A Study on Influence of Basalt Fiber Grid on Mechanical Properties of Sustainable Concrete

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Abstract: Concrete plays an important role in construction industry. Construction industry is always in search of new and better materials for improving concrete properties which is economical and sustainable. Conventional concrete possesses enough compressive resisting capacity but has negligible tensile strength. Sudden failure of concrete is due to its low ductility. Recent developments are being done to improve concrete properties. Fiber grids are used as strengthening agent of concrete. The inclusion of fiber grid in concrete makes concrete to perform better and it enhances its properties depending on the properties of fiber grid. The various kind of fiber grids are used in concrete such as glass fiber grid, carbon fiber grid, synthetic fiber grid, etc. Present research work focus on application of the basalt fiber grid by varying its percentages in concrete. Various experiments were performed to study the effect of basalt fiber grid on mechanical properties of concrete with 0%, 0.15%, 0.30% and 0.45% by weight of cement. M-25 and M-30 grade of concrete were used in experimental work. It was found that 0.45% of basalt fiber gird gives best result for given set of conditions. The basalt fiber grid concrete was tested for compressive strength, flexural strength and split tensile strength. It was observed that, by adding 0.45% of basalt fiber grid, properties of concrete like compressive strength, flexural strength and split tensile strength improved by 25.60 %, 20.12% and 46.12% respectively for M-25 grade of concrete. For M-30 grade of concrete, compressive strength, flexural strength and split tensile strength improved by 23.37%, 26.50% and 35.58% respectively.

Keywords: flexural strength, sustainable

1.0 Introduction

Concrete is mostly used as a construction material in world wide. Major construction material of infrastructural facilities in the 21st century is concrete. The word concrete comes from the Latin word "concretus" whose meaning is compact or condensed. The basic ingredients are used in concrete mix is sand, gravel (aggregate), cement (binding material) and water. Sometimes admixtures are used to change various properties of concrete like accelerators, retarders, water reducers, high range water reducers, etc. and also when to obtain high performance concrete or high strength concrete. Freshly mixed concrete can be moulded in to any shape and any size. Once the concrete gets hardened it achieves the shape of the mould and strength is also achieved in its hardened form. The chemical reaction between cement and water so that heat is released in large amount and it is called heat of hydration. Concrete is strong in compression but there are numerous drawbacks such as very less tensile strength, nature of brittle failure, low crack resistance, etc. The weakness in tension of concrete can be reducing by the use of conventional reinforcement bars and to some extent by the addition of a sufficient volume of certain fibers.

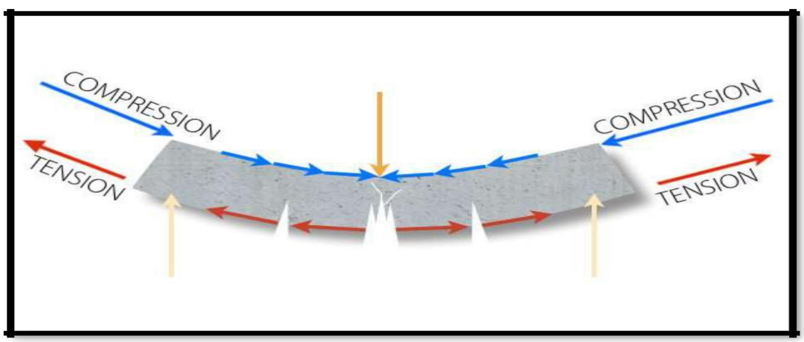


Figure 1 Cracking in Concrete member

1.1 Fiber Reinforced Concrete

In the built environment, there is continual interest and demand for new materials that are stronger, stiffer, and lighter-weight than their predecessors. The scientific and industrial path of fiber reinforced polymer (FRP) composites was successful primarily because these materials were able to offer higher structural efficiency and strength to weight ratios over tradition materials such as metals, plastics, and wood. These technologies offer exceptional performance; however, in recent years there have been growing concerns regarding the depletion and simultaneously increasing costs of petroleum resources which serve as feed-stocks for these polymer matrix materials. Additionally, there has been increased awareness regarding the environmental impact of synthetic materials during their manufacture, use, and end-life.

1.2 Basalt grid:

Continuous Basalt Fiber grid is made by impregnating woven basalt fiber scrim with asphalt and then drying to be final product. In normal temperature, the ratio of the elastic modulus between basalt fiber concrete and asphalt concrete is 24:1. This basalt fiber concrete has excellent resistance to deformation. The elongation at break is about 3.15%. Basalt fiber possesses the properties of high temperature and frost resistance (- 260℃~650℃), the same thermal expansion coefficient with asphalt concrete, high tensile strength, ultraviolet resistance, stable chemical resistance and ageing resistance. The stirring temperature of the asphalt concrete is up to 190℃. Basalt fiber is the best alternative of polyester fiber. It can beat asphalt at its stirring temperature (190℃), which is the excellent construction material for reinforced cement & concrete.

Figure2: Basalt grid

2.0 Materials and Experimental Setup

The methodology of the entire work is represented to illustrate the necessary test on the material before casting of the concrete. Various test methodology on concrete like test on fresh concrete as well as test on harden concrete explained as per relevant IS standards. In any concreting work some initial properties of its ingredient should be required to measure. Before carrying out concrete mix design, setting time of cement, sieve analysis of aggregates, specific gravity of the aggregate, water absorption and fineness modulus are calculated. After carrying out the preliminary tests, mix design should be carried out as per IS-10262-2009 given in Appendix A

2.1 Methodology of work

Literature study was carried out to know past researches, investigations and previous studies related to this thesis.

1. Collection of raw Materials

All the required materials were collected from local market and delivered to the laboratory. Which are; Cement, fine aggregate, coarse aggregate, basalt roving fiber etc.

2. Material Tests

Tests were performed on the ingredients of concrete mix to determine their properties required for mix design.

3. Mix Design

Concrete mix design was prepared for M-25 grade of concrete and M-30 grade of concrete.

4. Preparation of testing specimen

The prepared samples include concrete cubes, cylinders and beams.

5. Testing of Specimens

Different tests were carried out on the prepared concrete samples which are slump test, compressive strength test, split tensile strength test and flexural strength test.

3.0 Experimental Study

3.1Compressive Strength Test

For compressive strength test, cube specimens of dimensions 150mm x 150mm x 150 mm were casted for M-25 &M-30 grade of concrete. The various percentages of basalt fiber grid content were taken as 0 %, 0.15 %, 0.30 % and 0.45

Experimental Results:

0% Basalt fiber grid content	Compressive Strength (MPa)		
Average Strength	7 days	14 days	28 days
	19.11	24.88	30.46

Table 1: Compressive Strength of normal Concrete Cube M25 Grade

Basalt Fiber grid Content (By weight of cement) (%)	Compressive Strength (MPa)			
		7 days	14 days	28 days
0.15%	Average Strength	19.77	25.55	32.44
0.30%	Average Strength	22.96	27.22	35.13
0.45%	Average Strength	24.66	28.13	38.26

Table 2: Compressive Strength of Basalt fiber grid Concrete (M25 Grade)

3.2 Split tensile Strength test

For Split tensile strength test, cylinder specimens of size 150 mm diameter and 300 mm length were casted for M25 & M30 grade of concrete. The different percentages of basalt fiber grid content were taken as 0 %, 0.15 %, 0.30 % and 0.45 % respectively by weight of cement for the test. For split tensile strength test, 9 cylinders of concrete without basalt fiber grid and 9 cylinders of concrete of each proportions of basalt fiber grid casted.

After the period of 24 hours the cylindrical specimens were demoulded and were transferred to curing tank. These cylindrical specimens were tested under compression testing machine at 7days, 14 days and 28 days respectively as per IS 516-1959 and the load was noted at failure occurrence. In each category three cylinders were tested at 7 days, 14 days and 28 days respectively and their average value is reported. The split tensile strength of cylinder was calculated as per the following formula.

$$\text{Split tensile strength (Mpa)} = (2 \times P) / (\pi \times D \times L)$$

Where, P = failure load

D = diameter of the cylinder = 150 mm

L = length of the cylinder = 300 mm

Experimental Results:

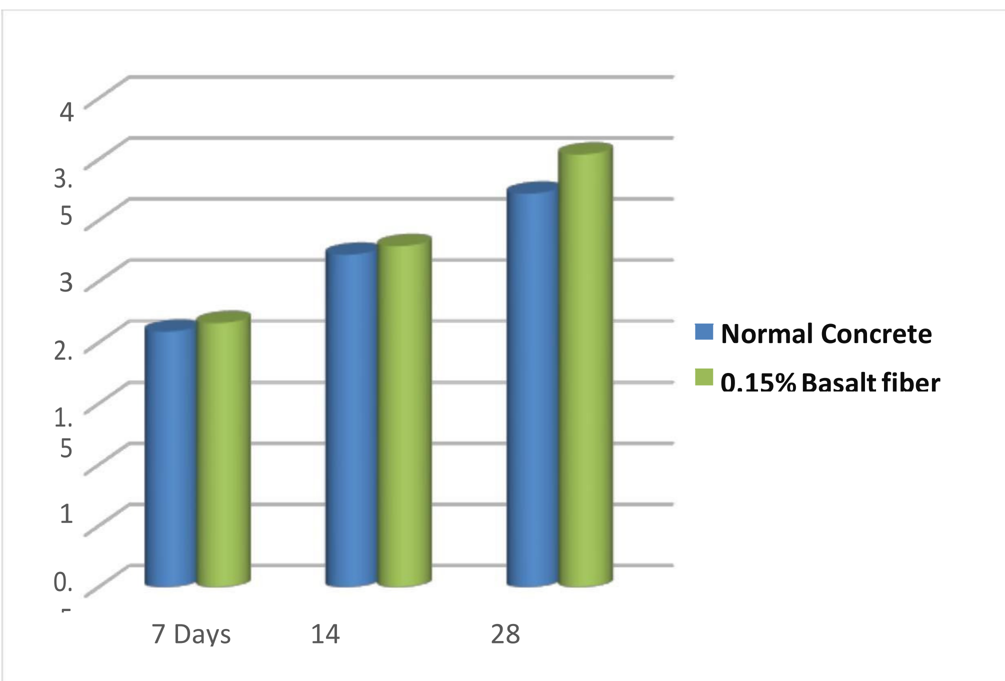
0% Basalt fiber grid content	Split Tensile Strength (MPa)		
Average Strength	7 days	14 days	28 days
	2.09	2.72	3.22

Table 3: Split Tensile Strength of Normal Concrete M25 Grade

Basalt Fiber grid Content (By weight of cement) (%)	Split Tensile Strength (MPa)			
		7 days	14 days	28 days
0.15%	Average Strength	2.16	2.79	3.54
0.30%	Average Strength	2.41	2.97	3.73
0.45%	Average Strength	2.48	3.02	3.88

Table 4: Split Tensile of Basalt fiber grid Concrete M25 Grade

Figure 1: Split tensile strength of normal and 0.15% basalt fiber grid (M-25)



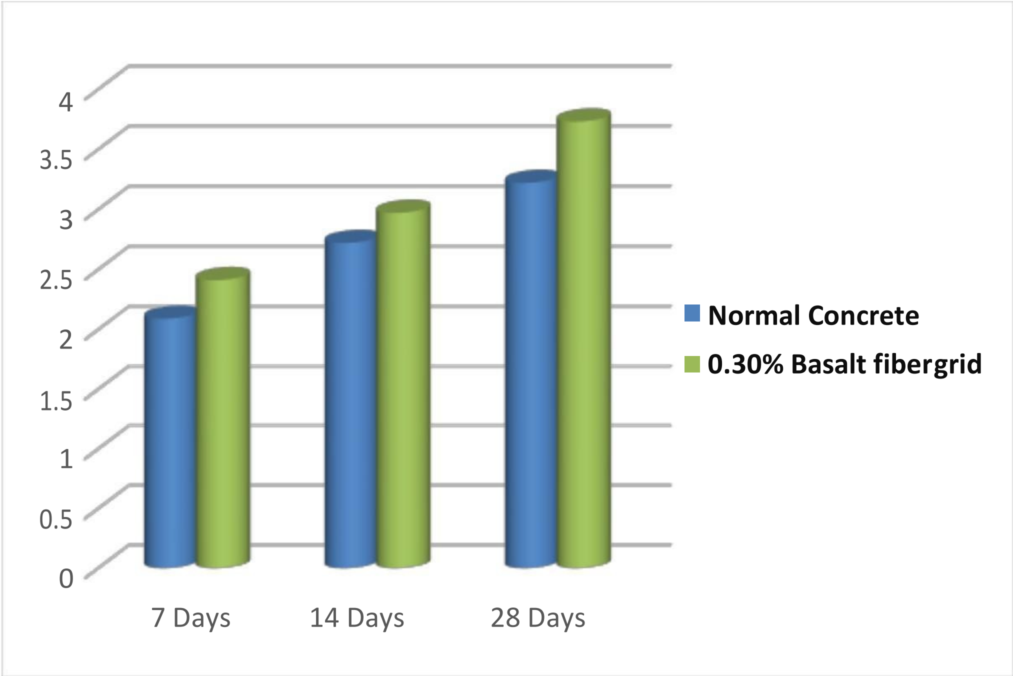


Figure 2: Split tensile strength of normal and 0.30% basalt fiber grid (M-25)

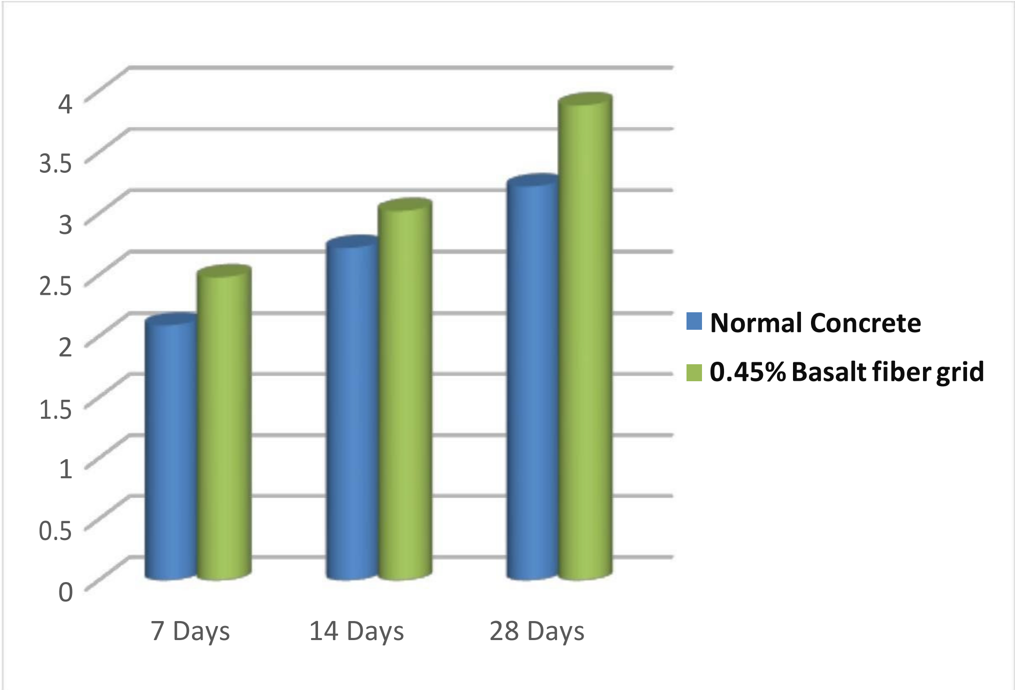


Figure 3: Split tensile strength of normal and 0.45% basalt fiber grid (M-25)

For Split tensile strength test, cylinder specimens of size 150 mm diameter and 300 mm length were casted for M30 grade of concrete.

0% Basalt fiber grid content	Split Tensile Strength (MPa)		
Average Strength	7 days	14 days	28 days
	2.68	3.08	3.81

Table 5: Split Tensile Strength of Normal Concrete M30 Grade

Basalt Fiber grid Content (By weight of cement) (%)	Split Tensile Strength (MPa)			
		7 days	14 days	28 days
0.15%	Average Strength	3.04	3.29	4.08
0.30%	Average Strength	3.38	3.71	4.26
0.45%	Average Strength	3.52	3.89	4.82

Table 6: Split Tensile of Basalt Fiber grid Concrete M30 Grade

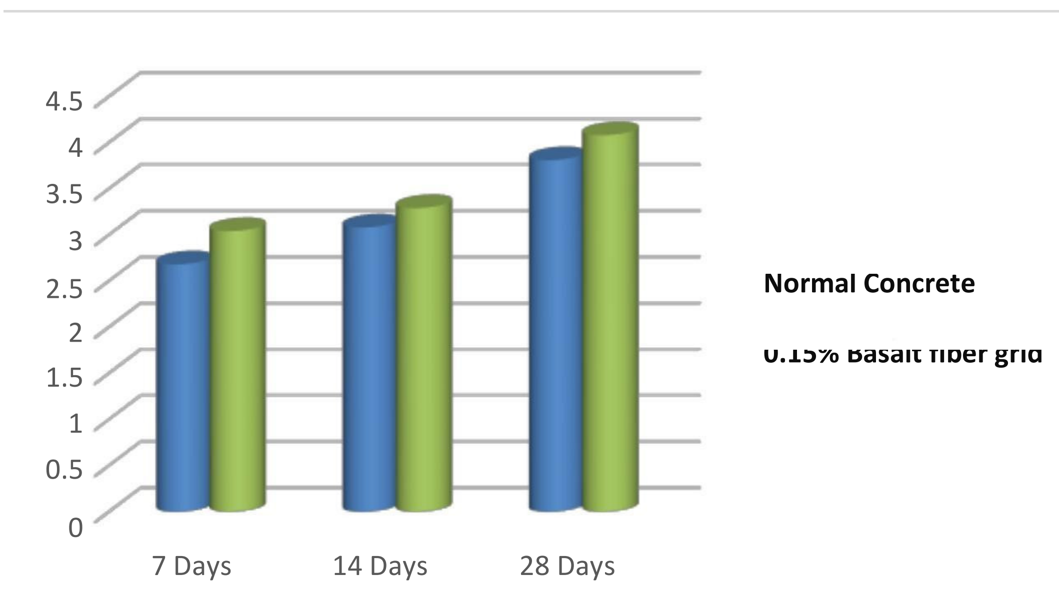


Figure 4: Split tensile strength of normal and 0.15% basalt fiber grid (M-30)

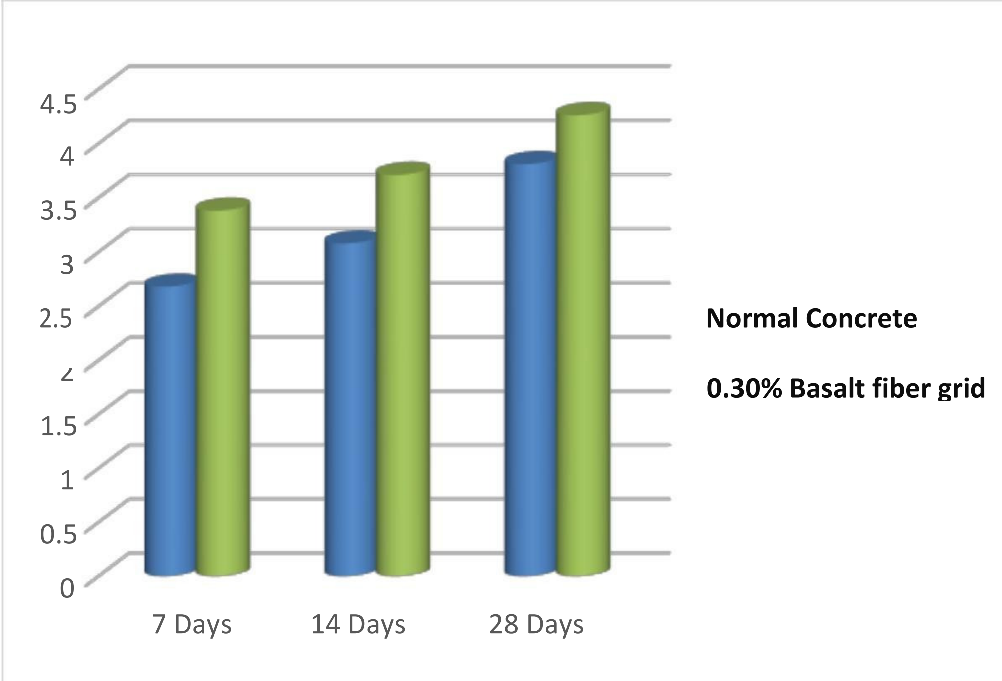


Figure 5 Split tensile strength of normal and 0.30% basalt fiber grid (M-30)

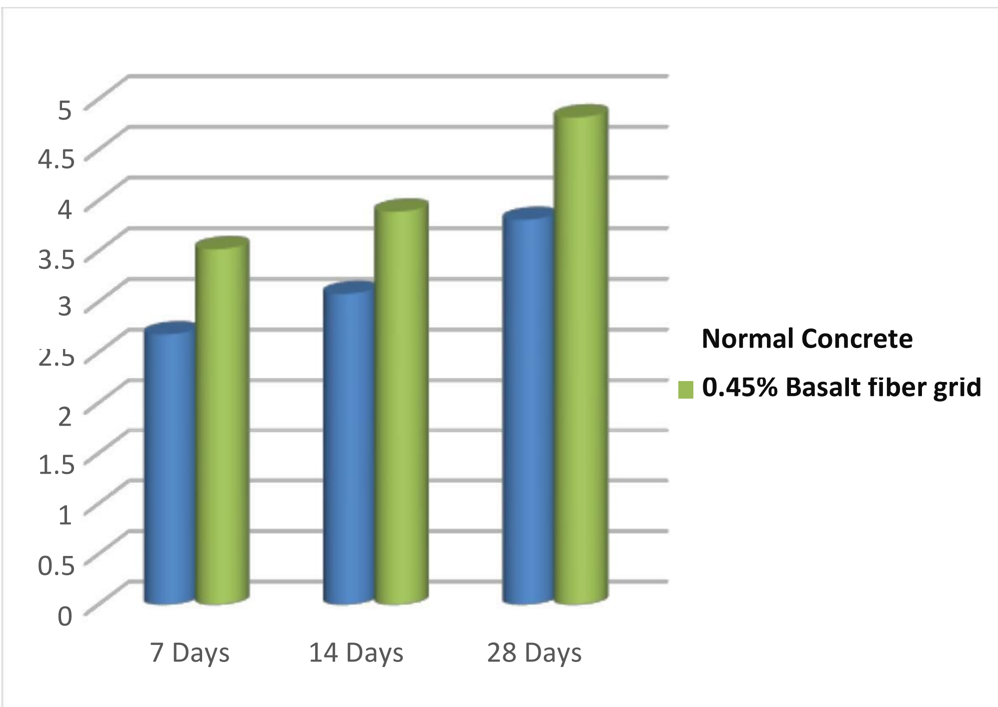


Figure 6: Split tensile strength of normal and 0.45% basalt fiber grid (M-30)

3.3 Flexural Strength Test

For flexural strength test, beam specimens of dimensions 100mm x 100mm x 500 mm were casted for M25 & M30 grade of concrete. The various percentages of basalt fiber grid content were taken as 0 %, 0.15 %, 0.30 % and 0.45 % respectively by weight of cement for this research work.The top surface of the beam specimens were levelled and finished. After the period of 24 hours the beam specimens were demoulded and were transferred to curing tank. These beam specimens were tested on three point flexural testing machine at 7days, 14 days and 28 days respectively as per IS 516-1959 and the load was noted at occurrence of failure. In each category three beams were tested at 7 days, 14 days and 28 days respectively and their average value is reported. The flexural strength of beam was calculated as per the following formula.Flexural Strength (Mpa) = (3 x P x L) / (2 x b x d2)

Experimental Results:

0% Basalt fiber grid content	Flexural Strength (MPa)		
Average Strength	7 days	14 days	28 days
	1.95	2.51	2.97

Table 7: Flexural Strength of Normal Concrete M25 Grade

Basalt Fiber grid Content (By weight of cement) (%)	Flexural Strength (MPa)			
		7 days	14 days	28 days
0.15%	Average Strength	2.13	3.18	3.81
0.30%	Average Strength	2.82	3.54	4.19
0.45%	Average Strength	3.28	3.79	4.34

Table 8: Flexural Strength of Basalt Fiber grid Concrete M25 Grade

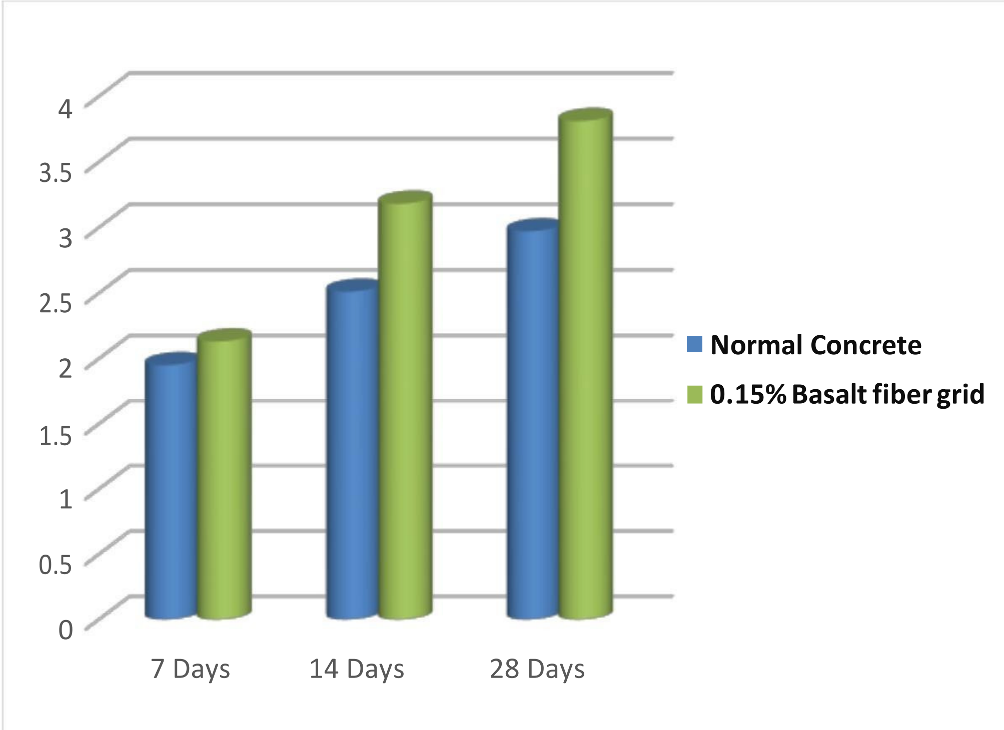


Figure 7: Flexural strength of normal and 0.15% basalt fiber grid (M-25)

Test For flexural strength test, beam specimens of dimensions 10cmx 10cm x 50cm were casted for M30 grade of concrete.

0% Basalt fiber grid content	Flexural Strength (MPa)		
Average Strength	7 days	14 days	28 days
	2.84	3.31	4.30

Table 9: Flexural Strength of Normal Concrete M30 Grade

Basalt Fiber grid Content (By weight of cement) (%)	Flexural Strength (MPa)			
		7 days	14 days	28 days
0.15%	Average Strength	3.16	3.79	4.64
0.30%	Average Strength	3.49	3.93	5.18
0.45%	Average Strength	3.83	4.23	5.83

Table10: Flexural Strength of Basalt fiber grid Concrete M30 Grade

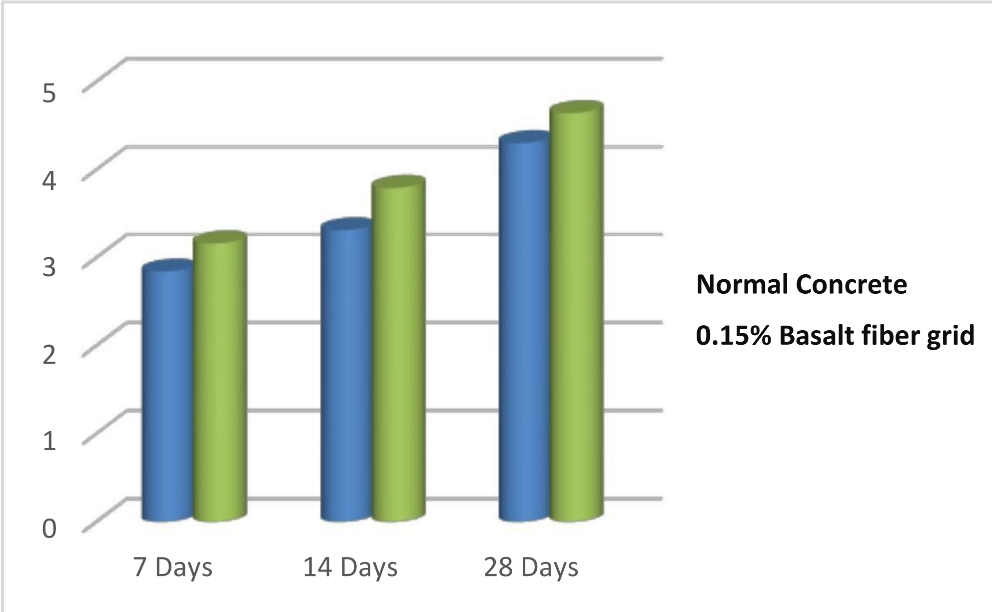


Figure 8: Flexural strength of normal and 0.15% basalt fiber grid (M-30)

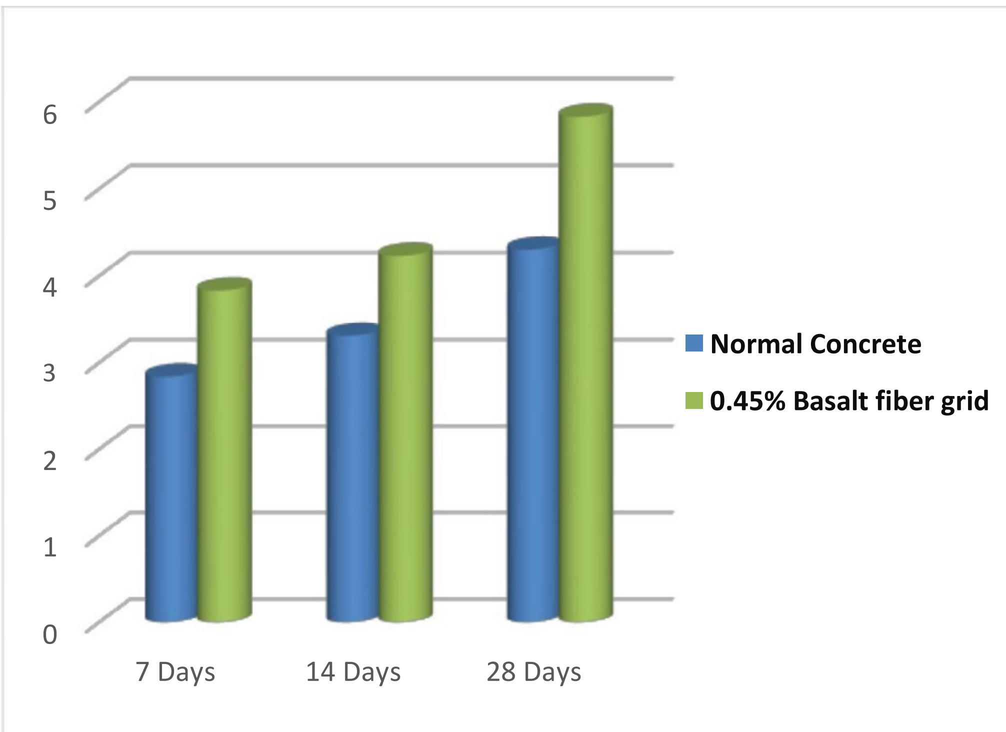


Figure 9 Flexural strength of normal and 0.45% basalt fiber grid (M-30)

4. Conclusions

- The compressive strength of concrete with basalt fiber grid is higher than concrete without basalt fiber grid at 7 days, 14 days and 28 days.
- For M-25 grade of concrete, the Compressive strength at 28 days for different proportions of basalt fiber grid increases with increase in proportion as compared to normal concrete which ranges from 6.5 % for 0.15% basalt fiber grid to 25.60 % for 0.45% basalt fiber grid.
- For M-30 grade of concrete, the Compressive strength at 28 days for different proportions of basalt fiber grid increases with increase in proportion as compared to normal concrete which ranges from 6.92 % for 0.15% basalt fiber grid to 23.37 % for 0.45% basalt fiber grid.
- When 0.45% of basalt fiber grid is used in M-25 & M-30 grade concrete, there is maximum strength gained as compared to other quantities of basalt fiber grids used in experiment.
- For M-25 grade of concrete, the split tensile strength at 28 days for different proportions of basalt fiber grid increases with increase in proportion as compared to normal concrete which ranges from 9.93 % for 0.15% basalt fiber grid to 20.12 % for 0.45% basalt fiber grid.
- For M-30 grade of concrete, the split tensile strength at 28 days for different proportions of basalt fiber grid increases with increase in proportion as compared to normal concrete which ranges from 7.08 % for 0.15% basalt fiber grid to 26.50 % for 0.45% basalt fiber grid.
- The increased percentages of basalt fiber grid shows the increment in split tensile strength at all ages compared to the concrete without basalt fiber grid. The basalt fiber grid of 0.45% shows more strength than any other amongst taken.

- During split tensile strength test, the normal concrete specimen has split into two pieces laterally while the basalt fiber grid used in concrete specimen retained the integrity between partially separated parts.
- For M-25 grade of concrete, the flexural strength at 28 days for different proportions of basalt fiber grid increases with increase in proportion as compared to normal concrete which ranges from 28.28 % for 0.15% basalt fiber grid to 46.62 % for 0.45% basalt fiber grid.
- For M-30 grade of concrete, the flexural strength at 28 days for different proportions of basalt fiber grid increases with increase in proportion as compared to normal concrete which ranges from 7.90 % for 0.15% basalt fiber grid to 35.58 % for 0.45% basalt fiber grid.
- The flexural strength of concrete with increasing percentage of basalt fiber grid show the increment in strength with compared to normal concrete at all ages. The basalt fiber grid of 0.45% shows the highest flexural strength amongst taken. As per the increment of percentages basalt fiber grid, the strength increases.
- When we used 0.45 % of basalt fiber grid with 5 cm centre to centre spacing then we get more strength.
- It was found that 0.45% of basalt fiber gird gives best result for given set of conditions.

4.1 Future Scope of Work

- The different centre to centre spacing for the basalt fiber grid can be taken in consideration for the further research work.
- Experiment can be further carried out using different types of fiber grid.
- Experiment can be further carried out using different w/c ratio.
- Experiment can be further carried out using different grades of concrete.

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