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Self-Compacting Concrete with Natural Fibre Reinforcement

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ABSTRACT

This study's goal is to make SCC stronger by adding coconut fiber to the mix. Natural fibers are those that are pollution-free, eco-friendly, and have no negative impact on climate. They are the best choice. Every year, a large quantity of natural fiber waste is used as a green building material. The bio-reserves may be saved if these natural fibers are utilized in building. The inclusion of CF created a more unified final product. To get over this problem, the right amount of admixture was added without altering the product's strength characteristics. In order to find out more about the characteristics of new concrete, researchers utilized slump testing, slump flow, a V- funnel, and an L-box. SCC's compressive and tensile strengths were also studied in depth. Due to this, two kinds of SCC with coconut fiber have been developed and their test results evaluated. These SCCs are produced by adding CF at a ratio of 0.5 and 1 percent to the weight of cement, respectively.
Keywords: Fly Ash, coconut fiber, Self-compacting concrete, super plasticizer

1. INTRODUCTION

In the past decade, self-compacting concrete (SCC) has emerged as one of the most significant breakthroughs in concrete technology. SCC is a kind of concrete that can compress on its own without the need of vibration or any other external force. Even in heavily reinforced concrete members, it fills all gaps, reinforcement spaces, and fills all recesses, all the way to near-level balance with no segregation. The removal of compaction work reduces placement costs, shortens construction time, and increases productivity as a consequence of using SCC in the construction industry. The use of SCC also reduces casting noise, improves working conditions, and allows for longer placement periods in urban locations. SCC also has the benefit of improving concrete manufacturing uniformity, as well as providing a smooth surface free of blowholes and other surface flaws. However, greater productivity, shorter construction times, and improved working conditions result in lower costs when SCC is implemented properly. Flowable concrete that can consolidate under its own weight is self-compacting concrete. The compaction process doesn't need any external vibrations. In tough circumstances and portions with crowded reinforcing, SCC's fluid nature makes it an excellent choice. However, because of the large amount of powder in self-compacting concrete, it maintains its cohesion while still having excellent flow properties.

Concrete ensures the strength, durability and requires compaction of concrete. The purpose of attaining the compaction of concrete is to attain the highest possible density. The dense microstructure will result in low permeability, resistance to chloride and sulphate attacks, high strength, improved durability, and low carbonation. If in case, there is inadequate compaction of concrete, there will be a formation of voids that result negatively on "physical" as well as "mechanical properties" of "concrete".

The undertaken "concrete" material for this method is considered because of

- Eco-friendly nature of the SCCs
- Recyclable
- Availability

1.1 Workability requirements for the fresh SCC:

These requirements are to be fulfilled at the time of placing. Likely changes in workability during transport should be taken into account in production. Typical acceptance criteria for Self-compacting Concrete with a maximum aggregate size up to 20 mm are shown in Table3.5.

2. CHARACTERSTICS OF FRESH SCC

Several types of performance measures are utilized to measure the quality of proposed SCC, which helps in comparing the systems and motivating the progress. There are many features that differentiate it from other materials, including its workability, which surpasses the maximum degree of consistency defined in EN 206.

1)Ability for filling 2) Ability to passing 3) Resistance to segregation

All three of the above-mentioned criteria must be met by a concrete mix in order for it to be classed as Self-compacting Concrete.

Table 3.5: Self-compacting Concrete Acceptance Criteria.

Method	standard values	
	Minimum	Maximum
"Slump flow by Abram's cone"	0650	0800
"T50cm slump flow"	2	05
"J-ring"	00	010
"V-funnel"	06	012
"Time increase, V-funnel at T5minutes"	00	+03
"L-box"	00,8	01,0
"U-box"	00	030
"Fill-box"	090	0100
"GTM Screen stability test"	00	015
"Orimet"	00	05

3. ACCEPTANCE CRITERIA FOR SELF-COMPACTING CONCRETE

Based on our knowledge and experience, the usual criteria for each test method are shown next to each technique. Future advancements, on the other hand, may result in the adoption of other requirements. Valuations outside of If the manufacturer accepts these ranges, they may be acceptable. may show acceptable performance under certain circumstances, such as wide gaps between reinforcing, layer depths less than 500 mm, short distance between point of discharge and flow, and few obstacles to pass through in the formwork, etc. Because there is currently no easy and accurate test that can be SCC's segregation resistance was determined using this method in all practical circumstances, extra caution should always be used to ensure that the mix does not segregate. As previously stated, SCC has three distinguishing characteristics in its current state: resistance to segregation or stability, defined as the capacity of new concrete to flow freely between reinforcements in crowded areas; and filling ability defined as the new concrete's capability to fill the form with its own weight; and filling ability defined as the c of fresh concrete to fill the form with its own weight and pass-through congested spaces between reinforcements. Outlines which of SCC new tests (listed above) are performed for every property in accordance with the criteria that are followed. The ASTM has standard recommendations for all of the tests, with the exception of the L-Box and Caisson tests, which are included in PCI's Interim Recommendations (PCI 2003), and the V-funnel test, which is included in EFNARC's guidelines for using SCC (see above) (EFNARC 2006).

4. MATERIALS USED FOR EXPERIMENTAL PROGRAMME

- **Cement:** Ordinary Portland cement of 53 grade was used and tested for physical and chemical properties as per IS: 4031 – 1988 The physical characteristics of the cement are as follows: consistency (37%), specific gravity (3.23), initial setting time (5 minutes), final setting time (355 minutes), fineness (1 percent residue) by sieve test, and soundness (1.5 mm).
- **Coarse Aggregate:** The crushed coarse aggregate of 20 mm maximum size rounded obtained from the local site is used in the present study whose Specific gravity is 2.60. Natural crushed aggregates from a quarry (gravel) with particle sizes ranging between 12.5 mm and 20 mm were utilized in this project. The physical findings of "coarse aggregates" were evaluated related to the International Standard IS: 2386. The IS code of practice, as mention in Table 4.5, describes the characteristics of "coarse aggregate". Specific gravity is 2.78, the impact value is 17.18 percent, the crushing value is 21.46 percent, the water absorption is 1.56 percent, the abrasion value is 24.4 percent, the fineness modulus is 5.25, the void ratio is 45.61 percent, and the bulk density is 1610 kilograms per cubic meter.
- **Fine Aggregate:** It was decided to utilize locally accessible sand brought from nearby river having its particle size of less than 4.75 mm, which corresponded to "grading Zone III of IS 383-1970". In accordance with IS 2386- IS code for "Methods of Test" for "Aggregates", the physical properties of sand has determined, and the following outcomes were drawn: 4.75mm maximum size, 1696kg/m3, specific gravity 2.62, water absorption (percentage) 1.37, fineness modulus 3.39, and a void ratio of 37.59 percent are all measured in kg per cubic meter.
- **Super Plasticizer:** Superplasticizer was used to obtain sufficient workability for the mixes of low water to cement ratios. It was a Sulphonated Naphthalene formaldehyde type of super plasticizer. Master Glenium Sky 8233, BASF Chemical Company Limited, Mumbai, provided the superplasticizer (HRWRA) with specific

gravity 1.220-1.225, pH > 6, Aspect Light Brown Liquid, and Relative Density 1.08 + 0.01 at 25°C. (According to the manufacturer's manual)

- **Fly Ash: -** Fly ash in appropriate quantity is to be added to improve the quality and durability of SCC and was used as cement replacement material In this application, fly-ash (Class-F) in accordance with "IS 3812 (Part I)" has been utilized as a partial substitute for "cement" to save costs. The typical chemical components found in class C fly-ash are listed in Table 3.8. Silica (SiO_2) accounts for 63.53 percent of the total chemical composition of fly ash, with Alumina (Al_2O_3) accounting for 27.40 percent, Calcium oxide (CaO) accounting for 1.26 percent, Ferric oxide (Fe_2O_3) accounting for 3.67 percent, Potassium oxide (K_2O) accounting for 0.85 percent, Magnesium oxide (MgO) accounting for 0.35 percent, Sodium oxide (0.19 percent), Phosphorus pent
- **Coconut Fibres:** Fibers are tiny bits of reinforcing material that have certain characteristics that distinguish them from one another. They may be characterized by a simple parameter known as the "aspect ratio," which is the ratio of the length to the diameter of the object being described. Coconut fiber has the following characteristics: density 1.2 g/cm3, water absorption 130-180 percent, tensile strength 175 MPa, aspect ratio 125, and diameter 0.02 mm.

5. TESTING PROGRAM

Mixing of relative quantity of the different ingredients used in concrete may be established with the goal of achieving a significant strength while doing it in the most cost-effective manner is called "Concrete mix design". This examination has been carried out in as per "IS: 10262-2009" for preparation of M60 grade of concrete

5.1 Mix Design

The proportions of the mix employed in this investigation were as follows: "1: 1.83: 2.51: 0.3 (C, FA, CA, w/c)" and "1:1.83: 2.51: 0.27 (C, FA, CA, w/c)" At 28 days. Intended mean strength for this case is 48.22 MPa, according to the manufacturer.

5.2 Test Methods of Fresh SCC

Slump flow test
V- funnel test
L- box test

Results For Test Methods

SCC Type	Slump flow	V Funnel	L Box
0% Fiber	3 sec.	9 sec	0.86
0.1% Fiber	4.1 sec.	10 sec	0.83
0.3% Fiber	4.5 sec.	12 sec	0.85
0.5% Fiber	4.3 sec	11 sec	0.84

5.3 Test Specimens

Compressive strength was determined using specimen of "size 150 mm x 150 mm x 150 mm", tensile strength was determined using round beams of "size 150 mm diameter and 3000 mm long", modulus of elasticity was obtain using cylinders of size 100 mm x 500 mm, and flexural strength was determined using reinforced concrete (R.C.) beams of "size 150 mm x 250 mm and 3000 mm", and modulus of rupture was determined using cube. All specimens are made by M30 grade of SCC, Among the 18 cubes and 9 cylinders, 6 cubes and 3 cylinders were made by M30 grade of SCC with 0% of natural fibre to the weight of cement, 6 cubes and 3 cylinders were made of 0.1% of natural fibre, and the remaining 6 cubes and 3 cylinders were made of 0.3% of natural fibre to the weight of cement.

6. RESULTS FOR COMPRESSIVES TRENGTH

A total of four specimens were tested to determine the compressive strength of fiber content (0 %, 0.1 %, 0.3 %, and 0.5 %) in volume fractions, with fiber content being measured at four different levels. Compared to control concrete, there is an increase in strength in volume fractions with a coir fiber content of 0.3 percent, followed by a reduction in strength after that, although the strength of all coir fiber specimens has increased when compared to control concrete. The specimens were evaluated for strength after "3, 7, 28, 90, and 180 days" of curing to determine their overall strength. In comparison to control concrete at twenty-eight days, 11.06 percent, 19.0 percent, and 25.0 percent increases in compressive strength were seen. In comparison to control concrete at twenty-eight days, the percentage improvements in compressive strength were observed.

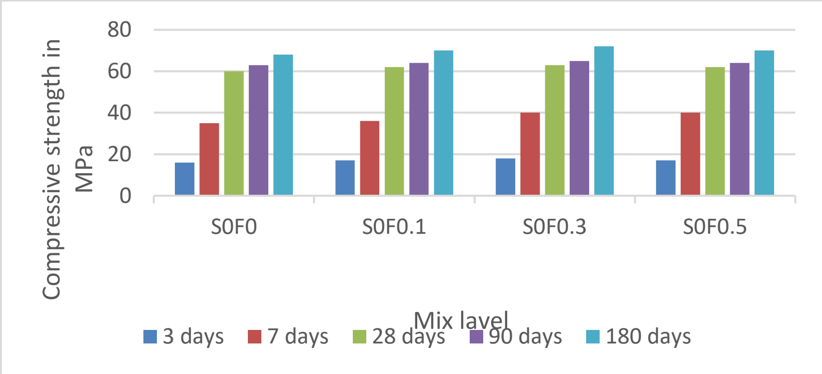

Figure 1 Effect of coir fiber on compressive strength at different curing ages

7. RESULTS FOR SPLIT TENSILE STRENGTH

Three specimens were examined to determine the split tensile strength with varying coir fibre contents (0 %, 0.1 %, 0.3 %, and 0.5 %) in volume fractions (0 %, 0.1 %, 0.3 %, and 0.5 %). Figure 5.12 shows that as the concrete's fibre content rises, so does its split strength. . Adding coir fibre to HSC in volume fractions up to 0.3 percent resulted in the greatest increase in strength when compared to control concrete at 3, 7, 28, 90, and 180 days. However, after 0.3 percent of fibre content in volume fractions, there was a decrease in strength that was higher than that of control concrete at "3, 7, 28, 90, and 180 days". At 28 days, 90 days, and 180 days, it exhibited a rise of 30.44 %, 32.96 %, and 39.33 %, respectively.

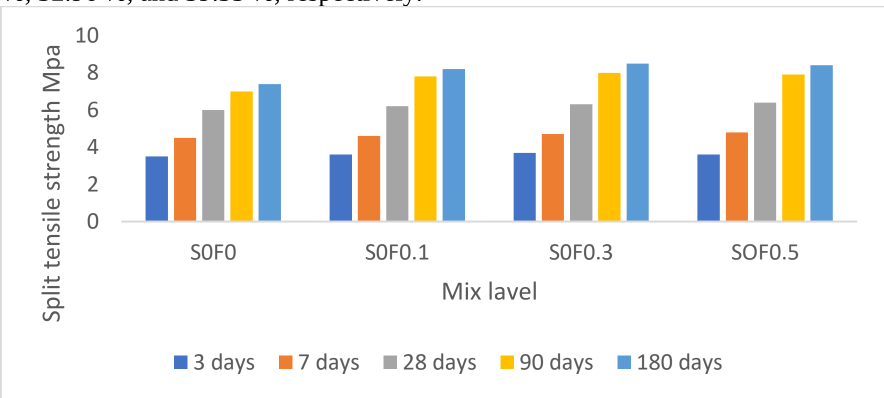

Figure 5.12 "Effect of coir fiber on Split tensile strength at different curing ages".

8. CONCLUSION

- The properties of coconut fiber reinforced concrete, compressive strength and tensile strength of concrete is investigated experimentally using the standard procedures.
- With respect to compressive strength, incorporating a small amount of CF 0.3% enhance the performance of concrete, as expected and counters harmful shrinkage effects in concrete.
- It was discovered that compressive strength at 0.3 percent fiber content in volume fractions was higher than the value obtained at 0 percent fiber content and also higher than the value obtained at 0.5 percent fiber content.
- The average split tensile strength of cubes that have been partly or completely replaced with recycled aggregate increases with the percentage of coir fiber used, which may reach 0.3 %.
- Adding coir fiber to HSC in volume fractions up to 0.3 percent resulted in the greatest increase in strength when compared to control concrete at 7, 28, 90, and 180 days. After adding 0.3 percent of fiber content in volume fractions, however, the maximum increase in strength was achieved when compared to control concrete at "7, 28, 90, and 180 days.
- In comparison to the control beam, the coir fiber reinforced beam, which contains just 0.3 percent coir fiber in volume fractions, exhibits a significant improvement in resilience; the percentage increase compared to the control beam is 31.76 percent.
- Comparing the experimental beam with 0.3 percent coir fiber content to the control beam, the highest increase in first crack, yield, and ultimate load was determined to be 24.67 percent, 18 percent, and 26.57 percent, respectively, when the control beam was used.

- When comparing the HSSFRC beams to the control beam, it can be seen that the deflection of the HSSFRC beams increases with increasing fiber content at all load levels.
- The optimal fiber volume fraction was determined to be 0.3 percent. Only the flexure mode caused all of the beams to fail. Under static and repetitive loading, high-strength fiber-reinforced concrete (HSSFRC) beams with a 0.3 percent fiber volume fraction demonstrated better load bearing capability, maximum increase in energy, and deflection ductility.
- The ultimate load carrying capacity of HSSFRC (0.3 percent fiber) beams was found to be 131.78 percent higher than the theoretical value, while the repeated load carrying capacity was found to be 165 percent greater than the theoretical value under experimental conditions.
- The experimental moment capacity of HSSFRC beams (0.3% fiber) was 101.78% greater under static loading and 131% greater for repeated loadings compared to theoretical value of control beam.

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