Testing and Mix Designing of Concrete made with Coconut Shell as Partial Replacement for Coarse Aggregate

Mr. Prashant K. Nawale[1], Mr. Sumit R. Thakur[2]
Department of Civil Engineering
[1, 2] SavitribaiPhule Pune University

Abstract- *Aggregates provide volume at low cost, comprising 66 percent to 78 percent of the concrete. With increasing concern over the excessive exploitation of natural and quality aggregates, the aggregate produced from industrial wastes and agriculture wastes being viable new source for building material. This study was carried out to determine the possibilities of using coconut shell as aggregate in concrete. Utilizing coconut shell as aggregate in concrete production not only solves the problem of disposing this solid waste but also helps conserve natural resources. In this paper, the physical properties of crushed coconut shell aggregate were presented. The fresh concrete properties such as density and slump and 28-day compressive strength of a lightweight concrete made with coconut shell as coarse aggregate also presented. The findings indicated that water absorption of the coconut shell aggregate was high about 24 % but the crushing value and impact value was comparable to that of other lightweight aggregates. It is concluded that crushed coconut shells are suitable when it is used as substitute for conventional aggregates in lightweight concrete production.*

Conventional coarse aggregate namely gravel and fine aggregate is sand in concrete will be used as control. While natural material is coconut shell as course aggregate will be investigate to replace the aggregate in concrete. In this studies, three different concrete mixes with different the combination of natural material content namely 0%, 10%, 20%, 30%.Three sample specimen will be prepared for each concrete mixes. The parameters will be tested are flexural strength, compressive strength, tensile strength. The effect of using different length of natural material aggregate will also investigate. The effect of aggregate content to workability will also examine. The expected outcomes of the study, is the combination of coconut shell has potential as lightweight aggregate in concrete. Also, using the combination of coconut shell as aggregate in concrete can reduce the material cost in construction because of the low cost and abundant agricultural waste.

This report presents an investigation on the behaviour of concrete specimens produced from coconut shell (CS) aggregates. Utilizing CS in concrete production not only solves the problem of disposing this solid waste but also helps conserve natural resources.
The attempt is made to prove in all respect the serviceability, durability and economy in the experimental study is structurally satisfying and can be implemented in rural areas by considering all technical aspect. The aim behind this is to use low cost material like coconut shell and thus taking close to the concept of low cost housing. All precaution is taken to maintain serviceability, strength and durability of the members. The method adopted is relevant to real social needs that are accessible, affordable and empowering impact as saving of material is achieved ultimately caring for natural resources. Thus it will be helpful for civil engineers and society to adopt this concept to fulfil the basic need of human that is housing.

Keywords - *Coconut shell, Partial Replacement, Compressive Strength, Control concrete, Strength analysis, Cost analysis.*

I. INTRODUCTION

Concrete is the widely used number one structural material in the world today. The demand to make this material lighter has been the subject of study that has challenged scientists and engineers alike. The challenge in making a lightweight concrete is decreasing the density while maintaining strength and without adversely affecting cost. Some of the lightweight aggregates used for lightweight concrete productions are pumice, perlite, expanded clay or vermiculite, coal slag, sintered fly ash, rice husk, straw, sawdust, cork granules, wheat husk, oil palm shell, and coconut shell. The high cost of conventional building materials is a major factor affecting housing delivery in India. In developing countries where abundant agricultural and industrial wastes are discharged, these wastes can be used as potential material or replacement material in the construction industry. This will have the double advantage of reduction in the cost of construction material and also as a means of disposal of wastes. It is at this time the above approach is logical, worthy and attributable. Presently in India, about 960 million tons of solid wastes are being generated annually as by-products during industrial, mining, municipal, agricultural and other processes. Of this 350 million tons are organic wastes from agricultural sources; 290 million tons are inorganic waste of industrial and mining sectors. However, it is reported that about 600 MT of wastes have been generated in India from agricultural sources alone. The use of coconut shell as coarse aggregate in concrete has never been a usual practice among the average citizens, particularly in areas where light weight concrete is required for non-load bearing walls, non-structural floors, and strip footings. Although coarse aggregate usually take about 50% of the overall self-weight of concrete, thereby determining the quality of reinforcement required to resist forces acting on the structural member. Little or no effort has been made to verify the strength and properties of the concrete made with these materials and the economic benefits derivable.

II. LITERATURE REVIEW

Ohler (1999), Olanipekun (2006): Coconuts show a wide diversity in size, weight, shape and colour, depending on genetic variety and maturity of the nut at harvest (Ohler, 1999) investigated, for one mix ratio (1:2:4) the suitability of coconut shell as substitute for either fine or coarse aggregate in concrete production. (Olanipekun et al., 2006).Investigated the comparative cost analysis and strength characteristics of concrete produced using crushed, granular coconut and Palm kernel shell as substitutes for conventional coarse aggregate. It was concluded that the coconut shell were suitable as low strength-giving lightweight aggregate when used to replace common coarse aggregate in concrete production.

AsokanPappu: Presently in India, about 960 million tonnes of solid waste is being generated annually as by-products during industrial, mining, municipal, agricultural and other processes. Of this 350 million tonnes are organic wastes from agricultural sources; 290 million tonnes are inorganic waste of industrial and mining sectors and 4.5 million tonnes are hazardous in nature. Advances in solid waste management resulted in alternative construction materials as a substitute to traditional materials like bricks, blocks, tiles, aggregates, ceramics, cement, lime, soil, timber and paint. To safeguard the environment, efforts are being made for recycling different wastes and utilise them in value added applications. In this paper, present status on generation and utilization of both non-hazardous and hazardous solid wastes in India, their recycling potentials and environmental implication are reported and discussed in details.

K. Gunasekaran, P.S.Kumar : The high cost of conventional building material is a major factor affecting housing delivery in India. In developing countries where abundant agricultural and industrial wastes are discharged, these wastes are can be used as potential material or replacement material in the construction industry. This will have double advantage of reduction of in the cost of construction material and also as a means of disposal of wastes. It is at this time the above approach is logical, worthy and attributable. One such alternative is coconut shell, which is a form of agricultural solid waste. It is one of the most promising agro wastes with its possible uses as coarse aggregate in the production of concrete. This has good potential to use in areas where crushed stones are costly. Statistical data show as that, India is producing nearly 27% of total world production and the annual production of coconut is reported to be more than 12 million tonnes. Presently the coconut shell waste being used in making mosquito coils, essence sticks, organic fertilizers, etc. Only few studies have been reported on use of coconut shells as aggregate in concrete.

In a research conducted on the use of stone dust as a partial replacement of stone dust in block concluded that the laboratory analysis indicated that there is an improvement in average compressive strength of the blocks with an increasing percentage stabilization of stone dust; same applies also to the increase in age of curing. An optimum percentage stabilization of 20% was obtained A – 5 laterite soil with 0.15 w/s ratio which gave the highest strength of 1.28 N/mm2, there was also a significant improvement in the properties of the soil with percentage increase in stone dust stabilization, thus concluded that the strength and durability of the blocks are generally improved by stabilization of stone dust.

It is observed from literature survey that the use of coconut shell is more advantageous as they enhance the mechanical properties of concrete. Presently, coconut shells are available at a low price in most of the tropical countries. Also the concrete obtained using coconut shell aggregate satisfies the minimum requirement of light weight concrete. Hence it is possible to make use of lightweight concrete making use of coconut shells as an aggregate in concrete.

III. METHODOLOGY

Problem Statement:

- Selection of type of grade of mix, mix design by an appropriate method, estimating total quantity of concrete required for the whole project work.
- Estimating quantity of cement, fine aggregate, coarse aggregate, coconut shells required for the project work for 0%, 10%, 20% and 30% replacement.
- Testing of properties of cement, fine aggregate, coarse aggregate and coconut shells by using various laboratory tests.

- Determining strength with respect to cost by strength and cost analysis.
- Finding feasibility of % replacement.

Test on ingredients materials:

A) Tests on cement:

- Fineness of cement = 3.0%
- Standard consistency = 36.25%
- Initial Setting Time = 50 minutes
- Final Setting Time = 563 minutes
- Soundness of cement = 1.0

B) Test on Fine Aggregate:

- Fineness modulus of Fine Aggregate = 3.19
- Specific Gravity of Fine Aggregate = 2.6
- Water Content in Fine Aggregate = 0.37%

C) Test on Coarse Aggregate:

- Fineness modulus of Coarse Aggregate= 6.90
- Impact value of Coarse Aggregate = 26.48

D) Test on Coconut Shells:

Crushed coconut shells of size 20 mm and 10 mm are used. Various test such as such as sieve analysis aggregate impact value etc; have been conducted on coconut shells to know their quality and grading.

1)Fineness modulus of Coconut shells;

Observation Table:

Sr. No	Sieve Size	Weight retain (gm)	Cumulative weight retained (gm)	% cumulative weight	% passing
1.	40 mm	-	-	-	-
2.	20 mm	76	76	1.52	98.48
3.	10 mm	4286	4362	87.24	12.76
4.	4.75 mm	483	4845	96.90	3.10
5.	2.36 mm	115	5000	100.00	00
6.	1.18 mm	-	-	-	-
7.	600 mic.	-	-	-	-
8.	300 mic.	-	-	-	-
9.	150 mic.	-	-	-	-
10.	**Total**	-	-	-	**685.66**

Table 1. Fineness modulus of Coconut shells

Fineness modulus of Coconut Shell = 6.85

Photograph 1. Mass Retained on Sieve

2)Impact Value of Coconut shells:

Observation Table:

Sr. No.	Particulars	Sample 1 (gm)	Sample 2 (gm)
1.	Total weight of dry sample (W_1)	350	350
2.	Weight Passing 2.36 mm Sieve (W_2)	101.12	100.13
3.	Aggregate impact value (W_2/W_1x100)	28.90	28.60
4.	Average Impact Value	28.75	

Table 2. Impact Value of Coconut shells

Impact value of Coarse Aggregate is = 28.75

Photograph 2. Impact Test

IV. MIX DESIGN

A) Mix Design for M20 Grade of Control Concrete (Conventional)

On basis of	Water	Cement	Fine Aggregate	Coarse Aggregate
Mass	191.6 lit	383 kg	546 kg	1187 kg
Ratio	0.5	1.0	1.42	3.09
Per Bag	24.35 lit	50 kg	72.42 kg	153.73 kg

Table 3.Table for Mix Proportion

B) Mix Design for M20 Grade of Coconut Shell Concrete for 10% replacement:

Assumptions:
Compressive strength required for 28 days = 20 MPa
Maximum size of aggregate = 20 mm (angular)
Degree of quality control = Good
Type of exposure = Mild

Data
Specific Gravity of Cement = 3.15
Specific Gravity of Fine Aggregate = 2.60
Specific Gravity of Coarse Aggregate = 1.05
Water Absorption of Fine Aggregate = 0%
Water Absorption of Coconut Shells = 1%
Slum required = 50 – 100 mm
Free moisture in Sand = 2%

Calculations:

1) **Target Mean Strength:**

f_t =fck + K x S
= 20 + 4.0 x 1.65
= 26.6 N/mm^2

2) **Selection of Water Cement Ratio:**

Free water cement ratio for target mean strength = 0.5
From table 5 of IS 456:2000 adopt water cement ratio of 0.5
Therefore, estimated water quantity for slump 50-100 mm = 191.6 kg/m^3

Determination of Cement Content:
Water cement ratio = 0.5
Water = 191.6 kg/m^3
Cement = 383 kg/m^3
This cement content is adequate for mild exposure condition.

Mix Design Calculations:
A) For 10% replacement:
1) Volume of Concrete = 1 m^3

2) Volume of Cement

$$=\frac{\text{Mass of Cement}}{\text{Specific Gravity of Cement}} \times \frac{1}{1000} = \frac{383}{3.15} \times \frac{1}{1000}$$
= 0.125 m^3

3) Volume of Water

$$=\frac{\text{Mass of Water}}{\text{Specific Gravity of Water}} \times \frac{1}{1000} = \frac{191.6}{1} \times \frac{1}{1000}$$

= 0.196 m^3

4) Volume of Coconut Shells

$$=\frac{\text{Mass of Coconut Shell}}{\text{Sp.Gravity of Coconut Shell}} \times \frac{1}{1000} = \frac{118.7}{1.05} \times \frac{1}{1000}$$

= 0.113 m^3

5) Volume of all in Aggregate = [a–(b + c + d + e)]

= [1–(0.1215 + 0.1916 + 0.113)]

= 0.57 m^3

6) Mass of Coarse Aggregate

= f x Vol of C. A. x Sp. Gravity of C. A. x 1000
= 0.57 x 0.6 x 2.74 x 1000 = 937.08 kg / m^3

7) Mass of Fine Aggregate
= f x Vol of F. A. x Specific Gravity of F. A. x 1000
= 0.57 x 0.4 x 2.6 x 1000
= 592.80 kg / m^3

Mix Proportions:-

1) Cement = 383 kg / m^3
2) Water = 191.6 kg / m^3
3) Fine Aggregate = 592.80 kg / m^3
4) Coarse Aggregate = 937.08 kg / m^3
5) Water Cement ratio = 0.5
6) Coconut Shell = 118.7 kg / m^3

C)Mix Design for M20 Grade of Coconut Shell Concrete for 20% replacement:

On basis of	Water	Cement	Fine Aggregate	Coarse Aggregate	Coconut shell
Mass	191.6 lit	383 kg	546 kg	756.24 kg	237.4 kg
Ratio	0.5	1.0	1.42	1.97	0.61
Per Bag	24.35 lit	50 kg	72.42 kg	98.72 kg	30.99 kg

D)Mix Design for M20 Grade of Coconut Shell Concrete for 30% replacement:

On basis of	Water	Cement	Fine Aggregate	Coarse Aggregate	Coconut shell
Mass	191.6 lit	383 kg	546 kg	572.112 kg	356.1 kg
Ratio	0.5	1.0	1.42	1.49	0.93
Per Bag	24.35 lit	50 kg	72.42 kg	74.68 kg	46.48 kg

V. CONCLUSION

The average moisture content and water absorption of crushed coconut shell was found to be 4.20% and 24% respectively. Since the coconut shells are wood based and organic material and therefore moisture retaining capacity would be more compared with the crushed stone aggregates. Due to the high water absorption of coconut shells the aggregate were pre-soaked for 24 hours in potable water prior to the mixing and were in surface saturated dry (SSD) condition during mixing to prevent absorption of mixing water. The experiments have shown that most kinds of wood based materials can be improved substantially by soaking and washing with water before mixing. This method was found to be easier and suitable and is therefore adopted in this investigation.

The aggregate impact value gives relative measure of the resistance of an aggregate to sudden impact or shock. The aggregate impact value should not be more than 45% by weight for aggregate used in concrete. It can be observed that the aggregate impact value (AIV) and aggregate crushing value (ACV) of coconut shell aggregates are much lower compared to crushed stone aggregate which indicates that this aggregates have good absorbance to shock.

The slump obtained for trial mix was 55 mm, which has showed that coconut shell concrete has a medium degree of workability. The fresh concrete density and hardened concrete density after 28 days (under SSD condition) using coconut shell was found to be in the range of 1975-2110 kg/m3 and 1880-1930 kg/m3.

The 28 days compressive strength of coconut shell concrete was found to be 22.32 N/mm2, 13.56 N/mm2, 9.32 N/mm2, and 8.22 N/mm2 for conventional, 10%, 20% and 30% replacement by coconut shell aggregate under full water curing.

Moreover, GEDAR gives a novel profundity change based topology control instrument used to move void hubs to new profundities to conquer the correspondence void areas. Our reproduction results demonstrated that geographic steering conventions in light of the position area of the hubs are more productive than weight directing conventions. Additionally, pioneering directing demonstrated vital for the execution of the system other than the quantity of transmissions required to convey the parcel. The utilization of hub profundity conformity to adapt to correspondence void areas enhanced essentially the system execution. GEDAR enhances the system execution when contrasted and existing submerged directing conventions for various situations of system thickness and movement load.

REFERENCES

[1] AsokanPappu et al, "Solid wastes generation in India and their recycling potential in building materials", International Journal of Building and Environment (2007), pg. 2311-2320.

[2] K. Gunasekaran, P. S .Kumar et al 2008," Proceedings of International Conference on Advances in Concrete and Construction, ICACC-2008", India pg. 450-459.

[3] E. A. Olanipekun, K. O. Oluola, et al 2006. "A comparative study of concrete properties using coconut shell and palm kernel shell as coarse aggregates", Building & environment 41 (2006), pg. 297-301.

[4] Kabiru Usman Rogo et al, "Exploratory study of coconut shell as a coarse aggregate in concrete", Journal of Engineering and Applied Sciences Vol 2, Dec 2010, pg. 123-130.

[5] AbdulfatahAbubakar et al, "Exploratory study of coconut shell as a coarse aggregate in concrete", Journal of Engineering and Applied Sciences Vol 3, Dec 2011, pg. 60-67.

[6] PayamShafigh et al, "Mix design and mechanical properties of oil palm shell lightweight aggregate concrete: A review", International Journal of the Physical Sciences Vol. 5(14), 18 October, 2010, pg. 2127-2134.

[7] M. Abdullahi et al, "Trial Mix Design Methodology for Palm oil Clinker (POC) Concrete", International Conference on Construction and Building Technology, ICCBT 2008-A-(45), pg. 507-516.

[8] H. Mahmud et al, "Influence of Sand/Cement on Mechanical Properties of PlamKernal Shell Concrete", Journal of Applied Sciences 9(9), 2009, pg. 1764-1769.

[9] SitiAminah BT Tukiman Et Al, "Investigate the combination of coconut shell and grained palm kernel to replace aggregate in concrete: A technical review", National Conference on Postgraduate Research (NCON-PGR) 2009, Malaysia, pg. 49-58.

[10] AmarnathYerramala et al, "Properties of Concrete with Coconut Shells as Aggregate Replacement", International

Journal of Engineering Inventions, vol 1, issue 6 (October 2012), pg 21-31.

[11] Delsye C. L. Teo et al, "Flexural behaviour of reinforced lightweight concrete beams made with oil palm shell (OPS)", Journal of Advanced Concrete Technology Vol 4, pg. 459-469.

[12] Majid Ali, "Coconut Fibre – A versatile material and its applications in engineering", Second International Conference on Sustainable Construction Materials and Technologies

[13] Adewuyi et al, "Exploratory study of periwinkle shells as coarse aggregates in concrete works", ARPN Journal of Engineering and Applied Sciences, vol 3, dec 2008, pg. 1-5.

[14] Olugbenga et al, "Potentials of coconut shell and husk ash on the geotechnical properties of lateritic soil for road works", International Journal of Engineering and Technology, vol 3 (2), 2011, pg. 87-94.

[15] U. Johnson Alengaram, "Ductility behaviour of reinforced palm kernel shell concrete beams", European Journal of Scientific Research, Vol 23, no. 3, pg. 406-420.

[16] Maninder Kaur et al, "A review on utilization of coconut shell as coarse aggregate in mass concrete", International Journal of Applied Engineering Research, vol 7, no.11 (2012)