COCONUT SHELL AS A PARTIALL REPLACEMENT OF COARSE AGGREGATE IN CONCRETE

Padma Charan Tripathy,Professor, Department of Civil Engineering, Raajdhani Engineering College, India
Amit Kumar Das,Assistant Professor, Department of Civil Engineering, Raajdhani Engineering College,

Abstract:
Waste management is a major issue, and the intensive exploitation of natural resources makes it difficult to locate resources. There are many advantages to using waste materials in construction, including cost savings, energy savings, and environmental protection. As an agricultural waste, coconut shell is one of the main sources of pollution. The use of coarse aggregate made from coconut shells in concrete promoted the use of environmentally friendly and sustainable building materials. The environment and building technology to enhance the natural world and building materials are the primary concerns of this research. This study examines the structural properties of concrete made with crushed, granular coconut shells in place of traditional coarse aggregate. Physical and mechanical characteristics of coconut shell concrete were examined as parameters. According to the test results, coconut shell can be utilised in place of coarse aggregate when making lightweight structural concrete.
Keywords: Coconut shell, sustainable materials, building materials, mechanical properties, lightweight concrete.

INTRODUCTION
One of the most adaptable building materials is concrete. Concrete production totals more than 10 billion tonnes a year, making it the most significant building material (Meyer, 2009). As a result, the production of concrete will require a significant amount of natural resources. Due to the rapid rise of infrastructure development and building activities worldwide, concrete production is rising (Amarnath, 2012). Additionally, by 2050, it's anticipated that the need for concrete would increase to almost 18 billion tonnes annually (Roskovic & Monteiro, 2006). Additionally, due to increased demand, a lack of raw materials, and the high cost of electricity, the price of construction materials is rising daily. The use of alternative components in construction materials is currently a global priority from the perspectives of energy savings and resource conservation. This calls for intensive research and development into potential new elements in order to produce environmentally friendly and sustainable construction materials. More than 93 countries grow coconut, and South East Asia is said to be the region where coconut first appeared. A concrete that has the potential to be employed in lightweight construction has been produced by employing agricultural waste, specifically the coconut, in place of the stone aggregate.
Modern construction uses structural lightweight aggregate concrete, which is an important and resourceful material. There are several uses for this type of concrete, including the construction of bridges, offshore oil platforms, and multistory building frames and floors.
Platforms, precast or prestressed elements (ACI 213R-87). Additionally, it resolves issues with weight and durability in structures that are exposed in buildings. Expanded Clay, Shale and Slate Institute claims that structural lightweight concrete offers significant cost savings and design flexibility by reducing dead loads, improving seismic structural response, extending spans, improving fire ratings, reducing story heights, using smaller structural members, using less reinforcing steel, and lowering foundation costs. Adeyemi (1998) suggested that coconut shells might be used in place of fine or coarse aggregate while producing concrete. Concrete constructed from coconut shells is easier to work with because of the flat surface on one side (Kanojia and Jain, 2015). According to Kanojia and Jain (2015), coconut shell also has the added

benefit of having a high lignin content, which increases the weather resistance of the composites. According to Olanipekun et al. (2006), the cost of concrete made from coconut shell and palm kernel shells, respectively, is reduced by 30% and 42%. In their investigation, Aminah et al. (2009) substituted coconut shell and grained palm kernel for the coarse aggregate. They came to the conclusion that the combination of these materials has the potential to be utilised as a lightweight aggregate in concrete and to lower the cost of construction materials.

Olutoge (2010) investigated the shells of palm kernels and sawdust (PKS). Olutoge (2010) discovered that replacing fine and coarse aggregates with sawdust and palm kernel shells (PKS) by 25 percent each can generate lightweight reinforced concrete slabs that can be used when minimal stress is required at a lower cost.

Additionally, a 7.4 percent decline in terms of the price per cubic metre of slab produced with sawdust/PKS (Olutoge, 2010). According to Shraddha (2014), the achieved flexural strength always decreases by 10% to 15% when compared to concrete made with coarse aggregates when coconut shells are used to replace coarse aggregates to the extent of 50%. This study primarily examines how well concrete with crushed coconut shell as a substitute for traditional coarse aggregate performs in terms of its strength qualities. The goal of the research is to promote the use of these seemingly waste products as building materials in the concrete industry for lightweight applications. It is also anticipated to serve the goal of encouraging home developers to research employing these materials in house construction.

EXPERIMENTAL PROGRAM

The primary goal of the current analysis was to examine how well CS concretes performed in terms of strength and other physical characteristics when cured in regular water. Some physical and mechanical characteristics of the concretes, such as compressive strength and splitting tensile strength, were used to evaluate their performance. The volume of the ingredients determined the concrete mix for each example. A constant water to cement ratio of 0.5 was used in the concrete mixture, which had the following weight ratios: 1 (cement), 1.5 (fine aggregate), and 3 (coarse aggregate). This study makes use of fine and coarse aggregate that is easily accessible locally. In this investigation, crushed coconut shells were substituted volumetrically at 0%, 10%, 25%, and 50% for concrete made using coarse aggregate based on stone chips. According to ASTM C39, each cylinder has been produced with dimensions of 100 mm and 200 mm. After the cylinder was cast, few specimens are shown in Figure 1. After 24 hours, the specimens were demolded and placed in ordinary water to cure until the test age. Three replica specimens were used for each test, and the average crushing loads were recorded.

Figure 1: Preparation of test specimen

Slump Cone Test

The most popular technique for assessing the workability of concrete is the slump test, which can employed either on the job site or in a lab. As seen in Figure 2, this test method offers a way to keep track of the consistency of unhardened concrete. A steel rod that was 0.6 metres long and 16 millimetres in diameter was used in this test to compact each layer of concrete 25 times in accordance with ASTM C143. Both the standard weight concrete and the concrete replacement with coconut shell underwent this test.

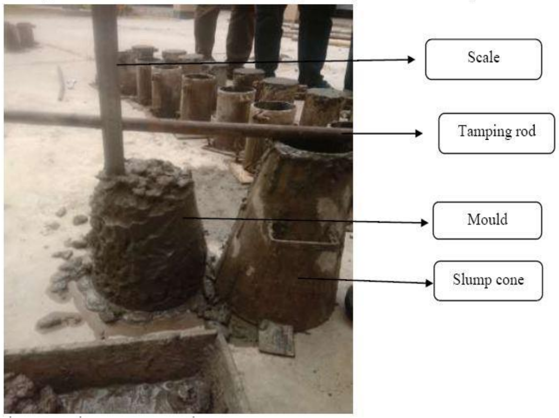


Figure 2: Slump test for the measurement of workability

Compressive strength test

On a compression testing equipment, concrete samples underwent compressive loading tests (shown in Figure 3). For the compression experiment, a total of 36 samples were cast. According to ASTM C39, a loading rate of 2.5 kN/s was used for the compressive strength test. The ultimate load was measured after applying load until the specimens failed.

Figure 3: Placement of cylindrical specimen for compressive strength test

Splitting Tensile Strength

It is used to analyse the shear resistance, bond strength, torsion, anchoring, crack resistance, and development length of reinforcement while designing lightweight structural concrete elements. The ASTM C496 standard was followed in performing this test. Samples were placed within the compression testing device (shown in Figure 4). Until the specimens failed, load was applied. Tensile strength is calculated by using the following equation $T=2P/\pi DL$

Where, T = tensile strength; P = failure load; D = diameter of the cylinder; and L = length of the cylinder.

Figure 4: Experimental set-up of splitting tensile strength test

I. RESULTS AND DISCUSSION

3.1 Physical properties of coconut shell

Concrete's density is mostly influenced by certain aggregate characteristics, such as unit weight, which vary by geographic location and rise with concrete compressive strength based on the amount of pozzolans used. To understand tangible behaviour, it is crucial to identify the key physical characteristics. For both coarse aggregate (stone chips and coconut shells) and fine aggregate (sylhet sand), the unit weight, specific gravity, moisture content, and water absorption parameters were calculated and shown in Table 1. As a binder, Portland Composite Cement was used. Portland cement's specific gravity, first setting time, and final setting time were found to be 3.02, 120, and 200 minutes, respectively. The materials laboratory of the department of civil engineering carried out grain size analyses for coarse aggregates. The grain size curves of the crushed coconut shell aggregates utilised as normal weight aggregates in place of stone chips are shown in Figure 5.

Table 1: Determination of physical properties of coarse and fine aggregates

Properties	Test results		
	Stone chips	Sand	oconut shell
Unit weight (kg/m^3)	1508	1627	545
Specific gravity	2.61	2.43	1.23
Water content (%)	3	0.75	11.3
Absorption (%)	3.3	4	26.4

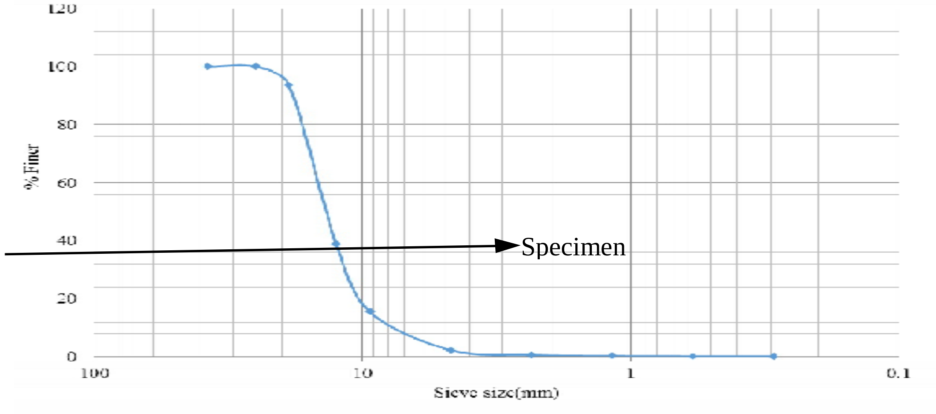
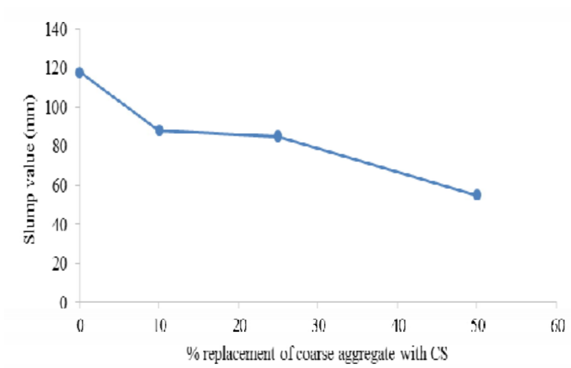


Figure 5: Grain size curves for crushed coconut shells

WORKABILITY



A slump test was used to gauge how easily concrete could be worked. The workability test results from the slump test for both normal weight concrete and the percentage of coarse aggregate replacement with CS are shown in Figure 6. With a higher percentage of stone chips replaced with CS, it has been found that the slump value decreases. In this study, every assessed slump was a real slump.

Compressive Strength

Compression testing has been performed for 0%, 10%, 25% and 50% replacement of stone chips with CS. It has been observed that the compressive strength of the concrete decreases as the percentage of the coconut shells increase in the concrete mixer as presented in Table 2. It is also observed that the concrete compressive strength of the cylinder specimens increases with the increasing curing days. According to ACI, a concrete is considered structural lightweight aggregate concrete when made with lightweight aggregates conforming to ASTM C 330 and has a compressive strength in excess of 2,500 psi (17.25 MPa) at 28 days of age. From Figure 7 it can be observed that the compressive strength (at 28 days and 90 days) of concrete produced with 10% and 25% replacement of stone chips with coconut shells is approximately 90% and 65% of the concrete produced with 100% stone chips coarse aggregate.

Table 2: Test results of compressive strength

Curing (days)	% replacement of CS	Crushing load (kN)	Compressive strength (MPa)
7	0	103.60	13.19
	10	101.40	12.91
	25	93.80	11.94
	50	72.92	9.28
28	0	210.72	26.83
	10	190.72	24.28
	25	131.04	16.68
	50	80.72	10.28
90	0	235.32	29.96
	10	208.40	26.53
	25	150.40	19.15
	50	88.40	11.26

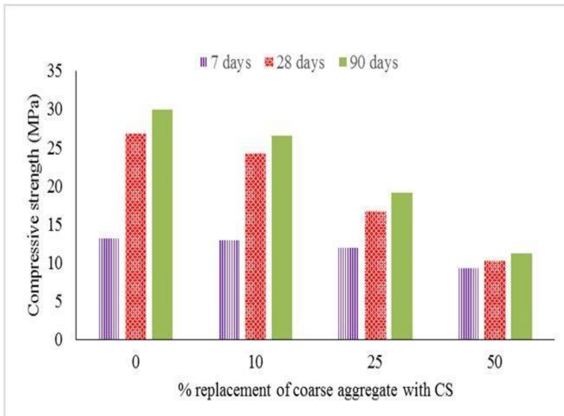


Figure 7: Compressive strength for different percentage of coconut shell concrete in different curing day

Splitting Tensile Strength

Test results of splitting tensile strength has been performed at 28 days for 0%, 10%, 25% and 50% replacement of stone chips with CS and presented in Table 3. From Figure 8 it has been observed that the splitting tensile strength of the concrete decreases with the increase of % replacement of stone chips through coconut shells. It is also observed that the splitting tensile strength is about 9% of its compressive strength. According to ACI 301-05, the minimum splitting tensile strength of concrete is 290 psi (2.0 MPa) for structural grade lightweight aggregates conforming to the requirements of ASTM C330. Therefore, concrete produced with 10% and 25% replacement of stone chips with coconut shells almost satisfies the strength requirements for lightweight concrete.

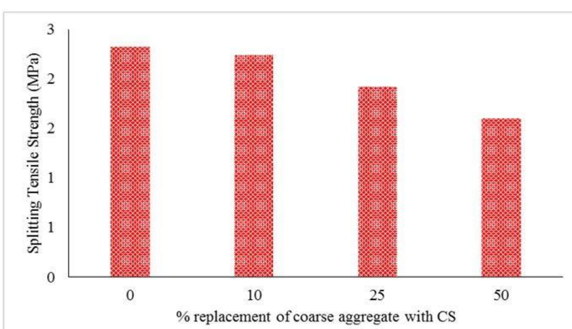


Figure 8: Variation of splitting tensile strength (28 days) with

% replacement of coarse aggregate with coconut shell

CONCLUSIONS

- Results of trials on the physical and mechanical properties of concrete that substituted coconut shells for coarse particles were provided in this study using mixing ratios of 1:1.5:3. These inferences can be made based on the experimental findings of this study:
- Coconut shells can be used as partial replacement for the conventional stone aggregates in concrete production.
- In terms of strength, 20% crushed stone chips can be replaced with coconut shells to produce structural lightweight concrete as per the requirements provided by American Concrete Institute.

REFERENCES

[1]. ACI 311-05. "Specifications for Structural Concrete". American Concrete Institute, Farmington Hills.
[2]. ACI 211.2-98. "Standard Practice for Selecting Proportions for Structural Lightweight Concrete". American Concrete Institute, Detroit, Michigan.
[3]. ACI 213R-87. "Guide for Structural Lightweight Aggregate Concrete". American Concrete Institute, Detroit, Michigan.
[4]. "Advantages of Structural Lightweight Aggregate Concrete". Expanded Clay, Shale and Slate Institute, www.escsi.org
[5]. ASTM C496-11. "Standard Test Method for Splitting Tensile Strength of Cylindrical Concrete Specimens".
[6]. ASTM C39-16b. "Standard Test Method for Compressive Strength of Cylindrical Concrete Specimens".
[7]. ASTM C143-15a. "Standard Test Method for Slump of Hydraulic-Cement Concrete".
[8]. Adeyemi A.Y. (1998). "An investigation into the suitability of coconut shells as aggregates in concrete production". Journal of Environment Design and Management, 1(2):17– 26.
[9]. Amarnath Y. R. C. (2012). "Properties of Concrete with Coconut Shells as Aggregate Replacement, International Journal of Engineering Inventions, 1(6).
[10]. Aminah S., Tukiman B. and Sabarudin B. M. (2009). "Investigation the combination of coconut shell and grained palm kernel to replace aggregate in concrete: A technical review", National Conference on Postgraduate Research (NCONPGR), UMP Conference Hall, Malaysia.
[11]. Kanojia A. and Jain S.K. (2015). "Performance of Coconut Shell as Coarse Aggregate in Concrete: A Review". International Research Journal of Engineering and Technology (IRJET), 2(4).
[12]. Meyer C. (2009). "The greening of the concrete industry". Cement Concrete Composite, 31:601–605.
[13]. Olanipekun, E.A., Olusola, K.O. and Ata, O. (2006). "A comparative study of concrete properties using coconut shell and palm kernel shell as coarse aggregates". Building and Environment, 41: 297–301.
[14]. Olutoge F.A. (2010). "Investigations on Sawdust and Palm Kernel Shells As Aggregate Replacement". ARPN Journal of Engineering And Applied Sciences, 5(4).
[15]. Roskovic R. and Monteiro P.J.M. (2006). Concrete: microstructure, properties, and materials. 3rd ed. New York: McGraw-Hill.
[16]. Shraddha D. (2014). "Sustainable Concrete by Partially Replacing Coarse Aggregate Using Coconut Shell". Journal on Today's Ideas Tomorrow's Technologies, 2(1): 1–14.

