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Effect of Chopped Basalt Fibre on the Workability and Compressive Strength of Concrete

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Abstract

With high ductility and sufficient durability, fibre reinforced concrete (FRC) is widely used. Various types of fibres such as steel, carbon, glass and polyester are generally used in concrete. Among the new advancement in field of FRC is the basalt fibre reinforced concrete. In the present study basalt chopped fibres were used in the concrete mixes and workability, compressive strength of the specimens was tested. A total of 4 mixes were prepared by varying the percentages of basalt fibres by weight of cement on M 25 grade of concrete mix. The experimental test result demonstrated a considerable increase in compressive strength. The workability of fresh concrete mixes is decreasing by increasing the percentage of chopped basalt fibre. However workable concrete mix is achieved up to 1.5% of Chopped BasaltFibre.

***Keywords:** Fibre Reinforced Concrete (FRC), Chopped Basalt Fibre, Compressive Strength, Workability*

I. INTRODUCTION

Basalt rock is a volcanic rock and can be divided into small particles then formed into continues or chopped fibres. Basalt fibre has a higher working temperature and has a good resistance to chemical attack, impact load, and fire with less poisonous fumes. Some of the potential applications of these basalt composites are: plastic polymer reinforcement, soil strengthening, bridges and highways, industrial floors, heat and sound insulation for residential and industrial buildings, bullet proof vests and retrofitting and rehabilitation of structures.

Fig.1. Chopped basalt fibre

Basalt is fine-grained, extrusive, igneous rock composed of plagioclase, feldspar, pyroxene and magnetite, with or without olivine and containing not more than 53 wt. % SiO2 and less than 5 wt. % total alkalis. Many types of basalt contain phenocrysts of olivine, clinopyroxene (augite) and plagioclase feldspar.

Basalt is divided into two main types, alkali basalt and tholeiites. They have a similar concentration of SiO_2, but alkali basalts have higher content of NA_2O and K_2O than tholeiites. The production of basalt fibres is similar to the production of glass fibres. Basalt is quarried, crushed and washed and then melted at 1500° C. The molten rock is then extruded through small nozzles to produce continuous filaments of basalt fibre.

Concrete is the most widely used in construction industry. It consists of a rationally chosen mixture of binding material such as cement, well graded fine and coarse aggregates, water and admixtures. Various types of fibres can be used in cement and concrete composite, such as steel or organic fibres. Among all the used fibres currently, steel fibre has high elastic modulus and stiffness and thus the addition of steel fibre is effective for improving the compressive strength and toughness of concrete.

But steel fibre rusts easily. Adding steel fibre to the concrete will increase the structure weight of the concrete and will cause a balling effect in mixing, and thus the workability will be lowered. Glass fibre has high sensitivity to alkaline conditions. The chemically inert and stiffer of carbon fibre has a disadvantage of high cost and anisotropy. Synthetic fibres, mainly polymeric fibre, etc., usually have low elastic modulus, low melting point, and poor interfacial bonding with inorganic matrices. New materials offer the promise of innovative applications in concrete composite. Basalt fibre (BF) is a new kind of inorganic fibre. The manufacturing pro-cess of this kind of fibre is similar to that of glass fibre, but with less energy consumed and no additives, it becomes a widely acceptable fibre. Other advantages such as high mod-ulus, heat resistance, good resistance to chemical attack, excellent interfacial shear strength, enable BF a good alternative to glass, carbon or aramidic fibre as a reinforcing material in concrete composite.

2. OBJECTIVES AND SCOPE OF THE STUDY

The objective of this study is as follows:-

- Perform laboratory test that are related to workability, compressive strength, by use of basalt fibre in the concrete.
- Understand the various applications involving BFRC.
- To obtain increase in compressive strength.
- To avoid harbour bacterial or microbial growth.
- To give resistant to aggressive liquids, acids and alkali’s
- To achieve great sound insulation property

3. EXPERIMENTAL WORK

3.1 Material used

The materials used for preparing a concrete mix were described below:-

3.1.1 Cement

Ordinary Portland cement of 53 grade was used, conforming to recommendations stated in IS 4031(1999). OPC manufactured from ultratech cement plant was used throughout the experimental work. The physical properties of OPC are tabulated in Table 1.

3.1.2 Fine Aggregate

Locally available artificial sand was used as fine aggregate. The test procedures as mentioned in IS-383(1970) were followed to determine the physical properties of fine aggregate as shown in Table 2.

3.1.3 Coarse Aggregate

Two single sized stone grit 10mm and 20mm sizes were used in respective proportions in concrete mixes. The aggregates were tested in accordance to

IS-2386 (Part I, III & IV). The results obtained are tabulated in Table 3.

3.1.4 Chopped basalt Fibre

Chopped Basalt fibre of golden brown colour was used in the concrete mixes. The density of the fibre is 1.9-2.1 g/cc and 6mm length fibre was used in this study. The specifications of these fibres are presented in Table 4.

3.1.5 Admixtures

In order to make the concrete mixes workable CHRYSO fluid RMC 2343 admixture was used. The addition of fibres reduces the workability; therefore in order to make it use for practical purposes admixtures in appropriate quantity was added to the mix.

3.1.6 Water

As per recommendation of IS: 456 (2000), the water to be used for mixing and curing of concrete should be free from deleterious materials. Therefore potable water was used in the present study in all operations demanding control over water quality.

Table 1: Physical properties of ordinary Portland cement

SR.NO.	PROPERTIES	VALUE
1.	Specific gravity	3.15
2.	Standard consistency	34%
3.	Initial Setting time in minutes	30
4.	Final setting time in minutes	600

Table 2: Physical properties of fine aggregate

SR.NO.	PROPERTIES	VALUE
1.	Specific gravity	2.65
2.	Fineness modulus	2.9
3.	Water absorption	2%
4.	Zone	III

Table 3: Physical Properties of coarse aggregate

SR.NO.	PROPERTIES	VALUE
1.	Specific gravity (20mm)	2.6
2.	Specific gravity (10mm)	2.6
3.	Fineness modulus(20mm)	2.596
4.	Fineness modulus(10mm)	2.273
5.	Water absorption(20mm)	2 %
6.	Water absorption(10mm)	2 %

Table 4: Physical Properties of Chopped Basalt Fabre

SR.NO.	PROPERTIES	VALUE
1.	Density (g/cc)	1.9-2.1
2.	Tensile Strength (MPa)	>1250
3.	Tensile Strength (MPa)	<3.1
4.	Tensile elastic modulus (Gpa)	>40
5.	Length (mm)	6

3.2 Concrete mix proportions

The mix design for M-25 grade concrete was done according the Indian Standard Recommended Method IS 10262-2009.The target mean strength was 31.6 MPa for the control mixture, the total cement content was 312 kg/m^3, fine aggregate is taken as 687.05 kg/m^3,10mm aggregate is taken as 357.26 kg/m^3, 20mm aggregate is taken as 918.69 kg/m^3 the water to cement ratio was kept as 0.45, the Super plasticizer content was taken as 6.24 kg/m^3 for all mixtures.

Cement, sand, Basalt fibre and fine and coarse aggregate were properly mixed together in accordance with IS code before water and admixture was added and was properly mixed together to achieve homogenous material. Water absorption capacity and moisture content were taken into consideration. The total mixing time was 7 minutes in concrete mixer. TheSlump cone test was then performed to check the workability of concrete mix.150mm x 150mm x 150mmcubes were used for casting. Samples were then casted and left for 24 hrs. before

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demoulding .They were then placed in the curing tank until the day of testing. The concrete specimens were cured in the tank for 7 and 28 days.

4. TEST PERFORMED

4.1 Workability

Slump cone test was carried out on each mix to ascertain workability of chopped basalt fibre reinforced concrete as well as control mixtures. The results of slump tests for M-25 grade concrete with and without Basalt Fibres were noted. The test performed is as shown in fig.2.

Fig.2. Slump cone test

4.2 Compression test

Compression test on concrete cubes with and without basalt fibre was conducted for 7 and 28 days. The load was applied till the formation of first crack. The maximum loads applied to the cube specimens were recorded. Mean of three values was taken as the compressive strength of the specimen. The experimental set up for this test is as shown in Fig.3. The compressive strength of cube can be calculated by using following formula-

$S_C = P/A$

Where,

S_C = Compressive strength of cube in MPa.

P = Load at failure in N.

A = Loaded area of cube in mm^2

Fig.3. Compression test

5. RESULTS

5.1 Workability

From the experimental results it was observed that there is gradual decrease in the slump values with an increase in basalt fibre dose, however workable concrete mix is achieved up to 1.5% of Chopped Basalt Fibre by using admixture. The results of slump cone tests are shown in table 5.

Table 5: Slump values

SR.NO.	CHOPPED BASALT FIBRE (%)	SLUMP (MM)
1.	0	160
2.	0.5	150
3.	1	130
4.	1.5	125

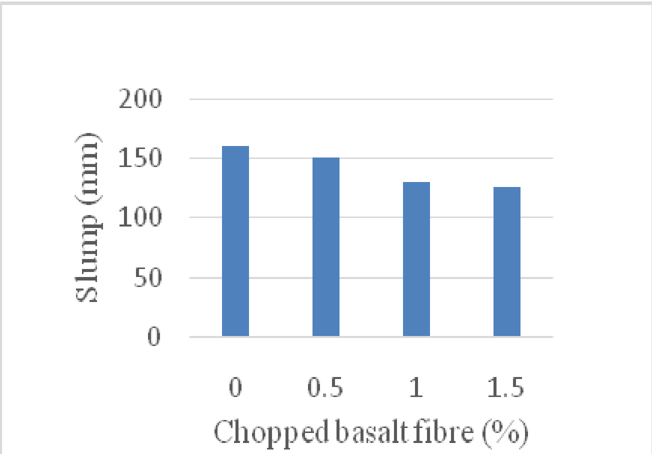

Fig.4Slump value of chopped basalt fibre specimens

Fig.4. illustrates the variation in slump value on addition of glass fibres.

5.2 Compression test

Compressive strength was measured at 7 and28 day of testing. The test results are shown in table 6.

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Table 5: Compressive strength values

SR.NO.	CHOPPED BASALT FIBRE (%)	COMPRESSIVE STRENGTH (MPa)	
		7 DAYS	28 DAYS
1.	0	27.03	35.63
2.	0.5	27.11	40.89
3.	1	28.37	42.37
4.	1.5	28.74	43.63

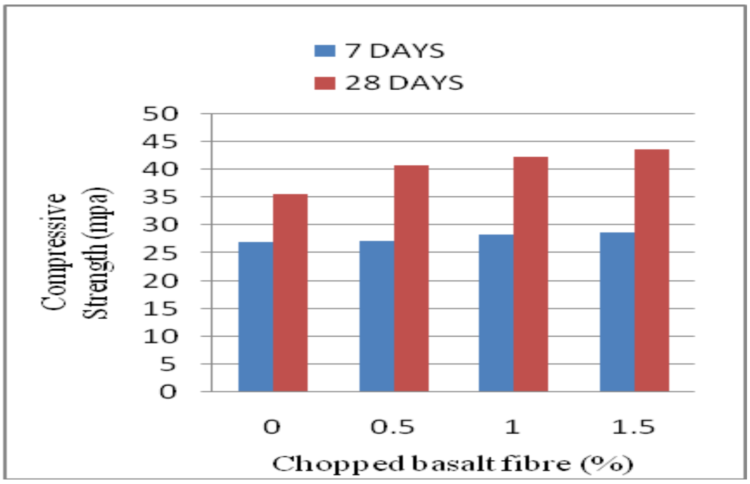

Fig.5 compressive strength of chopped basalt fibre specimens

Fig.5. Indicates the comparison of result of compressive strength using cube specimen of M25 grade concrete. It was observed that for addition of 1.5% fibre by weight of cement gives more compressive strength than other fibre percentage.

CONCLUSION

- From this study it was clear that the use of chopped basalt fibres advantageously improves the compressive strength.
- The increase in the content of percentage of fibres increases the compressive strength marginally.
- The percentage increase of compressive strength of chopped basalt fibre concrete mix compared with 28 days compressive strength

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of Plain Concrete at 1.5% basalt fibre by weight of cement is observed as 22 percent, at 1% is observed as 19 percent and at 0.5% it was 15 percent.

- The difference between compressive strength of basalt fibre reinforced concrete and plain concrete at 7days is very less as compared with the 28days strength, thus strength of basalt fibre reinforced concrete increases with the age of concrete.

- It was observed that the workability of concrete decreases with the addition of Basalt Fibres, but still concrete is useable for various purposes as slump obtained at higher percentage of basalt fibre (1.5%) is acceptable.

- The ductility characteristics have improved with the addition of basalt fibres. The failure of fibre concrete is gradual as compared to that of brittle failure of plain concrete.

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