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Experimental Study on the Use of Magnetised Water in Basalt Fiber Reinforced Concrete

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Abstract - *Concrete is a composite material which is made from a mixture of cement, aggregates, water and sometimes admixtures in required proportion. Water is the main ingredient in concrete for the various process including hydration process, proper curing etc. Magnetised water technology initiated in Russia, was found to be a new technique for increasing the strength characteristics of concrete. Conventional concrete has limited ductility, low impact, less abrasion resistance and little resistance against cracking. The addition of fibers can improve the strength of concrete. In this study the effect of magnetised water on the strength characteristics of basalt fiber reinforced concrete (M20) with MSand was studied. Cubes, cylinders and beams were casted to determine the compressive, split tensile and flexural strength test of concrete. The fibers were added at different percentages varying from 1 to 5 % by weight of cement. The optimum percentage addition of fiber was obtained at 3 % by weight of cement. In this project magnetised water was used in mixing of concrete. The result of research work showed that incorporation of basalt fiber and magnetised water effectively enhances the strength properties of concrete. Use of magnetized water has promising potentials in saving the amount of water used in concrete construction*.

***Key Words*: 1) Magnetised water,2) basalt fiber, 3) compressive strength, 4) split tensile strength, 5) flexural strength**

1. INTRODUCTION

Concrete is the construction material which is used worldwide. Therefore, it comes as no surprise that enormous amount of research has been undertaken to enhance its performance. The major disadvantage is that micro crack develop in concrete during curing. These micro cracks developed are responsible for the low tensile strength of concrete Hence fibers are incorporated to concrete to overcome these disadvantages. The addition of fibers in the concrete mix has many important effects. Water plays a major role in the concrete preparation. Water plays an important role in workability and strength of concrete. Water is the main ingredient in concrete for the different process including hydration process, proper curing etc. When water is mixed with cement,it forms a paste which binds the aggregate. Water helps in the hardening of concrete by the process known as hydration. Water consumption is increasing tremendously as the population and human needs increases. Water consumption in agricultural sector is around 70% and in industrial sector it is 20%. In concrete production there is more than one billion tons of water consumed each year. Replacing normal tap water with magnetised water during concrete preparation can enhance the split tensioe strength as well the flexural strength of concrete. Water after passed through the surroundings of a magnetic field of certain strength is called magnetic field treated water (MFTW) or magnetised water.

1.1 Basalt Fiber

Many fibers are used in the construction industry such as glass polyethylene, carbon fiber etc., one of the new fiber called Basalt rock fiber is added to this list. Basalt is a rock ,which is brown or dark in color formed from volcanic lava after solidification. It has better strength characteristics such as good hardness and thermal properties. Basalt rock fibers impart high strength and low cost high performance to solve the problem in the large project like cracking, structural failure of concrete. The structure of Basalt fiber is shown in figure below (Figure 1.1)

Fig 1.1: Basalt Fiber

1.2 Magnetised water

When water passes through a magnetic field, it is known as magnetised water. After magnetisation, the bond angle

changes and the structure of water gets aligned in one direction and the rate of hydration also increases. During magnetisation, the hydrogen bond association percentage changes and the bond angle get decreased. Here the larger water clusters are cut and they are broken down by external magnetic field to form double water molecules. Therefore, magnetised water has promising potentials in saving the amount of water used in concrete construction.

2. OBJECTIVES AND METHODOLOGY OF THE STUDY

The main objective of this project is to determine the effect of magnetised water in strength properties of basalt fiber reinforced concrete. Use of magnetised water instead of normal tap water in the preparation of concrete is a new technology to enhance the split tensile strength and flexural strength of concrete.

The objectives of the project are:

1. To determine the optimum percentage addition of fiber. The fibers were added at 0%, 1%, 3%, and 5% by weight of cement.
2. To establish the set up for producing magnetised water.
3. To compare the compressive strength , split tensile strength and flexural strength of basalt fiber reinforced concrete and magnetised water basalt fiber reinforced concrete for M20 grade of concrete mix
4. To carry out durability test

Concrete is a widely used construction material which is weak in tension. The inclusion of basalt fiber improves the strength of concrete. A new technique of using magnetised water can enhance the strength of concrete. This set up can be easily established at site. This is a cost effective method. The project methodology includes the study of the materials used for the project, design of M20 concrete using the observations from the test results and the preparation of magnetic water set up to produce magnetised water.

3. MATERIALS USED

The materials used in this experiments for making concrete mix are Portland Pozzolana cement as cementitious material, coarse aggregate of 20 mm size, MSand as fine aggregate, Basalt fiber and magnetised water. The properties of each of these materials add to the quality of concrete produced. In the present study, the material test for various materials were conducted as specified in the relevant IS codes for each material.

3.1 Cement

The cement used for preparing the concrete mix for this study was Portland pozzolana cement .The physical properties of cement were found by conducting material tests.

Table - 3.1: Physical properties of cement

Sr.N0.	Properties	Values
1	Consistency	34%
2	Initial setting time	75 minutes
3	Final setting time	255 minutes
4	Fineness	1%
5	Specific gravity	2.9

3.2 Fine aggregate

River sand is mainly used as fine aggregate. The fine aggregate used in this project was M sand. Clean and dry M sand passing through IS 4.75 mm sieve, confirming to zone II with specific gravity 2.50 was used for casting all specimens. The testing of sand was conducted as per IS: 383–2016

Table -3.2: Physical properties of fine aggregate

Sr.N0.	Properties	Values
1	Fineness	3.9
2	Specific gravity	2.50
3	Zone	II

3.3 Coarse aggregate

Crushed natural stone of size less than 20mm were used as coarse aggregate for the project work.

Table - 3.3: Physical properties of coarse aggregate (20 mm size)

Sr.N0.	Properties	Values
1	Fineness	5.9
2	Specific gravity	2.8
3	Zone	II

3.4 Basalt fiber

In this experiment, basalt fiber having Length 14 mm and diameter is 13 micron size was used. Properties of Basalt Fiber are shown in the table 3.4.

Table - 3.4 : Properties of basalt fiber

Sr.N0.	PROPERTY	UNIT	VALUE
1	Density of filament	Kg/m^3	2.7
2	Melting point	^0C	1350
3	Diameter	µm	13
4	Length	mm	14

5	Moisture content	%	<30%
6	Specific gravity	g/cc	2.8

3.5. Water magnetiser

In this project a large amount of magnetised water is required for mixing. Therefore, a magnetizing unit was established to produce magnetised water. There are different methods to produce magnetised water, such as by using permag magnetic filter, beaker and magnet method etc. In this project, water magnetiser was established to produce magnetised water. This system consist of a motor pump, magnetic field set up and pipes. In this set up strong magnets of 10 cm diameter are placed at th top and bottom of a PVC pipe for producing magnetic field with north and south pole. The length of the set up is 600 mm .The motor pump used is of power of 0.5 HP.

Fig - 3.1 : Water magnetizer

Fig – 3.2 : Arrangement of magnets

The magnetised water is prepared by circulating the water in the tank through the magnetic field for about 3 to 4 hours. This magnetised water was used while mixing the concrete.

The pH of magnetised water was found out by using pH meter. pH test were conducted for normal tap water, distilled water and magnetised water. The pH obtained for normal tap water was 6.8, for distilled water the value obtained was 7 and pH of magnetised water was 8.1. The change in pH shows the magnetisation of water.

4. EXPERIMENTAL WORK AND TEST

4.1 Mix Design

M20 concrete mix was proportioned according to the datas obtained from material tests. The mix design was carried out as per IS: 10262- 2019. The cement used is PPC. M sand is used as fine aggregate and has a specific gravity of 2.5 and it belongs to zone II. Water cement ration of 0.55 was chosen. The mix proportion is obtained as:

1: 1.86: 3.31 (w/c ratio = 0.55)

Table – 4.1: Mix proportion of M20 concrete

Water	Cement	Fine aggregate	Coarse aggregate
197 L	358 kg	664 kg	1183 kg
0.55	1	1.86	3.31

4.2 Compressive, Flexural, Split Tensile Strength and Durability tests

The cubes cylinders and beams were cured under normal conditions as per IS recommendations and were tested at 28 th days for determining the compressive strength, split tensile strength ,flexural strength test and durability test. The optimum percentage for addition of basalt fiber was determined. Cylinders and beams were casted at optimum percentage with and without magnetised water and strength tests were carried out.

5. EXPERIMENTAL RESULTS

5.1 Compressive strength test

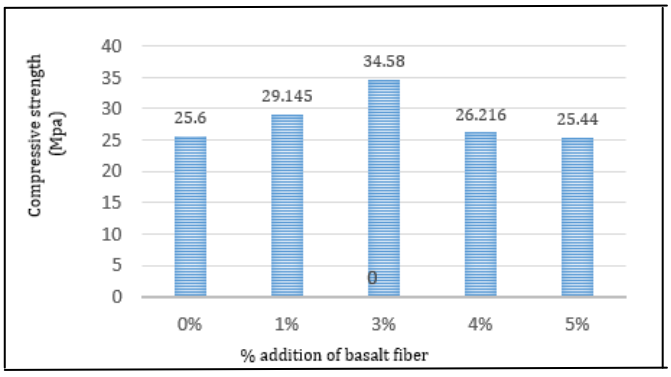
The cubical mould of size 150mmx150mmx150mm were casted to determine the 28th day compressive strength test. The optimum percentage addition of fibers was determined by varying the percentage of addition of fibers and then by carrying out compressive strength test. The figure 5.1 shows the compressive strength test.

Fig – 5.1: Compression Strength Test

Table – 5.1: Determination of optimum percentage addition of basalt fiber

Designation	% of Basalt Fiber by weight of cement	Average Compressive strength (MPa)
CM	0%	25.6
BFC1	1%	29.145
BFC3	3%	34.58
BFC4	4%	26.216
BFC5	5%	25.44

It is clear from the table 5.1 that the maximum compressive strength was obtained at 3% addition of basalt fiber by weight of cement .It showed a higher value by 35% to conventional concrete. Chart 5.1 shows compressive strength versus percentage addition of basalt fiber.



Chart– 5.1: Compressive strength versus Percentage addition of basalt fiber

5.1.1 Comparison in the compressive strength of concrete

The optimum percentage addition of fiber was obtained at 3%. The comparison in the compressive strength of concrete has been done using magnetised water. The results are as shown below in table 5.1.1

Table – 5.1.1: Comparison in the compressive strength of concrete

Designation	% addition of fiber	Average Compressive strength (MPa)
CM	0%	25.6
BFC3 (NW)	3%	34.58
BFC3 (MW)	3%	38.92

The strength of basalt fiber magnetised water concrete was about 38.92 MPa and that of basalt fiber reinforced concrete was 34.58 MPa. The chart 5.1.1. shows comparison in the compressive strength of concrete.

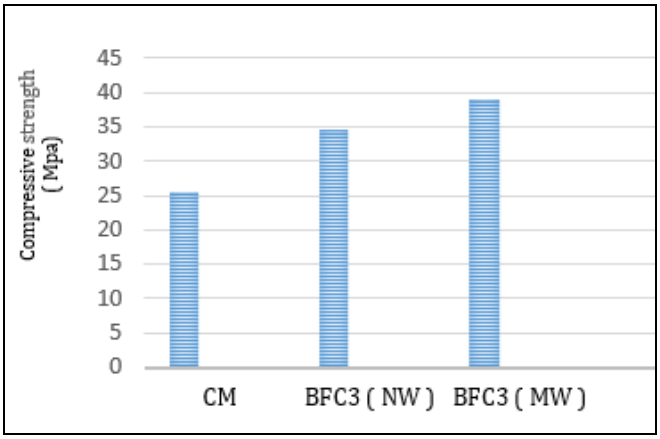


Chart – 5.1.1: Comparison in the compressive strength of concrete

5.2: Split tensile strength of concrete

The split tensile strength test was conducted on concrete cylinder specimens subjected to 28 days curing. The test set up has been shown below in figure 5.2.

Table – 5.2: Results from split tensile strength test

Designation	% of Basalt Fiber by weight of cement	Average Split Tensile strength (MPa)
CM	0%	3.1
BFC3 (NW)	3%	3.34
BFC3(MW)	3%	3.52

Fig – 5.2: Split Tensile Strength Test set up

The split tensile strength obtained for control mix and optimum(3%) percentage addition of basalt fiber by replacing normal water(NW) with magnetized water (MW) on 28 days test were given in Table 5.2. Chart 5.2 shows the split tensile strength Vs. strength of concrete for 28 days test.

The 28 days split tensile strength is maximum for BFC3(MW) while comparing with control mix (0%) and BFC3(NW).The comparison in the split tensile strength of basalt fiber reinforced concrete with normal water and magnetised water is shown below in the chart 5.2.

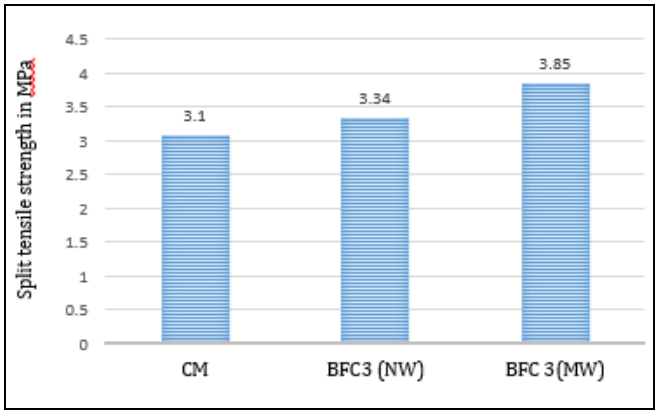


Chart – 5.2: Comparison of split tensile strength

5.3 Flexural Strength Test

The flexural strength test was conducted on beam specimens of size 150mmX150mmX700mm. The test set up has been shown in figure 5.3.

Fig-5.3: Flexural Strength Test

The flexural strength obtained for control mix and basalt fiber reinforced concrete with and without magnetised water at optimum percentage was given in Table 5.3.

Table- 5.3: Flexural Strength Test Results

Designation	% addition of fiber	Average flexural strength (MPa)
CM	0%	17.97
BFC3(NW)	3%	19.83
BFC3(MW)	3%	21.42

* The variation in the flexural strength values are due to the delay in testing as a result of lockdown

The flexural strength for basalt fiber reinforced concrete with magnetised water was found higher than that of basalt fiber reinforced concrete with normal water.

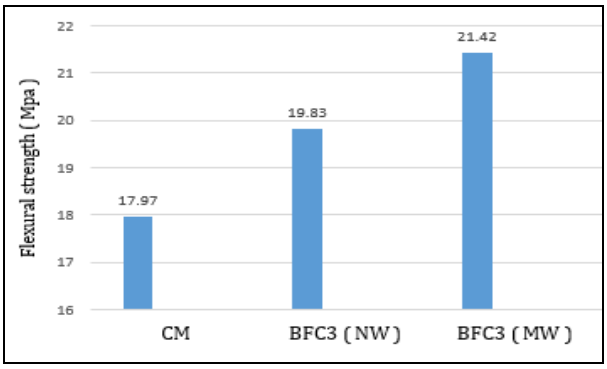


Chart – 5.3: Comparison of flexural strength

The comparison in the flexural strength of basalt fiber reinforced concrete with magnetised water and normal water is shown above in the chart 5.3.

5.4 Durability test

The ability of concrete to withstand weathering action, chemical attack, abrasion etc. while maintaining its desired engineering properties is called durability of concrete.

5.4.1 Acid attack test

Durability of concrete with magnetised water basalt fiber concrete was tested based on acid attack test (hydrochloric acid attack).Cubes of standard size was prepared using magnetised water and is cured for 7 days. It was kept in atmosphere for about 2 days and weighed. Then cubes are kept in 5% hydrochloric acid for 60 days. Again kept in atmosphere for 2 days and was weighed to find percentage weight loss.

$$\text{Percentage weight loss} = \left(\frac{W2-W1}{W1}\right) \times 100$$

Where,

W_1 = initial weight of specimen, W_2 = final weight of the specimen

The durability test results are shown in the table 5.4.

Table- 5.4: Results from Durability test

Specimen	Percentage addition of fiber by weight of cement	% weight loss
CM	0%	4.13
BFC3 (MW)	3%	5.61

The % weight loss is obtained from the table. The percentage weight loss for basalt fiber magnetised water concrete was obtained as 5.61 % and for control mix was obtained as 4.13 %. The percentage loss for basalt fiber reinforced magnetised water concrete was more compared to control mix. Since the difference in variation in percentage loss is less than 2% , basalt fiber reinforced concrete with magnetised water is durable.

6. CONCLUSIONS

Based on the experimental observations, following conclusions can be established:

- The present study has shown that basalt fiber magnetised water concrete has a considerable increase in compressive, split tensile and flexural strength.
- The optimum percentage addition of fiber was obtained at 3%.
- The specimen prepared with magnetised water shows 60 % increase in the compressive strength of concrete compared to that of control mix.
- The specimen prepared with magnetised water shows 50 % increase in the tensile strength of concrete compared to that of control mix.
- The specimen prepared with magnetised water shows 20 % increase in the flexural strength of concrete compared to that of control mix.
- The percentage of weight loss for the specimen using normal water was less compared to that of control mix.
- The use of basalt fiber reinforced magnetised water concrete improves the strength characteristics of concrete.

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