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Effect of Basalt fibers on the properties of high strength self-compacting concrete.

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Abstract*: *Concrete having characteristics strength of more than 65 MPa is categorized as high-strength concrete according to IS 456. The high strength concrete is more brittle compared to ordinary strength concrete and inclusion of fibers can increase the ductility of concrete. In the present study, high strength self-compacting concrete of characteristic strength of 90 MPa was developed as per the guidelines of EFNARC. Basalt fibers were considered to investigate its influence on the properties of high strength self compacting concrete. Three aspect ratios of 230, 530 and 600 were considered and are added in proportions of 0.1% and 0.4% by volume of concrete. The properties of concrete determine were fresh and hardened. Fresh properties such as slump flow test, V-funnel test, V-funnel T5 minutes and L-box test were determined as per EFNARC. Also, hardened properties such as compressive strength, split tensile strength and flexural strength were determined. A typical comparison on the effect of aspect ratio of basalt fibers and the dosage on the properties of concrete were determined. From the results, the optimum dosage of fibers was determined.

Keywords: **Basalt Fibers, Aspect ratio, self-compacting concrete.**

I. INTRODUCTION

The strength and durability character of HSC is significantly high and also utilization of HSC is continuously increasing in high rise buildings, bridges and mass constructions. Structural cost of HSC is comparably low and concrete weights also decreases by reducing sizes of members. But the drawbacks of HSC compared to normal concrete are tensile strength and flexural strength will be low, short term cracks may appear and more brittle by nature [1]. So, HSC may collapse suddenly may not show warnings due to its high brittleness.

In last decade of concrete studies acceptance and usage of SCC has been wider. SCC will flow by its self-weight without any compaction which reduces noise from vibrations and fastens construction duration. Segregation in SCC had quite important role because it may lead to non-homogeneous mix and blocking in congested area of reinforcement [2]. Segregation resistance is improved in SCC by adding fly ash and viscosity agents is helpful [3]. The properties and performance of SCC on HSC is most impactful than Normal concrete [4].

We know, High strength concrete is weak in tensile and flexural strength properties. So, Fibers added to concrete uniformly while mixing, then these fibers will arrest small cracks and also act as medium to transfer loads. Also, fiber will effectively improve mechanical properties [5]; these types of concretes are called as Fiber reinforced concrete (FRC). HS-SCC with fiber reinforcement is latest area of study due to its high flexural and tensile strength. There are many studies on steel, basalt, boron free type, E-glass, AR-glass and carbon fibers [6].

Basalt fiber is most common type of fiber made form extremely fine fibers of molten basalt rock with composition of minerals plagioclase, pyroxene and olivine; this type of rock is available in many areas around world [7]. Basalt fibers has similar chemical composition as many other fibers but had good characteristics like strength, high resistance to heat makes its as best fiber to use in concrete. Especially Basalt fibers in HS-SCC has shown better characteristics of concrete properties compare to other FRC.

Research Significance: This work is aimed to study how basalt fibers effects the fresh and hardened properties of HS-SCC by changing aspect ratios and dosage of basalt fibers. Where components of concrete and superplasticizer in all mixes were kept constant. From literature studies, basalt fibers as reinforcement in concrete are best material to improve mechanical properties and fresh properties of HS-SCC. Literature studies and research work made on basalt fibers with very high strength-SCC segment is rarely available so, this study is aimed to fill those gaps in research.

II. MATERIAL AND METHODS

A. Materials

Cement: This research is aimed to generate high strength (grade M90) self-compacting concrete. Since cement is important binding substance, we have used OPC 53 grade Birla cement with density 3.15 g/cm3 sourced from local dealer conformed to BIS specification of code IS:12269-1987.

Fly ash: Fly ash is partly replaced to cement in this study. Fly ash powder was brought from local sources which is produced by burning coal and materials. Fly ash was oven dried for 48 hours at 1000c to make it completely dry and then sieved with 150 microns sieve. The specific gravity of 150 microns sieved fly ash is 2.3.

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Fine aggregate (FA): Locally available river sand which is well graded and free from all impurities is used as FA in this research. Specific gravity of FA passing from 2.36 mm sieve is 2.48.

Coarse aggregate (CA): Crushed granite stone is used as CA which is dense and hard. Nominal size of CA is 4.75 mm retained and 10 mm passing which is clean and free from impurities is used with specific gravity 2.63 was found. Surface of coarse aggregate is completely dry during concrete mix.

Water: Water used in all concrete mixes were general municipal water from college laboratory which is free from impurities, oils and dust particles.

Basalt fibers: Basalt fibers are byproduct from melting basalt rock is used for study. Three different length were used 3, 9 and 12 mm with aspect ratio 230, 530 and 600 respectively shown in figure 1. Condition of basalt fiber is not too sticky and easily separated while mixing with concrete.

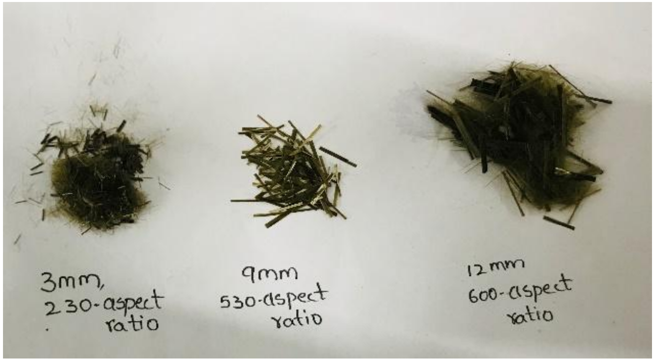

Fig. 1. Basalt fibers of length 3 mm, 9 mm and 12 mm with aspect ratio 230, 530 and 600 respectively.

Super Plasticizer: High performance and durable SP, MasterGlenium SKY 8233 is used as super plasticizer for all the concrete mixes. The product MasterGlenium is based on polycarboxylic ether and developed specially for HSC and HPC.

B. Methods

Fresh properties: Experiments conducted on fresh properties of the high strength SCC are Slump-flow test, V-funnel test for flowability and L-box test for passing ability conforming to EFNARC 2005. The test apparatus and standard procedure is followed according to EFNARC guidelines while conducting experiments.

Hardened properties: The compressive, Flexural and split tensile strength tests were conducted after 28 days of water curing as a part of hardened properties. The concrete cubes were casted of dimensions 10cm X 10cm X 10cm and tested in compression testing machine, cylinders of dimensions 10cm diameter to 20cm length and beams with dimensions 10cm X 10cm X 50cm were casted and tested conforming to Indian standard codes.

III. RESULTS AND DISCUSSION

A. Effect of aspect ratios and dosage of Basalt fibers on workability of concrete:

Fresh properties of SSC are performed to all seven mixes of three aspect ratios with two dosages of basalt fibers. Whereas Slump cone, V-funnel, T_5 minutes V-funnel and L box tests are conducted to examine flowability and passability of SSC. All the results shown in table 1 of slump cone test and L-box test are within the limits as per EFNARC 2005 guidelines. But there is slight deviation in V-funnel results of 0.4 percent volume of basalt fiber mixes of all aspect ratios. V-funnel T5 minutes test results of all mixes are in limits of EFNARC 2002 guidelines except fibers with aspect ratio 600. Different dosages 0.1% and 0.4% of basalt fibers and different aspect ratios 230, 530 and 600 of basalt fibers doesn't shown any significant impact on workability of SCC.

Table 1: High strength-SCC's Fresh properties.

Mixes	Slump (mm)	V-funnel (s)	V-Funnel T_5 (s)	L-Box (H_2/H_1)
Limits	550-800	<15	<25	<1
M90	592	13.6	22	0.44
BF230-0.1%	647	14.8	21.2	0.53
BF230-0.4%	577	16	23.4	0.51
BF530-0.1%	667	14.6	21.2	0.54
BF530-0.4%	602	16.8	24.2	0.41
BF600-0.1%	625	14.2	26	0.53
BF600-0.4%	602	17.2	26.2	0.55

B. Effect of aspect ratio and dosage of Basalt fibers on mechanical properties of HS-SCC:

Compressive strength: Compressive strength experiment is performed on specimens with and without reinforcement of Basalt fibers. The investigational results and their variations of 28 days cured cubes (10*10*10 cm) are shown in figure 2a and 2b for the mean value of three cubes. Figure 2a shows variations of compressive strength for different aspect ratios to 90 Mpa concrete mixes, in which dosage of 0.1% volume basalt fibers of 530 aspect ratio has yielded finest strength which improved 6.85% of strength compared to 90 Mpa concrete. However, the results 0.1% & 0.4% volume basalt fibers of aspect ratios 230 and 530 respectively improved studiedly than 90 Mpa conventional mix. Comparably strength of concrete containing 600 aspect ratio basalt fibers are approximately equal or less than 90 Mpa control mix. Figure 2b shows results of compressive strength for two volumes of basalt fiber with respect to three different aspect ratios and also control mix. Here 0.1% volume of basalt fibers of three varied aspect ratios 230, 530 and 600 are yielded better than 0.4% volume of basalt fibers, whereas strength increased 3.5% to 5% in each case. All three aspect ratios of 0.1% volume of basalt fiber concrete has shown slight improvement in strength than 90 Mpa conventional mix.

Split-Tensileestrength: Experiment results were presented in figure 3a and 3b indicate tensile strength of SSC for mean value of three cylinders at 28 days. Figure 3a brings up comparison of tensile strength by varied aspect ratios and different dosages of basalt fibers.The strength of 530 aspect ratio with 0.4% volume of basalt fibered concrete has increased 14% higher than 90 Mpa conventional mix.

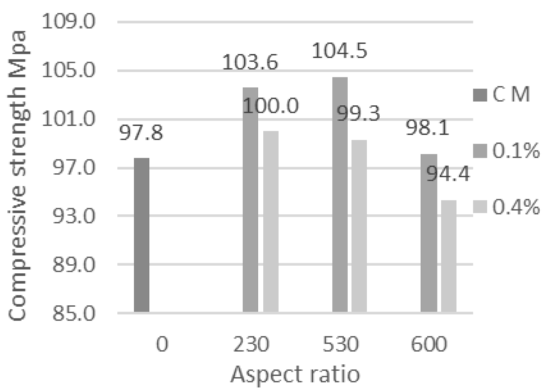

Fig. 2a

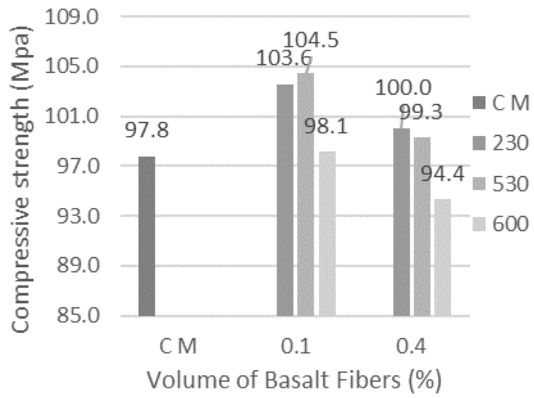

Fig. 2b

Fig. 2. Compressive strength of very HS-SCC, (2a) Aspect ratio vs strength & (2b) Volume of fibers vs strength.

Whereas 0.4% basalt fibered concrete of any aspect ratio resulted increased strength than 90 Mpa mix but 0.1% basalt fibered concrete of any aspect ratio shown slightly decrease in strength compared to 90 Mpa mix. Figure 3b brings up variations of split tensile strength for different dosages of basalt fibers to their respective aspect ratios. The strength for cylinders with 0.1% dosage of basalt fibers of 230, 530 and 600 aspect ratios are comparatively less than conventional 90 Mpa mix, whereas strength of cylinders with 0.4% dosage of basalt fibers of 230, 530 and 600 aspect ratios are improved by 3.5% to 14% than 90 Mpa mix so 0.4% dosage of basalt fibered concrete yields better split tensile strength.

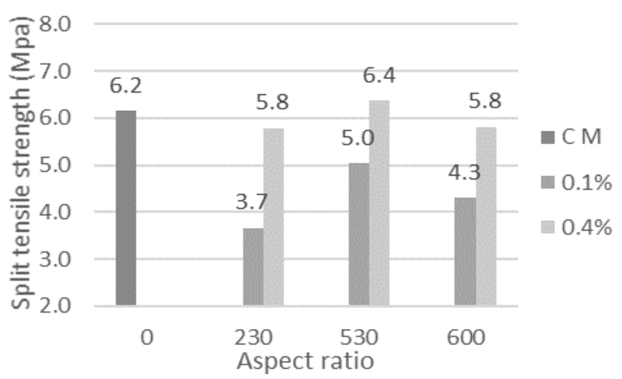

Fig. 3a

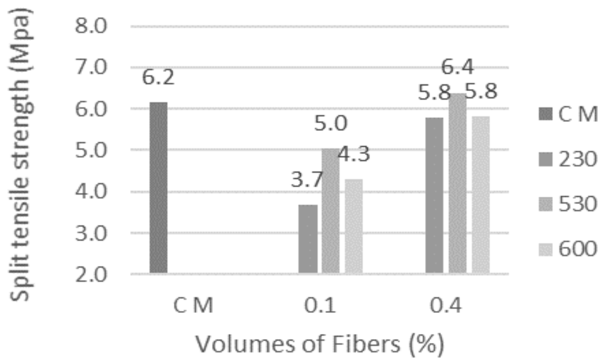

Fig. 3b

Fig. 3. Split tensile strength of very HS-SCC (3a) Aspect ratio vs strength & (3b) Volume of fibers vs strength.

Flexural strength: Flexural strength of 90 Mpa conventional mix and BFRC concrete mixes are figured in 4a and 4b as shown. Results of flexural strength for all the concrete mixes are between 7% to 11% compared to results of compressive strength test results which yielded good. From the figure 4a, the strength of concrete mix 530 aspect ratio of 0.4% dosage of basalt fiber is yielded by 21% compared to 90 Mpa concrete mix. Also, three concrete mixes of aspect ratios 230, 530 and 600 of 0.4% dosage of fibers is increased compared to conventional mix. Figure 4b is comparison of different dosage of basalt fibers to conventional mix, where as 0.4% volume basalt fibered concrete of all three aspect ratios 230, 530 and 600 are increased while compared to 0.1% volume of basalt fiber concrete and 90 Mpa concrete mix.

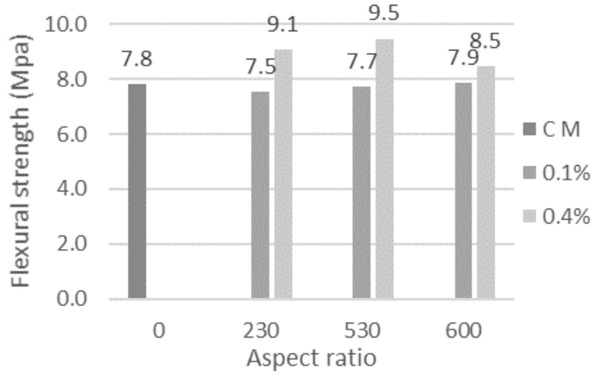

Fig. 4a

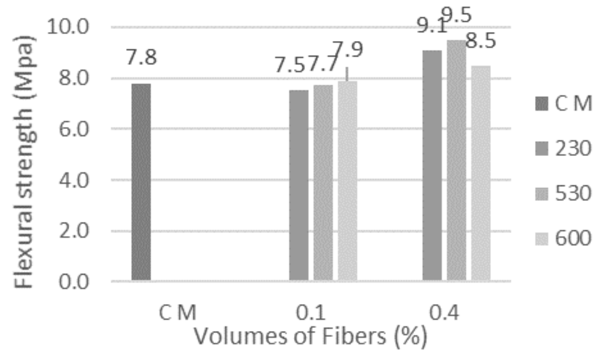

Fig. 4b

Fig. 4. Flexural strength of very HS-SCC, (4a) Aspect ratio vs strength & (4b) Volume of fibers vs strength.

IV. CONCLUSIONS

From the experimental study, the following conclusion are written.

- Characteristics compressive strength of 0.1 percent volume of basalt fibers with an aspect ratio 530 in concrete mix has improved by 6.58% than normal concrete.
- Split-tensile strength of 0.4 percent basalt fibered concrete with aspect ratio 530 has increased its tensile strength by 14% than normal concrete.
- Flexural strength of concrete mix with 0.4 percent basalt fibers of aspect ratio 530 has increased by 21% compared to conventional concrete mix
- From the results of fresh properties shown in table 1, we can conclude that all mixes had good workability as per EFNARC 2005 guidelines.
- Utilization of basalt fibers with an aspect ratio of 530 in SCC mixes is optimal compared to other aspect ratios and conventional mix.
- Dosage of basalt fibers has shown variations in mechanical properties of concrete mixes, where 0.1% dosage of fibers had highest compressive strength but flexural and tensile strength of concreted yielded well for 0.4% volume of basalt fibers.

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