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Use of Coconut Shell as Partly Substitution of Coarse Aggregate - An Experimental Analysis

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Abstract. Concrete is a premier construction material consisting of natural aggregate. Due to rapid industrialization and constructions in developing country like India, natural resources are depleting constantly. Search of alternative material for making concrete is a prime need in present scenario. Environmental issues; restrictions on local & natural access or sources and dispose of waste material are gaining great importance. Coarse aggregate is a major ingredient for making concrete for various types of construction works, including infrastructure development, low and high-rise buildings and domestic developments. It occupies about 65-80% part of concrete. Coconut Shell is a waste, generated by industrial and agricultural processes, and has created disposal and management problems that pose serious issues of environmental pollution. The waste coconut shell may be utilized to replace natural coarse aggregate. In present study, compressive strength of concrete of M - 20 grades has studied by replacing natural coarse aggregates at 0%, 5%, 10%, 20% and 30%, by weight with coconut shell. Compressive strength of coconut shell concrete has been evaluated on 7, 14, 21 and 28 days. The compressive strength of coconut shell concrete was reduced as percentage replacement increased. Concrete mixtures were tested and compared in terms of compressive strength of the conventional concrete. The study result shows that Coconut Shell Concrete (CSC) can be used as light weight concrete. Use of Coconut Shell as a substitute of aggregate will not only is cost effective and eco friendly, but also help to resolve the problem of shortage of conventional material such as coarse aggregate. Use of such materials also reduces the problem of disposal of waste material.

INTRODUCTION

Utilization of concrete is increasing at a very high rate due to infrastructural development activities in the world. Concrete is one of the world's most widely used construction material [1]. In addition, Concrete is the second most consumed substance in the world after water. Approximately ten billion tons of concrete is produced every year. Annual production represents one ton for every individual on the planet [2]. There are some negative impacts of more production of concrete like continuous extensive extraction of aggregate from natural resources will lead to its depletion and ecological imbalance [3]. So many researchers are in search of replacing coarse aggregate to make the concrete economical and to extend sustainable development [4]. This environmental reason has generated a lot of concern in the infrastructural development world. The role of sugarcane bagasse, wood chips, plastic waste, fabric waste, polyethylene, rice husk ash, rubber tires, vegetable fibers, paper and pulp industry waste, vegetable fibers, paper and pulp industry waste, peanut shell, waste glass, broken bricks are some cases of replacing aggregates in concrete [5]. Therefore, there is a need to explore and to find out suitable replacement material to substitute the natural stone. Coconut shell has high strength and modulus properties. Coconuts are being naturally available in nature and since its shells are non-biodegradable; they can be used readily in concrete, which may fulfill almost all the qualities of the original form of concrete. In developed nations, the construction industries have identified many artificial and natural lightweight aggregates (LWA) that have replaced conventional aggregates thereby reducing the

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size of structural members. Coconut shell is categorized as light weight aggregate. The coconut shell when dried contains cellulose, lignin and ash in varying percentage [6]. The purpose of this research is to disseminate awareness of using coconut shell as partial replacement of coarse aggregate in concrete and determining its compressive strength

COCONUT SHELL

Coconut is grown in more than 100 countries. India is the third largest, having cultivation in an area of about two million hectares for coconut production. Yearly output is close to approximately 8000 million nuts with an average of 4300 nuts per hectare [7]. The coconut industry in India accounts for over a quarter of the world's total coconut oil output and is set to grow further with the global increase in demand. Never the less, it is likewise the primary contributor to the nation's pollution problem as a solid waste in the form of shells, which involves an annual production of approximately 3.18 million tonnes. It also presents serious disposal problems for a local environment, is an abundantly available agricultural waste from local coconut industries. Coconut shell being a difficult and not easily degrade material if crushed to the size of sand can be a likely material to substitute sand. At present, coconut shell has also been burnt to produce charcoal and activated carbon for food and carbonated drinks and filtering mineral water use. The chemical composition of the coconut shell is similar to wood. It contains 33.61% cellulose, 36.51% lignin, 29.27% and ash at 0.61%. In developing countries, where abundant coconut shell waste is discharged, these wastes can be used as potential material or replacement material in the construction industry. This will receive the dual advantage of reduction in the monetary value of construction material and also as a means of disposal of wastes. Collection and processing of coconut shell is shown in figure 1.

FIGURE 1 Collection and Making of Coconut Shell Concrete

EXPERIMENTAL MATERIALS

Cement

Commercially available Ordinary Portland Cement of 43 grades cement confirming to IS 8112:1989 was used in the field [8] (Specification, Bureau of Indian Standards, New Delhi). The physical properties of OPC 43 grade cement is shown in table 1.

TABLE 1. Properties of Cement

S. No.	Test conducted	Observed values
1	Specific gravity of cement	3.15
2	Consistency	28%
3	Initial setting time	60 min
4	Final setting time	310 min

Fine Aggregate

Fine aggregate normally consists of natural, crushed or manufactured sand. Natural sand is the usual component for normal weight concrete. In some cases, manufactured light weight particles used for lightweight concrete and mortar. The maximum grain size and size distribution of the fine aggregate depends on the type of product being made. Fractions below 4.75 mm to 150 microns are termed as fine aggregate. Locally available Narmada river sand passed through 4.75mm IS sieve is applied as fine aggregate conforming to the requirements of IS 383:1970 [9]. The physical properties of fine aggregate as shown in table 2.

TABLE 2. Properties of Sand

S. No.	Parameters	Results
1	Specific Gravity	2.6
2	Fineness Modulus	3.3
3	Water absorption (%)	1.05
	Bulk density kg/cm^3	
4	Loose	1580
	Compacted	1750

Coarse Aggregate

Coarse Aggregate in concrete occupies 35% to 70% of the volume of the concrete. Smaller sized aggregates produce higher concrete strength. Particle shape and texture affect the workability of fresh concrete. Usually an aggregate with specific gravity more than 2.55 and absorption less than 1.5% can be regarded as being of good quality. Where aggregates strength is higher, concrete strength is also higher. Fractions from 20 mm to 4.75 mm are used as coarse aggregate. The Coarse aggregate are obtained from a local quarry (Maneri), conforming to IS 383:1970 is used [9]. The physical properties of coarse aggregate as shown in table 3.

TABLE 3. Properties of Coarse Aggregate

S. No.	Parameters	Results
1	Specific Gravity	2.76
2	Fineness Modulus	6.5
3	Water absorption (%)	1.35
	Bulk density kg/cm^3	
4	Loose	1600
	Compacted	1790

Coconut Shell

Coconut shell particles are used as reinforcing material for investigation. Shell particles of size between 20 mm 600 μ are prepared in grinding machine. Coconut shell has high strength and modulus properties. Coconut shells

were collected from various temples at Jabalpur to analyze its properties as shown in The physical properties of coconut shell is shown in table 4.

TABLE 4. Properties of Coarse Aggregate

S. No.	Parameters	Results
1	Specific Gravity	1.25
2	Water absorption (%)	20
	Bulk density kg/cm^3	
3	Loose	600
	Compacted	790
4	Shell thickness (mm)	2- 6

Water

Water is an important factor of concrete as it actually participates in the chemical reaction with cement. Potable water is employed in using of concrete.

EXPERIMENTAL METHODOLOGIES

The study is conducted to analyze the compressive strength of concrete when the natural coarse aggregate is partially replaced with waste coconut shell respectively. Concrete mix is designed as per IS: 10262-1982 [10], IS: 456-2000 [11] for the nominal concrete. The grade of concrete, which we adopted, is M-20. The concrete mix proportion (cement: fine aggregate: coarse aggregate) is 1:1.5: 3 by volume and a water cement ratio of 0.50.The Compressive strength tests were done on compression testing machine using cube samples. Three samples per batch were tested with the average strength values reported in this paper. The natural coarse aggregates were replaced with coconut shell as 0%, 5%, 10%, 20% and 30% by weight of M-20 grade concrete. Cubes of OPC (150mm × 150mm × 150mm) were examined and results were analyzed after curing of 7days, 14days, 21 days and 28 days. Due to high water absorption of coconut shell, they were presoaked in water for 24 hours, prior to mixing. Results obtained from the replacement are compared with data from a Conventional concrete. Compressive strength of coconut shell concrete for 7 days, 14 days, 21 days and 28 days are shown in table 5 to table 8, whereas comparison compressive strength of all these concrete specimen is shown in table 9 and in figure 2. Lab performances for determination of coconut shell concrete are shown in figure 3.

TABLE 5. Compressive Strength of coconut shell concrete at 7 days N/mm^2

S. No.	Specimen	Compressive Strength of concrete at 7 days N/mm^2
1	Conventional Concrete	15.50
2	5%	14.40
3	10 %	13.30
4	20 %	12.30
5	30%	11.45

TABLE 6. Compressive Strength of coconut shell concrete at 14 days N/mm^2

S. No.	Specimen	Compressive Strength of concrete at 14 days N/mm^2
1	Conventional Concrete	18.65
2	5%	18.20
3	10 %	17.70
4	20 %	16.40
5	30%	15.80

TABLE 7. Compressive Strength of coconut shell concrete at 21 days N/mm^2

S. No.	Specimen	Compressive Strength of concrete at 21 days N/mm^2
1	Conventional Concrete	19.90
2	5%	18.80
3	10 %	18.10
4	20 %	17.40
5	30%	16.35

TABLE 8. Compressive Strength of coconut shell concrete at 28 days N/mm^2

S. No.	Specimen	Compressive Strength of concrete at 28 days N/mm^2
1	Conventional Concrete	22.30
2	5%	20.45
3	10 %	20.10
4	20 %	18.70
5	30%	17.90

TABLE 9. Comparison of Compressive Strength (N/mm^2) CSC in 07, 14, 21, 28 days

S. No.	Specimen	7 days	14 days	21 days	28 days
1	0% Aggregate Replaced with Coconut Shell	15.50	18.65	19.90	22.30
2	5% Aggregate Replaced with Coconut Shell	14.40	18.20	18.80	20.45
3	10 % Aggregate Replaced with Coconut Shell	13.30	17.70	18.10	20.10
4	20 % Aggregate Replaced with Coconut Shell	12.30	16.40	17.40	18.70
5	30% Aggregate Replaced with Coconut Shell	11.45	15.80	16.35	17.90

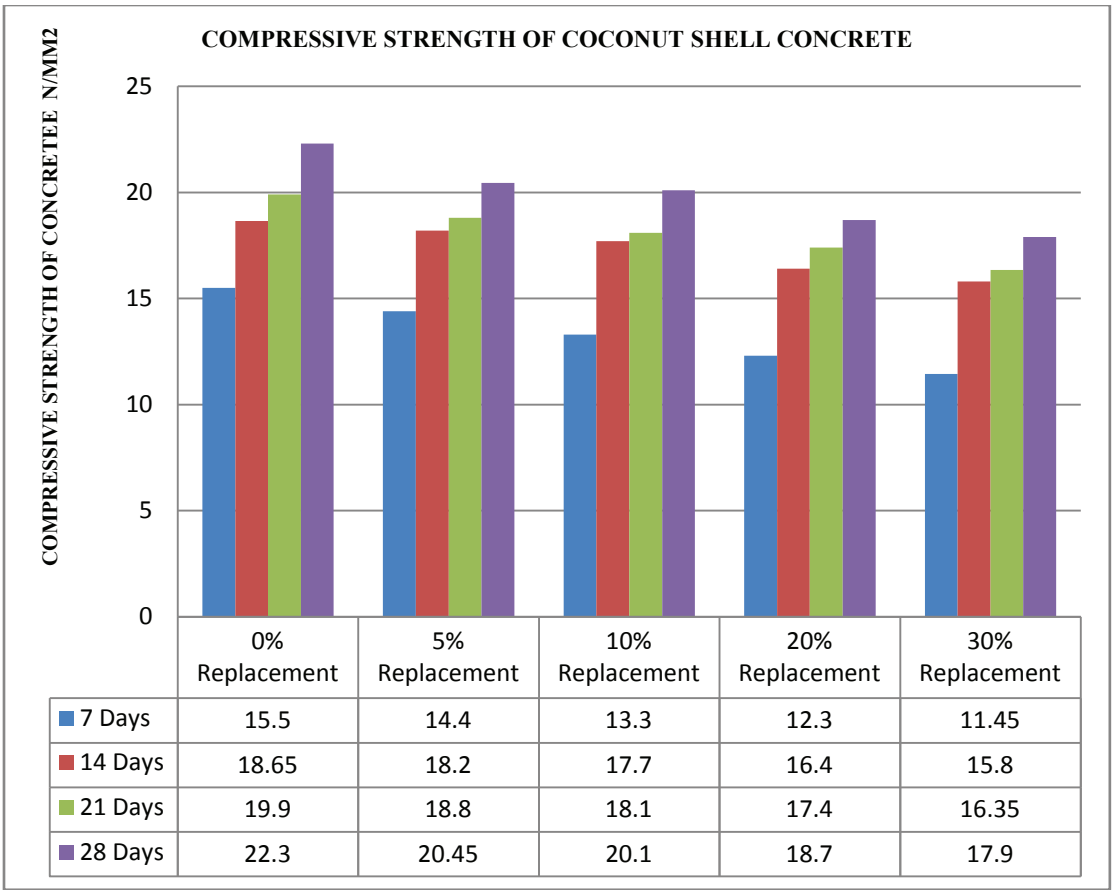

FIGURE 2 Comparison of Compressive Strength of Coconut Shell Concrete.

FIGURE 3 Lab Performance for Compressive Strength of Coconut Shell Concrete.

The different data presented above shows that the time period also depends upon different parameters of buildings and hence the effect of the same cannot be ignored.

RESULTS AND DISCUSSIONS

Compressive Strength of coconut shell concrete has been determined on partial replacement of natural coarse aggregate with waste coconut shell. Laboratory test has been performed for 5 % to 30% replacement of coarse aggregate with coconut shell for M-20 grade concrete. Varying strength of concrete was observed, which are measured in N/mm2. The results obtained for 7 days to 28 days compressive strength confirms the optimal percentage requirement for substitute of natural coarse aggregate with waste coconut shell are shown in figure 2 (Bar Graph).

CONCLUSIONS

The purpose of this research is to compare and find out the characteristic strength of M-20 grade Coconut Shell Concrete at the water cement ratio of 0.50. Using the waste coconut shell by replacing fast depleting conventional aggregate source construction material and thereby getting the solution for social and environmental issues. Based

on experimental investigations concerning the compressive strength of concrete, the following observations are drawn:

1. On 10% partial replacement of natural coarse aggregate with Waste Coconut Shell, Compressive Strength of coconut shell concrete has obtained 20.10 N/mm2 at 28 days. Thus, making the replacement both technically and economically feasible and viable. On further replacement, decrease in the compressive strength of Coconut Shell Concrete has been observed.
2. Coconut shell can be grouped under lightweight aggregate because 28 day air dry densities of coconut shell aggregate concrete are less than 2000 kg/m3. Actual density of coconut shell is in the range of 600-800 kg/m^3.
3. Experimental results and discussions of researches on coconut shell confirm that the coconut shell has potential as lightweight aggregate in concrete. Also, using the coconut shell as aggregate in concrete can reduce the material cost in construction because of the low cost and its abundant agricultural waste.
4. Coconut Shell Concrete can also be for non structural members e.g. partition wall, hollow concrete brick, floors tiles etc. Even after more than 10% partial replacement of coconut shell with aggregate.
5. Use of coconut shell waste as aggregate will reduce depletion of natural sources of conventional aggregate and will also be helpful to make eco - friendly environment.

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