REVIEW OF RESEARCH
ISSN: 2249-894X
IMPACT FACTOR : 5.7631(UIF)
VOLUME - 13 | ISSUE - 8 | MAY - 2024

OPTIMIZATION OF COCONUT FIBER REINFORCED CONCRETE: EXPERIMENTAL ANALYSIS OF COMPRESSIVE STRENGTH, ULTRASONIC PULSE VELOCITY, AND WORKABILITY

Ranganath T V L[1] and N. Syed Aleem[2]
[1 and 2] Lecturers, Civil and Architectural Engineering Section,
Department of Engineering, Higher College of Engineering,
University of Applied Science and Technology, Muscat, Sultanate of Oman.

ABSTRACT :

Although the concrete is strong in resisting the compressive stresses, it is weak in bearing the tensile stresses. Various fibers both natural and artificial fibers can be added to the concrete to improve the ductility of concrete. In the present investigation the concrete mix M40 was designed as per the IS standards. Different percentage of coconut fibers 0%, 0.5%, 1.5% and 3% were added to study the behavior of concrete. Slump test was carried out on fresh concrete to know the variation of workability of various mixes and destructive test like compression test was carried to understand the compressive behavior of concrete. Further nondestructive test like Ultrasonic pulse velocity tests were conducted. The results and compiled and conclusions are drawn and reported.

KEY WORDS: *Concrete mix design, Coconut fiber, Compressive strength and Ultrasonic Pulse velocity.*

1. INTRODUCTION

Concrete is the most extensively used building material in the world and about 7.3 billion m^3 of concrete is used worldwide every year. The benefits of using the concrete in civil engineering structures is its immense compressive strength, durability, cost effectiveness, hardness of dried concrete, ease of its mouldability etc. As concrete is made of natural brittle materials and the concrete is made up of different aggregates, the tensile strength of concrete is substantially less compared to its compressive strength. Microscopic cracks are developed in the concrete when the applied tensile stresses exceed the tensile strength of concrete, and this leads to change in the material properties of the concrete even before the crack begins to appear. This causes voids inside the concrete.

One of the methods to improve the tensile strength of concrete is addition of fibers to the concrete. The addition of fibers to the concrete also improves other properties of concrete such as tensile strength, impact resistance, abrasion resistance, shatter resistance, post-cracking ductility and strain capacity. Both natural fibers and synthetic fibers like polyester can be added to the concrete. Coconut fiber, Cotton, Coir, Sisal, Sugarcane pulp, Banana, Bamboo, Jute, Wood, Vegetables, Bagasse, Rice husk, Flax, Kenaf are some of the natural fibers that can be added to enhance the properties of concrete. The natural fibers are cheap and locally available in nature. Many a times addition of natural fibers will help the sustainability of environment. Among all the natural fibers the coconut fiber will improve the toughness of the concrete.

In the present investigation, an attempt has been done to study the improvement in the behavior of concrete by adding 0.5%, 1.5% and 3% of coconut fibers.

On this concrete the slump tests were conducted. The slump test results indicate the workability of concrete. The workability of the concrete is the ease with which the concrete can be mixed, transported, placed, and compacted. If the concrete is workable a least amount of energy is required to handle the concrete.

The compressive strength tests were conducted on the cubes made of these concrete with varying percentage of coconut fibers.

Further the Ultrasonic Pulse Velocity which measures the propagation of sound waves through the concrete is measured. The UPV results indicate the quality of concrete.

2. PROPERTIES OF MATERIALS AND COCONUT FIBER

The materials used for the casting of beams are cement, fine aggregates, coarse aggregates, water and coconut fibers.

2.1 Concrete Mix Design.

With the locally available materials and as per IS 10262-2019 the concrete mix was designed and concrete cubes of 150 x 150 x150 mm were prepared. The Characteristic cube compressive strength of concrete designed was (F_c) 30 N/mm^2.

The quantities of materials for different cubes are as shown in the Table 1 given below:

Table 1Mix proportion of concrete.

Mix designation	coconut fibers	Fine aggregate (kg)	Cement (kg)	coconut fibers	Fine aggregate (kg)	Coarse aggregate (kg)	Water (kg)
Mix 1 Control 0%	0	100%	6.467	0	8.51	10.41	3.03
Mix 2	0.5%	99.5%	6.467	0.042	8.46	10.41	3.03
Mix 3	1.5%	98.5%	6.467	0.12	8.38	10.41	3.03
Mix 4	3%	97%	6.467	0.2	8.25	10.41	3.03

2.2 Coconut Fiber properties

The coconut fiber that was used in the investigation was obtained from the outer part of the coconut. These coconut natural fibers look like hairs and contain fine particles that resembles sand particles. These particles are brown in color and light in weight.

Figure 1 Natural Coconut Fibers

3. CONCRETE MIXING AND PREPARATION OF SPECIMENS.

At the first stage the cement, fine aggregates, and coconut fibers are mixed in dry condition and then coarse aggregates and water are added to prepare the concrete.

The control concrete with no coconut fibers is prepared and the three mixes with 0.5%, 1.5% and 3% coconut fibers are respectively prepared.

Figure 2 Fine aggregates mixed with coconut fiber.

3.1 Mixing procedure:

1. Arrange all the ingredients of the concrete- Cement, fine aggregates, coconut fibers, Coarse aggregates, and water.
2. Scale all the ingredients' quantities.
3. All the ingredients will be mixed manually or by using a blender. Slump test was conducted.
4. The concrete mixture will be put on the cubes.
5. All the above steps will be repeated for 3%, 1.5%, and 0.5%.

4. PREPARATION OF TEST SPECIMENS AND TEST SETUP

4.1 Slump Test:

To study the workability of concrete a slump test was carried out on each of the sample. The slump test not only indicates the consistency of concrete but also identifies the defects in concrete if any. The slump test is commonly used in laboratories because of its simple apparatus and the simple procedure of conduction.

Slump test on 0.5% fiber concrete | Slump test on 1.5% fiber concrete | Slump test on 3% fibre concrete

Figure 3 Slump Test

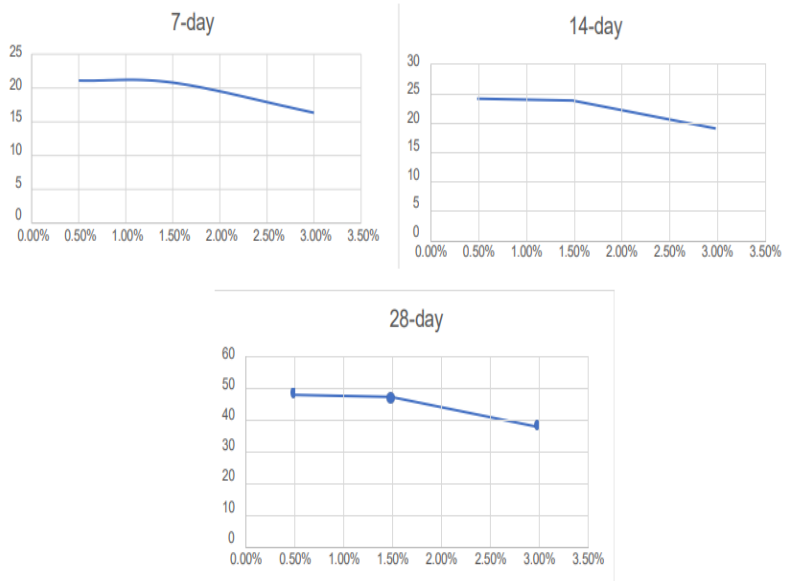
The slump test results are as follow:

Table 2 Slump Test Results

Sl. No	Type of Concrete	Slump Value in mm	Type of slump	Workability
1	Concrete with 0.5% Coconut fiber	160	True slump	Very High
2	Concrete with 1.5% Coconut fiber	95	True slump	Medium
3	Concrete with 3% Coconut fiber	10	Zero slump	Low

4.2 Compressive Test:

The cubes of size 150 x 150 x 150mm were casted with various percentages of coconut fiber were casted. These cubes were tested after 7-day curing, 14-days and 28-days curing. The cured cubes were removed out of curing tank and surface dried and then tested in compression testing machine. The loads on the specimen were gradually applied at the rate of 70 Kg/cm^2 per minute. The test results are plotted on graph and the results are as shown below.



4.3 Ultrasonic Pulse Velocity (Non-Destructive test)

Ultrasonic Pulse Velocity (UPV) is a Non-Destructive Test (NDT) conducted on hardened concrete conducted to determine the integrity and quality of concrete structure. The ultrasonic pulse velocity indicates mainly the density and Modulus of Elasticity of concrete. The pulse velocity is calculated by the formula.

$$Pulse\ Velocity = \frac{Width\ of structure}{Time\ taken\ by\ pulse\ to\ go\ through}$$

Figure 4 UPV Test

5. Test Results

The ultrasonic pulse velocity test results are compiled in the following table.

Table 3UPV Experiment Results

Part	Reading	Path Length, L (m)	Transit Time, t (µs)	Pulse Velocity (V) Km/s	Average V in Km/s
0.5%	1st	0.15	38.5	3.89 km/s	3.9 km/s
	2nd	0.15	37.4	4.01 km/s	
	3rd	0.15	34.1	3.84 km/s	
	4th	0.15	38.4	3.86 km/s	
1.5%	1st	0.15	38	3.95 km/s	3.88 km/s
	2nd	0.15	39.4	3.81 km/s	
	3rd	0.15	38.8	3.87 km/s	
	4th	0.15	38.6	3.89 km/s	
3%	1st	0.15	44	3.41 km/s	3.4 km/s
	2nd	0.15	44.1	3.4 km/s	
	3rd	0.15	44.2	3.39 km/s	
	4th	0.15	44.1	3.4 km/s	

The concrete can be generally graded based on the UPV results as

Table 4 UPV Results V/s Quality of Concrete

Pulse Velocity (km/second)	Concrete Quality (Grading)
Above 4.5	Excellent
3.5 to 4.5	Good
3.0 to 3.5	Medium
Below 3.0	Doubtful

6. DISCUSSION ON TEST RESULTS AND CONCLUSIONS

Based on the test results the following conclusions were drawn.

1. As the percentage of coconut fiber increases in concrete, the concrete becomes less workable. The workability of concrete is inversely proportional the percentage of coconut fiber (0.5%, 1.5% and 3%)
2. It was observed that the compressive strength of concrete was maximum for concrete with 0.5% coconut fiber when compared to other percentages. Further this behavior was same of 7-days, 14-days and 28-days cured concrete cubes.
3. Based on the Ultrasonic Pulse Velocity test it can be concluded that the concrete with 0.5% and 1.5% coconut fiber were good quality of concrete whereas 3% coconut fiber concrete was of medium quality.
4. Altogether, the concrete with 0.5% shows a comparative good performance.

7. REFERENCES:

1. BND. (2021). *information about coconut fiber.* Retrieved from *https://www.almrsal.com/post/1035714.*
2. Wangler, T. (2019*). Concrete. https://www.designingbuildings.co.uk/wiki/Concrete*
3. Bamigboye, G., Ngene, B., Aladesuru, O., Mark, O., Adegoke, D., & Jolayemi, K. (2020). *Compressive behavior of coconut fibre (Cocos nucifera) reinforced concrete at elevated temperatures.* Retrieved from *https://www.mdpi.com/2079-6439/8/1/5. S, S. (2017*, December 18).
4. Habibunnisa Syed, Ruben Nerella, Sri Rama Chand Madduru *Role of coconut coir fiber in concrete* Materials Today: Proceedings, www.elsiver.com/locate/matpr
5. Majid Ali *Natural fibres as construction materials,* Journal of Civil Engineering and Construction Technology Vol. 3(3), pp. 80-89, March 2012
6. Flávia Regina Bianchi Martinelli , Francisco Roger Carneiro Ribeiro , Markssuel Teixeira Marvila , Sergio Neves Monteiro , Fabio da Costa Garcia Filho and Afonso Rangel Garcez de Azevedo *A Review of the Use of Coconut Fiber in Cement Composites* Polymers-15-01309 retrived from https://polymers-15-01309.pdf

Ranganath T V L
Lecturer, Civil and Architectural Engineering Section,
Department of Engineering, Higher College of Engineering,
University of Applied Science and Technology, Muscat, Sultanate of Oman.

N. Syed Aleem
Lecturer, Civil and Architectural Engineering Section,
Department of Engineering, Higher College of Engineering,
University of Applied Science and Technology, Muscat, Sultanate of Oman.