Published by :
http://www.ijert.org

International Journal of Engineering Research & Technology (IJERT)
ISSN: 2278-0181
Vol. 6 Issue 04, April-2017

Experimental Investigation of Concrete using Coconut Shell as a Coarse Aggregate Replacement

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***Abstract*: The cost of traditional materials used in the concrete is the major factor which is increasing cost of constructions, so it is necessary to research for alternative construction materials. In this experimental investigation, the coconut shell used as a light weight aggregate in concrete, the properties of coconut shell concrete examined, Control concrete with normal aggregate and CS concrete with 10 - 30% coarse aggregate replacement with CS were made, and Constant water to cementitious ratio of 0.5 was maintained for all the concretes. Properties like compressive strength, consistency, workability 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 strengths of CS concretes were lower than control concrete. The paper aims at analyzing flexural and compressive strength characteristics of with partial replacement using M20 grade concrete. The project also aims to show that Coconut shell aggregate is a potential construction material and simultaneously reduces the disposing the wastes. Cubes are casted, tested and their physical and mechanical properties are determined. The main objective is to encourage the use of these „seemingly" waste products as construction materials in low-cost constructions.**

Key words: Light weight concrete, Compressive strength, Workability, Flexural strength,

1. INTRODUCTION

Concrete is a composite material which composed of aggregates, cement and water. Concrete is used more than any other manmade material in the world. In addition, concrete is the 2nd most consumed substance in the world-behind water. About 7.23 billion tons of concrete is produced every year. Annual production represents one ton for every person on the planet. Production of concrete is increasing due to high growth of infrastructure development and construction activities in the world , Production of concrete demands its constituents like aggregates, cement, water and admixtures. Sources of conventional aggregates occupy the major part of the concrete. The large scale production of concrete in construction activities using conventional coarse aggregate such as granite immoderately reduces the natural stone deposits and affecting the environment hence causing ecology imbalance. Extraction and processing of aggregates is also a major concern for environment. Therefore consumption of alternative waste material in place of natural aggregate in concrete production not only protects environment but also makes concrete a sustainable and environment friendly construction material. Different waste material like rubber, fly ash, glass, bottom ash, artificial sand etc has been used as alternative for replacing natural aggregates. Apart from the above mention waste material, a few studies shows that agriculture waste coconut shell can also be used as coarse aggregate for concrete.

2. NEED FOR THE STUDY:

The concrete as time goes on through a process of hydration of the cement paste, producing a required strength to withstand the load. The use of coconut shell as coarse aggregate in concrete has never been a usual practice among the average citizens, particularly in areas where light weight concrete is required for non-load bearing walls, non-structural floors, and strip footings. Although coarse aggregate usually take about 30% of the overall self weight of concrete. The cost of construction materials is increasing day by day because of high demand, scarcity of raw materials, and high price of energy. From the standpoint of energy saving and conservation of natural resources, the use of alternative constituents in construction material is now a global concern. For this, the extensive research and development works towards exploring new ingredients are required for producing sustainable and environment friendly construction material. Coconut shell represents more than 60% of the domestic waste volume. Coconut shell, which presents serious disposal problems for local environment .this will have the double advantage of reduction in the cost of construction material and also as a means of disposal of wastes.

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3. METHODOLOGY

The Experimental work requires preliminary investigations in a methodology manner.

3.1 Material and grade of mix

1. Selection of type of grade of mix, mix design by an appropriate method, trial mixes final mix proportions. 2. Easting total quantity of concrete required for the whole project work. 3. Easting quantity of cement, fine aggregate, Coarse aggregate, coconut shells required for the Experimental work. 4. Testing of properties of cement, fine aggregate, coarse aggregate and coconut shells.

3.2 Production of concrete mixes

Production of mix (normal concrete of grade M- 20) in the laboratory is carried out by IS method of concrete mix design (IS 10262-1982). Coconut shell concrete is produced by adding coconut shells in different percentage (i.e. 0% to 30%) replacement in concrete.

3.3 Test on ingredients

Materials the ingredients of concrete i.e. cement, fine aggregate, and fine aggregate, coconut shells are tested before producing concrete. The respective Indian standard codes are followed for conducting various tests on ingredients materials of the concrete.

3.4. Mix Design for M20 Grade of Conventional Concrete

Assumptions: Compressive strength required for 28 days = 20Mpa Maximum size of aggregate = 20mm (angular) Degree of quality control = Good Types of exposure = Mild Data: Specific Gravity of Cement = 3.15 Specific Gravity of fine Aggregate = 2.60 Specific Gravity of Coarse Aggregate = 2.75 Water Absorption of Fine Aggregate = 0.5% Water Absorption of Coarse Aggregate =1% Slum required =50-100mm Free moisture in sand =2% 3.5 Mix Design for M20 Grade of Coconut Shell Concrete Assumptions: Compressive strength required for 28 days = 20Mpa Maximum size of aggregate = 20mm (angular) Degree of quality control = Good Types of exposure = Mild

Data:Specific Gravity of Cement = 3.15 Specific Gravity of fine Aggregate = 2.60 Specific Gravity of Coarse Aggregate = 2.75 Water Absorption of Fine Aggregate = 0.5% Water Absorption of Coconut shell =1% Slum required =50-100mm Free moisture in sand =2%

Mix ratio 1: 1.635: 3.135

3.6. Preparation of Specimen:

Mass of Cement (in kg/m^3)	383
Mass of water (in kg/m^3)	191.6
Mass of Fine Aggregate(in kg/m^3)	626.36
Mass of Coarse Aggregate(in kg/m^3)	1200.8

3.6.1. Measurements of Ingredients:

All cement, sand, coarse aggregate and coconut shell measured with digital balance. Water is measured measuring cylinder of capacity 1 lit and measuring jar of capacity 100 ml and 200 ml.

3.6.2. Mixing of concrete: The ingredients are thoroughly mixed in concrete mixer. The sand, cement and aggregate are measured accurately and are mixed in dry state for normal concrete. Whereas for coconut shell concrete, first measured quantity of cement and other required ingredients as per mix design and then added in concrete mixer. Care is taken to avoid segregation of concrete.

3.6.3. Placing of Concrete: The fresh concrete is placed in the moulds by trowel. It is ensured that the representative volume is filled evenly in all the specimens to avoid accumulation of aggregate, segregation etc. While placing concrete in moulds compaction is done to remove entrapped air or voids in concrete.

3.6.4. Finishing of Concrete:

Concrete is worked trowel to give uniform surface. Care is taken not to add any extra cement, water or cement mortar for achieving good surface finish. The additional concrete is chopped off from the top surface of the mould for avoiding over sizes etc. Identification marks are given on specimens by embossing over the surface after initial drying.

3.6.5 De-moulding of Specimens:

The plain cement concrete specimens are demoulted after 24 hours of casting and kept in water tank for curing. Similarly coconut shells concrete specimens are de-moulded after 24 hours of casting and kept in water tank for curing at 7 days and after 28 days.

3.6.6. Curing of Specimens:

The specimens are de-moulded after 24 hours of casting and immediately stored for curing. M 20 grade conventional concrete and coconut shell concrete (CSC) specimens with partial replacement of 0% to 30% are cured in curing tank for 7 days and 28 days.

3.6.7. Testing Compressive testing slit tensile test are carried out on compressive testing machine (CTM) of capacity 2000 KN. Cube and Cylinders are tested for 7 days and 28 days.

4. EXPERIMENTAL WORK

4.1. Test Conducted On Hardened Concrete: Confirming to IS 516-1959 In present study cube compression test, flexural test on beams, slit tensile test on cylinders on conventional concrete and coconut shell concrete are carried out. The experimental results and discussion results for various tests are described below.

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4.2. Compressive Strength Test: A cube compression test is performed on standard cubes of conventional concrete and coconut shell concrete with partial replacement of 25% and 30% of size 150mm x 150mm after 7 days and 28 days of immersion in water for curing. The results for the test are shown in table. The compressive strength of the specimen is calculated by the following formula: fcu = P/A

Where, P = Failure load in compression (KN)
A = Loaded area of cube (mm^2)

4.3.Flextural Strength: Flexural strength is one measure of the tensile strength of concrete. It is a measure of an unreinforced concrete beam or slab to resist failure in bending. It is measured by $f_{bt}=\frac{Pl}{bd2}$. The flexural strength is expressed as *Modulus of Rupture* (MR) in psi (MPa) and is determined.

4.4. Split tensile Test: Splitting tensile strength test on concrete cylinder is a method to determine the tensile strength of concrete. The concrete is very weak in tension **due** to its brittle nature and is not expected to resist the direct tension. The concrete develops cracks when subjected to tensile forces. Calculated formula: $\mathbf{f_t}=\frac{2P}{\pi DL}$

Where, P= Compressive Load at failure
L=length of cylinder
D= dia. Of the cylinder

TEST RESULTS

0% Replacement
Cement Content: 383 Kg/m^3
Water Cement Ratio:0.5

Properties	7 days			28 days		
	1	2	Mean (N/mm^2)	1	2	Mean (N/mm^2)
Compressive strength	18.03	17.99	18.01	26.2	26.6	26.4
Split tensile strength	1.424	1.44	1.432	2.85	2.79	3.82
Flexural Strength	2.02	2.08	2.05	3.25	3.09	3.17

5% Replacement
Cement Content: 384.17 Kg/m^3
Water Cement Ratio:0.5

Properties	7 days			28 days		
	1	2	Mean N/mm^2	1	2	Mean N/mm^2
Compressive strength	17.82	17.99	17.90	24.06	24.18	24.12
Split tensile strength	1.12	0.98	1.050	2.64	2.256	2.448
Flexural Strength	2.17	1.79	1.981	2.015	2.551	2.283

10 % Replacement
Cement Content: 385.76 Kg/m^3
Water Cement Ratio:0.5

Properties	7 days			28 days		
	1	2	Mean N/mm^2	1	2	Mean N/mm^2
Compressive strength	16.85	16.75	16.80	24.45	17.09	20.77
Split tensile strength	1.220	1.210	1.215	1.84	2.04	1.94
Flexural Strength	1.843	1.621	1.732	2.78	2.29	2.535

15 % Replacement
Cement Content: 387.34 Kg/m^3
Water Cement Ratio:0.5

Properties	7 days			28 days		
	1	2	Mean N/mm^2	1	2	Mean N/mm^2
Compressive strength	17.9	17.5	17.7	24.87	24.35	24.61
Split tensile strength	1.38	1.27	1.32	2.61	2.53	2.57
Flexural Strength	1.984	1.69	1.837	2.99	2.79	2.89

20% replacement: Trail No:1
Cement Content: 388.13 Kg/m^3
Water Content: 0.5

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Properties	7 days			28 days		
	1	2	Mean N/mm^2	1	2	Mean N/mm^2
Compressive strength	12.48	13.33	12.90	20.32	20.49	20.41
Split tensile strength	1.23	1.10	1.16	1.87	2.09	1.98
Flexural Strength	1.95	1.69	1.820	2.78	2.42	2.60

20% replacement:Trail No:2
Cement Content :388.92 Kg/m^3
Water Content:0.5

Properties	7 days			28 days		
	1	2	Mean N/mm^2	1	2	Mean N/mm^2
Compressive strength	14.81	14.20	14.78	21.76	19.9	20.83

Trail No:3
Cement Content :389.71 Kg/m^3
Water Content:0.5

Properties	7 days			28 days		
	1	2	Mean N/mm^2	1	2	Mean N/mm^2
Compressive strength	15.7	14.3	15	20.89	22.89	21.89

25% Replacement
Cement Content: 390.50 Kg/m^3
Water Cement Ratio:0.5

Properties	7 days			28 days		
	1	2	Mean N/mm^2	1	2	Mean N/mm^2
Compressive strength	12.03	11.87	11.95	21.18	20.54	20.86
Split tensile strength	0.89	1.14	1.015	2.42	2.48	2.45
Flexural Strength	1.57	1.69	1.69	2.22	2.38	2.42

30% Replacement
Cement Content: 392.08 Kg/m^3
Water Cement Ratio:0.5

Properties	7 days		
	1	2	Mean N/mm^2
Compressive strength	10.89	11.58	11.23
Split Tensile strength	0.86	1.08	0.97

35% Replacement
Cement Content: 392.08 Kg/m^3
Water Cement Ratio:0.5

Properties	7 days		
	1	2	Mean N/mm^2
Compressive strength	10.67	11.45	11.06
Split Tensile strength	0.59	0.74	0.66

ANALYSIS

Compressive strength

0% Replacement	Cement Addition rate(kg/m^3)	7 days strength(N/mm^2)			Extra Cement(g)
		1	2	Mean N/mm^2	
0	383.00	18.03	17.99	18.01	0
5	384.17	17.82	17.99	17.90	150
10	385.76	16.85	16.75	16.80	200
10	386.55	17.55	16.21	16.89	250
15	387.34	17.90	17.50	17.70	300
20	388.13	12.48	13.33	12.90	350
20	388.92	14.87	14.20	14.78	400
20	389.71	15.7	14.3	15.0	450
25	390.50	12.03	11.87	11.95	450
25	391.29	12.57	13.01	12.79	500
30	392.08	10.89	11.58	11.23	550
35	392.87	10.67	11.45	11.06	600

Split tensile strength

0% Replacement	Cement Addition rate(kg/m^3)	3 days strength(N/mm^2)			7 days strength(N/mm^2)		
		1	2	Mean N/mm^2	1	2	Mean
0	_	0.81	0.83	0.823	1.424	1.44	1.432
5	384.17	0.726	0.746	0.736	1.120	0.98	1.050
10	385.76	0.700	0.740	0.720	1.220	1.210	1.210
10	380.55	0.760	0.760	0.760	1.300	1.260	1.280
15	387.34				1.380	1.270	1.32
20	388.13				1.23	1.10	1.16
20	388.92				1.37	0.96	1.165
25	390.50				0.89	1.14	1.015
30	391.29				0.86	1.08	0.97
35	392.08				0.59	0.74	0.66

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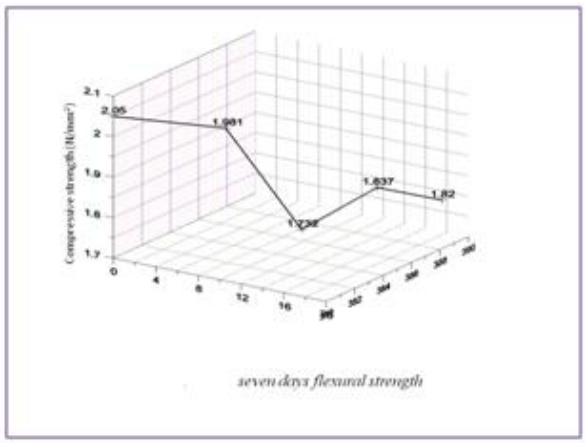
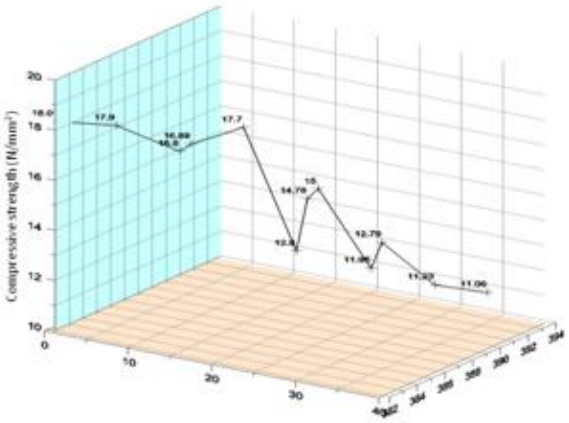
Flexural strength

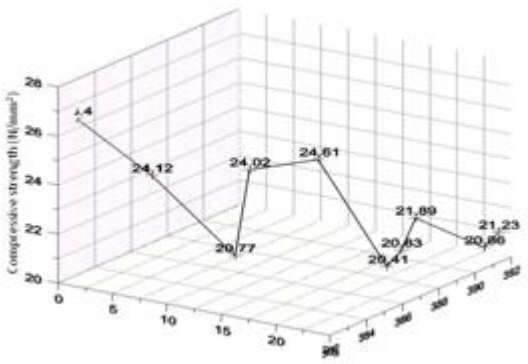
0% Replacement	Cement Addition rate(kg/m^3)	7 days strength(N/mm^2)			28days strength(N/mm^2)		
		1	2	Mean N/mm^2	1	2	Mean
0	_	2.02	2.08	2.05	3.25	3.09	3.17
5	384.17	2.17	1.79	1.981	2.015	2.551	2.283
10	385.76	1.843	1.621	1.732	2.78	2.29	2.535
15	387.34	1.984	1.69	1.837	2.99	2.79	2.89
20	388.13	1.95	1.69	1.82	2.78	2.42	2.60



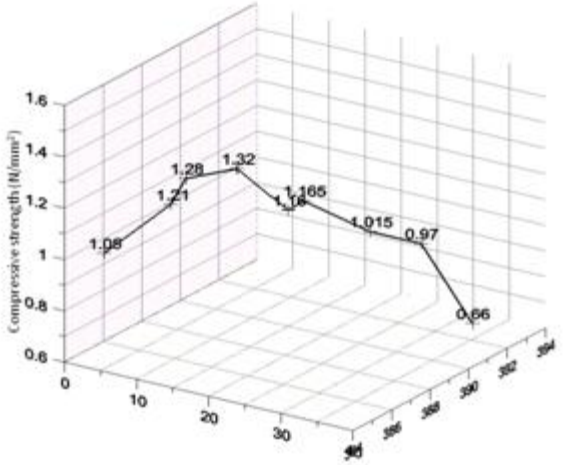
seven days flexural strength



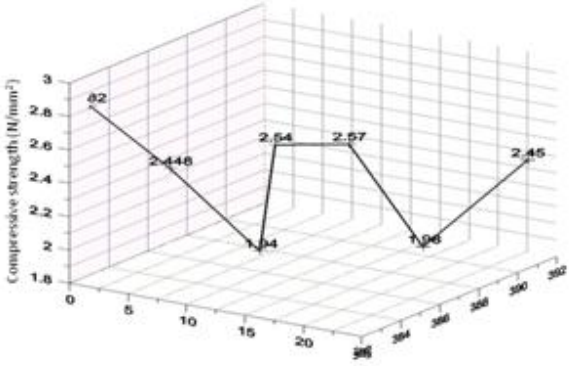
Seven days compressive strength (N/mm²)



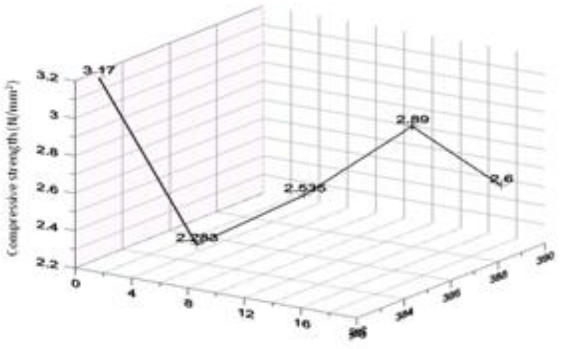
28 days compressive strength



Seven days split tensile strength (N/mm²)



28 days split tensile strength



28 days flexural strength

International Journal of Engineering Research & Technology (IJERT)
ISSN: 2278-0181
Vol. 6 Issue 04, April-2017

CONCLUSION:

The optimum replacement is obtained as 15% Can be used as coarse aggregate in the production of light weight concrete.

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