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PERFORMANCE OF BASALT FIBER IN CONCRETE

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Abstract: The project work was carried out on experimental investigation of basalt concrete. Properties of concrete were checked by testing cubes, cylinder & beams. The specimens were casted using M25 Grade concrete with locally available material. The object of present work was to study effect of addition of basalt addition of basalt fibers in the mix design and find out the maximum strength criteria. The specimens like cubes of 150x150x150 mm in size, cylinder 150x300 mm in size and beam 100x100x500 mm are tested for compressive strength, split tensile strength and flexural strength, and other test were conducted for cement, coarse aggregate & fine aggregate. The experimental results showed that the addition of basalt fiber in concrete enhance the properties of concrete.

Key words: ***basalt fiber, M25concrete, addition of basalt fiber, maximum strength, increasing post cracking response, improve energy absorption*.**

1. INTRODUCTION

Concrete is a composite material containing hydraulic cement, water, coarse aggregate and fine aggregate. The resulting material is a stone like structure which is formed by the chemical reaction of the cement and water. This stone like material is a brittle material which is strong in compression but very weak in tension. This weakness in the concrete makes it to crack under small loads, at the tensile end. These cracks gradually propagate to the compression end of the member and finally, the member breaks. The formation of cracks in the concrete may also occur due to the drying shrinkage. These cracks are basically micro cracks. These cracks increase in size and magnitude as the time elapses and the finally makes the concrete to fail.

The formation of cracks is the main reason for the failure of the concrete. To increase the tensile strength of concrete many attempts have been made. One of the successful and most commonly used method is providing steel reinforcement. Steel bars, however, reinforce concrete against local tension only. Cracks in reinforced concrete members extend freely until encountering are bar. Thus need for multi directional and closely spaced steel reinforcement arises. That cannot be practically possible. Fiber reinforcement gives the solution for this problem.

So to increase the tensile strength of concrete a technique of introduction of fibers in concrete is being used. These fibers act as crack arrestors and prevent the propogation of the cracks. These fibers are uniformly distributed and randomly arranged. This concrete is named as fiber reinforced concrete.

The main reasons for adding fibers to concrete matrix is to improve the post cracking response of the concrete, i.e., to improve its energy absorption capacity and apparent ductility, and to provide crack resistance and crack control. Also, it helps to maintain structural integrity and cohesiveness in the material. The initial researches combined with the large volume of follow up research have led to the development of a wide variety of material formulations that fit the definition of Fiber Reinforced Concrete.

2. MATERIALS

2.1 CEMENT

A cement is a binder, a substance used for construction that sets, hardens, and adheres to other materials to bind them together. Cement is seldom used on its own, but rather to bind sand and gravel together. Cement mixed with fine aggregate produces mortar for masonry, or withsand and gravel, produces concrete. Cement is the most widely used material in existence and is only behind water as the planet's most-consumed resource.

Cements used in construction are usually inorganic, often lime or calcium silicate based, and can be characterized as either hydraulic or non-hydraulic, depending on the ability of the cement to set in the presence of water.

2.2 FINE AGGREGATE

The fine aggregate sample taken for study and physical properties of fine aggregate. Both river sand and crushed stones may be used. Coarser sand may be preferred as finer sand increases the water demand of concrete and very fine sand may not be essential in High Performance Concrete as it usually has larger content of fine particles in the form of cement and mineral admixtures such as fly ash, etc. The sand particles should also pack to give minimum void ratio as the test results show that higher void content leads to requirement of more mixing water.

2.3 COARSE AGGREGATE

Coarse aggregates are components found in many areas of the construction industry. They have structural uses such as a base layer or drainage layer below pavements and in mixtures like asphalt and concrete. This lesson explores the various types of coarse aggregates.

The coarse aggregate sample taken for study and the physical properties of coarse aggregate. For coarse aggregate, crushed 12mm normal size graded aggregate was used. The specific gravity and water absorption of coarse aggregate were found to be 2.68 and 1.0%, respectively. The grading of coarse aggregate conforms to the requirement as per IS: 383 – 1970.The coarse aggregate is the strongest and least porous component of concrete. Coarse aggregate in cement concrete contributes to the heterogeneity of the cement concrete and there is weak interface between cement matrix and aggregate surface in cement concrete. By usage of mineral admixtures, the cement concrete becomes more homogeneous and there is marked enhancement in the strength properties as well as durability characteristics of concrete. The strength of High Performance Concrete may be controlled by the strength of the coarse aggregate, which is not normally the case with the conventional cement concrete.

2.4 WATER

Water is an important ingredient of concrete as it actively participates in the chemical reactions with cement. The strength of cement concrete comes mainly from the binding action of the hydrated cement gel. The requirement of water should be reduced to that required for chemical reaction of unhydrated cement as the excess water would end up in only formation of undesirable voids in the hardened cement paste in concrete. From High Performance Concrete mix design considerations, it is important to have the compatibility between the given cement and the chemical/mineral admixtures along with the water used for mixing.

2.5 BASALT FIBER:

Fig-1: Basalt Fiber

Regions of Basalt Rock in India:

Basalt rock (Deccan Trap) an area of about 500,000 square kilometre cover large part of the Maharastra, Kutch, Saurastra, Gujarat, Deccan, Central India, Madhya Pradesh, Hyderabad etc.

Basalt rock is formed after cooling of lava on earth crust. Basalt rock is a row material for making basalt fibers. Basalt is naturally hard, dense, dark brown to black colored rock. For making continuous basalt fibers, basalt rock is melt at 15000 c temperature. The material does not undergo any toxic reaction with water and air. Also do not have any side effects on human health. Basalt fibers have major qualities like acid resistance, alkali resistance. It is thermally, electrically and sound insulated. It also has crack resistance, corrosion resistance. Hence it can be used successfully in increasing life of construction in various field i.e. housing, railway, highway, bridges, runway and tunnels.

Fig-2: Processing of basalt fiber

Basalt fiber is a material made from extremely fine fibers of basalt. The manufacture of the basalt fiber is by melting the quarried basalt rock. The molten rock is then extruded through small nozzles to produce continous filaments of basalt fiber. The basalt fibers do not contain any other additives in a single producing process, which gives additional advantage in cost. Basalt fibers have better tensile strength than E glass fibers, greater failure strain than carbon fibers as well as good resistance to chemical attack. Impact load and fire with less poisonous fumes.

Basalt having a high modulus of elasticity and excellent heat resistance. The fibers made of it has significant capability of heat and acoustic resistance and are outstanding vibration isolators. Investigate the effect of using continuous basalt fibers in concrete subjected to high temperature and compared the results with that obtained using glass and carbon fiber.

Compared to carbon and aramid fiber, it has the features of wider application temperature range -452º F to 1200º F(-269º C to +650º C), higher oxidation resistance, higher radiation resistance, higher compression strength, and higher shear strength.

BASALT ROCK FIBER PRODUCTS:

1. Basalt Reinforcement Rod
2. Continuous Basalt Fiber
3. Basalt Geotextile

4. Basalt reinforcing mesh

3. MIX DESIGN FO R M25 GRADE CONCRETE

Table-1: MATERIALS REQUIRED AS PER IS METHOD OF DESIGN

W/C RATIO	QUANTITY OF MATERIALS (Kg/m³)		
	CEMENT	FINE AGGREGATE	COURSE AGGREGATE
0.4	478.95	641.6	1074.7

The properties of materials used are

- Specific gravity of cement = 2.87
- Specific gravity of fine aggregate = 2.63
- Specific gravity of coarse aggregate = 2.70

3.1 EXPERIMENTAL PROGRAMME

The following tests were made after 28 days curing:

- Workability test
- Compressive strength test
- Split tensile strength test,
- Flexural strength test (for beam)

3.1.1 Workability test

3.1.1.1 Slump cone test

The concrete slump test is an empirical test that measures workability of fresh concrete. The test measures consistency of concrete in that specific batch. It is performed to check consistency of freshly made concrete. Consistency refers to the case with test is popular due to the simplicity of apparatus used and simple procedure. Unfortunately, the simplicity of the test often allows a wide variability in the manner in which the test is performed. The slump test is used to ensure uniformly for different batches of concrete under field conditions, and to ascertain the effects of plasticizers on their introduction. Metal mould, in the shape of the frustum of a cone, open at both ends, and provided with the handle, top internal diameter 100mm, and bottom internal diameter 200mm with a height of 300mm.

Fig- 3: Slump test

The slumped concrete takes various shapes, and according to the profile of slumped concrete, the slump is termed as the true slump, shear slump or collapse slump is achieved, a fresh sample should be taken and the test repeated. A collapse slump is an indicated of too wet a mix or that it is a high workability mix, for which the slump test is not appropriate. Very dry mixes having 10 -40mm are used for foundation with light reinforcement, medium workability mixes, 50 – 90 mm for normal reinforcement concrete placed with vibration , high workability concrete > 100mm.

3.1.2 Compressive strength test

This test method covers the deformation of cube compressive strength concrete specimen. The specimen is prepared by pouring freshly mixed concrete into lubricated cube moulds. Consolidation is done extremely over vibrating table for 1-2 minutes. After vibration and finishing, the moulds are kept at normal atmosphere conditions for 231/2 ±½ hours after which demoulding is done. The specimen are then cured in water tank.

Fig -4: Compressive Strength Testing Arrangement

The test is conducted at surface dry condition. The specimen is tested at the age for 28 days of curing under the compression testing machine.

$$\text{Compressive strength (N/mm2)} = \frac{\text{Maximum load at failure} * 1000\ \text{N}}{\text{Loaded surface area (mm2)}}$$

The tests were carried out on a set of triplicate specimen and the average compressive strength values were taken.

3.1.3 Split tensile strength test

Splitting tensile strength test was conducted on concrete cylinders to determine the tensile nature of carbon black concrete. The wet specimen was taken from water after 28 days of curing. The surface of specimen was wiped out. The weight and dimensions of the specimen was noted. The cylinder specimen was placed on compression testing machine. The local was applied continuously without shock at a constant rate. The breaking load (p) was noted.

Splitting tensile strength test = 2 * breaking load (N/mm2)

Π * dia. of cylinder * length of cylinder

Fig -5: Split Tensile Strength Testing Arrangement

3.1.4 Flexural strength (beam):

Flexural strength test was conducted on concrete beam to determine the flexural nature of carbon black concrete. The wet specimen was taken from water after 28 days of curing. The surface of specimen was wiped out. The weight and dimensions of the specimen was noted. The load was applied continuously without shock at a constant rate. The breaking load (p) was noted.

Flexural strength (N/mm2) = PL/BD^2

3.1.5 PERMEABILITY TEST

Permeability testis used to find the durability of concrete with the help of water and air. It is done by using Concrete Permeability test Apparatus. Since permeability affects the destructiveness of saturated freezing this test is done. It is 3 cell apparatus, in which cubes of 100mm can be placed. Pressure gauge is placed to find the pressure applied in the apparatus; nearly 1.25 kgf/cm^2 air pressure is applied. Cell assembly is filled with water.

Permeability test of all the cubes after 28 days is shown in Table 6.By measuring the water and time, coefficient of permeability is found. Depending upon the quantity of water and time of flow, permeability varies for the concrete.It is determined by using the following formula

$$k = \frac{QL}{tAh}$$

Where, k = Darcy Coefficient of Permeability (m/s)

Q = Volume of water in m^3

L = Length of the test sample in metres, to the nearest 0.001m

t = Elapsed time in seconds

h = Applied pressure head in metres of water

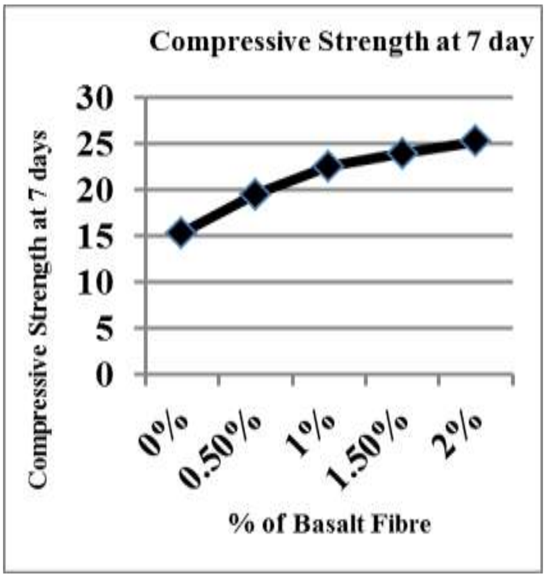
A = Area of the test sample in m^2

Fig-6: Permeability Testing Arrangement

4. RESULT AND DISCUSSION

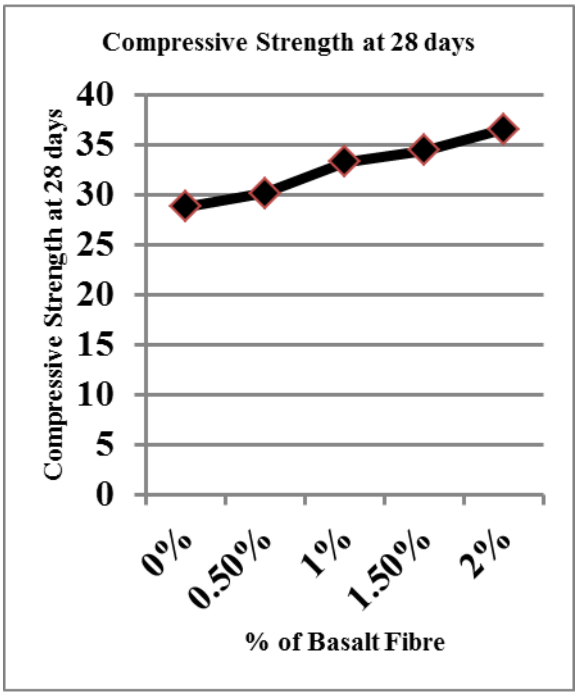
4.1 COMPRESSIVE STRENGTH AT 7 DAYS

% of Basalt Fiber	Sample 1	Sample 2	Sample 3	Average
0%	15.56	15.11	15.33	15.33
0.5%	19.78	19.55	19.11	19.48
1%	22.67	23.11	22	22.59
1.5%	24	24.22	23.55	23.92
2%	25.78	24.89	25.11	25.26



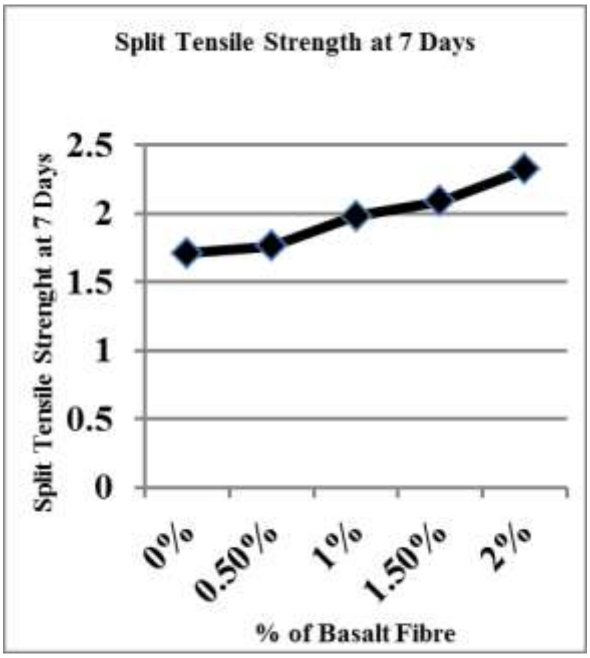
4.2 COMPRESSIVE STRENGTH AT 28 DAYS

% of Basalt Fiber	Sample 1	Sample 2	Sample 3	Average
0%	28.89	28.44	29.11	28.8
0.5%	30.22	30.44	29.77	30.14
1%	33.33	32.89	33.55	33.25
1.5%	34.67	34.89	33.78	34.45
2%	36.44	36.67	36.44	36.52



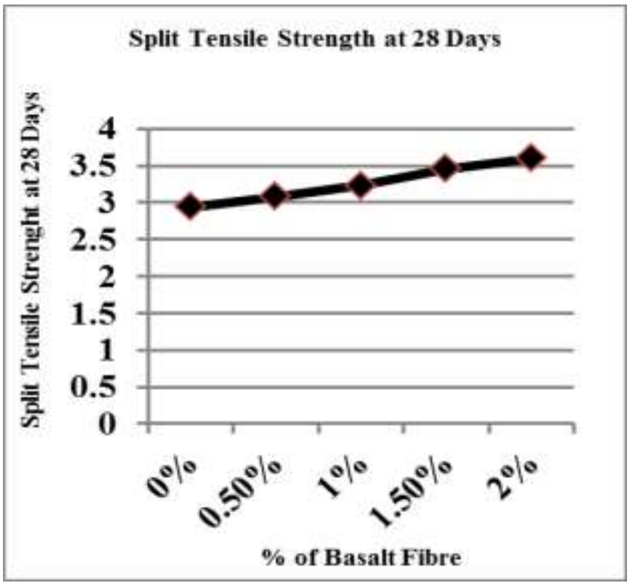
4.3 SPLIT TENSILE STRENGTH AT 7 DAYS

% of Basalt Fiber	Sample 1	Sample 2	Sample 3	Average
0%	1.69	1.83	1.62	1.71
0.5%	1.84	1.69	1.76	1.76
1%	1.91	1.98	2.05	1.98
1.5%	2.12	2.19	1.98	2.09
2%	2.3	2.41	2.26	2.32



4.4 SPLIT TENSILE STRENGTH AT 28 DAYS

% of Basalt Fiber	Sample 1	Sample 2	Sample 3	Average
0%	2.82	2.97	3.04	2.94
0.5%	3.11	2.97	3.18	3.08
1%	3.25	3.32	3.11	3.23
1.5%	3.39	3.53	3.46	3.46
2%	3.53	3.61	3.67	3.60

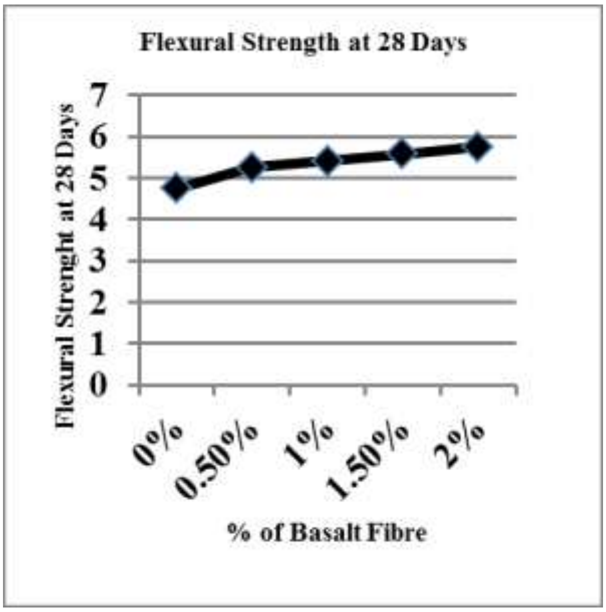


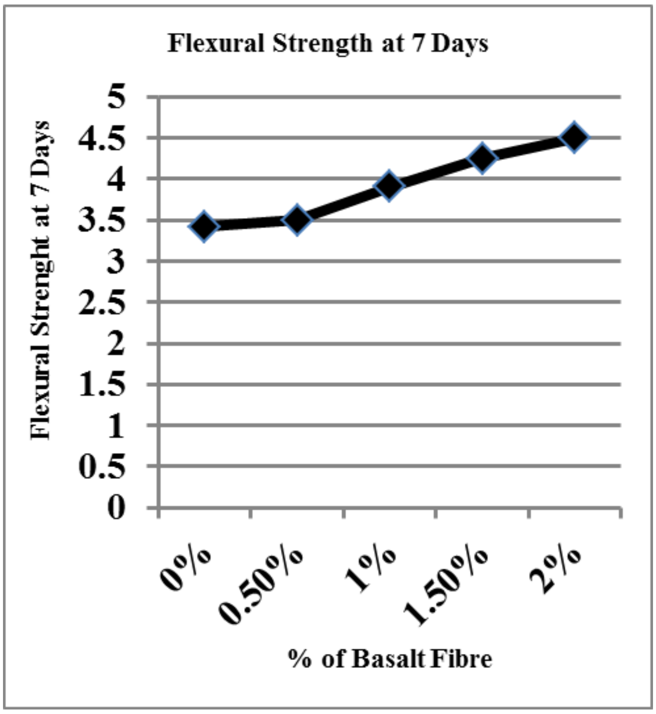
4.5 FLEXURAL STRENGTH AT 7 DAYS

% of Basalt Fiber	Sample 1	Sample 2	Sample 3	Average
0%	3.5	3	3.75	3.42
0.5%	3.75	3.25	3.5	3.5
1%	4	4.25	3.5	3.91
1.5%	4.25	4.5	4	4.25
2%	4.5	4.25	4.75	4.5

4.6 FLEXURAL STRENGTH AT 28 DAYS

% of Basalt Fiber	Sample 1	Sample 2	Sample 3	Average
0%	5	4.5	4.75	4.75
0.5%	5.25	5.5	5	5.25
1%	5.5	5	5.75	5.41
1.5%	5.75	5.5	5.5	5.58
2%	5.5	5.75	6	5.75





5.CONCLUSIONS

Based on the experimental investigation, the following findings are observed.

- Adding of basalt fiber 2% gives the maximum value
- 2% of basalt fiber improves the compressive strength values up to 21% when compared with the conventional concrete.
- 2% of basalt fiber improves the split tensile strength values up to 18% when compared with the conventional concrete.
- 2% of basalt fiber improves the flexural strength values up to 17% when compared with the conventioanl concrete.
- It shows the effective results so it reduces the cost of steel in construction
- From these results use of basalt fiber in low cost composites for civil infrastructure provide good mechanical properties at lower cost of basalt fiber.

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