BEHAVIOR OF COCONUT SHELL AS COARSE AGGREGATE IN CONCRETE

[1]A.Karthik, [2]S.Akshay kumar, [3]V. Sravya, [4]K.Harish, [5]M. Khalique Baig

[1]Associate Professor, Dept. of Civil Engineering, Aurora's Technological and Research Institute, Telangana, India.
[2,3,4,5]B. Tech, Dept. of Civil Engineering, Aurora's Technological and Research Institute, Telangana, India.

Abstract:

Coconut shell as coarse aggregate in concrete to determine the possibilities of using coconut shell as coarse aggregate in concrete production. The usage coconut shell as a coarse aggregate in concrete it comes under light weight concrete explores the influence of different replacements percentages on the structural integrity, load-carrying capacity and durability of the concrete elements. Considering the economic and environmental implications highlighting its potential as an eco-friendly and cost effective. In this evaluation series of concrete cubes are casted with varying percentages of coconut shell as a partial replacement to evaluate the various properties through the experimental investigations including compressive strength test at 28 days. The main objective is to encourage the use of these 'seemingly' waste products as construction materials in low-cost housing. It is expected to serve the purpose of encouraging housing developers in investing these lightweight concrete materials in house construction.

Keywords:
Sustainable construction materials, coconut shell aggregates, light weight concrete.

1.0 INTRODUCTION

Concrete is an artificial material similar to similar in appearance & properties to some natural lime stone rock. It can be assumed to be manmade composite. The major constituent of it is natural aggregate such as gravel or crushed rock, sand & fine particles of cement powder & ultimately mixed with the water. While the construction material cost is increasing day by day the reasons are high demand, scarcity of raw material as well as high price of energy Coconut shell represents more than 60% of domestic waste volume. Coconut shell is an abundantly available agricultural waste from local industries. So, in developing countries like India, these wastes can be used as potential material or replacement material in the construction field.

The production and manufacturing of concrete and its source material consume a considerable amount of energy, emitting a great footprint of CO_2 into the atmosphere. Hence, polluting the environment through expulsion of greenhouse gases into the climate Moreover, the continuous use of raw materials such as coarse aggregate, fine aggregate, cement and natural additives causes' pressure on the ground to explore more of its quantity to achieve the targeted objectives.

Therefore, continuous extraction of sources causes reduction of natural resources thereby increasing the cost of raw materials day by day from past decades, researchers are exploring some new sustainable and eco-friendly construction materials that can replace the conventional materials. Some of them are classified as treated demolished concrete's aggregates, plastic waste, glass waste, rubber waste, tin scraps, some natural and by-product Pozzolans, and bio and agricultural wastes.

Objectives:

The main objectives are briefly summarized below:

1. To study the properties of coconut shell, and to produce coconut shell aggregate concrete with 28 days compressive strength more than 25 N/mm^2.
2. To study the strength properties of concrete in replacement of coarse aggregate with coconut shell and cement
3. To study the behaviour of compressive strengths

4. Experimental study on strength characteristics of M25 grade concrete. Furthermore, mix with both coconut shell and fly ash was also employed with replacement of 20%, 25% and 30 % of coarse aggregates with coconut shell
5. To determine the percentage strength of concrete at 7 & 28 days.

The purpose of this research work is to develop a concrete with coconut shells as coarse aggregate. The whole entity could be called coconut shell aggregate concrete (CSAC). The vast amount of this discarded coconut shells resource is as yet unutilized commercially; its use as a building material, especially in concrete, on the lines of other 'Light weight aggregate' (LWA) is an interesting topic for study. The study of coconut shells will not only provide a new material for construction but will also help in the preservation of the environment in addition to improving the economy by providing new use for the coconut shells. Therefore attempts have been taken to utilize the coconut shells as coarse aggregate and develop the new structural 'Light weight concrete' (LWC).

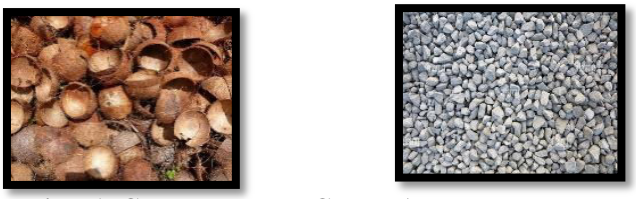


Fig – 1: Coconut shell as Coarse Aggregate

As

2.0. Literature Review

1. **K Gunasegaram et al., (2021):** Have studied that, the impact resistance of coconut shell aggregate concrete is high when compared with conventional concrete. So it can be used as flexural members. The experimental bond strength of coconut shell aggregate concrete is much higher compared to the theoretical bond strength as stipulated by IS 456:2000.
2. **Amarnath Yerramala et al. (2020):** They studied Properties of concrete with coconut shells (CS) as aggregate replacement were studied. Control concrete with normal aggregate and CS concrete with 10 - 20% coarse aggregate replacement with CS were made. Two mixes with CS and fly ash were also made to investigate fly ash effect on CS replaced concretes. Properties like compressive strength, split tensile strength, water absorption and moisture migration were investigated in the laboratory. The results showed that, density of the concretes decreases with increase in CS percent. Workability decreased with increase in CS replacement. Compressive and split tensile strengths of CS concretes were lower than control concrete.
3. **Maninder Kaur & Manpreet Kaur (2020):** It published a review paper in which it is concluded that use of coconut shells in cement concrete can help in waste reduction and pollution reduction. It is also expected to serve the aim of encouraging housing developers in investing these materials in house construction. It is also concluded that the Coconut Shells are more suitable as low strength-giving light weight aggregate when won't replace common coarse aggregate in concrete mix.
4. **J.P. Ries (2017):** He studied that Light-weight aggregate (LWA) plays important role in today's move towards sustainable concrete, Lightweight aggregates contributes to sustainable development by lowering transportation requirements, optimizing structural efficiency that results in a reduction in the amount of overall building material being used, conserving energy, Reducing labour demands and increasing the survive life of structural concrete.

3.0. Methodology

Materials used

(i) Cement
(ii) Fine Aggregate
(iii) Coarse Aggregate
(iv) Coconut shells
(v) Water

Processing Of Coconut Shell:

Coconut shells can be processed and used as a coarse aggregate in construction materials such as concrete and asphalt. Coarse aggregates are typically used to provide strength and stability to these materials. Here are the steps involved in processing coconut shells for use as coarse aggregates:

Fig – 2: Dressing of Coconut shells.

Properties of Materials:

Cement:

Cement used in the investigation was 53 Grade Ordinary Portland cement confirming to IS: 12269. The specific gravity of cement is 3.15. Ordinary Portland cement is used to prepare the mix design of M20, M25, M40 and M50 grade. The cement used was fresh and without any lumps water-cement ratio is 0.42 for this mix design using IS 10262-2019.

Table – 1: Properties of cement

S.No	Physical Properties	Test results
1.	Specific gravity	2.15
2.	Consistency of Cement	32%
3.	Initial setting time	30 mins
4.	Final setting time	560 mins
5.	Fineness of Cement	2.98

Fine Aggregate:

Specific gravity of the sand is 2.6. The sand obtained was sieved as per IS sieves (i.e., 4.75mm, 2.36). Sand is a naturally occurring coarse material collected of finely separated rock and mineral particles. It is defined by size, being finer than gravel and coarser than silt. Sand may also consign to a textural class of soil or soil type; a soil contains more than 85% sand-sized particle (by mass).

Table – 2: Properties of sand

S.No	Physical Properties	Test results
1.	Specific gravity	2.52
2.	Water absorption	1.01
3.	Bulking of Sand	8.01
4.	Fineness of sand	5.67

Water:

Portable water with PH value of 7.0 confirming to IS 456-2000 was used for making concrete and curing this specimen as well.

Coarse Aggregate:

The coarse aggregate was obtained from a local crushing unit having 20mm normal size. Aggregates are the essential constituent in concrete. They provide body to the concrete, decrease shrinkage and effect economy. Construction aggregate, or basically "Aggregate", is a wide group of coarse particulate material used in construction, as well as sand, gravel, crushed stone, slag, recycled concrete and geo - synthetic aggregates. Aggregates are the mainly mine material in the world.

Table – 3: Properties of Coarse aggregate

S.No	Physical Properties	Test results
1.	Sieve Analysis	2.81
2.	Flakiness and Elongation	35.3 & 35.3
3.	Specific gravity	2.20
4.	Water absorption	1.40
5.	Impact value	9.5%
6.	Crushing value	6.9%

Coconut shells:

Coconut shells which were already broken into two pieces were collected from local area, air dried for five days approximately at the temperature of 25 to 30ºC. Crushed shells were washed to remove fibres, mud, husk etc. The washed shells were dried in sunlight for another 5 days.

Table – 4: Properties of Coconut shells

S.No	Physical Properties	Test results
1.	Sieve Analysis	4.87
2.	Flakiness and Elongation	57% & 42.05%
3.	Specific gravity	1.10
4.	Water absorption	0.50%
5.	Impact value	2.50
6.	Crushing value	3.02
7.	Shell thickness	4mm

The crushed edges were rough and spiky. The surface texture of the shell was fairly smooth on concave and rough on convex faces. The coconut shells were crushed manually using hammers to a size such that it passes through a 12.5mm sieve and retained on 4.75mm sieve. The material passed through 12.5 mm sieve was used to replace coarse aggregate with CS. As Coconut shell having high water absorption, it is immersed in water for7 days and were used in saturated surface dry (SSD) condition before casting.

MIX DESIGN

Mix design for M25 grade of concrete with reference to the IS: 10262-2019:

Obtained proportions:

W	:	C	:	Fine Aggregate	:	Coarse Aggregate
$\frac{191.58}{C}$	:	$\frac{435.77}{C}$	:	$\frac{504.93}{C}$	:	$\frac{976.21}{C}$
$\frac{191.58}{435.77}$	:	$\frac{435.77}{435.77}$	:	$\frac{504.93}{435.77}$	:	$\frac{976.21}{435.77}$
0.44	:	1	:	1.15	:	2.24

1:1:2 (M_{25})

With the above data we cast the cubes and cylinders to determine the compressive Strength of concrete.

The casting process involves following steps:

1) Preparation of moulds
2) Oil/greasing to the surface the mould
3) Material mixing
4) Filling in cubes through compaction
5) Curing

Before casting of concrete we need to do tests on fresh concrete to determine the workability of concrete.

Tests on Fresh Concrete (Workability):

- Slump cone Test :

Specifications:

As per IS: 456 the degree of workability is classified as follows:

Table – 5: Specification for slump cone test

Degree of Workability	Slump
Very low	0-25 mm
Low	25-50 mm
Medium	50-100 mm
High	100-175 mm
Very high	>175 mm

- ❖ The obtained slump value is 96 mm and it is a shear slump. And it is classified as “Medium workable” concrete
- Compaction factor test :
  The compaction factor value for the sample tested is 0.92. The workability of concrete has to be considered as “Medium workable”.

Tests on Hardened Concrete:

1. Compressive strength test
2. Tensile strength test.

4.0. Results and Discussions:

7 and 28 days compressive strength & Tensile strength results:

We know that the concrete should attain 65% of strength for 7 days that is in the range of 15-17.5 N/mm^2 and maximum strength at 28 days i.e., 25 N/mm^2.

Table – 6: Compressive and Tensile strength results at 7 & 28 days.

S.No	Test at	% Replaced	Compressive Strength Test Results (N/mm^2)	Average	Tensile Strength Test Results (N/mm^2)	Average
1	7 days	Nominal	33.33	27.77	3.11	2.965
2			23.33		2.82	
3			26.66			
1	7 days	20%	13.55	14.20	1.98	1.94
2			15.66		1.90	
3			13.47			
1	7 days	25%	15.55	15.25	1.55	1.51
2			13.33		1.48	
3			16.88			
1	7 days	30%	12.44	13.77	1.55	1.48
2			15.55		1.41	
3			13.33			
1	28 days	Nominal	36	34.81	3.53	3.67
2			37.33		3.81	
3			31.11			
1	28 days	20%	17.77	17.47	3.11	3.04
2			16.88		2.97	
3			17.77			
1	28 days	25%	23.55	25.62	2.97	2.895
2			26.22		2.82	
3			27.11			
1	28 days	30%	20.88	19.26	2.54	2.47
2			18.66		2.40	
3			18.26			

7 Days Compressive strength test results:

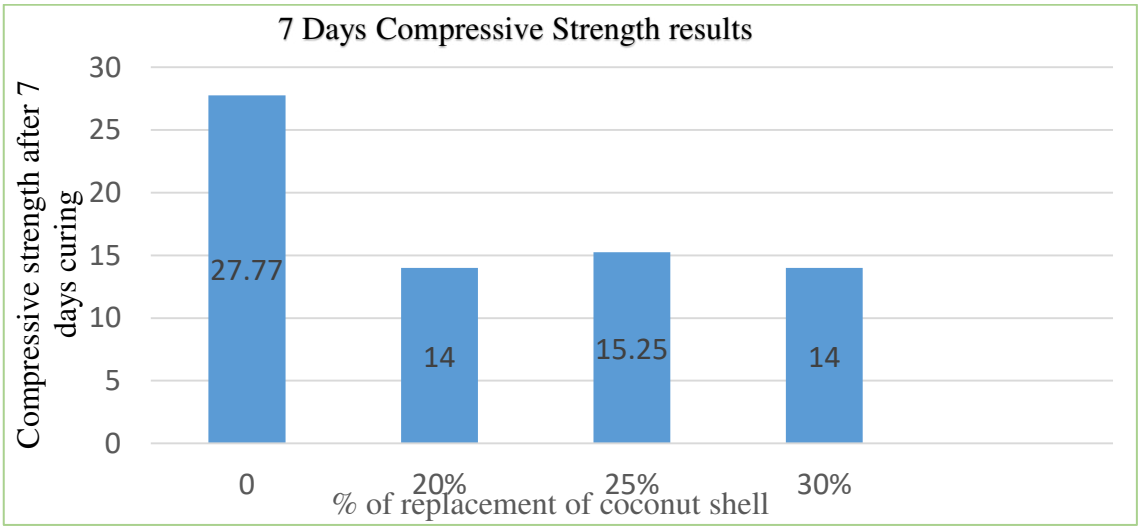
Fig -3: Cubes of nominal concrete under test

Fig – 4: Cubes of 20% replacement concrete under 7 days compression test

Fig- 5: Cubes of 25% replacement concrete under 7 days compression test

Fig – 6: Cubes of 30% replacement concrete under 7 days compression test

The graph showing that the 7 days compressive strength test results of hardened concrete.



With this we can conclude that the as replacement of 25% of coconut shell in concrete given

Required strength i.e., 15.25 N/mm^2 - range (15-17.5 N/mm^2)

7 Days Tensile strength test results:

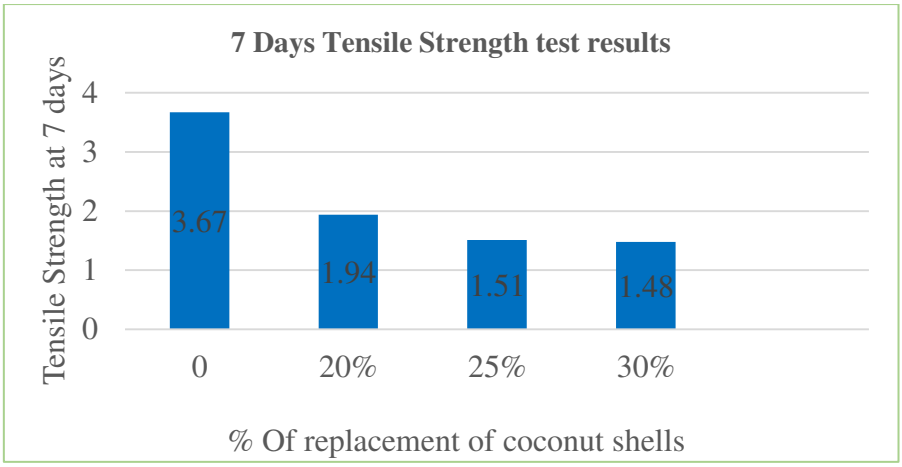
Fig – 7: Cylinders of nominal concrete under tensile test

Fig –8: Cylinder of 20% replacement under 7 days tensile test

Fig- 9: Cylinders of 25% replacement under 7 days tensile test

Fig -10: Cylinder of 30% replacement under 7 day's tensile test

The graph shows that the 7 days tensile strength results for different replacement % of coconut shell as coarse aggregate.



28 Days Compressive Strength test results:

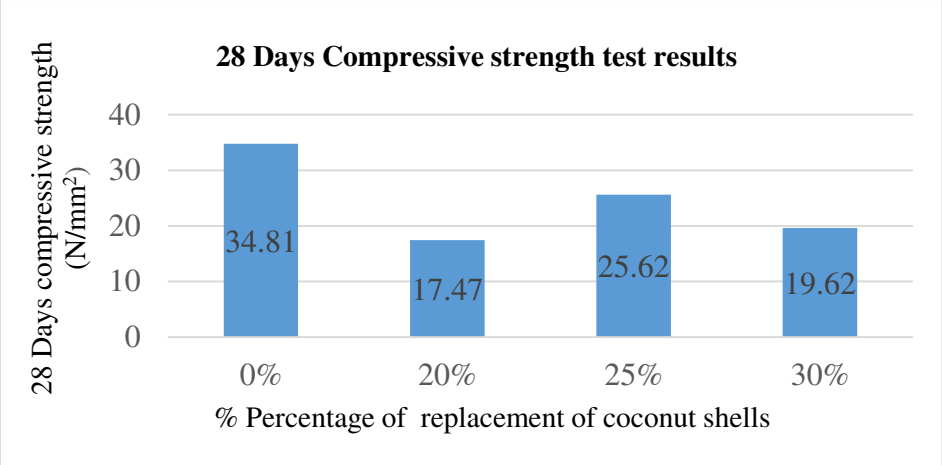
Fig – 11: Cubes of nominal concrete under 28 days compression test

Fig -12: Cubes of 20% replacement concrete under 28 days compression test

Fig-13: Cubes of 25% replacement concrete under 28 days compression test

Fig – 14: Cubes of 30% replacement concrete under 28 days compression test

The graph showing that the 28 days compressive strength test results of hardened concrete.



28 Days Tensile strength test results:

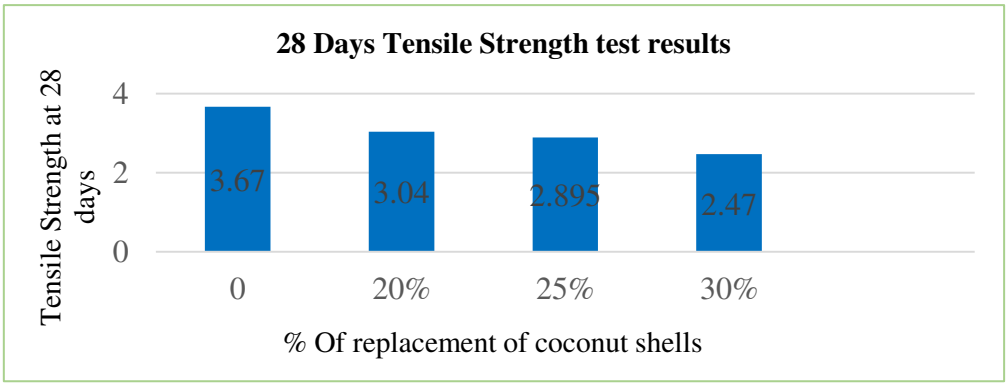
Fig –15: Cylinders of nominal concrete under 28 days tensile test

Fig – 16: Cylinders of 20% replacement under 28 day's tensile test

Fig -17: Cylinders of 25% replacement under 28 day's tensile test

Fig – 18: Cylinders of 30% replacement under 28 day's tensile test

The graph shows that the 28 days tensile strength results for different replacement % of coconut shell as coarse aggregate.



CONCLUSION:

Grade of Concrete Tested: M25

- From this study we can conclude that the usage of coconut shell as coarse aggregate in concrete is preferable and the replacement should be partially that 25% replacement has been good and enough to get the desired strength of concrete.
- In this study we replaced coconut shell in 3 percentages such as 20%, 25% and 30% for the replacement of 20% and 30% we got insufficient strength but for the replacement of 25% we got the strength as 25.67 N/mm^2 after 28 days curing.
- Hence we are able to prefer the coconut shells as coarse aggregate in concrete.
- In this investigation we found a problem with coconut shells are high water absorption which are to be used in saturated surface dry condition to avoid absorption of water quantity by coconut shells at the time of curing. With that after curing we need to dry the concrete for a while to remove surface moisture and at the time of test we get good results it gains desired strength.

References:

1. Shetty M.S Concrete Technology Theory and Practice revised edition S. Chand Company Limited, New Delhi.
2. Amarnath Yerramala et al (2020): studied on properties of concrete with coconut shells in concrete with replacement of 10%-20% investigated on properties of coconut shells.
3. Amarnath Yerramala Ramachandrudu C, Properties of Concrete with Coconut Shells as Aggregate Replacement, International Journal of Engineering Inventions, vol.1, Issue 6, October 2019.
4. K. Gunasekaran, “Utilization of Coconut Shell as Coarse Aggregate in the Development of Lightweight Concrete”, PhD Thesis, Department of Civil Engineering, SRM University, Kattankulathur, 2021.
5. Y. Amarnath, and C. Ramachandrudu, “Properties of Concrete with Coconut Shells as Aggregate Replacement”, International Journal of Engineering Inventions, Volume 1, Issue 6 (October 2020),
6. Maninder Kaur, “A Review on Utilization of Coconut Shell as Coarse Aggregates in Mass Concrete”, International Journal of Applied Engineering Research, ISSN 0973-4562 Vol. 7 No.11 (2020).
7. IS 10262:2019, Indian Standard for Concrete Mix Proportioning – Guidelines, Bureau of Indian Standard, New Delhi.
8. IS 456:2000, Indian Standard for Plain and Reinforced Concrete Code of Practice, Bureau of Indian Standard, New Delhi.

9. Yogesh Narayan Sonawane et al, Review on Utilization of Coconut Shell as Coarse Aggregates in Mass Concrete, International Journal of Applied Engineering Research, vol.7, Issue 11, 2019.
10. J. P. Ries, J. Speck, (2020), "Lightweight Aggregate Optimizes the Sustainability of Concrete", Concrete Sustainability Conference, National Ready Mixed Concrete Association.