ASSESSMENT OF HOOK END STEEL FIBRE AS A SUBSTITUTE MATERIAL IN HIGH PERFORMANCE CONCRETE BEAM

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SCHOOL OF CIVIL ENGINEERING
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By

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I hereby declare that all corrections and comments made by the supervisor(s)and examiner have been taken into consideration and rectified accordingly.

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ABSTRAK

Kajian telah dijalankan untuk mengenalpasti kandungan optimum gentian keluli yang perlu digunakan untuk mencapai keupayaan lenturan rasuk maksimum konkrit berprestasi tinggi. Gentian keluli hujung bercangkuk yang mempunyai garispusat 0.75 mm dan panjang 60 mm telah digunakan. Kandungan gentian keluli sebanyak 0%, 1%, 2% dan 3% telah digunakan dalam campuran konkrit. Kekuatan mampatan konkrit yang melebihi 70 MPa telah direka bentuk, kerana projek ini berfokus kepada konkrit berprestasi tinggi. Sejumlah empat ujian telah dijalankan berdasarkan kepada BS1881. Empat ujian tersebut adalan ujian meja aliran, ujian mampatan kiub, ujian ketegangan pisah dan ujian lenturan rasuk. Daripada ujian meja aliran apabila kandungan gentian keluli ditambah, aliran konkrit semakin berkurangan. Aliran konkrit untuk 0%, 1%, 2% and 3% gentian keluli adalah 654 mm, 605 mm, 584 mm dan 556 mm. Semakin bertambah kandungan keluli gentian, semakin itu dos superplastik perlu ditingkatkan untuk mengekalkan aliran konkrit yang sama. Melalui ujian mampatan, didapati bahawa tambahan gentian keluli meningkatkan kekuatan mampatan. Optimum gentian keluli sebanyak 2% dapat mencapai kekuatan mampatan sebanyak 105.7 MPa (14.9% peningkatan dalam kekuatan mampatan dari sampel kawalan). Selain itu, kekuatan tegangan juga meningkat dengan tambahan gentian keluli. Optimum gentian keluli sebanyak 2% dapat mencapai kekuatan tegangan 9.1% MPa (46.8% peningkatan dalam kekuatan tegangan dari sampel kawalan). Empat rasuk bersaiz 100 mm x 300 mm x 2000 mm telah direka untuk diuji dalam ujian lenturan rasuk. Kekuatan lenturan maksimum 21.65 MPa dicapai apabila 2% gentian keluli diguna. Peningkatan selanjut melebihi 2% gentian keluli akan mengurangkan kekuatan konkrit berprestasi tinggi. Kekakuan konkrit berprestasi tinggi dengan gentian keluli lebih tinggi dari sampel kawalan sebelum gagal.

ABSTRACT

A study was done to identify the optimum fibre content to achieve maximum flexural capacity of high performance concrete beam. Hook end steel fibre of diameter 0.75 mm and 60 mm length have been used. The proportion of steel fibre that have been used are 0%, 1%, 2% and 3% by mass, this is done by adding to concrete mixture. The targeted compressive strength of concrete is more than 70 MPa since it is high performance concrete. A total of four tests were conducted according to BS1881. The four tests conducted are flow table test, cube compression test, tensile splitting test and flexural test. From the flow test, as the steel fibre content increases the flow started to decrease. The flow result for 0%, 1%, 2% and 3% steel fibre are 654 mm, 605 mm, 584 mm and 556 mm respectively. The superplasticizer dose should be increased as steel fibre content increase to maintain the same flow. From the compressive test, the addition of steel fibre increases the compressive strength of high performance concrete. The optimum steel fibre of 2% able to achieve maximum compressive strength of 105.7 MPa (14.9% gain in compressive strength than control sample). Other than that, addition of steel fibre also improve the tensile strength of concrete. The optimum steel fibre of 2% able to achieve maximum tensile strength of 9.1 MPa (46.8% gain in tensile splitting strength than control sample). Four beams of 100 mm x 300 mm x 2000 mm size were casted for the four-point flexural test. The highest flexural strength that was obtained is 21.65 MPa which was achieved at 2% of steel fibre. Further increase of steel fibre more than 2% reduced the respective strength of high performance concrete. The stiffness of high performance concrete with steel fibre is high compared to control sample before failure.

TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

CHAPTER 1

INTRODUCTION

1.1 Introduction

High performance concrete is referred to concrete having strength more than 70 MPa in 28 days (Leung, 2001). The concrete structures which made from high performance concrete having advantages as it will have low dead load (Kumar et al., 2017). Therefore, the size of the beam structure and reinforcement will be reduced in concrete in order to reduce the dead load. When it comes to compressive strength the high performance concrete will have high compressive strength, whereas the tensile of the concrete will not be that good (Logoń, 2012).

Therefore, for the concrete which has a small cross section might have reduced reinforcement size, then the tensile capacity of concrete might be lower which contribute formation of crack very easily compared to the normal concrete. The flexural capacity of the concrete is also being an issue in the concrete where it failed when an object is exposed on top of the mid span of concrete, the flexural of beam can be observed where the compression will occur on top of concrete while the tension will occur on bottom of concrete. As the resisting compressive force of the high performance concrete is generally high, it is not being an issue, while at the bottom of the concrete the resisting force for tension will be low thus the reinforcement will be used to counter the crack formation on bottom of concrete. Since the concrete is high performance concrete, it might have reduced cross section in order to reduce the dead load of the concrete (Kumar et al., 2017). Therefore, the size or the number of reinforcement in the concrete will be reduced. At same time it will influence the flexural strength.

In order to overcome this problem, steel fibre are normally used to enhance the tensile capacity of the concrete as it have some capabilities in slowing down the rate of the crack and it will reduce the propagation of crack from bottom to top (Gao et al., 1997). Therefore, the steel fibre has been a material to enhance the tensile capacity of concrete and at the same time it could help in increasing the flexural strength of the high performance concrete.

When adding the steel fibre it could affect the workability or flow of the high performance concrete. One of the main characteristic of the high performance concrete is having a high workability (Kumar et al., 2017) which ease the self-compaction of concrete mixture, thus reducing the void in the mix and preserve the compressive strength of the concrete.

1.2 Problem statement

Concrete generally capable of resisting the compression force but it is weak in resisting the tension force. That is the reason why the reinforcement is being used in the concrete to enhance the tensile capacity of concrete. However, when the size of the reinforcement is reduced in concrete, then capabilities of concrete resisting the tensile will be low, and could cause reduction in flexural strength, cracks can easily propagate. Therefore, in order to maintain the tensile capacity of the concrete other alternatives can be used such as steel fibre which could contribute the compressive, tensile capacity and directly will improve the flexural capacity of the concrete (Gao et al., 1997).

Adding steel fibre could enhance the tensile capacity and will reduce the rate of cracking or progress of cracking due to loads, then minimize the crack propagation to compression zone which could reduce the possibilities of the concrete to failure. In this study, different proportions of steel fibre will be used in high performance concrete to enhance the tensile capacity of the concrete and the flexural capacity of the beam. The type of steel fibre that is going to be used is hook end steel fibre. The best optimum hook end steel fibre will be determined for the optimum fibre content which could contribute maximum flexural capacity.

One of the main characteristic of high performance concrete is that it will have high flow or high workability compared to conventional concrete by adding steel fibre might affect the workability of concrete. Therefore, the flow for different proportion of steel fibres will be measured accordingly.

1.3 Objectives

The objective of this study are as follows:

1) To determine the optimum hook end steel fibre that should be used in order to achieve high flexural strength.
2) To evaluate the mechanical properties of the high performance fibre reinforced concrete (HPFRC).
3) To determine the effect of different proportion of steel fibre towards the workability of high performance concrete.

1.4 Scope of work

The scope of the project is to cast the samples, identify the flexural strength of the beam, compressive strength, tensile splitting strength and workability of the concrete with different proportion of end hook steel fibre. The test data are taken, analyzed, and discussion made based on the result obtained.

1.5 Expected Outcome

The optimum hook end steel fibre content to be used in high performance concrete in order to get maximum flexural strength can be identified, the flow of concrete mixture with different hook end steel fibre proportion and then other mechanical properties of high performance fibre reinforce concrete can be obtained.

CHAPTER 2

LITERATURE REVIEW

2.1 Introduction

The conventional reinforced concrete beam is normally used in construction in order to receive the load from the slab and then transfer load to the column. In order for a beam to function well, it will generally have a larger section, but it contribute to higher dead load due to self-weight of the beam. The self-weight of the beam might be low since the low rise building construction will just have a few numbers of beams in the structure. But when it comes to high rise buildings, the issue cannot be ignored since there will be a huge number of beam structure. This would then contribute to a huge amount of dead load which is not suitable for the high rise building. Therefore, high performance concrete was used for high rise buildings in order to minimize cross sectional area and dead load (Kumar et al., 2017). Since the concrete is high performance concrete, the compressive strength of the concrete is more than 70MPa (Leung, 2001). However, it varies according to country, but there are still some issues regarding the cracking of high performance concrete. Therefore, adding some amount of steel fibre could help in improving the flexural strength of the beam which is closely related to the crack of the high performance concrete (Behbahani, 2010). There are various type of steel fibre available according to its shape and also aspect ratio, the type of steel fibre that have been decided for this project is hook end steel fibre (Dinh, 2009). Hence, it was decided to use different proportions of the hook end steel fibre to find out the optimum steel fibre that can be used to have good flexural strength. At the same time monitoring the compressive strength, tensile strength and also the workability of the high performance concrete.

2.2 High Performance Concrete

High performance concrete is basically being used in a place where there is a need for high strength concrete, high flow and high durability. The high performance concrete will have special particular combination which cannot be achieved by the conventional mixing materials. High performance concrete are made with some special material in order to have high strength, it will also have low water cementing ratio of between 0.20 to 0.45. It shows that the use of water reducing agent such as superplasticizers could contribute to high strength and workability of the concrete (Chang, 2004). Therefore, the material that will be used for mixing are fine sand, silica fume and superplasticizers. These materials are used with cement and water to produce a high performance concrete which will have strength of more 70MPa (Leung, 2001).

2.3 Mixing material

Some special materials been added to the concrete in order to achieve high strength and workability of the concrete, the materials are silica fume, superplasticizers and fine sand (1.18mm - 150 μm) without adding the coarse aggregate.

2.3.1 Silica Fume

Silica fume also having other name like micro silica or condensed silica fume which is a by products from the ferrosilicon alloys or silicon metal (Vaitkevičius and Šerelis, 2014). The use of silica fume in the high performance concrete is due to its function as the micro filler.

The pozzolanic materials are precious material which is very important in the production of high performance concrete. The cements hydration will affect the pozzolanic reaction of the silica fume, where here the cement has dominant in the formation of hydrated products. At the beginning, the silica fume will start react very fast, but as the time goes on the reaction of silica fume will slowly drop. Using silica fume in concrete gives in increased interfacial transition between the binder and steel fibres and between binder and aggregates (Habel et al., 2006).

As the carbon content in silica fumes is reduced, it could give a better compressive strength and also high flow which enhance the formation of high performance concrete. There was some research was done in order to find out the best proportion of silica fume to be used in order to strengthening the concrete, it was found that the addition of 15% is more than enough in order to maximum strength on the 28 days (Wu et al., 2016b). There are also some studies which describe that as long as the silica fume used in a total binder material, it will achieve a better particle packaging which directly could increase the strength of the concrete (Hariharan et al., 2011).

2.3.2 Superplasticizers

Superplasticizers usage in concrete is very important in order to achieve a better workability or flow. It is used in a small quantity of about 5% of the cement mass. The polycarboxylate ether based superplasticizers having a better workability compared to the naphtalene sulfonate based superplasticizer (Ghanbari, 2011). The third generation of plasticizers which is polycarboxylate ether allow the use of an amount of water to make the concrete. When the water content in concrete is low, it could cause a reduction in workability, therefore the use of superplasticizer could help in maintain workability. It is commonly known as the water dissipation agents (plasticizers) and also (superplasticizers) of high range of water reducer agents.

Scheydt et al. (2008) had shown that the superplasticizer could give high workability to high performance concrete. Studies have been done between the cement and superplasticizers. Tue et al. (2008) have found out the use of superplasticizer increases the workability of the high performance concrete due to the good spread of superplasticizer and concrete mixture. The method of addition of superplasticizer does not affect the hydration of the cement in initial period (Hoang et al., 2016). The dose or the amount of the superplasticizer should be added in a sufficient quantity based on the type of superplasticizer and also the mixture's suitability. Abbas et al. (2016) have found out that adding high amount of plasticizer only effect the early hydration process of cement but it also has given some effect on the development of the macrostructure.

2.3.3 Steel fibre

The steel fibre that are generally used in concrete is to enhance the hardness of the concrete. The fibres are normally added into the concrete to enhance the ductility, therefore it will reduce plastic shrinkage. Moreover, fibres are also added to enhance initial stiffness (Ranjbaran et al., 2018). The best characteristic of the steel fibre is that it has good resistance towards crack propagation and cracking when it is used together with the concrete (Muda et al., 2016). The steel fibres have the ability to hold the concrete even after cracking. Steel fibres are being used consistently in high performance concrete mixture due to its high strength, high modulus of elasticity and it having high resistance in alkaline environment. Steel fibre can be classified into several type, the performance of steel fibre varies according to it shape and size (Khadhum et al., 2006).

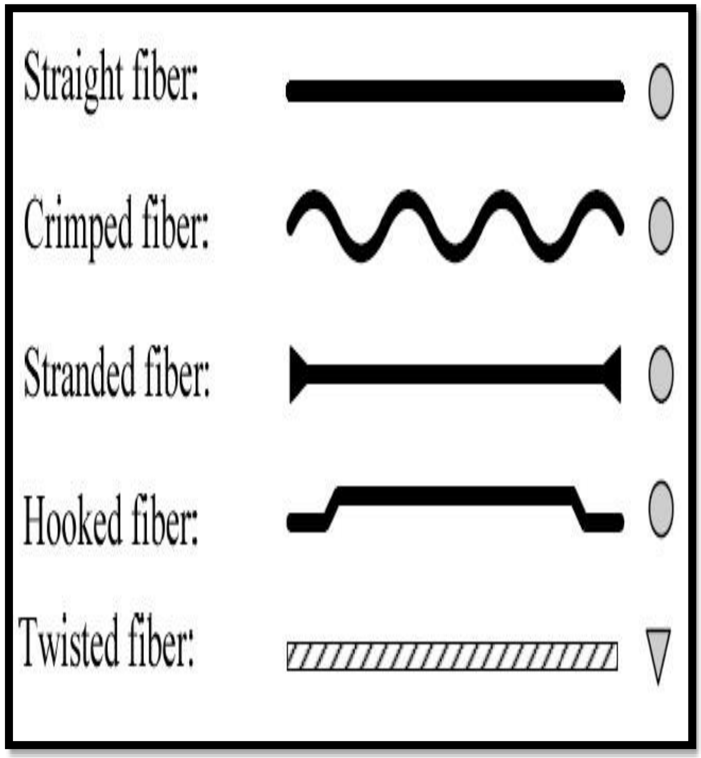


Figure 2.1: Types of Steel Fibres (Dinh, 2009)

There are about 5 types of steel fibre, each having different shapes. As shown in Figure 2.1, the type of steel fibre are straight fibre, crimped fibre, stranded fibre, hooked fibre and twisted fibre (Dinh, 2009). Previous studies have shown that the type of crimpled has low impact on the load deflection behavior, crack pattern and also the moment capacity (Khalil and Tayfur, 2013). The hooked end steel fibre are very effective in improving the flexural tensile strength compared to straight fibre (Pająk and Ponikiewski, 2013). The increase in aspect ratio of hooked end steel fibre increases the tensile and flexural strength (Yazıcı et al., 2007). Therefore, adding steel fibre in concrete will help in slowing down the appearance of the crack, alter the crack pattern and also will help in the reduction of crack on the concrete surface (Behbahani et al., 2012).

2.4 High Performance steel fibre reinforced concrete (HPFRC)

High performance steel fibre reinforced concrete is a concrete which comes with the addition of steel fibres. Since the high performance concrete being used for high rise building the dead load is reduced by reducing the size of the beam (Kumar et al., 2017), therefore the reinforcement size will be reduced, so it could affect the flexural strength of the beam. Since the steel fibre having the capabilities to hold the crack and reduce the rate of crack. Therefore, steel fibre will help in increase the tensile strength of the beam which could directly improve the flexural strength of the beam. Even though the use of steel fibre enhance the properties of beam, but still it will have some limitation, such as the percentage of steel fibre that can give optimum strength.

2.5 Previous studies

2.5.1 Flexural strength

Song and Hwang (2004) conducted a study where the samples of 15 test beam with dimensions of 150 mm x 150 mm x 530 mm was made. Hook end steel fibre of 35 mm long and 0.55 mm diameter were used. The steel fibre proportion of 0%, 0.5%, 1.0%, 1.5% and 2.0% were added into the mould. The test was conducted under three-point loading, with the use of ASTM C1018 as the guidelines for the flexural toughness determination and first crack strength of concrete. The flexural strength was then calculated accordingly.

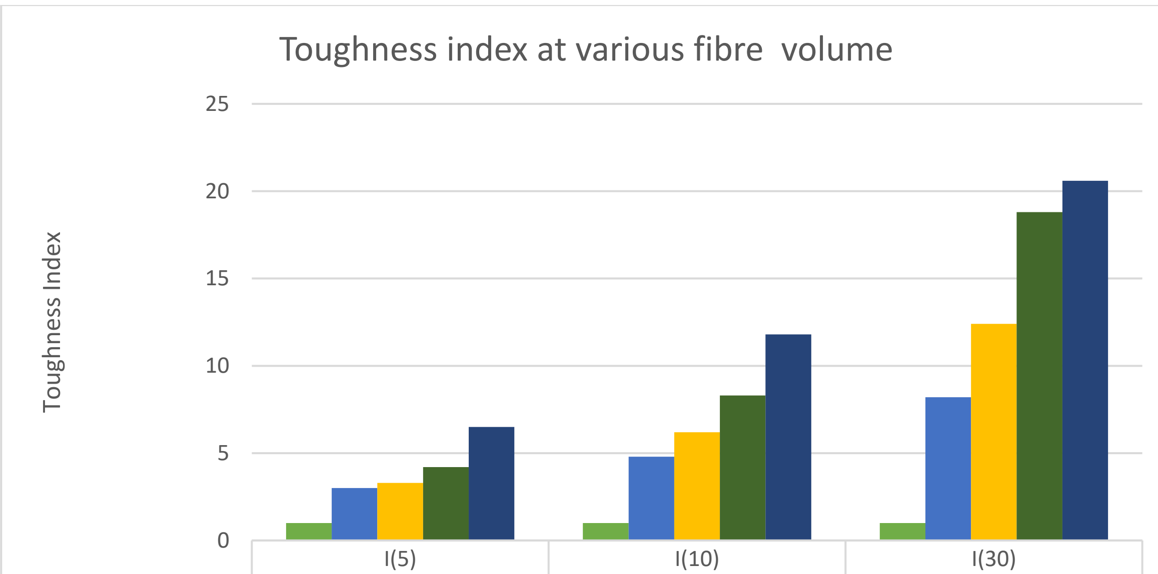
Fiber volume fraction (%)	Modulus of rupture	
	Measured (MPa)	Strength-effectiveness[a] (%)
0	6.4	–
0.5	8.2	28.1
1.0	10.1	57.8
1.5	12.3	92.2
2.0	14.5	126.6

Table 2.1: Flexural strength of concrete (from Song and Hwang, 2004)

The flexural strength of concrete by third point loading which was conducted by Song and Hwang (2004) are given in Table 2.1, shows the value of modulus of rupture according to the use of steel fibre in concrete. It shows that the modulus of rupture of plain concrete is 6.4 MPa, and then when the steel fibre content in concrete increases the modulus of rupture also increases.

The strength effectiveness value was computed by taking the plain concretes as the reference. It shows that when the 2.0% of steel fibre used, the strength effectiveness was 126.6%, which is about 6 times higher than the strength effectiveness of 0.5% of steel fibre. It shows an increase in flexural strength up to 2% of the steel fibre without decrease in strength, it could be because the optimum percentage of steel fibre might not be in the range of tested fibre.

The toughness index (I) have been calculated by Song and Hwang (2004), can be termed as the energy that is absorbed during deflecting the beam at the specified amount. The beam sample of 150 mm x 150 mm x 530 mm was under the load deflection curve which were tested in third point loading. The studies show that the concrete with steel fibre having higher toughness indices compared to concrete which not having steel fibre in it. The estimated indices are I_5 at 3δ, I_{10} at 5.5δ and I_{30} at 15.5δ, when they had assumed that the non-steel fibre concrete as an elastic brittle material.



	I(5)	I(10)	I(30)
Plain (0%)	1	1	1
Steel Fibre (0.5%)	3	4.8	8.2
Steel Fibre (1.0%)	3.3	6.2	12.4
Steel Fibre (1.5%)	4.2	8.3	18.8
Steel Fibre (2.0%)	6.5	11.8	20.6

Figure 2.2: Toughness indices of concrete with different proportion steel fibre (from Song and Hwang, 2004)

The result in Figure 2.3 shows the toughness indices of concrete with different proportion of steel fibre from the estimation of Song and Hwang (2004). It shows that when the volume of the steel fibre increases the toughness index of concrete with fibre increases, in other term we can conclude that when the steel fibre in concrete increases the energy that are required to deflect the beam will be increase or require more energy to deflect the beam.

2.5.2 Tensile strength

The tensile strength of the concrete is one of the most important properties which will affect the size and the extent of cracking in the structures. Moreover, the concrete having a very weak strength in tension due to its brittle properties. Therefore, the concrete not having the capabilities to resist the tension directly, will have the formation of cracks when the tensile force of the concrete exceeds the exposed tensile force. Therefore, it is necessary to determine the tensile strength of the concrete so we can identify the load at which the concrete may have cracked. Studies conducted on hook end steel fibre by Song and Hwang (2004) the tensile strength of the sample has been calculated as shown in Figure 2.4

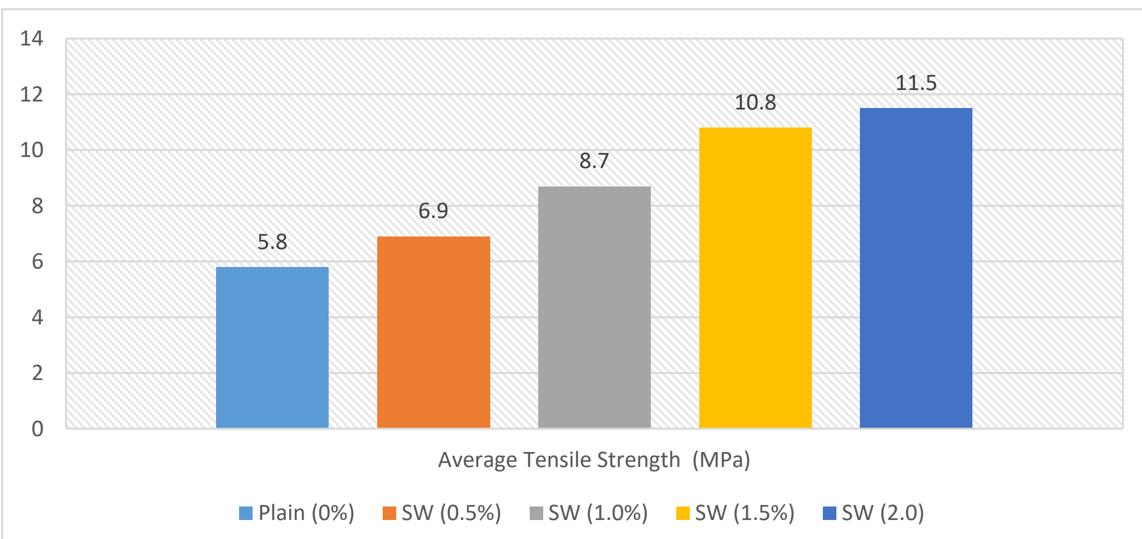


Figure 2.3: Average tensile strength of concrete with different proportion of steel fibre (Song and Hwang, 2004)

Figure 2.4 shows the tensile strength of the concrete against to proportion of the steel fibre used. The graph show that the tensile strength of the concrete increases with the increase of the steel fibre in concrete. The strength effectiveness of concrete with 0.5% and 2.0% are 18.97% and 98.3% respectively compared to the plain concrete. Therefore, the steel fibre in concrete has the capabilities in contributing the tensile strength. Therefore, tensile strength increases with the increase of steel fibre in concrete.

2.5.3 Compressive strength

Compressive strength test was conducted by Song and Hwang (2004) on concrete having the hook end steel fibre, where these fibre has been added in the concrete followed by cement of 430 kg/m^3, silica fume of 43 kg/m^3, water of 133 kg/m^3, superplasticizer of 9 kg/m^3, river sand of 739 kg/m^3 and crushed basalt of 1052 kg/m^3 were used in the production of concrete. The maximum size of the crushed basalt is 19 mm, and fine aggregate which having fineness modulus of 3.1. Silica fume addictive was used in order to improve the properties of the fresh and hardened states concrete to the volume of concrete mixture. The nominal size of the fibre having the diameter of 0.55 mm and the average length of 35 mm, the aspect ratio of it is 64. The volume of fibre which was used are 0%, 0.5%, 1.0%, 1.5% and 2.0% by volume. The mixing was done by mix the constitute material without including the fibres. This done to ensure the uniformity of the steel fibre arrangement in concrete. The concrete was compacted with the use of vibrating table. The cast concretes were tested for the compressive strength, the rate of the testing machine was at 0.3MPa/s until failure, the test was conducted on 15 cylindrical sample the testing was done in accordance to ASTM C39.

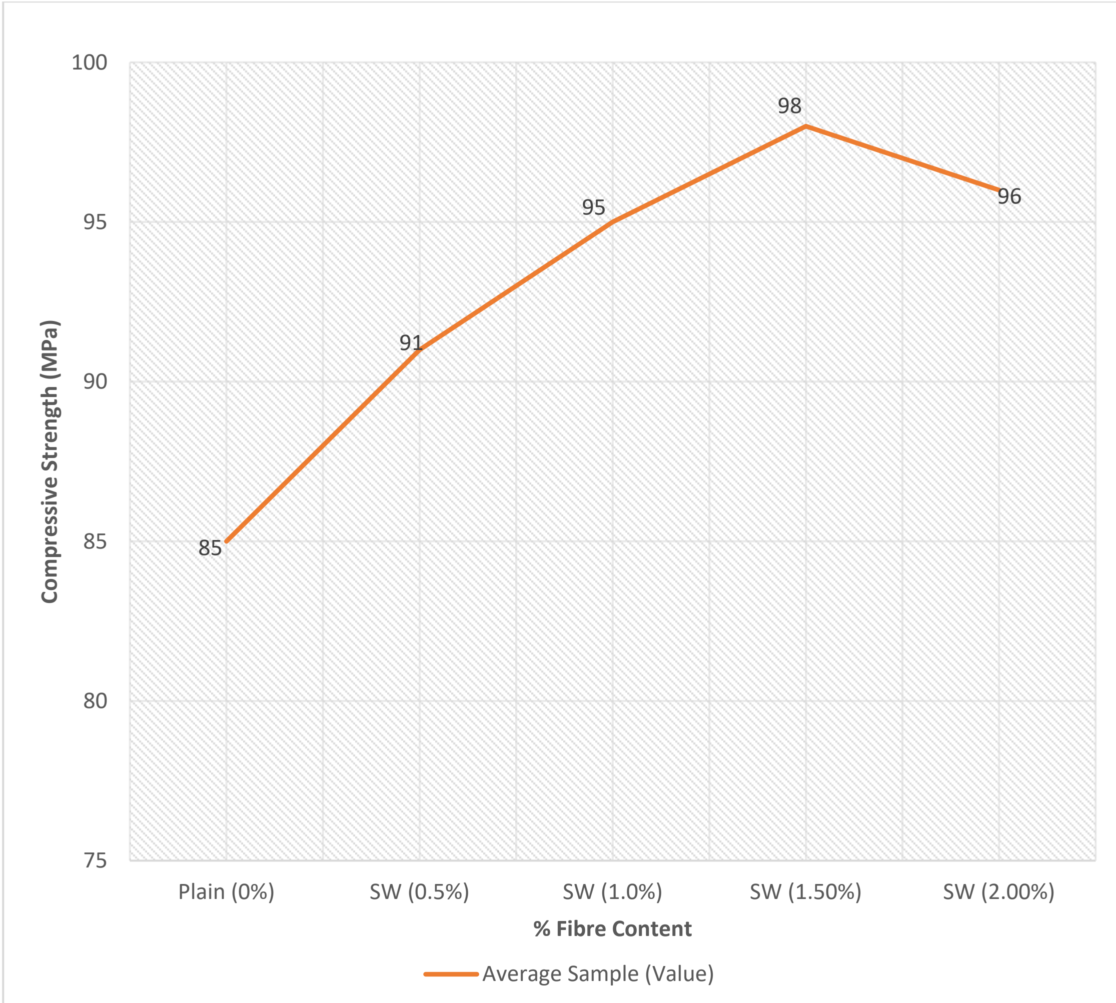


Figure 2.4 : Average compressive strength (MPa) vs steel fibre % (from Song and Hwang, 2004)

The compressive strength from the test that was conducted by Song and Hwang (2004) is shown in Figure 2.5. The strength of the concrete increases as the fibre content increases and at one point the strength of the concrete has started to drop. The strength of the concrete had increased when fibre volume of 0.5% to 2.0% have been used. Compressive strength for the control sample was 85 MPa, an increment of 13 MPa was found for the 1.5% steel fibre, and the peak compressive strength of concrete is 98 MPa at the point when steel fibre of 1.50% was used, then the strength of concrete drop to 96 MPa when the steel fibre increase further to 2.00%. Therefore, this could be related with the arrangement of the steel fibre in concrete as it might influence the strength or due to void that form surround the fibre which promote strength reduction in concrete.

2.6 Workability of concrete

Workability is one of the component which is important in concrete production, a suitable workability or flow should be achieved in order to make sure that the concrete mixture can be compacted very easily and thus reduce the void in concrete which directly contribute to strength reduction. The use of superplasticizer in concrete could increase the workability of the concrete. The superplasticizer of up to 5% of cement mass is suitable to be used for high flow concrete (Aruntas et al., 2008).

The addition of steel fibre also could affect the workability of the concrete, as the amount of steel fibre in concrete increases then the workability of concrete will start to reduce. At one level, if the proportion of steel fibre used in concrete mixture increased, the chances of getting balling effect is very high (Song and Hwang, 2004).

Balling effect is the condition where an amount of steel fibre crumbs together form several sphere, which is not suitable for the mixing, because the steel fibre will not be distributed evenly in the mixture, which in turn might affect the uniformity of steel fibre in concrete sample. So should be aware of balling effect during mixing time.

2.7 Curing of High Performance Concrete

Proper curing should be done on high performance concrete in order to obtain concrete strength, there are various type of curing method, for example wet gunny curing as in Figure 2.6. In some cases, steam curing and spraying of water are used.

Figure 2.5: The curing of concrete structure with wet gunny curing (Zeyad, 2017)

When gunny is used, it is important to ensure that the gunny is fully wet, for the curing process of concrete. Other method also can be used, whichever easiest, but the only different is the compressive strength due to different type of curing (Naderi et al., 2009).

CHAPTER 3

METHODOLOGY

3.1 Introduction

The project has been done according to correct order of work arrangement by referring to the standards and guidelines. The methodology has been arranged in a correct manner, in order to make sure that the lab works can be completed smoothly and on expected time. These arrangement, helps in completing every works on expected time. Therefore, a flow chart should be prepared, to have a better understanding of the work flow. The things that will be included in flow chart are the initial work before the casting starts until to testing of samples and conclusion of results as in Figure 3.1.

3.2 Overview

A laboratory experiment was conducted to find out the physical characteristic of concrete which are compressive strength, tensile strength and flexural strength of the beam. Different proportion of hook end steel fibres were added (0%, 1.0%, 2.0% and 3.0%) by the mass of the concrete by replacing the concrete mixture. Some trial mix was conducted until we have achieved our targeted strength of more than 70 MPa, this was done by modifying the mix proportion from previous journal (Hamiruddin et al., 2018). Then 4 beams were casted of 100 mm x 300 mm x 2000 mm, trial mix were tested for the targeted compressive strength, once this is achieved 1 beam are casted for the control sample and remaining 3 beam are casted according to decided proportion of steel fibres. Four tests are conducted in this project according to the British Standard. Cube test are conducted to identify the compressive strength of the concrete. Tensile splitting tests are conducted to identify the tensile strength of the concrete. Flexural test is conducted to identify the concrete's flexural capacity through beams. Moreover, flow table test also conducted to identify the workability of concrete mixture due to different proportion of steel fibre.

3.3 Flow chart of study

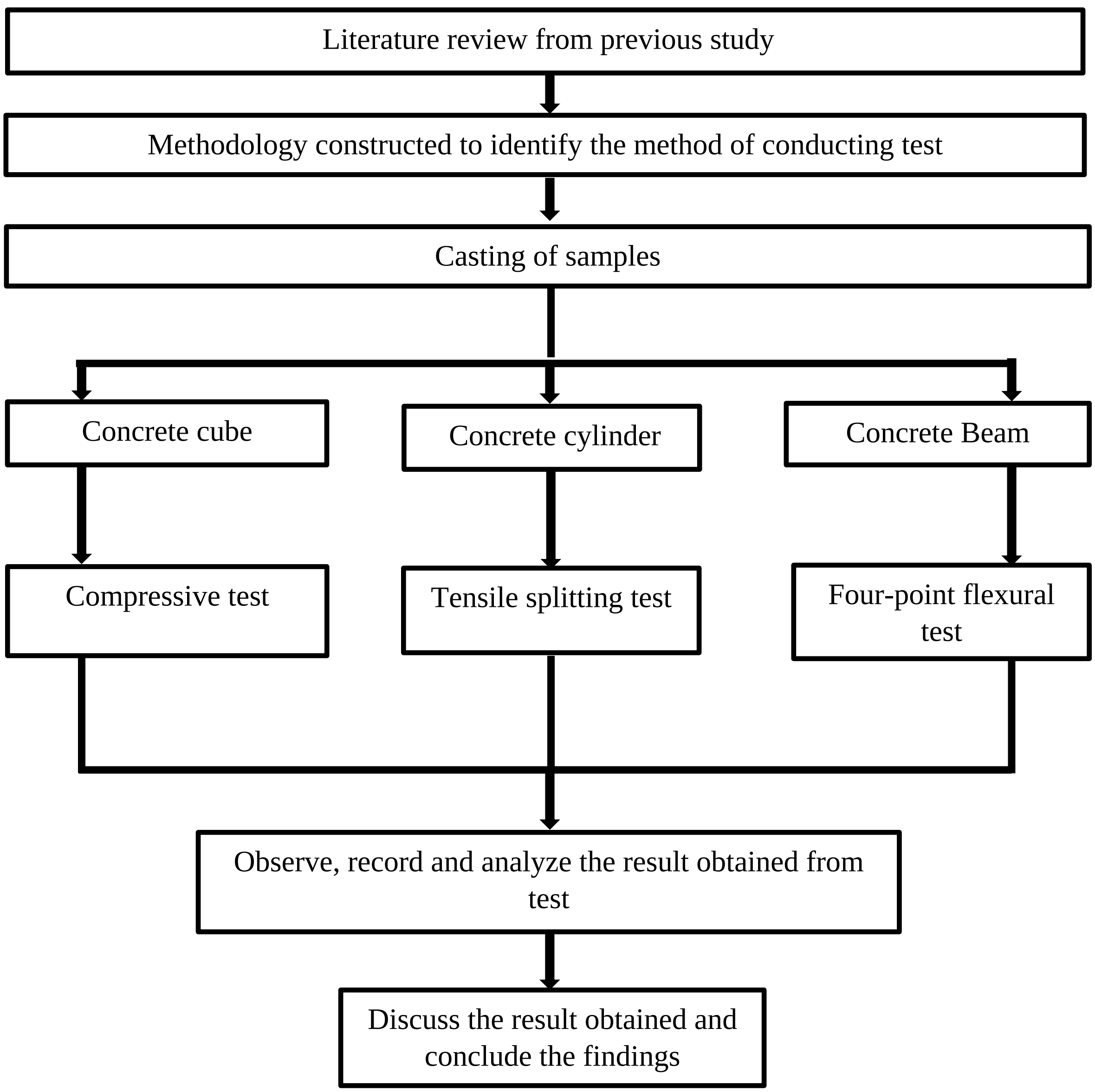


Figure 3.1: Flow chart of work progress

3.4 Beam specification

One of the characteristic of high performance concrete beam is it should have low dead load, so therefore have decided to use small size of beam which is long and thin, the dimension of the beam is 100mm x 300mm x 2000mm. Table 3.1 shows the parameter of the beam, Figure 3.2 show the completed beam reinforcement (1 set) and Figure 3.3 shows the detailing of the beam.

Table 3.1: Parameter of beam's component

Criteria	**Value**
Dimension of Beam	100 mm x 300 mm x 2000 mm
Reinforcement's diameter	10 mm
Shear Link's diameter	6 mm
Link Spacing c/c	300 mm
Concrete Cover	25 mm
Concrete's Grade	More than 70 MPa

Figure 3.2: Completed reinforcement for beam (1st set)

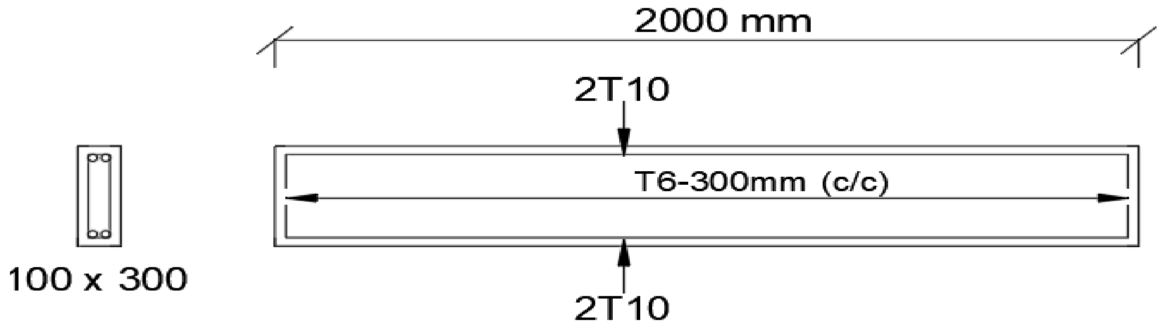


Figure 3.3: Detailing of beam

3.5 Materials preparation for beam

Basic materials that are needed for the beams are prepared, it is considered as the pre stages of beam casting. The reinforcement (Figure 3.4), shear link (Figure 3.5), spacer block (Figure 3.5) and formwork (Figure 3.6).

Figure 3.4: Reinforcement (T10)

Figure 3.5: Shear link (T6)

Figure 3.5: Spacer Block

Figure 3.6: Beam Formwork (100mm x 300mm x 2000mm)

3.6 Concrete mixing materials and proportion

The basic materials that were used for the concete mixing Ordinary Portland Cement (OPC) type 1 (Figure 3.7) which is normally used for the general use, silica fume (Figure 3.8), fine sand where the sand ranging from 1.18mm to 150μm (Figure 3.9) , superplasticizer Sika Viscocrete 2044 (Figure 3.10) and water, and some proportion of hook end steel fibre having length of 60mm and thickness of 0.75mm (Figure 3.11). Since the required sand is ranging from 1.18mm to 150μm therefore the sand is sieved (Figure 3.12) and the sand only in ranged are used.

Figure 3.7: OPC

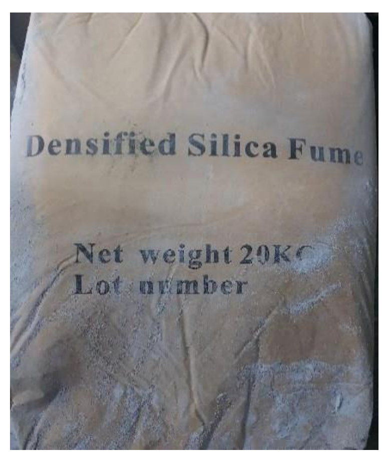


Figure 3.8: Silica fume

Figure 3.9: Fine sand (1.18mm to 150µm)

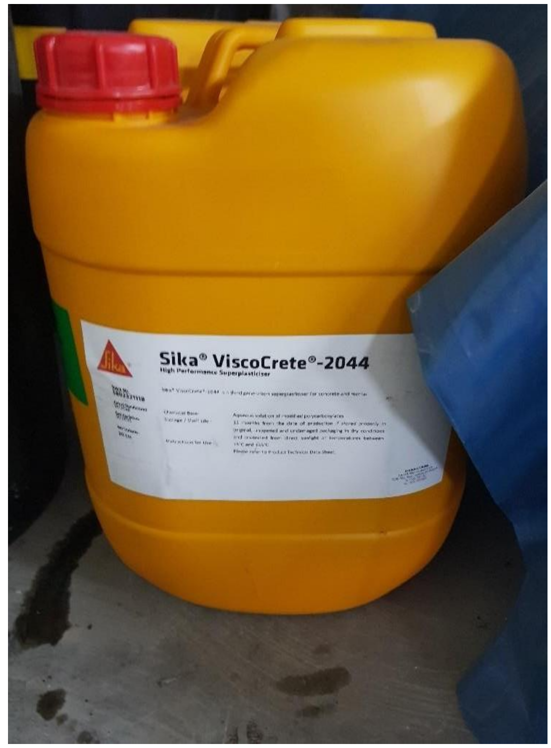


Figure 3.10: Superplasticizers (Viscocrete 2044)

Figure 3.11: Hook end steel fibre
Aspect Ratio: 80

Figure 3.12: Sand siever

There are 4 proportion for the mixes, where 1 of it is control sample of 0% where it will not have steel fibres, the rest will have steel fibre proportions as 1.0%, 2.0% and 3.0% respectively to the mass of concrete mixture. The mix proportion is taken from the previous study (Hamiruddin et al., 2018). The proportion have been modified to suit with the material in this laboratory. Trial mix is done to confirm with the expected strength, the project has been continued once have achieved desired strength.

Table 3.2: Mix Proportion (Percentage by mass)

Material	Beam A (Control Beam)	Beam B	Beam C	Beam D
Ordinary Portland Cement	55%	55%	55%	55%
Fine Sand (1.18mm - 150µm)	22.49%	22.49%	22.49%	22.49%
Silica Fume	7.2%	7.2%	7.2%	7.2%
Superplasticizer (Viscocrete 2044)	1.3%	1.3%	1.3%	1.3%
Water	14.01%	14.01%	14.01%	14.01%
Total	100%	100%	100%	100%
Steel Fibre added into concrete by mass of concrete mix	0%	1.0%	2.0%	3.0%

3.7 Mixing procedure

The concrete is casted by starting mixing the dry materials that are Ordinary Portland Cement (OPC), fine sand (1.18mm - 150µm), silica fume is inserted into the mixer, this is to make sure better spread between the dry material in other word it will have uniform distribution of dry materials. The mixing of dry materials is mixed up to 3 minutes, then