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Waste Coconut Shell as a Partial Replacement of Coarse Aggregate in Concrete Mix - An Experimental Study

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Abstract: ***In construction industry the rising cost of construction material is the great factor. The prices of building materials are rising day by day. Therefore this is a most priority of all human being to encourage or research on sustainable material which will help to use such waste material as construction material with less cost and safety of structure. The course aggregate is the main constituent of concrete mix, hence in this paper we used coconut shell as a coarse aggregate has been discussed based on the results obtained from test results. The use of coconut shell can also help the prevention of the environment. The paper aims at analyzing compressive strength of concrete (M20-1:1.5:3) produced using coconut shell as substitute for conventional coarse aggregate with 0%, 25%, 50%, 100% partial replacement. Three sample cubes are prepared for M20 grade concrete mix for each case another aim of this paper is to spread awareness about use of coconut shell as construction material in civil engineering.***

Keywords: Construction material, coconut shell, compressive strength of coconut shell**,** Coconut shell concrete**,** Waste Utilization

1. Introduction

Concrete is the vital civil engineering material. Its manufacturing involves utilization of ingredients like cement, sand, aggregates, water and required admixtures. Demand of construction material is increased due to infrastructural development across the world. Now time has come to think of some alternative materials for sustainable use in concrete mix. Day by day mount and type of waste materials has increased accordingly creating environmental issues. [1] Coconut is grown in more than 93 countries. South East Asia is regarded as the origin of coconut. India is the third largest, having cultivation on an area of about 1.78 million hectares. [8] Coconut shell is one of the waste material can also be used as a aggregate in concrete due to some reasons like large scale cultivation of coconut in coastal region of India including Keral, Andhra Pradesh, Goa, Kokan, etc. due to tough made tissue, shell is not decomposed easily and remain as solid waste for years.[1]

2. Coconut shell as coarse aggregate

The concrete obtained using Coconut Shell aggregates satisfies the minimum necessities of concrete. Coconut Shell concrete has superior workability because of the smooth surface on one side of the shells. The impact resistance of Coconut Shell concrete is high when compared with conventional concrete. Moisture retaining and water absorbing capacity of Coconut Shell are more compared to conventional aggregate. The amount of cement content may be more when Coconut Shell are used as an aggregate in the production of concrete compared to conventional aggregate concrete. The presence of sugar in the CS as long as it is not in a free sugar form, will not affect the setting and strength of concrete. It is found that wood based materials, being hard and of organic[10]

3. Intention

To prove the coconut shell concretes which are lightweight and can be use as an economical civil engineering material
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4. Research Material and testing

4.1 Materials

Research material are cement, natural fine aggregate , coarse aggregate, water and coconut shell.

4.2 Coconut Shell

Coconut shell is obtained from temples etc. they were sun dried for minimum 1 month before using crushed manually. The particle size of the coconut shell range from 5mm to 20mm. Cement- Ordinary Portland cement of 53 grade conforming to Indian Standard IS 12269-1987 9 was used throughout the experimental program.

4.3 Fine Aggregate

Naturally available fine aggregate from Tapi River

4.4 Coarse Aggregate

Crushed hard basalt chips of maximum size 20 mm were used in the concrete mixes. The bulk density of aggregate was 1545 kg/m3 and specific gravity was found to be 2.77

4.5 Water

Potable water conforming to IS 456-2000 11 was used for casting and curing

4.6 Testing Methodology

Test is carried out for finding compressive strength by using following experimental procedure.

Figure 1: Coconut shells before cutting

Figure 2: Coconut shells after cutting

5. Concrete Mix Design

Mix design is the process of selecting appropriate ingredients of concrete and determining their qualified amounts with the objective of producing a concrete of the compulsory strength, durability and workability as economical as possible.

5.1 Factor to be considered for mix design

1) The grade designation giving the characteristics requirement of concrete.
2) The type of cement influences the rate of development of compressive strength of concrete.
3) Maximum nominal size of aggregate to be used in concrete may be as large as possible within the limit prescribed by IS 456-2000.
4) The cement content is to be limited from shrinkage, creeping and cracking

5.2 Designs for M20 Grade of Concrete

1) As per IS 456-2000 mix design of M20 grade concrete we have to taken for experimental work.
2) Sieve analysis is done for zone determination so as per IS 383-1970.
3) Condition of exposure is moderate :as per IS 456-2000, page no. 20 Table no. 7 For M20 grade of concrete, minimum cement content =300kg/m3. Maximum free W/C ratio = 0.5.
4) As cement is OPC is considered.
5) Size of aggregate =4.76-12.5 mm (angular).
6) Workability of concrete: The concrete mix proportion chosen should be such that the concrete is of adequate workability for the placing condition of the concrete and can properly be compacted.
7) Degree of workability: medium.
8) Degree of supervision: Good

6. Sample Calculation for Concrete Mix

Standard cube are of 0.15mX0.15mX0.15m
No of cubes=24
Mix proportion for M20 grade cement=1:1.5:3
FOR M20 GRADE
For 6 cubes – Control Mix
$6(0.15 \times 0.15 \times 0.15)=0.02025m^3$
Assume 50% Extra for mixing = $0.02025X1.5=0.030375\ m^3$
Mix proportion:-1:1.5:3=5.5
Volume of cement=(0.030375)/(5.5)=5.5227×10^{-3}
Weight of cement=$5.5227 \times 10^{-3} \times 1428\ kg/m^3$=7.88Kg
Cement =7.88=8kg
Sand=1.5 X 8=12 kg
Aggregate=3 X 8=24kg

6.1 FOR 25 % REPLACEMENT (75%CA+25% CS)

For 6 cubes
Cement=8 kg
Sand=1.5 X 8=12 kg
25% Coconut Shell = 24 KgX (25/100)= 6 kg
Coarse aggregate=24kg -6kg =18kg

6.2 FOR 50% RESPLACEMENT (50%CA+50% CS)

For 6 cubes
Cement=8 kg
Sand=1.5 X 8=12 kg
50% Coconut Shell = 24 Kg X (50/100)= 12 kg
Coarse aggregate=12kg -12kg =12kg

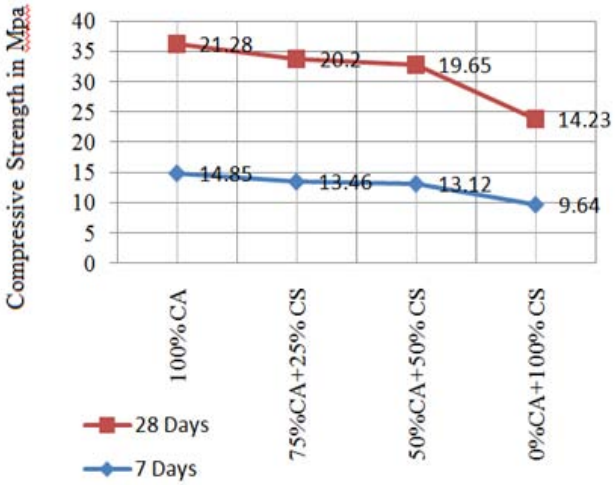
CA= Coarse Aggregate, CS= Coconut Shells

Figure 3: Cube Casting Samples

7. Compressive Strength Results

Samples	*Compressive Strength in Mpa*	
	7 Days	*28 Days*
Control Mix 100% CA	14.85	21.28
75%CA+25% CS	13.46	20.2
50%CA+50% CS	13.12	19.65
0%CA+100% CS	9.64	14.23

Figure 4: Testing on CTM



Graph 1: Testing Results

8. Result Discussion and Conclusion

Overall cost of construction will reduced. The maximum compressive strength in control mix is 21.28 N/mm^2 at 28 days, while the minimum strength at same days is 14.23 N/mm^2. Thus compressive strength decreased as percentage of coconut shell is increased. Therefore coconut shell can be used where light weight concrete is required. Proper bonding between coconut shell and cement is not possible because of surface area of coconut shell aggregate.[13]
In future, we can increase strength of coconut shell concrete by adding admixtures.

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