Experimental Assessment on Coconut Shell Powder as an Aggregate Material for Construction Bricks

Pranav Datar[1], Dr. Vikas Shinde[2]
[1, 2] Department of Mechanical Engineering
[1, 2] Sinhgad Institute of Technology, Maharashtra, India - 410401

Abstract- *Coconut shell is an agricultural waste and is available in large quantities throughout the tropical countries of the world, which are generally thrown away or burnt as a means of solid waste disposal. Hence there is need of development of new method of usage of the coconut shells to benefit the agricultural industry as well as other industries. In this work, the potential of coconut shell powder to be used as an aggregate material for making construction bricks is experimentally investigated. The bricks are made using coconut shell powder with soil in a ratio 5% (Sample 1), 10 % (Sample 2), 15% (Sample 3), 20% (Sample 4), 25% (Sample 5) and 30% (Sample 6) by volume. Test results have shown that compressive strength decreases with the increase in the volume of coconut shell powder. Bricks of Sample-1 give maximum average compressive strength of 4N/mm2 followed by Sample-3 2.36N/mm2, Sample-2 2.02N/mm2, Sample-4 and Sample-5 1.5N/mm2 and at Sample-6 0.6N/mm2. Also, Percent Water absorption by weight is observed to be increasing with the increase in the volume of coconut shell powder. Water absorption in Sample-1 is minimum i.e. 16.35% and further increases in remaining samples as the volume of coconut shell powder increases.Thus Sample-1 bricks fulfill the criteria for compression test and water absorption as mentioned in IS 3495(1 to 4) – 1992. Thus it proves that the coconut shell powder has potential to be used as an aggregate in construction bricks.*

Keywords- Coconut, Coconut Shell Powder, Construction Bricks.

I. INTRODUCTION

India is the third largest producer of coconut in the world. Annual production of coconut is 21.89 billion nuts (2012-13). Coconut contributes more than Rs.10000 crores annually to GDP [1].

Coconut shell (CS) which is the waste from coconut is having serious disposal problem. It is available in large quantities throughout the coastal part of India. It represents more than 60% of the domestic waste volume [2]. Bamgboye and Jekayinfa [3] regretted that 90% of coconut (empty fruit bunches, fibers, fronds, trunks, shell) was discarded as waste and either burned in the open air or left to settle in waste ponds. This way the coconut processing industries waste according to him contributed significantly to CO_2 and methane emissions. The wide availability of coconut shell makes it a suitable and dependable alternative for aggregate in construction bricks. This will have double advantage of waste management as well as pollution control.

II. LITERATURE REVIEW

The work started with the selection of keywords. Coconut, Coconut Shell Powder, Construction Bricks, Waste management these key words are used for extracting data related to the topic from various Journal papers and Conference papers. Coconut Development Board of India helped for getting statistical data regarding coconut production, current development in relation with waste management and our topic.

Thus various Journal papers, Conference papers, Project reports etc. having data related to our need were extracted. The criterion behind of selection was made on the basis of scope and objective of the work. Using this criterion, the papers were divided according to their objectives and only those having the objective of using coconut shell in construction and in mechanical engineering purposes and waste management were selected. Then from those papers, the next basis of classification was methodology used in the work. From this analysis of the literature following data was selected for the use in present work.

The properties of concrete using CS as coarse aggregate were experimentally investigated. In this study, Crushed coconut shell pieces were coarse aggregate, Ordinary Portland Cement (OPC) 53 Grade was binder and river sand was used as fine aggregate. Concrete was made by mixing these three in various ratios based on volume. The concrete with mixing ratio (cement: fine aggregate: coconut shell) 1:1.60:0.8, 1:1.60:0.7 and 1:1.47:0.65 satisfies the requirement of strength as per ASTM. The experiments proved that CS fulfills the requirements for use as lightweight aggregate [4].

Experimental assessment on coconut shells as aggregate in concrete is done. Here the materials used were Portland cement, sand, granite and coconut shells. A concrete mix of

ratio of 1:2:4 by volume, with a water cement ratio of 0.6 was used as control, to which the properties of all other mixes were compared. Coconut shells were used to replace 20%, 30%, 40%, 50% and 100% of the granite by volume. Experimental results show that 18.5% replacement of granite by coconut shell gave maximum compressive strength 20 Nmm-2 whereas the compressive strength of concrete produced by 20%, 30%, 40%, and 50% replacement were higher than 15Nmm-2, the minimum recommended for use in reinforced lightweight concrete construction [5].

In the Experimental Analysis of the use of Coconut Shell as Coarse Aggregate properties of coconut shell aggregate concrete is examined and the use of coconut shell aggregate in construction is tested. Portland Cement (OPC) 53 Grade, Coconut shell, crushed blue granite and river sand were used for making concrete. They replaced coarse aggregate with coconut shell, by volume. Specimens were cast by replacing 25%, 50%, 75% and 100% of coarse aggregate with coconut shells. Tests were conducted on the cast specimens after 28 days as mentioned in the IS code. Their experimentation results that in 25% replacement of the coarse aggregate showed properties similar to the nominal mix and 50% replacement showed properties similar to light weight concrete which can be used as filler materials in framed structures, flooring tiles, thermal insulating concrete etc. [6].

A technical review is performed on Combination of coconut shell and grained palm kernel as lightweight aggregate in concrete. The review concludes that Combination of coconut shell and grained palm kernel has potential to be used as lightweight aggregate in concrete. Also, using the combination of coconut shell and grained palm kernel shell as aggregate in concrete can reduce the material cost in construction because of the low cost and abundant availability of these agricultural wastes [7].

III. MATERIALS USED

Soil used for making bricks is a mixture of Red soil and Black soil with a ratio 4:1 by volume. It was obtained from farms near Malegaon (Nashik) this soil is being used for making conventional red bricks. Density of the soil used is 2.67 gm/cm^3.

The coconut shell powder was directly obtained from supplier at Tamilnadu, India. Fine coconut shell powder of 60 mesh size and density 1.57 gm/cm^3 was used. The potable water supplied by Malegaon Municipal Corporation was for mixing and curing.

IV. METHODOLOGY

Studying the previous researches for the proportion of coconut shell powder as aggregate with soil it was decided that the samples to be made with the coconut shell powder as 5%, 10%, 15%, 20%, 25% and 30% aggregate.

In an experimental investigation, [8] found out that replacement of granite with palm kernel shells by volume produced a better performance concrete than replacement by weight. Similarly in experimental assessment [5] replacement of granite with coconut shells by volume is used. If coconut shell powder would be used as aggregate with soil by weight for making bricks, due to its low density it would have reduced the share of soil. Hence with reference to [5] and [8] coconut shell powder is added as aggregate with the soil by volume.

For deciding the proportion, 50kg soil is taken as base since for making conventional red bricks, approximately 50kg soil is required to make 15 bricks. Thus for making the bricks 50kg (18726.9 cm3) soil was the base size in which the aggregate coconut shell powder was to be mixed.

1. Sample 1 (5% CSP and 95% soil)

In this sample 5% Coconut shell powder was to be added in soil by volume. The volume of Coconut shell powder to be added was based on the volume of 50 kg soil. 5% volume that means 936.32 cm^3 of coconut shell powder was required to be added to the soil and on the other hand 936.32 cm^3 of soil was required to be removed from 50 kg soil. Then for ease in measurement of material the volume was converted into mass of coconut shell powder and soil. It resulted in 1460.67gm of coconut shell powder to be added and 2500 gm of soil to be removed. Electronic measuring gauge was used for measurement of mass. Thus 1st Sample was the mixture of 1.46 kg of coconut shell powder and 47.5 kg of soil. Using the same procedure the remaining sample mixtures were made. Similarly the following mixtures are made.

Fig. 1 Mixtures of CSP and soil for making bricks

2. Sample 2 (10% CSP and 90% Soil) was made with 2.92 kg of coconut shell powder and 45 kg of soil.
3. Sample 3 (15% CSP and 85% Soil) was made with 4.48 kg of coconut shell powder and 42.5 kg of soil.
4. Sample 4 (20% CSP and 80% Soil) was made with 5.84 kg of coconut shell powder and 40 kg of soil
5. Sample 5 (25% CSP and 75% Soil) was made with 7.3 kg of coconut shell powder and 37.5 kg of soil.
6. Sample 6 (30% CSP and 70% Soil) was made with 8.76 kg of coconut shell powder and 35 kg of soil.

Fig. 2 Dies used for making bricks

Then water was added to all those mixtures and the clay was kept as it was for whole night before making bricks. Then bricks are made from those mixtures using aluminium dies. Dies having numbers 1, 2, 3, 4, 5 and 6 printed on them were used to make bricks. So that the bricks made of sample-1 were imprinted with number 1, the bricks of sample-2 were imprinted with number 2 and so on.

Thus all the bricks were made and dried for 2 days before putting them to the kiln for baking. Then the bricks were put to kiln for 15 days for baking. The bricks were kept at the 2nd row form upside at one of the corners of the kiln.

Fig. 3 Drying raw bricks before baking

Fig. 4 Kiln for baking bricks

Fig. 5 Bricks removed from the kiln

After getting removed from the kiln, the bricks were then ready for the testing.

V. TESTING

The testing of the bricks is performed referring the IS standard for testing of burnt clay bricks IS 3495(Part 1 to 4):1992. According to the given procedure, compression test, water absorption test and efflorescence test were performed. Hardness test was also performed.

For compression test, specimens were loaded axially; at a uniform rate of 14N/mm^2 per minute till the failure occurred. The maximum load at failure was noted. The compressive strength is obtained by,

$$\sigma_c = \frac{\text{Maximum load at failure (N)}}{\text{Area of bed face } (mm^2)}$$

Fig. 6 Specimen of sample 1 during compression test

Fig. 7 Specimen of sample 1 after compression test

For water absorption test, the specimens were first dried in oven at a temperature of 105º C. till a constant mass was obtained by it. Then it was cooled to room temperature and its mass (M1) was noted. After that the specimens were immersed in clean water at room temperature for 24 Hrs. The specimens were then removed and the weighing was done 3 minutes after the removal. Again the mass (M2) of specimens was noted.

Water absorption, percent by mass, after 24-hour immersion in cold water is given by,

$$\frac{M_2 - M_1}{M_1} \times 100$$

Table 1 Test results

Sample No.	% Share of CSP (by volume)	Avg. Compression Strength (N/mm^2)	% Water Absorption (by weight)
1	*5*	*4*	*16.35*
2	10	2.02	19.9
3	15	2.36	21.09
4	20	1.5	23.15
5	25	1.5	22.87
6	30	0.6	32.9

VI. RESULTS AND DISCUSSIONS

Compressive strength of brick depends on many parameters such as soil properties, mixture quality, baking etc. Here the share of soil in each sample is gradually decreased and share of coconut shell powder is increased. Experimental results show that compressive strength decreases with the increase in the share of coconut shell powder. The main reason behind this is the reduction in the share of soil but in case of Sample-2 and Sample-3, strength is increased slightly. This may be because of some problems in the mixture or during baking. The maximum compressive strength is obtained from Sample-1(5% CSP).

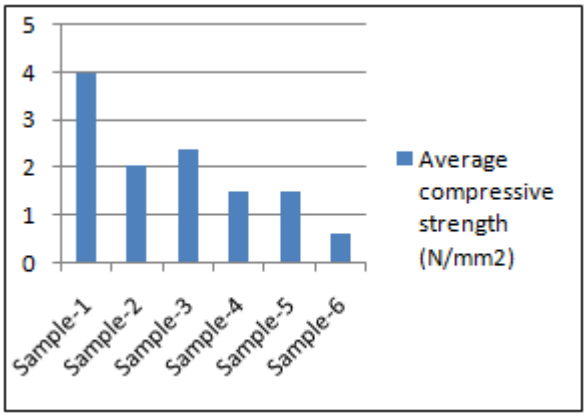

Fig. 8 Compression test results

% Water absorption increases with the increase in the increase in the share of coconut shell powder. This is because during the baking, coconut shell powder being burnt increases the porosity of the brick. The Sample-1 gives minimum water absorption i.e. 16.35%.

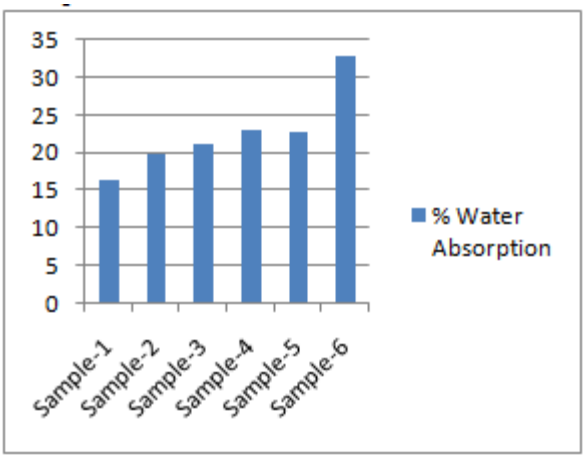

Fig. 9 Water Absorption test results

According to IS standards for testing of clay bricks, the compressive strength should not be less than $3N/mm^2$ and %

Water absorption should not exceed 20%. Thus bricks of Sample-1 satisfy the criteria for strength as well as water absorption.

VII. CONCLUSION

From this experimentation it is clear that Sample-1(5% CSP and 95% Soil) bricks fulfill the criteria for compression test and water absorption as mentioned in IS 3495(1 to 4) – 1992. Thus it proves that the coconut shell powder has potential to be used as an aggregate in construction bricks.

VIII. FUTURE SCOPE

Further study can be done to determine the optimum value of coconut shell powder to be used as aggregate for getting the maximum strength.

REFERENCES

[1]. Annual Report (2012-13), Coconut Development Board, India.

[2]. K. Gunasekaran, R. Annadurai, P.S. Kumar, 'Long term study on compressive and bond strength of coconut shell aggregate concrete', Construction and Building Materials, 28 (2012) 208–215.

[3]. Bamgboye A. Isaac and Jekayinfa .S. 'Energy Consumption Pattern in Coconut Processing Operations', Agricultural Engineering International: the CIGR Journal Manuscript EE 05 013. Vol. VIII. 2006.

[4]. K. Gunasekaran, P.S. Kumar, 'Mechanical and bond properties of coconut shell concrete', Construction and Building Materials, 25 (2011) 92–98.

[5]. Daniel Yaw Osei, 'Experimental assessment on coconut shells as aggregate in concrete', International Journal of Engineering Science Invention, Volume 2, Issue 5, May 2013, pp 7-11.

[6]. B.Damodhara Reddy, S.Aruna Jyothy , Fawaz Shaik, 'Experimental Analysis of the Use of Coconut Shell as Coarse Aggregate', IOSR Journal of Mechanical and Civil Engineering (IOSR-JMCE), Volume 10, Issue 6, Jan 2014, pp 6-13.

[7]. Siti Aminah Bt Tukiman and Sabarudin Bin Mohd, 'Investigate the combination of coconut shell and grind palm kernel to replace aggregate in concrete: a technical review', National Conference on Postgraduate Research (NCON-PGR) 2009, pp 49-58.

[8]. D.Y. Osei and E.N. Jackson, 'Experimental study of palm kernel shells as coarse aggregate in concrete', International Journal of Scientific and Engineering Research 3(8), 2012.