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Utilization of Coconut Fiber Ash As Sand Aggregate Replacement For Pavement Block

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ABSTRACT

Concrete is the primary material for any construction development. One of the real segment in concrete production is aggregate which are going very high demand in present and future. To sustain construction industry, use of alternative materials to the natural aggregates has been choice. A lot of studies has been discovered in electing waste material for the production of concrete. On the other side, disposal of agriculture waste is a great problem and become challenging to find natural resources due to extreme exploitation such as coconut fiber. Luckily, coconut fiber become high potential waste material specially used as material partially replacement in concrete due to its environmentally and nearly weightless properties. In this study, the production of pavement block are made using coconut fiber ash aggregate with the variables percentage or replacement. This research aimed to analyze the variation in strengths of coconut fiber concrete at variable fiber contents and to establish it with the conventional concrete. The various strength aspects analyzed are the splitting tensile strength and compression strength of the coconut fiber concrete at variables 0%, 20% 40% and 60% sand replacement. As a result, concrete with 40% fiber aggregate has the maximum of compressive and splitting tensile strength which are 43.84 MPa and 4.83 MPa respectively on 28th days of curing. Besides that, this research aimed to evaluate sound reduction ability of the pavement block based on the percentage of replacement of coconut fiber aggregate. In this research, the sound reduction is evaluated using the noise effect system trainer in order to find out the source from the three frequencies that are low, medium and high. The result showed that the pavement block with coconut fiber aggregate at 40% of fiber content has better sound reduction percentage compare to 0% fiber content for low frequency, medium frequency and high frequency with difference of 1.9% dB, 3% dB and 3.4% dB respectively. This product act as an alternative for green technology industries.

Keywords:
Coconut fibre; compressive strength; tensile strength; sound reduction

1. Introduction

Construction of building structure usually involve two components namely sub structure and super structure. Sub structure is structure that are construct and invisible under the ground level and the super structure is the structure above the ground level. Since the industry is booming and growing upward continuously in construction, there is need to improve the quality and performance during the construction process. Nowadays, construction industry focused based on the modular coordination concept. Modular coordination is a concept of dimensional coordination, which building components are dimensioned and positioned within standardization [1]. The concept benefits of producing structure efficiently and quickly which not require resource to locate the structure on site.

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Besides, large modules can be generate in a control quality and assembled with minimum number of worker [2].

For sustainable building creation, concrete is the most popular construction and building material and become the option because it was used in all phases from starting to end of construction process. However, quarrying activity have been identify as primarily stage in production of OPC. Production of Portland cement, an essential constituent of concrete leads to the release a lot of greenhouse gas, CO_2 and other gaseous [3]. According to Idris [4], the most important characteristic of limestone when subjected to high temperature is it decomposes high and expulsion of carbon dioxide gas. There are abundantly lot of study all over the world to replace its main constituents by the wastes generated from various sources such as domestic, industrial, agricultural and others. [5]

Based on the previous study, Shakya and Jain [6] had summarized several research work regarding of utilization of coconut shell and coconut fiber in the concrete. The coconut fiber or husk act as replacement of cementitious material such as cement, coarse aggregate and fine aggregate to produce concrete. It was reported that the use of coconut fiber as aggregate could increases the mechanical properties such compressive strength and splitting tensile strength. Until now, the partial replacement of concrete by coconut fiber has improved the mechanical properties of the concrete [7].

Fiber also become the option and considered as sustainable as it contribute to lower the waste production and it raw material use. There are various research studies has been done to prove fiber as good absorption of sound when partially replace OPC in concrete. It can be concluded that coconut coir as composite of matrix and filler can benefits as noise absorber in concrete [8]. Besides, experts have performed several studies in recent years by applying natural and sustainable material for acoustic building applications like reed and gypsum panel and characterized into their types [9].

The construction industry has identified use of coconut husk in cement concrete can help in waste reduction and pollution control. As a result, it is proven that coconut husk can replaced as coarse aggregate, fine aggregate and act as reinforcement to the concrete. This paper provides an experiment studies to utilize coconut fiber ash as sand aggregate replacement by several tests such sound reduction test, compression test and splitting tensile test in form of pavement block.

2. Methodology

Coconut shell waste were collected from coconut supplier and coconut plantation. The selection of the coconut shell must be correct as the research are focusing on the use of brown fiber which are more mature than white fiber. Cleaning and drying under the sun process is ran to remove dirt and moisture content.

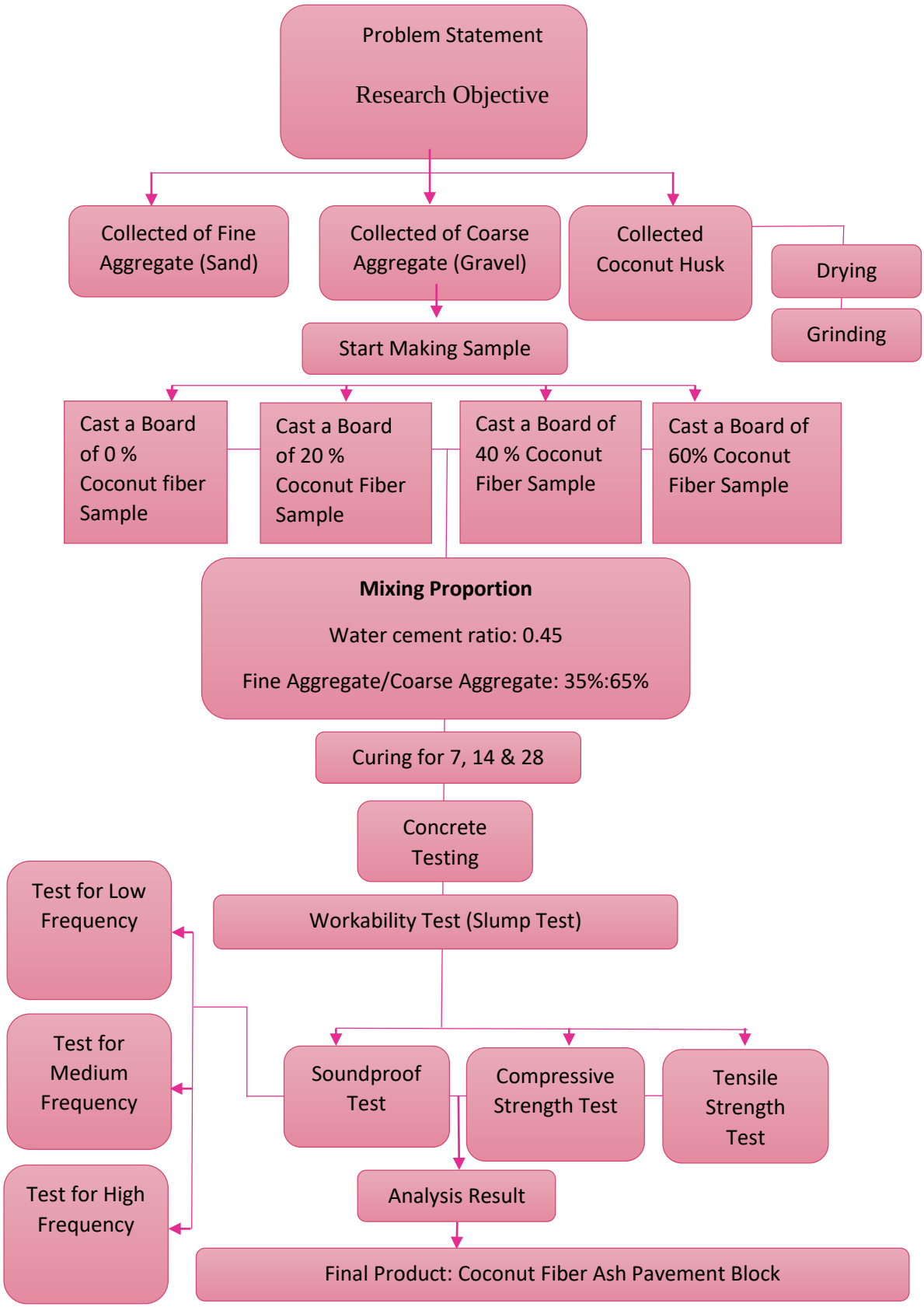

Fig. 1. Research Flow for Production and Testing on Pavement Block

Fig. 2. Coconut Fiber Drying Process

2.1 Material Used

Ordinary Portland Cement (OPC) with grade 53 was used in order to produce concrete mix. Fine aggregate used is sand and coconut fiber ash as its replacement. Sand must be not over dry and moist.

2.2 Preparation of Coconut Fiber Ash

Initially, the fiber is removed from the coconut shell and filtered into the machine to clean it from the dust particles. After that, the fiber dried under the sunlight approximately half day to remove the moisture content. To produce the coconut fiber ash, brown coconut fibers were chopped into the approximately length 1 to 2 cm and transferred to the grinder machine. The machine grind the coconut fiber and turned into fiber ash.

After that, the material is mixed and poured into plastic mold with thickness 40mm. The mixture is then undergoes compacting process to remove air bubbles by using tamping rode. There are total eight samples were casted with thickness 40 mm using plastic mold.

2.3 Determination of Sound Reduction Test (ISO 11654)

The Sound Proof Test is carried out to investigate the noise level that pass through the pavement block. There will be two samples to be tested with ISO 11654 using the Sound System Trainer. Before the test run, the sound is set to make comparison with the samples within sound reduction.

First of all, the machine is run with a low, medium and high frequency without any sample placed in it in order to get a control reading. The sound level meter is used to get the reading of sound level at 6 cm, 55 cm, 105 cm, 125 cm, 175 cm and 225 cm. The sample then was positioned at 115 cm location.

After that, the reading for the sound level is recorded using the sound level meter at low, medium and high frequency. The steps were repeated for others specimens.

2.4 Determination of Compression Strength (BS 5669)

Compressive strength of pavement block is tested after 7, 14 and 28 days of curing. The sample were compressed in vertical position using Universal Testing Machine (UTM). There are four number of sample has been tested and average were recorded.

The first step is by removing the specimens of 7 days curing from the curing tank and test in their wet condition. It is important to ensure the bearing surfaces of the machine were wiped clean to

avoid extraneous materials on it. Besides, the platens surface which will be contact with specimens must be cleaned from any materials. Figure shows the coconut husk concrete specimen on testing machine while compression test was ran.

Second, the cube sample was placed center on the lower platen to ensure the load applied on the surface sample is perfectly applied. The load applied in the range of 20 MPa to 40 MPa was set. The steps are repeated for other specimens on 14 and 28 days of curing.

For the observation, any unusual failure such as unsatisfactory and satisfactory failure were recorded. Satisfactory failure can be seen if the failure on both surface crack equally while unsatisfactory sample crack unevenly.

2.5 Determination of Splitting Tensile Strength (BS 1881)

Splitting tensile test of pavement block is tested after curing process of 7, 14 and 28 days. The Universal Testing Machine (UTM) was used to run the test. 4 samples will be test based on the curing period to take the average reading.

At first, the specimens of 7 days curing were removed from the curing tank. As previous test, the bearing surface must be clean from ant extraneous materials while the packing strips and steel loading pieces were wiped. Besides that, the specimens surface must wipe cleanly.

The sample was positioned horizontally within the machine and ready to run. The packing strips is carefully placed at both top and bottom of the plane of loading of the specimens. Last but not least, upper platen is ensured to parallel with the lower platens where the specimen placed. The load applied beyond the range of 1 MPa to 5 MPa. The maximum loadings was recorded and the average was calculated. Any unusual behavior of the specimens were recorded.

3. Results

3.1 Sound Reduction testing

For the control set, there will be no partition included so that the original sound level that is pass through at the distance of between 105 cm and 125 cm can be obtained. The result are shown in table 1 and figure 3.

Table 1
Sound Decibel for three type of frequencies

	SOUND (DECIBEL)								
DISTANCE		**LOW**			**MEDIUM**			**HIGH**	
	CS	0 %	40%	CS	0%	40%	CS	0%	40%
6	73.3	72.3	71.1	76.8	73.0	72.7	80.3	71.5	83.7
55	73.3	72.3	73.1	78.6	72.4	73.7	79.3	80.7	80.6
105	73.3	72.1	73.6	75.7	70.9	74.7	79.1	80.1	74.4
125	72.5	63.8	67.7	73.6	64.0	67.3	78.9	63.7	70.4
175	71.5	62.7	65.6	73.2	64.9	66.8	72.6	67.1	73.4
225	71.5	62.8	66.6	74.2	62.5	68.1	79.7	70.7	71.7
Average	**72.6**	**67.7**	**69.6**	**75.4**	**68.0**	**71.0**	**78.4**	**72.3**	**75.7**

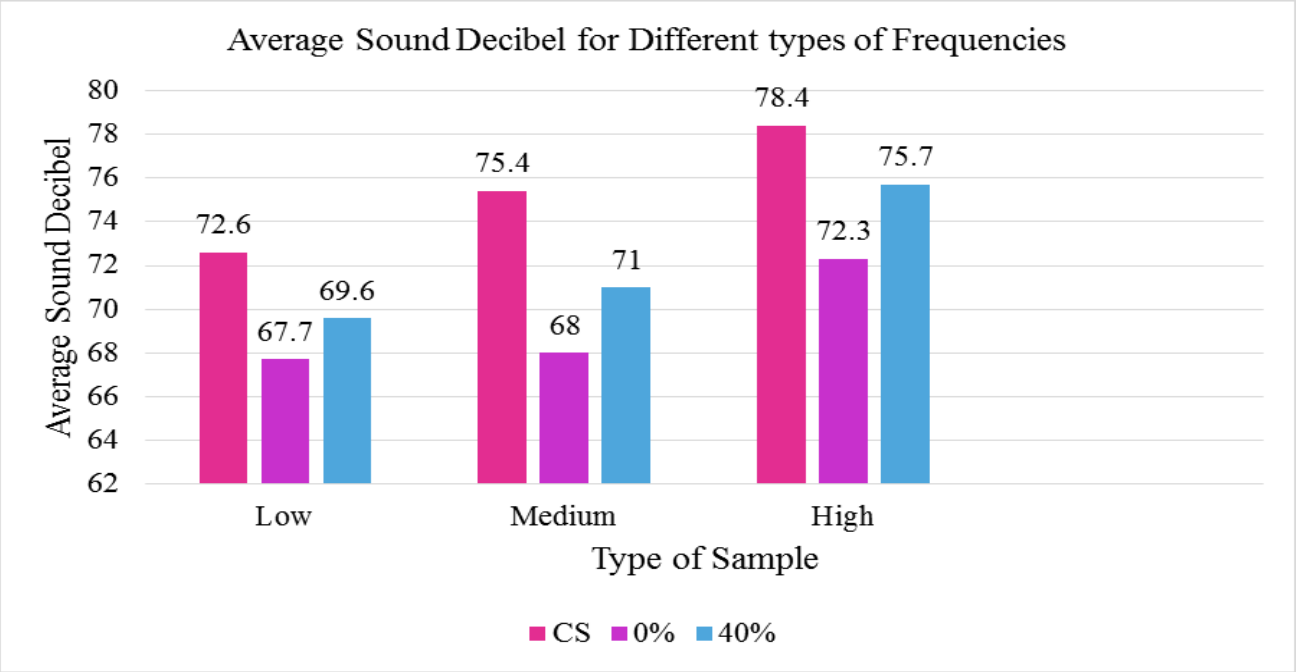

Fig. 3. Average Sound Decibel Value for Different Types of Frequencies within variable Percentage of Coconut Fiber Concrete, Note: CS is control set (no partition)

For the calculation, the average sound level for the three readings is taken before and after the sample is placed. For the control set, the average of reduction of noise are 72.6 dB for low, 75.4 dB for medium and for 78.4 dB for high frequency. For 0% fiber content concrete, the percentage of reduction of noise are 67.7 dB for low, 68 dB for medium and 72.3 dB for high frequency respectively and the percentage of reduction of noise of 40% fiber content concrete are 69.6 dB for low, 71 dB for medium and 75.7 dB for high frequency respectively. From the result obtained, 40% of fiber content has better sound reduction percentage compare to 0% fiber content at for low frequency, medium frequency and high frequency with difference of 2.73%, 4.23% and 4.49 % respectively. This proved that the coconut husk as part of aggregate concrete has better sound reduction level than conventional concrete.

3.2 Compressive Strength

Compressive strength is the parameter to determine the concrete performance. The test is conducted on coconut fiber aggregate concrete with different percentage replacement for 7^{th}, 14^{th} and 28^{th} days of curing period. The compressive strength of the concrete are shown in figure 4.

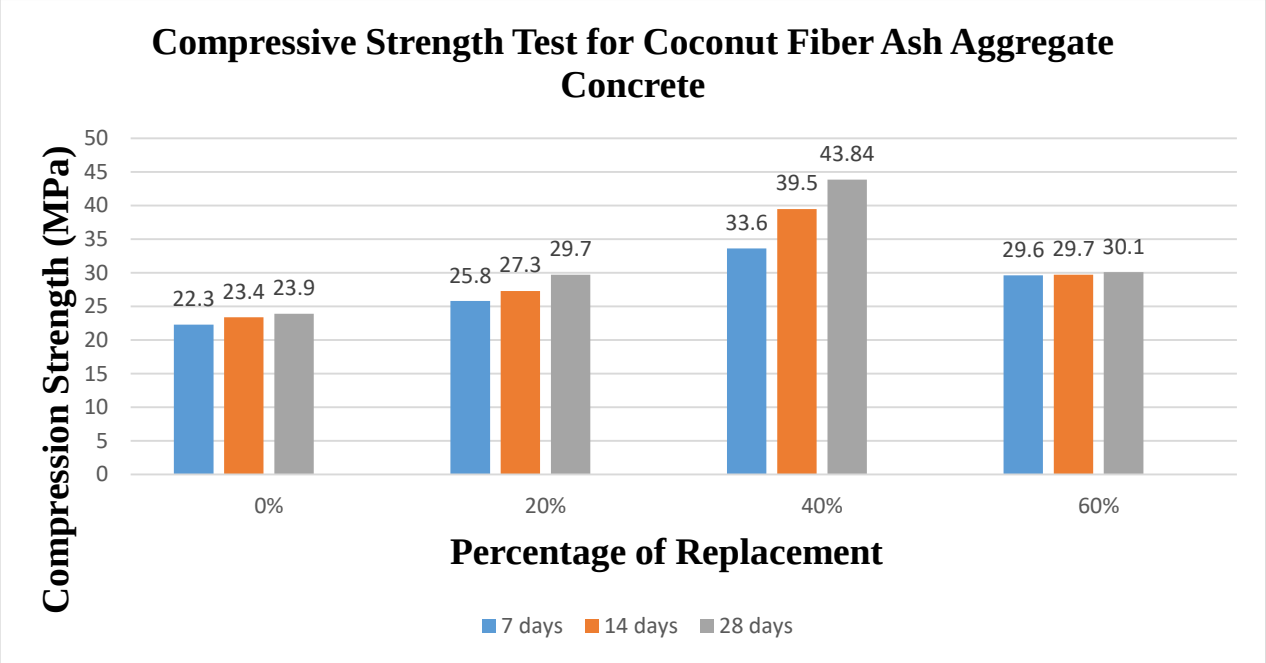

Fig. 4. Compressive Strength of Coconut Husk Aggregate Concrete with Variable Percentage Replacement

As shown in Figure 4, the compressive strength increases from 0% to 40% accordingly to ages but decrease at 60% fiber content because of reduction of cement content. The 40% replacement shows the highest compression strength 33.6 MPa, 39.5, and 43.84 for 7th, 14th and 28th days of curing respectively while 0% replacement have the lowest compression strength 22.3 MPa, 23.4 MPa and 23.9 MPa. This show that 40% is the optimum replacement of concrete mix. At 60% replacement there is slightly decrease in strength due to reduction of cement content.

For 7th days of curing the highest content of fiber represents the highest value of compressive strength at 33.6 MPa and the lowest is 22.3 MPa represent by 0% fiber content. Similar trend was observed on 14th days of curing which the highest compressive strength is 39.5 MPa come from 40% fiber content. Again, the minimum strength is 23.4 MPa shows by 0% fiber content. On 28th days of curing, 40% fiber content represents the highest compressive strength by 43.84 MPa and the lowest is 23.9 MPa from the 0% fiber content.

Overall, concrete with 40% have the highest compressive strength on 7th, 14th, and 28th days of curing. Further addition of fiber content which exceed 40% may cause reduction in strength. Therefore, 40% is the optimum replacement of the concrete mix.

3.3 Splitting Tensile Strength

Splitting tensile test is used to measure the bonding between aggregate and cement. The testing is conducted on the sample of concrete which coconut fiber is part of aggregate during curing periods.

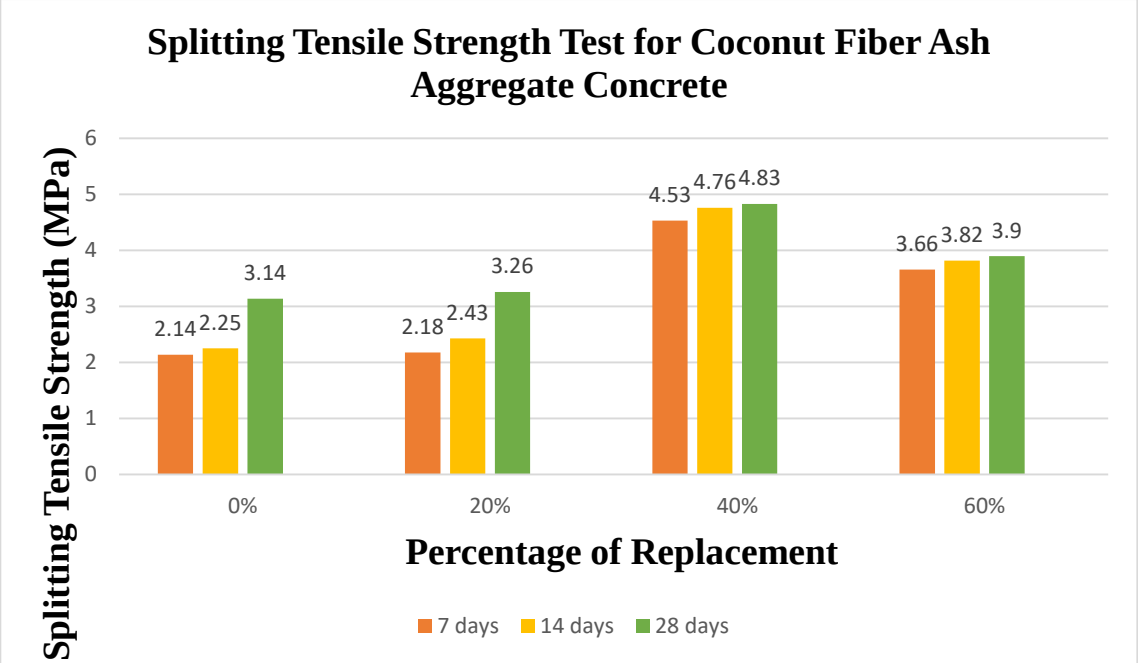

Fig. 5. Splitting Tensile Strength of Coconut Husk Aggregate Concrete with Variable Percentage Replacement

As shown in Figure 5, the tensile strength increases from 0% to 40% accordingly to ages but decrease at 60% fiber content that reduce the cement content. The 40% replacement shows the highest tensile strength 4.53 MPa, 4.76 MPa, and 4.83 MPa for 7th, 14th and 28th days of curing respectively while 0% replacement have the lowest tensile strength 2.14 MPa, 2.25 MPa and 3.14 MPa. This show that 40% is the optimum replacement of concrete mix. At 60 % replacement there is slightly decrease in strength cause by reduction of cement content. For 7th days of curing the highest content of fiber represents the highest value of tensile strength at 4.53 MPa and the lowest is 2.14 MPa represent by 0% fiber content. Similar trend was observed on 14th days of curing which the highest tensile strength is 4.76 MPa come from 40% fiber content. Again, the minimum strength is 2.25 MPa shows by 0% fiber content. On 28th days of curing, 40% fiber content represents the highest tensile strength by 4.83 MPa and the lowest is 3.14 MPa from the 0% fiber content. Overall, concrete with 40% have the highest tensile strength on 7th, 14th, and 28th days of curing. Further addition of fiber content which exceed 40% may cause reduction in strength. Therefore, 40% is the optimum replacement of the concrete mix.

4. Conclusions

The overall objective in this research is to utilize coconut fiber as part of aggregate to produce pavement block. In this research, several experiments were done such sound reduction test, compression strength test and splitting tensile strength test. The mechanical properties are the objectives in this research. The compressive strength of 40% of coconut fiber have the maximum value for 7th, 14th and 28th days of curing. This showed that increases of the fiber content leads to the increment of the compression strength. However, at replacement of 60% the reduction in compressive strength and some fracture behavior occur on the surface. This is because the formation of voids that may come from the air bubbles and fiber push during processing and this will gradually decrease strength of the concrete in long-term. For the splitting tensile strength, concrete specimens with 40% has the highest splitting tensile strength. The samples seen to gain more strength 4.83 MPa at 28 days of curing compared to 7 and 14 days which are 4.53 MPa and 4.76 MPa respectively. This

point out that the bonding strength of coconut fiber aggregate with the cement perform good adhesion. Sound reduction test has been done to analyze the percentage reduction of sound. From the result sample with the highest fiber content showed the highest value for low frequency, medium frequency and high frequency noise set. This show that the reduction sound of a concrete will be higher if the fiber content of concrete increases. In conclusion, for concrete mix, it is possible to use the coconut fiber in conventional concrete production either to replace the coarse aggregate of fine aggregate as long the optimum percentage of replacement is correct. Overall, the utilization of coconut fiber ash as fine aggregate can contribute to the economic production of concrete and at the same time disposal of waste is reduced.

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