Experimental Investigations of Normal M25 Grade Concrete Containing Basalt Rock Fibres

Kondreddy V Subbaiah[1], M.Prasanna kumar[2], K. Abhiram[3], B.karthik[4], G.Harish[5]
[1, 2] Asst. Professors, Dept of civil engineering
[3, 4, 5] Dept of civil engineering
[1, 2, 3, 4, 5] Holy Mary Institute Of Technology & Science

Abstract- *The aim of this project was to evaluate the performance of M25 grade basalt fibre concrete with the normal M25 grade concrete. Concrete has a good serviceability, but it is failing in some conditions due to the improper mixing which results in cracking. So the concrete is likely to be get replaced by other material like fibres, to get good serviceability. In the same way the additive material should be economic. Basalt is a naturally available material which will increase the strength of concrete by producing infinite variance in strength compared to normal concrete. The main aim of this investigation is first to obtain the strength of normal concrete of grade M25 with locally available ingredients and then to study the effect of different proportions of basalt fibre in the mix and to find out the effect on various mix proportions of basalt fibres in the mix range to the concrete. And the concrete specimens were tested at different age levels such as 7, 14, 28 for mechanical properties of concrete namely, cube compressive strength. Based on the laboratory experiments cube specimens have been designed for basalt fibre concrete tests. The basalt fibres in the concrete mixture have been carried in the range 0 to 6%. The basalt fibre containing concrete mixtures have been aged at 7, 14, 28 days. When basalt fibres are mixed in the concrete at different percentage values, different densities such as 6kg/m^3, 12kg/m^3, 18kg/m^3, 24kg/m^3, 30kg/m^3, 36kg/m^3 have been obtained.*

Keywords- Basalt fibre, Compressive strength.

I. INTRODUCTION

Basalt fibres are produced from basalt rocks, which are melted at 1400^0 C. Basalt fibres are environmentally safe, non-toxic, and possess high stability and insulating characteristics. Basalt Fibre Reinforced Polymer (BFRP) reinforcing bars have been recently introduced as an alternative to steel reinforcement for concrete structures and as external reinforcement for retrofitting of concrete structures. Unlike Carbon Fibre Reinforced Polymer (CFRP) and Glass Fibre Reinforced Polymer (GFRP) materials, basalt fibres have not been widely used. The limitation of their use may be attributed to the lack of fundamental research and extensive testing required establishing an appropriate design recommendations and guidelines. Chopped basalt fibres have been also introduced as an additive to concrete mixes to produce fibre reinforced concrete (FRC).

1.1.1 Manufacture

Basalt is made from a single material, crushed basalt, and from fibre requires the melting of the quarried basalt rock at about 1400^0 C (2550^{0}F). The molten rock is then extruded through small nozzles to produce continuous filaments of basalt fibres. There are three main manufacturing techniques, which are centrifugal- blowing, centrifugal- multi role and die-blowing. The fibres typically have a filament diameter of between 9 and13µm which is far enough above the respiratory limit of 5µm to make basalt fibre a suitable fibre replacement for asbestos. They also have a high elastic modulus, resulting in excellent specific strength.

1.1.2 Properties

The Table1 refers to the continuous basalt fibre specific producer. Data from all the manufactures are different. The difference is sometimes very large values. A carefully chosen quarry source and unlike other materials such as glass fibre, essentially no materials are added. The basalt is simply washed and then melted [8].

Table.1. Physical Properties Of Basalt Rock Fibres

property	Value [9]
Tensile strength	4.84GPa
Elastic modules	89GPa
Elongation at break	3.15%
Density	2.7g/cm^3

Basalt fibre is a “multi-performance” fibre. For example, It is resistant to alkalis and acids; it is thermally, electrically and sound Insulated; its tensile strength can be greater than large-tow carbon fibre, its elongation is better than small carbon fibre. Basalt has a 3-dimentional molecule and when compared with single infiltrating linear polymeric

fibres. It is cost effectiveness, anti aging, as well as other excellent Characteristics. Basalt fibre for cement and concrete is not expensive; it is a competitive alternative product of poly propylene fibre and poly acrylic nitride fibre. Basalt fibre is a typical ceramic fibre; it's easy to disperse when mixed with cement concrete and mortar. Therefore, basalt fibre concrete serves the functions of reinforcement, crack resistance, and can extend the life of construction in the fields of housing, bridges, Highways, railways, urban elevated roads, runways, ports, subway tunnels, the coastal Protection works, plant facilities.

1.1.3 History

The first attempts to produce basalt fibre were made in the United States in 1923 by Paul Dhe who was granted U.S. Patent 1,462,446. These were further developed after World War II by researchers in the USA, Europe and the Soviet Union especially for military and aerospace applications. Since declassification in 1995 basalt fibres have been used in a wider range of civilian applications.

1.1.4 Uses

- Heat protection
- Friction materials
- High pressure vessels (e.g. tanks and gas cylinders)
- Load bearing profiles
- Windmill blades
- Lamp posts
- Ship hulls
- Car bodies
- Sports equipment
- Concrete reinforcement (e.g. for bridges and buildings)
- Speaker cones
- Cavity wall ties

1.1.5. Chemical properties

Basalt is fine grained, extrusive, igneous rock composed of plagioclase, feldspar, pyroxene, magnetite, with or without olivine and containing not more than53 wt% of sio2 and less than 5 wt% of total alkalies. Many types of basalts contain phenocrysts of olivine, clinopyroxene (augite) and plagioclase feldspar. Basalt is divided into two main types, alkali basalt and tholeites. They have a similar concentration of sio_2, but alkali basalts have higher content of Na2o and K2o than tholeites.

Table2- Chemical Composition Of Cement & Basalt Fibre (%)

Oxide	cement	basalt
Sio2	19.71	69.51
Al2o3	5.20	14.18
Fe3o3	3.73	3.92
Cao	62.91	5.62
Mgo	2.54	2.41
K2o	0.90	1.01
Na2o3	025	2.74

II. MATERIALS USED & TEST RESULTS

The basic materials for mixing concrete are required such as

1. Cement
2. Fine aggregate
3. Coarse aggregate
4. Basalt rock fibres
5. Water

2.1. Cement

The cement used was DECCAN OPC 53 grade cement. The following Table 3 is the various tests conducted as per Indian Standards to determine the properties of this cement. For initial & final setting time IS: 8112-1989 is used and for standard consistency of cement IS: 4031(part-4) 1988. For specific gravity of cement (IS: 2720- part 3) is used.

Table 3: Results Of Tests On Cement

S. no	Properties	Values obtained	Specification
1	Specific gravity	3.02	3.15
2	Standard consistency	30%	0.3
3	Initial setting time	64 min	Min 30 min
4	Final setting time	260 min	Max 600 min

2.2 Fine aggregate (sand)

Sand was used as fine aggregate for the experiment. Various tests were conducted to determine the properties of sand which are shown in the Table-4. Grading is the particle-size distribution of an aggregate as determined by a sieve analysis. The tests were done according to IS: 2386 (Part-1) – 1963[3].

Table 4: Results Of Tests On Fine Aggregate

S. no	Properties	Values
1	Specific gravity	2.6
2	Fineness modulus	3.63
3	Water absorption	2.54
4	Zone	II

2.3 Coarse aggregate

Aggregate is commonly considered inert filler, which accounts for 60 to 80 percent of the volume and 70 to 85 percent of the weight of concrete. Maximum size of aggregate affects the workability and strength of concrete. It also influences the water demand for getting a certain workability and fine aggregate content required for achieving a cohesive mix. In this study the natural coarse aggregates are used, which was bought from the nearby quarry. Aggregates of 20 mm passed and 12.5 mm retained size were chosen for the experiment which is clean and free from deleterious materials. The following Table 5 shows the tests conducted in order to determine the properties of this aggregate.

Table 5: Results Of Tests On Coarse Aggregate

S. no	Properties	Values
1	Specific gravity	2.66
2	Fineness modulus	2.4
3	Water absorption	0.5%

2.4 Basalt fibre

The fibres used were chopped basalt fibre, which are uniformly and randomly distributed in the concrete matrix. Six different fibre contents were chosen 1%, 2%, 3%, 4%, 5%, and 6% for each mix. Chopped basalt fibres are shown in Figure 3. The chemical composition of basalt fibre is mentioned in below Table6.

Fig: 1 Chopped Basalt Fibres

Table 6. Chemical Composition Of Cement

oxide	**Chemical composition(%)**
Sio_2	69.51
Al_2o_3	14.18
Fe_3o_3	3.92
Cao	5.62
Mgo	2.41
K_2o	1.01
Na_2o_3	2.74

2.5. Water

Water used in concrete is free from sewage, oil, acid, strong alkalis or vegetable matter, clay and loam and is satisfactory to use in concrete.

III. EXPERIMENTAL PROCEDURE

In this experiment, the required materials cement, fine aggregate, coarse aggregate which are locally available were considered and then the suitable tests were conducted to them and used for concrete mix. The main required basalt fibre is then divided for the various mixes of basalt fibre concrete. Then the mix design casting, curing and test procedures were applied. In this experiment to achieve the objective we planned to prepare for 21 cubes with different proportions of basalt fibre concrete.

3.1 Mix design:

As per IS-10262-2009 for M25 grade concrete the mix proportion is 1:1:2 and the target mean strength was 25Mpa. The water cement ratio is maintained to 0.5. In this mix design no super plasticizer is added. The mix design is prepared with the various mix proportions of basalt fibre concrete containing basalt for an mm^3 1%, 2%, 3%, 4%, 5% and 6% respectively.

Figure 2: Mixing Of Concrete

3.2 Casting:

The basalt fibre concrete is generally mixed like normal concrete. The chopped basalt fibres are added to the ingredients of concrete and mixed with 0.5 water cement ratio. The fresh homogeneous concrete is prepared. The freshly mixed concrete is tested for slump and compaction factor test. The slump and compaction factor values are shown in below Table. And then the concrete is filled into the cube moulds. Before filling concrete, the cubes are well cleaned without any dust particles and then oil is painted inside the walls of cubes for smooth removal and finishing. The concrete mix is filled in the mould by three layers, and then each layer is compacted by giving 25 blows with the tamping rod. Then it is kept for 24 hours to room temperature and removed out. After this, the concrete blocks were cured for 7, 14, 28 days in curing tank.

Table. 7. Slump And Compaction Factor Test Results

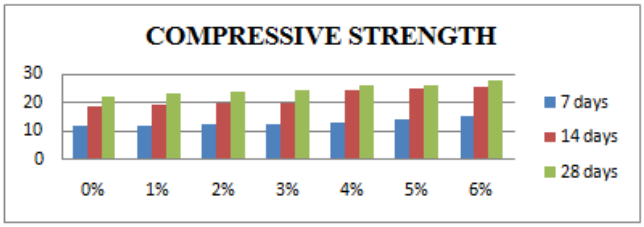
S. No	% of basalt	Slump value	Compaction factor value	Density kg/m^3
1	0%	120 mm	0.98	2419.55
2	1%	105 mm	0.96	2426.07
3	2%	100 mm	0.94	2443.85
4	3%	95 mm	0.92	2455.12
5	4%	90 mm	0.90	2435.56
6	5%	84 mm	0.89	2442.07
7	6%	80 mm	0.85	2443.85

IV. TESTING PROCEDURE

In this experiment different tests were conducted to find the properties of concrete when it is in plastic state, by slump cone test and compaction factor test. After the hardened state the compressive strength test is conducted for cube specimens of 150mm x 150mm x 150mm for calculating the mechanical properties of concrete. The cubes were tested under 200 tons compression testing machine to study the compressive strength of the cubes.

Table 8. Compressive Strength Test Results & Charts

S. no	% of basalt	Compressive strength test		
		7 days	14days	28 days
1	0%	11.9	18.66	22.22
2	1%	12.14	19.11	23.11
3	2%	12.32	19.77	23.56
4	3%	12.56	20.00	24.22
5	4%	13.1	24.44	25.77
6	5%	14.15	24.88	26.22
7	6%	15.2	25.56	28.00



V. CONCLUSION

Based on the investigation studies the following conclusions can be made:

- It has been observed that the workability of concrete decreases with the addition of Basalt Fibres.
- The percentage increase of compressive strength of basalt fibre concrete mix compared with 28 days compressive strength of Plain Concrete is observed less.
- The compressive strength of specimens gradually increased with the increase of basalt fibre content and its age.
- It was observed that, the percentage increase in the strength of basalt fibre concrete increases with the age of concrete.
- Also it was found from the failure pattern of the specimens, that the formation of cracks is more in the case of concrete without fibres than the basalt fibre concrete.
- It shows that the presence of fibres in the concrete acts as the crack arrestors. 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.
- From the references 10 and 11 there is no super plasticizer added to the concrete mix proportion to increase the workability of concrete.

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