Flexural Behaviour Of Self Cured RC Beams Strengthened Using Hemp Fibre

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Abstract: Objectives: To study the flexural behaviour of self-cured RC beams strengthened using Hemp fibre and to evaluate the suitability of short hemp fibre as a reinforcing agent in self-cured concrete. The experimental background is cited in the literature. Methods/Statistical Analysis: From the basic tested data a mix design for M30 grade self-cured concrete was made using 1% PEG-400. For obtaining optimum fibre content 15 numbers of cube (150 mm × 150 mm × 150 mm), beam (500 mm × 100 mm × 100 mm) and cylinder specimens (300 mm height and 150 mm diameter) were cast using hemp fibre proportion (0, 0.2, 0.3, 0.4, 0.5) by weight of cement in the laboratory and tested for mechanical properties. Further 3 numbers of Hemp fibre incorporated self-cured RC long beams (1200 mm × 100 mm × 150 mm) were prepared and tested for flexure under two point loading and compared with control beam. Findings: The test results for mechanical properties shows that the weight fraction of 0.4% Hemp fibre improves compressive strength, flexural strength and splitting tensile strength compared with control specimen by over 12.60%, 15.30% and 20% respectively. Self-cured RC long beams strengthened using Hemp fibre under two point loading showed better load deflection characteristics and improved ultimate flexural strength of 22% over control beam. Applications/Improvements: Fibre strengthening is utilized in crack resistance, crack control, better ductility. Hemp fibre reinforced polymer composites are increasingly being used in civil infrastructures foreexternally bonded reinforcement for strengthening of walls, beams and slabs, composite bridge decks. Keywords: Hemp fibre, PEG-400

I. INTRODUCTION

Plain concrete needs congenial atmosphere by providing moisture for a minimum period of 28 days for good hydration and to attain desired strength. The properties of hardened concrete, especially the durability, are greatly influenced by curing since it has a remarkable effect on the hydration of the cement. Any laxity in curing will badly affect the strength and durability of concrete. Self curing concrete is one of the special concretes in mitigating insufficient curing due to human negligence paucity of water in arid areas, inaccessibility of structures in difficult terrains and in areas where the presence of fluorides in water will badly affect the characteristics of concrete.

Curing is a serious problem faced in the construction industry. Most of the time, during public works the labourers usually neglect the proper curing practices, this will adversely affect the design life of the structures. Proper curing is an important factor in enhancing the service life and durability of structures. It helps to reduce the impact of reconstruction on the environment which leads to the limited use of non-renewable natural resources. Also at places where there is a scarcity of water, self curing concrete would be a great solution. Most commonly used agents are CeraPolyecure-W, Poly Vinyl Alcohol, Poly Ethylene Glycol etc. In this paper Poly Ethylene Glycol-400 (PEG 400) was used. PEG 400 is a type of internal curing agent.

Fibres are usually used in concrete to control cracking due to both plastic shrinkage and drying shrinkage and bridge across the cracks that develop in concrete1. The applications of natural fibre in concrete have provided an exciting prospect to the construction industry. To utilize natural fibre as reinforcement in concrete, it is important that the fibre reinforced concrete has appropriate physical and mechanical properties for an application. Addition of natural fibres does not improve FRC’s compressive strength distinctly compared to plain concrete. However, both the flexural load and energy absorption capacity of the FRC are increased over those of plain concrete. Hemp is a type of natural blast fibre. It is extracted from the blast of hemp plants. Hemp belongs to the family Mulberry, genus Cannabis. The fibre producing species is called Cannabis Sativa. Unlike other natural fibre such as wool and cotton, hemp fibre needs to be extracted from the blast before it can be utilized. The quality of hemp fibre is dependent on both the blast quality and the processing methods.

II. MATERIALS USED

In this experimental study cement, fine aggregate, coarse aggregate, Hemp fibre, PEG-400 were used.

2.1 Cement

Ordinary Portland Cement (OPC 53 grade) conforming to IS 12269:1987 was used.

2.2 Fine Aggregate

Tests were done according to IS 2386 (part 3):1963. M sand passing through 4.75mm sieve conforming to zone II as per IS 383:1970 was used for the experiment.
2.3 Coarse Aggregate
Coarse aggregate used in this study were 20mm nominal size, and were tested as per the Indian Standard Specifications IS 383:1970.

2.4 Hemp fibre
Hemp (Sun Hemp) is a type of natural blast fibre. It is extracted from the blast of hemp plants. Hemp belongs to the family Mulberry, genus Cannabis. Fibres for the study was obtained from Senthilvelantextiles, Andhra Pradesh. Physical properties are shown in table 4.

<table>
<thead>
<tr>
<th>Properties</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Specific gravity</td>
<td>1.50</td>
</tr>
<tr>
<td>Width (micrometers)</td>
<td>23.15</td>
</tr>
<tr>
<td>Moisture absorption(%)</td>
<td>9.40</td>
</tr>
<tr>
<td>Tensile stress (MPa)</td>
<td>900.00</td>
</tr>
</tbody>
</table>

2.5 Poly Ethylene Glycol-400
The self curing agent used for the study was PEG-400. It is a type of water soluble internal curing agent. Curing agent for the present study was obtained from Jay kay dyes and chemicals, Delhi.

2.6 Water
Portable drinking water was used for the present study.

III. DESIGN MIX
Concrete mix design has been adopted as per IS10262:2009 for M30 grade concrete. Mix design details and mix designation of cast specimens are given in Table 5 and 6 respectively.

<table>
<thead>
<tr>
<th>Material</th>
<th>Quantity</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fine Aggregate</td>
<td>795 Kg/m³</td>
</tr>
<tr>
<td>Coarse Aggregate</td>
<td>1080 Kg/m³</td>
</tr>
<tr>
<td>Water</td>
<td>160L</td>
</tr>
</tbody>
</table>

W/C ratio: 0.40, Mix ratio: 1:1.97:2.67

3.1 Wet mix procedure
1) The hemp fibre was added into the water container and stirred slowly.
2) The aggregate, sand, and cement were then added into mixer;
3) The mixer was started and run for 3 minutes;
4) All the water and fibres were slowly poured into the matrix;
5) The mix was stirred for 4 minutes;
6) Mixing was stopped for 2 minutes;
7) The mix was then stirred for a further 3 minutes before being poured and cast into oiled steel moulds.

IV. EXPERIMENTAL INVESTIGATION
4.1 Compressive strength
Preparation of specimens and testing was done as per IS: 516-1959. The compression test was carried out on a cubical specimen of size 150mm in a compression testing machine of capacity 2000kN at a loading rate of 14N/mm² per minute. The maximum load taken by the specimen was noted and the compressive strength was obtained by dividing maximum load by area of the cross section of specimen. Fig.1 shows the setup of cube compression test. Average compressive strength for 28 days is shown in Fig 4.

Compressive strength = \( \frac{P}{A} \) (MPa)

Eqn (4.1)

Where,
\[ P = \text{load at failure (N)} \]
\[ A = \text{cross sectional area of specimen (mm}^2) \]
4.2 Splitting tensile strength
Cylindrical specimen of diameter 150mm and height 300mm were tested for determining the splitting tensile strength as per IS 5816:1999 specification. The test was carried out by placing the cylindrical specimen horizontally between the loading surfaces of compression testing machine and the load was applied continuously without shock at the rate of 1.2N/mm²/min to 2.4N/mm²/min specimen splits in to two along the vertical diameter. Fig 2 shows the set up of splitting tensile strength of cylinder. Average splitting tensile strength for 28 days is shown in Fig 5

Splitting tensile strength = \( \frac{2P}{\pi DL} \) (MPa) ………………….. Eqn (4.2)
Where,

\[ P = \text{load at failure (N)} \]
\[ D = \text{diameter of the cylinder (mm)} \]
\[ L = \text{length of the cylinder (mm)} \]

4.3 Flexural strength
Beam specimen of size 500mm ×100mm × 100mm was tested for determining the flexural strength as per IS 516:1959 specifications. Centre and one third distance from either supports were marked on the specimen. The specimens were placed on the steel rollers resting on the bed of the testing machine. The load was then applied at the rate of 1.8kN per minute without shock. The breaking load and appearance of the fractured faces of concrete were noted. Fig 4.8 shows the test set up of flexural strength test on beam specimen. The fracture took place within the middle third of the span. Average flexural strength for 28 days is shown in Fig 6

Flexural strength = \( \frac{Pz}{bd^2} \) (MPa) ………………….. Eqn (4.3)
Where,

\[ P = \text{maximum load at failure (N)} \]
\[ b = \text{width of specimen (mm)} \]
\[ d = \text{depth of specimen (mm)} \]
\[ z = \text{span of the specimen (mm)} \]
4.4 Casting of long beams

3 numbers each of structural beams (1200mm×100mm×150mm) with 0% and 0.4% (optimum) of hemp fibres were cast and tested on 28th day. Using wet mixing technique fibres were mixed to the concrete randomly. The cast beams are shown in fig. 7. The beam specimen was provided with main reinforcement of 10 mm diameter rods and shear reinforcement of 8 mm diameter rods at 90 mm center to center.
4.5 Testing of self cured RC long beam specimen

The beam specimens were cured in water for 28 days and tested for flexural behaviour. Two-point loading was applied to the beams until failure occurs. The test results of the self cured hemp fibre reinforced concrete beams were compared with those of the beam specimen without hemp fibres. The test setup is shown in Fig. 8.

The ultimate load and first crack load were obtained for all the beams and the flexural strength was calculated as in Table 7.

<table>
<thead>
<tr>
<th>Type of beam and dosage of fibres</th>
<th>First crack load (kN)</th>
<th>Ultimate Load (kN)</th>
<th>Deflection (mm)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Control beam</td>
<td>20</td>
<td>45</td>
<td>5.7</td>
</tr>
<tr>
<td>0.4% Hemp</td>
<td>23</td>
<td>55</td>
<td>4.9</td>
</tr>
</tbody>
</table>

V. RESULTS

By studying the mechanical properties of specimen the optimum of hemp fibre was obtained as 0.4% by weight of cement. The beams were kept in simple supports and two-point load was applied through load cells. The mode of failure, first crack load, ultimate load and deflection were recorded for control beam and beams with hemp fibres of optimum dosage 0.4%.

VI. CONCLUSION

Based on the study of the results obtained from the experimental investigations, the following conclusions were made:

a) Study of mechanical properties proves that Hemp fibre improves compressive strength, flexural strength and splitting tensile strength as compared with control specimen by over 12.60%, 15.30% and 20% respectively.

b) From the flexural study done on long beams it was observed that the load capacity of optimum (0.4%) hemp fibre reinforced concrete beams increased by over 22% with respect to control beam with 0% hemp content.

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REFERENCE


