Studies on the Properties of Fiber Added Self-Compacting Concrete at Fresh and Hardened State

By

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CERTIFICATION OF APPROVAL

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Approved by,

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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.

MUHAMMAD HAFIZ BIN IZHAR

ABSTRACT

Self-compacting concrete has been gaining much interest in the field of studies of many researchers all over the world since last one decade. This research study aimed is to determine the optimum mix design for rheological properties of self-compacting concrete with the addition of fiber and also without the addition of fiber. The comparison of the hardened state of normal and also the fiber added SCC also will be done in this particular research. The strength or grade of the concrete target is between G40 to G50. The compressive strength test has been done during 3, 7, 28 and 56 days while the tensile strength test has been done only at 28 days. The result of the fresh and hardened properties of these two different SCC has been observed.

ACKNOWLEDGEMENT

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CHAPTER 1

INTRODUCTION

1.1 BACKGROUND

Self-compacting concrete (SCC) or sometimes being called as self-consolidating concrete was developed in Japan during the late 1980s. It is being developed because of the arising concerns about concrete durability which many researcher realize that poor compaction of the concrete was the main factor in the reducing quality of construction work. Well mix of SCC can flow under its own weight throughout every reinforcement bars and also move to every corner of the formwork is the solution of the arising concerns.

Although it seems like SCC might cost a few more dollars per cubic meters than the conventional concrete, it may reduce in other factors such as:

1. Reduced construction time
2. Reduced man power for placing and compacting
3. Lower equipment cost
4. Less noise since no vibrators are required
5. Ability to fill complex forms with congested reinforcement

The SCC is a high performance concrete which is highly flowable, non-segregating concrete that can spread into places, and fill the forms with reinforcement without using the vibrator. There are three key fresh properties of SCC:

1. Filling ability
   - The ability of the concrete to flow freely under its own weight, and to fill formworks of any dimension or shape without leaving voids.

2. Passing ability
    - The ability of concrete to flow freely in and around congested reinforcement without blocking

3. Resistance to segregation
    - During placement, the concrete must retain its homogeneity. There should be no serparation of aggregate from paste or water from solids and no tendency for coarse aggregate to sink downwards the concrete mass under gravity.

Various researches had been done in order to produce concrete with a high flowability and workability during its fresh state, but very strong and durable during its hardened state.

1.2 PROBLEM STATEMENT

One of the main problems in SCC is that it has no specific guidelines for the optimum mix design. In order to test the mechanical properties of the SCC, the mix design need to be determined for it to be the optimum mix design. The mechanical properties that can be determined during its hardened state are:

1. Compressive strength
2. Tensile strength
3. Elastic modulus

Before the concrete is hardened, which is during its fresh state, the rheological properties of the SCC also will need to be check for the purpose of finding the optimum mix design. So in order to check all the mechanical properties listed, we need to determine the optimum mix design for the SCC.

In addition, creep and shrinkage of the SCC in short term due to the high amount of powder is also one of the major problem. Last but not least, is the high cost of the material, not only for the admixture needed itself, but also for quality control for SCC.

1.3 OBJECTIVE AND SCOPE OF STUDY

The main objectives of this research are to determine the optimum mix design of G40-50 SCC using fiber addition for the following targets into consideration:

1. Based on rheological characteristics of fresh state
2. Based on mechanical and elastic properties in hardened state

This research will compare the result of the mechanical properties of three different content of SCC.

1. SCC content with 100% cement as filler
2. SCC content with partially Pozzolanic material as filler
3. SCC content with the introduction of Fiber content

This research will introduce different Fiber content by weight of cement and study the effect on the rheological properties and also mechanical properties.

The scope of work of this research was to investigate the flowability and also the workability of SCC in fresh state. Once it is hardened, it shall be tested for mechanical properties which are:

1. Compressive strength
2. Tensile strength
3. Elastic modulus

1.4 RELEVANCY OF THE PROJECT

This SCC research project is relevant. It is because nowadays, many European and other Asian country has been using Self-compacting Concrete as their main element of the building construction. In Malaysia, SCC is still not very popular among the construction company maybe because of costing and the difficulties to get this element. So, by doing this research, we hope that one day Malaysia will also implement the using of SCC as one of the element in building construction.

1.5 FEASIBILITY OF THE PROJECT

For this particular research, the SCC will be hardened in a form of 150 mm cube. This cube will be tested for compressive strength at 3, 7, 28 and 56 days. This will only take about 2 and a half month to be completed. The commencement of the mix will be done during the month of August and the completion of this research is predicted to be done in the month of November. Then, the collection and interpretation of result and date will be done in the month of December. This means that this project can be completed by the end of next year in the month of January. So, we can say that this project is feasible enough within the scope of time frame that is limited until January next year.

CHAPTER 2

LITERATURE REVIEW

2.1 INTRODUCTION

Concrete is a composite construction material that consists of aggregates and cementations' binder. The composition of concrete is made of cement, water, aggregates, admixtures, and additives.

Cement is a general name for a material that binds other material together. Cement can be divided into various types. The most common one used in building construction is Portland cement. This cement will bind the rocks together to form concrete.

By adding water to the dry cement, a chemical reaction called hydration will occur. The water / cement ratio (w/c) of the mixture has the most control over the final properties of the concrete. A mixture with high w/c will be more workable than a mixture with a low w/c.

The other important component for strength of the concrete is the aggregate. It is the rock that being bound by the hardened cement. Aggregate increases the strength of concrete and is a fundamental economical factor because it takes up large volume of the concrete and less expensive than the other component of concrete.

There are various type of concrete have been developed such as self-compacting concrete, shotcrete, and asphalt concrete. Self- Compacting Concrete is known by their extreme fluidity and behaving more like a thick fluid as opposed to conventional concrete.

2.2 SELF – COMPACTING CONCRETE

2.2.1 History of Self-Compacting Concrete

Self-compacting Concrete was first developed by Professor Okamura in Japan during the 1986. Beginning in 1983, the problem of the durability of concrete structures has been a major topic of interest in Japan. Sufficient compaction by skilled workers is required to make durable concrete structures. One possible solution to achieve durable concrete structures is by the employment of self-compacting concrete, which can be compacted into every corner of a formwork without the need for vibrating compaction.

Studies to develop self-compacting concrete have been carried out by Ozawa and Maekawa at the University of Tokyo. Various researches had been carried out in order to obtain the optimum SCC mix design method. Several methods were developed by different researchers. Okamura and Ozawa (1995) have proposed a simple mix proportioning system (the coarse and fine aggregate contents are kept constant so that self-compatibility can be achieved by adjusting the w/c ratio and superplasticizer dosage only.

Su and Miao (2003) in ***China***, method was developed to obtain SCC with less paste, hence reducing the cost. This method starts with the packing of all aggregates and later filled the aggregates voids with paste.

Whereas, in ***Sweden***, Peterson and Billberg (1999) developed an alternative method for mix design including the criterion of blocking, void and paste volume as well as the test result derived from paste rheology studies.

In the ***Netherlands***, from the period of 1995-1996, after the Japanese mix design method was introduce in 1997, it was shown that self-compacting concrete with segregation resistance could be made using Dutch materials. The SCC was applied to a building in 1997. In addition, the Dutch Precast Concrete Industry formed a research group to study the application of SCC in 1998.

On the other hand, the SCC has been used in practical structures in ***Thailand*** since 1992. While in ***Taiwan***, the investigation of SCC started in 1994 and since then there has been many application in practical structures due to increasing demand for construction and the shortage of skilled workers.

2.2.2 Properties of Self-Compacting Concrete

Most materials that are suitable for conventional concrete are also suitable to be used in the production of SCC, although there are significant differences in SCC production compared with conventional concrete production. The most important is that the properties of the SCC can be allowed to vary only within much tighter limits.

The properties of fresh SCC are also much more sensitive to variations in the quality and consistency of the mix constituents. In order to increase the cohesiveness, the powder content needs to be higher. Pulverised Fuel ash (PFA), or an inert material such as limestone powder are most commonly used. However, it is still possible to produce an SCC without adding any extra fine material. The problem when there is high content of powder is that the concrete will tend to having creed and also shrinkage. The introduction of *Fiber* as one of the filler in this research will expect to minimize the effect of creed and shrinkage of the SCC.

In general, the hardened properties of SCC are similar or superior to those of equivalent conventional concrete. It also could be said that the durability of the concrete is more guaranteed with the used of SCC as it reduces the potential for human error (in the form of poor compaction). The high fines content and the need for well graded aggregates in SCC also improve the concrete. It produces a more dense interfacial transition zone between the aggregate and the cement matrix. All these effects are beneficial for both strength and durability. The long term durability is restricted to a decade of limited use since the SCC is only recently used in the industry.

In addition, at similar w/c ratios, the characteristic strength of SCC is at least equal to the conventional concrete, and has similar strength development for the same grade. The Tensile strength is also comparable to the same grade of conventional concrete and drying shrinkage is also similar.

The result for achieving self-compactibility involves not only high deformability of the paste or mortar but also resistance to segregation between coarse aggregate and mortar when the concrete flows through the confined zone of rebars. Okamura and Ozawa (1993) have employed the following methods to achieve self-compactibility:

1. Limited aggregate content
2. Low water/powder ratio
3. Use of superplasticizer

2.3 FIBER

Fiber is added as the filler into the SCC mix proportion in order to improve the creep and shrinkage problem that might occur due to the high amount of powder content in the SCC.

As stated by Banthia (1996), in the hardened state, when fibers are properly bonded, they interact with the matrix at the level of micro-cracks and effectively bridge these cracks thereby providing stress transfer media that delays their coalescence and unstable growth. If the fiber volume fraction is sufficiently high, this may result in an increase in the tensile strength of the matrix.

Once the tensile capacity of the composite is reached, and coalescence and conversion of micro-cracks to macro-cracks has occurred, fibers depending on their length and bonding characteristics to continue to restrain crack opening and crack growth by effectively bridging across macro-cracks.

2.4 SUPERPLASTICIZER

Superplasticizer, also known as plasticizers, includes water-reducing admixtures. Superplasticizers are "high range water reducer". It is an admixtures that allow large water reduction or greater flowability without substantially slowing set time or increasing air entrainment. It is a chemical admixture that can be added to concrete mixtures to improve workability. The strength of the concrete is inversely proportional to the amount of water added or w/c ratio. It means that less water is needed in order to produce stronger concrete.

The amount that usually added to concrete is 2% per unit weight of cement. However, most commercially available superplasticizers come dissolved in water, so the extra water added need to be accounted for in mix proportioning. Adding an excessive amount of superplasticizer will result in excessive segregation of concrete.

Plasticizers are commonly manufactured from lignosulfonates, which is a byproduct from the paper industry.superplasticizers have generally been manufactures from sulfonated naphthalene formaldehyde or sulfonated melamine formaldehyde, although new generation products based on polycarboxylic ethers are now available.

The traditional lignosulfonate based plasticizers and naphthalene and melamine based superplasticizers disperse the flocculated cement particles through a mechanism of electrostatic repulsion. In normal plasticizers, the active substances are absorbed on to the cement particles, giving them a negative charge, which leads to repulsion between particles. Naphthalene and melamine superplasticizers are organic polymers. The long molecules wrap themselves around the cement particles, giving them a highly negative charge so that they repel each other.

The new generation of superplasticizers which is Polycarboxylate Ethers (PCE) is not only chemically different to the older sulphonated melamine and naphthalene based products but their action mechanism is also different. It gives cement dispersion by steric stabilization, instead of electrostatic repulsion. This kind of repulsion is stronger in its effect and gives improved workability retention to the cementatious mix. In addition, the chemical structure of PCE allows for a greater degree of chemical modification than the older generation products, offering a range of performance that can be tailored to meet specific needs.

2.5 VISCOSITY MODIFYING AGENTS (VMA)

The conventional method of improving the stability of flowing SCC is to increase the fines content by using a large amount of filler, reactive or inert. However, attempts are being made to reduce the fines content to the level of normal concrete in order to reduce the creep and shrinkage by using VMA to improve the stability. Current research shows that with low powder content and VMA had similar fresh concrete properties as SCC with high powder content produced without VMA. The sequence of adding the VMA ans superplasticizer into the concrete mixture is important. If VMA is added before the superplasticizer, it swells in water and it becomes difficult to produce flowing concrete. To avoid this problem, VMA should be adde after the superplasticizer has come into contact with the cement particles.

2.6 DURABILITY

Durability is defined as the capability of the concrete to maintain its long term structural performances. Durability of concrete is a relative properties because it is simultaneously depends on the chemical and physical characteristic of concrete and environmental conditions.

The environments that can affect the durability of concrete which concrete is exposed are atmosphere, soil condition and water. Among the attack that concrete are subjected into are sulphate attack, acid attack, carbonation, alkali-aggregate reaction, freezing-thawing and abrasion. Performance of concrete against all these attack is called Durability.

Carbonation is a major risk for reinforced concrete because it can lower alkalinity of the concrete to such extent that iron mar rust and spall the cover. In the design of concrete structures, carbonation is one of the many important factors that determine the service life of a concrete structure.

CHAPTER 3

METHODOLOGY

3.1 PROJECT IDENTIFICATION

The methodologies for this project are as follow:

Stage 1

1. 100% of cement of five mixes is being done in order to investigate the role of w/c ratio with different amount of superplasticizer for every mix
2. The mixes are as follows:

Mix. No	OPC	Coarse Aggregate		Fine Aggregate	Water	Superplasticizer (S/P)		W/C
		(5-10mm)	(10-14mm)			S/P %	S/P Weight	
BM1	450	700	200	1030	200	2.0	9.00	0.44
A1	450	470	250	1000	200	2.0	9.00	0.44
AS1	450	470	250	1000	200	2.5	11.25	0.44
AS2	450	470	250	1000	200	3.0	13.50	0.44
AS3	450	470	250	1000	200	3.5	15.25	0.44

Table 1: Mixes details for normal SCC

Stage 2

1. Replacement of filler is being done by using pozzolanic material in order to investigate the effect of different amount of pozzolanic material being added to the five mixes.
2. Test and analyze the rheological properties of all mixes.

Stage 3

1. The introduction of fiber in the mixes in order to investigate the effect of different amount of fiber to the creep and shrinkage problem.
2. The mixes are as follow:

Mix. No	OPC	Coarse Aggregate (5-10mm)	Coarse Aggregate (10-14mm)	Fine Aggregate	Water	Superplasticizer (S/P) S/P %	Superplasticizer (S/P) S/P Weight	W/C	Fiber (F) F %	Fiber (F) F Weight
F 1	450	470	250	1000	200	2.50%	11.25	0.44	0.50	2.25
F 2	450	470	250	1000	200	2.50%	11.25	0.44	1.00	4.5
F 3	450	470	250	1000	200	2.50%	11.25	0.44	1.50	6.75

Table 2: Mixes details for fiber added SCC

Stage 4

1. The hardened properties of the first three stages of mixes are being test by using the compressive strength test, tensile strength test and also the elastic modulus test.
2. All the data is being collected and recorded.

The main flow charts of the activities are as follow:

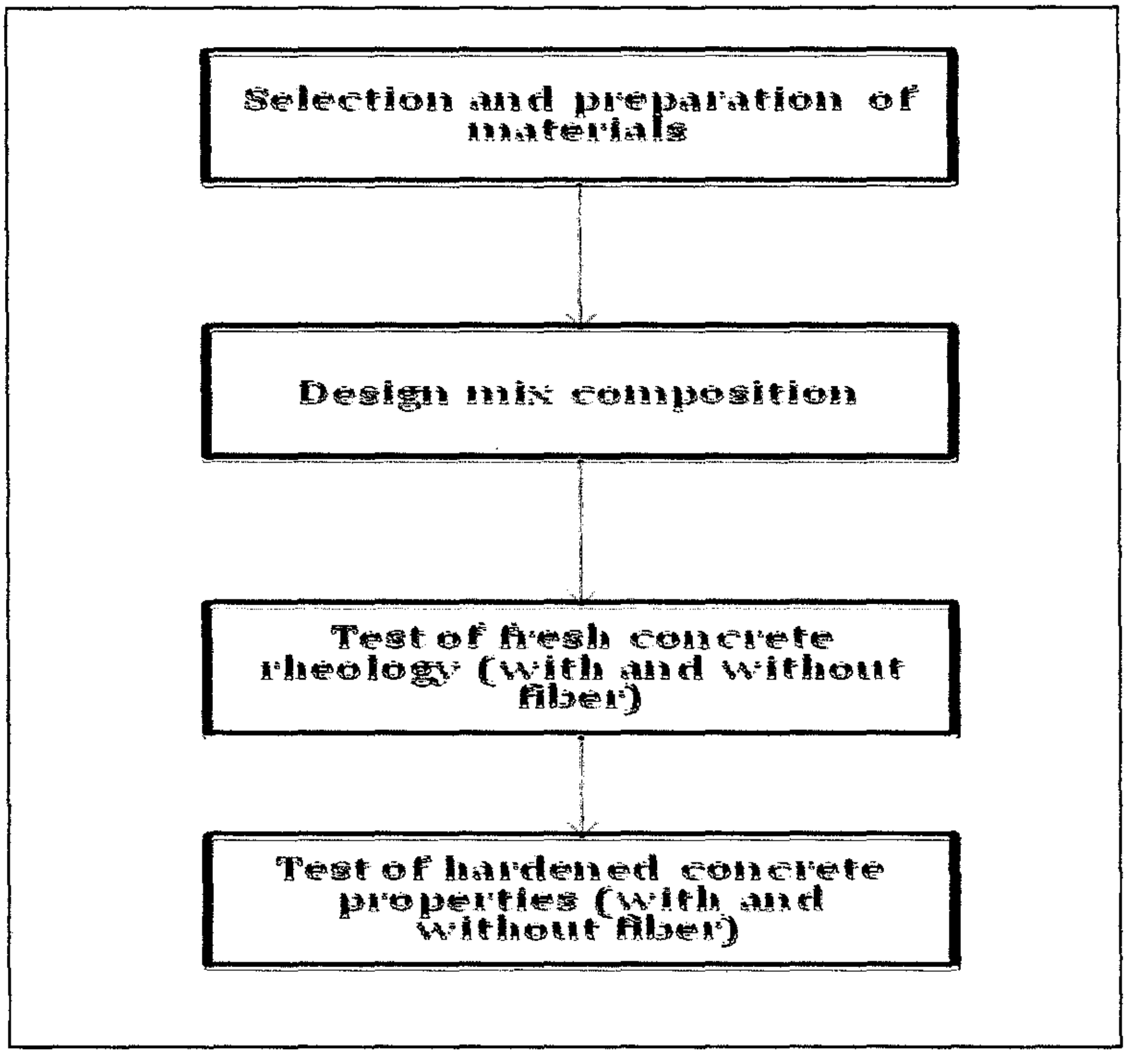

Figure 1: Flow chart of activities

3.2 MIXING AND CASTING

All the concrete mixes were prepared using a tilting drum mixer. The inferior of the drum was initially washed with water to prevent absorption. After the mixing is complete, tests were conducted to determine the rheological properties. The tests conducted were slump flow test, v-funnel test and L-box test. Then, 150mm cubic specimens were prepared for each mix proportion for compressive strength test. 150mm diameter and 300mm tall cylinder were prepared to calculate the tensile strength and lastly 100mm x 100mm x 750mm size plain concrete prisms for modulus elasticity were also prepared.

3.3 FRESH CONCRETE TESTS

3.3.1 Slump flow Test

Slump flow test is proposed for testing workability and deformability. The concrete spread on the plate is also checked for segregation. Procedures are as follow:

1. The fresh concrete is poured into a standard slump cone.
2. The cone is withdrawn vertically upwards in one movement.
3. The fresh concrete is spread onto the plate.
4. The diameter of the plate is recorded.

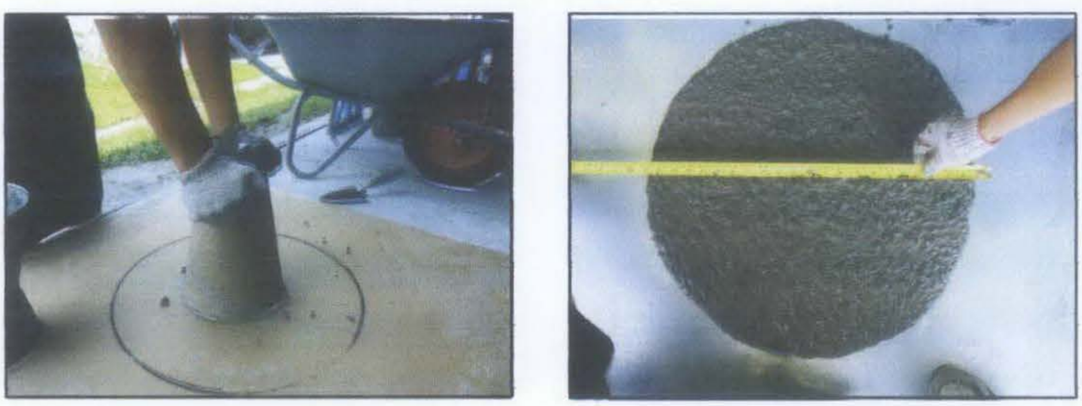

Figure 2: Slump Flow Measurement

3.3.2 V-funnel Test

V-funnel test is proposed for testing viscosity and deformability of concrete. The SCC with higher water content flows faster out of the funnel and has lower viscosity than SCC with lower water content. The procedures are as follows:

1. The V shaped funnel is filled out with fresh concrete.
2. The time taken for the concrete to flow out of the funnel is measured and recorded.

Figure 3: V-Funnel Test

3.3.3 L Box Test

The L Box test is proposed for testing the passing ability of the concrete in confined space. This test can be useful in two ways which are blocking and lack of stability of the SCC.

Figure 4: L-Box Test

3.4 HARDENED CONCRETE TEST

3.6.1 Compressive Strength Test

In BS 5328, the compressive strength is expressed as grade, which is the minimum characteristic cube strength. In the new BS EN 206-1 and BS8500, the characteristic compressive strength is expressed as a strength class.

3.6.2 Porosity Test

Porosity of concrete is used in determining or classifying its durability. The concrete with high porosity percentage will have lower compressive strength than the lower porosity percentage. The porosity test for this project is using vacuum saturation method. It is a method of assessing the total water absorption porosity of a material.

This method was conducted on slices of cylinders cores that have been cored from the 100 x 100 x 100 mm cubes. The cored slices were put inside the vacuum desiccators for 30 minutes, and then it is filled up with water and being leave for 6 hours. After 24 hours soaked iin water, the sample was dried at 100^0C.

The Porosity Percentage is calculated from:

$$P = \frac{W_{sat} - W_{oven}}{W_{sat} - W_{water}} \quad 100$$

- P is Vacuum Saturation Porosity (%)
- W_{sat} is weight in air of saturated sample
- W_{water} is weight in water of saturated sample
- W_{oven} is weight of oven dried sample

Figure 5: Coring the cube before Porosity test

3.5 EQUIPMENT AND TOOLS REQUIRED

3.4.1 Fresh Concrete Test

For this particular test, there are 3 equipments used. Those three equipments are:

1. Slump cone and plate
2. V-funnel
3. L-box

3.4.2 Hardened Concrete Test

For this test, two main equipments will be used:

1. Compressive strength test machine
2. Tensile strength test machine

CHAPTER 4

RESULTS AND DISCUSSION

4.1 SCC WITHOUT ANY ADDITION (NORMAL SCC)

4.1.1 SLUMP TEST RESULT

Mix. No	OPC	Coarse Aggregate		Fine Aggregate	Water	Superplasticizer (S/P)		W/C	Result (mm)
		(5-10mm)	(10-14mm)			S/P %	S/P Weight		
BM1	450	700	200	1030	200	2.0	9.00	0.44	
A1	450	470	250	1000	200	2.0	9.00	0.44	
AS1	450	470	250	1000	200	2.5	11.25	0.44	710
AS2	450	470	250	1000	200	3.0	13.50	0.44	620
AS3	450	470	250	1000	200	3.5	15.25	0.44	610

Table 3: slump test result

From Table 3 above, it can be seen that the slump flow diameters varies between 500mm and 700mm. Based on the European guidelines, this slump flow class satisfies for SF1 (520-650mm) and SF2 (660-750mm). This slump flow SCC is suitable for many normal application, or slightly reinforced concrete structures.

As from the above table, we can also get the optimum dosage of Superplasticizer that will be used for pozolanic material in the next semester. The optimum dosage of SP for this particular slump test is 2.5% of the weight of the OPC.

4.1.2 V – FUNNEL TEST RESULT

Mix. No	OPC	Coarse Aggregate		Fine Aggregate	Water	Superplasticizer (S/P)		W/C	Result (s)
		(5-10mm)	(10-14mm)			S/P %	S/P Weight		
BM1	450	700	200	1030	200	2.0	9.00	0.44	364.2
A1	450	470	250	1000	200	2.0	9.00	0.44	9.19
AS1	450	470	250	1000	200	2.5	11.25	0.44	6.19
AS2	450	470	250	1000	200	3.0	13.50	0.44	35.0
AS3	450	470	250	1000	200	3.5	15.25	0.44	29.0

Table 4: V-funnel test result

From Table 4 above, it shows that the time taken by the SCC mix to flow out from the V-funnel. The time taken is in seconds. The range of time for this test is between 6 seconds to 11 seconds. If the time is in this range then the SCC is a good quality SCC. From this test, we get the time varies from 6 seconds up to 364.2 seconds.

As for table above, we can also determine the optimum dosage of SP based on the time recorded. The time that is in the acceptable range is 6.19 seconds and 9.19 second which is from the dosage of 2% and also 2.5% of SP from the weight of the OPC. So, the optimum SP for this test we take it to be 2.5% also.

4.1.3 L BOX TEST RESULT

Mix. No	OPC	Coarse Aggregate		Fine Aggregate	Water	Superplasticizer (S/P)		W/C	Result (H_2/H_1)
		(5-10mm)	(10-14mm)			S/P %	S/P Weight		
BM1	450	700	200	1030	200	2.0	9.00	0.44	0.00
A1	450	470	250	1000	200	2.0	9.00	0.44	0.52
AS1	450	470	250	1000	200	2.5	11.25	0.44	0.29
AS2	450	470	250	1000	200	3.0	13.50	0.44	0.55
AS3	450	470	250	1000	200	3.5	15.25	0.44	0.28

Table 5: L Box test results

From Table 5 above, we can know the blocking ration of the SCC. The blocking ratio in this test is calculated by dividing the H2 with respect to H1. H2 is the height of the SCC at the edge of the horizontal member of the L Box while H1 is the height of the SCC left inside the vertical member of the L Box. The acceptable range for this test is between 0.8 and 0.9. From the result, the value is between 0 and 0.55.

We cannot say that our SCC fails. The result that we got slightly lower than the acceptable range is cause by the high water/Cement ratio. Based on our findings, the maximum w/c ratio that many researchers use is 0.4. As for our project we used 0.44. So, based on this result we take 3% of SP dosage to be the optimum.

4.1.4 COMPRESSIVE STRENGTH TEST

Mix Name	Day			
	3 Day	7 Day	28 Day	56 Day
BM1	32.97	41.71	52.44	62.88
A1	29.06	39.07	43.91	47.06
AS1	31.49	39.26	47.49	53.71
AS2	38.82	41.13	48.15	51.30
AS3	36.68	40.89	54.38	50.99

Table 6: Compressive strength test results

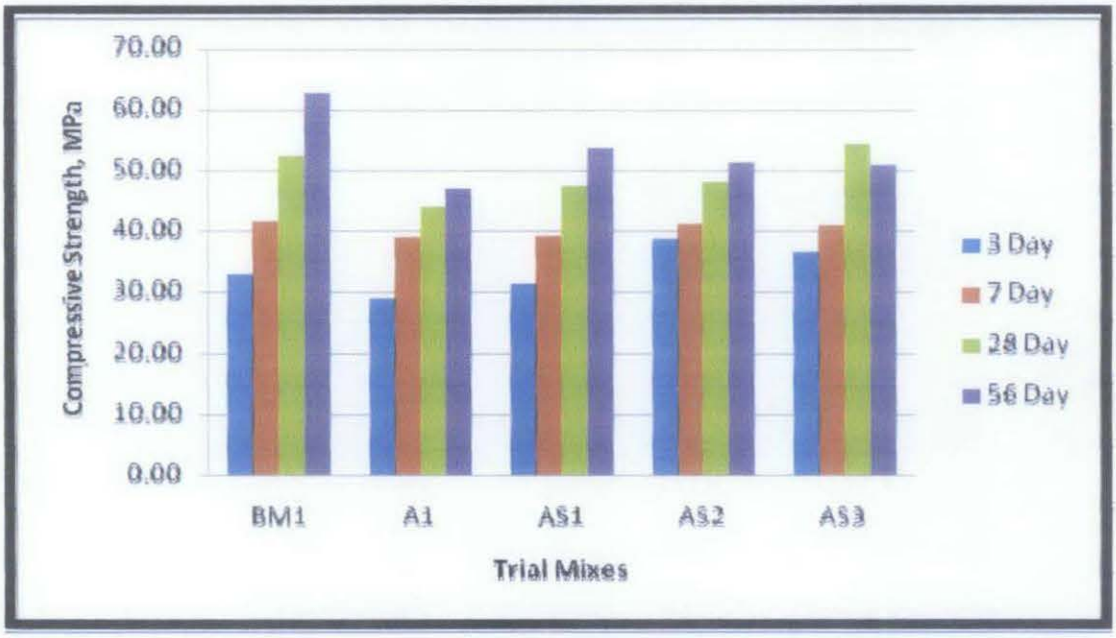

Figure 6: Compressive strength graph

From this result, we can see that as the time of curing increase, the strength of the SCC also increase. Based on the above result, we can see that mix AS3 is having the highest compressive strength compare to other mixes. As stated earlier, AS3 mix is using 3% of SP dosage. We expected the value of the strength will increase at 56 days of compressive strength test.

4.2 SCC WITH THE ADDITION OF FIBER

4.2.1 FRESH PROPERTIES

Mix. No	OPC	Coarse Aggregate (5-10mm)	Coarse Aggregate (10-14mm)	Fine Aggregate	Water	Superplasticizer (S/P) S/P %	Superplasticizer (S/P) S/P Weight	W/C	Fiber (F) F %	Fiber (F) F Weight
F 1	450	470	250	1000	200	2.50%	11.25	0.44	0.50%	2.25
F 2	450	470	250	1000	200	2.50%	11.25	0.44	1.00%	4.5
F 3	450	470	250	1000	200	2.50%	11.25	0.44	1.50%	6.75

Table 7: Specification of fiber added SCC

For fiber addition, we are using 3 different percentage of fiber which is 0.5%, 1.0%, and 1.5%. The percentage of fiber is taken from the total weight of the OPC. The other properties like OPC, aggregates, and also sand are still the same as the normal SCC. For SP dosage we take it to be 2.5% as it is our optimum SP dosage that we get from the previous test using the normal SCC or the trial mix. Then the testing of the 3 fresh properties testing is being done. Below are the results of the test:

Mix No.	Slump Flow Test (mm)	V- Funnel Test (s)	L- Box Test (mm) Blocking Ratio H_2/H_1
F1	510	50	0
F2	410	68	0
F3	450	56	0

Table 8: Results of fresh properties test

From this result, we can say that the fiber will make the SCC become less workable. The V-funnel result and also the L-box test result are not within an allowable range. This may be because of the structure of the fiber that makes the concrete become harder than the concrete without the addition of fiber.

4.2.2 COMPRESSIVE STRENGTH TEST

Mix Name	Day			
	3 Day	7 Day	28 Day	56 Day
F1	37.96	46.43	58.60	64.27
F2	35.55	44.49	55.21	58.545
F3	37.76	42.15	53.53	49.79

Table 9: Compressive Strength test results (fiber SCC)

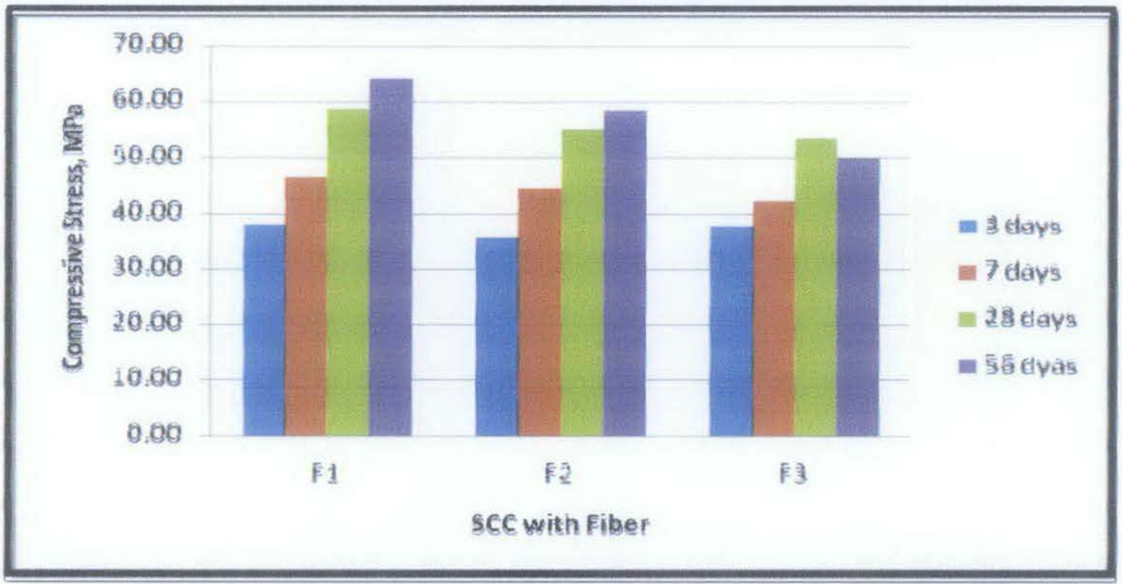

Figure 7: Compressive strength graph (fiber SCC)

Based on these results, the strength of the SCC with the addition of fiber are higher than the SCC without the addition of fiber. Thus, we can say that the effect of the fiber towards the SCC is increasing in compressive strength. Form this results, the higher compressive strength that we get is 58.6 MPa which is form mix number F1 with 0.5% of fiber added by percentage of the weight of the OPC. It is also increasing in strength with the increasing in time of curing of the SCC. We expected it to be increased higher than this number during the 56 days compressive strength test.

4.3 POROSITY TEST RESULTS

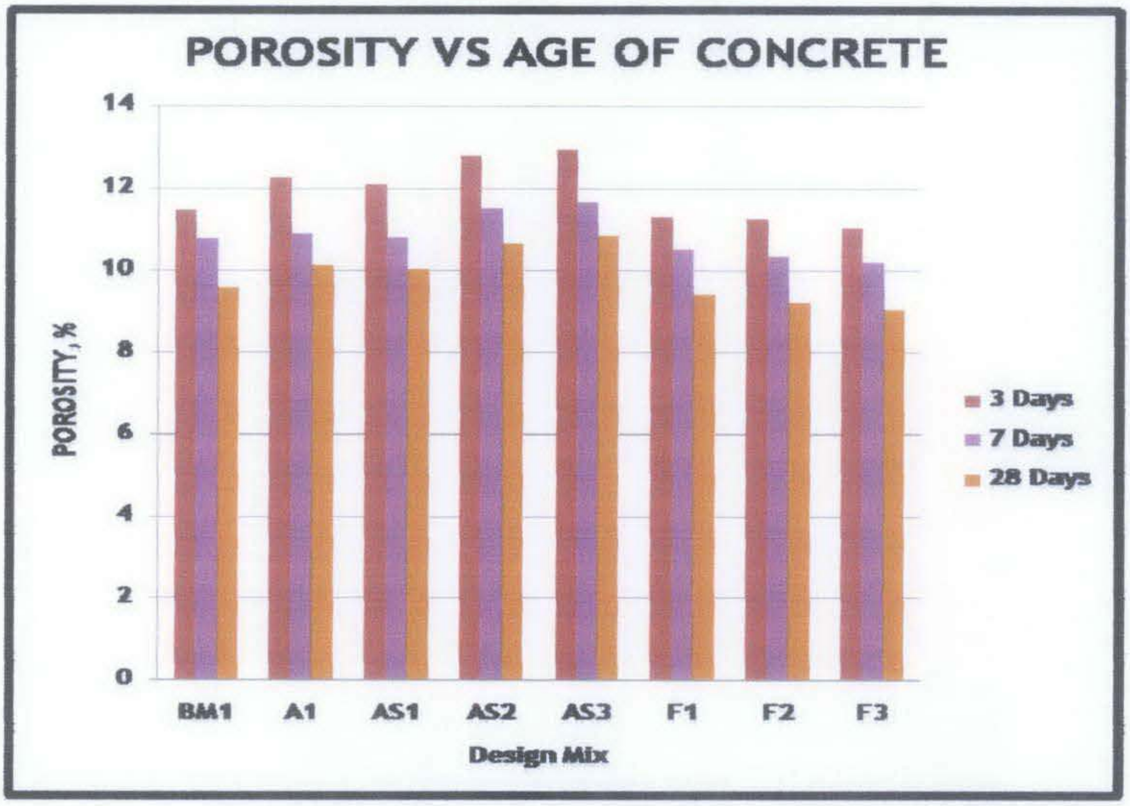

Figure 8: Porosity Results

From the chart above, we can see that there are not much different in the porosity of the concrete. What we can see is that all the 3 fiber mixes have the lowest porosity percentage compared to the other trial mixes. This is because the fiber that is being incorporated inside the concrete is helping the concrete itself to reduce the void of air within the concrete. The lower percentage of porosity will gives better quality of concrete. This is because the compressive strength will increase as the porosity percentage decrease. This can be proven from the chart. We can see that all the trial mixes have higher porosity percentage than the fiber added one and this will results in the lower compressive strength of the concrete than the fiber added SCC.

4.4 RESULT COMPARISON OF THE TWO DIFFERENT SCC

4.3.1 FRESH PROPERTIES RESULTS

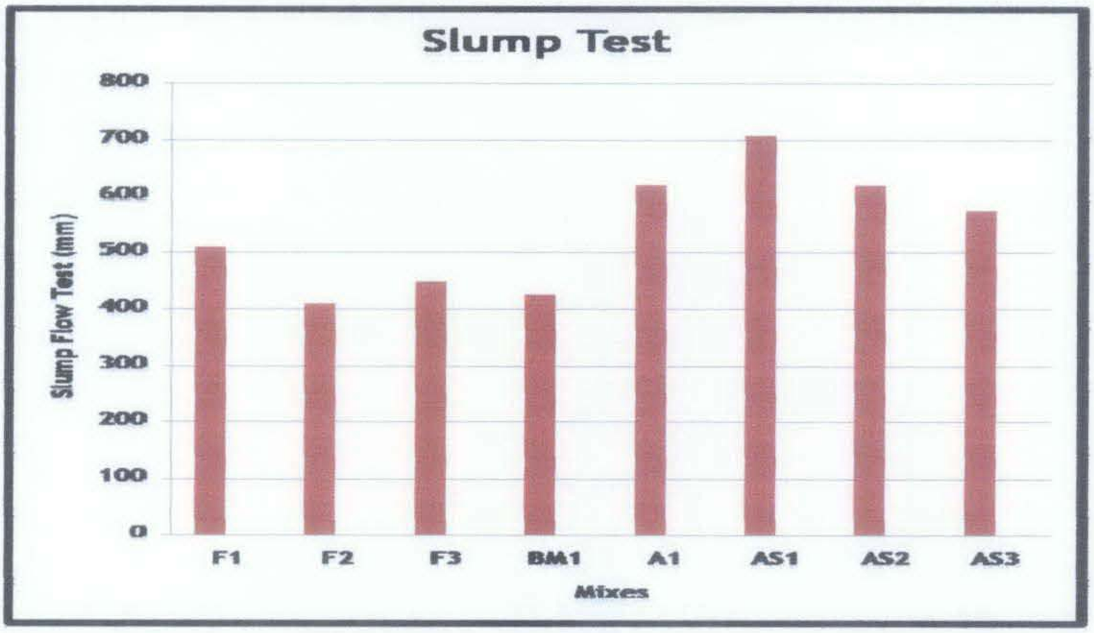

Figure 9: Slump Test Comparison

From this graph, we can see that the result for slump test of the SCC is being reduced as the fiber is being added. This means that by adding the fiber, it will reduce the workability and also the flowability of the concrete. Thus, among the 3 fiber mixes, we can see that F1 mix get the highest Slump results which indicates that the mix is the optimum mix for fiber addition in order to get allowable slump reading. The allowable slump taken from this experiment is from the range of 500 mm to 700 mm of the diameter of the SCC spread.

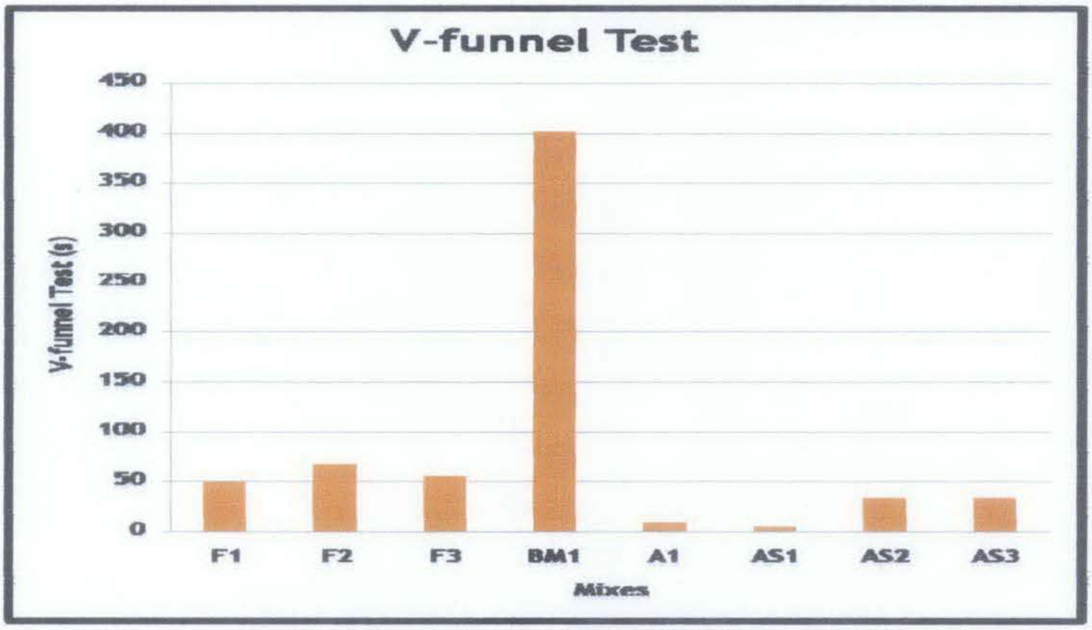

Figure 10: V-funnel Test Comparison

From the above bar chart, we can interpret that the lower time taken by the SCC to pass the test, the better the workability of the SCC. Based on these results, we can see that all 3 mix of fiber added SCC has increased the time taken to pass the V-funnel test. This means that the fiber reduce the flowability and also the workability of the SCC itself. The allowable range of time is from 6 to 11 seconds.

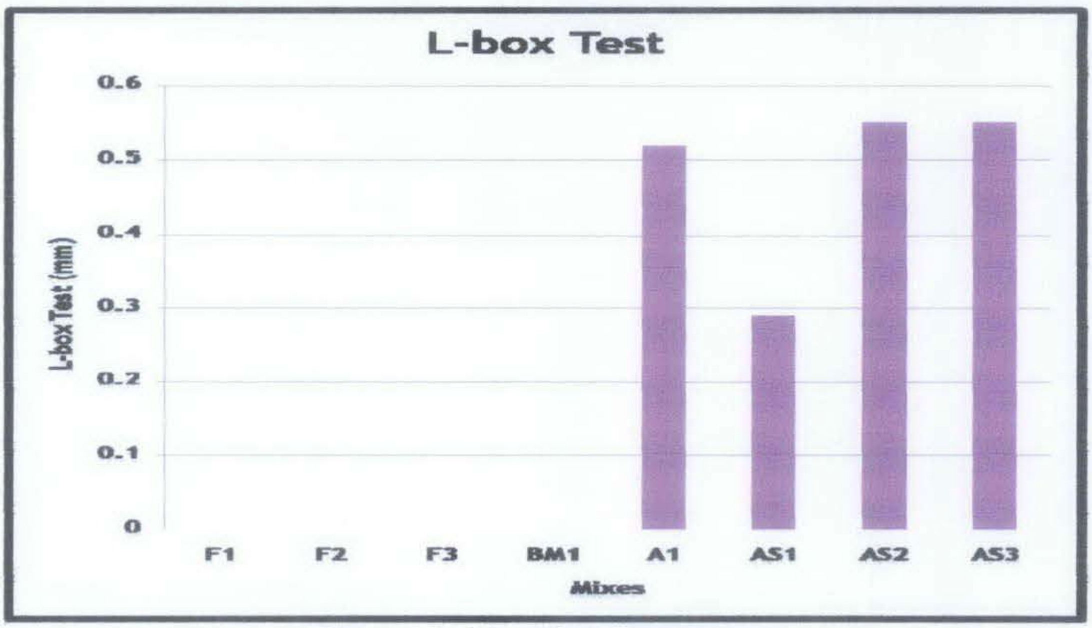

Figure 11: L-box Test Comparison

From the above data, we can see that none of the fiber mix SCC passes the L-box test. The blocking ratio from the L-box test is zero for all 3 mix of fiber added SCC. This means that the passing ability is reduce by adding the fiber.

4.4.2 HARDENED PROPERTIES

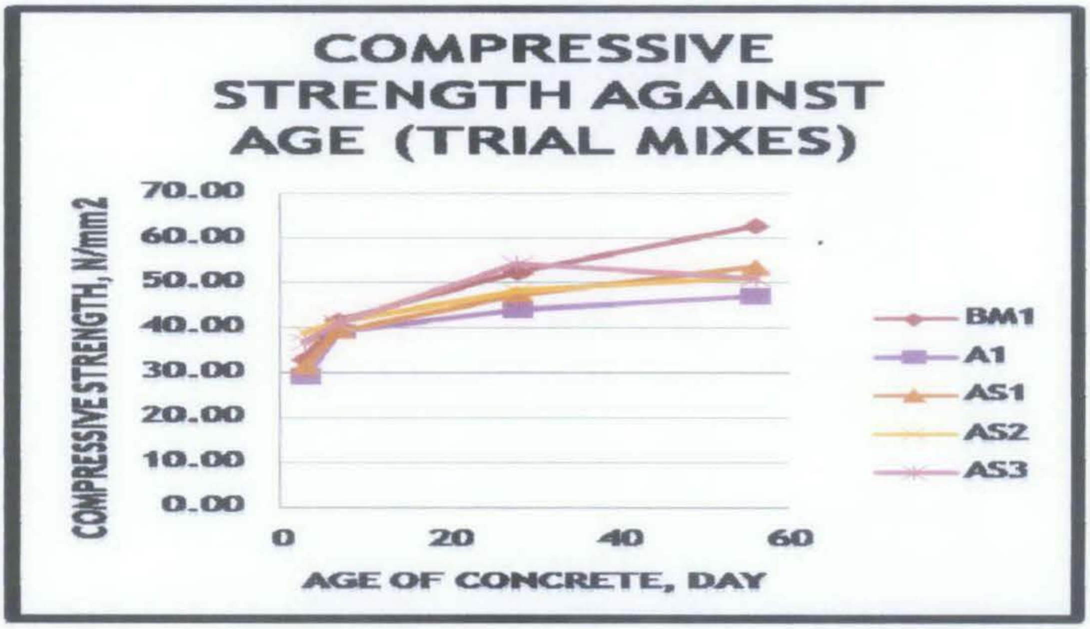

Figure 12: Compressive vs age (without fiber)

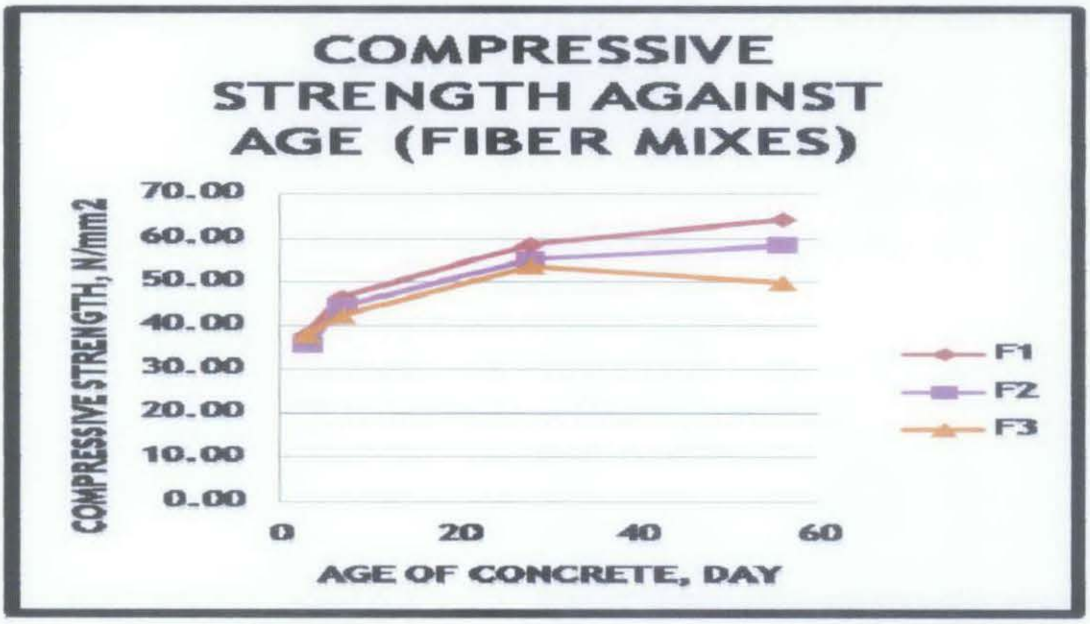

Figure 13: Compressive vs age (with fiber)

From the two graph above, we can see that the compressive strength of the fiber added concrete is slightly higher than the normal SCC. This means that the fiber will help in increasing the strength of the SCC. On the other hand, from the 3 fiber mix, we can see that F1 or with 0.5% fiber addition gives the highest compressive strength among all other mixes. This means that 0.5% fiber addition is the optimum amount of fiber that need to be added to this experiment in order to get high compressive strength. With the increasing value or amount of fiber added, the compressive strength will also decrease.

CHAPTER 5

CONCLUSION AND RECOMMENDATION

5.1 CONCLUSION

The objective of this studies is first to determine the optimum dosage of SP and then used it for finding the optimum dosage of fiber addition that will produce a high strength SCC. A total of 5 successful mixes have been done. The results from the earlier table are just the first step from our project. It is to determine the optimum dosage of the SP so that we can use it for the pozzolanic material and also fiber addition of the SCC.

Based on the result, we can take the maximum SP dosage to be 2.5% of the weight of the OPC. After having the optimum dosage, the fiber will be added differently and the compressive strength of the SCC will be checked of tested.

Based on the above table for fiber added SCC, we can see that the strength of the fiber added SCC is higher than the normal SCC or the trial one. Although there is not much of the difference, we can see that it has improved in term of strength. We can also see that the larger amount of fiber added into the concrete will result in the smaller reading of compressive strength. This means that will higher amount of fiber added inside the SCC, the compressive strength will be lowered. From this experiment, we get that 0.5% fiber addition will give the highest amount of compressive strength which is about 65 MPa after 56 days of curing.

However, for the fresh properties, the fiber added SCC is not that good. All the three mixes of the fiber added SCC has failed the V- funnel and also the L-box test. This means that the viscosity of the SCC after adding the fiber has been reducing. The passing ability of the concrete also has been reducing as it cannot flow freely through the steel bars at the L-box.

5.2 RECOMMENDATION

Some of the recommendations for future work that will need to be done are:

1. In order to get more accurate results, the concrete can be cured up to 100 days. These results will allow us to compare more on the real strength of the SCC itself. The expected results are to be higher than the results of the 56 days.

2. This experiment only uses 3 type of fiber added mixes due to cost constrain. In order to get variety of mixes and then to select the best optimum mix design for the amount of fiber added concrete, we can use more than 1.5% of fiber added SCC. We can add up the fiber up to about 3% of fiber and then see the difference off all fiber added SCC.

3. Based on our result, some of the mix has not achieved the SCC properties. This is because it does not pass the 3 type of fresh properties test which are slump, v-funnel and L-box test. So for future studies, we recommend that the amount of aggregate and also the amount of sand to be reduced in order to make it more workable and also increase the passing ability of the SCC.

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APPENDIXES

Concrete cube after testing

Slump measuring

Compressive Strength Machine

Concrete failure

Gantt Chart

NO	WEEK / DETAIL	FYP 1														FYP 2													
		WEEK																											
		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28
1	Selection of Project Topic																												
2	Preliminary Research Work																												
3	Submission of Extended Proposal						●																						
4	Proposal Defence																												
5	Testing SCC Mixes without Pozzolan																												
6	Submission of Interim Draft Report													●															
7	Submission of Interim Report														●														
8	Testing SCC mixes with pozzolan																												
9	Testing SCC mixes with fiber																												
10	Hardened properties test of SCC																												
	Data and Result Analysis																												
	Submission of Progress Report																						●						

	Submission of Draft Report																									●			
	Submission of Dissertation(Soft																										●		
	Submission of Technical Paper																										●		
	Oral Presentation																											●	
	Submission of Dissertation (Hard Bound)																												●

Legend:

FYP 1

FYP 2

TIME PLANNING

● SUGGESTED MILESTONE BY COORDINATOR