# COMPARISON ON THE EFFECTS OF DIFFERENT FIBERS ON SELF-COMPACTING CONCRETE

**By**

AHMAT ABAKAR MAKINE

Final Dissertation Report

Bachelor of Engineering (Hons)

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University Technology PETRONAS

Bandar Seri Iskandar

31750 Tronoh `

Perak Darul Ridzuan

## CERTIFICATION OF APPROVAL

COMPARISON ON THE EFFECT OF DIFFERET FIBERS ON

SELF-COMPACTION CONCRETE

By

AHMAT ABAKAR MAKINE

A project dissertation submitted to the

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Approved by,

________________________________________

ASS. PROF. DR. NASIR SHAFIQ

UNIVERSITI TEKNOLOGI PETRONAS

TRONOH, PERAK

SEPTEMBER, 2013

## CERTIFICATION OF ORIGINALITY

This is to certify that I am responsible for the work submitted in this project, that the original work is my own except as specified in the references and acknowledgements, and that the original work contained herein have not been undertaken or done by unspecified sources or persons.

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AHMAT ABAKAR MAKINE

# ABSTRACT

The project is intended to develop cost effective of Self- compacting Concrete (SCC) .Nowadays, the construction industry in Malaysia as well as in all over the world is looking for more economical construction materials. In addition, the existing of self-compacting concrete is facing brittleness problem due to their high binder (powder) content and low aggregate amount. Hence, the aim objective of this research is to investigate the effect of different fibers on properties of self-compacting concrete. The aim is supported by two sub-objectives which are to compose the effect of Copped Basalt Fiber (CBF) and Polyvinyl Alcohol Fiber (PVA) with addition of Fly ash (FA) as the filler material on compressive and tensile strength, and to investigate and compare the effect of PVA, CBF on the workability characteristic of SCC. This study can satisfy the requirements of construction standards of self-compacting concrete found in both European Federation of National Associations Representing for Concrete (EFNARC) and Japan Society of Civil Engineers (JSCE). To achieve the research objectives there are different concrete mix has been prepared in UTP concrete laboratory. Experimental work consists of 90 cubes of size 100mm$^3$, 10 cylinders of size 100 x 200 mm$^2$, and 10 beams of 100 x 100 x 500 mm$^3$. The compressive strength was tested for 7days, 28days, and 56days while the splitting tensile and flexural strengths were cast only for 28-days. The concrete mix used in this experimental study formed into two groups of concrete mix. The firs group consists of 100% OPC, while the second group consists of 70% OPC and 30% Fly ash. In each of the above groups different percentage of fibers i.e. 1% and 2% was added and the characteristics of fresh and hardened concrete were investigated. The research project showed that the fibers have slight effect of the fresh properties as well as hardened properties of self-compacting concrete mix (SCC).

# ACKNOWLEDGMENT

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# NOMENCLATURE

SCC = Self- compacting Concrete

CBF = Copped Basalt Fiber (CBF)

PVA = Polyvinyl Alcohol

FA = Fly ash

EFNARC =European Federation of National Associations Representing for Concrete

EFNARC = Japan Society of Civil Engineers (JSCE).

OPC= Ordinary Portland Cement

VMA = Viscosity Modifying Admixtures

AEA = Air Entraining Admixtures

# CHAPTER 1

## 1.1BACKGROUND

Concrete is the second biggest material developed by human being as food and water are the main consumption. The invention of concrete can be obtained by mixing some contents using standard ration and they are cement, fine aggregate, coarse aggregate as well as water. As those mixture added together, it will become a form and become hard like a stone which is called as concrete. Concrete are more economical compare to the steel as it gives higher compressive strength and don't have corrosive characteristic. As it is locally available materials, it is generally used in all the construction work nowadays in order to the concrete to have good strength and durability. The compaction basically is needed and can be done by using the vibration method and it requires sufficient skilled workers. However, the quality of the construction started to reduce inversely proportional to the reduction of the skilled workers. Okamura who realized the situation proposed the solution which required fewer amounts of workers used which is the concrete can be compacted without being compacted manually [1].

The self-compacting concrete or self-consolidating concrete was first discovered by Okamura in 1986 after the Japan had a major problem regarding to the durability of concrete structure in the early 1983. The normal concrete basically need to be compacted by using vibrator which required skilled labor worker. The two types of vibrator that are common used on building construction are immersion vibrators and surface vibrators which have their own specific application. In comparison with self-compacting concrete (SCC), it is an innovative concrete which not requires vibration for compacting process. This worldwide man-made material has the ability to flow on its own and can achieve full compaction by itself even in the presence of congested reinforcement [2].

## 1.2 Problem Statement

1- Brittleness of self-compacting concrete due to their high binder (powder) content.
2- High cost of producing the self-compacting concrete.

## 1.3 Objective:

The main objective of this research is to investigate the effect of different fibers on properties of self-compacting concrete. The main objective of the project is subdivided into two sub-objectives as below.

1- To investigate and compare the effect of Polyvinlyl alcohol (PVA) and basalt (CBF) fibers on the characteristic of SCC.
2- To study the effect of Fly ash on the fresh and hardened properties of the SCC.

## 1.4 Scope of Study

Firstly the project is started with the literature review related to the theory and research on self-compacting concrete and effect of different fibers of self-compacting concrete.

Secondly, data and results will be gathered for experimental works in the concrete laboratory which include the recommended test. Further testing and improvement will be carried out to gain the desired accuracy of results. The research is important for better understanding of the effect of fibers in the self-compacting concrete and also its performance for several aspects. The outcome of this project will benefit all the construction workers in having good construction work in future.

## 1.5 Relevancy of Project

Since a lot of concretes used in the construction work, it is important for us to find out the better improvement for the quality of the concrete for cost saving and future use. Nowadays, numerous types of high rise and mix building have been constructed because the land cost is expensive. In fact, high rise building is more risky and need better concrete for the durability of the building. Self-compaction concrete (SCC) has special characteristic which is high in workability and ductility, thus the durability of the concrete is also high. Another important aspect is that this material will help to save the construction cost as SCC doesn't need any labor workers for compaction. Besides, it reduces noise levels at construction site, thus, environmental pollution can be prevented.

### 1.6 Feasibility of Project

The project will be done in a length of two semesters that includes research study, laboratory experiments, data gathering and results analysis to achieve a comparison of different fibers in SSC on compressive and tensile strength. Based on the descriptions above, it is very clear that the project will be feasible and done within the time frame.

In the four months of the project (FYP 2), the following works are that have been achieved;

1. Performed at UTP in Civil Engineer lab works to prepare samples.
2. Perform compression strength test for 3days, 7days, 28days, and 90days for cube samples.
3. Perform compression fatigue test for 28days for cylinder sample.
4. Come out with result analysis based on the test.

Basically the project is having been done within the scope and time frame as plan. Everything is has track and all of the equipment and materials needed for the project in the Concrete Laboratory and the safety conducted.

# CHAPTER 2

## 2.0 LITERATURE REVIEW

## 2.1 Critical Analysis

From the report related to the Self-Consolidating Concrete by Frances Yang, SCC itself is stands for Self-Consolidating Concrete, or Self-Compacting Concrete and sometimes is called High-Workability Concrete, Self-Leveling Concrete, Those terms above are used to specify this highly workable concrete only requires little to no vibration for compaction [1]. It is the innovative concrete that can be compacted into every corner of the formwork by means of its self-weight only does not requires vibration for placing and compaction [3].

SCC has characteristic which is highly flowable in nature due to very careful mix proportioning, usually coarse aggregate is replacing with fines and cement, and adding some chemical admixtures additives like super plasticizer. It depends on the sensitive balance between creating more deformability while ensuring good stability, as well as maintaining low risk of blockage [4].

### 2.1.1 Chemical Admixture

The three principle chemical admixtures:

a) Super-plasticizer (synthetic high-range water reduces)
b) Viscosity Modifying Admixtures (VMA)
c) Air Entraining Admixtures (AEA)

### 2.1.2 Super-plastisizer

Superplasticizers cause a significant increase in flowability with little effect on viscosity. This can be explained through the experiment where the addition of 0.3 to 1.5 percent (by weight of cement) conventional superplasticizer to a concrete mix with 50-70 mm slump increases slump to 200-250 mm [5]. This means, it exhibited enormous increases in slumps at the recommended dosage [14].

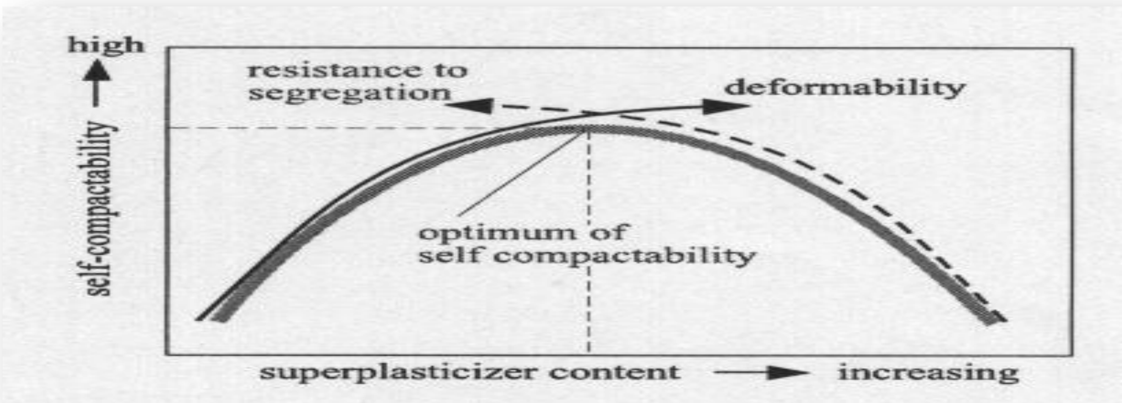



Figure 1 Effect of superplasticizer

**: Effects of superplasticizer.**

The new generation of superplasticizers is based on polycarboxylated ethers, which act as powerful cement dispersants that require less mix water to provide dramatic increase in flow [1]. At the recommended dosage rates the compressive strengths of test cylinders cast from superplasticized concretes were equal to or greater than the strengths of cylinders cast from the control mix even though no at-tempt was made in these tests to reduce the water-cement ratio. This was true for cylinders compacted by vibration as well as those not compacted by vibration [14].

The requirements for superplasticizer in self-compacting concrete are summarized below:

a) High dispersing effect for low water/powder (cement) ratio: less than approx. 100% by volume
b) Maintenance of the dispersing effect for at least two hours after mixing
c) Less sensitivity to temperature changes

### 2.1.3 Fibers Reinforcement Self-compacting Concrete

For some researches done, fibers are mixed together with concrete to enhance its tension and compression performance, as well as perseverance and durability of the concrete. Furthermore, fiber reinforced concrete (FRC) has also been proclaimed to give influence in increased shear and bending resistance in structural members, and to lead to improvement in the bond of reinforcing bars under monotonic and cyclic loading. These advantages enticed researchers to consider and evaluate fiber reinforced concrete for seismic applications as early as in the 1970's. High-performance fiber reinforced cement composites are a class of fiber reinforced concrete characterized by a tensile stress-strain response that exhibits strain-hardening behavior in tension accompanied by multiple shrinkage come up to relatively high composite strains.

### 2.1.4 The Effect Fly ash Fiber on SCC

Fly ash is the combustion residue (coal mineral impurities) in coal-burning electric power plants, which flies out with the flue gas stream and is removed by mechanical separators, electrostatic precipitators, or bag filters. It has long been used as a Portland cement additive or as an active addition in concrete [1–3], due to economic and technological benefits. Two general classes of fly ash can be defined: low-calcium fly ash (FL) produced by burning anthracite or bituminous coal, and high-calcium fly ash (FH) produced by burning lignite or sub-bituminous coal. FL is categorized as a normal pozzolan, a material consisting of silicate glass, modified with aluminum and iron [4]. The CaO content is less than 10%. FL requires Ca(OH)2 to form strength-developing products (pozzolanic activity), and therefore is used in combination with Portland cement, which produces Ca(OH)2 during its hydration.

It is well established that the use of fly ash (FA) in concrete increases the workability and contributes towards long-term strength. The incorporation of FA reduces the need of superplastisizer necessary to obtain a similar slump flow compared with the concrete containing only cement as binder [14]. The strength and shrinkage of SCC containing high volume FA were found to be similar to that of normal concrete. Also the shrinkage was not noticeably different from that of traditional concrete. The results were based at varying water to binder ratios [6]. The present work investigates selected properties of SCC containing FA at constant water to binder (PC+FA) ratio of 0.36. The properties comprised workability, density, compressive strength, absorption, ultrasonic pulse velocity and drying shrinkage. The dosage of chemical admixtures was maintained constant for all FA mixes.

### 2.1.5 The Effect of PVA Fiber on SCC

A report presented by (James S. Davidson, 2008) reported that the tensile strength of the PVA fiber typically between 1600 and 2500 MPa. This strength is considered a promising alternative to other fiber used in engineered cementations composite (ECC). The hydrophilic nature in PVA is very high and thus has a tendency to form strong chemical bonding between the fiber and the hydrated cementations matrix. This highly hydrophilic nature can cause the fiber to rupture rather than pull out during matrix crack. They also performed a test in which to investigate the use of PVA fiber reinforced concrete for rehabilitation and preventive maintenance of aging metal culverts using a spray-on liner application approach. They were preparing severe number of mix and performed the compression testing, flexure testing and tensile testing. The summary from the experiment, its shows the positive result of using PVA fibre in ECC such as increase the ductility. The hydrophilic property is good for water stopping. It has a tenacious bond with the concrete by chasing and absorbing the water in the crack and in all of the micro-fractures that branch off the main crack.

### 2.1.6 The Effect of Basalt Fiber on SCC

Basalt is a hard, dense volcanic igneous rock that can be found in most countries across the globe. For many years, basalt has been used in casting processes to make tiles and slabs for architectural applications. Additionally, cast basalt liners for steel tubing exhibit very high abrasion resistance in industrial applications. In crushed form, basalt also finds use as aggregate in concrete.

The basalt aggregates are higher in specific gravity, and lower in absorption and abrasion loss values. Based on this comparison, it is clearly obvious that basalt is likely to be suitable for use in concrete mixes and this research will investigate this matter.

**Table 1: Key Properties of Limestone and Basalt Aggregates**

| Aggregate Property | Basalt (Fine) | Basalt (Coarse | Limestone (Fine) | Limestone (coarse) |
|---|---|---|---|---|
| Specific Gravity Apparent | 2.943 | 2.917 | 2.673 | 2.626 |
| Specific Gravity (SSD) | 2.843 | 2.814 | 2.605 | 2.552 |
| Specific Gravity (Dry) | 2.791 | 2.765 | 2.558 | 2.508 |
| Absorption (%) | 1.854 | 1.763 | 2.70 | 3.80 |
| Abrasion (%) | 25.9 | 24.4 | 35.0 | 34.8 |

### 2.3 Relevancy and Recentness of the Literature

As it is point out above most of papers on the researches on SCC have started from the development of high rise building in the world around 80’s and 90’s of 20th century, thus the references are taken from the research papers and engineering journals which were written up to now.

# CHAPTER 3

## 3.0 METHODOLOGY

To obtain the above objectives we have built our methodology on the experimental work, there are tens mixes of self-compacting concrete with different fibers have been created.

The outcome of the experimental work could be achieve by examining the self-compacting concrete (SCC) on the fresh concrete and hardness concrete mixed

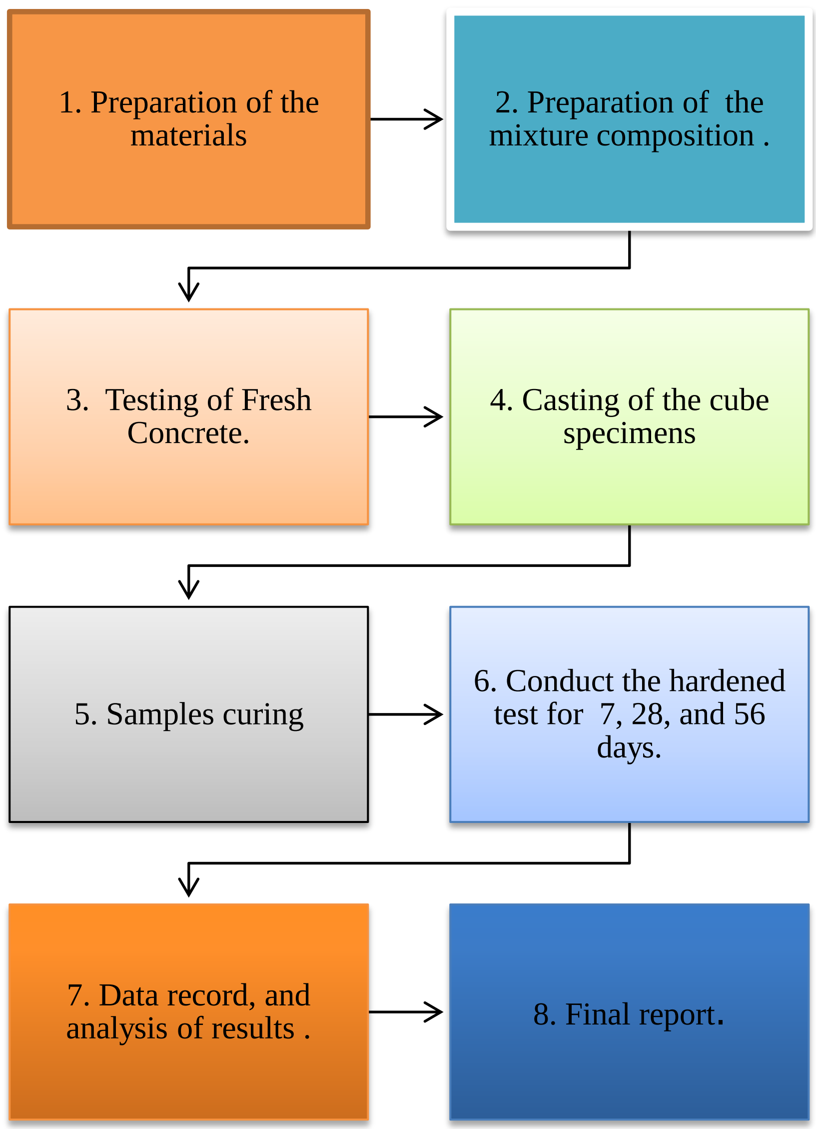
The project activities are conducted according to the methodology to meet the objectives of the research. Furthermore, a reading on literature review studies have been done to achieve the goals of sub objectives highlighted in the earlier part that need to be accomplished and finally to obtain the comparison of fibres of self-compacting concrete. A brief research about the topic is focused on the selected papers which concentrate on the different type of fibres like basalt (CBF) and PVA and fly ash itself.

The issues relevancy between the selected papers and our project's objective need to be taken into account to ensure the credibility of this project.

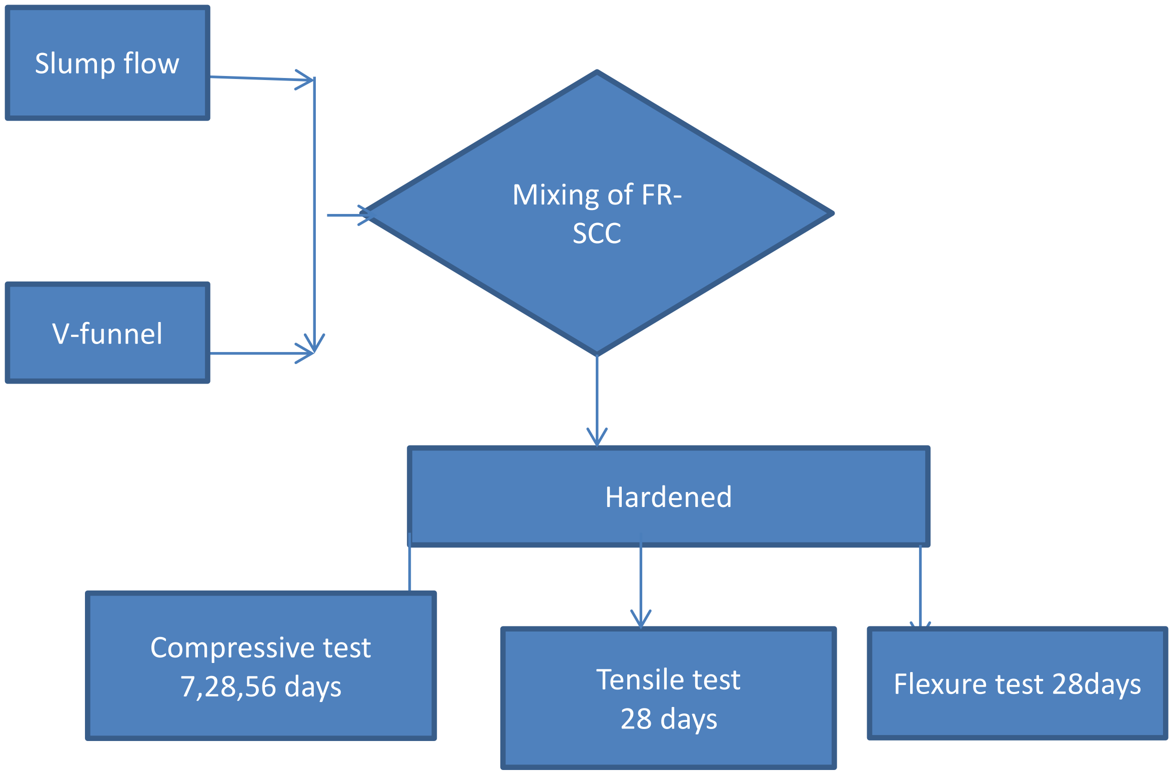
For the other sub objective which is to outline the study of effect of fibers and on self-compacting concrete, literature reviews as well as brief research about the topic are carried out on several resources such as books, journals and also internet

### 3.1 Project Activities Main Flow

The project activities planned throughout the two semesters are shown as in the flowchart below:



### 3.1.1 Flow chart for experiments




### 3.2 Project Activities

These are the details task done throughout the project.

1. Experiment work; for the FRESH CONCRETE TEST;

1) Slump test,

Slump flow test is proposed for testing workability and deformability. Slump flow test judges the capability of concrete to deform under its own weight against the friction of the surface with no external restraint present. No compaction energy must be applied during the test so that the SCC flows only under the influence of gravity. It is based on the slump test described in EN 12350-2. The result is an indication of the filling ability of self-compacting concrete.

The procedure is to pour the fresh concrete into a standard slump cone. Then withdraw the cone vertically upwards in one movement, without interfering with the flow of concrete. Without disturbing the base plate or the concrete, the largest diameter of the flow spread of the concrete to the nearest 10mm. Then the diameter of the flow spread at right angles to it is measured, and the mean of the reading is the slump flow.

2) V-funnel test,

   V-funnel test is proposed for testing viscosity and deformability of concrete. The viscosity of a suspension is dependent mainly on the water/solids ratio and the overall grading curve. This means that a SCC with higher water content flows faster out of the funnel and has a lower viscosity than SCC with lower water content.

   The test is carried out by filling a V shaped funnel with fresh concrete, and the time taken for the concrete to flow out of the funnel is measured and recorded as the V-funnel flow time

2.0 Experimental work :for HARDNED CONCRETE

a) Development of 10 (TEN) mix for FR-self-compacting concrete
b) Experiment on $100m^3$ of cube concrete to check the compression strength at 7, 28 and 56 days.
c) Experiment on 100 x 200 mm cylinder concrete to checking the splitting the tensile strength at 28 days
d) Experiment on 100 x 100 x 500 mm size of beam concrete to check the flexural strength at 28 days.

**3.3 Mixing Proportion**

There are 10 mixes of FR-SCC, where investigated and split into two groups based on binder of group, one was 100% OPC while the other group was 70% OPC + 30% Fly ash .fibers have been utilized as 1.0% and 2.0% by weight of binder per each group.

### Table 2: Concrete Mixture; Group 1, FR-SCC (Binder = 100% OPC)

| Mixing code | OPC kg/m3 | FLY ASH kg/m3 | F.A kg/m3 | C A (5-10mm)kg/$m^3$ | W/C | WATER (kg/m3) | SP% | SP | Fiber Type | Fiber % |
|---|---|---|---|---|---|---|---|---|---|---|
| **$G_1$-$M_1$-00** | 600 | 0 | 900 | 750 | 0.34 | 200 | 2 | 12 | | 0 |
| **$G_1$-$M_2$-1% PVA** | 600 | 0 | 900 | 750 | 0.34 | 200 | 2 | 12 | PVA | 1 |
| **$G_1$-$M_3$-2% PVA** | 600 | 0 | 900 | 750 | 0.34 | 200 | 2 | 12 | PVA | 2 |
| **$G_1$-$M_4$-1% BST** | 600 | 0 | 900 | 750 | 0.34 | 200 | 2 | 12 | CBF | 1 |
| **$G_1$-$M_5$-2% BST** | 600 | 0 | 900 | 750 | 0.34 | 200 | 2 | 12 | CBF | 2 |

### Table 3 : Concrete Mixture; Group2 FR-SCC (Binder =70% of OPC + 30% FLY ASH)

| Mixing code | OPC kg/m3 | FLY ASH kg/m3 | F.A kg/m3 | C A (5-10mm) kg/m3 | W/C | W/b | WATER (kg/m3) | SP % | SP | Fiber Type | Fiber % |
|---|---|---|---|---|---|---|---|---|---|---|---|
| **$G_2$-$M_1$-00** | 420 | 180 | 900 | 750 | 0.32 | 0.34 | 192 | 2 | 12 | ----- | 0 |
| **$G_2$-$M_2$-1% PVA** | 420 | 180 | 900 | 750 | 0.32 | 0.34 | 192 | 2 | 12 | **PVA** | 1 |
| **$G_2$-$M_3$-2% PVA** | 420 | 180 | 900 | 750 | 0.32 | 0.34 | 192 | 2 | 12 | **PVA** | 2 |
| **$G_2$-$M_4$-1% BST** | 420 | 180 | 900 | 750 | 0.32 | 0.34 | 192 | 2 | 12 | **CBF** | 1 |
| **$G_2$-$M_5$-2% BST** | 420 | 180 | 900 | 750 | 0.32 | 0.34 | 192 | 2 | 12 | **CBF** | 2 |

The work is divided into groups; the concrete mixture is used without fly-ash as shown in the table 1, while the fly- ash is used in the concrete mixture as in table 2.

## 3.4 Materials

Materials used in this project were studied separately to acquire the properties which can be important information in analyzing the behavior of the specimens. The materials involved in this project are; cement (OPC), fly ash, superplasticizers , sand, water, PVA fibers, basalt fibers and coarse aggregate.

### 3.4.1 Cement

The cement used in this project is Ordinary Portland Cement (OPC) type 1 according to BS 12 was used for all concrete mixes to maintain the consistency of material usage.

### 3.4.2 Aggregate

The aggregate were divided into two types which are coarse and fine aggregate. All the aggregate are available in the UTP Concrete Laboratory.

#### 3.4.2.1 Fine Aggregate (Sand)

The preparation of sand one day before mixing needed to be done to make sure the aggregate is dry. The sands are sieved to obtain the specified size of 3.0 to 3.735mm and below.

#### 3.4.2.2 Coarse Aggregate (Gravel)

The preparation of gravel also needed to be done one day before mixing. The gravel need to be washed first to remove the dirt on the gravel and keep at the dry place. The size is between (5-10mm).

### 3.4.3 Water

The water ratio for this project is 0.34. The purpose of having the low water/cement ratio is to prevent decreasing in concrete strength.

### 3.4.4 Polyvinyl Alcohol (PVA) Fiber

Polyvinyl alcohol fiber is considered as one of the most suitable polymeric fibers The PVA Fibre also available in UTP Concrete Laboratory. The portion of PVA fibre varies in each sample. It starts with 1.0% and 2.0%. The percentage of PVA fiber is calculated by cement weight. There are three sizes available in the UTP Concrete Laboratory which is 8mm, 12mm and 20mm. In this project, the 18 mm sizes have been used.

### 3.4.5 Basalt (CBF)

The basalt can be obtained from the UTP Concrete Laboratory.it is in different types in the filament diameters 18 µm and the length 25 mm.

### 3.4.6 Fly ash (FA)

Fly ash will be used as a cement replacement material. The quantity of fly ash replaced in the mixture is 180 $Kg/m^3$. The fly ash can be obtained from the UTP Concrete Laboratory.

### 3.4.7 Super plasticizer

The superplasticizers are a category of high range water reducer agent in that they are formulated from materials that allow much greater water reductions, or alternatively extreme workability of concrete in which they are incorporated. Commercially available, Sikament-NI, superplasticizer in the form of aqueous solution will be used as water reducing admixture for all concrete mixes. The superplasticizer can be obtained from the UTP Concrete Laboratory.

## 3.5 Proposed Tests for the Project

### *3.5.1* Fresh concrete

In order to characterize the flow and workability properties of the self-compacting concrete, we will discussed in the result so the fresh properties have been tested on the slump flow diameter and as well as for the V-funnel test according to the - standard Abram's con as defined .

Slump flow board - a non-absorbent rigid plate. A circle 500mm in diameter should be marked at the center in order to measure the $T_{50}$ value.

### *3.5.2* Compressive Strength Test

The compression test shows the compressive strength of hardened concrete. The compression test shows the best possible strength concrete can reach in perfect conditions. The compression test measures concrete strength in the hardened state. Testing should always be done carefully. Wrong test results can be costly. The strength is measured in Megapascals (MPa). The compressive strength is a measure of the concrete's ability to resist loads which tend to crush it.

The test will be conducted using Digital Compressive Testing Machine that available in UTP Concrete Laboratory. The test will be conducted on 7 days, 28 days, and 56 days from the samples casting date. This test only conducted for cube sample only.

### 3.5.3 Compression Tensile Test

The compression split tensile test is used to determine how many load cycles a material can sustain or the failure load level for a given number of cycles. The machine is available in UTP Concrete Laboratory. The sample set of cylinder samples will be tested for 28 days.

### 3.5.4 Flexural strength

The flexure test method measures behavior of materials subjected to simple beam loading. It is also called a transverse beam test with some materials. Maximum fiber stress and maximum strain are calculated for increments of load. Results are plotted in a stress-strain diagram. Flexural strength is defined as the maximum stress in the outermost fiber. This is calculated at the surface of the specimen on the convex or tension side. Flexural modulus is calculated from the slope of the stress vs. deflection curve. If the curve has no linear region, a secant line is fitted to the curve to determine slope.

## 3.6 Project Timeline

To keep track on the progress of the project as well as the key milestone, Gantt chart was prepared to provide a visual timeline for starting and finishing specific task, Several targets have been set for the final year project one (FYP I and FYP2).. Table below shows the timelines for the project.

**Table 4: Project Activities FYP1**

| No | Detail/Week | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1. | Selection of Project Title: comparison of different Fibres of Self- Compacting Concrete | | | | | | | | | | | | | | |
| 2. | Preliminary Research Work: Understanding the basics of the project (Project background, problem statement, objectives, etc.) | | | | | | | | | | | | | | |
| 3. | A Thorough Research Work: Study and research on the literatures of the project. | | | | | | | | | | | | | | |
| 4. | Preparation for proposal; defense | | | | | | | | | | | | | | |
| 5. | Project work continue | | | | | | | | | | | | | | |
| 6. | Equipment set up | | | | | | | | | | | | | | |
| 9. | Summit interim draft report | | | | | | | | | | | | | | |
| 10. | Summit interim final report | | | | | | | | | | | | | | |

**Table 5: Key Milestone**

| No | Detail/Week | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1. | Extended proposal submission | | | | | | | | | | | | | | |
| 2. | Viva proposal defense | | | | | | | | | | | | | | |
| 3. | Summit interim draft report | | | | | | | | | | | | | | |
| 4. | Completion and submission of final report (Interim Report) | | | | | | | | | | | | | | |

**Table 6: Project Activities FYP2**

| TASK/WEEK | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Project Work Continues | | | | | | | | | | | | | | | |
| Submission of Progress Study | | | | | | | | | | | | | | | |
| Project Work Continues | | | | | | | | | | | | | | | |
| Pre-SEDEX | | | | | | | | | | | | | | | |
| Submission of Draft Report | | | | | | | | | | | | | | | |
| Submission of Dissertation (soft bound) | | | | | | | | | | | | | | | |
| Submission of Technical Paper | | | | | | | | | | | | | | | |
| VIVA | | | | | | | | | | | | | | | |
| Submission of Project Dissertation (hard bound) | | | | | | | | | | | | | | | |

### 3.7 Tools Have been Used in This Project

Tools and equipment's are fundamental in ensuring the research activities can be carried out smoothly and efficiently. Figures below shows the major equipment's used in carrying out the fresh characteristic tests for the self-compacting concrete as well as the mechanical properties have been used to test the compressive strength, flexural and tensile strength of the produced self-compacting concrete

Figure 2*:* V shaped funnel

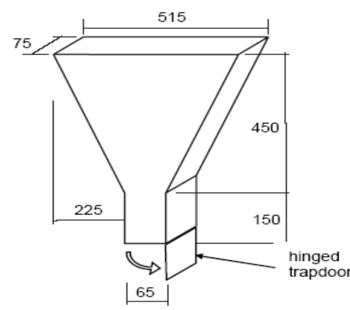



Figure 3*:* V-funnel dimension

Figure 4: Abram's cone

Figure 5: Slump flow board

Figure 6: Compression machine

Figure 7: Cement

Figure 4: CBF


Figure 5: MIXER

Figure 6 : FLY ASH

Figure 7 : PVA

# CHAPTER 4

## 4.0 RESULTS AND DISCUSSION

The variable to investigate and compare the effect of PVA, basalt and fly ash fibers on workability characteristic of SCC on the fresh concrete testes has been done on slump test and also V-funnel. And the second was for composed the effect of Basalt, Polyvinyl-alcohol (PVA) and Fly ash on compressive, flexural and tensile strength and

### 4.1 Result: - Fresh Testing

Figure 8 shows the slump flow. In this experiment the slump flow test is used to assess the horizontal free flow of SCC in the absence of obstructions. On lifting the slump cone, filled with concrete, the concrete flows. The average diameter of the concrete circle is a measure for the filling ability of the concrete. The time $T_{50cm}$ is a secondary indication of flow. The measures of the time taken is in seconds from the instant the cone is filled to the instant when horizontal flow reaches diameter of 500 mm.

Figure 8 slump flow diameter

The viscosity of the fresh concrete can be tested with the V-funnel test, whereby the flow time is measured as shown in figure 4.2. The funnel is filled with concrete and the time taken for it flow through the apparatus is measured.

**Table 7. Workability of Group 1, FR-SCC (Binder = 100% OPC)**

| NO | MIXING | Slump flow (mm) | SlumpT50(sec) | V-funnel (sec) |
|---|---|---|---|---|
| 1 | $G_1$-$M_1$-00 | 755 | 4 sec | 10 sec |
| 2 | $G_1$-$M_2$-1% PVA | 675 | 5 sec | 11 sec |
| 3 | $G_1$-$M_3$-2% PVA | 635 | 5 sec | 18 sec |
| 4 | $G_1$-$M_4$-1% BST | 670 | 5 sec | 13 sec |
| 5 | $G_1$-$M_5$-2% BST | 600 | 6 sec | 16 sec |

The table 7, represent the result of workability tests, conducted to achieve self-compacting concrete. There were too many trials have been done, as contents of coarse aggregate and fine aggregate with OPC and variation in water / content and super-plasticizer was carried out to achieve SCC mixes.

it can be seen that the slump flow diameters vary between 500mm and 700mm. from the European guidelines, this slump flow for group1 satisfies for $G_1$-$M_1$-00 (720 -790mm) and $G_1$-$M_2$-1% PVA (650-700mm) which is suitable for many normal application,

The maximum value of V-funnel time for the 100% OPC of the three mixing number $G_1$-$M_3$-2% PVA , $G_1$-$M_4$-1% BST and $G_1$-$M_5$-2% BST was 18 second ,13second and 16 second respectively , this high value due time because the fiber increased the time required for the mixes to pass through the funnel shape. In order to compare the effect of particular fiber the 1.0% of basalt fiber have recorded time more than the PVA and in case of 2.0% the different was marginal.

Chart 1 : Slump Flow of 100% OPC

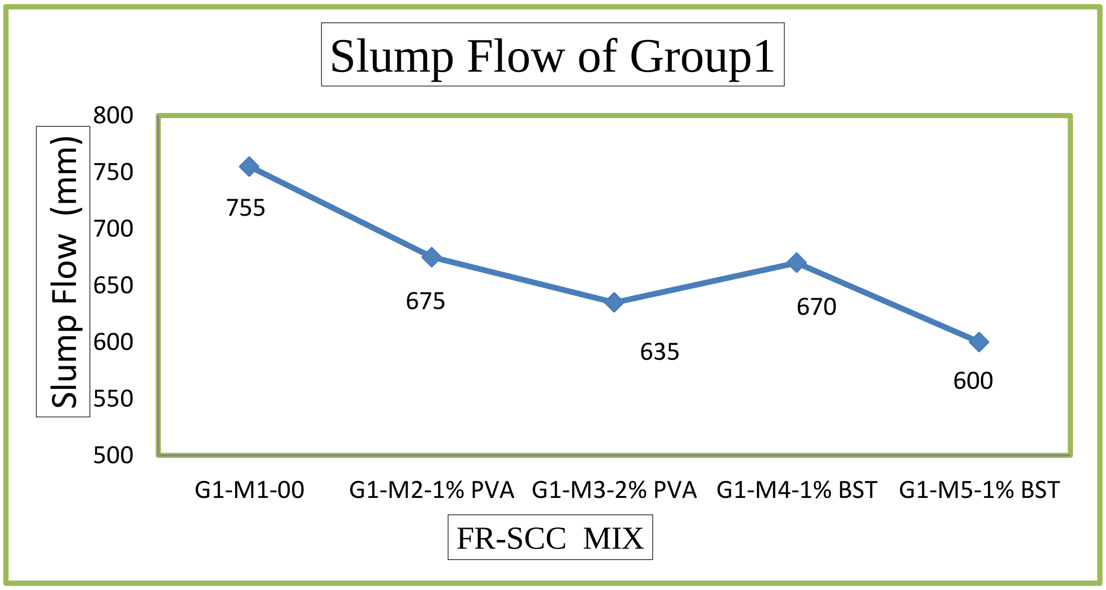



Chart 2: slump flow 100% OPC

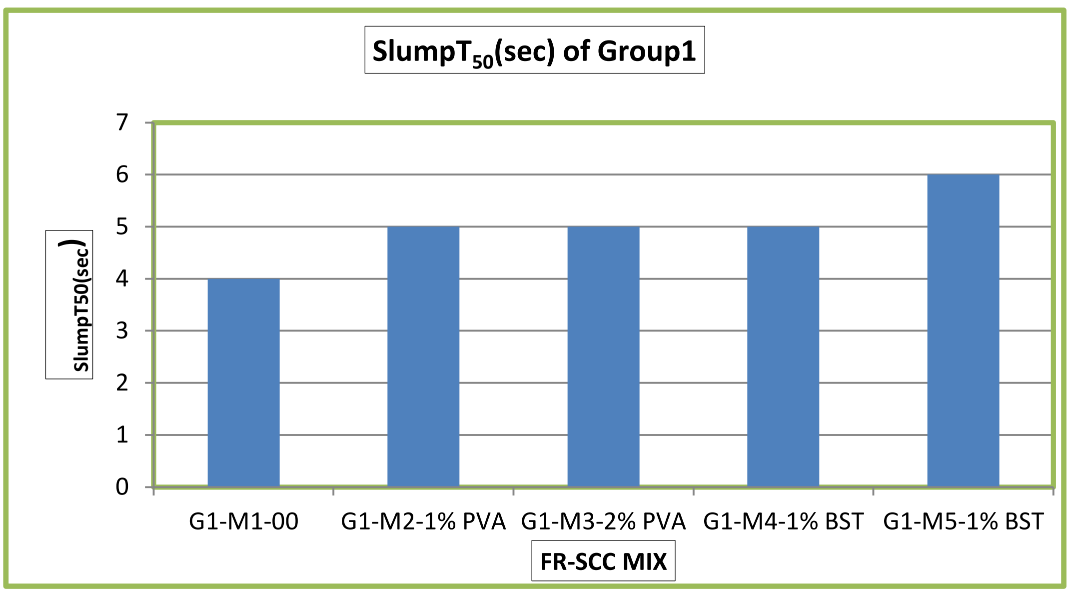


Chart 3 :V-funnel of 100% OPC

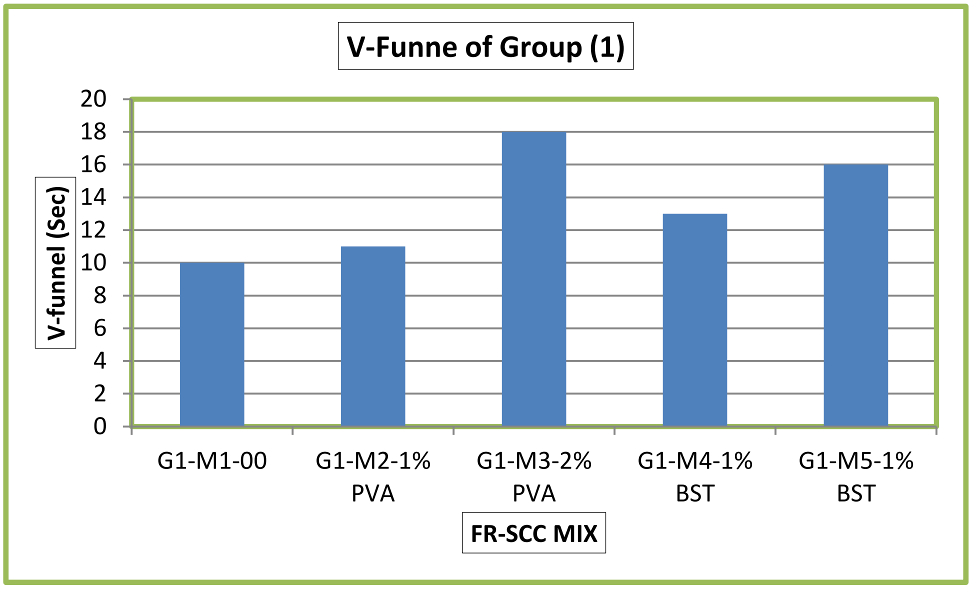
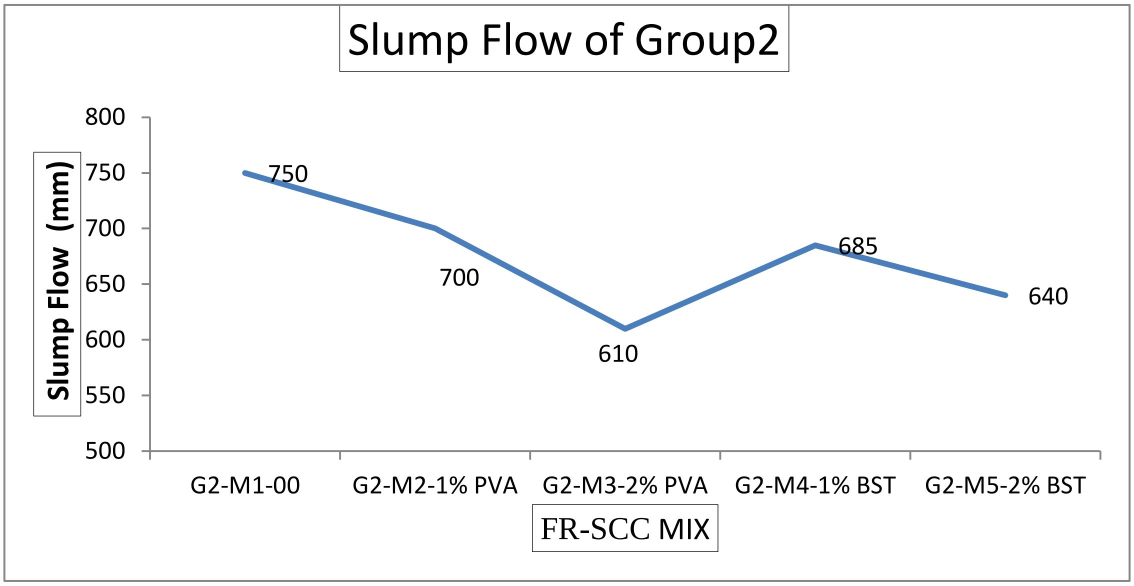



Table 8 : Workability of Group 2 FR-SCC (Binder =70% of OPC + 30% fly ash)

| NO | MIXING | Slump flow (mm) | SlumpT50(sec) | V-funnel (sec) |
|---|---|---|---|---|
| **1** | **$G_2$-$M_1$-00** | **750** | **4 sec** | **10 sec** |
| **2** | **$G_2$-$M_2$-1% PVA** | **700** | **5 sec** | **10 sec** |
| **3** | **$G_2$-$M_3$-2% PVA** | **610** | **6 sec** | **14 sec** |
| **4** | **$G_2$-$M_4$-1% BST** | **685** | **5 sec** | **11 sec** |
| **5** | **$G_2$-$M_5$-2% BST** | **640** | **6sec** | **13 sec** |

Table 8, shows the workability of group 2 mixing for FR-SCC, the binder was combination of 30% fly ash added to 70% OPC and the result can be acceptable. The high value of V-funnel for the two mixing number $G_2$-$M_3$-2% PVA and $G_2$-$M_5$-2% BST was 14 and 13 second respectively because the fly ash increase the ability of the mixture to pass through the V-funnel time , the effect of different fiber seem to be same.

Chart 4: Slump low 70% OPC+ 30% Fly ash




As seen in char 4, above, the different of flow diameter greatly influence the workability, i.e. the slump flow diameters obtained show high values, and no segregation were observed during the testing as the result obtained with V-funnel; the 2.0% of PVA in the mix of G2-M3 have slumped less than the other mix.

Chart 5: Slump Flow 70% OPC + 30% Fly ash

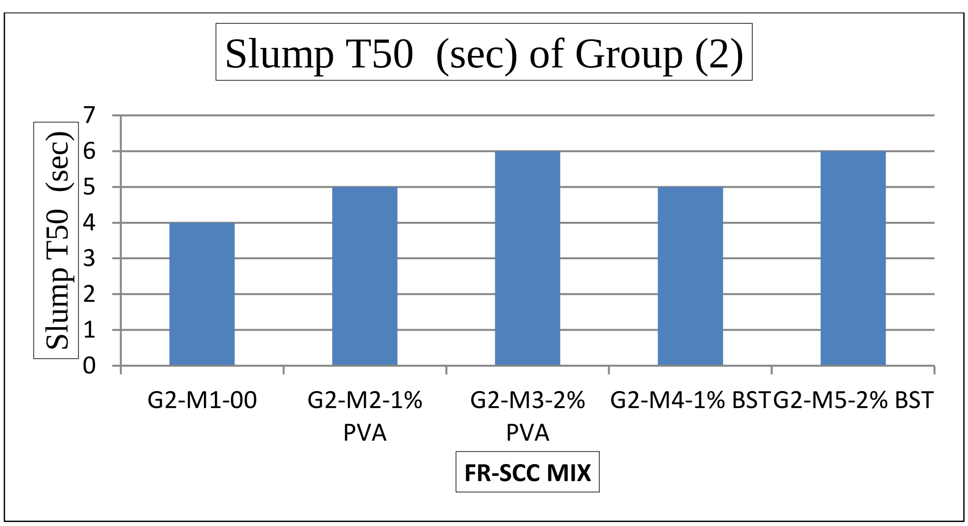
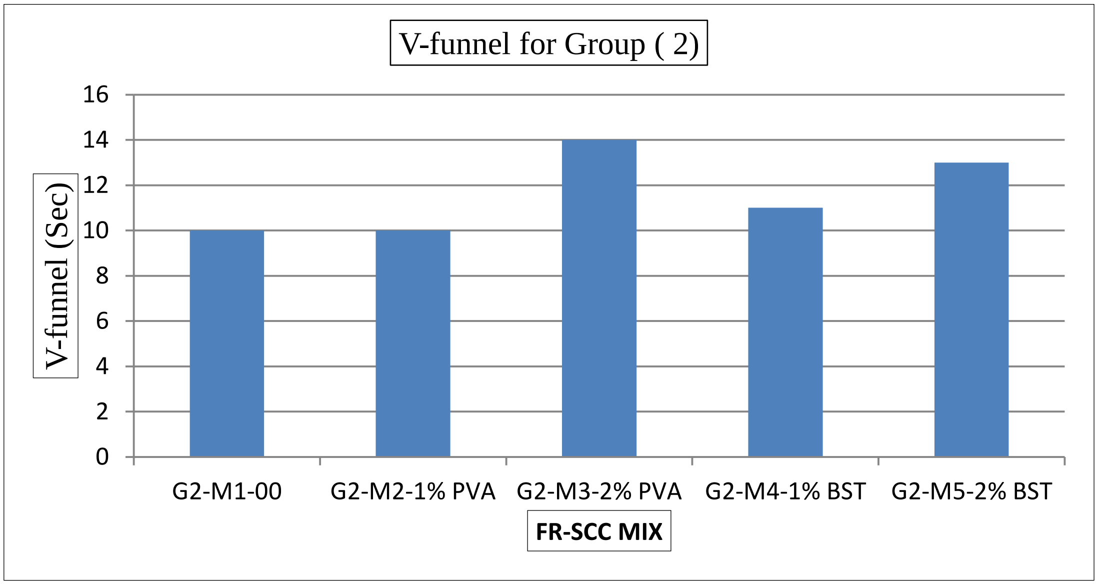


**Chart 6: V-funnel 70% OPC +30% fly ash for Group2**




In the chat show the result obtain from the v-funnel o group (2) 30% of fly ash ,the highest result was in mixed number 3, $G_2$-$M_3$-2% PVA was 14 second is ability to go through the v-funnel apparatus ,however the result is acceptable

### *4.2* Result of mechanical properties

The compressive strength test was conducted during days 7, 28 and 56. The objective of the test is to see the optimum percentage of fiber added in the concrete mixture. The cracking behaviour of the samples was observed during the test to see the cracking effect of adding fibre in the mixture. The results were tabulated and plotted into graph.

#### *4.2.1 Compressive strength test*

The compressive strength development of group one (1) within time is presented in *table 9*. Generally, for the combination of 100% dosages of OPC 2% of SP, the significant comment can be made on the graph, as all lines are different. The strength development was slower at the early age, but the strength once it had reached 28-days. The mixed $G_{1}$-$M_{1}$-00 had achieved strength of 54.95 Mpa at the age of 7-days, 70 Mpa for 8 days and 75.5 Mpa for 56 days, .we have achieved the highest strength, with 70 Mpa on G1-$M_4$-1% BST.

**Table 9: Compressive tests for 100% OPC**

| NO | Mix | 7 days | 28 days | 56 days |
|---|---|---|---|---|
| 1 | **$G_1$-$M_1$-00** | 54.94 | 70.78 | 75.5 |
| 2 | **$G_1$-$M_2$-1% PVA** | 52.91 | 64.77 | 78.77 |
| 3 | **$G_1$-$M_3$-2% PVA** | 55.63 | 69.53 | 71.49 |
| 4 | **$G_1$-$M_4$-1% BST** | 70.62 | 85.53 | 90.72 |
| 5 | **$G_1$-$M_5$-2% BST** | 64.81 | 61.18 | 57.59 |

Chart 7 : Compressive Strength Test For 100% OPC

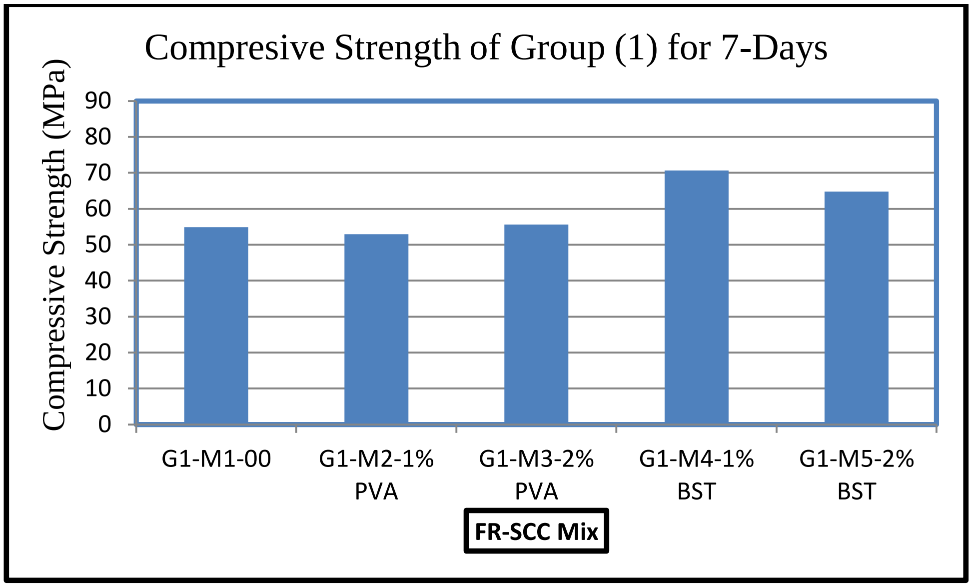
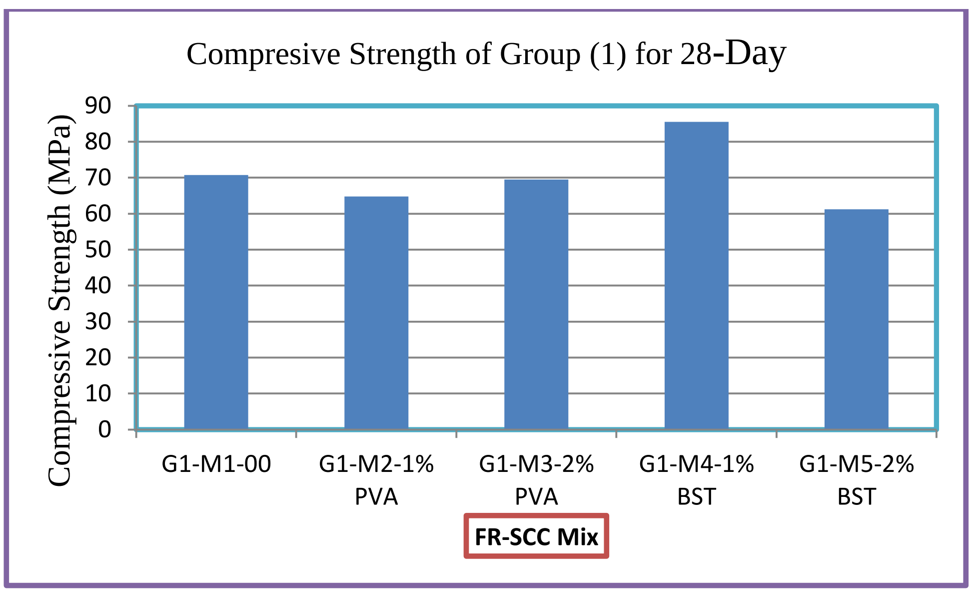



Chart 8 : Compressive Strength Test for 100% OPC



Development of self-compacting concrete it has relatively high compressive strength; the 90% of the compressive strength will develop at duration of 28 days. And we obtain the highest compressive strength when we add fiber about 1.0% of basalt the values was 90.72 Mpa , and is increased by 19.0% compare to without fiber and the lowest compressive strength 57 Mpa in this $G_1$-$M_4$-1% BST, 2.0% of fiber .because whenever the basalt stay longer it will reduce the amount compressive strength .

**Chart 9 : Compressive Strength Test for 100%OPC**

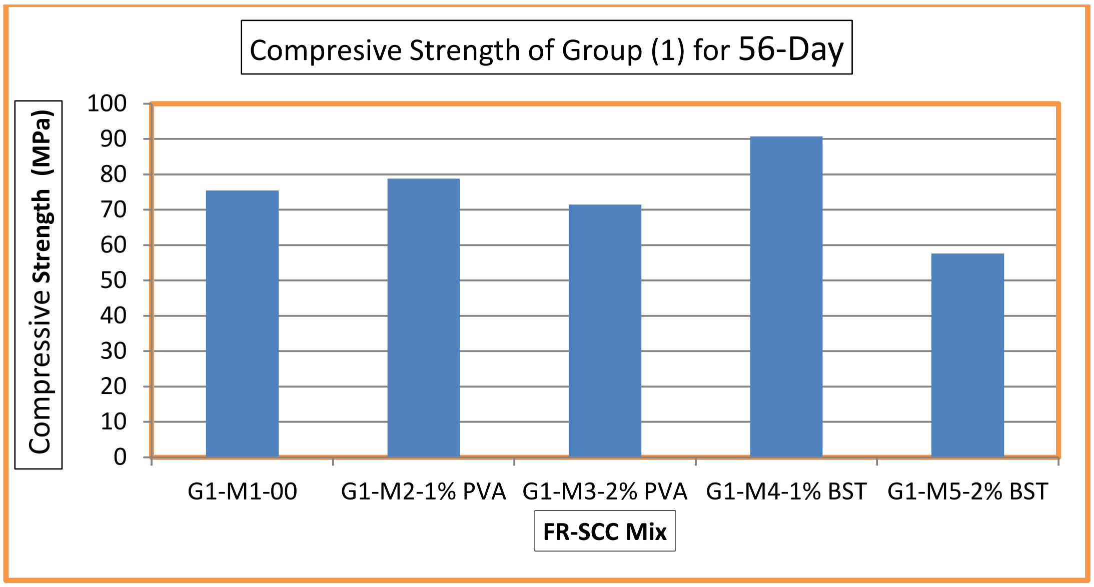
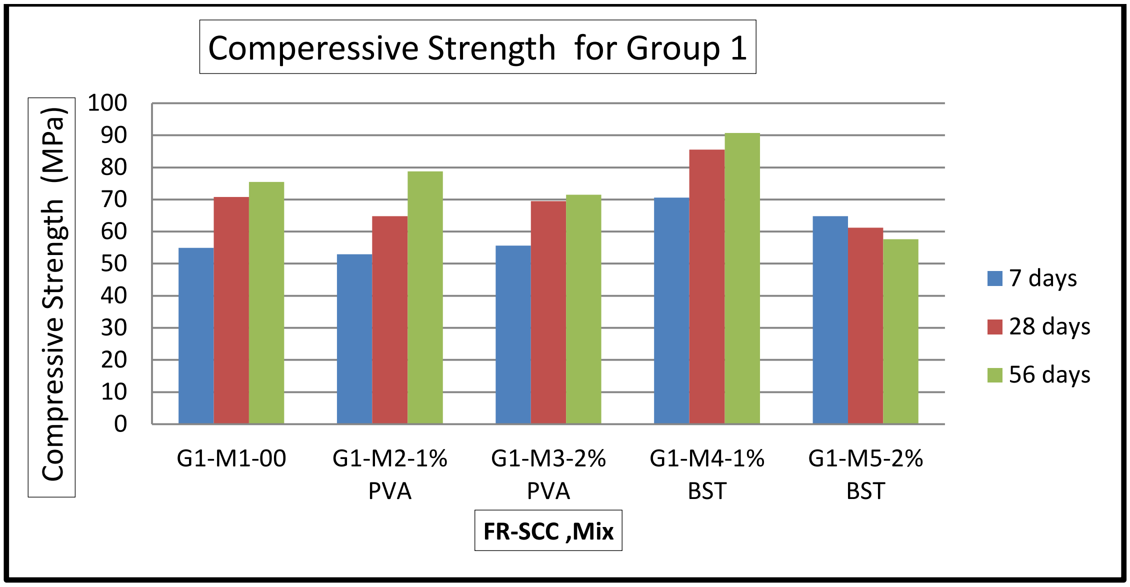


Chart 10 :  Compressive Strength Test for Group 1




As we have developed the compressive strength for the self-compacting concrete for the 100% OPC, the comparison of the addition of fibers on the SCC was obtain from the graph above , however the high strength on 7,28 and 56 days was in mixed number five $G_1$-$M_4$-1% BST the strength 70.62 Mpa,85.53 Mpa and 90.72 Mpa respectively compare to the other mixes .this due to less percentage for basalt is just 1% it does less effect much .however , the 2.0% of basalt have more effect in order to compare with the 1.0% and it reduce the strength of the SCC on the 7,28 and 56 days by 6.0 % between 7 days and 28 days and 12.0% between 28days with 56 days. Comparing the PVA with control increasing from 7days, 28 days and 56 days 20% compare to other mixes.

**Figure 9 : Compressive strength test for GROUP 1 ,A =OPC B= CBST and C= PVA**

**Table 10: Compressive tests for 70% OPC + 30% FLY ASH**

| NO | Mix | 7 days | 28 days | 56 days |
|---|---|---|---|---|
| 1 | **$G_2$-$M_1$-00** | 44.30 | 63.83 | 80.02 |
| 2 | **$G_2$-$M_2$-1% PVA** | 54.45 | 66.55 | 78.63 |
| 3 | **$G_2$-$M_3$-2% PVA** | 50.46 | 67.44 | 71.73 |
| 4 | **$G_2$-$M_4$-1% BST** | 46.73 | 70.42 | 74.94 |
| 5 | **$G_2$-$M_5$-2% BST** | 44.54 | 53.38 | 64.62 |

Chart 11: Compressive strength of 70% OPC +30% Fly ash

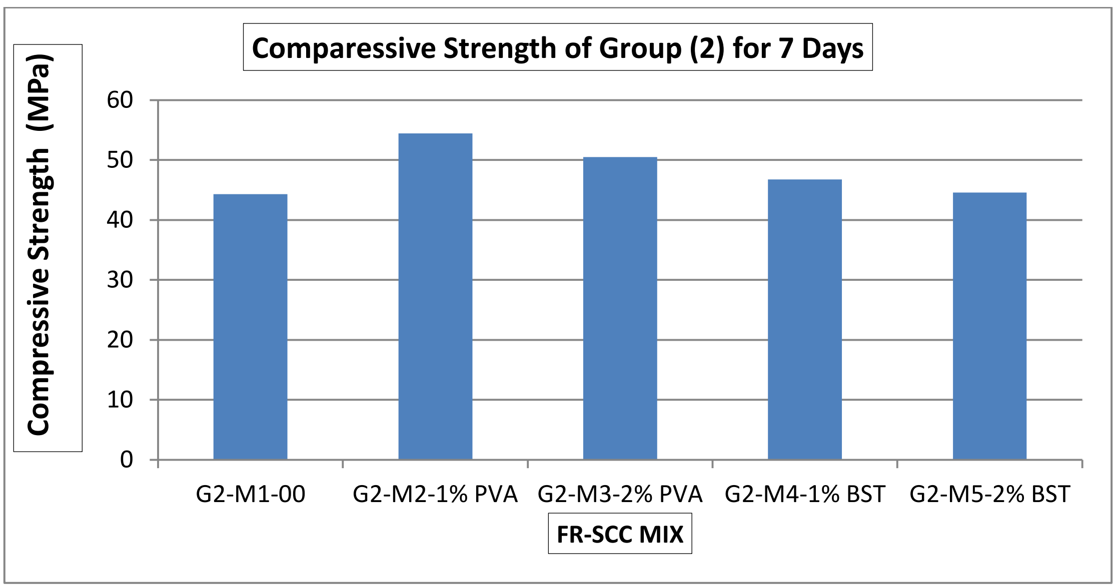



Chart 12 Group2 mixtures consist of 70% OPC and 30% Fly ash as CRM. The results of 7 days, obviously show the 0% fibre is much higher that mixture with fibre. Instead, the value keep decreasing as fibre percentage increased. Even at age of 7 days, the most high strength sample of PVA is 1% fibre. The 0% fibre still shows the lowest strength.

Chart 12: Compressive strength of 70% OPC +30% Fly ash

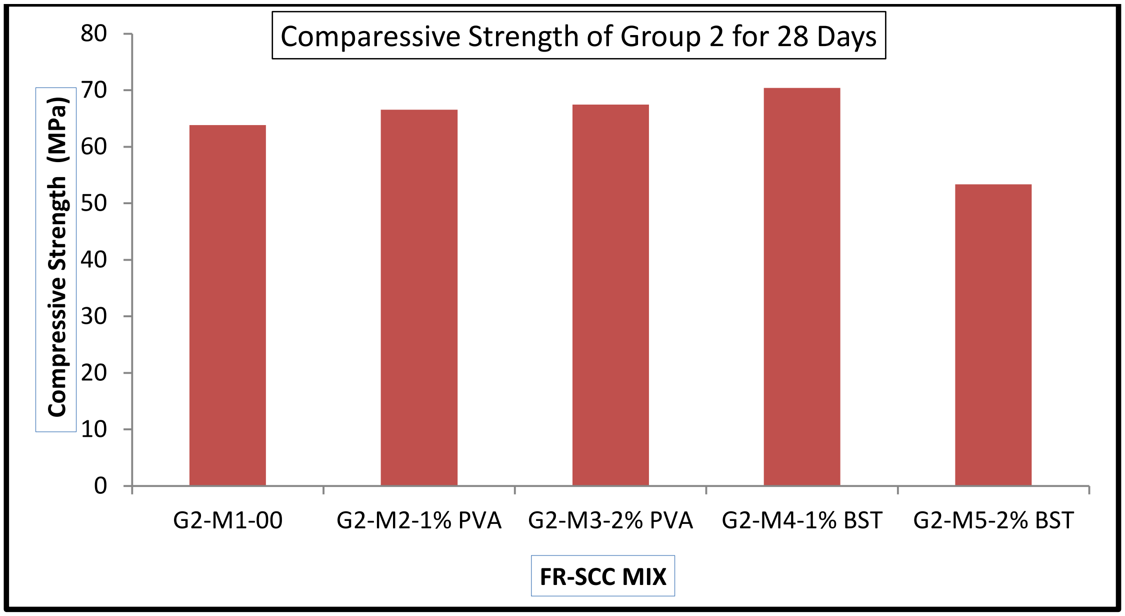
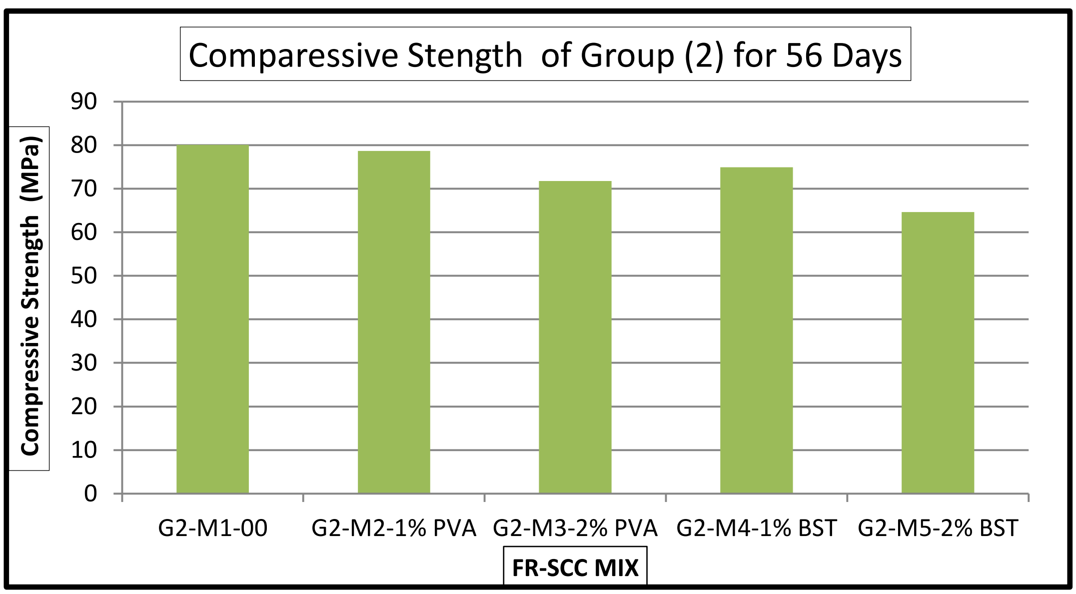
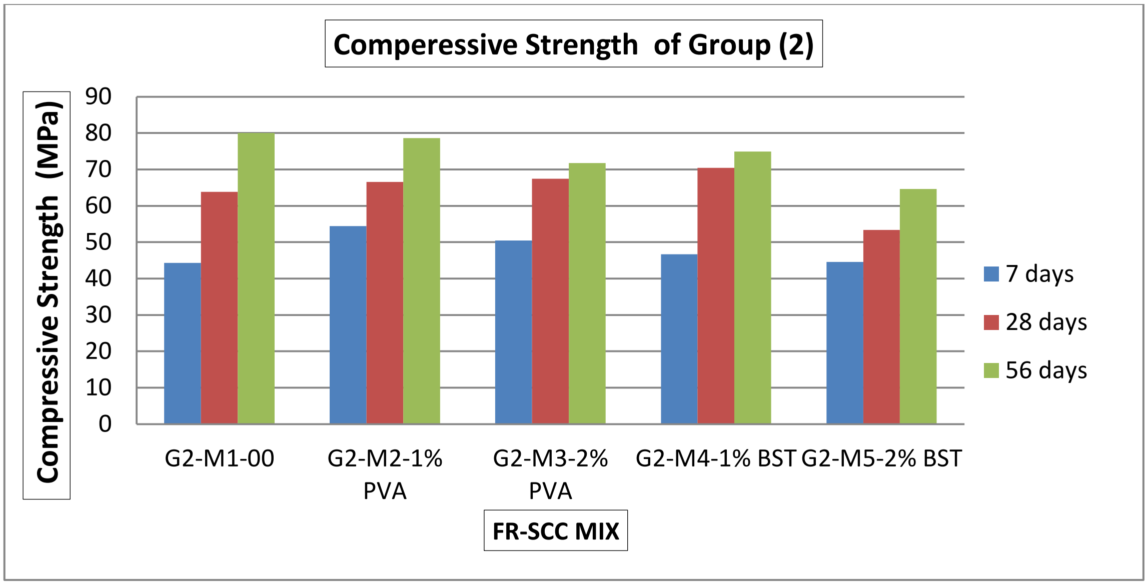



*Chart 13: C*ompressive Strength of 70% OPC + 30% Fly ash




Group2 mixtures consist of 70% OPC and 30% Fly Ash as CRM. The results show that 0% fiber achieved the highest value. It may not be good to put the cement replacement material together with PVA 2.0% fiber and as well with CBF.

Chart 14: Compressive Strength of 70% OPC + 30% Fly ash




Group 2 mixtures consist of 70% OPC and 30% Silica fumes as CRM. The results obviously show G1-M1-00the 0% fibre is much higher that mixture with fibre at age of 56 days. Instead, the value keep decreasing as fibre percentage increased. Even at age 28 days, the most high strength sample is 2% fibre increase by 5.0% percentage, but the result change at 7 days, as we increase the fibres of PVA percentage.

Figure 10 : Compressive Strength Test for GROUP 2, A =OPC B= CBST and C= PVA

### 4.2.2 Flexural test

**Table 11: MIXED 100% OPC**

| NO | Mix | Flexural |
|---|---|---|
| 1 | **$G_1$-$M_1$-00** | 7.775 |
| 2 | **$G_1$-$M_2$-1% PVA** | 6.625 |
| 3 | **$G_1$-$M_3$-2% PVA** | 8.715 |
| 4 | **$G_1$-$M_4$-1% BST** | 10.065 |
| 5 | **$G_1$-$M_5$-2% BST** | 8.35 |

Figure 11 Flexural test for GROUP 1, A =OPC B= PVA and C= CBST

Chart 15 : Flexural Test for 100% OPC

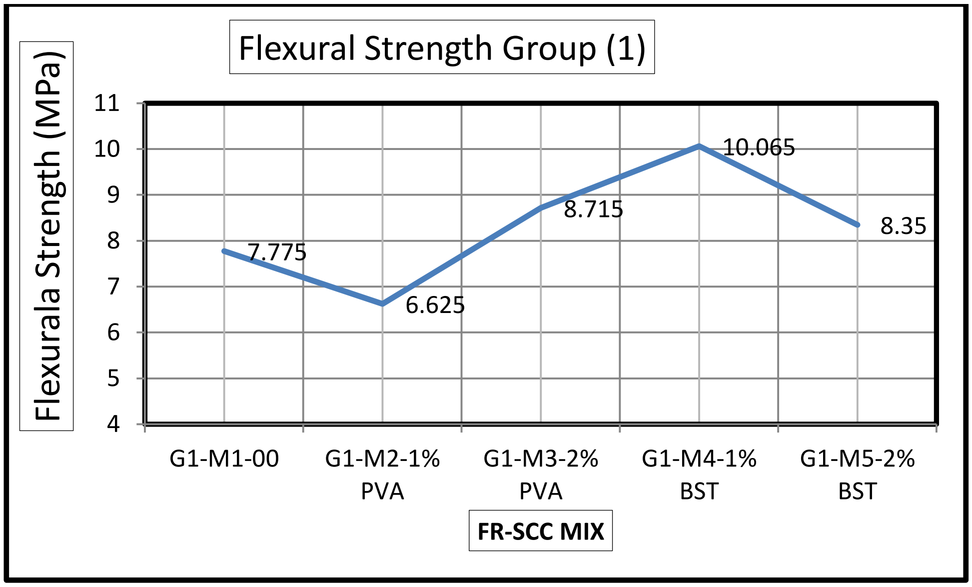


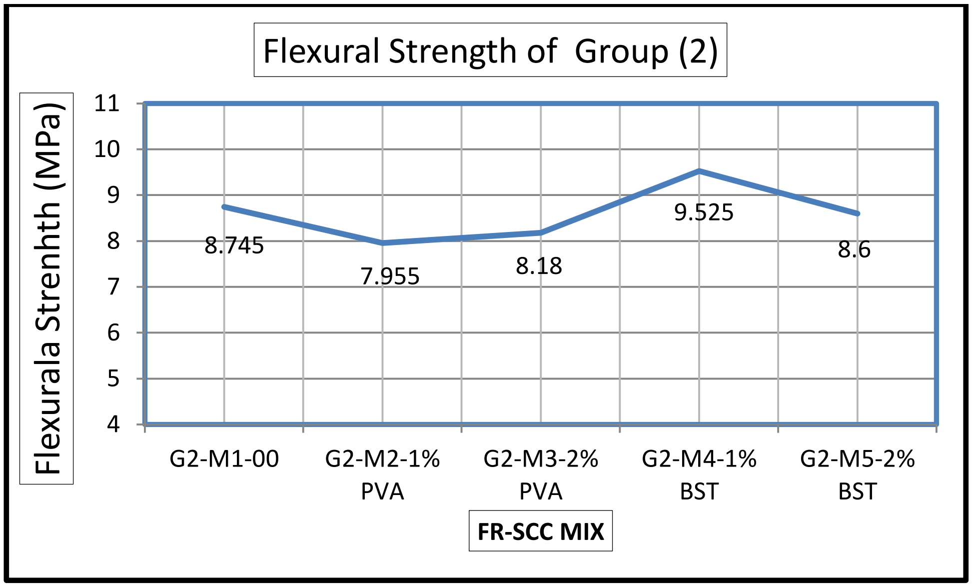

Chart 15 mixing group 1 for the flexural strength at G1-M4-BST 1.0% was 10.1 Mpa the highest value. Indeed it considerable but it have less ductility compare with PVA. We Have obtained less flexural when we added the 1.0% of PVA fiber, on other hand the PVA have high ductility.

**Table 4.6 Flexural test tests for 70% OPC + 30% FLY ASH**

| NO | MIX | Flexural |
|---|---|---|
| 1 | **$G_2$-$M_1$-00** | 8.745 |
| 2 | **$G_2$-$M_2$-1% PVA** | 7.955 |
| 3 | **$G_2$-$M_3$-2% PVA** | 8.18 |
| 4 | **$G_2$-$M_4$-1% BST** | 9.525 |
| 5 | **$G_2$-$M_5$-2% BST** | 8.6 |

Figure 12 : Flexural test for GROUP 2 , A =OPC B= PVA and C= CBF

Chart 16: Flexural Test For 70% OPC + 30% Fly ash



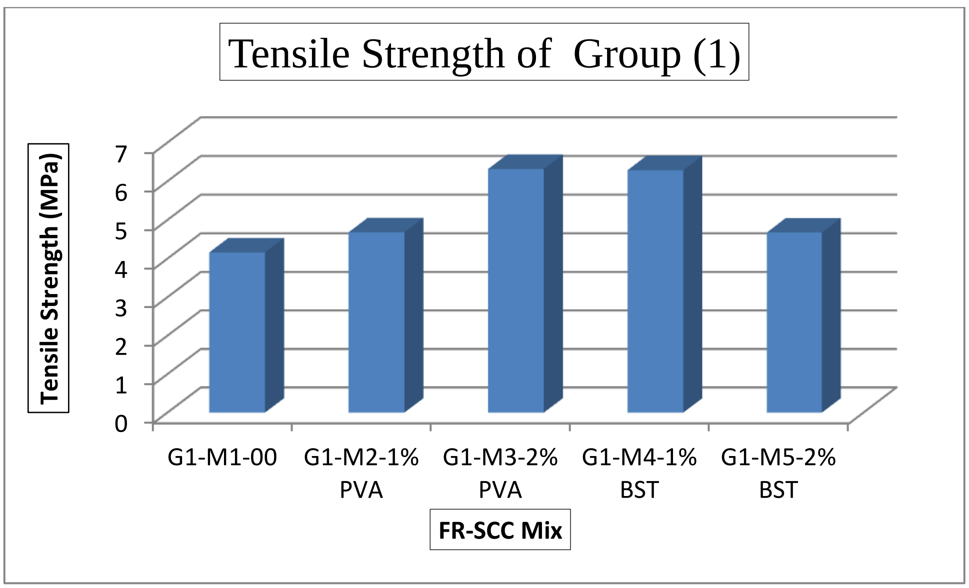

The flexural at char 16 and17, we found highs value for both compare to the mix on the 100% OPC with 70% OPC , ($G_1$-$M_4$-1% BST and $G_2$-$M_4$-1% BST ) and the value that get obtained ,(10.065 Mpa and 9.525 Mpa) respectively , due the effect of fiber 1.0% of the basalt have been consider as optimum percentage attend high value compare to other mixes

### *4.2.3 Tensile test*

**Table 4.7 Tensile test for 100% OPC**

| NO | Mix | Tensile |
|---|---|---|
| 1 | **$G_{1-}M_{1-}00$** | 4.161 |
| 2 | **$G_1$-$M_2$-1% PVA** | 4.683 |
| 3 | **$G_1$-$M_3$-2% PVA** | 6.317 |
| 4 | **$G_1$-$M_4$-1% BST** | 6.286 |
| 5 | **$G_1$-$M_5$-2% BST** | 4.676 |

Chart 17: Tensile Test for 100% OPC

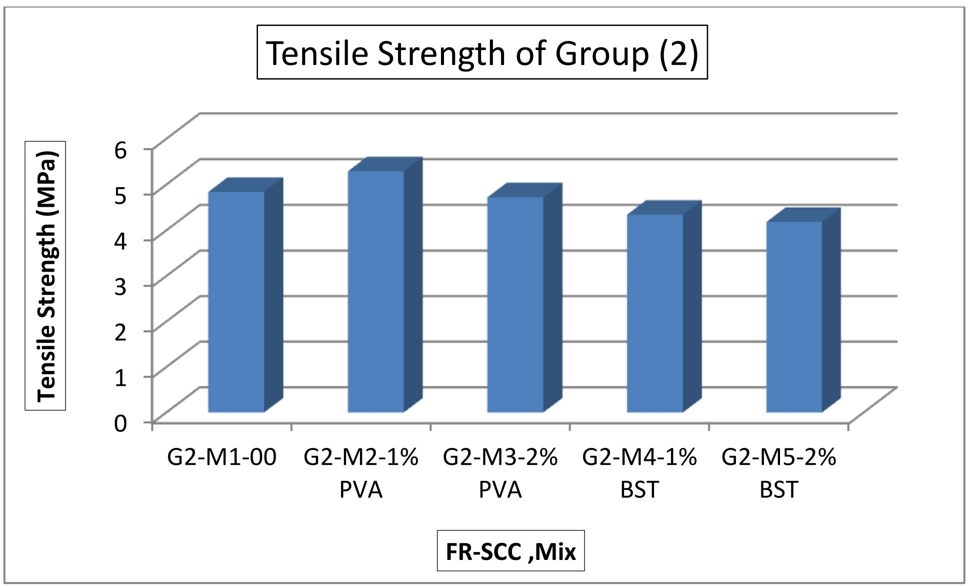



The result shown in the chart 13, We obtain the result on mixing of group (1) the fiber have very good impact on the tensile was high value in $G_1$-$M_3$-2% PVA was 6.317 Mpa .the second number was when we add the basalt in 1.0% the value was 6.286, it was no big difference we can consider at optimum value For group1 mixes 100% OPC compare to the PVA 1/0% and zero present fiber

**Table 4.8 Tensile Test for 70% OPC + 30% Fly ash**

| NO | Mix | Tensile |
|---|---|---|
| 1 | **$G_2$-$M_1$-00** | 4.837 |
| 2 | **$G_2$-$M_2$-1% PVA** | 5.289 |
| 3 | **$G_2$-$M_3$-2% PVA** | 4.720 |
| 4 | **$G_2$-$M_4$-1% BST** | 4.340 |
| 5 | **$G_2$-$M_5$-2% BST** | 4.183 |

Chart 18: Tensile Test for 70% OPC + 30% Fly ash




Since we have obtained our result and shown in the graph, the addition of percentage of the fiber has tensile effect on the self-compacting concrete. the group 2 composed of 30.0% fly ash with 70.0% OPC ($G_2$-$M_2$-1% PVA), the value was 5.29 Mpa and it have high result compare to the other mixes we have obtain 9.0% .

# CHAPTER5

## 5.0 Conclusions

The results of this project have been analyzed to meet the achievement and target of the objective earlier. The amount of the binder was found in SCC mixed to create the requirement of fresh properties in (JSCE and EFNARC).

There were10 mixes of FR-SCC have been developed and split into two groups based on binder types, group one and two were included 100% OPC and 70% OPC with 30% Fly ash respectively . Two types of fibers have been utilized as 1.0% and 2.0% by weight of binder per each group. The addition of the 30.0% of fly ash have enhanced the fresh properties compare with the 100% OPC while in term of hardened characteristics the fly ash did not increase it at early age, but at long term the fly ashes group owned more strength than that of 100%OPC.

Generally the two types of fibers have decrease the workability of fresh SCC result, but still the whole mixes can consider as SCC according to the two standards (JSCE and EFNARC). the comparison of the addition of fibers on the SCC was obtain from the graph above, however the high strength on 7, 28 and 56 days was in mixed number five $G_1$-$M_4$-1% CBF the strength 70.62 Mpa, 85.53 Mpa and 90.72 Mpa respectively, compare to the other mixes, this due to less percentage for basalt is just 1% it does not affect much. However, the 2.0% of basalt have more effect in order to compare with the 1.0% and it reduces the strength of the SCC on the 7, 28 and 56 days by 6 % between 7 days and 28 days and 12% between 28days with 56 days. The flexural we found highs value for both compare to the two groups ($G_1$-$M_4$-1% BST and $G_2$-$M_4$-1% BST) ,(10.065 Mpa and 9.525 Mpa) respectively , and 1.0% of the basalt have been consider as optimum percentage to attend high value compare to other mixes .

### 5.1 Recommendation

The following is the recommendations for this project for the SCC, which are proposed for future researches.

1. The research shall tests for fiber PVA and CBF incorporated concrete up until 90-days to get more accurate result, since in this project, 56-days concrete shows potential in obtaining greater compressive strength.
2. During the mixing of SCC, tests of FRESH concrete for the V-funnel should be carried out more frequently, since in this project obtained is increased more than normal the average .

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## *APPENDEX*

G2 – PVA. FLEXUREAL TEST

C1- M1-00, TENSILE TEST

G2-M1-00, COMPRESSIVE TEST

G1- M4-BST1, COMPRESSIVE TEST

CONCRETE AFTER TESTED