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Experimental Study on "Effect of Chopped Basalt Fiber Reinforced Concrete in Structural Behavior of Deep Beam"

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Abstract – *This paper deals with the structural behavior of chopped basalt fiber reinforced concrete deep beam and compressive strength property of fiber reinforced concrete. The fiber reinforced concrete has been one of the top most innovations in concrete technology, highlighting improved structural integrity of the structure. Deep beams are structural element loaded as simple beam and carried as compression force towards the support. One of the main parameter that affect the deep behavior is concrete compressive strength. Chopped basalt fibers are used in concrete to improve the mechanical properties of concrete, especially compressive strength. This present work deals with experimental study of compressive strength of chopped basalt fiber reinforced concrete and the influence of fiber in deep beam behavior. In order to determine the optimum fiber percentage in concrete , cube specimens are prepared with varying percentage of basalt fiber adding like 0.1%, 0.15%, 0.2%, 0.25%, 0.3% . Performance analysis of normal concrete deep beam and fiber reinforced concrete deep beam are made on the basis of initial cracking load, number of cracks, diagonal cracking behavior, moment carrying capacity, ultimate load, pre cracking and post cracking behavior etc. In results we have found that basalt fibers can be used as an additive to enhance the concrete quality, and in deep beam it affect the width of diagonal cracks, shear and flexural cracking behavior, initial cracking load, Ultimate failure load, number of cracks etc. But it does not made significant change in moment carrying capacity.*

Key Words: Deep beam, Chopped basalt fiber, Compressive strength, Crack arrester.

1. INTRODUCTION

Deep beams are progressively employed in modern construction and have practical applications in wide range of structures such as such as floor slab under horizontal load, short span beams carrying heavy loads, wall footing, shear wall etc. This structure mostly fail due to shear rather than flexure when sufficient amount of tension reinforcement is used. Concrete compressive quality is an imperative parameter that affect the shear strength of deep beam. The growth of fiber composites are revolutionary landmark in the history of construction industry. Basalt fibers in the concrete acts as the crack arrestors. The ductility and compressive characteristics have improved with the addition of basalt fibers. The surface area of fibers also affect the shear strength and compressive strength of concrete. Therefore the use of chopped basalt fibers enhance the compressive strength and shear strength of concrete. The use of chopped basalt fiber reinforced concrete in deep beam thereby affect the overall structural behavior of deep beam like width of diagonal crack, initial cracking load, no of cracks, ultimate failure load etc.

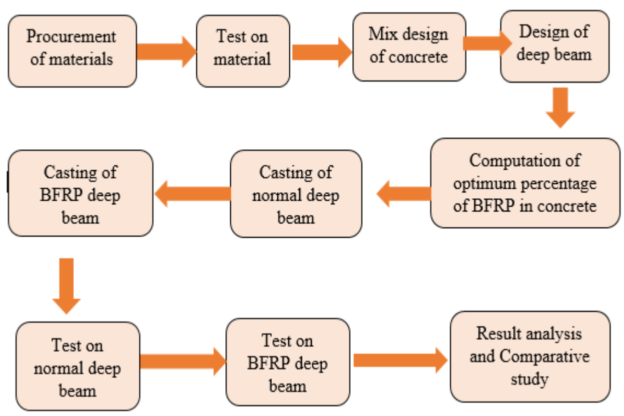
2. OBJECTIVES

The main objectives are

1) To evaluate compressive strength of concrete with respect to chopped basalt fiber addition.
2) To obtain the optimum fiber percentage in concrete.
3) To analyze the behavior of deep beam with and without fiber addition.

3. MEHEDOLOGY

The experiment is divided into definite sequences of work. The sequence of work are represented in the form of a flow diagram.



4. MATERIALS USED

4.1 Cement

Here Ordinary Portland Cement with 53 Grade is used. It is the cement used for normal construction. It has adhesive and cohesive properties so that it forms a good bond with other materials.

4.2 Fine aggregate

Those particles passing the 9.5mm (3/8 in.) sieve, almost entirely passing the 4.75mm sieve, and predominantly retained on the 75µm sieve are called fine aggregate. For increased workability and for economy as reflected by use of less cement, the fine aggregate should have a rounded shape. The purpose of the fine aggregate is to fill the voids in the coarse aggregate and to act as a workability agent.

4.3 Coarse aggregate

Those particles that are predominantly retained on the 4.75mm sieve and will pass through 3 inch screen, are called coarse aggregate. The coarser the aggregate the more economical the mix. Larger pieces offer less surface area of the particle than an equivalent volume of small pieces. Use of the largest permissible size of coarse aggregate permits a reduction in cement and water requirements.

4.4 Chopped basalt fiber

Chopped basalt fibers has more surface area therefore it can easily dispersed to concrete and make more compact structure with high compressive strength and shear strength at low percentage of fiber addition. In the current work chopped golden brown basalt fibers with aspect ratio 730 is used.

Fig -1: Chopped Golden Brown Basalt Fiber

4.5 Reinforcement Fe 415

The reinforcement provided for the deep beams are of Fe 415 with 16mm bar as main reinforcement and 8mm bar used as stirrup.

5. EXPERIMENTAL WORK

5.1 Mix design

Mix design is the process of determining the mix proportion for making concrete. Here mix design of M_{40} is done based is on IS 10262: 2019 & IS 456: 2000

Table-1: Mix proportion

Mix proportion	Water cement ratio
1:1.34:2.61	0.43

5.2 Specimen details and test setup

Concrete cubes of 150mm edge size with fiber addition of 0%, 0.15%, 0.2%, 0.25%, and 0.3% are prepared and find optimum chopped basalt fiber percentage in concrete.

Fig- 2 : Failure of plain concrete

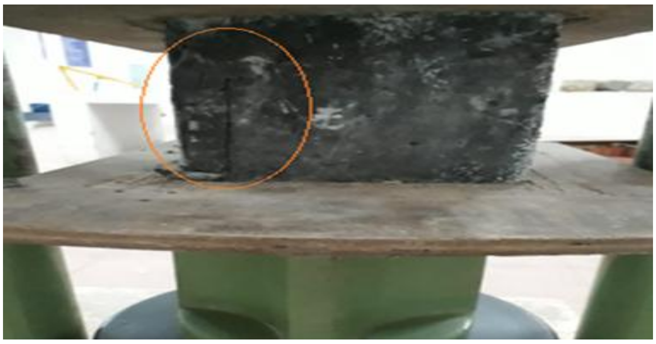


Fig- 3 : Failure of fiber reinforced concrete with 0.25% addition

Two sets of Deep beams including with and without fiber addition are casted. Dimensions and reinforcement details are listed below.

Dimension	700 x 350 x 150 mm
Main reinforcement	4 bars of 16 mm dia. bar
Stirrup	8mm dia. bar at 70 mm c/c

Table- 2: Deep Beam Details

Fig- 4: Reinforcement Cage

Fig -5: Deep beam specimen

6. TEST RESULTS AND DISCUSSION

6.1 Results Of Cubes

Compressive strength tests were carried out on concrete cubes in Universal Testing Machine (UTM) of capacity of 1000 kN under 0.5 mm/min loading rate. The average compressive strength of the control specimens and basalt fiber -reinforced concrete is shown in graph. The test result shows that when the percentage addition of basalt fiber increases the compressive strength also increases up to a limit of 0.25%. Then it decreases due to the presence of higher percentage addition of fiber causes the chance of concrete balling and voids in the mix. For the fracture of plain concrete, some vertical crack form on the surface of the specimen, but in Fiber reinforced concrete specimen remains a good appearance after fracture. I.e. fibers can restrain the lateral expansion of concrete.

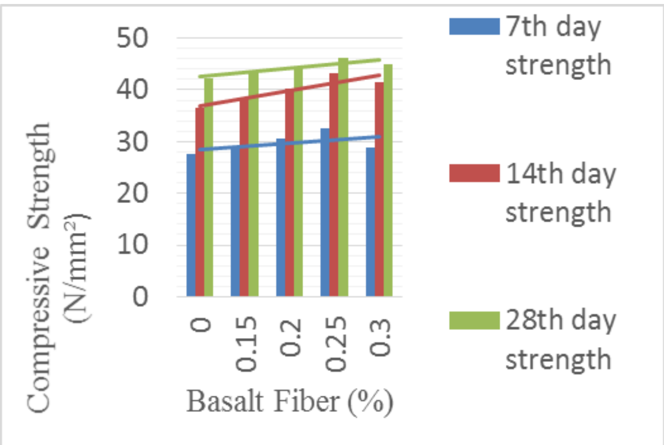


Fig- 6: Compressive strength of tested cubes

6.2 Results of deep beam

The specimens casted were tested on loading frame. The two specimens were tested at simply supported end conditions with a point load. In this experiment the performance of two beams were compared in terms of number of cracks, initial cracking behavior, ultimate conditions etc. The performance of two beams can be easily understand with the help of following figures and table

Fig -7 : Cracking behavior of normal deep beam

Fig- 8: Cracking behavior of BFRC deep beam

The control deep beam, after loading a small crack observed at the bottom of the deep beam which is called first crack or flexural crack. When the loading gradually increases then no. of crack pattern also increases. At last shear cracks begins to form near the supports and extend towards load position. The width of diagonal crack can be easily understand with the help of naked eye. Instead of this basalt fiber reinforced concrete deep beam shows better performance than previous one. Because the width of diagonal cracks cannot be understand with the help of naked eye. Number of flexural cracks are very less.

Table- 3: Load -deflection details of control beam and fiber reinforced deep beam

Specimen	Load at first crack	Deflection at first cracking load	Load at failure	Deflection at failure load
Control deep beam	173 kN	1.84mm	330 kN	4.78mm
Fiber reinforced deep beam	220 kN	1.42mm	420 kN	4.63mm

We can understand that due to the better dispersion of chopped fiber in the concrete can be act as a crack arrester in deep beam. The initial cracking load, ultimate load shows better performance than control deep beam. The moment carrying capacity of deep beam slightly depends on the fiber addition. That is chopped basalt fibers only act as shear reinforcement not flexural reinforcement.

7. CONCLUSIONS

From the experimental investigation on deep beam by using chopped basalt fiber reinforced concrete, the following conclusions can be drawn.

1) Chopped basalt fibers shows better bond strength on concrete and it significantly improve the compressive strength of concrete.
2) Concrete compressive strength more impart on shear strength other than flexural strength of deep beam.
3) In both cases flexural cracks were appeared first at the central bottom portion of the beam and not extent on full depth of beam.
4) Failure of deep beams was mainly due to diagonal cracking and it was along the lines joining the loading points and supports.
5) The basalt fiber reinforced concrete deep beam shows better resistance to diagonal crack and flexural crack. Therefore chopped basalt fibers can be used as an additive in concrete deep beam to enhance the crack arresting quality.
6) The moment carrying capacity of deep beam slightly depends on the fiber addition. That is chopped basalt fibers only act as shear reinforcement not flexural reinforcement.

8. FUTURE SCOPE

Study is limited to only compressive strength of chopped basalt fiber. Therefore there is a chance for further study on flexural strength and split tensile strength of basalt fiber and how they affect deep beam behavior.

The present work only oriented the deep beam crack behavior, deflection only. But not studied the Stress strain characteristics, shear span to depth ratio effect etc. This open better opportunity to further research.

This work fully focused on experimental result. So analytical study and validation is another opportunity of expanding investigation in this area.

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