Assessment of Concrete Strength Using Inexpensive Locally Available Materials -Flyash and Microfine Barites in Place of Concrete in Application of Building, Dam, Road Etc

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ABSTRACT

Concrete is the most versatile material for all types of construction works and has been used for innumerable construction works either, as plain concrete or as reinforced cement concrete or as precise concrete or prestressed concrete or in many other forms. Except water, no other material is being used in such large quantities About 12,000 million tones of concrete is used globally. The various ingredients of concrete are Cement, Water, Fine Aggregate and Coarse Aggregate. Ordinary Portland Cement (OPC) is the chief constituent of concrete. The production of Portland cement contributes about 7% of worlds total greenhouse gas CO emissions. Today, all nations including developed and developing countries facing a problem of environmental pollution Cement industry is one of the dominant industries in the galaxy of industries that have been cropped up in the recent past. If the Portland cement is manufactured in huge quantities, the chief raw material of lime stone reserves will be exhausted in the coming years. The production of Tone of Cement consumes 1.5 Tones of lime stone consequently 1 tone of CO_2 is emitted into the atmosphere. Hence studies are conducted to explore the alternate locally available inexpensive materials in place of ordinary Portland cement to the possible extent.

The Pozzolonic materials generally used in concrete are Fly-ash, Ground granulated blast furnace Slag, Silica fume, Rice husk ash and Meta Kantian. The Rayalaseema Thermal Power Plant is located at Kallamalla, Yerraguntla Mandal, YSR Kadapa district produces about 1 Million tone of Fly-ash annually. Barites, an inert mineral with specific gravity ranging from 3.8 to 4.6 is abundantly available in Mangampeta which is located 129 Km away from Anantapuram district. Barites can be mixed and grounded easily to get micro-fine powder form.

1.1 GENERAL

CHAPTER-I INTRODUCTION

The human lives and civilization had been conditioned by the ability of man to use/master the materials even from pre-historic times. With the advancement of civilization, man has been trying to use new/advanced materials and construction practices. The historians differentiated the periods of man's development such as Stone age', Bronze age and Iron age'. Now, the running period is the Concrete age'. The worldwide consumption of concrete, at present is about 12.000 million tonnes a year. Man consumes no other material in such tremendous quantities next to water. The world is experiencing population explosion problem and the natural resources are depleting rapidly There is no replenishment of the depleted natural resources. The world consumption of Portland cement has risen from 2 million tonnes in 1880 to 1.66 billion tonnes by 2000. This may go up to 2.00 billion tonnes by 2010. The world population in the year 2000 is 6.0billions and it may increase up to 9.0billions by2025.
The production of one tonne of cement consumes 1.5 tonnes of limestone, 80 units of electrical power apart from abatement of one tonne of CO_2 to the atmosphere. Out of all the worldwide 'green house gas CO_2 emissions, cement industry contributes about 7% of the emissions. As per Tim Hansen of National Aeronautics and Space Administration (NASA) USA, the earth has grown 20% darker due to air pollution.
In View of the large production of cement worldwide, and the appreciate quantities of greenhouse gas emissions from Cement industries, the manufacture of cement shall be made as much Environmental friendly as possible.

1.2 POZZOLANIC MATERIALS USED IN CONCRETE

Pozzolans are usually defined as siliceous or siliceous and aluminous materials which, though not cementitious themselves, react with lime, when in finely divided form, in the presence of water at ordinary temperatures and form stable and insoluble mineralogical phases possessing cementitious characteristics.

Pozzolanic materials generally used in concrete are Fly-ash, Ground Granulated blast furnace slag, Silica fume, Rice husk ash and Metakaolin.

(i). **Fly-ash:** It is the residue generated from the combustion of pulverized coal and collected from the flue gases using electrostatic precipitators or bag houses.

(ii). **Ground Granulated Blast Furnace Slag (GGBS):** It is obtained by grinding the granulated slag from Iron Industry.

(iii). **Condensed Silica Fume:** It is a bi-product obtained from the induction of arc furnaces in the silicon metal or ferrosilicon industries.

(iv). **Rice Husk Ash:** It is produced by burning rice husk in a controlled manner, which consists of large portion of amorphous silica.
(v). **Meta Kaolin:** It is obtained by calcination of pure or refined Kaolinitic clay at a temperature between 650°C to 850°C followed by grinding to achieve a fineness of 700 to 900m2/kg.

The prime uses of pozzolans in cement concrete action are filling supplying additional cementitious products.

The research works carried out on the use of pozzolans in Concrete revealed that the pozzolans have the following effects in concrete.

1. Decrease of capillary porosity.

2. Increased gel pores.

3. Reduction in micro cracking within the pore system.

4. Densification of Interfacial Transition Zone (ITZ) in between aggregate and hydrated cement paste.

1.3. ADVANTAGES OF CONCRETE

(i) **Economical:** Concrete is the most inexpensive and the readily available material. The cost of production of concrete is low compared with other engineered construction materials. Three major components: Water, aggregate and cement. Comparing with steel, plastic and polymer, they are the most inexpensive materials and available in every corner of the world. This enables concrete to be locally produced anywhere in the world, thus avoiding the transportation costs necessary for most other materials.

(ii) **Ambient temperature hardened material:** Because cement is low temperature bonded inorganic material and its reaction occurs at room temperature, concrete can gain its strength at ambient temperature.

(iii) **Ability to be cast:** It can be formed into different desired shape and sizes right at the constructions site.

(iv) **Energy efficiency:** Low energy consumption for production, compare with steel especially. The energy content of plain concrete is 450-750kwh/ton and that of reinforced concrete is 800-3200 kwh/ton, compared with 8000 kwh/ton for structural steel.

(v) **Excellent resistance to water:** Unlike wood and steel, concrete can harden in water and can withstand the action of water without serious deterioration. This makes concrete an ideal material for building structures to control, store, and transport water. Examples include pipelines (such as the central Arizona project, which provide water from Colorado River to central Arizona. The system contains 1560 pipe sections, each 6.7m long and 7.5m in outside diameter 6.4m inside diameter), dams, and submarine structures. Contrary to popular belief, pure water is not deleterious to concrete, even to reinforced concrete: it is the chemicals dissolved in water, such as chlorides, sulfates, and carbon dioxide, which cause deterioration of concrete structures.

(vi) **High temperature resistance:** Concrete conducts heat slowly and is able to store considerable quantities of heat from the environment (can stand 6-8hours in fire) and thus can be used as protective coating for steel structure.

(vii) **Ability to consume waste:** Many industrial wastes can be recycled substitute for cement or aggregate. Examples are fly ash, ground tire and slag.

(viii) **Ability to work with reinforcing steel:** Concrete and steel possess similar coefficient of thermal expansion (steel1.2*10-5; Concrete 1.1*10-5). Concrete also provides good protection to steel due to existing of CH (this is for normal condition). Therefore, while steel bars provide the necessary tensile strength, concrete provides a perfect environment for the steel, acting as a physical barrier to the ingress of aggressive species and preventing steel corrosion by providing a highly alkaline environment with pH about13.5 to passivity the steel.

(ix) **Less maintenance required:** No coating or painting is needed as for steel structures.

1.4 FLY-ASH UTILIZATION AND LIMITATIONS

Fly-ash is the synonym with flying ash' that came into vocabulary with the use of pulverised coal in boiler operations. In age-old grate boilers, coal used to be charged as lumps that get sintered progressively on a travelling grate. In the process, the ash gets into molten state upon furthered temperature. This molten ash, uponcooling, solidifies in clinker form that is popularly called as cinder. The concern to tap optimum energy out of coal has lead to pulverized coal combustion that has given way for fly-ash generation. Fly-ash is the residue generated out of the combustion of pulverized coal at regulated temperatures in boilers. Fly-ash is made up of very fine, predominantly spherical glassy particles. It is generally finer than the Portland cement.

Out of the various industrial wastes, coal ash is perhaps the most abundant, world over. In India about 120 million tonnes of fly-ash is being produced annually. About 65,000 hectors of land is being wasted to dump this waste. As of today, the utilization of fly-ash in cement and concrete is the most extensive and throughout widespread the world as compared to the other potential uses of fly-ash.

Utilization of fly-ash is becoming an increasingly attractive alternative to disposal, all over the world for the following reasons.

(i). Cost and problems associated with the disposal in an environmentally sound manner are minimized or eliminated.

(ii). Less area is required for disposal, thus enabling other uses of land.

(iii). There may be financial returns from fly-ash sales or at least processing costs may be decreased.

(iv). Use of fly-ash can replace some scarce or expensive natural resources.

(v). Conservation of non-renewable energy source required in processing and transportation of ash for disposal.

The fly-ash is used in cement and concrete as an ingredient in blended cement and as a mineral admixture in concrete. Sometimes fly-ash is also used as replacement to fine aggregate in concrete. The majority of the effects of fly-ash on concrete properties tend to improve concrete performance in field use both in fresh and hardened states.

In fresh concrete, fly-ash improves bleeding workability and reduces and segregation. Addition of fly-ash has significant influence on the rate of hydration reactions as well as on the effectiveness of the chemical admixtures particularly water reducing agents and air entraining agents.

In hardened state, the concrete made with all types of fly-ash which possess pozzolanic characteristics, usually develop strength near than those of similar concrete without fly-ash at later ages. Addition of fly-ash also increases the durability properties of concrete Such as resistance to sulphate attack, seawater attack, alkali silica reaction, corrosion of reinforcing steel in concrete etc.

1.4.1 LIMITATIONS OF INDIAN FLY-ASH

Based on the recent state of knowledge, the following are some of the general constraints on productive utilization of fly-ash.

(i). Fly-ash properties vary from plant to plant and within the plant also. Hence the non-uniformity in physical and mineralogical characteristics poses hurdles in effective and large-scale utilization of fly-ash.

(ii). Need for the use of additives or admixtures for satisfactory obtaining and acceptable mortar/concrete mixes in the field application.

(iii). Non availability of consistent supply of desired quality of fly-ash.

(iv). Lack of quality control and quality assurance of production, storage and supply sources.

(v). Slow rate of strength development of fly-ash mortar/concretes.

(vi). Increased demand for air entraining agent.

(vii). Effects of mix proportioning and laboratory testing when fly-ash is incorporated as an additional ingredient of concrete.

1.4.2 RAYALASEEMA THERMAL POWER PLANT (RTPP) FLY-ASH

The R.T.P.P., Muddanur, uses bituminous coal. The statistics of the ash production of R.T.P.P. shows that about 38% of ash is generated from the coal used in the boilers. About 65% of both dry and wet ash are being utilized for various purposes. i.e., in manufacturer of Portland pozzolana cement by local cement factories, in production of fly-ash bricks, asbestos industries, for filling low lying areas, and for roads and concrete works. The utilization of R.T.P.P. fly-ash in concrete works is merge. Very little or no literature is published available on the mechanical and durability properties of concrete using R.T.P.P. Fly-ash.

1.5 BARITES

Barites is a mineral obtained from barites mines. Kadapa District is a major mining centre for barites not only in the state but also in the country as a whole (Sinha R.K. -1980). Barites is also known as heavy spar, mainly used in oil and gas wells as a weighting agent in drilling muds. A substantial quantity of barites is also used in manufacture of barium chemicals for making glass, ceramic glasses, enamels, additives, paper steel hardening, paints, asbestos coating, steel products, rubber and other allied trades.

Due to its natural properties of high specific gravity, inertness and absorption of X-ray and Gamma rays radiation, barites as aggregate is used for shielding work in preparation of high density Concrete, plaster and floor screens for use in building works, in nuclear power plants, hospitals, X-Ray units, research stations and laboratories (N.V. Dutta -1989).

The use of limestone as filler in cement and concrete is increasing substantially as a response to environmental, economic, and quality issues. Because of the physical action of improving the pore system in concrete structures, thus improving the properties like permeability, shrinkage and creep, the use of fillers is recommended in concrete. The use of fillers is also desirable from an economical point of view enabling economy in the overall production of concrete (R. Magarotto et.al. 2005). Little or no published literature is available on the use of micro-fine, inert barites filler in concrete. In view of the abundantly available barites in Kadapa district, using barites for economic and environmental factors in concrete is a topic to be explored.

1.5.1 BARITES USES

(i) **Oil And Gas Drilling** The properties like insolubility in water, inertness and high specific gravity enable barytes application as a weighting agent in drilling operations to control pressure, prevent blow-out and at the same time to provide lubrication. Barytes powder containing minimum 90% barium sulphate with 4.15 specific gravity is recommended for drilling. For offshore drilling, the specific gravity should be 4.2. At least 97% ground barytes should pass through 75- micron IS sieve and 95% through 53- micron IS sieve.

(ii) **Chemical** Major barium chemicals obtained from barytes are carbonate, chloride, oxide, hydroxide, nitrate, peroxide and sulphate. Barium carbonate is used in glass industry, electro-ceramics and for removing inconvenient impurities in phosphoric acid. Barium hydroxide is used in the preparation of barium salts of organic acids which are utilised as additives for lubricating oils and as stabilisers for PVC.

(iii) **Paint** Barytes is used as filler and extender in paint industry. White pigment is manufactured from barytes. Barytes should be free from mud, clay or siliceous minerals. Presence of iron oxide is undesirable. The material should be in the form of dry powder.

(iv) **Glass** In glass manufacturing, barytes is added to the glass melt for making the glass more workable and enhancing its brilliance. Iron is the most undesirable impurity.

(v) **Rubber** Barytes is used as a filler and extender in rubber products. It is added to rubber compounds for reinforcement. Barytes containing minimum 99.5% $BaSO_4$ is usually preferred. Since such purity material is not found in nature, before use, barytes is normally bleached called 'blanc fixe'. The sieve residue through 75-micron and 150- micron sieve should be 4% and 0.01% max., respectively. BIS has prescribed IS:1683-1994 (Reaffirmed 2008) as specification of barytes for use in rubber industry.

(vi) **Other Uses** Barytes is used in the manufacture of asbestos products required for autobrake lining and other frictional materials. It is used as a filler in paper industry. Finely ground barytes and clay are used as suspension in Barvois system of coal washing. Barytes is also used in concrete aggregate required for reactor shielding. In medicine it is used in radiodiagnosis to highlight the abnormalisation of internal body parts. Barytes also finds use in explosives and pyrotechnics composition for which BIS has laid down specifications vide IS 7588-1992 (Reaffirmed 2011).

1.5.2 MANGAMPETA BARITES

One of the world's largest baryte deposits, accounting for more than 98% of India's baryte production. K.S. Mishra of the Geological Survey of India (GSI) was the first to report fullerene-bearing shungitic rocks from the volcano-sedimentary Proterozoic formations in association with the world's largest bedded barite (barytes) deposit at Mangampeta, Kadapa (Cuddapah) district, India in the 3rd International seminar & exhibition on exploration geophysics in Osmania University, Hyderabad on 9th November2006. Both C60 and C70 forms of fullerene were identified by laser desorption/ionization spectrometry in black carbonaceous shales (now called shungitic rocks) having an organic carbon content of 5-13%. The associated rocks include grey shales, dolomites and quartzites. (Dr. R. Jagadiswara Rao; Professor of Geology [Retired], Sri Venkateshwara University, Tirupati, AP 517502, India)

1.6 NECESSITY OF THE PRESENT INVESTIGATION

About 65% of the fly-ash generated at R.T.P.P., Muddanur is being utilized for various purposes. The percentage of fly-ash used in concrete is very less. Due to the non availability of the established /acceptable data on the mechanical and durability properties of fly-ash concrete using R.T.P.P. fly-ash, the use of R.T.P.P. fly-ash in concrete in the local areas is merge. The barites available is mainly used by ONGC and a part for manufacturing of Barium chemicals and paints. The rejected barites is cheaper and the material can easily de-pulverized to give a fineness of 450m2/kg. (Blaine's). Using of inert fillers in concretes for pore structure refinement and reducing shrinkage cracks is gaining importance in concrete industry. The locally available fly-ash and the micro-fine barites are cheaper and can be economically used in concrete. For sustainable development, the use of waste is essential: Secondly, by replacing the Portland cement to the extent possible by fly-ash and micro-fine barites filler adds to the sustainable concrete. In order to increase the scope and value for the use of fly-ash and barites in concrete production by established data on the mechanical and durability properties of concrete, an attempt is made in the present investigation, to evaluate the mechanical and durability properties of concrete with R.T.P.P. Muddanur Fly-ash and micro-fine barites filler.

1.7 OBJECTIVES OF THE PRESENT INVESTIGATION

In view of the less utilization of fly-ash in concrete locally, an established technical data on mechanical and durability properties of R.T.P.P. fly-ash concrete to improve the use of fly-ash in concrete for sustainable development is essential. Hence, the following studies have been undertaken in the present dissertation.

1. The study of the mechanical and durability properties of R.T.P.P. fly-ash concrete.

2. The study of mechanical and durability properties of fly-ash concrete using waste lime, micro-fine barites and super plasticizer.

3. The study of effect of elevated temperatures and sudden cooling on fly-ash concrete using lime, micro-fine barites and super plasticizer.

4. The study of the behaviour of fly-ash concrete under progressive compressive loading by using Portable Ultrasonic Non-destructive Digital Indicating Tester (PUNDIT).

5. Comparison of mechanical and durability properties of fly-ash concrete using lime, barites and super plasticizer with ordinary Portland cement (OPC) concrete.

6. Mathematical expressions relating mechanical and durability properties of concrete.

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2.1 GENERAL

CHAPTER-II LITERATURE REVIEW

One would not think of using wood for a dam, steel for parament or asphalt far a building frame, but concrete is used for each of these and many other uses than many other construction materials. Even where another material is the principal component of a structure, concrete is usually used with it for certain portion of the work. It is used to support, to enclose, to surface, and to fill. More people need to know more about concrete than about other specialized materials (J.W. Kelly-1961).

Concrete has been the most widely used construction material in the world for more than a century, due to well known reasons, such as a low relative cost, rasy availability, versatility, adaptability and adequate engineering properties for many structural applications Portland cenient concrete has already become the most commonly used material of estruction throughout the world. Almost all the concrete made today contains one or more chemical and mineral admixtures which are readily available and are used for achieving a variety of objectives (P.K. Melita-1994).

With the time, the high strength concretes became high performance concretes since they have more properties than simply a high strength Slowly, the environmental issues necessitated for the need of a concrete, which is more ecologically friendly than the usual concrete. When it is realized that one third of the world has the advantages of a high standard of living and that this one third is not interested in going back to the living standards of good old days and that two thirds of the world has only one thing in mind, that is to benefit from the same standard of living as they have, it is urgent that a sustainable development policy be enforced all over the planet to avoid repeating the same errors that were made and resulted in the present situation. The cement and concrete industry is no exception to this policy (P.C. Aitcin, 2000).

The economical, ecological issues and the demand for durable concrete make the concrete of 21" century a preen' and sustainable concrete. In view of the fast depletion of natural resources, it becomes the need of the hour to use less natural resources and more industrial bi-products, mine and other wastes for production of concrete which make the concrete 'green'.

2.2 FLY-ASH & ITS ROLE IN CONCRETE

2.2.1 **Fly-ash :** The fly-ash, like volcanic ash, is produced in man-made small-scale volcano like furnaces of coal burning power plants. Flvash is made up of very fine, predominantly spherical, glossy particles collected in the dust collection systems from the exhaust gases of fossil fuel power plants Depending upon the collection system, varying from mechanical to electrostatic precipitators, or bag houses, and fabric iters, about 85 to 99% of the ash from the flue gases is retrieved in the form of fly-ash.

Fly-ash generated in coal burning power plants is an inherently variable material because of several factors Mineralogical composition of coal, degree of pulverization, type of furnace and 16 oxidation conditions, the manner in which the fly-ash is collected and stored are the main reasons for the variability of fly-ash. - Fly-ash was recognized as pozzolanic ingredient for use in concrete as early as in 1914. However, the earliest comprehensive study on the use of fly-ash in concrete was conducted by Davis et. Al in 1937.

2.2.2 Fly-ash Physical Properties

The effective utilization of fly-ashes needs adequate knowledge of their physical, chemical and mineralogical properties. Particle shape and size, fineness, specific gravity and pozzolanic index are the physical properties which are mainly considered as the prime parameters for prediction of the performance of fly-ash in cement or concrete. Morphological studies on particle shape and surface characteristics of various types of fly-ash have been conducted by Mehta (1984 & 1988) and many others using scanning electron microscope (SEM). The results showed that fly-ash particles have typically spherical shape, some of which are hollow. In a number of fly-ash from different sources, the presence of significant amount of non- spherical or angular particles has also been detected by several investigators Mehta found that high calcium fly-ash were finer than the low calcium fly-ash and he related this difference to the presence of larger amounts of alkali sulphates in high calcium fly-ash.

(i).<u>Fineness</u> :

The Fineness is one of the primary physical properties of fly-ash that relates to its pozzolanic activity (Joshi -1979). finess is specified by the specific surface area determined by Blaine's air permeability method or by maximum amount of fly-ash retained on 4 No. 325 mesh sieve on wet sieving A large percentage of mal particles larger than the 45 u have been reported to have e effect on 28 days and 90 days strengths of normally cured Portland, om-flashes mortars. At the same time particles less than My had a positive influence on mortar strengths (Prigione et al. 1993) Specific Gravity: The specific gravity of fly-ash is related to shape as well as chemical composition of fly-ash particles. Like other physical properties, the specific gravity of different fly-ash varies over a wide range. Normally it ranges from 1.9 for a sub- bituminous ash to a high value of 2.96 for an iron rich bituminous ash (Caretta et al. 1986). When the spherical hematite and magnetite particles are present in sufficient quantity in fly-ash, the specific gravity may vary from 3.6 to 4.8. When mullite and quartz particles increase, the specific gravity decreases pulverization releases some of the gases trapped, during quenching inside hollow spherical particles and increases the bulk specific gravity of fly-ash Joshi 1979).

(ii).<u>Pozzolanic Activity</u> :

Fly-ash is generally judged of its quality in terms of strength potential. Fly-ash exhibit pozzolanic activity, Fly-ash is studied for its pozzolanic characteristics in two approaches: Lime activity strength (LRS) and pozzolanic activity Index (PAI). IS 3812 1981, Specification for fly-ash for use as pozzolona, and admixture accords two grades of fly-ash based on L.R.S. Grade I is identified with minimum 4 MPa. Whereas fly-ash with minimum 3MPa is categorized as Grade II. The same code has also specified pozzolanic activity index as another yard stick. The LRS reflects the strength of lime-pozzolanic reactions that are manifested out of calcium silicate hydrates. Though calcium aluminate hydrates form in lime pozzolanic reactions, they do not contribute for strength. Whereas the same mineralogy gets converted to calcium sufflaminate hydrates, drawing gypsum from the cement in the study of PAI, to contribute for its part of additional strength. In case of blending fly-ash with cement, PAI may be taken as the ultimate yardstick (Bhanumathi Das & Kalidas, 2002).

Chemical composition of fly-ash doesn't reflect the form in which various compounds are present. Yet the governing parameters indicative of the reactivity are its calcium oxide and carbon content The current ASTM requirement for the pomolanic activity with cement is that the strength developed by the specimens of the test mature, in which 35% of the cement by weight is replaced by fly-ash being seated, shall be a minimum of 75% of the control specimen Aller storage at 38 1.7°C for one day and then at 55 17°C for six days. The sum of silica alumina iron of fly-ash has been stipulated by ASTM and some other standards associations as a major requirement. The silica alumina content of flushes shows a good correlation withlong- term pozzolanic activity. As per Mehta (1983), the chemical analysis doesn'treflect its pollinic characteristics. Based on the reactive potential, SO and Rus render prizzolanicity to ashes.

2.2.3 Chemical properties

Chemical composition of fly-ash depends on the characteristics and emption of cell burned in power stations. The chief chemical submediants in fly-ash include Ella Alumina Wu, and des of calcium (Magnesium (Mg)), Solon20 NajOj, Sulphur
(80). Potassium (KO) and Titanium (TO). Un burnt carbon is another major constituent in all the fly-ash. Amongst these, SiO, and AlO, make up 40 to 80% of the fly-ash. For fly-ash to act as a pozzolana, it is necessary to have chemical constituents capable of reacting with lime in presence of water. Only glass or amorphous phases of oxides take part in pozzolanic reaction. Studies have shown no definite relationship between pozzolanic activity and proportion of individual oxides (Mehta -1984).

(i). Sulphur Trioxide :

The maximum SO, content allowed in the fly-ash by ASTM C 618 is 5%. The SO, content has been reported to affect to some degree the early age compressive strength of mortar/concrete. The higher the SO_2 content, the higher the resultant strength. Generally, the SO_2 limits are set below the optimum limit and thus the added S0, from fly-ash may be an advantage in some cases. However, the maximum limit of SO, content is to be stipulated in order to avoid excess sulphate in hardened concrete. Carbon content (Loss on ignition): Loss on ignition is the weight loss of fly-ashes burned at temperatures s 1000°C. It is related to the presence of carbonates, combined water in residual clay minerals and combustion of free carbon. Carbon is the most important of loss on ignition (LOI). Water required for workability of mortars and concrete depends on carbon content of fly-ash. The higher the carbon content of a fly-ash, the more water is needed to produce a paste of normal consistency. There appears to be no evidence that carbon content of fly-ash is detrimental to durability and strength development, if proper air entrainment is attained Lloshi and Lohtie, 1997). Magnesium Oxide (MgO): The formation of magnesium hydroxide in hardened concrete causes disruptive expansion. Hence, MgO present in fly-ash cement should be such that the MgOH), content should not caum disruptive actions in hardened concrete.

(ii).Alkalis :

The water showable alkalis in fly-ash are detrimental to concrete when aggregates are susceptible to alkali aggregate reaction. The temperature and duration play an important role in determination of total soluble alkalis when fly-ash is mixed with lime and water. The maximum limit of alkalis stipulated by various codes offers protection against undesirable amounts of alkalis Le, sodium and potassium ions in fly-ash concrete.

2.2.4 Mineralogical Composition

The mineralogical composition of fly-ash is influenced by type and source of fly-ash. Fly-ash contain one or more of the four crystalline phases viz., quartz, mullite, magnetite and hematite apart from substantial amounts of glassy material. In sub- bituminous fly-ash, the crystalline phases may include CA, CAS, Calcium Sulphate and alkali sulphates (P.K. Mehta-1989). Therefore, it is opined that it would be better to consider the source of fly-ash and its mineralogical composition than the chemical composition of fly-ash for estimating the performance of fly-ash.

Since it is the mineralogical composition, and not the chemical composition, which would govern this pozzolanic and cementitious behaviour of mineral admixtures, classifications and specifications emphasizing the chemical composition are more of a hindrance than of a help of promoting the use of mineral admixtures in cement and concrete industry (P.K. Mehta-1983).

TABLE 2.1 Properties Of Class F and Class C Fly-ash

S.No	Class F fly-ash (low calcium)	Class C fly-ash (high calcium)
1	Contains equal or less than 10% of lime (CaO).	Contains more than 10% of lime (CaO).
2	Contains lesser silica (SiO_2) content.	Contains more silica (SiO_2) class "F" flysah.
3	Particles are of hollow or thin walled spheres,.	Particles are spherical and irregular.
4	Particles size vary according to efficiency of collector.	Particle size depends on the efficiency of collector.
5	Contains lesser content of alkalies (MgO, Na_2O, k_2O).	Contains higher content of alkalies (MgO, Na_2O, k_2O) than class "F" fly-ash.

6	Contains aluminium silicate glass matrix with mullite, hematite and quartz.	Contains calcium rich glass matrix with C_2SiO_4, Ca-Mg silicates.

2.3 STRENGTH DEVELOPMENT IN CONCRETE WITH FLY-ASH

Fly-ash concrete in which a portion of the cement is normally replaced by fly-ash having adequate pozzolanic properties will yield greater strength than the similar concrete without fly-ash. However the rate of strength development and the level of strength depends on several factors. The most important being the properties of fly-ash, chemical composition, particle size, reactivity of fly-ash, curing, temperature and the presence of other additives (Hobbs 1983). The general belief that fly-ash concrete has low early strength emerged from the early findings, involving mostly low calcium class Fly-ash Further, the ashes used in most of the early works were produced from older power plants and were not so fine, and often exhibited much lower pozzolanic activity. When such ashes were used for replacing cement in concretes, they showed significantly lower strength at early ages.

When high calcium class C fly-ash is used, the strength development with time is likely to be different from that obtained from using class F fly-ash. The self hardening reactions in the class C Ayash are likely to occur within the same time frame as the normal Portland cement hydration reactions, giving equal or sometimes greater strength at early ages The pozzolanic activity of such cementitious fly-ash further enhances strength at later ages.

Class F bituminous fly-ash contributes to the long-term strength gain of concrete more than class C sub bituminous or lignite fly-ash inspite of its relatively slower rate of strength development at early ages Swamy and Mahmud (1986) reported that concrete containing 50% of low calcium bituminous fly-ash as cement replacement and using a superplasticizer is capable of developing 60MPa compressive strength at 28days and 20 to 30MPa at 3 days. It was noted by Cook (1982) that the field applications of low calcium fly-ash concrete with 400kg/m³ portland cement and 100kg/m³ of fly-ash yielded compressive strength of 70MPa at 50days. The water cement ratio was varied from 0.27 to 0.37. Cement replacement with fly-ash was varied from 40 to 60%. The test results indicated that fly-ash replacement levels upto 50% by weight of cement, could produce 40 to 60MPa strength at 28days.

Highly pozzolanic fly-ashes start their contribution to strength almost from the onset of Portland cement hydration. The low calcium. Ayashes exhibit significant pozzolanic activity about two weeks after bydration Compressive strength usually is good indicator of the quality of concrete with and without fly-ash and is directly related to the hydration characteristics of hardened cementitious material paste. In general, the effect of fly-ash on flexural strength, tensile strength, bond strength of concrete with steel, follows about the same pattern as compressive strength. Most other strength parameters are approximately proportional to compressive strength.

Swamy and Mahamud (1986) reported that increase in strength of 50 to 100% over the 28days strength of fly-ash concrete was achieved after one year under continuous moist or fog curing compared to only 18 to 25% of increase for the control or plain concrete under similar curing conditions. The acceleration of pozzolanic reaction of fly-ash in concrete is significantly influenced by curing temperatures at

early ages. The higher the curing temperature, the higher the rate of pozzolanic reactions. Pozzolanic reactions are highly temperature dependent.

Ravina (1981) studied the effect of fly-ash on concretes cured at elevated temperatures. It is concluded that quantities of fly-ash in concrete cured at elevated temperatures significantly improve its compressive strength but fly-ash contributes less to the concrete cured normally at ages less than 28days. Curing course and fine fly-ash concrete at elevated temperatures has a significant beneficial effect on strength of concrete at early and later ages. The curing regime is more important to the compressive strength development of fly-ash concrete compared with ordinary Portland cement concrete. Gopalan and Haque (1987) have reported that the strength of 91days air cured specimens was less than that of 7days fog cured specimens. On air curing the percentage loss of strength increased with an increase in flaysh content and curing period.

Due to fineness and pozzolanic activity, fly-ash in cement concrete significantly improve the quality of cement paste and microstructure of transition zone between the binder matrix and aggregate. As a result of continued process of pore refinement, due to addition of fly-ash hydration products in concrete, a gain in strength. development with curing age is achieved.

2.4 HIGH PERFORMANCE CONCRETE WITH FLY-ASH

There are a number of definitions in use for high performance concrete based on its applications all over the world American concrete institute (ACI) delines high performance concrete (HPC) as a specially engineered concrete, one or more specific characteristics of which have been enhanced through the selection of component materials and mix proportions" A major criticisms on the ACI definition of HPC is that durability of concrete is not mandatory, it is one of the options. A Strategic Highway Research Programme (SHRP), National Research Council(NRC), Washington DC study defines HPC as concrete with

1. A maximum water cement ratio of 0.35.

2. A minimum durability factor of 80% after 300 cycles of freezing and thawing as determined by ASTMC-666.

3. A minimum compressive strength criteria of either 21N/mm? within 4 hours, 34MPs within 24 hours or 69MPa within 28days.

RN, Swamy (1996) defines that A high performance concrete element is that which is designed to give optimized performance characteristics for a given set of load, usage and exposure conditions, oslatent with requirement of cost, service life and durability." According to Paul Zia (1996), high performance concrete je a onts in which enhancement of some or all of the properties of concrete, much as placement, compaction, no segregation, long term mechanical properties, early age strength, toughness, volume stability wide durability related properties resulting in extended service life in service environment achieved are enforced.

Any concrete, whether it is normal Portland cement concrete, high strength concrete, high performance concrete or high volume fly-ash concrete etc., is heterogeneous. It is next to impossibility at this junction of scientific / technological advancement to make concrete homogeneous. Due to the hydration, setting and hardening of concrete, the internal cracks, even without loading the concrete become inevitable which are again detrimental to durability of concrete. Then, to improve the performance of concrete to make it HPC, there are some methods which may be followed

2.4.1 High Performance Concrete Principles

Considerable progress is achieved in the state of art of HPC, but we can't expect that in the near future it will be possible to select 'on paper the materials and their proportions to make economical and HPC in a given place. It will be the art of the concrete engineers and scientists to find the best system of materials to achieve the lowest possible water/binder ratio to form a concrete mixture with a workability that can be controlled long enough to make the placing, consolidation and finishing of HPC as easy as that of usual concrete.

2.5 BARITES IN CONCRETE

Barites is one of the natural minerals having specific gravity ranging from
3.8 to 4.60. There are many types of natural (mineral) and metal aggregate available which have specific gravity more than 3.5 for making high density concretes. Hematite, magnetite, barites, limonite are some of the mineral aggregates, steel shots, steel punching, lead shots etc., are some of the metal aggregates which can be used for making high density concretes. Compared to other mineral and metal aggregates barites is cheaper and abundantly available in Andhra Pradesh. The total insitu reserves of barites in India is approximately 82.80 million tonnes. The insitu reserves of barites in Andhra Pradesh is 78.80 million tonnes. An estimated reserve of 74 million tonnes which is the single largest deposit of its kind in the world is the one which is located at Mangampet in Kadapa Dist (Narayana et.al.2005). Mostly barites is used as aggregate in heavy weight or high density concrete. The density of high density concrete ranges from 3360kg/m³ to 3840 kg/m³. High density barites concrete is normally used in building works in nuclear power plants, hospitals, X-ray units, research stations and laboratories etc., for radiation shielding and absorption.

Jagannathan et.al. (2003) have investigated the properties of high-density concrete using barites and found that an average density of 36KN/m³ can be obtained using barites as aggregate. The 28days compressive strength was found ranging from 25 to 31N/mm² using barites aggregate with 300-470 kg/m³ of cement and 0.5 to 0.55 water/cement ratiosThe X-ray and gamma ray attenuation depends on the mass of material through which the radiation passes. Hence the thickness of the shield can be accomplished by the use of heavy-density concrete that is concrete exceeding 35KN/m³ (Mehta 1997).

Narayana et al. (2005) have studied the use of barites in high density concrete and concluded that the high density barites concrete is just twice the cost of normal concrete and 14 times less than the cost of high density concrete produced with steel punching as course aggregate and sand as fine aggregate. There is very little or no information is available on the use of micro-fine barites as filler in normal strength, normal density OPC or PPC concretes. In the present investigation, micro-fine barites is used as filler in different concrete mixtures. Due to the barites abundantly available in Kadapa district, the use of barites would be economical for producing high density concrete. As the mechanical and durability properties of concrete are enhanced by using micro-fine barites in concrete, value could be added to barites by its utilization in concrete.

2.6 IMPACT OF FLY-ASH ON DURABILITY OF CONCRETE

Fly-ash may be used in concrete as a raw material for cement production, as an ingredient in blended cement, and an a partial replacement to cement. Sometimes fly-ash is also used as a partial replacement of fine aggregate and as aggregate in lightweight concrete. Flash has been the subject of research for more than 70 years and fyash has been used in concrete for over 50yearsIt is generally known that the major causes of deterioration of reinforced concrete structures are the corrosion of reinforcing steel, exposures to cycles of freezing and thawing, alkali silica reaction, and sulphate attack.

Fly-ash concretes are used where low heat of hydration is needed, where there is a risk of alkali-silica reaction, acid attack, chloride ingress or similar problems. When PFA is used in concrete in range of 50 to 70% contents, these are known as high volume fly-ash concretes (HVFC) which are primarily designed to reduce environmental impact. Much of the research carried out in recent years, suggests that increasing the proportions of PFA addition with concrete has considerable advantage (L.K.A. Sear, 2005).

CHAPTER-III
MATERIALS AND EXPERIMENTATION

3.1 GENERAL

To find out the suitability of any material for a particular use and for any successful investigation, number of trial tests has to be performed to study the performance of material and trend of results of investigation before arriving at a concrete conclusion. When a new material is to be used/adopted for a particular application, the properties of that material are to be very essentially known before the actual application without knowing the properties of the material; it may not be possible to recommend a particular material for a particular application. From pre- historic times, the human lives and Civilization had been conditioned by the ability of man to use/master the materials. The recent technological developments have opened many avenues for improving not only the mechanical but the durability properties of concrete by using suitable materials and methods.

3.1.1 MATERIALS USED

All the materials used in the present investigation are locally available materialsat
Kadapa.

CEMENT

Fig: 3.1. CEMENT

The various ingredients used in concrete the cement is the most important materialand energetically expensive.

Cement is the bonding material having cohesive &adhesive properties which makes it capable to unite the different construction materials and form the compacted assembly. Cement is a binder, a substance that sets and hardens as the cement dries and also reacts with carbon dioxide in the air dependently and can bind other materials together. The raw material used for the manufacture of cement consists mainly of lime, silica, alumina and iron oxide. These oxides interact with one another in the kiln to form more complex compounds.

The relative proportions of these oxide compositions are responsible for influencing the various properties of cement, in addition to rate of cooling and fineness of grinding. Portland

cement is the most common type of cement in general usage. It is a basic ingredient of concrete, mortar and plaster. It consists of a oxides of calcium, silicon and aluminum. Portland cement and similar materials are made by heating lime stone (a source of calcium) with clay and grinding this product (called clinker) with a source of sulfate (most commonly gypsum).prior to 1987, there was only one grade of OPC which was governed by IS269-1976. After1987, higher grade cements were introduced in India. The OPC was classified into 3 grades, namely 33 grade, 43 grade and 53 grade depending upon the strength of the cement at 28 days when tested as per IS4031-1988.

If the 28 days strength is not less than 33N/mm2, it is called 33 grade cement, if strength is not less than 43N/mm2, it is called 43grade cement, and if strength is not less than 53 N/mm2, it is called 53 grade cement. But the actual strength obtained by the specimens at the factory aren't much higher than the BIS specifications. Generally use of high grade cements offer many advantages of making stronger concrete. Although they are little costlier than low grade cement, they offre10-20% savings in cement consumption and also they offer many hidden benefits. In the table 3.1 approximate oxidecomposition limits of ordinary portland cement and The physical properties of cement arefurnished in tables 3.2 respectively.

Table -3.1: Approximate Oxide Composition Limits Of Ordinary Portland Cement

Chemical compounds	**Percentage**
Lime, Cao	**60-66**
Silica, Sio2	**17-25**
Alumina,Al2O3	**3-8**
Iron Oxide,Fe2O3	**0.5-6**
Magnesia, Mgo	**0.5-4**
Sulphur trioxide,SO3	**1-2**
Alkalis	**0.5-1.3**

Table 3.2 Physical Properties of Cement

S.No	**Parameter**	**Value**	**Permissible limit as per IS:8112-1989**
1	Intial Setting time(min)	90	Not less than 30 minutes
2	Final Setting time(min)	260	Not less than 600minutes

3	Specific gravity	3.15	Not less then 3.15
4	Finess(dry sieving)	3.5%	Not more than 10%
5	Compressive strength (Mpa) 3days 7days 28days	25 34 48	Not less than 23Mpa Not less than 33Mpa Not less than 43Mpa

3.1.1 FINE AGGREGATE

Fine aggregates are termed; when they pass through the sieve size of less than 4.75mm size is the separation limit fir coarse and fine aggregates. The aggregates which are having greater than 4.75 mm are termed as coarse and less than 4.75 mm are termed as fine aggregates. The fine aggregate shall consist if natural sand or, subject to approval, other inert materials with similar characteristics, or combinations having hard, strong, durable particles. Fine aggregate from different sources shall not be mixed or stored in the same pile nor used alternatively in the same class of construction or mix. The fine aggregates should be should be sound free from deleterious and inorganic substances. Fine aggregates function arises in filling the voids created by the coarse aggregates. Silicais the predominant content in the fine aggregate.

Fig: 3.2. FINE AGGREGATE

Here in the present work, the sand which is passing through IS sieve of less than 4.75mm is selected as a fine aggregate material for the making of concrete.
For the preparation of concrete specimens in the present investigation, the locally available sand from the Penna river near by Chennur in Kadapa district was used. The sand confirmed to Zone-II as per IS383:1987. The result of sieve analysis is given in the table 3.3 and properties of fine aggregates table3.4. The specific gravity of sand was 2.60 and the fineness modulus was 2.622. The compacted and loose bulk densities were 1760 and 1630kg/m³ respectively.

Table 3.3 Sieve Analysis Of Fine Aggregates

IS Sieve Desigation	**Quantity retained (grams)**	**Percentage retained**	**Cummulative percentage retained**	**Cumulative percentage passing**	**Limits for Zone-II IS:383- 1987**
10.0mm	0	0	0	100	100
4.47mm	0	0	0	100	90-100
2.36mm	43	2.1	2.1	97.9	75-100

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1.18mm	565	28.2	30.3	69.7	55-90
600 microns	343	17.2	47.5	52.5	35-59
300 microns	695	34.8	82.3	17.7	8-30
150 microns	354	17.7	100	0	0-10

Table 3.4 Properties Of Fine Aggregates

S.No	**Property**	**Value**
1	Specific Gravity	2.65
2	Fineness Modulus	2.49
3	Bulk density	1260 Kg/m^3
4	Water Absorption	1%

3.1.2 COARSE AGGREGATE

Since at least three quarters of the volume of concrete is occupied by aggregate, itis not surprising that its quality is of considerable importance. The properties of aggregate greatly affect durability and structural performance of the concrete. Particles having size greater than 4.75mm is generally categorized as coarse aggregate.

Fig: 3.3. COARSE AGGREGATE

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Coarse aggregates are the main load bearing members of the concrete, so they occupy the higher number when compared to the cement and fine aggregates. The qualityand quantity of these plays a vital role in best concrete making practice.

Here in the current work, the coarse aggregates selected are of the size 20mm and 12mm combination.60% of 20 mm and 40% of 12 mm are chosen for the present work.

The coarse aggregate used for preparation of concrete specimens was crushed granite metal confirming to IS383:1987. The specific gravity of coarse aggregate was

2.67 and the fineness modulus was 6.618. The size of the aggregate was 20 mm down graded having loose and compacted bulk density values 1600 and 1791 kg/m³ respectively. The sieve analysis of coarse aggregate is furnished in table 3.5 and properties of coarse aggregates in table 3.6.

Table 3.5 Sieve Analysis Of Coarse Aggregates

IS Sieve Desigation	Quantity retained (grams)	Percentage retained	Cummulative percentage retained	Cumulative percentage passing	Limits for Zone-II IS:383-1987
40.0mm	0	0	0	100	100
20.0mm	0	0	0	100	95-100
10.0mm	3105	62.1	62.1	37.9	15-55
4.47mm	1882	37.64	99.74	0.26	0-10
2.36mm	13	0.26	100	100	-
1.18mm	0	0	0	100	-
600 microns	0	0	0	100	-

Table 3.6 Properties Of Coarse Aggregates

S.No	Property	Value
1	Specific Gravity	2.68
2	Fineness Modulus	8.65
3	Bulk density	1540 Kg/m^3
4	Water Absorption	0.5%

3.1.3 WATER

Plays a vital role in good concrete practice. Extra addition than the requirement in concrete is a considered as a crime. Since it imparts capillary pores in concrete which can reduce the strength of the concrete considerably. Regarding quality- generally the yard water is an important ingredient of concrete as it actively participates in the chemical reaction with cement known as hydration. This hydration imparts the cohesive nature to the cement particles in binding the coarse and fine aggregates by releases the products of hydration known astir calcium silicates and di-calcium silicates. The quantity and quality of the water stick is “the water which is used for drinking water can be a good for concrete making.

The Municipal drinking water was used for mixing and curing of concrete. The physical chemical properties of water used are as furnished in table3.7.

Table 3.7 Physical Analysis Of Water

S.No	Parameter	Value	Permissible limit as per IS Limits
1	PH	7.5	6.5-8
2	Inorganic Solids	250	3000 (max)
3	Sulphates	30	400 (max
4	Acidity	20	50
5	Total alkalinity as $CaCo_3$	82.6	120 (max)
6	Chlorides	120	2000 (max)
7	Organic Solids	90	200

All parameters are expressed in mg/lit except PH

3.1.4 FLY-ASH

Fly-ash having specific gravity of 2.43 procured from Rayalaseema thermalpower plant (R.T.P.P) at Kalamalla near Muddanur of Kadapa District, A.P. was used in the concrete for replacement of cement. The properties of fly-ash are presented in table 3.8.

Fig: 3.4 FLY-ASH

Table 3.8 Properties Of Fly-ash

Component	Value	Limits as per IS:3812-1981	Limits as per ASTM:C618
Silicon Dioxide (SiO_2) (%)	53.1	35 (min)	-
(SiO_2 + Al_2O_3 + Fe_2O_3) (%)	87.3	70% (min)	70% (min)
Magnesium MgO (%)	0.43	5% (max)	5% (max)
Sodium Oxide Na_2O	0.82	1.5(max)	-

3.1.5 BARITES

The micro-fine $BaSO_4$, used in the present study was brought from the local pulverizing mill. The powder was sieved through 45u sieve and used in the preparation of concrete mixtures. More than 98% of the country's production of comes from Andhra Pradesh while the small deposits in Rajasthan, Himachal Pradesh, Madhya Pradesh and Bihar partly account for the balance. The physical and chemical properties of used in the study are given in tables 3.9 & 3.10.

Fig:3.5 BARITES

Table 3.9 Physical Properties Of Barites

S.No	Property	Value
1	Appearance	Light Grey
2	Specific gravity	4.1
3	PH	8

Table 3.10 Chemical Properties Of Barites

S.No	Property	Value
1	$BaSO_4$	88%
2	FeO_3	0.05%
3	SiO_2	2.1
4	Al_2O_3	0.02%
5	CaO	0.05%
6	Loss on ignition	2.3%
7	Total alkalies	0.7%

3.1.6 SUPER PLASTICIZER

The super plasticizer used in the present study is CENTRIPLAST-FF90, aproduct of Mc-Bauchemie chemicals, India. The super plasticizer was brough from Al- chem, Sales Pvt Ltd., Mc bauchemic chemical distributors, Chennai. The properties of super plasticizer are listed in table 3.11.

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Fig: 3.6 SUPER PLASTICIZER

Table 3.11 Properties Of Super Plasticizers

S.No	Property	Value
1	Form	Liquid
2	Colour	Light Brown
3	Specific Gravity	1.15
4	Chlorides	NIL
5	Solid Content	37.8% by mass

3.3 PREPARATION OF THE CONCRETE SPECIMENS

The 150x150x150mm size (internal dimensions) cast iron moulds were used to cast the concrete specimens. After through mixing of all the ingredients of concrete, the concrete was poured in cube moulds. Concrete was compacted by using 16mm diameter steel rod. After filling the mould with concrete in three layers, the moulds were kept on the ibrating plat form. The moulds were vibrated for 2 minutes. The excess concrete was removed by steel scale and the cubes were demoulded after 24 hours and immersed in clean water for curing till testing.

For compression, acid attack, alkaline attack, sulphate attack, temperature resistance and non-destructive tests, 150x150x150mm cubes were prepared. For water permeability test 150mm diameter and 150mm height cylinders were prepared. For split tensile trength test 300mm high 150mm diameter specimens were prepared. For Rapid chloride permeability test, 100mm diameter, 50mm thick specimens were casted.

3.4 MIX PROPORTIONS

Mix design is the process of selecting suitable ingredients of concrete and determining their relative quantities with the purpose of producing an economical concrete which has certain minimum properties notably, workability, strength and durability. The various methods of mix proportioning generally used for the design of ordinary concrete are all based on the relation between strength and water cement ratio as well as workability, water/cement and aggregate/ cement ratios. Mix design methods being empirical, minor variations exist in the process of selecting the mix proportions using different methods. When concrete durability is to be considered in mix design, the limiting values of water/ cement ratios depending on exposure conditions, suitable air entrainment for freezing and thawing, low water content, low absorption and low permeability for frost resistance, suitable type of cement for chemical attack, suitable abrasion resistance material (coarse aggregate), for abrasion resistance, natural aggregates like basalts, dolerites, lime stones etc., for fire resistance should be adopted. The proportions of fly-ash, lime and gypsum in AFLG concrete mixes in the present studywas decided based on the maximum compressive strength obtained for neat fly-ash+lime+gypsum.

The mix proportion of 1:2.01:3.74 and water/cement ratio, 0.53 was arrived for M20 grade OPC controlled concrete by trial mixtures using IS10262:1982 method. For fly-ash concrete (CF mixes) and AFLG, BFLB, CFB mixes, the volume of concrete was adjusted duly reducing sand content. For SF mixes (using super plasticizers), the slump is maintained same as that of fly-ash concrete reducing water/cement ratio. Fly-ash concretes were proportioned replacing 10%, 20%, 30% and 40% of cement by RTPP fly-ash. The details of mix proportions of M20 grade concrete are given in table 3.12.

Table 3.12 Details Of Mix Proportions For M20 Grade Fly-ash Concrete

Mix designation	**OPC control**	**CF10**	**CF20**	**CF30**	**CF40**
W/b ratio	0.53	0.53	0.53	0.53	0.53
W/c ratio	0.53	0.58	0.66	0.75	0.88
Cement Kg/m^3	330	297	264	231	198
Fly-ash Kg/m^3	0	33	66	99	132
Sand Kg/m^3	665	656	648	639	630
Coarse aggregate Kg/m^3	1235	1235	1235	1235	1235
Water Lit/m^3	175	175	175	-	-

3.5 MIX PROPORTIONS OF CONVENTIONAL CONCRETE

For conventional concrete M20 mix proportion is 1:1.5:3Size of mould is L = 0.15m, B= 0.15m, D= 0.15m

Volume of mould = 0.15 x 0.15 x 0.15 m^3 = 3.375 x 10^{-3} m^{3}As per IS : 456-2000 extra 52% taken for wastage purpose

→3.375 x 10^{-3} x 1.52

→ 5.13 x 10^{-3} m^3

Density of cement = 1440 kg/ m^3 Density of fine aggregate = 1550 kg/m^3 Density of coarse aggregate = 1600 kg/m^3 **CALCULATION**

COMPRESSIVE STRENGTH OF CUBES

Cement =[$\frac{5.13 \times 10^{-3} \times 1}{1+1.5+3}$] × 1440

=1.343 kg

Fine aggregate =[$\frac{5.13 \times 10^{-3} \times 1.5}{1+1.5+3}$] × 1550

=2.168 kg

Coarse aggregate =[$\frac{5.13 \times 10^{-3} \times 3}{1+1.5+3}$] × 1600

=4.477 kg

Water cement ratio = 0.45
W = 0.45 × 1.343 W = 604.35 ml

Table 3.13 Volume Of Materials For Conventional Concrete

Cement	1.343 kg
Fine aggregate	2.168 kg
Coarse aggregate	4.477 kg

CHAPTER 4

WORK PROCEDURE AND TESTS

ON CONCRETE

4.1 MANUFACTURE OF CONCRETE

Concrete can be manufactured by adopting the conventional techniques used in the manufacture of Portland cement concrete. In the laboratory, the fly ash and the aggregates were first mixed together in saturated surface dry conditions. The alkaline solution was then added to the dry materials and the mixing continued for further about 4 minutes to manufacture the fresh concrete.

The fresh concrete could be handled up to 120 minutes without any sign of setting and without any degradation in the compressive strength. The fresh concrete was shown in Figure 4.2.The fresh concrete was cast into the moulds immediately after mixing, in three layers for cubical specimens of size 150mm x 150mm x 150mm. For compaction of the specimens, each layer was given 60 to 80 manual strokes using a Roding bar.

Fig 4.1 FRESH CONCRETE

4.2 CASTING OF CONCRETE CUBES

The moulds of size 150×150×150mm^{3}are kept ready before mixing. Total 36 cubes are casted. The bolts of the moulds carefully tightened because if bolts are not kept tight the concrete mixture coming out of the mould when vibration takes place. Then moulds are cleaned and oiled on all contact surfaces of the moulds and place the moulds on vibration table. The concrete is filled into moulds and place the moulds on vibrating table. The concrete is filled into moulds in layers and then vibrated. The top surface of concrete is struck off level with a trowel. The number and date of casting are put of the top surface of the cubes.

Fig.4.2.CUBES OF 150MM×150MM×150 MM SIZE

4.3 CURING OF CONCRETE

Heat curing of low calcium fly-ash based concrete is generally recommended. Heat curing substantially assists the chemical reaction that occurs in the paste. Both curing time and curing temperature influence the compressive strength of concrete. The curing time varied from 4 hours to 96 hours. Longer curing time improved the polymerization process resulting in higher compressive strength. The rate of increase in strength was rapid up to 24 hours of curing time and beyond 24 hours, the gain in strength was only moderate.

Higher curing temperature of concrete resulted in higher compressive strength. Heat curing can be achieved by either steam curing or dry curing. Compressive strength of dry cured concrete is approximately 15% more than that of steam cured concrete. The temperature required for heat curing can be as low as 30°.

In tropical climates, this range of temperature can be provided by the ambient conditions. Also, the start of heat curing of concrete can be delayed for several days. The delay in the start of heat curing up to five days did not produce any degradation in the compressive strength. In fact, such a delay in the start of heat curing substantially increased the compressive strength of concrete. This may be due to the inaction that occurs prior to the start of heat curing.

Curing can be described as keeping the concrete moist and worm enough so that the hydration of cement can continue. More elaborately, it can be described as the process of maintaining satisfactory moisture content and a favorable temperature in concrete

during the period immediately following the placement. Curing is being given a place of increasing importance as the demand for high quality concrete is increasing. The cubes, Slabs etc are cured at 7 to 28. So that hydration of cement may continue until the desired properties are developed to a sufficient degree to meet the requirement of service.

Fig: 4.3 CURING OF WATER

After casting, concrete specimens were cured immediately. Two types of curing were used in this study, i.e. Oven curing and Ambient curing. For Oven curing, the test specimens were cured in the oven and for Ambient curing, they were kept under ambient conditions for curing at room temperature.

The specimens were oven-cured at 60^{O}C and 100^{O}C for 24 hours in the oven. After the curing period, the test specimens were left in the moulds for at least six hours in order to avoid a drastic change in the environmental conditions. After remolding, the specimens were left to air-dry in the laboratory until the day of testing. The oven cured specimen sand the specimens under ambient curing were shown in figure.

Fig 4.4 CURED SPECIMENS

4.4 TESTS ON CONCRETE

4.4.1 WORKABILITY TEST

The test is carried out using a metal mould in the shape of a conical frustum known as a slump cone or Abrams cone, that is open at both ends and has attached handles. The tool typically has an internal diameter of 100mm at the top and of 200mm at the bottom with a height of 305mm. the cone is placed on a hard non absorbent surface.

This cone is filled with fresh concrete in 3stages. Each time, each layer is tamped with 2 times with a 600mm long bullet nosed metal rod measuring 16mm in diameter. At the end of the third stage the concrete is struck off flush with the top of the mould. The mould is carefully lifted vertically upwards, so as not to disturb the concrete cone. The concrete then slumps. The slump of the concrete is measured by measuring the distance from the top of the slumped concrete to the level of the slump cone.

Fig: 4.5 SLUMP CONE

Testing On Concrete Slump Cone Test

The slump test is the most commonly used method. Consistency is a term very closely related to workability. It is a term which describes the state of fresh concrete. It is used for the determination of the consistency of freshly mixed concrete, where the maximum size of the aggregate does not exceed 38 mm. The slump test is suitable for slumps of the medium to high workability, slump in the range of 25-125 mm; the test fails to determine the differences in workability in stiff mixes which has zero slumps, or for wet mixes that give a collapse slump.
Its refers to the ease with which the concrete flows. It is used to indicate the degree of wetness. Workability of concrete is mainly affected by consistency i.e. wetter mixes will be more workable than drier mixes, but concrete of the same consistency may vary in workability. It is also used to determine consistency between individual batches. The apparatus used for conducting the slump test consists of slump cone or Abrams cone with handles and foot pieces.

The size of the slump cone is 20-cm diameter base, 10 cm diameter top and 30 cm height. Foot pieces can be fixed to the clamps on the base plate has lifting handle for easy transportation. One graduated steel tamping rod 16 mm diameter ×600 mm long rounded at one end graduated in mm. The internal surface of the mould is thoroughly cleaned and free from moisture and adherence of any old set concrete before commencing the test. The mould should be placed on smooth surface. Oil is applying on internal surface of the mould and applies the smooth surface where the mould is placed. The types of slump are as follows.

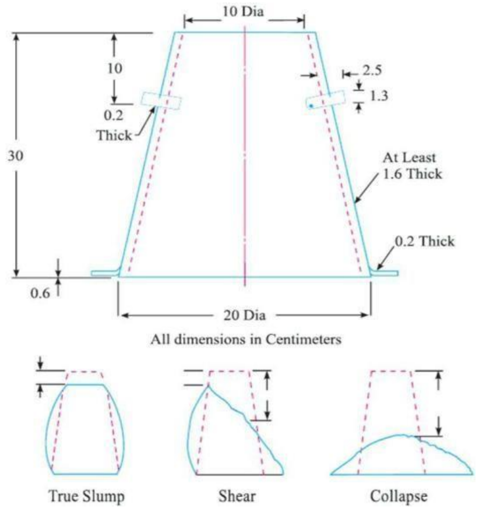

Fig: 4.6 SLUMP CONE DETAIL

- **Collapse:** In a collapse slumps the concrete collapses completely.
- **Shear:** In a shear slump the top portion of the concrete shears off and slips sideways.
- **True:** In a true slump the concrete simply subsides, keeping more or less to shape.

4.4.2 COMPRESSIVE STRENGTH TEST

For compressive strength test cubes of size 150×150×150 mm3 made. test was done on the hydraulic testing machine. Compressive strength is defined as resistance of concrete to axial loading. Cubes are put in the machine and after tighten its wheel start button is pressed as pressure is begin to apply. Reading of meter is note down when cracks are there on cubes.

The compressive strength of concrete is generally considered to be the most valuable property, since, in many practical cases the concrete is used to resist compressive stresses. Never the less, strength usually gives an all-round, overall picture of the quality of concrete because it is directly related to structure of the cement paste. The compressive strength of various concrete mixtures The was

determined by testing concrete cubes following the procedure explained in Chapter 3.

Cast the cubes of M20 Mix of 1:1.5:3 proportions with water cement ratio
0.45 and after 24 hrs it hardened and remove from the mould and keep it in water. Take away the specimen from water. Take the dimensions of the specimen to the closet 0.15m × 0.15m × 0.15m. Clean the bearing surface of the testing machine. Place the specimens within the machine in such a way that the load shall be applied. Align the specimen centrally on the bottom plate of the machine. Apply the load and take the readings for 7days, 14 days, 28days.

Compressive strength formula for any material is the load applied at the point of failure to the cross-section area of the face on which load was applied.

Compressive Strength = Load / Cross-sectional Area Where P is load and, A is area of cube.

Fig: 4.7 CTM

5.1 GENERAL

CHAPTER 5 RESULTS

The results of the present instigation and discussions on the mechanical properties viz. Compressive strength, split tensile strength of concrete mixtures with fly-ash, (fly-ash + super plasticizer) and (fly-ash + micro-fine barites) are presented in this chapter.

5.2. TESTING ON MATERIALS

5.2.1. TESTS ON CEMENT

The following tests are done on the cement.

(i) Fineness of cement
(ii) Specific gravity of cement
(iii) Normal consistency
(iv) Initial setting time and final setting time

(i) Fineness Of Cement

Weight accurately 100grams of cement and place it on a standard 90 micron IS sieve. Break down any air set lumps in the cement sample with fingers. Continuously sieve sample giving circular and vertical motion for a period of 15 minutes. Mechanical sieving deices may also be used. Weigh the residue left on the sieve.The percentage weight of residue over total sample is reported as, % weight of residue = the percentage residue of the sample should not exceed 10%.

Table -5.1: Observations Of Fineness Of Cement Test

Trial No	**1**	**2**	**3**
Weight of cement(in grams)	100	100	100
Weight of residue on sieve(in grams)	4	4.5	4.5
Fineness	4	4.5	4.5

Fineness of cement=4.33%. Hence it is in permissible limits.

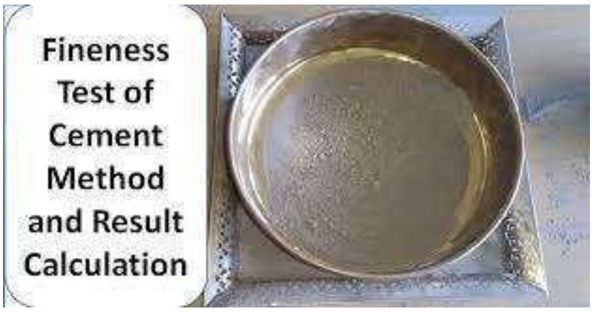

Fig: 5.1. FINENESS OF CEMENT

(ii) Specific Gravity Test

Weigh a clean and dry Le Chatelier flask or specific gravity bottle with its stopper (W1).place a sample of cement upto half of flask (about 64gm) and weight with its stopper (W2). Add kerosene (polar liquid) to cement in flask till it is about half full.mix thoroughly with glass rod to remove entrapped air. Continue stirring and add more kerosene till it is flush with the graduate mark. Dry the outside and weigh (W3).entrapped air may be removed by vacuum pump, if available. Empty the flask, clean it refill with clean kerosene flush with graduated mark wipe dry the outside and weigh(W4).

Table -5.2: Observations Of Specific Gravity Of Cement Test

TEST	VALUE
Air temperature	$22^{o}c$
Weight of cement	64 gms
Initial reading of flask	0 ml
Final reading of flask	20.4 ml
Volume of cement particles	20.4 ml
Specific gravity	3.13

Specific gravity = weight of cement /volume of kerosene = 64/20.4
Limits: Specific gravity of cement = 3.13 Hence it is within permissible limit.

(iii) Initial And Final Setting Time

1. Take 400 gms of cement and prepare a neat cement paste with 24.65% (0.85p) of water by weight of the cement where P is the standard consistency of cement as found in consistency.
2. Gauge time is kept between 3 to 5 minutes. Start the stop watch at the instant when the water is added to the cement. Fill the vicat mould with the cement and smoothen the surface of the paste making it level with the top of the mould. The cement block thus prepared is known as the test block.
3. For the initial setting time place the test blocks confined in the mould and resting on non-porous plate under the rod bearing the needle, lower the needle gently in contact with the surface of the test block.
4. In the beginning the needle completely pierces the test block. Repeat this procedure until the needle fails to pierce the block for about 5mm measured from the bottom of the mould. The period elapsing between the time when is added to the cement at the time at which the needle fails to pierces the test block by about 5mm is the initial setting time.
5. For determining the final setting time, replace the needle of the vicat's apparatus by the needle with an annular attachment.
6. The cement is considered finally set upon applying the final setting needle gently to the surface of the test block; the needle makes an impression thereon, while the attachment fails to do so, the period elapsing between the time when water is added to the cement and the time at which the needle makes an impression on the

surface of the test block while attachment fails to do so shall the final setting time.

(iv) Normal Consistency :

- For preparing one mould, take 400 gms of cement and prepare a paste of the cement with a weighed quantity of water, taking care that the time of gauging is not less than 3 minutes.
- Gauging time is counted from the time of adding water to the dry cement until commencing to fill the mould. Fill the vicat mould with this paste, the mould resting upon non porous plate.
- After completely filling the mould, smoothen off the surface of the paste, making it level with the top of the mould. The mould may be slightly shaken to expel air.

Fig.5.2 VICAT APPARATUS

- Prepare trial paste with varying percentage of water firstly add an percentage of water then insert the plunger into the paste and the plunger should penetrate up to 5-7 mm if not then increases the water percentage by 1% to 0.25% between the percentage range determined by the pervious test and test as described in above steps until the amount of water necessary for making up the paste.

Table -5.3: Test Results Of Cement

S.No	DESCRIPTION	TEST RESULTS	ISCODE LIMITS	IS CODES
1.	Specific gravity	3.13	3.10-3.15	IS:269-1989
2.	Fineness modulus	4.33%	<10%	IS:4031-1988
3.	Normal consistency	29%	>26%	IS:4031-1988 (part4)
4.	Initial setting time	60 mints	>30minutes	IS:269-1989
5.	Final Setting time	9hours45 minutes	<10hours	IS:269-1989

5.2.2. Tests On Fine Aggregate

The following tests are conducted to know the properties of fine aggregate:

(i) Grading of sand

(ii) Specific gravity & water absorption test

(iii) Bulking of sand

(i) Grading Of Sand – Sieve Analysis

➢ Take 1 kg of sample from a sample of about 50 kg. by quartering or through riffle box. Arrange the relevant sieves one above the other which the sieve size increasing to the top. Put the pan at the bottom.

➢ Place the sieve in the top sieve and cover it. Shake the set of sieves for 20 to 30 minutes in a sieve shaker.

➢ Weight the amount of aggregate retained on each sieve along with pan. From its grading characteristics, find its fineness modulus.

➢ The size of sieves used is: 4.75mm, 2.36mm, 1.18mm, 600µ, 300µ, 150µ & a pan.

Table -5.4: Observations Of Sieve Analysis Test

S.NO.	Seive Size In Mm	Wt. Retained In Gms.	%Wt. Retained	Cum.% Wt. Retained	% Finer
1	4.75	10	1	1	99.0
2	2	40	4	5	95.0
3	1	318	31.8	36.8	63.2
4	0.6	293	29.3	66.1	33.9
5	0.3	277	27.7	93.8	6.2
6	0.15	60	6	99.8	0.2
7	0.075	2	0.2	100	0

From the table the fineness modules of the sand=4.02% Hence it is within permissible limits.

(ii) Specific Gravity And Water Absorption Of Fine Aggregate

Calibrate the flask by weighing it empty and full with water at room temperature. Roll and ignite the flask gently in an inclined position, to eliminate air bubbles. Take a sample of fine aggregate and soak it in water and keep it for 24±1/2 hours. The temperature should be24 ± 5oC. Take out and spread the sample on a clean flat surface exposed to gently moving current of warm air until the material just reaches free running condition. Place the sand loosely in a conical mould and tamp it on surface 25 times. Lift the mould vertically.

If the sand remains its shape, it means free surface moisture is present. Continue the drying with constant stirring until the cone of sand slumps on the removal of the mould. This indicates that sand has reached a surface dry condition. Immediately weigh 500gm of saturated surface dry sand in the flask.

Fill the flask with water to the top of the cone. Roll the flask in an inclined position to eliminate all air bubbles and replace with water by means of foundation pen filler. Wipe the flask dry and weigh it accurately. Calculate the specific gravity. Weigh the remaining 1000 gm of saturated surface dry sand in the tray of known weight. Dry the sample in an oven at 100-110oC for 24 hours. Weigh the dry sand with tray. Calculate the absorption capacity as the percentage of oven dry mass.

Table -5.5: Specific Gravity And Water Absorption Test

S.NO.	Description	Trial 1(gm)
1	Weight of pycnometer (W1)gm	647
2	Weight of pycnometer + dry soil(W2)gm	1463
3	Weight of pycnometer + dry soil + water(W3)gm	2030
4	Weight of pycnometer + water (W4)gm	1528
5	Temperature of water in c	$4^{o}c$

Specific gravity of sand (G) =(W2-W1)×GT/(W4-W1)-(W3-W2)=2.59 The specific gravity of given fine aggregate is obtained as 2.59.

(iii) Bulking Of Sand

Take 1000 ml measuring jar. Fill it with dry loose sand up to 500ml without tamping at any stage of filling. Then pour that sand on a pan and mix it thoroughly with water whose volume is equal to 2% of that of dry loose sand. Fill the wet loose sand in the container and fix the volume of the sand which is in excess of the dry volume of the sand. Repeat the procedure for moisture content 4%,6%,8% etc., and note down the readings. Continue the procedure till the sand gets completely saturated
i.e. till it reaches the original volume of 500 ml.

Table -5.6: Observations of bulking of sand test results

S.NO.	Volume of loose sand (v1) ml	% moisture content added	Volume of wet loose sand(ml)	%bulking (v2-v1)/v1
1	500	2	580	16
2	500	4	610	22
3	500	6	620	24
4	500	8	570	14

The maximum bulking of the given sand is 0.24@6% of moisture content.

5.2.3. Tests on Coarse Aggregate

The following tests are conducted to know the properties of coarse aggregate:

(i) Specific gravity & water absorption test
(ii) Aggregate crushing value test
(iii) Aggregate impact value test

(i) Specific gravity & water absorption test

A sample of aggregate not less than 2 kg is taken. It is thoroughly washed to remove the finer particles and dust adhering to the aggregates. It is then placed in a wire basket and immersed in distilled water at a temperature between 22oC to 32oC. Immediately after immersion, the entrapped air is removed from the sample by lifting the basket containing it 25mm above the base of the tank and allowing it to drop 25 times at the rate of about one drop per sec. during the operation, care is taken that the basket and aggregate remain completely immersed in water. They are kept in water for a period of 24±1/2 hours afterwards.

The basket and aggregate are then jolted and weighed (weight W1)in water at a temperature 22^0C to 32^0C . The basket and the aggregate are then removed from water and allowed to drain for a few minutes and then the aggregate is taken out from the basket and placed on dry cloth and the surface is gently dried with the cloth. The aggregate is transferred to the second dry cloth and further dried.
The empty basket is again immersed in water, jolted 25 times and weighted in water (weightW2). The aggregate is exposed to atmosphere away from direct sunlight for not less than 10minutes until it appears completely surface dry. Then the aggregate is weighed in air (weightW3). Then the aggregate is kept in the oven at a temperature of 100 to 110^0C and maintained at this temperature for 24± ½ hours. It is then cooled in the air-tight container, and weighed (weighedW4).

Fig.5.3. PYCNOMETER

Table -5.7: Observations of Specific Gravity and Water Absorption Test

S.NO	Description	10mm	20mm
1	Weight of sample(g)	1000	1500
2	Weight of vessel +sample+ water(g)(A)	3372	3690
3	Weight of vessel + water(B)	2754	2754
4	Weight of saturated &surface dry sample (C)	990	1482
5	Weight of oven dry sample (D)g	982	1464
6	Specific gravity=D/C-(A-B)	2.64	2.681
7	Water absorption% dry weight (C-D)×100/D	0.81%	1.22%

Calculation
Specific gravity =D/C-(A-B) Water absorption=(C-D)×100/D Where,
Ws= the weight in gm of the saturated aggregate in water (W1-W2),

W3= the weight in gm of the saturated surface-dry aggregate in air, and W4= the weight in gm of oven-dried aggregate in air.
Specific gravity = D/C-(A-B) =2.64
Water absorption % dry weight =(C-D) ×100/D =0.81%
For 20 mm
Specific gravity= D/C-(A-B) =2.68

Water absorption %dry weight=(C-D)×100/D =1.22%

(ii) Aggregate Crushing value test

The standard aggregate crushing test is made on aggregate passing a 12.5 mm I.S. Sieve. If required, or if the standard size is not available, other sizes up to 25 mm may be tested. But owing to the no homogeneity of aggregates the results will not be comparable with those obtained in the standard test. About 6.5 kg material consisting of aggregates passing 12.5 mm and retained on 10 mm sieve is taken. The aggregate in a surface dry condition is filled into the standard cylindrical measure in three layers approximately of equal depth. Each layer is tamped 25 times with the tamping rid and finally leveled off using the tamping rod as straight edge.

The weight of the sample contained in the cylinder measure [A]. The same weight of the sample is taken for the subsequent repeat test The cylinder of the test apparatus with aggregate filled in a standard manner is put in position on the base-

plate and the aggregate is carefully leveled and the plunger inserted horizontally on this surface. The plunger should not jam in the cylinder. The apparatus, with the test sample and plunger in position, is placed on the compression testing machine and is loaded uniformly up to a total load of 40 tons in 10 minutes time. The load is then released and the whole of the material removed from the cylinder and sieved on a 2.36 mm I.S. Sieve. The fraction passing the sieve is weighed (B).

The aggregate crushing value = ×100 Where,

B = Weight of friction passing 2.36 mm sieve,

A = Weight of surface-dry sample taken in mould.

The aggregate crushing value should not be more than 45 per cent for aggregate used for concrete other than for wearing surface, and 30 per cent for concrete used for wearing surface such a runways, roads and air field pavements.

Table -5.8: Observations & Calculations of Aggregate Crushing value test

S.NO	Total of dry aggregate sample(A) gm	Weight of fines passing 2.36 mm IS sieve(B) gm	Aggregate crushing value =× 100
1.	2812	466.5	16.589

The crushing value of given aggregate is 16.589%. As per standard value it should be less than 30%. So it is also with in permissible limits.

Fig: 5.4 AGGREGATE CRUSHING VALUE TEST

(iii) Aggregate Impact Value Test

The aggregate impact value gives relative measure of the resistance of an aggregate to sudden shock or impact. This in some aggregates differs from its resistance to al slow compressive load. The test sample consists of aggregate passing through 12.5 mm and retained on 10 mm I.S.Sieve. The aggregate shall be dried in an oven for a period of four hours at a temperature of 100^0C to 110^0C and cooled. The aggregate is filled about one-third full and tamped with 25 stokes by the tamping rod.
A further similar quantity of aggregate is added and tamped in the standard manner. The measure is filled to over-flowing and then struck off level. The net

weight of the aggregate in the measure is determined [weight A] and this weight of aggregate shall be used for the duplicate test on the same material.
The whole sample is filled into a cylindrical steel cup firmly fixed on the base of the machine. A hammer weight about 14 kgs is raised to a height of 380 mm above the upper surface of the aggregate in the cup and allowed to fall freely on the aggregate. The test sample shall be subjected to a total 15 such blows each being delivered at an interval of not less than one second.
The crushed aggregate is removed from the cup and the whole of it is sieved on
2.36 mm I.S.Sieve. The fraction retained on the sieve is also an accuracy of 0.1 gm. [weight B]. The fraction retained on the sieve is also weighed [weight C]. If the total weight [B+C] is less than the initial weight A by more than one gm the result shall be discarded and a fresh test made.
Two tests are made. The ratio of the weight of fines formed to the total sample weight in each test is expressed as percentage.
Therefore, Aggregate Impact Value =×100
Where, B = weight of fraction passing 2.36 mm I.S. Sieve.
A = weight of oven-dried sample.
The aggregate impact value should not be more than 45 percent by weight for aggregates used for concrete other than wearing surfaces and 30 per cent by weight for concrete to be used as wearing surfaces, such as runways, roads and pavements.

Table -5.9: Results Of Impact Test Aggregates

S.NO	Details	Trails
1.	Total weight of aggregate sample filling the cylindrical measure =(A) grams	2116
2.	Weight of aggregate passing 2.36 mm sieve after the test=(B) grams	633
3.	Weight of aggregate retained on 2.36 mm sieve after the test =(C) grams	99
4.	Difference in weight =A-(B+C) grams	1384
5.	Aggregate impact value	15.63%

The impact value of given aggregate is 15.63%. as per standard values, it should be less than 45%. So it is also with in permissible limits.

5.2.3 Tests on Water

Municipal drinking water was used for mixing and curing of concrete. The physical chemical properties of water used are as furnished in table3.4

Table 5.10:Physical Analysis Of Water

S.No	Parameter	Value	Permissible limit as per IS Limits
1	PH	7.5	6.5-8
2	Inorganic Solids	250	3000 (max)
3	Sulphates	30	400 (max
4	Acidity	20	50
5	Total alkalinity as $CaCo_3$	82.6	120 (max)
6	Chlorides	120	2000 (max)
7	Organic Solids	90	200

All parameters are expressed in mg/lit except PH

5.3 TEST ON CONCRETE

5.3.1 WORKABILITY TEST

Workability is the property of freshly mixed concrete that determines the ease with which it can be properly mixed, placed, consolidated and finished without segregation. The workability of the fresh concrete was measured by means of the conventional slump test as per IS 1199:1989. Before the fresh concrete was cast into moulds, the slump value of the fresh concrete was measured using slump cone. In this project work, the slump value of the fresh concrete was maintained in the range of 30mm to 40mm.

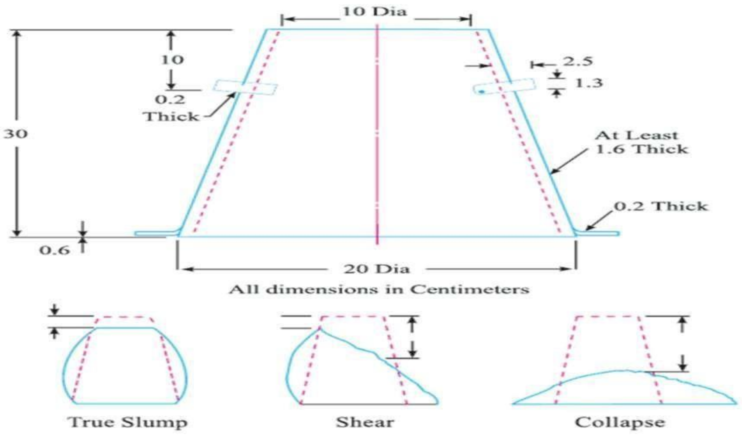

Fig:5.5 SLUMP TEST

The workability of concrete for different water cement ratio are found. The test results are tabulated in Table 5.11

TABLE 5.11 Slump Value Of Concrete

Type of concrete	Slump value	Water/ cement	Type of slump
Conventional concrete	50mm	0.45	Zero slump
Fly-ash 100%	100mm	0.5	True slump
Fly-ash 50%	230mm	0.55	Shear slump

Result: The workability of conventional concrete is achieved as zero slump and for addition of 100% fly ash the value obtained as true slump (80-100mm)

5.3.2 COMPRESSION STRENGTH TEST

The compressive strength test on hardened fly-ash based concrete was performed on standard compression testing machine of 3000kN Capacity, as per IS 516-1959. Totally 81 number of cubical specimens of size 100mm x 100mm x 100mm was casted and tested for the compressive strength at the age of 7days, 14days and 28days. The compressive strength test was performed as shown in Figure 3.2. Each of the compressive strength test data corresponds to the mean value of the compressive strength of three test concrete cubes.

Fig: 5.6 COMPRESSION STRENGTH TEST

The compressive strength of concrete is generally considered to be the most valuable property, since, in many practical cases the concrete is used to resist compressive stresses. Never the less strength usually gives an allround, overall picture of the quality of concrete because it is directly related to structure of the cement paste.

5.3.2.1 EFFECT OF FLY-ASH ON COMPRESSIVE STRENGTH OF CONCRETE

The Compressive strength of concrete mixtures of M20 grade replacing ordinary Portland cement (OPC) with fly-ash ranging from 10% to40% at 10% increments is investigated. The results of compressive strength of concrete at 3days,7days,14days,28days are represented in table 5.12

TABLE 5.12 Compressive Strength Of Fly-ash Concrete

Mix designation	Compressive strength –Mpa			
	3days	**7days**	**14days**	**28days**
Control	16.4	21.5	24.8	27.9
CF10	15.6	20.9	24.1	27.3
CF20	15.1	20.3	23.5	26.9
CF_{30}	12.2	19.5	22.1	26.3
CF40	10.6	18.3	18.9	25.6

It is observed that the compressive strength decrease with increase in fly-ash content at all ages, the concrete with 10% and 20% fly-ash showed a little higher values of compressive strength than the corresponding OPC concrete. At three days, the percentage decrease in compressive strength is 7.93%, 25.6%, 35.6%, 40.24%. for concrete with 10%, 20%, 30%, 40% of fly-ash respectively. Due to the slow pozzolanic reaction, the compressive strength at early ages decreases with increase in fly-ash content. At 28 days, Concrete with 10%,20%,30%,40% replacement of cement by fly-ash showed 2.15%, 2.87%, 8.24%, 14.3% decrease in compressive strength respectively compared to the OPC control concrete. Due to the progress in pozzolanic reaction of fly-ash, the compressive strength.

5.3.2.2 EFFECT OF (FLY-ASH + SUPER PLASTICIZER) ON COMPRESSIVE STRENGTH OF CONCRETE:-

The 3days, 7days,14days,28days Compressive strength results of concrete having 10 to 40% of OPC replaced by fly-ash increments of 10% and with 0.5% of melamine-based plasticizer by weight of fly-ash are presented in table 5.13.

TABLE 5.13: Compressive Strength Of (Fly-ash +Super Plasticizer) Concrete

Mix designation	Compressive Strength –Mpa			
	3 days	**7days**	**14days**	**28days**
Control	16.4	21.5	24.8	27.9
CFS10	17.1	23.4	27.9	31.3
CFS20	16.9	23.1	27.3	30.7
CFS$_{30}$	16.5	22.6	26.1	29.5
CFS 40	13.8	20.5	25.8	28.9

Table 5.13. it can be seen that the compressive strength values of concrete with (Flash + Super plasticizer) are higher than the corresponding Compressive strength values of concrete without super plasticizer at all the ages. The difference in strength is more at early ages shows decreasing trend with (increase in) age. It can also be observed that the increase in compressive strength of super plasticizer fly-ash concrete is less at late ages. The increase in compressive strength of fly-ash concrete with super plasticizer at 3days is 13.2%,38.52%, 50.94%, 40.81%respectively for 10%,20%30%,
40 of fly-ash compared to fly-ash concrete without super plasticizer. At days the increase in compressive strength is 14.6%, 13.2%, 15.2%, 20.9% for super plasticized
fly-ash concrete with 10% ,20%,30%,40%.

5.3.2.3 EFFECT OF (FLY-ASH + MICRO-FINE BARITES) ON COMPRESSIVE STRENGTH OF CONCRETE:-

The compressive strength results of concrete with 10 to 40% fly-ash and 10% of barites by weight of fly-ash in addition to fly-ash at 3days, 7days, 14days, 28days are presented in table 5.14.

TABLE 5.14: Compressive Strength Of (Fly-ash +Micro-fine Barites) Concrete

Mix designation	Compressive Strength Mpa			
	3days	7days	14days	28days
Control	16.4	21.5	24.8	27.9
CFMB10	18.3	26.6	29.1	33.1
CFMB20	18.1	26.1	28.8	32.4
CFMB30	17.6	25.0	27.9	32.0
CFMB40	16.8	24.1	26.5	29.6

The effect of addition of 10% of micro-fine barites by weight of fly-ash on concrete within 10 to 40% replacement of cement is studied and it is Observed that the compressive strength of fly-ash concrete is improved by the addition of micro-finebarites. It can be observed that essive strength of concrete with replacement of 10 to 40% OPC by fly-ash can be improved by the addition of barites which yield strength higher ban the respect to control OPC concrete mix at all ages. By addition of barites fillar, the refinement in microstructure of cement paste and the transition zone might be influenced considerably to the extent of improving the strength of fly-ash concreteat all ages. The trend improvement of strength with age in fly-ash with the addition barites.

5.4 ADVANTAGES

- Uses no Portland cement.
- The price of fly ash is low.
- Reduces the carbon dioxide emission.
- Uses industrial by products like fly-ash and blast furnace slag.
- Due to more content of fly-ash concrete will give smooth surface.

6.1 CONCLUSION

CHAPTER 6 CONCLUSIONS

Based on the experimental investigations carried out, the following conclusions have been drawn on concrete mixtures.

6.1.1 The compressive strength of concrete decreases with increase in fly-ash content from 10% to 40% at all ages. The addition of super plasticizer increases the compressive strength, but the increase in strength with the all ages.

6.1.2 Fly-ash up to 20% shows compressive strength more than the target mean strength of M20 grade OPC concrete at 28days.

6.1.3 (Fly-ash +lime + gypsum) in proportions of (65:25:10) replaced up to 40% in concrete shows compressive strength more than the target mean strength at 28 days.

6.1.4 The compressive strength of fly-ash concrete increases with addition of micro-fine barites at all ages and strength is higher compared to strength of fly-ash concrete with (Flysh+gypsum). (Fly-ash + micro-fine barites) and super plasticizer.

6.1.5 The addition of micro-fine barites improves alkaline resistance of fly-ash concrete. The replacement of OPC by (Fly-ash+barites+ gypsum) shows alkaline resistance more than OPC concrete at 30 and 40% replacement levels.

6.1.6 The sulphate resistance of OPC concrete increases with replacement of OPC by fly-ash up to 40% Further the effect of fly-ash on sulphate resistance is marginal. The super plasticizer has very little or no effect on the sulphate resistance of fly-ash concrete. With the addition micro-fine barites there is an improvement in the sulphate resistance of fly-ash concrete.

6.1.7 The addition of time (Fly-ash+Micro-fine barites) decreases the sulphate resistance of fly-ash concrete.

6.1.8 The chloride resistance of OPC concrete increases with addition of fly-ash. With the increase in fly-ash content, there is an increase in chloride resistance up to 40% Fly-ash content, further, there is a marginal decrease in chloride resistance. The addition of super plasticizer improves the chloride resistance of fly-ash concrete. The addition of micro-fine barites improves the chloride resistance of fly-ash and super plasticized fly-ash concrete.

6.1.9 In M_{20} grade concretes, the water permeability increases with increase in replacement of cement by fly-ash. The super plasticizer has very less effect on permeability of fly-ash concrete at the age of 28days. Addition of micro-fine barites decreases the permeability of fly-ash concretes.

6.1.10 The permeability of fly-ash concrete with (Fly-ash+ micro-fine barites) is higher than the fly-ash concrete at 28days.

6.1.11 Addition of 10% of micro-fine barites by weight of Fly-ash improves the temperature resistance of fly-ash concrete up to 300°C.

6.1.12 Fly-ash up to 20% replacement shows almost the same behaviour of Mao grade OPC concrete in respect of initiation and propagation of cracks. Addition of micro-fine barites improves the resistance to cracking in fly-ash concrete up to 40% fly-ash content.

6.2 SUGGESTIONS FOR FUTURE STUDY

6.2.1 A detailed study may be carried out on all the concrete mixtures by varying the water/cement ratio and grade of concrete. Detailed investigation on the reinforced concrete may be carried out.

6.2.2 A detailed study may be done on the porosity, heat of hydration, transition one characteristics of concrete mixtures with micro-fine barites duly varying the micro-fine barites content.

6.2.3 Studies may be carried out by varying the test pressure and time of the water permeability to find out the permeability of concretes.

6.2.4 A detailed study on the effect of inert heavy weight micro-fine fillers on the high strength concrete may be carried out and the proposed equations may be verified for their validity in respect of reinforced concrete.

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