Mechanical behaviour on concrete of coconut coir fiber as additive

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Abstract. Fiber is one of the famous waste material in this country and fibre also can be used in order to increase the mechanical properties of concrete. Mechanical properties of concrete will be testing such compression strength and splitting tensile strength. Concrete has low tensile strength due to the brittleness properties. The coconut coir fibre processed by using the fabricated. Then the coconut coir fibre will be a sink in sodium hydroxide for 1 week and in pure water for 2 weeks at room temperature. The authorities that are already going through under treatment gave coconut coir fibre and it had been cut into a size of 25mm to 30mm. Three different ratios used in this research, which is 3%, 4% and 5% of coconut coir fibre as an additive to the concrete. There will be two types of specimens, which are cube size of 100mm x 100mm and cylinder 100mm diameter with 200mm length. All the samples cured in a water tank for 7 and 28days. The rate that had been using for this compression strength and splitting tensile strength follow the British Standard (BS 1881-116:1983). This research outcome is the addition of coconut coir fibre with concrete to increase the compression strength of the cube sample but it has lower strength than normal concrete. Meanwhile, for the splitting tensile strength of this reinforced concrete with coconut coir fibre as an additive has higher strength than normal concrete. The result proved that the addition of fibre will increase the mechanical properties of concrete but at the same time, it will decrease the workability of concrete.

1. Introduction
Agricultural wastes are an unavoidable by-product of most human activity. Economic development and rising living standard have led to increases in the quantity and complexity of generated waste. In Malaysia, the major agricultural crops are rubber, oil palm, cocoa, rice and coconut. Out of the total quantities of residues generated, only 27% is used, the rest is disposed of by burning. The generation of these residues poses a major disposal problem now that burning is being actively discouraged by the Department of Environmental of Malaysia [1–3]. Recently, a large demand for construction materials in the building industry has brought the need to convert wastes to useful construction materials such as bricks, which are mostly used around the world. Due to renewable and biodegradable, natural fibre has been increasingly adopted to replace man-made fibres in building materials [4]. Agricultural wastes such as banana leaves [5–7], oil palm, pineapple leaves, sugarcane bagasse [8,9], fly ash, craft pulp, coconut coir, rice husk, rice straw, kenaf [10,11], jute, hemp, corncob and sawdust were used in the production of cement-based composites. Based on the literature, the utilisation of natural fibre reinforced cement composites offer several advantages, e.g., increased flexural strength, post-crack load bearing capacity, improved bending strength, etc. [12–17]. Reis [18] stated that the use of
coconut fibres in polymer concrete shows better flexural strength than synthetic fibres. The increment in flexural strength with the addition of a low percentage of coir fibre has been reported [19]. On the other hand, research done by C. Asasutjarit et al. [20] found that moisture content, thickness swelling and water absorption increase proportionally to the increasing of coconut coir ratio.

2. Materials and methods

2.1. Mixed design
The mixture proportion of fresh concrete and waste materials produced in the laboratory are shown in Table 1 and Table 2. Mixed design for this study was using concrete grade 25 for whole samples in including normal samples and additive concretes samples. Then, a total of the cement was used are 61.56 kg, fine aggregates 90.40 kg, coarse aggregates 211 kg, and water 30.80 kg. Total of 54 samples concrete mixtures were produced for coconut coir fibre mixed, the fibre was added in a ratio of 3%, 4%, 5%.

| Table 1. Mix proportion of cube concrete. |
|------------------------------------------|
| **CCF %** | **w/c ratio %** | **CCF (kg)** | **Cement (kg)** | **Fine Aggregate (kg)** | **Coarse Aggregate (kg)** | **Water (kg)** |
| NC     | 0           | 0.5         | 0              | 0.38                   | 0.558                  | 1.302          | 0.19          |
| MC 1   | 3           | 0.5         | 0.24           | 0.38                   | 0.558                  | 1.302          | 0.19          |
| MC 2   | 4           | 0.5         | 0.49           | 0.38                   | 0.558                  | 1.302          | 0.19          |
| MC 3   | 5           | 0.5         | 0.73           | 0.38                   | 0.558                  | 1.302          | 0.19          |

| Table 2. Mix proportion of cylinder concrete. |
|---------------------------------------------|
| **CCF %** | **w/c ratio %** | **CCF (kg)** | **Cement (kg)** | **Fine Aggregate (kg)** | **Coarse Aggregate (kg)** | **Water (kg)** |
| NC     | 0           | 0.5         | 0              | 0.38                   | 0.558                  | 1.302          | 0.19          |
| MC 1   | 3           | 0.5         | 0.49           | 0.38                   | 0.558                  | 1.302          | 0.19          |
| MC 2   | 4           | 0.5         | 0.97           | 0.38                   | 0.558                  | 1.302          | 0.19          |
| MC 3   | 5           | 0.5         | 1.46           | 0.38                   | 0.558                  | 1.302          | 0.19          |

2.2. Lab testing
The concrete test carried out by using BS 1881-116:1983: Compressive Strength Concrete Specimen. There is a total of 54 samples used in which consists of 18 cube samples for compression testing and 18 cylinder samples for splitting tensile testing and 18 cube samples for density and water absorption testing. Splitting tensile strength determined by following to BS 1881-117:1983. The testing was done after cured for 7 and 28 days.

3. Results and discussion

3.1. Workability
Table 3 shows the slump test result. Workability of the concrete shows that normal concrete had higher workability compare to the concrete with coconut fibre as an additive. Workability for normal concrete is 60mm while for concrete with coconut fibre as an additive had less workability which 25mm, 30mm, 38mm with different proportion of additive.

| Table 3. Slump test result. |
|------------------------------|
| **Types of Mixture** | **Coconut Coir (%)** | **w/c** | **Slump Test (mm)** | **Types of Slump** | **Percentage of Reduction (%)** |
|----------------------------|----------------------|---------|---------------------|-------------------|-------------------------------|
There are many factors that affect the result of slump either it is true or failed slump. The higher the water content in the mixture, the higher the slump value. This is because water has a high workability. Other than that, the size of the coarse aggregate also can give an effect to the slump. The small size of coarse aggregate has high workability compare to big size. With the same water-cement ratio, for sure small size of coarse aggregate will have a good quality of workability based on the ranged. Based on the slump test result above, the higher the amount of additional fibre in the mixture of concrete, the lower the value of the workability of the concrete.

|   |   |   |   |   |   |
|---|---|---|---|---|---|
| NC | - | 0.5 | 60 | True | 100 |
| CF 1 | 3 | 0.5 | 38 | True | 54 |
| CF 2 | 4 | 0.5 | 30 | True | 49 |
| CF 3 | 5 | 0.5 | 25 | True | 36 |

**Figure 1.** (a) Normal concrete slump and (b) coconut fiber slump.

3.2. Compression strength testing

The information for ordinary cement at 7 days of compressive quality which is 18.23 MPa where 72.8% of solidity decrease which is worthy in term of 7 days of relieving. At that point, the estimation of 28 days of ordinary cement demonstrates expanding esteem, which is 30.3 MPa whenever contrasted and 7 days concrete result of the required esteem is 22.27 MPa. In this way, the quality of ordinary cement has increment specifically relative to 7 and 28 days. As referred to Raheem. et. al [21] hypothesis, it was ordinarily the concrete was expanded their quality because of the development at the relieving periods. In the course of action of cement, the bond deed as a paste, which ties together the totals to accomplish the last cast item. As expressed in Figure 2, 3% has the most noteworthy compressive quality in both 7 and 28 days, which is 19.53MPa and 24.10MPa individually. Plainly the utilization of 3% coconut coir as an added substance to the concrete upgrades somewhat concrete compressive quality for solid blend grade 25 [22]. As expressed in Figure 2, it is demonstrated 3% of the use of coconut coir is more successful as opposed to 4% and 5% of coconut coir utilised. At that point, the result of each solid for 4% and NC at 28 days are somewhat expanded which is 21.43MPa for 4% and 22.27MPa for NC.
Figure 2. Compressive strength result.

The line graph above shows that the compressive strength result is not consistent. There are many factors, which can affect the consistency of normal concrete strength. Firstly, the more quantity of fibre in concrete will make the concrete become dryer than less fibre. Since the concrete dryer, it will reduce the compressive strength. Secondly, the technique of compaction to the samples does not do properly in every sample. Next, the superficial of the concrete is one of the factors that can decrease the strength of the concrete. This is because if there a small defect on the surface of the concrete, it can give negative impacts to the strength of the concrete.

Figure 3 (a) shows the type of crack of normal concrete. The compressive of the machines to the samples are equally even on the flat surface of the concrete. The explosive occurs at the edge of the concrete cube samples. This cause by the void in the samples of the concrete. Size of the aggregate is one of the factors that produce explosive cracks. The smaller the size of aggregate, the presence of a void in the sample is decreased. Figures 3 (b) shows types of crack of coconut coir fibre concrete. All the sample had plastic shrinkage because a non-bleeding concrete will reduce the restriction provided by the under the dehydrated surface. Dampening subgrade is one of the preventive methods to decrease the presence of plastic shrinkage cracking.
3.3. Splitting tensile testing

Figure 4 shows the splitting strength result. Based on the line graph, the splitting tensile strength of normal concrete is lower than 3% of coconut coir fibre concrete. The 4% and 5% of coconut coir fibre are lower than normal concrete. This demonstrated 4% and 5% concrete is extremely weak in strain. The sample not expected can oppose the immediate strain that applied. It is demonstrated that usage of 4% and 5% of coconut coir is not successful because of cannot accomplish the maximum tensile of normal concrete.

It is because of the sample fragile nature, which is keeping the sample to oppose an applied tensile force. This may due to an abundance of usage of coconut coir, which cannot make appropriate holding in the concrete, which prompts the low shear power of the concrete. Thus, it is principal to decide the tensile force of concrete to settle the concrete individuals may break. With 2.79 MPa and 2.33 MPa, test 4% and 5% still have brought down tensile strength contrasted with normal concrete so that not successfully to be utilized in regards to a similar grade of concrete which is grade-25.

The recorded splitting tensile strength for all mixes with an expansion of CF demonstrates higher strength contrasted with the normal concrete. On can be seen in compressive strength, one might say that the expansion in the rates of CF, likewise increment the tensile strength. The expansion at age 7 days was discovered higher at 3% and low at 4% and 5% of CF. It very well may be effectively seen that 3% expansion of CF had given the most astounding splitting tensile among every one of the samples tested.

The totals bind free shrinkage of the mix and cracks are made in their vicinity. This prompts the untimely burst of the mortar, which is then proliferated the aggregates. This can bring down the shear strength of the concrete, which is prompt, the concrete to crack. Figure 4 demonstrates that the diminishing pattern of 4% and 5% which can be identified with the untimely break of the mortar on account of overabundance usage of coconut coir.
Figure 5 shows concrete with coconut coir fibre as an additive sample after being tested. There are clear indications that coconut coir fibre bonding to each other to increase the splitting tensile strength of the sample. However, when there is a large amount of fibre in concrete, it can reduce the workability of concrete since the concrete becomes drier. Coconut coir fibre plays an important role in contributing to the splitting tensile strength because it bonds closely.

3.4. Density testing

Density values for composites following 7 and 28 days of curing are shown in Figure 4.5. From the figure, the value of density has diminished with an expanding weight percent of coconut fibre. The composite cement fortified with 5% of coconut fibre has the least value, which is 1960 kg/m³ while the reference sample showed the most astounding value of around 2270 kg/m³ for 7 days.

Density values of the composites following 28 days of restoring yet demonstrating a comparable pattern of the outcome as shown following 7 days of curing. The diminishing values of density with the expansion of coconut fibre are shown in Figure 4.5. The most elevated value of density (2260 kg/m³) is given by the reference sample without coconut fibre, and the composite contains the most noteworthy measure of coconut fibre has the least value of density, which is 2120 kg/m³.
3.5. Water absorption testing

Table 4. Result of water absorption.

| Types of mixture | Coconut Coir % | Water Absorption (Kg) |
|------------------|----------------|-----------------------|
|                  |                | 7days Kg   | 28days Kg |
| NC               | 0              | 0.11       | 0.15      |
| MC 1             | 3              | 0.14       | 0.17      |
| MC 2             | 4              | 0.19       | 0.19      |
| MC 3             | 5              | 0.22       | 0.21      |

Water absorption results for composites following 7 days of relieving are shown in Table 4. Water absorption expanded with expanding weight percent of coconut fibre. The composite cement strengthened with 5% of coconut fibre has the most astounding worth, which is 0.22 kg though, the reference sample showed the least value of about 0.11 kg.

Water absorption results for 28 days of curing demonstrated a similar pattern of increment in water absorption with the expansion of coconut fibre (Table 4). The most minimal value of water absorption (0.15 kg) is given by the reference sample without coconut fibre, and the composite contains the most noteworthy measure of coconut fibre has the most elevated value of water absorption which is 0.21 kg.

From the general results of water absorption following 7 days and 28 days of curing, it was demonstrated that the water absorption expanded with expanding weight percent of the coconut fibre. It was likewise seen that by expanding the day of curing, the value of water absorption additionally diminished. The reference sample without coconut fibre demonstrated the minimal level of water absorption contrasted with the composite. In this research, both density and water absorption are contrarily relative to the expanding of coconut fibre content. The higher substance of coconut fibre in composites brought about low density, yet high in water absorption and moisture content. It demonstrates that less dense of composites have more void spaces than dense ones with the goal that more water can be absorbed.

4. Conclusion

Strength: Concrete that uses wastes coconut coir plentifully have higher strength when utilising 3% of coconut coir as an added substance in concrete and give a high estimation of the grade 25 contrasted with normal concrete with a similar grade. Compressive strength and splitting tensile strength of coconut coir fibre were decreased by 4% and 5% than normal concrete and 3% CCF.

Density: The normal concrete has a high density compared to the concrete with coconut coir fibre. For water absorption, the higher the coconut coir fibre percentage, the higher the water absorption of concrete.

5. Recommendations

- The different size of Coconut Coir Fiber can affect the strength and properties of the concrete fibre.
- The modification of mixing and water-cement ratio for the workability and properties of concrete.

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