

# Coconut-Shell as a fractional substitute to coarse aggregate in mix concrete – a Study

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## ABSTRACT

Cost is the most important factor in civil engineering construction. Day by day construction cost rises due increase in the cost of material. Therefore its prime importance that the cost of construction should remain in control. In this paper Coconut-Shell is used as partial substitute in different percentages to replace coarse aggregate in concrete mix for making M-20 grade. Main objective of paper to analyzing physical property of fresh concrete that is slump value and of hard concrete that is compressive strength of concrete M-20 by mixing waste Coconut-Shell as foreign material in conventional concrete mix with 0%,10%,20%,30%,40%,50%, 60% and 70% partial replacement. The cube samples of M-20 grade concrete mix are cast for analyzing purpose. The important aim of this paper is to utilize the waste product to make concrete environmental friendly.

**Key words:** Coconut-Shells, concrete, Coconut-Shell concrete, solid waste utilization, slump value, Compressive strength

## 1. INTRODUCTION

Concrete is an important key materials and widely used in making concrete mix. In making concrete various types of materials are used like cement, sand, coarse aggregate, water and optimum percentage of ad-mixture [1]. As we know in modern world different types of waste materials exist and their dumping in open area create difficulty to environment therefore it's important for engineering technology to use these waste materials as a raw materials so that it is eco-friendly [2]. Among these waste materials Coconut-Shell is also important waste material which found in large scale around the world. More than 93 countries coconut is grown in large mass. India is considered the third largest coconut producer with 1.78 million hectares Kerala, Andhra Pradesh; Goa etc. are the coastal region where coconuts are cultivated in abundant [3].

*Coconut-Shell a partial substitute to coarse aggregate:* Waste coconut-shell is considered natural important filler because of high strength, modulus properties with high lignin content and its weather resistant properties make it suitable for construction material as a concrete making by replacement with coarse aggregate. Coconut is naturally one of the organic materials obtained from nature [4]. Due to its low cellulose content Coconut-Shell absorb less moisture and make it effective source of natural material for reinforcing epoxy resin towards their flexural properties [5]. However Coconut-Shell is the one of major problem for environment as it is largely existing agricultural waste from local coconut industries approximately 3.18 million tons of Coconut-Shell produce annually .which is one of the serious issues. By using waste Coconut-Shell in making concrete as partial replacement of coarse aggregate help in solid waste management [6, 7]. Due to Coconut-Shell compatibility with cement as coarse aggregate hence no

pre-treatment is required before utilizing it as coarse aggregate in concrete mix .Its smooth surface finish of Coconut-Shell make it better workable [8, 9].

## 2. MATERIAL USED

Material used in experiment study was locally available are (Table No.1)

**Table No 1: Material with their physical properties**

Material	Physical properties
<b>Cement Ordinary Portland cement</b>	OPC-53 confirming to IS: 12269-1987 Specific gravity -3.15
<b>Fine aggregate</b> available in nearby local River sand as per IS: 383-1970	Specific gravity - 2.60 Fineness modulus - 3.30
<b>Coarse aggregate</b> with maximum size of 20mm	Specific gravity -2.7 Fineness modulus -6.50 Water absorption – 0.92%
<b>Coconut-Shell</b> –Collected from temples and from local shops	Specific gravity -1.33 Shell thickness -5-10mm Water absorption – 0.25
<b>Water</b>	Potable drinking water confirming IS: 456-2000

## 3. METHODOLOGY

**Step 1 Design mix:** Mix Design as per IS 456-2000 and IS: 10262-1982 for M20 Grade Mix taken for experimental study. For Zone determination Sieve analysis is carried as per IS 383-1970. Exposure Condition is moderate. As per IS:456-2000 for M20 mix according to minimum 300 Kg/m<sup>3</sup> cement content and maximum 0.5 Water Cement ratio as per IS :456-2000. OPC-53 grade Cement confirming IS: 12269-1987, coarse aggregate in between 4.75mm to 12.75mm of angular shape are used in Mix. Workability is of medium degree under good supervision condition.

**Step 2 Mixing of aggregate:** Proper mixing is done as per IS 456:2000 for making proper concrete cubes

**Step 3 Curing of sample:** Curing of cubes done (Tank curing) after 24 hrs for 28 days as per IS 456:2000

**Step 4 Testing on sample:** On fresh concrete slump cone test is done for obtaining the workability as per

On hard concrete the compressive strength test is done to obtain the compressive strength as per IS 516-1959

## 4. RESULT

### Design Mix: Sample calculation For Mix-20 (1: 1.5:3)

Cube of standard Size =  $0.15\text{m} \times 0.15\text{m} \times 0.15\text{m}$

Total number of cubes- 216

Control mix calculation For 9 cubes

Calculation of material for concrete for 9 cubes

*Wet volume*  $9 \times (0.15\text{m} \times 0.15\text{m} \times 0.15\text{m}) = 0.030375\text{cum}$

*Increase*  $0.030375\text{ cum}$  for dry volume concrete by 50% consideration  
 $= (0.030375) + (0.030375 \times .50)$

*Total Dry volume* =  $0.045562\text{ cum}$

*We adopt proportion of mix for M20 grade* (1: 1.5 : 3) as per IS: 456 – 2000

*Volume of cement* =  $(0.045562) / (1 + 1.5 + 3) = 8.284 \times 10^{-3}$

*Wt of cement* =  $8.284 \times 10^{-3} \times 1428\text{kg/cum} = 11.83\text{ Kg}$

*Weight Of sand* =  $1.5 \times 11.83\text{Kg} = 17.75\text{kg}$

*Weight of aggregate* =  $3 \times 11.83\text{Kg} = 35.50\text{Kg}$

### For 10% Coconut-Shell in coarse aggregate for 9 cubes

*Volume of cement* =  $(0.045562) / (1 + 1.5 + 3) = 8.284 \times 10^{-3}$

*Wt of cement* =  $8.284 \times 10^{-3} \times 1428\text{ kg/cum} = 11.83\text{ Kg}$

*Wt Of sand* =  $1.5 \times 11.83\text{Kg} = 17.75\text{kg}$

*Weight of 10 % of Coconut – Shell in coarse aggregate* =  $35.5 \times (10/100) = 3.55\text{Kg}$

*Weight of coarse aggregate* =  $35.50\text{Kg} - 3.55\text{Kg} = 31.95\text{ Kg}$

**For 20% Coconut-Shell in coarse aggregate for 9 cubes**

$$\text{Volume of cement} = (0.045562) / (1 + 1.5 + 3) = 8.284X 10^{-3}$$

$$\text{Wt of cement} = 8.284X 10^{-3} X 1428\text{kg/cum} = 11.83 \text{ Kg}$$

$$\text{Weight Of sand} = 1.5X 11.83\text{Kg} = 17.75\text{kg}$$

$$\text{Weight of 20 \% of Coconut – Shell in coarse aggregate} = 35.5X (20/100) = 7.10\text{Kg}$$

$$\text{Weight of coarse aggregate} = 35.50\text{Kg} - 7.105\text{Kg} = 28.40 \text{ Kg}$$

**For 30% Coconut-Shell in coarse aggregate for 9 cubes**

$$\text{Volume of cement} = (0.045562) / (1 + 1.5 + 3) = 8.284X 10^{-3}$$

$$\text{Wt of cement} = 8.284X 10^{-3} X 1428\text{kg/cum} = 11.83 \text{ Kg}$$

$$\text{Weight Of sand} = 1.5X 11.83\text{Kg} = 17.75\text{kg}$$

$$\text{Weight of 30 \% of Coconut – Shell in coarse aggregate} = 35.5X (30/100) = 10.65\text{Kg}$$

$$\text{Weight of coarse aggregate} = 35.50\text{Kg} - 10.65\text{Kg} = 24.85 \text{ Kg}$$

**For 40% Coconut-Shell in coarse aggregate for 9 cubes**

$$\text{Volume of cement} = (0.045562) / (1 + 1.5 + 3) = 8.284X 10^{-3}$$

$$\text{Wt of cement} = 8.284X 10^{-3} X 1428\text{kg/cum} = 11.83 \text{ Kg}$$

$$\text{Weight Of sand} = 1.5X 11.83\text{Kg} = 17.75\text{kg}$$

$$\text{Weight of 40 \% of Coconut – Shell in coarse aggregate} = 35.5X (40/100) = 14.20\text{Kg}$$

$$\text{Weight of coarse aggregate} = 35.50\text{Kg} - 14.205\text{Kg} = 21.30 \text{ Kg}$$

**For 50% Coconut-Shell in coarse aggregate for 9 cubes**

$$\text{Volume of cement} = (0.045562) / (1 + 1.5 + 3) = 8.284X 10^{-3}$$

$$\text{Wt of cement} = 8.284X 10^{-3} X 1428\text{kg/cum} = 11.83 \text{ Kg}$$

$$\text{Weight Of sand} = 1.5X 11.83\text{Kg} = 17.75\text{kg}$$

$$\text{Weight of 50 \% of Coconut – Shell in coarse aggregate} = 35.5X (50/100) = 17.75 \text{ Kg}$$

$$\text{Weight of coarse aggregate} = 35.50\text{Kg} - 17.75\text{Kg} = 17.75 \text{ Kg}$$

**For 60% Coconut-Shell in coarse aggregate for 9 cubes**

$$\text{Volume of cement} = (0.045562) / (1 + 1.5 + 3) = 8.284X 10^{-3}$$

$$\text{Wt of cement} = 8.284X 10^{-3} X 1428\text{kg/cum} = 11.83 \text{ Kg}$$

$$\text{Weight Of sand} = 1.5X 11.83\text{Kg} = 17.75\text{kg}$$

*Weight of 60 % of Coconut – Shell in coarse aggregate =  $35.5X (60/100) = 21.30Kg$*

*Weight of coarse aggregate =  $35.50Kg - 21.30Kg = 14.20Kg$*

**For 70% Coconut-Shell in coarse aggregate for 9 cubes**

*Volume of cement =  $(0.045562) / (1 + 1.5 + 3) = 8.284X 10^{-3}$*

*Wt of cement =  $8.284X 10^{-3} X 1428kg/cum = 11.83 Kg$*

*Weight Of sand =  $1.5X 11.83Kg = 17.75kg$*

*Weight of 70 % of Coconut – Shell in coarse aggregate =  $35.5X (70/100) = 24.85Kg$*

*Weight of coarse aggregate =  $35.50Kg - 24.85Kg = 10.65 Kg$*

**Workability Test Result:**

The Slump Cone Test of Coconut-Shell Concrete is shown in Table No. 2 and is also represented as in graphical format in Figure No. 1.

**Table No 2: Slump Cone Value of Coconut-Shell Concrete**

Coconut-Shell %in concrete	Slump value mm
0%	72
10%	67
20%	60
30%	51
40%	45
50%	38
60%	32
70%	26

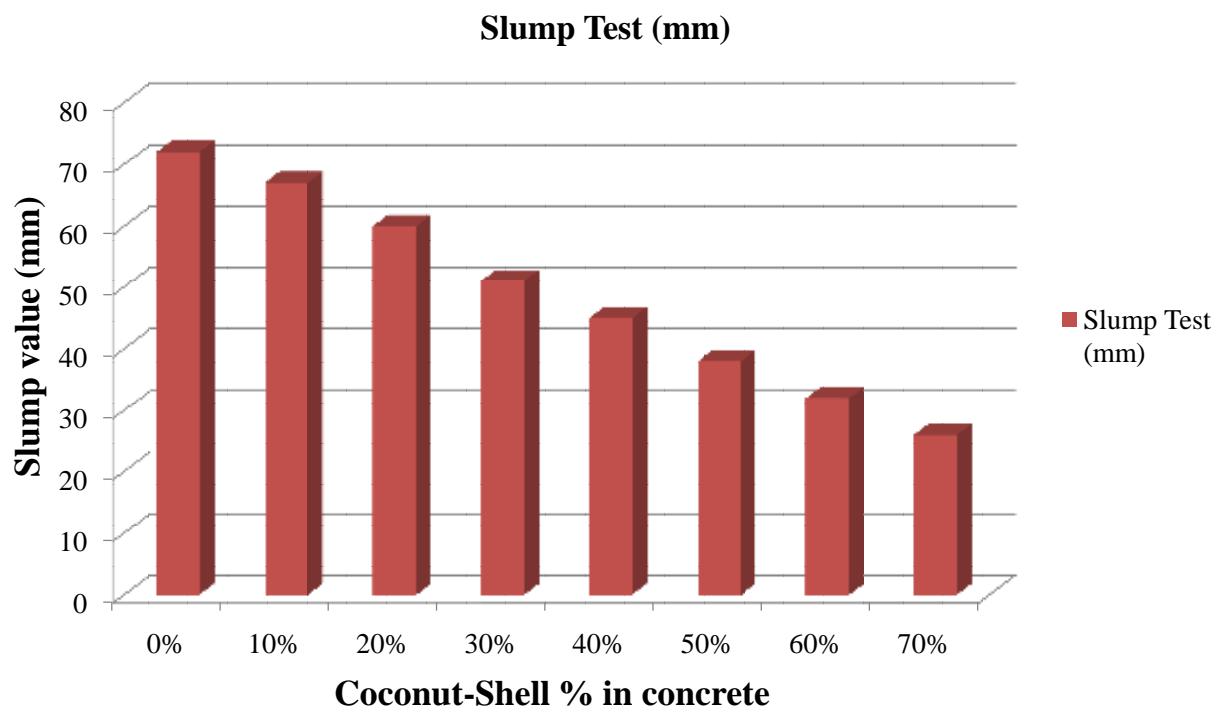


Figure No. 1: Slump Test Graphs

**Compressive Strength Test Result:**

The Compressive Strength Test of Coconut-Shell Concrete is shown in Table No. 3 and is also represented as in graphical format in Figure No. 2.

Table No 3: Compressive Strength Test (N/mm<sup>2</sup>)

Coconut-Shell % in concrete	Compressive Strength N/mm <sup>2</sup> in number of days of Casting cube		
	Day7	Day 14	Day 28
0%	14.65	19.25	21.24
10%	13.85	18.92	20.55
20%	13.63	17.75	19.95
30%	12.55	16.12	18.83
40%	11.95	15.40	17.07
50%	9.05	13.04	16.67
60%	7.64	10.14	13.05
70%	6.48	7.06	11.48

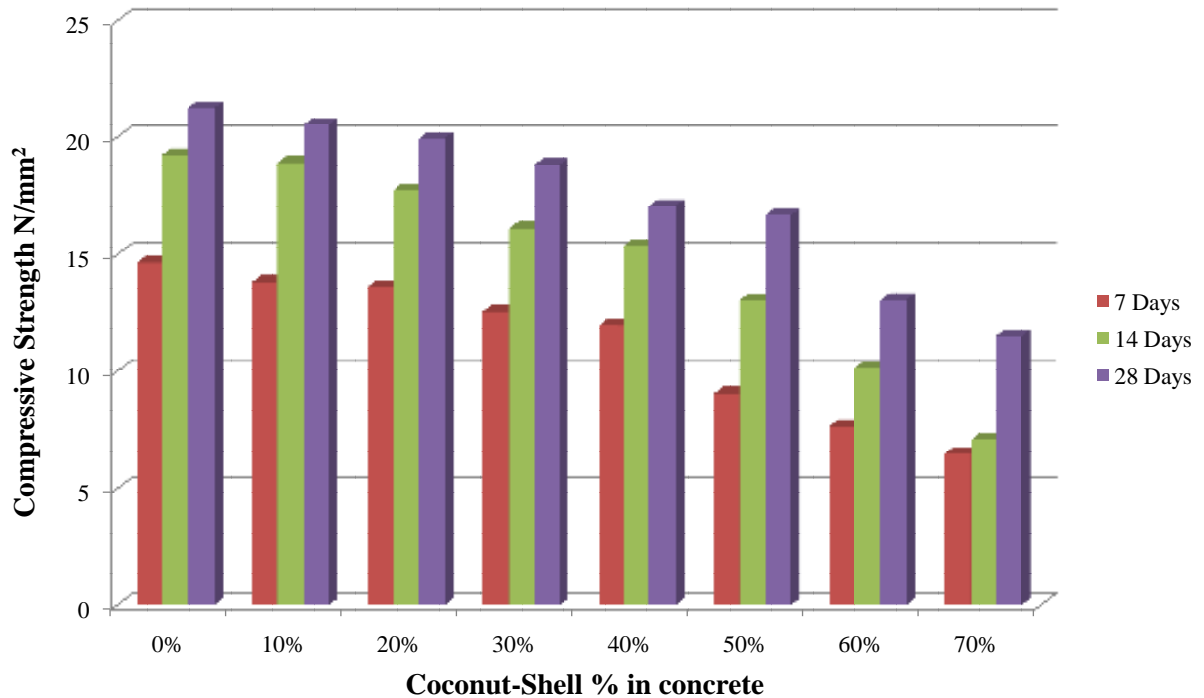


Figure 2: Compressive Strength Test (N/mm<sup>2</sup>)

An increase in the percentage of Coconut-Shell by replacing coarse aggregate in conventional concrete results in the graph shows a decline in compressive strength, which therefore may be used in light weight structure. The use of these waste Shells will decrease the cost of construction also.

## 5. CONCLUSION

Due to rough surface and relatively smooth surface finish on either sides of Coconut-Shell bond between cement and Coconut-Shell is not so strong or sufficient bond which ultimately results in-

- Results shows increase in Coconut-Shell Percentage by replacing coarse aggregate in conventional concrete results decrease in workability
- Results shows increase in Coconut-Shell Percentage by replacing coarse aggregate in conventional concrete results decrease in compressive strength
- Coconut-Shell is used as raw material in making concrete will reduced the construction cost.
- As the compressive strength is low as compared to conventional concrete therefore this concrete may use in light weight concrete works
- As in this case no admixture is used hence in future workability and compressive strength can increase by using admixture in making concrete mix.
- Concrete making with waste Coconut-Shell of such huge amount of waste make it environmental friendly.

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