concrete is inversely proportion to the amount of water added or the water to cement proportion. For the production of high strength concrete the amount to water should be kept less and for the less water the constraints of workability come in mix. The concrete made is of no use unless it is workable. To conquered this problem, the use of plasticizer in concrete makes the concrete workable with the impartation of strength into it. It is not a substitute for the bad

design mix design, by the use of plasticizer the specific requirement can be easily achieved.

4.3 Test methods

4.3.1 Specific Gravity

Specific gravity is the ratio of the mass of substance in a given volume to the mass of the equal volume of the water at same degree temperature. The absolute specific gravity is that in which only the volume of solid substance is considered but in case of aggregates the volume of aggregates is included. If the volume of aggregates included the voids, then it is known as “apparent specific gravity”. Specific gravity test is done with the help of pycnometer. The following is the procedure used for the calculation of specific gravity of sand.

1. Firstly, weight the dry pycnometer
2. Take the weight of sand, pycnometer and water
3. Take only the weight of water and pycnometer
4. Take weight of sand and again weight of sand after 24 hours of oven.

Fig 2: Pycnometer

Fig 3: Weighing balance

Experiment

Wt. of dry pycnometer = 639gm

W= weight of sand, pycnometer and water=1846gm

W1= water and pycnometer=1534gm

W2= weight of sand after 24 hours of oven=490.5gm

Specific gravity = W2/ (W2-(W-W1))

= 490.5/(490.5-(1846-!534))

= 2.747

4.3.2 Water absorption test

Water absorption test is done to determine the holding capacity of water. Water absorption capacity is depend on the type of the material used. The following is the procedure used for the calculation of water absorption.

Experiment

W2=weight of the basket in water (1000gm)

W1=weight of basket + weight of aggregates (3500gm)

W3=weight of aggregates before oven drying (4020gm)

W4=weight of aggregates after oven drying (3980gm)

Water absorption = (w3-w4/w3)*100

=0.99%

It should be lies in (0.1-2)

4.3.3 Sieve Analysis of Fine and Coarse Aggregates as per IS: 2386(Part-1)-1963

The size of the particles are distributed as per the sieve analysis is termed as the grading of the aggregates. The curve plotted determined the cumulative percentage of the aggregates passing through the sieves represented on ordinates with the opening of sieve to the logarithmic scale which is presented on the abscissa is termed as grading curve. Analysis of the aggregates represents size distribution, because using the same shape and size of aggregates results in more void formation in the concrete therefore distribution of size is necessary. The usage of small size aggregates fills the voids between the larger particles and result in less quantity of sand and cement.

The result of sieve analysis of the aggregates which used in this experimental work is given in the clause **4.2.2.**

4.3.4 Slump Test

It measures the workability and fluidity of the concrete. It also tells us about the concrete consistency and stiffness.

The consistency indicates the amount of water added. This test is widely used as it is simple and less apparatus is required. It measures the workability of fresh concrete.

4.3.4.1 Principle

Slump test is the measure the ease with which the concrete can flow. This test is the convention of the inverted compacted cone of the concrete under the free fall of gravity. As per IS: 1199-1959, the slump is measured in millimeters of subsistence of the specimen. A slump cone, tampering rod and scale is required for the experiment. The slump cone has the base diameter of 20cm and the top diameter of the frustum of concrete is 10cm with the vertical height of 30cm. The base plate of the cone is kept on the smooth surface and concrete in poured in 3 layer ,tampering is done with the tampering rod of diameter 16mm on each subsequent layer.

When the mould is filled completely the top surface of the cone is leveled by screening and rolling motion of the tampering rod.

The mould should not be move during the pouring of concrete. The leveled cone is lifted in such a way that supported concrete will not slump. The diminishing height measured from the center of the slumped concrete is called slump. This decrease in height is measured with the scale and taken as the value of slump.

If any specimen of the slump, collapse or shear off laterally gives incorrect result, in that case we need to repeat the test with the different proportion of the materials

Table7: Slump Values while replacing cement with silica fume

% SF	SLUMP (MM)
0	108
5	97
10	94
15	85

4.3.5 Compressive Strength of Concrete

Compressive test is done on the cubes of size 150x150x150cm or 10x10x10cm, after the casting these cube are kept for 24 hours in the mould, then after cubes are placed in the curing tank. At the ages of 7days, 14 days and 28 days cubes are tested in the machine to determine the strength; specimens are place right angle to that as cast.

The quantities of different proportions are calculated and weighed separately, the coarse and fine aggregates are mixed to get the uniform distribution for batch then silica fume and cement are mixed, this dry mixture is mixed thoroughly for 5 to 10 min after that 60-70% water without the plasticizer is added. Superplasticizers added to remaining 30 % of water and put into the mixture. After thoroughly mixing the concrete cubes are casted and kept for 24 hrs.

The load is applied gradually at the speed of 5.2KN/ m; this speed is controlled at constant rate by fine adjustment. The care should be taken that no sudden shock given to specimen.

The load is applied until the cracks developed or the monitor shows reverse readings. The peak load should be noted for the calculation of the compressive strength.

Fig. 4: Casting of moulds

Fig. 5: Compression testing machine

4.3.6 Split Tensile Strength of Concrete

Splitting tensile strength was performed on cylinder of diameter 150mm and height 300mm .The specimens are casted by same procedure like cube casting ,concrete for different proportion of silica fume and steel fibers is casted for cubes, cylinder and beams. The test is performed on the compression testing machine but the rate of loading is different in case of tensile strength. The cylinder marked with the uniform lines, so that while placing on the plate it lies in line of action. The gradual load is applied without giving sudden load, the shock to specimen results in the formation of cracks.

The magnitude of the split tensile stress due to the load applies is given by the formula:

T= 0.637P/DL

T = Split Tensile Strength in MPa

P = Applied load,

D = Diameter of cylindrical specimen in mm.

L =Length of cylinder specimen in mm.

The failure takes place to the line of action where the load applied. The method of tampering greatly influence the strength of specimen, if the tampering is not done in a proper way there are chances of presence of voids that considerably reduces strength. Again while pouring the concrete into cylinder tampering is done in three equal layers like slump. One should also care while casting that cylinder should be properly oiled. After tampering the specimens were placed on the vibrator and vibrated for 6 sec, the upper edge is made smooth by trowel and specimens are kept for 24 hours. After that moulds were opened and specimens were kept in the curing tank.

After 7 days the specimens are takeoff from the curing tank and kept in open air for 4 to 5 hrs. then cubes were experimented. The cubes are aligned such that they are at the right angle toward their face that side as cast. The loading is exercised deliberately so that no sudden shock till the failure of the specimen occurs and thus the split tensile strength was obtained.

Fig 6: Split Tensile Test

Fig 7: Cracks under Loads

4.3.7 Flexural Testing of Concrete

Flexural testing was performed on the beam of size 100x100x500. The procedure for casting the beam for different proportion of silica fumes and steel fibers is same as for cubes and cylinders. Flexural strength is formulate as modulus of rupture (MR) in psi and can be calculated by standard tests method ASTM C 78 third point loading. The flexural testing machine is accommodated with two steel rollers of diameter 38mm on which the specimen is sustained. The load is equally applied to both the rollers, the specimen is kept under the compression testing machine and the load applied at the one-third of the both edge of the beam. The loading is applied at the rate of 0.1 KN/s, this much load is applied until the specimen breaks down.

Formula used for flexural strength ‘fb’

fb = PL/bd2

When ‘a ' is more than 13.3 cm for a 10·0 cm specimen

fb = 3Pa/bd2

When ‘a’ is smaller than 13·3 cm but greater than 11·0 cm for a 10·0 cm specimen

Where ‘a’ is the distance between the line of fracture and the nearer support, measured on the center line of the tensile side of the specimen in cm.

b = Width of the specimen (= 100 mm)

d = Depth of the specimen (= 100 mm)

L = Span of the specimen (= 500 mm)

The quantity of the coarse aggregates, fine aggregates and cement for the different proportion of silica fume and steel fibers are weighed separately. Water is added to the mix and after the superplasticizers is added. Firstly 50-70% of the water is added and mixed thoroughly for 3 to 4 minutes to form uniform mix. Superplasticizers are added to the remaining water and then it is poured to the concrete mix. After that the concrete mix was filled into the beams and gets vibrated to ensure proper compaction. The casted cubes were retained to the open air for 24 hours for get hardened. The specimen were put out from the moulds and placed in the curing tank.

4.4 DESIGN MIX

4.4.1 Objectives of Mix Design

1. To acquire the required strength in compression and ease to flow.

2. The main objective is to design the most economical mix with optimum combination of ingredients.

3. To improve the durability.

4.4.2 Design of Normal Concrete as Per IS 10262:2009

Here, concrete grade made is M50.

OPC 43 grade cement is used conforming to IS code 8112 Specific gravity of cement= 3.15.

Specific gravity of fine aggregate= 2.49

Specific gravity of coarse aggregate= 2.66

Fine aggregate taken from zone-II

Minimum cement content 320 kg/m3.

Maximal cement content 450 kg/m3

Maximum water to cement proportion is 0.33

Workability 100 mm slump

Crushed angular aggregate is used.

Degree of supervision is good.

Chemical admixture super plasticizer is added Plasticizer added = 1%

Target strength of mix proportioning

f’ck= fck+ 1.65s

where,

f*ck= target average compressive strength after 28 days.

fck= characteristic compressive strength after 28 days.

S= standard mean deviation.

Taken s= 5 MPa

Therefore target strength = 50+ 1.65*5 = 58.25 MPa.

Calculation of Water cement ratio

Water cement ratio is taken according to table 5 of IS 456, maximum water cement ratio is 0.45. Based on experience water-cement ratio is taken as 0.33

0.33<0.45, hence O.K

Selection of water content

According to IS 10262-2009, from table 2, the maximum water content is 186 litre (for 25 to 50 mm slump range)

The required water content is needed to be increased by 3% for every 25mm increase in the slump.

Estimated water content for 10mm slump=186+6/100*186

197 litres

By the addition of superplasticizers water content is need to be reduced up to 29 percent. Hence the arrived water content is =197x0.71=140 litre.

Cement Content

Water cement ratio is 0.33

Cement content 140/0.33= 424.24 kg/m^3

The amount of cement that is minimum for severe exposure condition is 320 kg/m3. Cement taken 424 kg/m3

Hence O.K

Volume of coarse aggregate and fine aggregate

V= [W + (C/Sc) + (1/P) . (Fa / Sfa)] X (1/1000)

V= [W + (C/Sc) + {1/(1-P)} . (Ca / Sca)] X (1/1000)

Where,

V= volume of fresh concrete minus the volume of air content entrapped.

W= per cubic meter water content (kg).

C= mass of cement per cubic meter.

Sc= specific gravity of concrete.

P= proportion of fine aggregate to total aggregate.

Fa= fine aggregate i.e sand (kg) per cubic meter of concrete.

Ca= mass of coarse aggregate (kg) per m3 of concrete.

Sfa= specific gravity of fine aggregate

Sca= specific gravity of coarse aggregate

As per IS 10262-2009 code, for 20mm size of aggragates entrapped air is limited to 2 %.

Assuming fine aggregate by percentage of volume of total aggregate = 35 %

Volume of cement = 424/3.15*1/1000=0.134m^3

Volume of water=.140m^3

Volume of chemical admixture=0.00740 m^3

Volume in all aggregates = 1-(0.134+0.140+0.00740)

=0.7186 m^3

Mass of fine aggregate = 0.7186*0.31*2.69*1000

=599.24 kg/m^3

Mass of coarse aggregates =0.7186*0.69*2.74*1000

=1358 kg/m^3

Ratio of 20mm coarse aggregate to 10mm coarse aggregate is 0.6 : 0.4 Therefore,

Cement = 424 kg/m3

Fine aggregate = 599.24 kg/m^3

Coarse aggregates =1358 kg/m^3

water : cement : FA : CA(20mm) = 0.33 : 1 : 1.41 : 3.20

CHAPTER 5
RESULT AND DISSCUSSION

5.1 General

In this chapter the result obtained from the various tests which are conducted on the materials used for the production of concrete mix and on the concrete specimens are presented. An experimental program was performed to achieve the objective of the present study. The aim of the experiment was to investigate the influence of the silica fume and the steel fibers on the compressive, flexural and the split tensile strength, so as to access its feasibility in the use pavements. The experiment involves the casting, curing and testing of the specimen at different stages. The entire specimen with the different proportion of silica fumes and steel fibers and without the SF and steel fibers is tested.

The work performed for the experiment included the following:

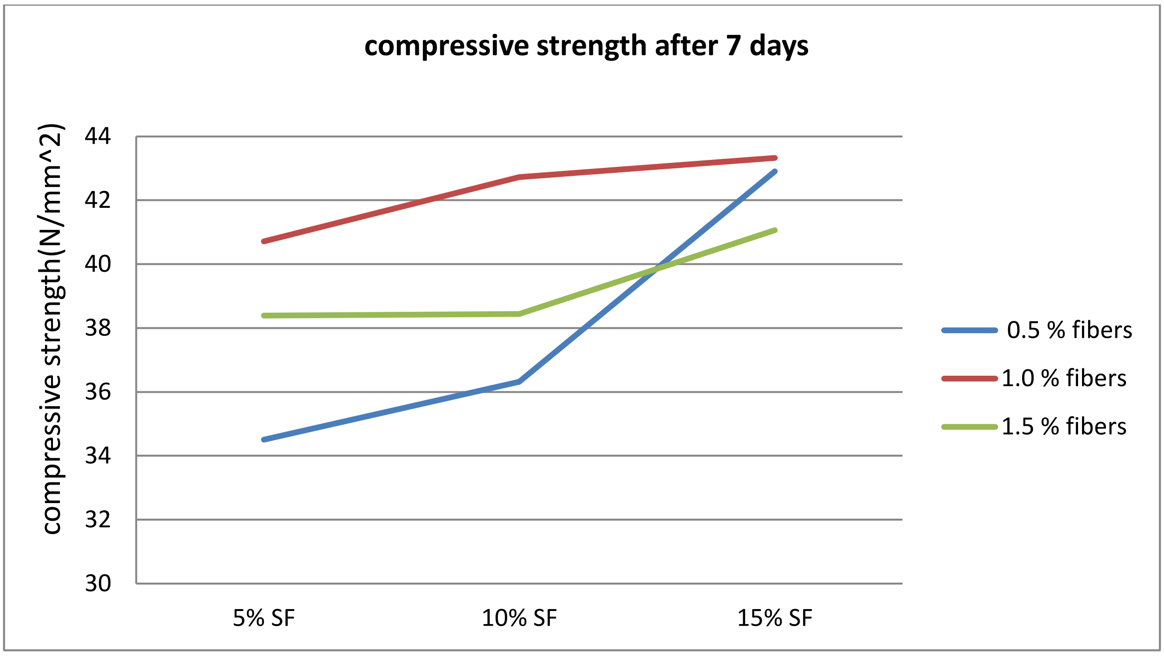
1. Testing of the materials used in the production of concrete mix.
2. Design mix for the pavement quality concrete according to the IS code 10262:2009
3. Calculation for the proportion of the materials used for the making of the concrete according to the design mix.
4. Casting of the concrete specimen and curing for the different stages.
5. Performing the tests on the cured specimen to determine the compressive, flexural, split tensile strength of the specimen at different stages.
6. Combining and analysis of the results.

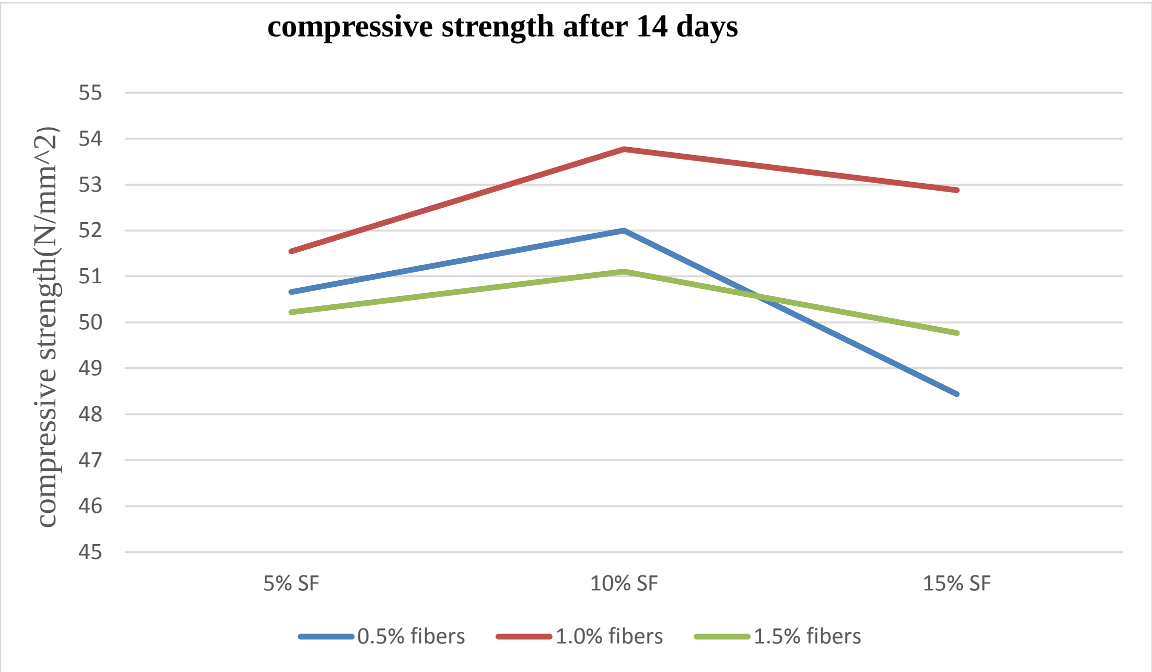
5.2 Compressive Strength

Compressive strength is the resistance to the load applied to the concrete; this is the utmost important characteristics that give the ideas about the other parameters. Compressive strength of specimen judge whether the concreting is done in a proper way or not. When the member is under compression its failure takes place in vertical planes along the diagonals. Due to the lateral tensile strains the verticals cracks occur in the concrete. Compressive strength of the concrete is depends on many factors like, material used, type of curing, water-cement ratio and the control of quality during the production of the concrete. Two types of specimen viz. cubical and cylindrical are used for the compression test; generally two sizes of cubes 10 x10x10 cm or 15x15x15 cm are used for the testing according to the size of the aggregates. Testing of specimen is done after 7days, 14days and 28days of curing, samples are made for control mix and with the different proportion of the silica fumes i.e. 5%, 10% and 15% by the volume of cement is replaced. For the each proportion of silica fume and steel fibers three samples are casted for the testing after 7 days, 14 days and 28 days. The average results of the concrete cubes tested at different stages are shown in Table

Table 8 - Compressive Strength of Cubes

Compressive strength (Mpa)									
SF	Steel fibers 7 days				14 days		28 days		
0	0.5	1	1.5	0.5	1	1.5	0.5	1	1.5
5%	34.51	40.71	38.39	50.66	51.55	50.22	63.55	61.77	61.55
10%	36.32	42.73	38.44	52	53.77	51.11	64	62	63.11
15%	42.91	43.33	41.06	48.44	52.88	49.77	64.22	60.88	58.22


compressive strength after 7 days
compressive strength(N/mm^2)
44
42
40
38
36
34
32
30
5% SF
10% SF
15% SF
0.5 % fibers
1.0 % fibers
1.5 % fibers


compressive strength after 14 days
compressive strength(N/mm^2)
55
54
53
52
51
50
49
48
47
46
45
5% SF
10% SF
15% SF
0.5% fibers
1.0% fibers
1.5% fibers

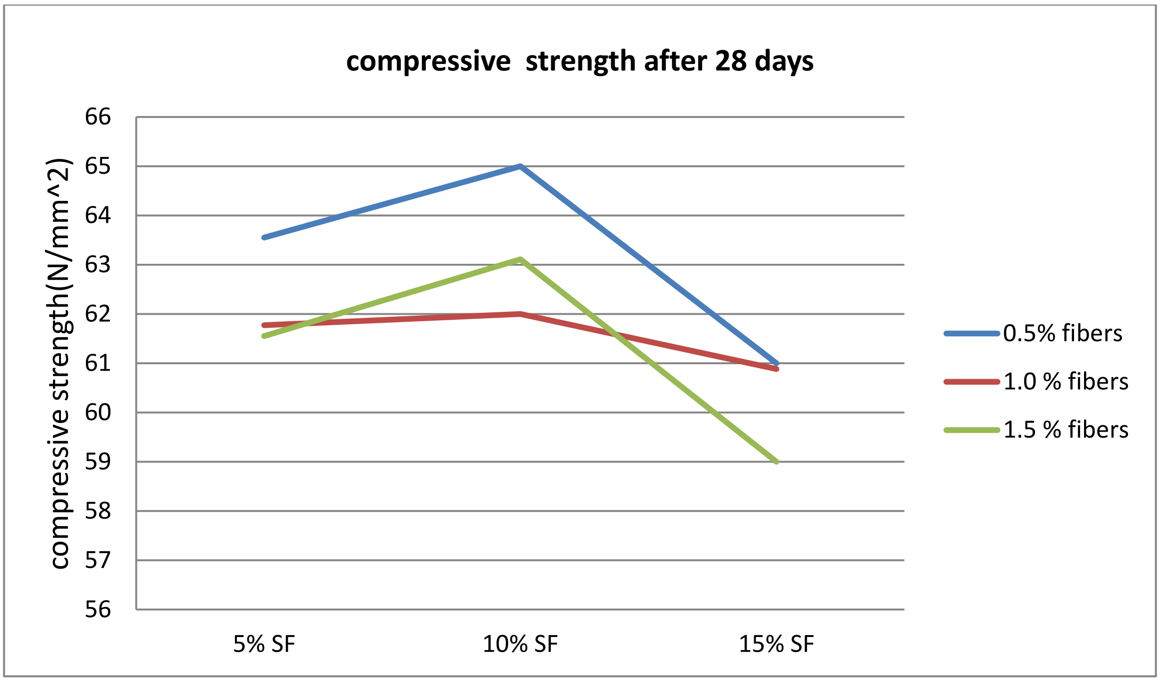


Figure 3: Variation in the Compressive Strength of Concrete with the increase in the content of silica fume and steel fibers

The compressive strength is determined for the different proportion of silica fume and steel fibers. It is evaluated that the strength of compression of the concrete increase with the increase of silica fume content and for the different proportion of steel fibers. Compressive strength for 5% silica fume with 0.5% of the steel fibers is increased by 7.81 percent as compared to the control mix after 7 days. Thus increase in the compressive strength after 7 days by increasing the silica fume content from 5 to 15% and with 0.5% of the steel fibers is 24.34 percent.

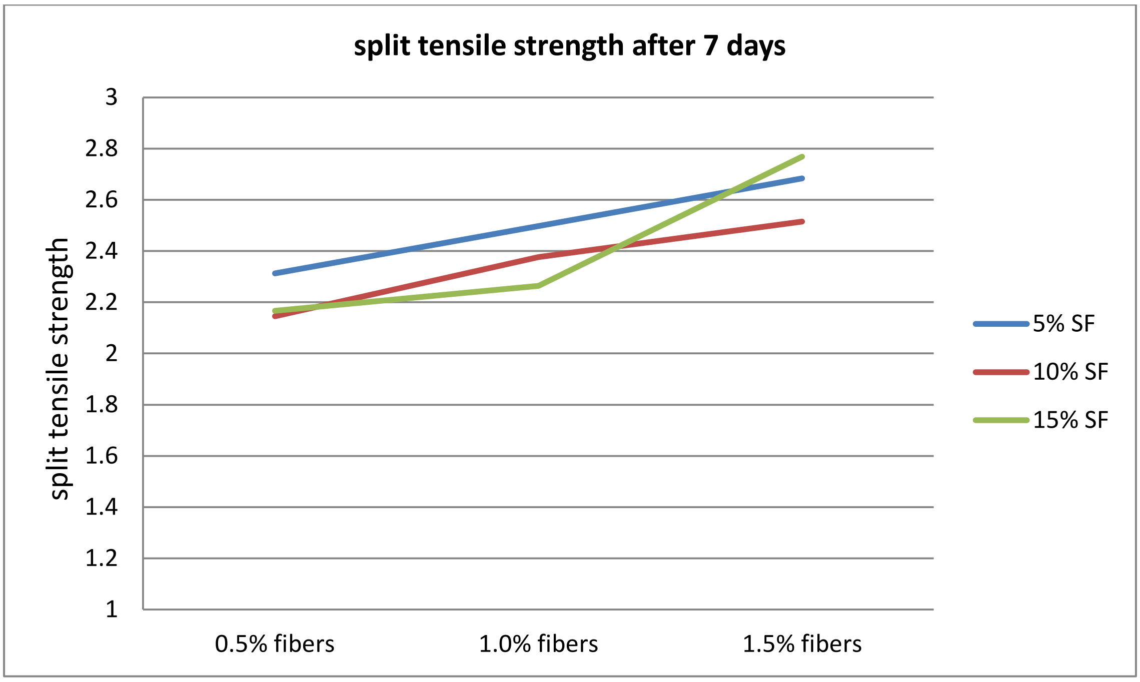
The results show that the combined effect of silica fume and the steel fibers on the compressive strength is higher than the concrete containing only silica fume. This result can be clearly depending on increasing the bond strength of cement paste with the aggregates by means of filling effect of silica fume. For all the concrete with the silica fume and the steel fibers is found higher than the concrete without silica fume/steel fibers. The replacing of silica fume with cement in the concrete reduces the distribution void space and porosity. Moreover, silica fume possess some cementious properties which enhances the pozzolonic activities. It is found that the strength of the concrete depends on the distribution of void spaces and porosity.

5.3 Split Tensile Strength

The 300mm x 150 mm cylinders were used for testing the split tensile strength after 7 days, 14 days and 28 days. Specimens have been made for control mix and compared with different percentages replacement of cement with Silica Fume i.e. for 0%, 10% and 15 % and steel fibers. Samples have been casted for each percentage i.e. three for 7 days, three for 14 days and three for 28 days. The split tensile strength of all the mixes was determined at the age of 7 days, 14 days and 28 days for various replacement levels Silica fume and steel fibers in concrete mix. The results of split tensile strength of concrete are reported in Table which shows the gain in split tensile strength for different levels of Silica fume replacement with cement and steel fibers.

Table 9: Split Tensile Strength of Cylinder

Split tensile strength (Mpa)									
SF	Steel fibers 7 days				14 days		28 days		
0	0.5	1	1.5	0.5	1	1.5	0.5	1	1.5
5%	2.313	2.479	2.683	2.975	3.074	3.165	3.058	3.221	3.202
10%	2.145	2.376	2.515	3.014	3.137	3.101	3.110	3.202	3.181
15%	2.167	2.264	2.768	2.983	3.158	3.130	3.0952	3.158	3.145



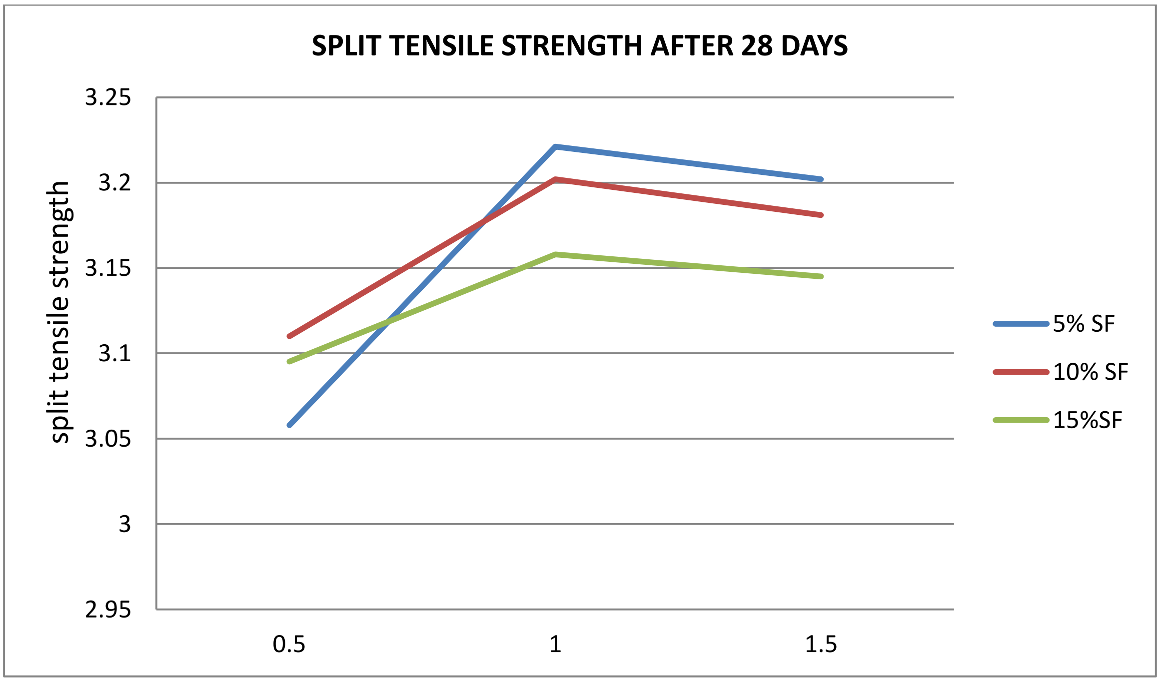


Figure 3: Variation in the Concrete Split tensile strength with the increase in the content of silica fume and steel fiber

Increasing the content of silica fume and steel fibers a considerable increase in the split tensile strength of concretes were obtained. From the result it is concluded that the splitting tensile strength increases with the increase of silica fume content but the value goes higher up to the combination of 15% silica fume and 1% of steel fibers.

After 7 days there is increase of 14.35 percent with the replacement of 5% silica fume and 0.5 % steel fibers as compared to the control mix.

After 28 days there is decrease in the splitting tensile strength of 5.89 percent on the addition of 1.5 percent of steel fibers and 5% of silica fume as compared to the 1% of the steel fibers with the same content of silica fume.

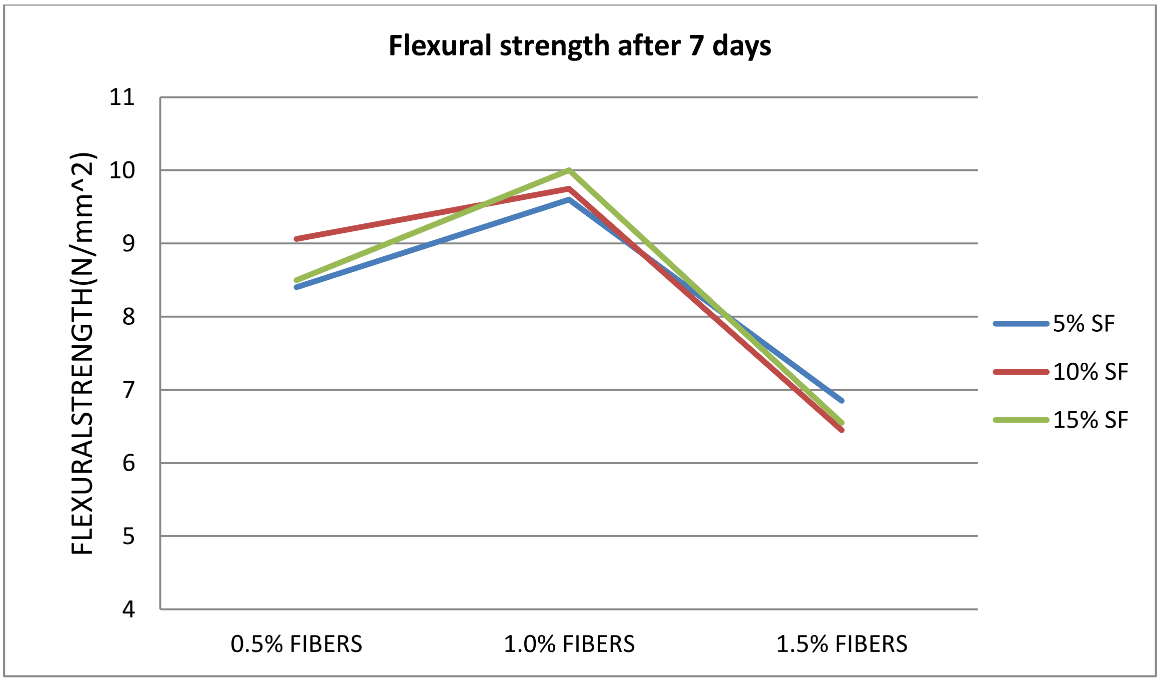
For the strength purpose 1% of the steel fibers is acceptable for split tensile strength.

5.4 Flexural strength

The mostly used concrete structure which guarded to flexure is a highway or runway pavement and inspection on such pavements is commonly tested by doing the bending test. When the concrete is under the bending loads, then tensile and compressive stresses and in most of the cases direct shear stresses are developed. The 100 mm x 100mm x 500 mm beams were used for testing the compressive strength after 7 days,14 days and 28 days. Specimens has been made for control mix and compared with different percentages replacement of cement with silica fume i.e. for 0%, 5%, 10% and 15%. Three samples have been casted for each percentage i.e. three for 7 days, three for 14 days and three for 28 days testing. . Flexural strength is about 10 to 20% of the compressive strength which totally depend on the type, size and the volume of coarse aggregates used. This flexural strength is determined by the third point loading which is lower than the MR determined by central loading.

Table 10: Flexural Strength of Concrete

Flexural strength (Mpa)									
SF	Steel fibers 7 days				14 days		28 days		
0	0.5	1	1.5	0.5	1	1.5	0.5	1	1.5
5%	8.4	9.6	6.85	9.3	11.1	9.25	11.8	13.6	10.75
10%	9.05	9.75	6.45	12.2	12.75	8.25	14.7	15.25	11.75
15%	8.5	10	6.55	9.95	11	9.5	12.95	14	11.9



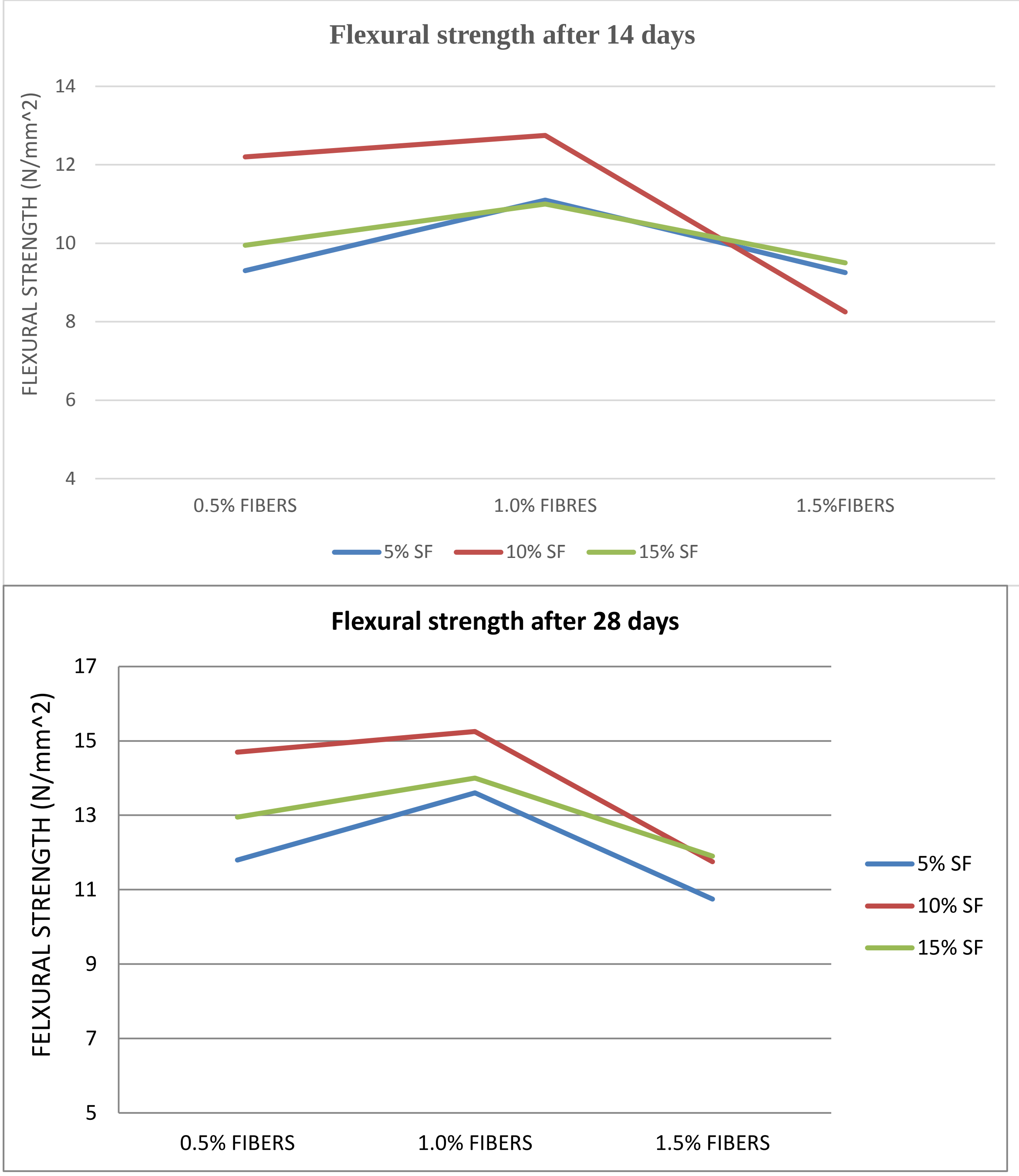


Figure 3: Variation in the Flexural strength of Concrete with the increase in the content of silica fume and steel fiber

As similar results with split tensile strength of the concrete there is significant increase in the flexural strength was observed by adding silica fume and steel fibers. After 28 days there is increase of 5.35 % with the addition of 0.5% of steel fibers and 5% silica fume as compared to the normal mix, and with the increase of the proportion of fibers content from 0.5 to1%

there is increase of 15.25% .After addition of 1.5 % of the steel fibers with the same content of the silica fume there is a decrease of 9.76%, therefore the optimum results are obtained with the fiber content of 1 percent.

CHAPTER 6

CONCLUSION AND RECOMMENDATIONS FOR FURTHER STUDY

6.1 General

The present study was undertaken to determine the flexure strength, compressive strength and concrete split tensile strength with varies level of replacement of cement with Silica fume and the addition of steel fibers. Cement was partially replaced by silica fume and at three different levels of replacement i.e. 0%, 5%,10% and 15%. Tests were performed 28 days later curing of concrete. Various samples for the different proportion of silica fume and the steel fibers in concrete with different percentage were produced for determine flexure strength, compressive strength and split tensile strength of concrete with 0.33 water-cement ratio. Super-plasticizer "Sikament 2000 NS" was used in all the mixes at 0.5% and 1% level by weight of cementious material.

As we know the concrete is weak in tension, so to resist the heavy load it needs to be flexible, therefore the steel fibers are added to make flexibility. By the addition of steel fibers the concrete can restored in original position. Also silica fume is added to increase the workability of the concrete mix. Moreover we know that its flexibility will increase by the addition of fibers but it will be up to some optimum concentration, so this optimum concentration will be determined.

6.2 Conclusion

6.2.1 Analyzing compressive strength

The graphs of compressive strength depicts that with the increase in percentage of silica fume by replacing it with cement, there is a increase in the compressive strength of the concrete cubes at the water- cement ratio of 0.33. The maximum compressive strength of the cubes is found at by replacing 10 % of cement with silica fume. But on further replacement of cement with silica fume, the compressive strength of cubes not much influenced.

Here, the compressive strength increases because silica fume possess some cementing properties and the reduction in the strength of the concrete is due to the pozzolonic activity and pore structure of the cementious material. As replacing of cement with silica fume reduces clinker content of the cement the amount of cementious material forms from pozzolonic reaction gets decreased. It is found out that the strength of the concrete depends on the distribution of the void space and porosity.

6.2.2 Analyzing split tensile strength

Graph of split tensile strength test shows that concrete split tensile strength varies in the same fashion as compressive strength. Increasing the content of silica fume and steel fibers, a considerable increase in concrete split tensile strength was acquired. From the result it is concluded that the splitting tensile strength increases with the increase of silica fume content but the value goes higher up to the combination of 15% silica fume and 1% of steel fibers.
The increase in the split tensile strength test is due to the lower fineness modulus of the silica fume so its increases the cohesiveness of the material. But on further replacing the cement by silica fume the tensile strength decreases

6.2.3 Analyzing flexural strength

The above graph of flexural strength of concrete portrays that by replacing cement with silica fume and addition of steel fibers, the flexural strength of the concrete varies in the same manner as that of compressive strength and tensile strength. With the increase of the proportion of fibers content from 0.5 to1% there is increase of 15.25% .After addition of 1.5 % of the steel fibers with the same content of the silica fume there is a decrease of 9.76%, therefore the optimum results are obtained with the fiber content of 1 percent.

This increases in flexural strength of concrete is due to cementious property of marble dust and its lower fineness modulus which provides cohesiveness property to the material.

6.3 ESTIMATION AND COSTING

To perform compressive strength with the material we casted twenty seven cubes. Out of which nine cubes casted each for 5%, 10%, 15% of silica fume with the constant proportion of 0.5% of steel fibers. In this nine cubes, three cubes for 7 days another three for 14 days and the rest three for 28 days. Similarly, for the same proportion of silica fume with varying the content of steel fibers from 0.5% to 1% same numbers of cubes were casted.

Similarly 27 cylinder casted for split tensile strength test, nine cubes each for 5%, 10%, 15%, of silica fume with the constant proportion of 0.5% of steel fibers. In this nine cylinder, three were casted for 7 days another three for 14 days and the rest three for 28 days. Similarly, for the same proportion of silica fume with varying the content of steel fibers from 0.5% to 1% same numbers of cylinder were casted.

In the same manner the casting of beams for the flexural testing is done.

Table 11: Quantity of material required for specimen with one proportion

% SF	Cement (Kg)	Fine Aggregate (Kg)	Coarse Aggregate (20 mm) (Kg)	Coarse Aggregate (10 mm) (Kg)	Silica Fume (Kg)	Super plasticizer (ml)	Water (litre)
0	16	22.56	30.72	20.48	0	160	5.28
5	15.2	22.56	30.72	20.48	0.800	160	5.28
10	14.6	22.56	30.72	20.48	1.60	160	5.28
15	13.2	22.56	30.72	20.48	2.40	160	5.28

6.3.1 Cost Analysis

Here if we analyze the cost, then we find out that steel fibers are easily available in the market, though it is a waste product therefore it does not cost much. A bag of 100kg of steel fibers cost around 3500 to 4000rs. Silica fume is also waste of silicon metal therefore, use of silica fume in concrete mix enhances the concrete strength as well contributes to eco-friendly environment. A bag of 25 kg of silica fume cost around 600 to 650rs.

6.4 Recommendations

The partial replacement of cement with the silica fume and addition of steel fibers increases the strength of the concrete but this increase in strength can be enhanced if we use steel fibers of different aspect ratio.

Presently we are using the steel fibers of same aspect ratio i.e. 65 and distribute randomly in the concrete mix, but if we use fibers of different aspect ratio the bonding between the steel fibers and cement gets more strengthen which alternatively increase the strength of concrete mix.

References:

1) Mastali M.dalvand “use of silica fume and recycled steel fibers in self-compacted concrete (SSC).” *Construction and building material*

2) Faut koksal et.al. “combined effect of silica fume and steel fibers on the mechanical properties of high strength concrete” *Construction and Building Materials 22 (2008) 1874–1880*

3) Mahmoud Nili ” Combined effect of silica fume and steel fibers on the impact resistance and mechanical properties of concrete” *International Journal of Impact Engineering 37 (2010) 879e886*

4) Farid Bouziadi et.al. “effects of fibres on the shrinkage of high-strength concrete under various curing temperatures” *Construction and Building Materials 114 (2016) 40–48*

5) ozgur eren et.al. “Effect of silica fume and steel fibers on some properties of high-strength concrete” *Department of Civil Engineering, Eastern Mediterranean University, Magusa, 10, Turkey*

6) IRC: 58-2002, “Guideline for Design of Rigid Pavements for Highways.” The Indian Road Congress, New Delhi, 2002.

7) IS: 456-2000: Code of practice- plain and reinforced concrete, Bureau of Indian Standard, New Delhi-2000.

8) IS: 516-1959 (Reaffirmed 2004): Methods of tests for strength of concrete, Bureau of Indian Standard, New Delhi-2004

9) IS: 10262-1982 (Reaffirmed 2004): Recommended guidelines for concrete mix design, Bureau of Indian Standard, New Delhi-2004

10) IS: 8112-1989 (Reaffirmed 2005): Specification for 43 Grade Ordinary Portland Cement, Bureau of Indian Standard, New Delhi-2005.

11) IS: 9103-1999 (Reaffirmed 2004): Concrete Admixtures-Specifications, Bureau of Indian Standard, New Delhi-2004.

12) IS: 383-1970: Specification for Coarse and Fine Aggregates from Natural Sources for Concrete, Bureau of Indian Standard, New Delhi-1970.

13) IS: 1199-1959 (Reaffirmed 1999): Methods of Sampling and Analysis of Concrete, Bureau of Indian Standard, New Delhi-1999.

14) IS: 2386 (Part I,III)-1963: Methods of Test for Aggregates for Concrete, Bureau of Indian Standard, New Delhi-1963.

15) IS: 4031 (Part 4,5&6)-1988: Methods of Physical Tests for Hydraulic Cement, Bureau of Indian Standard, New Delhi-1988.

16) IS: 5816-1999: Methods of test for Splitting Tensile Strength of Concrete, Bureau of Indian Standard, New Delhi-1999.

17) Handong Yan et.al. “The effect of silica fume and steel fiber on the dynamic mechanical performance of high-strength concrete” *Cement and Concrete Research 29 (1999) 423–426*