OPENING MINDS:
RESEARCH FOR SUSTAINABLE
DEVELOPMENT

Study of the Compressive Strength of *Kitul* Palm Fibre-Reinforced Concrete Composites

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1 INTRODUCTION

Concrete is the most versatile building material that is currently in use. It is possible to cast it to fit almost any shape. Fibre-reinforced concrete can be identified as concrete which uses fibrous material to increase its structural integrity. Each of the fibre material currently in use such as steel, cellulose, glass, nylon, polyester, carbon and natural fibres lends varying properties to the fibre-reinforced concrete composites. (Ariyarathna and Bandara, 2014). The study of natural fibres has become popular due to its renewability, eco-friendly and economical nature. (Vajje and Murthy, 2013)

The aim of this research is to develop *Kitul* palm fibre-reinforced concrete composites and study the compressive strengths. The properties of the fibres were identified initially and then the mix designs were developed by varying the percentage of short, discrete *Kitul* palm fibres that are uniformly distributed and randomly oriented.

Three mix designs were developed to determine the influence of varying *Kitul* palm fibre content for the compressive strength of *Kitul* fibre-reinforced concrete composites and to compare the compressive strength with conventional concrete.

2 METHODOLOGY

2.1 Identifying the properties and characteristics of *Kitul* Palm fibre

The morphological structure and the dimensions of the fibres were investigated. The breaking force and elongation were tested according to the standard ASTM D3822. The moisture content was determined by the oven drying method using the standard ASTM D2495.

2.2 Mix Design Development

The British standard of BS 5328 Grade 20 concrete mix ratio 1: 2: 4 in respect of cement, sand and gravel was the mix design ratio selected for this development. The three mix designs were developed by adding 2.5 cm length *Kitul* fibres of 0.5%, 1% and 1.5% based on the weight of the cement. It was observed that the increase of fibre length and the volume decrease the compressive strength due to the formation of air voids. (Libo and Nawawi, 2014)

2.3 Casting Cubes for Compressive Strength Test

First the cubic moulds were prepared by cleaning and lubricating. Then they were filled with concrete in three layers. Each of the layers was compacted by applying

35 uniform blows. The excess concrete was removed from the top of mould and the top surface was finished evenly.

The formed cubes were kept for 24 hours and removed from the moulds. Then the finished cubes were submerged in a water bath for curing. The British standard BS1881-115 was used to determine the compressive strength of the specimens. The compressive strength test was carried out after 7 and 28 days. Three specimens from each mix design were tested and the average compressive strength was calculated. Figure 1 shows *Kitul* fibre reinforced concrete composite specimens de-moulded after 24 hours.

Figure 1: *Kitul* fibre reinforced concrete composites

3 RESULTS AND DISCUSION

Figure 2 shows the microscopic view of the *Kitul* palm fibres. It was observed under 40X magnification using the optical microscope.

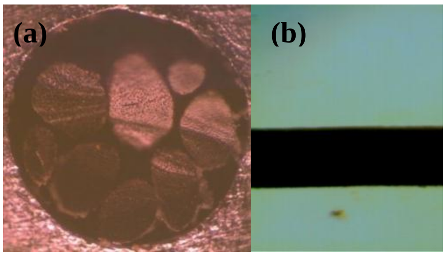

Figure 2: Microscopic view of *Kitul* palm fibres. (a) Cross sectional view (b) Longitudinal view

The cross-sectional view of the *Kitul* Palm fibres were identified as oval shaped and the longitudinal view of the fibres showed featureless evenness. This microscopic appearance cause interlock between the fibre and the matrix and the evenness helps to carry the load.

Table 1 shows the properties of the fibre. These properties influence the bond between the fibre and the cement matrix. The moisture content of the fibres helps to adhere to mortar because the mix design development process is aqua-based.

Table 1: Properties of *Kitul* palm fibre

Properties	Results
Length (cm)	65.00
Diameter (mm)	0.85
Breaking force (N)	35.67
Tenacity(cn/tex)	10.26
Elongation (%)	45.20
Moisture content (%)	14.00

The compressive strength of the mix designs was compared with grade 20 plain concrete. Therefore, the standard, compressive strength of 20 Nmm^{-2} was considered for the comparisons given below. After 7 days the compressive strength should achieve 65% from the value which is 13 Nmm^{-2}.

- Mix Design I - This was developed by using 0.5% of *Kitul* fibres for the weight of cement. The compressive strength of the specimens after 28 days shown in Table 2.

Table 2: Compressive strength test results of Mix design I after 28 days

Specimen no.	Compres. strength (Nmm^{-2})	Average compressive strength (Nmm^{-2})
1	22.0	22.1
2	23.1	
3	21.3	

After 28 days, the average compressive strength gained as 22.1 Nmm^{-2}. Hence addition of 0.5% fibres increased the compressive strength by 2.1 Nmm^{-2}

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compared to grade 20 plain concrete.
The samples were not tested after 7 days because of the very low value compared with the standard. Therefore, the test was not conducted as it does not have practical importance.

- Mix design II- 1% of *Kitul* fibres were added for the weight of cement in this development. Tables 3 and 4 show the compressive strength test results of the specimens.

Table 3: Compressive strength test results of Mix design II after 7 days

Specimen no.	Compres. strength (Nmm^{-2})	Average compressive strength (Nmm^{-2})
1	22.6	25.7
2	26.6	
3	23.5	

The mix design II displayed an average compressive strength as 25.7 Nmm^{-2} after 7 days. Therefore, the addition of 1% of fibres increased the compressive strength more than 13 Nmm^{-2} compared to conventional grade 20 concrete.

Table 4: Compressive strength test results of Mix design II after 28 days

Specimen no.	Compres. strength (Nmm^{-2})	Average compressive strength (Nmm^{-2})
1	28.6	30.1
2	32.2	
3	29.7	

After 28 days the average compressive strength of mix design II was 30.5 Nmm^{-2}. This is 10.1 Nmm^{-2} more than plain grade 20 concrete. Hence, the compressive strength of mix design II showed better results than grade 20 plain concrete.

- Mix design III- The compressive strength test results after addition of 1.5% fibres shows in Tables 5 and 6.

Table 5: Compressive strength test results of Mix design III After 7days

Specimen no.	Compres. strength (Nmm^{-2})	Average compressive strength (Nmm^{-2})
1	14	16.6
2	17.3	
3	18.6	

After 7 days the compressive strength of the development was 16.6 Nmm^{-2}. This is 3.6 Nmm^{-2} higher than the compressive strength standard of grade 20 concrete.

Table 6: Compressive strength test results of Mix design III After 28days

Specimen no.	Compres. strength (Nmm^{-2})	Average compressive strength (Nmm^{-2})
1	28.2	28.4
2	28.6	
3	28.4	

After 28 days the compressive strength of mix design III increased by 8 Nmm^{-2} more than grade 20 conventional concrete.

Figure 3 shows average compressive strength against fibre percentages.

It is apparent that the addition of *Kitul* fibres improves the compressive strength of the fibre-reinforced concrete composite. All the 3 mix designs showed increased compressive strength than grade 20 plain concrete.

From the three mix designs, the best results were obtained from mix design II of 1% *Kitul* fibres reinforced concrete composite.

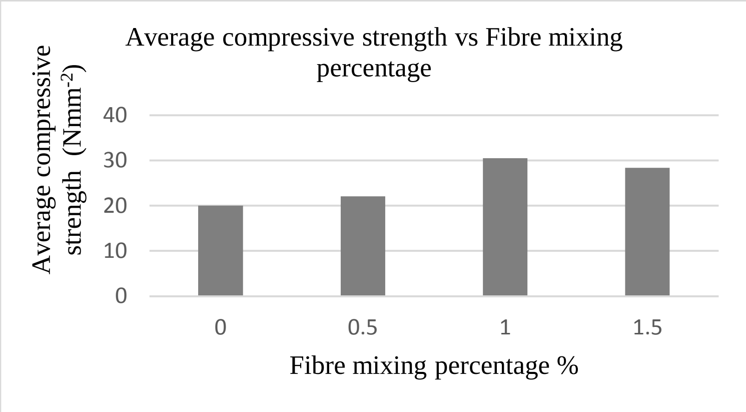

Figure 3: Average compressive strength vs. fibre mixing

4 CONCLUSION AND RECOMMENDATION

The findings of the study indicate that the addition of *Kitul* fibres to concrete improved the compressive strength. From the three mix designs, the addition of 1% *Kitul* fibres gave optimal value. Further increase of fibres decreases the strength as it causes voids, segregation and harshness of concrete and mortar. *Kitul* fibre reinforced concrete composites with 1% of fibre can be used to replace 30Nmm^{-2} conventional concrete development in the construction industry.

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