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COCONUT SHELL (CS): AS A PARTIAL REPLACEMENT FOR FINE AGGREGATES ON SIDEWALK PAVEMENT

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Abstract: **This paper gives an audit of the use of coconut shells and coconut fiber in street development. Coconut shells and coconut fiber are new waste materials utilized in the sidewalk and parkway industry. A few investigations demonstrated that coconut fiber can build the soundness, slide obstruction and strong modulus while coconut shells can improve the aberrant rigidity and static wet blanket conduct of the changed black-top asphalt. Conversely, coconut fiber doesn't improve the exhaustion life of the altered bituminous blends. As a rule, the past research shows that coconut shell and coconut fiber essentially improves the building properties of black-top blends when blended in with altered bitumen. The conventional mix practiced in the field was adopted for the production of coconut shell aggregate concrete paver blocks. For comparison purposes, conventional aggregate concrete paver blocks were produced and tested in parallel.**

Keywords: **Powdered Coconut shell, fine aggregates, concrete.**

1. INTRODUCTION

One of the most critical problems in environmental protection and natural resource conservation is waste management. Different changes in the environment and an increase in population are one of the main causes of the many processes of deterioration which have altered the ecosystem of our own planet, together with the generation of municipal solid waste (MSW).

Therefore, the importance of creating and reusing waste to create a greener and healthier place on earth is highly significant. Using coconut shells as a representative for using agricultural waste will be emphasized in this research. The idea of being renewable, low-cost, lightweight, having high specific strength and stiffness have made agricultural waste ideal for use as a construction material.

Objective

The main objective of the study is to investigate if using powdered coconut shell as a partial replacement for fine aggregates could meet the standard compressive strength of ACI for sidewalk pavement.

2. REVIEW OF RELATED LITERATURE

The researchers' study is based on the different literatures cited here. The goal of this study is to improve the cost effectiveness of construction materials by using recycled aggregate for sidewalks. And on how we can use waste material as a useful construction material such as sidewalk or footpath.

Synthesis

The researchers found some studies that conducted a test regarding CSP. The first one used CSP as a partial substitute to fine aggregate in making an asphaltic concrete with a percentage ratio of 10%, 20%, 30% and 40 % CSP. The mechanical properties of concrete having a 10% CSP passed. The second study also used a CCS as partial substitute for river sand. The ratios were 0:100, 25:75, 50:50 and 100:0 CCS to river sand. The samples are cured for 14, 21 and 28 days and tested for their compressive strength. The 50:50 ratio that were cured for 28 days passed the compressive strength of a lightweight concrete having a 16.44 N/mm2. The other one literature used CSP as a filler in concrete grade 30 (1%, 3%, and 5% CSP) and the result shows that 1% and 3% passed. These results shows that the CSP has a good quality as a partial substitute for fine aggregate in making different materials in construction with the use of right percentage.

3. METHODOLOGY

The idea of partial replacement for fine aggregates by using Powdered Coconut Shells is based on previous studies that the researchers found in their library that used a coarse aggregate in creating hollow block. Since the prices of construction materials are getting more expensive, the researchers thought of an economical way such as using waste material as a partial replacement to fine aggregates.

The disposal of rural waste materials, for example, rice husks, groundnut husks, corn cobs, and coconut shells have comprised an ecological challenge. Hence, there is a need to convert them into valuable materials to limit their negative effects on nature. Nowadays, specialists have started to use these losses as a partial replacement for traditional concrete-making materials and came up with exciting findings.

Also, the reuse of agricultural waste in the production of concrete may decrease the expense of creation and harmful diseases brought by the disposal of solid waste. So, both the expense of construction materials and transfer of waste can be decreased if agricultural waste can be reused.

4. RESULT AND DISCUSSIONS

There may be a possibility to increase the strength of a concrete with Coconut shell as replacement for aggregates. According to the researchers, the Coconut shell particles with decreased size may avoid problems associated with the shape and thus improving the bond between the aggregate particles and cement paste. Increased bond between particles may lead to higher strength. On the other hand reduced particle size may increase surface area and can lead to higher water demand that can cause strength reduction. The researcher's recommendation on problems regarding later demand is using water reducing admixtures. But using admixtures can either stabilize or break your cement mix; you need to have further knowledge with using admixtures.

Figures and Tables

Table 1: Physical Properties of Coconut Shells

Physical Properties	Coarse Aggrega	Fine Aggregate	Recommended Value
Moisture Content Dry (%)	0.14	12.93	Depend on the Drying period of the aggregate
Moisture Content wet (%)	0.14	11.45	
Specific Gravity	2.73	1.05*	Normal weight aggregate 2.5-2.8
Water Absorption (%)	[illegible]	[illegible]	[illegible]
Aggregate Impact Value (%)	15	2.7	Maximum 30%
Flakiness Index (%)	15.69	99.19	Maximum 25%
Elongation Index (%)	58.54	50.56	Maximum 25%

****The specific gravity of the coconut shell satisfies the value for a lightweight aggregate, which is less than 2*

Table 1 shows the data gathered by the researchers through experiment and research.

Table 2: Sieve Analysis for the Powdered Coconut Shells

Sieve No.	Percentage of Passing F = 100 - f
10 mm	100
4.7 mm	99.1
2.36 mm	94.9
1.18 mm	83
600µ	48.5
300µ	19.6
150µ	2.7
PAN	0

Table 2 shows the passing percentages per sieve no. data gathered from the conducted sieve analysis by the researchers.

Table 3: Workability of Concrete (slump inches)

Coconut Shell Replacement	0%	10%	20%	30%
Slump (in)	4	3.8	3.2	2.7

The variation of the slump with the replacement of a coconut shell aggregate is shown in Table 3. The results indicate that the slump tends to increase with the increment of coconut shell percentages, resulting in higher workability.

Table 4: The relationship between Concrete Compressive Strength and Curing Days

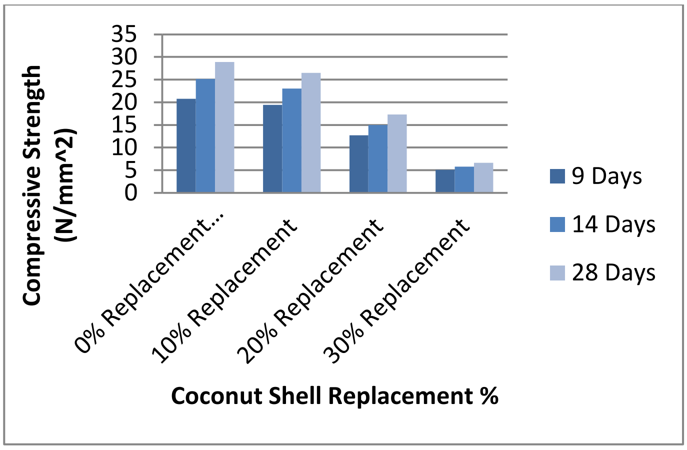

Table 4 represents the difference in strength of three samples per blending within 9, 14, and 28 days being submerged on a curing tank. The result indicates that the sample with 10% fine aggregate replacement has the nearest strength to the pure mix compared to the other samples.

Table 5: The numerical data from above table (Table 4) in Mpa / PSI respectively

	9 DAYS	14 DAYS	28 DAYS
0% Replacement	20.79 / 3015.3346	25.17 / 3650.6	28.87 / 4187.24
10% Replacement	19.43 / 2818.0832	23.01 / 3337.32	26.46 / 3837.7
20% Replacement	12.71 / 1843.43	14.99 / 2174.12	17.33 / 2513.504
30% Replacement	5.06 / 733.891	5.8 / 841.219	6.66 / 965.9513

Table 5 shows the detailed numerical data from Table 4. To convert Mpa to Psi, multiply it to 145.037737797.

Abbreviations and Acronyms

- **C.C.S. –** Crushed Coconut Shell
- **C.S.P. –** Coconut Shell Powder
- **P.C.S. –** Powdered Coconut Shell

<u>SOLUTIONS AND EQUATIONS</u>

For the Fineness Modulus of Powdered Coconut Shell:

- Percentage Retained100 = 252.21 = **<u>2.522</u>**

For the Specific Gravity of Powdered Coconut Shell: *Specific gravity* = 1.05 g/mL1 g/mL= **<u>1.05</u>**

For the Water Absorption of Powdered Coconut Shell:

- There are 3 powdered coconut shell samples weighed and placed inside an oven for 24hours at 1050 C. Next, the specimens were submerged with water provided at the lab for another 24 hours. After that, the samples were weighed once again after the surface water was removed. The percentage of water absorption was calculated as: (data used is the percentage closest to average answer)

- *WaterAbsorption (%)* = m2−m1m1 x 100 =

  0.0463−0.04510.0463 = **<u>2.592%</u>**

(Based on the maritime code BS 6349 specifies that water absorption should not exceed 3% when tested in accordance with BS 812-2)

For the Water/Cement Ratio:

- Conducted amount of water (kg)Conducted amount of cement (kg)= 560177= **<u>0.316 or 0.32</u>**

For Volume of Cement, m^3:

- *Conducted amount of cement (kg)* **x** (*W/C Ratio)* **x** 11000m^3 = 560(0.32) (11000) = **<u>0.177</u>**

For Volume of Water, m^3:

- (Conducted amount of water) **x** 11000m^3 =

  177 (11000) = **<u>0.177</u>**

For Entrapped Air and Volume of Air:

- **Based on ACI 211.1, Table A1.533.** The conducted amount of water (kg) is 177 and the result of slump on the conducted slump test was at the average of 96 mm. Therefore the approximate amount of entrapped air is **<u>0.5%-1%</u>**.

Table 6: Data Used On Actual Making of Cylindrical Samples

		SAMPLE 1		SAMPLE 2	SAMPLE 3	SAMPLE 4
		Pure Mix		90% - 10% Cut for Sand and PCS (respectively)	80% - 20% Cut for Sand and PCS (respectively)	70% - 30% Cut for Sand and PCS (respectively)
MATERIALS		1.0 cubic meter to 0.00625 cubic meter				
GRAVEL	3/4	747	4.66875	4.66875	4.66875	4.66875
	3/8	320	2	2	2	2
CEMENT		560	3.5	3.5	3.5	3.5
SAND		*614*	*3.8375*	*3.45375*	*3.07*	*2.68625*
POWDERED COCONUT SHELL		*0*	*0*	*0.38375*	*0.7675*	*1.15125*
WATER		177	1.10625	1.10625	1.10625	1.10625

Table 5 contains the data used for reference on the actual making of the cylindrical samples. The amount of aggregates and water is an assumption for making an actual mixing of concrete for an area of 1 cubic meter. The researchers converted it to a lesser area that would be enough to fit all 12 molder for samples. The table also shows difference of the amount of PCS and sand per sample.

Figure 1: Copy of the Design Mix used for batching concrete cylinder samples

Calculation of Design Mix

By ACI 211.1

Material Properties

Attributes:	**Fine Aggregate**	**Powdered Coconut Shell**
Fineness Modulus	2.8	2.522
Specific Gravity (SSD)	2.542	1.05
Absorption, %	3.39	26.05

Coarse Aggregate

Maximum Size:	**G-3/4** 70% & **G-3/8** 30%
Specific Gravity (SSD)	2.807
Absorption, %	0.800

Design Specification Objectives:

Strength at 28 days, psi 4000 Min. Cement content, kg/cu.m.: 560

Specified max W/C ratio 0.32 Specified max. slump, inches: 5”

Calculation of Batch Weight per Cubic Meter:

Target strength 4000 psi

Target slump 3”- 5”

a. Cement factor; bags/m^3 14.00

b. Cement, kg 560.0

c. W/C Ratio 0.32

d. Mixing Water, kg 177

e. Cement Vol., m^3 0.177

f. Volume of water, m^3 0.177

g. Entrapped air, % (from ACI) 0.5% - 1%

h. Vol. of air, m^3 less than 0.01

5. CONCLUSION

The physical properties of the powdered coconut shell are determined by conducting tests and analyzing the results. PCS has a high water absorption percentage compared to sand which is 2.6% while sand has 0.5% only.

While being mixed with the aggregates and water, the PCS obviously absorbing the water quickly that is why they needed to mix it before the bonding of aggregates gets weak. What happened on the 30% blend is that the PCS absorbed so much water before the aggregates bonded, which is why when the researchers tested its compression strength and the sample gets crushed, the inside of it is mostly clay and it’s very dry. Water is absorbed fast because of the amount of PCS added.

Based on the results, the coconut shell powder is viable as a partial replacement to fine aggregates with a blending of 10% (Powdered CS): 90% (Sand). The difference in strength of 10% blend and the pure mix has a small gap. For the other blend, the 20% blend has strength of **17.33 Mpa/2513.504 Psi** and based on what is defined in the ASTM 567, it is within the category of lightweight concrete.

Therefore, the design for 10% blend of PCS could be possibly used on a 24.13Mpa/3500psi design of concrete or lower desired strength. And the 20% blend of PCS could be used for lightweight concrete design. For the 30% blend, that would be just a reference that the higher the blending percentage of PCS, the lower the compression strength will be.

6. RECOMMENDATIONS

The researcher's study was only made up to 30% crushed coconut shells as a partial fine aggregate (70% sand) and they did not use an Admixture for the design mix. Future researchers are recommended to do the following:

- The blending ratio of 15% (PCS):85% (sand) or any number that is not yet used on the previous study can be studied especially those numbers within the gaps of 10%-20%. (Refer from the results for better scope).

- Admixtures can be used for future studies. It can be included in the design mix to ensure the quality of concrete during mixing, transporting, placing, and curing; and to overcome certain emergencies during concrete operating.

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