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PERFORMANCE OF HOOKED END STEEL FIBER REINFORCED CONCRETE WITH VARIATION OF FIBER CONTENT

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Abstract: This study presents a performance of hooked end steel fiber reinforced concrete (SFRC) with variation of fiber content. The experimental study involves volume fraction of 0.5%, 1.0% and 1.5%. As a comparison plain concrete samples have been cast and tested. The fresh mixed concrete samples of plain concrete and SFRC mixture were tested with slump test to investigate the workability. Meanwhile, the hardened concrete samples were tested under compressive strength test, splitting tensile test and flexural strength test to observe the mechanical properties. The concrete mixes were designed in accordance with the D.O.E (Department of Environment) method of concrete mix design for C25. The water-cement ratio was kept at 0.50 and admixture was used to enhance the workability of concrete mixture throughout experimental work. The significant increase in compressive, split tensile and flexural strength is observed with the addition of hooked end steel fibers in plain concrete. The mechanical properties of hooked end SFRC achieve the maximum strength at 1.5% of volume fraction in 28 days for 37.767 MPa, 5.954 MPa and 6.661 MPa on compressive strength, splitting tensile strength and flexural strength accordingly. However, the workability is decreasing with the addition of fiber content in concrete from 30mm to 11mm drop in HFRC3.

Keywords: *steel fiber reinforced concrete, hooked end steel fiber, mechanical properties*

1.0 Introduction

In modern times, a wide range of engineering materials including ceramics, plastics, cement, and gypsum products incorporate fibers to enhance composite properties. The enhanced properties include tensile strength, compressive strength, elastic modulus, crack resistance, crack control, durability, fatigue life, resistance to impact and abrasion, shrinkage, expansion, thermal characteristics and fire resistance (ACI Committee 544, 2002).

Fiber-reinforced concrete (FRC) is concrete containing fibrous material which improve the toughness, durability, impact resistance (resiliency), fatigue and abrasion resistance of the cementitious matrix. Fibers include steel fibers, glass fibers, synthetic fibers and natural fibers where each of its results varying properties to the concrete. The physical and mechanical properties of the composite material depend on the proportions of the components as well as the properties of each component. According to CNR-DT 204/2006 (2007), the minimum volume fraction of the fibers for structural applications must not be less than 0.3%.

Steel fiber reinforced concrete (SFRC) has advantages over conventional reinforced concrete for several end uses in construction. One of the examples is steel fiber reinforced shotcrete (SFRS) for tunnel lining, rock slope stabilization and as lagging for the support of excavation. Manpower in placing mesh or reinforcing bars in these applications may be eliminated. However, SFRC tend to ball in the mix and create workability problems. ACI Committee 544 (2002) stated that balling of the fibers during mixing is related to a number of factors. The most important factors appear to be the aspect ratio of the fibers, the volume percentage of fibers, the maximum size and gradation of the aggregates and the method of adding the fibers to the mixture. Too many fibers to a mixture which more than about 2 percent by volume or even 1 percent of a fiber with a high aspect ratio can cause balling in mixture.

The purpose of this study is to present the results of mechanical properties in SFRC. This advancement intended to cater reinforcement congestion issues in structure. Reinforcing steel is continuous and is specifically located in the structure to optimize performance. Fibers are discontinuous and are generally distributed randomly throughout the concrete matrix. The type of fiber considered in this study is collated hooked end steel fiber. Several tests were carried out and various samples were developed to investigate the mechanical properties of SFRC with standardized tests and experimental study.

2.0 Literature review

Steel fiber reinforced concrete (SFRC) is concrete made of hydraulic cements containing fine and coarse aggregate and discontinuous discrete steel fibers. Properties of SFRC in both the freshly mixed and hardened state including durability are a consequence of its composite nature.

The use of steel fibers in concrete helps to improve the mechanical properties of concrete structure. Thus, Patil and Sangle (2016) investigated the effect of steel fibres on torsional strength improvement of concrete. The research evaluates the torsional strength and combined torsional-shear-bending strength. In this study, 20% of fly ash (class-C) is added as a replacement of binder to its weight and 1.5% steel fibres by weight of concrete. Experimental results show an improvement in torsional strength, combined torsional-shear-bending strength and crack resistance of concrete by addition of steel fibres in the concrete and a decrease in the deflection. Based on the experimental results the modified coefficient of the empirical formulae has been suggested to predict the torsional strength and torsional stress of steel fibre reinforced concrete.

Based on the test result done by Babar et.al (2015), the significant increase in compressive and split tensile strength is observed with the addition of hooked end steel fibers in plain concrete. However, this increase depends on addition of amount of fiber content. The optimum fiber content for increase in compressive strength is 1.5%. The addition of steel fibers also decreased crack spacing and sizes, increased deformation capacity and also changed the mode of brittle failure to ductile. The ultimate shear stress and cracking shear stress are directly proportional to percent fiber content and inversely proportional to shear span to depth ratio. Maximum percentage increases are 60.70% and 54.54% respectively for shear span-depth ratio of 1.0 and fiber content of 2.0%.

The impact of steel fiber in concrete can be related to fiber bridging action. In plain concrete, crack bridging is provided by aggregate locking action. Li and Wu (1992) stated that when fibers are added to concrete, an additional bridging action is brought into effect, superimposing on the aggregate bridging effect. The combines bridging action in a fiber reinforced concrete (FRC) can be very beneficial to increase the stress carried across the crack.

3.0 Methodology

This study aims at exploring of using 0.5%, 1.0% and 1.5% volume fraction of hooked end steel fiber in concrete to investigate the mechanical properties of hooked end SFRC. The fresh concrete properties were analyzed by slump test to check the workability. Meanwhile, the hardened concrete properties were investigated by compressive strength, splitting tensile strength and flexural strength test.

3.1 Material properties

The test specimens were cast using ordinary Portland cement, fine aggregate, coarse aggregate, water and hooked end steel fiber according to JKR 20800-0183-14 Section D: Concrete Works. The maximum size of aggregate used was 20 mm. Hooked end steel fiber of length 35mm and 0.5mm diameter with 65 aspect ratio were used throughout the experimental work as in Figure 1.

Figure 1: Collated of hooked end steel fiber HE 0.55/35

3.2 Concrete mix design

The concrete mixes were designed in accordance to D.O.E method. The concrete mix design was prepared for C25 grade of concrete. The water-cement ratio is kept at 0.5 and admixture named Sika ViscoCrete-2199 is chloride free according to BS5075 was applied to enhance the workability of mixture. Dosage of admixture added in concrete mixture is 1.5% by cement weight. The variation of fiber content involves in this study is 0.5%, 1.0% and 1.5% of concrete volume. The mix proportion is given in Table 1.

Table 1: Mix proportion of Hooked End SFRC

Mixture No.		Volume fraction, v_f (%)	Quantity of material					w/c (%)
			Cement (kg/m^3)	Fine aggregate (kg/m^3)	Coarse aggregate (kg/m^3)	Admixture (l)	Steel fiber (kg)	
Plain concrete	PC	0	340	721.50	1228.50	0.24	0	0.5
Hooked end fiber reinforced concrete (HFRC)	HFRC1	0.5					1.57	
	HFRC2	1.0					3.14	
	HFRC3	1.5					4.71	

According to JKR 20800-0183-14 Section D: Concrete Works, the materials were placed in the concrete mixer in the following sequence. First, all dry materials such as coarse aggregates, fine aggregates and cement are together dry mixed for approximate for 1 minute. A plenty of water are added into mixture followed by the steel fiber. After mixing the content, the rest of the water mixing together with the super-plasticizer was added. All batches were mixed for a total time of 5 minutes in order to prevent fresh concrete from segregation and the mixing duration was kept as low as possible.

The samples were cast in several types of mould size as in Figure 2. For compression strength test, it would casted in cubes of 150 mm x150 mm x 150 mm for 24 samples. Meanwhile, for split tensile strength test and flexural strength test, the samples would casted in cylindrical mould of diameter 100 mm and 200 mm length and prism of 100 mm x 100 mm x 500 mm in 3 samples of each mixes respectively. After completion of concrete casting, the concrete was left overnight to set so that the moulds could be removed easily for curing process in water tank. Curing is designed to keep the concrete moist by preventing the loss of moisture from the concrete while it is gaining its strength.

Figure 2: Concrete samples in setting process

3.3 Test on fresh and hardened concrete

The slump test was done to determine the workability or consistency of freshly mixed concrete. It is carried out to check the quality of concrete during construction according to MS 26: Part 1:1991 Section 2. Section 2 specifies the methods to determine the slump test. The procedure is detailed including measurements and the types of slump. In addition, the result is indirectly shows the efficiency of water-cement ratio added in the concrete mixture. Several factors which influence the concrete slump test are material properties such as chemistry, fineness, particle size distribution, moisture content and temperature of cementitious materials. Size, texture, combined grading, cleanliness and moisture content of the aggregates also affected the result.

For hardened concrete testing, the samples would be tested for compressive strength, splitting tensile strength and flexural strength. The curing process plays important roles on strength development and durability of concrete. Through curing process, it would maintain the moisture to make sure it achieves the strength required. Thereafter, the concrete cube should be tested on day 7 and day 28 to measure the compressive strength. Method for determination of compressive strength of concrete cubes can be referring to MS 26: Part 2: 1991 Section 3 accordance to BS EN 12390 Testing Hardened Concrete-Part 3: Compressive strength test specimens.

Secondly, the split tensile strength test was done according to BS EN 12390 Part 6 for 28 days after curing for cylindrical samples. This Part of this British Standard describes the method for the determination of the indirect tensile splitting strength of cylindrical concrete test specimens. Splitting tensile strength test on concrete is a method to determine the tensile strength of concrete. The concrete is very weak in tension due to its brittle nature and it develops cracks when subjected to tensile forces. Thus, it is necessary to determine the tensile strength of concrete to determine the load at which the concrete members may crack.

Finally, after 28 days of curing process, the 100 mm x 100 mm x 500 mm size prism samples were removed from curing tanks. All samples were tested under three-point loading test to observe the flexural tensile strength and crack development. The advantages of this test are ease of the specimen preparation and testing procedure. Method for determination of flexural strength can be referring to BS EN 12390-5:2009 for hardened concrete. All result obtained from experimental work would be tabulated in Section 3.

4.0 Result and discussion

From the result obtained, the effect of fiber content variation in concrete are analyzed and discussed below.

4.1 Properties of fresh concrete

The experimental results show that the slump of hooked end steel fiber reinforced concrete has decreasing trend when the volume fraction is increase. In this study, 1.5% volume fraction has the lowest workability of fresh concrete. The result of slump is shown in Table 2.

Table 2 indicates a slump value of 30 mm for plain concrete with no steel fiber added into the concrete. Once the fiber was added into the concrete, all mixes had a slump drop of 25 mm for 0.5% in HFRC1, 17 mm for 1.0% in HFRC2 and 11 mm for 1.5% fiber volume fraction in HFRC3. An average of 5 mm to 8 mm of slump decreased in every 0.5% of fiber volume fraction increased. The dosages of super-plasticizer of each mixes are exactly the same including the rest of the quantities of mix proportion except the steel fiber content. The conclusion can be made that, steel fiber in concrete reduces the workability because the mixture becomes thicker and hard even though the admixture was applied.

Table 2: Slump values recorded and percentage drop for each mix batch

Mix No.		Volume fraction, v_f (%)	Slump (mm)	Percentage Drop (%)
Plain concrete	PC	0	30	0
Hooked end fiber reinforced concrete (HFRC)	HFRC1	0.5	25	16.67
	HFRC2	1.0	17	43.33
	HFRC3	1.5	11	63.33

4.2 Properties of hardened concrete

The mechanical properties of SFRC investigated in this study are compressive strength, splitting tensile strength and flexural strength.

4.2.1 Compressive strength

Concrete properties of plain concrete and hooked end SFRC are shown in Table 3. All properties were achieved the strength of 25N/mm^2 for 28 days. In compression properties, the ultimate strength is slightly affected the presence of steel fibers with observed increases ranging from 0 to 17% for up to 1.5% volume fraction of fibers.

Table 3: Compressive strength data of each mix batch

Mix No.		Volume fraction,v_f (%)	Compressive strength (MPa)	Maximum load (kN)	Increase in compressive strength (%)	Day
Plain concrete	PC	0	29.15	655.84	0	Day 7
			32.35	727.79	0	Day 28
Hooked end fiber reinforced concrete (HFRC)	HFRC1	0.5	29.53	664.47	1.32	Day 7
			35.80	805.59	10.69	Day 28
	HFRC2	1.0	30.22	680.02	3.69	Day 7
			36.32	817.22	12.29	Day 28
	HFRC3	1.5	33.06	743.83	13.42	Day 7
			37.77	849.76	16.76	Day 28

Figure 3 shows the variation of compressive strength respect to different volume fraction of steel fibers 0%, 0.5%, 1.0% and 1.5% for day-7 and day-28 for each mixes. The increment is averagely by 14% to 21% from day-7 to day-28. As the volume of the fibers increased, the compressive strength increased significantly. Steel fiber usually reduces brittleness of concrete by providing post cracking ductility and increase toughness. According to Corinaldesi and Nardinocchi (2016), the positive effect on compressive strength is due to the confinement of the steel fiber in the samples due to increment of volume fraction. Confinement in concrete refers to reinforcement that is applied in concrete which produce smaller spacing for higher strength. However, it is up to certain limit of volume fraction due to balling effect in concrete (ACI Committee 544, 2002).

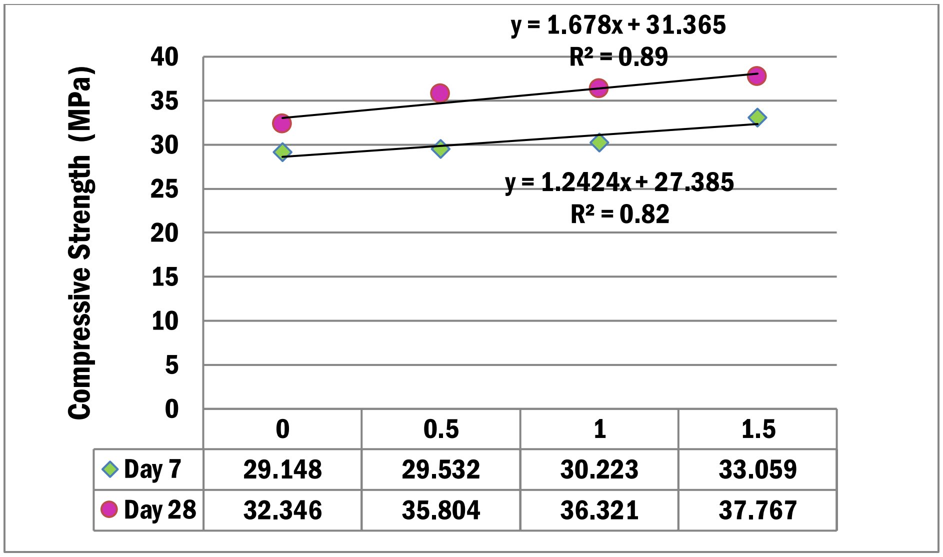

Figure 3: Variation of compressive strength with respect to volume fraction, v_f

4.2.2 Splitting tensile strength

As a result of the inclusion of fibers into the plain concrete matrix, the brittle mode of failure is changed into a ductile mode as steel fibers increase the energy absorption capacity and enhance the lateral stiffness to the section. From Table 4, it is observed that the day-28 split tensile strength increased continuously up to 1.5% volume fraction corresponding to the increase of steel fiber added into the mixes. It indicated that increases of split tensile strength proportional to the volume fraction of steel fiber.

Table 4: Split tensile strength for each mix batch

<table>
<tr><th colspan="2">Mix No.</th><th>Volume fraction,vf (%)</th><th>Split tensile strength (MPa)</th><th>Maximum load (kN)</th><th>% increase in Split Tensile Strength</th></tr>
<tr><td>Plain concrete</td><td>PC</td><td>0</td><td>5.37</td><td>168.70</td><td>0</td></tr>
<tr><td rowspan="3">Hooked end fiber reinforced concrete (HFRC)</td><td>HFRC1</td><td>0.5</td><td>5.44</td><td>170.74</td><td>1.21</td></tr>
<tr><td>HFRC2</td><td>1.0</td><td>5.64</td><td>177.31</td><td>5.1</td></tr>
<tr><td>HFRC3</td><td>1.5</td><td>5.95</td><td>187.04</td><td>10.87</td></tr>
</table>

According to the result of split tensile strength obtained in this study, it clearly shows that the strength of concrete for the cylinder samples with steel fibers of 0.5%, 1.0% and 1.5% volume fraction exceeded the plain concrete sample as shown in Figure 4. It can be seen that the increase in steel fiber content led to a steady increase in the splitting tensile strength. The percentage increments in the split tensile strength compared to plain concrete sample are 1.21%, 5.1% and 10.87% respectively. Browsing through the relevant literature, it can be observed that the increment in split tensile strength was agreed by the most results reported in the literature.

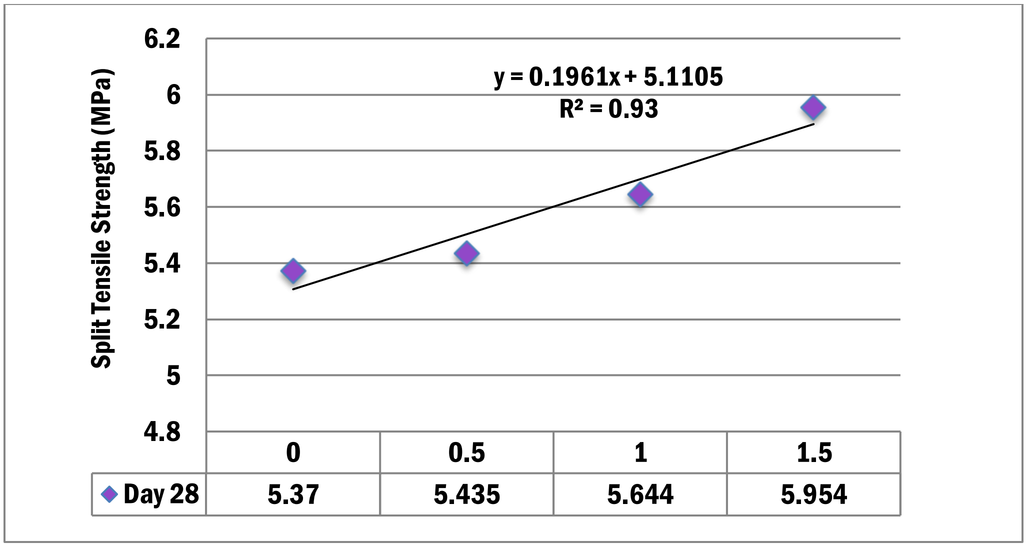

Figure 4: Variation of split tensile strength vs volume fraction, v_f

According to Mathew A.B. et.al (2015), it implies that the addition of fibers onto the composite matrix improves the tensile behavior which is a critical parameter when it comes to failure of the composite. The enhancement of tensile strength can be verified in totality only after conducting direct tensile strength testing which helps in inducing pure tensile forces on the cross section of the specimen uniaxially.

4.2.3 Flexural strength

The flexural strength on each samples are varies due to different of volume fraction added into mixes. The trend of strength increment is proportional to the percentage of steel fiber content. Table 5 below shows the flexural strength recorded during the test and percentages increases compared to plain concrete sample. From flexural strength test, maximum load resisted by the sample can be obtained.

Table 5: Flexural strength data for each mix batch

Mix No.		Volume fraction,vf (%)	Flexural strength (MPa)	Maximum load (kN)	% increase in Flexural Strength
Plain concrete	PC	0	4.211	8.422	0
Hooked end fiber reinforced concrete (HFRC)	HFRC1	0.5	4.53	9.06	7.58
	HFRC2	1.0	5.26	10.52	24.91
	HFRC3	1.5	6.61	13.22	56.97

Figure 5 showed the modulus of rupture of the concrete corresponding to the increase of steel fiber added into the mixes. It has been observed that the flexural strength of concrete for the prism with steel fibers of 0.5%, 1.0% and 1.5% volume fraction exceeded the plain concrete sample. It can be noticed that, the presents of steel fiber in concrete improved the flexural strength. The percentage increase in the flexural strength for prism with steel fibers 0.5%, 1.0% and 1.5% compared to plain concrete sample by 7.58%, 24.91% and 56.97% respectively. Mahadik S.A. et.al (2014) stated that this may be due to the fact that the steel fibers effectively hold the micro cracks in concrete mass where it helps to transfer the loads at the internal micro cracks.

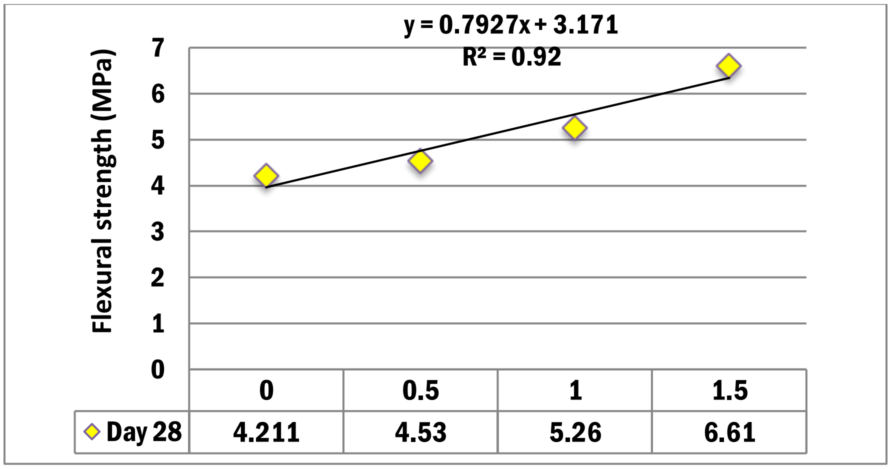

Figure 5: Variation of flexural strength vs volume fraction, v_f

4.2.4 Fiber content analysis

The steel fiber content was analyzed through cylinder samples for each mixes excluding plain concrete sample. The objective of this analysis is to investigate the fiber content added in samples whether it is according to designed amount or not by quantity comparison. Fiber content can be related to fiber bridging effect in concrete. In plain concrete, fiber bridging is provided by aggregate locking action between coarse and fine. When steel fibers are added into concrete, an additional bridging action will superimpose on the aggregate bridging effect. Thus, it resulted on strength increment in the mechanical properties in steel fiber reinforced concrete for compressive strength, splitting tensile strength and flexural strength effects.

The demolishing and separating process was done manually by hammer. In this process, steel fibers are sieved and separated from concrete as shown in Figure 6 and make sure there is no residual of concrete before weighing process to get the exact quantity of steel fiber added into the mixes. After the mass of fiber content was taken, it was listed in Table 6 to see the comparison. The percentage of fiber content reduction is 35.5%, 24.1 and 24.3% for HFRC1, HFRC2 and HFRC3 respectively.

(i) (ii) (iii)

Figure 6: Fiber content of cylinder sample before weighing process (i) HFRC1 (ii) HFRC2 (iii) HFRC3

Table 6: Quantity of fiber content for each mix

Mix No.	Volume fraction, v_f (%)	Quantity of steel fiber required (kg)	Quantity of steel fiber weighted (kg)	Percentage of reduction (%)
HFRC1	0.5	0.186	0.12	35.5
HFRC2	1.0	0.369	0.28	24.1
HFRC3	1.5	0.555	0.42	24.3

The percentage reduction occurred during mixing and casting process. In a typical procedure, initially dry materials mixed for 1 minute in a concrete mixer and followed by water and super-plasticizer. One of the major problems in SFRC mixture is fiber balling. According to ACI Committee 544 (2002), fiber balling always occurred during mixing when fibers are added too fast and it felt on each other and stacked up in the mixer. In addition, steel fiber in concrete reduces the workability because the mixture becomes thicker and hard even though the admixture was applied. The reduction in quantity of steel fiber added in sample slightly affected the mechanical properties of reinforced concrete. However, the mechanical properties in SFRC was still increased if compared to plain concrete due to steel fiber bridging action on crack propagation in SFRC as observed in experimental study. The steel fiber bridging action can be referred in Figure 7.

Zhihong et.al. (2006) stated that the bridging action increases with the number of the steel fibers across the crack surface and the stress intensity factor near the crack tip decreases thereby. In addition, bridging action increases with the strength of the matrix because the matrix with higher strength can provide stronger interfacial bond with steel fibers.

(i) (ii) (iii)

Figure 7: Fiber bridging in cylinder sample (i) HFRC1 (ii) HFRC2 (iii) HFRC3

4.2.5 Result comparison with previous study

In order to investigate the relationship between parameters among mechanical properties of SFRC, a several number of experimental data have been collected from previously published literature which reported compressive, split tensile and flexural strength. Mechanical properties of SFRC could be affected by many factors which mainly including sample geometry, concrete composition, water-cement ratio, steel fiber geometry and etc. It is difficult to collect data of sample with similar parameters, so the comparison will be made in wider aspect of experimental parameter. However, the information is only focused on 28 days of concrete strength.

For comparing the literature results, steel fiber content, aspect ratio and water-cement ratio seems to be the main governing experimental parameter to be discussed. In addition, other parameter can be influenced in differences in compressive strength among the literatures are concrete mix proposition and casting condition. The increment and development of compressive strength also graphically represented in Figure 8. Although there is slightly different compared to current study, it obviously shows the strength increment is gradually due to larger aspect ratio of steel fiber. The increment can be ranging from 2% - 36% by the result from present study.

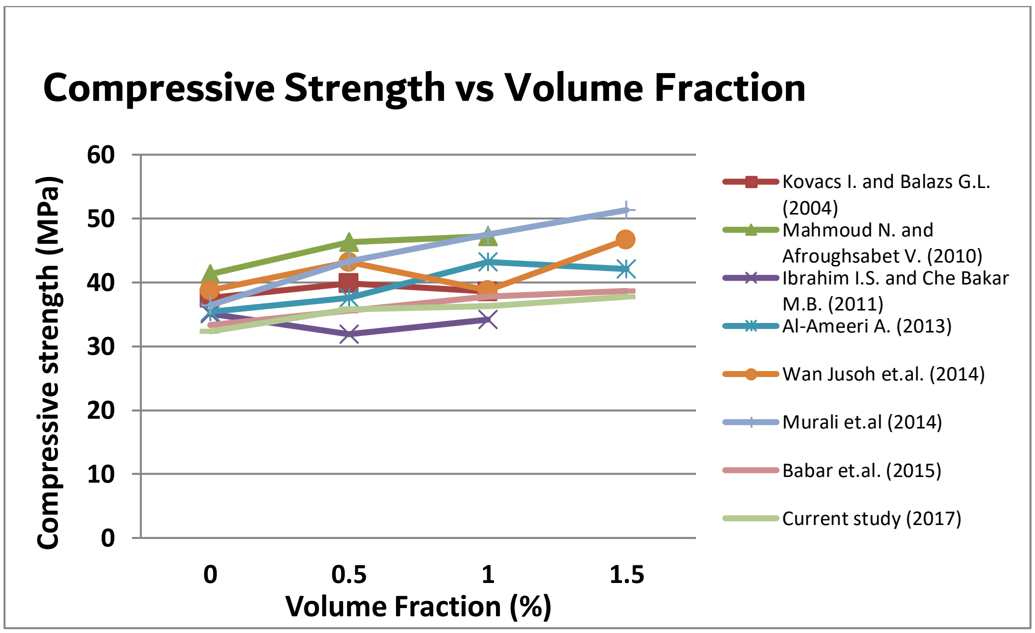

Figure 8: Summary of compressive strength in previous literature

Comparison between present and previous study due to tensile strength are numerically and graphically represented in Figure 9. According to the graph, reduction of splitting tensile strength values compared to present study in the range of 6% to 71% shows considerable differences due to the different concrete composition and fiber content regarding to aspect ratio of steel fiber. However, observed splitting tensile strength in the literatures shows the increment. It can be concluded that split tensile strength is influenced by the changes of fiber content and produce significant increment in strength which approximately proportional to the fiber content.

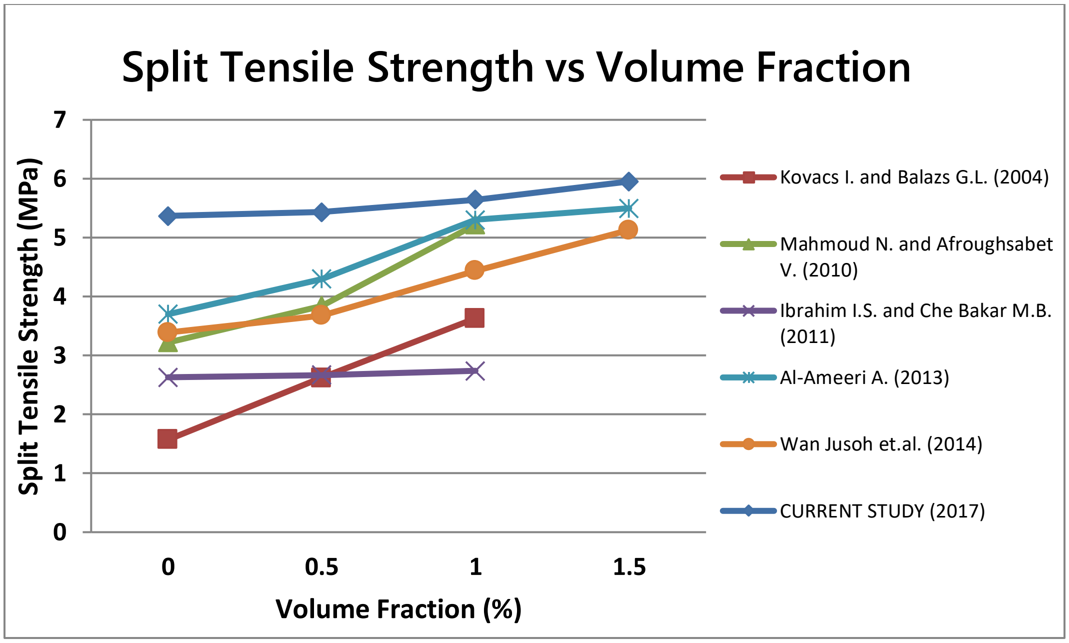

Figure 9: Summary of split tensile strength in previous literature

For flexural strength behavior, improved toughness is an important characteristic of SFRC. The literature review indicates that the addition of steel fiber into concrete significantly increases the flexural strength other than the increases of aspect ratio. In addition, comparison by the present study shows the increment in flexural strength in the range of 5% to 81% with the variation of concrete composition and fiber content added into concrete mix. Comparison between present and previous study due to flexural strength is graphically represented in Figure 10.

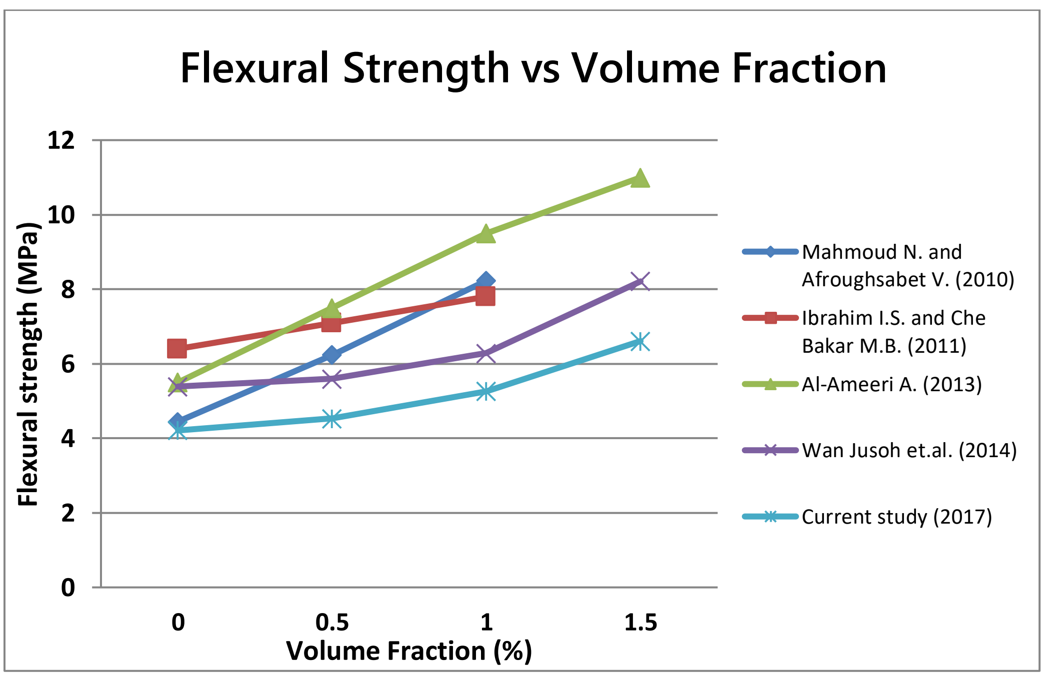

Figure 10: Summary of flexural strength in previous literature

4.2.6 RILEM specification for steel fiber reinforced concrete

The RILEM Committee TC162 has recently published two methods which can be used for calculating the structural behavior of SFRC. These two well-known methods are the σ-w-method and the σ-ε-method. The σ-w -method describes the crack-bridging stresses of the material as a function of its (discrete) crack width whereas the σ-ε-method relates the stress to the fictitious strain in a certain region around the crack. The European pre-standard ENV 1992-1-1 (Eurocode 2: Design of Concrete Structures - Part 1: General rules and rules for buildings) has been used as a general framework for this design method proposed.

The characteristics strength developed by this study can be related to RILEM TC 162-TDF specification based on the technical notes on SFRC to check the acceptability in the mix design in Table 7. It can be simplify by summarizing the information in Table 8. The comparison made between compressive strength and flexural strength to RILEM specification. However, the value of compressive and flexural is obtained from the average strength respect to variation of volume fraction from 0.5% to 1.5%. It can be concluded that, the mix design of the study is acceptable because the value is beyond the RILEM specification.

Table 7: Steel Fiber reinforced concrete strength class in RILEM

Table 1 – Steel fibre reinforced concrete strength classes: characteristic compressive strength f_{fck} (cylinders), mean $f_{fctm,fl}$ and characteristic $f_{fctk,fl}$ flexural tensile strength in N/mm^2; mean secant modulus of elasticity in kN/mm^2

Strength class of SFRC	C20/25	C25/30	C30/37	C35/45	C40/50	C45/55	C50/60
f_{fck}	20	25	30	35	40	45	50
$f_{fctm,fl}$	3.7	4.3	4.8	5.3	5.8	6.3	6.8
$f_{fctk,fl}$	2.6	3.0	3.4	3.7	4.1	4.4	4.8
E_{fcm}	29	30.5	32	33.5	35	36	37

Table 8: Summary of characteristic strength

Characteristics	RILEM	Present study (2017)	Remarks
$f_{ck,\,cube}$ (MPa)	25	36.63	Acceptable
Mean $F_{ctm,fl}$ (MPa)	3.7	5.47	Acceptable

5.0 Conclusion

These study achievements at exploring of using various volume fraction of steel fiber in concrete and several conclusions can be drawn.

i. The concrete mixes were designed in accordance with the D.O.E method for C25 grade. The water-cement ratio is kept at 0.50 was used to enhance the workability of mix throughout experimental work. The significant increase in compressive strength, splitting tensile strength and flexural strength is directly proportional to the addition of fiber content in plain concrete.

ii. The workability is decreasing with respect to fiber content in concrete from 30 mm drop in plain concrete to 11 mm drop in HFRC3. The percentage of reduction in slump compared to PC is 16.67%, 43.33% and 63.33% for 0.5%, 1.0% and 1.5% respectively.

iii. All mix design demonstrated higher mechanical properties relative to plain concrete at all ages. The mechanical properties of hooked end SFRC in various volume fractions achieve the maximum strength at 1.5% of volume fraction in 28 days for 37.767 MPa, 5.954 MPa and 6.661 MPa on compressive strength, splitting tensile strength and flexural strength accordingly.

iv. Fiber content can be related to fiber bridging effect in concrete. The steel fiber content was analyzed through cylinder samples for each mixes excluding plain concrete sample. Although there is reduction in quantity of steel fiber added in sample, it is not affected the mechanical properties of SFRC if compared to plain concrete due to steel fiber bridging action on crack propagation in steel fiber reinforced concrete

v. The comparison made in compressive strength, $f_{ck,\, cube}$ and mean flexural strength, $f_{ctm,fl}$ to RILEM specification. The compressive strength obtained from this study is 36.63 MPa and mean flexural strength is 5.47 MPa. It can be concluded that the mix design of the study is acceptable because the value is beyond the RILEM specification.

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