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INCORPORATING NATURAL FIBRES FOR PRECAST SLAB PANELS

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Abstract: The addition of small closely spaced and uniformly dispersed fibres to concrete can act as a crack arrester and improves its static and dynamic properties. This is known as fibre reinforced concrete, which can also be defined as the concrete containing fibrous materials which increases its structural performance. So usage of coconut coir as a replacement material for steel reinforcement cage in reinforced precast concrete slab panel will be investigated. At the initial stage concrete cubes, cylinders and prisms were casted with different coconut coir compositions (0.5%,1.0% &1.5%) for water cement ratio of 0.3. From that it has observed that 1% of coconut coir would give the optimum result for concrete having 0.3 water cement ratio. Two sets of slab specimens as control specimen (without coconut coir) and with optimum percentage (1.0%) of coconut coir were casted and subjected to center-point line loading test (ASTM C 293) and dropping weight test (ASTM D 1557) to evaluate structural suitability and impact energy absorption of precast slab panel. Concrete permeability apparatus used to compare the water permeability between plain concrete and coconut coir mixed concrete.

keywords: Coconut coir mixed concrete, Energy absorption, Natural fibres, Permeability, Precast slab panels, Structural suitability

1. Introduction

The Portland cement concrete is a brittle material and possesses a very low tensile strength, limited ductility and little resistance to cracking. If internal micro cracks are present in concrete and due to its poor tensile strength propagation of such micro cracks leading to brittle fraction of concrete. When load is applied the internal cracks propagate and open up due to stress and additional cracks are formed. The development of these cracks is the cause of inelastic deformation in concrete. (Saandeepani and Murthy, 2013)

Basically fibres are two types as "synthetic (polymeric) fibre" made from various materials processed by chemical means and "natural fibres" processed and purified materials taken from part of the mineral, plants and animals. Natural fibres again can be divided into natural inorganic fibres such as Basalt, Asbestos etc. and the natural organic fibres such as coconut, palm, jute, sisal, banana, pine, sugarcane, bamboo etc.

Coconut coir is a natural fibre extracted from the husk of coconut that is found between the hard, internal shell and the outer coat of a coconut and also easily to obtain. Coconut coir fibre is widely used in Sri Lanka for various purpose applications such as floor mats, doormats, brushes, mattresses, etc. Coconut fibre is an abundant, versatile, renewable, cheap, lignocellulosic fibre and more resistant to thermal conductivity. As well coconut coir is relatively water-proof material and durable fibre. Even though it has advantageous properties, the coir fibre composites still have some undesirable properties such as dimensional instability, flammability which not suitable for high temperature application and degradability with humidity, ultraviolet lights, acids and bases.

In the existing industry, steel is the reinforced material regularly used throughout the world. Modern civil engineering field tends to highly concentrate on environmental friendly alternatives.

Environmental destruction such as pollution of air and water has been occurring in some regions by rapid development, production and in consequence of the consumers choosing of materials like iron, steel, glass, cement and aluminium caused to limit mineral resources. In this sense, it is obvious that coconut coir will satisfy such fundamental requirements by minimizing energy consumption, conserving non-renewable natural resources such as mineral by reducing pollution and maintaining a healthy environment. These materials can easily be found particular in Sri Lanka even for very low cost.

When it comes to the strength point of view, it is vital to be making sure that following engineering criteria would be met by these proposed materials. Individual experiments have already been carried out to check the compressive, flexural and tensile strength as well as impact energy absorption in past literature. But they have not concentrated on going for an actual application such as pre-cast slab panel using coconut fibre. Therefore, this research will approach and emphasize the suitability of those materials and take into account in the industry as an alternative for the existing steel.

Chougale, and Pimple, D., (2014) have conducted an investigation to study the possibilities to use the coconut coir fibre in addition to the other constituents of concrete and to study the strength properties. The testing of various material constituents of concrete has been carried out according to the Indian Standard specifications. To identify the effects on workability and mechanical strength properties due to the addition of these coconut coir fibres, workability tests such slump, V-B tests and the mechanical strength tests on standard specimens such as compressive strength, split tensile strength and flexural strength tests were conducted on the different aspect ratio (75 and 125). 30M grade concrete with the water cement ratio of 0.5 has been used. Figure 1 shows that the obtained results from the experiment.

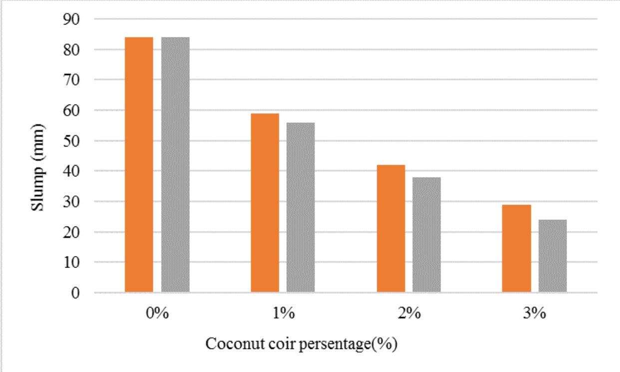


Figure 1(a): Slump vs. fibre content.

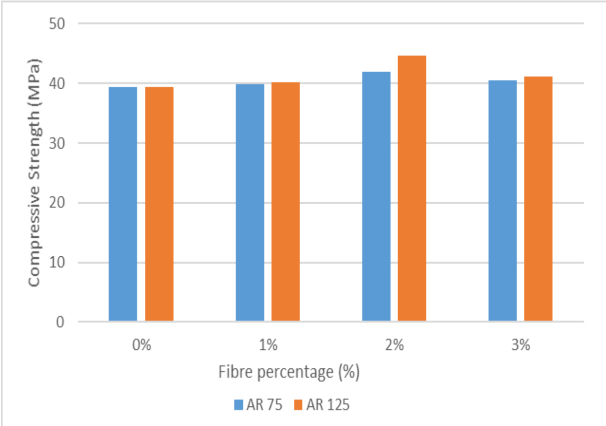


Figure 1(b): Compressive strength vs. fibre content

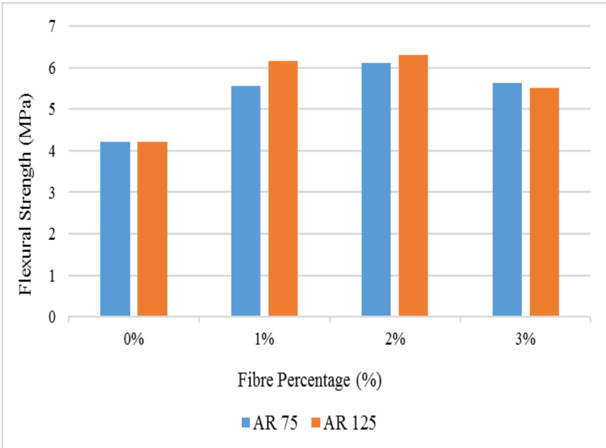


Figure 1(c): Flexural strength vs. fibre content.

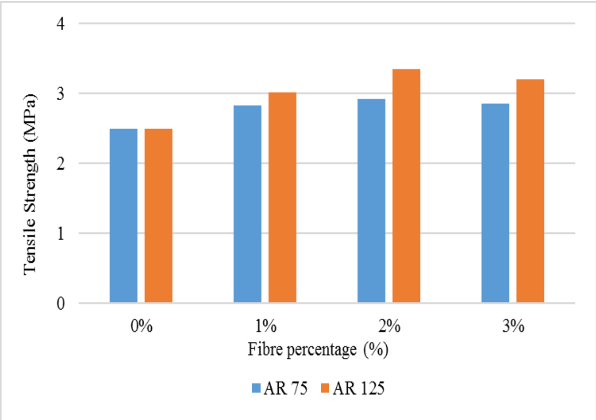


Figure 1(d): Split tensile strength vs. fibre content

2. Methodology

2.1 Sample preparation

This research is carried out in two stages. During the first stage coconut coir fibre which were found from Waligame area will be introduced to the concrete mix to obtain the optimal percentage of fibres that can achieve higher compressive strength, tensile strength and flexural strength.

Figure 2 shows the coconut coir used for the prepared samples. Figure 3 shows mixing apparatus that was used during the experiments.

Table 1 shows the sample preparation for coconut coir of adding of coconut coir of 0% which acts as the control specimen 0.5 %,1% and 1.5%of total volume for the mix.

Table 2 shows the number of test parameters to be cast to evaluate compressive, tension and flexural strength of coconut coir mixed concrete.

Figure 2: Coconut coir used for the samples

Figure 3: Mixing apparatus

Table 1: Sample Composition for Coconut Coir

Sample No	Coconut Coir fibre Diameter (mm)	Coconut Coir fibre Length (mm)	Water/Cement	Coconut Coir Percentage
C0	0.4*0.4	40±5	0.3	0
C1	0.4*0.4	40±5	0.3	0.5 %
C2	0.4*0.4	40±5	0.3	1.0 %
C3	0.4*0.4	40±5	0.3	1.5 %

Table 2: Number of test specimens of coconut coir

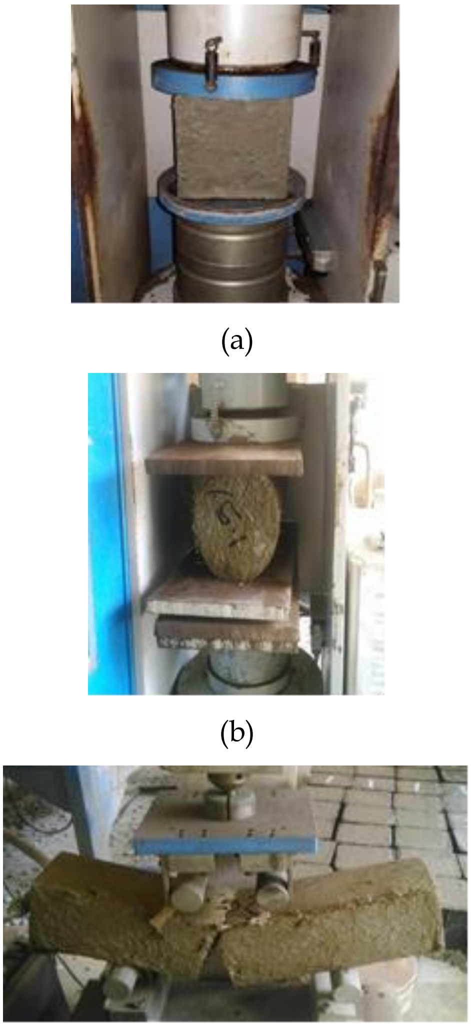
Sample No	Coconut coir fibre percentage	No. of cubes to check compression strength			No. of beams to check flexural strength	No. of cylinders to check tensile strength
		7 days	14 days	28 days	28 day	28 day
C0	0	3	3	3	2	3
C1	0.5 %	3	3	3	2	3
C2	1.0 %	3	3	3	2	3
C3	1.5 %	3	3	3	2	3

2.2 Experimental procedure

The size of the cubes and prism described in Table 3.2 is 150x150x150mm and 100 x 100 x 500 mm respectively. Cubes and prism were casted according to BS 1881-108 (1988) and cured until the testing day of the specimen. Concrete was mixed based on the mix design in accordance with BS 5328. Slump was evaluated for each set of specimen on the day of mixing before casting the cubes (BS 1881 102).

These test specimens were crushed on 7th, 14th and 28th day form they are casted. Compressive strength was measured in accordance with BS 1881 115(1988) and BS 1881 116(1988). Flexural strength was measured in accordance with BS EN 12390-5 (2000). For each mix proportion mentioned above cylindrical specimens were prepared of the size 150mm in diameter and 300mm in height.

Figure 4 shows that the testing of prepared cubical, cylindrical and prism samples inside the laboratory.



(a)

(b)

(c)

Figure 4: Testing of Samples. (a) Compression Test. (b) Split Tensile Test. (c) Flexural Test

2.3 Casting of Precast Slab Panels

Using the results obtained in the first stage of the research effect of incorporating coconut coir reinforced concrete for slab panel is checked.

Two sets of specimens were casted. One is without coconut coir as control specimen and the other one is with coconut coir. Two specimens will be casted in each set to evaluate mechanical behaviour and energy absorption capacity of coconut coir mixed concrete.

Table 3 shows the details of slab specimens that casted in the second stage.

Figure 5 and Figure 6 shows the dimensions of specimens and preparation of the slab specimens, respectively.

Figure 6(a) shows the reinforcement cage prepared with 10mm diameter tor steel bar. Figure 6(b) shows the placing of reinforcement cage with 25mm bottom cover. Figure 6(c) shows the prepared slab panels with 10mm diameter tor steel bars as the control specimen.

Table 3: Composition of Samples

Specimen	Reinforcement Bars	Coconut Coir
Reinforced concrete	10mm Tor steel at 150mm in both directions	Non
Coconut coir mixed concrete	10mm Tor steel at 150mm in both directions	1%

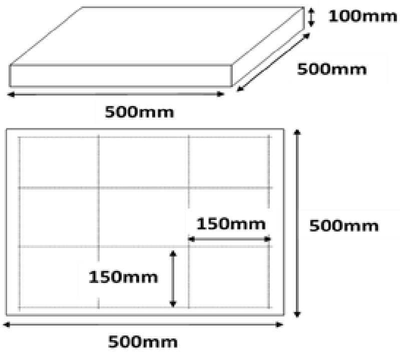


Figure 5: Dimensions of Specimens

In order to check the structural suitability of precast slab panel, flexural test and impact resistance test are performed in accordance with Centre-point line loading test (ASTM C 293) and Dropping weight test (ASTM D 1557) respectively.

Figure 7 shows that loading arrangement for flexural strength test.

(a)

(b)

(c)

Figure 6: Preparation of Samples.
(a) Reinforcement cage. (b) Placing of reinforcement cage. (c) Prepared slab panels

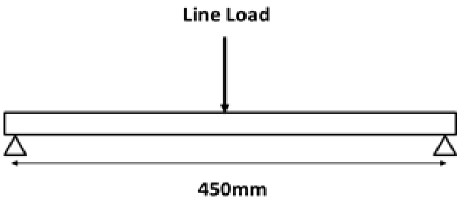


Figure 7: Loading Arrangement for Flexural Test

3. Results and Discussion

3.1 Variation of Compressive Strength with Coconut Coir Content

According to the test data obtain, there is a significant increment in the compressive strength comparing to the control specimen.

Figure 8 graphically represent the variation of compressive strength with respect to different fibre percentages.

Table 4 indicates the 7 day, 14 days and 28 days' cube compressive strength of each samples prepared inside the laboratory.

Table 5 indicates the improvement of compressive strength compared to the control specimen as a percentage.

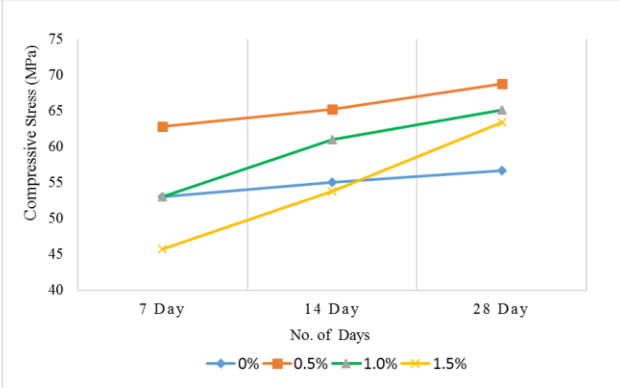


Figure 8: Variation of Compressive Strength with fiber percentage

Table 4: Cube Compressive Strength of prepared sample

Coconut Coir Percentage (%)	Compressive Strength (N/mm2)		
	7 Day	14 Day	28 Day
Control	53.03	55.02	56.66
0.5%	62.84	65.22	68.78
1.0%	53.02	61.02	65.1
1.5%	45.76	53.8	63.38

Table 5: Variation of compressive Strength

Coconut Coir Percentage (%)	Percentage of increment of compressive strength with control specimen (%)		
	7 Day	14 Day	28 Day
Control	0	0	0
0.5%	14.19	27.63	21.39
1.0%	0	10.9	14.9
1.5%	0	0	11.86

3.1 Variation of Tensile Strength with Coconut Coir Content

It can be observed that there is an improvement in the tensile strength compared to the control sample.

Figure 9 shows variation of tensile strength for different percentages of coconut coir.

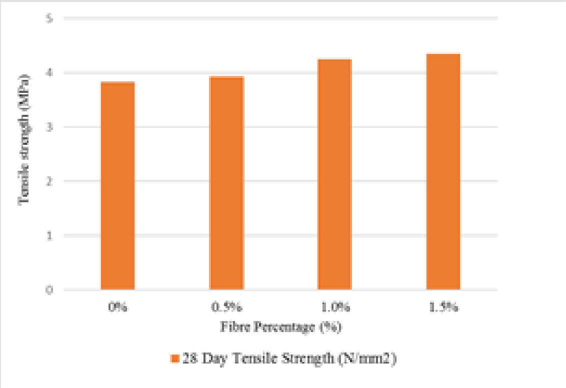


Figure 9: Variation of Tensile Strength with fiber percentage

Table 6 indicates the improvement of tensile strength compared to the control specimen as a percentage.

Table 6: Variation of Tensile Strength

Coconut Coir Percentage (%)	28 days Tensile Strength (MPa)	Percentage of increment of tensile strength with control specimen (%)
Control	3.82	0
0.5%	3.92	2.62
1.0%	4.25	11.26
1.5%	4.35	13.87

3.2 Variation of Flexural Strength with Coconut Coir Content

It can be observed that there is an improvement in the flexural strength compared to the control sample.

Figure 10 shows the variation of flexural strength for different percentage of coconut coir.

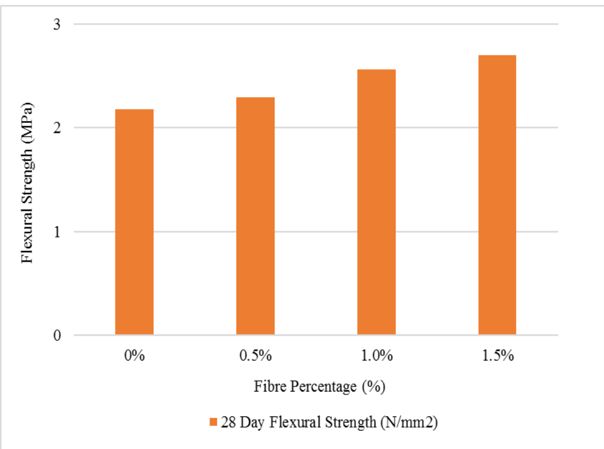


Figure 10: Variation of Flexural Strength with fiber percentage

Table 7 indicates the improvement of flexural strength compared to the control specimen as a percentage.

Table 7: Variation of Flexural Strength

Coconut Coir Percentage (%)	28 days Flexural Strength (MPa)	Percentage of increment of flexural strength with control specimen (%)
Control	2.18	0
0.5%	2.29	5.05
1.0%	2.56	17.43
1.5%	2.70	23.58

3.2 Variation of Slump with Coconut Coir Content

As the fiber is introduced to the concrete slump value of the concrete starts to reduce. The variation of the slump values with the fiber content is shown in the Figure 11

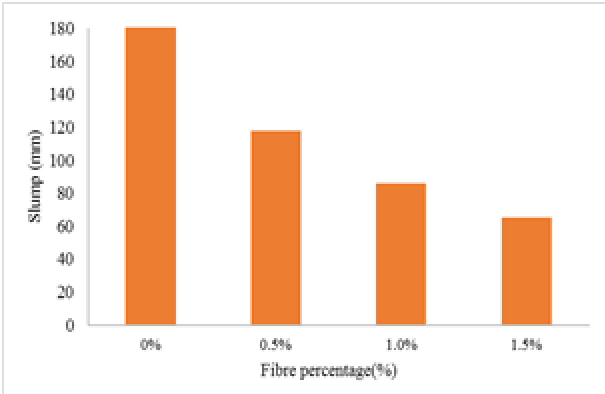


Figure 11: Variation of Flexural Strength with fiber percentage

Table 8 indicates the reduction of slump value compared to the control specimen as a percentage.

Table 8: Variation of Slump

Coconut Coir Percentage (%)	Casting day slump (mm)	Percentage of reduction of slump with control specimen (%)
Control	185	0
0.5%	118	36.22
1.0%	86	53.51
1.5%	65	64.86

According to the slump values obtained, it can be identified that workability of concrete is getting reduced with the increment of coconut coir percentage.

4. Conclusion

Compressive strength of the coconut coir mixed concrete shows some variation from the control specimen. Due to the inclusion of coconut coir in to concrete, the maximum increment in the compressive strength was 21.39 % with 0.3 W/c ratio.

Tensile strength of concrete is improved due to inclusion of coconut coir in to ordinary concrete. Due to the inclusion of coconut coir in to concrete, the maximum increment in tensile strength was 13.87%.

Flexural strength of concrete is improved due to inclusion of coconut coir in to ordinary concrete. Due to the inclusion of coconut coir in to concrete, the maximum increment in flexural strength was 23.58%.

When the fiber content increased, slump which indicates the workability of the mix is reduced. Due to the inclusion of coconut coir in to concrete, the maximum reduction in slump was 64.86% with 1.5% of fibre percentage.

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