Coconut shell as partial replacement of coarse aggregate

Dewanshu Ahlawat, L.G. Kalurkar*
Department of Civil Engginering
MGM's Jawaharlal Nehru Engineering College, Aurangabad
Mahatma Gandhi Mission (MGM), N-6, CIDCO, Aurangabad - 431003, Maharashtra, INDIA
***Corresponding Author:** E-mail: lgkalurkar111@gmail.com , Tel.: +91 240 2482893 , Fax:+91 240 2482232

ABSTRACT

The rising cost of construction material is a matter of concern. The reason for increase in cost is high demand of concrete and scarcity of raw material. Hence the concrete technologists must search for some economical alternative to the coarse aggregate. In this study, M 20 grade of concrete was produced by replacing granite by coconut shell. Forty five cubes were casted and their compressive strength and densities were evaluated at 7 and 28 days. The density and compressive strength of concrete reduced as the percentage replacement increased. Concrete produced by 2.5%, 5%, 7.5%, 10% replacement attained divergent 28 days compressive strength. These results showed that Coconut shell concrete can be used in reinforced concrete construction. Its utilization is cost effective and eco friendly.

Keywords: *Coarse Aggregate, Coconut Shell, Compressive Strength, Density, Waste Utilization*

1. Introduction

Concrete is world's most widely used construction material. The utilization of concrete is increasing at a higher rate due to development in infrastructure and construction activities all around the world [1]. However there are some negative impacts of more production of concrete like continuous extensive extraction of aggregate from natural resources will lead to its depletion and ecological imbalance [2]. Researchers are in search of replacing coarse aggregate to make concrete less expensive and to lead sustainable development [3]. This environmental reason has generated a lot of concern in the construction world (Fig.1). The use of sugarcane bagasse, wooden chips, plastic waste, textile waste, polyethylene, rice husk ash, rubber tyres, vegetable fibers, paper and pulp industry waste, groundnut shell, waste glass, broken bricks are some examples of

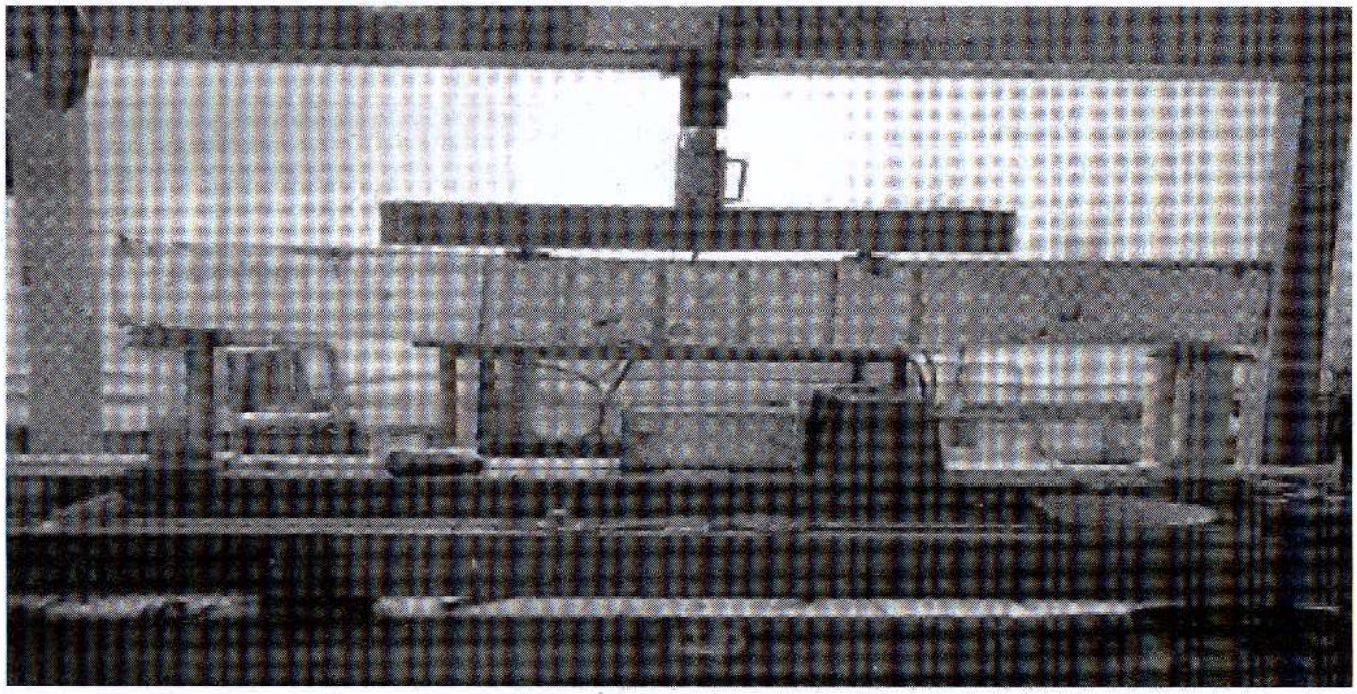

Fig. 1 Coconut shell concrete beam testing on universal testing machine

replacing aggregates in concrete[4]. Coconut shell is categorized as light weight aggregate. The coconut shell when dried contains cellulose, lignin, pentosans and ash in varying percentage [5]. In Asia, the construction industry is yet to realize the advantages of light weight concrete in high rise buildings [6]. Coconut shells are not commonly used in construction industry and are often dumped as agricultural waste. The aim of this research is to spread awareness of using coconut shell as partial replacement of coarse aggregate in concrete and determining its compressive strength and density. Until now, Industrial by products and domestic wastes has been utilized in concrete, but the use of agricultural waste in concrete is in its infancy stage. Coconut shell is an agricultural waste. The materials are proportioned by their weights. The water cement ratio is obtained by conducting various workability tests. The obtained results are compared with that of conventional mix. Tests are as per the specified procedure of Indian Standard Codes.

2. Materials and Method

The raw materials used in this experimentation were locally available and these included Ordinary Portland Cement (O.P.C) as binding agent, river sand as fine aggregate, crushed granite and coconut shell as coarse aggregate. Potable tap water was used for mixing and curing throughout the entire investigation. The permissible and tolerance limits of water were checked as per the I.S 456-2000[14].

Cement: Ordinary Portland cement grade 53, conforming to I.S 12269-1987[12] was used. Cement must develop appropriate strength. It must represent the appropriate rheological behavior.

Table 1. Propeties of Ordinary Portland Cement

Sr. No.	Physical Property	Test Results
01	Standard Consistency	29.7%
02	Fineness of Cement (%)	7.9%
03	Specific Gravity	3.16
04	Initial Setting Time	42 mins.
05	Final Setting Time	227 mins.

Fine Aggregates: River sand was used as the fine aggregate, conforming to Zone-II as per I.S 383-1970[13].The sand was air dried and sieved to remove any foreign material, prior to mixing.

Table 2. Propeties of Fine Aggregates

Sr. No	Physical Property	Test Results
01	Specific Gravity	2.4
02	Fineness Modulus	2.33
03	Bulk Density(kg/m^3)	1620

Coarse Aggregates: Coarse aggregate consists of 50% of self weight of concrete and 70% of volume of concrete.

Table 3. Propeties of Coarse Aggregates

Sr. No	Physical Property	Test Results
01	Specific Gravity	2.8
02	Fineness Modulus	2.36
03	Bulk Density (kg/m^3)	1670
04	Water Absorption	0.22

Coconut Shell: Coconut shells were collected from temples to analyze the properties of coconut shell. The physical properties of Coconut shell are shown below.

Table 4. Propeties of Coconut Shell

S. No	Physical Property	Test Results
01	Specific Gravity	1.36
02	Shell Thickness (mm)	(2-7)
03	Bulk Density(kg/m^3)	820
04	Water Absorption	0.24

3. Preparation of Specimens:

Concrete Mix Design: M-20 grade of concrete was designed by I.S 10262-1982[11] method. The natural coarse aggregates were replaced as 0%, 2.5%, 5%.7.5%, 10%.The test results were analyzed and compared with theoretical values, obtained from various codes. Due to high water absorption of coconut

shell, they were pre-soaked in water for 24 hours, prior to mixing.

Batching and Mixing: Weigh Batching was practiced with the help of electronic weigh balance. Batching was done as per the mix proportions. Mixing was done in tilting mixer. It was mixed for 2-3 minutes, after addition of water.

Placing and Compaction: Cubes are cleaned and oiled to prevent the formation of bond between concrete and moulds. Place the fresh concrete in cubes in 3 layers, tamping each layer 25 times. The entrapped air in concrete is removed by table vibrator. Anything kept on the table gets vibrated.

Demoulding: After placing fresh concrete in moulds, it was allowed to set for 24 hours. It was marked with some permanent identification mark i.e. A1, A2, A3, etc. Concrete cubes are now kept in curing tank for 7, 14 and 28 days. After 28 days, concrete cubes were removed from curing tank to conduct tests on hardened concrete.

4. Results and Discussion:

Compressive Strength:
Compressive strength is defined as resistance of concrete to axial loading. Cubes were placed in Universal Testing Machine (U.T.M), and load was applied. The readings on dial gauge were recorded and compressive strength was calculated. The results of Compressive strength are given in Table 5.
Compressive Strength = P/A
Where, P= Maximum load and A= Cross Sectional Area.

Table 5. Compressive strength of Coconut Shell Concrete (N/mm^2) with increase in % of replacement

Curing Days	0%	2.5%	5%	7.5%	10%
07	15.09	14.93	14.79	14.58	14.40
28	20.27	19.71	19.53	19.08	18.91

The maximum compressive strength of 20.27 N/mm^2 was attained at 0% replacement, while the minimum strength of 18.91 N/mm^2 was attained at 100% replacement. At 10% replacement, concrete attained 18.91 N/mm^2 marginally less than 20 N/mm^2, the minimum recommended for use as structural concrete according to the requirements of [7].The strength decreased as the percentage replacement increased. As the coconut shell increased, the surface area increased, thus requiring more cement for proper bonding. Since cement content was constant, there was no extra bonding and strength reduced [8].

Density: The results of density determination is given in Table 6.It is observed that as percentage replacement increased, density of concrete decreased, thus making it light weight concrete [9, 10].

Table 6. Density of Coconut Shell Concrete (kg/m^3) with % of replacement

Curing Days	0%	2.5%	5%	7.5%	10%
07	2410	2402	2394	2387	2371
28	2538	2516	2491	2465	2436

Bar Charts: The bar charts are drawn for compressive strength results. These are drawn between compressive strength and percentage replacement of coconut shell concrete at 7 and 28 daysof curing to observe the variation of results as shown in Figs. 2.

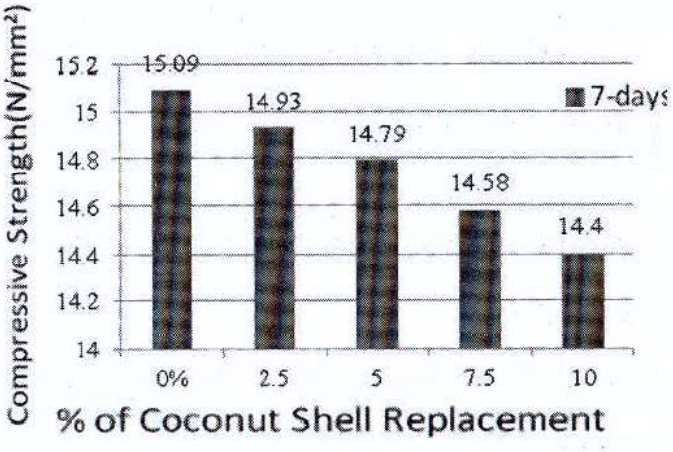

Fig.2a Coconut shell concrete compressive strength on curing for 7 days

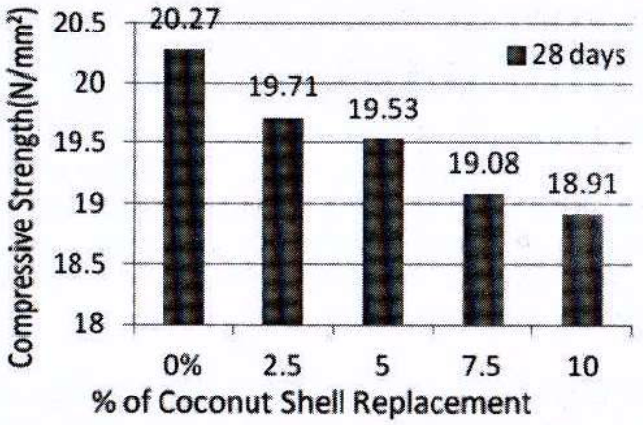

Fig.2b Coconut shell concrete compressive strength on curing for 28 days

5. Conclusions and Recommendations:

It is concluded that:

- Increase in percentage replacement by coconut shell reduces compressive strength of concrete.
- Increase in percentage replacement by coconut shell reduces Density of concrete.
- Coconut Shell can be used as partial replacement of coarse aggregate in R.C.C concrete.

The following recommendations are made at the end of the study.

- Effect of different admixtures can be studied on Coconut Shell Concrete (C.S.C)
- Evaluating Bond Strength of Coconut Shell Concrete(C.S.C)
- Coconut Shell- Cement compatibility

6. References:

[1] J. M. Crow, The Concrete Conundrum,2006, www.chemistryworld.com accessed on Dec.2, 2014.

[2] A short and W. Kinniburgh, Lightweight Concrete, *Applied Science Publishers*, London

[3] Daniel Y.O, (2013), Experimental Assessment on Coconut Shell as aggregate in concrete, *International Journal of Engineering Science Invention*. 2(5), 7-11.

[4] Maninder Kaur, Manpreet Kaur,(2012), A review on utilization of coconut shell as coarse aggregate in mass concrete, *International Journal of Applied Engineering Research*, 7(11), 5-8.

[5] Kulkarni V.P, Kumar .S, (2013) Comparative study on coconut shell aggregate with conventional concrete, 2(12), 67-70.

[6] Shetty M.S, *Concrete Technology Theory and Practice* (1991), 3rd edition, S. Chand Company Limited, New Delhi.

[7] British Standard Institutions, BS 8110 – Part1, The structural use of concrete, BSI, London 1997.

[8] Kabiru Usman Rogo, Selah Abu-Bakr Exploratory study of coconut shell as aggregate in concrete production, *Journal of Engineering and Applied Sciences*, Vol.2, Dec 2010.

[9] Gunasekaran K, Kumar P.S, Laxmipathy M Mechanical and Bond properties of Coconut Shell Concrete Construction and Building Material (2011), 92-96.

[10] Utsev,J.T,Taku,J.K,2012, Coconut shell ash as partial replacement of ordinary Portland cement in concrete production, *International Journal of Scientific and Technology Research*, 1(8), 86-89.

[11] I.S 10262-1982: Recommended guidelines for concrete mix design, 1982

[12] I.S 12269-1987: Specifications for 53 grade Ordinary Portland Cement, 1987

[13] I.S 383-1970: Specifications for coarse and fine aggregates, 1970

[14] I.S 456-2000 Indian Standard: Plain and Reinforced Cement Concrete Code of practice.