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Effect on the Mechanical Properties of Self-Compaction Concrete by Partial Replacement with Grinded Fibers

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***Abstract**: The development of Self-compacting concrete (SCC) is a progressive milestone in the historical backdrop of real estate and construction industry bringing about transcendent use of SCC overall these days .In this study, the effects on the mechanical properties of the Self-compacting concrete (SCC) with partial replacement of cement by grinded fiber were studied, a mixture of equal proportion of grinded glass and basalt fiber of length 6mm was used. The volume fraction of the grinded glass and basalt mixture taken are 0%, 0.15%, 0.30%, 0.45% and 0.60% by weight of cement. In order to better understand the effect of the grinded fibers on the mechanical properties of SCC, cubes and cylinders were casted and tested for compressive strength, split tensile strength and flexural strength. For each test, data was collected and then compared with target (0%) fiber specimen. The study showed remarkable improvements in all properties of self-compacting concrete such as a compressive strength as well as enhanced durability.*

***Key words:** Compressive strength, Flexural strength, Self-compacting concrete, Split tensile strength*

I. INTRODUCTION

The presence of voids in the concrete due to improper compaction results in the loss of strength which may prove to detrimental to the structure as result proper compaction is essential during casting of reinforced concrete structure [1-2]. Self-compacting concrete due to its ability to fill spaces or voids under self weight provides a solution to this problem [3]. Self-compacting concrete was initially created in Japan and Europe [4]. It is a concrete that does not require any kind of external vibration or compaction as it can flow and fill all the sections of the formwork even in a highly congested or reinforced structure or section purely on the basis of gravity. The development of Self compacting concrete by Prof. H.Okamura in 1986 has caused a huge effect on the development/real estate business by providing a solution to the problems or shortcoming posed by conventional concrete [5]. The properties of SCC are better compaction resulting in increase of compressive strength, lower modulus of elasticity, better bond between various particles, ability to withstand high temperatures in case of fire and excellent final concrete finish [6].

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Several research have pointed out that fiber reinforced concrete have much more ductility than ordinary concrete resulting in increase in overall efficiency.

Fiber reinforcement results in increasing the Tensile strength at rupture but no significant increase in Ultimate tensile strength [7].At introductory stage and the solidified state, Inclusion of fibers improves the properties of Self-compacting concrete.

II. OBJECTIVES

A) To design SCC of M30 grade by replacement of cement by equal proportion of grinded basalt and glass fibers.

B) To investigate the effect of grinded equal proportion of basalt and glass fibers on fresh properties of SCC

C) To study the effect on the compressive strength of SCC with equal proportion of grinded basalt and glass fibers.

D) To study the effect on the tensile strength of SCC with equal proportion of grinded basalt and glass fibers.

E) To study the effect on the flexural strength of SCC with equal proportion of grinded basalt and glass fibers.

III. MATERIALS

A) Cement*:* Cement is one of the most basic construction materials used today because of its adhesive and cohesive properties which are very useful for bonding purposes. Ordinary Portland cement (OPC) – 43 Grade (Khyber Cement) conforming to IS: 12269-1987 was used for the exploratory program. The physical properties of the cement as given below:

Table I: Physical Properties Of Cement

Sr.no	Property	Value
1	Standard Consistency	32%
2	Fineness	3%
3	Soundness (mm)	3mm
4	Initial setting time (min)	45min
5	Final setting time (min)	345min
6	Specific gravity	2.98

B) Fine aggregate*:* Fine aggregates are the ones which pass through 4.75mm IS sieve by the process of sieving. Aggregates used in this exploratory work are manufactured sand which was transported from a nearby crusher facility. Their specific gravity was measured to be 2.65.

Table II: Physical Properties of Fine Agg

Sr.no	Property	Value
1	Type	Manufactured
2	Surface Texture	Crystalline
3	Specific gravity	2.65
4	Water absorption	3.7%
5	Grading zone	Zone II

C) Coarse aggregate: The aggregates most by far of which are held on 4.75mm IS sieve and contains only that a ton of fine material as is permitted by the code particulars are named as coarse aggregates. For our experiment, crushed stone was utilized of size 10mm and 20 mm and specific gravity of 2.68.

Table III: Physical Properties of Coarse Aggregate

Sr.no	Property	Value
1	Surface texture	Crystalline
2	Particle shape	Angular
3	Specific gravity	2.68

D) Water*:* Tap water was used in our examination.

E) Fly ash: Fly ash is finely divided powder which has similar properties to ordinary Portland cement. The specific gravity of the fly ash used is 2.3 and its bulk density is 11gm/cc.

F) Admixture*:* A water reducing admixture named AURAMIX-400 was used in our examination. AURAMIX-400 is a super plasticizer produced by FOSROC and it helps in improving the workability of the mixture as well strength, enhances the compaction and finishing.

Table IV: Properties Of Auramix-400

Sr.no	Property	Value
1	Appearance	Light orange liquid
2	Ph	Min 6
3	Volumetric mass	1.08 kg/liter
4	Alkali content	<1.4g Na_2O
5	Chloride content	Nil

G) Fiber: Fiber is a characteristic or built string or used as a piece of composite materials, or, when tangled into sheets, used to make things, for instance, paper, papyrus. Glass and Basalt fibers were used in our investigation. In this study, Alkali resistant glass fiber having a modulus of elasticity of 72 GPA and 6mm length and Basalt fiber of 6mm were used.

Figure I: Glass fibers

Figure II: Basalt fibers

IV. METHODOLOGY

A) Collection of Materials
B) Mix Design
C) Preliminary tests
D) Batching, Mixing, Casting and Curing
E) Result and Discussion
F) Conclusion

The main phase of this work was to create a unique blend of SCC of M30 grade with the superplasticizer and to consider its fresh and solidified properties. For creating SCC of solidarity M30 grade, the blend was planned dependent on EFNARC 2005 code. The SCC blends which yielded agreeable fresh properties and required compressive strength, were chosen and taken for further examination. In the second phase of examination, plain SCC was partially replaced by different volume of equal proportion of grinded Basalt and Glass fiber by weight of cement. A water reducing admixture named AURAMIX-400 was used in the examination.

V. MIX DESIGN ADOPTED OF SCC

Mix-Design of M30 grade SCC was finished after EFNARC code 2005.A water reducing admixture named AURAMIX-400 was utilized to lessen the water content and enhance the workability and strength of the mix.. In this exploratory program 20% fly ash was utilized as a replacement of cement to reach the target strength as well make it more economical. A mix proportion of 1:0.43:2.035:1.805:0.013(Binder: water: fine aggregate: coarse aggregate: super-plasticizer was adopted and has been tabulated below:

Table V: Mix Design Scc

Binder	Cement	Fly ash	Water	FA	CA	SP
440	352	88	189.2	895.5	794.20	5.72
1	-	0.20	0.43	2.035	1.805	0.013

VI. TESTS

A) Slump flow and T_{50} test
B) L-box test
C) V-funnel and V-funnel test at T_5 mins
D) Compression test
E) Split-tensile test
F) Flexural strength test

VII. BATCHING AND MIXING

In this study, the mechanical properties of Self-compacting concrete (SCC) of M30 grade with partial replacement of cement by an equal proportion of grinded basalt and glass fiber by weight of cement were studied. For each mix six numbers of cubes (150×150×150) mm, six numbers of cylinders (150×300) mm and six numbers prisms (100×100×500) mm were prepared and investigations were conducted to study the mechanical properties of plain SCC and SCC of M30 grade with partial replacement of cement by an equal proportion of grinded basalt and glass fiber by weight of cement. Thirty numbers of cubes (150x150x150) mm were casted, thirty numbers of cylinders (150x300) mm were casted and thirty numbers of prisms (100x100x500) mm were casted.

VIII. RESULT AND DISCUSSION

In this whole exploratory program, the effect on the mechanical properties of Self-compacting concrete (SCC) with partial replacement of cement by equal proportion of grinded basalt and glass fiber by weight of cement was studied. Furthermore, the effect of grinded basalt and glass fiber on the fresh properties of concrete such as slump etc was also studied. The different observations due to grinded basalt and glass fiber seen during the fresh state as well as hardened state of concrete are listed below:

Effect on the fresh concrete properties

- A reduction in the value of flow was seen with replacement of cement by grinded basalt and glass fiber as compared to plain SCC.
- The reason for this reduction in the value of flow is due to the fact that due to incorporation of fiber the concrete becomes much more structured which restrains the mixture from segregation and flow.
- Due to the increase in the fiber percentage, the slump flow decreases.
- As the flow of slump decreases, there is reciprocal effect on the value of T_{50} measured in terms of time (sec) that is it shows an increase in value.
- Due to increase in the slump flow value, the L-box value increase**s.**
- Due to decrease in the slump value as a result of increase in the fiber percentage, the value of V-funnel and T_5 flow test increases.
- The T_{50} flow and V-funnel test value are dependent with each other and are measured in time (sec).

Table No VI: Description of Mixes

Designation	Fiber content (%)	Description
PSCC	0.0%	Plain Self-compacting concrete
FSCC-1	0.15%	Basalt and Glass replaced SCC
FSCC-2	0.30%	Basalt and Glass replaced SCC
FSCC-3	0.45%	Basalt and Glass replaced SCC
FSCC-4	0.60%	Basalt and Glass replaced SCC

Table VII: Fresh Concrete Results

Sample	Slump flow	T50 flow	L-box	V-funnel	T5 flow	Remarks
PSSC	675	1.8	1	5	10.5	**Satisfactory**
FSCC-1	600	2.6	0.85	8	12.5	**Satisfactory**
FSCC-2	550	3.9	0.80	9	14	**Satisfactory**
FSCC-3	490	5.4	0.69	11	16	**Not satisfactory**
FSCC-4	440	6	0.59	12	17.5	**Not satisfactory**

Effect on the hardened properties

In order to understand the effect on the mechanical properties of Self-compacting concrete (SCC) with partial replacement of cement by grinded fiber, various Fiber reinforced Self compacted concrete (FSCC) mixes were made and standard specimen were casted. The standard specimen where then tested for compressive strength at 7and28days.Tensile and flexural strength were also tested at 7and28days. The results are summarized in the table VII & IX as shown:

Table VIII: Fresh Concrete Results At 7 Days

Mixes	7-Days CS(MPA)	7-Days SPT(MPA)	7-Days FS(MPA
PSCC	22	1.31	9.12
FSCC-1	23.5	1.47	11.55
FSCC-2	26	1.90	14.33
FSCC-3	25.20	1.70	13.70
FSCC-4	24.20	1.50	12.65

TABLE IX: FRESH CONCRETE RESULTS AT 28DAYS

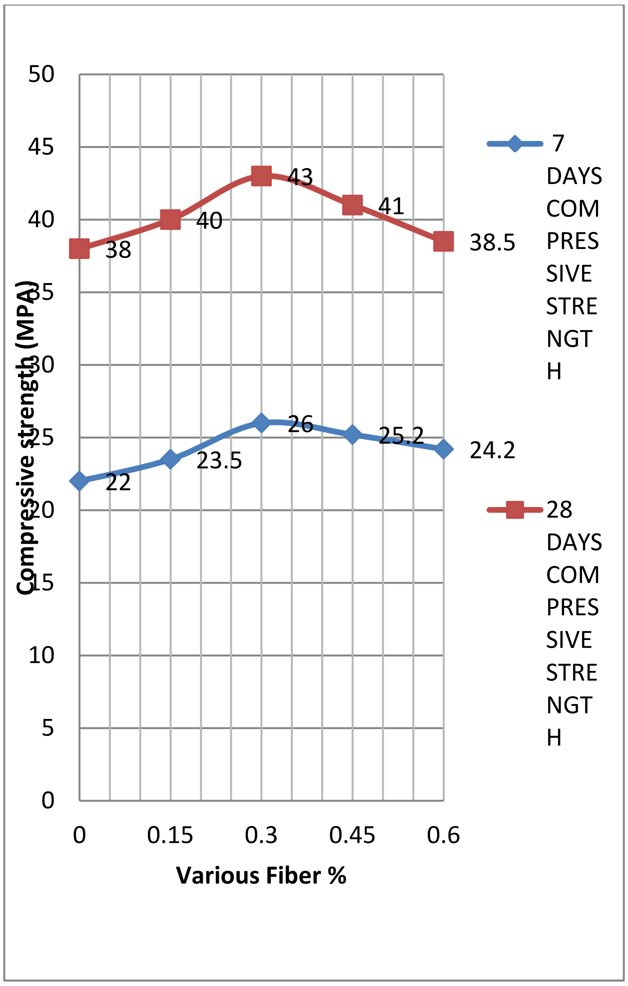
Mixes	28-Days CS(MPA)	28-Days SPT(MPA)	28-Days FS(MPA
PSCC	38	3.42	12
FSCC-1	40	3.91	14.50
FSCC-2	43	4.56	17.22
FSCC-3	41	3.93	14.25
FSCC-4	38.5	3.55	13.33

A) COMPRESSIVE STRENGTH TEST (in MPa)

The mean values of the samples tested for 7 and 28 days compressive strength are shown below in the form of figure. As seen in the table figure III, with the increase in the % of fiber there is an increase in the compressive strength of the mix till 0.30% fiber content after that the mix shows a decrease in the compressive strength. The mix shows an increase of 6.81%, 18.81%, 14.54% &10.0% for 7 days & 5.26%, 13.15%, 7.89% & 1.31% compressive strength compressive strength for 28 days at 0.15%, 0.30%, 0.45%&0.60% fibers respectively with respect to plain Self-compacted concrete. However, there is a decrease of 3.07% & 6.92% compressive strength for 7 days & 4.65% & 10.46% for 28 days at 0.45%& 0.60% fibers respectively when compared to 0.30% fiber mix. The results indicate that FSCC-2 is the optimum mix where the mix shows the max or greatest compressive strength for both 7 as well as 28 days.

Larger fluctuations in the graph can be seen in the case of 28 days compressive strength as opposed to 7 days. It indicates the fibers have a more profound effect in the case of later-age compressive strength as opposed to early age compressive strength.

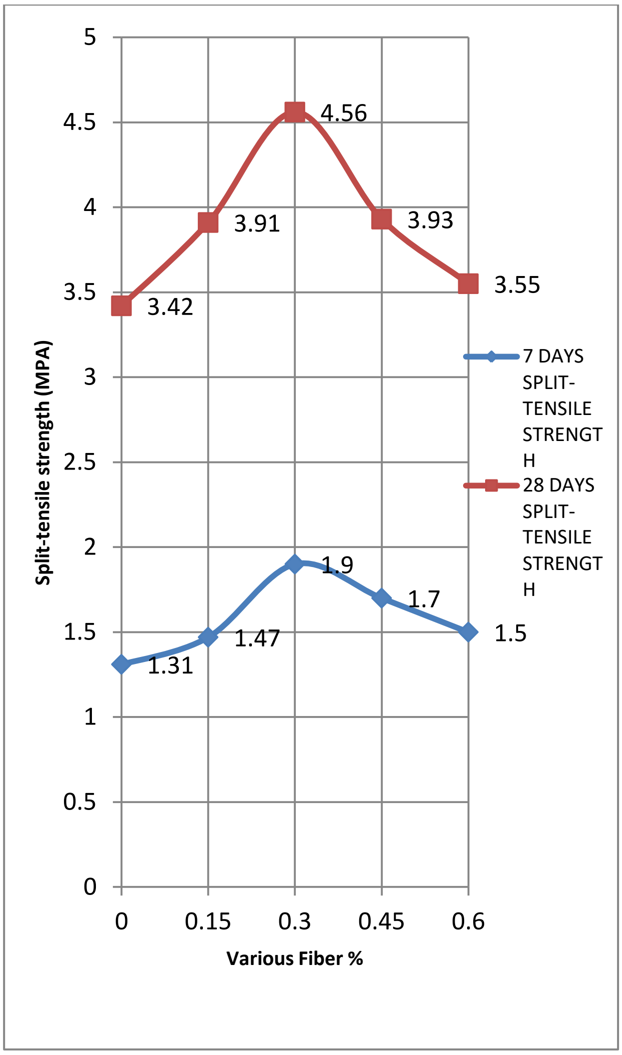
Figure III: showing effect on the Compressive strength of SCC with various grinded fiber %



B) SPLIT TENSILE STRENGTH (in MPa)

The mean values of the samples tested for 7days & 28 days Split tensile strength are shown below in the form of figure. As seen in the figure IV, with the increase in the % of fiber there is an increase in the split tensile strength of the mix till 0.30%fiber content after that the mix shows a decrease in the split tensile strength. The mix shows an increase of 12.21%, 45.03%, 29.77%&14.50% split-tensile strength for 7 days & 14.33%, 33.33%, 14.91%&3.80% split-tensile strength for 28 days at 0 .15%, 0.30%, 0.45%&0.60% fiber respectively with respect to plain Self-compacted concrete. However, there is a decrease of 10.52% &21.05%tensile strength for 7 days &13.81 % &22.14%tensile strength for 28 days at 0.45%&0.60 fibers respectively when compared to 0.30% fiber mix. The results indicate that FSCC-2 is the optimum mix where the mix shows the max or greatest split-tensile strength for both 7 as well as 28 days. Larger fluctuations in the graph can be seen in the case of 28 days split-tensile strength as opposed to 7 days. It indicates the fibers have a more profound effect in the case of later-age split-tensile strength as opposed to early split-tensile strength.

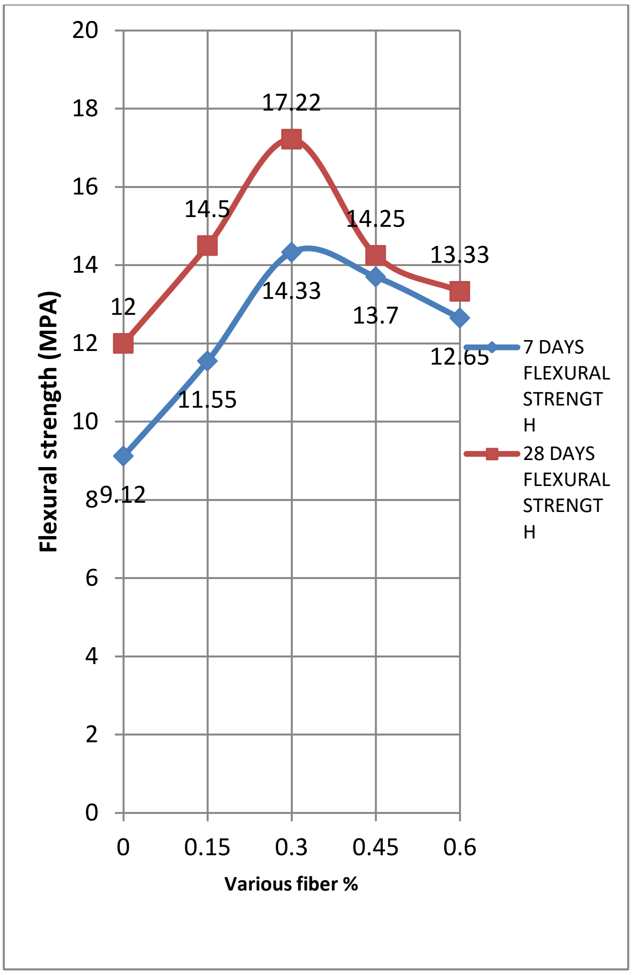
Figure IV: showing effect on the Split-tensile strength of SCC with various grinded fiber %



C) FLEXURAL STRENGTH (in MPa)

The mean values of the samples tested for 7days & 28 days flexural strength are shown below in the form of table. As seen in the table 12, with the increase in the % of fiber there is an increase in the flexural strength of the mix till 0.30%fiber content after that the mix shows a decrease in the flexural strength. The mix shows an increase of 26.64%, 57.12%, 50.21%& 38.70% flexural strength for 7 days & 20.83%, 43.50%, 18.75%&11.0%flexural strength for 28 days at 0 .15%, 0.30%, 0.45%&0.60% fiber respectively with respect to plain Self-compacted concrete. However, there is a decrease of 4.39 % & 11.72%flexual strength for 7 days & 17.24 % &22.59%flexural strength for 28 days at 0.45%& 0.60 fibers respectively when compared to 0.30% fiber mix. The results indicate that FSCC-2 is the optimum mix where the mix shows the max or greatest flexural strength for both 7 as well as 28 days. Larger fluctuations in the graph can be seen in the case of 28 days flexural strength as opposed to 7 days.

Figure V: showing effect on the Flexural strength of SCC with various grinded fiber %



IX. CONCLUSIONS

The different observations in light of the test performed on the specimens are given as under:

- A reduction in the value of flow was seen due to replacement of cement by grinded basalt and glass fibers as compared to plain SCC**.**
- The replacement of cement by fibers causes a decrease in the fresh properties of SCC such as slump flow, etc.
- The replacement of cement by fibers results in an increase in the hardened properties of SCC such as Compressive strength, Split tensile strength & flexural strength. However there was an optimum mix % at which the strength was highest followed by decrease in the strength. Mix having 0.30% grinded basalt and glass fiber showed the highest Compressive strength. The same thing was also noticed in Split tensile strength and Flexural strength.
- There was a decrease of 3.07% &6.92% Compressive strength at 7days and 4.65%&10.46% Compressive strength at 28days when the percentage of fibers increased above the optimum mix i.e. 0.30% with respect to the optimum mix.
- Similarly, there was a decrease of 10.52% &21.05% Split tensile strength at 7days and 13.81%&22.14% Split tensile strength at 28 days when the percentage of fibers increased above the optimum mix i.e. 0.30% with respect to the optimum mix.
- Decrease of 4.39 % & 11.72% flexural strength at 7 days & 17.24% & 22.59% flexural strength at 28days when the percentage of fibers increased above the optimum mix i.e. 0.30% with respect to the optimum mix.

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