Effect of Magnesium Sulfate Attack on Basalt Fiber Reinforced Concrete with Partial to Full Replacement of Natural Sand by M - Sand

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Abstract - *In this study basalt 12mm chopped fibers are used and manufactured sand is used as partial to full substitute of natural sand to overcome the lack of good quality river sand and to prepare economic concrete mixes and tested for different strength tests of concrete. A total of 7 mixes of M30 grade of concrete were prepared by varying the percentage of M sand with a fixed percentage of basalt fibers. All the specimens were tested for compressive, split tensile and flexural strength in the laboratory and results were reported. M30 grade of concrete is achieved and addition of basalt fiber with 100% M sand gave the highest compressive and tensile strength and improved flexural strength to some extent.*

Key Words: **Basalt Fiber, Fiber Reinforced Concrete, Sulfate Attack, Manufactured Sand, Compressive Strength, Split Tensile Strength, Flexural Strength.**

1. INTRODUCTION

Concrete made with Portland cement is rich in compression but poor in tension and so leans to be brittle. The poor tension strength can be conquered by the use of steel reinforcement and to some extent by the addition of enough quantity of fibers. The inclusion of various sort of fibers in concrete have drastically improved its compressive, tensile and flexural strength.

Conventional concrete is changed by unsystematic distribution of tiny discrete fine fibers to enhance its mechanical properties is referred as fiber reinforced concrete (FRC). Many fibers have been used till now to improve the properties of conventional concrete. A new advanced fiber called Basalt fiber is a new inorganic fiber material with high heat resistance, high dielectric property, corrosion resistance, high chemical stability high resistant to alkaline, acidic and salt attack and low cost, thus it is a classic ceramic fiber with a nearly density (2.63- 2.8g/cm^3) as cement concrete and mortar, Use of basalt fiber has shown improved results in the compressive, tensile & flexural strength of concrete.

In the present study to overcome the lack of good quality natural river sand and to study the contribution of M sand in strength aspects of co concrete and to make concrete economic, Basalt fiber reinforced concrete is prepared by replacement of natural sand with M sand in different percentage i.e. 20%, 40%, 60%, 80%, and 100%.

2. TYPES OF FIBER

- Steel Fiber
- Polypropylene Fiber
- Glass Fiber
- Asbestos Fibers
- Carbon Fibers
- Organic Fibers
- Basalt fiber

2.1 Basalt Fiber

Igneous rock is formed through the cooling and solidification of magma or lava. Metamorphic rock is the result of the conversion of an existing rock type, the protolithic, in a process referred as metamorphism, which means “change in for” and basalt originates from volcanic magma and floor volcanoes, a very hot fluid or semifluid material under the earth’s crust, solidified in the open air. Basally is a usual word referred for different volcanic rocks, which are gray, dark in color, produced from the molten lava after solidification.

Basalt fiber is made in a constant process by melting crushed basalt rock at 1500^{o}c temperature and is stretched into extremely fine fibers of basalt, which is composed of the minerals plagioclase, pyroxene, and olivine. The fiber has high strength of extension and has excellent ductility and its corrosion and fire resistance is far better than other types of fibers.

Fig -1: Basalt fiber

3. SULFATE ATTACK

Sulfate attack is found as one of the serious deteriorative problems takes place when the materials, such as concrete, mortars and buildings, are subjected to this environment. Sulfate ions in soil, sea water, ground water and may lead to decay of reinforced concrete structures by producing swelling and cracking, sulfate cation type, sulfate concentration and the time of exposure. Various buildings affected by sulfate degradation frequently require to be repaired or, in most severe cases, they need to be rebuilt.

The current study is made to study the effect of magnesium sulfate on conventional concrete, basalt fiber reinforced concrete and basalt fiber reinforced concrete with addition of varying percentage of M sand by observing the changes of strength by measuring through compression, Tensile and flexural tests. The study help to clarify the large significance of understanding the physical strength of concrete subjected to sulfate environments and role of basalt fiber played in concrete subjected to sulfate environment.

Preparation of Magnesium sulfate solution

Specimens are subjected to magnesium sulfate attack in the artificially created sulfate environment in a curing tank or large drums. 3/4th full capacity of tank or drum is estimated and magnesium sulfate powder measured as 10% of the 3/4th estimated capacity of tank/drum is dissolved and added in the tank and tank is filled water till its 3/4th capacity and again the water in the tank is stirred to thoroughly dissolve magnesium sulfate in the water and the specimens are immersed in the solution and kept for 62days.

4. MATERIALS AND METHODOLOGY

Cement

Ultra Tech OPC 43 grade cement is used in the present study for preparation of all the specimens.

Fine Aggregate

According to IS-383-1970, Table 4, fine aggregate used in the present study is procured from a local supplier and the sieve analysis has shown that the sand was confirming to zone-I.

M Sand

The M sand use in the present work is laid to zone-II. Which is available near Guramatti village near RCU, Belagavi .This M sand has specific gravity is 2.57. In this project M sand is replaced for different mixes as 20%, 40%,60%,80%,100%.

Coarse Aggregate

Coarse aggregate used in the present work is angular dust free type, 20mm and down size coarse aggregates are used. The aggregates were procured from a local supplier at Kakti, Belagavi.

Water

Water used for the preparation of wet concrete, preparation of hydrochloric acid solution and for curing of specimens is normal tap water.

Basalt Fibers

Basalt fibers of size 12mm chopped pieces are used in present study. Basalt fibers are measured as 2% of the weight of cement.

Table -1: Specific gravity of materials used

Material	Specific gravity
Cement	3.15
Fine aggregate	2.5
M Sand	2.57
Coarse aggregate	2.82

4.1 Mix Design

Design M30 grade of concrete

The mix design for M30 grade of concrete is done according to the guidelines of IS 10262-2009. The mix proportion obtained for the above design are as follows

Table -2: Mix proportions

W/C ratio	Cement	Fine aggregate	Coarse aggregate
0.45	427 kg/m^3	594 kg/m^3	1234 kg/m^3
	1	1.4	2.89

Table -3: Details of all mix designs in project

Mix design	Material Quantties (kg/m³)						
	Cement	Coarse aggregate	Fine aggregate	M-Sand (in % of fine aggregate)		Water in liters	Basalt Fiber (2% of cement)
M1	427	1234	594	0%	0	192	0
M2	427	1229	591	0%	0	192	8.54
M3	427	1229	469	20%	121	192	8.54
M4	427	1229	352	40%	242	192	8.54
M5	427	1229	235.5	60%	362	192	8.54
M6	427	1229	117.5	80%	482.5	192	8.54
M7	427	1229	0	100 %	603	192	8.54

Table -4: Details of testing specimens

Details of Strength Specimen								
Mix Design (M30)	M1	M2	M3	M4	M5	M6	M7	Total
Cube	3	3	3	3	3	3	3	21
Cylinder	3	3	3	3	3	3	3	21
Beam	3	3	3	3	3	3	3	21
Total =								63
Details of durability Specimen								
Cube	3	3	3	3	3	3	3	21
Cylinder	3	3	3	3	3	3	3	21
Beam	3	3	3	3	3	3	3	21
Total =								63

4.2 Mixing Procedure

1. Estimated quantities of cement, fine aggregate and coarse aggregate are weighed as per the mix proportions obtained by mix design above 1:1.39:2.88 which corresponds to M30 grade of concrete and w/c ratio of 0.45.
2. First weighed coarse aggregate and fine aggregate of respective mix are thoroughly mixed and then cement is added and dry mixed again.
3. If the mix design contains addition of fiber and Partial replacement of M sand with natural sand then the fiber is weighed as 2% of total estimated cement in the respective mix and M sand is replaced as percentage weight of natural sand and the weighed M sand and fiber are added to the dry mix of coarse and fine aggregate along with cement
4. All the design materials are thoroughly dry mixed and then the required quantity of water as per design is added and workable mix is prepared.
5. This fresh concrete is filled in the respective moulds of cube, cylinder and beam in 3 layers and each layer is compacted by hand and after 3 layers vibrating machine is used for complete compaction of concrete and smooth finishing over the top surface is given and mark the designation of the specimen.
6. After 24 hours of casting the moulds are demoulded and the casted specimen are weighed and kept for curing process of 28days .
7. As above procedure same number of specimen are casted for durability test so after 28days of curing durability specimens are surface dried and weighed and kept for magnesium sulfate attack for 62 days.
8. Strength specimens after 28 days of curing are removed from water and surface dried and weighed and tested for compressive, tensile and flexural strength.
9. Durability specimens after 62 days of sulfate attack are removed from solution and surface dried and weighed and tested for compressive, tensile and flexural strength.
10. Effect of fiber and M sand on strength and durability is studied and Results of strength and durability are compared.

4.3 Strength Test Procedures

Compressive strength test

The compression test was conducted as per IS 516 – 1959. The load was applied without shock and increased continuously until the resistance of the specimen to the increasing load breaks down and no greater load can be sustained. The maximum load applied to the specimen was then recorded and the appearance of the concrete for any unusual features in the type of failure was noted.

F = P/A

Where,

P= load at failure

A= Area of cross section of the specimen

Split tensile strength test

Testing for split tensile strength of concrete is done as per IS 5816-1999. The test is conducted on compression testing machine of capacity 2000kN as shown in figure. The cylinder is placed horizontally between the loading surfaces of compression testing machine and the load is applied until failure of the cylinder along the vertical diameter. The maximum load applied to the specimen was recorded and appearance of the concrete for any unusual features in the type of failure was noted.

F = 2P/πDL

Where,

P= load at failure

L= length of the cylinder and

D= diameter of the cylinder.

Flexural strength test

Flexural strength test is done as per IS: 516-1959. Prisms are tested for flexure in compression testing machine of capacity 2000kN as shown in Figure. The bearing surfaces of the supporting and loading rollers are wiped clean before loading. The prisms are placed in the machine in such a manner that the load is applied to the uppermost surface along the two lines spaced 28 cm apart. The axis of the specimen is aligned with the axis of the loading device. The specimen is loaded till it fails and the maximum load (P) applied to the specimen during test is noted. After fracture the distance (a) between the crack and nearest support is measured. The flexural strength of the specimen is expressed as the modulus of rupture.

F = PL/bd² when a is greater than 20 cm or

F = 3Pa/bd² when a is less than 20 cm

Where,

a= the distance between the line of fracture and the nearest support
b=measured width in cm of the specimen,
d=measured depth in cm of the specimen was supported, and
p=maximum load in kg applied on the specimen.
If a is less than 11.0 cm the test result is discarded.

5. RESULTS AND DISSCUSSON

5.1 Comparison Of Compressive Strength With And Without Subjected To Sulfate Attack

Table -5: Results of compressive strength with and without subjected to sulfate attack

Mix Design	28 days Strength N/mm²	62 days strength in N/mm²
M1	39.70	30.67
M2	40.00	41.04
M3	41.63	42.22
M4	43.04	43.85
M5	43.93	44.30
M6	45.04	47.56
M7	46.00	49.78

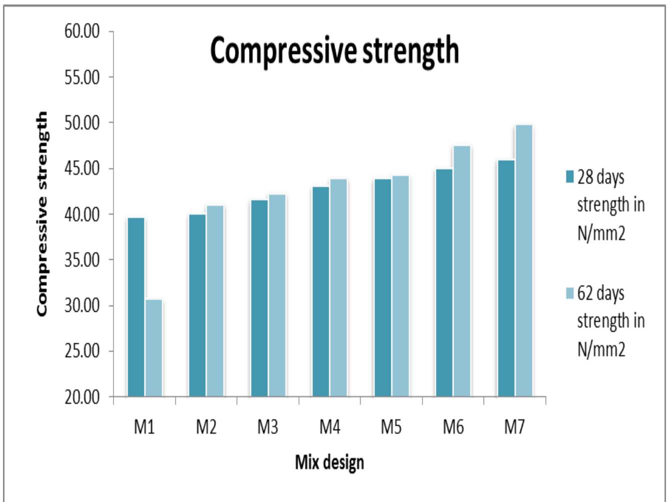

Chart -1: Graphical representation compressive strength with and without subjected to sulfate attack

- Compressive strength of 62 days conventional concrete is very much less than compressive strength of 28 days conventional concrete.

- Because of the use of basalt fiber and partial replacement of M sand other all mixes from M2 to M7 showed the improvement in compressive strength of 62 days than 28 days compressive strength.

5.2 Comparison Of Split Tensile Strength With And Without Subjected To Sulfate Attack

Table -6: Results of split tensile strength with and without subjected to sulfate attack

Mix Design (M30)	28 days strength in N/mm²	62 days strength in N/mm²
M1	3.35	3.58
M2	3.82	3.89
M3	3.96	4.62
M4	4.27	5.00
M5	4.59	5.19
M6	5.02	5.38
M7	5.26	5.94

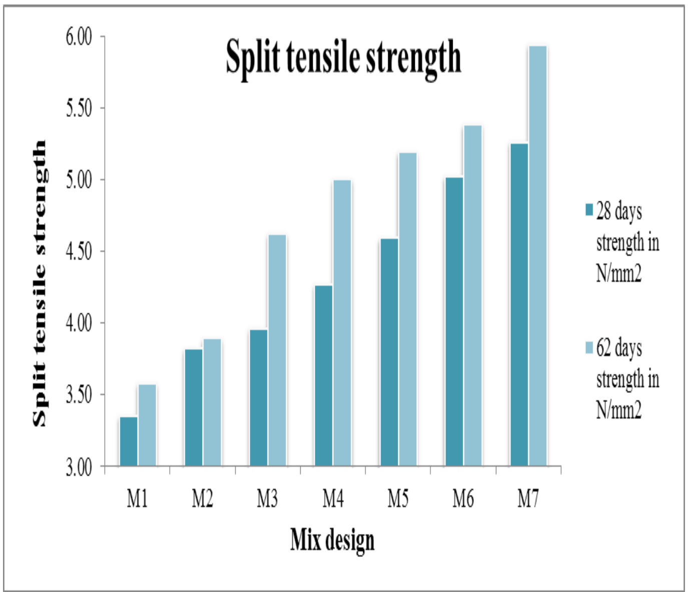

Chart -2: Graphical representation tensile strength with and without subjected to sulfate attack

- Split tensile strength of 62 days of all mixes was higher than split tensile strength of 28 day.
- Split tensile strength of conventional concrete and concrete containing basalt fiber and partial replacement of M sand was not at all affected by magnesium sulfate attack.

5.3 Comparison Of Flexural Strength With And Without Subjected To Sulfate Attack

Table -7: Results of flexural strength with and without subjected to sulfate attack

Mix Design (M30)	28 days strength in N/mm²	62 days strength in N/mm²
M1	3.98	3.01
M2	4.07	3.16
M3	5.42	3.61
M4	5.87	4.82
M5	6.48	5.27
M6	6.78	6.33
M7	7.83	7.23

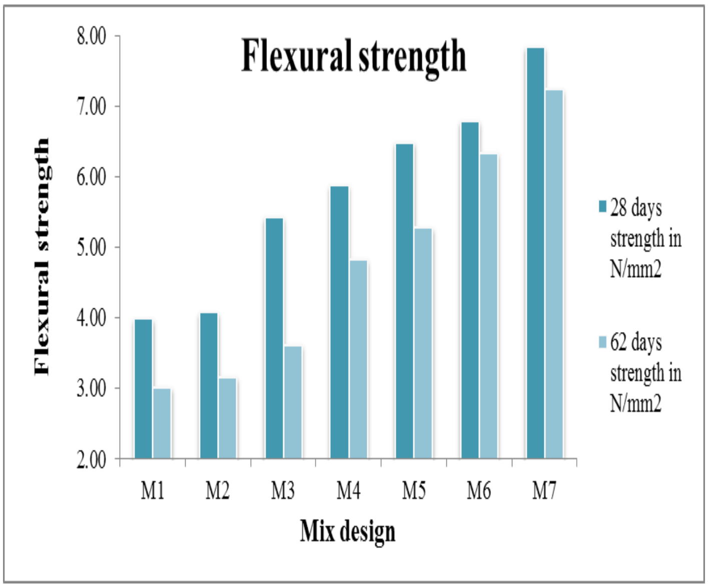

Chart -3: Graphical representation flexural strength with and without subjected to sulfate attack

- Flexural strength of 62 days of all mixes was lower than flexural strength of 28 day.
- Flexural strength of conventional concrete and concrete containing basalt fiber and partial replacement of M sand was highly affected by magnesium sulfate attack.

6. CONCLUSIONS

From the above section of results and discussion the following conclusions can be drawn.

1. Addition of 2% basalt fiber in concrete gives higher compressive and tensile and strength of concrete.
2. Concrete specimens containing 2% basalt fiber gives more strength than concrete without fiber (conventional concrete) when subjected to sulfate attack.
3. Inclusion of 2% basalt fiber with various percentage of M sand (i.e. 20%, 40%, 60%, 80, and 100% as replacement to natural sand) showed gradual increment in compressive, tensile and flexural strength of 28 days of concrete.
4. Basalt fiber reinforced concrete with various percentage of M sand (i.e. 20%, 40%, 60%, 80, and 100% as replacement to natural sand) showed gradual increment in compressive, tensile and flexural strength even after 62 days magnesium sulfate attack.
5. After 62 days of magnesium sulfate attack, basalt fiber reinforced concrete with various percentage of M sand gave higher value of compressive and tensile strength than the compressive and tensile strength of 28 days of concrete.
6. Flexural strength of conventional concrete as well as concrete containing basalt fiber and M sand was affected by 62 days of magnesium sulfate attack and hence resulted in lower value of flexural strength than 28 days flexural strength of concrete.
7. The combination of 2% basalt fiber and use of 100% M sand instead of natural sand gave the maximum value of compressive strength, tense strength and flexural strength of concrete.
8. From the above results it is concluded that, basalt fiber acts as a good resistance to sulfate attack on concrete.
9. From the results it is clear that, M sand used in the study can be used as 100% replacement to natural sand along with the inclusion of 2% basalt fiber.

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