Effect of Bamboo Fibers in Fresh and Hardened Properties of Self Compacting Concrete

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Abstract

Background/Objectives: An attempt has been made in the present investigation to assess the outcome of bamboo fibers on strength behaviour of FRSCC. An innovative natural plant bamboo fiber, having numerous benefits such as economical, low density, environmental-friendly, sustainable and biodegradeble. Bamboo fibers extracted by using mechanical method was used in this study. Methods/Statistical Analysis: Proportion of mix of SCC has been arrived by trial and error method. Nine trial mixes were investigated totally, keeping w/c quotient constant for all mixes and variation parameter is percent-age of weight fraction of (0.25, 0.5, 0.75, 1 and 1.25 %) of bamboo fibers (l/d ratio = 40) of 4.9 mm length to the weight of cement. Finally, 18 cubes, 18 cylinders and 18 beams casted, out of which 15 are BFRSCC beams, 3 are control beams without fibers made with SCC. Findings, Applications/Improvements: The outcome of using bamboo fibers in the strength behavior in compression, split tensile and the flexural had studied. The maximum enhancement in compressive and split tensile strength for 28 days was observed to be 43.2 N/mm² and 6.9 N/mm², hence optimum fiber content is 1% for aspect ratio of 40. The addition of bamboo fibers also make concrete much resistive in flexure and for 28 days maximum improvement was resulted 8.1 N/mm², consequently addition of bamboo fiber content increases the flexural strength.

Keywords: Bamboo Fiber, Fiber Reinforced Concrete, Performance, Self-Compacting, Strength

1. Introduction

SCC is now an emerging technique in the field of concrete technology and an innovative idea to tackle the difficulty of concreting through heavy reinforcement. It is exclusive, because of its characteristics like pickup ability, flow ability, pump ability, and make production of concrete more industrialized. Its necessary to develop a compaction free construction system by reducing the overall expenditure of the project, which improves the quality of work and provide safety in the work environment.

SCC makes an industrialized production, decreases the cost of in site cast construction, enhance quality, durability, consistency of concrete and eradicate few of the potential for human made mistake and substitute the physical compaction of fresh concrete with a advanced semi-automatic placing technology which improve health, safety around and in the construction site.

The concept of fibers in a brittle mix was first recorded with Egyptians who used a hair of animals and straw as reinforcement for bricks and walls in housing. These fibers will provides the various mechanical properties and design applications. Now a days, natural plant fibers are widely in use for engineering fields as replacement for manufacturing fibers. However less potential is required to raise those fiber productions on the earth because of less area to grow for such natural plants. For that the solution is Bamboo, which is having the characteristics of both grass and wood. Also it is extremely strengthy in its longitudinal track due to muscular fiberbundle.
2. Experimental Investigations

2.1 Materials

2.1.1 Cement

Ordinary Portland cement-53 grade has been used in this study. As per IS 4031:1988 its tested and confirm to IS 12269:2004. Table 1 represent the cement Physical characteristics.

### Table 1. Physical characteristics of cement (OPC 53 grade)

| Sl. No. | Properties            | Test Method                        | Test Results | Limitations As per IS 12269-2004 |
|---------|------------------------|------------------------------------|--------------|-----------------------------------|
| 1       | Normal Consistency in (%) | Vicat Apparatus (IS: 4031 Part-4) | 33%          | 30 - 35%                          |
| 2       | Specific Gravity       | Sp. Gr bottle (IS: 4031 Part-4)    | 3.12         | ≤ 3.15                            |
| 3       | Initial Setting Time   | Vicat Apparatus (IS: 4031 Part-5)  | 40 Min       | > 30                              |
| 4       | Final Setting time     |                                    | 220 Min      | < 600                             |
| 5       | Fineness of cement     | Sieve test on 90μSieve (IS: 4031 Part-1) | 5.00%     | < 10%                             |

### Table 2. Physical characteristics coarse aggregate

| Sl. No. | Physical Properties          | Results                  | Code of Reference                  |
|---------|------------------------------|--------------------------|-----------------------------------|
| 1       | Specific gravity             | 2.65                     | IS 2386 part 3-1986               |
| 2       | Water absorption             | 0.15%                    | IS 2386 part 3-1986               |
| 3       | Bulk density (kg/m3)         | 1366(loose)1439(rodded)  | IS 2386 part 3-1986               |
| 4       | Finess modulus               | 2.81                     | IS 2386 part 2-1986               |
| 5       | Impact value                 | 9.76%                    | IS 2386 part 3-1986               |
| 6       | Loss angles abrasion         | 35.4%                    | IS 2386 part 3-1986               |
| 7       | Flakiness index              | 14.06%                   | IS 2386 part 3-1986               |
| 8       | Elongation index             | 62.4%                    | IS 2386 part 3-1986               |
for all mixes of concrete. Table 2 represent the coarse aggregate Physical characteristics.

### 2.1.3 Fine Aggregates
The size of aggregate smaller than 4.75 mm, considered as fine aggregate. Crushed and rounded sand of Siliceous and calcareous sand can be used where content should be in the range of 25% to 20% of the total volume of the mixture. Its acts as extremely important role in the turn down of separation. Locally obtainable sand pass in 4.75 mm sieve was used for all the mix. The aggregates used were conformed to zone II according to IS: 383-1970. Table 3 represent the Physical characteristics of Fine Aggregate.

### 2.1.4 Super Plasticizer (SP)
The chemical admixture used to develop workability of the fresh state of concrete without using any additional water. The commercially available brand Glenium B233 was used in the current study. Table 4 represent the characteristics of Glenium B233 (Super plasticizer).

#### Table 3. Physical properties of fine aggregate

| Sl. No. | Physical Properties | Results | Code of Reference |
|---------|---------------------|---------|-------------------|
| 1       | Specific gravity    | 2.5     | IS 2386 part 3-1963 |
| 2       | Finess modulus      | 2.81    | IS383-1970        |
| 3       | Bulking             | 10%     | IS 2386 part 3-1963 |
| 4       | Bulk density        | 1432(loose)1600(rodded) | IS 2386 part 3-1963 |

#### Table 4. Properties of glenium B233 (Super plasticizer)

| Parameters                        | Results                  | Specifications(as per IS 9103) |
|-----------------------------------|--------------------------|-------------------------------|
| Physical state                    | Light brown liquid       | Light brown liquid            |
| Chemical name of active Ingredient| Polycarboxylate Polymers | Polycarboxylate Polymers      |
| Relative density at 25 C          | 1.083                    | 1.08±0.02                     |
| Ph                                | 6.92                     | Min.6                         |
| Chloride ion content (%)          | 0.0079                   | Max 0.2                       |
| Dry material content              | 34.58                    | 34 (±5%)                      |
2.1.5 Bamboo Fibers

Bamboo fibers are natural fibers that are extracted from the bamboo tree and used as replacement for natural fiber have several benefits such as low price and density, environmental friendly, sustainable and biodegradable. In this study bamboo fibers are extracted by using mechanical method was used. Scanning electron microscopy test has been conducted to find the micro structure of bamboo fibers and failure analysis as well as the diameter of bamboo fiber. Different stages of bamboo fiber extraction was shown in the Figure 1 to 5.

![Figure 1. Different ages of raw bamboo.](image-url)
Figure 2. Longitudinal striped bamboo.

Figure 3. Longitudinal striped bamboo under roller.
3. Result

In the current studies an attempt has been made to determine the effect of bamboo fiber by examining their fresh and hardened state characteristics and tabulated in tables and figures. The compression machine with capacity of 200 tonnes was used to measure compression and split tensile strength test.

3.1 Fresh Properties of SCC

Slump value varies from 655 mm for normal self compacting concrete to the 720 mm for 1.25% fiber content. The values of slump with corresponding fiber content is as shown in the Table 6 and the workability test which are carried out for the mixes with fiber content 0.5, 0.75, 1, 1.25 %. Its observed that outcome confirms to least and

![Bamboo fiber of diameter 1.156 mm Of aspect ratio (l/d)=40.](image1)

![Scanning electron microscoping image of bamboo fiber diameter 1.156 mm.](image2)
highest recommended values and increase of fiber content the slump flow also increased linearly. Consequently bamboo fibers are suitable for SCC as it satisfies the majority of the workability references of EFNARC.

3.2 Hardened Properties - BFRSCC

3.2.1 Compressive Strength

Test for determination of compressive strength of concrete employ a specimen of cube 150mmX150mm size and allowed be in water for 7, 14, and 28 days. The test results are shown in Table 6. As noted from the results PM3 with 1% of bamboo fibers which gives high compressive strength in the early age and little less strength in later days. Figure 6 represents a variation of the compressive strengths of normal SCC (NSCC) and other mix proportions (PM1, PM2, PM3 and PM4) with different percentage of fibers.

Table 6. Variation of compressive strength for different mix proportions

| Sl. No. | Mix  | Average Compressive Strength N/mm² |
|--------|------|-----------------------------------|
|        |      | 7 Days   | 14 Days   | 28 Days   |
| 1      | NSCC | 22.9     | 30.8      | 34.5      |
| 2      | PM1  | 26.1     | 35.2      | 39.8      |
| 3      | PM2  | 27.2     | 34.1      | 40.6      |
| 4      | PM3  | 29.8     | 38.9      | 43.2      |
| 5      | PM4  | 28.2     | 36.6      | 42.6      |

Figure 6. Variation of compressive strength for different mix proportions.
3.2.2 Split Tensile Strength
Test for split tensile strength employ specimen cylinder of 150 mm X 300 mm size which allowed to be in water for 7, 14 and 28 days and tested. The outcome of split tensile strength for different mix proportion are shown in

Table 7. Variation of split tensile strength for different mix proportions

| No. | Mix   | Split Tensile Strength (N/mm²) |
|-----|-------|--------------------------------|
|     |       | 7 Days | 14 Days | 28 Days |
| 1   | NSCC  | 2.2    | 2.9     | 4.1     |
| 2   | PM1   | 3.4    | 4.2     | 5.3     |
| 3   | PM2   | 4.1    | 5.9     | 6.2     |
| 4   | PM3   | 4.4    | 6.1     | 6.9     |
| 5   | PM4   | 4.1    | 5.8     | 6.4     |

3.2.3 Flexural Strength
Flexural test of concrete employs specimen beam of 150 mmX150 mmX450 mm size which allowed to be in water for 7, 14 and 28 days which underwent to flexure in a universal testing machine. The test outcome of flexural

![Figure 7: Variation of split tensile strength for different mix proportions.](image)
Table 8. Variation of flexural strength for different mix proportions

| No | Mix   | 7 Day | 14 Day | 28 Day |
|----|-------|-------|--------|--------|
| 1  | NSCC  | 3.6   | 4.5    | 4.9    |
| 2  | PM1   | 4.1   | 5.7    | 6.2    |
| 3  | PM2   | 5.3   | 6.7    | 7.1    |
| 4  | PM3   | 6.1   | 7.2    | 7.8    |
| 5  | PM4   | 6.6   | 7.9    | 8.1    |

Figure 8. Variation of flexural strength for different mix proportions.

strength for different mix proportion are shown in Table 8 and Figure 8.

4. Conclusion

- The bamboo fibers can be used as innovative fibers in SCC to enhance strength of concrete and improve the ductility of concrete and its post-cracking load carrying capacity.
- The strength difference between bamboo fiber self compacting concrete specimens and control self compacting concrete specimen.
- Workability of fresh state was found to reduce with an increase in the content of fiber which also
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- Adding up of bamboo fibers of 1.0% by weight cause a major enhancement in early and also long term compression and split tensile strength of concrete. The maximum improvement in 28 days strength was observed to be 43.2 N/mm² and 6.9 N/mm², hence 1% fiber addition is optimum fiber content for aspect ratio of 40 from compressive and split tensile strength view.
- The addition of bamboo fibers makes the concrete very resistant in flexure and highest enhancement in 28 days strength was observed to be 8.1 N/mm², consequently addition of fiber content increases the flexural strength.
- Nan-Su method is used for mix design of SCC, simple mix design and the dosage of chemical admixture will be determined by trial and error as substantial result of properties of fresh and hardened state.

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