Journal of **N**onlinear **A**nalysis and **O**ptimization
Vol. 15, Issue. 1, No.15 : 2024
ISSN : **1906-9685**

AN EXPERIMENTAL STUDY ON RESISTANCE OF CONCRETE TO ACID ATTACK BY USING MINERAL ADMIXTURES

[1]K NAZIYA,[2]G RAJESH
[1]Student,[2]Assistant Professor
Department Of Civil Engineering
PVKKIT,Anantapur

ABSTRACT

Concrete is a widely used construction material for various types of structures due to its structural stability and strength. The usage as well as the behavior of durability of concrete structures, built during the last first half of the century with Ordinary Portland Cement (OPC) and plain round bars of mild steel, the ease of procuring the constituent materials (whatever may be their character) of concrete and the information that almost any mixture of the constituents leads to a mass of concrete have bred contempt. The Ordinary Portland Cement (OPC) is one of the most important ingredients used for the manufacture of concrete and has no alternative in the civil construction industry. Unfortunately, production of cement involves emission of large amounts of carbon-dioxide gas into the atmosphere, it causes green house effect and the global warming, and hence it is replacement of some other material, like mineral admixtures (Silica fume and Fly ash and GGBS).

Acidic attack is one of the world's wide problems that may cause gradual but severe damages to concrete structures. Concrete can be attacked by the sulphates present in the soil or in the sea water, and by sulphuric acid produced from either sewage or sulpur dioxide present in the atmosphere of industrial cities. Most acid attacks concrete by a process of dissolution and leaching, converting the constituents of the cement paste into readily soluble salts. The amount of attack depends on the properties of the aggressive agent and its concentration. Damage is to be estimated if the pH of the acidic solution is lower than six.

In this study the past decades covered the sulphates attacks from different aspects to improve the resistance of concrete to acid attacks, used mineral additives such as Fly ash and Silica fume. In this study, the different admixtures were used to study their sole and combined effects on the resistance of concrete in addition to their effects on mechanical and durability properties by the replacement of admixtures by 10%, 20% & 30% by the weight of cement.

I. INTRODUCTION

1.1 GENERAL

Concrete is a widely used construction material for various types of structures due to its structural stability and strength. The usage, behaviour as well as the durability of concrete structures, built during the last first half of the century with Ordinary Portland Cement (OPC) and plain round bars of mild steel, the ease of procuring the constituent materials (whatever may be their qualities) of concrete and the knowledge that almost any combination of the constituents leads to a mass of concrete have bred contempt. The Ordinary Portland Cement (OPC) is one of the main ingredients old for the making of concrete and has no substitute in the civil creation industry. Unfortunately, production of cement involves emission of large amounts of carbon-dioxide gas into the atmosphere, a major contributor for green house effect and the global warming, hence it is inevitable either to search for another material or partly replace it by some other material. The investigate for any such matter, which can be used as an substitute or as a complementary for cement must lead to global sustainable maturity and lowest promising ecological impact.

Acidic attack is one of the world's wide problems that may cause gradual but severe damages to concrete structures. Concrete can be attacked by the sulphates present in the soil or in the sea water, and by sulphuric acid produced from either sewage or sulpur dioxide present in the atmosphere of industrial cities. Most acid attacks concrete by a process of dissolution and leaching, converting the constituents of the cement paste into readily soluble salts. The scale of harass depends on the properties of the belligerent agent and its meditation. Damage is to be estimated if the pH of the acidic result is lower than six.

Every concrete structure should perform its intended function through the expected life time of the structure, irrespective of external exposure conditions. The ability of concrete to withstand any environmental condition that may result in premature failures or several damages is a major concern to the engineering professional.

The weakening achieve of acid media on cement based constructions has become a distressing problem all more than the world. These media generally occur as acidic rains and mist, industrial and urban sewages and acidic ground water. The extent of attack depends not only on the type of concentration of attacking acid, but also on the properties of the material including the cement used. Acid attack is one of the phenomena that may disintegrate concrete structures depending on the type and concentration of acid. Certain acids such as oxalic acid are considered as harmless, while weak solutions of some acids have insignificant effects. Even though acids normally attack and leach away the calcium compounds of the paste, they may not willingly attack confident aggregates, such as siliceous aggregates calcareous aggregates often react willingly with acids.

Many researchers in the past decades covered the sulphates attacks from different aspects to improve the resistance of concrete to acid attacks, many researchers used mineral additives such as Fly ash and Silica fume. The use of these artificial pozzolanas can achieve not only economical and ecological benefits, but technical benefits as well. however, it is also well known that mineral additives may decrease the premature might of concrete.

In this study, the different admixtures were used to study their sole and combined effects on the resistance of concrete in addition to their effects on mechanical and durability properties by the replacement of admixtures by 5%, 10%, 15%& 20% by the weight of cement.

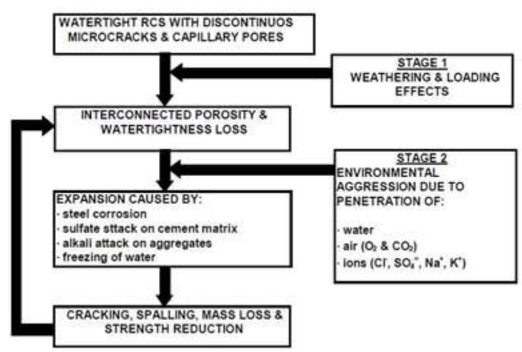

Figure 1.1. A holistic representation of concrete deterioration from environmental effects. Adapted from Mehta (1, 2).

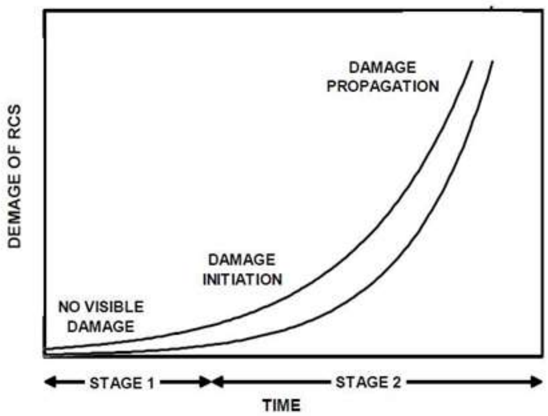

Figure1. 2. A two-stage damage model for reinforced concrete structures (RCS). Adapted from Mehta (1, 2).

1.2. OBJECTIVES

The main objectives of this study are:

1. To develop an acidic resistance concrete mix with good workability and high-early-strength to withstand harsh environmental conditions.

2. To study the physical and mechanical and durability properties of these concrete mixes in terms of changes with respect to time and duration.

For this study the following tests are adopted.

- Normal consistency
- Initial setting and Final setting time
- Workability test
- Soundness test
- Compressive strength test
- Split tensile test
- Water absorption test
- Acid test

3. To assess the effect of concrete containing different mineral admixtures cured under different curing regimes.

1.3. SCOPE

- The scope of this study is to develop the acidic resistance concrete made from OPC with partial replacement of different admixtures incorporated samples.
- In this study a concrete mix was developed using mineral admixtures. The effect of cement replacement of 5, 10, 15 & 20 % by fly ash, silica fume by keeping the total cementitious content i.e. cement plus admixtures constant.
- In this present investigation water binder ratio was kept constant as 0.50 for the mixes in the investigations.
- The quantity of coarse aggregates was kept the same for all the mixes and the quantity of fine aggregates (sand) was suitably adjusted for the different cement replacement levels with different admixtures, the strength and durability properties of concrete blocks cast using these mixes were studied.
- In this the various mechanical and durability properties of these mixes was then studied.
- In this study, it is aimed to obtain an acid resistance concrete with a practicable range that would yield concrete with satisfactory high strength.

1.4. ENVIRONMENTAL IMPACT:

Cement manufacture causes environmental impacts at all stages of the process. These embrace emissions of flying fumes in the form of soil, gases, noise and shaking when working machinery and during blasting in quarries and damage to scenery from quarrying. Cement manufacture contributes greenhouse gases both, directly through the production of carbon dioxide when calcium carbonate is heated, producing lime and carbon dioxide and indirectly through the use of energy, particularly if the energy is sourced from fossil fuels. The cement manufacturing process produces about 5% of global man-made CO2 emissions, of which 50% is from the chemical process, and 40% from burning fuel. The amount of CO2 emitted by the cement manufacturing is nearly 900kg of CO2 for every 1000kg of cement produced.

The replacement of primary raw materials consumed in cement manufacture with supplementary cementitious materials and mineral additions, including power station fly ash and granulated blast furnace slag or limestone fines will help in reducing the CO2 emissions as these materials mainly substitute for clinker in cement. Thus it will have a positive environmental impact.

II. LITERATURE REVIEW

2.1 GENERAL

In the last decades many experiments and researches have been done to investigate the effects of concrete influenced by the acidic attacks and the impact of chemicals on cementization. Literature relating to blended cements in concrete and the effect of curing regimes on this concrete are numerous. In this chapter, only literature concerning those aspects related to this particular research i. e. the mechanical and durability properties of hardened concrete incorporating metakaolin, fly ash, silica fume and slag as a mineral admixtures added to concrete made with the Portland cement are discussed. This survey also includes the effect of curing conditions on the various properties of concrete.

N.I. Fattuhi and B.P Hughes examined the effect of acid attack on concrete with different admixtures or protective coatings were used in an attempt to improve the chemical resistance of a standard concrete mix. The admixtures included pulverized fuel ash, styrene butadiene latex, water reducing, super plasticizing, retarding and water-proofing agents. Coatings, with PMMA and polymer emulsions, were brushed onto hardened concrete cubes. Forty I02 mm cubes containing the different admixtures or coatings were immersed in a channel with a solution of continuously flowing sulphuric acid. Twenty cubes contained centrally placed short mild steel bars. The changes in weight with time for each cube were determined continuously up to 172 days exposure, and the situation of the reinforcement was visually examined at termination. The effects of admixture additions on the workability and compressive strength of the concrete were also investigated

M. Collepardi adopted a holistic approach to examine concrete durability problems by taking into account physical aspects (such as capillary porosity, micro-cracking, macro voids) and chemical reactions. A ternary representation of the complex damage process in reinforced concrete structures was used by examining the coexistence of the main three elements effecting the concrete durability:

a) Interconnected porosity,

b) Exposure to aggressive agents, and

c) Presence of water.

This model was adopted to examine two specific examples of the concrete damage dealing with the cement matrix, the embedded aggregates:

-Sulphate attack of the cement matrix.

-Alkali-aggregate reaction.

S Turkel, B Felekoglu and S Dulluc examined the Acidic attack represents a topic of increasing significance, owing to the spread of damages of concrete structures in both urban and industrial areas. Cement type is an important factor affecting performance of cement based materials in an aggressive environment, and compare the acid resistance of a pozzolanic cement (CEM IV-A/32·5) with Portland cement (CEM I 32·5) that was made from the same clinker. For this reason, 50mm mortar cubes were prepared with two different kinds of cement according to TS EN 196-1. After 28 days of hardening, the samples were immersed into four different concentrations of hydrochloric, nitric and sulphuric acid solutions for a period of 120 days. The changes in weight loss and compressive strength values for each acid solution within the test time were recorded. The acid resistance of mortars prepared from Portland cement was improved than the pozzolanic cement incorporated samples after 120 days of acid attack.

H. Siad , H. A. Mesbah, and S. Kamali Bernard tested the performance of natural pozzolanas on the behavior of self-compacting concrete under sulphuric and hydrochloric acid attacks, to compare the hydrochloric and sulphuric acid behaviors of a SCC-containing Algerian natural pozzolanas with SCC-containing fly ash and limestone filler additions. For this reason, twelve formulations were prepared with three different strength classes (30, 50, and 70 MPa). After 28 days of curing, The samples were immersed in hydrochloric sulphuric acid solutions for a period of 12 weeks. The changes in mass loss and compressive strength loss for each acid solution within the test time were recorded. The Scanning Electron Microscope (SEM) and XRD analysis were used to better identify with the mechanism of deterioration of each type of concrete. In spite of their economical properties, the results confirm that the use of Algerian natural pozzolanas contributes to the improvement of resistance of SCC under sulphuric and hydrochloric acid attacks.

Adriana Estokova, Vlasta Ondrejka and Alena Luptakova focused on Analysis of the Selected Characteristics Changes of Cement Composites Exposed to the Sulphate Environment is identified as having a detrimental effect on concrete. The main problem, still, is the effect of hydrogen sulphide and its derivatives, which leads to sulphuric acid oxidization. Sulphuric acid oxidization can be caused due to harass of destructive media obviously obtainable in surroundings. Another option of oxidization configuration is biogenic acid cause through the agency of bacteria. The deterioration conflict of concrete depends on the type and chemical masterpiece of the cement as well as the pH of the violent acid.

The paper is alert on the study of chemical decomposition of concrete samples consequential in increased leakage due to sulphate environment. Sulphate aggressive atmosphere was represented by 0.5 % solution of H2SO4 (pH value of 0.99) and 0.5 % Al2 (SO4)3 solution (sulphate concentration of 3,000 mg/L). Distilled water used as orientation medium as proper escape recreation environment. Concrete composites with/without coal fly ash cement substitution were used for the experiments. The laboratory experiments proceeded through the 60 days. No significant differences in chemical composition of concrete samples before and after the experiment were observed except for the iron, aluminium and silicon concentrations. abbreviation the results of chemical symphony of the liquid media previous to and after the experiments, the preliminary concentrations of Ca in leachates have been enlarged 2.0 to 3.5, 16.4 to 18.3 and 4.1 to 5.1 times for distilled water, sulphuric acid and aluminium sulphate, respectively. In point of vision of calcium escape, the concrete example with fly ash was inclusive to be more disparate to sulphuric acid in correlation to the model without fly ash.

The primary concentrations of Si have been improved 1.9 to 1.91, 3.2 to 3.3 and 1.89 to 1.92 times for distilled water, sulphuric acid and aluminium sulphate, respectively. In casing of all fluid media the growing character of pH values have been noticed. The most evident increase of pH value to the alkali expanse was experiential in case of distilled water (more than 1.8 times for both types of composites).

2.2 MINERAL ADMIXTURE

Mineral admixtures refer to the finely divided materials which are added to obtain specific engineering properties of cement mortar and concrete. The other, evenly central, objectives for using mineral admixtures in cement concrete consist of economic profit and environmentally safe recycling of engineering and other waste by-products. Unlike chemical admixtures, they are used in reasonably large amounts as replacement of cement and or of fine aggregate in concrete. In the past, natural pozzolanas such as volcanic earths, tuffs, trass, clays, and shale's, in raw or calcined form, have been successfully used in building various types of structures such as aqueducts, monuments and water retaining structures. Natural pozzolanas are still used in some parts of the world. However, in recent years, many industrial waste by-products such as fly ash, slag, silica fume, red mud, and rice husk ash and highly reactive metakaolin has recently become available as a very active pozzolanic material for use in concrete. Unlike fly ash, slag, or silica fume, this material is not a byproduct but is manufactured from a high-purity kaolin clay by calcinations at temperatures in the region of 700 to 800°C are rapidly becoming the main source of mineral admixtures for use in cement and concrete.

2.3 TYPES OF MINERAL ADMIXTURE

Mineral admixtures can be classified in two groups:

- Pozzolanic materials and inert filler materials.
- Pozzolanic materials are mineral admixture contains reactive silica which once added to cement reacts with calcium hydroxide to form C-S-H such as volcanic ash, burnt clay, and fly ash. Using pozzolanas lower the heat of hydration, increase later strength, and increase durability. Inert materials are mineral admixtures which do not affect the strength of concrete and used as workability aids such as hydrated lime, dust of normal weight aggregates, and colouring pigments.

2.3.1 Fly Ash as Mineral Admixture

Fly ash is a byproduct of the combustion of pulverized coal in thermal power plants. A dust-collection system removes the fly ash, as a fine particulate residue, from combustion gases before they are discharged into the atmosphere (Figure1.4). The types and relative amounts of incombustible matter in the coal used decide the chemical composition of fly ash. Above 85% of most fly ash is comprised of chemical compounds and glasses formed from the elements silicon, aluminum, iron, calcium, and magnesium. Generally, fly ash from the combustion of sub bituminous coals contains more calcium and less iron than fly ash from bituminous coal; also, fly ash from sub bituminous coals contains very little unburned carbon. Plants that control only infrequently (peak-load stations) and that burn bituminous coals generate the largest percentage of unburned carbon. Fly-ash particles are typically sphere-shaped, ranging in diameter from <1 µm up to 150 µm.

Fly ashes show pozzolanic activity. The American Society for Testing and Materials (ASTM) (ASTM, 1975) defines a pozzolanas as "a siliceous or siliceous and aluminous material which in itself possesses little or no cementitious value but which will, in finely divided form and in the presence of moisture, chemically react with calcium hydroxide at ordinary temperature to form compounds possessing cementitious properties." Fly ashes contain metastable aluminosilicates that will act in response with calcium ions, in the amount of moisture, to form calcium silicate hydrates.

The term fly ash was first used in the electrical power industry around 1930. The first complete data on the use of fly ash in concrete in North America were reported by Davis et al. (1937). The first most important practical application was reported in 1948 with the publication of the U.S. Bureau of Reclamation's data on the utilize of fly ash in the construction of the Hungry Horse Dam. Worldwide acceptance of fly ash as a component of concrete slowly followed these early efforts, but interest was particularly noticeable in the wake of the rapid increases in energy costs (and hence cement costs) that occurred during the 1970s In recent years, it has become evident that fly ashes differ in significant and definable ways that reflect their combustion and, to some extent, their origin. The ASTM recognizes two general classes of fly ash:

- Class C, normally produced from lignite or sub bituminous coals
- Class F, normally produced from bituminous coals

Table 2.1 The Chemical composition of Fly ash

Constituents	Percentage (%)
SiO_2	60.48
Al_2O_3	28.15
Fe_2O_3	4.52
CaO	1.71
K_2O	1.41
MgO	0.47
Na_2O	0.14
L.O.I	1.59

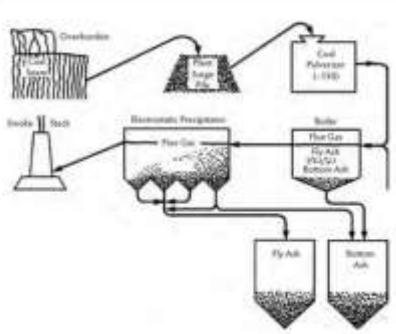

Figure 2.1. Schematic of fossil fuel plant

III. MATERIALS AND METHODS

In recent years, improvements in concrete properties have been achieved by blending cements with cementitious admixtures such as fly ash (FA), and silica fume (SF). Incorporation of these materials in concrete mixes improves the durability concrete. The movement of aggressive substances such as chloride ions and carbon dioxide into concrete which are the main causes of deterioration of concrete structures that affect their integrity and long term serviceability life, is thus very much reduced. The deterioration of concrete is not a result of only aggressive agents, but the overall quality of concrete and also plays a major role. In view of this problem, a growing number of concrete structures are constructed or under construction with the use of cement replacement materials. Therefore any attempt to alleviate the deterioration-risk implies producing good performance concrete capable of withstanding the harsh environmental conditions.

In this chapter, the materials and methods described together with their properties. In this the tests carried out on different concrete mixes, curing regimes, mix proportions and casting of specimens are discussed.

3.1 MATERIALS

3.1.1 Ordinary Portland Cement (53 grade)

Ordinary Portland Cement (OPC) is one of several types of cement being manufactured throughout the world, are some of the more commonly used. OPC is the common purpose cement used in concrete constructions. OPC is a compound of lime (CaO), silica (SiO_2), alumina (AL_2O_3), iron (Fe_2O_3) and sulphur trioxide (SO_3), Magnesium (MgO) is present in small quantities as an impurity related with limestone. SO_3 is added at the grinding step to retard the setting time of the finished cement. When cement raw materials containing the proper proportions of the essential oxides are ground to a suitable fineness and then burnt to incipient Fusion in a kiln, chemical combination takes place, largely in the solid state resulting in a product aptly named clinker. This clinker, when ground to a proper fineness, together with a small amount of gypsum (SO3) is Portland cement. In fact, cement powder is “nothing else” other than a combination of oxides of calcium, silicon, aluminium and iron. The cement used throughout the test programme was Ordinary Portland Cement (OPC) of 53 grade confirming to IS 4031:1988 was used in the present study. The specific gravity of cement is taken as 3.15. The chemical and physical properties of cement are presented in following tables.

3.1.1.1 Chemical composition

Although Portland cement consists essentially composed of four major oxides: lime (CaO), silica (SiO2), alumina (Al2O3), and iron (Fe2O3) and also Portland cement contains small amount of magnesia (MgO), alkalies (Na2O and K2O), and sulfuric anhydrite (SO3).

Chemical composition Limits of Oxides in Portland cement are given below

Table: 3.1 Chemical composition of OPC

S.NO	Oxide Composition	Percent Content
1	Lime, CaO	63
2	Silica,SiO2	20
3	Alumina,Al2O3	6
4	Iron oxide,Fe2O3	3
5	Magnesia, MgO	1.5
6	Sulphur trioxide, SO3	2
7	Potassium oxide,K2O	1
8	Sodium oxide,Na2O	1
9	Tricalcium silicate,C3S	54.1
10	Dicalcium silicate,C2S	16.6
11	Tricalcium aluminate,C3A	10.8
12	Tetra calcium aluminoferrite,C4AF	9.1

Physical properties of the Ordinary Portland cement is shown in the following tables

Table 3.2: Fineness of Ordinary Portland cement

Trail NO,	1	2	3
Weight in cement (g)	100	100	100
Quantity of Cement Retained (%)	6	7	6

Table 3.3: Soundness of Ordinary Portland Cement

Test for Physical Requirement	Anjani O.P.C 53 Grade	IS 4031 (Part 3) :1987
Lechatlier Method(mm)	1	<10

Table 3.4: Normal Consistency of Ordinary Portland cement

Test Physical Requirement	Anjani O.P.C 53 Grade	IS 4031 (Part 4) :1988
Normal Consistency (%)	31	Not Specified

Table 3.5: Setting Time of Ordinary Portland Cement

Test Physical Requirement	Anjani O.P.C 53 Grade	IS 4031 (Part 5):1988
Initial setting time(minutes)	48	>30
Final setting time(minutes)	250	<600

3.1.2 Fine Aggregate

Locally available natural sand is used as fine aggregate in the present work. The most common ingredient of sand is silica, usually in the form of quartz, which is chemical inert and hard. The sand is free from clayey matter, silt and organic impurities etc. therefore used as a fine aggregate in concrete. The size of sand is that passing through 4.75 and retained on 150 micron IS sieve. The specific gravity of Sand is taken as 2.7. Sand is tested for specific gravity, in accordance with IS: 2386-1963.

3.2. METHODS

Details of experimental programme

- Materials used in this study and its properties.

- Mechanical properties of concrete containing various replacement of mineral admixtures.
- Durability properties of concrete containing various replacement of mineral admixtures.

Parameters tested in this study

- Normal consistency,
- Initial setting & Final setting time
- Soundness
- Workability
- Compressive strength
- Split tensile strength
- Water absorption
- Acid test.

IV. RESULTS AND DISCUSSIONS

4.1 GENERAL

Concrete is the most widely used manufactured material in the construction industry. It's the most important property is durability which relates the performance of the material to its service life under various environmental conditions. The ability of concrete to withstand and satisfactorily and for long periods the effects of load, time, and environment depends very much on how the engineering properties of the material are constituted initially and how they are allowed to develop with age.

The use of cementitious and pozzolanic siliceous industrial by-products as mineral admixtures-in concrete can bring improvements in engineering properties of concrete (strength, impermeability and general durability). Normal pozzolana additives due to their low surface area and reactivity are not generally able to improve the early strength which is crucial to the strength and stability of structural concrete applications and durability of concrete. The problem, though, could be solved by using a mixture of normal (such as fly ash and silica fume) and a highly reactive pozzolana, to produce a durable concrete which does not suffer from low early strength.

Also the durability of concrete during its service life may be significantly affected by the environmental conditions to which it is exposed, and in order to produce a concrete of high quality, the placing of an appropriate mix must be followed by a planned curing system in a suitable environment during the early stages of hardening.

This part presents and discusses the results of this investigation on the effect of curing conditions on the engineering properties such as of various concrete mixes made with cement replacement materials such as fly ash (FA) and silica fume (SF). The results obtained are used to analysis the effect of these cement replacement materials on the above engineering properties.

Based on the various tests that are conducted in laboratory is to analysis the strength and durability characteristics and their results correlate with the study and derive positive result and improvement. The results of the present investigation are presented both in tabular and graphical forms in order to facilitate the analysis, interpretation of the results is carried on each phase of the experimental work. This interpretation of the results obtained is based on the current knowledge available in the literature as well as on the results obtained. The significance of the results is assessed with reference to the standards specified by the relevant IS codes.

- The normal consistency of cement sample prepared with replacement of different mineral admixtures ranging from 5, 10, 15 and 20%.
- Both the initial and final setting time of cement sample prepared with replacement of different mineral admixtures ranging from 5, 10, 15 and 20% and are compared with ordinary cement. If the difference is less than 30 minutes, the change is considered to be

insignificant and if it is more than 30 minutes, the change is considered to be significant.

- The sieve analysis of fine and coarse aggregate which is used for the present experimental work.
- The soundness of the cement with the partial replacements of mineral admixtures are determined.
- The workability test of fresh concrete was measured by the partial replacements of mineral admixtures.
- The average compressive strength of concrete of at least three cubes (150*150*150 mm) prepared with mineral admixture under consideration is compared with that of three cubes prepared with ordinary cement (for 3 days, 7 days, 28 days, 60 days and 90 days).
- The average split tensile strength of concrete of at least three cylinders prepared with mineral admixture under consideration is compared with that of three cylinders prepared with ordinary cement (for 28,60 and 90 days).
- The water absorption test of concrete of at least three cubes prepared with mineral admixture under consideration is compared with that of three cubes prepared with ordinary cement.
- The acidic resistance test of concrete of at least three cubes prepared with mineral admixture under consideration is compared with that of three cubes prepared with ordinary cement (for 28 days).

4.2 RESULTS OF NORMAL CONSISTENCY TEST

4.2.1 Normal consistency of cement with replacement of fly ash

The variation of normal consistency of cement paste with addition of fly ash is shown in the table 4.1. The normal consistency test shows a very slight increase with the partial replacement of cement by fly ash at different dosages of 5, 10, 15, and 20 % in ordinary Portland cement which are 2% respectively.

Table 4.1: Variation of Normal consistency with replacement of fly ash

S.NO	Details of Material	Normal Consistency (%)
1	100% cement + 0% FA	32
2	95% cement +5% FA	34
3	90% cement +10% FA	34
4	85% cement +15% FA	34
5	80% cement +20% FA	34

4.2.2 Normal consistency of cement with replacement of silica fume

The variation of normal consistency of cement paste with addition of silica fume is shown in the table 4.2**.** The normal consistency test shows a very slight increase with the partial replacement of cement by silica fume at different dosages of 5, 10, 15, and 20 % in ordinary Portland cement which are 2% and 4% respectively.

Table 4.2: Variation of Normal consistency with replacement of silica fume

S.NO	Details of Material	Normal Consistency (%)
1	100% cement + 0% SF	32
2	95% cement +5% SF	34
3	90% cement +10% SF	34
4	85% cement +15% SF	36
5	80% cement +20% SF	36

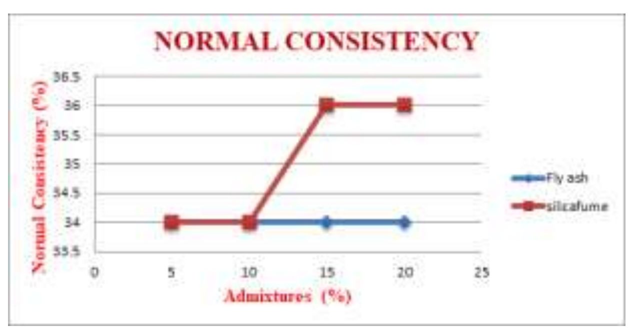

Figure 4.1: Effect on Normal Consistency for replacement of Cement with different

admixtures

From figure 4.1 it can be seen that the percentage of water required for producing a cement paste of Standard Consistency is increasing with the increase in the amount of admixtures, when used as a partial replacement of cement. The Standard Consistency of normal cement is 32%. The Consistency value increases up to 38% at a replacement percentage of 20 with respect to the Consistency value of normal cement paste.

4.3 RESULTS OF INITIAL AND FINAL SETTING TIME

4.3.1 Initial and final Setting time of cement with replacement of fly ash

The variations in the initial and final setting times of cement with addition of fly ash. From table 4.3 it is observed that both the initial and final setting times got retarded and accelerated by replacement of fly ash in the ordinary Portland cement.

Table 4.3: Initial and Final setting time values cement with replacement of fly ash

S.NO	Details of Material	Initial Setting Time (minutes)	Final Setting Time (minutes)
1	100% cement + 0% FA	45	300
2	95% cement +5% FA	50	300
3	90% cement +10% FA	60	290
4	85% cement +15% FA	70	280
5	80% cement +20% FA	70	260

4.3.2 Initial and final Setting time of cement with replacement of silica fume

The variations in the initial and final setting times of cement with addition of silica fume. From table 4.4 it is observed that both the initial and final setting times got retarded and accelerated by replacement of silica fume in the ordinary Portland cement.

Table 4.4: Initial and Final setting time values cement with replacement of silica fume

S.NO	Details of Material	Initial Setting Time (minutes)	Final Setting Time (minutes)
1	100% cement + 0% SF	45	300
2	95% cement +5% SF	45	340
3	90% cement +10% SF	45	340
4	85% cement +15% SF	50	330
5	80% cement +20% SF	50	310

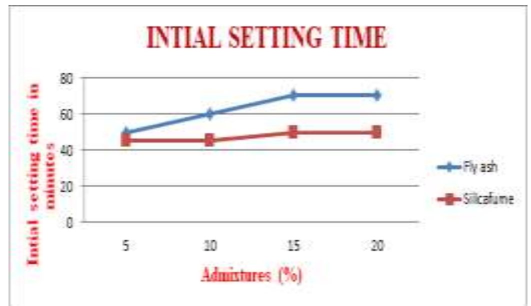

Figure 4.2: Effect on initial setting time for replacement of cement with different Admixtures

From above results it can be known that the initial setting time of normal cement paste is 45 minutes. From figure 4.2 the initial setting time was found to increase as the replacement percentage increases after the replacement of 5%. As per the Indian standards, the initial setting time should not be less than 30 minutes. Here all the replacement percentages satisfy this requirement.

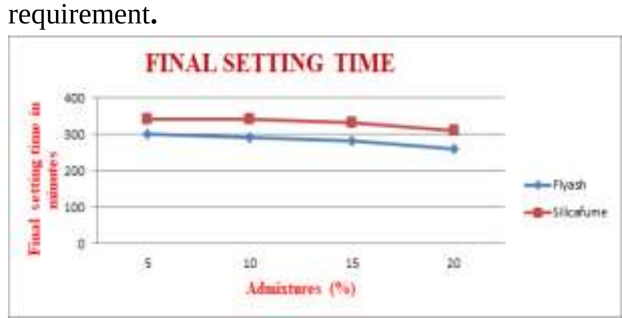

Figure 4.3: Effect on final setting time for replacement of cement with different admixtures

From above results it can be known that the final setting time of normal cement paste is 300 minutes. From figure 4.3 the final setting time was found to decrease as the replacement percentage increases after the replacement of

5%, As per the Indian standards, the final setting time should not be more than 600 minutes. Here all the replacement percentages satisfy this requirement.

4.5 WORKABILITY

Workability is related to the compatibility, mobility and stability of fresh concrete. Slump test is used to determine the workability of fresh concrete. Slump test as per IS: 1199 – 1959 is followed. In this test the vertical settlement, measured in mm and it is termed as slump. No test measures workability directly, but there are tests that measure properties related to workability

The following table gives the rough guide of workability of concrete in terms of slump for various types of work.

Table 4.8: Workability of concrete as per IS: 1199-1959

Type of work	Slump in mm
Concrete for road work	20-30
Ordinary R.C.C works for beams and slabs etc.	50-100
Columns, retaining walls and thin vertical section	75-150
Vibrated concrete	12-25
Mass concrete	25-50

V. CONCLUSIONS

In the interest of the reliability of the study and the testing of factors of acidic attack of cement based materials. Although the detailed conclusions derived from each chapter are given at the end of that chapter, the overall major conclusions regarding their mechanical and durability properties, with cement replacement materials can be extracted from the test results presented in this thesis and may be summarized as follows. However these conclusions are offered within the limitation of the tests conditions and procedures, as well as the limited duration of the study period.

Mineral admixtures are used as partial replacement of cement at different levels produced concrete with high strength and acceptable structural grade concrete. Curing conditions adopted in this research produced significant changes in the properties of concretes especially those containing different replacement levels.

Based on the test data and analysis of results presented in this thesis, the following conclusions can be drawn.

- With regard to normal consistency and setting time of OPC with mineral admixtures, increases when the addition of mineral admixture.
- Although the soundness of cement was found to be increase, after the replacement percentage of mineral admixtures increases.
- It was noticed that the slump values increases with the increase in the percentage replacement of fly ash, beyond that it also found that slump values decreases with the increase in the percentage replacement of silica fume.
- It can be seen that the replacement percentage of fly ash is between 5% to 20%, maximum strength is obtained at 20 %. It is found that compressive strength also increases with the increase in the percentage replacement of fly ash.
- It can be seen that the replacement percentage of silica fume is between 5% to 20%, maximum strength is obtained at 5 and 10 %. It is found that compressive strength also increases with the increase in the percentage replacement up to a 10 percentage and beyond that it is found to be decrease.
- For split tensile test the maximum strength of fly ash maximum strength is obtained at 20 %. And similarly for silica fume maximum strength is obtained at 5 and 10 %.
- From the results it was found that the

optimum replacement of silica fume and fly ash are 10%, 10% 20% and 20 % respectively.

- All mineral admixtures were very effective in improving the strength of concrete.
- It appears that the water absorption values increases with the increase in the percentage replacement of fly ash beyond that it also found that water absorption values decreases with the increase in the percentage replacement of silica fume.
- This indicates the acid test values increases with the increase in the percentage replacement of fly ash, beyond that it also found that acid test values decreases with the increase in the percentage replacement of and silica fume.

REFERENCES

1. Mehta, P.K.,"Concrete Technology at the Crossroads -Problems and Opportunities", Concrete Technology Past, Present and Future, SP-144, ACI, Detroit, 1994, pp 1-31.

2. Mehta, P.K., "Durability-Critical Issues for the Future", Concrete International, V. 19, No. 7, July, 1997, pp 27- 33.

3. Ayaz Malik, University of Alberta, Acid Attack on Concrete.

4. M. Collepardi “Sulphate Attack and Alkali-Silicaexpansion”, Enco, Engineering Concrete, Ponzano Veneto (TV) Italy, 2005.

5. Vladimir Zivica & Adolf Bajza,1. Acidic attack of cement-based materials—a review Part Factors of rate of acidic attack and protective measures, 2002.

6. Vladimir Zivica, Acidic attack of cement based materials – a review Part 3: research and test methods, 2004.

7. Kolapo O. Olusola and Opeyemi Joshua, Effect of Nitric Acid Concentration on the Compressive Strength of Laterized Concrete, Vol. 2, No. 10, 2012.

8. Emmanuel K. Attiogbe and Sami H. Rizkalla, Response of concrete to sulphuric acid attack, 1989, ACI Material journal, Title no. 85-M46.

9. N.I. Fattuhi and B.P Hughes, Effect of Acid Attack on Concrete with Different Admixtures or Protective Coatings, 1983.

10. Pomeroy CD. In: Dhir RK, Green JW,Benefits of concrete as a construction material. Protection of Concrete Proceedings of International Conference Dundee. London: Eand FN Spon, 1990. p. 1 –12.

11. Neville AM. Durability of Concrete, Pitman Publishing Lilited, London: 1973.

12. JE Kruger, J Botha, Sewer corrosion and its control. A literature survey of the status quo. Fibre-cement Association Pipeline Engineering Lectures, South Africa, octynov, 1987, 13 pp.

13. Jambor J. Increase of resistance of concrete by means of technological measurements. Protection of concrete structures in aggressive media, Bratislava. 1978. p. 39 –61. (in Slovak).

14. Y Ballin, MG Alexander, In: RK, Dhir, JW Green, Ed. Carbonic acid water attack of Portland cement, protection of Concrete, Proc Int Conf Dundee, E and F.N. Spon, 11–13 Sept. 1990, pp. 93–104.

15. RN Swamy, S Takinawa, In: RK Dhir, JW Green, Ed. Surface coatings to preserve concrete durability, Protection of Concrete. Proc Int Conf Dundee, 11–13 Sept. 1990, E and FN Spon, pp. 93–104.