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A STUDY ON MECHANICAL AND DURABLE PROPERTIES OF HIGH STRENGTH FIBER REINFORCED CONCRETE BY PARTIAL REPLACEMENT OF CEMENT WITH SILICA FUME AND FLYASH

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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 green house effect and global warming, hence it is inevitable either to search for another material or partly replace it by some other material. 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. 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 10%, 15% of silica fume &10%, 20% and 30% of fly ash by the weight of cement with a constant amount of 0.5% steel hook fibers are added by volume of concrete, throughout the study.

Key words: High strength concrete, workability, compressive strength.

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 green house 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 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.

High strength concrete (HSC) is used extensively throughout the world like in the gas, oil, nuclear and power industries are among the major uses. The application of such concrete is increasing day by day due to their greater structural performance, environmental friendliness and energy conserving implications. Apart from the usual risk of fire, these concretes are exposed to high temperatures and pressures for considerable period of time.

The primary difference between high-strength concrete (HSC) and normal-strength concrete (NSC) relates to the compressive strength that shows the maximum resistance to concrete sample to applied pressure. Although there is no precise point of separation between high-strength concrete and normal-strength concrete, the American Concrete Institute (ACI) defines high-strength concrete as concrete with a compressive strength greater than 60MPa.

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 10%, 15% of silica fume &10%, 20% and 30% of fly ash by the weight of cement with a constant amount of 0.5% steel hook fibers are added by volume of concrete, throughout the study.

1.2 HIGH STRENGTH CONCRETE (HSC)

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

Seeding: This involves adding a small amount of finely ground, fully hydrated Portland cement to the fresh concrete mix. This method may not hold much promise.

Revibration: Concrete under goes plastic shrinkage. Mixing water produces continuous capillary channels, bleeding and water accumulates at some selected places reducing strength of concrete. Controlled Revibration removes all these defects and increases the strength of concrete.

High speed slurry mixing: It involves the advanced preparation of cement-water mixer which is then blended with aggregate to produce concrete. Higher compressive strength obtained is attributed to more efficient hydration of cement particle and water achieved in the vigorous blending of cement paste.

Inhibition of cracks: Replacement of 2-3% of fine aggregate by polythene or polystyrene “lentcules” 0.025 mm thick and 3-4 mm in diameter results in higher strength. They appear to acts as crack arresters without requiring extra water for workability.

Use of admixtures: Use of water reducing agents are known to produce increase compressive strength.

Sulpher impregnation: Satisfactory high strength concrete have been produced by impregnating low strength porous concrete by sulpher. The process consist of wet curing the fresh concrete specimen for 24 hours, drying them at 120^0 C for 24 hours, immersing the specimen in molten sulphur under vacuum for 2 hrs and then releasing the vacuum and soaking them for an additional one hour for further penetration of sulpher into the concrete. The sulpher infiltrated concrete has given strength up to 58 MPa.

Use of cementitious aggregates: It has been found that use of cementitious aggregate has yielded high strength. Cement fondu is a type of clinker. This glassy clinker when finely ground results in this type of cement. When coarsely crushed, it makes a kind of aggregate known as ‘ALAG’. Using ALAG as aggregate strength up to 125 MPa has been obtained with w/c ratio 0.32.

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. TYPE 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.

These admixtures are classified as follows:

1) Mineral admixtures:

- Silica fume
- Fly ash
- Ground granulated blast furnace slag

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- Rice husk ash

2) Chemical admixture:

- Accelerating admixture
- Retarding admixture
- Water-reducing admixture
- Air entering admixture
- Super- plasticizing admixture

2.3 SILICA FUME

Now a day, we need to look at a way to reduce the cost of building materials, particularly cement is currently so high that only rich people and governments can afford meaningful construction. Studies have been carried out to investigate the possibility of utilizing a broad range of materials as partial replacement materials for cement in the production of concrete.

Silica fume is a waste by-product of the production of silicon and Ferro-silicon alloys. It is available in different forms, of which the most commonly used is in a dandified form. Silica Fume consists of very fine vitreous particles with a surface area between 13,000 and 30,000m2/kg and its particles are approximately 100 times smaller than the average cement particles. Silica fume used was conforming to ASTM C (1240-2000) Silica fume, also referred to as micro silica or condensed silica fume, is a byproduct material that is used as a pozzolanic.

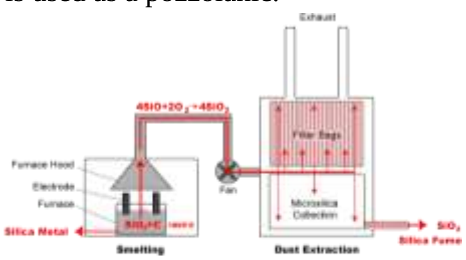

Fig.2.1. Silica Fume capturing process in Silicon Industry.

This byproduct is a result of the reduction of high-purity quartz with coal in an electric arc furnace in the manufacture of silicon or ferrosilicon alloy. Silica fume rises as an oxidized vapor from the 2000°C furnaces. When it cools it condenses and is collected in huge cloth bags. The condensed silica fume is then processed to remove impurities and to control particle size. (S. Bhanja, 2004 et. al)

The American concrete institute (ACI) defines silica fume as a ''very fine non-crystalline silica produced in electric arc furnaces as a byproduct of production of elemental silicon or alloys containing silicon''. Silica fume is also known as micro silica, condensed silica fume, volatized silica or silica dust. It is usually a grey colored powder, somewhat similar to Portland cement or some fly ashes. It can exhibit both pozzolanic and cementitious properties. Silica fume has been recognized as a pozzolanic admixture that is effective in enhancing the mechanical properties to a great extent. Addition of silica fume to concrete improves the durability of concrete and also in protecting the embedded steel from corrosion. When fine pozzolana particles are dispersed in the paste, they generate a large number of nucleation sites for the precipitation of the hydration products.

Fig2.2: Sample of silica fume used in concrete

2.3.1 ADVANTAGES OF USING SILICA FUME IN CONCRETE

- High early compressive strength
- High tensile, flexural strength and modulus of elasticity
- Very low permeability to chloride and water intrusion
- Enhanced durability
- Increased toughness

- Increased abrasion resistance on decks, floors, overlays and marine structures
- Superior resistance to chemical attack from chlorides, acids, nitrates and sulfates and life-cycle cost efficiencies.
- Higher bond strength
- High electrical resistivity and low permeability

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, Togay Ozbakkaloglu 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 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.

A.Annadurai1, A. Ravichandran examined on development of mix design for high strength Concrete with Admixtures. The results of mix design developed for high strength concrete with silica fume and High range water reducing admixture (HRWR). It involves the process of determining experimentally the most suitable concrete mixes in order to achieve the targeted mean strength. In this research work 53 grade ordinary Portland cement, the locally available river sand, 10 mm graded coarse aggregate were selected based on ASTM C 127 standard for determining the relative quantities and proportions for the grade of concrete M60. For this design ACI 211.4R-93 guidelines were followed. Totally Five mixes were designed one mix was treated as basic mix with HRWR - 0.5% without silica fume, Four mixes were designed with Micro silica quantities varied from 5 to 9 percent weight of cementitious materials and HRWR varies between 0.6% to 0.9% with increment of 0.1% . Each mix 2 numbers of 150mm x 300 mm cylinders were cast then kept in curing tank after 24 hours of time period. After 28 days of curing the specimens were tested and the appropriate mix proportions were obtained.

I. B. Muhit1, S. S. Ahmed2, M. M. Amin1 and M. T. Raihan examined on industrial byproducts such as Silica Fume (SF) and Fly Ash (FA) can be utilized to enhance the strength and water permeability characteristics of High Performance Concrete (HPC). This paper investigates the individual effects of Silica Fume and Fly Ash as a partial replacement of Ordinary Portland Cement (OPC) on water permeability, compressive strength, split tensile strength and flexural tensile strength of High Performance Concrete (HPC). To investigate these properties of concrete, the total investigation was categorized into two basic test groups - SF Group for Silica Fume and FA Group for Fly Ash. Seven types of mix proportions were used to cast the test specimens for both groups. The replacement levels of OPC by Silica Fume were 0%, 2.5%, 5%, 7.5%, 10%, 15% and 20% where replacement levels of OPC by Fly Ash were 0%, 5%, 10%, 15%, 20%, 25% and 30%. 1% super-plasticizer was used in all the test specimens for high performance and to identify the sharp effects of Silica Fume and Fly Ash on the properties of concrete. Water-binder ratio was kept 0.42 for all cases and the specimens were tested at ages of 7, 14 and 28 days.10% Silica Fume and 20% Fly Ash showed the lowest water penetration depth of 11mm and 15 mm respectively. 7.5% Silica Fume and 10% Fly Ash were found to be optimum for maximum compressive strength, maximum split tensile strength as well as maximum flexural tensile strength.

III. SCOPE AND OBJECTIVE OF PRESENT WORK

3.1. SCOPE AND OBJECTIVE

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.

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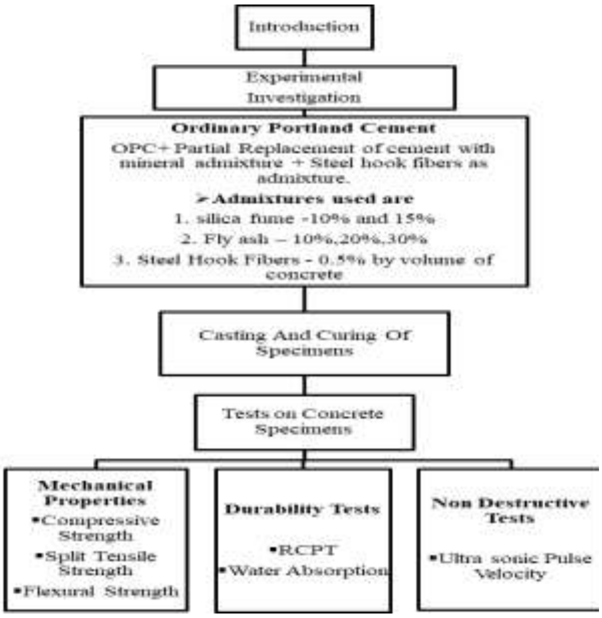
- To determine the chloride penetration of concrete using Rapid Chlorine Penetration Test (RCPT).
- For safe construction, to find the how much percentage of silica fume and fly ash is partially replaced by cement and steel fibers as an admixture to attains strength at maximum level.

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. Silica Fume and
   b. Fly-Ash
3. Fine aggregates
4. Coarse aggregates
5. Steel hook fibers as admixture and
6. 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 minute**	>30
4	Final setting time	**350 minute**	<600
5	Specific gravity	**3.14**	-

The chemical composition of cement was analysed 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

4.3.1 TESTS ON CEMENT

4.3.1.1 FINENESS OF CEMENT BY DRY SIEVING METHOD

The degree of fineness of cement is a measure of the mean size of grains in cement. The finer cement has quicker action with water and gains early strength through its ultimate strength remains unaffected. However, the shrinkage and cracking cement will increase with the fineness of cement. Apparatus used to determine the sieve analysis are I.S. Sieve No. 9 (90 Microns)**,** Weighing Balance capacity 5 kg as per **IS: 4031(part 1)-1996**.Weigh 100 grams of the given cement and sift it continuously for 15 minutes on IS. Sieve 9 no air set lumps may be broken down by fingers but nothing should be rubbed on the sieves. Find the weight of residue of the sieved after the sifting is over and report the values as a percent of the original sample taken.

4.3.1.2 NORMAL CONSISTENCY

About 400g of cement was initially taken and mixed with water, 00The paste was filled in the mould of Vicat's apparatus and care was taken such that the cement paste was not pressed forcibly in the mould and the surface of filled paste was smoothened and levelled. A square needle 1mm×1mm of size is to be attached to the plunger and then lowered gently on to the surface of the cement paste and is released quickly. As plunger pierces the cement paste, reading on scale was recorded. The experiment was performed carefully away from vibrators and the other disturbances. The test procedure was repeated by increasing the percentage of mixing water at 0.5% increment until the needle reaches 5 to 7 mm from the bottom of the mould. When this condition is fulfilled, the amount of water added was taken as the correct percentage of water for normal consistency. The entire test was completed within 3 to 5 minutes, if the time taken to complete the experiments exceeds 5 minutes, the sample was rejected and fresh sample was taken and the operation was repeated again. Fresh cement was taken for each repetition of the experiment. The plunger was cleaned each time the experiment is done.

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The normal consistency of Cement sample prepared with different replacements of Fly ash (10%, 20% and 30%) is compared with Ordinary Cement. Both the initial and final setting time of Cement sample prepared with different replacement of Fly ash (10%, 20% and 30%) are compared with Ordinary Cement. If the difference is less than 30 minutes, the change is considered to be insignificant and it is more than 30 minutes, the change is considered to be significant

4.3.1.3 RESULTS OF NORMAL CONSISTENCY

Table 4.4 gives the result of normal consistency for different replacement percentages of Cement with Fly ash. Normal consistency test shows very slight increase in consistency of Cement for different dosages 0%, 10%, 20% and 30% of Fly ash in Ordinary Portland Cement.

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.	90%OPC + 10% FA	34
3.	80%OPC + 20% FA	35
4.	70%OPC + 30% FA	36

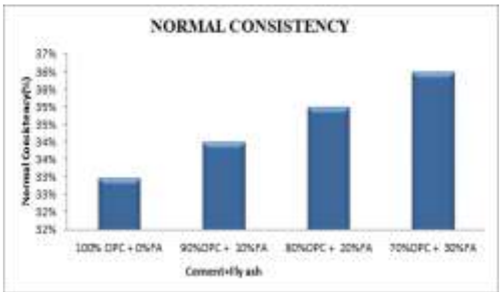

Fig 4.1 Normal Consistency for Replacement percentages of Cement by Fly Ash

TABLE 4.5 VARIATION OF STANDARD CONSISTENCY FOR DIFFERENT REPLACEMENT PERCENTAGES OF CEMENT WITH SILICA FUME

Sl. No	Mix Proportion	Normal Consistency (%)
1.	100%OPC + 0%SF	33
2.	90%OPC + 10% SF	35
3.	80%OPC+15%SF	36

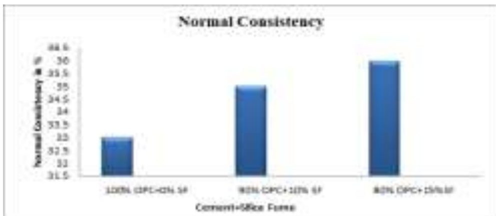

Fig 4.2 Normal Consistency for Replacement percentages of Cement by silica fume.

From the fig 4.1and 4.2 it is observed that for different replacement percentages of Cement with Fly ash and silica fume, normal consistency increased. The 0%, 10%, 20% and 30% replacement of Cement with Fly ash results in increase of normal consistency, it varies as 33, 34, 35 to 36 percent respectively.

The 0%, 10%,15% replacement of cement by silica fume also results in increase of normal consistency, varies from 33,35 and 35.But at 10% and 15% replacement of cement by silica fume results in same consistency.

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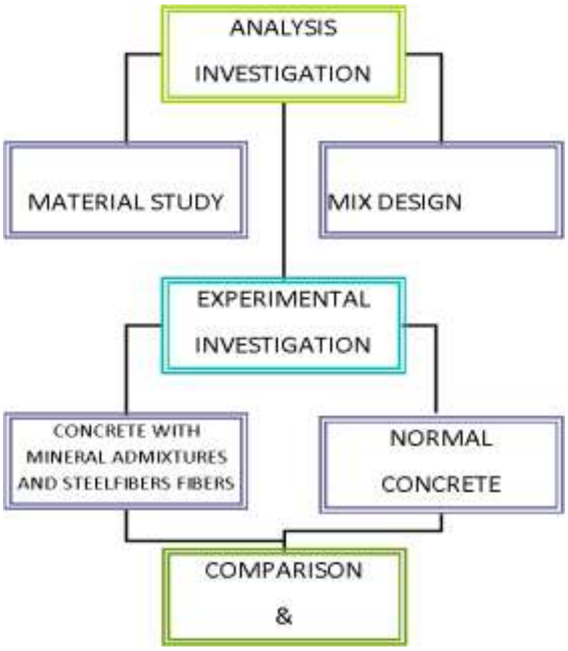
V. METHODOLOGY



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 M60 GRADE CONCRETETHAT ARE USED IN HSFRC

Sample	Cement (%)	Silica fume (%)	Fly Ash (%)	F.A (kg/m³)	C.A (kg/m³)	W/C Ratio	Water (liters)	Steel fibers (% by volume of concrete)
Controlled mix	100	0	0	651	1254	0.35	147	0.5
10%SF+10%FA+0.5%SHF	80		10	651	1254	0.35	147	0.5
10%SF+020%FA+0.5%SHF	70	10	20	651	1254	0.35	147	0.5
10%SF+30%FA+0.5%SHF	60		30	651	1254	0.35	147	0.5
15%SF+10%FA+0.5%SHF	75		10	651	1254	0.35	147	0.5
15%SF+20%FA+0.5%SHF	65	15	20	651	1254	0.35	147	0.5
15%SF+30%FA+0.5%SHF	55		30	651	1254	0.35	147	0.5

Where SF=silica fume FA=fly ash SHF=steel hook fibers

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 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

1. Hand mixing:

Hand mixing is practiced for small scale unimportant concrete works. As the missing cannot be through and efficient, it is desirable to add 10% more cement to cater for the interior concrete produced by this method. Hand mixing should be done over an impervious concrete or brick floor of sufficient large size to take one bag of cement. Spread out the measured quantity of coarse aggregate in alternate layers. Pour the cement on the top of it and mix design dry then shovel turning the mixture is spread out in thickness of about 20 cm. Water is taken in water-can fitted with rose-head and sprinkled over the mixture and simultaneous turned over. Water in small quantity should be added towards the end of the mixing to get the just required consistency. At the stage, even a small quantity to later make difference.

2. Machine mixing:

Machine mixing is most effective method to mix the concrete. Concrete mixers commercially available are used by the concrete industry. Drum mixers are broadly used for mixing which are having blades attached to the inside of the rotatable drum. In commercial there are two other main types of mixers used like batch mixers and continuous mixers.

5.2.3 PLACING

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

5.2.4 MOULD DETAILS

The internal dimensions of the mould are:

SPECIMEN	DIMENSION
Cube size	150mm x150mm x 150mm
Cylinder size	300mm Depth, 150mm Diameter
Prism size	500mm x 100mm x 100mm

5.2.5 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.

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Fig 5.1: Sampling of concrete

5.2.6 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.

5.2.7 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.

Fig 5.2: 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. The different types of tests conducted on concrete are

1 .Compressive strength test
2. Split tensile strength test
3. Flexural strength test

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 number of days (3, 7, 28, 56 and 90 days) in water at 25± 2^{0}C 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 5.3: Cube compressive strength testing machine.

Fig 5.4: Split tensile test on cylinder

Fig 5.5: Flexural strength test on beam

5.5. TESTS FOR DURABILITY

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5.5.1 WATER ABSORPTION TEST

One of the most important properties of a good quality concrete is low-permeability, especially one resistant to freezing and thawing. The water absorption test is carried out at the age of 28 day according to standard procedure **ASTM C 642-11**. For the water absorption test, 100 x 200mm size of cylinder is cut into three parts (top, middle, bottom) of 50mm thickness and 100mm diameter, then specimens are dried in an oven at 100o to 110o C for not less than 24 hours. After removing each specimen from the oven, allow it to cool in dry air to a temperature of 20o to 25o C and determine the mass.

Fig 5.6: concrete specimen used for water absorption test

If the difference between values obtained from two successive values of mass exceeds 0.5% of the lesser value, return the specimens to the oven for an additional 24h drying period, and repeat the procedure until the difference between any two successive values is less than 0.5% of the lowest value obtained. Note down the last value. The material is then immersed in water, often 23°C for 48 hours or until equilibrium. The specimens are removed, surface dried and then weighed again. It is then placed in an autoclave and boiled for 5 hours and then allowed to lose heat and maintain temperature for about 14 hours. The specimens are again surface dried and weighed. Finally the immersed weight of the specimen in water is measured.

Water absorption is expressed as increase in weight percent.

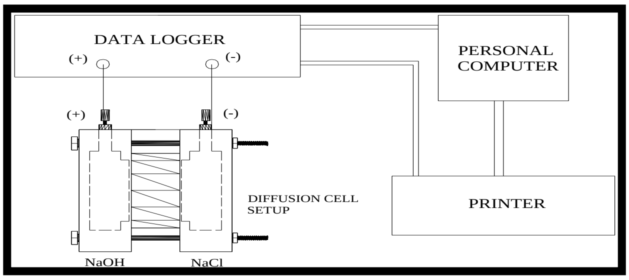
Percentage of Water Absorption = [(Wet weight - Dry weight)/ Dry weight] x 100

5.5.2 RAPID CHLORIDE PENETRATION TEST

This test method was originally developed by the Portland Cement Association, under a research program paid for by the Federal Highway Administration (FHWA). The original test method may be found in FHWA/RD-81/119, “Rapid Determination of the Chloride Permeability of Concrete.” Since the test method was developed, it has been modified and adapted by various agencies and standard’s organizations. These include:

- **AASHTO T277**, “Standard Method of Test for Rapid Determination of the Chloride Permeability of Concrete”
- **ASTM C1202**, “Standard Test Method for Electrical Indication of Concrete ‘Ability to Resist Chloride Ion Penetration”

The rapid chloride penetration test is carried out as **per AASHTO T277, (ASTM C1202)** test. In this a water-saturated, 50-mm thick, 100-mm diameter concrete specimen is subjected to a 60 V applied DC voltage for 6 hours using the apparatus. In one reservoir is a 3.0 % NaCl solution and in the other reservoir is a 0.3 M NaOH solution. The total charge passed is determined and this is used to rate the concrete.



5.7(a) Typical layout of Diffusion and RCPT Experiment Unit

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Fig. 5.7 (b) RCPT TEST

The total charge passed is a measure of the electrical conductance of the concrete during the period of the test.

$$Q = 900 \times (I_0+2I_{30}+2I_{60}+2I_{90}+2I_{120}+2I_{150}+2I_{180}+2I_{210}+2I_{240}+2I_{270}+2I_{300}+2I_{330}+I_{360})$$

Where

Q = Charge Passed (Coulombs),

I_0 = current (amperes) immediately after voltage is applied, and

I_t = current (amperes) at‘t’ minutes after voltage is applied

Table 5.2 presents the chloride ion penetrability based on charge passed as **per ASTM C 1202.**

TABLE 5.2.CHLORIDE ION PENETRABILITY BASED ON CHARGE PASSED

Charge Passed (Coulombs)	Chloride Ion Penetrability
> 4000	High
2000 – 4000	Moderate
1000 – 2000	Low
100 – 1000	Very Low
< 100	Negligible

VI. RESULTS 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

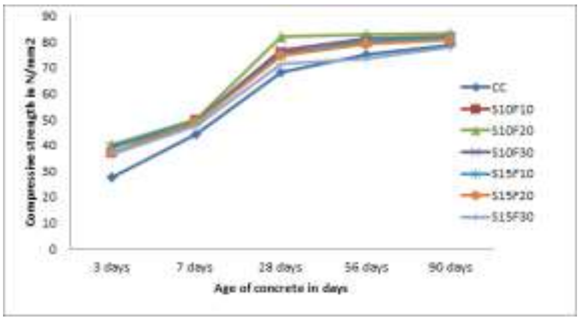

Fig No.6.1: Compressive Strength Comparison of All Proportions of Concrete with 0.5% steel hook fibers as admixture

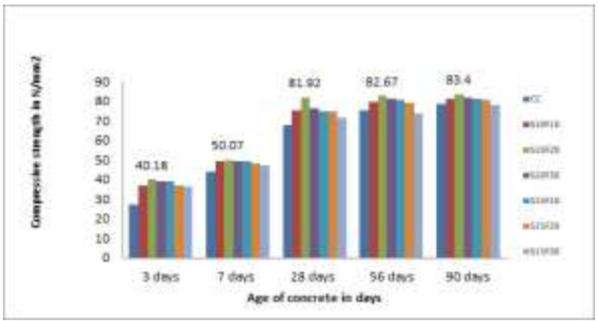

Fig No.6.2: Compressive Strength Comparison of All Proportions of Concrete

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

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.

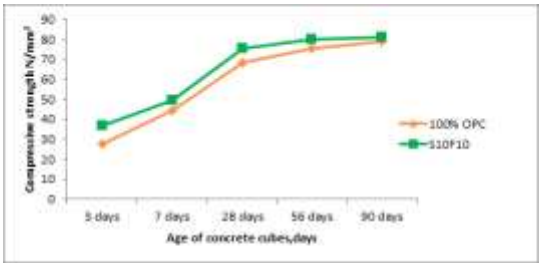

Fig 6.3: compressive strength comparison of controlled concrete with 10% silica fume and 10% fly ash replaced to cement with 0.5% steel hook fibres by volume of concrete.

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.

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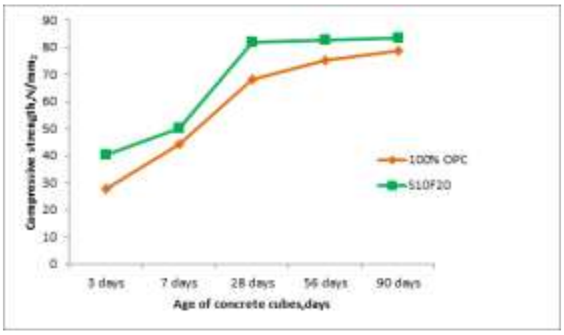

Fig 6.4: compressive strength comparison of controlled concrete with 10% silica fume and 20% fly ash replaced to cement with 0.5% steel hook fibres by volume of concrete.

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.

CASE-3: Compressive strength comparison of controlled concrete with 10% Silica fume and 30% fly ash replaced concrete with 0.5% steel hook fibers as admixture.

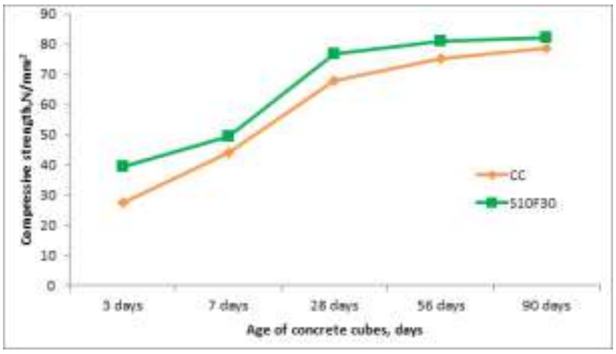

Fig 6.5: compressive strength comparison of controlled concrete with 10% silica fume and 30% fly ash replaced to cement with 0.5% steel hook fibres by volume of concrete.

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 30% 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 (S10F30) the compressive strength variation for 3, 7, 28, 56 and 90 days are 39.33, 49.63, 76.60, 81.06 and 82.00 N/mm^2.At this proportion the compressive strength of concrete is increased by 12.51%.

CASE-4: Compressive strength comparison of controlled concrete with 15% Silica fume and 10% fly ash replaced concrete with 0.5% steel hook fibers as admixture.

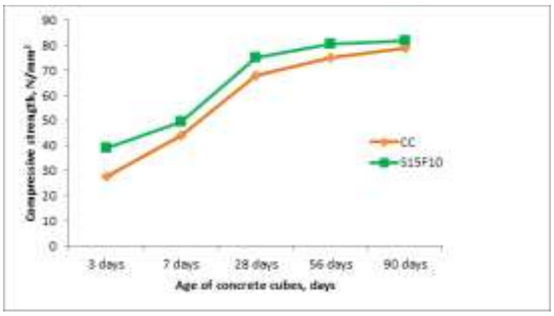

Fig 6.6: compressive strength comparison of controlled concrete with 15% silica fume and 10% fly ash replaced to cement with 0.5% steel hook fibres by volume of concrete.

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 15% 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 (S15F10) the compressive strength variation for 3, 7, 28, 56 and 90 days are 39.18, 49.48, 74.88, 80.51, and 81.55 N/mm^2.At this proportion the compressive strength of concrete is increased by 10%.

CASE-5: Compressive strength comparison of controlled concrete with 15% Silica fume and 20% fly ash replaced concrete with 0.5% steel hook fibers as admixture.

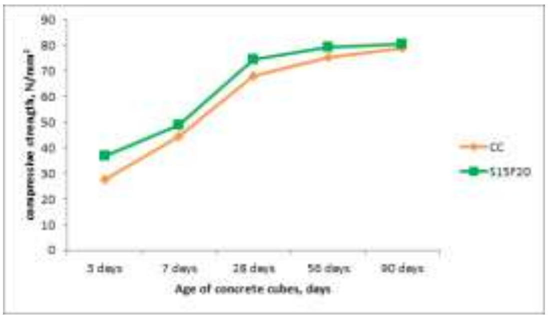

Fig 6.7: compressive strength comparison of controlled concrete with 15% silica fume and 20% fly ash replaced to cement with 0.5% steel hook fibres by volume of concrete.

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 15% 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 (S15F20) the compressive strength variation for 3, 7, 28, 56 and 90 days are 36.96, 48.67, 74.67, 79.11 and 80.66 N/mm^2.At this proportion the compressive strength of concrete is increased by 9.8%.

CASE-6: Compressive strength comparison of controlled concrete with 15% Silica fume and 30% fly ash replaced concrete with 0.5% steel hook fibers as admixture.

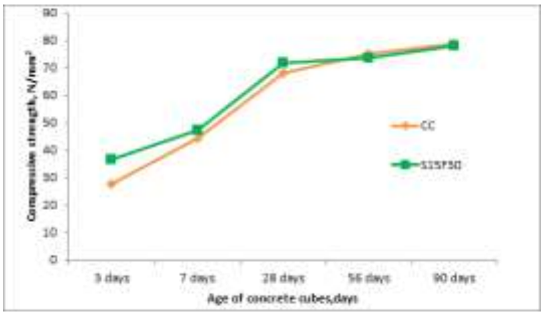

Fig.6.8: compressive strength comparison of controlled concrete with 15% silica fume and 30% fly ash replaced to cement with 0.5% steel hook fibres by volume of concrete.

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 15% silica fume and 30% 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 (S15F20) the compressive strength variation for 3, 7, 28, 56 and 90 days are 36.41, 47.33, 71.55, 73.55 and 78 N/mm^2.At this proportion the compressive strength of concrete is increased by 5.11%.

Compressive Strength Variation of HSFRC for Different Replacements Levels of Silica Fume and Fly Ash

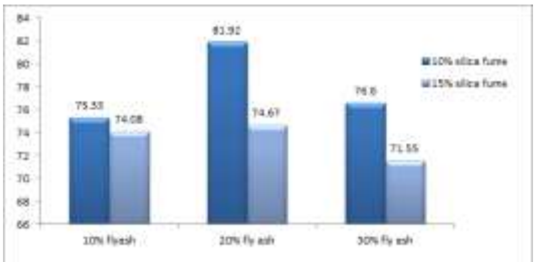

Fig 6.9 28 days compressive strength variation for 10% and 15% silica fume for every 10%, 20% and 30% of fly ash replacement.

From above graph it is observed that, for every 10%, 20% and 30% of fly ash replacement the variation compressive strength reaches maximum at 10% silica fume. With increasing silica fume replacement to 15% shows decreasing compressive strength values. It is concluded that, at 10% silica fume and 20% fly ash replacement gives maximum 28 days compressive strength as 81.92 N/mm^2. So this replacement percentage (S10F20) considered as optimum dosage.

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 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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