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Effect of Steel Fiber Aspect Ratio on the Properties of High Strength Self Compacting Concrete

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***Abstract:** The High strength concrete defined as per IS 456 as the concrete having characteristic compressive strength more than 65 MPa. The self-compacting concrete has lot of advantages including concreting at congested reinforcement locations, better finish, good compaction etc. The inclusion of fibers in the concrete mix decreases the brittle nature of concrete thereby the ductility increases. Different types of fibers are available for inclusion in concrete like steel, glass, polypropylene, basalt, etc. In the present investigation, high strength concrete having characteristic strength of 90 MPa was developed and hooked ended steel fibers are used and the hardened properties are determined. Steel fibers having diameter of 1 mm and lengths of 25 and 50 mm were added to concrete in 0.125%, 0.25% and 0.5% by volume of concrete. Three hardened properties compressive strength, split tensile Strength and flexural strength were determined. Out of the two lengths of fiber i.e with two aspect ratios, the fiber with 50 mm length yielded better results.*

***Keywords:** self-compacting concrete, steel fiber, aspect ratio.*

I. INTRODUCTION

High strength concrete (HSC) attributes are used for prominent structures and extensive range spans especially in the construction [1]of thermal power plants. HSC has high performance compared to standard strength concrete

Self-compacting concrete (SCC) is a highly flow concrete for its ability to compact without the essential of either internal or external vibration and it can flow between obstructions and fill the voids and high steel junctions. This type of concrete does not require any compaction and it saves time and labour. Especially in mass concreting this special type of concrete is highly demand where the mechanical vibration can be neglected [2]

Self-compacting concrete having higher strengths of above M-65 is categorized as High strength self- compacting concrete (HSSCC) [3]. In the present work the targeted characteristic compressive strength for 28 days is taken as 90 MPa

Several research's founded fibers adding to matrix improves tensile strength.

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Fiber reinforced self - compacting concrete (FRSCC) is considered as a semi-ductile material [4] because as fibers having crack arresting phenomena this converts brittle failure into a ductile failure. However the strength of a concrete is dependents [5] on aspect ratio,dosage and orientation of fibers. In the present study two different values of aspect ratios of 25 and 50 were considered.
Steel fiber shows much better results when compared with other fibers. Therefore fiber reinforced self-compacting concrete(SFRSCC) [6] has very higher importance .In the present work steel fibers of namely hooked-end (H) were considered to observe the changes in mechanical behavior of HSSCC with steel fibers dosage of 0.125,0.25 and 0.5 Percentages of volume of concrete and compared with conventional concrete.

RESEARCH SIGNIFICANCE

This research aimed to study the mechanical behavior of HSSCC the objective were

- A detailed experimental investigation was conducted to find out the mechanical performance of self-compacting concrete (compressive, split-tensile and flexural strength) without and with addition of different dosages of steel fibers
- To examine the effect of aspect ratio and dosage by influencing the steel fibers in to the HSSCC

II. MATERIALS AND METHODS

OPC 53 Grade cement is taken as a primary binding material with a characteristic compressive strength after 28 days and fly ash was added to concrete which was considered as a secondary binding material in this current investigation. The material properties of cement and fly ash are specific gravity is 3.15 and 2.01 respectively. Natural river sand meeting the requirements to Zone-III as per the provisions of IS 383 was taken as Fine Aggregate (FA).crushed stones granite origin were used as coarse aggregate (CA) conforming as per IS 383 provisions was selected. The specific gravity of FA and CA was 2.48 and 2.63 respectively. Portable municipal water which is free from dissolved impurities conforming provisions to IS 456 limits was used for both casting and curing. Steel fibers are used namely hooked-end with two different aspect ratios of 25 and 50 were taken in the current investigation. The properties of steel fiber were given in table-1.Master Glenium SKY-8233 is taken as a super plasticizer for obtaining workability is bought from local industry.

MIX DESIGN

In this study M-90 grade of concrete was designed as per IS 10262 provisions and a total of 7 mixes were casted.
The mixes are defined as control, H-25-0.125, H-25-0.25, H-25-0.5, H-50-0.125,

H-50-0.25, H-50-0.5 the first letter specifies type of a fiber and second number indicates aspect ratio and dosage of steel fibers in percentage. The masses of concrete are cement, fly ash, fine and coarse aggregate, water, super plasticizer are 500, 100, 673, 775, 186, 2.5 kg/m^3 respectively and the dosages of 0.125, 0.25, 0.5 percentage of volume of concrete.

Table-1 Physical properties of steel fiber

S. no	Steel fiber	Length (L) (mm)	Diameter (D) (mm)	Aspect ratio (L/D)	Tensile strength (MPa)
1	H-25	25	1	25	1130
2	H-50	50	1	50	1130

*H represents hooked end fiber

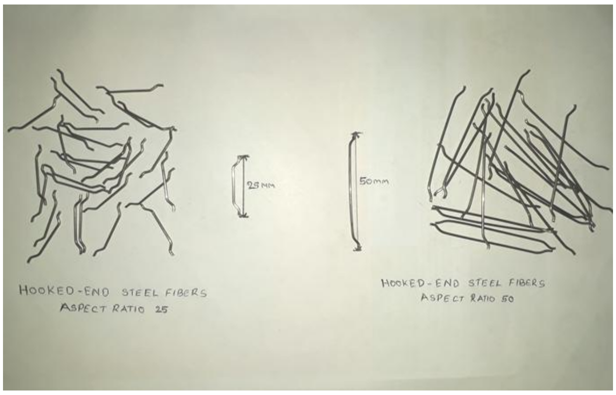

Fig-1 steel fibers with aspect ratio of 25&50

Methods

(i)Fresh properties

To examine the fresh properties of a HSSCC such as flow ability,passing ability the following experiment are conducted slump-flow,L-box and j-ring tests were implemented respectively as per EFNARC provisions the results of these tests were listed in table-2

(ii)Compressive test

To evaluate compressive strength of HSSCC for the mixes a standard dimension specimen of 100 x 100 x100 mm was selected and test was performed at the end of completing 28 days of environment curing as per BIS 516(1959) provisions.

(iii) Split tensile strength

To evaluate split tensile strength of HSSCC a cylinder shaped of size 200 mm height and 100 mm diameter was selected and test was performed at the end of completing 28 days of environment curing as per BIS 516(1959) provisions.

(iv) Flexural strength

To evaluate flexure strength of a HSSCC a standard beam dimension specimens of size 100 X100 X 500 mm was selected and test was conducted at the end of completing 28 days of environment curing as per BIS 516(1959) Provisions.

III. RESULTS AND DISCUSSTIONS

3.1 Effect of aspect ratio and dosage of steel fibers on fresh properties of HSSCC

To find out the workability of HSSCC fresh properties are conducted. From table-2 the following observations are made as the dosage of steel fibers increasing the workability gets slightly reduces due to less workability. In fresh properties the effect of aspect ratio does not shows munch variation however in mix H-25-0.5 the v-funnel result does not within in the limits this is because of more fiber content.

3.2 Effect of aspect ratio and dosage of steel fibers on compressive strength of HSSCC

An extensive experiment compressive strength test was conducted for all 7 mixes on 100*100*100mm cube sampling. The figure 2(a) displays the variation of 28 days compressive strength against dosage of steel fibers and figures 2(b) displays the variation of strength against type and aspect ratio of steel fibers and compared with 90Mpa control concrete. The observations are for H-25 & H-50 there is a rise in strength 9.8% & 6.6% by increasing the dosage of fibers from 0.125% to 0.25% and there is an reduction in compressive strength of 5.7% & 4.74% by increase of dosage from 0.25% to 0.5% respectively this is due to low workability. However there is an improvement in compressive strength for H-25 & H-50 compared to 90 MPa control concrete

Table-2 Fresh properties of concrete

Mixes	Slump flow (mm)	V-funnel (s)	V-Funnel T_5 (s)	L-Box (H_2/H_1)
Limits	550-800	<15	<25	<1
Control concrete	586	12.2	20	0.43
H-25-0.125	684	12.6	20.2	0.62
H-25-0.25	626	14.8	23.4	0.54
H-25-0.5	572	16	25.2	0.43
H-50-0.125	672	11.8	21	0.76
H-50-0.25	619	15.2	27	0.79
H-50-0.5	562	20.2	29.4	0.89

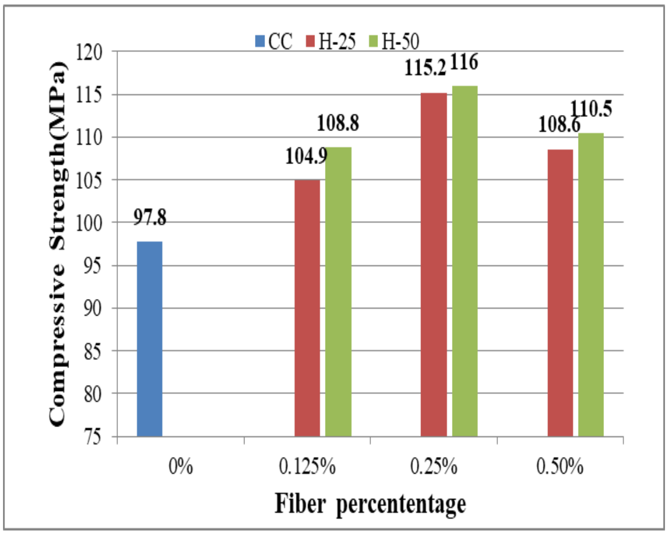

Fig 2(a)

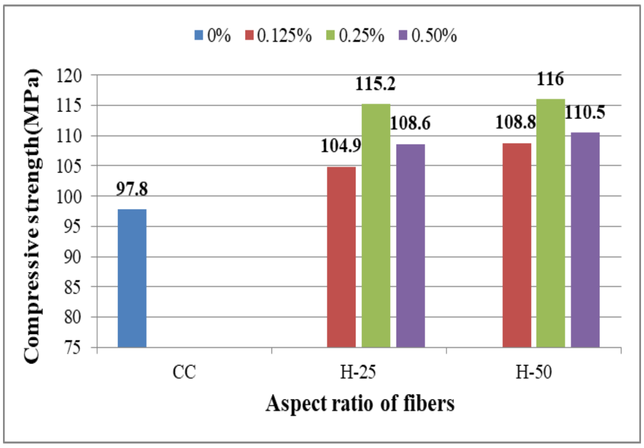

Fig 2(b)

Fig-2 Compressive strength HSSCC 2(a) fiber percentage vs strength & 2(b) Aspect ratio of steel fiber vs strength

From fig 2(b) as Aspect ratio increases from 25 to 50 there is a rise in compressive strength of concrete by 3.7%, 0.69% and 1.74% for 0.125,0.25 and 0.5 percentages of fibers respectively

3.3 Effect of aspect ratio and dosage of steel fibers on split tensile strength of HSSCC

Split tensile strength was conducted for all 7 mixes on 100mm diameter 200mm height cylinder sampling. The figure 3(a) displays the variation of 28 days tensile strength against dosage of steel fibers and figures 3(b) displays the variation of strength against type and aspect ratio of steel fibers and compared with control concrete. The observations are for H-25 there is an rise in strength 5% &14.9%, by increasing the dosage of fibers from 0.125% to 0.25% and 0.25% to 0.5% respectively. For H-50 also there is a rise in strength 4.15% & 28.99% by rising the dosage of steel fibers from 0.25% to 0.5% .However there is rise in tensile strength for H-25 & H-50 compared to control concrete that shows increase in tensile strength by adding fibers to concrete.

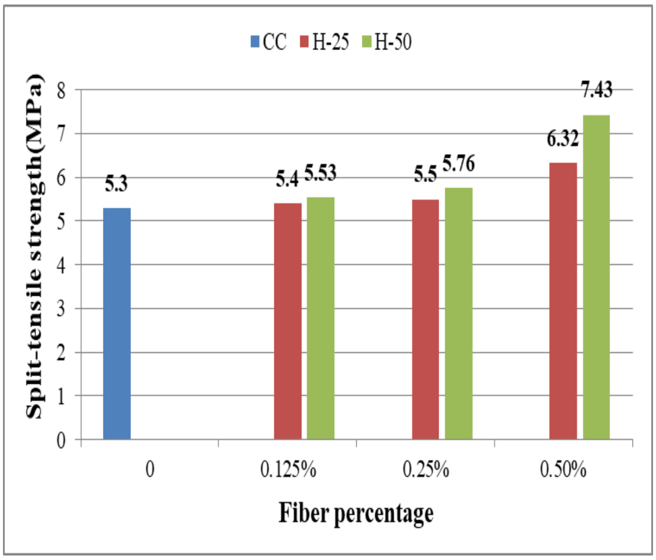

Fig 3(a)

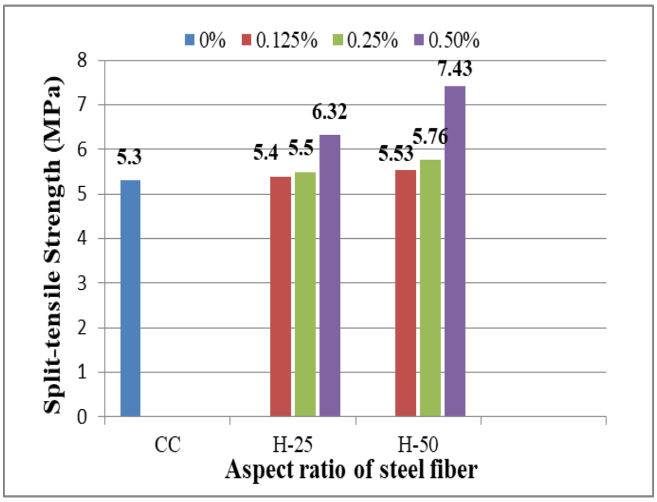

Fig 3(b)

Fig-3 Split-tensile strength HSSCC 3(a) fiber percentage vs strength & 3(b) Aspect ratio of steel fiber vs strength

From fig 3(b) as Aspect ratio increases from 25 to 50 there was a rise in tensile strength of concrete by 20.2%,4.72% and 17.5% at 0.125, 0.25 and 0.5 percentages of fibers respectively

3.4 Effect of aspect ratio and dosage of steel fibers on flexural strength of HSSCC

Flexural strength test was examined for all 7 mixes on 100*100*500 mm beam sampling. The figure 4(a) displays the variation of 28 days Flexural strength against dosage of steel fibers and figure 4(b) displays the variation of strength against type and aspect ratio of steel fibers and compared with control concrete. The observations are for H-25 there is an rise in strength 1.19% & 7.05% by increasing the dosage of fibers from 0.125% to 0.25% .For H-50 also there is rise in strength 1.74& 7.72% by increasing the dosage of fibers from 0.25% to 0.5%.However there is an increase in flexural strength for H-25 and H-50 compared to control concrete

From fig 4(b) as Aspect ratio increases from 25 to 50 there was an improvement in flexural strength of concrete by 3.7%, 0.69% and 1.74% for 0.125, 0.25 and 0.5 percentages of fibers respectively. However there is an in tensile strength also for H-25 & H-50 compared to control concrete that shows improvement in flexural strength by addition of fibers.

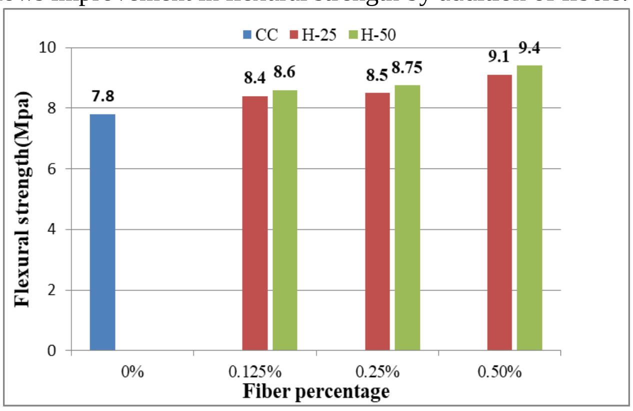

Fig 4(a)

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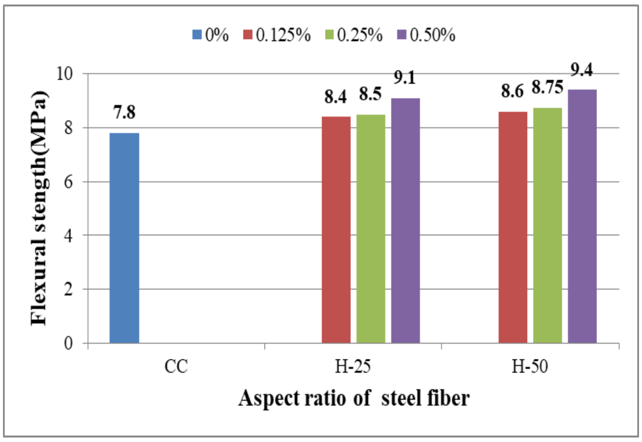

Fig 4(b)

Fig-4 Flexural strength HSSCC 4(a) fiber percentage vs strength & 4(b) Aspect ratio of steel fiber vs strength

IV. CONCLUSIONS

Form the above results and data the following conclusions can be written

- In fresh properties the workability gets lesser by increasing the dosage of fibers from 0.125% to 0.5%
- By increasing the aspect ratio there is an improvement in compressive, tensile and flexural strength of HSSC
- By Adding steel fibers to matrix split-tensile and flexural strength has increased gradually but in compressive strength there is a gradual decrease at 0.5% dosage of fibers in strength, however it is also rises when compared to control concrete of 90MPa.
- The highest compressive strength occurred at H-50-0.25 which is 18.6% more compare to control concrete but for tensile and flexural strength occurred at same mix H-50-0.5 by 40.1% and 20.5% respectively compared with control concrete

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