Flexural Behaviour of Basalt Chopped Strands Fibre Reinforced Concrete Beams

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Abstract:
The present paper of the experimental investigation conducted on the use of basalt chopped strands fibre of length 6mm and 12mm, having an aspect ratio of around 500 was employed in equal percentages of 0.2 percentage by weight in cast concrete and tests like compressive strength, flexural strength and split tensile strength. Conventional concrete have very low tensile strength and small resistance to cracking. Internal cracks were inherently present in concrete and its poor tensile strength is due to the propagation of such micro cracks. Fibres added to a certain percentage of the concrete improve the strain value as well as crack resistance and flexure strength.

Keywords: Basalt chopped strands Fiber, Compressive strength, Flexural strength, Split tensile strength

I. INTRODUCTION

Basalt rock is a volcanic rock and can be divided into small particles then formed into continuous or chopped fibers. Basalt fiber has a higher working temperature and has a good resistance to chemical attack, impact load, and fire with less poisonous fumes. Some of the potential applications of these basalt composites are: plastic polymer reinforcement, soil strengthening, bridges and highways, industrial floors, heat and sound insulation for residential and industrial buildings, bullet proof vests and retrofitting and rehabilitation of structures. Also, it can be work in a wide range of temperatures (~269 to 650°C). Basalt fibers have complex. It has higher tensile strength than steel and are rust free as they are chemically inert. The defects and micro-cracks emanate from excess water, bleeding, plastic settlement, thermal and shrinkage strains, and stress concentrations imposed by external restraints are rectified by using basalt strands chopped fiber. Its properties enabling them as replacement for asbestos, high strength glass, silica, chemical resistant glass and other special fibers in many applications.

A.OBJECTIVES

- The main objective of this investigation was
- To Study the flexural behavior of basalt chopped strands fibre reinforced concrete.
- To compare Compressive strength of the Cube and the Split tensile strength of the Cylinder.
- To investigate the load-deformation characteristic and load carrying capacity.

II. LITERATURE REVIEW

Nayan Rathod, et. all(2015): The experimental program consist of casting and testing of RC beam of size 150mmx150mmx700mm with concrete mix design for M-25 grade concrete. In this paper mainly flexural strength of normal concrete is compared with 1% and 2% of basalt chopped strands fiber reinforced concrete in 14 and 28 days. At 14 days average flexural strength is maximum when 2% basalt fiber is used. About 40% to 50% increase in strength is observed and at 28 days average compressive strength is maximum when 1% and 2% fibers are used. About 83% & 92% increase in compressive strength than the design strength, when the basalt fibers are introduce in concrete. One should take care of basalt fiber during mixing with concrete. It should be not allowed to mix more than 1.5 minute, otherwise it will segregate. The basalt fibers are add in the concrete before adding of water, otherwise it will stick at surface.

Sangamesh Upasi, et. all (2014) The Experimental Program Consist Of Casting And Testing Of RC Beam Of Size 200mmx350mmx3000mm With Concrete Mix Design For M-30 Grade Concrete. Volume Content of Basalt Chopped Strand Fiber Is Added 1%, 1.5%, 2%, 2.5%. The Length Of 6mm And 12mm Size Basalt Chopped Fiber Were Used With 50% Combination Of Each Size. The Higher Flexure Strength Of Basalt Fiber Reinforced Concrete Can Be Obtained By Adding 2% Basalt Fiber And The Percentage Increase In Flexure Strength Is 78.94%. The Workability Of Basalt Fiber Reinforced Concrete Decreases As The Percentage Of Fibers In It Increases. The Higher Compressive Strength Of Basalt Fiber Reinforced Concrete Can Be Obtained By Adding 2% Basalt Fibers And The Percentage Increase In Compressive Strength Is 17.57%. The Higher Impact Strength Of Basalt Fiber Reinforced Concrete Can Be Obtained By Adding 2% Basalt Fibers And The Percentage Increase In Impact Strength Is 22.53%. The Higher Tensile Strength Of Basalt Fiber Reinforced Concrete Can Be Obtained By Adding 2% Basalt Fibers And The Percentage Increase In Tensile Strength Is 65.93%.

Fathima Irine I .A (2014) the experimental program consist of casting and testing of RC beam of size 100mm x100mmx500mm with concrete mix design for M-30 grade concrete. The Volume of basalt chopped strands fiber added at 1kg/m³, 2kg/m³, 4kg/m³ for each mix of concrete specimen. The percentage increase of compressive strength of basalt fiber concrete mix compared with 28 days compressive strength of Plain Concrete is observed as 14%. The percentage increase of


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split tensile strength of basalt fiber concrete mix compared with 28 days compressive strength of Plain Concrete is observed as 62%. The flexural strength of basalt fiber concrete is also found have a maximum increase of 54% at 4kg/m³ of fiber content. Also it was found from the failure pattern of the specimens, that the formation of cracks is more in the case of concrete without fibers than the basalt fiber reinforced concrete. It shows that the presence of fibers in the concrete acts as the crack arrestors. The ductility characteristics have improved with the addition of basalt fibers. The failure of fiber concrete is gradual as compared to that of brittle failure of plain concrete. From the results, it was observed that the percentage increase in the strength of basalt reinforced concrete increases with the age of concrete.

**Tehmina Ayub, et. All (2014)** The experimental program consist of casting and testing of RC beam of size 150mmx250mmx100mm with concrete mix design for M-40 grade concrete. In this paper about 1%, 1.5%, 2%, 2.5%, 3% of Basalt chopped strands fiber volume content is used. Specimens containing 3% volume of the Basalt fibers showed higher stress values, followed by the specimens containing 2% and 1% volume of the Basalt fibers. The use of 1%, 2%, and 3% Basalt fibers increased the flexural strength of the concrete as 18.15%, 36.12%, and 27.17% higher than that of the concrete without fibers. This results that Basalt fibers were fully active and showed resistance against extensive cracking and the dilation of concrete. With the increasing fiber volume, the resistance against cracking was also increased.

**Padmanabhan Iyer (2014)** the experimental program consist of casting and testing of RC beam of size 150mmx250mmx100mm with concrete mix design for M-35 grade concrete. Basalt chopped strands fiber of varying length of 12 mm, 36 mm, and 50 mm were used and varying volume of basalt chopped strands fiber dosage 4 kg/m³, 8 kg/m³, and 12 kg/m³ are used. The optimum fiber length and dosage for basalt fiber which provided the good performance (flexural, compressive, and split tensile strength) is 30 mm basalt chopped strands fiber at 8 kg/m³. It showed a 21% increase in flexural strength, 38% increase in compressive strength, and a 14% increase in split tensile strength compared to the plain concrete control specimen. The optimum fiber length and dosage for basalt chopped strands fiber which provided the best performance (flexural, compressive, and split tensile strength) is the 36 mm filament at 8 kg/m³. It showed 23% increase in flexural strength, 24% increase in compressive strength, and 4% increase in split tensile strength compared to plain concrete control specimen. The medium length (36 mm) and long (50 mm) filaments tend to lump at the high fiber dosage of 12 kg/m³. The 36 mm and 50 mm basalt chopped strands fibers dispersed uniformly at 12 kg/m³ and have performed (flexural, compressive, and split tensile strength) better than filament fibers of the same length and dosage.

### III. EXPERIMENTAL PROGRAM

**A) Cement**

An OPC 33 grade sample was tested to obtain the following characteristics of the Specific Gravity 3.1 and Standard consistency 32%.

**B) Coarse Aggregate**

In the present investigation, locally available crushed stone aggregate of size 20 mm and down, was used and the various tests, carried out on the aggregates in the test value on Specific gravity 2.754, Water absorption 1.23% and Fineness modulus 2.263.

**C) Fine Aggregate**

In the present investigation, the river sand, which was available at Chennai, was used as fine aggregate and the test value on Specific gravity 2.641, Water absorption 1.84% and Fineness modulus 3.652.

**D) Properties of Basalt chopped strands Fibre**

- Length of fiber – 6mm and 12mm
- Elongation – 3.1
- Tensile strength - 3200 Mpa
- Specific gravity - 1.15
- Resistance to alkali - Excellent
- Water absorption - 4 %
- UV resistance – High

**III. EXPERIMENTAL PROGRAM**

**V. MIX DESIGN**

**MIX DESIGN RATIO FOR M301:1.62:3.32**

**Table: 1 M30 Grade of Concrete Quantity for 1m³**

<table>
<thead>
<tr>
<th>Material</th>
<th>Quantity</th>
</tr>
</thead>
<tbody>
<tr>
<td>CEMENT</td>
<td>394 kg</td>
</tr>
<tr>
<td>FINE AGGREGATE</td>
<td>636 kg</td>
</tr>
<tr>
<td>COARSE AGGREGATE</td>
<td>1310.82 kg</td>
</tr>
<tr>
<td>W/c</td>
<td>0.4</td>
</tr>
<tr>
<td>Basalt chopped strands fiber</td>
<td>0.2%</td>
</tr>
</tbody>
</table>
In size of beam 1200×150×200mm is selected. The fibre (6mm and 12mm) added at 0.2% in four number of beam casted. The control cube specimen was casted in 150×150×150 mm size is used to determine the compressive strength and cylinders in 100mm diameter × 300mm length size is used to determine the split tensile strength.

**EXPERIMENTAL DISCUSSION**

It is well known that fibres usually have effect on compressive strength, which slightly increases the test results. From cube results it was found that compressive strength of the cubes keeps on increasing with the 0.2 percentage of basalt chopped strands fiber getting added up.

**A) Compression Test**

The compression test was conducted on cube specimens cured for 28 days. The test cubes were removed from the moist storage 24 hours before testing. The top and bottom bearing plates of the compression testing machine were wiped and cleaned before the placement of the specimen. Cube moulds of size 150 x 150 x 150 mm were casted and allowed for curing in a curing tank for 28 days. These cubes were tested on compression testing machine as per I.S. 516-1959. The compressive strength was calculated as follows: Compressive strength (MPa) = Failure load / cross sectional area.

Table 2. Compression Test Graph of control mix and 0.2% basalt fibre mix added

<table>
<thead>
<tr>
<th>Type of concrete</th>
<th>Specimen</th>
<th>Initial Crack Load (kN)</th>
<th>Compressive Strength (N/mm²)</th>
<th>Avg. Compressive Strength N/mm²</th>
</tr>
</thead>
<tbody>
<tr>
<td>Conventional concrete</td>
<td>1</td>
<td>870</td>
<td>32.78</td>
<td>33.63</td>
</tr>
<tr>
<td></td>
<td>2</td>
<td>900</td>
<td>33.56</td>
<td></td>
</tr>
<tr>
<td></td>
<td>3</td>
<td>930</td>
<td>34.56</td>
<td></td>
</tr>
<tr>
<td>0.2% Basalt fiber</td>
<td>1</td>
<td>900</td>
<td>37.56</td>
<td>38.57</td>
</tr>
<tr>
<td></td>
<td>2</td>
<td>930</td>
<td>38.67</td>
<td></td>
</tr>
<tr>
<td></td>
<td>3</td>
<td>950</td>
<td>39.61</td>
<td></td>
</tr>
</tbody>
</table>

**B) Split Tensile Strength Test**

For tensile strength test, cylinder specimens of dimension 150 mm diameter and 300 mm length were cast. The specimens were demoulded after 24 hours of casting and were transferred to curing tank wherein they were allowed to cure for 7, 14 and 28 days. These specimens were tested on compression testing machine in each category, three cylinders were tested and their average value is reported. Tensile strength was calculated as follows as split tensile strength:

\[ \text{Tensile strength (MPa)} = \frac{2P}{\pi DL}, \text{ Where, P = failure load, D = diameter of cylinder, L = length of cylinder} \]

Table 3. Split Tensile Strength

<table>
<thead>
<tr>
<th>Age of Concrete</th>
<th>Split Tensile Strength (MPa)</th>
</tr>
</thead>
<tbody>
<tr>
<td>7 days</td>
<td>1.38</td>
</tr>
<tr>
<td>14 days</td>
<td>2.16</td>
</tr>
<tr>
<td>28 days</td>
<td>3.07</td>
</tr>
</tbody>
</table>

**C) Flexural Strength Test**

The flexural strength of concrete beam was determined based on IS: 516 –1959. Beam specimens of size 1200 mm x 150 mm x 200 mm were casted. The samples were demoulded after 24 h from casting and kept in a water tank for 28 days curing. The specimens were placed in loading frame and tested for flexural strength.
The strain behaviour of the specimens containing basalt chopped strands fibre up to 0.2% behaves in a similar trend to the control specimen. For these cases which contain 0.2% basalt chopped strands fibre behaves like a brittle material of which the total energy is generated is elastic energy. There is significant change in strain of the concrete due to addition of fibres. Descending portion of the curve becomes more and more flatten as the fibre volume fraction increases. The relationship with different volume fraction of nylon fibre is shown in Fig. 8. Two different behaviour patterns are obtained as shown in stress strain curve. However, non-linear behaviour is seen for the other specimens which contains more than 0.2% of basalt chopped strands fibre. Here, once the peak stress is reached the specimen continues to yield. Therefore it can be stated that concrete with higher percentage of basalt chopped strands fibre possess higher toughness, since the generated energy is mainly plastic. Also it was found that as fibre volume increase failure strain also increases, which leads to more area under the curve, thus enhancing the toughness of the concrete.

VII. RESULT AND CONCLUSION

This paper has been concerned with the investigation of some mechanical behaviour of concrete with basalt chopped strands fibres. The experiments were done on compressive, tensile and Flexural behaviour of fiber reinforced concrete. Hence the conclusions summarized as: From the result, it is found that

i. Fibre reinforced concrete gives more strength compared to normal concrete. The following quantity of fibre 0.2% was added in concrete and their strength was compared with normal mix concrete and hence found that the concrete with basalt added is stronger than normal mix.

ii. Thus, with the addition of fibres the compressive strength was increased even if, it was insignificant.

iii. The addition of basalt chopped fibres to concrete also improved the tensile strength compared to plain concrete.

iv. The addition of fibres improved the flexural strength of concrete significantly. The fibre reinforced concrete has the ability to hold on the crack of the concrete and resist the concrete beams from falling apart.

v. As the concrete is a fundamental material in the field of construction engineering, the improvement of its mechanical properties by the addition of this fibre will certainly increase the use of this composite material which will offer more strong and durable structures in the future and will open a new era in the field of construction materials.

VIII. REFERENCE


