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STUDY ON STRENGTH AND DURABILITY PROPERTIES OF FIBER REINFORCED CONCRETE USING FLYASH AND SILICA FUME

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ABSTRACT

The cost of construction materials is currently so high that only governments, corporate organizations and wealthy individuals can afford to do meaningful constructions. Unfortunately, production of cement involves emission of large amount of carbon-dioxide gas into the atmosphere, a major contributor for greenhouse effect and global warming, hence it is inevitable either to search for another material or partly replace it by some other material. The search for any such material, which can be used as an alternative or as a supplementary for cement should lead to global sustainable development and lowest possible environmental impact. The use of supplementary cementitious materials or mineral admixtures such as silica fume as fly ash in concrete fits very well with sustainable development. The volume of silica fume and fly ash in concrete mixtures contain lower quantities of cement.

High-strength concrete is precise, where reduced weight is important or where architectural considerations for small support elements. By carrying loads very efficiently than normal-strength concrete, high-strength concrete also reduces the total amount of material placed and lower the overall expenditure and weight of the structure. High-strength concrete columns can hold more weight and therefore be made slimmer than regular strength concrete structures, which allows for more useable space, especially in the lower floors of buildings. High Strength Concrete is also used in other engineering structures like bridges, fly-over etc. From the general principles behind the design of high-strength concrete mixtures, it is clear that high strengths are made possible by reducing porosity, in homogeneity, and micro cracks in the hydrated cement paste.

In the present study, the different admixtures were used to study their individual and combined effects on the resistance of concrete in addition to their effects on workability, durability and compressive strength by the replacement of admixtures by 5%,10%, 15% of fly ash by the weight of cement with a constant amount of 0.5% steel hook fibres are added by volume of concrete, throughout the study.

KEY WORDS: Fly ash, compressive strength, durability, workability

I. INTRODUCTION

1.1 GENERAL

The cost of construction materials is currently so high that only governments, corporate organizations and wealthy individuals can afford to do meaningful constructions. Unfortunately, production of cement involves emission of large amount of carbon-dioxide gas into the atmosphere, a major contributor for greenhouse effect and global warming, hence it is inevitable either to search for another material or partly replace it by some other material. The search for any such material, which can be used as an alternative or as a supplementary for cement should lead to global sustainable development and lowest possible environmental impact. The use of supplementary cementitious materials or mineral admixtures such as silica fume as fly ash in concrete fits very well with sustainable development. The volume of silica fume and fly ash in concrete mixtures contain lower quantities of cement.

With the passage of time to meet the demand, there was a continual search in human being for the development of high strength and

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durable concrete. The history of high strength concrete (HSC) is about 35 years old, in late 1960s the invention of water reducing admixtures lead to the high strength precast products and structural elements in beam were cast in situ using high strength concrete (HSC). After the technology has come to age and concrete of the order of M60 to M120 are commonly used. Concrete of the order of M200 and above are a possibility in the laboratory conditions. The definition of high strength concretes (HSC) is continually developing. In the 1950s 34 N/mm^2 was considered high strength concrete, and in the 1960s compressive strengths of up to 52 N/mm^2 were being used commercially. More recently, compressive strengths approaching 138N/mm^2 have been used in cast-in-place buildings. The dawn of pre-stressed concrete technology has given incentive for making concrete of high strength. In India high strength concrete is used in pre-stressed concrete bridges of strength from 35N/mm^2 to 45N/mm^2. Presently Concrete strength of 75 N/mm^2 is being used for the first time in one of the flyover at Mumbai.Also in construction of containment dome at Kaiga power project used High Strength Concrete (HSC) of 60MPa with silica fume as one of the constituent.

1.2HIGH STRENGTH CONCRETE

High-strength concrete structures can hold more weight and therefore be made slimmer than normal strength concrete columns, which allows for more useable space, especially in the lower floors of buildings. High-strength concrete is specified where reduced weight is important or where architectural considerations call for small support elements. By carrying loads more efficiently than normal-strength concrete, high-strength concrete also reduces the total amount of material placed and lower the overall cost of the structure.

- To put the concrete into service at much earlier age, for example opening the pavement at 3-days.
- To build high-rise buildings by minimizing column sizes and increasing available space.
- To build the superstructure of long span bridges and to enhance the durability of bridge decks.
- To satisfy the specific requirements of special applications, such as durability, modulus of elasticity and flexural strength. Some of these applications include dams, grandstand roofs, marine foundations, parking garages and heavy duty industrial floors.

There are special method of making high strength concrete such that,

- Seeding
- Revibration
- High speed
- slurry mixing
- Inhibition of cracks
- Use of admixtures
- Sulphur impregnation
- Use of cementitious aggregate

1.3 HIGH PERFORMANCE CONCRETE

In recent years, the terminology "High-Performance Concrete" has been introduced into the construction industry. The American Concrete Institute (ACI) defines high-performance concrete as concrete meeting special combinations of performance and uniformity requirements that cannot be always achieved routinely by using conventional constituents and normal mixing, placing and curing practices. A commentary to the definition states that a high-performance concrete is one in which certain characteristics are developed for a particular application and environment. Examples of characteristics that may be considered critical for an application are:

- Ease of placement
- Early age strength
- Long-term mechanical properties
- Permeability
- Density
- Heat of hydration
- Compaction without segregation

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- Toughness
- Volume stability
- Long life in severe environments

II. REVIEW OF LITERATURE

2.1 INTRODUCTION

As our aim is to develop high strength concrete which does concern on the strength of concrete, it also having many other aspects to be fulfilled like less porosity, capillary absorption, durability. Also now a day's one of the great applications in various structural fields are high strength fiber reinforced concrete, which is getting popularity because of its positive effect on various properties of concrete.

2.2 TYPES OF ADMIXTURES

According to ASTM C-125, admixture is a material other than water, aggregates and hydraulic cement used as an ingredient of concrete and added to the batch immediately before or during mixing. If these materials are blended during the manufacture of cement, it is called as an additive.

2.3 FLY ASH

Fly ash is the most widely used supplementary cementations material in concrete. It is a byproduct of the combustion of pulverized coal in electric power generating plants. Upon ignition in the furnace, most of the volatile matter and carbon in the coal are burned off. During combustion, the coal's mineral impurities (such as clay, feldspar, quartz, and shale) fuse in suspension and are carried away from the combustion chamber by the exhaust gases. In the process, the fused material cools and solidifies into spherical glassy particles called fly ash. The fly ash is then collected from the exhaust gases by electrostatic precipitators or bag filters. Fly- ash particles are typically spherical, ranging in diameter from <1 µm up to 150 µm. Fly ash is a finely divided powder resembling portland cement. (Vikrant S. Vairagade et. Al, 2012)

Fig 1: The sample of fly ash used in concrete

2.4 TYPES OF FLY ASH: (As per ASTM C 618)

Class F fly ash

Class-F fly ash is produced by burning of harder, older anthracite and bituminous coal. Class F are generally low-calcium fly ashes with carbon contents less than 5% but sometimes as high as 10%. This fly ash is pozzolanic in nature, and contains less than 20% lime (Cao). Possessing pozzolanic properties, the glassy silica and alumina of Class F fly ash requires a cementing agent, such as Portland cement, quicklime, or hydrated lime, with the presence of water in order to react and produce cementations compounds. Class F ashes will only react with the by-products formed when cement reacts with water. Alternatively, the addition of a chemical activator such as sodium (water glass) to a Class F ash can leads to the formation of HSC.

Class C fly ash

Class-C ashes are produced from the burning of younger lignite or sub bituminous coal. In addition to having pozzolanic properties, Class C ashes also have some self-cementing properties. Class C ashes in the presence of water will react and harden just like cement and gain strength over time but not Class F ashes. Class C fly ash generally contains more than 20% lime (Cao) with carbon content less than 2%. Unlike Class F, self-cementing Class C fly ash does not require an activator. Alkali and sulphate (SO4) contents are generally higher in Class C fly ashes.

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- Being a pozzolana, fly ash has the ability to act cementitious with the presence of cement and water. This process is able to happen because of fly having silica and alumina.
- Fly ash on a micro level takes the form of a sphere which allows the particle to fit easily within the pores of the concrete. This circular form of the fly ash also allows the concrete to be more fluid and workable. When it comes to setting the concrete, it's a benefit for workers by it having this feature making it easier to place.

Performance properties between Class C and F ashes vary depending on the chemical and physical properties of the ash and how the ash interacts with cement in the concrete.

2.4.1 USE OF FLY ASH IN CONCRETE

It has been above 70 years to research and use fly ash. With its application, the action mechanism of fly ash had been recognized. During the initial stage, only its pozzolanic activity is paid attention. Many researchers devoted themselves to the research of the potential activity of fly ash and the hydration process of fly ash cement. With the deepening of the cognition for fly ash properties, some people found that the particles of fly ash have the morphology that is different to other pozzolanic materials. It is the unique particle morphology to make it have the ability reducing water, which other pozzolanic materials do not have. It influences not only the rheological property of fresh mortar but also the initial structure of hardened cement stone.

In the end of 1970s, Jan de Zeeuw and Abersch put forward that the role of fly ash, which its particle size is less than 30, may be similar to that of the micro-particle of un-hydrated cement in cement stone. In 1981, Danshen and Yinji and Danshen summarized the previous research results and put forward the hypothesis of "fly ash effects." They considered that fly ash has three effects in concrete, i.e., morphological, activated and micro aggregate effects. The three effects are relative each other. This shows that the morphological effect is the important aspect of fly ash effects.

The specific improvement lies in the following aspects:

- Incorporating FA by the method of super-substituting, a widely used design method, effectively increases the total amount of binder in RCC and makes it easier to compact.
- Substituting Fly Ash for a part of cement in RCC can remarkably decrease the quantity of heat produced by cement hydration.
- Formation by vibration and rolling, and also by its required low water-cement ratio, can somehow make up the early age strength of FRCC, which is often cut down by the incorporation of a large amount of FA in ordinary concrete. With the previously mentioned advantages, FRCC is gradually extended in pavement construction. Possessing so many favorable properties, amount of Fly Ash in FRCC can further be promoted and the performance of pavement can still be guaranteed, while taking rational ratio design as prerequisite.

2.5. Use of Mineral Admixtures

The benefits of mineral admixtures may be broadly classified into three categories viz., engineering benefits, economics benefits and ecological benefits.

2.5.1 Engineering benefits

The incorporation of finely divided particles into concrete mixtures tends to improve the workability and reduce the water requirement at a given consistency (except silica fume). There is an enhancement of ultimate strength, impermeability and durability to chemical attack. An improved resistance to thermal cranking is obtained due to the lower heat of hydration of blended Cements and increased tensile strain capacity of concrete containing mineral admixtures.

2.5.2 ECONOMIC BENEFITS

Cement represents the most expensive component of a concrete mixture. As it is a highly energy intensive material, the increasing energy costs reflect on higher Cement costs. Most of the pozzolanic and cementitious materials in use today are industrial by-products, which require no expenditure of energy for use as mineral admixtures. When used as partial Cement replacement, up to 70% Cement by mass, mineral admixtures can result in substantial energy and cost savings.

2.5.3 ECONOMIC BENEFITS

The total volume of pozzolanic and cementitious by-products generated every year by thermal power plants and metallurgical industries exceed 900 million tones. Many of these by-products contain toxic elements, which can be hazardous to human health if not disposed in a safe manner. Thus dumping into lakes, low lying areas, streams or landfills and use as a road base is not a safe practice because the toxic elements can find their way into ground water. The Cement and concrete industry preferred disposal of by-product mineral admixtures because most of the harmful metals can be safely incorporated into the hydration products of Cement.

2.6 EARLIER RESEARCHERS

P.S Song, S.Hwang examined on mechanical properties of high strength steel fiber reinforced concrete.The marked brittleness with low tensile strength and strain capacities of high-strength concrete (HSC) can be overcome by the addition of steel fibers. This paper investigated the mechanical properties of high-strength steel fiber-reinforced concrete. The properties included compressive and splitting tensile strengths, modulus of rupture, and toughness index. The steel fibers were added at the volume fractions of 0.5%, 1.0%, 1.5%, and 2.0%. The compressive strength of the fiber-reinforced concrete reached a maximum at 1.5% volume fraction, being a 15.3% improvement over the HSC. The splitting tensile strength and modulus of rupture of the fiber-reinforced concrete improved with increasing the volume fraction, achieving 98.3% and 126.6% improvements, respectively, at 2.0% volume fraction. The toughness index of the fiber-reinforced concrete improved with increasing the fraction. The indexes I_5, I_{10}, and I_{30} registered values of 6.5, 11.8, and 20.6, respectively, at 2.0% fraction. Strength models were established to predict the compressive and splitting tensile strengths and modulus of rupture of the fiber-reinforced concrete. The models give predictions matching the measurements.

Vahid Afroughsabet, To gayOzbakkaloglu examined on Mechanical and durability properties of high-strength concrete containing steel and polypropylene fibers.the effect of the addition of steel and polypropylene fibers on the mechanical and some durability properties of high-strength concrete (HSC). Hooked-end steel fibers with a 60-mm length were used at four different fiber volume fractions of 0.25%, 0.50%, 0.75%, and 1.0%. Polypropylene fibers with a 12-mm length were used at the content of 0.15%, 0.30%, and 0.45%. Some mixtures were produced with the combination of steel and polypropylene fibers at a total fiber volume fraction of 1.0% by volume of concrete, in order to study the effect of fiber hybridization. All the fiber-reinforced concretes contained 10% silica fume as a cement replacement. The compressive strength, splitting tensile strength, flexural strength, electrical resistivity, and water absorption of the concrete mixes were examined. Results of the experimental study indicate that addition of silica fume improves both mechanical and durability properties of plain concrete. The results also indicate that incorporation of steel and polypropylene fibers improved the mechanical properties of HSC at each volume fraction considered in this study. Furthermore, it was observed that the addition of 1% steel fiber significantly enhanced the splitting tensile strength and flexural strength of concrete. Among different combinations of

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steel and polypropylene fibers investigated, the best performance was attained by a mixture that contained 0.85% steel and 0.15% polypropylene fiber. Finally, the results show that introducing fibers to concrete resulted in a decrease in water absorption and, depending on the type of fibers, significant or slight reduction in the electrical resistivity of concrete compared to those of the companion plain concrete.

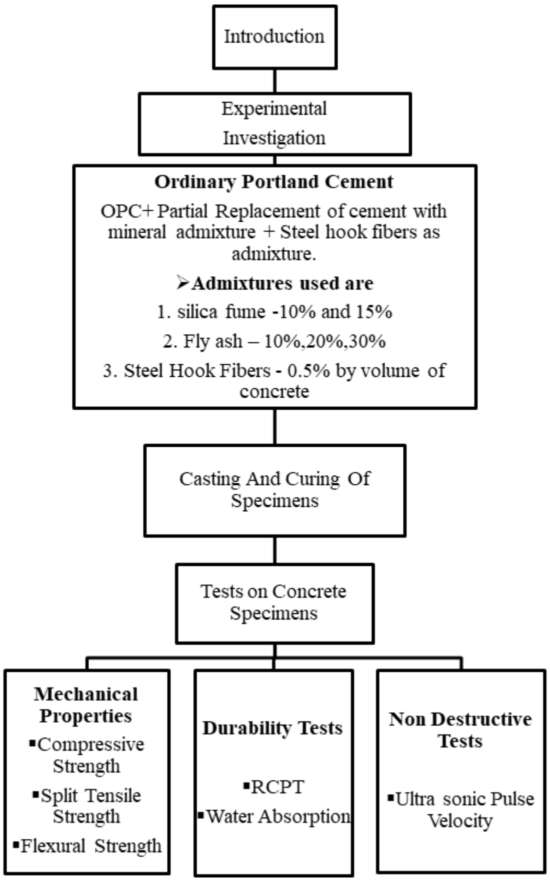
III. SCOPE AND OBJECTIVE OF PRESENT WORK

3.1 SCOPE

The objective of the present work is to develop concrete with good strength, less porous, less capillarity so that durability will be reached. For this purpose it requires the use of different pozzolanic materials like Fly ash and silica fume along with fiber. So the experimental program to be undertaken;

- To reduce the impact of waste materials on environment.
- To find out the percentage use of admixtures feasible for construction.
- To determine the mix proportion with Fly ash and silica fume with fiber to achieve the desirable needs.
- To determine the water/ binder ratio, so that design mix having proper workability and strength.
- To investigate different basic properties of concrete such as compressive strength, splitting tensile strength, flexural strength etc., and comparing the results of different proportioning.
- To determine the chloride penetration of concrete using Rapid Chlorine Penetration Test (RCPT).
- For safe construction, to find the how much percentage of silica fume and fly ash is partially replaced by cement and steel fibers as an admixture to attains strength at maximum level.

3.2 OBJECTIVE OF PRESENT WORK



IV. MATERIALS AND EXPERIMENTAL STUDY

4.1 GENERAL

The physical and chemical properties of cement, fine aggregates, coarse aggregates and water used in this investigation are analyzed based on standard experimental procedure laid down in standard codes like Indian standard code, ASTMC, and Bureau of Indian standard codes.

4.2 MATERIALS

The materials used in present investigation include;

1. Cement-Ordinary Portland Cement (OPC)
2. Mineral Admixtures-
   a. Fly-Ash
3. Fine aggregates
4. Coarse aggregates
5. Water

4.3 CEMENT

Ordinary Portland cement of 53 grades was selected for the experimental investigation. The compressive strength characteristics of cement were tested as per IS: 4031-1988 and IS: 12269-1987(9).The cement used in present study was Zuari cement. The experiments such as standard consistency, initial setting time, final setting time and specific gravity of cement are conducted on ordinary Portland cement.

TABLE 4.1 PHYSICAL PROPERTIES OF OPC

S.No	Characteristic of cement	Value	Code specifications (IS 4031-1988)
1	Fineness of cement	94.76%	-
2	Normal consistency	33%	Not specified
3	Initial setting Time	40 minutes	>30
4	Final setting time	350 minutes	<600
5	Specific gravity	3.14	-

The chemical composition of cement was analyzed according to standard procedures laid down in IS 4301(part-5):1988. The results of analysis are presented in table 4.2.

TABLE 4.2 CHEMICAL COMPOSITION OF CEMENT

S.NO	Oxide	Present Content
1	Cao	65.49
2	SiO_2	21.67
3	Al_2O_3	5.97
4	Fe_2O_3	3.85
5	SO_3	1.66
6	MgO	0.78
7	K_2O	0.46
8	Na_2O	0.12

The percentage compositions of major compounds (known as BOGUE compounds) present in cement are tabulated below.

TABLE 4.3 THE PERCENTAGE COMPOSITION OF THE MAJOR COMPOUNDS PRESENT IN THE TEST CEMENT

S.No	Name of The Compound	Conversion Formulae	% present in Cement
1	Tri-Calcium Silicate ($3Cao.SiO_2$)	$4.07(Cao)-7.60(siO_2)-6.72 (Al_2O_3)-1.43 (Fe_2O_3)-2.85(SO_3)$	51.49
2	Di-calcium Silicate ($2Cao.SiO_2$)	$2.87 (SiO_2)-0.754 (3 Cao.SiO_2)$	23.37
3	Tri-calcium aluminate ($3CaO.Al_2O_3$)	$2.65 (Al_2O_3)-1.69 (Fe_2O_3)$	9.31
4	Tetra-calcium alumina ferrite ($4CaO.Al_2O_3.Fe_2O_3$)	$3.04 (Fe_2O_3)$	11.70

TABLE 4.4 VARIATION OF STANDARD CONISTENCY FOR DIFFERENT REPLACEMENT PERCENTAGES OF CEMENT WITH FLY ASH

Sl. No	Mix Proportion	Standard Consistency (%)
1.	100%OPC + 0% FA	33
2.	95%OPC + 5% FA	34
2.	90%OPC + 10% FA	35
3.	85%OPC + 15% FA	36

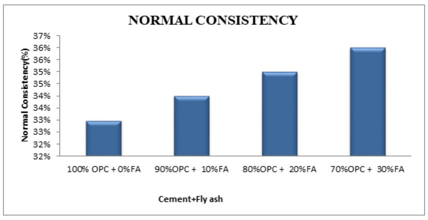


Fig 2: Normal Consistency for Replacement percentages of Cement by Fly Ash

From the fig 4.1, it is observed that for different replacement percentages of Cement with Fly ash, normal consistency increased. The 5% ,10%, 15%replacement of Cement with Fly ash results in increase of normal consistency, it varies as 33, 34, 35 to 36 percent respectively.

4.3.1. RESULTS OF INITIAL AND FINAL SETTING TIMES

Table 4.6 gives the result of initial and final setting time for different replacement percentages of Cement with Fly ash. Initial setting time test results shows very slight increase in initial setting time of Cement for different dosages 5%, 10%, 15% of Fly ash in Ordinary Portland Cement. Final setting time test results shows very slight decrease in final setting time of Cement for different dosages 5%, 10%, 15% of Fly ash in Ordinary Portland Cement.

TABLE 4.5 INITIAL AND FINAL SETTING TIME FOR DIFFERENT PERCENTAGES OF CEMENT WITH FLY ASH

S.NO	Mix Proportion	Initial Setting Time (minutes)	Final Setting Time (minutes)
1	100% OPC +0% FA	40	350
2	95% OPC + 5% FA	60	320
3	90% OPC +10% FA	70	280
4	85% OPC +15% FA	80	250

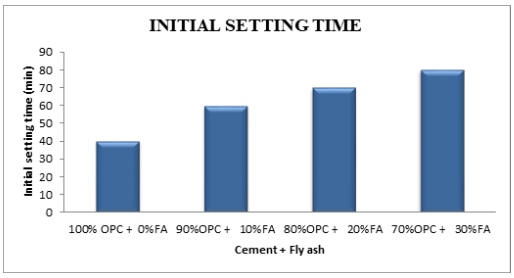


Fig 3. Initial setting time for Different Replacement percentages of Cement with Fly Ash

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From the fig 4.3 it is observed that for different replacement percentages of Cement with Fly ash, initial setting increased. The 0%, 10%, 20% and 30% replacement of Cement with Fly ash results in increase of initial setting time, it varies as 40, 60, 70 to 80 percent respectively.

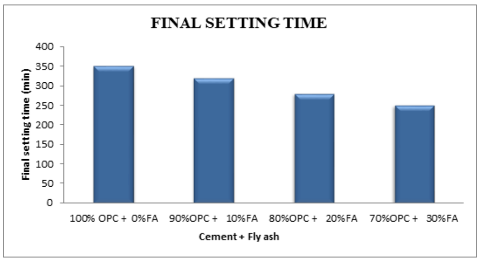

Fig 4. Effect on Final setting time for Different Replacement Percentages of Cement with Fly Ash

From the fig 4.4, it is observed that for different replacement percentages of Cement with Fly ash, final setting decreased. The 0%, 5%, 10% and 15% replacement of Cement with Fly ash results in decrease of final setting time, it varies as 350, 320, 280 to 250 percent respectively.

4.4. WATER

Water used for drinking can also be used for mixing concrete. Impurities in the water may affect concrete, its setting time, and its Compressive strength and Split tensile strength. Water has two functions in a concrete mix. Firstly, it reacts chemically with the cement to form a cement paste in which the inert aggregates are held in suspension until the cement paste has hardened. Secondly, it serves as a vehicle or lubricant in the mixture of fine aggregates and cement. The characteristics of water, to which various chemical and biological substances were spiked, are presented in the table below and were analyzed according to the standard methods for the examination of water (APHA 1994).Results compile **to IS 3025 and IS 456-2000.**

TABLE 4.6 .CHARACTERISTICS OF WATER

S.No	Parameter	Units	Concentration
1	P^H	-	6.7
2	Total Dissolved solids	mg/l	370
3	Alkalinity	mg/l	118
4	Acidity	mg/l	12
5	Hardness	mg/l	139
6	Sulphates	mg/l	19
7	Chlorides	mg/l	66

4.5. FINE AGGREGATE

Sand is a naturally occurring material from Rock and Minerals by weathering and is composed of majorly sio_2, and Calcium carbonate. The sand used throughout the experimental work wasobtained from the Muthireveluvanka near Chittoor, Chittoor district, Andhra Pradesh. This type of sand was used by many of researchers as an ingredient in concrete. According to **IS 650:1966**, the sand used in cement concrete should confirm to the following specifications.

- Sand shall be of quartz, light gray or whitish variety.
- It shall be free from silt.
- The grains shall be angular. The shape of grains shall approximate to spherical form, enlarged and flattened grains being present only in negligible quantities.

Grading:

- Passing through 2mm IS sieve 100%
- Retained on 90µ IS sieve 100%
- Particle size greater than 1 mm 33.33%
- Particle size smaller than 1 mm and greater than 500 µ 33.33%
- Particle size smaller than 500 µ 33.33%

Sand shall be free from organic impurities. Loss of weight on interaction with hydrochloric acid shall not exceed 0.25%

The specific particle size composition of the sand was prepared as per the **IS 650:1966 and IS 383:1970**. Sand was thoroughly washed with tap water to remove impurities like decayed vegetable matter, humus, organic matter and deleterious materials like clay, fine silt and fine dust and was oven dried for 24 hours and cooled to room temperature. This sand was used for the experimental work. These impurities most

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probably reduce the strength and durability of the cement mortar.

The properties of sand were analyzed in accordance with the procedures laid down in **IS 2386(Part I and Part II):1963** and were presented in Table 4.9.

TABLE 4.7. PROPERTIES OF FINE AGGREGATES

S.no	Properties	Results
1.	Specific gravity	2.583
2.	Bulking of sand	4
3.	particle size variation	0.15 to 4.75
4	Water absorption for sand	1
5	Bulk Density of Sand	1460
6	Fineness modulus osand.	2.8

The properties of sand like specific gravity of sand is 2.583, and Bulking of sand is 4%. Particle size variation of sand is between 0.15 to 4.75 mm. Water adsorption for sand is noticed as 1%. Bulk density of sand is abserved as 1460 kg/m^3. The fineness modulous of sand is 3.8%.And in this study sand is confirming to Zone II.The table 4.6, clearly reveals that the percentage of sand passing through IS sieve 4.75 mm is 98.5 % and percentage of sand passing through IS sieve 2.36 mm is 95.5 %. The percentage of sand passing through IS sieve 1.18 mm is 64%. The percentage of sand passing through IS sieve 0.6 mm is 36.5%, The percentage of sand passing through IS sieve 0.3 mm is 15.5 %. The percentage of sand passing through IS sieve 0.15 mm is 0.5% and percentage of sand retained in the pan is 0.5%.

TABLE 4.8 FINENESS MODULUS OF FINE AGGREGATE

S.No	IS Sieve	Weight Retained	%Weight Retained	Cumulative% Weight Retained	%Passing
1	10mm	0	0	0	100
2	4.75mm	15	1.5	1.5	98.5
3	2.36mm	30	3.0	4.5	95.5
4	1.18 M	315	31.5	36	64
5	600 M	275	27.5	63.5	36.5
6	300 M	210	21	84.5	15.5
7	150 M	60	6	90.5	9.5
Fineness Modulus = 2.80			Total = 280.0		

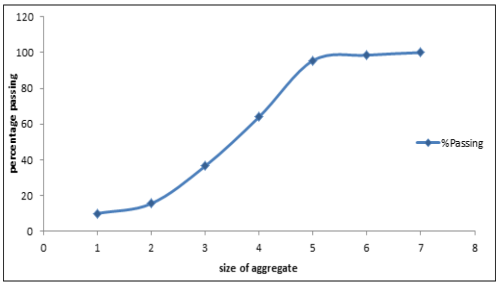

Fig 5. Fineness modulus of fine aggregate

4.6. COARSE AGGREGATE

Gravels are popularly used as Coarse aggregates, which are free from organic impurities and silt. As per **Indian standard specifications IS 383-1970** the coarse aggregates were tested and placed in table 4.12. Locally available gravels of size 20 mm passing 10 mm retained are taken and specific gravity of coarse aggregate is arrived as 2.68.

Coarse aggregate are the crushed stone is used for making concrete. The commercial stone is quarried, crushed, and graded. Much of the crushed stone used is granite, limestone, and trap rock. The last is a term used to designate basalt, gabbro, diorite, and other dark- collared, fine- grained igneous rocks. Graded crushed stone usually consists of only one kind of rock and is broken with sharp edges. The sizes are from 0.25 to 2.5 in (0.64 to 6.35 cm), although larger sizes may be used for massive concrete aggregate. Granite is a coarse-grained, igneous rock having an even texture and consisting largely of quartz and feldspar with often small amounts of mica and other minerals. There are many varieties. Granite is very hard and compact, and it takes a fine polish, showing the beauty of the crystals. Granite is the most important building stone. Granite is extremely durable, and since it does not absorb moisture, as limestone and sandstone do, it does not weather or crack as these stones do. The colors are usually reddish, greenish, or gray. Rainbow granite may have a black or dark-green background with pink, yellowish, and reddish mottling; or it may have a pink or lavender background with dark mottling. The density is 2,723 kg/m3, the specific gravity 2.68, and the crushing strength 158 to 220 MPa.

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TABLE 4.9. COARSE AGGREGATE PROPERTIES

S.No	Properties	Unit	Results
1.	Specific gravity	-	2.68
2.	Particle size variation	mm	6.35 to 6.4 to 20mm
3	Fineness Modulus	-	6.26
4	Water Absorption	%	0.5
5	Bulk Density	kg/m^3	1469.8
6	Elongation index	%	20.49
7	Flakiness index	%	13.19

The table 4.13 clearly shows that the percentage of gravel passing through IS sieve 20 mm is 92.7 % and percentage of gravel passing through IS sieve 12.5mm is 42.2 %. The percentage of gravel passing through IS sieve 10 mm is 20.2 %. The percentage of coarse aggregate passing through IS sieve 0.6 mm is 0.5%, and the percentage of gravel passing through IS sieve 4.75 and 2.36 mm is 0 %. From this it is very clear that gravel is graded between 20 mm to 10 mm.

From the above data it is evident that 92.7 % of gravel is retained in 20 mm and 42.2 % of gravel is retained in 12.5 mm sieves only.

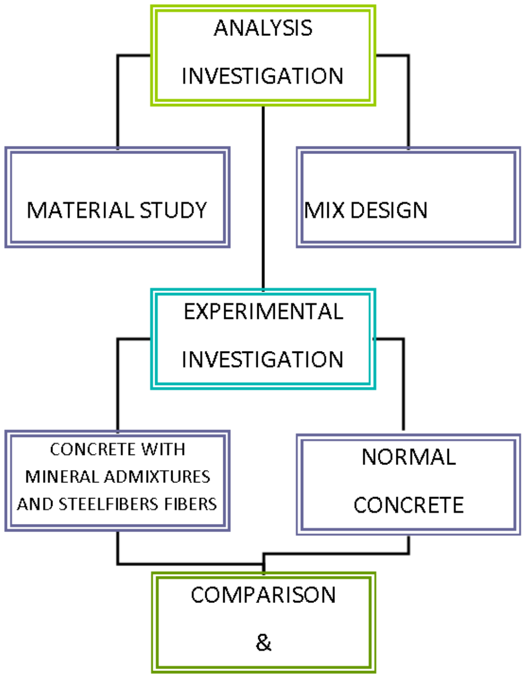
4.7. FLY ASH

For this project Fly ash is taken from Rayalaseema thermal power plant (RTPP), Kadapa. RTPP has installed ESP for segregation and collection of fly ash into six different fields. As the field number increases the fineness of fly ash increases but the quantity decreases. Field-1 fly ash has coarse particles and is not suitable for concrete applications. Since maximum availability of fly ash is from field-2, some of them was used for our study. This fly ash conforms to the requirements of **IS: 3812 part-I and also ASTMC-618 type-F.**

TABLE 4.10.PROPERTIES OF FLY ASH

Sl. No.	Characteristics	Percentage
1	Silica,SiO2	49-67
2	Alumina,Al2O3	16-28
3	Iron oxide,Fe2O3	4-10
4	Lime, CaO	0.7-3.6
5	Magnesia, MgO	0.3-2.6
6	Sulphur trioxide, SO3	0.1-2.1
7	Loss of ignition	0.4-0.9
8	Surface area,(m2/kg)	230-600
9	Specific gravity	2.3

V. METHODOLOGY



5.1 MIX-PROPORTIONS OF HSFRC FOR M60 GRADE

Mix Proportions:

	Water	Cement	Fine aggregate	Coarse aggregate
Proportion by Weight	147kg	420	650.916	1254.24
Proportion by Ratio	0.35	1	1.55	2.985

TABLE 5.1 MIX-PROPORTIONS FOR M53 GRADE CONCRETE THAT ARE USED IN HSC

Sample	Cement (%)	Fly Ash (%)	F.A (kg/m^3)	C.A (kg/m^3)	W/C Ratio	Water (liters)
Controlled mix	100	0	651	1254	0.35	147
5% FA	95	5	651	1254	0.35	147
10% FA	90	10	651	1254	0.35	147
15% FA	85	15	651	1254	0.35	147

Where

FA=fly ash

5.2 PREPARATION OF CONCRETE

Production of quality concrete requires meticulous care exercised at every stage of manufacture of concrete. It is interesting that the ingredients of good concrete and bad concrete are the same. If meticulous care is not exercised and good rules are not observed the resultant concrete is going to be of bad quality. With the same material if intense care is taken to exercise control at every stage it will result in good concrete. The various stages of

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manufacture of concrete are:

a) Batching
b) Mixing
c) Placing
d) Compaction
e) Curing

5.2.1 BATCHING

Batching is of two types. They are explained below:

(a) Volume batching:

Volume batching is not good method for proportioning, because of difficulty it offers to measure granular materials in terms of volume. Volume of moist sand loose condition weighs much less than the same volume of dry compacted sand. The amount of solid granular material in cubic meter is indefinite quantities because of this for quality concrete materials have to measure by weighing only.

(b) Weigh Batching:

Weigh batching is the correct method of measuring materials. For important concrete invariably, weigh batching system should be adopted. Use of weight system in batching, facilities accuracy, flexibility and simplicity. Different types of weigh batches are available. The particular type to be used depends upon the nature of job.

5.2.2 MIXING

Though the mixing of the materials is essential for the purpose of uniform concrete, the mixing should ensure that the mass becomes homogeneous, uniform in color and consistency. There are two methods adopted in mixing concrete. They are given below:

1. Hand mixing
2. Machine mixing

5.2.3 PLACING

The concrete must be placed in systematic manner to yield optimum result.

5.2.3.1 MOULD DETAILS

The internal dimensions of the mould are:

SPECIMEN	DIMENSION
Cube size	150mm x150mm x 150mm
Cylinder size	300mm Depth, 150mm Diameter

5.2.4 COMPACTION

Compaction of concrete is this process adopted for expelling the entrapped air from the concrete In the process of mixing. Transporting and placing of concrete air is likely to get entrapped in the concrete. The lower the workability higher is the amount of air entrapped. In other words, stiff concrete mix has high % of entrapped air and therefore would need higher compacting efforts than high workable mixes.

If this is not removed fully the concrete losses strength considerably. The relationship between loss of strength the air voids left due to lack of compaction. It can be seen that 5% voids reduce the strength of concrete by above 30% and 10% voids reduce the strength by over 50% .Therefore, it is imperative that 100% compaction of concrete one of the most important aim to kept in mind in good concrete-making practices.

Fig 6: Sampling of concrete

5.2.5 CURING

Concrete while hydrating, releases high heat of hydration. The heat is harmful from the point of view of volume stability. If the heat generated is removed by some means, the adverse effect due to the generation of heat can be reduced. This can be done by a through water curing.

5.2.5.1 WATER CURING

This is by far the test method of curing as it satisfies all the requirements of curing, namely, promotion of hydration, elimination of shrinkage and adsorption of the heat of hydration.

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Fig 7 : Above figure shows a curing tank in which concrete specimens were kept for 3,7,28,56,90 days for hydrating of concrete.

5.3 TESTS CARRIED OUT ON FRESH CONCRETE

5.3.1 SLUMP CONE TEST

Slump cone test apparatus was made according to IS: 7320-1974 and used for calculating normal consistency of concrete Fresh concrete was filled in slump cone by tamping each layer for 25 times with a tamping rod. Later metal cone is raised slowly in a vertical direction. As soon as the settlement of concrete slump of the concrete measured by scale.

5.3.2 COMPACTION FACTOR TEST

Place the concrete sample gently in the upper hopper to its brim using the hand scoop and level it. Cover the cylinder and Open the trap door at the bottom of the upper hopper so that concrete falls in to the lower hopper .Push the concrete sticking on its sides gently with the road. Open the trap door of the lower hopper and allow the concrete to fall in to the cylinder below.

Cut of the excess of concrete above the top level of cylinder using trowels and level it. Clean the outside of the cylinder. Weight the cylinder with concrete to the nearest 10 g. This weight is known as the weight of partially compacted concrete (w1). Empty the cylinder and then refill it with the same concrete mixture in 3 layers approximately 5cm deep, each layer being heavily rammed to obtain full compaction. Level the top surface. Weigh the cylinder with fully compacted. This weight is known as the weight of fully compacted concrete (w2).Find the weight of empty cylinder (W)

Compaction Factor= (W1-W2 / W2-W)

5.4 TESTS FOR HARDENED CONCRETE

Testing of hardened concrete play an important role in controlling and conforming the quality of cement concrete works. Systematic testing of raw materials fresh concrete and hardened concrete are inseparable part of any concrete with regard to both strength and durability the test methods should be simple, direct convenient to apply one of the purposes of testing hardened concrete is to conform that the concrete used at site has developed the required strength. As the hardening concrete takes time, this is an inherent disadvantage in conventional test can be carried out to predict 3,7, 28,56,90 days strength but mostly when correct materials are used and careful steps are taken at every stage of the work, concrete normally the required strength. Tests are made by casting cubes or cylinder from representative concrete. It is to be removed that standard compressive test specimens give a measure of the potential strength of the concrete and not of the strength of the concrete structure. Knowledge of the strength of concrete is structure is cannot be directly obtained from tests on separately made specimens.

5.4.1 COMPRESSIVE STRENGTH TEST

Cubes with dimensions of 150mm×150mmx150mm are used for Compression test, durability test (acid). The size of the cylinder was 15 cm diameter and 30 cm length was used for Split tensile test. All these specimens were casted in cast iron moulds confirming to relevant codes of Indian standards. Prior to casting of specimen, moulds were cleaned, lubricated with oil and all the bolts are fastened tightly so that there is no leakages in the mould. The curing was done by immersing concrete specimens in a tank containing water. This method of curing is called as water curing by immersion. The concrete specimens were cured for specified

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number of days (3, 7, 28, 56 and 90 days) in water at 25± 20C and later specimens are taken out of water for testing**.**

Compressive Strength Testing Machine is used for the determination of compressive strength for cubes and cylinders. The specimens after subjected to curing drying for 1 day are loaded in compressive strength testing machine. It is able to provide compressive load up to 2000kN. When tested concrete cubes should fail by developing of a crack in body of cubes.

Fig 8: Cube compressive strength testing machine.

5.4.2 SPLIT TENSILE STRENGTH TEST

The main advantages of this method is that the same type of specimen and the same testing machine as are used for the compressive test can be employed for this test, that is gaining popularity splitting test simple to perform and gives more uniform result than other tension tests. Strength determined in the splitting test is believed to be closer to that true tensile strength of concrete than the modulus of rupture. Splitting strength gives about 5-12% higher value than the direct tensile strength agreement with what is generally observed for conventional concrete. The presence of fibres again had little effects on the test results.

Fig 9: Split tensile test on cylinder

5.4.3 FLEXURAL STRENGTH TEST

The ultimate flexural strength analysis presented in this paper is based on the conventional compatibility and equilibrium conditions used for normal reinforced concrete except that the contribution of the fibers in the tension is recognized.

The analysis is based on the following assumptions,

1. Plane sections remain plane after bending
2. The compressive forces equal the tensile forces.
3. The internal moment equals the applied bending moment.

The actual and assumed stress and strain distributions at failure are shown. The stress block is assumed to be a parabolic one with the compressive stress of concrete being taken as the neutral axis depth is taken as the stress block into rectangular and parabolic portions. The depth of the parabolic portion is assumed to be a straight line up to a depth of stress block in rectangular and parabolic portions. The depth of the parabolic portion is assumed height of the elastic un-cracked zone of concrete is very small compared to the neutral axis depth and is therefore assumed that the tensile contribution of fibers is represented by a rectangular stress block over the whole of the tensile zone.

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Fig 10: Flexural strength test on beam

VI. RESULT AND DISCUSSION

GENERAL

The results of present investigation are presented both in tabulated and graphical forms. In order to facilitate the analysis, interpretation of results is carried out at each phase of experimental study. This interpretation of the results obtained based on the current knowledge available in the literature as well as on the basis of results obtained. The significance of results is assessed with reference to the standards specified by the relevant IS codes.

Also durability of concrete during its service life may be significantly affected by the environmental condition to which it is exposed, and in order to produce a concrete of high quality, appropriate mix, curing system in a suitable to the environmental condition during the early stages of hardening. The durability test "Rapid Determination of the Chloride Permeability of Concrete was also being taken into consideration the cubes were cut in the size of 50mm width and 100mm diameter and were tested.

The cubes, cylinder and beams were taken tested 3, 7, 28, 56 and 90 days and results were obtained and the graphical views were shown in the below tabulations. By the results the calculations shows the increasing the compressive strength, split tensile strength, flexural strength.

This result shows the maximum addition of steel fibers and fly ash at the peak point this makes the maximum utilization of steel fibers and fly ash should be added to the concrete at certain intervals to attain the maximum strength.

6.1. COMPRESSIVE STRENGTH RESULTS:

The compressive strength of concrete for different replacements of cement with 10% and 20% of silica fume and 10%,20% and 30% of fly-ash with 0.5% steel hook fibres by volume of concrete were tested for 3,7,28,56 and 90 days using compressive test machine. The water to cement ratio was taken as 0.35. Three cubes were casted for each proportion and the average of three test samples was taken for the accuracy for results. At the room temperature, the concrete cubes were cured. The values of crushing loads obtained are taken and the compressive strength obtained are shown in table 6.1

TABLE 6.1.COPRESSIVE STRENGTH COMPARISION FOR ALL PROPORTIONS OF CONCRETE WITH 0.5% STEEL HOOK FIBRES AS ADMIXTURE

S. NO	SAMPLE	AVERAGE COMPRESSIVE STRENGTH				
		3 days	7 days	28 days	56 days	90 days
1	Controlled mix	27.62	44.23	68.07	75.18	78.74
2	10%SF+10%FA+0.5%SHF	36.96	49.40	75.33	79.77	81.11
3	10%SF+20%FA+0.5%SHF	40.18	50.07	81.92	82.67	83.40
4	10%SF+30%FA+0.5%SHF	39.33	49.63	76.60	81.06	82.00
5	15%SF+10%FA+0.5%SHF	39.18	49.48	74.88	80.51	81.55
6	15%SF+20%FA+0.5%SHF	36.96	48.67	74.67	79.11	80.66
7	15%SF+30%FA+0.5%SHF	36.41	47.33	71.55	73.55	78.00

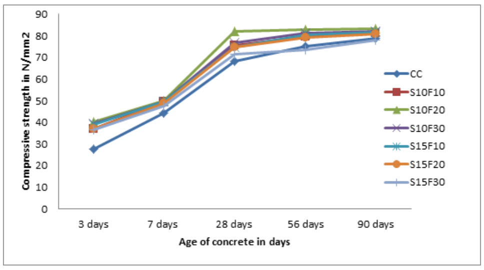

Fig No.11 : Compressive Strength Comparison of All Proportions of Concrete with 0.5% steel hook fibers as admixture

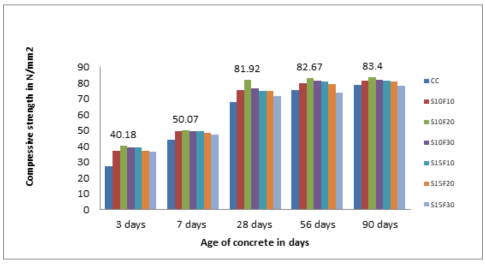

Fig No.12: Compressive Strength Comparison of All Proportions of Concrete

6.2 COMPRESSIVE STRENGTH COMPARISON OF DIFFERENT PROPO-RTIONS OF CONCRETES WITH COTROLLED CONCRETE:

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CASE-I: Compressive strength comparison of controlled concrete with 10% Silica Fume and 10% fly ash replaced concrete with 0.5% steel hook fibers as admixture.

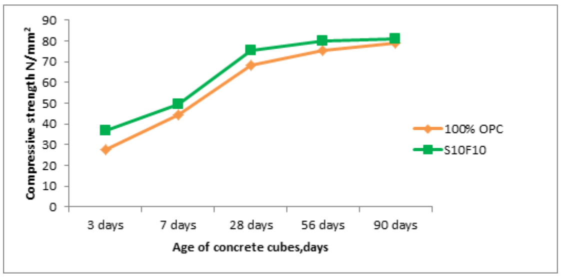

Fig 13: compressive strength comparison of controlled concrete with 10% silica fume and 10% fly ash replaced to cement with 0.5% steel hook fibres by volume of concrete.

The above graph shows the variation of compressive strength with increase in age of concrete. On comparing with controlled concrete, the compressive strength of concrete on replacing cement with 10% silica fume and 10% fly ash with 0.5% steel hook fibres as admixture shows higher results (green).The compressive strength of controlled concrete for 3,7,28,56 and 90 days are 27.62, 44.23, 68.07, 75.18 and 78.74 N/mm^2.

Compressive strength of concrete, increases with the addition of mineral admixtures. For this proportion (S10F10) the compressive strength variation for 3, 7, 28, 56 and 90 days are 36.96, 49.40, 75.33, 79.77 and 81.11 N/mm^2.At this proportion the compressive strength of concrete is increased by 10.7%.

CASE-2: Compressive strength comparison of controlled concrete with 10% Silica fume and 20% fly ash replaced concrete with 0.5% steel hook fibers as admixture.

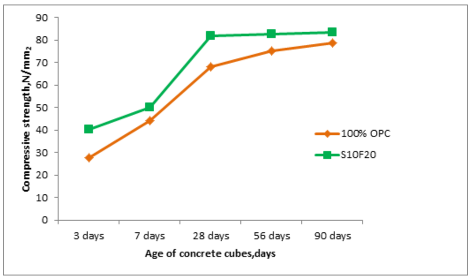

Fig 14: compressive strength comparison of controlled concrete with 10% silica fume and 20% fly ash replaced to cement with 0.5% steel hook fibres by volume of concrete.

The above graph shows the variation of compressive strength with increase in age of concrete. On comparing with controlled concrete, the compressive strength of concrete on replacing cement with 10% silica fume and 20% fly ash with 0.5% steel hook fibres as admixture shows higher results (green).The compressive strength of controlled concrete for 3,7,28,56 and 90 days are 27.62, 44.23, 68.07, 75.18 and 78.74 N/mm^2.

Compressive strength of concrete increases, with the addition of mineral admixtures. For this proportion (S10F20) the compressive strength variation for 3, 7, 28, 56 and 90 days are 40.18, 50.07, 81.92, 82.67 and 83.40 N/mm^2.At this proportion the compressive strength of concrete is increased by 20.34%.

This proportion gives the optimum compressive strength compared to all other proportions.

6.3 SPLIT TENSILE TEST RESULTS

TABLE 6.2 SPLIT TENSILE STRENGTH RESULTS OF CONCRETE MADE WITH DIFFERENT REPLACEMENT LEVELS OF SILICA FUME AND FLY ASH

Days	Cases	Average split tensile strength (N/mm2)
28 days	Controlled mix	3.27
	10% SF+10% FA+ 0.5% steel fibers	4.5
	10% SF+20% FA+ 0.5% steel fibers	5.2
	10% SF+30% FA+ 0.5% steel fibers	4.8
	15% SF+10% FA+ 0.5% steel fibers	4.2
	15% SF+20% FA+ 0.5% steel fibers	4.4
	15% SF+30% FA+ 0.5% steel fibers	3.8

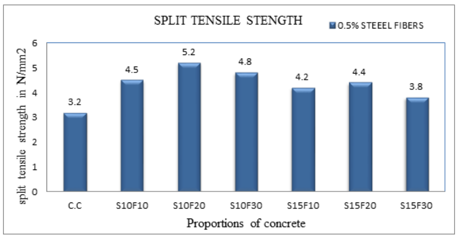

Fig 15: Tensile strength at 28 days for various percentages of Silica Fume and Fly Ash

From above graphs it has been seen that, the comparison of split tensile strength results of concrete for various replacements of silica fume and fly ash with 0.5% steel hook fibers as admixture. At 10% silica fume and 20% fly ash gives maximum 28 days split

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strength as 5.2N/mm2.

6.4 FLEXURAL STRENGTH TEST RESULTS

TABLE 6.3: FLEXURAL STRENGTH OF CONCRETE WITH DIFFERENT PERCENTAGE OF SILICA FUME AND FLY ASH

S.No	Age	Sample	Load (KN)	Average Modulus of rupture (MPa)
1	28	Controlled mix	18.75	14.06
2	28	S10F10	20.8	15.60
3	28	S10F20	26.00	19.50
4	28	S10F30	20.8	15.60
5	28	S15F10	25.95	19.46
6	28	S15F20	20.70	15.52
7	28	S15F30	20.40	15.30

S= % of silica fume, F= % of fly ash

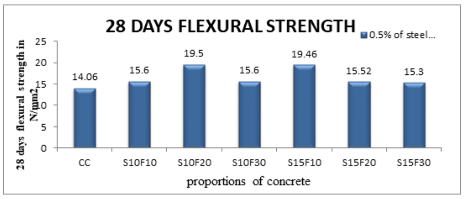

Fig 16: Flexural strength at 28 days for various percentages of Silica Fume and Fly Ash

From above graphs it has been seen that, the comparison of flexural strength results of concrete for various replacements of silica fume and fly ash with 0.5% steel hook fibers as admixture. At 10% silica fume and 20% fly ash gives maximum 28 days split strength as 5.2N/mm2, next higher value occurs at 15% silica fume and 10% fly ash with 0.5% steel hook fibers as 12.97 N/mm2.

6.5 STRENGTH COMPARSION

TABLE 6.4: 28 DAYS STRENGTH COMPARISON IN PERCENTAGE

Test	S10F10	**S10F20**	S10F30	S15F10	S15F20	S15F30
Compressive strength	10.7%	**20.34%**	12.51%	10%	9.8%	5.11%
Split Tensile Test	37.61%	**60.85%**	47.70%	29.66%	37%	18.04%
Flexural Test	10.99%	**38.74%**	10.99%	38.42%	10.45%	8.85
Compressive strength on cylinder	9.21%	**19.37%**	9.15%	6.18%	13.35%	5.86%

S= % of silica fume f= % of fly ash

From above graph, it is observed that the percentage variation of compressive strength, Tensile strength and Flexural strength is maximum at 10% silica fume and 20% fly ash replacement with 0.5% steel hook fibers.

6.6 NON-DESTRUCTIVE TEST RESULTS

6.6.1ULTRA SONIC PULSE VELOCITY TEST

TABLE6.5: RESULTS OF ULTRA-SONIC PULSE VELOCITY TEST

S.No	Samples	Length (mm)	path time (μ-sec)	Average pulse velocity (km/sec)	quality of concrete
1	Controlled mix	150	34.63	4.33	Good
2	S10F10	150	35.80	4.19	Good
3	S10F20	150	35	4.28	Good
4	S10F30	150	38.7	3.87	Good
5	S15F10	150	39.7	3.77	Good
6	S15F20	150	35.8	4.18	Good
7	S15F30	150	36.33	4.15	Good

S= % of silica fume F= % of fly ash

From above table it is observed that, the average pulse velocity for all proportions of concrete are in between 3.5 km⁄sec to 4.5 km⁄sec. As per BS 12504-4, 2004 code it is concluded that all the samples are graded as good quality concrete.

6.7 DURABILITY TEST RESULTS

TABLE 6.6 WATER ABSORPTON TEST FOR DIFFERENT PROPRTIONS OF CONCRETE

S. No	Sample	Wet weight (kgs)	Dry weight (kgs)	Water absorption in %
1	CC	9.56	9.40	1.70
2	S10F10	9.52	9.42	1.06
3	S10F20	9.53	9.45	0.84
4	S10F30	9.44	9.39	0.53
5	S15F10	9.44	9.35	0.96
6	S15F20	9.46	9.40	0.63
7	S15F30	9.49	9.44	0.53

From above table it is observed that, the percentage water absorption for different proportions of concrete varies with the silica fume and fly ash replacement. With increase in silica fume and fly ash replacement to cement shows decreased percentage of water absorption because of their fine particle size. At 10% and 15% replacement of silica fume with 30% fly ash gives low water absorption as 0.53%.

Table 6.7 Permeability Of Chloride In Concrete For Every 30 Minutes Intervel Up To 6 Hours By Using Rcpt Apparatus For Different Dosages Of Silica Fume And Fly Ash As Cement Replacent And Steel Fibers As Admixture:

S.NO	SAMPLE	I_0	I_{30}	I_{60}	I_{90}	I_{120}	I_{150}	I_{180}	I_{210}	I_{240}	I_{270}	I_{300}	I_{330}	I_{360}	I cumulative in mA	$I_{average}$ in coulombs	Penetrability of chloride
1	CC	8	8	8	8	9	9	9	9	10	10	11	12	12	2.30	2070	M
2	10%SF+10%FA+0.5%SHF	8	10	9	10	12	11	12	13	17	20	19	17	18	3.26	2934	M
3	10%SF+20%FA+0.5%SHF	0	0	1	2	2	4	6	6	8	10	11	14	16	1.44	1296	L
4	10%SF+30%FA+0.5%SHF	0	1	1	1	1	1	2	2	8	8	8	10	10	0.96	8624	VL
5	15%SF+10%FA+0.5%SHF	8	8	9	9	9	9	10	10	12	12	17	17	19	2.73	2457	M
6	15%SF+20%FA+0.5%SHF	0	0	0	1	1	5	5	5	6	10		11	11	1.23	1107	L
7	15%SF+30%FA+0.5%SHF	0	0	0	1	1	2	2	2	4	4	4	6	6	0.58	522	VL

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SF= % of silica fume
FA= % of fly ash
SHF=Steel hook Fibers

The Rapid Chloride Permeability Test results are presented in the above table 6.5 for different dosages of 10% and 15% of silica fume and 10%, 20% 30% of fly replacement to cement with a constant proportion of 0.5% steel hook fibers are added to the concrete. The results were noted for every 30min up to 6hours from RCPT apparatus by summing up the readings the calculations are done by using Table 5.7 presents the chloride ion penetrability based on charge passed as per ASTM C 1202 is decided.

The effects on different dosages of silica fume, fly ash and steel fibers, the test results of chloride permeability through Rapid Chloride Permeability Test are presented in the table 6.5.2 for different proportions of concrete. The concrete specimen tested by RCPT according to the results noted for combinations of OPC with 10% silica fume and 30% fly ash as replacement to cement and addition of steel fibers at the 0.5% showed the very low permeability to chloride ion permeability and at 15% silica fume and 30% fly ash as replacement to cement and addition of steel fibers at the 0.5% also showed very low permeability to chloride ion.

From above test results it is observed that, with increase in percentage of silica fume and fly ash replacement to cement shows higher resistance to chloride ion permeability.

VII. CONCLUSION

Based on the results obtained from the present investigation the following conclusions were made;

1. By the addition of steel hook fibers in concrete leads to increase in compressive strength and makes concrete into ductile.
2. In split tensile and flexural tests, we notices that crack width reduced due to the presence of steel fibers when compared with conventional specimen.
3. When the cement is replaced with 10% silica fume and 20% fly ash gives the optimum compressive strength, split tensile strength and flexural strength.
4. At 10% silica fume and 20% fly ash replacement to cement, compressive strength were increased up to 20.34% when compared with conventional concrete for 28 days.
5. At 10% silica fume and 20% fly ash replacement to cement, split tensile strength were increased up to 60.85% when compared with conventional concrete for 28 days.
6. At 10% silica fume and 20% fly ash replacement to cement, flexural strength were increased up to 38.74% when compared with conventional concrete for 28 days
7. The addition of silica fume and fly ash as replacement to cement, its normal consistency and initial setting time increases with increase in percentage and final setting time decreases with increase in percentage.
8. The use of mineral admixtures in concrete causes considerable reduction in the volume of large pores at all ages and thereby reduces the permeability of concrete mixes because of its high fineness and formation of C-S-H gel.

SCOPE OF FURTHER STUDY:

From the results it is conclude that the silica fume and fly ash are better replacements to cement. The rate of strength gain is high. After performing all the tests and analyzing the result, the following conclusions can be derived:

1. With decrease in W/C ratio strength of concrete increases.
2. Workability of concrete decreases as increase with % of silica fume and fly ash.
3. Compressive strength of concrete may increases when the cement replacement is below 10% of silica fume.
4. From literature it is observed that, the

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compressive strength of concrete increases with the percentage increase of steel hook fibers.

5. With the addition of chemical admixtures on reducing water content leads to increase in strength of concrete.
6. To produce High Strength/Performance Concrete with high ductility fibers are the critical elements which should be present in the design mix.

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