Nile Higher Institute
For Engineering and Technology

Department Of Civil Engineering

"Effect of Polypropylene fiber on self- compacted concrete containing silica fume (10% by weight of cement)”

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ABSTRACT

The (brittle) behavior of concrete, although used in many fields, impedes its use in some applications that require (flexible) behavior, wherefore several types of fibers were utilized among them polypropylene fiber, that enhances pre-crack tensile strength, toughness, ductility performance, impact resistance, flexural strength resistance, and failure mode. This project investigates the properties and performance of self-compacted concrete made with different dosages of self-compacted agent (1.8% and 2.1%) and various contents of polypropylene fiber (0-0.3%, by mass of cement). Silica fume was used as a cement replacement material with a content of (10%) by mass of cement.

This project complies with Egyptian code ECP: 203 (2020), Egyptian standard specification ES requirements (4756-1/2005) (Appendix A). The results showed that the mechanical properties of concrete improved with the addition of polypropylene fiber. The fresh properties of concrete improved with increasing self-compacted agent dosage. Increasing polypropylene fiber content affects the fresh properties negatively.

1Chapter 1: Initial Report

1.1 Project Definition

The field of strength of materials, also called mechanics of materials, typically refers to various methods of calculating the stresses and strains in structural members, such as beams, columns, and shafts. Designers and contractors often come across problems, which call for special solutions involving concrete. A special concrete a concrete made with special ingredients or by a special process may be ideally suited to the need.

The research work is divided into the following activities to resolve the given issues:

- Literature review: The aim is to get knowledge about the current state of the art in the field of concrete technology in general.
- General information: The aim is to understand how special types of concrete are made and the contribution of such materials
- Experimental investigations: The aim is to perform experiments in laboratory-controlled environments to obtain a better understanding of the properties of SCC and failure mechanisms to develop more efficient concrete material.

1.2 The Problem

Explore the properties of Self Compacted Concrete (SCC) as a special type of concrete material

1.3 Study Objectives

In this research, the concentration was on:

- Define the SCC and its components and material properties
- find the results of fresh and hardened concrete tests
- conclude the best properties and components of SCC

1.4 Existing Solutions

Using the propylene fiber for aggregates, we compare the results of the tests with other research or previous work to reach a better judgment of such material. To understand the effect of using such materials in different fields, the following parameters have been investigated:

- The type and properties of SCC.
- The configuration of the tests and their results.
- The amount of components materials.

1.5 Design Constraints

The primary constraints faced during our research work are classified into these categories:

1.5.1 Economic

There is a need to search for financial support sources for students, or full or partial grants contribute to solving some of the problems of the students.

1.5.2 Environmental

No direct environmental constraints, but the process of cement manufacture is affecting the environment.

1.5.3 Sustainability

No sustainability constrains

1.5.4 Ethical

No ethical constraints

1.5.5 Health and Safety

No Health and Safety constraints

1.5.6 Social and Political

No Social and Political constraints

2 Ch2: Introduction

2.1 Aggregates

2.1.1 Introduction to aggregates:

The volume of aggregate used in concrete represents three-quarters of the volume of concrete mass, and therefore it is the body of concrete that resists loads and various weather factors. Therefore, the properties of the aggregate used greatly affect the properties and durability of concrete, as well.

Concrete consists of rocky granules held together by a cementitious substance. The name of aggregate is given to the rock granules that are generally gradual in size, such as sand and gravel. The aggregate in concrete represents 75% of the volume of the concrete block.

The aggregate helps the volume changes resulting from the formation and hardening of the cement.

2.1.2 Division of aggregates:

According to the source:

a- Aggregate from natural sources: It is the aggregate taken from quarries without any change to its natural properties during the production steps.
b- Aggregate manufactured according to certain processes: such as heat treatment to produce stretchy materials characterized by light weight, such as burn clay.
c- Colored aggregate for architectural concrete: It is used for architectural and decorative purposes, such as glass and marble granules.

2.1.3 General properties of the aggregate:

2.1.3.1 For size:

a) Small aggregate: It is the group of particles, most of which (95%) passes through the 4.76 mm standard sieve or sieve No. 5.
b) Large aggregate: it is the group of particles, most of which (95%) of the standard sieve 4.76 mm or sieve No. 5
c) Aggregate: a mixture of large and small aggregates.

The surface area of aggregate particles increases the smaller the aggregate particle size, Small-scale aggregate granules also require a larger amount of cement paste to coat them.

2.1.3.2 For the shape:

a) Round: Like the sand of the desert.
b) Angular: Like breaking stones.
c) Irregular: such as gravel.
d) Padded: Like a stratified rock cut
e) Sticky.

2.1.3.3 For surface condition:

a) Vitreous: Like black flint.
b) Soft: like free gravel.
c) Rough: like a pumice stone.

The granules with shiny surfaces do not give cohesion with the cement paste, such as the rubble with rough surfaces, and the higher the porosity in the aggregate, the lower the concrete strength.

2.1.4 Sinusoidal gradient:

It is to separate the different measured grains from the aggregate from each other and this is done by using the analysis by sieves by shaking the aggregate in a movement from the sieves arranged according to the size of its holes and placed on top of each other so that the largest of them are measured at the top and then weigh the reserved on each sieve and then calculate the percentage of the aggregate passing through Each sieve is then signed with a graphic mark between the size of the opening and the percentage of aggregate passing through it. This drawing expresses the extent of the volumetric distribution of the aggregate or the extent of the granular grading. The granular grading is divided into:-

- ✓ Graduated aggregate: it contains most of the sizes of the standard sieves.
- ✓ Well-graded aggregate: it contains the appropriate quantities of different sizes.
- ✓ Ungraded aggregate: It is the one in which there is no one or more of the different aggregate sizes and it appears clearly in the graph, as the gap is represented by a horizontal line.

Some of the different sizes of granules and standard sieves

Figure 2-1: Standard Sieve Test

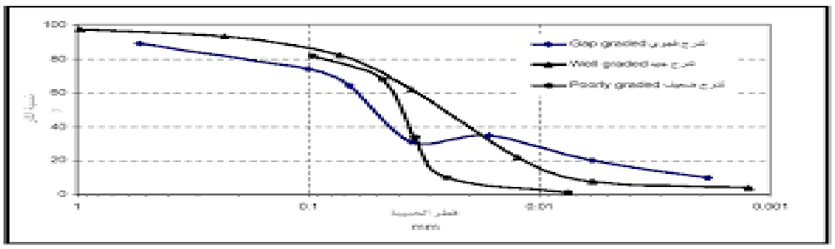

Figure 2-2:Gradient Curve

2.1.5 Softness meter:-

It is the factor that describes the size of the average aggregate and it is used = a lot of work in the study of concrete aggregates.

- ✓ Fineness meter = sum of percentages reserved on the nine standard sieves divided by 100.
- ✓ Fineness meter for sand = (2 to 3.75).
- ✓ Calibrator for the smoothness of the gravel = (5 to 8).

It is the measurement of the smallest sieve hole that allows at least 95% of the large aggregate to be poured. The aggregate size in concrete structures must be no more than 40 mm or 1:3 thickness of the roof slab or 1:5 of the pure distance between the reinforcing steel. In ordinary concrete works, the nominal size is The largest aggregate is 40 mm, while in paving works, it is 65 mm, block concrete 150 mm.

2.1.6 Volumetric increase of small aggregates:-

If we add water to the sand and then stir it, a thin layer of water envelops the sand grains and raises the grains away from each other as a result of the effect of the surface tension phenomenon, thus increasing the size of the sand. The required quantity, causing a change in the proportions of the concrete mix.

2.1.7 Granular gradient of aggregate

- The purpose of the experiment:

1- Determination of the size distribution of particles of large aggregate (gravel) and small aggregate (sand) by analysis using standard sieves.
2- Graphically showing the granular gradation of the aggregate and comparing it with the limits given in the standard specifications for concrete aggregate.
3- Determining the criteria of fineness and the largest legal size of the aggregate.
4- Finding the optimum granular gradient for the aggregate used in concrete mixtures to give a concrete mixture that is easy to operate and has high pressure resistance.

2.1.7.1 Used sieves:

- ✓ There is a set of standard sieves used, part for gravel and part for sand.
- ✓ In the case of small aggregates, the standard set of sieves used is:

  Size 0.075, 0.149, 0.291, 0595, 1.190, 2.38, 4.76 mm.
- ✓ In the case of large aggregates, the standard set of sieves used are:

  Size 4.76, 9.51, 19.05, 38.0 mm.
- ✓ In the case of mixed aggregates, the two sets of sieves are used together.

2.1.7.2 Definitions:

- ✓ 4.76 mm sieve: This means that the sieve opening is a square with dimensions of 4.76 * 4.76, which is the sieve separating the large and small aggregates.
- ✓ Fineness meter: It is the sum of the percentages reserved on the nine standard sieves divided by 100. Specifications specify the fineness criterion for the aggregate used to make concrete from (5-8).
- ✓ The largest nominal size: It is the smallest size of the sieve that allows the passage of at least 95% of the large aggregate or mixture.

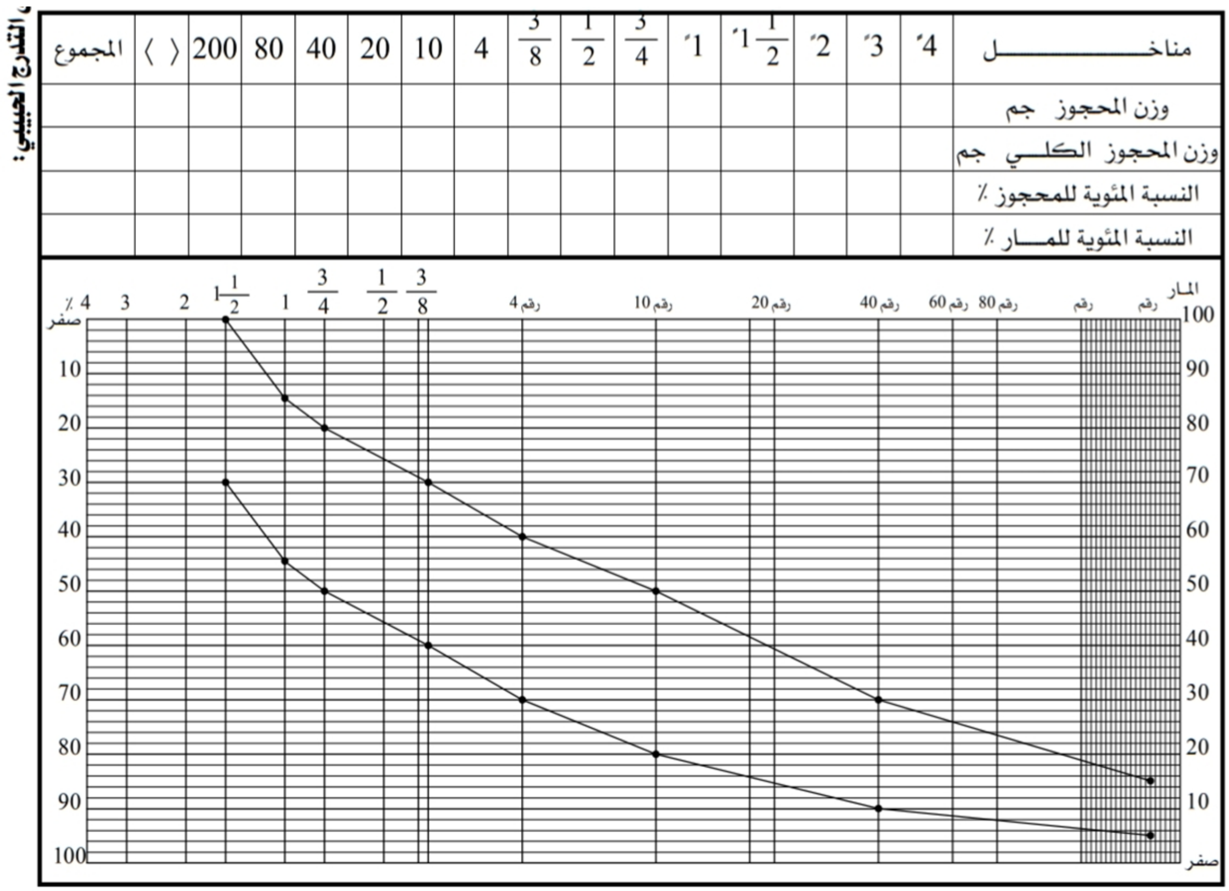

Figure 2-3: sieve analysis test

2.1.7.3 Steps of the experiment :-

1- The test sample to be tested shall be prepared taking into account the following:-

a) The sample taken for aggregate tests must be fully representative of the group taken from it, as it is taken with approximately equal quantities of aggregates from different locations, provided that this is from separate points on the sides of the source from the top, middle and bottom, provided that these quantities are fully representative of the majority of the grains.

b) It is not taken from points where large particles are concentrated, as it usually happens at the bottom of the rubble, provided that the number of points from which the aggregate quantities are taken is not less than ten points. Quantity needed to take the test.

c) The sample taken is reduced to the necessary quantity by:-

- Sample divider.
- By way of division:

The sample is divided in this way by making a conical pile, provided that the rubble is piled up by placing it at the top of the cone and then letting it flow in an orderly manner on its sides, taking care not to move the center of the cone and returning the rubble scattered around the base to the sides of the pile.

This process is done three times, then the third conical pile is flattened, then the flat circular pile is divided into four sections by placing two plates of wood or metal on its surface in the form of two perpendicular diameters and then pressing them. This process is done one more time, until the necessary quantity for the test is obtained.

1- It was dried in a drying oven at a temperature of 110 ° C for about 24 hours, then its weight was determined.

2- A group of sieves are arranged on top of each other according to the size of their opening, so that the largest is the highest.

3- Sieves are placed on the mechanical shaking device, then the aggregate sample is placed over the upper sieve, and the sieves are covered with a special cover.

4- The vibrator is operated for 20 minutes, then the device is stopped, and the aggregates are weighed on each sieve.

5- The total reserved weight on each sieve is calculated as follows.

- Total retained weight on the sieve = retained on the same sieve + retained on the larger sieves.

6- The percentage of reserved is calculated as follows:-

7- The percentage of passerine is calculated as follows:-
- Passing percentage = 100 - reserved percentage.

8- Draw the granular gradient curve and compare it with the specifications.

2.1.7.4 Features and measurements:-

The percentage of losses in the sample should not exceed 2% of the original sample weight.

Practical example:-

A sample weighing 3000 g was prepared, which is a mixture of small and large aggregates. Then it was sieved using the nine previously mentioned sieves.

Required:-

Divide the sample according to the size of the grains, draw the gradient curve, and find the criteria for fineness and the largest legal size.

The solution :-

The maximum size is 38 mm

- Conditions of the Egyptian Code for the selection of aggregates:-

1- The natural aggregate granules must be solid, durable, free from harmful substances, and not have a negative impact on the properties of concrete.
2- When using aggregates in structural elements exposed to wetness, it must be ensured that it is free of any siliceous materials.
3- The aggregate should be graded according to the Egyptian standard specifications with different sizes of particles and distributed uniformly in the comprehensive mixture.
4- Calibrated and distributed for small aggregates not less than 2.7 for pre-stressed concrete.
5- The largest nominal size of the aggregate shall not be more than 40 mm for reinforced concrete and not more than 25 mm for prestressed concrete.

2.2 Cement

2.2.1 Definition of cement:-

Cement is one of the most important non-metallic non- metallic materials in construction work (cement, lime, gypsum, etc.), and it is the material that has the property of cohesion and adhesion, which binds particles of rocks, aggregates and building materials to form an integrated building block. The chemical composition of different types of cement is complex and diverse. All of them were consistent in the presence of lime, silica, alumina and iron oxide in varying proportions, and all types of cement agreed in the property of the ability to form and harden under water.

2.2.2 Types of cement:

2.2.2.1 Portland cement

Portland cement is the product of burning calcareous and clay materials after mixing them well, then the combustion product (clinker) is ground, and it is not allowed to add other materials to the burning product except a percentage of gypsum and water

Portland cement also consists of a retirement crack (lime) and an acid crack (clay), which contains many types of mineral silica and contains iron and aluminum compounds, which are of great and technical importance in the production process

2.2.2.2 fast hardening Portland cement

- It is a type of Portland cement and is faster in the hardening of - the earth and machines than ordinary Portland cement.

Quick cement is characterized by its smoothness and high quality because it contains tri-calcium silicate ratio of 4500-5000 cm2, which makes it similar to ordinary Portland cement, but differs in the composition of the materials by a small percentage.

- It is also used in normal construction works, roads and cold weather, but not freezing. Because the hardener helps generate heat in order to protect the concrete from low temperatures that sometimes lead to the destruction of concrete.

2.2.2.3 3- Low-temperature Portland cement

1- One of the types of Portland cement, which is called tank cement. The cement may be manufactured with materials and quantities that have a lower temperature than ordinary cement. Tri-calcium silicate and tri-calcium aluminate are also lower than ordinary Portland cement.

2- The strength of manufactured concrete is the same as that of ordinary cement with a lifespan of 7 days. It may be used in large and large buildings such as bridges, dams, concrete blocks, retaining walls and tanks

2.2.2.4 Cement kiln products

It is one of the types of Portland cement that produces less heat and is more resistant to chemical reactions.

Cement is also made by mixing clinker grinding, ordinary Portland cement, with kiln slag materials, which, according to British standards, make up less than 65% of the final cement.

2.2.2.5 construction cement

- It is one of the types of Portland cement, and ordinary Portland cement is added to it with few additives and softeners to be used in docks and marine facilities that do not need to absorb mortar quickly through bricks.

2.2.2.6 White cement

- White cement is the most widely used and popular type of cement
- White cement is made from iron-free compounds, limestone and limestone. Which is in manganese and iron in small quantities so as not to affect the color of the white cement
- White cement is used in the steps of finishing an apartment on red bricks, interior decorations and exterior finishes. It is also used in small, large and various architectural projects.

2.2.2.7 Alumina cement

- - Alumina cement is a type of cement that differs in composition and properties from Portland cement. It is manufactured by mixing bauxite and slaked lime using clinker, which makes concrete and cement hard.
- - Aluminum cement is used in the manufacture of factory concrete for its durability. It also generates high heat through the cement hardening and making the concrete wet for 24 hours from the time the concrete hardens.

2.2.3 Properties of cement:

2.2.3.1 Softness

- The smoothness of the cement affects the rate of its reaction. The finer the grains, the larger the surface area and the faster the reaction processes. Therefore, the smoothness of the cement leads to the cement gaining early and high resistance and size stability. It also improves the workability of concrete and reduces the amount of water.

2.2.3.2 reaction heat

- Experiments have proven that there is a close relationship between the cement resistance rate and the temperature emission rate. The reaction temperature is of great importance for the concrete industry. The concrete mix that starts in an atmosphere of not less than 5 ° C can continue to solidify if adequate measures are taken to prevent the dispersion of hydration into the atmosphere even if it decreases. Atmospheric temperature, also when making block concrete, the temperature in the hollow of the concrete block is higher than on the outer surface in contact with the air, and this results in thermal stresses that lead to cracks in the concrete block

2.2.3.3 Contraction and expansion:

These two phenomena occur as a result of the internal forces associated with dryness and humidity. The cement paste shrinks if it dries up in the air, and its volume increases by a smaller percentage if it hardens in water. The value of shrinkage or expansion depends mainly on the ratio of water and cement in the mixture, in addition to other factors such as the relative humidity in the surrounding atmosphere and the amount of exposed surface. Shrinkage or expansion is accompanied by internal forces in both concrete and steel reinforcement, and cracks are generated that affect the resistance and construction properties.

2.2.3.4 setting and hardening of cement

- ❖ Cement setting means the loss of plasticity of the cement paste (initial setting) and then start to harden enough to bear a certain weight (final setting). about 10 hours
- ❖ Factors affecting setting time are chemical composition, gypsum percentage, temperature, fineness, aeration of cement before grinding, amount of mixing water.

2.2.3.5 Cement Compression Resistance

- The resistance of cement in pressure is the most important characteristic when used in facilities, and the pressure resistance of pure cement is greater than its resistance if mixed with sand, and the resistance increases with time for the continuation of cement reactions, also the resistance of cement in compression depends on the chemical composition, degree of burning, age

2.2.4 Cement grade:

1-The compressive strength of cement mortar and the rate of acquisition of early resistance are distinguished through six ranks, where the resistance increases at a certain age by increasing the rank (32.5, 42.5, 52.5) and symbolizes the pressure resistance of cement mortar in mega pascals at the age of 28 days and the early resistance increases by using early-resistance cement (R) Compared to ordinary cement (N)

2- The rate of gaining pressure resistance increases as the smoothness of the cement increases to increase the surface area of the cement granules, with the stability of other factors. The rate of gaining resistance also increases with an increase in tri-calcium silicate compared to cement that contains a higher percentage of calcium silicate compound. As for composite cements, their effect on resistance varies according to the type of cement. Clinker replacement material

2.2.5 Cement tests:

2.2.5.1 Softness test

- 100 gm of dry cement is sieved with a 0.09 mm standard sieve (170 sieve) for 15 minutes (manual sifting) or 5 minutes (static vibrating sieves), then the cement reserved on the sieve is weighed, and the fineness is calculated in terms of the percentage of the weight reserved on the mentioned standard sieve. The specifications stipulate that the proportion of the reserved weight shall not exceed 10% of the cement

2.2.5.2 Cement specific weight determination test

- A sample of cement is weighed and the density vial is filled with a liquid that does not react with the cement (kerosene or oil) up to a certain volume. Then the cement is placed inside the density vial (with light methods to expel air bubbles) and the volume is read on the capillary tube and the specific weight is calculated by dividing the weight of the cement by its volume

2.2.5.3 Water required cement paste of standard consistency

- A sample of cement weighing 400 g is prepared, to which an appropriate amount of water is added (estimated as a percentage of the weight of the cement) and the mixing process is carried out well to prepare the cement paste, noting that the mixing time is about 4 minutes, which is the period from the start of adding water to the cement until the start of filling the mold
- The vickat mold resting on a completely non-porous slab is filled at once with the previously prepared cement paste and the surface is leveled with the edge of the mold with the weapon of the standard mixing trowel
- The mold with the dough is placed under the rod holding the needle of the vickat device, which slowly droops until it touches the surface of the dough and is then left to fall freely into the dough.
- The amount of penetration of the tip of the cylindrical needle into the cement paste is determined by determining the distance between it and the bottom of the vickat mold through the exercises on the ruler of the device. Several experimental doughs are reworked in different quantities until the amount of water that gives the standard paste is reached.

2.2.5.4 Cement mortar pressure test

- Devices : 7 cm rib cube of durable metal with polished surfaces, and electric vibrator
- Test method: The quantities needed to make cement mortar are prepared in a ratio of 3:1 (185 gm cement + 555 gm standard sand + 74 cm3 water, or 10% of the mortar volume). Then water is added to it and mixed well for 4 minutes, and the mold is placed assembled on the vibrating machine after it is completely fixed and a funnel is placed over it to facilitate filling
- The mortar, after mixing it, is placed directly in the mold, then the mold is shaken to compress the mortar for two minutes at the specified speed. The funnel is not lifted until after the shaking period ends.
- The mold is lifted and placed in an atmosphere with a relative humidity of not less than 90% and a temperature of about 20 ° C for 24 hours.

2.3 Concrete mixing water

- What is the function of the mixing water used in concrete?
There are two functions of mixing water in concrete
(Primary role and a secondary role)

2.3.1 Primary role:

1. It helps in the process of hydration of cement, as it makes the cement react with the substance (water), where the result is hydration, the formation of hydrated potassium sulfate compounds and making the compounds adhere to each other, with the least amount of water needed to hydrate the cement to form compounds that hold Compounds of aggregates are connected to each other 90 g, the amount of water is 1/2 the amount of cement, so the excess water that is added to the necessary water makes the aggregate run into the cement mixture, and this facilitates the operation process of the concrete

2. It helps to wet the surface of the aggregate particles, where part of the aggregate is dry, so if this part enters Concrete leads to the absorption of part of the hydration water and leads to the incomplete hydration process, and this weakens the concrete's resistance.

2.3.2 Secondary role:

1. The aggregate granules are washed to get rid of the organic compounds and impurities

2. Concrete treatment is an important process where the benefit of the treatment is a part of the cement that interacts with the mixing water and the part of it is a coarse part that does not interact and when treated with water it interacts with water and this increases the pressure resistance of the concrete.

3. Avoid the occurrence of cracks shrinkage drought.
Where if conditions occur and it has not been sprayed for a period of weeks, shrinkage cracks will occur. Dryness is likely to occur. The roofed concrete slabs will be random cracks that are superficial, and we should avoid them with good treatment of concrete. (It must last for a week from pouring concrete)

2.3.3 Other types of mixing water:

1. Any potable water is used as mixing water. It is not required that the non-potable water is not suitable for mixing. Some types of non-potable water can be used in some types of concrete.

If the project is remote and there is no potable water, two experiments must be conducted before using it, where we prepare cubes of cement with potable water and cement with potable water. If the resistance of the non-potable cement reaches 90% more than the resistance of potable cement, it can be used.

In the mixing water, it is stipulated that the salt content in it should not exceed:

2.00 grams per liter of total dissolved salts (T.D.S).

0.50 grams per liter of chloride salts in the form of cl.

0.30 grams per liter of sulfate salts in the form of so3.

1.00 grams per liter of carbonate and bicarbonate salts.

0.10 grams per liter of sodium sulfide salts.

0.20 grams per liter of organic matter.

2.00 grams per liter of inorganic materials, which are clay and suspended matter.

2. in general - the pH - (pH) of the mixing water is not less than (7) and analyzes must be carried out to find out the actual number before using the water.
As for the second experiment, the setting time
(If the setting time is quick, it is considered a defect, and if the setting time is slow, it is considered a fault)
The Egyptian code specified that the initial setting time is not less than 45 minutes and the final setting time is not more than 10 hours). The initial setting time for drinking is 80 minutes, and for the non-drinkable one is 12 minutes, and the Egyptian Code defines Yazid for the initial setting for 30 minutes.

Sea water can be used in ordinary concrete, but after conducting experiments, it cannot be used in armed concrete.

2.3.4 Degrees of texture:

a) Dry texture b) soft texture c) wet

2.3.4.1 Texture Dry:

The proportion of water does not exceed 0.4 to 0.42 and the proportion of water: cement is 0.4.

2.3.4.2 Plastic texture:

The percentage of water ranges from 0.45 to 0.6

2.3.4.3 Wet texture:

The ratio of water to cement is more than 0.6

- We put water inside the concrete to provide operability, which reflects the ease of making concrete

In the airstrip, concrete is installed in large areas, so we do not need a high operability of concrete

Pour into a large chop squared of wood, pour and bleed easily

Important / in the concrete of roads as a result of pouring concrete in large areas (easy to compact the concrete) we resort to grades with a small amount of water

Concrete pours into large areas, such as the bridge mule. We do not need concrete of high resistance, and we do not need concrete of high fluidity.

To achieve high fluidity of concrete and maintain high resistance, we use additives that we put in the mixing water

There are harmful substances when pouring concrete:

It causes negative effects on concrete

1- Dirt or fine materials that enter the mixing water and cause

* Get rid of the aggregate granules, preventing the cohesion of the granules with each other

* Late setting

* Causes volume changes

* Decreased cement resistance

2- Organic materials

If you enter it happens

* Late setting

* Prevents particles from sticking to each other

* Causes volume changes

Simple calculation of the amount of water for concrete

If we need to calculate the amount of water for a concrete mix, first find the cement content by weight and m/h ratio.

If we assume that 80 kg of cement is required for the concrete mix and the ratio of m / h is 0.45

The required amount of water = weight of cement x ratio m/h

Therefore, the amount of water required = 80 kg x 0.45 = 36 liters

2.4 Chemical admixtures

Chemical admixtures are defined as substances or mixtures of several chemicals that are added to the concrete mix in limited quantities before or during concrete mixing to make the concrete acquire new features that suit the purposes for which it is designed, whether this mixing is through central mixing stations, ready-mix concrete factories or mixed on the site.

2.4.1 Despite the many types of additives, there are 3 main types, and they are...

- Reaction accelerating admixtures
- Reaction slow-down admixtures
- water reducing admixtures

2.4.2 Chemical admixtures conditions:-

Chemical admixtures can cause damage, so care must be taken when using it and used in necessary cases, with a commitment to fulfilling the instructions of the manufacturer companies for it and in the lowest quantities, and also the obligation to fulfill the following conditions…

1. To make concrete structurally safe
2. That there is no damage to the building or the concrete mix
3. The admixtures should be economic and do not affect the project funds
4. It should have no effect on the correct mixing ratio of concrete.

2.4.3 Advantages of using chemical additives:-

There are some uses and advantages of chemical additives, which help concrete to:

1. Accelerate or delay the setting time of concrete in hot weather
2. Production of lightweight concrete
3. Improving the workability of concrete
4. It increases the stability of concrete
5. Get a waterproof and waterproof concrete.

2.4.4 Types of admixtures:-

Admixtures are classified into 3 sections and are considered to be used in construction work…

2.4.4.1 Chemical admixtures:

Chemical additives include many types, one of these types is (set accelerating admixtures). These additives aim to shorten the setting time of concrete, as they make the concrete settle before the damages resulting from concrete freezing occur after settling directly in cold weather.
This helps in many features that help to speed up the project time and save a lot of money through...

- Remove the formwork columns early
- Overcoming the problem of concrete setting late in cold weather, saving some time
- Reducing concrete processing time, and that leads to saving in project money
- Early use of facilities, by reducing construction time.

*Set retarding admixtures: These admixtures slow down the setting time of concrete and are used in hot weather, where the concrete sets "quickly" in hot weather as a result of the evaporation of the mixing water It is also working to reduce the resistance rate of concrete over time, and this reduction can reach 50% as it deals with difficult working conditions such as: -

- The difficult conditions for pouring concrete, and consequently the need for the concrete to remain in a fresh state for as long as possible, such as wells and others….
- In the case of concrete pouring in hot weather, initial setting can occur quickly before the pour is completed
- Preventing the apparent setting of concrete as a result of the high temperature in the surrounding atmosphere, such as the concrete used in lining oil wells for example, where temperatures reach about 400 degrees (Fahrenheit) where the outer surface of the concrete freezes while the internal concrete body remains unsuspected.
- Obtaining concrete with prominent aggregates visible on its surface for architectural purposes, by placing a layer of these additives on the internal surfaces, and this causes a delay in the setting time for the concrete surfaces opposite to the grinding, as it is easy after dismantling the formwork to remove the cement mortar only from the surface using a wire brush the aggregate appears prominently on the surface.
- Admixtures that reduce mixing water: WRA (WATER REDUCING AGENT) This admixture works to strengthen the compressive strength and give operability and reduce the amount of cement with the stability of pressure resistance and operability, and also has a role in meeting the unwanted increase in the amount of water during mixing and pouring on site and uses in the pouring of foundations in case of high groundwater level or rainfall.
- Admixtures of an anti-bacterial substance: "ANTI PACTERIAL ADMIXTURES" This admixtures are used in ground concrete and wall concretes in which there are bacteria that

have been corroded by bacteria, and adding these materials to any type of cement, the resulting cement is called anti-bacterial cement. These admixtures are concentrated and strong to prevent the vital activity of microorganisms such as bacteria and mold (microbiological organisms). This cement is used in the work of concrete floors or walls for swimming pools or floors of dairy factories, food preservation factories, etc. In addition, cement preserves floors from the action of bacteria, it also preserves the floor from corrosion by some acids.

- Admixtures for concrete injection (FLEXIN): It is a substance that is injected into reinforced concrete in the event of cracks and defects in the parts of the building, especially those underground exposed to moisture so that this material is resistant to the impact of corrosion, is flexible, bears temperature, quick drying after use and is appropriate.
- Coloring concrete admixtures (COLORED CONCRETE ADMIXTURES): Some architectural works require concrete to have a colored surface and therefore it is necessary to add colored materials to the mixture from which a thin layer is poured on the surface of the concrete. These admixtures are metal oxides and other similar materials, and they are required to be chemically inert and not change their colors when exposed to sunlight. The colored substance is added to the mixture, which requires concrete to have a colored surface, especially for regular concrete, such as manganese dioxide and chromium hydroxide.

2.4.4.2 2 - AIR ENTRAINING AGENT:

is made by mixing a certain amount of this addition into the concrete mixture, which produces a large group of microscopic air bubbles uniformly distributed on the surface of the mixture. These bubbles affect the fresh concrete in terms of operability and maturity, and also affect the hardened concrete in terms of freezing and permeability and has the effect of increasing durability and endurance and contributes to reducing the weight of the structure and its work as it is used in roads, airports and light concrete (foam).

2.5 Types of concrete

There are many types of concrete used in the construction process, differing among themselves in their composition and use as well as their engineering properties. The following is a brief summary of the most important of those types used in the construction industries:

2.5.1 Plain Concrete

Ordinary concrete consists of rubble, cement and water without the presence of steel reinforcement, and therefore it is used in works that are not subject to tensile stresses to a degree greater than the concrete's bearing capacity for tensile strength, such as the work of cleaning mattresses under the foundations, the work of floors and concrete blocks such as marine fenders, and some of its properties can be improved according to the purpose for which it is designed.

2.5.2 Reinforced Concrete

It is ordinary concrete used with steel reinforcement as shown in Figure (2-7), so that the reinforcement can withstand the tensile stresses generated on the sector.

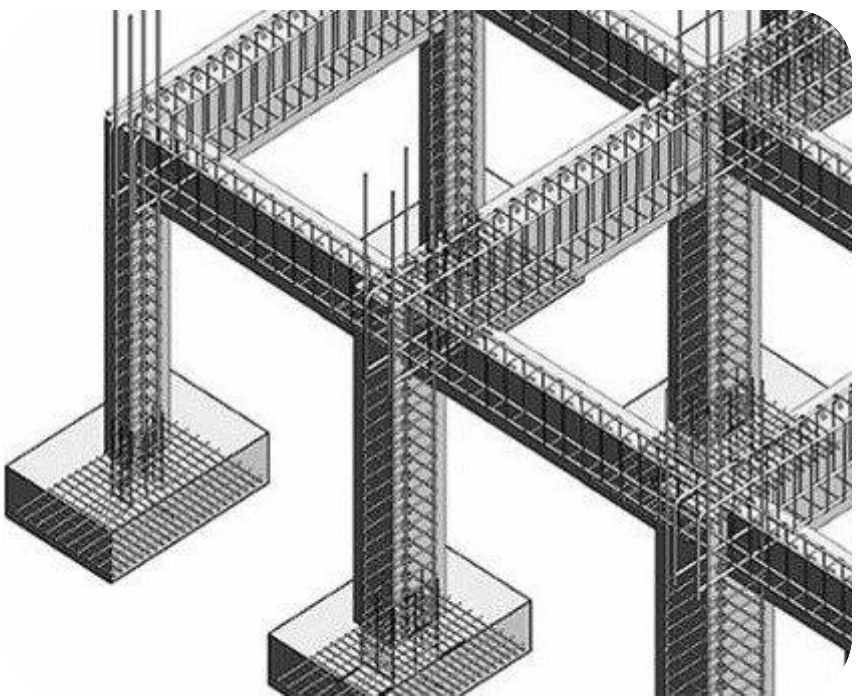

Figure 2-4:Reinforced concrete consists of ordinary concrete reinforced with reinforcement to resist tensile stresses.

2.5.3 Pre-stressed concrete

It is ordinary concrete that is loaded with pressure stresses after pouring and before being loaded with operational loads so that these stresses are enough to meet the tensile stresses that will result from the effect of operating loads and therefore do not need a main reinforcement steel to resist these stresses, because the final result of the stresses generated along the concrete sector are often pressure stresses Thus, the concrete is capable of bearing it as shown in Figure (2-8), and it is noted in this type of concrete that the concrete used must be of high pressure resistance in order to be able to withstand the pressure stresses affecting it before and after the application of operating loads on it, and due to the durability and resistance of this concrete With high loads, it is suitable for use in bridges and precast concrete elements.

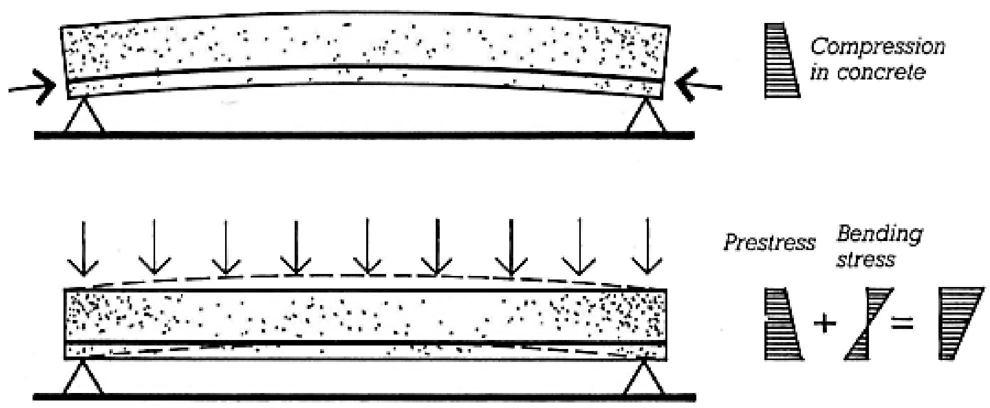

Figure 2-5 :Behavior of a concrete beam under the influence of pre-stressing where the whole sector is subjected to compressive stresses.

Steel bars used in pre-stressed concrete consist of Tendons, which are wires, strands of wire, or steel bars.

Pre-stressed concrete is divided into two types in terms of methods of stress gain:

First: Pre-tension method

In this method, concrete is given pre-stresses and is often used with precast concrete elements, where steel cables are tightened in the molds to be poured before the concrete pouring process, then concrete is poured into the molds around these cables and then left to harden while leaving the cables taut (within the limits of flexibility) as shown in Figure (2-9), and after the concrete has hardened, the tensile forces affecting the cables are removed as they try to shrink inside the hardened concrete, which leads to the generation of compressive stresses on the concrete through the cohesion forces between iron and concrete. This method is mainly used in factories Pre-stressed precast units due to the availability of advanced methods of steam treatment and the production of a large number of units in the shortest time.

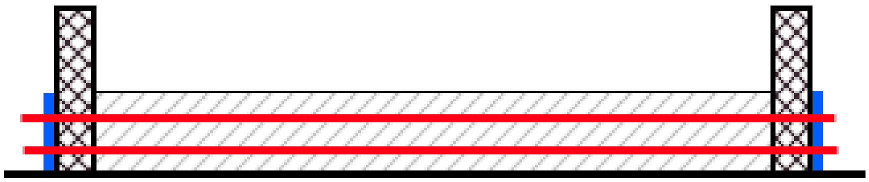

Figure 2-6:is an illustration of the pre-tensioning method for a concrete element

Second: Post-tension method

In this method, empty ducts are installed inside the concrete with free-moving steel cables placed inside these tracks without tension, then concrete is poured around these pipes and left to harden completely, then the cables are tightened after the concrete hardens as shown in Figure (2-10)), and despite the absence of any cohesion forces between concrete and steel, after removing the tensile forces affecting the steel, this causes pressure stresses on the steel plates installed at both ends of the concrete element, which in turn are transmitted to the concrete by loading, then the spaces between the steel cables tracks are injected. From the inside, grout mortar that hardens and reduces the chance of cables loosening or rusting.

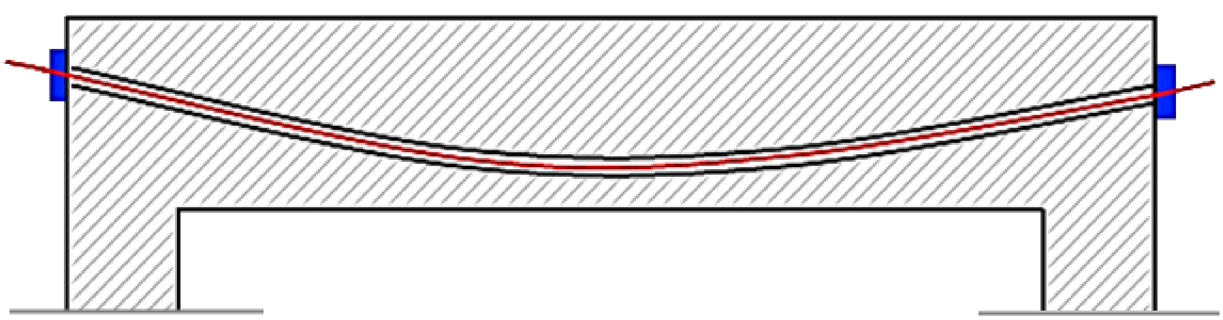

Figure 2-7:is an illustration of the post-tensioning method for a concrete beam

2.5.4 Precast Concrete

It is reinforced, ordinary or pre-stressed concrete that is poured and treated in factories prepared for that, then it is supplied to the place of installation where it is installed and then ready for use, through which it is possible to pour slabs, columns, walls, concrete blocks, fence units, stairs as shown in the figure (2-11), and one of the most important features of this concrete is the process of controlling the quality of concrete, where it is possible to control the following properties of concrete:

- Use of good graded aggregate.
- Use the optimal mixing ratio of water for the mixture.
- Conducting the process of mixing and compacting concrete in an engineering manner.
- Exact handling of items.
- Using the appropriate insulating materials and additives.

Figure 2-8:Installation of precast elements in a housing project

2.5.5 High strength concrete

It is concrete with a high pressure resistance of more than 60 N/mm2, and it is obtained from the available local materials that are used in the manufacture of regular concrete, but this type of concrete contains an additional substance, which is superplastieizers, which enables us to reduce the mixing water to less Possible ratio and thus achieving the highest possible resistance to pressure and at the same time obtaining a reasonable operability of the mixture that enables us to process the casting smoothly, and one of the most important considerations in the manufacture of high-resistance concrete is to choose materials that are homogeneous with each other to obtain good concrete that has high resistance and durability as well as acceptable operability.

High-strength concrete is mainly used in high structures, bridges and water structures, in order to take advantage of its high strength value to obtain the least space for sections and thus achieve the lowest size and weight of the structure.

2.5.5.1 Fiber reinforced Concrete

It is ordinary concrete with added fibers distributed randomly throughout the concrete mass as shown in Figure (2-12). These fibers are divided in terms of type into:
→ Steel fibers, which are pieces of steel with a diameter of 0.5 to 0.8 mm and a length ranging from 3 to 8 cm
→ Synthetic fibers such as polypropylene, polyester or acrylic and take the same measurements as steel.
The fibers improve the properties and resistance of concrete in both shear and tensile, as it reduces the width of the cracks and redistributes it, that is, it transforms the mechanism of failure in the concrete sector from shelling collapse to ductile collapse, where the value of the strength criteria of the material increases significantly, and fiber concrete is widely used in Military installations, machine bases, road projects, and precast units. It is worth noting that fibers are not a substitute for steel reinforcement because they do not increase the tensile strength of concrete in bending by a large percentage.

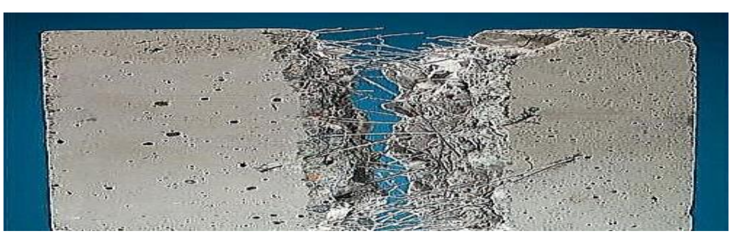

Figure 2-9:The collapse form of a sample of fibrous concrete that shows the fiber particles distributed within the concrete sector

2.5.5.2 Self-compacting Concrete

It is a concrete that has a high degree of fluidity and fluidity as shown in Figure (2-13), as well as a high resistance to granular separation, and it can be poured effectively in narrow and crowded places with reinforcement without the need to use means of compaction such as vibrators, and the two basic elements for the manufacture of this concrete are additives to improve viscosity, and additives Reducing the mixing water (super plasticizer) in order to achieve the high fluidity of this concrete.

Figure 2-10:High fluidity and flow are the most important characteristics of self-compacting concrete

2.5.5.2.1 The main advantages of self-compacting concrete

• Ease of casting in sectors crowded with rebar and narrow sectors and therefore do not need to use vibrators.
• The ability to pour large quantities of concrete in short periods.
• No granulomatous separation.
• You do not need to level the surface after pouring in most cases.
• Do not give an opportunity to increase the mixing water due to its high fluidity.
The main properties required to obtain self-compacting concrete are:
• First: a high degree of flow and liquidity, and this is achieved by the following:
• The use of super plasticizers.
• The use of gradient aggregates.
• Second: a high degree of resistance to granular separation.
• Reducing the nominal size of the largest aggregate.
• Reducing the perfusion to the lowest possible degree by reducing the mixing water.
• Third: It has a high capacity for casting and filling in narrow or crowded sectors with rebar under the influence of its weight.
• Use of viscosity-improving additives.
• Reducing the nominal size of the largest aggregate.

2.5.5.3 Lightweight Concrete

Due to the heavy weight of traditional concrete, we note the high self-weight of the elements of origin, and therefore with the effect of operating loads, the impact load on the foundations is relatively large, and therefore there was a need to develop a new type of concrete with a specific weight less than traditional concrete, where the weight of light concrete reaches 20 kg / m3 It has been possible to manufacture structural concrete with a weight ranging from 14 to 19 kg / m 3 compared to 22-25 kg / m 3 for conventional concrete, and therefore the total weight affecting the foundations as a result of the self-weight of the structure is less. Light concrete can be classified into the following:

• Concrete free of fine materials: it consists mainly of cement and large graded aggregates only, and sometimes air is added through additives. The density of this aggregate ranges from 2/3 to 3/4 the density of conventional concrete made of the same aggregates.

• Light aggregate concrete: It is the most common and can be used as construction concrete. The aggregate used in it is industrial, such as: expanded clay, vermiculite, and foam (polystyrene).

2.5.5.4 Heavyweight Concrete

It is a special concrete for the protection from nuclear and atomic radiation, as it works to reduce the effect of these radiations and their absorption, as a result of its weight and density. 40 kg/m3. Iron pieces may be used as aggregate, with a density of 56 kg/m3, provided that the aggregate used meets the requirements of installation and radiation protection.

Since the aggregate consisting of iron pieces tends to separate when mixed and poured by traditional methods, in this case, heavy pre-compacted concrete is used, where the concrete mortar is pushed through the voids of the aggregate after compacting, compacting and saturating it with water so that the mortar displaces the existing water and fills the voids.

2.5.5.5 Shotcrete

It is concrete or mortar that is ejected with air pressure from the nozzle of the ejector cannon at a high speed to the surface to be covered as shown in Figure (2-14), and it is mostly used in restoration work and lining tunnels and canals, which are cases in which it is difficult to use traditional methods of concrete pouring.

In general, there are two ways to implement and pour ejected concrete, which are either by mixing on the dry, where the components of the concrete are mixed on the dry first, then water is added at the nozzle of the ejector cannon and pushed under air pressure to the surface to be poured, or the wet method is used where the ingredients are mixed with the use of water and then It is pumped to the surface, and in both methods, the surface to be concreted must be well prepared in order to achieve cohesion between the concrete and the surface.

Figure 2-11:The process of pouring shotcrete for a concrete wall

To compensate for the loss in the cement content during the concrete extrusion process and its falling off as a result of reflux, the cement content in the concrete mixture is increased with the addition of setting accelerators in order to speed up the setting process of the extruded concrete the roof.

The disadvantage of this concrete is that it is exposed to shrinkage to a large extent, due to the increase in the proportion of water and cement content in it compared to the proportion of aggregates. To treat this, fibers are used with this concrete by mixing it with it in order to reduce shrinkage.

2.5.5.6 Mass Concrete

Figure 2-12 : Pouring large quantities of concrete in a bridge project

It is concrete with large volumes and blocks and it is present when pouring dams and foundations that require large volumes of concrete or any other element for which the volume of concrete required is so large that it requires taking the necessary precautions as a result of heat generation resulting from cement hydration and the consequent shrinkage and cracking of concrete. These precautions are represented in the items the following:

• Use of low heat emission cement, provided that the mixture is poor in cement.

• Using crushed ice in the mixture to cool the concrete.

• The presence of a network of pipes that pass inside the concrete block and through which cycles of cold water pass to cool the concrete block around it.

• Casting on low-height layers to control temperatures.

• Surface insulation of concrete in order to reduce the difference between the temperature drop between the surface of the concrete and its interior.

3 Ch3: Literature Review

3.1 Self-compacted concrete

3.1.1 Introduction

Self-compacting concrete is a modern and emergency technology in the construction industry of the viscosity-improving additives and mixing water-reducing additives (superplasticizers) are the two components. The basics needed to produce this concrete. It is a type of concrete that is used on it has a wide range, which has high advantages that distinguish it from ordinary concrete. And self-compacting concrete High performance concrete properties in terms of mechanical properties and durability.

Self-compacting concrete has eliminated the biggest defects and problems of ordinary concrete, which is poor execution resulting from transportation, labor, poor compaction, and granular separation resulting from concrete transportation and handling, and excessive mixing and falling from high heights when pouring. Self-compacting concrete has been developed In Japan in the eighties to reach the maximum degree of durability and access to concrete structures. High performance and with technological progress, this concrete has been produced in many countries such as Turkey and America. In Egypt, some research was recently conducted at Mansoura University to produce concrete. Self-compacting using local materials and special requirements for operability were studied as well Special and necessary tests for this concrete. In general, the test results showed the possibility of manufacturing self-compacting concrete using local materials available in Egypt with a high degree of success.

The topic:

Self-compacting concrete: It is a type of concrete that is widely used and has high advantages about ordinary concrete.

It is a concrete characterized by a high degree of fluidity and flow ability, and the absence of granular separation. Which makes it have a superior ability to reach the narrowest and deepest places easily and packaging without The need to use vibrators or external pressure means to compact the concrete, so it is called Self-compacting concrete, superplasticizers are the main component of concrete production.

And self-compacting concrete has high performance concrete properties both in terms of properties mechanical or durability. Self-compacting concrete was developed in Japan in the

1980s to reach Maximum durability and access to high-performance concrete structures and with technological advances in Building materials are becoming more widespread in the world.

Self-compacting concrete in its new and hardened state is economically efficient, that is, it Shorten construction time as well as reduce labor and equipment required and improve working and living environment, That is, it may consume a large amount of industrial by-products and reduce construction noise and health risks and enhances the completion of the construction process. In general, self-concrete is used Compaction for the construction of reinforced concrete elements with closely arranged reinforcement sections and masonry elements With limited compressive capabilities, small building elements and exposed concrete parts that Requires high quality surface and concrete surface concrete building elements and concrete parts Armed in environmental noise and sensitive locations. Compared with ordinary concrete, concrete self-compacting on large quantities of superplasticizers and viscosity-modifying mixtures. Associated Plugins content of; Fly ash, granular blast furnace slag and silica fumes rice husk ash, etc. In a mixture of cement or concrete provides many benefits for fresh and hardened concrete such as improving workability and final strength values. It also reduces construction cost. Self-compacting concrete with high-volume granular blast furnace slag is specified by replacing a large amount of granulated blast furnace slag, this ratio is generally more than 40 - 50% cement in self-compacting concrete mixes.

3.1.2 Characteristics to be achieved in self-compacting concrete:

3.1.2.1 High degree of fluidity and fluidity :

This is achieved by:

Increasing the fluidity of the dough using superplasticizers or using a high percentage of mixing water And reduce the internal friction between the granules by reducing the proportion of large aggregates in the mixture or using a ratio of gradient soft powder.

3.1.2.2 high resistance to granular separation :

This is achieved by:

Reducing the separation between solids in the mixture by reducing the largest nominal size of the aggregate Or reduce the proportion of aggregates or use additives to improve viscosity or reduce the proportion of mixing water Reducing perfusion (free water) to the lowest possible degree.

3.1.2.3 Reducing perfusion (free water) to the lowest possible degree :

This is achieved by:

By using less mixing water or by using a powder with a high surface area or Increasing the percentage of viscosity-improving additives Which has a high capacity for casting and filling in narrow or crowded sectors with rebar And that under the influence of its weight and without the occurrence of blockage or stopping of the concrete.

1- To have a high resistance to intergranular separation during pouring and pouring of concrete :

This is achieved by:

Using additives to improve viscosity or reduce the proportion of mixing water.

The compatibility between the size of the sectors and the distance between the skewers on the one hand and the size of the large aggregate and its percentage in on the other hand, the mixture Reducing or reducing the larger nominal size of the aggregate the proportion of aggregates in the mixture.

The three main characteristics of self-compacting concrete are:

1- filling capacity:

This property of concrete is the ability to flow under its own weight without any vibration provided by intent.

2- Ability to pass:

This property is the ability of concrete to maintain its uniformity.

3- Insulation resistance:

It is the resistance of concrete to not undergo segregation when it flows during the self-compression process.

3.1.2.4 Design principles of concrete mix:

To achieve the desired combination of properties in fresh self-compacting concrete mixes: The fluidity and viscosity of the paste are adjusted and balanced by careful selection and proportioning to the cement and additives, by reducing the water/powder ratio and then adding a superplasticizer and (Optional) Viscosity-modifying mixture Correct control of these components in self-compacting concrete Its compatibility and reactivity is the key to achieving good filling capacity, passing ability and resistance to separation. In order to control temperature rise and heat shrinkage cracking as well as strength, The fine powder content may contain a large proportion of type l a and all additives to maintain The cement content is at an acceptable level. Paste or putty is the medium for transporting aggregates; so the size of the dough should be larger than the size of the vacuum in the aggregate so that all individual aggregate particles are completely covered and lubricated with a layer of the dough. This increases the fluidity and reduces the friction of the aggregate. The ratio of coarse to fine aggregate in the mixture is reduced so that the individual coarse aggregate particles completely surrounded by a layer of dough. This reduces aggregate entanglement and suspension as the concrete passes through narrow openings or gaps between reinforcement and increases the passing capacity of self-compacting concrete.

3.1.2.5 The main advantages of self-compacting concrete are:

1- Rapid placement without mechanical incorporation.
2- Improving buildability.
3- Reduce the permeability of concrete structures.
4- Reduce voids in heavily reinforced areas.
5- Eliminates the problems associated with concrete vibration, so there is no risk of damage to the molds due to Vibration as common in traditional formwork.
6- It creates high quality structures while improving structural integrity.
7- High durability, strength and reliability.
8- Reduce the costs of concrete vibrating and compacting workers on site
9- It allows for innovative architectural features, as it can be used in complex shapes. Create Smoother and more aesthetic surface finishes
10- Allows for easier pumping, and there are many flow techniques available.
11- Are characterized by high strength and high durability.
12- It has low shrinkage and creep
13- cost effective
14- Do not give an opportunity to interfere in the site to add water to the mixture due to its fluidity.
15- The ability to pour a large amount of concrete in a short period of time.

3.1.2.6 Requirements for the materials needed to make self-compacting concrete:

The materials used in the production of self-compacting concrete must meet all the requirements of the code the materials must be suitable for the purpose of their use in concrete, and they must not contain harmful substances that may affect the quality and durability of concrete.

3.1.2.6.1 cement:

The cement used must be in conformity with the Egyptian specifications, according to its smoothness The cement used, the initial and final setting time, and the cement's compressive capacity ranges between Its ratio ranges from (400 - 500) kg / m 3 .

3.1.2.6.2 aggregate:

Both small and large aggregates used in self-compacting concrete must meet the requirements Included in the test guide attached to the Egyptian code.

- Big mound:

The nominal size of the large aggregate should be as small as possible, not exceeding 20 mm it is made of limestone or dolomite.

- Small aggregate:

Sand that is suitable for use in ordinary concrete is suitable for use in self-contained concrete Compaction, taking into account that the fine part of sand with a nominal size of less than 0.125 mm is considered of fillers or powders, and the moisture content of aggregates must be accurately measured to obtain concrete self-compacting with stable quality.

3.1.2.6.3 Mixing water:

Potable water and water free of salt and organic materials are considered usable in self-compacting concrete, according to the technical requirements of the Egyptian Code.

3.1.2.6.4 chemical additives:

Chemical additives are widely used in self-compacting concrete such as superplasticizers. Super plasticizer (which is one of the basic elements necessary to reach the required operational In addition to other additives such as shrink reducers, viscosity-improving additives and additives slowed down by setting.

3.1.2.6.5 Mineral additives and fillers:

Mineral additives with pozzolanic properties are used as fly ash or blast furnace slag and silica dust for the purpose of improving operational and resistance to particulate separation, and a percentage of Cement content in the mixture with fillers such as limestone powder and dolomite and granite to achieve the required streamlining and reduce costs.

3.1.2.6.6 fiber:

Fibers may be used in self-compacting concrete to improve mechanical properties such as bending strength And toughness, such as steel fibers, reduce plastic shrinkage and granular separation and increase Resistance against fire, such as polymeric fibers, but it must be ensured that the mixing process is easy Transportation, traffic and casting when using fibers in concrete.

3.1.2.7 Properties of the materials used in the mixture:

3.1.2.7.1 cement:

Ordinary Portland cement was used, with the following properties:

1- Smoothness = (5 %)

1- Standard strength = (26%)
2- Initial setting time = (85 minutes)
3- Final setting time = (4 hours)
4- Consistency of size (Le Chatelier) = (2 mm)
5- bending resistance = 39 kg/cm2

3.1.2.7.2 2- aggregate:

Aggregate has the following properties:
Volumetric weight:
1- Per pound = 1750 kg / m3
2- Dolomites = 1645 kg/m3
3- Per sand = 1671 kg/m3
Specific weight
1- For the sand = 2.522
2- Dolomites = 2.563
Per sand = 2.49
- Empty Ratio:
1- For sand = 30.62%
2- For dolomite = 42.5%
Clay and fine materials: 9.1%

5- Absorption:
1-for the mixture = 0.566%
2-for dolomite = 1.541%
3- Crushing coefficient of gravel: 12.85%
4- Berry Factories: 28.34%

3.1.2.7.3 Water:

The water used in the concrete mix shall be clean and free from harmful substances such as oil Acids, organic materials and any materials that may adversely affect concrete or steel reinforcement.

The pH of the mixing water shall not be less than 7.

Potable water is suitable for use in mixing self-compacting concrete

It is not allowed to use sea water in mixing self-compacting concrete

7- Extras:

Additives must meet all Egyptian standards. 0 Additives must not have an effect

Harmful to concrete or steel reinforcement, especially its durability over time.

2 - Steel Fiber Reinforced Concrete (SFRC)

Fiber Reinforced Concrete can be defined as a composite material consisting of mixtures of cement, mortar or concrete and discontinuous, discrete, uniformly dispersed suitable fibers. Fiber reinforced concrete are of different types and properties with many advantages. Continuous meshes, woven fabrics, and long wires or rods are not considered to be discrete fibers. Fiber is a small piece of reinforcing material possessing certain characteristics properties. They can be circular or flat. The fiber is often described by a convenient parameter called "aspect ratio". The aspect ratio of the fiber is the ratio of its length to its diameter. The typical aspect ratio ranges from 30 to 150. Fiber-reinforced concrete (FRC) is concrete containing fibrous material which increases its structural integrity. It contains short discrete fibers that are uniformly distributed and randomly oriented. Fibers include steel fibers, glass fibers, synthetic fibers, and natural fibers. Within these different fibers, the character of fiber reinforced concrete changes with varying concretes, fiber materials, geometries, distribution, orientation, and densities. Fiber-reinforcement is mainly used in shotcrete, but can also be used in normal concrete. Fiber-reinforced normal concrete is mostly used for on-ground floors and pavements, but can be considered for a wide range of construction parts (beams, pliers, foundations, etc.) either alone or with hand-timed rebar’s Concrete reinforced with fibers (which are usually steel, glass or "plastic" fibers) is less expensive than hand-timed rebar, while still increasing the tensile strength many times. The shape, dimension, and length of fiber is important. A thin and short fiber, for example, short hair-shaped glass fiber, will only be effective the first hours after pouring the concrete (reduces cracking while the concrete is stiffening) but will not increase the concrete tensile strength and having fibers as the additional ingredients, dispersed uniformly at random in small percentages, i.e. between 0.3% and 2.5% by volume in plain concrete. SFRC products are manufactured by adding steel fibers to the ingredients of concrete in the mixer and by transferring the green concrete into molds. The product is then compacted and cured by the conventional methods. Segregation or balling is one of the problems encountered during mixing and compacting SFRC. This should be avoided for uniform distribution of fibers. The energy required for mixing, conveying, placing and finishing of SFRC is slightly higher. Use of pan mixer and fiber dispenser to assist in better mixing and to reduce the formation of fiber balls is essential. Additional fines and limiting maximum size of aggregates to 20mm occasionally, cement contents of 350 kg to 550 kg per cubic meter are normally needed.

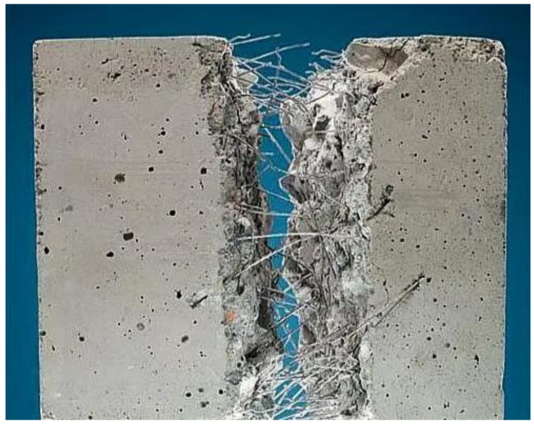

Figure 3-1:steel fiber

Steel fibers are added to concrete to improve the structural properties, particularly tensile and flexural strength. The extent of improvement in the mechanical properties achieved with SFRC over those of plain concrete depends on several factors, such as shape, size, volume, percentage and distribution of fibers. Plain, straight and round fibers were found to develop very weak bond and hence low flexural strength. For a given shape of fibers, flexural strength of SFRC was found to increase with aspect ratio (ratio of length to equivalent diameter). Even though higher ratios of fibers gave increased flexural strength, workability of green SFRC was found to be adversely affected with increasing aspect ratios. Hence aspect ratio is generally limited to an optimum value to achieve good workability and strength. Grey suggested that aspect ratio of less than 60 are best from the point of handling and mixing of fibers, but an aspect ratio of about 100 is desirable from strength point of view. Schwarz however suggested aspect ratio between 50 and 70 is more practicable value for ready mix concrete. In most of the field applications tried out to date, the size of the fibers varies between 0.25 mm and 1.00mm in diameter and from 12mm to 60mm in length, and the fiber content ranged from 0.3 to 2.5 percent by volume. Higher contests of fiber up to 10% have also been experimented. Addition of steel fibers up to 5% by volume increased the flexural strength to about 2.5 times that of plain concrete. As explained above, mixing steel fibers considerably improves the structural properties of concrete, particularly tensile and flexural strength. Ductility and post cracking strength, resistance to fatigue, spalling and wear and tear of SFRC are higher than in the case of conventional reinforced concrete. SFRC is therefore found to be a versatile material for the manufacture of wide varieties of precast products such as manhole covers, slab elements for bridge decks, highways, runways, and tunnel linings, machine foundation blocks, door and window frames, piles, coal storage bunkers, grain storage bins, stair cases and break waters. Technology for this manufacture of SFRC light, medium and heavy duty manholes covers has been developed in India by Structural Engineering Research Centre, Chennai. Field experiments with two percent of fiber content indicated that SFRC runway slabs could be about one half the thickness of plain concrete slabs for the same wheel load coverage. Cement Research Institute of India (CRI) also demonstrated the use of SFRC in one of the jet bays at Delhi airport. Other field experiments in which SFRC has been used are the slabs of parking garage at Heathrow airport in London, spillway deflectors in Sweden, mine cribbing in Utah, USA.

There are various applications of fiber reinforced concrete and one of them is in the construction of concrete pavements. Fiber reinforced concrete (FRC) is defined as a composite material consisting of concrete reinforced with discrete randomly but uniformly dispersed short length fibers. The fibers can be made of steel, polymer or natural materials. Woven fabrics, long wires, bars, and continuous wire mesh are not considered discrete fibers. FRC is considered as a material of improved properties and not as reinforced cement concrete whereas reinforcement is provided for local strengthening of concrete in tension region. Since in FRC, fibers are distributed uniformly in concrete, it has better properties to resist internal stresses due to shrinkage. As fibers improve specific material properties of the concrete, impact resistance, flexural strength, toughness, fatigue resistance, ductility also improved. Fibers generally used in cement concrete pavements are steel fibers and organic polymer fibers such as polypropylene and polyester.

Steel fibers have been used for a long time in construction of roads and also in floorings, particularly where heavy wear and tear is expected. Specifications and nomenclature are important for a material to be used as the tenders are invited based on specifications and nomenclature of the items. Such nomenclature is not available in Delhi Schedule of Rates. In a work where steel fiber reinforced concrete was used for overlays just like flooring, the following nomenclature can be adopted for concreting of small thickness. Providing and laying 40 mm steel fiber reinforced cement concrete in pavement (in panels having area not more than 1.5 sum) consisting of steel fiber @ 40kg per cubic meter of concrete and cement concrete mix of 1:1.95:1.95 (1 cement: 1.95 coarse sand of fineness modulus 2.42: 1.95 stone aggregate 10 mm and down gauge of fineness modulus 5.99) over existing surface i/c cement slurry, consolidating, tapping, and finishing but excluding the cost of steel fibers which shall be paid separately, complete as per direction of Engineer in Charge (Cement to be used shall be OPC 43 grade and sand and aggregate have to be washed). Second item of fibers was provided separately as “Providing and mixing steel fibers of dia 0.45 mm in cement concrete duly cut into pieces not more than 25 mm in length.”

Figure 3-2: Pavement with steel fiber reinforced concrete

Though the item of steel fiber reinforced concrete has been provided with a design mix of concrete, which is almost of 1:2:2 grading, it can now be used of mix like M30 or M35. Since in the executed item, the thickness was to be restricted, the stone aggregates used were of 10 mm size and below however, in case of the concrete of more than 75 mm thickness, stone aggregates of 20 mm grading can be used. The construction was carried out more than a decade back. It is observed that the performance of the concrete is satisfactory even after many years of construction (Figure 1). Even, no corrosion has been observed in the steel fibers. In fact the concreting has been done just like flooring item in this case over already existing hard surface. In such a case a bonding coat should also be provided like a coat of cement slurry. The fiber reinforced concrete has been provided in small panels considering the workability. Though vacuum dewatered concrete has not been done with steel fiber reinforced concrete but the same is also possible. Vacuum dewatered concrete, though cannot be done in small thickness like 40 or 50 mm but can be used if thickness is 100 mm or more.

Polymer Fiber Reinforced Concrete

Polymeric fibers are being used now because of their no risk of corrosion and also being cost effective (Sirdar et al, 2005). Polymeric fibers normally used are either of polyester or polypropylene. Polymer fiber reinforced concrete (PFRC) was used on two sites with ready mix concrete and vacuum dewatering process. The nomenclature can be used in the works as given here. "Providing and laying ready mix fiber reinforced cement concrete of M35 grade (The concrete shall also have minimum works test beam flexural strength of 40 kg per sqm at 28 days) in required slope and camber in panels i/c shaping at drainage points as required using cementitious materials not less than 435 kg per cum of finished concrete from ACC/L&T/AHLCON/ UNITECH or equivalent batching plant for all leads and lifts with

Fibercom-CF/Fiber mesh/Recon or equivalent (100 % virgin synthetic fiber size 12 mm long) to be mixed @ 900 grams per cum of concrete i/c finishing with screed vibration, vacuum dewatering process, floating, troweling, booming and normal curing etc. complete as per standard manufacturer's specifications and as per direction of Engineer in charge (All related equipment shall be arranged by the contractor. Cost of centering, shuttering, grooving etc. shall be paid separately. Design Mix shall be got approved from the Engineer in Charge). In both the sites, vacuum dewatered concrete was used. Both the sites are to be used for parking. In a site, fiber reinforced concrete was used over a base cement concrete of lean mix of 1:4:8 (Figure 2) while in other site it was laid over water bound macadam (WBM) (Figure 3). When dewatered concrete it has no problem of water being coming out on surface during compaction process but when it is done over WBM, a lot of concrete water is soaked by WBM and thus the concrete loses the water to WBM and the water which comes out during dewatering/compaction process is not in same quantity as in case of lean concrete. It appears that it is better to provide base concrete than WBM as the base. The groove was made in one case before setting of concrete and also panels were cast with expansion joints in one direction. No cracks were observed in the direction in which expansion joints were provided assuming this is longitudinal direction. In lateral direction, no joints were provided and the width of such panel was about 12 m. It was later observed that cracks have developed in this direction

As it is known that the width of 12 m is too long for expansion/ contraction. It has been observed that almost at about one–third of the panel width, such cracks developed i.e. size of panel from one side is about 4 m and from other side it is about 8m. From the site observation, it is therefore inferred that the panel should have the size of about 4m x 4m in the temperature conditions of Delhi however small variation can also be made as per site conditions. In other case, the contractor delayed the cutting of grooves and thereafter the area was occupied due to some urgent requirements, the cracks in both the directions developed. The cracks were almost in line. Later on the grooves were made through cutters. It has been observed that the distance of cracks in one side was almost near to 4 m and on other side at about 7 to 9 m (Figure 5). Thus from this case study also, inference can be made that grooves if made in panels of 4m x 4m, it would be appropriate. In both the cases, no lateral grooves were made, as working was not a problem due to use of vacuum dewatering process. In both the cases, horizontal line cracks have been observed indicating that the grooves in other direction are also essential. From this, it is imperative that polymer fiber reinforced concrete should be laid in panels or grooves should be provided so that concrete acts like in panels. Cutting grooves is easy as it can be made after casting of the concrete. But it should not be delayed for long and should be made before concrete achieves its desired strength. The size of panels may be kept around 4m x 4m. Thus, fiber reinforced concrete has advantage over normal concrete particularly in case of cement concrete pavements. Polymeric fibers such as polyester or polypropylene are being used due to their cost effective as well as corrosion resistance though steel fibers also work quite satisfactorily for a long time. It appears that fiber reinforced concrete should be laid on base concrete of lean mix such as 1:4:8 cement concrete rather than over WBM and provided with grooves in panels of about 4m x 4m to avoid expansion/ contraction cracks. Grooves can be made after casting of concrete through cutters.

Benefits of Using Steel Fibers in Concrete

The use of steel fiber in concrete can improve its many properties. The benefits of using steel fibers in concrete are as follows:

. Steel Fibers are generally distributed throughout a given cross section whereas reinforcing bars or wires are placed only where required

. Steel fibers are relatively short and closely spaced as compared with continuous reinforcing bars of wires.

. It is generally not possible to achieve the same area of reinforcement to area of concrete using steel fibers as compared to using a network of reinforcing bars of wires.

Steel Fibers are typically added to concrete in low volume dosages (often less than 1%), and have been shown to be effective in reducing plastic shrinkage cracking.

. Steel Fibers typically do not significantly alter free shrinkage of concrete, however at high enough dosages they can increase the resistance to cracking and decrease crack width (Shah, Weiss, and Yang 1998).

Figure 3-3: Steel Fibers in Concrete

3.1.3 Steel Fibers in Concrete can improve:

- Crack, Impact and Fatigue Resistance
- Shrinkage Reduction
- Toughness- by preventing/delaying crack propagation from micro cracks to macro-cracks.

3.1.3.1 Benefits of Steel Fiber Reinforced Concrete

- SFRC distributes localized stresses.
- Reduction in maintenance and repair cost.
- Provides tough and durable surfaces.
- Reduces surface permeability, dusting and wear.
- Cost saving.
- They act as crack arrestor.
- Increases tensile strength and toughness.
- Resistance to impact.
- Resistance to freezing and thawing

3.1.4 Effect of Fibers in Concrete

- Fibers are usually used in concrete to control plastic shrinkage cracking and drying shrinkage cracking. They also lower the permeability of concrete and thus reduce the bleeding of water. Some types of fibers produce greater impact, abrasion and shatter resistance in concrete. Generally, fibers do not increase the flexural strength of concrete, so it cannot replace moment resisting or structural steel reinforcement. Some fibers reduce the strength of concrete. The amount of fibers added to a concrete mix is measured as a percentage of the total volume of the composite (concrete and fibers) termed volume fraction (Vf). Vf typically ranges from 0.1 to 3%. Aspect ratio (l/d) is calculated by dividing fiber length (l) by its diameter (d). Fibers with a non-circular cross-section use an equivalent diameter for the calculation of aspect ratio. If the modulus of elasticity of the fiber is higher than the matrix (concrete or mortar binder), they help to carry the load by increasing the tensile strength of the material. An increase in the aspect ratio of the fiber usually segments the flexural strength and toughness of the matrix. However, fibers that are too long tend to "ball" in the mix and create workability problems. Some recent research indicated that using fibers in concrete has a limited effect on the impact resistance of concrete materials. This finding is very important since traditionally people think the ductility increases when concrete reinforced with fibers. The results also pointed out that the microfibers are better in impact resistance compared with the longer fibers.

3.1.4.1 The necessity of Fiber Reinforced Concrete

1 It increases the tensile strength of the concrete.

2. It reduces the air voids and water voids the inherent porosity of gel.

3. It increases the durability of the concrete.

4. Fibers such as graphite and glass have excellent resistance to creep, while the same is not true for most resins. Therefore, the orientation and volume of fibers have a significant influence on the creep performance of rebars/tendons.

5. Reinforced concrete itself is a composite material, where the reinforcement acts as the strengthening fiber and the concrete as the matrix. It is therefore imperative that the behavior under thermal stresses for the two materials be similar so that the differential deformations of concrete and the reinforcement are minimized.

6. It has been recognized that the addition of small, closely spaced and uniformly dispersed fibers to concrete would act as crack arrester and would substantially improve its static and dynamic properties.

3.1.4.2 EXPERIMENTAL STUDY OF PROPERTIES OF STEEL FIBER

3.1.4.2.1Material used:

CEM-I 32.5 N procured from a local manufacturer (Cherat cement) was used in the production of concrete. Normal weight crushed stone 4–8 mm in size, 0.8% water absorption and specific gravity of 2.67 was used as coarse aggregate. Fine aggregate of 0–4 mm size, 0.82% water absorption and specific gravity of 2.89 was used.

An expanded metal wire mesh (17 mm × 17 mm) in dimension was selected and was cut manually in the lab to get closed and straight steel fibers of 17 mm length.

3.1.4.2.2 Experimental purpose:

Trial mixes were performed to finalize a reference concrete mix design with target strength of (24 MPa). After finalization of reference mix design, straight and closed steel fibers were added to concrete by different volume fraction of concrete (0.25%, 0.5%, and 0.75%). Compositions of all the concrete mixes are summarized in Table below

Mix	Cement (kg/m^3)	Fine aggregate (kg/m^3)	Coarse aggregate (kg/m^3)	Water (kg/m^3)	Steel fibers (kg/m^3)
M-REF	400	730	1385	205	0
M-CSF0.25	400	730	1385	205	20
M-CSF0.5	400	730	1385	205	40
M-CSF0.75	400	730	1385	205	60
M-SSF0.25	400	730	1385	205	20
M-SSF0.5	400	730	1385	205	40
M-SSF0.75	400	730	1385	205	60

3.1.4.2.3 Results and discussion: -

Fresh concrete properties: test results for fresh concrete properties: workability, density and air content are summarized in Table below.

Concrete mix	Slump (mm)	Density (kg/m^3)	Air contents (%)
M-REF	105	2301	2.2
M-CSF0.25	88	2304	2.8
M-CSF0.5	77	2308	3.5
M-CSF0.75	58	2319	4
M-SSF0.25	94	2306	2.7
M-SSF0.5	84	2311	3.4
M-SSF0.75	67	2321	3.8

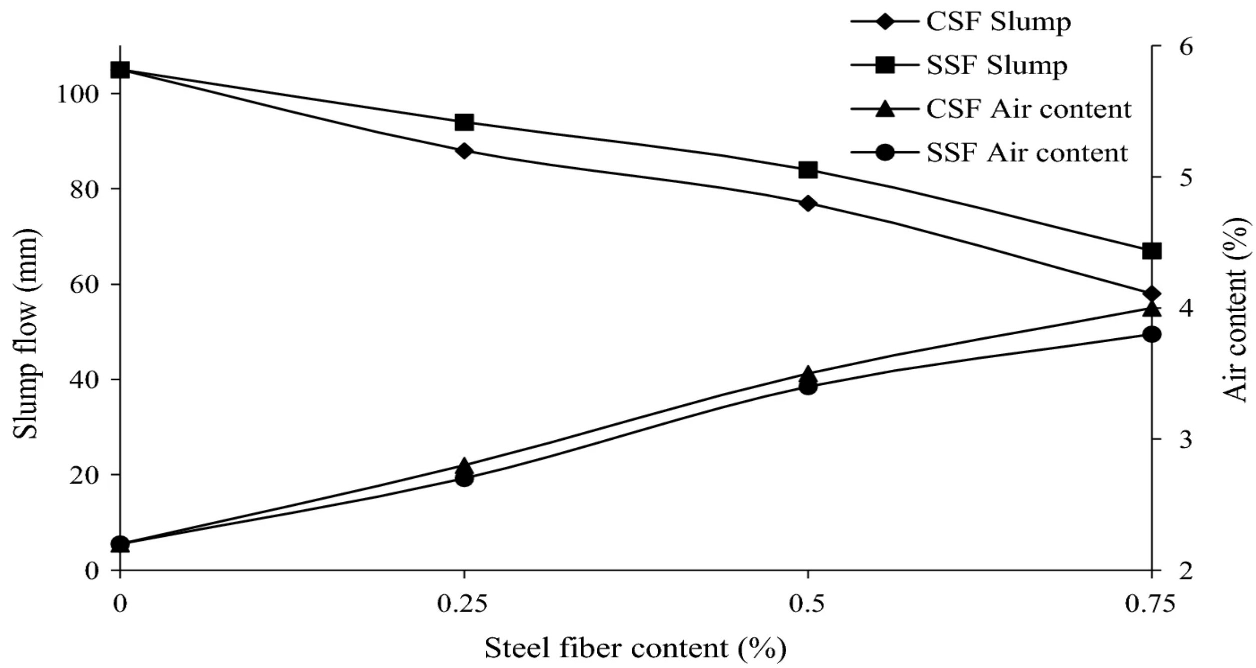

Fig showing the relation between slump flow and air content after adding steel fiber.
Results showed no change in the fresh concrete density of all mixes. With an increase in air content of fresh concrete when steel fibers were added to it.
Hardened concrete properties:
Concrete mixes were tested **after 28 days** of moist curing for compressive strength, split tensile strength, modulus of elasticity and flexural strength in Table below:

Mix type	CS (MPa)	STS		MOE (MPa)	FS		Toughness (J)
		MPa	St. Dev.		MPa	St. Dev.	
M-REF	25.2	2.26	0.09	23,610	4.2	0.14	1
M-CSF0.25	25.4	2.4	0.09	23,730	4.9	0.19	28
M-CSF0.5	26.4	2.6	0.06	24,180	5.5	0.12	42
M-CSF0.75	25.8	2.7	0.03	23,910	5.8	0.10	48
M-SSF0.25	25.3	2.3	0.01	23,680	4.4	0.10	22
M-SSF0.5	25.8	2.47	0.04	23,950	4.8	0.19	37
M-SSF0.75	26.4	2.56	0.04	24,210	5.2	0.1	45

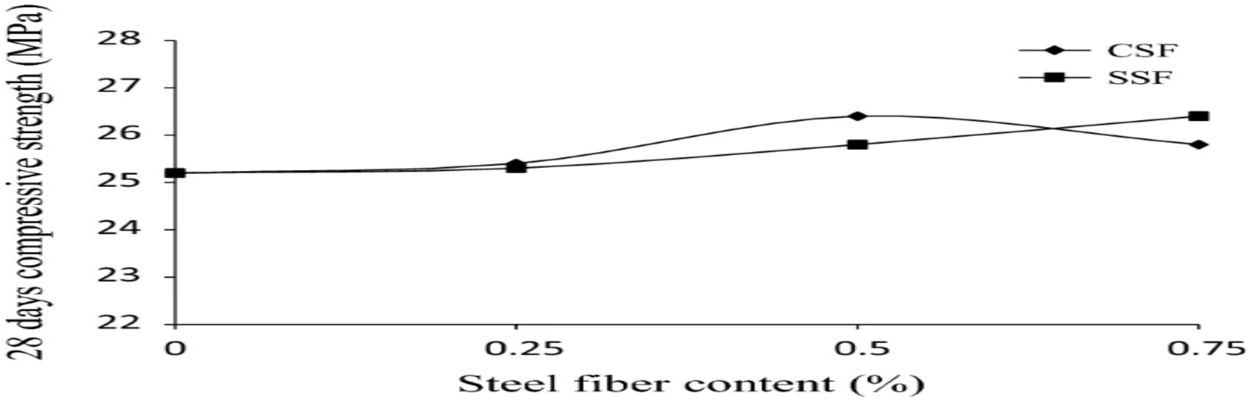

Figure 3-4:Variation in 28 days compressive strength of concrete with steel fibers addition

Modulus of elasticity:

There was small variation in the modulus of elasticity of concrete with the addition of straight and closed steel fibers in different percentages. Results for modulus of elasticity of concretes in this study are also graphically presented in Fig below

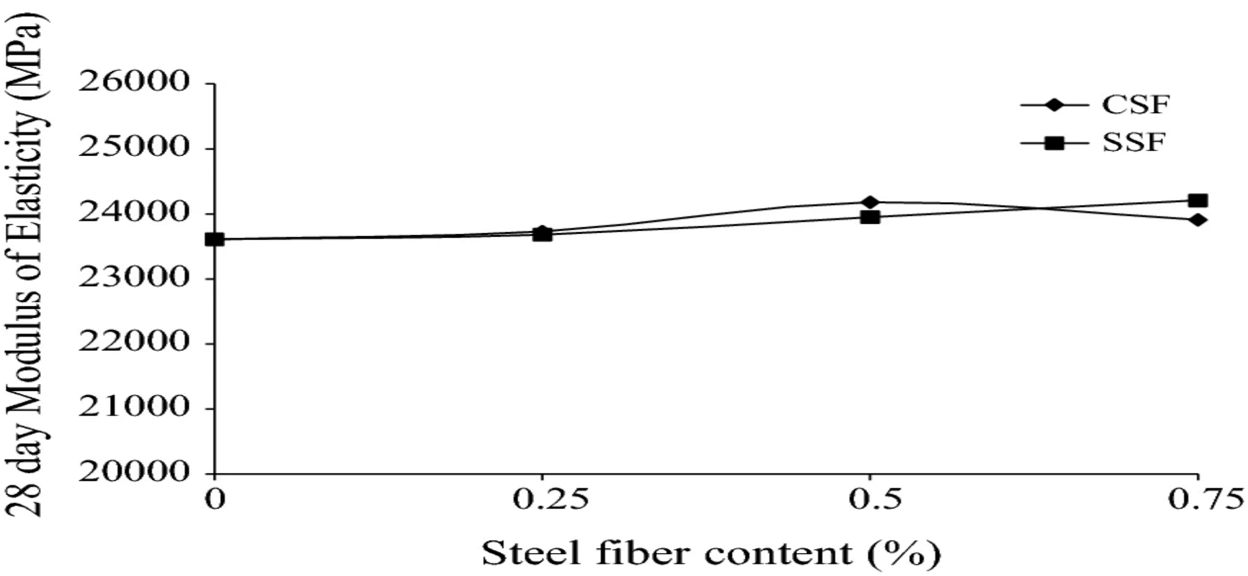

Figure 3-5:Variation in modulus elasticity of concrete with steel fibers addition

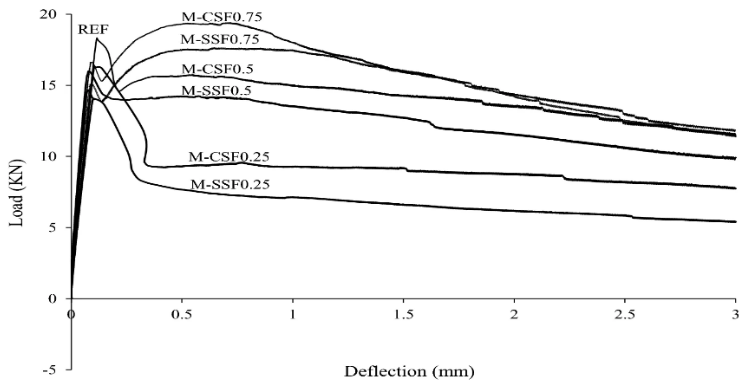

Figure 3-6:Load–deflection curves for concrete after adding steel fibers

3.1.5 Applications of Steel Fiber Reinforced Concrete

Steel fiber reinforced concrete provides superior resistance to cracking and crack propagation due to increased tensile strength in concrete structures.It is known that plain cement concrete does not have good tensile properties to resist flexure in structural members. In case of concrete reinforcement steel, cracks still appear on the tension face due to bending. So, to prevent cracking of concrete, especially in the case of water retaining structures, or water transporting structures, it is advisable to design structural concrete as uncracked section. This results in heavy structural design with resulting in high cost. Steel fiber reinforced concrete is a low cost solution for uncracked section design of concrete members. Use of steel fiber reinforcement in concrete enhances the ability of structural members to carry significant stresses. The use of fibers increases the toughness of concrete under any type of loads. Fibers in concrete has the ability absorb more energy. As recommended by ACI Committee 544, steel fiber reinforced concrete is used as supplementary material to prevent cracking, to improve resistance to impact or dynamic loading and to prevent material disintegration. A guide to design of concrete structures with steel fiber reinforcement has also been published by American Concrete Institute. The applications of Steel Fiber reinforced concrete are for so varied and so widespread, that it is difficult to categories them. Following are the common applications of steel fiber reinforced concrete constructions:

Tunnel linings
Manholes,
Risers,
Burial Vaults,
Septic tanks
Curbs,
Pipes,
Covers,
Sleepers
Roller compacted concrete with steel fibers

3.1.6 Application of Steel Fiber Reinforced Concrete in other Structures:

3.1.6.1 A) Highway and Airfield Pavements:

- Repair of existing pavement.
- Reduction in pavement thickness.
- Increase in resistance to impact.
- Increase in transverse and longitudinal joint spacing
- Smooth riding surface.

3.1.6.2 B) Hydraulic Structures:

- Resistance to cavitation or erosion damage.
- Repair of spilling basin.

3.1.6.3 C) Fiber Shotcrete (FRS):

The inclusion of steel fibers in shotcrete improves many of the mechanical properties of the basic material viz the toughness, impact resistance, shear strength, flexural strength, and ductility factor. FRS has been used for

- Rock stabilization, tunnels, dams, mines.
- Bridges arches, dome structures, power-house
- Stabilization of slopes to prevent landslides repair of deteriorated concrete surface, water channel etc.

A seminar report on fiber reinforced concrete is available which provides more information and mix design of fiber reinforced concrete. The technology used for production, properties and structural use of fiber reinforced concrete is also explained.

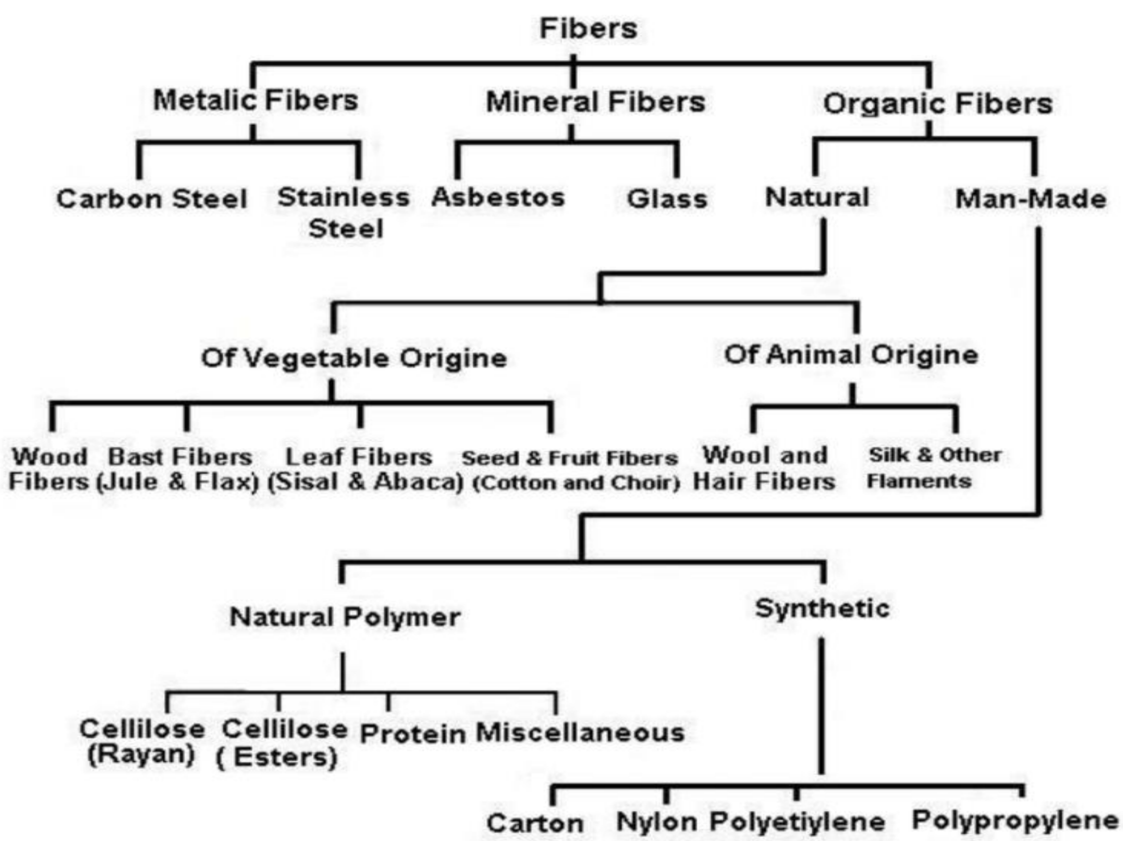

Figure 3-7:Fiber Types

3 – Fly ash

Fly ash is used as a supplementary cementitious material (SCM) in the production of Portland cement concrete. A supplementary cementitious material, when used in conjunction with Portland cement, contributes to the properties of the hardened concrete through hydraulic or pozzolanic activity, or both. As such, SCM's include both pozzolans and hydraulic materials. A pozzolan is defined as a siliceous or siliceous and aluminous material that in itself possesses little or no cementitious value, but that will, in finely divided form and in the presence of moisture, chemically react with calcium hydroxide at ordinary temperatures to form compounds having cementitious properties. Pozzolans that are commonly used in concrete include fly ash, silica fume and a variety of natural pozzolans such as calcined clay and shale, and volcanic ash. SCM's that are hydraulic in behavior include ground granulated blast furnace slag and fly ashes with high calcium contents (such fly ashes display both pozzolan and hydraulic behavior).

The potential for using fly ash as a supplementary cementitious material in concrete has been known almost since the start of the last century (Anon 1914), although it wasn't until the mid-1900s that significant utilization of fly ash in concrete began (for example, USBR 1948) following the pioneering research conducted at the University of California, Berkeley (Davis 1937).The last 50 years has seen the use of fly ash in concrete grow dramatically with close to 15 million tons used in concrete, concrete products and grouts in the U.S. in 2005 (ACAA 2006).

Historically, fly ash has been used in concrete at levels ranging from 15% to 25% by mass of the cementitious material component. The actual amount used varies widely depending on the application, the properties of the fly ash, specification limits, and the geographic location and climate. Higher levels (30% to 50%) have been used in massive structures (for example, foundations and dams) to control temperature rise. In recent decades, research has demonstrated that high dosage levels (40% to 60%) can be used in structural applications, producing concrete with good mechanical properties and durability (Marceau 2002).

Increasing the amount of fly ash in concrete is not without shortcomings. At high levels problems may be encountered with extended set times and slow strength development, leading to low early-age strengths and delays in the rate of construction. These drawbacks become particularly pronounced in cold-weather concreting. Also, the durability of the concrete may be compromised with regards to resistance to deicer-salt scaling and carbonation.

Figure 3-8:Fly ash, a powder resembling cement, has been used in concrete since the 1930.

For any given situation there will be an optimum amount of fly ash that can be used in a concrete mixture which will maximize the technical, environmental, and economic benefits of fly ash use without significantly impacting the rate of construction or impairing the long- term performance of the finished product. The optimum amount of fly ash will be a function of wide range of parameters and must be determined on a case-by-case basis.

This report discusses issues related to using low to very high levels of fly ash in concrete and provides guidance for the use of fly ash without compromising the construction process or the quality of the finished product. For the purposes of this document the replacement levels shown in Table 1 will be used to represent low, moderate, high and very high levels of fly ash.

Table 1. Dosage Levels of Fly Ash

Level of Fly Ash % by mass of total cementitious material	Classification
<15	Low
15-30	Moderate
30-50	High
>50	Very High

Figure 3-9:Design Levels of Fly ash

The Nature of Fly Ash

Fly ash is a by-product of burning pulverized coal in an electrical generating station. Specifically, it is the unburned residue that is carried away from the burning zone in the boiler by the flue gases and then collected by either mechanical or electrostatic separators (Figure 2).The heavier unburned material drops to the bottom of the furnace and is termed bottom ash; this material is not generally suitable for use as a cementitious material for concrete, but is used in the manufacture of concrete masonry block.

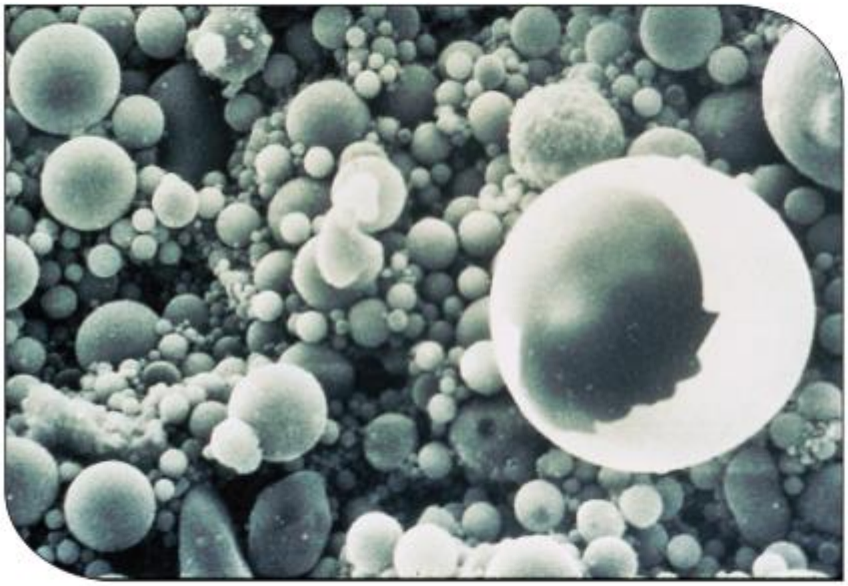

Figure 3-10: Micrograph showing spherical fly ash particles.

Fly ash is a pozzolanic material. It is a finely-divided amorphous alumina silicate with varying amounts of calcium, which when mixed with Portland cement and water, will react with the calcium hydroxide released by the hydration of Portland cement to produce various calcium-silicate hydrates (C-S-H) and calcium-aluminate hydrates. Some fly ashes with higher amounts of calcium will also display cementitious behavior by reacting with water to produce hydrates in the absence of a source of calcium hydroxide. These pozzolanic reactions are beneficial to the concrete in that they increase the quantity of the cementitious binder phase (C-S-H) and, to a lesser extent, calcium-aluminate hydrates, improving the long- term strength and reducing the permeability of the system. Both of these mechanisms enhance the durability of the concrete. Detailed information on the nature of fly ash and pozzolanic reactions in concrete can be found in the ACI Committee 232 report on Fly Ash in Concrete and other sources (Helmuth 1987).

Effect of Fly Ash on the Properties of Fresh Concrete

- Workability

The use of good quality fly ash with a high fineness and low carbon content reduces the water demand of concrete and, consequently, the use of fly ash should permit the concrete to be produced at a lower water content when compared to a Portland cement concrete of the same workability (Figures 4 and 5). Although the exact amount of water reduction varies widely with the nature of the fly ash and other parameters of the mix, a gross approximation is that each 10% of fly ash should allow a water reduction of at least 3%.

A well-proportioned fly ash concrete mixture will have improved workability when compared with a Portland cement concrete of the same slump .This means that, at a given slump, fly ash concrete flows and consolidates better than a conventional Portland cement concrete when vibrated .The use of fly ash also improves the cohesive- ness and reduces segregation of concrete .The spherical particle shape lubricates the mix rendering it easier to pump and reducing wear on equipment (Best 1980)

It should be emphasized that these benefits will only be realized in well-proportioned concrete. The fresh properties of concrete are strongly influenced by the mixture proportions including the type and amount of cementing material, the water content, the grading of the aggregate, the presence of entrained air, and the use of chemical admixtures.

Coarser fly ashes or those with high levels of carbon generally produce a smaller reduction in water demand and some may even increase water demand (Figures 4 and 5). Careful consideration should be given before using these fly ashes in concrete especially at higher levels of replacement in structural concrete.

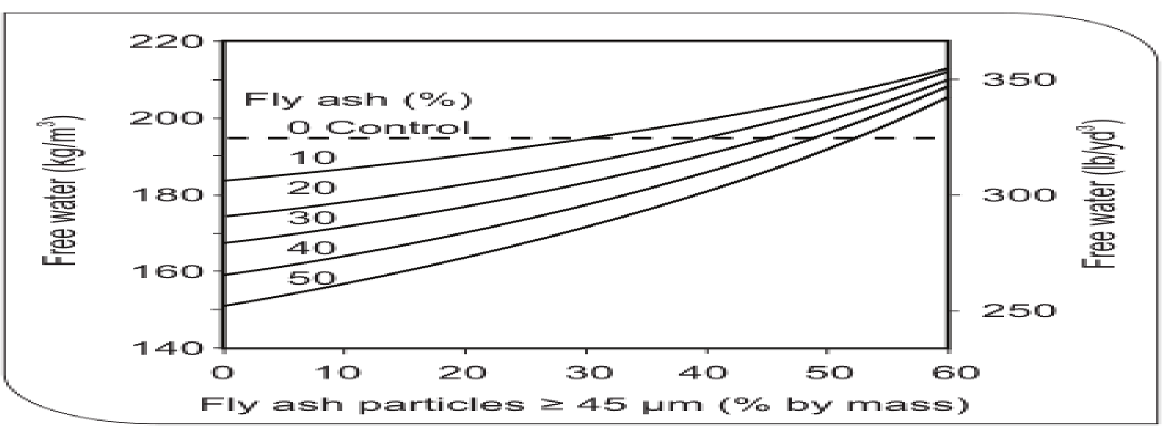

Figure 3-11:Effect of fly ash fineness on water demand of concretes proportioned for equal slump.

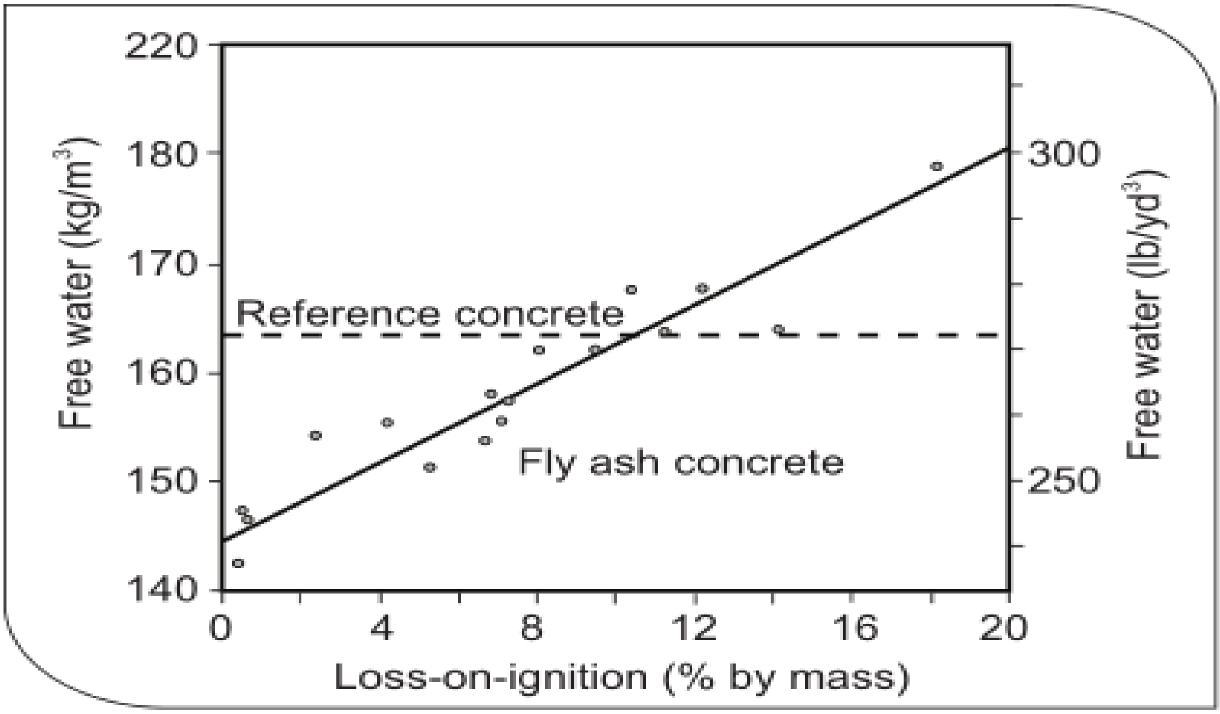

Figure 3-12:Effect of fly ash LOI on water demand of concretes proportioned for equal slump.

- Bleeding

Generally fly ash will reduce the rate and amount of bleeding primarily due to the reduced water demand. Particular care is required to determine when the bleeding process has finished before any final finishing of exposed slabs.

High levels of fly ash used in concrete with low water contents can virtually eliminate bleeding. Therefore, the freshly placed concrete should be finished as quickly as possible and immediately protected to prevent plastic shrinkage cracking when the ambient conditions are such that rapid evaporation of surface moisture is likely. The guidance given in ACI 305, Hot Weather Concreting should be followed.

An exception to this condition is when fly ash is used without an appropriate water reduction, in which case bleeding (and segregation) will increase in comparison to Portland cement concrete.

- Air Entrainment

Concrete containing low-calcium (Class F) fly ashes generally requires a higher dose of air-entraining admixture to achieve a satisfactory air-void system. This is mainly due to the presence of unburned carbon (Figure 6) which absorbs the admixture. Consequently, higher doses of air-entraining admixture are required as either the fly ash content of the concrete increases or the carbon content of the fly ash increases. The carbon content of fly ash is usually measured indirectly by determining its loss-on-ignition (LOI).

The increased demand for air entraining admixture should not present a significant problem to the concrete producer provided the carbon content of the fly ash does not vary significantly between deliveries. It has been shown that as the admixture dose required for a specific air content increases, the rate of air loss also increases.

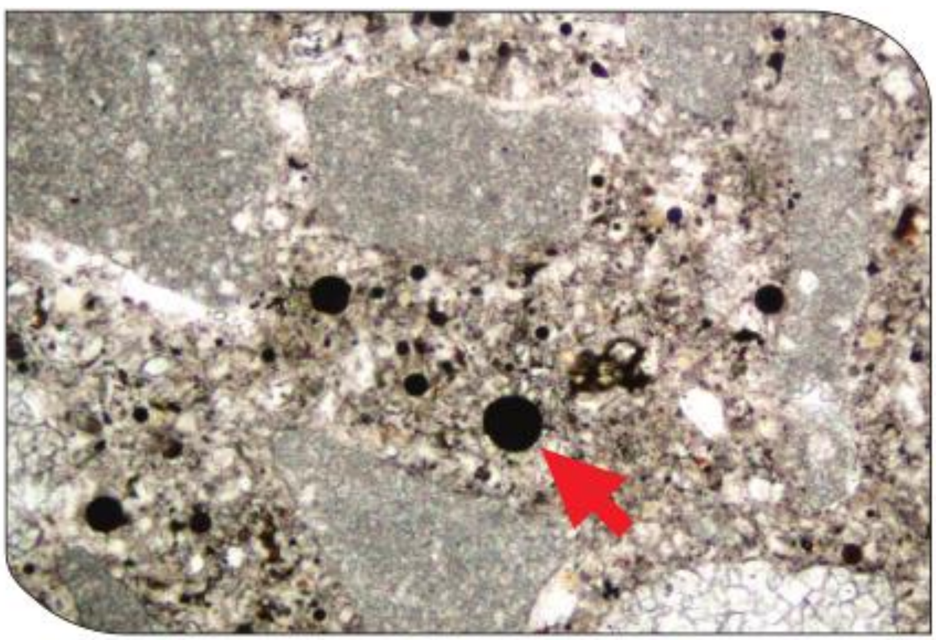

Figure 3-13:Concrete in thin section. Fly ashes with a high content of unburnt carbon (highlighted with arrow) generally require higher doses of air-entraining admixture.

Generally, high-calcium fly ashes require a smaller increase in the air-entrainment dose compared to low-calcium fly ashes. Some Class C fly ashes high in water-soluble alkali may even require less admixture than those mixes without fly ash.

- Setting Time

The impact of fly ash on the setting behavior of concrete is dependent not only on the composition and quantity of fly ash used, but also on the type and amount of cement, the water-to-cementitious materials ratio (w/cm), the type and amount of chemical admixtures, and the concrete temperature. It is fairly well-established that low-calcium fly ashes extend both the initial and final set of concrete as shown in Figure 7.

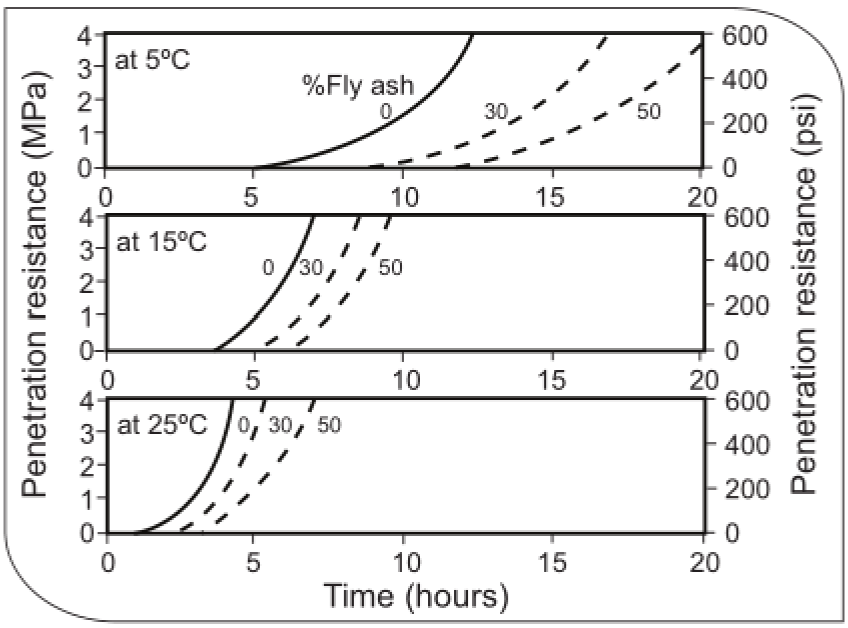

Figure 3-14:Effect of fly ash and temperature on the penetration resistance of setting concretes proportioned for equal strength at 28 days and workability (Concrete Society 1991).

During hot weather the amount of retardation due to fly ash tends to be small and is likely to be a benefit in many cases.

During cold weather, the use of fly ash, especially at high levels of replacement, can lead to very significant delays in both the initial and final set. These delays may result in placement difficulties especially with regards to the timing of finishing operations for floor slabs and pavements or the provision of protection to prevent freezing of the plastic concrete. Practical considerations may require that the fly ash content is limited during cold-weather concreting .The use of set-accelerating admixtures may wholly or partially offset the retarding effect of the fly ash. The setting time can also be reduced by using an ASTM C150 Type III (or ASTM C1157 Type HE) cement or by increasing the initial temperature of the concrete during production (for example, by heating mix water and/or aggregates).

Higher-calcium fly ashes generally retard setting to a lesser degree than low-calcium fly ashes, probably because the hydraulic reactivity of fly ash increases with increasing calcium content. However, the effect of high-calcium fly ashes is more difficult to predict because the use of some of these ashes with certain cement-admixture combinations can lead to either rapid (or even flash) setting or to severely retarded setting (Wang 2006 and Roberts 2007).

With all fly ashes, but especially with higher-calcium fly ashes, testing is required before a new fly ash source is introduced to a plant. Testing can determine the effect of the fly ash on the setting behavior of concrete produced with the other plant materials. This testing should be conducted at a range of fly ash levels and at different temperatures.

- Heat of Hydration

The reduction in the rate of the heat produced and hence the internal temperature rise of the concrete has long been an incentive for using fly ash in mass concrete construction. One of the first full-scale field trials was conducted by Ontario Hydro (Mustard 1959) during the construction of the Otto Holden Dam in Northern Ontario around 1950.Two elements of the dam, measuring 3.7 x 4.3 x 11.0 m (12 x 14 x 36 ft.), were constructed with embedded temperature monitors. One element was constructed using a concrete with 305 kg/m ^{3} (514 lb./yd. ^{3}) of Portland cement and the other with a concrete with the same cementitious material content but with 30% of the Portland cement replaced with a Class F fly ash. Figure 8 shows the results from this study indicating that the use of fly ash reduced the maximum temperature rise over ambient from 47°C to 32°C (85°F to 58°F).

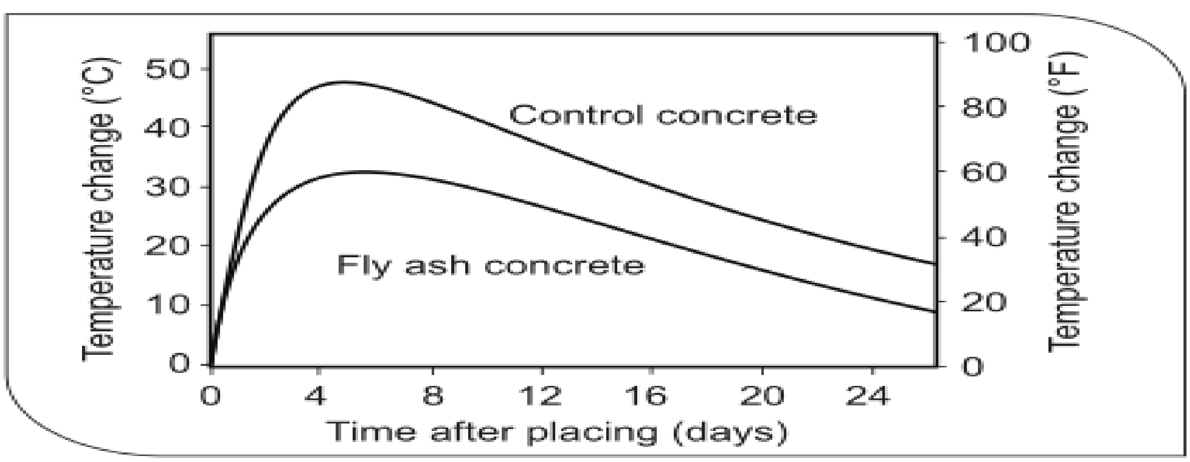

Figure 3-15:Effect of fly ash on temperature rise in concrete dams.

In massive concrete pours where the rate of heat loss is small, the maximum temperature rise in fly ash concrete will primarily be a function of the amount and composition of the Portland cement and fly ash used, together with the temperature of the concrete at the time of placing. Concrete with low Portland cement contents and high fly ash contents are particularly suitable for minimizing autogenous temperature rises. For example, Langley and coworkers (Langley 1992) cast three 3.05 x 3.05 x 3.05 m (10 x 10 x 10 ft.) blocks with embedded thermocouples, and showed that the incorporation of 55% fly ash reduced the peak temperature by 29°C (52°F) when the cementitious material content was held constant and by 53°C (95°F) when the total cementitious content was reduced (Table 4).The high-volume fly ash (HVFA) concrete mixes (with ~ 55% Class F fly ash) were effective in reducing both the rate of heat development and the maximum temperature reached within the concrete block.

Table 4. Temperature Rise in Large Concrete Blocks Produced with HVFA Concrete

Mix	Cement kg/m³ (lb/yd³)	Fly ash kg/m³ (lb/yd³)	w/cm	Max. temp °C (°F)	Time to max. (h)
1	400 (674)	-	0.33	83 (181)	24
2	180 (303)	220 (370)	0.27	54 (129)	96
3	100 (168)	125 (211)	0.49	30 (86)	168

(Langley 1992)

Table 5. Temperature Rise in Large Concrete Monoliths Produced with HVFA Concrete

Mix	Cement kg/m³ (lb/yd³)	Fly ash kg/m³ (lb/yd³)	w/cm	Strength MPa (psi) 1-day	Strength MPa (psi) 3-day	Max. temp °C (°F)	Time to max. (h)
1	365 (600) Type I	-	0.45	10.3 (1495)	-	68 (154)	29
2	125 (211) Type I	155 (261)	0.46	1.6 (230)	5.1 (740)	44 (111)	53
3	170 (287) Type I	220 (370)	0.29	8.4 (1220)	15.6 (2260)	54 (129)	57
4	330 (556) Type II	-	0.50	7.3 (1060)	14.0 (2030)	55 (131)	75
5	125 (211) Type I	155 (261)	0.41	2.5 (365)	8.4 (1220)	47 (117)	98

(Bisaillon 1994)

shows data from a later study (Bisaillon 1994) using large monoliths (2.5 x 4.0 x 5.0 m)

(8.2 x 13.1 x 16.4 ft.) Cast with HVFA concrete with Type F fly ash.

These results again indicate that the autogenous temperature rise can be kept very low with high-volume fly ash when the total cementitious content is kept low (in this case 280 kg/m 3 (472 lb./yd. 3)). This property can be very advantageous when early-age strength is not important. Higher early-age strengths can be achieved by raising the cementitious material content of the HVFA system, although this does result in an increase in the autogenous temperature rise.

HVFA concrete systems have been successfully used in commercial applications to control the temperature rise in large placements (Mehta 2000, Mehta 2002, and Manmohan 2002).

Most published work on the effects of fly ash on the rate of heat development and temperature rise in concrete have focused on low-calcium Class F fly ashes .Work by the Bureau of Reclamation (Dunstan 1984) indicated that the rate of heat development generally increases with the calcium content of the ash. Fly ashes high in calcium may produce little or no decrease in the heat of hydration (compared to plain Portland cement) when used at normal replacement levels. Similar results have been reported for studies on insulated mortar specimens (Barrow 1989), where the use of high-calcium ash (> 30% CaO) was found to retard the initial rate of heat evolution but did not reduce the maximum temperature rise. However, Carrette (1993) reported that there was no consistent trend between ash composition and temperature rise for concretes containing high levels of fly ash (56% by mass of cementitious mate- rial). Calcium levels of the ashes used in the study ranged up to 20% CaO. Conduction calorimetry studies conducted at Ontario Hydro in Canada (Thomas 1995) using a wide range of fly ashes (2.6% to 27.1% CaO) showed that the 7-day heat of hydration of cement-fly ash pastes was strongly correlated with the calcium content of the fly ash in agreement with Dunstan (1984). However, these studies also indicated that high-calcium fly ashes could be used to meet performance criteria for ASTM C150 Type IV or ASTM C1157 typ LH cements when used at a sufficient replacement level (Figure9).

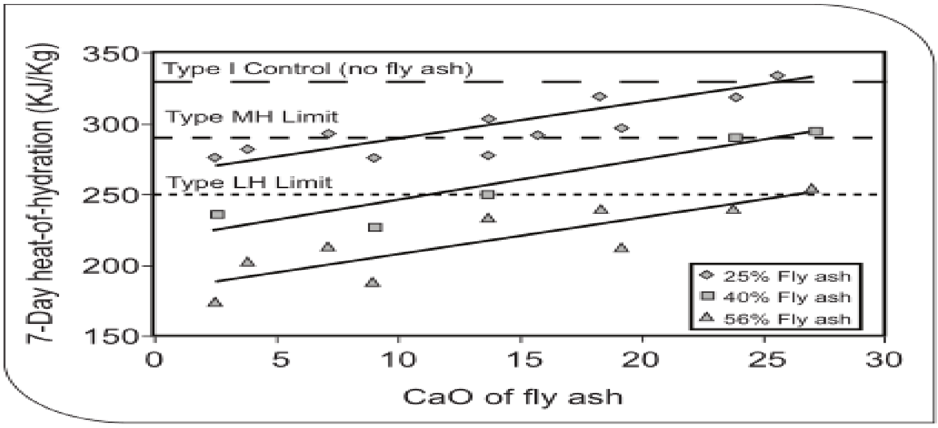

Figure 3-16:Effect of fly ash on heat of hydration using conduction (isothermal) calorimetry (Thomas 1995).

High levels of high-calcium (Class C) fly ash have been used to control the temperature rise in mass concrete foundations. One example is the concrete raft foundation for the Windsor Courthouse (Ellis Don 1996).This 10,000 m ^{3} (13,000 yd. $^{3)}$ concrete raft was 1.2 m (4 ft.) thick and was placed in pours 1400 m ^{3} to 1700 m ^{3} (1830 yd. ^{3} to 2220 yd. ^{3}) in volume, with placement rates (pumping the concrete) of up to 100 m ^{3} /h (130 yd. ^{3} /h). Concrete with 50% Class C fly ash was used to control temperature while thermocouples were used to determine when thermal blankets could be removed without causing thermal shock.

- Finishing and Curing

The use of fly ash can lead to significant retardation of the setting time, which means that finishing operations may have to be delayed. At normal temperatures, the rate of the pozzolanic reaction is slower than the rate of cement hydration, and fly ash concrete needs to be properly cured if the full benefits of its incorporation are to be realized. When high levels of fly ash are used it is generally recommended that the concrete is moist cured for a minimum period of 7 days. It has been recommended that the duration of curing be extended further (for example, to 14 days) where possible, or that a curing membrane be placed after 7 days of moist curing (Malhotra 2005). If adequate curing cannot be provided in practice, the amount of fly ash used in the concrete should be limited.

The finishing and curing requirements for high-volume fly ash concrete exposed to cyclic freezing and thawing in the presence of deicing salts is discussed in the section Effect of Fly Ash on the Durability of Concrete.

3.1.6.4 EXPERIMENTAL STUDY OF PROPERTIES FLY ASH IN CONCRETE

For fly ash concrete, materials are collected and their physical properties also to defined by conducting experiments. As following

- Cement: Ordinary Portland cement of 43 grade conforming to Indian standard IS 12269(1987).
- Fly ash- FLY ASH obtained from Lakshmi Fly Ash Brick manufacturing company at Coimbatore
- Aggregates- 20 mm to 4.75 mm aggregates taken as coarse aggregates and below 4.75 mm aggregates taken as fine aggregates.

Properties of mixture in table below:

Fly ash content	Fly ash (kg)	Cement (kg)	Sand (kg)	aggregates (kg)
0%	0.000	7.500	11.250	22.500
10%	0.750	6.750	11.250	22.500
20%	1.500	6.000	11.250	22.500
30%	2.250	5.250	11.250	22.500
40%	3.000	4.500	11.250	22.500
50%	3.750	3.750	11.250	22.500

Molding process:

6 cubes were molded, in which 3 cubes tested after 7 days and rest 3 cubes tested after 28 days. Concrete is mixed by hand and thoroughly mixed and the concrete placed in cubes with the minimum delay. It was well compacted by rodding, temping and vibrating to remove all air voids after placing

Curing process:
Concrete cubes were cured in fresh water for (7 to 28) days at room temperature.
Testing process:
After removing of mould, concrete cubes are tested in laboratory. Various tastes were done.
For find physical property of material, specific gravity of cement, initial setting time, moisture content and standard consistency was determined, to check workability of concrete slump test was conducted, and for strength of concrete compressive strength was conducted by compressive strength testing machine.
Results and discussion:

1- Setting time: by result it can see that as amount of fly ash increased in cement, initial setting time also increased and it take more time to settle as curve below

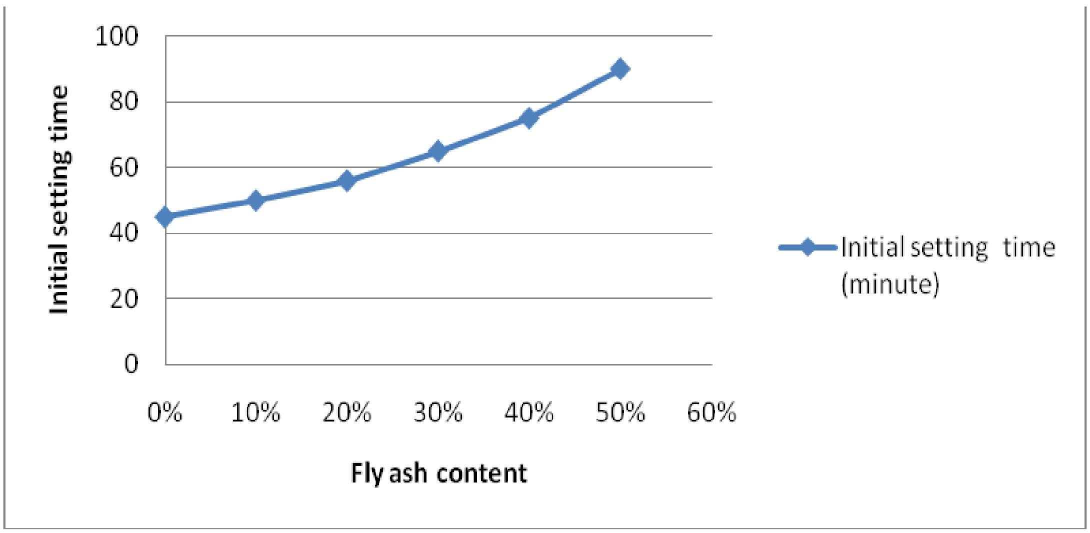

Figure 3-17: effect of fly ash on initial setting time

Content	wt. of cement (grams)	Wt. of fly ash (grams)	Initial setting time (minute)
0%	400	0	45
10%	360	40	50
20%	320	80	56
30%	280	120	65
40%	240	160	75
50%	200	200	90

2- Slump value

As amount of fly ash increased slump values increased

Fly ash content	Slump value (mm)
0%	25
10%	28
20%	33
30%	40
40%	45
50%	50

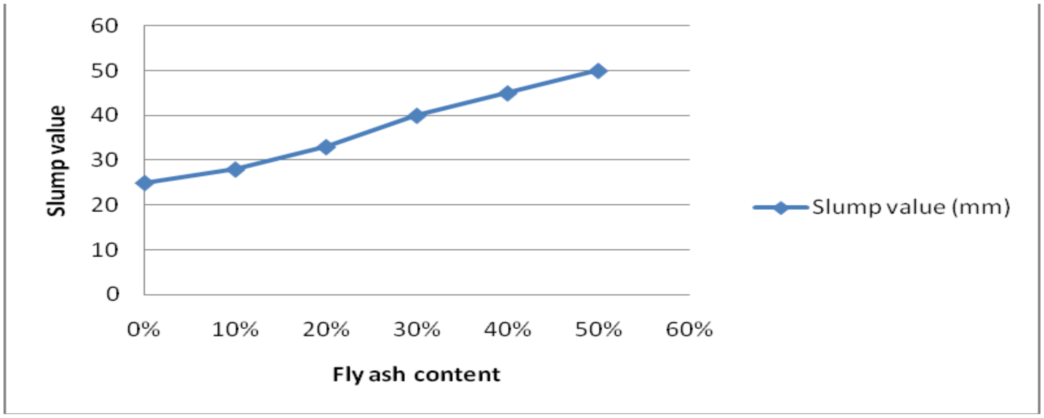

Figure 3-18: effect of fly ash on Slump Value

2- compressive strength of concrete:

Amount of fly ash increased compressive strength decreased, up to (30-40%) is safe to use in concrete mix and 50% fly ash cement concrete has not enough compressive strength to use for construction.

Concrete grade	Sample content (Fly ash)	compressive strength (7days) N/mm^2	compressive strength (28days) N/mm^2
M20	0%	27	35.92
	10%	22.77	35.68
	20%	19.23	31.17
	30%	18.10	26.03
	40%	16.96	25.82
	50%	8.726	18.24

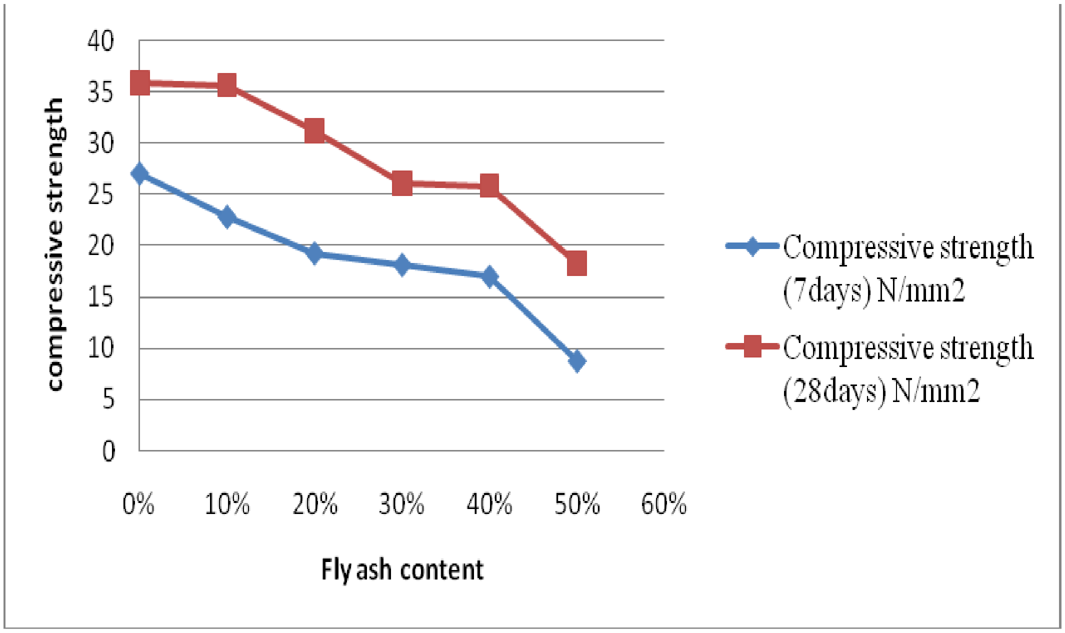

Figure 3-19: effect of fly ash on Compressive Strength

4 – Silica fume: -

In recent years, there has been considerable interest in improving the properties of concrete by incorporating various pozzolanic materials in the concrete mix. One of these materials, silica fume, has been receiving much attention because of its favorable contributions to Portland cements

Concrete properties.

Silica fume is a byproduct from the production of ferrosilicon and silicon metal in an electric arc Furnace. This byproduct is usually composed of more than 90 percent silicon dioxide and may contain traces of other oxides, depending on the furnace charge and the silicon metal being produced.

Initial investigations of the use of silica fume in concrete were conducted in the 1950's and 1960's, but most of the actual mix design work and the use of silica fume in concrete were not started until 1969. The Norwegians have been the most active in the development of silica fume concrete.

Silica fume particles are very small. Gives a fineness of 20 000 m*2/kg.

Points out: “From the specific gravities and specific surfaces of silica fumes and Portland cement, It can be shown that around each grain of Portland cement there are about 100 000 grains.
Effect of silica fume on concrete:
Since the advent of civilization different types of cement materials have been used for construction practices, the arrival of Ordinary Portland Cement has changed the entire construction activities however, due to the many defects associated with the properties of cement and construction materials manufactured using Ordinary Portland Cement in addition to the cost factor trying to put one to use other materials For economical construction and to improve the properties of mortar and concrete, many waste materials are also generated in huge quantities from various industrial activities.
Now attempts have been made to use this waste or industrial by-products in construction activities to solve the problems of environmental pollution and safe and economical construction. Silica fume is one of these industrial products that are used and tried to obtain stronger and durable concrete and it is one of the pozzolane that has a very large surface area, which leads To a better and regular use of the calcium hydroxide released during the hydration of ordinary Portland cement, also because of its very fine size it acts as a filler between the cement jelly grains.
Effect of silica fume on the properties of hard concrete:

Compressive strength: the compressive strength of concrete containing silica fume increases due to filling the voids and due to the excellent pozzolanic properties, by improving the transitional area, but this effect depends on several different factors such as: the quality of silica fume, the water-cement ratio, the amount of cement, the type of cement, the type of cement.

A and plasticizer dose, curing conditions and age of concrete. The data in Table shows the following:

(A) Although black carbon is softer than silica dust, the effect of this material on the compressive strength of concrete is similar to the effect of silica bar at the age of seven days, which means that there is a physical effect of silica dust and black carbon materials on concrete represented in filling voids and maintaining compressive strength.

(B) Silica fume cement concrete shows outstanding performance after 28 days of curing with water in comparison with concrete containing carbon black or containing Portland cement. Therefore, the previously proposed recommendations for curing concrete containing silica dust for a period of at least 14 days seem reasonable and on scientific grounds.

Water-cement ratio	The strength after 7 days of maturation		
	Cement	Silica fume	Black carbon
0.25	80.2	80.2	74.8
0.25	57.7	55.1	57.4
0.5	34.6	34.4	33.3
The strength after 28 days of maturation			
0.25	91.6	108.9	93.3
0.25	73.7	68.6	76.4
0.5	51.9	57.9	48

Permeability:

There is a clear effect of silica fume on the porous composition of cement and mortar paste by forming a dense and more homogeneous cement composition, which reduces the number of large pores. For information, silica fume not only reduces the permeability of the cement paste mass, but also reduces the permeability of the transitional zone, which is known to be very weak. The following table shows that when 10% of silica fume is added to the concrete of ordinary Portland cement, the permeability coefficient decreases by 400 times. The permeability of concrete containing 100 kg/m3 of cement with 20% silica fume is equivalent to that of ordinary cement with a content of 250 kg/m2 of cement, which means that 20 kg of silica fume is equivalent to 150 kg of ordinary Portland cement.

The data in the previous and following tables show that the effect of silica dust on reducing permeability is much greater than improving compressive strength, especially at low levels of silica dust and the amount of cement. These properties are reflected positively on concrete containing silica dust and its outstanding performance in improving concrete durability when exposed to aggressive environments.

Portland cement (kg/m^2)	Silica fume (kg/m^2)	Permeability (kg/pascal mm sec)
100 100 100	0 10 20	×10 -8 1.6 ×10 -11 4 ×10 -13 5.7
250	0	×10 -13 4.8
250	25	×10 -15 1.8

White Efflorescence:

Efflorescence is attributed to the deposition of a white crust on the concrete surface as a result of the dissolution and leaching of slaked lime and its reaction with carbon dioxide in the air, leading to the production of calcium carbonate on the concrete surface. Since silica dust is an active pozolon, it consumes this slaked lime and prevents the formation of this white rash. Therefore, adding silica fume to concrete prevents such problems.

Application of silica fume concrete:

Because of its extreme fineness and high silica content, silica fume is a very effective pozzolanic material. Standard specifications for silica fume used in cementitious mixtures are ASTM

Silica fume is added to Portland cement concrete to improve its properties, in particular its compressive strength, bond strength, and abrasion resistance. These improvements stem from both the mechanical improvements resulting from addition of a very fine powder to the cement paste mix as well as from the pozzolanic reactions between the silica fume and free calcium hydroxide in the paste.

Addition of silica fume also reduces the permeability of concrete to chloride ions, which protects the reinforcing steel of concrete from corrosion, especially in chloride-rich environments such as coastal regions and those of humid continental roadways and runways (because of the use of deicing salts) and saltwater bridges.

Prior to the mid-1970s, nearly all silica fume was discharged into the atmosphere. After environmental concerns necessitated the collection and landfilling of silica fume, it became economically viable to use silica fume in various applications, in particular high-performance concrete. Effects of silica fume on different properties of fresh and hardened concrete include:

Workability:

With the addition of silica fume, the slump loss with time is directly proportional to increase in the silica fume content due to the introduction of large surface area in the concrete mix by its addition. Although the slump decreases, the mix remains highly cohesive.

Segregation and bleeding:

Silica fume reduces bleeding significantly because the free water is consumed in wetting of the large surface area of the silica fume and hence the free water left in the mix for bleeding also decreases. Silica fume also blocks the pores in the fresh concrete so water within the concrete is not allowed to come to the surface.

Effect of temperature on physical and mechanical properties of concrete containing silica fume:

Heat-resistant materials are usually used for structural purposes. The need for such building materials is particularly important in the chemical and metallurgical industries and for the thermal shielding of nuclear power plants. Thus the effect of high temperatures on physical and mechanical properties of concrete was investigated. In this study ordinary Portland cement has been partially replaced by ratios of silica fume. The heat treatment temperature varied from 100 to 600 C by increments of 100 C for three hours without any load. Concrete specimens were treated at each temperature level. The specimens were heated under the same condition for each temperature level. Comparison between physical and mechanical properties during heat treatment were investigated. All specimens were moist-cured for 28 days after casting. Tests were carried out on specimens cooled slowly to room temperature after heating. Results of this investigation indicated that the replacement of ordinary Portland cement by 10% silica fume by weight improved the compressive strength by about 64.6%, but replacement of ordinary Portland cement by silica fume by ratios 20 and 30% improved the compressive strength by only 28% at 600 C.

This could be attributed to the additional tobermorite gel (CSH phase) which formed due to the reaction of silica fume with Ca (OH)

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3.1.6.5 EXPERIMENTAL STUDY OF PROPERTIES SILICA FUME IN CONCRETE

3.1.6.5.1 Material used:

Ordinary Portland cement (OPC) of Type-I was used as a binder, The crushed aggregate of 20 mm maximum size was used as a coarse aggregate in the concrete. The hill sand was used as a fine aggregate after sieving through standard sieve No.4 (4.75 mm). The aggregates were washed before use in the mix to separate the silt, clay, organic impurities, or any undesired sticky material that adversely affects the quality of concrete. After washing, the wet aggregates were left at room temperature to get the saturated surface dry condition. The coal bottom ash (CBA) was used as a partial replacement material for sand.

Table 1. Properties of cement and coal bottom ash.

Material	Physical Properties		Chemical Analysis (% Age)						
	Blaine (cm^2/g)	Specific Gravity	SiO_2	CaO	Al_2O_3	MgO	K_2O	Fe_2O_3	LOI
Cement	3008	3.14	20.78	60.89	5.11	3.00	0.00	3.17	1.71
CBA	-	2.30	35.37	3.307	28.18	1.956	0.976	20.64	-
Silica Fume	-	2.22	93.28	0.23	0.49	0.9	0.98	1.3	-

Table 2. Concrete mix proportion.

S.No	Mix Type	OPC (kg)	Sand (kg)	CBA (kg)	SF (kg)	C.A (kg)	Water (kg)	W/C (kg)
01	Plain	20	40	0	0	80	10	0.5
02	10CBA	20	38	2	0	80	10	0.5
03	20CBA	20	36	4	0	80	10	0.5
04	30CBA	20	34	6	0	80	10	0.5
05	7.5SF	18.5	32	0	1.5	80	10	0.5
06	10SF	18	30	0	2	80	10	0.5
07	12.5SF	17.5	28	0	2.5	80	10	0.5
08	7.5SF10CBA	18.5	38	2	1.5	80	10	0.5
09	7.5SF20CBA	18.5	36	4	1.5	80	10	0.5
10	7.5SF30CBA	18.5	34	6	1.5	80	10	0.5
11	10SF10CBA	18	38	2	2	80	10	0.5
12	10SF20CBA	18	36	4	2	80	10	0.5
13	10SF20CBA	18	34	6	2	80	10	0.5
14	12.5SF10CBA	17.5	38	2	2.5	80	10	0.5
15	12.5SF20CBA	17.5	36	4	2.5	80	10	0.5
16	12.5SF20CBA	17.5	34	6	2.5	80	10	0.5

3.1.6.5.2 Specimen Preparations and Test Method

The standard size of (150 mm × 300 mm) cylindrical specimens were cast for the determination of compressive strength and splitting tensile strength of concrete. Abram's cone apparatus was used to measure the workability (slump test) of each concrete mix. After 24 h, the concrete specimens were demolded and placed in clean water to cure for 28 and 90 days, respectively. The compressive strength of concrete samples was assessed by an automatic Tecno-Test compression testing machine, having a load capacity of 3000 KN. The tensile strength of concrete specimens was assessed using a Universal Testing Machine (UTM) having a load capacity of 1800 KN. For the corrosion analysis test, cylindrical specimens of 100 × 200 mm were cast. A bar of 12 mm diameter, and 300 mm in length was placed in the center of all specimens. The samples were first immersed in water for 28 days after demolding. After 28 day curing period, specimens were then immersed into the water tank containing a solution of 3% NaCl for 14 days. After 14 days, the samples were removed from the water tank and allowed to air dry. This wet and air-dry curing cycle continued for 90 days.

3.1.6.5.3 Results and Discussions:

1. Workability:

The workability of various mixtures containing different percentages of SF and CBA. From the figure, it can be seen that the highest workability recorded was 114 mm, which represents plain concrete, while the smallest workability was recorded at 34 mm when using 15% silica fume as cement replacement and 30% coal bottom ash as fine aggregate replacement. From the results, it can be concluded that workability decreases as the percentage of SF and CBA increases also found that due to the porous nature of CBA, the workability reduces as CBA absorbs higher amounts of water during mixing. who found that as the dosage of silica fume increased, the workability decreased, because of the porous nature of CBA and SF. Furthermore, Figure 4 shows the workability of mixes containing silica fume as cement replacement with 5, 10, and 15%. From the Figure 2, it can be seen that as the percentage of SF increases, the workability decreases.

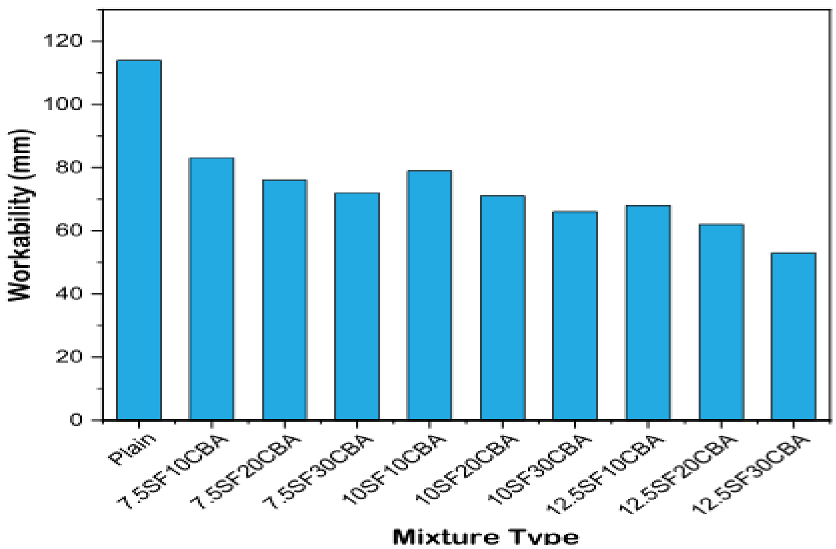


Figure 3-20:Workability of mixture blended with different percentages of CBA

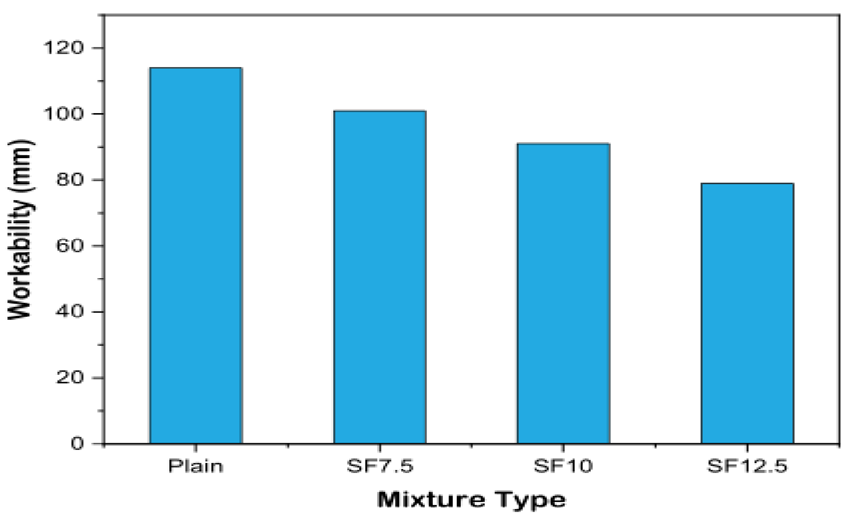


Figure 3-21: Workability of mixture blended with different percentages of Sf

3.1.6.5.4 Workability of mixture blended with SF.

2. Compressive Strength

The compressive strength of concrete containing various percentages of silica fume. The Maximum strength after 28- and 90-day curing was achieved for the mixture containing 12.5% silica fume. An increment of 15.76% and 11.98% could be noted after 28- and 90-day water curing, respectively. Furthermore, Figure 5 is clear evidence that as the percentage of silica fume increases, the strength of concrete increases

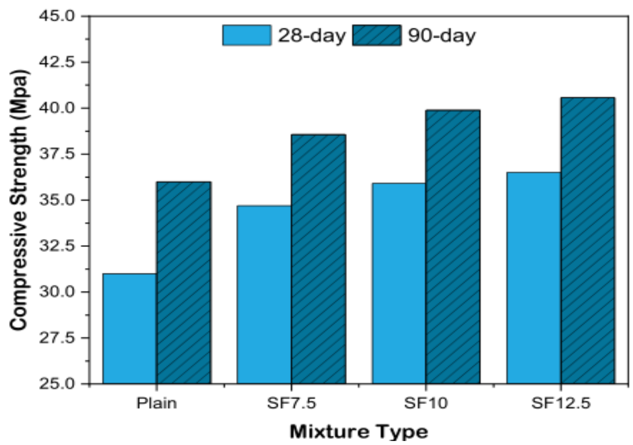


Figure 3-22: The compressive strength of concrete containing various percentages of silica fume.

3.1.6.5.5 Compressive strength of concrete with Silica Fume.

3. Split Tensile Strength

The tensile strength of concrete containing silica fume after 28- and 90-day water curing. When 12.5% SF was substituted with cement, the maximum strength was 4.29 Mpa and 4.66 Mpa after 28 and 90 days of water curing, respectively. Similarly, for the same curing periods, the minimum strength was found to be 3.63 Mpa and 3.64 Mpa, respectively, when 7.5% SF was replaced with cement. However, a marginal increment of almost 4% could be seen for the 12.5 SF mix when compared with 10 SF. Roy et al. and Hanumesh et al. in their study, concluded that the strength of concrete starts decreasing when the amount of SF exceeds by 10% cement replacement in their study, mentioned a decrease in the strength of SF beyond 10% replacement of cement. The maximum amount of SF added in the current study was 12.5%, which was not used in the previous investigations. Though a very marginal increment of 3.96% after 28-day water curing could be seen from Figure 8 for 12.5 SF when compared with 10 SF.

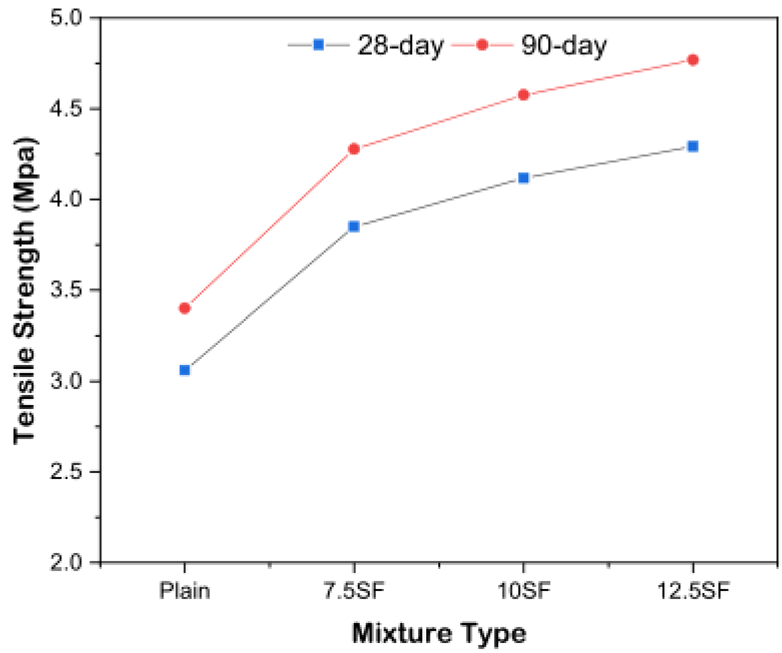


Figure 3-23: The Tensile strength of concrete containing various percentages of silica fume.

3.1.6.5.6 Tensile Strength of concrete mixed with SF.

The split tensile strength of concrete mixed with various amounts of silica fume (7.5–12.5%) replaced with cement and CBA (10–30%) substituted with fine aggregates. From the figure, it could be finalized that the mixture containing 30% CBA and 12.5% SF has the maximum tensile strength. The optimum tensile strength was found to be 4.74 Mpa and 5.21 Mpa after 28- and 90-day water curing, respectively. Tensile strength was raised by up to 35.44% and 36.85% after 28- and 90-day curing, respectively, as compared to ordinary concrete. However, the minimum tensile strength of 3.45 Mpa and 3.79 Mpa was found under mixture 7.5 SF10 CBA after 28- and 90-day curing. The increase in tensile strength could be attributed to the surface area of silica fume and CBA.

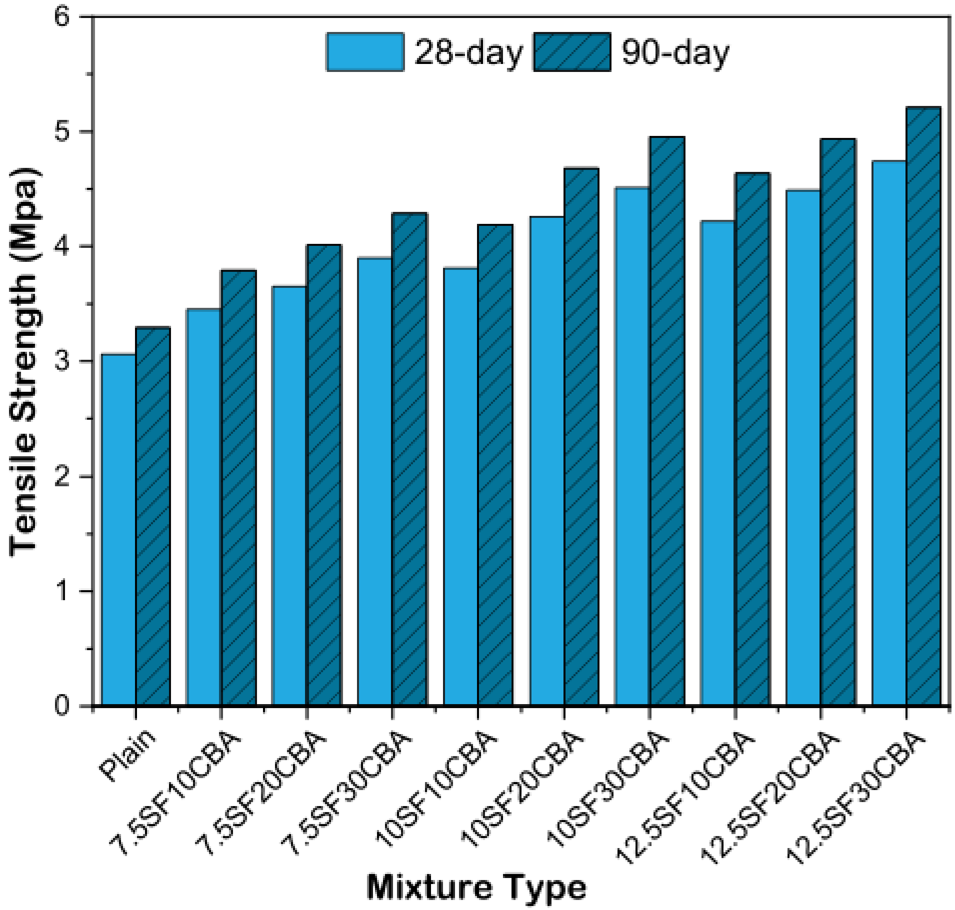


Figure 3-24 :Tensile Strength of concrete mixed with CBA and SF.

4 Ch4: Experimental Program

4.1 The materials used in the mixture:

4.1.1 Cement

It is the soft bonding material that hardens and hardens, thus having cohesive and adhesive properties in the presence of water, which makes it able to bind the components of concrete to each other. The most important use of cement is mortar and concrete, where it binds synthetic or natural materials to form strong building materials that are resistant to normal environmental influences. Concrete should not be confused with cement, as cement refers to the dry powder used to bind aggregate materials to concrete. There are two types of cement used in construction: hydrated cement and non-aqueous cement

Cement industry is considered of strategic industries. However, it is a simple industry compared to the major industries, and it depends on the availability of raw materials for that

cement composition

The basic mixture for the cement industry consists of

- Limestone for the extraction of lime (Calcite)
- Clay for the extraction of silica and bauxite.
- Clay lime has specifications of approximately 80% lime, 20% clay, and remedial materials: iron oxides (fe2o3), bauxite (Al_2O_3), sand (SiO_2) and these materials are added to reach the desired
  Composition3

4.1.2 Sand

Sand that has a fineness calibration of approximately 3 gives the best workability and the greatest pressure resistance.
As for the large aggregate: the size of the large aggregate should range between 9 to 13 mm, and the cohesion strength (BOND) for granules size 76 mm is equal to 10% of the cohesion strength of 13 mm granules
3 / m / h ratio: it is known that reducing this ratio increases the pressure resistance "taking into account the operating and casting factors"
And any change in the ratio affects the final resistance.
It was found that high-strength concrete, the optimum ratio for it, ranges from 0.27 to 0.5

4.1.3 Aggregate

Aggregate is an inert granular material such as sand, gravel and crushed rock, which together with water and cement constitute the basic components of concrete. For a high quality concrete mix, the aggregate must be clean, solid and strong, and the aggregate particles must be free from any absorbing chemicals or covered with any type of clay or any kind of fine materials that may contribute to the deterioration of the condition and quality of concrete. . The aggregate, which constitutes (60-70%) of the total concrete volume, can be divided into two types: fine aggregate and coarse aggregate.

- Fine aggregates in general consist of natural sand or crushed rock, so that the grains of that aggregate can pass through a sieve with holes of diameters (9.5 mm) or (3/8) in.
- For coarse aggregate, its granules are greater than (0.19 inches) or (4.75 mm), but they generally range from 3/8 to (1.5) inches or (9.5 - 37.5) mm in diameter.

4.1.3.1 The characteristics that must be available in the selected aggregate are:

- Durability
- The shape of the particles and the texture of the surface of the particles.
- Abrasion and slip resistance.
- Unit weight and spaces
- Absorption and surface moisture
- granular gradient

4.1.4 water

The compressive strength of concrete is a major characteristic of concrete mix. The change in the amount of water changes the strength of the concrete. If water is used in larger quantities, it may result in more voids and greatly develop nesting in the hardened concrete. This results in a decrease in density, durability and strength. The lower the water/cement ratio, the stronger the concrete.

- An essential element in the chemical reaction with the cement, and it is also necessary for it to be absorbed by the aggregate used in concrete.
- Water is necessary for the processes of softening concrete while it hardens.
- Water gives the mixture consisting of coarse and fine aggregates and cement an appropriate degree of ductility that helps it to operate and form
- In the presence of water, a larger amount of aggregate can be mixed with the same amount of cement.
- The water gives a volume of concrete ranging between 15-20%.
- Part of the water in the concrete mix is lost during the evaporation process

4.1.5 Silica fume

Silica fume is a byproduct of producing silicon metal or ferrosilicon alloys. One of the most beneficial uses for silica fume is in concrete. Because of its chemical and physical properties, it is a very reactive pozzolan. Concrete containing silica fume can have very high strength and can be very durable. Silica fume is available from suppliers of concrete admixtures and, when specified, is simply added during concrete production. Placing, finishing, and curing silica-fume concrete require special attention on the part of the concrete contractor.

- Silica-fume concrete

should be transported, placed, finished, and cured following the good concreting practices outlined by the American Concrete Institute. Flatwork containing silica fume concrete generally requires less finishing effort than conventional concrete. The photo shows the "one-pass" finishing process in which the silica-fume concrete is placed, consolidated, and textured with little or no waiting time between operations. To gain the most benefits from using silica fume, the concrete must be cured effectively. The SFA or your concrete supplier can provide any necessary assistance concerning construction operations.

- Silica-fume concrete does not just happen. A specifier must make a conscious decision to include it in concrete to achieve desired concrete properties. Assistance in specifying silica-fume concrete for high strength or increased durability can be obtained from the SFA or from major admixture suppliers.
- Silica fume for use in concrete is available in wet or dry forms. It is usually added during concrete production at a concrete plant as shown in the photo. Silica fume-concrete has been successfully produced in both central-mix and dry-batch plants. Assistance is readily available on all aspects of handling silica fume and using it to produce consistent, high-quality concrete.

4.1.6 Viscocrete 3425

Sika Viscocrete
3425-is a third generation superplasticizer for homogenous
concrete and mortar.
It meets the requirements for superplasticisers according to ASTM-C- 494 Types G
and F and BS EN 934 part 2: 2001.

- Uses

Sika Viscocrete® -3425 is especially suitable for the production of concrete mixes which require high early strength development, powerful water reduction and excellent flowability Sika ViscoCrete® -3425 is mainly used for the following applications

- Precast Concrete
- ν Concrete with highest water reduction (Up to 30%).
- Self Compacting Concrete (SCC)

❖ Characteristics / Advantages

Sika ViscoCrete® -3425 as a powerful superplasticisier acts by different mechanisms. Through surface adsorption and sterical separation effect on the cement particles, In parallel to the hydration process, the following properties are obtained

- Strong self-compacting behavior Therefore suitable for the production of self-compacting concrete.
- Extremely powerful water reduction (resulting in high density and strengths).
- Excellent flowability (resulting in highly reduced placing and compacting efforts)
- ν Improved shrinkage and creep behavior
- ν Reduced rate of carbonation of the concrete.
- ν Improved Water Impermeability.

4.1.7 polypropylene fiber

- Used as secondary reinforcement, polypropylene fibers help reduce shrinkage and control cracking. To use these fibers, concrete mix design does not have to be altered, and no special equipment or slump modifications are required, even for pumping or shotcreting Only two things must be determined: how much fiber to add and what length of fiber to use. Polypropylene fibers are manufactured in small bundles. During the mixing operation, the movement of aggregate shears these bundles into smaller bundles and individual fibers. If the jobsite is more than a 30-minute drive, the fibers should be added at the site.

❖ FIBER LENGTH

- In fiber-reinforced concrete, cracks can open only if the tensile stresses in the concrete exceed the tensile strength or the pull-out strength of the fibers. The longer the fibers are, the stronger the bond between fibers and paste is and thus the greater the fiber pull-out strength is. If fibers are too long, uniform distribution of the fibers becomes difficult. Longer fibers can be used when larger aggregates are present to shear the bundles of fiber apart. Short fibers are used with small or lightweight aggregate.
- Polypropylene fibers tend to hold the concrete mix together. This slows the settlement of coarse aggregate and thus reduces the rate of bleeding. A slower rate of bleeding means a slower rate of drying and thus less plastic shrinkage cracking. In hardened concrete, polypropylene fibers act as crack arresters. Like any secondary reinforcement, the fibers tend to stop cracks from propagating by holding the concrete together so cracks cannot spread wider or grow longer. However, since polypropylene fibers are distributed throughout the concrete, they are effective close to where cracks start at the aggregate-paste interface

4.1.8 Mixture table

Group B - Silica fume (10%)

OPC	Silica fume (10%)	W/C	water	C.A	F.A	Viscocrete 3425		Polypropylene Fiber	
						%	kg	%	kg
10.935	1.215	0.48	5.832	16.2	32.4	0	0	0	0
10.935	1.215	0.48	5.832	16.2	32.4	1.8	0.2187	0	0
10.935	1.215	0.48	5.832	16.2	32.4	1.8	0.2187	0.1	0.0122
10.935	1.215	0.48	5.832	16.2	32.4	1.8	0.2187	0.2	0.0243
10.935	1.215	0.48	5.832	16.2	32.4	1.8	0.2187	0.3	0.0365
10.935	1.215	0.48	5.832	16.2	32.4	2.1	0.2552	0	0
10.935	1.215	0.48	5.832	16.2	32.4	2.1	0.2552	0.1	0.0122
10.935	1.215	0.48	5.832	16.2	32.4	2.1	0.2552	0.2	0.0243
10.935	1.215	0.48	5.832	16.2	32.4	2.1	0.2552	0.3	0.0365

4.1.9 Batching of concrete

Figure 4-1:Batching

4.1.10 Fresh concrete tests

4.1.10.1 Slump-flow test

4.1.10.1.1 Test Objectives:

Measurement of free flow in the event that there is no obstacle in the concrete Path

4.1.10.1.2 Test steps:

1. Clean the disc well with water and then dry it carefully so that there is no trace of the cleaning water left

2. The mold is placed fixed in the center of the disc by pressing its handles with your hand

3. The mold is filled twice so that the height of each layer is equal to half the height of the mold

4. Note that concrete is self-compacting, so there is no need for a rod to compact or level the surface

5. The metal mold after direct filling is raised regularly in a vertical direction

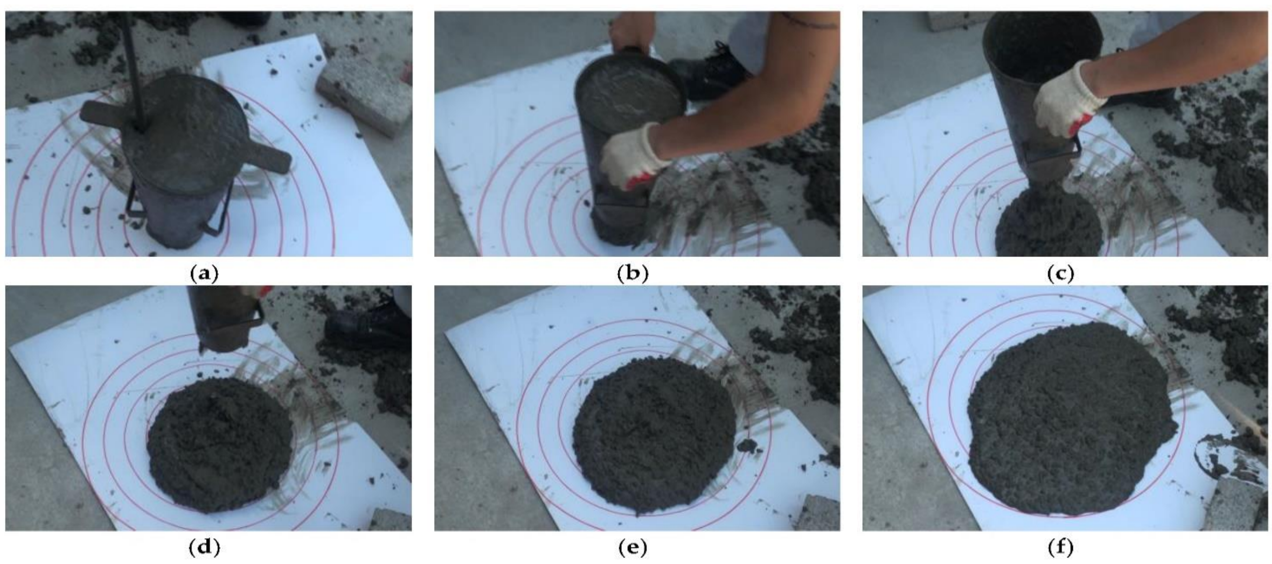


Figure 4-2: Slump Flow Test

4.1.10.2 V - FUNNEL TEST

4.1.10.2.1 Test Objectives :

Measuring the concrete's ability to change course through a narrow area without the occurrence of a blockage where time measurement completely concrete passage in the repression and must not exceed the time 10 seconds.

4.1.10.2.2 Test steps:

1. Equipment repression in the form of 7 is made up.

2. We use about 12 liters of concrete to hold the test.

2. Prove repression on the ground fixed and put underneath pot

4. lock the bottom hole of repression.

5. We fill oppression or concreted without your blood pressure.

6. We open the door to the lower suppression during the 10 seconds of filling funnel concrete

7. Allow concrete to flow under the influence of gravity.

8. Use the stopwatch to record the time it takes to fully offload repression

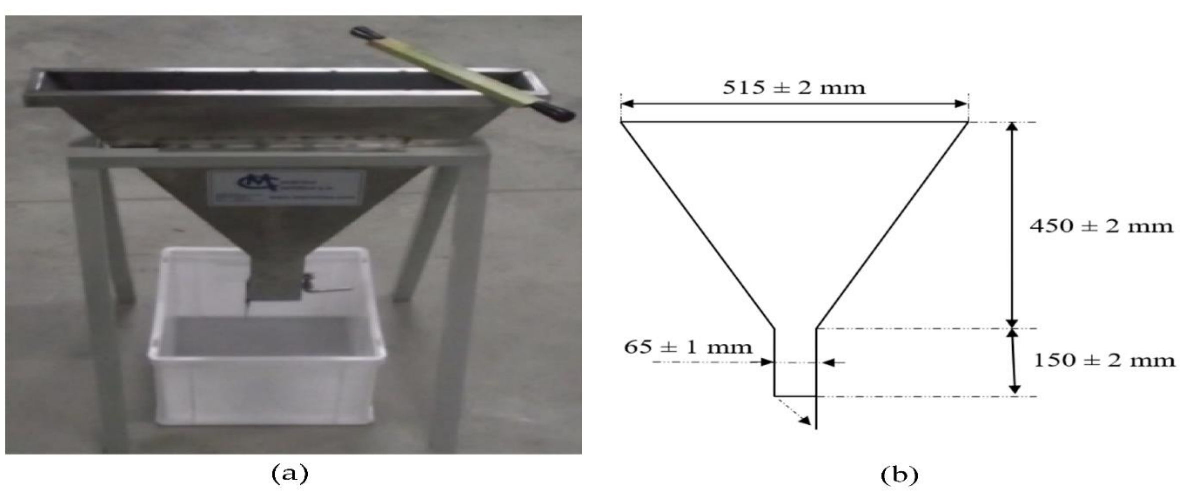


Figure 4-3:V-Funnel apparatus

4.1.10.3 L-Box test

4.1.10.3.1 Test Objectives :

Determination of the passing capacity of self-compacting concrete

4.1.10.3.2 Test steps:

1. The device horizontally while ensuring ease of opening and closing the gate

2. Wetting the surfaces of the device without leaving any drops stuck water

3. Filling the vertical part concreted with left for two minutes after lift the gate to rush concrete in the horizontal device through Skewers steel.

4. Measuring the time in seconds required for the concrete front to reach the 200mm mark.

5. Measuring the time required in seconds for the introduction of concrete in order to reach the mark of 400 mm.

6. When the concrete stops are measured. H2 - H1

7. A visual examination is done.

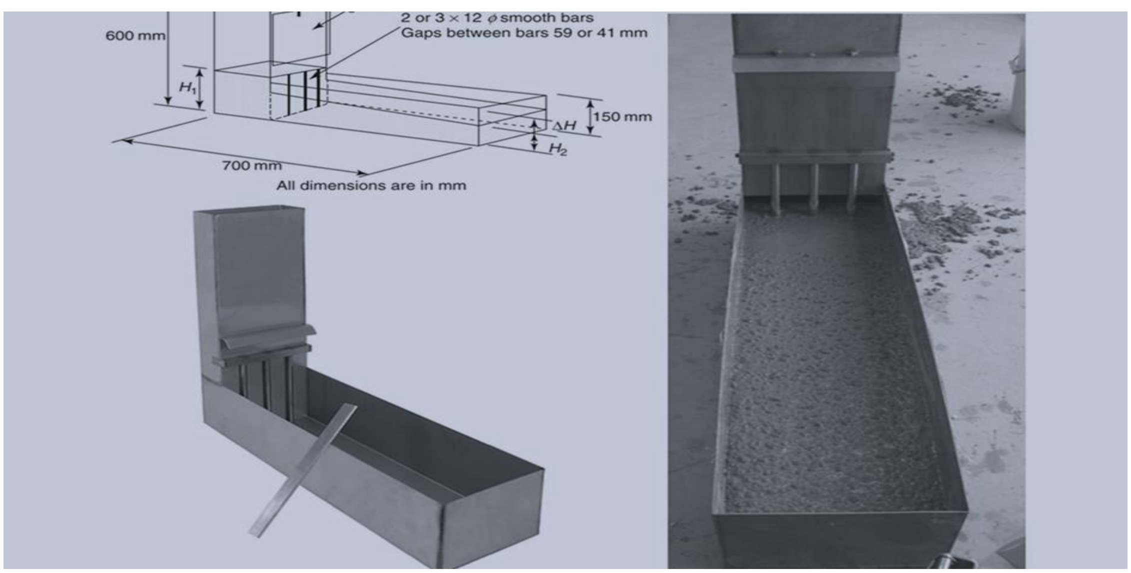


Figure 4-4:L-box Apparatus

4.2 Fresh concrete test results

4.2.1 Slump-flow test (J-ring)

Mix No	Fiber percentage (%)	Viscocrete3425 (%)	Diameter (cm)	L2 (cm)	L1 (cm)	L2-L1 (cm)
2	0	1.8	68	9.6	9.2	.4
3	0.1	1.8	62	11.8	11.2	.6
4	0.2	1.8	58	12.8	12	.8
5	0.3	1.8	52	11.9	10.7	1.2
6	0	2.1	74	13.6	13	.6
7	0.1	2.1	69	12.9	12	.9
8	0.2	2.1	62	12.2	10.8	1.4
9	0.3	2.1	58	15.1	13	2.1



Figure 4-5: J-Ring Test

4.2.2 V-Funnel test

Mix No	Fiber percentage (%)	Viscocrete3425 (%)	time (s)
2	0	1.8	7.3
3	0.1	1.8	7.9
4	0.2	1.8	8.4
5	0.3	1.8	8.7
6	0	2.1	5.8
7	0.1	2.1	6.3
8	0.2	2.1	6.9
9	0.3	2.1	7.6

Figure 4-6:V-Funnel Test (Batching)

4.2.3 L-Box test

Mix No	Fiber percentage (%)	Viscocrete3425 (%)	H2/H1 (cm)
2	0	1.8	0.96
3	0.1	1.8	0.93
4	0.2	1.8	.91
5	0.3	1.8	0.88
6	0	2.1	0.94
7	0.1	2.1	0.93
8	0.2	2.1	0.92
9	0.3	2.1	0.87

Figure 4-7:L-Box Test (Batching)

After completing the tests for each mixture, we poured:

- 6 cubes

- 3 beams (For each mixture)

- 3 cylinders

Figure 4-8:Concrete Pouring

4.2.4 Results of Hardened concrete tests:

4.2.4.1 cube Compressive strength results after 7

4.2.4.1.1 The first mixture

cube	weight	Load (kN)	Compressive Strength MPa (N/mm^2)
1	2.394	244.5	24.4
2	2.297	190.3	19.0
3	2.349	187.8	18.7

Cube (1)

Cube (2)

Cube (3)

Figure 4-9 : Cube compressive test (After 7 Days).First Mix

4.2.4.1.2 The second mixture

cube	weight	Load (kN)	Compressive Strength MPa (N/mm^2)
1	2.371	190.3	19
2	2.245	220.4	22
3	2.313	187.4	18.7

Cube (1)

Cube (2)

Cube (3)

Figure 4-10: Cube compressive test (After 7 Days). Second Mix

4.2.4.1.3 The third mixture

Cube	weight	Load (kN)	Compressive Strength MPa (N/mm^2)
1	2.215	235.3	23.5
2	2.225	158.5	15.8
3	2.210	265.9	26.5

Cube (1)

Cube (2)

Cube (3)

Figure 4-11 : Cube compressive test (After 7 Days). Third Mix

4.2.4.1.4 The Fourth mixture

cube	weight	Load (kN)	Compressive Strength MPa (N/mm^2)
1	2.362	232	23.2
2	2.338	237.5	23.7
3	2.339	241.5	24.1

Cube (1)

Cube (2)

Cube (3)

Figure 4-12: Cube compressive test (After 7 Days). Fourth Mix

4.2.4.1.5 The Fifth mixture

cube	weight	Load (kN)	Compressive Strength MPa (N/mm^2)
1	2.364	264.3	26.4
2	2.436	265	26.5
3	2.406	275.6	27.5

Cube (1)

Cube (2)

Cube (3)

Figure 4-13: Cube compressive test (After 7 Days). Fifth Mix

4.2.4.1.6 The sixth mixture

cube	weight	Load (kN)	Compressive Strength MPa (N/mm^2)
1	2.280	157.6	15.7
2	2.335	188.9	18.8
3	2.260	195.1	19.5

Cube (1)

Cube (2)

Cube (3)

Figure 4-14: Cube compressive test (After 7 Days). Sixth Mix

4.2.4.1.7 The seventh mixture

cube	weight	Load (kN)	Compressive Strength MPa (N/mm^2)
1	2.295	219.5	21.9
2	2.290	201.8	20.1
3	2.405	172.4	17.2

Cube (1)


Cube (2)


Cube (3)


Figure 4-15 : Cube compressive test (After 7 Days). Seventh Mix

4.2.4.1.8 The eighth mixture

cube	weight	Load (kN)	Compressive Strength MPa (N/mm^2)
1	2.260	191.5	19.1
2	2.290	207.2	20.7
3	2.295	205.1	20.5

Cube (1)


Cube (2)


Cube (3)

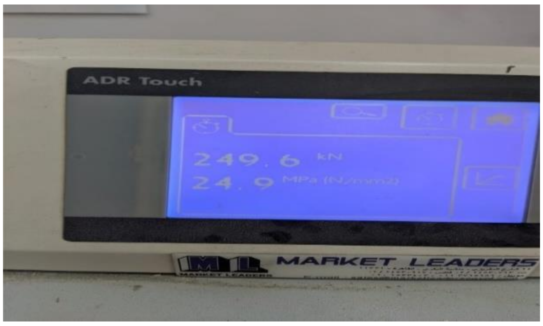

Figure 4-16: Cube compressive test (After 7 Days). Eighth Mix

4.2.4.1.9 The ninth mixture

Cube	weight	Load (kN)	Compressive Strength MPa (N/mm^2)
1	2.370	246.2	24.6
2	2.345	249.6	24.9
3	2.330	206.9	20.6

Cube (1)

Cube (2)



Cube (3)

Figure 4-17 : Cube compressive test (After 7 Days). ninth Mix

4.2.4.2 cube Compressive strength results after 28

4.2.4.2.1 The first mixture

cube	weight	Load (kN)	Compressive Strength MPa (N/mm^2)
1	2.365	295.3	29.5
2	2.370	314.5	31.4
3	2.360	285.7	28.5

Cube 1

Cube 2

Figure 4-18 : Cube compressive test (After 28 Days). First Mix

4.2.4.2.2 The second mixture

cube	weight	Load (kN)	Compressive Strength MPa (N/mm^2)
1	2.270	426.1	42.6
2	2.330	223.6	22.3
3	2.265	378.3	37.8

Cube 1

Cube 2

Cube 3

Figure 4-19 : Cube compressive test (After 28 Days). Second Mix

4.2.4.2.3 The third mixture

cube	weight	Load (kN)	Compressive Strength MPa (N/mm^2)
1	2.400	382.1	38.2
2	2.300	378.5	37.8
3	2.391	337.3	33.7

Cube (1)

Cube (2)

Cube (3)

Figure 4-20 : Cube compressive test (After 28 Days). Third Mix

4.2.4.2.4 The Fourth mixture

cube	weight	Load (kN)	Compressive Strength MPa (N/mm^2)
1	2.375	410	41
2	2.370	414	41.4
3	2.375	455.3	45.5

Cube 1

Cube 2

Cube 3

Figure 4-21: Cube compressive test (After 28 Days). Fourth Mix

4.2.4.2.5 The fifth mixture

Cube	weight	Load (kN)	Compressive Strength MPa (N/mm^2)
1	2.250	440.9	44
2	2.310	429.3	42.9
3	2.205	429.3	42.9

Cube (1)


Cube (2)


Cube (3)


Figure 4-22 : Cube compressive test (After 28 Days). Fifth Mix

4.2.4.2.6 The sixth mixture

Cube	weight	Load (kN)	Compressive Strength MPa (N/mm^2)
1	2.370	363.1	36.3
2	2.355	245.9	24.5
3	2.310	281.5	28.1

Cube (1)

Cube (2)

Cube (3)

Figure 4-23 : Cube compressive test (After 28 Days). Sixth Mix

4.2.4.2.7 The seventh mixture

cube	weight	Load (kN)	Compressive Strength MPa (N/mm^2)
1	2.395	376.3	37.6
2	2.285	283.2	28.3
3	2.350	281.1	28.1

Cube (1)

Cube (2)

Figure 4-24 : Cube compressive test (After 28 Days). Seventh Mix

4.2.4.2.8 The eighth mixture

cube	weight	Load (kN)	Compressive Strength MPa (N/mm^2)
1	2.375	341.2	34.1
2	2.340	382.4	38.2
3	2.305	348.3	34.8

Cube (1)

Cube (2)

Cube (3)

Figure 4-25 : Cube compressive test (After 28 Days). Eighth Mix

4.2.4.2.9 The ninth mixture

cube	weight	Load (kN)	Compressive Strength MPa (N/mm^2)
1	2.420	431	43.1
2	2.290	310.6	31
3	2.305	354.3	35.4

Cube (1)

Cube (2)

Cube (3)

Figure 4-26: Cube compressive test (After 28 Days). ninth Mix

4.2.4.3 Cylinder crushing results after 28 days

Cylinder	weight	Load (kN)	Tensile Strength MPa (N/mm^2)
1	3.990	147.2	4.6
2	4.040	137.4	4.3
3	3.815	112.1	3.5

4.2.4.3.1 The first mixture

Cylinder 1

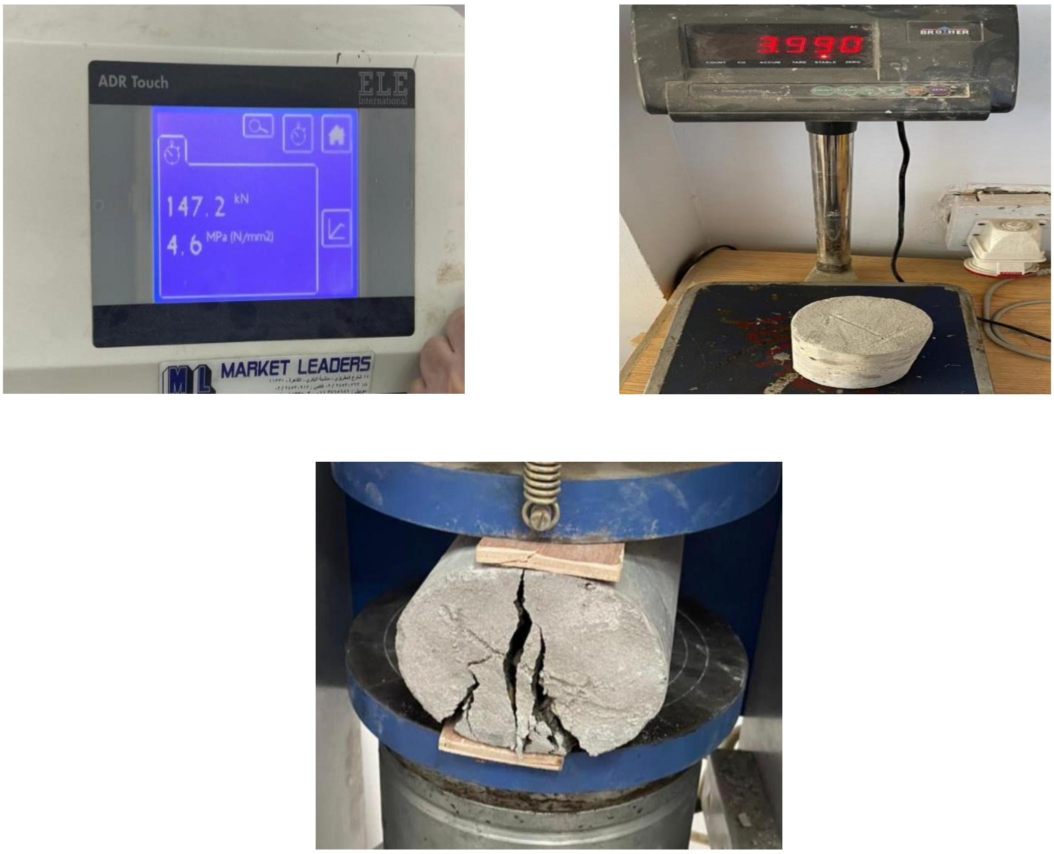


Figure 4-27 : Cylinder Tensile test (After 28 Days). First Mix

Cylinder 2

Cylinder 3

Figure 4-28 : Cylinder Tensile test (After 28 Days). Second Mix

4.2.4.3.2 The second mixture

Cylinder	weight	Load (kN)	Tensile Strength MPa (N/mm^2)
1	3.815	113.7	3.6
2	3.845	129.7	4.1
3	3.795	121.1	3.8

Cylinder 1

Cylinder 2

Cylinder 3

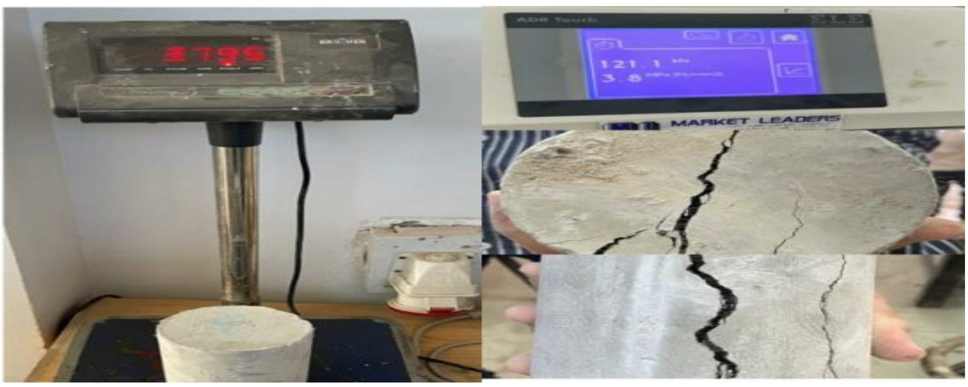


Figure 4-29 : Cylinder Tensile test (After 28 Days). Second Mix

4.2.4.3.3 The third mixture

Cylinder	weight	Load (kN)	Tensile Strength MPa (N/mm^2)
1	3.865	115.7	3.6
2	3.850	138.1	4.3

Cylinder 1

Cylinder 2

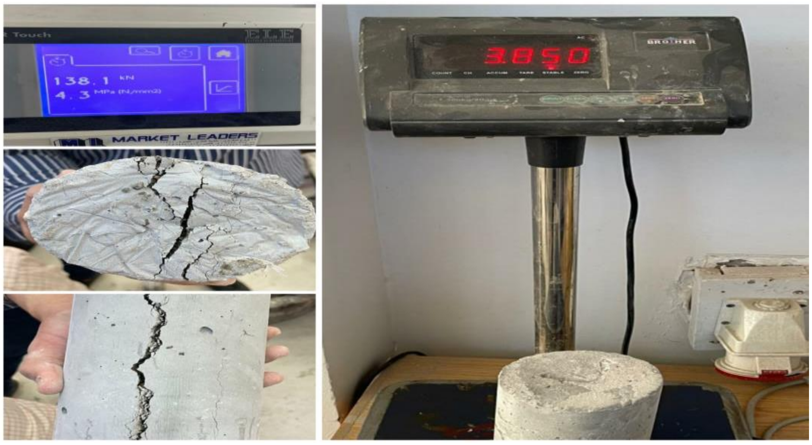


Figure 4-30 : Cylinder Tensile test (After 28 Days). Third Mix

4.2.4.3.4 The fourth mixture

Cylinder	weight	Load (kN)	Tensile Strength MPa (N/mm^2)
1	3.725	143.9	4.5
2	3.815	131.6	4.1

Cylinder 1

Cylinder 2

Figure 4-31 : Cylinder Tensile test (After 28 Days). Fourth Mix

4.2.4.3.5 The fifth mixture

Cylinder	weight	Load (kN)	Tensile Strength MPa (N/mm^2)
1	3.480	119.6	3.8
2	3.815	152.8	4.8

Cylinder 1

Cylinder 2

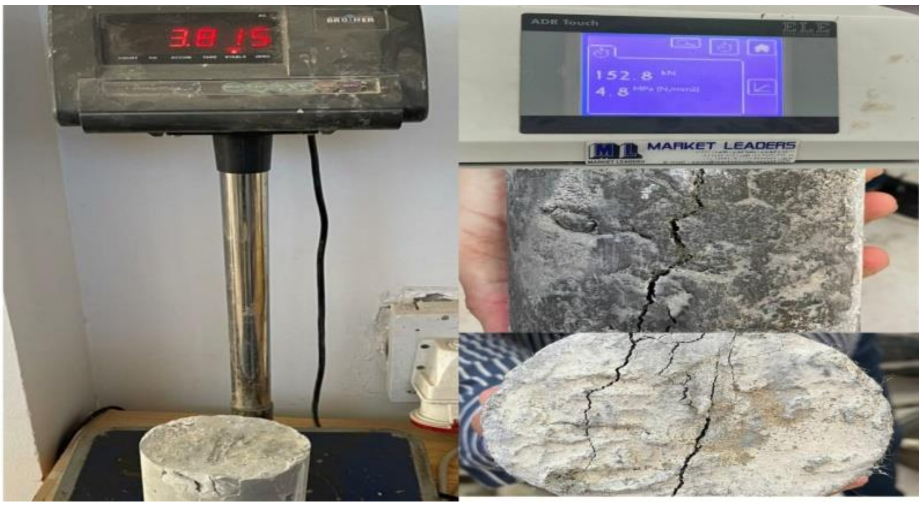


Figure 4-32: Cylinder Tensile test (After 28 Days). Fifth Mix

4.2.4.3.6 The sixth mixture

Cylinder	weight	Load (kN)	Tensile Strength MPa (N/mm^2)
1	3.67	105.3	3.3
2	3.945	80.3	2.5

Cylinder 1

Cylinder 2

Figure 4-33 : Cylinder Tensile test (After 28 Days). Sixth Mix

4.2.4.3.7 The seventh mixture

Cylinder	weight	Load (kN)	Tensile Strength MPa (N/mm^2)
1	3.705	108.3	3.4
2	3.965	121	3.8

Cylinder 1

Cylinder 2

Figure 4-34 : Cylinder Tensile test (After 28 Days). Seventh Mix

4.2.4.3.8 The eighth mixture

Cylinder	weight	Load (kN)	Tensile Strength MPa (N/mm^2)
1	3.860	118.7	3.7
2	3.800	116.4	3.7

Cylinder 1

Cylinder 2

Figure 4-35 : Cylinder Tensile test (After 28 Days). eighth Mix

4.2.4.3.9 The ninth mixture

Cylinder	weight	Load (kN)	Tensile Strength MPa (N/mm^2)
1	3.690	108.4	3.4
2	3.830	126.4	4

Cylinder 1

Cylinder 2

Figure 4-36 : Cylinder Tensile test (After 28 Days). ninth Mix

4.2.4.4 Beams crushing results after 28 days

4.2.4.4.1 The first mixture

Beam	weight	Load (kN)	Flexural Strength MPa (N/mm^2)
1	11.315	10.861	4.887
2	11.135	8.578	3.860
3	10.350	7.208	3.243

Beams 1

Beams 2

Beams 3

Figure 4-37 : Flexural Strength test (After 28 Days). First Mix

4.2.4.4.2 The second mixture

Beam	weight	Load (kN)	Flexural Strength MPa (N/mm^2)
1	10.870	7.802	3.511
2	10.120	6.453	2.904
3	11.020	10.049	4.522

Beams 1

Beams 2

Beams 3

Figure 4-38 : Flexural Strength test (After 28 Days). Second Mix

4.2.4.4.3 The third mixture

Beam	weight	Load (kN)	Flexural Strength MPa (N/mm^2)
1	11.690	11.751	5.288
2	11.580	12.421	5.590
3	11.645	12.605	5.672

Beam1

Beam 2

Beam 3

Figure 4-39 : Flexural Strength test (After 28 Days). Third Mix

4.2.4.4.4 The Fourth mixture

Beam	weight	Load (kN)	Flexural Strength MPa (N/mm^2)
1	12.180	12.758	5.741
2	12.125	12.179	5.480
3	12.153	12.469	5.611

Beams 1

Beams 2

Figure 4-40 : Flexural Strength test (After 28 Days). Fourth Mix

4.2.4.4.5 The Fifth mixture

Beam	weight	Load (kN)	Flexural Strength MPa (N/mm^2)
1	11.190	12.505	5.627
2	11.485	13.424	6.041
3	11.895	13.422	6.040

Beams 1

Beams 2

Beams 3

Figure 4-41 : Flexural Strength test (After 28 Days). Fifth Mix

4.2.4.4.6 The Sixth mixture

Beam	weight	Load (kN)	Flexural Strength MPa (N/mm^2)
1	11.360	9.428	4.243
2	10.920	10.008	4.504
3	11.190	9.718	4.373

Beams 1

Beams 2

Beams 3

Figure 4-42 : Flexural Strength test (After 28 Days). Sixth Mix

4.2.4.4.7 The Seventh mixture

Beam	weight	Load (kN)	Flexural Strength MPa (N/mm^2)
1	11.080	10.864	4.889
2	10.405	9.657	4.345
3	10.910	9.500	4.275

Beams 1

Beams 2

Beams 3

Figure 4-43 : Flexural Strength test (After 28 Days). Seventh Mix

4.2.4.4.8 The eighth mixture

Beam	weight	Load (kN)	Flexural Strength MPa (N/mm^2)
1	11.645	11.521	5.184
2	11.205	11.091	4.991
3	11.155	11.162	5.023

Beam 1

Beam 2

Beam 3

Figure 4-44: Flexural Strength test (After 28 Days). Eighth Mix

4.2.4.4.9 The sixth mixture

Beam	weight	Load (kN)	Flexural Strength MPa (N/mm^2)
1	12.345	13.308	5.988
2	12.530	12.873	5.793
3	12.280	12.871	5.792

Beams 1

Beams 2

Beams 3

Figure 4-45 : Flexural Strength test (After 28 Days). Sixth Mix

5 Ch5: Results and Discussion

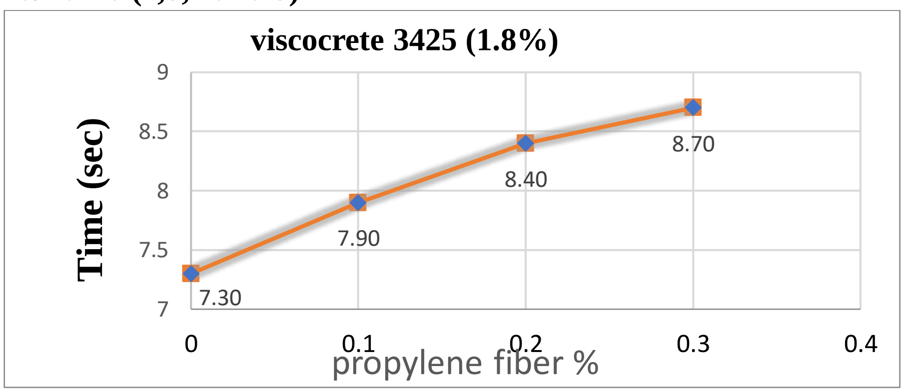
5.1 Results of fresh concrete tests

5.1.1 V – Funnel test

Mix No	Fiber percentage (%)	Viscocrete3425 (%)	time (s)
2	0	1.8	7.3
3	0.1	1.8	7.9
4	0.2	1.8	8.4
5	0.3	1.8	8.7
6	0	2.1	5.8
7	0.1	2.1	6.3
8	0.2	2.1	6.9
9	0.3	2.1	7.6

5.1.1.1 The relationship between (Time and Polypropylene Fiber)

5.1.1.1.1 Mixture No (2,3,4 and 5)



5.1.1.1.2 Mixture No (6,7,8 and 9)

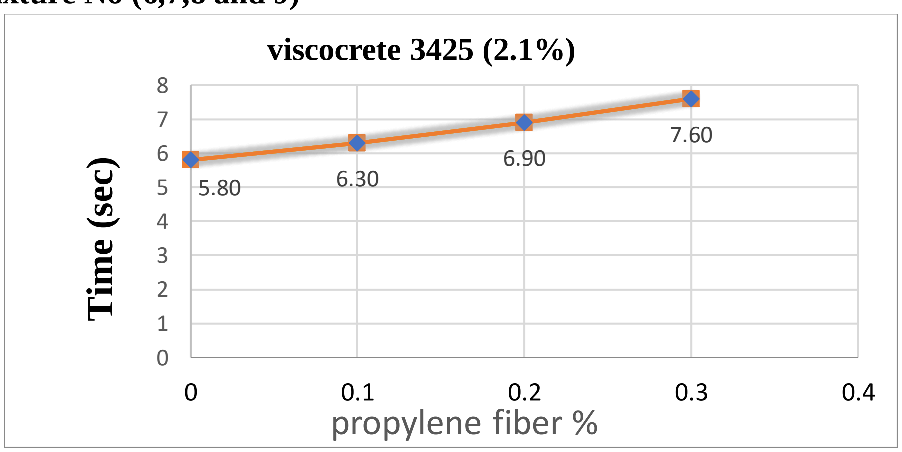


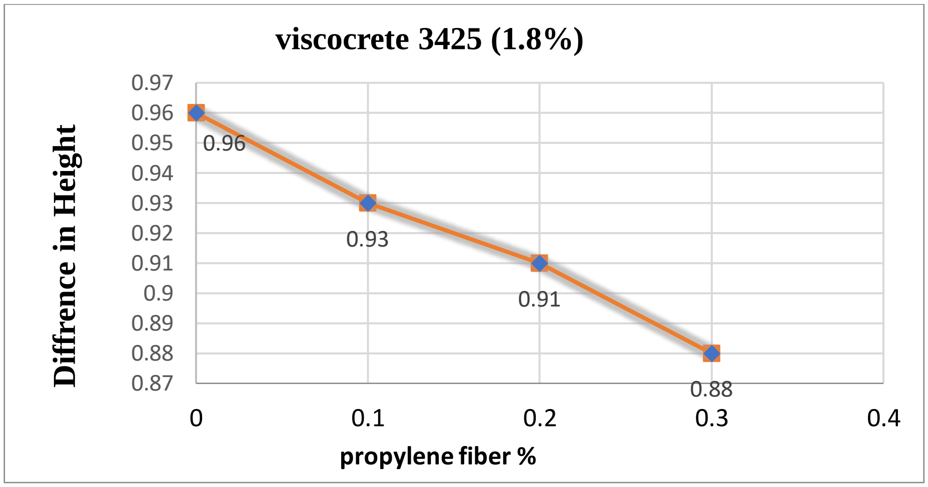
Figure 5-1 : The relationship between (Time and Polypropylene Fiber)

5.1.2 (L – Box test)

Mix No	Fiber percentage (%)	Viscocrete3425 (%)	H2/H1 (cm)
2	0	1.8	0.96
3	0.1	1.8	0.93
4	0.2	1.8	.91
5	0.3	1.8	0.88
6	0	2.1	0.94
7	0.1	2.1	0.93
8	0.2	2.1	0.92
9	0.3	2.1	0.87

5.1.2.1 The relationship between (H2/H1 and Polypropylene Fiber)

5.1.2.1.1 Mixture No (2,3,4 and 5)



5.1.2.1.2 Mixture No (6,7,8 and 9)

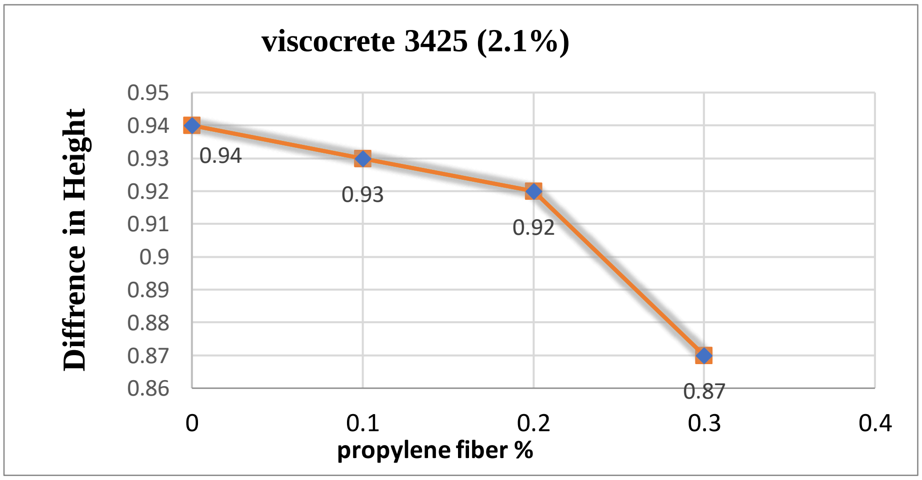


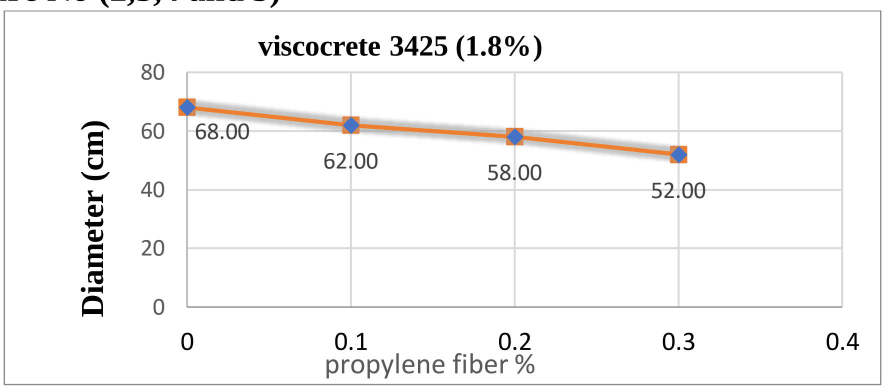
Figure 5-2 : The relationship between (H2/H1 and Polypropylene Fiber)

5.1.3 (J – Ring Test)

Mix No	Fiber percentage (%)	Viscocrete3425 (%)	Diameter (cm)	L2 (cm)	L1 (cm)	L2-L1 (cm)
2	0	1.8	68	9.6	9.2	.4
3	0.1	1.8	62	11.8	11.2	.6
4	0.2	1.8	58	12.8	12	.8
5	0.3	1.8	52	11.9	10.7	1.2
6	0	2.1	74	13.6	13	.6
7	0.1	2.1	69	12.9	12	.9
8	0.2	2.1	62	12.2	10.8	1.4
9	0.3	2.1	58	15.1	13	2.1

5.2 The relationship between (Diameter and Polypropylene Fiber)

5.2.1 Mixture No (2,3,4 and 5)



5.2.2 Mixture No (6,7,8 and 9)

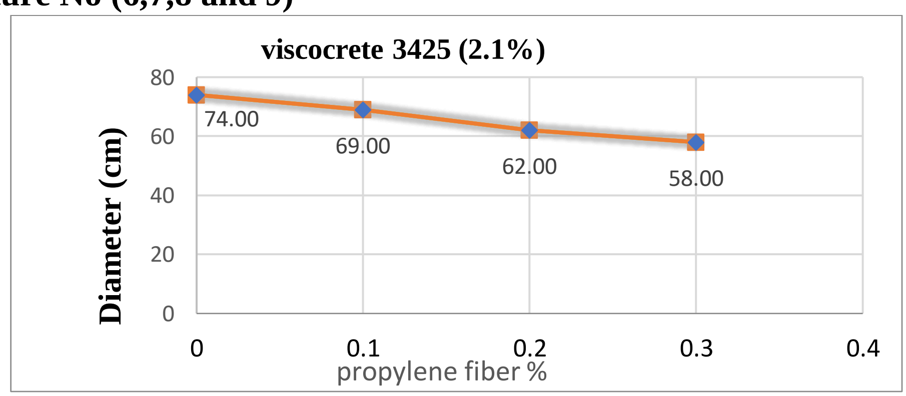
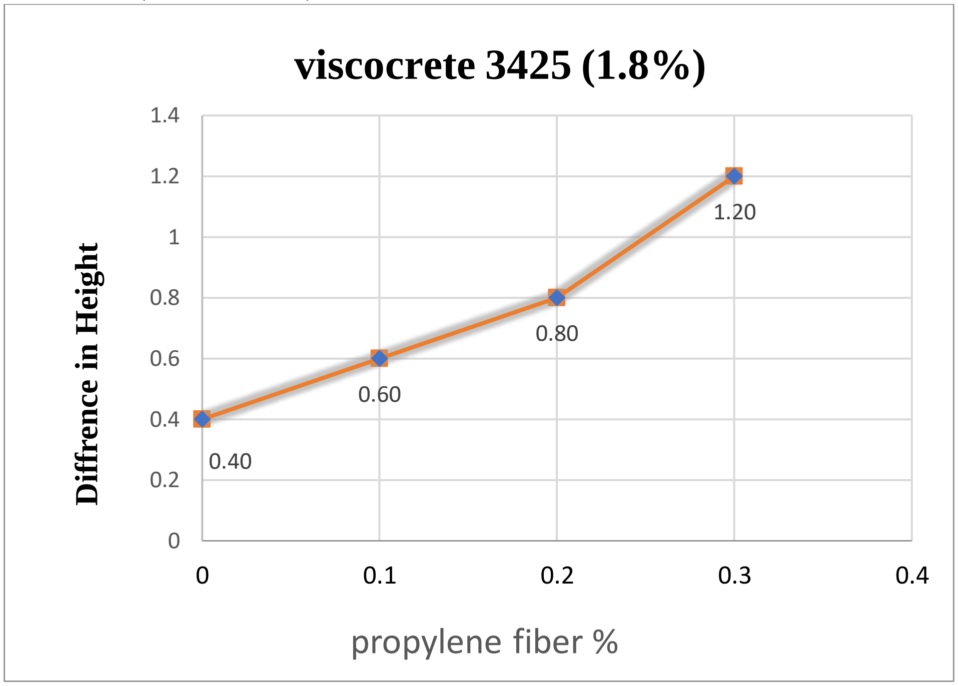


Figure 5-3 : The relationship between (Diameter and Polypropylene Fiber)

5.3 The relationship between (L2-L1 and Polypropylene Fiber)

5.3.1 Mixture No (2,3,4 and 5)



5.3.2 Mixture No (6,7,8 and 9)

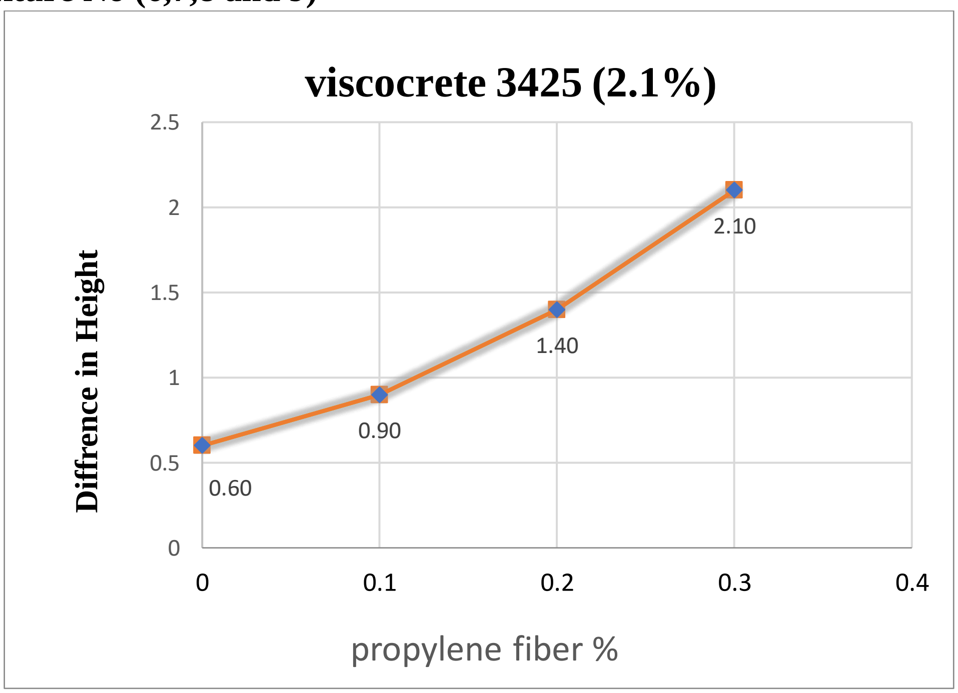


Figure 5-4 : The relationship between (L2-L1 and Polypropylene Fiber)

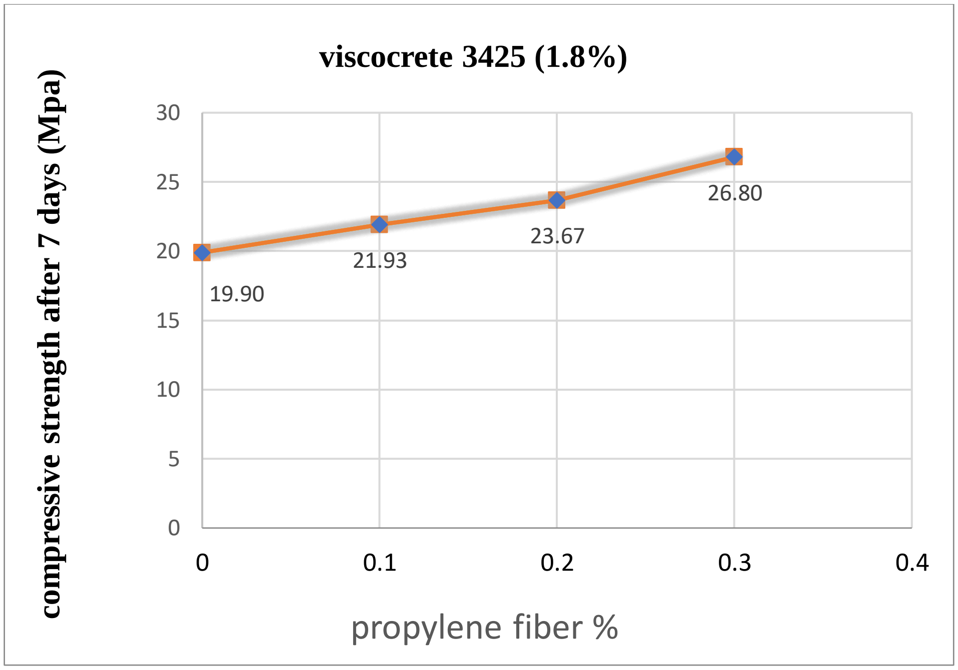
5.4 Results of Hardened concrete tests:

5.4.1 Average cube Compressive strength results after 7 ,28 days

Results After 7 day					
Mix Number	**Weight (Kg)**	**Fracture Load (KN)**	**Compressive Strength (N/mm2)**	**Polypropylene Fiber (%)**	**Viscocrete 3425 (%)**
1	**2.33**	**207**	**20.70**	**0**	**0**
2	**2.36**	**199**	**19.90**	**0**	**1.8**
3	**2.37**	**219.3**	**21.93**	**0.1**	**1.8**
4	**2.24**	**236.7**	**23.67**	**0.2**	**1.8**
5	**2.34**	**268**	**26.80**	**0.3**	**1.8**
6	**2.33**	**180**	**18.00**	**0**	**2.1**
7	**2.29**	**197.3**	**19.73**	**0.1**	**2.1**
8	**2.28**	**201**	**20.10**	**0.2**	**2.1**
9	**2.37**	**233.7**	**23.37**	**0.3**	**2.1**
Results After 28 day					
Mix Number	**Weight (Kg)**	**Fracture Load (KN)**	**Compressive Strength (N/mm2)**	**Polypropylene Fiber (%)**	**Viscocrete 3425 (%)**
1	**2.36**	**298**	**29.80**	**0**	**0**
2	**2.29**	**342.3**	**34.23**	**0**	**1.8**
3	**2.33**	**365.7**	**36.57**	**0.1**	**1.8**
4	**2.34**	**426.3**	**42.63**	**0.2**	**1.8**
5	**2.24**	**433**	**43.3**	**0.3**	**1.8**
6	**2.34**	**296.3**	**29.63**	**0**	**2.1**
7	**2.37**	**313.3**	**31.33**	**0.1**	**2.1**
8	**2.37**	**357**	**35.70**	**0.2**	**2.1**
9	**2.28**	**365**	**36.50**	**0.3**	**2.1**

5.4.1.1 Compressive test after 7 days (cubes)

5.4.1.1.1 Mix no 2,3,4,5



5.4.1.1.2 Mix no 6,7,8,9

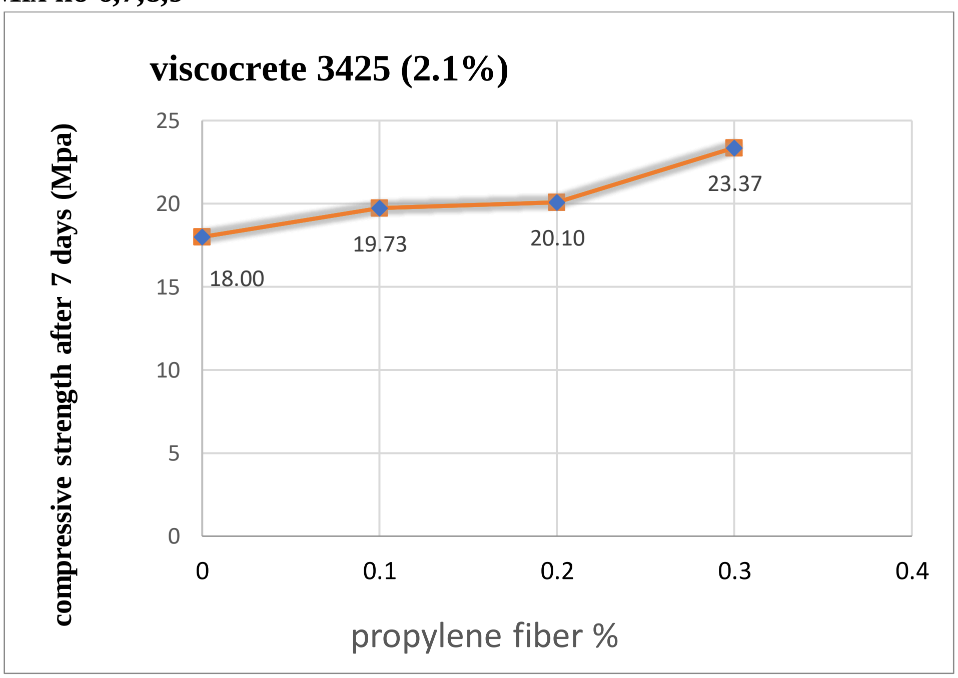
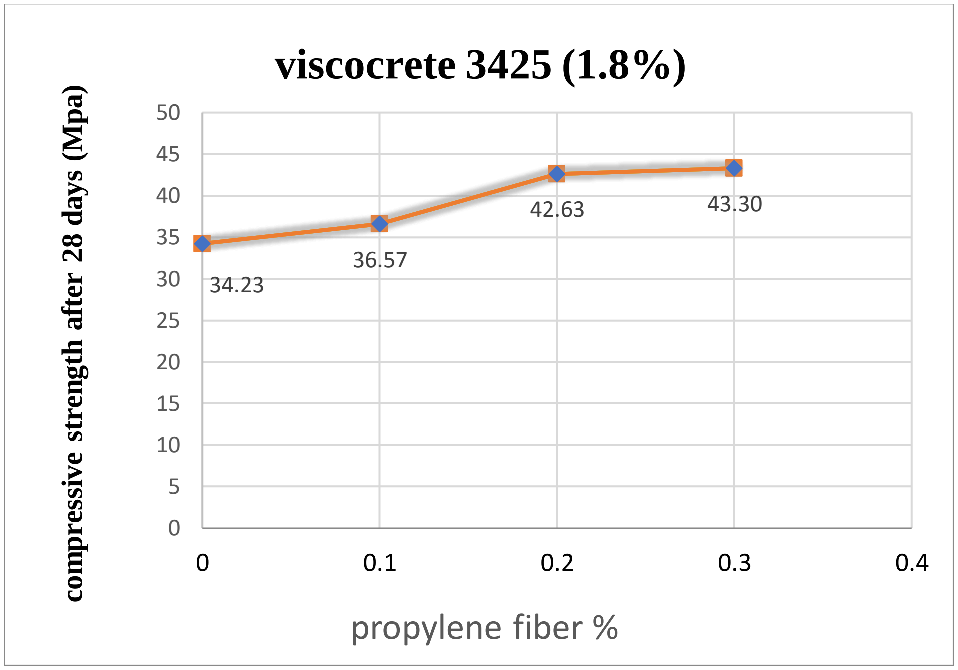


Figure 5-5 :Compressive test Result after 7 days

5.4.1.2 Compressive test after 28 days (cubes)

5.4.1.2.1 Mix no2,3,4,5



5.4.1.2.2 Mix no 6,7,8,9

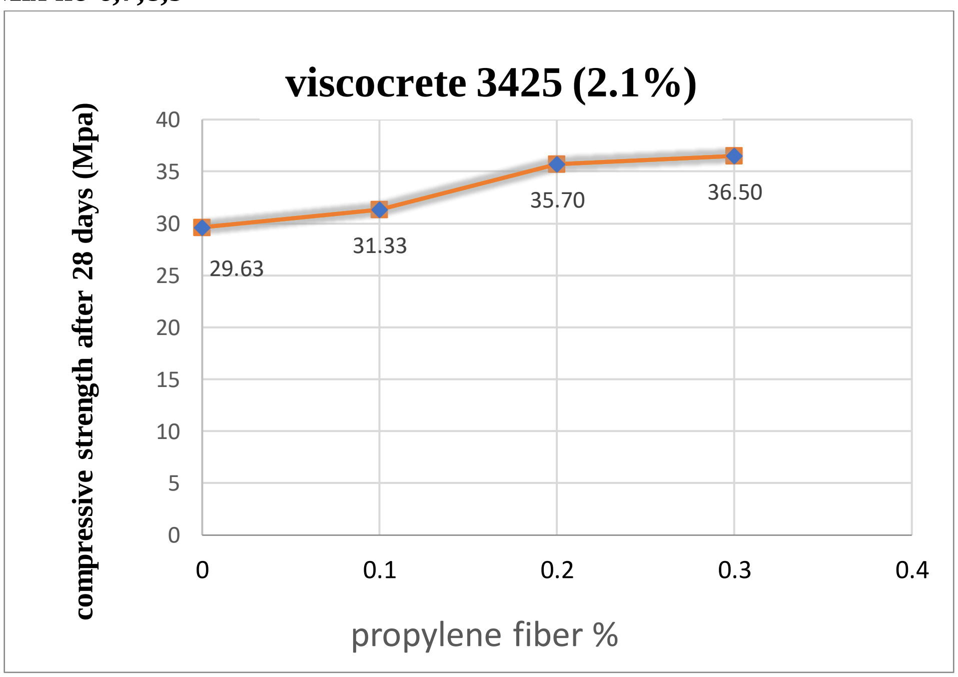


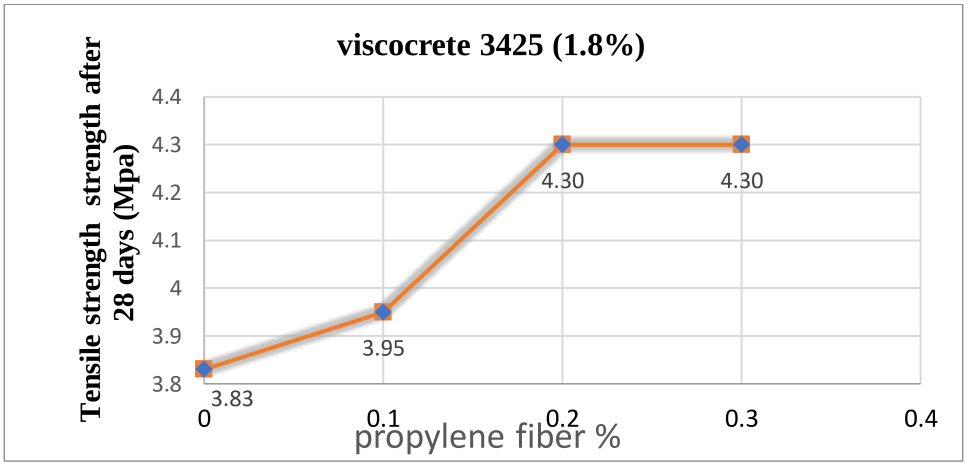
Figure 5-6 :Compressive test Result after 28 days

5.4.2 Cylinder Tensile strength test

Mix Number	Fracture Load (KN)	Tensile Strength (N/mm2)	Polypropylene Fiber (%)	Viscocrete 3425 (%)
1	129.74	4.13	0	0
2	120.322	3.83	0	1.8
3	124.09	3.95	0.1	1.8
4	135.08	4.30	0.2	1.8
5	135.08	4.30	0.3	1.8
6	91.1	2.90	0	2.1
7	113.09	3.60	0.1	2.1
8	116.24	3.70	0.2	2.1
9	116.24	3.70	0.3	2.1

5.4.2.1 Tensile strength after 28 days (cylinders)

5.4.2.1.1 Mix no2,3,4,5



5.4.2.1.2 Mix no 6,7,8,9

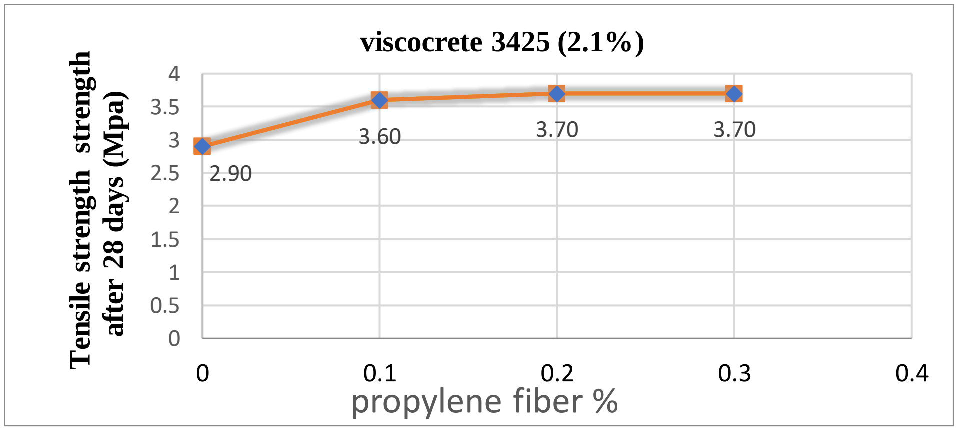


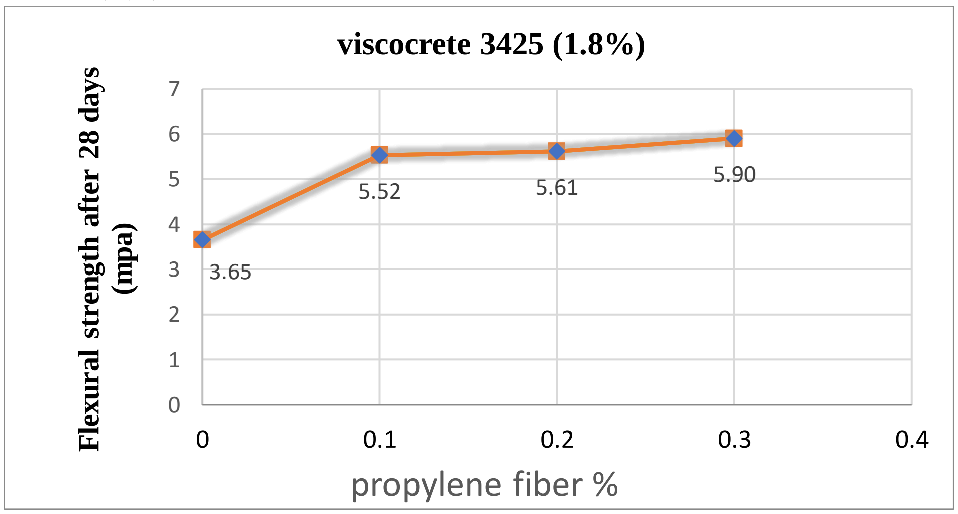
Figure 5-7 :Tensile strength after 28 days (cylinders)

5.4.3 Average beam Flexural strength results after 28 days

Mix Number	Fracture Load (KN)	Flexural Strength (N/mm2)	Polypropylene Fiber (%)	Viscocrete 3425 (%)
1	8.8	4.00	0	0
2	8.1	3.65	0	1.8
3	12.2	5.52	0.1	1.8
4	12.46	5.61	0.2	1.8
5	13.1	5.90	0.3	1.8
6	9.71	4.37	0	2.1
7	10	4.50	0.1	2.1
8	11.26	5.07	0.2	2.1
9	13.02	5.86	0.3	2.1

5.4.3.1 Flexural test after 28 days (beams)

5.4.3.1.1 Mix no2,3,4,5



5.4.3.1.2 Mix no 6,7,8,9

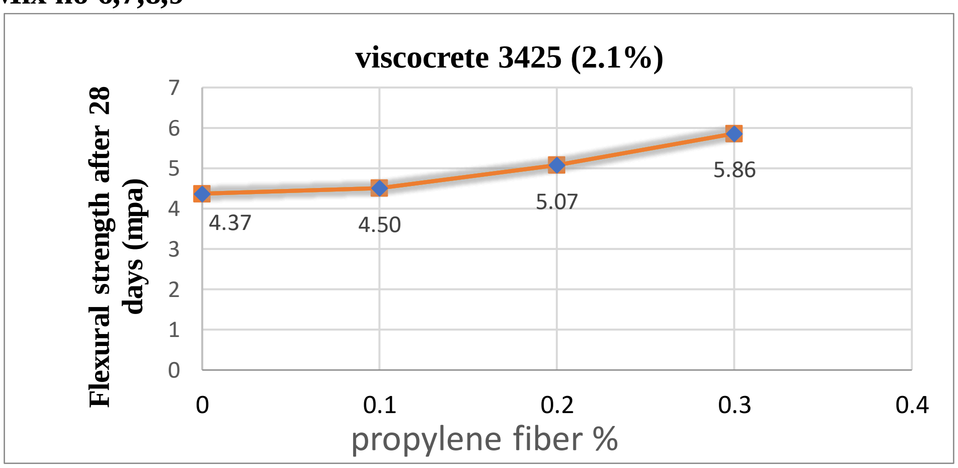


Figure 5-8 :Flexural test after 28 days (beams)

6 Conclusion

SCC is a new type of high-performance cementitious material, and at the same time a new type of production method for casting concrete structures. However, SCC mainly remains a cement-based material, which means that most of our knowledge and understanding based on VC is not obsolete. SCC pushes the limits of classical concrete technology. However, the main driving forces and the fundamental chemical, physical, and mechanical laws remain unchanged. Nevertheless, due to its specific mix design, SCC can sometimes behave differently in comparison with VC.

SCC has high potential for greater acceptance and wider applications in highway bridge construction in the all over world. An NCHRP Research Project has been initiated to develop design and construction specifications to supplement the AASHTO LRFD Bridge Design and Construction Specifications. Based on above results conclusions are drawn and discussions the **following:**

- Self-Compacting Concrete (SCC) technology can save time, cost, enhance quality, durability and Moreover it is a green concept.
- Since the concrete is capable of self-consolidating and reaching the difficult areas in molds, manual variables in terms of placing and compacting concrete is nil. This factor ultimately yields defect less, better-quality concrete structures.
- Cast-in-place concrete construction in tight space and congested reinforcement, such as, drilled shafts, columns and earth retaining systems, can be accelerated by using SCC.
- SCC can't be produced without a sufficient amount of S.P.
- In slump test, When the S.P. Increased in Batches, the diameter of flowing Concrete increased, and the time for SCC to reach 500 mm in diameter decreased.
- In V-funnel test, When the S.P. Increased in Batches, the time for SCC to exit the funnel decreased.
- In V-funnel test, When the PP fiber dose Increased in Batches, the time for SCC to exit the funnel Increased.
- In L-box test, When the S.P. Increased in Batches, the height of SCC at the lower end increased.
- In L-box test, When the PP fiber dose Increased in Batches, the Difference in height of SCC at the lower end decreased.
- In J-ring test, When the S.P. Increased in Batches, the time for SCC to exit the funnel decreased. The diameter of flowing Concrete increased, and the time for SCC to reach 500 mm in diameter decreased. Also, the difference between the inner and outer heights were Increased.
- In J-ring test, When the PP fiber dose Increased in Batches, The diameter of flowing Concrete decreased, And the difference between the inner and outer heights were Increased.
- The compressive and flexure strength were adequate in all Batches for the tested samples

7 Suggested future work

Using another type of fibers to compare their results in both fresh and hardened properties of Scc, and also Using Different types of Pozzolanic materials with Different dose in case of replacement or addition to cementitious materials ratio.

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Appendices

Appendix A: Project Standards

1.Egyptian code ECP: 203 (2020): Egyptian code of practice for design and construction of reinforced concrete structures, Annual Book for testing of materials, part 3, Ministry of Housing and Urbanization, Housing and Building Research Center, Cairo, Egypt.

2.Egyptian standard specification ES requirements (4756-1/2005)

Appendix B: Relation with Environment

Fly ash and Silica fume causes environmental pollution and the storage cost of fly ash is very high, the use of fly ash in concrete technology, both in terms of environmental pollution and the positive impact on the country's economy, is indisputable. Fly Ash concrete offers a holistic approach that can help us achieve the goals of meeting the increasing demands of concrete, enhancing concrete durability with little or no increase in cost (in some cases low cost), and environmentally disposing of large amounts of solid waste products from power plants that coal-fired Several investigations involving concrete containing fly ash had reported to exhibit excellent mechanical and durability properties.

LIST OF FIGURES: