

ASSESSING THE PROPERTIES OF HIGH PERFORMANCE CONCRETE
USING FLY ASH AND METAKOALIN

Submitted in partial fulfillment of the requirements for the award of Bachelor
of Technology degree in Civil Engineering

By

REVENTH C J (REG.NO:37200906)

KUMARAN K (REG.NO:37200905)



**DEPARTMENT OF CIVIL ENGINEERING
SCHOOL OF BUILDING AND ENVIRONMENT**

SATHYABAMA

**INSTITUTE OF SCIENCE AND TECHNOLOGY
(DEEMED TO BE UNIVERSITY)**

JEPPIAAR NAGAR, RAJIV GANDHI SALAI, CHENNAI - 600 119

**Accredited with Grade "A" by NAAC
MARCH - 2021**



SATHYABAMA

INSTITUTE OF SCIENCE AND TECHNOLOGY

(DEEMED TO BE UNIVERSITY)

Accredited with "A" grade by NAAC

Jeppiaar Nagar, Rajiv Gandhi Salai, Chennai – 600 119

www.sathyabama.ac.in



DEPARTMENT OF CIVIL ENGINEERING

BONAFIDE CERTIFICATE

This is to certify that this Project Report is the bonafide work of REVANTH C J (37200906) AND KUMARAN K (37200905) carried out the project entitled **EXPERIMENTAL STUDY ON GEOPOLYMER CONCRETE USING DIFFERENT TYPES OF FINE AGGREGATE** under my supervision from SEPTEMBER 2020 TO APRIL 2021

Internal Guide

Mrs.B. PRIYADHARSHINI

Head of the Department

Submitted for Viva voce Examination held on

Internal Examiner

External Examiner

DECLARATION

We REVANTH C J (37200906) AND KUMARAN K (37200905) hereby declare that the Project Report entitled EXPERIMENTAL STUDY ON GEOPOLYMER CONCRETE USING DIFFERENT TYPES OF FINE AGGREGATE done by us under the guidance of Ms. ASS.PROF.B.PRIYADHARSHINI is submitted in partial fulfilment of the requirements for the award of Bachelor of Engineering / Technology degree in civil engineering

1.

2.

SIGNATURE OF THE

CANDIDATE

DATE:

PLACE:

ACKNOWLEDGEMENT

We are pleased to acknowledge our sincere thanks to Board of Management of **SATHYABAMA** for their kind encouragement in doing this project and for completing it successfully. We are grateful to them.

We convey our thanks to **Dr. S. Packialakshmi, M.E., Ph.D.,** and **Dr. R. Padmapriya, M.E., Ph.D.,** Heads of the Department, **Department of Civil Engineering** for providing us necessary support and details at the right time during the progressive reviews.

We would like to express our sincere and deep sense of gratitude to our Project Guide **Mrs. Priyadharshini, M.E., Department of Civil Engineering** for his valuable guidance, suggestions and constant encouragement paved way for the successful completion of our project work.

We wish to express our thanks to all Teaching and Non-teaching staff members of the Department of Civil Engineering who were helpful in many ways for the completion of the project.

ABSTRACT

Concrete is the most commonly used building material. Since 1990, global cement production has increased significantly. Cement production causes significant environmental emissions due to the emission of CO₂ gas. In recent years, supplementary cementitious materials such as silicon oxide fumes, fly ash, slag, Rice Husk Ash, and Metakaolin have been used as cement substitute materials to increase HSC while improving workability, capacity, and durability while decreasing permeability.

Metakaolin is a type of aluminum silicate that has been dehydroxylated. Based on recent research, it is clear that Metakaolin is a fully effective pozzolanic cloth that correctly complements the power parameters of concrete. The addition of fly ash to concrete improves its workability as well as its strength and toughness. Strong overall performance concrete is the most recent development in concrete (HPC). It is gaining popularity and is being used in a number of high-profile ventures, including nuclear power plants, flyovers, and multi-story homes. This study paper concludes the investigation into the partial replacement of cement with metakaolin and flyash as an absolutely extraordinary share in HPC for M30 grade of integrate. For Metakaolin and fly ash, the substitution amounts were 10% (by weight). The final results are compared to normal concrete (compressive strength, break tensile strength, flexural strength, and durability).

TABLE OF CONTENT

CHAPTER No	TITLE	PAGE No
	ABSTRACT	v
	TABLE OF CONTENT	vi
	ACKNOWLEDGEMENT	iv
	LIST OF TABLES	ix
	LIST OF FIGURES	x
1	INTRODUCTION	1
	1.1 GENERAL	1
	1.2 HIGH PERFORMANCE CONCRETE(HPC)	1
	1.3 SALIENT FEATURES OF HPCS	2
	1. 4 PROPERTIES OF HPC	2
	1.5SUPPLEMENTARYCEMENTITIOUSM ATERIALS FORMS	2
	1.6 METAKOALIN	3
	1.7 FLYASH	3
	1.8 BENEFITS AND USES OF METAKOALIN	4
	1.9 BENEFITS AND USES OF FLYASH	4

2	LITERATURE REVIEW	6
	2.1 GENERAL	6
	2.2 LITERATURE STUDY	6
3	3.1 OBJECTIVE	12
	3.2 SCOPE	12
4	MATERIAL PROPERTIES	12
	4.1 INTRODUCTION	12
	4.2 CEMENT	13
	4.3 FINE AGGREGATE	13
	4.4 COARSE AGGREGATE	14
	4.5 WATER	15
	4.6 SUPER PLASTICIZER	16
	4.7 METHODOLOGY	17
5	MIX DESIGN	18
	5.1 INTRODUCTION	19
	5.2 Construction Requirements for M30 GRADE CONCRETE MIX FOR MIX DESIGN	19
	5.3 MIX DESIGN FOR FLYASH AND METAKOALIN22 BASED HPC	

6	EXPERIMENTAL INVESTIGATION	26
	6.1 TESTS ON FRESH CONCRETE	26
	6.2 TESTS ON HARDENED CONCRETE	27
	6.3 CLORIDE RESISTANCE TEST	28
7	RESULTS AND DISCUSSIONS	36
	7.1 COMPRESSIVE STRENGTH	36
	7.2 SPLIT TENSILE STRENGTH	36
	7.3 CLORIDE RESISTANCE STREGTH	36
8	CONCLUSION	38
	REFERENCE	38

LIST OF TABLES

TABLE NO	TITLE	PAGENO
4.2	PHYSICAL PROPERTIES OF OPC	13
4.3	FINE AGGREGATE'S PHYSICAL PROPERTIES	14
4.4	STANDARD COARSE AAGREGATE'S PHYSICAL PROPERTIES	15
4.5	DETAILS OF SUPER PLASTICIZER	16
5.2	MIX PROPORTION OF CONCRETE	22
5.3	MIX PROPORTION OF ADMIXTURE ADDED CONCRETE	24
6.1.1	SLUMP CONE TEST	25
6.1.2	COMPACTION FACTOR TEST	26
6.1.3	FLOW TABLE TEST	27
6.3.1	COMPRESSION STRENGTH ON CUBES	30
6.4.1	SPLIT TENSILE STRENGTH ON THE CYLINDER	33

LIST OF FIGURES

Figure NO	TITLE	PAGENO
6.3.1	COMPRESSIVE STRENGTH	30
6.3.1	COMPRESSIVE STRENGTH READING	31
6.4.1	SPLIT TENSILE STRENGTH	32
6.4.1	SPLIT TENSILE STRENGTH READING	34
6.4	CHLORIDE RESISTANCE STRENGTH	35

CHAPTER-1

INTRODUCTION

1.1 GENERAL

High Performance Concrete (HPC) is a concrete invention. It's gaining attention and is being used in a variety of high-profile projects. Mineral admixtures such as Metakaolin, Silica Fume, Fly Ash, GGBFS, Rice Husk Ash, and others are more widely used in HPC manufacturing. Concrete's strength and stability have increased as a result of the use of such products. The current study looks at the compressive strength, break tensile strength, thermal strength, and durability of M30 grade concrete mixes containing varying percentages of high reactivity Metakaolin and Fly Ash by weight of cement, as well as some acceptable Super Plasticizer. The addition of up to 10% by weight of Metakaolin and Fly Ash to cement improved the strength properties of HPC mixes, according to the study's findings. After 28 days of exposure to these chemicals, HPC mixes demonstrated increased resistance to chloride attacks.

A "High performance Concrete" has a high toughness for any given strength class in general. High-performance concrete (HPC) is described by the American Concrete Institute (ACI) as "concrete that meets special performance and uniformity requirements that cannot always be met systematically by using only traditional materials and standard mixing, positioning, and curing practices." In harsh environments, it may be essential to improve positioning and compaction without segregation, long-term mechanical properties, early age strength, volume stability, or service life. Concretes with both of these properties have a higher intensity. As a result, although high strength concrete is often high in quality, it is not always high in efficiency.

1.2 HPSCS SALIENT FEATURES

1. A compressive power of more than 50 MPa.
2. Inadequate Water-Binder Ratio
3. Cement Grains with Reduced Flocculation
4. A wide selection of grain sizes

5. Cement Paste Densified
6. There is no bleeding in the homogeneous mix
7. Decreased Capillary Porosity.
8. Pores that are not continuous
9. A more robust Transition Zone at the interface of Cement Paste and Aggregate
10. . Low content of free lime
11. Endogenous Shrinkage is a term that refers to shrinkage
12. Successful Aggregate Confinement.
13. Minor micro-cracking until roughly 65-70 percent of the fck is extracted
14. Fracture surface that is smooth

1.4 HIGH PERFORMANCE CONCRETE PROPERTIES

According to the Civil Engineering Research Foundation (CERP), high-performance concrete (HPC) is a concrete that has had one or more of the following properties reinforced.

1. Ease of installation
2. Mechanical properties over time
3. Early-life strength
4. tenacity
5. Consistency of volume
6. Longer service life in harsh conditions

1.5 SUPPLEMENTARY CEMENTITIOUS MATERIALS TYPES:

As part of the overall cementitious plan, supplementary cementitious materials are used in concrete. Depending on the properties of the materials and the desired effect on concrete, they may be used in addition to or as a partial substitute for Portland cement or blended cement in concrete.

The following mineral admixtures are the most commonly used in the supplementation of cementitious materials to achieve HPC:

1. kaolin metakaolin
2. Volcanic ash
3. Fume of Silica

1.6 METAKAOLIN

Concrete is the most widely used building material on the planet. It is the second most heavily consumed substance, after water, with approximately six billion tons produced each year. This is because there are so many raw materials available for cement production. Environmentalists' fears about the harm caused by staple extraction and carbon dioxide emissions during cement processing, on the other hand, have put pressure on researchers to use partial substitution of cement with supplementary substances to reduce cement use. These materials may also be gifts, commercial waste, or byproducts that need less energy to make. The opposite issues that lead to such stresses are incidents causing serious deterioration of concrete buildings. To address these problems, as well as other environmental concerns about the handling of waste industrial byproducts, Portland cement and pozzolans mixtures are now commonly used in concrete production. Pozzolan was originally associated with naturally formed volcanic ashes and calcined earths, which react with lime in the presence of water at low temperatures. Admixtures of silicious aluminous substances that, when finely divided and in the presence of water, can react with chemical compounds containing hydrated oxide Ca(OH)_2 to form compounds with fabric-forming properties. This broad description includes waste products such as fly ash (FA), rice husk ash, and silica fume (SF).

1.7 FLY ASH

Fly ash is a fine powder produced as a byproduct of power plant pulverized coal combustion. Fly ash is a pozzolan, which is a substance comprising aluminous and siliceous material that, when combined with water, forms cement. When fly ash is combined with lime and water, a compound similar to Portland cement is formed.

As a result, fly ash can be used as a primary component in a wide range of construction materials, including mixed cement, mosaic tiles, and hollow blocks. Fly ash increases the strength and segregation of concrete and makes it easier to pump when used in concrete mixes.

1.8 METAKAOLIN'S BENEFITS AND USES BENEFITS

Some of the benefits of metakaolin are as follows:

1. Improved compressive and flexural strength
2. Reduced permeability (which includes chloride permeability)
3. Lower efflorescence potential, which occurs when calcium is transported to the surface by water and reacts with atmospheric carbon dioxide to form calcium carbonate, which precipitates as a white residue on the floor.
4. Increased exposure to chemical attacks. The durability has improved
5. Reduction of alkali-silica reactivity's effects (ASR)
6. Improved workability and completion of concrete
7. Concrete shrinkage is minimized as a result of "particle packing," which increases the density of the concrete. The color of the concrete was enhanced by lightening it, allowing for the tinting of lighter integral coloration.

USES OF METAKAOLIN:

Metakaolin can be used in the following ways:

1. Concrete with high quality, high strength, and low weight
2. Precast and poured-mold concrete
3. Products made of fibre cement and ferro cement
4. Reinforced glass fibre concrete is a type of reinforced glass fibre concrete.
5. Countertops, drawings, and other works of art (see as an instance the unfastened-standing sculptures of Albert Varna)
6. Stucco and mortar are used in this project.

1.9 BENEFITS AND USES OF FLYASH BENEFITS:

In many markets, fly ash can be a cost-effective replacement for Portland cement. Fly ash is often referred to as an environmentally friendly substance because it is a byproduct with a low embodied energy, which is the amount of energy used in the production and transportation of a building material. Portland cement, on the other hand, has a very high embodied energy since it takes a lot of heat to produce.

Fly ash needs less water than Portland cement and is easier to deal with in cold environments. Other benefits include:

1. produces a wide range of fixed times
2. Resistance to cold weather
3. Major strength gains may be achieved depending on the application.
4. It has the potential to be used as an admixture.
5. Assumed to be constructed of a non-shrinkable material
6. It creates dense concrete with a smooth surface and fine detail.
7. Outstanding adaptability
8. 8.It helps to reduce fracturing, permeability, and bleeding.
9. Reduces hydration heat
10. When opposed to no-fly-ash blends, it allows for a lower water-cement ratio for identical slumps.
11. Lowers CO2 emissions.

USES:

Fly ash is a key component in a wide range of cement-based products, including poured concrete, concrete blocks, and stone. One of the most popular applications for fly ash is Portland cement concrete pavement, also known as PCC pavement. Road building projects using PCC would necessitate a substantial amount of concrete, and substituting fly ash would result in significant cost savings. Fly ash has also been used as a mine fill and as an embankment, and it is becoming more common among Federal Highway Administration contractors. The rate of substitution (of fly ash for Portland cement) is commonly reported to be 1 to 1 1/2 pounds of fly ash for 1 pound of cement. As a result, the fine aggregate content of the concrete mix must be decreased to accommodate the increased volume of fly ash.

CHAPTER 2

LITERATURE REVIEW

2.1 GENERAL

This chapter has defined the literature studies of Geo Polymer concrete beams.

2.2 LITERATURE STUDY

Durability and toughness Good Performance Concrete Properties Using High Reactivity Metakaolin is a type of clay (B. B. Patil¹ and P. D. Kumbhar² Vol.2, Issue 3, May-June 2012, pp-1099-1104) The International Journal of Modern Engineering Research is a peer-reviewed international publication dedicated to the advancement of modern engineering research (IJMER). Concrete is perhaps the most commonly used building material on the planet.

Because of cost savings, energy savings, environmental safety, and resource conservation, mineral admixture in cement has increased dramatically as the concrete industry has developed. However, environmental concerns, both in terms of the harm caused by raw material extraction and carbon dioxide emissions during cement manufacture, have placed pressure on cement producers to limit cement use by using supplementary materials. High Performance Concrete (HPC) is the most recent advancement in concrete production. It's becoming more popular, and it's being used in a number of high-profile projects right now. Fly ash, rice husk ash, metakaolin, silica fume, and other mineral admixtures are becoming more popular in the formulation of HPC blends. The incorporation of such materials has increased the strength and resilience of concrete. In recent years, there has been a lot of interest in using calcined clay in the form of high reactivity metakaolin (HRM) in concrete. The current study investigates the workability, compressive power, and durability of M60 grade HPC mixes containing varying percentages of high reactivity metakaolin by weight of cement, as well as some suitable superplasticizer.

According to the results of the report, adding HRM up to a suitable content of 7.5 percent by weight of cement improved the workability and strength properties of HPC. HPC mixes showed improved resistance to chemical attacks such as chlorides and sulphates after 180 days of exposure to these chemicals. The effect of metakaolin inclusion on the mechanical properties of concrete- (Vikas Srivastava, October 2012) The use of waste/non-conventional materials in cement and concrete matrices is becoming more common.

These materials are widely used as a partial substitute for cement, lowering building costs and helping to overcome limitations associated with the use of Ordinary Portland Cement (OPC) alone. Furthermore, these products usually improve the strength and other aspects of cement/concrete matrices' durability. Metakaolin is an unusual/waste material that can be used to support the building industry. Metakaolin significantly increases the compressive, tensile, flexural, and bend strength of concrete, as well as the modulus of elasticity; however, the workability is slightly reduced. This paper addresses research done to assess the suitability of metakaolin in the development of concrete.

Superplasticizer metakaolin concrete's relative strength, pozzolanic activity, and cement hydration (S.Wild, J.M.Khatib, A.Jones, Cement and Concrete Research, Volume 26, Issue 10, October 1996, Pages 1537-1544).

The function of metakaolin (MK) in increasing concrete strength, as well as the key mechanisms, are discussed. Curing times ranged from 1 to 90 days for metakaolin concretes with MK contents ranging from 0% to 30%. The 'filler effect,' accelerated OPC hydration, and the pozzolanic reaction are addressed in terms of changes in relative strength as curing time and metakaolin material are increased. The observed results show that an optimum OPC replacement level of 20 wt percent MK exists and that MK's contribution to strength is limited beyond 14 days.

Construction and Building Materials, August 2010; 24(8):1404-1411, Eva Vejmelková. An analysis of the strength, toughness, and durability properties of high-performance concrete containing Czech metakaolin.

Despite the fact that metakaolin's capacity as a pozzolanic material to boost the mechanical and durability properties of concrete when used as a partial

replacement for Portland cement has been well known in concrete research, its use in the construction industry has been restricted to date due to its high price dictated by low production amounts. However, given the current scarcity of silica fume and high-quality slag in some countries, concrete producers' attitudes toward metakaolin could shift in the near future. This paradigm shift can be aided by providing a more detailed view of the properties of composite materials containing metakaolin, resulting in a more thorough understanding of the benefits of metakaolin. This paper assesses a wide range of parameters for metakaolin-based high performance concrete (HPC), including basic physical properties, mechanical and fracture-mechanical properties, toughness characteristics, hydric and thermal properties, and chloride binding characteristics. The experimental results show that in the majority of cases, replacing Portland cement with 10% metakaolin as an ideal volume enhances or has no effect on substantial properties of the tested HPC. Basic physical properties, heat transfer properties, and storage properties are very similar to common HPC; mechanical and fracture-mechanical properties are slightly worse after 28 days but improve later; water- and water vapour transport parameters are significantly reduced; frost resistance is improved; and resistance to de-icing salts is slightly worse but still meets the required requirements. The chemical resistance of concrete with 10% metakaolin instead of Portland cement in filtered water and HCl, slightly worse in $MgCl_2$, and nearly the same in NH_4Cl , Na_2SO_4 , and CO_2 . Carbonation decreases when chloride binding capacity increases.

The Effect of Fly Ash Additive on the Properties of Concrete- (C.Marthong, T.P.Agrawal-International Journal of Engineering Research and Applications-Vol. 2, Issue4, July-August 2012, pp.1986-1991)

Because of the increased long-term resilience of concrete combined with environmental advantages, the use of fly ash in concrete as a partial substitute for cement is becoming more widespread today. Ordinary Portland cement (OPC) grades 33, 43, and 53 of the Bureau of Indian Standards (BIS) are widely used in the construction industry. This paper presents a comparative study of the impact on concrete properties of various grades of OPC partially replaced by fly ash. The primary variable investigated in this analysis is the variation of fly ash dosages of 10%, 20%, 30%, and 40%. The compressive strength, durability, and shrinkage of

concrete were primarily examined. The addition of fly ash enhances the concrete properties in all grades of OPC up to a certain percentage of replacement, according to the test results.

An investigation into the use of fly ash concrete in the marine environment- (s. Bhanu pravallika¹, V. lakshmi², vol. 3, issue 5, may 2014). Apart from water, potable water is the most important ingredient in the manufacture of traditional concrete, and concrete is the most commonly used commodity on the earth. Fresh water accounts for just 2.5 percent of the world's water bodies, with ground water accounting for the vast majority. According to a World Meteorological Organization survey, more than half of the world's population will lack access to safe drinking water by 2025. Coastal planning officials have long faced the challenge of constructing and sustaining long-lasting concrete structures in a salt water environment. Disimination occurs as a result of the incremental penetration of sea salts, which results in the formation of expansive and leachable compounds. Cement is the most expensive and energy-intensive part of concrete. By partly replacing cement with fly ash, the unit cost of concrete can be lowered as much as possible. In India, fly ash is a popular byproduct of thermal projects. Waste products such as fly ash (which would otherwise be toxic to the environment) can be used as a partial substitute for cement in concretes, and the fly ash has been shown to be more resistant to chloride ion penetration than concrete made with ordinary Portland cement. The current research mixed and cured two grades of reference fly ash concrete, M20 and M25, with potable water.

The same fly ash concrete grades were prepared once more, but this time with potable water for mixing and curing in sea water. The same grades of fly ash concrete were prepared using sea water for both mixing and curing. On specimens cured for 7, 28, and 90 days, the properties of fresh concrete and hardened concrete were studied.

Concrete workability with pulverised fuel ash and metakaolin- (J. Bai, S. Wild, B. B. Sabir, J. M. Kinuthia-Magazine of Concrete Research ISSN 0024-9831, E-ISSN 1751-763X- Volume 51 Issue 3, June 1999, pp. 207-216).

The workability of concrete containing pulverised fuel ash (PFA) and metakaolin (MK) as partial replacements for Portland cement (PC) was studied. The aim of this research is to investigate the viability of using PFA and MK as PC blends in terms of the flow properties of the resulting concrete. 90 mixtures containing 0, 10, 20, 30, and 40% complete replacement of cement with metakaolin (0–15%) and PFA (0–40%) were prepared for concretes with water to binder ratios of 0, 4, 5, and 6. The slump, compacting factor, and Vibe time measurements were used to assess the workability of the concrete. When the mixtures contained only MK, the workability was significantly reduced, with greater reductions observed as the MK replacement level increased. In comparison, increasing the amount of PFA replaced greatly improved the workability of the mixtures. It was discovered that adding PFA to concretes containing PC, PFA, and MK blends would compensate for the loss in workability caused by the inclusion of MK. However, at low cement replacement rates, PFA will only increase workability if a superplasticizer is used. The degree of workability restoration given by PFA is influenced by the amount of cement replacement, MK/PFA ratio, and water to binder (w/b) ratio. When superplasticizer is used at low w/b ratios ($= 0.4$), there is a crucial MK/PFA ratio (0.4) above which workability decreases with the replacement number and below which workability increases. In general, the presence of PFA not only compensates for MK's lack of workability, but also offers economic benefits.

At high temperatures, the processing of fly ash and metakaolin-containing concrete (Abid Nadeem, Shazim Ali Memon, Tommy Y Lo, Construction and Building Materials, July 2014).

Ordinary concrete is believed to be fire resistant, but at high temperatures, high strength concrete experiences substantial damage or even catastrophic failure. The aim of this study was to assess the high-temperature performance of High Performance Concrete (HPC) made with Fly Ash (FA) and Metakaolin (MK). The test programme involves variables such as partial cement replacement with MK ranging from 5% to 20%, FA ranging from 20% to 60%, temperatures ranging from 27°C to 800°C, and two types of cement. Mechanical efficiency was measured using compressive power, while reliability was measured using chloride permeability and water sorptivity measures.

Furthermore, Image Pro-plus software was used to perform quantitative analysis on selected concrete specimens using SEM images. According to the results of the samples, the mechanical and toughness properties of HPC deteriorated at high temperatures. The loss of compressive strength was greater with rapid cooling than with incremental cooling. This is due to thermal shock, which was more pronounced at 400 °C. Both blends demonstrated substantial improvements in charge pass and captivity values between 400 °C and 600 °C in terms of durability. In terms of longevity, both blends demonstrated major improvements in charge pass and captivity values between 400 °C and 600 °C. As a result, 400 °C can be considered the critical temperature for modifying the properties of HPC. The pore area fraction increased with increasing temperature, according to quantitative analysis of SEM images of the Interfacial Transition Zone (ITZ). As a result, the microstructure weakened, reducing the strength and toughness of the concrete. In general, FA20 outperformed MK mixes (MK10 and MK20) at high temperatures (400 °C and above), while FA20 degraded faster. As a result, MK mixes should be used with caution, especially in structures that will be exposed to temperatures of 400 °C or higher.

CHAPTER-3

AIM AND SCOPE

3.1 OBJECTIVE

This project's key objectives are as follows:

1. Perform comparative and combination research on the effects of the effects of metakaolin (MK) and fly ash (FA) on concrete properties.
2. Conduct comparative studies on concrete strength and durability.

3.2 SCOPE

The following are the project's objectives:

1. To proportion materials for M30 grade concrete and examine its efficacy (Controlled Concrete Specimen).
2. Collect Metakaolin from a local supplier and Fly Ash from a nearby power plant.
3. Conduct a concrete strength study (compression, split tensile, and thermal strength) on the pozzolanic addition described above.
4. Conduct a Toughness Analysis (Chloride Resistance) of concrete for the previously described Pozzolanic addition.

CHAPTER 4

MATERIAL PROPERTIES

4.1 INTRODUCTION

Cement, coarse aggregate, and fine aggregate samples are used in material testing. Both of these studies, as well as their findings and observations, are discussed in this chapter.

4.2 CEMENT

In this work, Chettinad Cement OPC 43 grade conforming to IS: 12269-1987 was used for casting cubes and cylinders for all concrete mixtures. The initial and final setting times, specific gravity, natural consistency, and soundness of cement are all measured. The results of the numerous cement tests have been made public.

Table: 4.2 Physical properties of Ordinary Portland cement

S. No	Property	Test Method	Test Results	IS Standard
1.	Normal Consistency	Vicat Apparatus (IS: 4031 Part - 4)	30%	25-35%.
2.	Specific gravity	Sp. Gr bottle (IS: 4031 Part - 4)	3.15	3.1-3.6
3.	Initial setting time Final setting time	Vicat Apparatus (IS: 4031 Part - 4)	125 minutes 245 Minutes	Not less than 30 mins. Not less than 10 hrs.
4.	Fineness	Sieve test on sieve no.9 (IS: 4031 Part – 1)	1.3%	10%
5.	Soundness	The Chatlier-Le-Chatlier process	1mm	Not more than 10 mm



1.3 FINE AGGREGATES

1. The sand used in the experimental programme was sourced locally and met IS: 383-1970 grading zone III.
2. Before washing to remove dust, the sand was sieved through a 4.75 mm sieve to remove any particles larger than 4.75mm.
3. The physical properties of fine aggregates and the effects of sieve analysis are listed.

Table: 4.3 Physical properties of Fine Aggregate

S. No	Property	Method	Fine Aggregate
1.	Specific gravity	Pycnometer IS:2386 Part 3-1986	2.65
2.	Bulk Density Loose Compacted	IS:2386 Part 3-1986	1.73x10 ³ kg/m ³
3.	Bulking	IS:2386 Part 3-1986	6% w c
4.	Flakiness Index	(IS:2386 Part 2-1963)	--

5.	Elongation Index	(IS:2386 Part 2-1963)	--
6.	Fineness Modulus	Sieve Analysis (IS:2386 Part 2-1963)	3.62
7.	Water absorption	IS:2386 Part 3-1986	1%

4.4 COARSE AGGREGATE

Locally accessible coarse aggregates with maximum sizes of 20 mm and 12.5 mm were used in this analysis. The coarse aggregates were subjected to IS: 383-1970 testing. The aggregates were sieved through a 20 mm sieve before being retained on a 12.5 mm sieve. The 12.5 mm aggregates were then sieved through a 12.5 mm sieve before being retained on a 4.75 mm sieve. Following that, the aggregates were washed to remove dust and dirt before being dried to the surface. Various test findings have been made public.

Table: 4.4 Physical properties of Normal Coarse Aggregate

S. No	Property	Method	Normal Coarse Aggregate
1.	Specific gravity	Pycnometer is a type of thermometer.	2.75
2.	Bulk Density Loose Compacted	IS:2386 Part 3 -1986	20 mm 1.59x10 ³ kg/m ³ 12.5 mm 1.42x10 ³ kg/m ³
3.	Bulking	IS:2386 Part 3 -1986	--
4.	Flakiness Index	(IS:2386 Part 2 -1963)	8.08%

5.	Elongation Index	(IS:2386 Part 2 -1963)	0%
6.	Fineness Modulus	Sieve Analysis (IS:2386 Part 2-1963)	20m8.15 12.5mm6 .07
7.	Water absorption	IS:2386 Part 3 -1986	0.5%

4.5 WATER

The water used for mixing and curing was potable and clear of any oils, acids, alkalis, sugar, salts, organic materials, or other contaminants that may be harmful to concrete or steel, according to IS : 3025 – 1964 part 22, part 23, and IS : 456 – 2000 [Code of Practice for Plain and Reinforced Concrete]. The pH level should not be lower than 6. The current solids were within the allowable limits as described in IS: 456 – 2000 clause 5.4.

4.6 SUPER PLASTICIZER

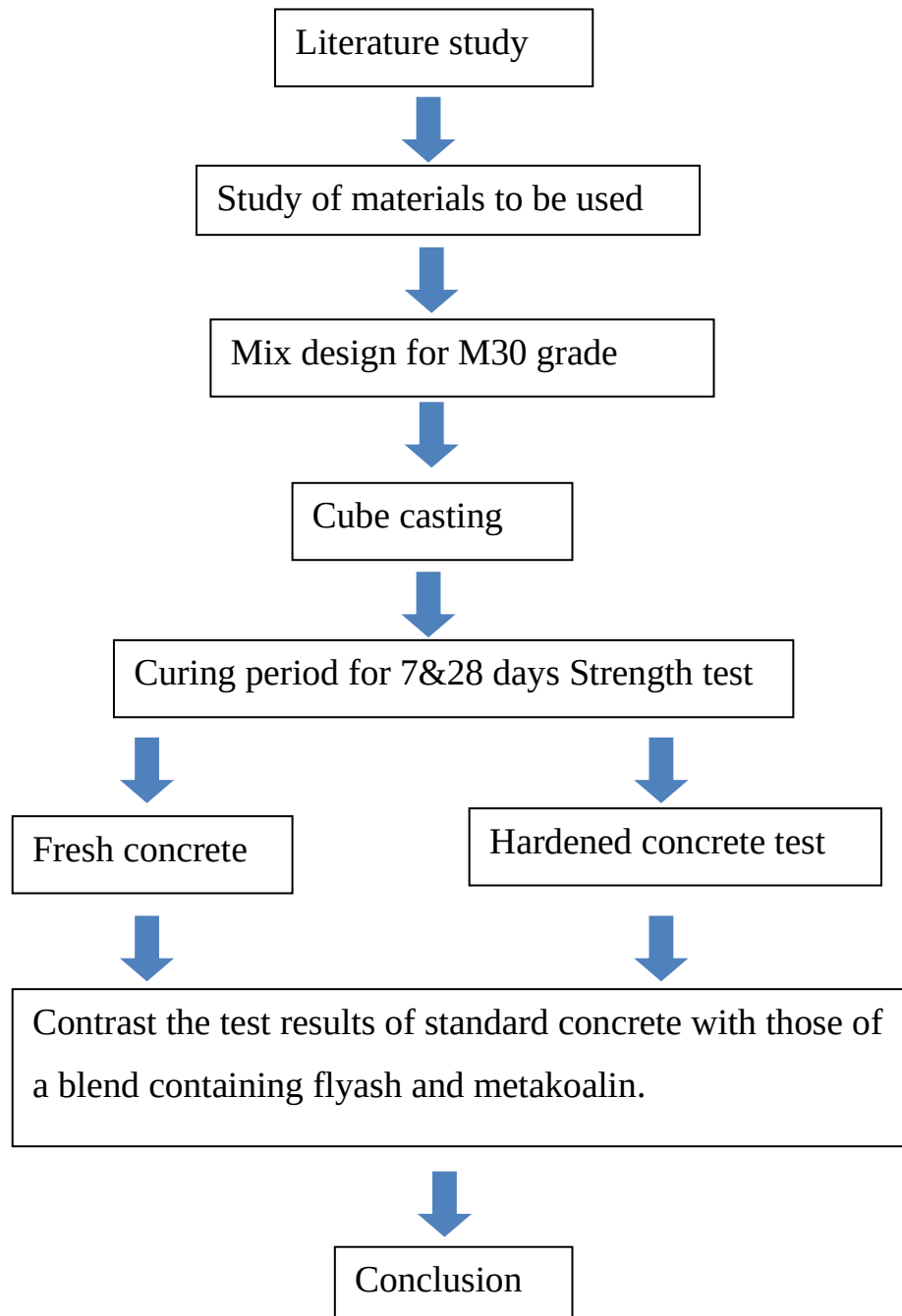
Super plasticizers are high-range water-reducing admixtures used to boost flow or workability at lower water-cement ratios without compromising compressive strength. By forming a thin film around the cement particles as these admixtures disperse in cement agglomerates, they dramatically minimize paste viscosity. Admixture that helps to minimize the amount of water in the atmosphere. Glenium conforming to IS 9103: 1999 [Specification for concrete admixtures], ASTM C – 494 [Standard Specification for Chemical Admixtures for Concrete] types F, G, and BS 5075 part.3 [British Standards Institution] was used in the current work. Table 3.7 provides details about the super plasticizer that was used.

Table: 4.5 Details of Super Plasticizer

S. No.	Property	Result
1.	Form or state	Liquid (sulphonated naphthalene-based formaldehyde)
2.	Color	Brown
3.	Specific gravity	1.220 to 1.225 at 30°C
4.	Chloride content	Nil to IS:456
5.	Air entrainment	About 1% more air is entrained.
6.	Compatibility	Except for high alumina cement, it can be used for any form of cement. When added separately to the mix, Conplast SP430 is compatible with other forms of Fosroc admixtures.
7.	Workability	Can be used to create flowing concrete that does not require
8.	Cohesion	The dispersion of cement particles improves cohesion, reducing segregation and improving surface finish.
9.	Compressive strength	Early power is increased by up to 20%. Power can be improved by up to 20% depending on the W/C ratio and other mix parameters.
10.	Durability	Reducing the w/c ratio allows for an improvement in density and impermeability, which increases the resilience of concrete.
11.	Dosage	The addition rate is usually in the range of 0.5 - 2.0 liters/100 kg cement.

4.7 METHODOLOGY

It defines the project's workflow as follows:



4.8 MIX DESIGN

The method of choosing suitable mixtures is referred to as mix design. concrete materials and deciding their relative proportions with the intention of producing concrete with the least amount of strength and endurance possible while being as cost-effective as possible. The mix specification is carried out in compliance with the Indian standard IS: 10262-2009.

PREPARATION OF SPECIMENS

The method of producing high-performance concrete is similar to that of producing cement concrete. In a dry state, coarse aggregates, sand, and bottom ash were combined.. Then, thoroughly mix for 3–4 minutes to obtain a homogeneous mix of the formulated mixture solution of sodium hydroxide and sodium silicate, as well as additional water depending on the water-to-high performance binder ratio. High performance concrete based on fly ash and metakolin was discovered to be viscous, cohesive, and dark in colour. After homogeneous mixing, the workability of fresh high performance concrete was calculated using flow table apparatus in compliance with IS 5512-1983 and IS 1727-1967. Three layers of 150 mm concrete cubes are cast. Each plate is compacted with a 16 mm diameter tamping rod. To ensure proper concrete compaction, both cubes were put on a table vibrator and vibrated for 2 minutes. After compacting the concrete, the top surface was levelled with a trowel. All cubes were remoulded and placed in the laboratory for curing under laboratory ambient conditions after 24 hours of casting.

CHAPTER 5

MIX DESIGN

5.1 INTRODUCTION

Both traditional and HPC concrete mixes are built in compliance with Indian standards IS: 10262-2009.



FIG.5.1 MIX CONCRETE

5.2 MIX DESIGN FOR CONCRETE M30 GRADE

Mix Design Specifications OPC53 is the cement grade.

Medium is the form of exposure.

Coarse aggregate size: 20 mm

Cement specific gravity: 3.15

Fine aggregate real gravity: 2.54

Coarse aggregate specific gravity: 2.85

(i) Target strength for mix proportion

The target mean compressive strength at 28 days is given by

$$f'_{ck} = f_{ck} + 1.65S$$

From IS 10262:2000 $S = 5 \text{ N/mm}^2$ (S – Standard Deviation)

$$f'_{ck} = 30 + (1.65 \times 4)$$

$$= 36.6 \text{ N/mm}^2$$

(ii) Selection of water cement ratio

From IS456:2000 table 5

Exposure condition: Moderate

W/C ratio = 0.4

Maximum water cement ratio = 0.5

Adopt 0.45

$0.45 < 0.5$ (hence ok)

(iii) Selection of water content

From IS10262:2009 tables 2

Aggregate size = 20 mm = 186 liters (25 - 50mm slump)

From IS456 - Page 17

Reinforced wall-medium (slump 50 - 100, 75 - 100)

Adopt 75mm (slump)

Estimated water content for 100mm slump

$$= 186 + ((3/100) \times 186)$$

$$= 191.58 \text{ litres}$$

(iv) Cement content

$$\begin{aligned}\text{W/C ratio} &= 0.45 \\ \text{Cement content} &= 186/0.45 \\ &= 413.4 \text{ Kg/m}^3\end{aligned}$$

$$\begin{aligned}\text{IS 456:2000 Table 5,} \\ \text{Minimum cement content} &= 360 \text{ Kg/m}^3\end{aligned}$$

From IS 456:2000 cl.8.2.4.2
Cement content is limited to 450 Kg/m^3

$$\begin{aligned}\text{Cement content} &= 360 \text{ Kg/m}^3 < 413.4 \text{ Kg/m}^3 < \\ 450 \text{ Kg/m}^3\end{aligned}$$

(v) Proportion of volume of coarse and fine aggregate content

From IS10262:2009 tables 3

1. Volume of coarse aggregate (20 mm) and fine aggregate (zone II) for a water cement ratio of 0.5 = 0.60.
2. The water cement ratio in the current work is 0.45. As a result, the amount of coarse aggregate must be increased in order to reduce the fine aggregate material. As the water cement ratio decreases by 0.05, the proportion of coarse aggregate increases by 0.01 (at a rate of + 0.01 for every + 0.05 decrease in the water cement ratio).
3. As a result, the right proportion of coarse aggregate volume for the water cement ratio of 0.4 = 0.5.
4. coarse aggregate volume for a water cement ratio of 0.4 = 0.5
5. Proportion of FA volume = $1 - 0.5 = 0.5$.

(vi) Mix calculation

$$\begin{aligned}\text{a) Concrete length} &= 1 \text{ m}^3 \\ \text{b) Cement length} &= \frac{\text{Mass of cement}}{(\text{sp. gravity of cement}) \times (\text{density of cement})} \\ &= 413.4 / (3.15 \times 1000) \\ &= 0.1314 \text{ m}^3\end{aligned}$$

$$\begin{aligned}
 \text{c) Volume of water} &= \frac{\text{Mass of water}}{(\text{sp. gravity of water}) \times (\text{density of water})} \\
 &= 191.58 / (1 \times 1000) \\
 &= 0.192 \text{ m}^3 \\
 \text{d) Volume of all in aggregate} &= a - (b + c) \\
 &= 1 - (0.1314 + 0.192) \\
 &= 0.6766 \text{ m}^3 \\
 \text{e) Mass of coarse aggregate} &= e \times \text{Volume of coarse aggregate} \times \\
 &\quad \text{Specific gravity of coarse aggregate} \times \\
 &\quad 1000 \\
 &= 0.6766 \times 0.5 \times 2.85 \times 1000 \\
 &= 964.2 \text{ kg.} \\
 &= e \times \text{volume of fine aggregate} \times \text{Specific} \\
 &\quad \text{gravity of fine aggregate} \times 1000 \\
 &= 0.6766 \times 0.5 \times 2.54 \times 1000 \\
 &= 859.3 \text{ kg.}
 \end{aligned}$$

MIX DETAILS

The mix proportion used in this analysis is 1:1.89:3.0, with a water/cement ratio of 0.4, as shown in table M30 concrete.

TABLE 5.2 Mix proportion of concrete

Water	Cement	Fine aggregate	Coarse aggregate
192	413 kg/m ³	859.3 kg/m ³	964.2 kg/m ³
0.4	1	2.0	2.5

5.3 .MIX DESIGN OF HIGH PERFORMANCE CONCRETE BASED ON FLY ASH AND METAKOALIN

(i) Power goal for mix proportion

The mean compressive strength goal at 28 days is given by

$$f'_{ck} = f_{ck} + 1.65S$$

From IS 10262:2000 $S = 5 \text{ N/mm}^2$ (S – Standard Deviation)

$$f'_{ck} = 30 + (1.65 \times 4)$$

$$= 36.6 \text{ N/mm}^2$$

ii) Selection of Quantity of fly Ash

At a solution-to-bottom ash ratio of 0.35 and a bottom ash fineness of 430 m²/kg, bottom ash in the amount of 405 kg/m³ is needed to achieve the target mean strength of 36.6MPa. (Based on previous research).

(iii) Calculating the sum of alkaline activators

Calculate the number of alkaline activators while keeping the following in mind:

The solution-to-bottom-ash mass ratio is 0.35. i.e: Mass of (Na₂SiO₃+ NaOH)/bottom ash = 0.35

$$\text{Mass of (Na}_2\text{SiO}_3 + \text{NaOH})/405 = 0.35$$

$$\text{Mass of (Na}_2\text{SiO}_3 + \text{NaOH}) = 141.7 \text{ kg/m}^3$$

IV) Absolute solid content in alkaline solution calculation

$$\text{Solid content in sodium silicate solution} = (50.32/100) \times 70.88$$

$$= 35.67 \text{ kg/m}^3$$

$$\text{Solid content in sodium hydroxide solution} = (38.20/100) \times 70.88$$

$$= 27.29 \text{ kg/m}^3$$

$$\text{Total Solid content in both alkaline solutions} = 62.96 \text{ kg/m}^3$$

v). Selection of water content

The water content per cubic metre of geopolymer concrete for a medium degree of workability and a fineness of bottom ash of 430m²/kg is measured in Table 2. A water content of 110 kg/m³ is present. Water substance modification For sand conforming to grading-I, correction in water content is taken from Table 3

$$\text{Adjustment in water content} = -1.5\%$$

$$\begin{aligned}\text{Total quantity of water required} &= 110 - (1.5/100) \times 110 \\ &= 108.35 \text{ kg/m}^3\end{aligned}$$

$$\begin{aligned}\text{Water content in alkaline solutions} &= 141.75 - 62.96 \\ &= 78.79 \text{ kg/m}^3.\end{aligned}$$

vii. Calculation of additional quantity of water

$$\begin{aligned}&= [\text{Total quantity of water}] - [\text{Water present in alkaline solutions}] \\ &= 108.35 - 78.79 = 29.46 \text{ kg/m}^3\end{aligned}$$

viii. Selection of wet density of high-performance concrete

Wet density of geopolymer concrete is 2,528 kg/m³ for the fineness of fly ash of 430 m²/kg

ix. Selection of fine-to-total aggregate content

Fine-to-total aggregate content is 35% for fineness modulus of sand of 3.35

x. Calculation of fine and coarse aggregate content

$$\begin{aligned}\text{Total aggregate content} &= [\text{Wet density of GPC}] - [\text{Quantity of bottom ash}] + [\text{Quantity of both solutions} + \text{extra water, if any}] \\ &= 2528 - [405 + 141.75 + 29.46]\end{aligned}$$

$$= 1951.79 \text{ kg/m}^3$$

Sand content = [Fine to total aggregate content in %] x [Total quantity of All-in-aggregate]

$$= (35/100) \times 1951.79$$

$$= 683.13 \text{ kg/m}^3$$

Coarse aggregate content = [Total quantity of all-in-aggregate]-[Sand content]

$$= 1951.79 - 683.13$$

$$= 1268.66 \text{ kg/m}^3$$

Quantity of materials required per cubic meter for M30 grade of HPC.

Concrete is shown in below Table.

TABLE 5.3 Mix proportion of admixture added concrete

Ingredients of hpc concrete	Fly ash	NaOH	Na ₂ SiO ₃	Sand	Coarse aggregate	Total water (W/GPB)
Quantity (kg/m ³)	405	70.88	70.88	683.13	1268.66	108.35
Proportion	1	0.35		1.82	3.37	0.211

CHAPTER 6

EXPERIMENTAL INVESTIGATION

6.1 TEST ON FRESH CONCRETE

6.1.1 SLUMP CONE TEST

In the slump cone test, a slump cone 30cm in height is used to assess the strength of fresh concrete. The slump cone was refilled and tamped 15 times with fresh concrete. After filling, the slump cone is vertically removed and the concrete is able to stand alone without any support. The concrete will then settle, and the height it has subsided will be measured. This procedure was repeated several times with different water cement ratios.

Table 6.1.1 Slump cone test

S.NO	Water cement ratio	Initial height of slump h1 in cm	Height of subsided h2 in cm	Slump h1-h2 in cm	Type of slump
1	0.40	30	30	0	Zero
2	0.50	30	28	2	True
3	0.55	30	24	10	Shear
4	0.60	30	21	18	Shear
5	0.65	30	18	15	Shear
			Average	7.5	Shear

Result:

Slump cone test of the concrete = 7.5 cm.



Fig 6.1 slump cone test

6.1.2 COMPACTION FACTOR TEST

The compaction factor is used to decide if new concrete is workable. A compaction factor machine is being used in this analysis. First, new concrete with a lower water-to-cement ratio was made. An upper hopper, a lower hopper, and a cylinder comprise a compaction factor machine. Trap doors are located at the bottom of hoppers. The empty weight of the cylinder was calculated.

Without being compacted, the concrete is first placed in the upper hopper. The trap door in the upper hopper was then opened, allowing concrete to fall on the lower hopper. After that, the lower trap door was opened, causing the concrete to collapse on the cylinder. The surface of the cylinder was wiped clean, and the weight was registered. The upper hopper was then filled with concrete and compacted, and the process was repeated. This procedure was repeated for various water cement ratios, with the results announced.



Fig 6.2CompactionFactor Test

Table 6.1.2 Compaction factor test

S.NO	Water cement ratio	Wt of concrete with partial compacted w1 kg	Wt of concrete with fully compacted w2 kg	Compaction factor (w1/w2)x100
1	0.40	10.99	12.32	89
2	0.50	12.10	12.46	97
3	0.55	12.50	13.49	92
4	0.60	12.92	13.78	93
5	0.65	13.25	14.01	94
			Average	93

Result:

Compaction factor of concrete = 93%

6.1.3 FLOW TABLE TEST

The flow table test is used to decide whether the concrete is usable or not. For this examination, the same slump cone mould was used. The slump cone was left on the flow table when new concrete was poured. The mould was then removed vertically, and the original diameter of the concrete was weighed. After turning on the pump, the concrete was allowed to vibrate for 5 minutes. The final diameter of the concrete was measured after vibration. This procedure was repeated for different water cement ratios, and the findings were written.

Table 6.1.3 Flow table test

S.NO	Water cement ratio	Initial diameter in cm	Spread diameter in cm	Percentage of flow
1	0.40	19	38	52
2	0.50	19	39	56
3	0.55	20	41	64
4	0.60	20	42	68
5	0.65	20	43	74
			Average	62.8

Calculation :

$$\text{Flow percentage} = \frac{\text{spread diameter in cm} - 25}{25} \times 100$$
$$= \frac{38 - 25}{25} \times 100 = 52$$

Result:

Flow percentage of the concrete = 62.8%

6.2 TESTS ON HARDENED CONCRETE

To test hardened concrete, various moulds such as cubes, tubes, and beams must be cast. After 24 hours of casting, it is cured for the necessary time.

Fig 6.3 moulding



Fig 6.3 Mould



Fig 6.4 Casting

6.2.1 Introduction About Hardened Concrete

The compressive strength of hardened concrete is the most critical parameter and a good predictor of the overall quality of the concrete. It is largely determined by the water cement ratio of the mix, as well as the curing and post-casting ages. Concrete compressive strength is measured on cubical specimens at different ages, such as 3 days, 7 days, and 28 days, using a compressive strength measuring system.

Concrete's tensile strength is thought to be equal to its compressive strength. On cylindrical specimens, it is measured using either a flexure test or a split cylinder test. Although the tensile strength of concrete has no practical application, it is determined to show how a brittle material like concrete has a very low tensile strength in contrast to its compressive strength.

6.3 TEST ON HARDENED CONCRETE

Another important property of hardened concrete is its modulus of elasticity. It is discovered by examining cylindrical specimens. The stress strain curve and modulus of elasticity are calculated by plotting the applied stress and subsequent deformation in the specimens. A concrete modulus of elasticity test is needed to measure deflection and predict shrinkage cracking..

6.3.1 COMPRESSIVE STRENGTH

The compressive strength of hardened concrete is calculated by the compressive test. Under perfect conditions, the compressive strength of concrete is demonstrated by the compressive test. Hardened concrete's compressive strength is calculated. Testing should be carried out with great caution. After the specimen was centred in the measuring system, the test was carried out at a standardised stress of 140 kg/cm²/minute. Loading was continued until the dial gauge's needle clearly reversed direction of motion. The needle's change of course indicates that the specimen failed. The dial gauge reading, which was at the time the ultimate load, was registered. The ultimate cube compressive force is proportional to the ultimate load divided by the cross sectional area of the specimen. The compressive strength of concrete shows the overall resilience of the material.

The research specimen has a cubical shape and measures 150mmx150mmx150mm. If the aggregate's largest normal size does not exceed 20mm, 10mm cubes may be used as an alternative. Compressive strength tests are carried out on specimens of known age, preferably from separate batches made for testing at each age. After wiping away the surface moisture, all of the cubes were checked in a saturated condition. After 7 and 28 days of self-curing, three cubes from each trial mix were measured using a compression testing machine with a capacity of 2000KN in accordance with IS 516-1959.



Table 6.3.1 Compression Strength on cubes

S.NO	MIX	MATERIAL USED	STRENGTH ON 7 th DAY (N/mm ²)	STRENGTH ON 28 th DAY (N/mm ²)
1	M30	Conventional concrete	17.1	26.6
2	M30	Fly ash	22.9	41.7
3	M30	Metakoalin	24.5	35

FIGURE 6.3.1 Compression Strength

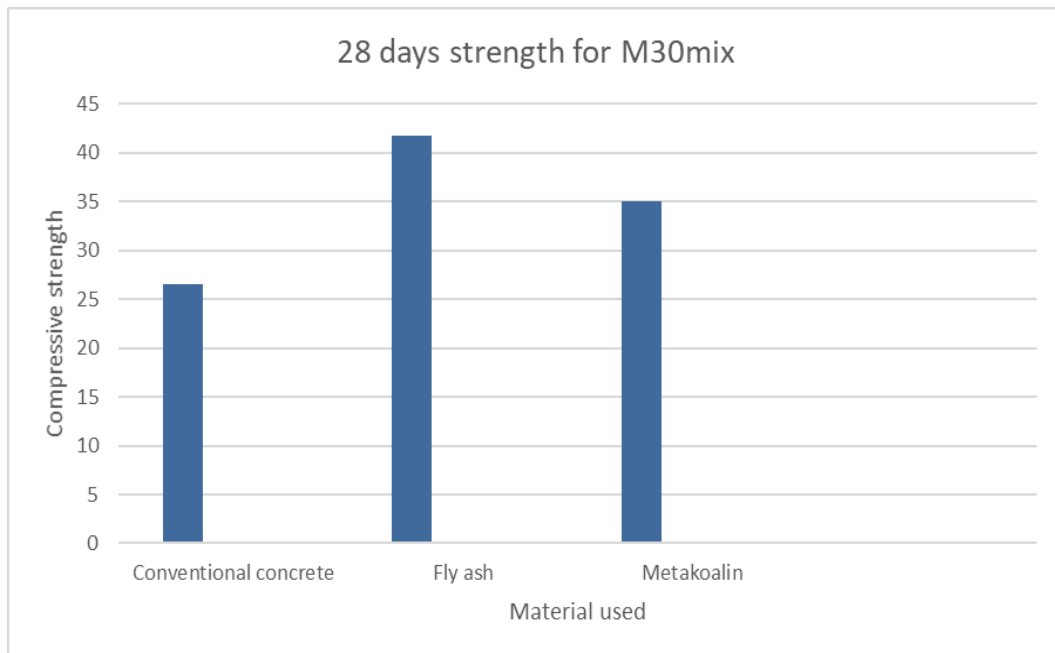
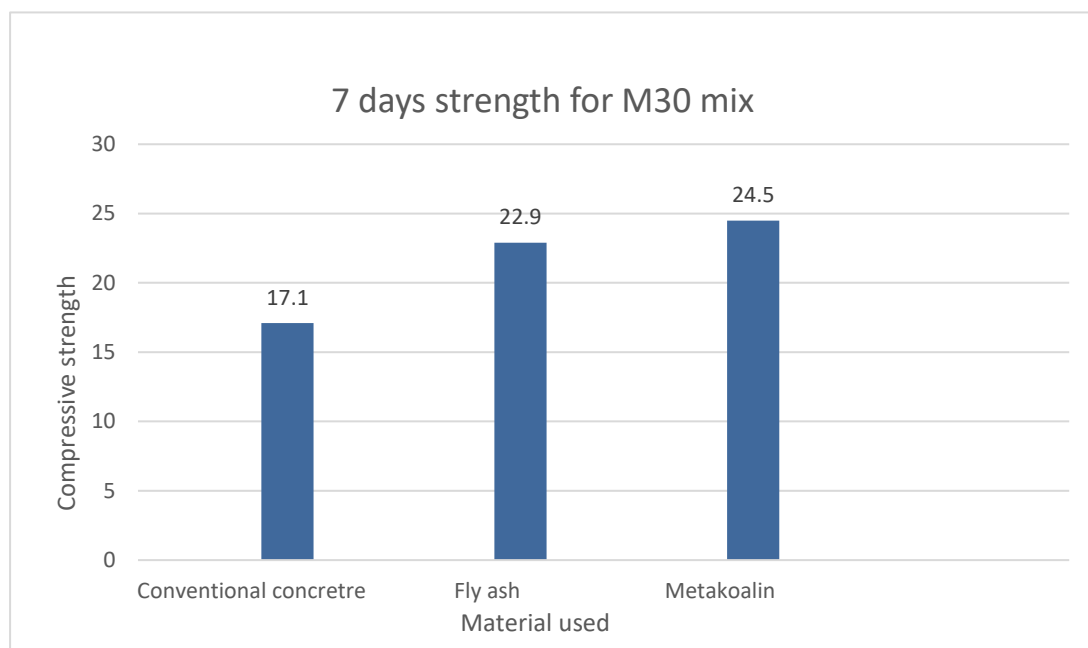


FIGURE 6.3.1 Compression Strength Reading



6.4.1 SPLIT TENSILE STRENGTH OF CONCRETE

Tensile strength is a fundamental and critical property of concrete. Because of its low tensile strength and porous nature, concrete is generally assumed to withstand direct stress. The load at which the concrete members would fail, on the other hand. Aside from the flexural measurement, there are two approaches for measuring concrete tensile strength: (a) direct methods and (b) indirect methods. The direct approach has a variety of drawbacks, including difficulties in properly keeping the specimen in the testing machine without adding stress concentration and applying a free-of-eccentricity uniaxial tensile load to the specimen. The cylinder measures 150 mm in diameter and 300 mm in height. Splitting tests, also known as split tensile strength of concrete, are well-known indirect tests for determining concrete strength. An elastic study shows that fairly uniform tensile strength emerges over nearly the entire loaded diameter as a result of the compression loading. The formula determines the degree of tensile stress (IS 5816-1970).



S.NO	MIX	MATERIAL USED	STRENGTH ON 7 th DAY (N/mm ²)	STRENGTH ON 28 th DAY (N/mm ²)
1	M30	Conventional concrete	5.2	6.9
2	M30	Fly ash	7.05	17.1
3	M30	Metakoalin	5.15	9.9

Table 6.4.1 Split tensile strength on the cylinder

Figure 6.4.1 Split tensile strength

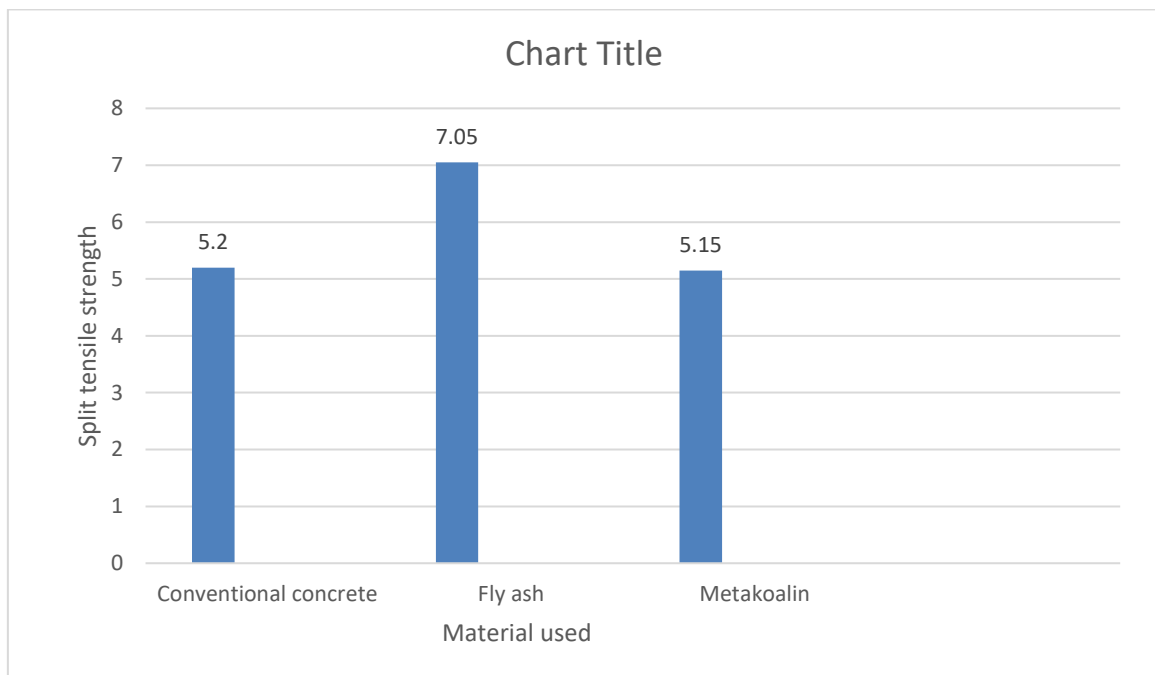
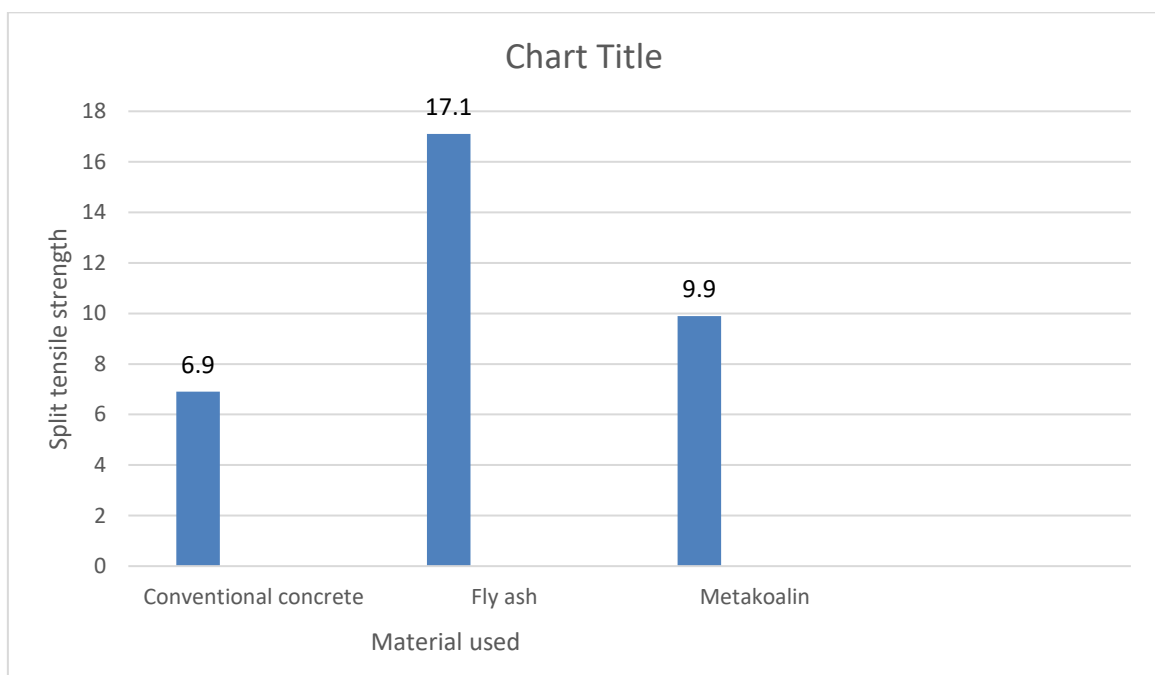


FIGURE 6.4.1 Split Tensile Strength Reading



6.3 CHLORIDE RESISTANCE TEST:

1. To assess the volume of chloride in aggregate, chloride tolerance tests are used.
2. The use of aggregates with a high chloride content limits the lifetime of the house, resulting in poor construction quality.

CHAPTER- 7

RESULT AND DISCUSSION

7.1 Compression strength

The M25 grade mix proportion is used in this analysis, and the mix ratio is 1:1.8:2.96. 16 cubes were cast to test compressive force. Averaging three specimens over seven and twenty-eight days was used to calculate the total compressive strength at 150mm x 150mm x 150mm scale cubes. After 28 days, the compressive strength of plain concrete and self-curing concrete is 26.7 and 41.7 MPa, respectively. As a result, self-curing concrete has far greater compressive strength than conventional concrete. The optimum PEG-400 dose for compressive intensity was determined to be 1%. As the percentage of PEG-400 in the concrete rises to more than 1%, the strength deteriorates. We also discovered that a 1.5 percent PEG-400 dose achieves the target strength of 35 Mpa.

7.2 Split Tensile strength

A total of 16 cylinders were cast to test split tensile strength. The gross split tensile strength of a 300mm X 150mm cylinder was determined by averaging three specimens over seven and twenty-eight days. Simple concrete has a split tensile strength of 6.9 Mpa after 28 days, while self-curing concrete has a split tensile strength of 17.1 Mpa, which is significantly higher than normal concrete. Based on the observed maximum split tensile power, the optimum dose was calculated to be 1%. As the PEG-400 content is increased by more than 1%, the strength of the concrete decreases. We discovered that the tensile strength of PEG-400 1.5 percent split is 9.9 Mpa, which is greater than the tensile strength of standard concrete, which is 6.9 Mpa.

7.3 chloride resistance strength

Resistance to chloride ion penetration is a critical feature of structural materials that needs to be addressed further. Mineral admixture, it is commonly agreed, greatly increases this due to the chloride binding and pore filling effects. This pore filling effect is thought to be beneficial in the case of MK. An accelerated chloride permeability test was performed on all of the concretes, and the

cumulative charge passing in 6 hours is shown in Fig. 11 as a measure of chloride permeability. On top of that, the ASTM C1202 chloride ion penetrability limits were superimposed. All of the MK concretes have very low chloride permeabilities in the range of 148–305 C due to the MK in these mixtures. The control concrete (MK0) has a low chloride permeability of about 1162 C, meaning that the MK-containing mixtures performed significantly better. Previously, it was discovered that as the proportion of MK increased, so did the resistance to chloride ion penetration (Kim et al. 2007; Boddy et al. 2001). Furthermore, high reactivity MK significantly decreased chloride ion penetration in concrete, and such reductions can be expected to have a significant effect on the service life of reinforced concrete in chloride environments, according to Gruber et al. (2001). According to Abbas et al. (2010), the addition of MK increased the system's ability to bind chloride ions, thus decreasing the supply of free chloride ions. Since free chloride ions in pore water are the leading cause of steel reinforcement corrosion. In hydrated cement, C3A reacts with chloride ions to form inert products such as Friedels salt ($3\text{CaO} \cdot \text{Al}_2\text{O}_3 \cdot \text{CaCl}_2 \cdot 10\text{H}_2\text{O}$). As pozzolanic material, such as MK, is used to substitute a portion of the cement, the high alumina content of that material facilitates chloride ion binding even more (Schiessl 1988).

CHAPTER – 8

CONCLUSION

The plastic density of the mixtures was reduced by using MK and flyash as partial substitutes for cement.

The results show that high strength and high performance concretes with compressive strengths exceeding 100 MPa can be constructed using local MK and cement engineered for a low water/binder ratio of 0.3.

Because of the dilution effect of partial cement replacement, the best amount of OPC replacement by MK and flyash was 10%, which provided the highest compressive strength as compared to other replacement rates. These concretes also had a relatively high modulus of elasticity and a 28-day splitting tensile strength that was approximately 5.15 percent of their compressive strength. The splitting tensile strengths and elastic modulus results followed the same pattern as the compressive strength results, with the highest values at 10% replacement. In terms of longevity, it was discovered that as the replacement percentage increased, the water permeability, absorption, and chloride permeability of local MK and flyash decreased. This may be attributed to the filler impact of MK and flyash particles in the concrete, which has significantly decreased its permeability or porosity.

REFERENCES

1. P.D.Kumbhar and B.B.Patil (2012) Durability and toughness High-Performance Concrete with Highly Reactive Metakaolin Properties, International Journal of Modern Engineering Research (IJMER), Vol.2, Issue 3.
2. Vikas Srivastava, Rakesh Kumar, and V.C. Agarwal (2012) Effect of metakaolin inclusion on the mechanical properties of concrete International Journal of Civil Structural Engineering, 2(3), pp. 893–900.
3. untamed (1996). The relative strength, pozzolanic behaviour, and cement hydration of superplasticized Metakaolin concrete were investigated. Cement Concrete Study, 26(10), 1537-1544.

4. Sobolev (2004) creation of a new method for proportioning high-performance concrete mixtures. *Cement and Concrete Composites*, 26(7).
5. Bonakdar, M. Bakhshi, and M. Ghalibafian (2005) High-Performance Characteristics Metakaolin with a High Reactivity in Concrete
6. IS: 10262-(2009), Recommendations for Concrete Mix Style, Bureau
7. of Indian Standards, New Delhi, India.
8. M. Kokubu, Fly ash as cement, in *The Cement Association of Japan (Ed.), Proceedings of the 5th International Symposium on the Chemistry of Cement: Part 4. Admixtures and Unique Cements*, v. 4, Tokyo, 1968
9. H.G.Mundal, Variation of Concrete Strength Due to High Temperature, *International Journal of Research in Engineering & Technology (IMPACT: IJRET)*
10. Phan LT, Carino NJ (2003) CodeStrong Quality Concrete Strength Temperature Relationship Provisions at Elevated Temperatures, *Material Structure*, 36(256): 91–98.
11. M. L. Gambhir, —Concrete technologyll, Tata McGraw-Hill Education, 2004.
12. M.S.Shetty, Theory and Practice of Concrete Technology, S.Chand& Company LTD.
13. M. L. Gambhir, Concrete technologyll, Tata McGraw-Hill Education, 2004.
14. Amit Mittal, M.B. Kaisare and RajendraKumar Shetty, Tarapur Atomic Power Project 3&4, Nuclear Power Corporation of India Ltd.
15. Malhotra S. K, Dave N. G (1999) “The effect of adding fly ash and burnt claypozzolana on some engineering properties of cement composites has been studied.” *Cement & Concrete Composites* (1999), vol 21,
16. A.M.Poppe, G. Baert and N.De Belie, Strength and Durability of high_x0002_volume FlyashConcrete.
17. Jiping Bai, AlbinasGailus Flyash and Metakaolin Concrete Consistency
18. Tiwari A.K, Jha D.N. &Venkateshwaran D. High Quality Concrete Characteristics