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A Comprehensive Study on Compressive Strength of Concrete with the Replacement of Aggregates by Coconut Shells and Crushed Stone Dust

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Abstract

The replacement of sand by crusher stone dust in concrete often achieves cost saving and imparts specific engineering properties to the finished product. To use crusher stone dust effectively and economically, it is important to understand the difference between sand and crushed stone dust concretes. The differences in the rate of strength development between the two types and the ways in which this may be influenced by method of mix proportioning are particular importance. When properly proportioned and placed crushed stone dust concrete generally shows improved ultimate strength, durability and finish. The properties of both freshly mixed and hardened concretes are intimately and complexly associated with the characteristics and relative proportions of the materials used in their manufacture. In fresh concrete the coarse and fine aggregates are suspended in cement paste. The consistency of the mass is controlled by the fluidity of the paste and the quantity and grading of aggregates. In hardened concrete, properties such as strength are functions of the density of paste, which is controlled by the ratio of water to cement in the original matrix. Hence, there are practical limits to the relative proportions of cement, water and aggregate in normal concretes. For a port land cement of given composition, the strength and porosity of the hardened mass are dependent almost entirely up on water-cement ratio. The lower the ratio, the greater is the strength and the water tightness. Durability in service, or resistance to weathering and attack by aggressive environment, is as function of both strength and water tightness. The crusher stone dust influences the rheological properties of the plastic concrete, the strength, finish, porosity and durability of hardened mass, and the cost and energy consumed by the manufacturing of the final product. From the experimental results and discussion, the coconut shell and stone dust has potential as recycled dust lightweight aggregate in concrete. Also, using the stone dust and coconut shell as fine and coarse aggregate in concrete can reduce the material cost in construction because of the low cost and abundant product waste. It is concluded that the Coconut Shells are more suitable for lightweight aggregate when used to replace normal coarse aggregate in concrete production by **20%** of aggregates. The compressive strength noted with 20% of replacement is 20.32 N/mm^2 which approximately similar to the replacement with 0% as 20.44 N/mm^2.

Keywords: Concrete, Coconut Shell, Stone Dust, Sand and Compressive Strength

1 INTRODUCTION

Disposal of industrial wastes like fly ash, silica fume, and blast furnace slag and crusher stone dust is becoming a serious problem from environmental and economical considerations. While technologies which can transform these wastes in to value added products are most welcome. Use of such materials as replacements for conventional building materials can achieve the twin objectives of waste disposal and 'natural resource conservation' together. A crusher stone dust is an alternative material to sand for making concrete. Considerable amounts of crushed stone dust are produced while crushing the rocks for the production of coarse aggregate either in a quarry or at the construction sites of large projects. Large scale use of such crusher stone dust in making structural grade concrete can lead to economy in the material cost of the projects.

The specific areas where crushed stone dust can be used are

- As fine aggregate in structural concrete members
- In making brick blocks masonry construction
- In making precast structural elements like RCC ventilators, jellies, rings for wells and water storage tubs.
- To fill the gaps between particles on the surface layer and to improve the viscosity of bitumen content in highway construction

In lining of drains Infrastructure development across the world created demand for construction materials. Concrete is the premier civil engineering construction material. Concrete manufacturing involve consumption of ingredients, aggregates, water and admixture(s). Among all the ingredients, aggregates form the major part. Two billion tons of aggregate are produced each year the United States. Production is expected to increase to more than 2.5 billion tons per by the year 2020. Similarly, the consumption of the primary aggregate was 110 million tones in U.K in the year 1960 and reached nearly 275 million tones by 2006.Use of natural aggregate in such a rate leads to a question about the preservation of natural aggregates sources. In addition operations associated with aggregate extraction and processing are the principal causes of environmental concerns. In light of this, in the contemporary civil engineering construction, using alternative materials in place of natural aggregate in concrete production makes concrete as sustainable and environmentally friendly construction material. Different alternative waste materials and industrial byproducts such as fly ash, bottom ash, recycled aggregates, foundry sand, china clay sand, crumb rubber, glass were replaced with natural aggregate and investigated properties of the concretes. Apart from above mentioned waste materials and industrial byproducts, few studies identified that coconut shells, the agricultural by product can also be used as aggregate in concrete. According to a report, coconut is grown in more than 86 countries worldwide, with a total production of 54 billion nuts per annum. India occupies the premier position in the world with an annual production of 13 billion nuts, followed by Indonesia and the Philippines. Limited research has been conducted on mechanical properties of concrete with coconut shells as aggregate replacement. However, further research is needed for better understanding of the behavior of coconut shells as aggregate in concrete.

2 MATERIALS

The high demand for concrete in the construction using normal weight aggregates such as gravel and granite drastically reduces the natural stone deposits and this has damaged the environment thereby causing ecological imbalance, there is a need to explore and to find out suitable replacement material to substitute the natural stone. In developed countries, many natural materials like Pumice, Scoria and Volcanic debris and manmade materials like expanded blast-furnace slag, vermiculite and clinker are used in construction works as substitutes for natural stone aggregates. In India, commercial use of non-conventional aggregates in concrete construction has not yet started. India is the third largest producer of coconut products in the world. Coconut trees are widely cultivated in the southern states of India, especially Kerala. Kerala got is name itself derived from a world kera meaning coconut tree. Kerala is densely populated state and most of its population use coconut or its by product in their daily activities coconut shells thus get accumulated in the main land without being degraded for around 100 to 120 years. Disposal of these coconut shells is therefore a serious environmental issue. In this structure, the study on use of coconut shell as a substitute or partial replacement of coarse aggregate in concrete is gaining importance in terms of possible reduction of waste product in environment and finding a sustainable alternative for non renewable natural aggregates

3 EXPERIMENTAL WORK

Materials Testing

The different materials used in preparation of concrete specimens are cement, sand, crusher stone dust and coconut shells, coarse aggregate.

Tests for cement: Here we conduct different tests on cement. The test results are given below in a tabular column

S.No.	Properties	Test Results	Standard Results
01	Fineness Of Cement	91.2%	minimum 90%
02	Normal Consistency	26%	22 – 30%
03	Initial Settling Time	70 min	>_45min
04	Final Settling Time	190 min	<_360min
05	Fine Aggregate	Sand	Stone Dust
06	Fine Modulus	2.53	2.51

Fine aggregate*:* Sand

Locally available river sand conforming to zone II of IS: 383-1970 was used

a) Specific gravity: The test was done as per IS: 2386 (part III)

Weight of sample, W_i = 600 gm, Saturated surface dry weight, W_s = 610 gm

Wt of pycnometer + saturated surface dry weight + full of water, W = 1887.3 gm

Weight of pycnometer + full of water, W_p = 1510 gm, Oven dry weight, W_0 = 596.0 gm

$$\text{Specific gravity} = \frac{\text{Weight of sand}}{\text{Weight of an equivalent volume of water}} = \frac{W_s}{W_s - W + W_p}$$

$$= \frac{610}{610 - 1887.3 + 1510} = 2.62$$

b) Water absorption $= \frac{W_s - W_o}{W_o} = \frac{610 - 596}{596} = 2.34\ \%$

c) Free surface moisture $= \frac{W_i - W_o}{W_o} = \frac{600 - 596}{596} = 0.67\ \%$

d) Fineness modulus = 2.65
e) Bulk density - 1703 kg/m^3

Fig.1.fineness modulus of sand

ii) Crusher stone dust

Locally available crusher stone dust confirming to zone II of IS: 383-1970
a) Specific gravity: The test was done as for IS 2386 (part III)
Weight of sample W_i = 600 gm, Saturated surface dry weight, W_s = 605.9 gm
Wt of pycnometer + saturated surface dry wt + full of water, W = 1898.1 gm
Pycnometer + full of water, W_p = 1510 gm, Oven dry weight, W_o = 593.5 gm

Specific gravity = $\frac{W_s}{W_s - W + W_p} = \frac{605.9}{605.9 - 1898 + 1510} = 2.78$

b) Water absorption $= \frac{W_s - W_o}{W_o} = \frac{605.9 - 593.5}{593.5} = 1.97\ \%$

c) Free surface moisture $= \frac{W_i - W_o}{W_o} = \frac{600.0 - 593.5}{593.5} = 1.09$

d) Fineness modulus = 6.98
e) Bulk density - 1910 kg/m^3

Fig.2.fineness modulus of crushed stone dust

iii) Coconut Shell Aggregate: CSA, which is produced using CS aggregates, was the main concrete studied in this investigation. CS is discarded at coconut industries as half-shell rounds. CS was collected from the local coconut oil mills to analyze the properties of CS in this study. CS have maximum thickness in range of 2-8mm, they were crushed to the required sizes (Fig below) in the range 3-12 mm in length using the specially developed crusher. The sieve analysis was conducted and the particle size distribution of CS is presented in Figure.

Fig.3.Coconut Shell

a) Specific Gravity:

Weight of saturated aggregate suspended in water with basket = W_1 = 2770g

Weight of basket suspended in water = W_{2s}= 2100 g

Weight of saturated aggregate in water = (W_1-W_2)g = W_s= 2770-2100=670 g

Weight of saturated surface dry aggregate in air = W_4=1945 g

$$\text{Specific gravity} = \frac{W_4}{W_3 - (W_1 - W_2)}$$

Specific gravity=1945/670 =2.9

Specific gravity of coarse aggregate lies between 2.6 to 2.9

b) Water absorption $=\frac{2000-1680}{2000} \times 100$ =16%

Impact Value Test:

S.No.	Details	Trail Number		Average	Trail Number		Average
		1	2		1	2	
1	Weight of aggregate sample in the cylindrical measure, W1gm(excluding empty weight of cylindrical measure)	500	500	500	500	500	500
2	Weight of crushed aggregates after passing through 2.36 mm sieve, W2 gm	180	220	200	55	60	57.5
3	Aggregate impact value: (W2/W1)*100	36	44	40%	11	12	11.5

Concrete Mix M20 Workability Values:

% of CS replacement	W/C	Mix ratio	Compaction factor	Slump
0	0.5	1:1.5:3:0.5	0.8	30
5	0.5	1:1.5:3:0.5	0.8	30
10	0.5	1:1.5:3:0.5	0.8	30
15	0.5	1:1.5:3:0.5	0.8	30
20	0.5	1:1.5:3:0.5	0.8	30
25	0.5	1:1.5:3:0.5	0.8	30

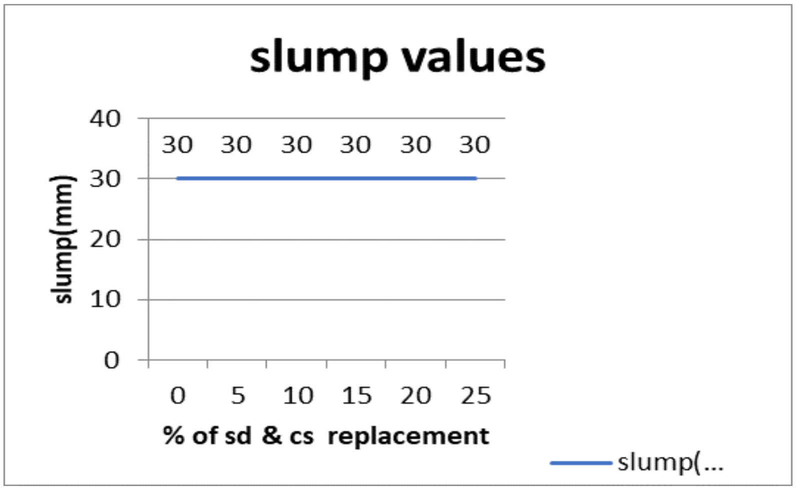

Fig.4. Slump cone test values

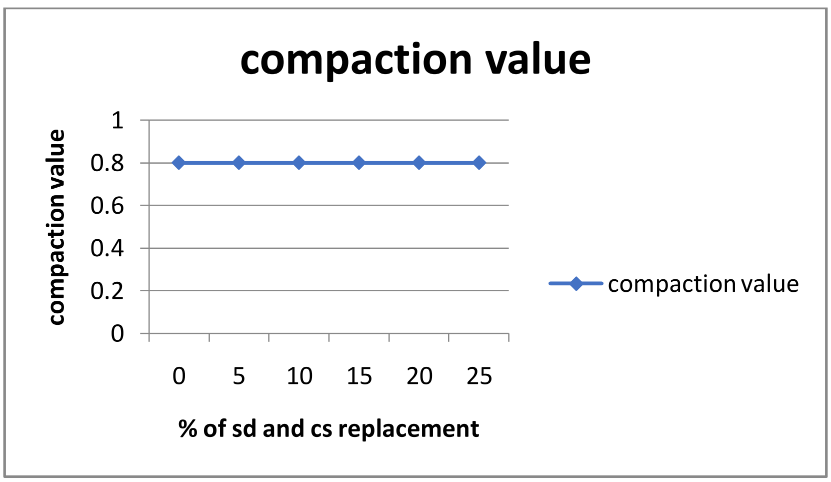

Fig.5. Compaction factor test result

Compressive strength of M 20 grade of concrete in N/mm^2:

% of SD & CS replaced	0	5	10	15	20	25
7 days	13.11	10.99	12	12,55	12.88	9.38
14 days	14.44	12.99	13.33	13.77	14.22	12
28 days	20.44	19.66	19.87	19.98	20.32	18.88

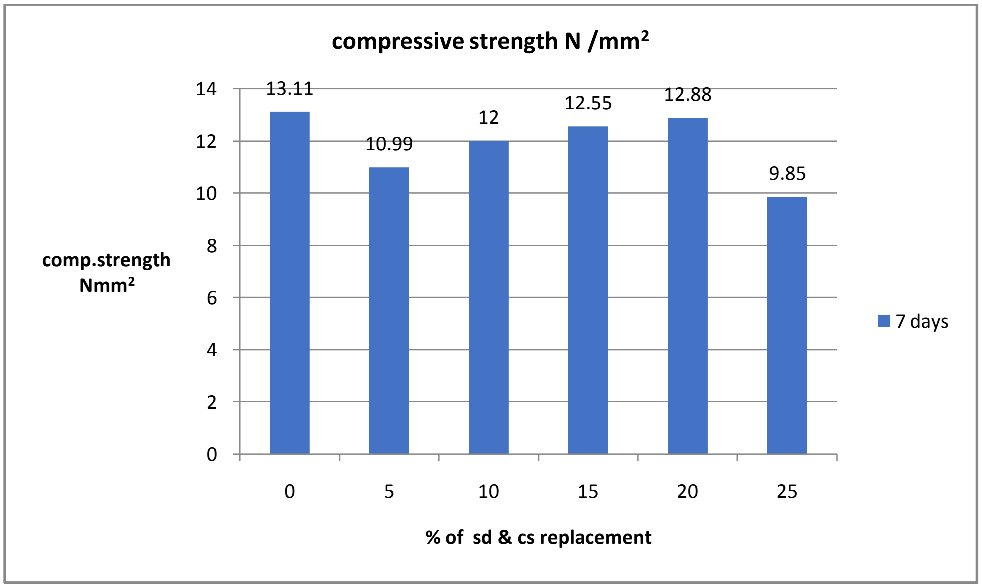

Fig.6. Compressive strength analysis of M20 sd & cs concrete at 7 days

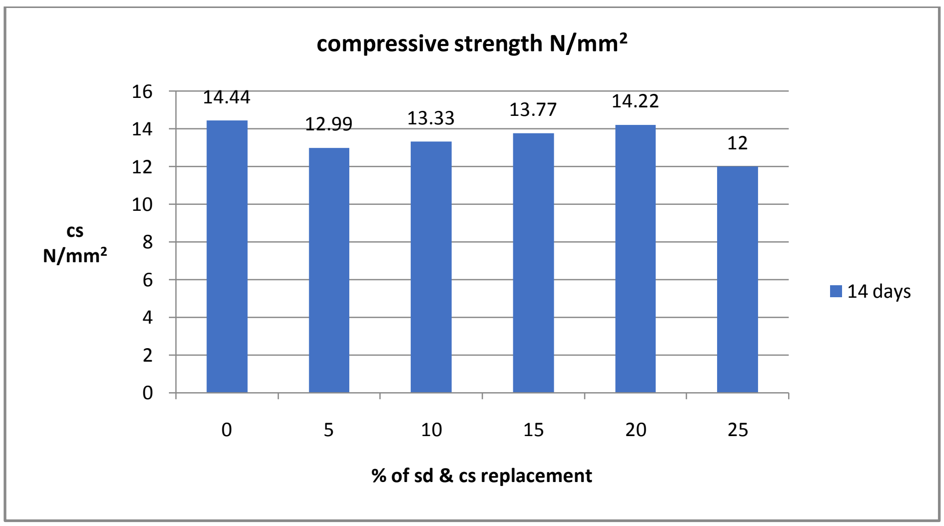

Fig.7. Compressive strength analysis of M20 SD& CS concrete at 14 days

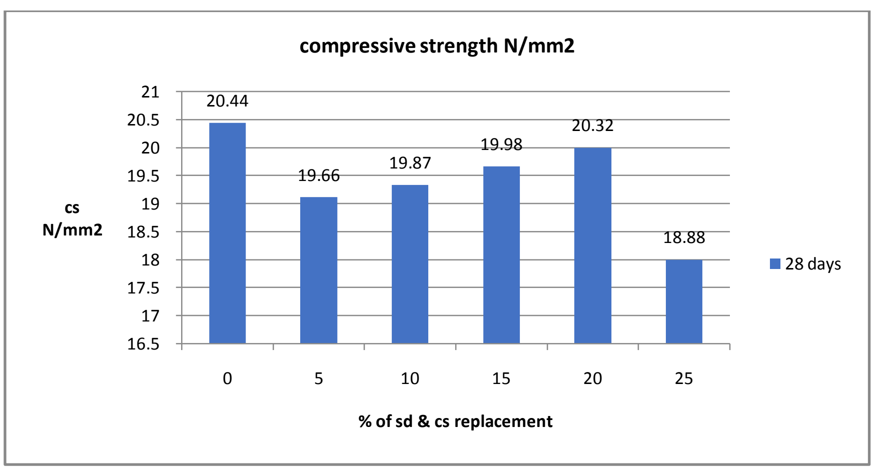

Fig.8. Compressive strength analysis of M20 SD & CS concrete at 28 days

4 CONCLUSION

From the experimental results and discussion, the coconut shell and stone dust has potential as recycled dust lightweight aggregate in concrete. Also, using the stone dust and coconut shell as fine and coarse aggregate in concrete can reduce the material cost in construction because of the low cost and abundant product waste. Coconut Shell and stone dust in conventional Concrete can be used in rural areas and places where coconut is abundant and may also be used where the conventional aggregates are costly. Coconut shell and stone dust concrete is also classified as structural lightweight concrete. It is concluded that the Coconut Shells are more suitable for lightweight aggregate when used to replace normal coarse aggregate in concrete production by **20%** of aggregates. The tests give an idea how the strength of concrete varies when the stone dust and coconut shells are partially replaced as fine and coarse aggregates. The percentage of water required to produce same workability increases with percentage of replacement of Sand by crusher stone dust. The above results give the idea of replacement of the natural aggregates which are now more needed and more cost. This recycled replacement concrete can be used in nonstructural places more conveniently at parking places, floors, outdoor areas, etc. **The compressive strength noted with 20% of replacement is 20.32 N/mm^2 which approximately similar to the replacement with 0% as 20.44 N/mm^2.**

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