Study on Properties of Concrete with Agricultural Waste

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Abstract

This paper presents the overview on agricultural waste for concrete development. in India the production of waste materials from agriculture is increasing day by day. Agricultural wastes are biologically decomposable in the open exposure. In this investigation coconut shell (agricultural waste)is used as coarse aggregate in concrete. The size of coconut shell is chosen as 10 mm to develop concrete and the concrete termed as coconut shell aggregate concrete (CSAC). The results of an experimental work carried out on the coconut shell aggregate concrete is produced by using coconut shell aggregate. The coconut shell aggregate replacement for conventional granite aggregate is 100 percentages in this investigation. The mix ratios of (1 : 1.6 : 2.4 and 1 : 1.8 : 2.7) were used through the investigation. The test specimens, Cubes of size(100 X 100 X 100) mm, cylinder of size 150 mm diameter and 300 mm height, prism of size (100 X 100 X 500) mm were cast. Compressive strength test, flexural strength test and modulus of elasticity test were conducted at 28th days. The test results of coconut shell aggregate concrete are nearer to the conventional granite aggregate concrete at 28 days. The increment of results from the prepared two concrete mixes is goes to first mix. The reason may be due to higher cement content and lesser water cement ratio. However, concrete obtained from coconut shells (CS) exhibited normally comparable compressive strength with Conventional Granite Aggregate Concrete (CGAC) in the two mix proportions. Considering the strength it was concluded that coconut shells were normally suitable when used as substitute in concrete production.

Keywords: *Agricultural waste, Coconut shell, Coconut shell aggregate (CSA), Coconut shell aggregate concrete (CSAC), Conventional granite aggregate (CGA), Conventional granite aggregate concrete (CGAC),*

1. INTRODUCTION

Agricultural wastes as coarse aggregate in concrete is one of the economic advantages. The properties of agricultural waste (coconut shell) such as mechanical and durability properties are suitable in concrete making. In low-cost building construction, utilizing the waste discarded coconut shell as coarse aggregate in the matrix part of concrete is suitable one. Pre-treatment is not necessary for coconut shell aggregate before using in concrete, because there is no dust and oil coating in surrounding the coconut shell after discarded the coconut for cooking benefits. Coconut shell was collected from the local coconut oil mills. In this experimental work the size of discarded coconut shell is chosen as 10 mm to avoid flakiness effect by concave and convex shape of coconut shell. The coconut shell nominal size of 10 mm is collected by sieving the discarded shells. The presents of dusts also removed by sieving the discarded coconut shells. The biological decomposition is not affect the coconut shell after the coconut shell encapsulated into the concrete even though coconut shell is wood based material is referred in literatures. Regarding properties of coconut shell, the physical and mechanical properties were studied. Coconut shell aggregate concrete mix design is derived based on volume batch method due to lesser specific gravity. In this study the coconut shell 100% replaced for the conventional granite aggregate in volume batch method. The final objective of the research is to evaluate the compressive strength, flexural strength and modulus of elasticity for the selected two mix ratios and comparing the results with conventional granite aggregate concrete.

2. MATERIALS AND PROPERTIES

2.1. Cement

Ordinary Portland cement (OPC) is the most common type of binder used for concrete production and hence, OPC 53 Grade conforming to Indian Standard IS 12269:1987 was used as a binder. The local brand name of the OPC cement used is Ramco super grade. These properties are shown in Table 1 and coconut shell is shown in fig 1.

Table – 1. Properties of OPC 53 grade

Properties	
Fineness – Specific surface, (m^2/g)	305
Initial setting time, (min)	76
Final setting time, (min)	430
Soundness, (Le Chatelier method), (mm)	0.4
Specific gravity	3.07
Magnesia (MgO), %	1.37
Alkalies, %	0.5
Chloride, %	0.02
Loss on ignition, %	1.5

Fig -1: Well graded Coconut Shell

2.2. Fine Aggregate

River sand was used throughout the investigation as fine aggregate conforming to grading zone III as per IS 383:1970. The sand was air-dried and sieved to remove any foreign particles prior to mixing.

2.3. Crushed Granite Aggregate (CGA)

Crushed granite aggregate (CGA) - 10 mm sizes were used for Conventional Concrete. Crushed Granite aggregate concrete (CGAC) was produced and compare with CSAC. The bulk density, specific gravity, water absorption, aggregate impact value, aggregate crushing value, aggregate abrasion value, and particle size distribution were determined and shown in Table 2.

2.4. Coconut Shell Aggregate (CSA)

Coconut Shell Aggregate Concrete (CSAC), which is produced using Coconut Shell Aggregate (CSA), is the main concrete in this investigation. Coconut shell was collected from the local coconut oil mills to analyze the properties in this study. It have maximum thickness in range of (2-8) mm, they were crushed using Ball Mill equipment which is available at mechanical engineering, research engine laboratory in Annamalai University. The required crushed sizes are in the range of (4.75 – 10) mm. The sieve analysis was conducted and the Particle size distribution of CS is determined. The test results are shown in Table 2.

2.5. Water

The quality of water is important because contaminants can adversely affect the strength of concrete. Water used for producing and curing the concrete. It should be reasonably clean and free from deleterious substances such as oil, acid, alkali, salt, sugar, silt, organic matter and other elements which are detrimental to the concrete. If the water is drinkable, it is considered to be suitable for concrete making. Hence, potable tap water from Concrete Laboratory of Structural engineering Department at Annamalai University was used in this study for mixing and curing.

Table-2: Properties of coconut shell aggregate and conventional granite aggregate

Sl. No	Mechanical properties		CSA	CGA
1	Maximum size (mm)		10	10
2	Shell thickness (mm)		2 to 8	-
3	Specific gravity		1.7	2.68
4	Impact value (%)		7	12.4
5	Crushing value (%)		2	6.3
6	Abrasion value (%)		0.4	1.85
7	Attrition value (%)		0.67	4.3
8	Bulk density (kg/m^3)	Compacted	640	1650
		Loose	530	1450
9	Fineness modulus		6.3	6.94
10	Moisture content (%)		4	-
11	Water absorption (%)		22	0.5

3. MIX PROPORTION

Mix design is the process of selecting an optimum proportion of cement, fine and coarse aggregates and water to produce a concrete with specified properties of workability, strength, and durability. The best mix involves a balance between economy and the required properties of concrete. Based on the properties of the available materials, the mix proportions of the CS concrete were approximated using absolute volume method. Hence, the mix design for the CSAC in this study was based on performances of trial mixes and the measure of the selected mix was so adjusted to get the most favorable mix proportion.

3.1 Workability

Workability is the fresh concrete property. It is an ability of fresh concrete to satisfy the followings mobility for mixing, transporting, placing, and better compaction. The following Slump cone test, compaction factor test, Vee – bee consist meter test, Kelly ball test is the method of testing for workability measurement of fresh concrete. In this thesis work slump cone method is selected for the workability measurement of conventional granite aggregate concrete and coconut shell aggregate concrete. The measured slump values are presented below in Table 3.

Table – 3: Mix proportion results

Mass in (kg/m^3)		w/c	Mass in (kg/m^3)		Mix ratios			Slump (mm)
C	W		FA	CA	C	FA	CA	
450	180	0.40	711.74	1083.62	1	1.6	2.4	25
400	180	0.45	728.78	1083.62	1	1.8	2.7	40

3.2 Coconut Shell Aggregate Concrete

When wood based materials are used as aggregate in concrete, the biological decomposition is not apparent. This message is referred from the collected literature. Coconut shell aggregate concrete produced with maximum size of aggregate as 10mm.It is targeted to produce CSAC of compressive strength more than 20 N/mm^2 to meet the minimum strength of structural concrete as per IS IS 456 - 2000.

3.3 Conventional Granite Aggregate Concrete

Conventional concrete mixes were produced with crushed granite aggregate of maximum sizes 10 mm. the size of granite aggregate is chosen based on the coconut shell aggregate size of 10 mm. the minimum size of coarse aggregate is to avoid the flakiness effect of coconut shell aggregate due to its concave and convex shape in inner and outer surfaces. By minimizing the size below 12 mm the flakiness effect will not appear and affect the bonding of concrete.

4. MECHANICAL PROPERTIES

The objective of the study is to determine and compare the engineering properties of coconut shell aggregate with conventional granite aggregate. Mechanical properties of Conventional Granite Aggregate Concrete and Coconut Shell Aggregate Concrete were tested and compared.

4.1 Compressive Strength Test

Cubes of size 100 mm were cast for testing the compressive strength at the end of 28 days. The cubes were tested as per IS 516-1959. The load was applied without shock and was increased until the specimen failed, and the maximum load applied to the specimen during the test was recorded. The appearances of the fractured faces of concrete failure were noted in fig 2 and the test results are presented in Table 4. The Compressive Stress relation between CSAC and CGAC of Trial Mix I and II shown in fig 3.

Fig.2: Compressive Strength Test Setup

Table. 4: Compressive Strength Test Results

Mix No	Type of Concrete	Load (kN)	Compressive strength (N/mm^2)	Average compressive strength (N/mm^2)
1	CSAC	226	22.60	21.33
		218	21.80	
		196	19.60	
	CGAC	338	33.80	31.87
		326	32.60	
		292	29.20	
2	CSAC	176	17.60	17.73
		180	18.00	
		187	18.70	
	CGAC	258	25.80	26.40
		262	26.20	
		272	27.20	

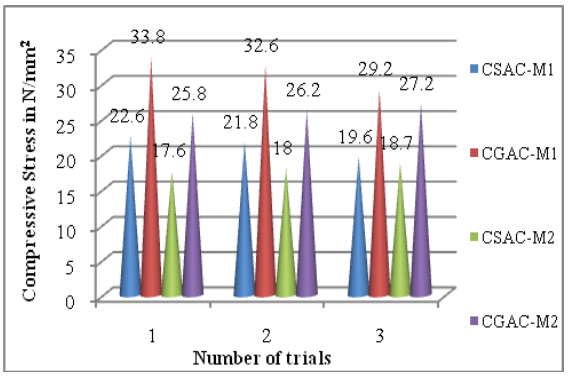

Fig.3: Compressive Stress relation between CSAC and CGAC of Trial Mix I and II

4.2. Flexural Strength Test

Two-point load method was adopted to measure the flexural strength of concrete prism. As per ASTM C78-84 guidelines prism of size (100x100x500) mm were cast for testing at the end of 28 days. Tested

prism shown in Fig.4 and the test results are presented in Table 5.

Fig.4: Flexural Strength Test Setup.

Table. 5: Flexural Strength Test Results

Mix.No	Type of Concrete	Load (kN)	Flexural strength (N/mm^2)	Average Flexural strength (N/mm^2)	As per IS 456:2000 $0.7\sqrt{fck}$
1	CSAC	14	7	7.08	3.32
		16	8		3.26
		12.5	6.25		3.09
	CGAC	19	9.50	9.58	4.07
		18	9		3.99
		20.5	10.25		3.78
2	CSAC	9	4.50	6	2.93
		12	6		2.97
		15	7.50		3.02
	CGAC	17	8.50	9.17	3.55
		19	9.50		3.58
		19	9.50		3.65

4.3. Modulus of Elasticity Test

Cylinders of 150 mm diameter and 300 mm height were casted for the determination of elastic modulus using CGAC and CSAC. The elastic modulus of the specimens were calculated from the graph and compared with conventional concrete.Modulus of elasticity test setup shown in Fig.5 and the test results are presented in Table 6. Relationship between Stress and Strain is shown in fig 6.

Fig.5: Modulus of Elasticity Test Setup

Table.6: Modulus of Elasticity Test Results

Mix. No	Type of Concrete	Modulus of Elasticity Values (N/mm^2) $x10^4$	Average Modulus of Elasticity Values (N/mm^2) $x10^4$
1	CSAC	2.45	2.47
		2.01	
		2.94	
	CGAC	2.90	2.91
		2.86	
		2.97	
2	CSAC	1.43	1.81
		2.01	
		1.99	
	CGAC	2.12	2.09
		1.97	
		2.17	

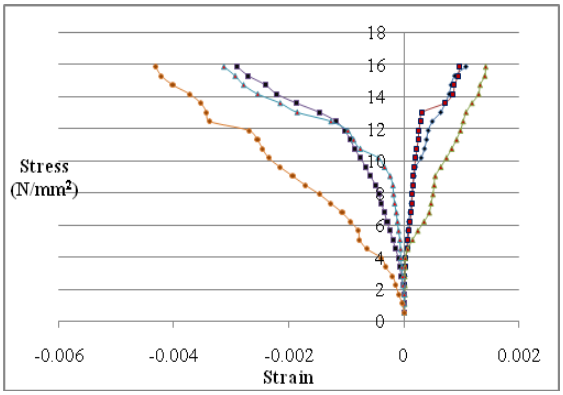

Fig.6: Relationship between Stress and Strain of CGAC and CSAC

5. CONCLUSIONS

The use of coconut shell as coarse aggregate in concrete provides an alternate for the crushed granite aggregate. This study established that coconut shell can be used as coarse aggregate in the production of concrete with lesser density. The test results obtained from this study also provide significant understanding on basic Material properties and Mechanical properties of coconut shell aggregate concrete. This study gives suggestions for the proper use of coconut shell which will hopefully lead to promotion of sustainable development in the construction industry for the greener environment. Based on the experimental investigation, the following conclusions were arrived.

- The amount of cement content used is same when coconut shells are used as an aggregate in the production of concrete compared to conventional aggregate concrete to produce approximately equal strength.
- To satisfy the criteria of structural concrete by trial mix 1 and 2, coconut shell requires the cement content of (450 and 400) kg/m^3 in the production of concrete using coconut shell as aggregate.
- Coconut shell aggregate concrete has better workability because of the smooth surface on one side of the shells and the size of coconut shell used in this study.
- The 28-day average densities of coconut shell aggregate concrete (CSAC) were (1678 and 1758) kg/m^3 for trial mix 1 and 2and these are less than the conventional granite aggregate concrete (CGAC) density of (2325 and 2544) kg/m^3. From these results the coconut shell aggregate concrete is defined as structural lightweight concrete.
- The 28-day compressive strength of coconut shell aggregate concrete (CSAC) were (21 .33 and 17.73) N/mm^2 for trial mix 1 and 2 and these are merely less than conventional granite aggregate concrete (CGAC) strength of (31.87 and 26.40) N/mm^2.
- The flexural strengths of coconut shell aggregate concrete (CSAC) were (7.08 and 6) N/mm^2 for trial mix 1 and 2and corresponding conventional granite aggregate concrete strength were (9.58 and 9.17) N/mm^2.
- The flexural strengths of coconut shell aggregate concrete (CSAC) are approximately (6.61 and 6.77) % of its respective compressive strengths of (21.33and 17.73) N/mm^2.
- Modulus of elasticity of coconut shell aggregate concrete (CSAC) is approximately (15.12) % is less than conventional granite aggregate concrete (CGAC) from the initial tangent modulus results of graphs for trial mix - I.
- Modulus of elasticity of coconut shell aggregate concrete (CSAC) is approximately (13.40) % is less than conventional granite aggregate concrete (CGAC) from the initial tangent modulus results of graphs for trial mix - II.
- In general, the basic engineering properties namely compressive strength, flexural strength, modulus of elasticity of coconut shell aggregate concrete were compared reasonably and all results lies well and nearly same to the conventional granite aggregate concrete from the tested two trial mix ratios.

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