Experimental Study on Performance of High Volume Fly Ash Concrete

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Abstract

More than 88 million tons of fly ash is generated in India each year. Most of the fly ash is of Class F type. The percentage utilization is around 10 to 15%. To increase its percentage utilization, an extensive investigation was carried out to use it in concrete. This article presents the results of an experimental investigation dealing with concrete incorporating high volumes of Class F fly ash. Portland cement was replaced with three percentages (40%, 45%, and 50%) of Class F fly ash. Tests were performed for fresh concrete properties: slump, air content, unit weight, and temperature. Compressive, splitting tensile and flexural strengths were determined up to 28 days of testing. Test results indicated that the use of high volumes of Class F fly ash as a partial replacement of cement in concrete decreased its 28-day compressive, splitting tensile strength and flexural strengths of the concrete. Based on the test results, it was concluded that Class F fly ash can be suitably used up to 50% level of cement replacement in concrete for use in precast elements and reinforced cement concrete construction.
Keywords: HVFA, Fly ash is a pozzolan, HSC

I. Introduction

A. *General*

Cement is the most cost and energy intensive component of concrete. The unit cost of concrete can be reduced by partial replacement of cement with fly ash. Fly ash is the byproduct of coal burning power plants, is an industrial waste product containing large amounts of silica, alumina and small amount of unburned carbon, which pollutes environment.

The disposal of fly ash is one of the major issues for environmentalists as dumping of fly ash as a waste material may cause severe environmental problems/hazards. The utilization of fly ash instead of dumping it as a waste material can be partly used on economic grounds as pozzolana for partial replacement of cement and partly because of its beneficial effects such as lower water demand for similar workability, reduced bleeding, and lower evolution of heat. It has been used particularly in mass concrete applications and large volume placement to control expansion due to heat of hydration and also helps in reducing cracking at early ages.

Fly ash, being primarily pozzolanic, can actually replace a percentage of the Portland cement, to produce a stronger, more durable and more environment friendly concrete.

In general, the compressive strength and resistance to chloride-ion penetration of the concrete made with high-volume fly ash (HVFA) blended cements were superior or equal to that of the concrete in which the cement and the unground fly ash had been added as separately batched materials at a concrete mixer. For high-volume fly ash blended cements made with fine fly ashes, the improvement in the mechanical properties and durability characteristics was marginal, while for the HVFA blended cements made using a coarse fly ash, the improvement was significant.

The properties of the fresh concrete determined included the slump, air content, slump loss, stability of air content, bleeding, and setting time; those of the hardened concrete investigated included the compressive strength, flexural and split tensile strengths, modulus of elasticity.

High-volume fly ash concrete has emerged as construction material in its own right. This type of concrete normally contains more than 50% fly ash by mass of total cementitious materials. Many researchers have used high volumes of Class C and Class F fly ashes in concrete. In this article, an effort has been made to present the results of an investigation carried out to study the effect of replacement of cement with high volumes of Class F fly ash on the properties of concrete.

B. *Definition Of Fly Ash*

Fly ash is a siliceous material that has the capacity to create cementitious compounds when combined with water. However, due to differences in coals from different sources and designs of coal-fired boilers, not all fly ash produced is similar in composition. The chemical composition of fly ash could differ depending on where it was produced and by which company. Due to this variation in composition, standards were created to regulate the composition of fly ash used for specific purposes. For example, fly ash meant to be used as a replacement of portland cement in concrete must meet requirements set in ASTM C618-12, "Standard

Specification for Coal Fly Ash and Raw or Calcined Natural Pozzolan for Use in Concrete." ASMT C618-12 defines two classes of fly ash, Class F and Class C, which are acceptable for use in concrete.

Class F Fly ash: Fly ash normally produced from burning anthracite or bituminous coal falls in this category. This class of fly ash exhibits pozzolanic property but rarely if any, self-hardening property.

Class C Fly ash: Fly ash normally produced from lignite or sub- bituminous coal is the only material included in this category. This class of fly ash has both pozzolanic and varying degree of self cementitious properties. (Most class C fly ashes contain more than 15 % CaO. But some class C fly ashes may contain as little as 10 % CaO.

1) *Advantage Of Fly Ash*

- Fly ash is a pozzolan. A pozzolan is a siliceous or alumino-siliceous material that, in finely divided form and in the presence of moisture, chemically reacts with the calcium hydroxide released by the hydration of portlandcement to form additional calcium silicate hydrate and other cementitious compounds. The hydration reactions are similar to the reactions occurring during the hydration of Portland cement. Thus, concrete containing fly ash pozzolan becomes denser, stronger and generally more durable long term as compared to straight Portland cement concrete mixtures.
- Fly ash improves concrete workability and lowers water demand. Fly ash particles are mostly spherical tiny glass beads. Ground materials such as Portland cement are solid angular particles. Fly ash particles provide a greater workability of the powder portion of the concrete mixture which results in greater workability of the concrete and a lowering of water requirement for the same concrete consistency. Pump ability is greatly enhanced.
- Fly ash generally exhibit less bleeding and segregation than plain concretes. This makes the use of Fly ash particularity valuable in concrete mixtures made with aggregates deficient in fines.
- Sulfate and Alkali Aggregate Resistance. Class F and a few Class C fly ashes impart significant sulfate resistance and alkali aggregate reaction (ASR) resistance to the concrete mixture.
- Fly ash has a lower heat of hydration. Portland cement produces considerable heat upon hydration. In mass concrete placements the excess internal heat may contribute to cracking. The use of fly ash may greatly reduce this heat build up and reduce external cracking.
- Fly ash generally reduces the permeability and adsorption of concrete. By reducing the permeability of chloride ion egress, corrosion of embedded steel is greatly decreased. Also, chemical resistance is improved by the reduction of permeability and adsorption.
- Fly ash is economical. The cost of Fly Ash is generally less than Portland cement depending on transportation. Significant quantities may be substituted for Portland cement in concrete mixtures and yet increase the long term strength and durability. Thus, the use of Fly Ash may impart considerable benefits to the concrete mixture over a plain concrete for less cost.

2) *Applications Of Fly Ash*

Fly ash could have different properties depending on where it was obtained or how it was obtained. For this reason, fly ash applications are encountering resistance on traditional builders due to tendency to effloresce and major concerns about freeze/thaw performance.

Other major concerns about using fly ash concrete are:

- Slower strength gain
- Seasonal Limitation, and
- Increase in air entraining admixtures.
- Higher fly ash contents can produce an increase of salt scaling.

3) *Uses Of Fly Ash*

First of all, the spherical shape of fly ash creates a ball bearing effect in the mix, improving workability without increasing water requirements. Fly ash also improves the pump-ability of concrete by making it more cohesive and less prone to segregation. The spherical shape improves the pump-ability by decreasing the friction between the concrete and the pump line. In addition, some fly ashes have been shown to significantly decrease heat generation as the concrete hardens and strengthens. Fly ash, as do all pozzolanic materials, generally provide increased concrete strength gain for much longer periods than mixes with portland cement only.

The biggest reason to use fly ash in concrete is the increased life cycle expectancy and increase in durability associated with its use. During the hydration process, fly ash chemically reacts with the calcium hydroxide forming calcium silicate hydrate and calcium aluminate, which reduces the risk of leaching calcium hydroxide and concrete's permeability. Fly ash also improves the permeability of concrete by lowering the water-to-cement ratio, which reduces the volume of capillary pores remaining in the mass. The spherical shape of fly ash improves the consolidation of concrete, which also reduces permeability.

Other benefits of fly ash in concrete include resistance to corrosion of concrete reinforcement, attack from Alkali-silica reaction, sulfate attack and acids and salt attack.

C. High Volume Fly Ash Concrete

Fly ash, a principal by-product of the coal-fired power plants, is well accepted as a pozzolanic material that may be used either as a component of blended Portland cements or as a mineral admixture in concrete. In commercial practice, the dosage of fly ash is limited to 15%-20% by mass of the total cementitious material. Usually, this amount has a beneficial effect on the workability and cost economy of concrete but it may not be enough to sufficiently improve the durability to sulfate attack, alkali-silica expansion, and thermal cracking.

For this purpose, larger amounts of fly ash, on the order of 25%-35% are being used.From theoretical considerations and practical experience the authors have determinedthat, with 50% or more cement replacement by fly ash, it is possible to producesustainable, high-performance concrete mixtures that show high workability, highultimate strength, and high durability.

1) Behavior Of High Volume Fly Ash Concrete

It is generally observed that a higher substitution of Portland cement by fly ash reduces the water requirement for obtaining a given workability, mainly due to three mechanisms

- Fly ash gets absorbed on the surface of oppositely charged cement particles and prevents them from flocculation, releasing large amounts of water, thereby reducing the water-demand for a given workability.
- The spherical shape and the smooth surface of fly ash particles help to reduce the interparticle friction and thus facilitate mobility.
- Due to its lower density and higher volume per unit mass, fly ash is a more efficient void-filler than Portland cement.
- 1.3.2 Applications of high volume fly ash concrete
- HVFA system has proven to be an economical construction material. Several applications of HVFA concrete in structures, and pavements have been reported all over the world.
- Little information is available on long term properties and durability aspects of HVFA concrete, particularly, in India, where there is a lot of variation in quality and properties of fly ash.

A detailed study is hence necessary to reveal these aspects before prescribing the high volume fly ash Technology in practical application considering the availability of local materials and climatic condition in our country.

D. Objectives Of The Study

- The objective of the present study is as follows
- The objective of the present investigation is to develop fly ash as a partial replacement of cement on concrete by replacing 0, 40, 45 and 50 percentage of the weight of cement by fly ash.
- Concrete containing high volume of fly ash exhibited excellent mechanical properties, good durability with regard to repeated freezing and thawing, very low permeability to chloride iron.
- The investigation is also aimed to find out the compressive strength, split tensile strength and flexural strength with percentage of cement replacement by fly ash for characteristic strength of concrete.

II. REVIEW OF LITERATURE

A. General

The published researches by various authors on topics that are closely related to the behavior of the high volume fly ash concrete are discussed in this chapter. The main contents discussed in this chapter are properties, comparison of fly ash in concrete mix, and its feasibility for use as a replacement for cement in concrete.

B. Literature Review

Vanita Aggarwal et al. (2010) discussed about that this paper the development of high volume fly ash concrete for construction with reference to its predecessor like High Strength Concrete (HSC)and High Performance Concrete (HPC).The construction techniques have been modernized with focus on high strength, dense and uniform surface texture, more reliable quality, improved durability and faster construction. The strength of concrete having more than 40% replacement of cement by fly ash suffers adversely though water/binder ratio is gradually reduced. Water/binder ratio, quality of concrete and the age of curing are inter-related and effects high strength of concrete.

Mohd Mustafa Al Bakari et al. (2011) investigation this paper the fly ash is rich in silicate and alumina, hence it reacts with alkaline solution to produce aluminosilicate gel that binds the aggregate to produce a good concrete. The compressive strength increases with the increasing of fly ash fineness and thus the reduction in porosity can be obtained. The properties of fly ash-based geopolymer are enhanced with few factors that influence its performance. Fly ash-based geopolymer is better than normal concrete in many aspects such as compressive strength, exposure to aggressive environment, workability and exposure to high temperature. Kumar Metha (2010) concluded that this paper the concrete structures suffer from lack of durability which has an adverseeffect on the resource productivity of the industry. The theory and construction practice with concrete mixtures containing more than 50% fly ash by mass of the cementitious materials. Mechanisms are discussed by which the incorporation of high volume of fly ash in concrete reduce the water demand, improve the workability, minimizes cracking due to thermal and drying shrinkage, and enhances durability to reinforcement corrosion, sulfate attack and alkali-silica expansion. The high-volume concrete offers a holistic solution to the problems of meeting the increasing demands for concrete in the future. The reducing environmental impacts of two industries that are vital to economic development namely the cement industry and the coal-fired power industry.

Duran-Herrera et al.(2011) explained this paper heat release and heat flow were analyzed through isothermal and semi-adiabatic calorimeter, illustrating that heat release per unit mass of cement is independent of w/b, contrasting with the time of setting results that vary by several hours between the three different w/b ratios. The beneficial effects of the super plasticizer in terms of cement reduction and slump retention. Correlation between the fly ash substitution and slump loss, setting times, compressive strength and static modulus of elasticity were established and they represent very useful tools for the practical application of the results. For the range of FA substitutions studied in this work, the slump was increased by 10–40 mm. Fly ash additions do not retard the hydration reactions. Fly ash substations of 15% increased the modulus of elasticity by up to 8% in comparison with the reference concrete.

Dale P., and Chiara F., (2010) discussed about this paper due to long delay in setting times that produce concurrently long delays in finishing the concrete in the field. The reductions depend on the class of fly ash and suggest that trial mixtures would be a necessity to apply these technologies to each specific fly ash/cement/admixture combination being employed in the field. A nearly constant value was obtained for the cumulative heat release produced at either the initial or the final set time. The replace 50% are more of the Portland cement with a material that might otherwise being land filled. The high volume fly ash concrete mixture can be susceptible to long delay in finishing and sometime lack necessary early age strength development. The rheological measurement of yield stress may provide a faster indication of setting then conventional.

Smith Songpiriyakij et al. (2010) concluded that this paper fly ash was more reactive than Rice Husk and Bark ash (RHBA). Compressive strength, degree of reaction, and microstructure of the geopolymer were investigated to observe the effect of SiO2/Al2O3 ratio. It was also shown that not only the reactivity of the source materials but also the quality of the matrix contributed to the enhancement of compressive strength of the geopolymer paste. RHBA is a good silicon-rich source and can be used to partially replace fly ash to produce high Si/Al ratio geopolymers. Its incorporation can change the geopolymers mechanical properties. The compressive strength of the geopolymer increased with decreases in the sodium dioxide/silica dioxide and sodium dioxide aluminum trioxide ratio.

Dale P., et al. (2010) explained this paper high volume fly ash concretes have been proposed as one potential approach for achieving substantial reductions in cement usage, but their usage is sometimes hampered by reduced early age strengths and dramatically increased setting times. The optimizing the particle sizes of the cement and fly ash for achieving desired performance in a blended product will be presented. The maximum fly ash volumetric replacement for cement and fly ash with known surface areas. Blended cement mortars that provided similar compressive strength development to the control mortar also provided generally similar performance with respect to other early-age properties, including heat release, semi-adiabatic temperature rise, and autogenously deformation.

Cengiz D., (2005) discussed about this paper the strength properties of high volume fly ash roller compacted and superplasticized workable concrete cured at moist and dry curing conditions. Concrete mixtures made with 0%, 50% and 70% replacement of normal Portland cement (NPC) with two different low-lime Class F fly ashes, good and low quality, were prepared. The producing high-strength concrete was possible with high-volume fly ash content. A simple efficiency factor is proposed through which the influence of curing conditions on HVFA system can be observed. The efficiency factor is not constant but depends on different parameters, including curing condition, curing time and fly ash replacement ratio. HVFA concrete attained satisfactory or higher compressive and tensile strengths when compared with NPC concrete.

PothaRaju et al. (2004) explained this paper the relatively few studied have been undertaken on heat-induced changes in fly ash concrete. The Structural property of concrete that has been studied most widely as a function of heat exposure is compressive strength. The specimens were tested for flexural strength in the hot condition immediately after removing from the oven. The fly ash concrete with fly ash content up to 20% showed improved performance than the concrete without fly ash, by retaining more of its strength. Similar losses were observed as that of fly ash concrete with 20% fly ash content in all mixes. Exposure time has a significant effect on the residual flexural strength of concrete, as bulk loss of strength occurs within the 1 h of exposure in all mixes.

Cengiz D., (2002) concluded that this paper the Concrete mixture made with 50% and 70% replacement ordinary Portland cement with fly ash was prepared. Some concrete mixtures were also made super plasticizer. The volume fly ash concrete attained satisfactory compressive and tensile strength at 1 day of age. The strength and shrinkage properties of the concrete mixture cured at 20c temperature with 65% relative humidity. Concrete made with super plasticizer showed higher shrinkage than concrete made without super plasticizer. HVFA concrete mixture made with optimum water content showed significantly lower shrinkage value when compared to ordinary Portland cement concrete.

Kearsleya and Wainwright (2001) explained this paper the compressive strength of concretes cured under sealed conditions and shows that up to 67% of the cement could be replaced without any significant reductions in strength. There appears to be little difference in the performance of the ungraded and the graded fly ashes used in this investigation. Based on the results of this investigation, it can therefore be concluded that replacing high proportions of cement with fly ash does not significantly affect the long-term compressive strength of wellcured foamed concrete. Equations have been derived that can be used to predict the strength of foamed concrete of different densities at different ages. The long-term gain of strength observed was for well-cured samples and this gain of strength might not be as great with specimens that have not been so well-cured.

Ganesh babu and Siva Nageswararao (1994) investigation this paper the fly ash concrete are known to have a lower early age strength and there have been many effort to improve this in recent year. The early age strength behavior of fly ash concrete will help designing the concrete for any specific requirement. The early strength behavior has shown that the efficiency of fly ash can be assessed through the use of the two constant, general and percentage efficiency factors. The percentage efficiency factor was seen to vary from about 0.8 at 10% to a value of about 0.2 at 75% replacement. The efficiency concepts at the different percentage of fly ash replacement was also assessed and were seen t ovary to vary from 1.1 to .015 for replacements ranging from 10-75%. The decrease in the efficiency was quite steep initially up to about 35% and flattening out later at higher percentage.

Van D H., et al (2010) discussed about this paper the performance of high-volume fly ash (HVFA) concrete more quickly, two key properties governing this process can be studied, namely water penetrability and gas permeability. With respect to HVFA mixtures optimized for usage in an environment exposed to carbonation with wetting and drying, we adopted the latter approach. Differences between all mixtures regarding permeable porosity, a measure related to the total water content after vacuum saturation, are less pronounced. The fly ash applied had an excellent quality regarding loss of ignition and fineness. A measure related to the total water content after vacuum saturation is less pronounced.

Atis and Celik (2002) investigation this paper the abrasion of high volume fly ash concrete made with 50% and 70% of cement replacement with fly ash was assessed in terms of its relation to flexural tensile strength. Comparisons were also made between fly ash concrete. The abrasion resistance increased as flexural tensile strength increased. The high volume fly ash concrete made with 50% and 70% of cement replacement with fly ash was assessed in terms of its relation to flexural tensile strength. Optimum water-cementitious material ratio was used to produce zero-slump concrete. The mix containing 70% fly ash exhibits a slightly lower abrasion value than the concrete containing 50% fly ash and control normal concrete. A stronger relation existed between abrasion and flexural tensile strength than that between abrasion and compressive strength.

Nath and Sarker (2011) discussed about this paper the positive effects of fly ash as a partial replacement of cement on the durability of concrete are recognized through numerous researches; however, the extent of improvement depends on the properties of fly ash. Concrete mixtures with fly ash as 30% and 40% of total binder were used to cast the test specimens. The compressive strength, drying shrinkage, sorptivity and rapid chloride permeability of the fly ash and control concrete specimens were determined. Fly ash in concrete decreased drying shrinkage when the w/b ratio and the binder content were adjusted to achieve the same 28-day strength of the control concrete. Incorporation of fly ash reduced the sorptivity of concrete in early age and it decreased further at six months. The fly ash concretes yielded better resistance to chloride ion penetration both at 28 and 180 days.

Bouzoubaa et al. (2001) concluded that this paper the mechanical properties and durability of concrete made with a high-volume fly ash (HVFA) blended cement using a coarse fly ash that does not meet the fineness requirement of ASTM C 618. The properties of the fresh concrete determined included the slump, air content, slump loss, stability of air content, bleeding, and setting time; those of the hardened concrete investigated included the compressive strength, flexural- and splitting-tensile strengths, Young's modulus of elasticity, drying shrinkage, resistance to abrasion, chloride-ion penetration, freezing and thawing cycling, and to deicing salt scaling. The results show that except for the resistance of the concrete to the deicing salt scaling, the mechanical properties and the durability of concrete made with this blended cement were superior to the concrete in which the ungrounded fly ash and the cement had been added separately at the mixer.

Papayianni and Valliasis (2005) explained this paper concretes containing a high volume of fly ash differ from conventional mixes in the cementitious phase. This result in a different behavior under heating compared to plain Portland cement concretes. To find the elastic response of fly ash concrete four series of concrete mixtures were manufactured: one with cement only, another with 30% by mass partial replacement of cement by fly ash, and two with 30% and 40% by mass replacement of cement by ground fly ash. It is suggested that the cementitious phase of concretes containing fly ash is more sensitive to heating. This could be attributed to higher loss of water. Entrapped by the hydrates of fly ash cement paste and to their higher creep-like deformations.

C. *Conclusion From Literature Review*

From the review of literature presented above, the following are the major conclusions;
The construction techniques have been modernized with focus on high strength, dense and uniform surface texture, more reliable quality, improved durability and faster construction.The compressive strength increases with the increasing of fly ash fineness and thus the reduction in porosity can be obtained. Correlation between the fly ash substitution and slump loss, setting times, compressive strength and static modulus of elasticity were established and they represent very useful tools for the practical application of the results. The replace 50% are more of the Portland cement with a material that might otherwise being land filled.

The high volume fly ash concrete mixture can be susceptible to long delay in finishing and sometime lack necessary early age strength development. The fly ash concrete with fly ash content up to 20% showed improved performance than the concrete without fly ash, by retaining more of its strength. Based on the results of this investigation, it can therefore be concluded that replacing high proportions of cement with fly ash does not significantly affect the long-term compressive strength of well cured foamed concrete.

III. MATERIALS PROPERTIES

A. *Introduction*

The materials used in the production of High volume fly ash concrete were cement, fly ash, fine and coarse aggregates, a high range water reducer. This experimental study is to investigate the physical and chemical properties of various materials used as an ingredient for concrete.

B. *Materials*

1) Cement

The cement used should confirm to IS specifications. There are several types of cements are available commercially in the market of which Portland cement Specific Gravity is 3.15 the most known and available everywhere. OPC 53 grade confirs to IS 8112:1989 is used for this study.

2) Fly Ash

Fly ash from Mettur Thermal Power Station as collected from the source was used. The sieve analysis results are shown in Table 3.1.

Table - 3.1
Sieve analysis of fly ash

IS SIEVE SIZE (micron)	*PERCENTAGE FINER*
600	*99.9*
300	*97.7*
150	*77.5*

Compounds	*Mettur fly ash*
Sio_2	*54.5*
Alo_2	*23.2*
Fe_2O_3	*6.0*
Mgo& Cao	*6.5*
S	*0.7*
Mg	*2.8*
Alkali metal Oxide	*2.7*
LOD	*2.8*
75	*27*
>75	*0*

Table - 3.2
Chemical composition of mettur fly ash

Color	*Whitish gray to gray with slight black fines*
Bulk Density	*1.2g/cc*
Specific Gravity	*1.9 to 2.0*
Fineness	*2000 to 2200sq.cm/g*
Moisture	*Nil*

3) Fine Aggregate

Naturally available fine aggregate is used for casting specimens. The fine aggregate was passing through 4.75mm sieve and had a specific gravity of 2.68. The grading zone of fine aggregate was zone II as per Indian Standard Specification (IS 383).

4) Coarse Aggregate

Coarse aggregate are the crushed stone is used for making concrete. The maximum size of coarse aggregate used for this investigation is 20mm and the specific gravity is 2.78.

5) Water

Water is an important ingredient of concrete as it chemically participates in the reactions with cement to form the hydration product C-S-H gel. The strength of cement concrete depends mainly from the binding action of the hydrated cement paste gel. A higher water-binder ratio will degrease the strength, durability, water-tightness and other related properties of concrete. As per Neville, the quantity of water added should be the minimum required for chemical reaction of hydrated cement, as any excess of water would lead end up only in the formation of undesirable voids (capillary pores) in the hardened cement concrete paste. Hence, it is essential to use a little paste as possible consistent with the requirements of workability and chemical combination with cement.

From HSC mix considerations, it is important to have the compatibility between the given cement and the chemical and mineral admixtures along with the water used cement and mineral admixtures along with the water used for mixing. HSC with its high content of cementitious materials is susceptible to a rabid loss of workability on account of high amount of heat of hydration generated. Therefore attention is required to see that the initial hydration rate of cement should not be significantly affected. Quality and quantity of water is required to be looked very carefully.

The water used for making concrete should be free from undesirable salts that may react with cement and admixture and reduce their efficiency. Silts and suspended particles and undesirable as they interfere with setting, hardening and bond characteristics. Algae in mixing water may cause a marked reduction in strength of concrete either by combining with cement to reduce the bond or by causing large amount of air entrainment in concrete.

Water conforming to the requirements of BIS: 456-2000 is found to be suitable for making concrete. It is generally stated that water fit for drinking is fit for making concrete. For the present investigation, drinking water supply to sathyamangalam town from bhavani sager dam was used for making concreting along.

Table - 3.4
Mix Proportion

Mix proportion M30	1 cement	1.83 FA	2.32 CA	0.45 W/C
Cement	438		kg/m^3	
water	197		Litre	
Fine aggregate	800		kg/m^3	
Coarse aggregate	1015		kg/m^3	
Water-cement ratio	0.45			

C. *Chemical Admixtures*

HSC is a low water binder ratio and has ultrafine particles in the form of mineral admixture such as fly ash. Effective dispersion of cement and fly ash is necessary to achieve proper microstructure of the hardened concrete as well as the workability of the concrete without increasing the unit water and cement content of a mix. Hence, the chemical admixtures are essential ingredients in the HSC mix, as the increase in the efficiency of cement paste by improving the workability of the mix and there by resulting in considerable decrease of water requirement. Thus, with W/B ratio as low as 0.3 or less, the concrete can be produce with the use of chemical admixtures. The water content could be reduced, thereby effective control on W/B ratio could be maintained to achieve the desired strength and improved durability. Chemical admixtures are used primarily in concrete mixes in order to accomplish the following effects.

1) Increasing the workability without altering the mixture proportions.
2) Reducing both water and cement content in the mixture for purpose of reducing creep, shrinkage and thermal strains caused by cement hydration.
3) Reducing the mixing water volume and water-binder ratio in order to increase concrete strength and improved durability.

Through there are many types of chemical admixtures available, the following are the commonly used admixtures.

1) Plasticizers and the superplasticizer
2) Retarders
3) Air entertaining

Plasticizer and superplasticizer, being surfactant in nature to disperse the cementitious particles in the mix, thus fluidity of the concrete mix is increased. Retarders reduce the initial rate of hydration of cement so that the fresh concrete retains its workability for a longer time. Air entertaining agents artificially introduce (entrain) air bubbles, which increase the workability of the mix by their wall bearing action and also enhance the resistance to deterioration of hardened concrete.

1) *Superplasticizers*

Super plasticizers procedure extreme workability and thus flowing concrete. They achieve reduction in the water content without loss of workability.

Super plasticizers are water reducers, which are capable of reducing water contents by about 30%. However, it is to be noted that full efficiency of super plasticizer can be noted that full efficiency of super plasticizer can be got only when it is added to a mix that has an initial slump 20-30mm. addition of super plasticizer to stiff concrete mix reduces its water reducing efficiency. Depending on the solid content of the mixture, a dosage of 1-2% weight of cement is advisable.

For the present investigation, a super plasticizer by the name CONPLAST SP430 has been used for obtaining workable concrete at low W/B ratio. CONPLAST SP430 complies with BIS:9103-1999 and BS:5075-part3 and ASTM C494.Super plasticizer molecules and cement grains are oppositely charged and hence repel each other. This increases the mobility and hence makes the concrete flow.

Super plasticizers enable savings in cement for a given strength and ideal for pumping concrete, casting heavily reinforced concrete members, and the precast elements of concrete.The Properties of super plasticizer is shown in the table 3.4

Table - 3.4
Properties of Superplasticizer

PROPERTIES	RESULTS OBTAINED
Type	Sulfonated naphthalene formaldehyde condensate
Specific gravity	1.22 to 1.225 at 30°
Chloride content	Nil as per BIS:456 and BS:5075
Recommended dosage	0.6 to 1.5 liters per 100Kg of cement
Approximate additional air entrainment	1% at normal dosage
Compatibility	All type of cement except high alumina cement
Solid content	40%
Workability	Produce high workable flowing concrete mix without segregation and requires no compaction.
Cohesion	Minimizing segregation and improving surface finish
Compressive strength	Early strength up to 40 to 50%

IV. METHODOLOGY

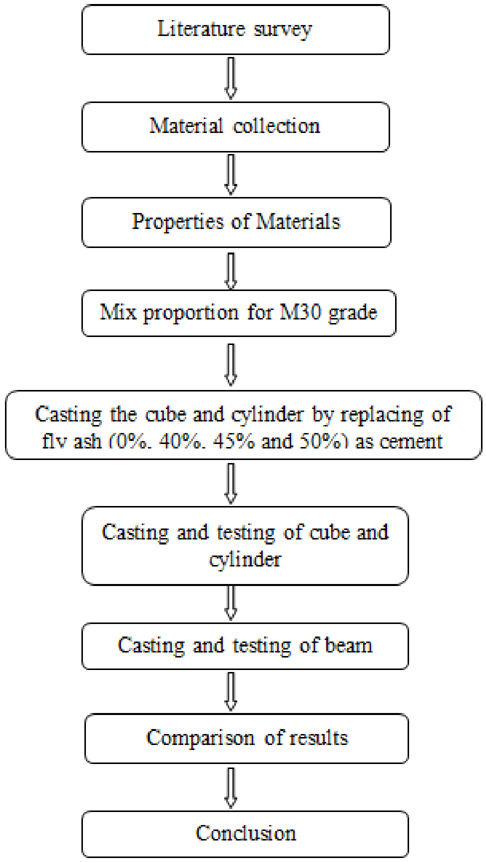

Fig. 4.1: Flow chart for Methodology

A. *Description*

1) *Review Of Literature*
   – Published literatures are studied to know the properties of high volume fly ash concrete
2) *Material Collection*
   – Cement and fly ash are the materials collected for experimental work.
3) *Material Study*
   – Preliminary tests for cement, fine aggregate, coarse aggregate and fly ash are conducted and the properties of materials are determined.
4) *Design Of M30 Grade Concrete*
   – The mix design adopted to determine the mix proportion for M30 grade concrete is IS10262: 2009.
5) *Casting And Testing Of Concrete*
   – Casting the specimen of M30 grade are casted for adopted mix proportion replacing of fly ash 0%, 40%, 45% and 50% as cement.
   – Specimens are tested to ensure correct mix proportion and for comparison.
   – Test on compressive strength for M30 grade concrete at 7 days, 28 days and 90 days of curing are conducted.
   – Test on split tensile strength and flexural strength for M30 grade concrete at 28 days and 90 days of curing are conducted.
6) *Casting And Testing Of Beam*
   – Casting the specimen of M30 grade are casted for adopted mix proportion replacing of fly ash 0%, 40%, 45% and 50% as cement.
   – Test on flexural strength for M30 grade concrete at 28 days and 90 days of curing are conducted.
7) *Comparison Of Results*
   – Conventional concrete specimens of M30 grade of concrete is compared to replacement of fly ash with cement 40%, 45% and 50% at 28 days and 90 days.
   – The results of the tests are tabulated.
   – Graphs are plotted for comparison of test results.

B. Conclusion

- The slightly slower rate of strength development during the first 28 days.

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