"EXPERIMENTAL STUDY OF CONCRETE AS A PARTIAL REPLACEMENTOF CEMENT BY FLY ASH AND SILICA FUME"

THESIS

SUBMITTED IN PARTIAL FULFILLMENT OF THE REQUIREMENT FOR THE AWARD OF THE DEGREE OF

MASTER OF TECHNOLOGY

In

CIVIL ENGINEERING

(Structural Engineering)

SUBMITTED BY:
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UNDER THE SUPERVISION OF
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SHIV KUMAR SINGH INSTITUTE OF TECHNOLOGY & SCIENCE, INDORE

DEPARTMENT OF CIVIL ENGINEERING

SESSION: 2019-2020

SHIV KUMAR SINGH INSTITUTE OF TECHNOLOGY & SCIENCE, INDORE
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CERTIFICATE

This is to certify that the work embodies in this dissertation entitled “**EXPERIMENTAL STUDY OF CONCRETE AS A PARTIAL REPLACEMENT OF CEMENT BY FLY ASH AND SILICA FUME”** being submitted by **Mr.Pushpak Sanvaliya (0856CE16MT12)** for partial fulfillment of the requirements for the award of the degree of **Master of Technology** in **Structural Engineering** discipline to **Rajiv Gandhi Proudyogiki Vishwavidyalaya, Bhopal (M.P.)** during the academic year 2019-2020 is a record of bonafide piece of work, carried out by him under my supervision and guidance in the **"Department of Civil Engineering"**, **Shiv Kumar Singh Institute Of Technology and Science, Indore (M.P.)**

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CERTIFICATE OF APPROVAL

The dissertation entitled "**EXPERIMENTAL STUDY OF CONCRETE AS A PARTIAL REPLACEMENT OF CEMENT BY FLY ASH AND SILICA FUME"** being submitted by **Mr.Pushpak Sanvaliya (0856CE16MT12)** has been examined by us and is hereby approved for the award of the degree of **"Master of Technology in Structural Engineering"**, for which it has been submitted. It is understood that by this approval the undersigned do not necessarily endorse or approve any statement made, opinion expressed of conclusion drawn therein, but approve the dissertation only for the purpose for which it has been submitted.

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// शपथ–पत्र //

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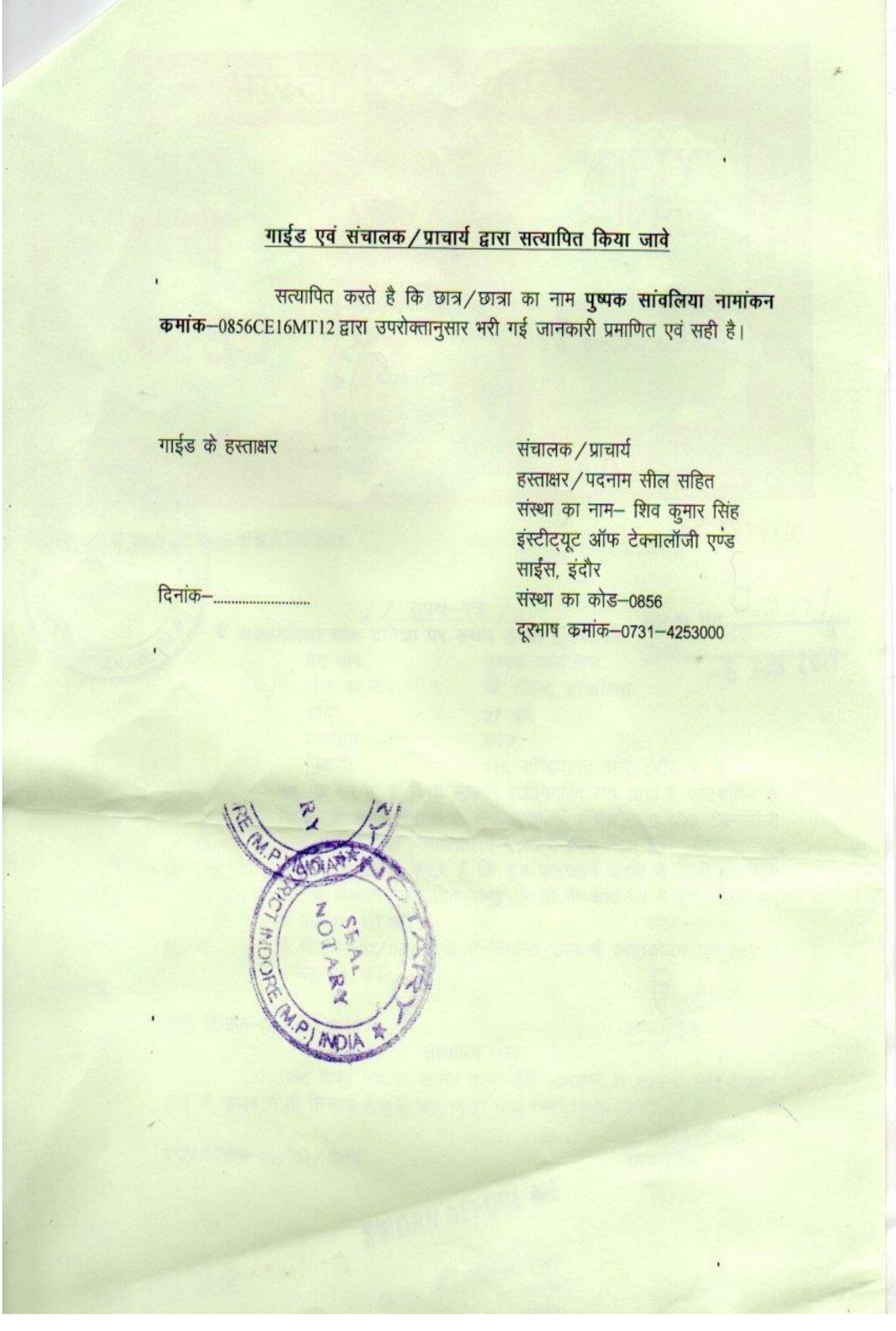

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DECLARATION - I

I **Pushpak Sanvaliya**, Student **of Master of Technology** in **Structural Engineering** discipline, session: 2019-2020, **Shiv Kumar Singh Institute Of Technology and Science, Indore (M.P.)**, hereby declare that the work presented in this dissertation entitled “**EXPERIMENTAL STUDY OF CONCRETE AS A PARTIAL REPLACEMENT OF CEMENT BY FLY ASH AND SILICA FUME”** is the outcome of my own work, is bonafide and correct to the best of my knowledge and this work has been carried out taking care of Engineering Ethics. The work presented here does not infringe any patented work and has not been submitted to any other university or anywhere else for the award of any degree or any professional diploma to the best of my knowledge.

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SESSION: 2019-2020

DECLARATION-II

I hereby declare that the work, which is being presented in the dissertation entitled "**EXPERIMENTAL STUDY OF CONCRETE AS A PARTIAL REPLACEMENT OF CEMENT BY FLY ASH AND SILICA FUME"** in partial fulfillment of requirements for the award of the degree of **Master of Technology** in **Structural Engineering** in the department of Civil engineering an authentic record of my own work carried out under the guidance of **Miss. Lavina Talawale.** I have not submitted the matter embodied in this report for the award of any other degree.

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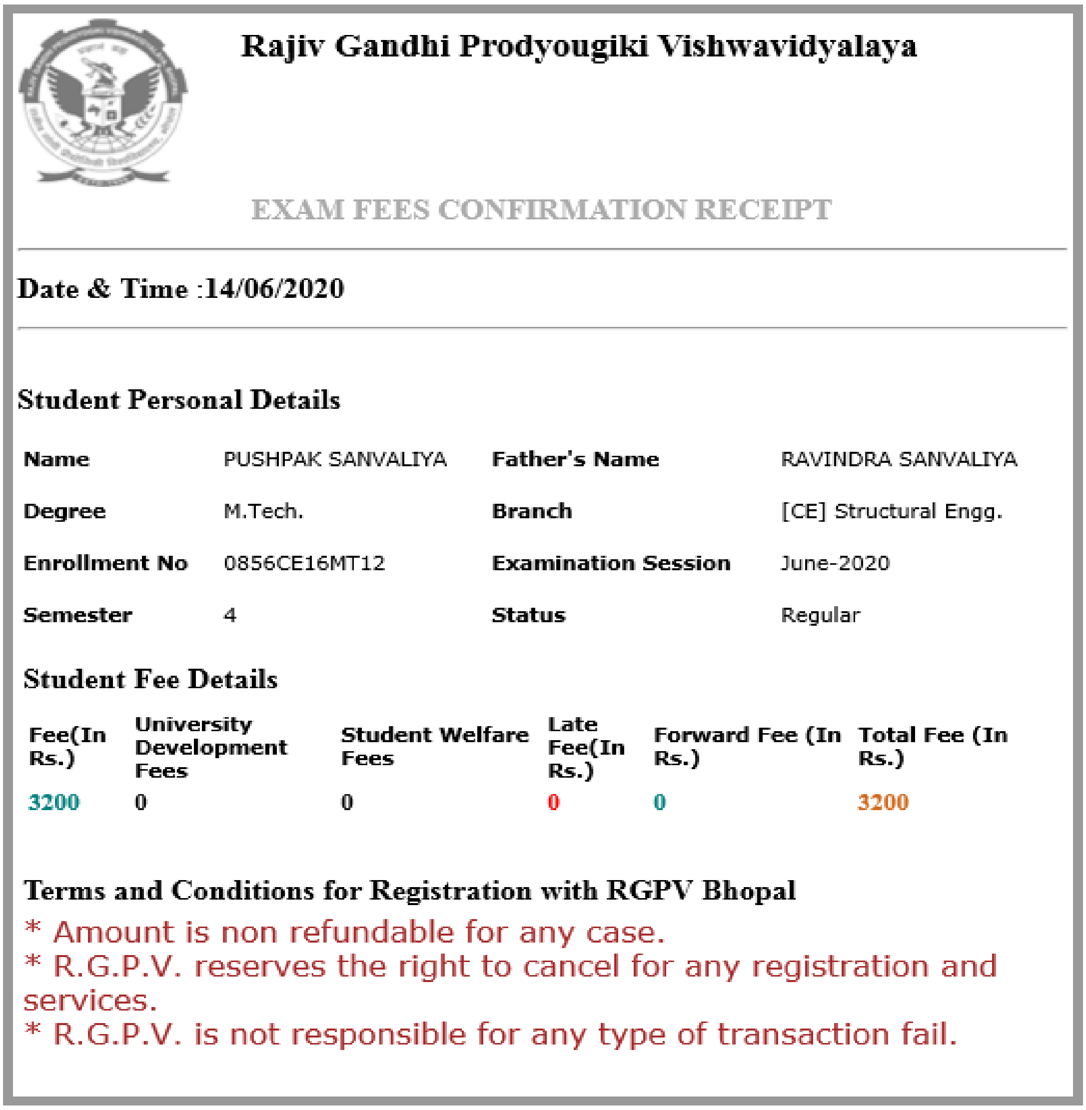

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ABSTRACT

The use of Silica Fume and Fly Ash in the present days is to increase the strength of cement concrete. The Cement replaced by Fly Ash with 0%, 5%, 10%, 15%, 20%, 25%, 30%, and 35% and by Silica Fume with 15% common for all mixes as a partial replacement of cement for 7, 14 & 28 days for M20, M25 and M30 grade of concrete. Casted 150 mm x 150 mm x 150 mm cubes for Compressive strength, 100 mm x 100 mm x 500 mm beams for Flexural Strength, and Cylinder size 150 mm diameter and 300 mm height are casting for Split Tensile Strength and Slump cone for workability of concrete and other properties like compacting factor and slump were also determined for three mixes of concrete. The use of cement and production of cement creates much more environmental issues & costlier. To avoid such circumstances, the content of cement is reduced in concrete and replaced by silica fume which reduces cost & addition silica fume also increases strength. Concrete is the most widely used and versatile building material which is generally used to resist compressive forces. By addition of some pozzolanic materials, the various properties of concrete viz, workability, Strength, Resistance to cracks and permeability can be improved.

Key Words: Compressive Strength, Flexural Strength, Split Tensile Strength, Workability of Concrete, Fly Ash and Silica Fume.

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Date:	**Pushpak Sanvaliya**
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CHAPTER 1

INTRODUCTION

1.1 Introduction

Concrete is a most commonly used building material which is a mixture of cement, sand, coarse aggregate and water. It is used for construction of multi-storey buildings, dams, road pavement, tanks, offshore structures, canal lining. The method of selecting appropriate ingredients of concrete and determining their relative amount with the intention of producing a concrete of the necessary strength durability and workability as efficiently as possible is termed the concrete mix design. The compressive strength of harden concrete is commonly considered to be an index of its extra properties depends upon a lot of factors e.g. worth and amount of cement water and aggregates batching and mixing placing compaction and curing. The cost of concrete prepared by the cost of materials plant and labour the variation in the cost of material begin from the information that the cement is numerous times costly than the aggregates thus the intent is to produce a mix as feasible from the practical point of view the rich mixes may lead to high shrinkage and crack in the structural concrete and to development of high heat of hydration is mass concrete which may cause cracking. The genuine cost of concrete is related to cost of materials essential for produce a minimum mean strength called characteristic strength that is specific by designer of the structures. This depends on the quality control measures but there is no doubt that quality control add to the cost of concrete. The level of quality control is often an inexpensive cooperation and depends on the size and type of job nowadays engineers and scientists are trying to enhance the strength of concrete by adding the several other economical and waste material as a partial substitute of cement or as a admixture fly ash, Glass Powder, steel slag etc are the few examples of these types of materials. These materials are generally by-product from further industries for example fly ash is a waste product from power plants and Glass Powder is a by-product resulting from decrease of high purity quartz by coal or coke and wood chips in an electric arc furnace during production of silicon metal or ferrosilicon alloys but nowadays Glass Powder is used in large amount because it enhances the property of concrete.

Concrete is a very strong and versatile mouldable construction material. It consists of cement, sand and aggregate (e.g., gravel or crushed rock) mixed with water. The cement and water form a paste or gel which coats the sand and aggregate. When the cement has chemically reacted with the water (hydrated), it hardens and binds the whole mix together. The initial hardening reaction usually occurs within a few hours. It takes some weeks for concrete to reach full hardness and strength. Concrete can continue to harden and gain strength over many years.

Early history

Surprisingly, concrete has a very long if somewhat episodic history. In a Neolithic settlement excavated at Yiftahel in southern Galilee in Israel, a floor of burnt lime plaster was found. It is thought to be the earliest use of concrete. The fragments of a kiln were found on the site - the lime to make the concrete may have been burnt in it. The lime had been mixed with stone and laid 30-80mm deep and given a smooth finish. Mesolithic hut floors at Lepenski Vir in Serbia (the former Yugoslavia) were also made of a lime-bound concrete. Egyptian murals from the second millennium BC depict the making of mortar and concrete. Around 500 BC, at Camiros on Rhodes, the ancient Greeks built a 600,000 litre capacity underground cistern lined with fine concrete[1].

Roman Concrete

The above discoveries hardly point to the intensive use of concrete; otherwise, due to its durability, concrete would likely have been found at many more ancient sites. We have to turn to the Romans for the widespread use of concrete. The Romans discovered that by mixing lime and rubble with pozzolana[2] sands and water, they could make a very strong building material which they called opus caementicium. It even had the added bonus of being able to set under water, so it could be used in the construction of aqueducts and harbours. Perhaps most notable of the many Roman concrete structures that are still standing today are the Coliseum and the Pantheon in Rome. The Romans typically used concrete to construct walls and roofs. Forms were used with the stone and mortar being placed in alternating layers, with the mortar being pounded into each layer of stone. Finished concrete was then faced with brick or tiles. Of particular note is the dome of the Pantheon. Built in 127 AD, heavy travertine (a type of limestone) was used in the wall concrete, whilst broken pumice was used as lightweight aggregate in the 43 metre diameter dome in order to reduce the lateral thrust on the walls. Originally a temple dedicated to all the pagan Roman gods, it has since served as the Roman Catholic Church of St. Mary and the Martyrs.From the Romans to the VictoriansAfter the fall of the Western Roman Empire (AD 476), construction techniques used by the Romans were generally abandoned, but not necessarily lost. Three Saxon concrete 'pan' mixers dated around 700 AD have been discovered in an excavation in Northampton. They consist of 2-3 metre diameter shallow bowls excavated in bedrock, each with a centre socket that would have held a vertical shaft. Concentric grooves in their bases are thought to have been worn by mixing paddles fixed to a horizontal beam that rotated around the centre shaft. The Normans also had knowledge of concrete, and, like the Romans, used it for wall in-fill. They found that pounded tiles and bricks mixed in with lime mortar and sand produced a similar reaction to that of the Roman pozzolana (the crushed tiles and bricks providing the needed silica and alumina). The use of hydraulic setting pozzolanic concrete in the construction of the 150 mile (240 km) long Canal du Midi has been documented. Constructed between 1667 and 1681, it links Toulouse with Sète on France's Mediterranean coast.

Development of Natural and Portland cements

At this point, to continue our historical account of concrete, we have to digress a bit and look at the development of Portland cement, the essential ingredient that binds modern concrete together.

In 1756, John Smeaton, an engineer from Leeds, was commissioned to build the third lighthouse on the Eddystone Rocks in the English Channel near Plymouth. The first lighthouse, built of timber, had burnt down, the second, also of timber, had been blown down in a gale. Smeaton chose to build his lighthouse of interlocking cut blocks of stone. He experimented with various ingredients to find a quick-setting mortar for use in the construction of the base which was washed by the sea at high tide.

His experiments led him to use a burnt lime from South Wales and a trass (volcanic tuff) from Italy. His lighthouse stood and operated for over two hundred years, from 1759 to 1876, when it was replaced by the present lighthouse. It was dismantled down to the base and re-erected on Plymouth Hoe, where it can be seen today. Smeaton outlined his researches on mortar in a book titled, A Narrative of the Eddystone Lighthouse.

In 1796, a Mr Parker of London took out a patent on a process to produce cement by heating septarian nodules found on the shore at Harwich.

The nodules were of marl, which is a mix of clay and limestone. The nodules had the right proportions of silica and alumina (from the clay) and calcium (from the limestone), that, when burnt and ground down, produced a cement which set faster and was stronger than the traditional lime mortar. He called his product Roman cement. Other producers of similar "natural" cements sprang up in the early 19th century.

In 1813, Joseph Aspdin (1788-1855), a Leeds bricklayer, bought a copy of Smeaton's book, and this likely inspired his own research into cement. In 1824, he patented his "Portland Cement". It was made by calcining limestone, mixing and slaking the burnt lime with puddled clay, then drying the mix, breaking it into lumps and burning it again (double burning), before grinding the resultant clinker down to a powder between millstones. Gypsum was added to prevent flash setting.

Supplied in barrels, his dry powder was easily mixed with water and sand to produce a strong mortar which set quickly. He developed his new cement to produce exterior renders which could be lined-out to give the appearance of Portland stone, hence the name. It was also intended for casting various architectural mouldings and features (stucco work).

Joseph's younger son William (1815-1864), fell out with his family and moved to Rotherhithe in London in 1841, where he set up a business and further developed his father's product into the Portland cement that we know. He added more limestone (the soft local chalk) to the mix and calcined it at a much higher temperature.

By the end of the 19th century, improved manufacturing techniques (e.g., horizontal rotary kilns and ball mills) had ensured sufficient consistency of product so that Portland cement overtook and superseded the production of natural cements[3] .

A world transforming material

It could be justifiably argued that since the late 1800s onwards, when consistent mass produced Portland cement became readily available, that the world that we live in has been transformed by the design and construction of all sorts of concrete structures; the list is large: dams, bridges, skyscrapers, water and sewerage systems, public buildings, schools, hospitals, shopping centres, airport and rail termini, ports, factories and sporting stadia, houses, foundations, cast beams, floor slabs, walls and stair units, monuments, art and landscape projects; from the good, to the bad and the down-right ugly. Even boat hulls have been made in cast concrete.

Reinforced concrete

On its own, concrete has excellent resistance to compression (crushing), but is very poor in tension (stretching). To give it good load bearing capability when under tension, it has to be reinforced with steel bars (rebar), polymer strands or fibres. Bars and strands can be tensioned during casting of pre-cast concrete structures such as floor and bridge beams. When the concrete has set, the tension is released and the reinforcement tries to pull back to its original length, but can't, as it is now bound into the set concrete. It thus imparts a pulling force which gives the cast structure great strength.

1.2Material used

1.2.1 Sand
1.2.2 Cement (OPC 53 Grade)
1.2.3. Aggregate
1.2.4 Silica Fume

1.2.5 Fly Ash

1.2.1 Sand

Sand is a naturally occurring coarse material collected of finely separated rock and mineral particles. It is defined by size, being finer than gravel and coarser than silt. Sand may also consign to a textural class of soil or soil type; i.e. a soil contain more than 85% sand-sized particle (by mass). In terms of particle size as used by geologists, sand particle range in diameter as of 0.0625 mm to 2 mm. An individual particle in this range size is termed a *sand grain*. Sand grains are among gravel (with particles ranging from 2 mm up to 64 mm) and silt(particles smaller than 0.0625 mm down to 0.004 mm). The dimension specification between sand and gravel has remained even for other than a century, but particle diameter as small as 0.02 mm be considered sand under the Albert Atterberg standard in utilize during the early on 20th century. A 1953 engineering standard published by the American Association of State Highway and Transportation Officials set the least sand size at 0.074 mm. A 1938 specification of the United States Department of Agriculture was 0.05 mm. Sand feel granular when rubbed between the fingers (silt, by comparison, feels like flour).

Fig. 1.1 - Sand

1.2.2 Cement

Ordinary Portland cement is used to prepare the mix design of M-20, M-40 and M-50 grade. The cement used was fresh and without any lumps water-cement ratio is 0.42 for this mix design using IS 456:2007.Cement is an extremely ground material having adhesive and cohesive properties which provide a binding medium for the discrete ingredients. Chemically cement constitutes 60-67% Lime (CaO), 17-25% Silica (SiO_2), 3-8% Alumina (Al_2O_3), 0.5-6% Iron Oxide (Fe_2O_3), 0.1-6% Magnesia (MgO), 1-3% Sulphur Trioxide (SO_3), 0.5-3% Soda And Potash (Na_2O+K_2O).

Fig. 1.2 - Cement

1.2.3Aggregate

Aggregate are the essential constituent in concrete. They provide body to the concrete, decrease shrinkage and effect economy. Construction aggregate, or basically "Aggregate", is a wide group of coarse particulate material used in construction, as well as sand, gravel, crushed stone, slag, recycled concrete and geo-synthetic aggregates. Aggregates are the mainly mine material in the world. Aggregates are an element of composite materials such as concrete and asphalt concrete; the aggregate serve as reinforcement to add strength to the overall combined material. Due to the comparatively high hydraulic conductivity value as compare to most soils, aggregates are generally used in drainage applications such as foundation and French drains, septic drain fields, retaining wall drains, and road side edge drains. Aggregates used as support material under foundations, roads, and railroads.

Fig. 1.3 –Aggregate

1.2.4 Silica Fume

Silica Fume is a byproduct in the decrease of high-purity quartz with coke in electric arc furnaces in the manufacture of silicon and ferrosilicon alloys. Micro silica consist of fine particle with a surface area on the order of 215,280 ft^2/lb (20,000 m^2/kg) when precise by nitrogen adsorption techniques, with particle just about one hundredth the size of the average cement Because of its excessive fineness and high silica content, micro silica is a very efficient pozzolanic material particle. Micro silica is added to Portland cement concrete to enhance its properties, in particular its compressive strength, bond strength, and abrasion resistance. These improvement stems from both the mechanical improvements resulting from addition of a extremely fine particle to the cement paste mix as well as from the pozzolanic reactions between the micro silica and liberated calcium hydroxide in the paste. Addition of Silica Fume also decrease the permeability of concrete to chloride ions, which protect the reinforcing steel of concrete from corrosion, especially in chloride-rich environment such as coastal region. While Silica Fume is incorporated, the rate of cement hydration increases at the early hours due to the liberate of OH ÿ ions and alkalis into the pore fluid. It has been reported that the pozzolanic reaction of Silica Fume is very significant and the no evaporable water content decreases between 90 and 550 days at low water /binder ratios with the addition of Silica Fume.

Fig. 1.4 - Fly Ash and Silica Fume

Table 1.1 –Physical Properties of Silica Fume

Properties	**Observed Values**
Colour	Dark grey
Specific gravity	2.2
Fineness modulus	20000m^2/kg
Bulk Modulus	240kg/m^3

Table 1.2 –Chemical Properties of Silica Fume

Properties	**Observed value**
Sio2	90-96%
Al2o3	0.6 -3.0%
Fe2o3	0.3-0.8%
Mgo	0.4-1.5%
Cao	0.1-0.6%
Na2o	0.3-0.7%
K2o	0.04-1.0%
C	0.5-1.4%
S	0.1-2.5%
Loss of ignition (C+S)	0.7-2.5%

1.2.5 Fly Ash

Fly ash is a group of materials that can vary significantly in composition. It is residue left from burning coal, which is collected on an electrostatic precipitator or in a baghouse. It mixes with flue gases that result when powdered coal is used to produce electric power. Since the oil crisis of the 1970s, the use of coal has increased. In 1992, 460 million metric tons of coal ash were produced worldwide. About 10 percent of this was produced as fly ash in the United States. In 1996, more than 7 million metric tons were used in concrete in the U.S. Economically, it makes sense to use as much of this low-cost ash as possible, especially if it can be used in concrete as a substitute for cement.Coal is the product of millions of years of decomposing vegetable matter under pressure, and its chemical composition is erratic. In addition, electric companies optimize power production from coal using additives such as flue-gas conditioners, sodium sulfate, oil, and other additives to control corrosion, emissions, and fouling. The resulting fly ash can have a variable composition and contain several additives as well as products from incomplete combustion.Most fly ash is pozzolanic, which means it’s a siliceous or siliceous-and-aluminous material that reacts with calcium hydroxide to form a cement. When Portland cement reacts with water, it produces a hydrated calcium silicate (CSH) and lime. The hydrated silicate develops strength and the lime fills the voids. Properly selected fly ash reacts with the lime to form CSH–the same cementing product as in

Portland cement. This reaction of fly ash with lime in concrete improves strength. Typically, fly ash is added to structural concrete at 15-35 percent by weight of the cement, but up to 70 percent is added for mass concrete used in dams, roller-compacted concrete pavements, and parking areas. Special care must be taken in selecting fly ash to ensure improved properties in concrete.

Fig. 1.5 – Fly Ash

1.3 Project Objective

In the present Experimental Investigation the following are the main objectives.

1. Comparative study of the behavior of the concrete with & without Fly Ash and Silica Fume.
2. To determine the Compressive Strength of concrete with and without Fly Ash and Silica Fume in different proportions at different grade.
3. To determine the Flexural Strength of concrete with and without Fly Ash and Silica Fume in different proportions at different grade.
4. To determine the Split Tensile Strength of concrete with and without Fly Ash and Silica Fumein different proportions at different grade.
5. To find the optimum percentage of Fly Ash and Silica Fumefor obtaining the maximum strength of concrete.

1.4 Formulation of Research

In this stage of work cement is partially replaced byFly Ash and Silica Fumer in different percentages as shown in the table below. 8 batches are prepared in different proportions including conventional concrete mix (Cement as binder, Sand as fine aggregates & Natural Coarse Aggregates). Cubes, Cylinder and Beams are casted for determining Compressive Strength, Split Tensile Strength and Flexural Strength respectively at 7, 14 and 28 days.

Table 1.3 - Formulation of work

BM	Cement (%)	Fly Ash(%)	Sand (%)	Natural Coarse Aggregates (%)	Silica Fume %
1	100	0	100	100	0
2	80	5	100	100	15
3	75	10	100	100	15
4	70	15	100	100	15
5	65	20	100	100	15
6	60	25	100	100	15
7	55	30	100	100	15
8	50	35	100	100	15

1.5Organization of the Thesis

The Thesis has been organized in five chapters as follows:

Chapter-2: Literature Review- A review of recent literature on the properties of SF & FA concrete has been discussed on the basis of which the need of the present investigation has been identified.

Chapter-3: Experimental program- It describes the carried out, the sizes and number of specimens, testing methods and the associated instrumentation, and experiment carried out.

Chapter-4: Results and Discussions- The analysis of the results, the related discussion and salient observations from the testing have been included in a sequential manner.

Chapter-5: Conclusions and Future scope- The significant conclusion obtained from experimental investigations of this study have been integrated and presented in a logical sequence and recommendations for further research made. Future scope are few samples of concrete with different percentage of using Fly Ash and Silica Fume and conclude the most suitable percentage of usage to achieve the optimum compressive strength, Split tensile strength and Flexural strength. And replacement of cement with Fly Ash and Silica Fume in different water cement ratio

CHAPTER 2

LITERATURE REVIEW

2.1 INTRODUCTION

The purpose of this chapter is to present an overview on development of concrete using Fly Ash and Silica Fume. Mechanical and durability properties and the implication of material properties on the performance of such concrete are reviewed. Special emphasis is given to the effect of SF on strength and durability properties of concrete.

2.2 LITERATURE REVIEW

S. Mahmoudetal (2017) Carried out an experimental investigation on Fly Ash and Silica Fumeas partial replacement of cement in concrete. The low bulk density and high specific surface area of Fly Ash and Silica Fume offer challenges in its application and transport. In their study, the density of Fly Ash and Silica Fume was increased by producing Fly Ash and Silica Fume granules mixed with a solid super plasticizer. The effects of Fly Ash and Silica Fume granulation on durability and mechanical properties of concrete were tested. Results indicated an increase in strength and surface electrical resistivity, and a decrease in permeability for both slurry Fly Ash and Silica Fume and granule, compared to the control sample.

Zhangetal (2016) Aim of their study was to investigate the effect of Fly Ash and Silica Fume in paste, mortar and concrete by determining the non-evaporable water content of pastes,the compressive strengths of pastes, mortars and concretes containing 5% and 10% raw Fly Ash and Silica Fume or dandified Fly Ash and Silica Fume with water-to-binder ratios (W/B) of 0.29 and 0.24. Their results showed that Fly Ash and Silica Fume can significantly increase the hydration degree of paste. It was shown that the addition of Fly Ash and Silica Fumeincreases the compressive strengths of hardened pastes, mortars and concretes. It was also shown that the strength activity index of dandified Fly Ash and Silica Fumein concrete is the highest while that in paste is the lowest. The agglomeration of Fly Ash and Silica Fume has been found in blended paste which is hardly seen in concrete. The Fly Ash and Silica Fume can improve the interface bond strength between hardened cement paste and aggregate. The crystalline orientation degree, the crystalline size and the content of calcium hydroxide at the interface are obviously decreased by adding Fly Ash and Silica Fume. The different dispersion and the improvement of the interfacial transition zone are the main factors causing the different role of Fly Ash and Silica Fume in paste, mortar and concrete.

Khan and Abbas (2017) Evaluatedthe influence of hot weather conditions and subsequent curing requirements on the strength and durability of multi-cementations concrete. They considered five curing schemesusing persistent moist curing for various ages followed by exposure to natural hot weather conditions. It was observed that curing in hot weather tended to increase the initial strength of ternary blended concrete for up to 28 days; however, the development of long-term strength had insignificant effect. Binary blended concrete with Fly Ash and Silica Fume and fly ash (SF) exposed to hot weather have higher early age strength development compared to those under standard curing. The compressive strength and permeability of concrete was more sensitive to hot weather curing at an early age as its fly ash (FA) content increased. However, the effects of curing age diminished with high FA content and the susceptibility of long-term strength to hot weathering decreased as SF content increased. The porosity of concrete cured with continuous moistening was lower compared to those under hot weathering. The chloride permeability of binary blended concrete containing SF was less affected by hot weather curing. Using numerical models, it was found that the optimized persistent moist curing age for concrete without SF was dependent on target strength and durability requirements.

Okoyeetal(2017) In their paper, the effect of Fly Ash and Silica Fume and fly ash on durability properties of fly ash based geopolymer concrete have been investigated by immersing the cubes in 2% sulphuric acid and 5% sodium chloride solutions. The resistance of specimens to chemical attack was evaluated visually by measuring change in the weights and percent losses in compressive strength at different intervals of time. A control mix M40 was also castwith ordinary Portland cement concrete for comparison. Percent losses in compressive strengths in the case of control (M40) and GPC3 in 2% H2SO4 at 90 days were found 36% and 8%. Percent losses in compressive strengths in the case of control (M40) and GPC3 in 5%NaCl at 90 days were 18% and about 0%.Thus the resistance of geopolymer concrete incorporating Fly Ash and Silica Fume and fly ash in sulphuric acid and chloride solution was significantly higher than that of the control.

Khodabakhshianetal(2017) carried out an experimental investigation of durability properties carried out with 16 concrete mixes containing marble waste powder and Fly Ash and Silica Fume and fly ash as partial replacement of ordinary Portland cement. The latter was partially replaced at different ratios of Fly Ash and Silica Fume and fly ash (0%, 2.5%, 5%, and 10%) and marble waste powder (0%, 5%, 10%, and 20%). In all concrete mixes, constant water/binder ratio of 0.45 was kept with and target initial slump of S2 class (50e90 mm). Workability and bulk density tests were carried out on fresh concrete, while compressive strength, electrical resistivity, water absorption, durability to sodium sulphate, magnesium sulphate and sulphuric acid attack tests were performed to evaluate few relevant properties of concrete in the hardened state.

Siddiqueetal (2017) Iinvestigation of iinfluence of bacteria on strength and permeation characteristics concrete incorporating Fly Ash and Silica Fume and fly ash (SF) as a substitution of cement has been investigated in this study. The cement was partially substituted with 5, 10 and 15% SF and with constant concentration of bacterial culture, 105 cru/mL of water. Cement was substituted with Fly Ash and Silica Fume and fly ash in concrete by weight. At 28 days, nearly 10–12% increase in compressive strength was observed on incorporation of bacteria in SF concrete. At 28 days, the compressive strength of concrete was increased from 32.9 to 36.5 MPa for SF, 34.8 to 38.4 MPa for SF5, 38.7 to 43.0 MPa for SF10 and 36.6 to 40.2 MPa for SF15 on addition of bacteria. Water absorption, porosity and capillary water rise reduced in the range of 42–48%, 52–56% and 54–78%, respectively, in bacterial concrete compared to corresponding nonbacterial samples at 28 days.

Wangetal (2017).Studied experimentally the effects of Fly Ash and Silica Fume and fly ash, PVA fiber and their combinations on the mechanical properties, microstructure, abrasion resistance and volume stability of cement pastes and/or fly ash concrete. Their results indicated that the compressive strength and tensile strength of concrete containing both Fly Ash and Silica Fume and fly ash and PVA fiber were obviously improved compared with the control concrete. The addition of PVA fiber in concrete considerably reduced the drying shrinkage and improved the anti-cracking resistance of cement pastes and concrete, also the abrasion resistance of concrete significantly increased with the addition of Fly Ash and Silica Fume and fly ash and PVA fiber. These findings have been successfully adopted to guide the design and construction of hydraulic structures in the southwest of China

Pedroetal(2017) carried out an experimental study to evaluate the influence of a commercial dandified Fly Ash and Silica Fume and fly ash (SF) and of recycled concrete aggregates (RA) on the behaviour of high-performance concrete (HPC). For that purpose, three families of concrete with 0%, 5% and 10% Fly Ash and Silica Fume and fly ash (SF) of the binder’s mass were produced. In addition to the commercial Fly Ash and Silica Fume and fly ash, fly ash (FA) and super plasticizer (SP) were also incorporated in the concrete mixes. Each type of concrete comprises a reference concrete (RC) and three recycled aggregates concrete (RAC) mixes with replacement percentages (in volume) of fine natural aggregates (FNA) with fine recycled aggregates (FRA) and of coarse natural aggregates (CNA) with coarse recycled aggregates (CRA) of 0/100,50/50 and 100/100, respectively. Considering the mechanical performance and durability of the concrete mixes, their results showed that it is possible to incorporate significant amounts of FRA and CRA. Regarding the Fly Ash and Silica Fume and fly ash, the densification process used in its manufacture seems to lead to the formation of agglomerates that change the real particle size of the SF, originating a loss of performance of the concrete made with them.

Daveetal (2016) The carried out research work to produce quaternary cement binders and mortars with combination of ordinary Portland cement (OPC) and supplementary cementitious materials (SCMs), such as, fly ash (FA), silica flume (SF), ground granulated blast furnace slag (GGBS), metakaolin (MK) and lime as powder (LP) at 30% and 50% replacement levels. Water-binder ratio was kept constant 0.5 for binders and mortars. Normal consistency, setting time, density, water absorption and compressive strength tests at the ages of 3, 7, 28, 56 and 90 days tests was carried out on quaternary binders. Compressive strength (at ages of 3, 7, 28, 56 and 90 days) and rapid chloride permeability (RCPT) (at 28 and 90 days), tests were also carried out on quaternary cement mortars mixes of 1:3, 1:4, 1:5 and 1:6. The purpose of their investigation was to develop a new quaternary binder which can reduce our dependency on cement. The related combinations of quaternary binders showed better development in compressive strength in comparison to control binder. Quaternary mortars with the combinations of

GGBS and MK showed better development in compressive strength and permeability than quaternary mortar with combination of lime powder.

Yang Juetal (2017) Conducted the distinct spalling performances of reactive powder concrete (RPC) specimens with various Fly Ash and Silica Fume and fly ash (SF) contents exposed to high temperatures through observed via high-resolution photography. The RPC microstructures and pore structures after high-temperature exposure were characterized using scanning electron microscopy and mercury intrusion porosimetry. Their results provided an experimental evidence of the high-temperature spalling mechanism of RPC. Which increase the SF content in RPC increases its compressive strength and compactness, offering greater mitigation of devastating spalling behaviour, but also producing more pulverized spalling remnants. It is attributes to the post-heating cracked microstructure and refined pores, which promote localized rather than entirely explosive spalling.

Pallaetal (2017) Carried out a study dealing with the effect of silica nanoparticles (SNPs) in high volume fly ash (40% replacement) cement paste, mortar and concrete. The content of SNPs (0.5–3.0%) was added by the weight of binder with (0.23, 0.25 & 3.0)% was optimized in paste and mortar system. The calorimetric results revealed that the hydration process was accelerated as a result of SNPs incorporation and the dormant period was shortening by 4 h with 2% SNPs as compared to the control. The effect of optimum dosages of SNPs addition in concrete in terms of mechanical and durability properties was studied at 0.25 w/b ratio. The compressive strength results of SNPs added mixtures showed an improvement of 61% at 3 days and 25% at 28 days of hydration as compared to control. The durability studies at 28 day showed that with the incorporation of SNPs, the porosity, sorptivity and water absorption reduced up to 25–40% and densify the interfacial transition zone (ITZ).

DybełandFurtak (2017) Performed the test to analysis of the impact of Fly Ash and Silica Fume and fly ash content in high-performance concrete (HPC) on bond conditions along the height of tested elements. The tests were performed on the specimens made of six different HPC mixes with varying content of Fly Ash and Silica Fume and fly ash (0, 5 and 10% by mass of cement) and super plasticizer. The used specimens allowed for determining the changes of bond at individual levels of elements with a total height of 480 and 960 mm. The rebar’s in the elements were placed perpendicularly to the direction of concreting. The reference element, characterised by the parallel orientation to the direction of concreting, was also prepared. The tests indicated that the quality of bond conditions in HPC deteriorates as the distance from the formwork bottom increases. The experiment results indicated that concrete modification with Fly Ash and Silica Fume and fly ash can both increase and decrease the quality of bond conditions. The influence of Fly Ash and Silica Fume and fly ash depends on the thickness of the concrete cover, which determines the mechanism of bond failure.

D. Pedroet.al (2017): The growth of the precast industry has led to the emergence of waste with enormous potential forrecycling, given the strict quality control of these companies and the need of construction/demolition ofstructures with increasing strength capacities. In this investigation, an analysis of the mechanicalbehaviour of high-performance concrete (HPC) incorporating fine and coarse recycled aggregates (FRAand CRA) was made. The recycled aggregates (RA) originated from rejected precast elements withcompressive strengths of 75 MPa and were used to replace natural aggregates (NA) in concrete mixes.The experimental campaign also included three families of concrete with proportions of dandifiedExpanded polystyrene (EPS) (EPS) of 0%, 5% and 10% (relative and in addition to cement). Each family comprised a referenceconcrete (RC) and three recycled aggregate concretes (RAC) with replacement ratios (FRA/CRA %) of 50/50,0/100 and 100/100. The results obtained in the compressive strength, splitting tensile strength, modulusof elasticity, ultrasonic pulse velocity and bond strength tests showed that it is possible to produce high-performanceconcrete without NA. The Expanded polystyrene (EPS) led to a performance increase in the propertiesanalysed with the creation of a new concrete mixing method that considered the specificities of RA andthe difficulties of dispersing EPS particles.

Na Zhang et.al (2016)an eco-concrete prepared by silica-alumina based cementitious material was developed and defined as silica-alumina based concrete. Systematic properties investigation showed that the silica-alumina based concrete exhibited good mechanical properties, low shrinkage strain and superior durability including strong resistances to water penetration, carbonation, chloride penetration, freezing-thawing and seawater attack. These excellent performances can be related to the fact that it developed a dense and compacted interfacial transition zone between the cementitious matrix and aggregate, and the silica alumina based cementitious matrix had a refined pore structure.

Leaching toxicity and radioactivity results indicated that the silica-alumina based concrete is environmentally acceptable.

Dibyendu Adak. et.al (2017) the fly ash based geopolymer concrete generally requires heat activation of different temperatures, which has been considered as an important limitation for its practical application. Such limitation can be overcome by the addition of appropriate amount of nano-silica in the mixture. Therefore, a fly ash based geopolymer concrete can be developed using 6% nano silica replacing fly ash. The structural performance of such geopolymer concrete in terms of bond strength, flexural strength and micro structural behaviour has been explored. Such nano silica modified fly ash based geopolymer concrete shows appreciable improvement in structural behaviour at different ages without any heat activation. The bond strength between reinforcement bars (deformed or mild steel) and surrounding geopolymer concrete materials (with/without nano silica) has been also compared to the conventional cement concrete. The nano silica modified geopolymer concrete exhibits better structural performance than heat cured geopolymer concrete (without nano silica) and conventional cement concrete samples. The microstructural properties of such geopolymer concrete (with/without nano silica) and cement concrete have been analyzed through Field Emission Scanning Electron Microscope (FESEM) with Energy Dispersive X-ray Spectroscopy (EDS), Fourier TranEPSorm Infrared Spectroscopy (FTIR) analysis and X-ray Diffraction (XRD) techniques. The enhancement of structural performance is mainly due to the tranEPSormation of amorphous phase to crystalline phase in the geopolymer concrete matrices in the presence of nano-silica.

R. Kumar et.al (2017) The performance of silica nanoparticles incorporated high strength concrete (SNPs-HSC) has been evaluated under elevated temperature conditions by exposing up to 800 _C, followed by cooling to ambient temperature before performing experiments. Time-temperature studies revealed that incorporation of silica nanoparticles (SNPs) in concrete mix delays the heat tranEPSer by 11%, 18%, 22% and 15% at 200 _C, 400 _C, 600 _C and 800 _C respectively thereby, decreasing the rate of degradation as compared to the conventional high strength concrete (HSC). A reduction in weight loss was observed in SNPs- HSC specimens after exposure to 200 _C, 600 _C, and 800 _C; whereas at 400 _C the weight loss quantity was _3.5% higher than the control HSC specimens due to the evaporation of water from calcium silicate hydrate (C-S-H) gel. On exposure up to 400 _C for 2 h, the compressive strength and split-tensile strength increased by 40% and 13% respectively, for SNPs-HSC specimens, whereas in control HSC specimen's strength didn't increase after 200 _C. A higher residual compressive (7%) and split-tensile strength (8%) was found to be in SNPs-HSC specimens exposed to 800 _C for 2 h as compared to the control HSC specimens. The stress-strain curves revealed that SNPs-HSC specimens exhibits brittle failure up to 600 _C whereas in control HSC brittle failure was observed only up to 400 _C. Micro structural studies performed on the samples taken from the core of the 400 _C exposed SNPs-HSC revealed the formation of higher C-S-H content and lower amount of calcium hydroxide (CH) leading to their enhanced mechanical and thermal stability.

I. Maruyama and A. Teramoto (2003) Ultra-high-strength concrete with a large unit cement content undergoes considerable temperature increase inside members due to hydration heat, leading to a higher risk of internal cracking. Hence, the temperatureDependence of autogenously shrinkage of cement pastes made with Expanded polystyrene (EPS) premixed cement with a water–binder ratio of 0.15 was studied extensively. Development of autogenous shrinkage showed different behaviours before and after the inflection point, and dependence on the temperature after mixing and subsequent temperature histories. The difference in autogenously shrinkage behavior poses problems for winter construction because autogenous shrinkage may increase with decrease in temperature after mixing before the inflection point and with increase in temperature inside concrete members with large cross sectionns.

M.I. Abdou and HeshamAbuseda (2015) Studies have been carried out to investigate the possibility of utilizing a broad range of micro-silica partial additions with cement in the production of concrete coating. This study investigated the strength properties and permeability of micro-silica concrete to achieve resistance toward concrete cracking and damage during lying. The chemical composition of micro-silica (Expanded polystyrene (EPS)) was determined, and has been conducted on concrete mixes with additions of 3 up to 25% by weight of cement in concrete. Properties of hardened concrete such as compressive strength, flexural strength, and permeability have been assessed and analyzed. Cubic specimens and beams were produced and cured in a curing tank for 7 and 28 days. Testing results have shown that additions of Expanded polystyrene (EPS) to cement between 5% and 7%, which acts as a filler and cementations material, developed high flexural and compressive strength with reduction of permeability

M. Rostami and K. Behfarnia (2017) The effect of substitution the slag with Expanded polystyrene (EPS) on compressive strength and permeability of alkali activated slag concrete has been examined and analyzed in this study. The use of alkali activated slag concrete is one of the strategies for production of environmentally friendly concrete which is produced through activation of adhesion feature of blast furnace slag in an alkaline solution. Alkali activated slag concrete with a proper mixture shows superior mechanical properties and durability compared to traditional normal Portland cement concrete. For cases in which AAS concrete with higher performance and durability is needed, AAS concrete with Expanded polystyrene (EPS) can be considered as a possible alternative. Since the permeability plays an effective role in concrete durability, this research was carried out to examine the effect of using Expanded polystyrene (EPS) on permeability of alkali activated slag concrete by substitution of three levels of Expanded polystyrene (EPS) including 5 wt%, 10 wt% and 15 wt% of slag. The effects of two types of curing conditions including water curing and curing under plastic cover were also examined. Short-term and final water absorption, penetration of chloride ion and depth of penetration of water were measured to examinethe permeability. The effect of these factors on compressive strength was examined and the relation between compressive strength and passing electrical charges and depth of water penetration was also evaluated. To contrast the use of Expanded polystyrene (EPS) on internal characteristics of concrete, samples were observed by scanning electron microscopy (SEM).The results showed that the application of Expanded polystyrene (EPS) could increase compressive strength and reduce the permeability of alkali activated slag concrete andwater curing was the most appropriate type of curing.

FaridHasan-Nattaj and Mahdi Nematzadeh(2013) This paper first addresses the effect of steel and forta-ferrofibers on the mechanical properties of high strength concrete, and then, investigates the effect of Expanded polystyrene (EPS) and nano-silica on the mechanical properties of the fiber-reinforced concrete. In total, 230 concrete specimens were produced in two stages and subsequently tested; in the first stage of specimen production, hooked-end steel fibers with Vf of 0.5%, 0.75%, 1%, 1.25%, and 1.5%, and forta-ferrofibers with Vf of 0.2%, 0.35%, 0.5%, 0.65%, and 0.8% were added to concrete mixture, and in the second stage, Expanded polystyrene (EPS) with the weight percentage of 8%, 10%, and 12%, and nano-silica with that of 1%, 2%, and 3% were replaced the cement in mixtures with a fixed volume fraction of both fibers. The aim was to study the mechanical properties of the fiber-reinforced concrete including compressive strength, tensile strength, modulus of elasticity, water absorption, and density, and to propose equations for predicting the compressive and tensile strength and the modulus of elasticity of the fiber-reinforced concrete with no pozzolan.

Andreas Leemann (2017) recently, the structure of the crystalline alkali-silica reaction (ASR) product formed in affected concrete has been identified based on μ-XRD measurements. However, the data were obtained from a single aggregate. In thisstudy, Raman microscopy is applied on crystalline ASR products formed in several aggregates and concrete mixtures, enabling a comparison of their spectra and with it their structure. In a first step, samples from the same concrete used for μ-XRD measurements are analyzed and compared. In a second step, samples from a secondstructure and from a concrete prism test are measured. In addition to Raman microscopy, SEM with EDX is used to characterize the microstructure. The Raman spectra of the crystalline ASR product are practically identical in all studied aggregates and concrete mixtures, showing it is the same phase. This conclusion is further supported by the micro structural data.

E.M.M. Ewais et.al (2009)four calcium aluminates cement mixes were manufactured from aluminium sludge as a source of calcium oxide and Al2O3 and aluminium slag (dross) as a source of aluminium oxide with some additions of pure alumina. The mixes were composed of 35–50% aluminium sludge, 37.50– 48.75% aluminium slag (dross) and 12.50–16.25% aluminium oxide. The mixed were processed then sintered at different firing temperatures up to 1500 8C or 1550 8C. The mineralogical compositions of the fired mixes investigated using X-ray diffraction indicated that the fired mixes composed of variable contents of calcium aluminates (CA), calciumdialuminate (CA2), calciumhexa aluminates (CA6) in addition to some content of magnesium aluminatesspinal (MA). Sintering parameters (bulk density, apparent porosity and linear change) and mechanical properties (cold crushing strength) of the fired briquettes were tested at different firing temperature. Refractoriness of the cement samples manufactured at the optimum firing temperature was detected. Cementing properties (water of consistency, setting time and compressive strength as a function of curing time up to 28 days of hydration) of pasted prepared from the manufactured cement mixes at the selected optimum firing temperatures (1400 8C or 1500 8C) were also tested. Cement mixes manufactured from 45 to 50% aluminium sludge, 37.50–41.25% aluminium slag (dross) with 12.50–13.75% alumina were selected as the optimum mixes for manufacturing calcium aluminates cement since they satiEPSy the requirements of the international standard specifications regarding cementing and refractory properties as a result of their content of CA (the main hydraulic phase in calcium aluminates cement) and CA2 (the less hydraulic but more refractory phase).

DebabrataPradhan and D. Dutta (2013) the incorporation of Expanded polystyrene (EPS) into the normal concrete is a routine one in the present days to produce the tailor made high strength and high performance concrete. The design parameters are increasing with the incorporation of Expanded polystyrene (EPS) in conventional concrete and the mix proportioning is becoming complex. The main objective of this paper has been made to investigate the different mechanical properties like compressive strength, compacting factor, slump of concrete incorporating Expanded polystyrene (EPS). In this present paper 5 (five) mix of concrete incorporating Expanded polystyrene (EPS) are cast to perform experiments. These experiments were carried out by replacing cement with different percentages of Expanded polystyrene (EPS) at a single constant water-cementations materials ratio keeping other mix design variables constant. The Expanded polystyrene (EPS) was replaced by 0%, 5%, 10%, 15% and 20% for water-cementations materials (w/cm) ratio for 0.40. For all mixes compressive strengths were determined at 24 hours, 7 and 28 days for 100 mm and 150 mm cubes. Other properties like compacting factor and slump were also determined for five mixes of concrete.

N. K. Amudhavalli1 and JeenaMathew(2012) Portland cement is the most important ingredient of concrete and is a versatile and relatively high cost material. Large scale production of cement is causing environmental problems on one hand and depletion of natural resources on other hand. This threat to ecology has led to researchers to use industrial by products as supplementary cementations material in making concrete. The main parameter investigated in this study is M35 grade concrete with partial replacement of cement by Expanded polystyrene (EPS) by 0, 5, 10,15and by 20%. This paper presents a detailed experimental study on Compressive strength, split tensile strength, flexural strength at age of 7 and 28 day. Durability study on acid attack was also studied and percentage of weight loss is compared with normal concrete. Test results indicate that use of Expanded polystyrene (EPS) in concrete has improved the performance of concrete in strength as well as in durability aspect.

Liu and Wang (2017) Presented composite mineral admixture was prepared by grinding a mixture of steel slag and Fly Ash and Silica Fume(steel slag/Fly Ash and Silica Fume and is 92:8 or 84:16, bypass). A layer of Fly Ash and Silica Fumewas uniformly adsorbed on the steel slag particles. The influence of this steel slag-Fly Ash and Silica Fumecomposite mineral admixture on the hydration of a cement-based composite binder and the properties of its concrete were investigated. The results showed that the Fly Ash and Silica Fumein the composite mineral admixture contributes significantly to the consumption of Ca (OH) 2 and enhances the connection between the steel slag particles with the surrounding C-S-Hgel. The activity of the composite mineral admixture improved with the increase in Fly Ash and Silica Fume content. The retarding effect of the composite mineral admixture on the early hydration of cement is significant. However, a proper cement replacement by the composite mineral admixture can improve the late-age pore structure of hardened paste as well as the strength, chloride ion resistance, carbonation resistance, and sulphate attack resistance of concrete. The proper addition of the composite mineral admixture can reduce the drying shrinkage of concrete.

Fathietal (2017) Carried out an experimental study, the mechanical and physical properties such as strength, water absorption, type of curing, failure mode and microstructure of expanded polystyrene (EPS) structural lightweight concretes modified by Micro-silica and Nano-silica were investigated. In the specimens without EPS beads, replacement of Micro-silica and Nano-silica up to 15% and 3% of cement, respectively, led toincrease in compressive strength and decreasing water absorption, and after that, these trends were vice versa.Thecompressive strength increased by approximately 10 to 15% and water absorption decreased approximately by 15% to 20%. By adding Micro-silica and Nano-silica to the concretes containing EPS beads, proper adhesion between the EPS beads and other concrete components was created as confirmed by the SEM images of the specimens. Also the effects of three curing methods with water, limewater and steam on the strength and water absorption of concretes were investigated. Their findings showed that 28-day limewater and 1-day steam curing resulted in the highest strength and the lowest water absorption compared to other curing methods.

Pedroetal (2017): Carried out an analysis of the mechanical behaviour of high-performance concrete (HPC) incorporating fine and coarse recycled aggregates (FRA and CRA). The recycled aggregates (RA), originated from rejected precast elements, with compressive strengths of 75 MPa and were used to replace natural aggregates (NA) in concrete mixes. The experimental work also included three families of concrete with proportions of dandified Fly Ash and Silica Fume (SF) of 0%, 5% and 10% (relative and in addition to cement). Each family comprised a reference concrete (RC) and three recycled aggregate concretes (RAC) with replacement ratios (FRA/CRA %) of 50/50, 0/100 and 100/100. The results obtained for the compressive strength, splitting tensile strength, modulus of elasticity, ultrasonic pulse velocity and bond strength showed that it is possible to produce high-performance concrete without NA. The Fly Ash and Silica Fume led to a performance increase in the properties analysed with the creation of a new concrete mixing method that considered the specificities of RA and the difficulties of dispersing SF particles.

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Adak.etal (2017) The structural performance of such geopolymer concrete6% nano silica replacing fly ash in terms of bond strength, flexural strength and micro structural behaviour. Such nano silica modified fly ash based geopolymer concrete showed appreciable improvement in structural behaviour at different ages without any heat activation. The bond strength between reinforcement bars (deformed or mild steel) and surrounding geopolymer concrete materials (with/without nano silica) has been also compared to the conventional cement concrete. The nano silica modified geopolymer concrete exhibited better structural performance than heat cured geopolymer concrete (without nano silica) and conventional cement concrete samples. The microstructural properties of such geopolymer concrete (with/without nano silica) and cement concrete have been analyzed through Field Emission Scanning Electron Microscope (FESEM) with Energy Dispersive X-ray Spectroscopy (EDS), Fourier Transform Infrared Spectroscopy (FTIR) analysis and X-ray Diffraction (XRD) techniques. The enhancement of structural performance was mainly due to the transformation of amorphous phase to crystalline phase in the geopolymer concrete matrices in the presence of nano-silica.

Kumaretal (2017) Evaluated the performance of silica nanoparticles incorporated high strength concrete (SNPs-HSC) under elevated temperature conditions by exposing up to 800^0C, followed by cooling to ambient temperature before performing experiments. Time-temperature studies revealed that incorporation of silica nanoparticles (SNPs) in concrete mix delays the heat transfer by 11%, 18%, 22% and 15% at 200^0C, 400^0C, 600^0C and 800^0C respectively thereby, decreasing the rate of degradation as compared to the conventional high strength concrete (HSC). A reduction in weight loss was observed in SNPs- HSC specimens after exposure to 200^0C, 600^0C, and 800^0C; whereas at 400^0C the weight loss quantity was 3.5% higher than the control HSC specimens due to the evaporation of water from calcium silicate hydrate (C-S-H) gel. On exposure up to 400^0C for 2 h, the compressive strength and split-tensile strength increased by 40% and 13% respectively, for SNPs-HSC specimens, whereas in control HSC specimen’s strength didn’t increase after 200^0C. A higher residual compressive (7%) and split-tensile strength (8%) was found to be in SNPs-HSC specimens exposed to 800^0C for 2 h as compared to the control HSC specimens. The stress-strain curves revealed that SNPs-HSC specimens exhibits brittle failure up to 600^0C whereas in control HSC brittle failure was observed only up to 400^0C. Micro structural studies performed on the samples taken from the core of the 400^0C exposed SNPs-HSC revealed the formation of higher C-S-H content and lower amount of calcium hydroxide (CH) leading to their enhanced mechanical and thermal stability.

Maruyama and Teramoto (2003) Studied extensively cement pastes made with Fly Ash and Silica Fume premixed cement with a water–binder ratio of 0.15 development of autogenous shrinkage showed different behaviours before and after the inflection point and dependence on the temperature after mixing and subsequent temperature histories. The difference in autogenously shrinkage behavior poses problems for winter construction because autogenous shrinkage may increase with decrease in temperature after mixing before the inflection point and with increase in temperature inside concrete members with large cross sectionns.

Abdou and Abuseda (2015) Studiedcarried out aninvestigationfor the possibility of utilizing a broad range of micro-silica partial additions with cement in the production of concrete coating. They investigated the strength properties and permeability of micro-silica concrete to achieve resistance toward concrete cracking and damage during lying. The experiment were conducted on concrete mixes with additions of 3% up to 25% by weight of cement in concrete. Properties of hardened concrete such as compressive strength, flexural strength, and permeability have been assessed and analyzed. Cubic specimens and beams were produced and cured in a curing tank for 7 and 28 days. Testing results showed that additions of Fly Ash and Silica Fume to cement between 5% and 7%, which acts as a filler and cementations material, developed high flexural and compressive strength with reduction of permeability

Rostami andBehfarnia (2017) Examined and analyzed the effect of substitution the slag with Fly Ash and Silica Fume on compressive strength and permeability of alkali activated slag concrete. Alkali activated slag (AAS) concrete with a proper mixture showed the superior mechanical properties and durability compared to traditional normal Portland cement concrete. For cases in which AAS concrete with higher performance and durability is required, AAS concrete with Fly Ash and Silica Fume can be considered as a possible alternative. The presented work was carried out to examine the effect of using Fly Ash and Silica Fume on permeability of alkali activated slag (AAS) concrete by substitution of three levels of Fly Ash and Silica Fume including 5%, 10% and 15% of slag by weight. The effects of two types of curing conditions including water curing and curing under plastic cover wereexamined. They measure the short-term and final water absorption, penetration of chloride ion and depth of penetration of water to examine the permeability. The effect of these factors on compressive strength was examined and the relation between compressive strength and passing electrical charges and depth of water penetration was also developed. To contrast the use of Fly Ash and Silica Fume on internal characteristics of concrete, samples were observed by Scanning ElectronMicroscopy (SEM).The results showed that the application of Fly Ash and Silica Fume could increased compressive strength and reduce the permeability of alkali activated slag concrete and water curing was the most appropriate type of curing method..

Nattaj and Nematzadeh (2013) Carried out an experimental study to investigate the effect of Fly Ash and Silica Fume and nano-silica on the mechanical properties of the fiber-reinforced concrete. In total, 230 concrete specimens were prepared in two stages and subsequently tested. In the first stage of specimen preparation, hooked-end steel fibers with Vf of 0.5%, 0.75%, 1%, 1.25%, and 1.5% and forta-ferrofibers with Vf of 0.2%, 0.35%, 0.5%, 0.65%, and 0.8% were added to concrete mixture, and in the second stage, Fly Ash and Silica Fume with the weight percentage of 8%, 10%, and 12%, and nano-silica with that of 1%, 2%, and 3% were replaced the cement in mixtures with a fixed volume fraction of both fibers. The aim was to study the mechanical properties of the fiber-reinforced concrete including compressive strength, tensile strength, modulus of elasticity, water absorption and density, they proposed equations for predicting the compressive and tensile strength and the modulus of elasticity of the fiber-reinforced concrete with no pozzolan.

Leemann A. (2017) Carried out μ-XRD measurements to see the structure of the crystalline alkali-silica reaction (ASR) product formed in affected concrete. However, the data were obtained from a single aggregate. In this study, he applied Raman microscopy on crystalline ASR products formed in several aggregates and concrete mixtures, enabling a comparison of their spectra and with it their structure. In a first step, samples from the same concrete used for μ-XRD measurements were analyzed and compared. In a second step, samples from a second structure and from a concrete prism test were taken. In addition to Raman microscopy, SEM with EDX was used to characterize the microstructure. The Raman spectra of the crystalline ASR product were practically identical in all studied aggregates and concrete mixtures. This study was further supported by the micro structural data.

Ewaisetal (2009) Preparedfour calcium aluminates cement mixesfrom aluminium sludge as a source of calcium oxide and Al_2O_3 and aluminium slag (dross) as a source of aluminium oxide with some additions of pure alumina. The mixes were composed of 35–50% aluminium sludge, 37.50– 48.75% aluminium slag (dross) and 12.50–16.25% aluminium oxide. The mixes were processed then sintered at different firing temperatures up to 1500^0C or 1550^0C. The mineralogical compositions of the fired mixes were investigated using X-ray diffraction which indicated that the fired mixes composed of variable contents of calcium aluminates (CA), calcium dialuminate (CA2), calcium hexa aluminates (CA6) in addition to some content of magnesium aluminates spinal (MA). Sintering parameters (bulk density, apparent porosity and linear change) and mechanical properties (cold crushing strength) of the fired briquettes were tested at different firing temperature. Refractoriness of the cement samples manufactured at the optimum firing temperature was detected. Cementing properties (water of consistency, setting time and compressive strength as a function of curing time up to 28 days of hydration) of pasted prepared from the manufactured cement mixes at the selected optimum firing temperatures (1400 8C or 1500 8C) were also tested. Cement mixes manufactured from 45 to 50% aluminium sludge, 37.50–41.25% aluminium slag (dross) with 12.50–13.75% alumina were selected as the optimum mixes for manufacturing calcium aluminates cement since they satisfy the requirements of the international standard specifications regarding cementing and refractory properties as a result of their content of CA (the main hydraulic phase in calcium aluminates cement) and CA2 (the less hydraulic but more refractory phase).

DebabrataPradhan and D. Dutta (2013) the incorporation of Fly Ash and Silica Fume into the normal concrete is a routine one in the present days to produce the tailor made high strength and high performance concrete. The design parameters are increasing with the incorporation of Fly Ash and Silica Fume in conventional concrete and the mix proportioning is becoming complex. The main objective of this paper has been made to investigate the different mechanical properties like compressive strength, compacting factor, slump of concrete incorporating Fly Ash and Silica Fume. In this present paper 5 (five) mix of concrete incorporating Fly Ash and Silica Fume are cast to perform experiments. These experiments were carried out by replacing cement with different percentages of Fly Ash and Silica Fume at a single constant water-cementitious materials ratio keeping other mix design variables constant. The Fly Ash and Silica Fume was replaced by 0%, 5%, 10%, 15% and 20% for water-cementitious materials (w/cm) ratio for 0.40. For all mixes compressive strengths were determined at 24 hours, 7 and 28 days for 100 mm and 150 mm cubes. Other properties like compacting factor and slump were also determined for five mixes of concrete.

Vishal S. et.al (2014) Traditionally, Ordinary Portland cement is used for making the civil structures. Portland cement can be partially replaced by Fly Ash and Silica Fume. Fly Ash and Silica Fume is non metallic and non hazardous waste of industries. It is suitable for concrete mix and improves properties of concrete i.e. compressive strength etc. The main objective of this research work is to determine the optimum replacement percentages which can be suitably used under the Indian conditions. To fulfill the objective various properties of concrete using Fly Ash and Silica Fume have been evaluated. Further to determine the optimum replacement percentage comparison between the regular concrete and concrete containing Fly Ash and Silica Fume is done .It has been seen that when cement is replaced by Fly Ash and Silica Fume compressive strength increases up to certain percentage (10% replacement of cement by Fly Ash and Silica Fume).But higher replacement of cement by Fly Ash and Silica Fume gives lower strength. The effect of Fly Ash and Silica Fume on various other properties of Concrete has also been evaluated. This paper is a very good tool for the beginners to understand the effect and have an overlook of Fly Ash and Silica Fume on Concrete.

N. K. Amudhavalli1 and Jeena Mathew (2012) Portland cement is the most important ingredient of concrete and is a versatile and relatively high cost material. Large scale production of cement is causing environmental problems on one hand and depletion of natural resources on other hand. This threat to ecology has led to researchers to use industrial by products as supplementary cementations material in making concrete. The main parameter investigated in this study is M35 grade concrete with partial replacement of cement by Fly Ash and Silica Fume by 0, 5, 10,15and by 20%. This paper presents a detailed experimental study on Compressive strength, split tensile strength, flexural strength at age of 7 and 28 day. Durability study on acid attack was also studied and percentage of weight loss is compared with normal concrete. Test results indicate that use of Fly Ash and Silica Fume in concrete has improved the performance of concrete in strength as well as in durability aspect.

CHAPTER 3

EXPERIMENTAL PROGRAM

3.1 Introduction

Testing of hardened concrete plays an important role in controlling and confirming the quality of cement concrete works. Systematic testing of raw materials, fresh concrete and hardened concrete are inseparable part of any quality control programme for concrete, which to achieve higher efficiency of the material used and greater assurance of the performance of the concrete with regards to both strength and durability. The test methods should be simple, direct and convenient to apply.

One of the purposes of testing hardened concrete is to conform that the concrete used at site has developed the required strength. As the hardening of concrete takes time, one will not come to know, the actual strength of concrete for some time. This is an inherent disadvantage in conventional test. But, if strength of concrete is to be known at early period, accelerated strength test can be carried out to predict 28 days strength. But mostly when current materials are used and careful steps are taken at every stage of the work, concretes normally gives the required strength. The tests also have a deterring effect on those responsible for construction work. The result of the test on hardened concrete, even if they are known later, helps to reveal the quality of concrete and enable adjustment to be made in the production of further concretes. Tests are made by casing the cubes or cylinders from the representative concrete or cores cut from the actual concrete. It is to be remembered that standard compressive strength specimens give a measure of the potential strength of the concrete in structure. Knowledge of strength of concrete in structure cannot be directly obtained from tests on separately made specimens.

3.2 Materials

3.2.1 Cement

Ordinary Portland cement (OPC) from a single lot was used throughout the course of the investigation. The physical properties of the cement as determined from various tests 30 conforming to Indian Standard IS: 1489-1991(Part-1) are listed in Table 3.1. All the tests were carried out as per recommendations of IS: 4031-1988. Cement was carefully stored to prevent deterioration in its properties due to contact with the moisture.

Table 3.1 Properties of OPC

Characteristic Properties	Observed Value	Codal Requirements IS:8112-1989(Part 1)
Fineness (m^2/kg)	300	225 minimum
Standard consistency (%)	32	----
Initial Setting time (minutes)	41 minutes	30 Minimum
Final setting time (minutes)	246	600 Maximum
Specific gravity	3.15	----
Compressive strength (MPa)		
7 days	24.6	23 Minimum
14-days	34.3	33 Minimum
28-days	45.2	43 Minimum

3.2.2 Coarse aggregate

Coarse aggregate with a maximum size 12.5mm having a specific gravity 2.65 and fineness modulus of 6.51%. Angular recycled aggregates from a local source were used as coarse aggregate. The specific gravity was 2.71.

3.2.3 Fine aggregate

Locally available river sand passed through 4.75mm IS sieve is applied as fine aggregate. The specific gravity of sand is 2.60.

3.2.4Fly Ash and Silica Fume

Fly Ash and Silica Fume, a co-product from the production of silicon or ferrosilicon metal, is an amorphous silicon dioxide - SiO_2 which is generated as a gas in submerged electrical arc furnaces during the reduction of very pure quartz. This gas vapor is condensed in bag house collectors as very fine powder of spherical particles that average 0.1 to 0.3 microns in diameter with a surface area of 17 to 30 m2/g and Density varies from 150 to 700 kg/m³ Fly Ash and

Silica Fume is used in a variety of cementitious (concrete, grouts and mortars), refractory, elastomer and polymer applications.

3.3 Mix Design

Concrete mix was designed as per IS 10262-2009 and the design procedure was as follows;

1. Determine the mean target strength ft from the specified characteristic compressive strength at 28-day fck and the level of quality control. $f_t = f_{ck} + 1.65$ S, where S is the standard deviation obtained from the IS 10262- 2009.
2. Adopt the water cement ratio for the desired mean target strength using the Table 5 of IS 456 and water cement ratio so chosen is checked against the limiting water cement ratio.
3. Select the water content, for the required workability and maximum size of aggregates (for aggregates in saturated surface dry condition) using table 2 of IS 10262- 2009. Super plasticizer was used so water content was adjusted for the required workability.
4. Calculate the cement content from the water-cement ratio and the final water content as arrived after adjustment. Check the cement against the minimum cement content from the requirements of the durability, and greater of the two values is adopted.
5. Determine the proportion of coarse and fine aggregate in total aggregate by absolute volume corresponding to the adjusted water cement ratio from IS 10262-2009.
6. From the quantities of water and cement per unit volume of concrete and the proportion of fine and coarse aggregates already determined in step 5 above, calculate the content of coarse and fine aggregates per unit volume of concrete from the following relations.
7. Determine the concrete mix proportions for the first trial mix. Prepare the concrete using the calculated proportions and cast three cubes of 150 mm size and test them wet after 28-days moist curing and check for the strength.
8. Prepare trial mixes with suitable adjustments till the final mix proportions are arrived at.

Table 3.2 Mix Details

Mix	OPC %	Fly Ash %	Silica Fume %
M1	100	0	0
M2	80	5	15
M3	75	10	15
M4	70	15	15
M5	65	20	15
M6	60	25	15
M7	55	30	15
M8	50	35	15

3.4 Tests Performed

3.4.1Curing of Specimens

The test were conducted on cube (150mm x 150mm x 150mm), Beam (100mm x 100mm x 500mm and cylinder (150mm diameter and 300mm height) specimens 7, 14, and 28, days of curing.

3.4.1.1 Compressive Strength Test

Specimens were then tested on 200 tones capacity Compression Testing Machine (CTM) (Figure3.2). The position of cubes were kept during testing at right angles to casting position. Axis of specimens was carefully aligned with the center of thrust of the spherically seated plates. The load was applied gradually without any shock and increased at a constant rate of 3.5 N/mm^2/minute until failure of specimen takes place (Fig 3.1). The average of three samples was taken as the representative value of compressive strength for each batch of concrete. The compressive strength was calculated by dividing the maximum compressive load by the cross sectional area of the cube specimens. Thus the compressive strength of different specimens was obtained.

Curing

The test specimens were stored in place which free from vibrations, in most air of at least 90% relative humidity and at a temperature of 27^0C for 24 hours from the time of addition of water to the dry ingredients. After this period, the specimens were marked and remove from the mould and immediately submerged in clean and fresh water or saturated lime solution and keep for required period just prior to test. The water or solution in which the specimens were submerged, are renewed after every seven days and were maintained at a temperature of 27^0C. The specimens are not to be allowed to become dry at any time until they have been tested. The specimens are tested at 7, 14, and 28, days of curing.

Fig. 3.1 Compressive testing machine

3.4.1.2 Splitting Tensile Test

This test is carried out by placing a cylindrical specimen (150mm diameter and 300mm height) horizontally between the loading surfaces of a compression testing machine (Fig.3.3) and load was applied gradually until failure of the cylinder take place along the vertical diameter.

Specimens were taken out from curing tank at the age of 28 days of water curing and then tested on 200 tones capacity Compression Testing Machine (CTM) as per IS: 516 and 1199.

The split tensile strength was determined by using the following formula.

Split tensile Strength (MPa) = 2P / ΠDL

P = Splitting Load in N

D= diameter of cylinder sample (mm)

L = length of cylinder sample (mm).

Fig. 3.2 Splitting Tensile Testing Machine

3.4.1.3 Flexural Strength Test

All the beam specimens were tested on a Universal testing machine of 2000 kN capacity in the “Structural Engineering” lab. The testing procedure of all the beam specimens was same. First the beams were cured for a period of 28 days, then its surface was cleaned with the help of sand paper. After this the specimens were given a white wash with an identification number. Such type of specimens enabled to detect cracks during testing at various stages of loading. Two points transverse loading was used to testing the beam specimens for determining Flexural strength.

Fig. 3.3 Flexural strength Testing Machine

3.4.2 Tests on Concrete – Workability

Workability is considered to be that property of plastic concrete which indicates its ability to handle,transport and most importantly, place with a minimum loss of homogeneity. More precisely, it defines that it can be fully compacted with minimum energy input. There should be no sign of any segregation or bleeding in a workable concrete after placing. The workability of all the mixes of concrete used in the present work was controlled by conducting slump test, using slump cone appartus (Fig 3.1). It was observed that the slump value for all the mixes were maintained in the range of 20-80 mm, which is acceptable as per code IS-7320.

Fig. 3.4 Slump cone apparatus

CHAPTER 4

RESULTS AND DISCUSSIONS

4.1 Introduction

The objectives of the present study was to examine the strength properties of concrete at different percentages of Fly Ash and Silica Fume. Properties which have to examined are:

1. Compressive strength
2. Splitting tensile strength
3. Flexural strength
4. Workability of concrete mixes

Compressive Strength test and splitting tensile strength was conducted on a 200T Compression Testing Machine, The detailed analysis and discussion of the test results as obtained from the experimental program is presented in following sections.

4.2 Compressive Strength Test Results

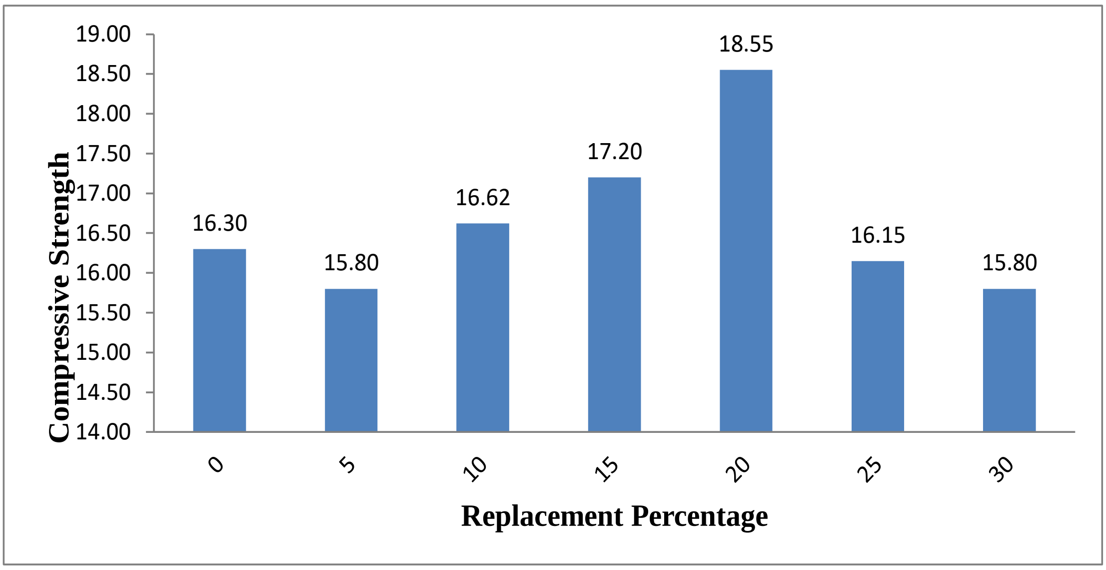
The results of the compressive strength tests conducted on concrete specimens of different mixes cured at different ages are presented and discussed in this section. The compressive strength test were conducted at curing ages of 7, 14, and 28, days. The compressive strength test results of all the mixes at different curing ages are given in Table 4.1. Variation of compressive strength of all the mixes cured at 7, 14, and 28, days are also shown in Graph 4.1, 4.2, & 4.3 shows the variation of compressive strength of concrete mixes w.r.t control mix (100%OPC+0%SF+0%FA) after 7, 14, and 28, days respectively.

Table 4.1 Compressive strength (MPa) results of all mixes at different curing ages

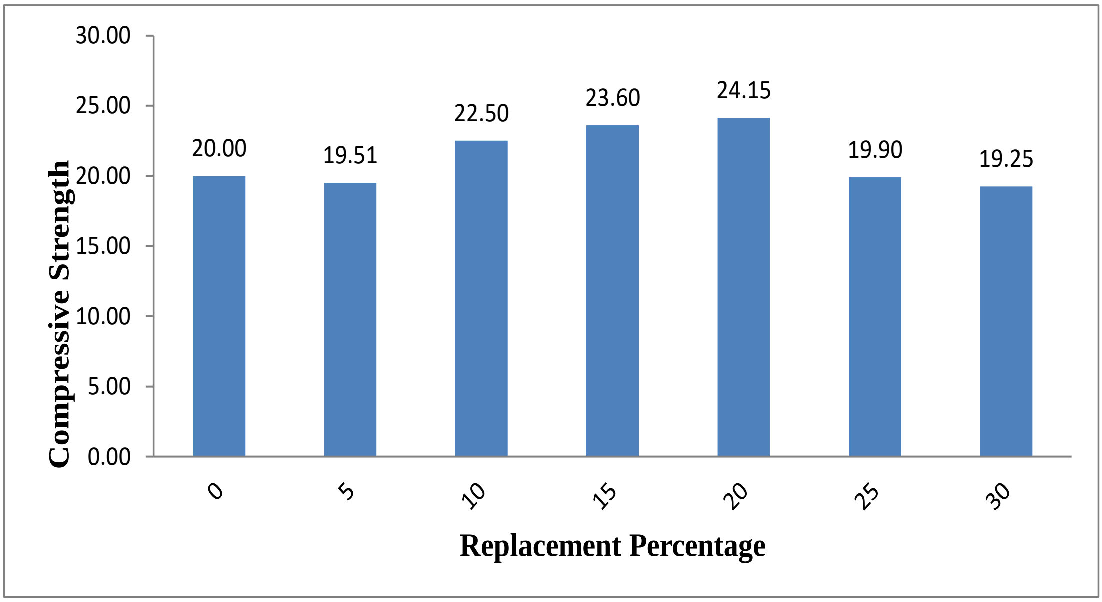
Mix No.	Description-M20	7 days	14 days	28 days
1	**100%OPC+0%FA+0%SF**	16.30	20.00	25.95
2	**95%OPC+5%FA+15%SF**	15.80	19.51	24.16
3	**90%OPC+10%FA+15%SF**	16.62	22.50	26.30
4	**85%OPC+15%FA+15%SF**	17.20	23.60	27.80

5	**80%OPC+20%FA+15%SF**	18.55	24.15	28.46
6	**75%OPC+25%FA+15%SF**	16.15	19.90	25.63
7	**70%OPC+30%FA+15%SF**	15.80	19.25	24.80

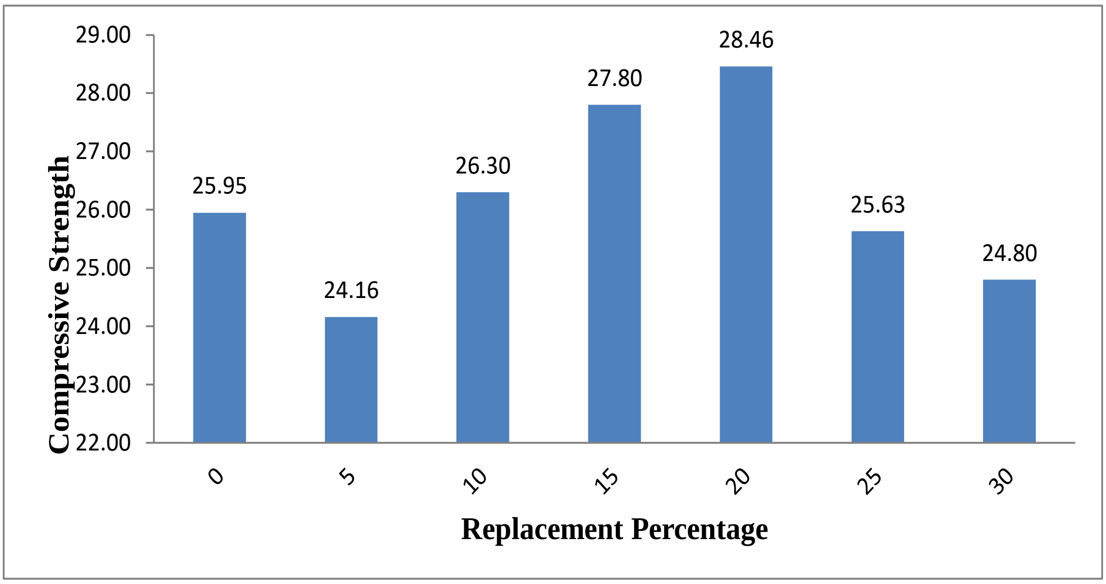
Graph:4.1 Compressive Strength at 7 days for M20



Graph:4.2 Compressive Strength at 14 days for M20



Graph:4.3 Compressive Strength at 28 days for M20



Graph: 4.4 Compressive Strength in N/mm^2 at various ages for M20

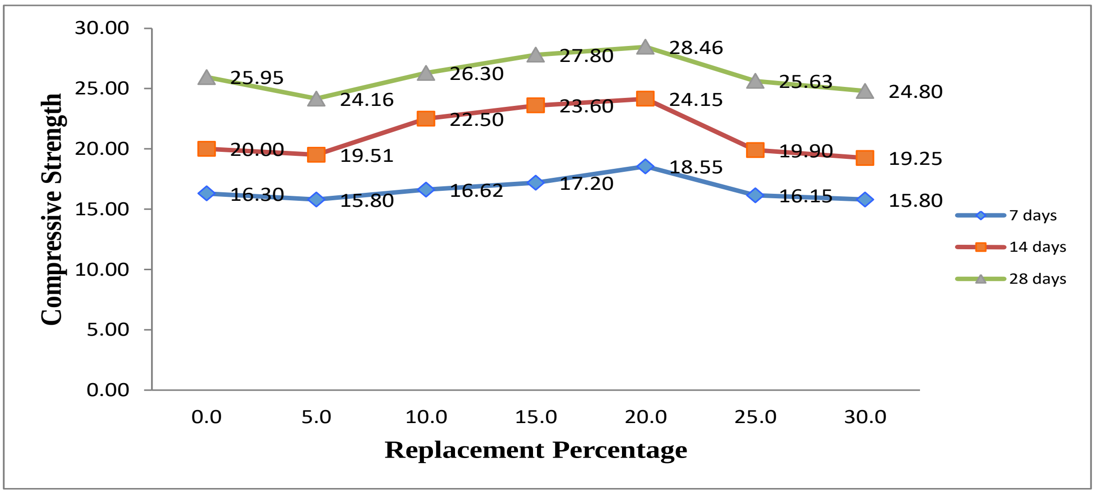
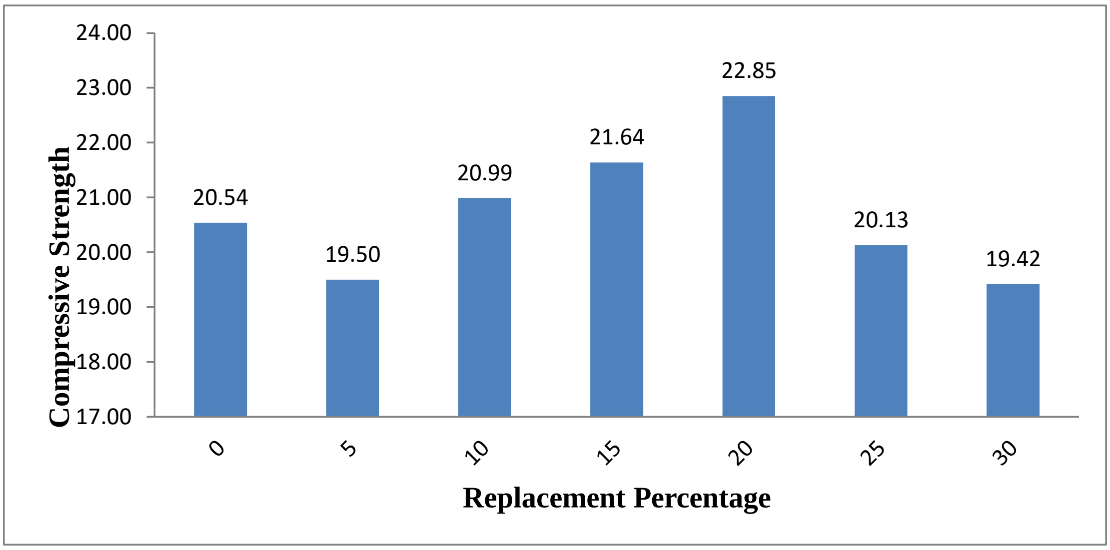


Table 4.2 Compressive strength (MPa) results of all mixes at different curing ages

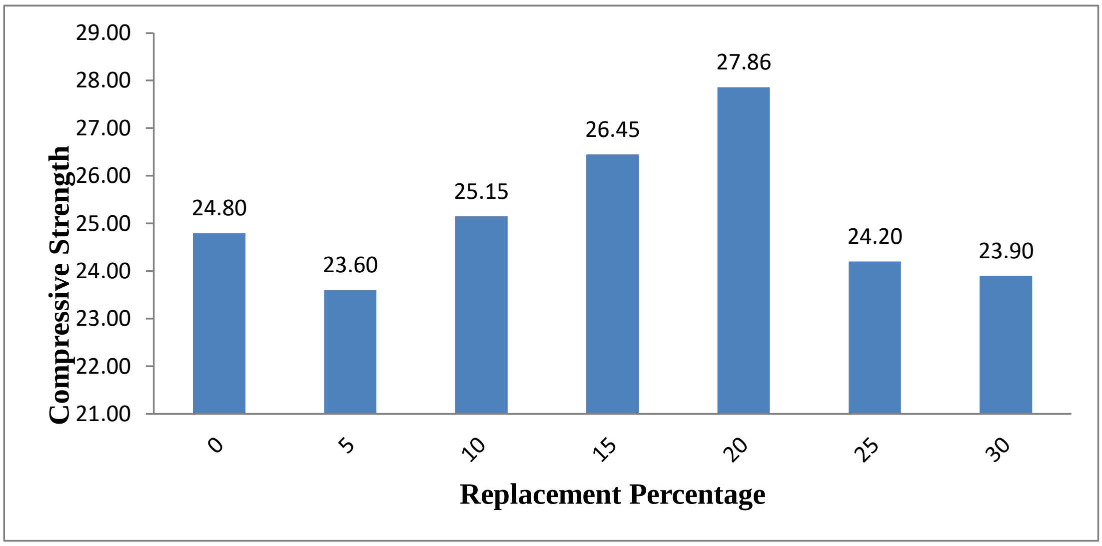
Mix No.	Description-M25	7 days	14 days	28 days
1	**100%OPC+0%FA+0%SF**	20.54	24.80	30.50
2	**95%OPC+5%FA+15%SF**	19.50	23.60	29.43
3	**90%OPC+10%FA+15%SF**	20.99	25.15	30.99

4	**85%OPC+15%FA+15%SF**	21.64	26.45	31.52
5	**80%OPC+20%FA+15%SF**	22.85	27.86	33.20
6	**75%OPC+25%FA+15%SF**	20.13	24.20	30.20
7	**70%OPC+30%FA+15%SF**	19.42	23.90	29.50

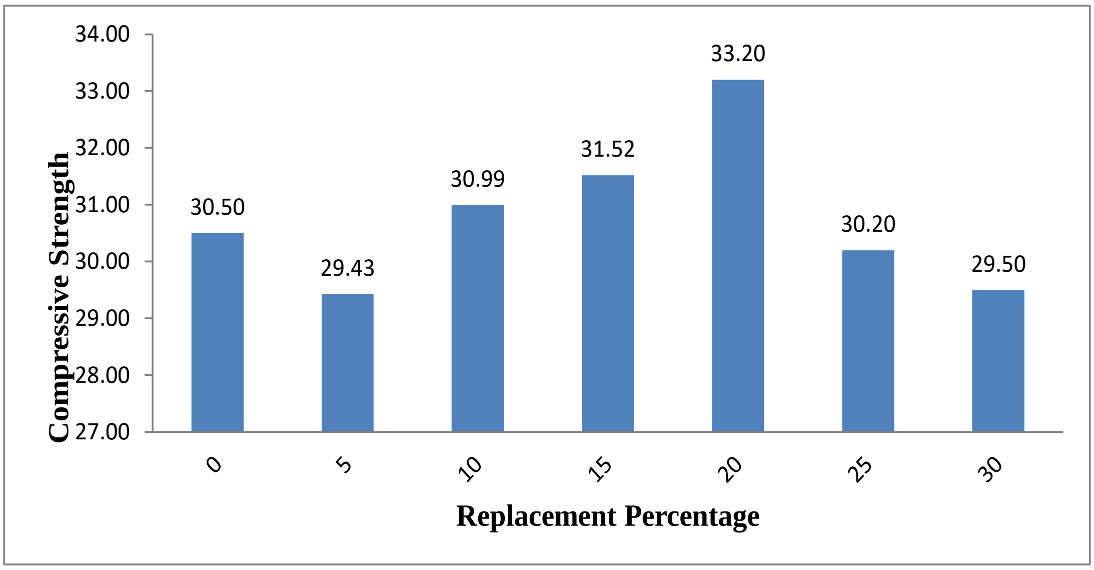
Graph:4.5 Compressive Strength at 7 days for M25



Graph:4.6 Compressive Strength at 14 days for M25



Graph:4.7 Compressive Strength at 28 days for M25



Graph: 4.8 Compressive Strength in N/mm^2 at various ages for M25

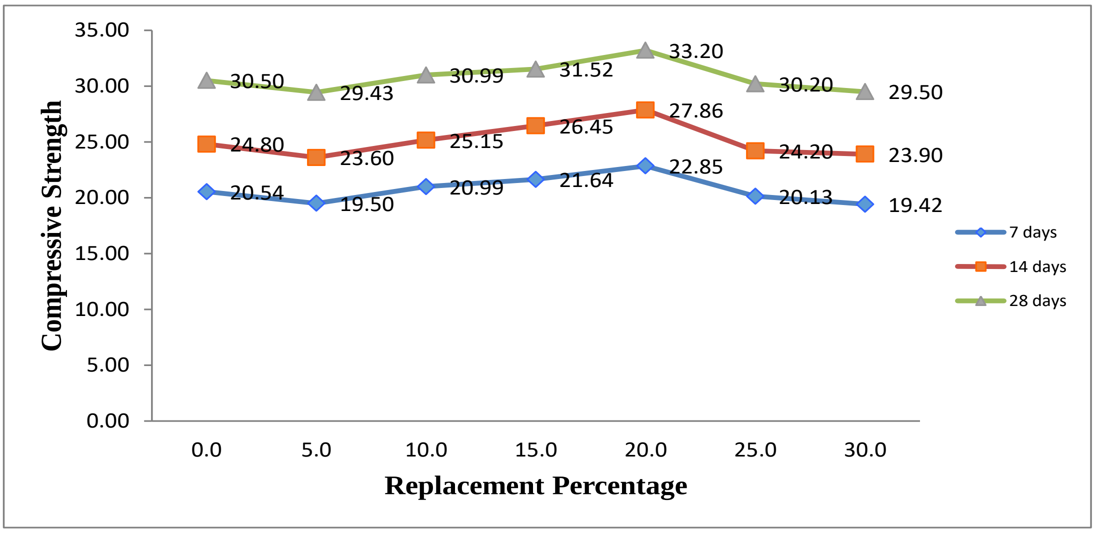
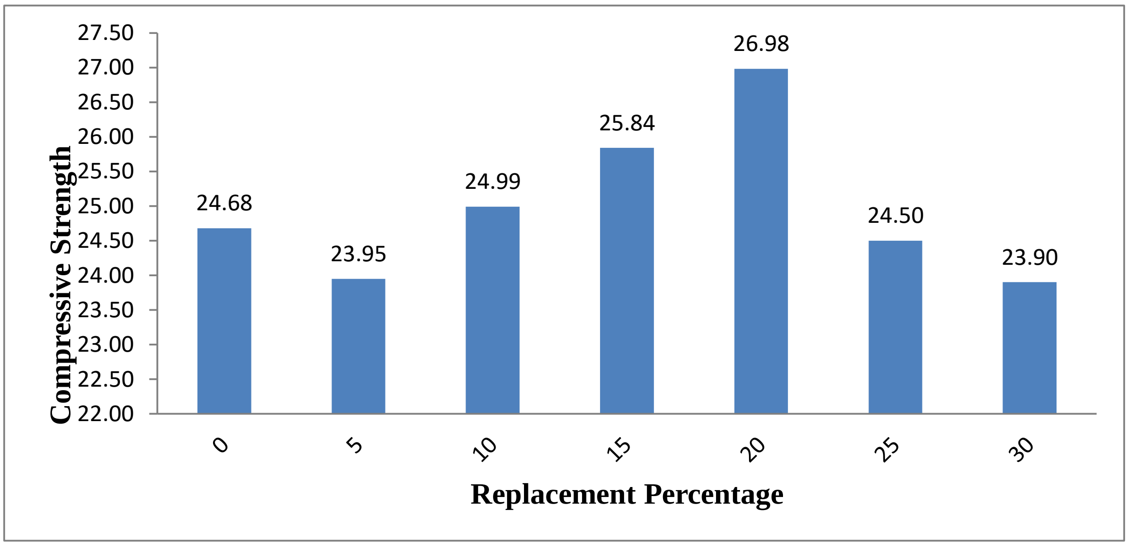


Table 4.3 Compressive strength (MPa) results of all mixes at different curing ages

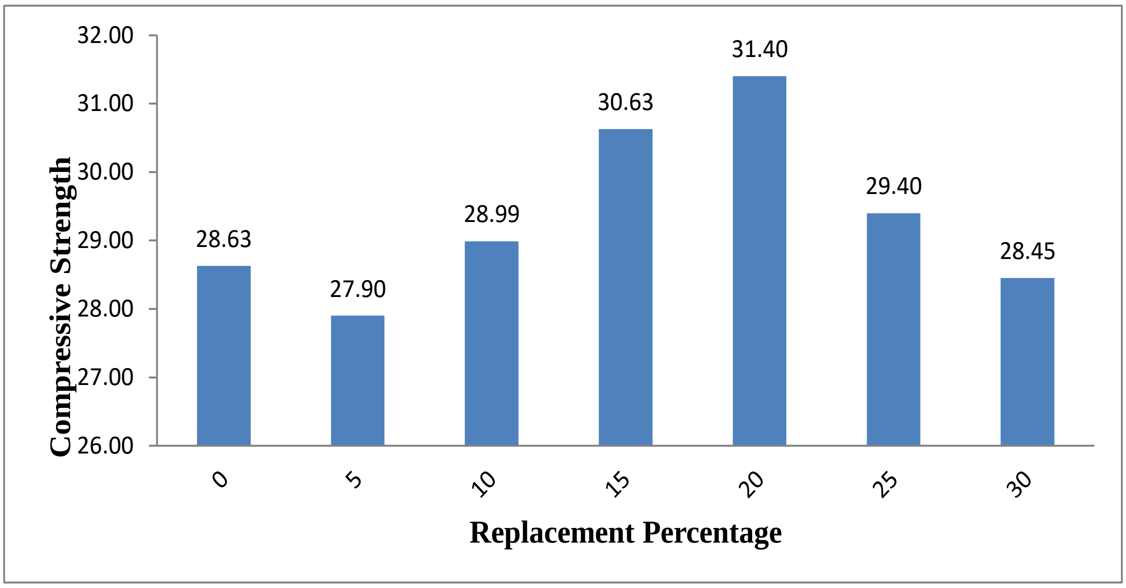
Mix No.	Description-M30	7 days	14 days	28 days
1	**100%OPC+0%FA+0%SF**	24.68	28.63	35.60
2	**95%OPC+5%FA+15%SF**	23.95	27.90	34.90
3	**90%OPC+10%FA+15%SF**	24.99	28.99	36.05

4	**85%OPC+15%FA+15%SF**	25.84	30.63	36.94
5	**80%OPC+20%FA+15%SF**	26.98	31.40	37.00
6	**75%OPC+25%FA+15%SF**	24.50	29.40	35.10
7	**70%OPC+30%FA+15%SF**	23.90	28.45	34.65

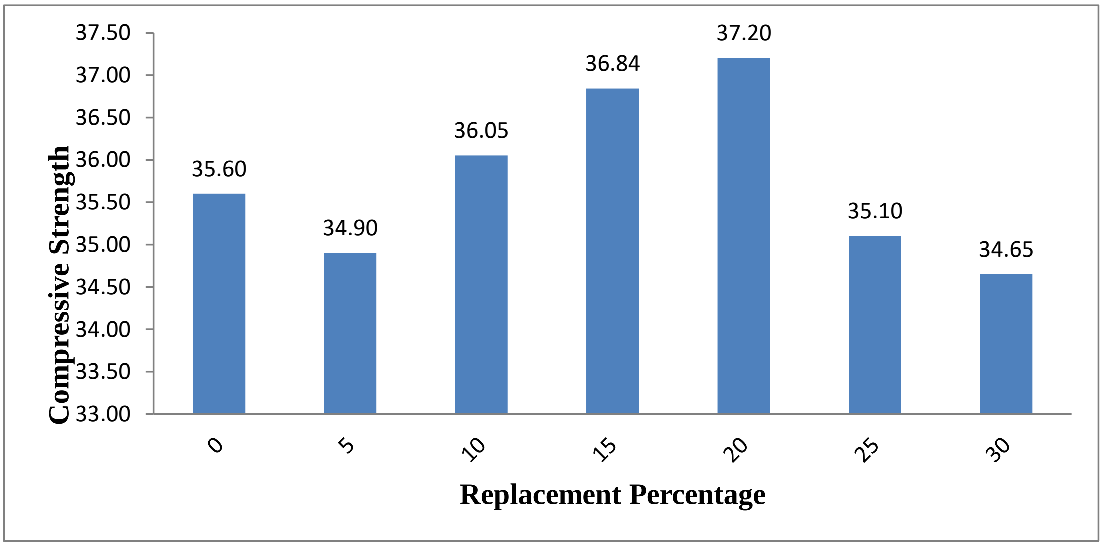
Graph:4.9 Compressive Strength at 7 days for M30



Graph:4.10 Compressive Strength at 14 days for M30



Graph:4.11 Compressive Strength at 28 days for M30



Graph:4.12 Compressive Strength in N/mm^2 at various ages for M30

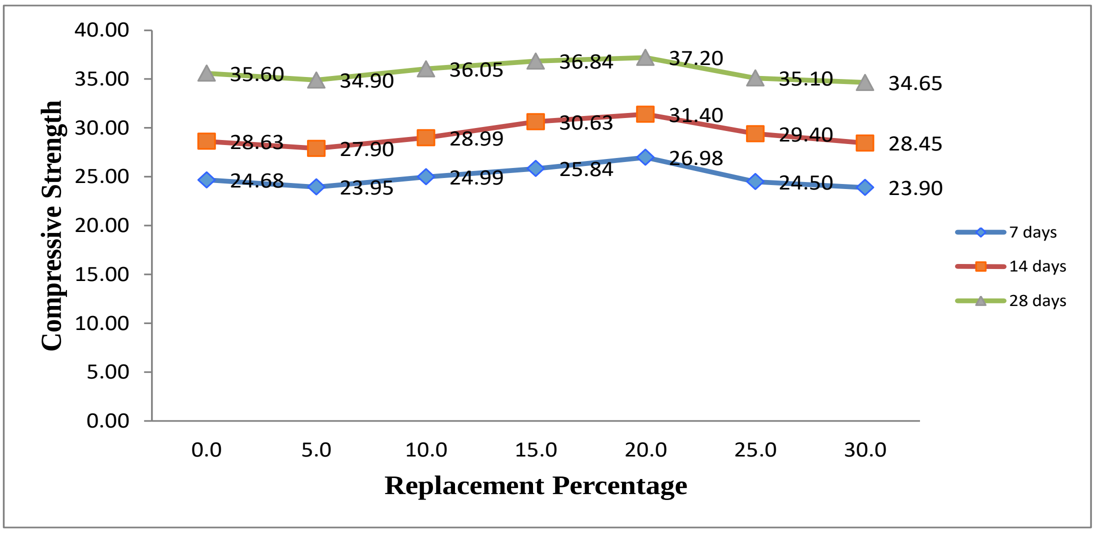


Table 4.1, 4.2 and 4.3 are shows that there is an increase in compressive strength with the increase in Fly Ash percentages upto 20%, thereafter there is a decrease in compressive strength with further increase in Fly Ash in all the curing ages of concrete.

The results of compressive strength for M25 concrete and M30 are given in table 4.2 and 4.3. The variation of compressive strength with replacement percentages Fly Ash is shows in Graph 4.4, 4.8 and 4.12. Again the trend of compressive strength with Fly Ash and Silica Fume is same as for M20 concrete.

4.3Split Tensile Strength Test Results

The results of the splitting tensile strength tests conducted on concrete specimens of different mixes cured at different ages are presented and discussed in this section. The splitting tensile strength test was conducted at curing ages of 28 days. The splitting tensile strength test results of all the mixes are shown in Table 4.4, 4.5 and 4.6. Variation of splitting tensile strength (MPa) with replacement percentage is shown in Graph 4.13, 4.14 and 4.15. Comparison of strength with replacement percentage is shown Graph 4.16.

Table 4.4 Split Tensile Strength (MPa) results of all mixes at 28 days.

Mix No.	Description-M20	28 days
1	**100%OPC+0%FA+0%SF**	3.60
2	**95%OPC+5%FA+15%SF**	3.40
3	**90%OPC+10%FA+15%SF**	3.80
4	**85%OPC+15%FA+15%SF**	4.10
5	**80%OPC+20%FA+15%SF**	4.35
6	**75%OPC+25%FA+15%SF**	3.52
7	**70%OPC+30%FA+15%SF**	3.20

Table 4.5 Split Tensile Strength (MPa) results of all mixes at 28 days.

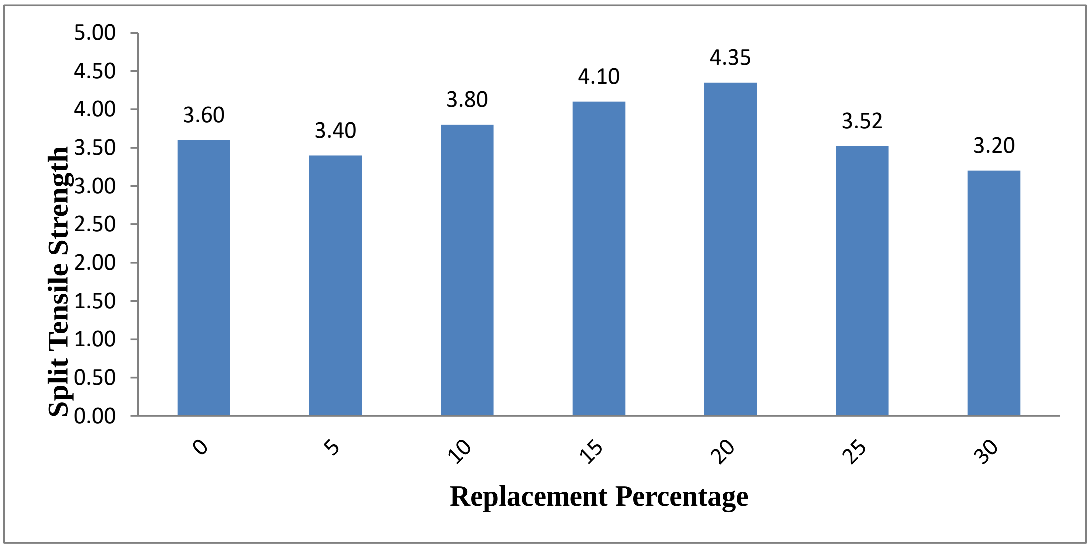
Mix No.	Description-M25	28 days
1	**100%OPC+0%FA+0%SF**	3.92
2	**95%OPC+5%FA+15%SF**	4.00
3	**90%OPC+10%FA+15%SF**	4.11
4	**85%OPC+15%FA+15%SF**	4.36

5	**80%OPC+20%FA+15%SF**	4.60
6	**75%OPC+25%FA+15%SF**	3.80
7	**70%OPC+30%FA+15%SF**	3.40

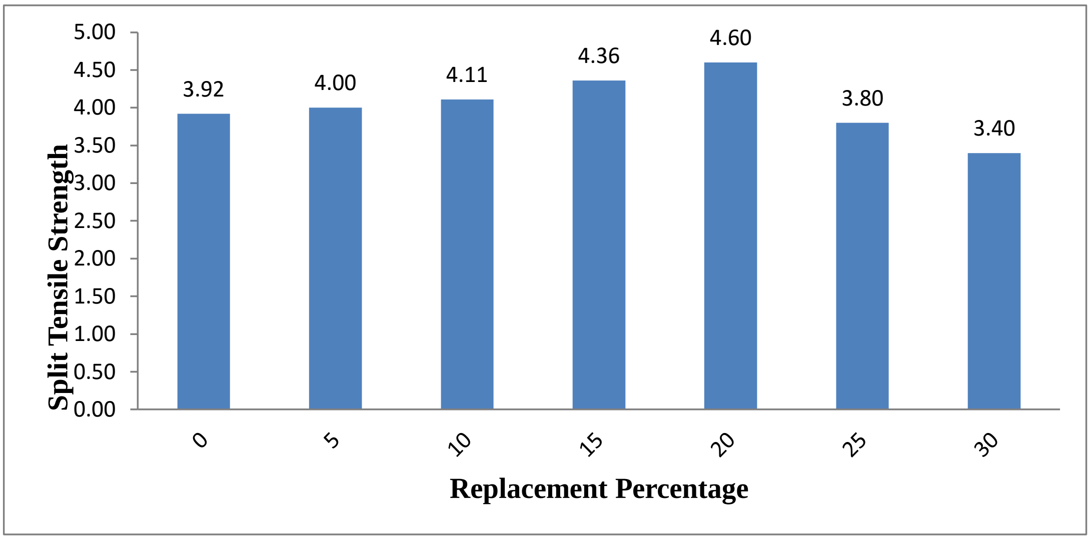
Table 4.6 Split Tensile Strength (MPa) results of all mixes at 28 days.

Mix No.	**Description-M30**	**28 days**
1	**100%OPC+0%FA+0%SF**	4.25
2	**95%OPC+5%FA+15%SF**	4.36
3	**90%OPC+10%FA+15%SF**	4.51
4	**85%OPC+15%FA+15%SF**	4.80
5	**80%OPC+20%FA+15%SF**	5.10
6	**75%OPC+25%FA+15%SF**	4.00
7	**70%OPC+30%FA+15%SF**	3.75

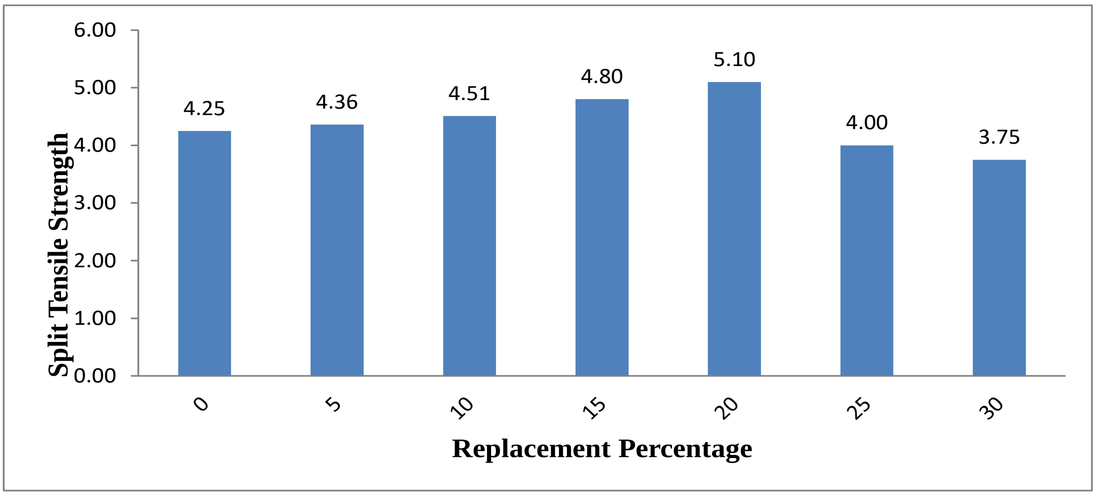
Graph:4.13 Split Tensile Strength at 28 days for M20



Graph:4.14 Split Tensile Strength at 28 days for M25



Graph 4.15 Split Tensile Strength at 28 days for M30



Graph: 4.16 Split Tensile Strength in N/mm^2 at 28 days

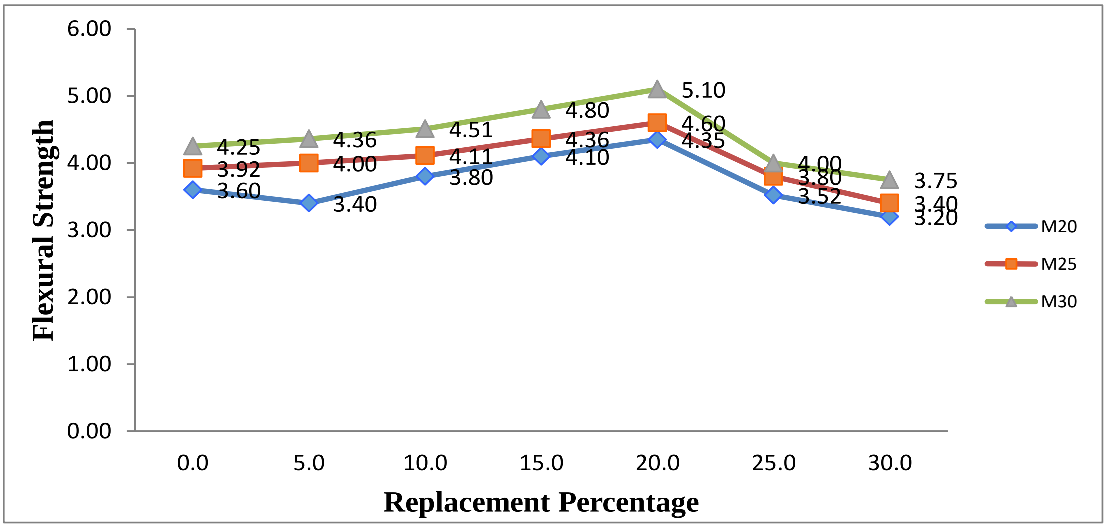


Table 4.4, 4.5 & 4.6 shows that the splitting tensile strength test results of the samples follow an increasing trend till the 20% replacement thereafter there is decrease in the tensile strength. As the percentage replacement of the Fly Ash increases in the mix there is a rising trend in the graph observed in the tensile strength of the mix up to replacement level of 20% and as the percentage replacement increases to 20% there is decrease in the tensile strength observed probably due to an increase in Fly Ash replacement percentage.

4.4 Flexural Strength Test Results

The results of the flexural strength tests conducted on concrete specimens of different mixes cured at different ages are presented and discussed in this section. The flexural strength test was conducted at curing ages of 28 days. The flexural strength test results of all the mixes at different curing ages are shown in Table 4.7, 4.8 and 4.9.Variation of flexural strength of all the mixes cured at 28 days with replacement percentage of fly ash is also shown in Graph 4.17,4.18 and 4.19.

Table 4.7 Flexural Strength (MPa) results of all mixes at 28 days

Mix No.	Description-M20	28 days
1	**100%OPC+0%FA+0%SF**	3.10
2	**95%OPC+5%FA+15%SF**	3.25
3	**90%OPC+10%FA+15%SF**	3.58
4	**85%OPC+15%FA+15%SF**	3.98
5	**80%OPC+20%FA+15%SF**	4.35
6	**75%OPC+25%FA+15%SF**	3.05
7	**70%OPC+30%FA+15%SF**	2.87

Table 4.8 Flexural Strength (MPa) results of all mixes at 28 days

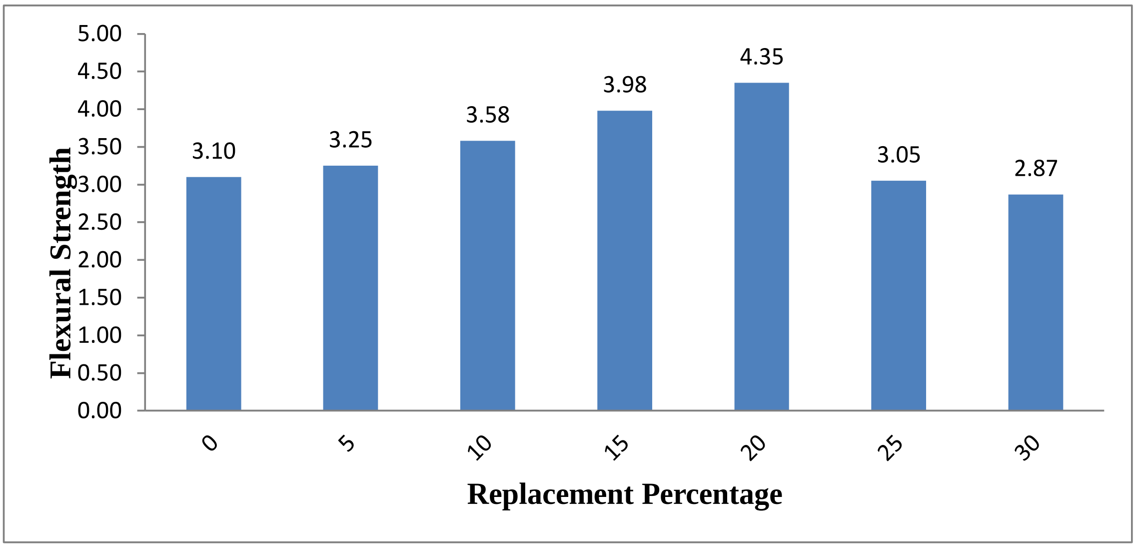
Mix No.	Description-M25	28 days
1	**100%OPC+0%FA+0%SF**	3.64
2	**95%OPC+5%FA+15%SF**	3.73
3	**90%OPC+10%FA+15%SF**	4.04
4	**85%OPC+15%FA+15%SF**	4.46
5	**80%OPC+20%FA+15%SF**	4.70
6	**75%OPC+25%FA+15%SF**	3.46
7	**70%OPC+30%FA+15%SF**	3.10

Table 4.9 Flexural Strength (MPa) results of all mixes at 28 days

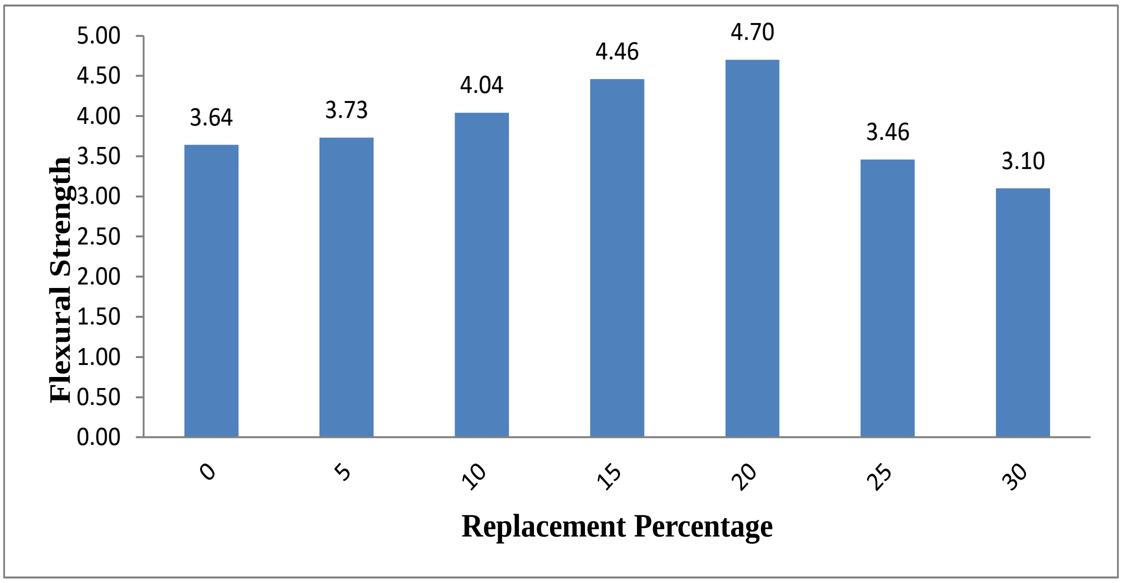
Mix No.	Description-M30	28 days
1	**100%OPC+0%FA+0%SF**	4.17
2	**95%OPC+5%FA+15%SF**	4.22
3	**90%OPC+10%FA+15%SF**	4.50
4	**85%OPC+15%FA+15%SF**	4.90
5	**80%OPC+20%FA+15%SF**	5.02
6	**75%OPC+25%FA+15%SF**	4.10
7	**70%OPC+30%FA+15%SF**	3.85

Table 4.7, 4.8 &4.9 shows that the flexural strength test results of the samples follow an increasing trend till the 20% replacement thereafter there is decrease in the flexural strength. As the percentage replacement of the Fly Ash increases in the mix there is a rising trend in the graph observed in the flexural strength of the mix upto replacement level of 20% and as the percentage replacement increases to 20% there is decrease in the flexural strength observed probably due to an increase in Fly Ash replacement percentage.

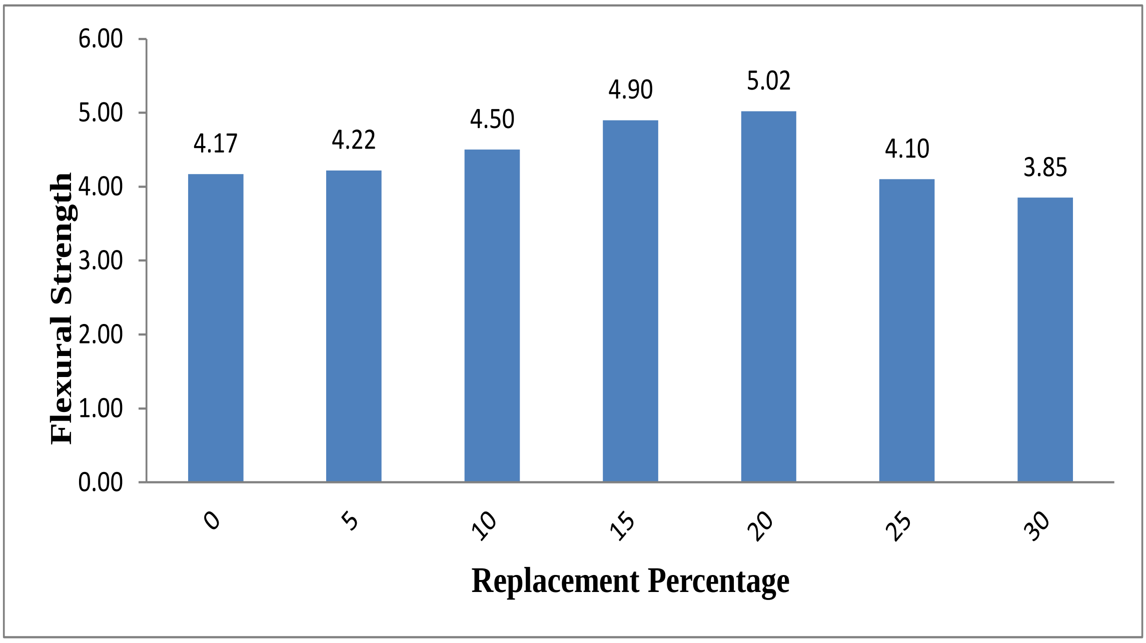
Graph:4.17 Flexural Strength at 28 days for M20



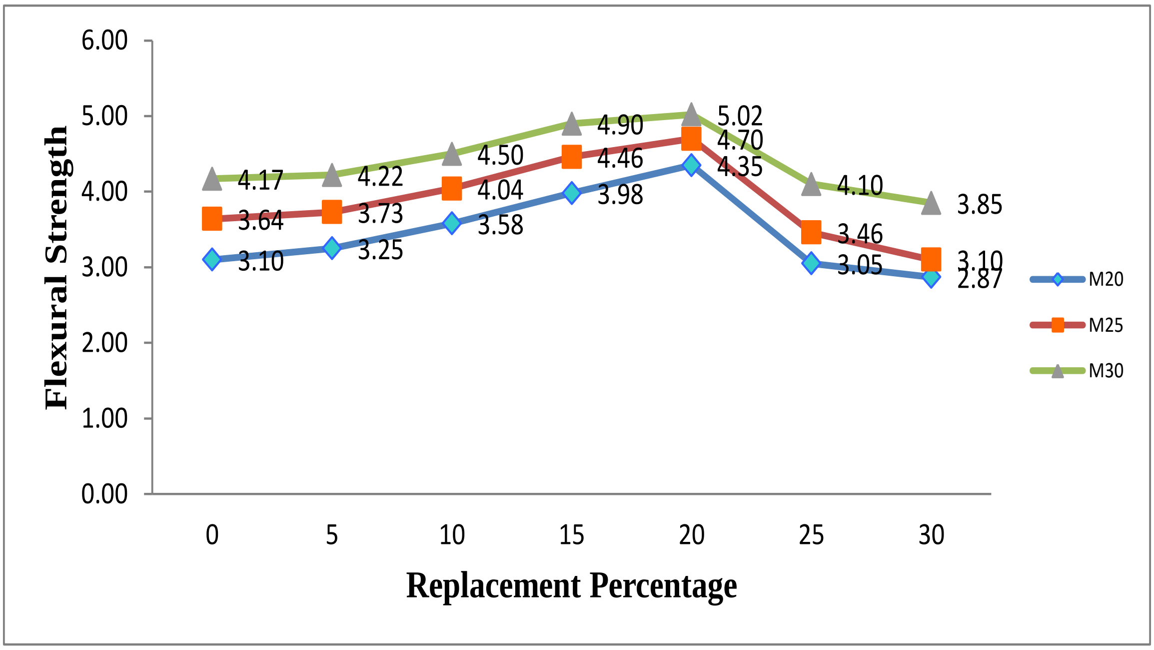
Graph:4.18 Flexural Strength at 28 days for M25



Graph 4.19 Flexural Strength at 28 days for M30



Graph 4.20 Flexural Strength in N/mm^2 at 28 Days



4.5 Workability of Concrete Mixes

The workability of concrete mixes was found out by slump test as per procedure given in chapter 3. Water cement ratio (w/c) was kept constant 0.5 for all the concrete mixes. The workability results of different concrete mixes were shown in Table 4.10, 4.11 and 4.12.

Table 4.10 Workability results of all mixes at 28 days

Mix No.	Description-M20	Slump (mm)
1	**100%OPC+0%FA+0%SF**	72.00
2	**95%OPC+5%FA+15%SF**	64.00
3	**90%OPC+10%FA+15%SF**	59.00
4	**85%OPC+15%FA+15%SF**	53.00
5	**80%OPC+20%FA+15%SF**	44.00
6	**75%OPC+25%FA+15%SF**	32.00
7	**70%OPC+30%FA+15%SF**	27.00

Table 4.11 Workability results of all mixes at 28 days

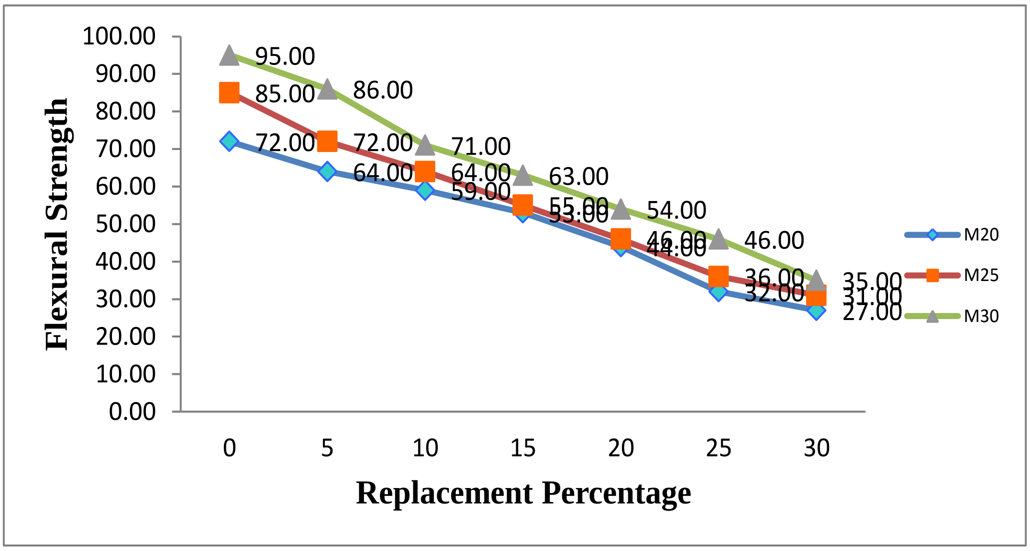
Mix No.	Description-M25	Slump (mm)
1	**100%OPC+0%FA+0%SF**	85.00
2	**95%OPC+5%FA+15%SF**	72.00
3	**90%OPC+10%FA+15%SF**	64.00
4	**85%OPC+15%FA+15%SF**	55.00
5	**80%OPC+20%FA+15%SF**	46.00
6	**75%OPC+25%FA+15%SF**	36.00
7	**70%OPC+30%FA+15%SF**	31.00

Table 4.12 Workability results of all mixes at 28 days

Mix No.	Description-M30	Slump (mm)
1	100%OPC+0%FA+0%SF	95.00
2	95%OPC+5%FA+15%SF	86.00
3	90%OPC+10%FA+15%SF	71.00
4	85%OPC+15%FA+15%SF	63.00
5	80%OPC+20%FA+15%SF	54.00
6	75%OPC+25%FA+15%SF	46.00
7	70%OPC+30%FA+15%SF	35.00

Graph 4.21 shows that as the Fly Ash in percentage to concrete mix increases, the workability of concrete mix was found to decreases as compared to control mix (fresh concrete) of Fly Ash into concrete mix further decreases the workability. The same trend was observed in other concrete mix.

Graph 4.21 Slump (mm) at 28 days



CHAPTER 5

CONCLUSIONS AND FUTURE SCOPE

5.1 Conclusion

Compressive strength, Flexural strength, and Split tensile strength of concrete Mixes made with and without Fly Ash and Silica Fume has been determined at 7, 14, & 28 days of curing. The strength gained has been determined of Fly Ash and Silica Fume added concrete with addition of 0%, 5%, 10%, 15%, 20%, 25% & 30% and 15% Fly Ash and Silica Fume added as a common for all replacement for M20, M25 and M30 grade as a partial replacement of cement in conventional concrete. From the results it is conclude that the Fly Ash and Silica Fume is a superior replacement of cement. The rate of strength increase in Fly Ash and Silica Fume concrete is high. After performing all the tests and analyzing their result, the following conclusions have been derived:

1. The results achieved from the existing study shows that the combination of Fly Ash and Silica Fume are great potential for the utilization in concrete as replacement of cement.
2. Workability of concrete decreases as proportion of Fly Ash and Silica Fumes increases.
3. Maximum compressive strength was observed when Fly Ash and Silica Fume replacement is about 20% and 15% respectively.
4. Maximum split tensile strength was observed when Fly Ash and Silica Fume replacement are about 20% and 15% respectively.
5. Maximum flexural strength was observed when Fly Ash and Silica Fume replacement are about 20% and 15% respectively.

5.2 Recommendations for Future Research

From this research, there are few recommendations to develop, to extend and to explore the usage of Fly Ash and Silica Fume in concrete:

i.) Define the effect of Fly Ash and Silica Fume on concrete with the replacement of mixture of coarse and fine aggregate.

ii.) Define the effect of Fly ash on concrete with the replacement of mixture of coarse and fine aggregate.

ii.) Replacement of cement with Fly Ash and Silica Fume in different water cement ratio.

iii.) Selected few samples of concrete with different percentage of usingFly Ash and Silica Fume and conclude the most suitable percentage of usage to achieve the optimum compressive strength.

CHAPTER 6

REFERENCES

1. ACI committee 544. 1982. State-of-the-report on Fly Ash and Silica Fume reinforced concrete, (ACI 544.1R-82), Concrete International: Design and Construction. 4(5): 9-30, American Concrete Institute, Detroit, Michigan, USA.
2. ACI Committee 544. 1989. Measurement of properties Fly Ash and Silica Fumes reinforced concrete, (ACI 544.2R-889). American Concrete Institute, Detroit, Michigan, USA.
3. ASTM C 1240-11 "standard specification for Fly Ash and Silica Fume used in cementitious mixtures".
4. Bhanja, S., B. Sengupta, b., (2003) "Modified water- cement ratio law for Fly Ash and Silica Fume concretes ". Cement and Concrete research, 33, pp 447-450.
5. Mohamed s. Morsy, Sayed s. Shebl, Effect of Fly Ash and Silica Fume and metakaolinepozzolana on the performance of blended cement pastes against fire, Ceramics - Silikáty 51 (1) 40-44 (2007).
6. S. Vishal, Ghutke1, Bhandari S. Pranita (2014) . Influence of Fly Ash and Silica Fume on concrete. IOSR Journal of Mechanical and Civil Engineering (IOSR-JMCE). PP 44-47(2014).
7. Zain, M.F.M., Safiuddin, Md. And Mahmud, H.(2000) "Development of high performance concrete using Fly Ash and Silica Fume at relatively high water-binder ratios", Cement and Concrete Research, Vol.30,pp 1501-1505.
8. Pradhan D, Dutta. D. (2013). Influence of Fly Ash and Silica Fume on Normal Concrete. Int. Journal of Engineering Research and Applications Vol. 3, pp.79-82.
9. Amudhavalli N. K., Mathew Jeena. **(2012**)Effect of Fly Ash and Silica Fume on strength and durability parameters of concrete.International Journal of Engineering Sciences & Emerging Technologies.Volume 3, Issue 1, pp: 28-35.
10. Karein S. Mahmoud Motahari ,Ramezanianpour A.A. , TaghiEbadi , IsapourSoroush , (2017) A new approach for application of Fly Ash and Silica Fume in concrete: Wet Granulation.Construction and Building Materials page573–581.

11. Zhang Zengqi , Zhang Bo , Yan Peiyu (2016) Comparative study of effect of raw and densifiedFly Ash and Silica Fume in the paste,mortar and concrete. Construction and Building Materials 105 .page 82–93.
12. Khan M.I, Abbas Y.M. (2017) Curing optimization for strength and durability of Fly Ash and Silica Fume and fuel ash concretes under hot weather conditions.Construction and Building Materials 157 (page) 1092–1105.
13. Okoye Francis N, PrakashSatya , Singh Nakshatra B. (2017) Durability of fly ash based geopolymer concrete in the presence of Fly Ash and Silica Fume.Journal of Cleaner Production 149. (Page) 1062-1067.
14. Ali K., Ghalehnovi .M ,Brito J. de , Shamsabadi E. A, (2017) Durability performance of structural concrete containing Fly Ash and Silica Fume and marble industry waste powder.Journal of Cleaner Production 170 (page) 42and60.
15. Siddique R, Jameel A, Singh M. ,Hunek .D. B , Mokhtar A. A. , Belarbi. R., Rajor. A. (2017) Effect of bacteria on strength, permeation characteristics and micro-structure of Fly Ash and Silica Fumeconcrete.Construction and Building Materials 142 (Page) 92–100.
16. Wang. L. , Zhou S.H. , Y. Shi , Tang S.W. , Chen E.(2017) Effect of Fly Ash and Silica Fume and PVA fiber on the abrasion resistance and volume stability of concrete. Composites Part B 130. (page) 28 and 37.
17. Pedro D., de Brito J., Evangelista L. (2017) Evaluation of high-performance concrete with recycled aggregates: Use of densifiedFly Ash and Silica Fume as cement replacement. Construction and Building Materials 147 (page) 803–814.
18. Dave N , Mishra A K , Srivastava A. , Kaushik S K. (2016). Experimental analysis of strength and durability properties of quaternary cement binder and mortar. Construction and Building Materials 107 (page) 117–124.
19. Ju Y., Tian K., Liu H. , Reinhardt H.W , Wang L.(2017). Experimental investigation of the effect of Fly Ash and Silica Fumes on the thermal spalling of reactive powder concrete.Construction and Building Materials 155 (page) 571–583.
20. Palla R., Karade S.R., Mishra G., Sharma U., Singh L.P. (2017). High strength sustainable concrete using silica nanoparticles. Construction and Building Materials 138. (Page) 285–295.

21. Dybel P., Furtak K. (2017) Influence of Fly Ash and Silica Fume content on the quality of bond conditions in high-performance concrete specimens. Archives of civil and mechanical engineering 17 (page) 795 – 805.
22. Liu J., Wang D. (2017) Influence of steel slag-Fly Ash and Silica Fume composite mineral admixture on the properties of concrete. Powder Technology 320 (page) 230–238.
23. Kawabata Y., Seignol J.F., Martin R.P., Toutlemonde F. (2017).Macroscopic chemomechanical modelling of alkali-silica reaction of concrete under stresses. Construction and Building Materials 137 (page) 234–245.
24. Fathi M., Yousefipour A., Farokhy E. H. (2017). Mechanical and physical properties of expanded polystyrene structural concretes containing Micro-silica and Nano-silica. Construction and Building Materials 136 (page) 590–597.
25. Pedro D., de Brito J., Evangelista L. (2017). Mechanical characterization of high performance concrete prepared with recycled aggregates and Fly Ash and Silica Fume from precast industry. Journal of Cleaner Production 164 (page) 939 and 949.
26. Zhang N., Li H., Peng D., Liu X. (2016). Properties evaluation of silica-alumina based concrete: Durability and environmental friendly performance. Construction and Building Materials 115 (page) 105–113.
27. Adak D., SarkarM. ,Mandal S.(2017) Structural performance of nano-silica modified fly-ash based geopolymer concrete. Construction and Building Materials 135 (page) 430–439.
28. Kumar R., Singh S., Singh L.P. (2017) Studies on enhanced thermally stable high strength concrete incorporating silica nanoparticles. Construction and Building Materials 153 (page) 506–513.
29. Maruyama I., Teramoto A. (2013). Temperature dependence of autogenous shrinkage of Fly Ash and Silica Fume cement pastes with a very low water–binder ratio. Cement and Concrete Research 50 (page) 41–50.
30. Abdou M.I., Abuseda H. (2016) Upgrading offshore pipelines concrete coated by Fly Ash and Silica Fume additive against aggressive mechanical laying and environmental impact. Egyptian Journal of Petroleum (page) 25, 193–199.

31. Rostami M., Behfarnia K. (2017). The effect of Fly Ash and Silica Fume on durability of alkali activated slag concrete. Construction and Building Materials 134 (page) 262–268.
32. Nattaj F. H., Nematzadeh M. (2017).The effect of forta-ferro and steel fibers on mechanical properties of high-strength concrete with and without Fly Ash and Silica Fume and nano-silica. Construction and Building Materials 137 (page) 557–572.
33. Indian Standard IS: 516-1959, bureau of India standards, ManakBhawan, 9 BahadurShahZafarMarg, New Delhi 110002.
34. Indian Standard IS 383-1970, Bureau of India Standards, ManakBhawan, 9 BahadurShahZafarMarg, New Delhi 110002.
35. Indian Standard IS: 10262-2009, Bureau of India Standards, ManakBhawan, 9Bahadur Shah ZafarMarg, New Delhi 110002.
36. Indian Standard IS: 4031-1988, Bureau of India Standards, ManakBhawan, 9Bahadur Shah ZafarMarg, New Delhi 110002.
37. Indian Standard IS: 1489-1991(Part-1), Bureau of India Standards, ManakBhawan, 9Bahadur Shah ZafarMarg, New Delhi 110002.
38. Indian Standard IS 456-2000, Bureau of India Standards, ManakBhawan, 9 BahadurShahZafarMarg, New Delhi 110002.
39. Leemann A. (2017) Raman microscopy of alkali-silica reaction (ASR) products formed in Concrete. Cement and Concrete Research 102 (2017) 41-48.
40. Ewais E.M.M., Khalil N.M., Amin M.S., Ahmed Y.M.Z., Barakat M.A. (2009). Utilization of aluminum sludge and aluminum slag (dross) for the manufacture of calcium aluminate cement. Ceramics International 35 (page) 3381–3388.
41. Palla R., Karade S.R., Mishra G., Sharma U., Singh L.P. (2017). High strength sustainable concrete using silica nanoparticles. Construction and Building Materials 138. (Page) 285–295.
42. Dybel P., Furtak K. (2017) Influence of Fly Ash and Silica Fume content on the quality of bond conditions in high-performance concrete specimens. Archives of civil and mechanical engineering 17 (page) 795 – 805.
43. Liu J., Wang D. (2017) Influence of steel slag-Fly Ash and Silica Fume composite mineral admixture on the properties of concrete. Powder Technology 320 (page) 230–238.

44. Kawabata Y., Seignol J.F., Martin R.P., Toutlemonde F. (2017).Macroscopic chemomechanical modelling of alkali-silica reaction of concrete under stresses. Construction and Building Materials 137 (page) 234–245.
45. Fathi M., Yousefipour A., Farokhy E. H. (2017). Mechanical and physical properties of expanded polystyrene structural concretes containing Micro-silica and Nano-silica. Construction and Building Materials 136 (page) 590–597.
46. Pedro D., de Brito J., Evangelista L. (2017). Mechanical characterization of high performance concrete prepared with recycled aggregates and Fly Ash and Silica Fume from precast industry. Journal of Cleaner Production 164 (page) 939 and 949.
47. Zhang N., Li H., Peng D., Liu X. (2016). Properties evaluation of silica-alumina based concrete: Durability and environmental friendly performance. Construction and Building Materials 115 (page) 105–113.
48. Adak D., SarkarM. ,Mandal S.(2017) Structural performance of nano-silica modified fly-ash based geopolymer concrete. Construction and Building Materials 135 (page) 430–439.
49. Kumar R., Singh S., Singh L.P. (2017) Studies on enhanced thermally stable high strength concrete incorporating silica nanoparticles. Construction and Building Materials 153 (page) 506–513.
50. Maruyama I., Teramoto A. (2013). Temperature dependence of autogenous shrinkage of Fly Ash and Silica Fume cement pastes with a very low water–binder ratio. Cement and Concrete Research 50 (page) 41–50.
51. Abdou M.I., Abuseda H. (2016) Upgrading offshore pipelines concrete coated by Fly Ash and Silica Fume additive against aggressive mechanical laying and environmental impact. Egyptian Journal of Petroleum (page) 25, 193–199.
52. Rostami M., Behfarnia K. (2017). The effect of Fly Ash and Silica Fume on durability of alkali activated slag concrete. Construction and Building Materials 134 (page) 262–268.
53. Nattaj F. H., Nematzadeh M. (2017).The effect of forta-ferro and steel fibers on mechanical properties of high-strength concrete with and without Fly Ash and Silica Fume and nano-silica. Construction and Building Materials 137 (page) 557–572.

54. Indian Standard IS: 516-1959, bureau of India standards, ManakBhawan, 9 BahadurShahZafarMarg, New Delhi 110002.
55. Indian Standard IS 383-1970, Bureau of India Standards, ManakBhawan, 9 BahadurShahZafarMarg, New Delhi 110002.
56. Indian Standard IS: 10262-2009, Bureau of India Standards, ManakBhawan, 9Bahadur Shah ZafarMarg, New Delhi 110002.
57. Indian Standard IS: 4031-1988, Bureau of India Standards, ManakBhawan, 9Bahadur Shah ZafarMarg, New Delhi 110002.
58. Indian Standard IS: 1489-1991(Part-1), Bureau of India Standards, ManakBhawan, 9Bahadur Shah ZafarMarg, New Delhi 110002.
59. Indian Standard IS 456-2000, Bureau of India Standards, ManakBhawan, 9 BahadurShahZafarMarg, New Delhi 110002.
60. Leemann A. (2017) Raman microscopy of alkali-silica reaction (ASR) products formed in Concrete. Cement and Concrete Research 102 (2017) 41-48.
61. Ewais E.M.M., Khalil N.M., Amin M.S., Ahmed Y.M.Z., Barakat M.A. (2009). Utilization of aluminum sludge and aluminum slag (dross) for the manufacture of calcium aluminate cement. Ceramics International 35 (page) 3381–3388.

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https://precast.org/2010/05/using-fly-ash-in-concrete/
http://citeseerx.ist.psu.edu/viewdoc/download?doi=10.1.1.429.360&rep=rep1&type=pdf
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https://www.ijert.org/research/experimental-study-on-the-mechanical-properties-of-concrete-using-micro-silica-and-nano-silica-a-step-towards-sustainability-IJERTV5IS110315.pdf
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1 CHAPTER 1 INTRODUCTION 1.1

Introduction Concrete is a most commonly used building material which is a mixture of cement, sand, coarse aggregate and water.

It is used for construction of multi-storey buildings, dams, road pavement, tanks, offshore structures, canal lining. The method of selecting appropriate ingredients of concrete and determining their relative amount with the intention of producing a concrete of the necessary strength durability and workability as efficiently as possible is termed the concrete mix design. The compressive strength of harden concrete is commonly considered to be an index of its extra properties depends upon a lot of factors e.g. worth and amount of cement water and aggregates batching and mixing placing compaction and curing. The cost of concrete prepared by the cost of materials plant and labour the variation in the cost of material begin from the information that the cement is numerous times costly than the aggregates thus the intent is to produce a mix as feasible from the practical point of view the rich mixes may lead to high shrinkage and crack in the structural concrete and to development of high heat of hydration is mass concrete which may cause cracking.

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The genuine cost of concrete is related to cost of materials essential for produce a minimum mean strength

called characteristic

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strength that is specific by designer of the structures. This depends on the quality control measures

but there is no doubt that quality control add to the cost of concrete.

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The level of quality control is often an inexpensive cooperation and depends on the size and type of job nowadays engineers and scientists are trying to enhance the strength of concrete by adding the several other economical and waste material as a partial substitute of cement or as a admixture fly ash, Glass Powder, steel slag etc are the few examples of these types of

materials. These materials are generally by-product from further industries for example fly ash is a waste product from power plants and Glass Powder

is a by-product

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resulting from decrease of high purity quartz

by

coal or coke

and wood chips

in an electric arc furnace during production of silicon metal or ferrosilicon alloys

but nowadays Glass Powder is used in large amount because it enhances the property of concrete.

2 1.2Material used 1.2.1 Sand 1.2.2 Cement (OPC 53 Grade) 1.2.3. Aggregate 1.2.4 Silica Fume 1.2.5Fly Ash 1.2.1

Sand Sand is a naturally occurring coarse material collected of finely separated rock and mineral particles. It is defined by size, being finer than gravel and coarser than silt. Sand may also consign to a textural class of soil or soil type; i.e. a soil contain more than 85% sand-sized particle (by mass).

In terms of particle size as used by geologists, sand particle range in diameter as of 0.0625 mm to 2 mm. An individual particle in this range size is termed a sand grain. Sand grains are among gravel (with particles ranging from 2 mm up to 64 mm) and silt(particles smaller than 0.0625 mm down to 0.004 mm). The dimension specification between sand and gravel has remained even for other than a century, but particle diameter as small as 0.02 mm be considered sand under the Albert Atterberg standard in utilize during the early on 20th century. A 1953 engineering standard published by the American Association of State Highway and Transportation Officials set the least sand size at 0.074 mm. A 1938 specification of the United States Department of Agriculture was 0.05 mm. Sand feel granular when rubbed between the fingers (silt, by comparison, feels like flour). Fig. 1.1 - Sand

3 1.2.2

Cement Ordinary Portland cement is used to prepare the mix design of M-20, M-40 and M-50 grade. The cement used was fresh and without any lumps water-cement ratio is 0.42 for this mix design using IS 456:2007.Cement is an extremely ground material having adhesive and cohesive properties which provide a binding medium for the discrete ingredients. Chemically cement constitutes 60-67% Lime (CaO), 17-25% Silica (SiO 2), 3-8% Alumina (Al 2 O 3), 0.5-6% Iron Oxide (Fe 2 O 3), 0.1-6% Magnesia (MgO), 1-3% Sulphur Trioxide (SO 3), 0.5-3% Soda And Potash (Na 2 O+K 2 O).

Fig. 1.2 - Cement 1.2.3

Aggregate Aggregate are the essential constituent in concrete. They provide body to the concrete, decrease shrinkage and effect economy. Construction aggregate, or basically “Aggregate”, is a wide group of coarse particulate material used in construction, as well as sand, gravel, crushed stone, slag, recycled concrete and geo-synthetic aggregates. Aggregates are the mainly mine material in the world.

Aggregates are an element of composite materials such as concrete and asphalt concrete; the aggregate serve as reinforcement to add strength to the overall combined material. Due to the comparatively high hydraulic conductivity value as compare to most soils, aggregates are generally used in drainage applications such as foundation and French drains, septic drain fields, retaining wall drains, and road side edge drains. Aggregates used as support material under foundations, roads, and railroads.

4 Fig. 1.3 –Aggregate 1.2.4

Silica Fume

Silica Fume

is a byproduct in the decrease of high-purity quartz with coke in electric arc furnaces in the manufacture of silicon

and ferrosilicon

alloys.

Micro silica

consist of fine particle with a surface area on the order of 215,280 ft^2/lb (20,000 m^2/kg) when precise by nitrogen adsorption techniques, with particle just about one hundredth the size of the average cement

Because of its excessive fineness and high silica content, micro silica is a very efficient pozzolanic material

particle.

Micro silica is added to Portland cement concrete to enhance its properties, in particular its compressive strength, bond strength, and abrasion resistance. These improvement stems from both the mechanical improvements resulting from addition of a extremely fine particle to the cement paste mix as well as from the pozzolanic reactions between the micro silica and liberated calcium hydroxide in the paste.

0: https://www.ijraset.com/fileserve.php?FID=19456 72%

Addition of Silica Fume also decrease the permeability of concrete to chloride ions, which protect the reinforcing steel of concrete from corrosion,

especially in chloride-rich environment such as coastal region. While Silica Fume is incorporated, the rate of cement hydration increases at the early hours due to the liberate of OH ÿ ions and alkalis into the pore fluid. It has been reported that the pozzolanic reaction of Silica Fume is very significant and the no evaporable water content decreases between 90 and 550 days at low water /binder ratios with the addition of Silica Fume.

5 Fig. 1.4 - Fly Ash and Silica Fume

0: https://www.ijrte.org/wp-content/uploads/papers/v7i6c2/F10850476C219.pdf 52%

Table 1.1 –Physical Properties of Silica Fume Properties Observed Values Colour Dark grey Specific gravity 2.2 Fineness modulus 20000m 2 /kg Bulk

Modulus 240kg/m 3 Table 1.2 –Chemical Properties of Silica Fume Properties Observed value

0: https://etd.ohiolink.edu/!etd.send_file?accession=dayton1544644895468858&disposition=inline 80%

Sio2 90-96% Al2o3 0.6 -3.0% Fe2o3 0.3-0.8% Mgo 0.4-1.5% Cao 0.1-0.6% Na2o 0.3-0.7% K2o 0.04-1.0% C 0.5-1.4% S 0.1-2.5%

Loss of ignition (C+S) 0.7-2.5%

6 1.2.5

0: https://precast.org/2010/05/using-fly-ash-in-concrete/ 100%

Fly Ash Fly ash is a group of materials that can vary significantly in composition. It is residue left from burning coal,

which is collected on an electrostatic precipitator or in a baghouse.

It mixes with flue gases that result when powdered coal is used to produce electric power. Since the oil crisis of the 1970s, the use of coal has increased. In 1992, 460 million metric tons of coal ash were produced worldwide.

About 10 percent of this was produced as fly ash in the United States.

In 1996, more than 7 million metric tons were used in concrete

in the U.S. Economically, it makes sense to use as much of this low-cost ash as possible, especially if it can be used in concrete as a substitute for cement.Coal is the product of millions of years of decomposing vegetable matter under pressure,

and its chemical composition is erratic.

In addition, electric companies optimize power production from coal using additives such as flue-gas conditioners, sodium sulfate, oil, and other additives to control corrosion, emissions, and fouling. The resulting fly ash can have a variable composition and contain several additives as well as products from incomplete combustion.

Most fly ash is pozzolanic, which means it’s a siliceous or siliceous-and-aluminous material that reacts with calcium hydroxide to form a cement.

When Portland cement reacts with water, it produces a hydrated calcium silicate (CSH) and lime.

The hydrated silicate develops strength and the lime fills the voids.

Properly selected fly ash reacts with the lime to form CSH–the same cementing product as in Portland cement.

This reaction of fly ash with lime in concrete improves strength. Typically, fly ash is added to structural concrete at 15-35 percent by weight of the cement,

but up

to 70 percent is added for mass concrete used in dams, roller-compacted concrete pavements, and parking areas.

Special care must be taken in selecting fly ash to ensure improved properties in concrete.

Fig. 1.5 – Fly Ash

7 1.3 Project Objective In the present Experimental Investigation the following are the main objectives. 1. Comparative study of the behavior of the concrete with & without Fly Ash and Silica Fume. 2. To determine

the Compressive

Strength of concrete with and without Fly Ash

and Silica Fume

in different proportions at different grade. 3.

To determine the Flexural

Strength of concrete with and without

Fly Ash and Silica Fume

in different proportions at different grade. 4. To determine the

Split Tensile Strength of concrete with and without Fly Ash and Silica Fumein different proportions at different grade. 5. To find the optimum percentage of Fly Ash and Silica

Fumefor obtaining the maximum strength of concrete.

8 1.4 Formulation of Research In this stage of work cement is partially replaced byFly Ash and Silica Fumer in different percentages as shown in the table below. 8 batches are prepared in different proportions including conventional concrete mix (Cement as binder, Sand as fine aggregates & Natural Coarse Aggregates). Cubes, Cylinder and Beams are casted for determining Compressive Strength, Split Tensile Strength and Flexural Strength respectively at 7, 14 and 28 days. Table 1.3 - Formulation of work BM Cement (%) Fly Ash(%) Sand (%) Natural Coarse Aggregates (%) Fly Ash and Silica Fume % 1 100 0 100 100 0 2 95 5 100 100 15 3 90 10 100 100 15 4 85 15 100 100 15 5 80 20 100 100 15 6 75 25 100 100 15 7 70 30 100 100 15 8 65 35 100 100 15

9 1.5Organization of the Thesis The Thesis has been organized in five chapters as follows: Chapter-2: Literature Review- A review of recent literature on the properties of SF & FA concrete has been discussed on the basis of which the need of the present investigation has been identified. Chapter-3: Experimental program- It describes the carried out, the sizes and number of specimens, testing methods and the associated instrumentation, and experiment carried out. Chapter-4: Results and Discussions- The analysis of the results, the related discussion and salient observations from the testing have been included in a sequential manner. Chapter-5: Conclusions and Future scope- The significant conclusion obtained from experimental investigations of this study have been integrated and presented in a logical sequence and recommendations for further research made. Future scope are

few samples of concrete with different percentage of using Fly Ash and Silica Fume and conclude the most suitable percentage of usage to achieve the optimum compressive strength,

Split tensile strength and Flexural strength.

and

replacement of cement with Fly Ash and Silica Fume

in different water cement ratio

10

CHAPTER 2 LITERATURE REVIEW 2.1 INTRODUCTION The purpose of this chapter is to present an overview on development of concrete using Fly Ash and Silica Fume. Mechanical and durability properties and the implication of material properties on the performance of such concrete are reviewed. Special emphasis is given to the effect of SF on strength and durability properties of concrete. 2.2 LITERATURE REVIEW S. Mahmoudetal (2017)Carried out an experimental investigation on Fly Ash and Silica Fumeas partial replacement of cement in concrete. The low bulk density and high specific surface area of Fly Ash and Silica Fume offer challenges in its application and transport. In their study,

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the density of Fly Ash and Silica Fume was increased by producing Fly Ash and Silica Fume granules mixed with a solid super plasticizer. The effects of Fly Ash and Silica Fume

granulation on durability and mechanical properties of concrete were tested. Results indicated an increase in strength and surface electrical resistivity, and a decrease in permeability for both slurry Fly Ash and Silica Fume and granule, compared to the control sample. Zhangetal (2016)Aim of their study was to investigate the

effect of Fly Ash and Silica Fume in paste, mortar and concrete

by determining the non-evaporable water content of pastes,the compressive strengths of pastes, mortars and concretes containing 5% and 10% raw Fly Ash and Silica Fume or dandified Fly Ash and Silica Fume with water-to- binder ratios (W/B) of 0.29 and 0.24. Their results showed that Fly Ash and Silica Fume can significantly increase the hydration degree of paste. It was shown that the addition of Fly Ash and Silica Fumeincreases the compressive strengths of hardened pastes, mortars and concretes. It was also shown that the strength activity index of dandified Fly Ash and Silica Fumein concrete is the highest while that in paste is the lowest. The agglomeration of Fly Ash and Silica Fume has been found in blended paste which is hardly seen in concrete. The Fly Ash and Silica Fume can improve the interface bond strength between hardened cement paste and aggregate. The crystalline orientation degree, the crystalline size and the content of calcium hydroxide at the interface are obviously decreased by adding Fly Ash and Silica Fume. The different dispersion and the improvement of the

11 interfacial transition zone are the main factors causing the different role of Fly Ash and Silica Fume in paste, mortar and concrete. Khan andAbbas (2017) Evaluatedthe influence of hot weather conditions and subsequent curing requirements on the strength and durability of multi-cementations concrete. They considered five curing schemesusing persistent moist curing for various ages followed by exposure to natural hot weather conditions. It was observed that curing in hot weather tended to increase the initial strength of ternary blended concrete for up to 28 days; however, the development of long-term strength had insignificant effect. Binary blended concrete with Fly Ash and Silica Fume and fly ash (SF) exposed to hot weather have higher early age strength development compared to those under standard curing. The compressive strength and permeability of concrete was more sensitive to hot weather curing at an early age as its fly ash (FA) content increased. However, the effects of curing age diminished with high FA content and the susceptibility of long-term strength to hot

weathering decreased as SF content increased. The porosity of concrete cured with continuous moistening was lower compared to those under hot weathering. The chloride permeability of binary blended concrete containing SF was less affected by hot weather curing. Using numerical models, it was found that the optimized persistent moist curing age for concrete without SF was dependent on target strength and durability requirements. Okoyeetal(2017) In their paper, the effect of Fly Ash and Silica Fume and fly ash on durability properties of fly ash based geopolymer concrete have been investigated by immersing the cubes in 2% sulphuric acid and 5% sodium chloride solutions. The resistance of specimens to chemical attack was evaluated visually by measuring change in the weights and percent losses in compressive strength at different intervals of time. A control mix M40 was also castwith ordinary Portland cement concrete for comparison. Percent losses in compressive strengths in the case of control (M40) and GPC3 in 2% H2SO4 at 90 days were found 36% and 8%. Percent losses in compressive strengths in the case of control (M40) and GPC3 in 5%NaCl at 90 days were 18% and about 0%.Thus the resistance of geopolymer concrete incorporating Fly Ash and Silica Fume and fly ash in sulphuric acid and chloride solution was significantly higher than that of the control.

12 Khodabakhshianetal(2017) carried out an experimental investigation of durability properties carried out with 16 concrete mixes containing marble waste powder and Fly Ash and

0: http://citeseerx.ist.psu.edu/viewdoc/download?doi=10.1.1.429.360&rep=rep1&type=pdf 95%

Silica Fume and fly ash as partial replacement of ordinary Portland cement.

The latter was partially replaced at different ratios of Fly Ash and Silica Fume and fly ash (0%, 2.5%, 5%, and 10%) and marble waste powder (0%, 5%, 10%, and 20%). In all concrete mixes, constant water/binder ratio of 0.45 was kept with and target initial slump of S2 class (50e90 mm). Workability and bulk density tests were carried out on fresh concrete, while compressive strength, electrical resistivity, water absorption, durability to sodium sulphate, magnesium sulphate and sulphuric acid attack tests were performed to evaluate few relevant properties of concrete in the hardened state. Siddiqueetal (2017) Iinvestigation of iinfluence of bacteria on strength and permeation characteristics concrete incorporating Fly Ash and Silica Fume and fly ash (SF) as a substitution of cement has been investigated in this study. The cement was partially substituted with 5, 10 and 15% SF and with constant concentration of bacterial culture, 105 cru/mL of water. Cement was substituted with Fly Ash and Silica Fume and fly ash in concrete by weight. At 28 days, nearly 10–12% increase in compressive strength was observed on incorporation of bacteria in SF concrete. At 28 days, the compressive strength of concrete was increased from 32.9 to 36.5 MPa for SF, 34.8 to 38.4 MPa for SF5, 38.7 to 43.0 MPa for SF10 and 36.6 to 40.2 MPa for SF15 on addition of bacteria. Water absorption, porosity and capillary water rise reduced in the range of 42–48%, 52– 56% and 54–78%, respectively, in bacterial concrete compared to corresponding nonbacterial samples at 28 days. Wangetal (2017).Studied experimentally the effects of Fly Ash and Silica Fume and fly ash, PVA fiber and their combinations on the mechanical properties, microstructure, abrasion resistance and volume stability of

cement pastes and/or fly ash concrete. Their results indicated that the compressive strength and tensile strength of concrete containing both Fly Ash and Silica Fume and fly ash and PVA fiber were obviously improved compared with the control concrete. The addition of PVA fiber in concrete considerably reduced the drying shrinkage and improved the anti-cracking resistance of cement pastes and concrete, also the abrasion resistance of concrete significantly increased with the addition of Fly Ash and Silica Fume and fly ash and PVA fiber. These findings have

13 been successfully adopted to guide the design and construction of hydraulic structures in the southwest of China Pedroetal(2017) carried out an experimental study to evaluate the influence of a commercial dandified Fly Ash and Silica Fume and fly ash (SF) and of recycled concrete aggregates (RA) on the behaviour of high-performance concrete (HPC). For that purpose, three families of concrete with 0%, 5% and 10% Fly Ash and Silica Fume and fly ash (SF) of the binder’s mass were produced. In addition to the commercial Fly Ash and Silica Fume and fly ash, fly ash (FA) and super plasticizer (SP) were also incorporated in the concrete mixes. Each type of concrete comprises a reference concrete (RC) and three recycled aggregates concrete (RAC) mixes with replacement percentages (in volume) of fine natural aggregates (FNA) with fine recycled aggregates (FRA) and of coarse natural aggregates (CNA) with coarse recycled aggregates (CRA) of 0/100,50/50 and 100/100, respectively. Considering the mechanical performance and durability of the concrete mixes, their results showed that it is possible to incorporate significant amounts of FRA and CRA. Regarding the Fly Ash and Silica Fume and fly ash, the densification process used in its manufacture seems to lead to the formation of agglomerates that change the real particle size of the SF, originating a loss of performance of the concrete made with them. Daveetal (2016) The carried out research work to produce quaternary cement binders and mortars with combination of ordinary Portland cement (OPC) and

supplementary cementitious materials (SCMs),

such as,

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fly ash (FA), silica flume (SF), ground granulated blast furnace slag (

GGBS), metakaolin (MK) and

lime as powder (LP) at 30% and 50% replacement levels. Water-binder ratio was kept constant 0.5 for binders and mortars. Normal consistency, setting time, density, water absorption and compressive strength tests at the ages of 3, 7, 28, 56 and 90 days tests was carried out on quaternary binders. Compressive strength (at ages of 3, 7, 28, 56 and 90 days) and rapid chloride permeability (RCPT) (at 28 and 90 days), tests were also carried out on quaternary cement mortars mixes of 1:3, 1:4, 1:5 and 1:6. The purpose of their investigation was to develop a new quaternary binder which can reduce our dependency on cement. The related combinations of quaternary binders showed better development in compressive strength in comparison to control binder. Quaternary mortars with the combinations of

14 GGBS and MK showed better development in compressive strength and permeability than quaternary mortar with combination of lime powder. Yang Juetal (2017) Conducted the distinct spalling performances of reactive powder concrete (RPC) specimens with various Fly Ash and Silica Fume and fly ash (SF) contents exposed to high temperatures through observed via high-resolution photography. The RPC microstructures and pore structures after high-temperature exposure were characterized using scanning electron microscopy and mercury intrusion porosimetry. Their results provided an experimental evidence of the high-temperature spalling mechanism of RPC. Which increase the SF content in RPC increases its compressive strength and compactness, offering greater mitigation of devastating spalling behaviour, but also producing more pulverized spalling remnants. It is attributes to the post-heating cracked microstructure and refined pores, which promote localized rather than entirely explosive spalling. Pallaetal (2017) Carried out a study dealing with the effect of silica nanoparticles (SNPs) in high volume fly ash (40% replacement) cement paste, mortar and concrete. The content of SNPs (0.5–3.0%) was added by the weight of binder with (0.23, 0.25 & 3.0)% was optimized in paste and mortar system. The calorimetric results revealed that the hydration process was accelerated as a result of SNPs incorporation and the dormant period was shortening by 4 h with 2% SNPs as compared to the control. The effect of optimum dosages of SNPs addition in concrete in terms of mechanical and durability properties was studied at 0.25 w/b ratio. The compressive strength results of SNPs added mixtures showed an improvement of 61% at 3 days and 25% at 28 days of hydration as compared to control. The durability studies at 28 day showed that with the incorporation of SNPs, the porosity, sorptivity and water absorption reduced up to 25–40% and densify the interfacial transition zone (ITZ). DybełandFurtak (2017) Performed the test to analysis of the impact of Fly Ash and Silica Fume and fly ash content in high-performance concrete (HPC) on bond conditions along the height of tested elements. The tests were performed on the specimens made of six different HPC mixes with varying content of Fly Ash and Silica Fume and fly ash (0, 5 and 10% by mass of cement) and super plasticizer. The used specimens allowed for determining the changes of bond at individual levels of elements with a total height of 480 and 960 mm. The rebar's in the elements were placed perpendicularly to the

15 direction of concreting. The reference element, characterised by the parallel orientation to the direction of concreting, was also prepared. The tests indicated that the quality of bond conditions in HPC deteriorates as the distance from the formwork bottom increases. The experiment results indicated that concrete modification with Fly Ash and Silica Fume and fly ash can both increase and decrease the quality of bond conditions. The influence of Fly Ash and Silica Fume and fly ash depends on the thickness of the concrete cover, which determines the mechanism of bond failure. Liu and Wang (2017) Presented composite mineral admixture was prepared by grinding a mixture of steel slag and Fly Ash and Silica Fume(steel slag/Fly Ash and Silica Fume and is 92:8 or 84:16, bypass). A layer of Fly Ash and Silica Fumewas uniformly adsorbed on the steel slag particles. The influence of this steel slag-Fly Ash and Silica Fumecomposite mineral admixture on the hydration of a cement-based composite binder and

the properties of its concrete were investigated. The results showed that the Fly Ash and Silica Fumein the composite mineral admixture contributes significantly to the consumption of Ca (OH) 2 and enhances the connection between the steel slag particles with the surrounding C-S-Hgel. The activity of the composite mineral admixture improved with the increase in Fly Ash and Silica Fume content. The retarding effect of the composite mineral admixture on the early hydration of cement is significant. However, a proper cement replacement by the composite mineral admixture can improve the late-age pore structure of hardened paste as well as the strength, chloride ion resistance, carbonation resistance, and sulphate attack resistance of concrete. The proper addition of the composite mineral admixture can reduce the drying shrinkage of concrete. Fathietal (2017)Carried out an experimental study,

0: https://www.sciencedirect.com/science/article/abs/pii/S0950061817300545 87%

the mechanical and physical properties such as strength, water absorption, type of curing, failure mode and microstructure of expanded polystyrene (EPS) structural lightweight concretes modified by Micro-silica and Nano-silica were investigated. In the specimens without EPS beads, replacement of Micro-silica and Nano-silica up to 15% and 3% of cement, respectively, led toincrease in compressive strength and decreasing water absorption, and after that, these trends were vice versa.

Thecompressive

strength increased by approximately 10 to 15% and water absorption decreased approximately

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by 15%

to 20%. By adding Micro- silica and Nano-silica to the concretes containing EPS beads, proper adhesion between the EPS beads and other concrete components was created as confirmed by the SEM

16 images of the specimens. Also the effects of three curing methods with water, limewater and steam on the strength and water absorption of concretes were investigated. Their findings showed that 28-day limewater and 1-day steam curing resulted in the highest strength and the lowest water absorption compared to other curing methods.

Pedroetal (2017):Carried out an analysis of the mechanical behaviour of high- performance concrete (HPC) incorporating fine and coarse recycled aggregates (FRA and CRA). The recycled aggregates (RA), originated from rejected precast elements, with compressive strengths of 75 MPa and were used to replace natural aggregates (NA) in concrete mixes. The experimental work also included three families of concrete with proportions of dandified Fly Ash and Silica Fume (SF) of 0%, 5% and 10% (relative and in addition to cement). Each family comprised a reference concrete (RC) and three recycled aggregate concretes (RAC) with replacement ratios

(FRA/CRA %) of 50/50, 0/100 and 100/100. The results obtained for the compressive strength, splitting tensile strength, modulus of elasticity, ultrasonic pulse velocity and bond strength showed that it is possible to produce high-performance concrete without NA. The Fly Ash and Silica Fume led to a performance increase in the properties analysed with the creation of a new concrete mixing method that considered the specificities of RA and the difficulties of dispersing SF particles. Zhangetal (2016) Developed an eco-concrete by silica-alumina based cementitious material was developed and defined as silica-alumina based concrete. Their systematic properties investigation showed that the silica-alumina based concrete exhibited good mechanical properties, low shrinkage strain and superior durability including strong resistances to water penetration, carbonation, chloride penetration, freezing-thawing and seawater attack. These excellent performances can be related to the fact that it developed a dense and compacted interfacial transition zone between the cementitious matrix and aggregate, and thus silica alumina based cementitious matrix had a refined pore structure. Leaching toxicity and radioactivity results indicated that the silica-alumina based concrete is environmentally acceptable. Adak.etal (2017) The structural performance of such geopolymer concrete6%

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nano silica replacing fly ash in terms of bond strength, flexural strength and micro structural behaviour. Such nano silica modified fly ash based geopolymer concrete showed appreciable improvement in structural behaviour at different ages without any heat

17 activation. The bond strength between reinforcement bars (deformed or mild steel) and surrounding geopolymer concrete materials (with/without nano silica) has been also compared to the conventional cement concrete. The nano silica modified geopolymer concrete exhibited better structural performance than heat cured geopolymer concrete (without nano silica) and conventional cement concrete samples. The microstructural properties of such geopolymer concrete (with/without nano silica) and cement concrete have been analyzed through Field Emission Scanning Electron Microscope (FESEM) with Energy Dispersive X-ray Spectroscopy (EDS), Fourier Transform Infrared Spectroscopy (FTIR) analysis and X-ray Diffraction (XRD) techniques. The enhancement of structural performance was mainly due to the transformation of amorphous phase to crystalline phase in the geopolymer concrete matrices in the presence of nano-silica.

Kumaretal (2017) Evaluated the performance of silica nanoparticles incorporated high strength concrete (SNPs-HSC) under elevated temperature conditions by exposing up to 800 0 C, followed by cooling to ambient temperature before performing experiments. Time-temperature studies revealed that incorporation of silica nanoparticles (SNPs) in concrete mix delays the heat transfer by 11%, 18%, 22% and 15% at 200 0 C, 400 0 C, 600 0 C and 800 0 C respectively thereby, decreasing the rate of degradation as compared to the conventional high strength concrete (HSC). A reduction in weight loss was observed in SNPs- HSC specimens after exposure to 200 0 C, 600 0 C, and 800 0 C; whereas at 400 0 C the weight loss quantity was 3.5% higher than the control HSC specimens due to the evaporation of water from calcium silicate hydrate (C-S-H) gel. On exposure up to 400 0 C for 2 h, the compressive strength and split-tensile strength increased by 40% and 13% respectively, for SNPs-HSC specimens, whereas in control HSC specimen's strength didn't increase after 200 0 C. A higher residual compressive (7%) and split-tensile strength (8%) was found to be in SNPs-HSC specimens exposed to 800 0 C for 2 h as compared to the control HSC specimens. The stress-strain curves revealed that SNPs-HSC specimens exhibits brittle failure up to 600 0 C whereas in control HSC brittle failure was observed only up to 400 0 C. Micro structural studies performed on the samples taken from the core of the 400 0 C exposed SNPs-HSC revealed the formation of higher C-S-H content and lower amount of calcium hydroxide (CH) leading to their enhanced mechanical and thermal stability.

18 Maruyama and Teramoto (2003) Studied extensively cement pastes made with Fly Ash and Silica Fume premixed cement with a water–binder ratio of 0.15 development of autogenous shrinkage showed different behaviours before and after the inflection point and dependence on the temperature after mixing and subsequent temperature histories. The difference in autogenously shrinkage behavior poses problems for winter construction because autogenous shrinkage may increase with decrease in temperature after mixing before the inflection point and with increase in temperature inside concrete members with large cross sectionns. Abdou and Abuseda (2015)Studiedcarried out an investigationfor the possibility of utilizing a broad range of micro-silica partial additions with cement in the production of concrete coating. They investigated the strength properties and permeability of micro- silica concrete to achieve resistance toward concrete cracking and damage during lying. The experiment were conducted on concrete mixes with additions of 3% up to 25% by weight of cement in concrete. Properties of hardened concrete such as compressive strength, flexural strength, and permeability have been assessed and analyzed. Cubic specimens and beams were produced and cured in a curing tank for 7 and 28 days. Testing results showed that additions of Fly Ash and Silica Fume to cement between 5% and 7%, which acts as a filler and cementations material, developed high flexural and compressive strength with reduction of permeability Rostami andBehfarnia (2017) Examined and analyzed the effect of substitution the slag with Fly Ash and Silica Fume on compressive strength and permeability of alkali activated slag concrete. Alkali activated slag (AAS) concrete with a proper mixture showed the superior mechanical properties and durability compared to traditional normal Portland cement concrete. For cases in which AAS concrete with higher performance and durability is required, AAS concrete with Fly Ash and Silica Fume can be considered as a possible alternative. The presented work was carried out to examine the effect of using

Fly Ash and Silica Fume on permeability of alkali activated slag (AAS) concrete

by substitution of three levels of Fly Ash and Silica Fume including 5%, 10% and 15% of slag by weight. The effects of two types of curing conditions including water curing and curing under plastic cover wereexamined. They measure the short-term and final water absorption, penetration of chloride ion and depth of penetration of water to examine the permeability. The effect of these factors on compressive strength was examined and the

19 relation between compressive strength and passing electrical charges and depth of water penetration was also developed. To contrast the use of Fly Ash and Silica Fume on internal

characteristics of concrete, samples were observed by Scanning ElectronMicroscopy (SEM).The results showed that the application of Fly Ash and Silica Fume could increased compressive strength and reduce the permeability of alkali activated slag concrete and water curing was the most appropriate type of curing method. . Nattaj and Nematzadeh (2013)Carried out an experimental study to investigate the effect of Fly Ash and Silica Fume and nano-silica on the mechanical properties of the fiber-reinforced concrete. In total, 230 concrete specimens were prepared in two stages and subsequently tested. In the first stage of specimen preparation, hooked-end steel fibers with Vf of 0.5%, 0.75%, 1%, 1.25%, and 1.5% and forta-ferrofibers with Vf of 0.2%, 0.35%, 0.5%, 0.65%, and 0.8% were added to concrete mixture, and in the second stage, Fly Ash and Silica Fume with the weight percentage of 8%, 10%, and 12%, and nano-silica with that of 1%, 2%, and 3% were replaced the cement in mixtures with a fixed volume fraction of both fibers. The aim was to study the mechanical properties of the fiber-reinforced concrete including compressive strength, tensile strength, modulus of elasticity, water absorption and density, they proposed equations for predicting the compressive and tensile strength and the modulus of elasticity of the fiber-reinforced concrete with no pozzolan. Leemann A. (2017) Carried out μ-XRD measurements to see the structure of the crystalline alkali-silica reaction (ASR) product formed in affected concrete. However, the data were obtained from a single aggregate. In this study, he applied Raman microscopy on crystalline ASR products formed in several aggregates and concrete mixtures, enabling a comparison of their spectra and with it their structure. In a first step, samples from the same concrete used for μ-XRD measurements were analyzed and compared. In a second step, samples from a second structure and from a concrete prism test were taken. In addition to Raman microscopy, SEM with EDX was used to characterize the microstructure. The Raman spectra of the crystalline ASR product were practically identical in all studied aggregates and concrete mixtures. This study was further supported by the micro structural data. Ewaisetal (2009) Prepared four calcium aluminates cement mixesfrom aluminium sludge as a source of calcium oxide and Al 2 O 3 and aluminium slag (dross) as a source of

20 aluminium oxide with some additions of pure alumina. The mixes were composed of 35–50% aluminium sludge, 37.50– 48.75% aluminium slag (dross) and 12.50–16.25% aluminium oxide. The mixes were processed then sintered at different firing temperatures up to 1500 0 C or 1550 0 C. The mineralogical compositions of the fired mixes were investigated using X-ray diffraction which indicated that the fired mixes composed of variable contents of calcium aluminates (CA), calcium dialuminate (CA2), calcium hexa aluminates (CA6) in addition to some content of magnesium aluminates spinal (MA). Sintering parameters (bulk density, apparent porosity and linear change) and mechanical properties (cold crushing strength) of the fired briquettes were tested at different firing temperature. Refractoriness of the cement samples manufactured at the optimum firing temperature was detected. Cementing properties (water of consistency, setting time and compressive strength as a function of curing time up to 28 days of hydration) of pasted prepared from the manufactured cement mixes at the selected optimum firing temperatures (1400 8C or 1500 8C) were also tested. Cement mixes manufactured from 45 to 50% aluminium sludge, 37.50–41.25% aluminium slag (dross) with 12.50–13.75% alumina were selected as the optimum mixes for manufacturing calcium aluminates cement since they satisfy the requirements of the international standard specifications regarding cementing and refractory properties as a result of their content of CA

(the main hydraulic phase in calcium aluminates cement) and CA2 (the less hydraulic but more refractory phase). DebabrataPradhan and D. Dutta (2013) the incorporation of Fly Ash and Silica Fume into the normal concrete is a routine one in the present days to produce the tailor made high strength and high performance concrete. The design parameters are increasing with the incorporation of Fly Ash and Silica Fume in conventional concrete and the mix proportioning is becoming complex. The main objective of this paper has been made to investigate the different mechanical properties like compressive strength, compacting factor, slump of concrete incorporating Fly Ash and Silica Fume. In this present paper 5 (five) mix of concrete incorporating Fly Ash and Silica Fume are cast to perform experiments. These experiments were carried out by replacing cement with different percentages of Fly Ash and Silica Fume at a single constant water-cementitious materials ratio keeping other mix design variables constant. The Fly Ash and Silica Fume was replaced by 0%, 5%, 10%, 15% and 20% for water-cementitious materials (w/cm) ratio for 0.40. For all mixes compressive strengths were determined at 24 hours, 7 and 28 days

21 for 100 mm and 150 mm cubes.

Other properties like compacting factor and slump were also determined for five mixes of concrete.

Vishal S. et.al (2014) Traditionally, Ordinary Portland cement is used for making the civil structures. Portland cement can be partially replaced by Fly Ash and Silica Fume. Fly Ash and Silica Fume is non metallic and non hazardous waste of industries. It is suitable for concrete mix and improves properties of concrete i.e. compressive strength etc. The main objective of this research work is to determine the optimum replacement percentages which can be suitably used under the Indian conditions. To fulfill the objective various properties of concrete using Fly Ash and Silica Fume have been evaluated. Further to determine the optimum replacement percentage comparison between the regular concrete and concrete containing Fly Ash and Silica Fume is done .It has been seen that when cement is replaced by Fly Ash and Silica Fume compressive strength increases up to certain percentage (10% replacement

of cement by

Fly Ash and Silica Fume).But higher

replacement of cement by Fly

Ash and Silica Fume

gives lower strength. The effect of Fly Ash and Silica Fume

on

various other properties of Concrete has also been evaluated. This paper is a very good tool for the beginners to understand the effect and have an overlook of Fly Ash and Silica Fume on Concrete. N. K. Amudhavalli 1 and Jeena Mathew (2012)Portland cement is the most important ingredient of concrete and is a versatile and relatively high cost material. Large scale production of cement is causing environmental problems on one hand and depletion of natural resources on other hand. This threat to ecology has led to researchers to use industrial by products as supplementary cementations material in making concrete. The main parameter investigated in this study is M35 grade concrete with

partial replacement of cement by Fly Ash and Silica Fume

by 0, 5, 10,15and by 20%. This paper presents a detailed experimental study on Compressive strength, split tensile strength, flexural strength at age of 7 and 28 day. Durability study on acid attack was also studied and percentage of weight loss is compared with normal concrete. Test results indicate that

0: http://citeseerx.ist.psu.edu/viewdoc/download;jsessionid=0C9AF93600EBEBC5E74E763B348DA634?doi=10.1.1.672.9438&rep=rep1&type=pdf 100%

use of Fly Ash and Silica Fume in concrete has

improved the performance of concrete in strength as well as in durability aspect.

22 CHAPTER 3 EXPERIMENTAL PROGRAM 3.1 Introduction Testing of hardened concrete plays an important role in controlling and confirming the quality of cement concrete works. Systematic testing of raw materials, fresh concrete and hardened concrete are inseparable part of any quality control programme for concrete, which to achieve higher efficiency of the material used and greater assurance of the performance of the concrete with regards to both strength and durability. The test methods should be simple, direct and convenient to apply. One of the purposes of testing hardened concrete is to conform that the concrete used at site has developed the required strength. As the hardening of concrete takes time, one will not come to know, the actual strength of concrete for some time. This is an inherent disadvantage in conventional test. But, if strength of concrete is to be known at early period, accelerated strength test can be carried out to predict 28 days strength. But mostly when current materials are used and careful steps are taken at every stage of the work, concretes normally gives the required strength. The tests also have a deterring effect on those responsible for construction work. The result of the test on hardened concrete, even if they are known later, helps to reveal the quality of concrete and enable adjustment to be made in the production of further concretes. Tests are made by casing the cubes or cylinders from the representative concrete or cores cut from the actual concrete. It is to be remembered that standard compressive strength specimens give a measure of the potential strength of the concrete in structure. Knowledge of strength of concrete in structure cannot be directly obtained from tests on separately made specimens. 3.2 Materials 3.2.1 Cement Ordinary Portland cement (OPC) from a single lot was used throughout the course of the investigation. The physical properties of the cement as determined from various tests 30 conforming to Indian Standard IS: 1489-1991(Part-1) are listed in Table 3.1. All the tests were carried out as per recommendations of IS: 4031-1988.

0: http://www.ijsrp.org/research-paper-0516/ijsrp-p53113.pdf 97%

Cement was carefully stored to prevent deterioration in its properties due to contact with the moisture.

23 Table 3.1 Properties of

OPC 3.2.2 Coarse aggregate Coarse aggregate with a maximum size 12.5mm having a specific gravity 2.65 and fineness modulus of 6.51%. Angular recycled aggregates from a local source were used as coarse aggregate. The specific gravity was 2.71. 3.2.3 Fine aggregate Locally available river sand passed through 4.75mm IS sieve is applied as fine aggregate. The specific gravity of sand is 2.60. 3.2.4Fly Ash and Silica Fume Fly Ash and Silica Fume, a co-product from the production of silicon or ferrosilicon metal, is an amorphous silicon dioxide - SiO 2 which is generated as a gas in submerged electrical arc furnaces during the reduction of very pure quartz. This gas vapor is condensed in bag house collectors as

0: https://www.hoperacafe.it/article/34815/silica-fume-uses.html 100%

very fine powder of spherical particles that average 0.1 to 0.3 microns in diameter with a surface area of 17 to 30 m2/g

and Density varies from 150 to 700 kg/m^3 Fly Ash and Characteristic Properties Observed Value

0: http://www.ijsrp.org/research-paper-0516/ijsrp-p53113.pdf 44%

Codal Requirements IS:8112-1989(Part 1)

Fineness (m 2 /kg) 300 225 minimum Standard consistency (%) 32 ---- Initial Setting time (minutes) 41 minutes 30 Minimum Final setting time (minutes) 246 600 Maximum

Specific gravity 3.15 ---- Compressive strength (MPa) 7 days 14-

days 28-days 24.6 34.3 45.2 23 Minimum 33 Minimum 43 Minimum

24

0: https://www.hoperacafe.it/article/34815/silica-fume-uses.html 100%

Silica Fume is used in a variety of cementitious (concrete, grouts and mortars), refractory, elastomer and polymer applications. 3.3

Mix Design Concrete mix was designed as per IS 10262-2009 and the design procedure was as follows; 1. Determine the mean target strength ft from the specified characteristic compressive strength at 28-day fck and the level of quality control. f t = f ck + 1.65 S, where S is the standard deviation obtained from the IS 10262- 2009. 2. Adopt the water cement ratio for the desired mean target strength using the Table 5 of IS 456 and water cement ratio so chosen is checked against the limiting water cement ratio. 3. Select the water content, for the required workability and maximum size of aggregates (for aggregates in saturated surface dry condition) using table 2 of IS 10262- 2009. Super plasticizer was used so water content was adjusted for the required workability. 4. Calculate the cement content from the water-cement ratio and the final water content as arrived after adjustment. Check the cement against the minimum cement content from the requirements of the durability, and greater of the two values is adopted. 5. Determine the proportion of coarse and fine aggregate in total aggregate by absolute volume corresponding to the adjusted water cement ratio from IS 10262- 2009. 6. From the quantities of water and cement per unit volume of concrete and the proportion of fine and coarse aggregates already determined in step 5 above, calculate the content of coarse and fine aggregates per unit volume of concrete from the following relations. 7. Determine the concrete mix proportions for the first trial mix. Prepare the concrete using the calculated proportions and cast three cubes of 150 mm size and test them wet after 28-days moist curing and check for the strength. 8. Prepare trial mixes with suitable adjustments till the final mix proportions are arrived at.

25 Table 3.2 Mix Details Mix OPC % Fly Ash % Fly Ash and Silica Fume % M1 100 0 0 M2 95 5 15 M3 90 10 15 M4 85 15 15 M5 80 20 15 M6 75 25 15 M7 70 30 15 M8 65 35 15 3.4 Tests Performed 3.4.1Curing of Specimens The test were conducted on cube (150

mm x 150mm x 150mm), Beam (100mm x 100mm x 500mm and cylinder (150mm diameter and 300mm height)

specimens 7, 14, and 28, days of curing. 3.4.1.1 Compressive Strength Test Specimens were then tested on 200 tones capacity Compression Testing Machine (CTM) (Figure3.2). The position of cubes were kept during testing at right angles to casting position. Axis of specimens was carefully aligned with the center of thrust of the spherically seated plates.

0: 435b784a-50bf-43e2-9dce-a3967f3adfaf 66%

The load was applied gradually without any shock and increased at a constant rate of 3.5

N/mm 2 /minute until failure of specimen takes place (Fig 3.1). The average of three samples was taken as the representative value of compressive strength for each batch of concrete. The compressive strength was calculated by dividing the maximum compressive load by the cross sectional area of the cube specimens. Thus the compressive strength of different specimens was obtained. Curing The test specimens were stored in place which free from vibrations, in most air of at least 90% relative humidity and

0: https://pdfs.semanticscholar.org/2af4/8608da5de46de1b613f165ca7c387b051ad6.pdf 81%

at a temperature of 27 0 C

for 24 hours from the time of addition of water to the

dry ingredients. After this period, the specimens were marked and remove from the mould and immediately submerged in clean and fresh water or saturated lime solution and keep for required period just prior to test. The water or

26 solution in which the specimens were submerged, are renewed after every seven days and were maintained at a temperature of 27 0 C. The specimens are not to be allowed to become dry at any time until they have been tested. The specimens are tested at 7, 14, and 28, days of curing. Fig. 3.1 Compressive testing machine 3.4.1.2 Splitting Tensile Test This test is carried out by placing a cylindrical specimen (150mm diameter and 300mm height)

0: 435b784a-50bf-43e2-9dce-a3967f3adfaf 76%

horizontally between the loading surfaces of a compression testing machine (Fig.3.3) and load was applied gradually until failure of the cylinder

take place along the vertical diameter. Specimens were taken out from curing tank at the age of 28 days of water curing and then tested on 200 tones capacity Compression Testing Machine (CTM) as per IS: 516 and 1199.

The split tensile strength was determined by using the following formula.

0: https://www.ijert.org/research/experimental-study-on-the-mechanical-properties-of-concrete-using-micro-silica-and-nano-silica-a-step-towards-sustainability-IJERTV5IS110315.pdf 55%

Split tensile Strength (MPa) = 2P / ΠDL P = Splitting Load in N D= diameter of cylinder sample (mm) L = length of

cylinder

sample (mm).

27 Fig. 3.2 Splitting Tensile Testing Machine 3.4.1.3 Flexural Strength Test All the beam specimens were tested on a Universal testing machine of 2000 kN capacity in the “Structural Engineering” lab. The testing procedure of all the beam specimens was same. First the beams were cured for a period of 28 days, then its surface was cleaned with the help of sand paper. After this the specimens were given a white wash with an identification number. Such type of specimens enabled to detect cracks during testing at various stages of loading. Two points transverse loading was used to testing the beam specimens for determining Flexural strength. Fig. 3.3 Flexural strength Testing Machine 3.4.2 Tests on Concrete – Workability

28 Workability is considered to be that property of plastic concrete which indicates its ability to handle,transport and most importantly, place with a minimum loss of homogeneity. More precisely, it defines that it can be fully compacted with minimum energy input. There should

be no sign of any segregation or bleeding in a workable concrete after placing. The workability of all the mixes of concrete used in the present work was controlled by conducting slump test, using slump cone appartus (Fig 3.1). It was observed that the slump value for all the mixes were maintained in the range of 20- 80 mm, which is acceptable as per code IS-7320. Fig. 3.4 Slump cone apparatus

29 CHAPTER 4 RESULTS AND DISCUSSIONS 4.1 Introduction The objectives of the present study was to examine the strength properties of concrete at different percentages of Fly Ash and Silica Fume. Properties which have to examined are: 1. Compressive strength 2. Splitting tensile strength 3. Flexural strength 4. Workability of concrete mixes Compressive Strength test and splitting tensile strength was conducted on a 200T Compression Testing Machine, The detailed analysis and discussion of the test results as obtained from the experimental program is presented in following sections. 4.2

Compressive Strength Test Results

The results of the compressive strength tests conducted on concrete specimens of different mixes cured at different ages are presented and discussed in this section. The compressive strength test were conducted at curing ages of 7, 14, and 28, days. The compressive strength test results of all the mixes at different curing ages are given in Table 4.1. Variation of compressive strength of all the mixes cured at 7, 14, and 28, days are also shown in

Graph 4.1, 4.2, & 4.3 shows the variation of compressive strength of concrete mixes w.r.t control mix (100%OPC+0%SF+0%FA) after 7, 14, and 28, days respectively. Table 4.1 Compressive

strength (

MPa) results of all mixes at different curing ages

Mix No. Description-M20 7 days 14 days 28 days 1 100%OPC+0%

0: 435b784a-50bf-43e2-9dce-a3967f3adfaf 55%

FA+0%SF 16.30 20.00 25.95 2 95%OPC+5%FA+15%SF 15.80 19.51 24.16 3 90%OPC+10%FA +15%SF 16.62 22.50 26.30 4 85%OPC+15%FA+15%SF 17.20 23.60 27.80

30 5 80%OPC+20%FA+15%SF 18.55 24.15 28.46 6 75%OPC+25%FA+15%SF 16.15 19.90 25.63 7 70%OPC+30%FA+15%SF 15.80 19.25 24.80

Graph:4.1 Compressive Strength at 7 days for M20 16.30 15.80 16.62 17.20 18.55 16.15 15.80 14.00 14.50 15.00 15.50 16.00 16.50 17.00 17.50 18.00 18.50 19.00 Compressive Strength Replacement Percentage

Graph:4.2 Compressive Strength at 14 days for M20 20.00 19.51 22.50 23.60 24.15 19.90 19.25 0.00 5.00 10.00 15.00 20.00 25.00 30.00 Compressive Strength Replacement Percentage

31 Graph:4.3 Compressive Strength at 28 days for M20 25.95 24.16 26.30 27.80 28.46 25.63 24.80 22.00 23.00 24.00 25.00 26.00 27.00 28.00 29.00 Compressive Strength Replacement Percentage Graph: 4.4 Compressive Strength in N/mm 2 at various ages for M20 16.30 15.80 16.62 17.20 18.55 16.15 15.80 20.00 19.51 22.50 23.60 24.15 19.90 19.25 25.95 24.16 26.30 27.80 28.46 25.63 24.80 0.00 5.00 10.00 15.00 20.00 25.00 30.00 0.0 5.0 10.0 15.0 20.0 25.0 30.0 Compressive Strength Replacement Percentage 7 days 14 days 28 days Table 4.2 Compressive strength (MPa) results

of all mixes at different curing ages Mix No. Description-M25 7 days 14 days 28 days 1 100% OPC+0%

0: 435b784a-50bf-43e2-9dce-a3967f3adfaf 55%

FA+0%SF 20.54 24.80 30.50 2 95%OPC+5%FA+15%SF 19.50 23.60 29.43 3 90%OPC+10%FA +15%SF 20.99 25.15 30.99

32 4 85%OPC+15%FA+15%SF 21.64 26.45 31.52 5 80%OPC+20%FA+15%SF 22.85 27.86 33.20 6 75%OPC+25%FA+15%SF 20.13 24.20 30.20 7 70%OPC+30%FA+15%SF 19.42 23.90 29.50

Graph:4.5 Compressive Strength at 7 days for M25 20.54 19.50 20.99 21.64 22.85 20.13 19.42 17.00 18.00 19.00 20.00 21.00 22.00 23.00 24.00 Compressive Strength Replacement Percentage

Graph:4.6 Compressive Strength at 14 days for M25 24.80 23.60 25.15 26.45 27.86 24.20 23.90 21.00 22.00 23.00 24.00 25.00 26.00 27.00 28.00 29.00 Compressive Strength Replacement Percentage

33 Graph:4.7 Compressive Strength at 28 days for M25 30.50 29.43 30.99 31.52 33.20 30.20 29.50 27.00 28.00 29.00 30.00 31.00 32.00 33.00 34.00 Compressive Strength Replacement Percentage Graph: 4.8 Compressive Strength in N/mm 2 at various ages for M25 20.54 19.50 20.99 21.64 22.85 20.13 19.42 24.80 23.60 25.15 26.45 27.86 24.20 23.90 30.50 29.43 30.99 31.52 33.20 30.20 29.50 0.00 5.00 10.00 15.00 20.00 25.00 30.00 35.00 0.0 5.0 10.0 15.0 20.0 25.0 30.0 Compressive Strength Replacement Percentage 7 days 14 days 28 days Table 4.3 Compressive strength (MPa) results

of all mixes at different curing ages Mix No. Description-M30 7 days 14 days 28 days 1 100% OPC+0%

0: 435b784a-50bf-43e2-9dce-a3967f3adfaf 55%

FA+0%SF 24.68 28.63 35.60 2 95%OPC+5%FA+15%SF 23.95 27.90 34.90 3 90%OPC+10%FA +15%SF 24.99 28.99 36.05

34 4 85%OPC+15%FA+15%SF 25.84 30.63 36.94 5 80%OPC+20%FA+15%SF 26.98 31.40 37.00 6 75%OPC+25%FA+15%SF 24.50 29.40 35.10 7 70%OPC+30%FA+15%SF 23.90 28.45 34.65

Graph:4.9 Compressive Strength at 7 days for M30 24.68 23.95 24.99 25.84 26.98 24.50 23.90 22.00 22.50 23.00 23.50 24.00 24.50 25.00 25.50 26.00 26.50 27.00 27.50 Compressive Strength Replacement Percentage

Graph:4.10 Compressive Strength at 14 days for M30 28.63 27.90 28.99 30.63 31.40 29.40 28.45 26.00 27.00 28.00 29.00 30.00 31.00 32.00 Compressive Strength Replacement Percentage

35 Graph:4.11 Compressive Strength at 28 days for M30Graph: 4.12 35.60 34.90 36.05 36.84 37.20 35.10 34.65 33.00 33.50 34.00 34.50 35.00 35.50 36.00 36.50 37.00 37.50 Compressive Strength Replacement Percentage Graph:4.12 Compressive Strength in N/mm 2 at various ages for M30 24.68 23.95 24.99 25.84 26.98 24.50 23.90 28.63 27.90 28.99 30.63 31.40 29.40 28.45 35.60 34.90 36.05 36.84 37.20 35.10 34.65 0.00 5.00 10.00 15.00 20.00 25.00 30.00 35.00 40.00 0.0 5.0 10.0 15.0 20.0 25.0 30.0 Compressive Strength Replacement Percentage 7 days 14 days 28 days

Table 4.1, 4.2 and 4.3 are shows that there is an increase in compressive strength with the increase in Fly Ash percentages upto 20%, thereafter there is a decrease in compressive strength with further increase in Fly Ash in all the curing ages of concrete. The results of compressive strength for M25 concrete and M30 are given in table 4.2 and 4.3. The variation of compressive strength with percentages Fly Ash is shows in Fig 4.2 and Fig 4.3 for M25 and M30 concretes. Again the trend of compressive strength with Fly Ash and Silica Fume is same as for M20 concrete.

36 4.3

Split

Tensile Strength Test Results The results of the splitting tensile strength tests conducted on concrete specimens of different mixes cured at different ages are presented and discussed in this section. The splitting tensile strength test was conducted at curing ages of 28 days. The splitting tensile strength test results of all the mixes at different curing ages are shown in Table 4.3.Variation of splitting tensile strength of all the mixes cured at28 days is also shown in

Fig. 4.2 shows the variation of splitting tensile strength of concrete mixes w.r Table 4.3 Splitting tensile strength (MPa) results of all mixes at different curing ages. Table 4.4 Split

TensileSstrength (MPa) results of all mixes at different curing ages Mix No. Description-M20 28 days 1 100%OPC+0%

0: 435b784a-50bf-43e2-9dce-a3967f3adfaf 55%

FA+0%SF 3.60 2 95%OPC+5%FA+15%SF 3.40 3 90%OPC+10%FA+15%SF 3.80 4 85%OPC+15% FA+15%SF 4.10 5 80%OPC+20%FA+15%SF 4.35 6 75%OPC+25%FA+15%SF 3.52 7 70%OPC +30%FA+15%SF 3.20

Table 4.5 Split TensileSstrength (MPa) results of all mixes at different curing ages Mix No. Description-M25 28 days 1 100%OPC+0%

0: 435b784a-50bf-43e2-9dce-a3967f3adfaf 55%

FA+0%SF 3.92 2 95%OPC+5%FA+15%SF 4.00 3 90%OPC+10%FA+15%SF 4.11 4 85%OPC+15% FA+15%SF 4.36

37 5 80%OPC+20%FA+15%SF 4.60 6 75%OPC+25%FA+15%SF 3.80 7 70%OPC+30%FA+15%SF 3.40

Table 4.6 Split TensileSstrength (MPa) results of all mixes at different curing ages Mix No. Description-M25 28 days 1 100%OPC+0%

0: 435b784a-50bf-43e2-9dce-a3967f3adfaf 55%

FA+0%SF 4.25 2 95%OPC+5%FA+15%SF 4.36 3 90%OPC+10%FA+15%SF 4.51 4 85%OPC+15% FA+15%SF 4.80 5 80%OPC+20%FA+15%SF 5.10 6 75%OPC+25%FA+15%SF 4.00 7 70%OPC +30%FA+15%SF 3.75

Graph:4.13 Split Tensile Strength at 28 days for M20 3.60 3.40 3.80 4.10 4.35 3.52 3.20 0.00 0.50 1.00 1.50 2.00 2.50 3.00 3.50 4.00 4.50 5.00 Split Tensile Strength Replacement Percentage

38 Graph:4.14 Split Tensile Strength at 28 days for M25 3.92 4.00 4.11 4.36 4.60 3.80 3.40 0.00 0.50 1.00 1.50 2.00 2.50 3.00 3.50 4.00 4.50 5.00 Split Tensile Strength Replacement Percentage Graph 4.15 Split Tensile Strength at 28 days for M30 4.25 4.36 4.51 4.80 5.10 4.00 3.75 0.00 1.00 2.00 3.00 4.00 5.00 6.00 Split Tensile Strength Replacement Percentage

Graph: 4.16 Split Tensile Strength in N/mm 2 at 28 days 3.60 3.40 3.80 4.10 4.35 3.52 3.20 3.92 4.00 4.11 4.36 4.60 3.80 3.40 4.25 4.36 4.51 4.80 5.10 4.00 3.75 0.00 1.00 2.00 3.00 4.00 5.00 6.00 0.0 5.0 10.0 15.0 20.0 25.0 30.0 Flexural Strength Replacement Percentage M20 M25 M30

39 Table 4.4, 4.5 & 4.6 shows that the splitting tensile strength

test results of the samples follow an increasing trend till the 20% replacement thereafter there is decrease in the tensile strength. As the percentage replacement of the Fly Ash increases in the mix there is a rising trend in the graph observed in the tensile strength of the mix up to replacement level of 20% and as the percentage replacement increases to 20% there is decrease in the tensile strength observed probably due to an increase in Fly Ash replacement percentage. 4.4 Flexural

Strength Test Results The results of the splitting tensile strength tests conducted on concrete specimens of different mixes cured at different ages are presented and discussed in this section. The splitting tensile strength test was conducted at curing ages of 28 days. The splitting tensile strength test results of all the mixes at different curing ages are shown in

Table 4.3.Variation of splitting tensile strength of all the mixes cured at 28 days is also shown in

Table 4.4. Graph 4.5, shows the variation of splitting tensile strength of concrete mixes w.r.

t control mix (90%OPC+0%SF) after 28 days respectively. Table 4.7 FlexuralSstrength (MPa) results of all mixes at different curing ages Mix No. Description-M20 28 days 1 100%OPC+0%

0: 435b784a-50bf-43e2-9dce-a3967f3adfaf 55%

FA+0%SF 3.10 2 95%OPC+5%FA+15%SF 3.25 3 90%OPC+10%FA+15%SF 3.58 4 85%OPC+15% FA+15%SF 3.98 5 80%OPC+20%FA+15%SF 4.35 6 75%OPC+25%FA+15%SF 3.05 7 70%OPC +30%FA+15%SF 2.87

40

Table 4.8 FlexuralSstrength (MPa) results of all mixes at different curing ages Mix No. Description-M25 28 days 1 100%OPC+0%

0: 435b784a-50bf-43e2-9dce-a3967f3adfaf 55%

FA+0%SF 3.64 2 95%OPC+5%FA+15%SF 3.73 3 90%OPC+10%FA+15%SF 4.04 4 85%OPC+15% FA+15%SF 4.46 5 80%OPC+20%FA+15%SF 4.70 6 75%OPC+25%FA+15%SF 3.46 7 70%OPC +30%FA+15%SF 3.10

Table 4.9 FlexuralSstrength (MPa) results of all mixes at different curing ages Mix No. Description-M25 28 days 1 100%OPC+0%

0: 435b784a-50bf-43e2-9dce-a3967f3adfaf 55%

FA+0%SF 4.17 2 95%OPC+5%FA+15%SF 4.22 3 90%OPC+10%FA+15%SF 4.50 4 85%OPC+15% FA+15%SF 4.90 5 80%OPC+20%FA+15%SF 5.02 6 75%OPC+25%FA+15%SF 4.10 7 70%OPC +30%FA+15%SF 3.85

41

Table 4.7, 4.8 &4.9 shows that the flexural strength test results of the samples follow an increasing trend till the 20% replacement thereafter there is decrease in the flexural strength. As the percentage replacement of the Fly Ash increases in the mix there is a rising trend in the graph observed in the flexural strength of the mix upto replacement level of 20% and as the percentage replacement increases to 20% there is decrease in the flexural strength observed probably due to an increase in Fly Ash replacement percentage. Graph:4.17 Flexural Strength at 28 days

for M20 3.10 3.25 3.58 3.98 4.35 3.05 2.87 0.00 0.50 1.00 1.50 2.00 2.50 3.00 3.50 4.00 4.50 5.00 Flexural Strength Replacement Percentage Graph:4.18 Flexural Strength at 28 days for M25

3.64 3.73 4.04 4.46 4.70 3.46 3.10 0.00 0.50 1.00 1.50 2.00 2.50 3.00 3.50 4.00 4.50 5.00 Flexural Strength Replacement Percentage

42 Graph 4.19 Flexural Strength at 28 days for M30 4.17 4.22 4.50 4.90 5.02 4.10 3.85 0.00 1.00 2.00 3.00 4.00 5.00 6.00 Flexural Strength Replacement Percentage

Graph 4.20 Flexural Strength in N/mm 2 at 28 Days 3.10 3.25 3.58 3.98 4.35 3.05 2.87 3.64 3.73 4.04 4.46 4.70 3.46 3.10 4.17 4.22 4.50 4.90 5.02 4.10 3.85 0.00 1.00 2.00 3.00 4.00 5.00 6.00 0 5 10 15 20 25 30 Flexural Strength Replacement Percentage M20 M25 M30 4.5 Workability of Concrete Mixes The workability of concrete mixes was found out by slump test as per procedure given in chapter 3. Water cement ratio (W/b) was kept constant 0.5 for all the concrete mixes. The workability results of different concrete mixes were shown in

Table 4.

43 Table 4.10 Workability results of all mixes at 28 days Mix No. Description-M20 Slump (mm) 1 100%OPC+0%

0: 435b784a-50bf-43e2-9dce-a3967f3adfaf 55%

FA+0%SF 72.00 2 95%OPC+5%FA+15%SF 64.00 3 90%OPC+10%FA+15%SF 59.00 4 85%OPC +15%FA+15%SF 53.00 5 80%OPC+20%FA+15%SF 44.00 6 75%OPC+25%FA+15%SF 32.00 7 70% OPC+30%FA+15%SF 27.00

Table 4.11 Workability results of all mixes at 28 days Mix No. Description-M25 Slump (mm) 1 100%OPC+0%

0: 435b784a-50bf-43e2-9dce-a3967f3adfaf 55%

FA+0%SF 85.00 2 95%OPC+5%FA+15%SF 72.00 3 90%OPC+10%FA+15%SF 64.00 4 85%OPC +15%FA+15%SF 55.00 5 80%OPC+20%FA+15%SF 46.00 6 75%OPC+25%FA+15%SF 36.00 7 70% OPC+30%FA+15%SF 31.00

44

Table 4.12 Workability results of all mixes at 28 days Mix No. Description-M25 Slump (mm) 1 100%OPC+0%

0: 435b784a-50bf-43e2-9dce-a3967f3adfaf 55%

FA+0%SF 95.00 2 95%OPC+5%FA+15%SF 86.00 3 90%OPC+10%FA+15%SF 71.00 4 85%OPC +15%FA+15%SF 63.00 5 80%OPC+20%FA+15%SF 54.00 6 75%OPC+25%FA+15%SF 46.00 7 70% OPC+30%FA+15%SF 35.00

Table 4.14 shows that as the Fly Ash in percentage to concrete mixincreases, the workability of concrete mix was found to decreases as compared to control mix (fresh concrete) of Fly Ash into concrete mix further decreases the workability. The same trend was observed in other concrete mix.

Graph 4.21 Slump (mm) at 28 days 72.00 64.00 59.00 53.00 44.00 32.00 27.00 85.00 72.00 64.00 55.00 46.00 36.00 31.00 95.00 86.00 71.00 63.00 54.00 46.00 35.00 0.00 10.00 20.00 30.00 40.00 50.00 60.00 70.00 80.00 90.00 100.00 0 5 10 15 20 25 30 Flexural Strength Replacement Percentage M20 M25 M30

45 CHAPTER 5 CONCLUSIONS

AND FUTURE SCOPE 5.1 Conclusion

Compressive strength, Flexural strength, and Split tensile strength of concreteMixes made with and without Fly Ash and Silica Fume has been determined at 7, 14, & 28 days of curing. The strength gained has been determined of Fly Ash and Silica Fume added concrete with addition of 0%, 5%, 10%, 15%, 20%, 25% & 30% and 15% Fly Ash and Silica Fume added as a common for all replacement for M20, M25 and M30 grade as a partial replacement of cement in conventional concrete. From the results it is conclude that the Fly Ash and Silica Fume is a superior replacement of cement. The rate of strength increase in Fly Ash and Silica Fume concrete is high. After performing all the tests and analyzing their result, the following conclusions have been derived: 1. The results achieved from the existing study shows that the combination ofFly Ash and Silica Fume are great potential for the utilization in concrete as replacement of cement. 2. Workability of concrete decreases as proportion ofFly Ash and Silica Fumes increases. 3. Maximum compressive strength was observed when Fly Ash and Silica Fume replacement is about 20% and 15% respectively. 4. Maximum split tensile strength was observed whenFly Ash and Silica Fume replacement are about 20% and 15% respectively. 5. Maximum flexural strength was observed whenFly Ash and Silica Fume replacement are about 20% and 15% respectively.

46 5.2 Recommendations for Future Research From this research, there are few recommendations to develop, to extend and to explore the usage ofFly Ash and Silica Fume in concrete: i.) Define

the effect of Fly Ash and Silica Fume on concrete

with the replacement of mixture of coarse and fine aggregate. ii.) Define the effect of Fly ash on concrete with the replacement of mixture of coarse and fine aggregate. ii.) Replacement of cement with Fly Ash and Silica Fume in different water cement ratio. iii.) Selected few samples of concrete with different percentage of usingFly Ash and Silica Fume and conclude the most suitable percentage of usage to achieve the optimum compressive strength.

47

CHAPTER 6

REFERENCES 1. ACI committee 544. 1982. State-of-the-report on Fly Ash and Silica Fume reinforced concrete, (ACI 544.1R-82), Concrete International: Design and Construction. 4(5):

9-30, American Concrete Institute, Detroit, Michigan, USA. 2. ACI Committee 544. 1989. Measurement of properties Fly Ash and Silica Fumes reinforced

concrete, (ACI 544.2R-889). American Concrete Institute, Detroit, Michigan, USA. 3. ASTM C 1240-11 “standard specification for Fly Ash and Silica Fume used in cementitious mixtures”. 4. Bhanja, S., B. Sengupta, b., (2003) “Modified water- cement ratio law for Fly Ash and Silica Fume concretes “. Cement and Concrete research, 33, pp 447-450. 5. Mohamed s. Morsy, Sayed s. Shebl, Effect of Fly Ash and Silica Fume and metakaolinepozzolana on the performance of blended cement pastes against fire, Ceramics - Silikáty 51 (1) 40-44 (2007). 6. S. Vishal, Ghutke1, Bhandari S. Pranita (2014) . Influence of Fly Ash and

Silica Fume on concrete. IOSR Journal of Mechanical and Civil Engineering (

IOSR- JMCE).

PP 44-47(2014). 7. Zain, M.F.M., Safiuddin, Md. And Mahmud, H.(2000) “Development of high performance concrete using

Fly Ash and

Silica Fume at relatively high water- binder ratios”, Cement and Concrete Research,

Vol.30,pp 1501-1505. 8. Pradhan D, Dutta. D. (2013). Influence of Fly Ash and Silica Fume on Normal Concrete. Int. Journal of Engineering Research and Applications Vol. 3, pp.79- 82. 9. Amudhavalli N. K., Mathew Jeena. (2012)Effect of Fly Ash and

Silica Fume on strength and durability parameters of concrete.International Journal of Engineering Sciences & Emerging Technologies.

Volume 3, Issue 1, pp: 28-35. 10.

Karein S. Mahmoud Motahari ,Ramezanianpour A.A. , TaghiEbadi , IsapourSoroush , (2017) A new approach for application of Fly Ash and Silica Fume in concrete: Wet Granulation.Construction and Building Materials page573–581.

48 11. Zhang Zengqi , Zhang Bo , Yan Peiyu (2016) Comparative study of effect of raw and densifiedFly Ash and Silica Fume in the paste,mortar and concrete. Construction and Building Materials 105 .page 82–93. 12. Khan M.I, Abbas Y.M. (2017) Curing optimization for strength and durability of Fly Ash and Silica Fume and fuel ash concretes under hot weather conditions.Construction and Building Materials 157 (page) 1092–1105. 13. Okoye Francis N, PrakashSatya , Singh Nakshatra B. (2017) Durability of fly ash based geopolymer concrete in the presence of Fly Ash and Silica Fume.Journal of Cleaner Production 149. (Page) 1062-1067. 14. Ali K., Ghalehnovi .M ,Brito J. de , Shamsabadi E. A, (2017) Durability performance of structural concrete containing Fly Ash and Silica Fume and marble industry waste powder.Journal of Cleaner Production 170 (page) 42and60. 15. Siddique R, Jameel A, Singh M. ,Hunek .D. B , Mokhtar A. A. , Belarbi. R., Rajor. A. (2017) Effect of bacteria on strength, permeation characteristics and micro-structure of Fly Ash and Silica Fume

concrete.Construction and Building Materials 142 (Page) 92–100. 16. Wang. L. , Zhou S.H. , Y. Shi , Tang S.W. , Chen E.(2017) Effect of Fly Ash and Silica Fume and PVA fiber on the abrasion resistance and volume stability of concrete. Composites Part B 130. (page) 28 and 37. 17.

Pedro D., de Brito J., Evangelista L. (2017) Evaluation of high-performance concrete with recycled aggregates: Use of

densifiedFly Ash and Silica Fume as cement replacement. Construction and Building Materials 147 (page) 803–814. 18. Dave N , Mishra A K , Srivastava A. , Kaushik S K. (2016). Experimental analysis of strength and durability properties of quaternary cement binder and mortar. Construction and Building Materials 107 (page) 117–124. 19. Ju Y., Tian K., Liu H. , Reinhardt H.W , Wang L.(2017). Experimental investigation of the effect of Fly Ash and Silica Fumes on the thermal spalling of reactive powder concrete.Construction and Building Materials 155 (page) 571– 583. 20. Palla R., Karade S.R., Mishra G., Sharma U., Singh L.P. (2017). High strength sustainable concrete using silica nanoparticles. Construction and Building Materials 138. (Page) 285–295.

49 21. Dybel P., Furtak K. (2017) Influence of Fly Ash and Silica Fume content on the quality of bond conditions in high-performance concrete specimens. Archives of civil and mechanical engineering 17 (page) 795 – 805. 22. Liu J., Wang D. (2017) Influence of steel slag-Fly Ash and Silica Fume composite mineral admixture on the properties of concrete. Powder Technology 320 (page) 230–238. 23. Kawabata Y., Seignol J.F., Martin R.P., Toutlemonde F. (2017).Macroscopic chemomechanical modelling of alkali-silica reaction of concrete under stresses.

Construction and Building Materials 137 (page) 234–245. 24. Fathi M., Yousefipour A., Farokhy E. H. (2017).

Mechanical and physical properties of expanded polystyrene structural concretes containing Micro-silica and Nano-silica.

Construction and Building Materials 136 (page) 590–597. 25. Pedro D., de Brito J., Evangelista L. (2017). Mechanical characterization of high performance concrete prepared with recycled aggregates and Fly Ash and Silica Fume from precast industry. Journal of Cleaner Production 164 (page) 939 and 949. 26. Zhang N., Li H., Peng D., Liu X. (2016). Properties evaluation of silica-alumina based concrete: Durability and environmental friendly performance.

Construction and Building Materials 115 (page) 105–113. 27.

Adak D., Sarkar M. ,Mandal S.(2017) Structural performance of nano-silica modified fly-ash based geopolymer concrete.

Construction and Building Materials 135 (page) 430–439. 28. Kumar R., Singh S., Singh L.P. (2017) Studies on enhanced thermally stable high strength concrete incorporating silica nanoparticles. Construction and Building Materials 153 (page) 506–513. 29. Maruyama I., Teramoto A. (2013). Temperature dependence of autogenous shrinkage of Fly Ash and Silica Fume cement pastes with a very low water– binder ratio. Cement and Concrete Research 50 (page) 41–50. 30. Abdou M.I., Abuseda H. (2016) Upgrading offshore pipelines concrete coated by Fly Ash and Silica Fume additive against aggressive mechanical laying and environmental impact. Egyptian Journal of Petroleum (page) 25, 193–199.

50 31. Rostami M., Behfarnia K. (2017). The effect of Fly Ash and Silica Fume on durability of alkali activated slag concrete. Construction and Building Materials 134 (page) 262–268. 32. Nattaj F. H., Nematzadeh M. (2017).

The

effect of forta-ferro and steel fibers on mechanical properties of high-strength concrete with and

without Fly Ash and Silica

Fume and nano-silica. Construction and Building Materials 137 (page) 557–572. 33. Indian Standard IS: 516-1959, bureau of India standards, ManakBhawan, 9 BahadurShah ZafarMarg, New Delhi 110002. 34. Indian Standard IS 383-1970, Bureau of India Standards, ManakBhawan, 9 BahadurShah ZafarMarg, New Delhi 110002. 35. Indian Standard IS: 10262-2009, Bureau of India Standards, ManakBhawan, 9Bahadur Shah ZafarMarg, New Delhi 110002. 36. Indian Standard IS: 4031-1988, Bureau of India Standards, ManakBhawan, 9Bahadur Shah ZafarMarg, New Delhi 110002. 37. Indian Standard IS: 1489-1991(Part-1), Bureau of India Standards, ManakBhawan, 9Bahadur Shah ZafarMarg, New Delhi 110002. 38. Indian Standard IS 456-2000, Bureau of India Standards, ManakBhawan, 9 BahadurShah ZafarMarg, New Delhi 110002. 39. Leemann A. (2017) Raman microscopy of alkali-silica reaction (ASR) products formed in Concrete. Cement and Concrete Research 102 (2017) 41-48. 40. Ewais E.M.M., Khalil N.M., Amin M.S., Ahmed Y.M.Z., Barakat M.A. (2009). Utilization of aluminum sludge and aluminum slag (dross) for the manufacture of calcium aluminate cement. Ceramics International 35 (page) 3381–3388.

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use of Fly Ash and Silica Fume in concrete has	use of fly ash and silica fume in concrete has

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8 100%

Fly Ash Fly ash is a group of materials that can vary significantly in composition. It is residue left from burning coal,

which is collected on an electrostatic precipitator or in a baghouse.

It mixes with flue gases that result when powdered coal is used to produce electric power. Since the oil crisis of the 1970s, the use of coal has increased. In 1992, 460 million metric tons of coal ash were produced worldwide.

About 10 percent of this was produced as fly ash in the United States.

In 1996, more than 7 million metric tons were used in concrete

in the U.S. Economically, it makes sense to use as much of this low-cost ash as possible, especially if it can be used in concrete as a substitute for cement.Coal is the product of millions of years of decomposing vegetable matter under pressure,

and its chemical composition is erratic.

In addition, electric companies optimize power production from coal using additives such as flue-gas conditioners, sodium sulfate, oil, and other additives to control corrosion, emissions,

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Fly Ash? Fly ash is a group of materials that can vary significantly in composition. It is residue left from burning coal, which is collected on an electrostatic precipitator or in a baghouse. It mixes with flue gases that result when powdered coal is used to produce electric power. Since the oil crisis of the 1970s, the use of coal has increased. In 1992, 460 million metric tons of coal ash were produced worldwide. About 10 percent of this was produced as fly ash in the United States. In 1996, more than 7 million metric tons were used in concrete in the U.S. Economically, it makes sense to use as much of this low-cost ash as possible, especially if it can be used in concrete as a substitute for cement. Coal is the product of millions of years of decomposing vegetable matter under pressure, and its chemical composition is erratic. In addition, electric companies optimize power production from coal using additives such as flue-gas conditioners, sodium sulfate, oil, and other additives to control corrosion, emissions, and fouling. The resulting fly ash can have a variable composition and contain several additives as well as products from incomplete combustion. Most fly ash is pozzolanic, which means it’s a siliceous or siliceous-and-aluminous material that reacts with calcium hydroxide to form a cement. When portland cement reacts with water, it produces a hydrated calcium silicate (CSH) and lime. The hydrated silicate develops strength and the lime fills the voids. Properly selected fly ash reacts with the lime to form CSH–the same cementing and fouling. The resulting fly ash can have a variable composition and contain several additives as well as products from incomplete combustion.

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When Portland cement reacts with water, it produces a hydrated calcium silicate (CSH) and lime.

The hydrated silicate develops strength and the lime fills the voids.

Properly selected fly ash reacts with the lime to form CSH–the same cementing product as in Portland cement.

This reaction of fly ash with lime in concrete improves strength. Typically, fly ash is added to structural concrete at 15-35 percent by weight of the cement,

but up

to 70 percent is added for mass concrete used in dams, roller-compacted concrete pavements, and parking areas.

Special care must be taken in selecting fly ash to ensure improved properties in concrete.

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nano silica replacing fly ash in terms of bond strength, flexural strength and micro structural behaviour. Such nano silica modified fly ash based geopolymer concrete showed appreciable improvement in structural behaviour at different ages without any heat

17 activation. The bond strength between reinforcement bars (deformed or mild steel) and surrounding geopolymer concrete materials (with/without nano silica) has been also compared to the conventional cement concrete. The nano silica modified geopolymer concrete exhibited better structural performance than heat cured geopolymer concrete (without nano silica) and conventional cement concrete samples. The microstructural properties of such geopolymer concrete (with/without nano silica) and cement concrete have been analyzed through Field Emission Scanning Electron Microscope (FESEM) with Energy Dispersive X-ray Spectroscopy (EDS), Fourier Transform Infrared Spectroscopy (FTIR) analysis and X-ray Diffraction (XRD) techniques. The enhancement of structural performance was mainly due to the transformation of amorphous phase to crystalline phase in the geopolymer concrete matrices in the presence of nano-silica.

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17 100%	17: https://www.hoperacafe.it/article/34815/silica-fume-uses.html 100%
very fine powder of spherical particles that average 0.1 to 0.3 microns in diameter with a surface area of 17 to 30 m2/g	very fine powder of spherical particles that average 0.1 to 0.3 microns in diameter with a surface area of 17 to 30 m2/g.

19 100%	19: https://www.hoperacafe.it/article/34815/silica-fume-uses.html 100%
Silica Fume is used in a variety of cementitious (concrete, grouts and mortars), refractory, elastomer and polymer applications. 3.3	Silica fume is used in a variety of cementitious concrete, grouts and mortars, refractory, elastomer and polymer applications.

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6 52%

Table 1.1 –Physical Properties of Silica Fume Properties Observed Values Colour Dark grey Specific gravity 2.2 Fineness modulus 20000m 2 /kg Bulk

6: https://www.ijrte.org/wp-content/uploads/papers/v7i6c2/F10850476C219.pdf 52%

Table III: Physical properties of Silica Fume Properties Observed value Color of silica fume Light to Dark grey Specific gravity 2.2 Surface area 20000 m 2 /kg Bulk

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5 72%	5: https://www.ijraset.com/fileserve.php?FID=19456 72%
Addition of Silica Fume also decrease the permeability of concrete to chloride ions, which protect the reinforcing steel of concrete from corrosion,	Addition of silica fume also reduces the permeability of concrete to chlorideions, which protects the reinforcing steel of concrete from corrosion.

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9 32%	9: https://www.pooledfund.org/Document/Download/3857 32%
the density of Fly Ash and Silica Fume was increased by producing Fly Ash and Silica Fume granules mixed with a solid super plasticizer. The effects of Fly Ash and Silica Fume	the effects of fly ash and silica fume on chloride and oxygen permeability were studied. PC was replaced by both fly ash and silica fume 13 to form a ternary system. The results showed that incorporation of fly ash and silica fume

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12 **87%**

the mechanical and physical properties such as strength, water absorption, type of curing, failure mode and microstructure of expanded polystyrene (EPS) structural lightweight concretes modified by Micro-silica and Nano-silica were investigated. In the specimens without EPS beads, replacement of Micro-silica and Nano-silica up to 15% and 3% of cement, respectively, led toincrease in compressive strength and decreasing water absorption, and after that, these trends were vice versa.

12: https://www.sciencedirect.com/science/article/abs/pii/S0950061817300545 **87%**

the mechanical and physical properties such as strength, water absorption, type of curing, failure mode and microstructure of expanded polystyrene (EPS) structural lightweight concretes modified by Micro-silica and Nano-silica were investigated. In the specimens without EPS beads, replacement of Micro-silica and Nano-silica up to 15 and 3 wt% of cement, respectively, led to compressive strength increase and water absorption decrease, and after that, these trends were vice versa.

13 **97%**

by 15%

to 20%. By adding Micro- silica and Nano-silica to the concretes containing EPS beads, proper adhesion between the EPS beads and other concrete components was created as confirmed by the SEM

16 images of the specimens. Also the effects of three curing methods with water, limewater and steam on the strength and water absorption of concretes were investigated. Their findings showed that 28-day limewater and 1-day steam curing resulted

13: https://www.sciencedirect.com/science/article/abs/pii/S0950061817300545 **97%**

by approximately 15 to 20%. By

adding Micro-silica and Nano-silica to the concretes containing EPS beads, proper adhesion between the EPS beads and other concrete components was created as confirmed by the SEM images of the specimens. Also the effects of three curing methods with water, limewater and steam on the strength and water absorption of concretes were investigated. The findings showed that 28-day limewater and 1-day steam curing resulted in the highest strength and the lowest water absorption compared to other curing methods.

in the highest strength and the lowest water absorption compared to other curing methods.

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1	75%

The genuine cost of concrete is related to cost of materials essential for produce a minimum mean strength

1: https://www.ijert.org/research/experimental-study-on-the-mechanical-properties-of-concrete-using-micro-silica-and-nano-silica-a-step-towards-sustainability-IJERTV5IS110315.pdf 75%

The actual cost of concrete is related to cost of materials required for producing a minimum mean

strength

2	78%

strength that is specific by designer of the structures. This depends on the quality control measures

2: https://www.ijert.org/research/experimental-study-on-the-mechanical-properties-of-concrete-using-micro-silica-and-nano-silica-a-step-towards-sustainability-IJERTV5IS110315.pdf 78%

strength

that is specified by designer of the structures and also depends on the quality control measures.

3	81%

The level of quality control is often an inexpensive cooperation and depends on the size and type of job nowadays engineers and scientists are trying to enhance the strength of concrete by adding

3: https://www.ijert.org/research/experimental-study-on-the-mechanical-properties-of-concrete-using-micro-silica-and-nano-silica-a-step-towards-sustainability-IJERTV5IS110315.pdf 81%

The extent of quality control is often an economical compromise and depends on the size and type of job. Nowadays engineers and scientists are trying to increase the strength of concrete by adding

23 55%

Split tensile Strength (MPa) = 2P / ΠDL P = Splitting Load in N D= diameter of cylinder sample (mm) L = length of

23: https://www.ijert.org/research/experimental-study-on-the-mechanical-properties-of-concrete-using-micro-silica-and-nano-silica-a-step-towards-sustainability-IJERTV5IS110315.pdf 55%

Split Tensile Strength = 2P/πDL (N/mm^2) Where P = load at failure in N D = diameter of the specimen in mm L = length of

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7 80%

Sio2 90-96% Al2o3 0.6 -3.0% Fe2o3 0.3-0.8% Mgo 0.4-1.5% Cao 0.1-0.6% Na2o 0.3-0.7% K2o 0.04-1.0% C 0.5-1.4% S 0.1-2.5%

7: https://etd.ohiolink.edu/!etd.send_file?accession=dayton1544644895468858&disposition=inline 80%

SiO2 19.85 95.5 Al2O3 4.85 1.7 Fe2O 3.7 0.4 SO3 3.12 - MgO 2.34 0.1 Na2O 0.22 - K2O 0.76 - Compound (%) C3S 47.55

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21 81%	21: https://pdfs.semanticscholar.org/2af4/8608da5de46de1b613f165ca7c387b051ad6.pdf 81%
at a temperature of 27 0 C for 24 hours from the time of addition of water to the	at a temperature of 27±2°C for 24hrs from the time of addition of water to the

Instances from: http://www.ijsrp.org/research-paper-0516/ijsrp-p53113.pdf

16	97%

Cement was carefully stored to prevent deterioration in its properties due to contact with the moisture.

23 Table 3.1 Properties of

16: http://www.ijsrp.org/research-paper-0516/ijsrp-p53113.pdf
97%

Cement was carefully stored to prevent deterioration in its properties due to contact with the moisture. Table 3.1: Physical properties of

18	44%

Codal Requirements IS:8112-1989(Part 1)

Fineness (m 2 /kg) 300 225 minimum Standard consistency (%) 32 ---- Initial Setting time (minutes) 41 minutes 30 Minimum Final setting time (minutes) 246 600 Maximum

Specific gravity 3.15 ---- Compressive strength (MPa) 7 days 14-

18: http://www.ijsrp.org/research-paper-0516/ijsrp-p53113.pdf
44%

Codal Requirements IS:8112-1989 (Part 1) 1 Fineness (90 micron IS Sieve) 2 % 10% (Maximum) 2 Specific gravity 3.12 3.15 3 Soundness 2 mm 4 Initial setting time 65 minutes 30 (Minimum) 4 Final setting time 370 minutes 600 (Maximum) 6 Standard consistency 34 percent 7 3-days compressive strength 24.70 MPa 23 (Minimum) 7-days

Instances from: http://www.jairjp.com/SEPTEMBER%202012/07%20VIKAS%20SRIVASTAVA.pdf

4 77%	4: http://www.jairjp.com/SEPTEMBER%202012/07%20VIKAS%20SRIVASTAVA.pdf 77%
resulting from decrease of high purity quartz by coal or coke and wood chips in an electric arc furnace during production of silicon metal or ferrosilicon alloys	resulting from the reduction carbothermic of high–purity quartz with coal or coke and wood chips in an electric arc furnace during the production of silicon metal or silicon alloys.

Instances from: 383a8bca-6d99-4246-bedd-d7750a1a597b

11 90%	11: 383a8bca-6d99-4246-bedd-d7750a1a597b 90%
fly ash (FA), silica flume (SF), ground granulated blast furnace slag (GGBS), metakaolin (MK) and	fly ash (FA), silica fume (SF), ground granulated blast furnace slag (GGBS), metakaolin (MK), and

Instances from: 435b784a-50bf-43e2-9dce-a3967f3adfaf

20 66%

The load was applied gradually without any shock and increased at a constant rate of 3.5

20: 435b784a-50bf-43e2-9dce-a3967f3adfaf 66%

The load was applied without shock and increased continuously at a rate of

22 76%

horizontally between the loading surfaces of a compression testing machine (Fig.3.3) and load was applied gradually until failure of the cylinder

22: 435b784a-50bf-43e2-9dce-a3967f3adfaf 76%

horizontally between the loading surfaces of a compression testing machine and the load is applied until failure of the cylinder

24 55%

FA+0%SF 16.30 20.00 25.95 2 95%OPC+5%FA+15%SF 15.80 19.51 24.16 3 90%OPC+10%FA+15%SF 16.62 22.50 26.30 4 85%OPC +15%FA+15%SF 17.20 23.60 27.80

30 5 80%OPC+20%FA+15%SF 18.55 24.15 28.46 6 75%OPC+25% FA+15%SF 16.15 19.90 25.63 7 70%OPC+30%FA+15%SF 15.80 19.25 24.80

24: 435b784a-50bf-43e2-9dce-a3967f3adfaf 55%

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EXPERIMENTAL STUDY OF CONCRETE AS A PARTIAL REPLACEMENT OF CEMENT BY FLY ASH AND SILICA FUME

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Abstract - The use of Silica Fume and Fly Ash in the present days is to increase the strength of cement concrete. The Fly Ash was replaced by 0%, 5%, 10%, 15%, 20%, 25%, 30%, and 35% and Silica Fume was replaced by 15% common for all mixes as a partial replacement of cement for 7, 14 & 28 days for M20, M25 and M30 grade of concrete. Casted 150 mm X 150 mm X 150 mm cubes for Compressive strength, 100 mm X 100 mm X 500 mm beams for Flexural Strength, and Cylinder size 150 mm diameter and 300 mm height are casting for Split Tensile Strength and Slump cone for workability of concrete and other properties like compacting factor and slump were also determined for three mixes of concrete. The use of cement and production of cement creates much more environmental issues & costlier. To avoid such circumstances, the content of cement is reduced in concrete and replaced by silica fume which reduces cost & addition silica fume also increases strength. Concrete is the most widely used and versatile building material which is generally used to resist compressive forces. By addition of some pozzolanic materials, the various properties of concrete viz, workability, Strength, Resistance to cracks and permeability can be improved.

Key Words: Compressive Strength, Flexural Strength, Split Tensile Strength, Workability of Concrete, Fly Ash and Silica Fume.

1. INTRODUCTION

Concrete is a most commonly used building material which is a mixture of cement, sand, coarse aggregate and water. It is used for construction of multi-storey buildings, dams, road pavement, tanks, offshore structures, canal lining. The method of selecting appropriate ingredients of concrete and determining their relative amount with the intention of producing a concrete of the necessary strength durability and workability as efficiently as possible is termed the concrete mix design. The compressive strength of harden concrete is commonly considered to be an index of its extra properties depends upon a lot of factors e.g. worth and amount of cement water and aggregates batching and mixing placing compaction and curing. The cost of concrete prepared by the cost of materials plant and labour the variation in the cost of material begin from the information that the cement is numerous times costly than the aggregates thus the intent is to produce a mix as feasible from the practical point of view the rich mixes may lead to high shrinkage and crack in the structural concrete and to development of high heat of hydration is mass concrete which may cause cracking.

1.1 Sand

Sand is a naturally occurring coarse material collected of finely separated rock and mineral particles. It is defined by size, being finer than gravel and coarser than silt. Sand may also consign to a textural class of soil or soil type; i.e. a soil contain more than 85% sand-sized particle (by mass).

1.2 Cement

Ordinary Portland cement is used to prepare the mix design of M-20, M-40 and M-50 grade. The cement used was fresh and without any lumps water-cement ratio is 0.42 for this mix design using IS 456:2007.Cement is an extremely ground material having adhesive and cohesive properties which provide a binding medium for the discrete ingredients. Chemically cement constitutes 60-67% Lime (CaO), 17-25% Silica (SiO_2), 3-8% Alumina (Al_2O_3), 0.5-6% Iron Oxide (Fe_2O_3), 0.1-6% Magnesia (MgO), 1-3% Sulphur Trioxide (SO_3), 0.5-3% Soda And Potash (Na_2O+K_2O).

1.3 Aggregate

Aggregate are the essential constituent in concrete. They provide body to the concrete, decrease shrinkage and effect economy. Construction aggregate, or basically "Aggregate", is a wide group of coarse particulate material used in construction, as well as sand, gravel, crushed stone, slag, recycled concrete and geo-synthetic aggregates. Aggregates are the mainly mine material in the world.

1.4 Silica Fume

Silica Fume is a byproduct in the decrease of high-purity quartz with coke in electric arc furnaces in the manufacture of silicon and ferrosilicon alloys. Micro silica consist of fine particle with a surface area on the order of 215,280 ft^2/lb (20,000 m^2/kg) when precise by nitrogen adsorption techniques, with particle just about one hundredth the size of the average cement Because of its excessive fineness and high silica content, micro silica is a very efficient pozzolanic material particle.

1.5 Fly Ash

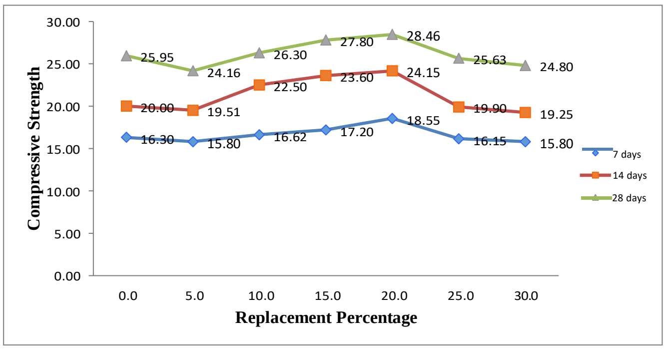
Fly ash is a group of materials that can vary significantly in composition. It is residue left from burning coal, which is collected on an electrostatic precipitator or in a baghouse. It mixes with flue gases that result when powdered coal is used to produce electric power. Since the oil crisis of the 1970s, the use of coal has increased. In 1992, 460 million metric tons of coal ash were produced worldwide

2. RESULT AND DISCUSSION

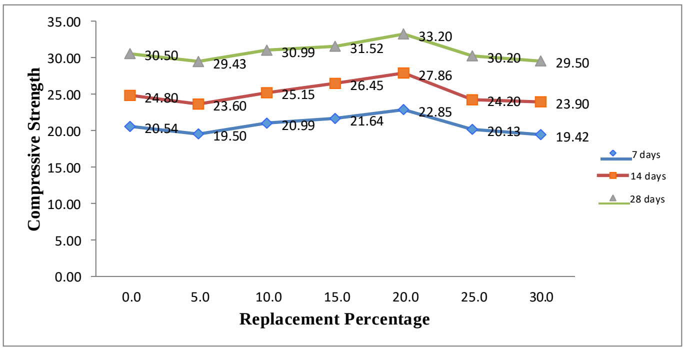
2.1 Compressive Strength Test Results

The results of the compressive strength tests conducted on concrete specimens of different mixes cured at different ages are presented and discussed in this section. The compressive strength test were conducted at curing ages of 7, 14, and 28, days. The compressive strength test results of all the mixes at different curing ages are given in Table 4.1. Variation of compressive strength of all the mixes cured at 7, 14, and 28, days are also shown in Graph 4.1, 4.2, & 4.3 shows the variation of compressive strength of concrete mixes w.r.t control mix (100%OPC+0%SF+0%FA) after 7, 14, and 28, days respectively.

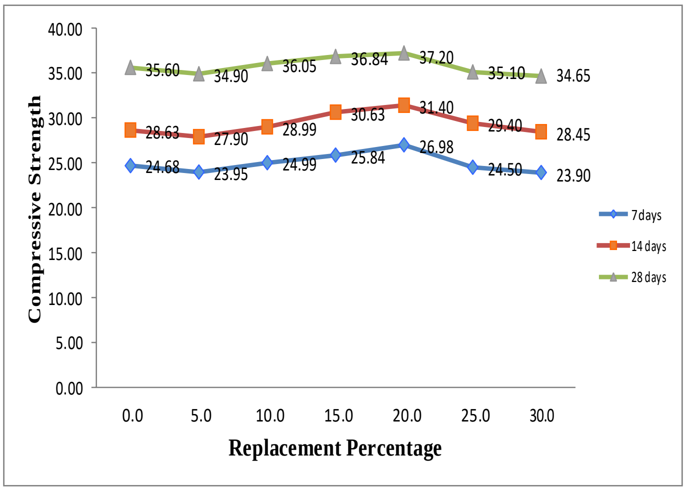
Graph: 2.1 Compressive Strength in N/mm² at various ages for M20



Graph: 2.2 Compressive Strength in N/mm² at various ages for M25



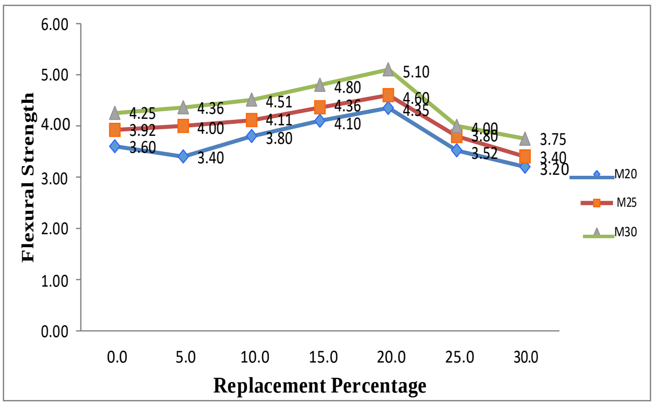
Graph: 2.3 Compressive Strength in N/mm² at various ages for M30



2.2 Split Tensile Strength Test Results

The results of the splitting tensile strength tests conducted on concrete specimens of different mixes cured at different ages are presented and discussed in this section. The splitting tensile strength test was conducted at curing ages of 28 days. The splitting tensile strength test results of all the mixes at different curing ages are shown in Table 4.3.Variation of splitting tensile strength of all the mixes cured at28 days is also shown in Fig. 4.2 shows the variation of splitting tensile strength of concrete mixes w.r Table 4.3 Splitting tensile strength (MPa) results of all mixes at different curing ages.

Graph: 2.4 Split Tensile Strength in N/mm² at 28 days

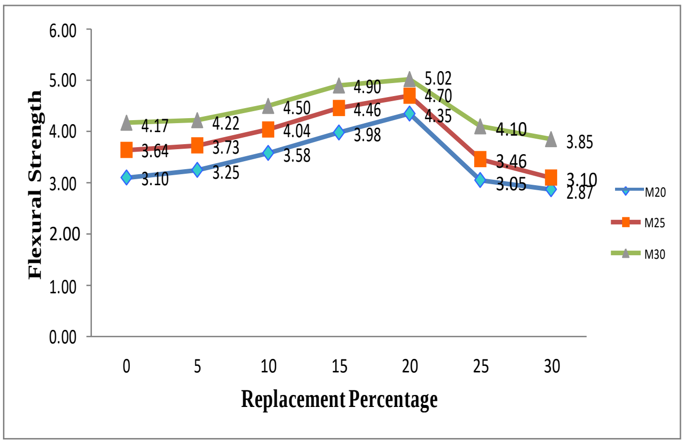


2.3 Flexural Strength Test Results

The results of the splitting tensile strength tests conducted on concrete specimens of different mixes cured at different ages are presented and discussed in this section. The splitting tensile strength test was conducted at curing ages of 28 days. The splitting tensile strength test results of all the mixes at different curing ages are shown in Table

4.3.Variation of splitting tensile strength of all the mixes cured at 28 days is also shown in Table 4.4. Graph 4.5, shows the variation of splitting tensile strength of concrete mixes w.r.t control mix (90%OPC+0%SF) after 28 days respectively.

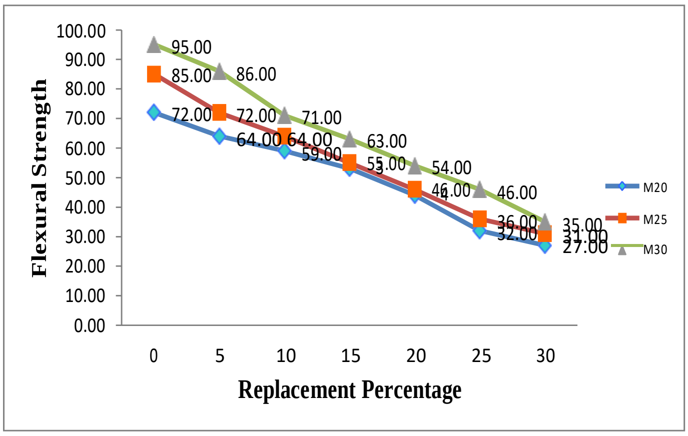
Graph 2.5 Flexural Strength in N/mm² at 28 Days



2.4 Workability of Concrete Mixes

The workability of concrete mixes was found out by slump test as per procedure given in chapter 3. Water cement ratio (W/b) was kept constant 0.5 for all the concrete mixes. The workability results of different concrete mixes were shown in below.

Graph 2.6 Slump (mm) at 28 days



3. CONCLUSIONS

Compressive strength, Flexural strength, and Split tensile strength of concrete Mixes made with and without Fly Ash and Silica Fume has been determined at 7, 14, & 28 days of curing. The strength gained has been determined of Fly Ash and Silica Fume added concrete with addition of 0%, 5%, 10%, 15%, 20%, 25% & 30% and 15% Fly Ash and Silica Fume added as a common for all replacement for M20, M25 and M30 grade as a partial replacement of cement in conventional concrete. From the results it is conclude that the Fly Ash and Silica Fume is a superior replacement of cement. The rate of strength increase in Fly Ash and Silica Fume concrete is high. After performing all the tests and analyzing their result, the following conclusions have been derived:

1. The results achieved from the existing study shows that the combination ofFly Ash and Silica Fume are great potential for the utilization in concrete as replacement of cement.

2. Workability of concrete decreases as proportion ofFly Ash and Silica Fumes increases.

3. Maximum compressive strength was observed when Fly Ash and Silica Fume replacement is about 20% and 15% respectively.

4. Maximum split tensile strength was observed whenFly Ash and Silica Fume replacement are about 20% and 15% respectively.

5. Maximum flexural strength was observed whenFly Ash and Silica Fume replacement are about 20% and 15% respectively.

4. FUTURE SCOPE

From this research, there are few recommendations to develop, to extend and to explore the usage ofFly Ash and Silica Fume in concrete:

i.) Define the effect of Fly Ash and Silica Fume on concrete with the replacement of mixture of coarse and fine aggregate.

ii.) Define the effect of Fly ash on concrete with the replacement of mixture of coarse and fine aggregate.

ii.) Replacement of cement with Fly Ash and Silica Fume in different water cement ratio.

iii.) Selected few samples of concrete with different percentage of using Fly Ash and Silica Fume and conclude the most suitable percentage of usage to achieve the optimum compressive strength.

5. REFERENCES

1. ACI committee 544. 1982. State-of-the-report on Fly Ash and Silica Fume reinforced concrete, (ACI 544.1R-82), Concrete International: Design and Construction. 4(5): 9-30, American Concrete Institute, Detroit, Michigan, USA.

2. ACI Committee 544. 1989. Measurement of properties Fly Ash and Silica Fumes reinforced

concrete, (ACI 544.2R-889). American Concrete Institute, Detroit, Michigan, USA.

3. ASTM C 1240-11 “standard specification for Fly Ash and Silica Fume used in cementitious mixtures”.
4. Bhanja, S., B. Sengupta, b., (2003) “Modified water-cement ratio law for Fly Ash and Silica Fume concretes “. Cement and Concrete research, 33, pp 447-450.
5. Mohamed s. Morsy, Sayed s. Shebl, Effect of Fly Ash and Silica Fume and metakaolinepozzolana on the performance of blended cement pastes against fire, Ceramics - Silikáty 51 (1) 40-44 (2007).
6. S. Vishal, Ghutke1, Bhandari S. Pranita (2014) . Influence of Fly Ash and Silica Fume on concrete. IOSR Journal of Mechanical and Civil Engineering (IOSR-JMCE). PP 44-47(2014).
7. Zain, M.F.M., Safiuddin, Md. And Mahmud, H.(2000) “Development of high performance concrete using Fly Ash and Silica Fume at relatively high water-binder ratios”, Cement and Concrete Research, Vol.30,pp 1501-1505.
8. Pradhan D, Dutta. D. (2013). Influence of Fly Ash and Silica Fume on Normal Concrete. Int. Journal of Engineering Research and Applications Vol. 3, pp.79-82.
9. Amudhavalli N. K., Mathew Jeena. **(2012**)Effect of Fly Ash and Silica Fume on strength and durability parameters of concrete.International Journal of Engineering Sciences & Emerging Technologies.Volume 3, Issue 1, pp: 28-35.
10. Karein S. Mahmoud Motahari ,Ramezanianpour A.A. , TaghiEbadi , IsapourSoroush , (2017) A new approach for application of Fly Ash and Silica Fume in concrete: Wet Granulation.Construction and Building Materials page573–581.
11. Zhang Zengqi , Zhang Bo , Yan Peiyu (2016) Comparative study of effect of raw and densified Fly Ash and Silica Fume in the paste, mortar and concrete. Construction and Building Materials 105 .page 82–93.
12. Khan M.I, Abbas Y.M. (2017) Curing optimization for strength and durability of Fly Ash and Silica Fume and fuel ash concretes under hot weather conditions.Construction and Building Materials 157 (page) 1092–1105.
13. Okoye Francis N, PrakashSatya , Singh Nakshatra B. (2017) Durability of fly ash based geopolymer concrete in the presence of Fly Ash and Silica Fume. Journal of Cleaner Production 149. (Page) 1062-1067.
14. Ali K., Ghalehnovi .M ,Brito J. de , Shamsabadi E. A, (2017) Durability performance of structural concrete containing Fly Ash and Silica Fume and marble industry waste powder.Journal of Cleaner Production 170 (page) 42and60.
15. Siddique R, Jameel A, Singh M. ,Hunek .D. B , Mokhtar A. A. , Belarbi. R., Rajor. A. (2017) Effect of bacteria on strength, permeation characteristics and micro-structure of Fly Ash and Silica Fume concrete.Construction and Building Materials 142 (Page) 92–100.
16. Wang. L. , Zhou S.H. , Y. Shi , Tang S.W. , Chen E.(2017) Effect of Fly Ash and Silica Fume and PVA fiber on the abrasion resistance and volume stability of concrete. Composites Part B 130. (page) 28 and 37.
17. Pedro D., de Brito J., Evangelista L. (2017) Evaluation of high-performance concrete with recycled aggregates: Use of densifiedFly Ash and Silica Fume as cement replacement. Construction and Building Materials 147 (page) 803–814.
18. Dave N , Mishra A K , Srivastava A. , Kaushik S K. (2016). Experimental analysis of strength and durability properties of quaternary cement binder and mortar. Construction and Building Materials 107 (page) 117–124.
19. Ju Y., Tian K., Liu H. , Reinhardt H.W , Wang L.(2017). Experimental investigation of the effect of Fly Ash and Silica Fumes on the thermal spalling of reactive powder concrete. Construction and Building Materials 155 (page) 571–583.
20. Palla R., Karade S.R., Mishra G., Sharma U., Singh L.P. (2017). High strength sustainable concrete using silica nanoparticles. Construction and Building Materials 138. (Page) 285–295.
21. Dybel P., Furtak K. (2017) Influence of Fly Ash and Silica Fume content on the quality of bond conditions in high-performance concrete specimens. Archives of civil and mechanical engineering 17 (page) 795 – 805.
22. Liu J., Wang D. (2017) Influence of steel slag-Fly Ash and Silica Fume composite mineral admixture on the properties of concrete. Powder Technology 320 (page) 230–238.
23. Kawabata Y., Seignol J.F., Martin R.P., Toutlemonde F. (2017).Macroscopic chemomechanical modelling of alkali-silica reaction of concrete under stresses.

Construction and Building Materials 137 (page) 234–245.

24. Fathi M., Yousefipour A., Farokhy E. H. (2017). Mechanical and physical properties of expanded polystyrene structural concretes containing Micro-silica and Nano-silica. Construction and Building Materials 136 (page) 590–597.

25. Pedro D., de Brito J., Evangelista L. (2017). Mechanical characterization of high performance concrete prepared with recycled aggregates and Fly Ash and Silica Fume from precast industry. Journal of Cleaner Production 164 (page) 939 and 949.

26. Zhang N., Li H., Peng D., Liu X. (2016). Properties evaluation of silica-alumina based concrete: Durability and environmental friendly performance. Construction and Building Materials 115 (page) 105–113.

27. Adak D., Sarkar M. ,Mandal S.(2017) Structural performance of nano-silica modified fly-ash based geopolymer concrete. Construction and Building Materials 135 (page) 430–439.

28. Kumar R., Singh S., Singh L.P. (2017) Studies on enhanced thermally stable high strength concrete incorporating silica nanoparticles. Construction and Building Materials 153 (page) 506–513.

29. Maruyama I., Teramoto A. (2013). Temperature dependence of autogenous shrinkage of Fly Ash and Silica Fume cement pastes with a very low water–binder ratio. Cement and Concrete Research 50 (page) 41–50.

30. Abdou M.I., Abuseda H. (2016) Upgrading offshore pipelines concrete coated by Fly Ash and Silica Fume additive against aggressive mechanical laying and environmental impact. Egyptian Journal of Petroleum (page) 25, 193–199.

31. Rostami M., Behfarnia K. (2017). The effect of Fly Ash and Silica Fume on durability of alkali activated slag concrete. Construction and Building Materials 134 (page) 262–268.

32. Nattaj F. H., Nematzadeh M. (2017).The effect of forta-ferro and steel fibers on mechanical properties of high-strength concrete with and without Fly Ash and Silica Fume and nano-silica. Construction and Building Materials 137 (page) 557–572.

33. Indian Standard IS: 516-1959, bureau of India standards, ManakBhawan, 9 BahadurShah ZafarMarg, New Delhi 110002.

34. Indian Standard IS 383-1970, Bureau of India Standards, ManakBhawan, 9 BahadurShah ZafarMarg, New Delhi 110002.

35. Indian Standard IS: 10262-2009, Bureau of India Standards, ManakBhawan, 9Bahadur Shah ZafarMarg, New Delhi 110002.

36. Indian Standard IS: 4031-1988, Bureau of India Standards, ManakBhawan, 9Bahadur Shah ZafarMarg, New Delhi 110002.

37. Indian Standard IS: 1489-1991(Part-1), Bureau of India Standards, ManakBhawan, 9Bahadur Shah ZafarMarg, New Delhi 110002.

38. Indian Standard IS 456-2000, Bureau of India Standards, ManakBhawan, 9 BahadurShah ZafarMarg, New Delhi 110002.

39. Leemann A. (2017) Raman microscopy of alkali-silica reaction (ASR) products formed in Concrete. Cement and Concrete Research 102 (2017) 41-48.

40. Ewais E.M.M., Khalil N.M., Amin M.S., Ahmed Y.M.Z., Barakat M.A. (2009). Utilization of aluminium sludge and aluminum slag (dross) for the manufacture of calcium aluminate cement. Ceramics International 35 (page) 3381–3388.

PHOTOGRAPHS


COMPRESSION TESTING MACHINE (ELECTRICALLY OPERATED)