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Performance Evaluation of Waste Coconut Shells and Coir Fiber as Substitute for Coarse and Fine Aggregate in Structural Concrete Members

Shruthi H G[1], Harshith M K[2], Pruthvi M[3], Sharath Kumar M[4]

[1] *Assistant Professor, Department of Civil Engineering, ATME College of Engineering, Mysuru, Karnataka, India*

[2,3,4] *U.G. Students, Department of Civil Engineering, ATME College of Engineering, Mysuru, Karnataka, India*

Abstract - *The utilization of coconut shells and coir fibre sand as partial replacement for fine and coarse aggregates has been investigated. This research work includes the experimental study of using locally available coconut shells as partial replacement with coarse aggregates and coir fibre sand obtained from metal casting industries as partial replacement with sand to achieve maximum compressive strength of concrete. At the moment, 90% of this waste is disposed of to landfill as non-hazardous waste while only 10% is beneficially reused. In the present study, steps have been taken to partially replace the fine aggregate with coir fibre sand.The use of coconut shells and coir fibre sand in concrete will considerably decrease the scarcity of natural aggregates. Because of this reason coconut shells and coir fibre sand are utilized as partial replacement in fine and coarse aggregates in concrete with 0%, 5%, 10%, 15%, 20%, 25% and 30% substitution in M20 concrete. These were casted and tested for compressive strength and split tensile strength after a curing period of 3, 7 and 28 days. Based on the results presented in this project, it can be concluded that concrete mixture can be prepared with coir fibre sand and coconut shells as partial replacement to improve the strength of concrete structure.*

***Key Words*: Coconut shells, Coir fiber, Compressive strength, Split tensile strength, Fine aggregates , Coarse aggregates.**

1. INTRODUCTION

Concrete is the main part of any construction work which is composed of gravels or crushed stones, sand, hydrated cement etc. It has been used over a century in all construction work. Now-a-days, the construction sector is expanding rapidly on a large scale involving newer techniques. The consumption of natural resources in construction is phenomenal and results in high cost. To overcome the use of natural resources and by attempting to use waste materials like coir fiber and coconut shells in concrete could result in low cost construction. Also the use of coir fiber and coconut shells in construction could help to avoid the problems related to environment pollution. All recycling and reuse of waste products involves research aimed at acquiring a full understanding of such products in order to determine suitable and specific applications.

Coconut are referred to as "king of the tropical fibre" and "tree of life". Global production of coconut is 51 billion nuts from an area of 12 million hectares. South East Asia is regarded as the origin of coconut. Coconut shell is a natural material that is available abundantly. Coconut shells are reused in many applications and some amounts of it are exported. Coconut shells are used in the production of light weight concrete. It has a superior workability because of the smooth surface on one side of the shells.

The impact resistance of coconut shells is high when compared with conventional concrete. Coconut fibers are extracted from the outer shell of a coconut. These are two types of coconut fibers, brown fibers extracted from matured coconuts and white fibers extracted tender coconuts. Brown fibers are thick, strong and have high abrasion resistance which is used commonly.

The main objective of this research work is to reduce the environmental waste by proper utilization of coconut shells & coir fibers as partial replacement of waste cement in concrete.

2. MATERIALS

A. Cement

Portland cement is the most common type of cement in general usage. It is a basic ingredient of concrete, mortar and plaster. Of the various ingredients used in concrete, cement is the most energetic and expensive.

In the present investigation OPC 53 grade cement is used.

Table 2.1: Physical properties of Cement

Elements	Content
Specific Gravity	3.29
Fineness Modulus	7.9%
Standard Consistency	34%
Initial Setting time	45min
Final Setting time	300min

The table 2.1 shows the physical properties such as specific gravity, fineness modulus, standard consistency, initial and final setting time of Ordinary Portland Cement (OPC 53 grade).

Table 2.2: Chemical properties of Cement

Oxides	Percentages
Cao	62.85
SiO2	20.98
Al2O3	5.42
Fe2O3	3.92
MgO	1.76
SO3	2.36
Na_2O	0.28
K_2O	0.53
Loss of Ignition	1.90

Table 2.2 shows the chemical composition of Ordinary Portland Cement (OPC 53 grade) that has been used for this experimental study.

B. Water

Combining water with a cementitious material forms a cement paste by the process of hydration. The cement paste glues the aggregate together, fills voids within it, and makes it flow more freely. Lower water to concrete ratio yields a stronger, more durable concrete, while more water gives a free-flowing concrete with a higher slump. Impure water used to make concrete can cause problems when setting or in causing premature failure of the structure.

C. Fine aggregate

It is the aggregate most of which passes 4.75 mm IS sieve and contains only so much coarser as is permitted by specification According to size the fine aggregate may be described as coarse sand, medium sand and fine sand. IS specifications classify the fine aggregate into four types according to its grading as fine aggregate of grading Zone-1 to grading Zone-4. The four grading zones become progressively finer from grading Zone-1 to grading Zone-4. 90% to 100% of the fine aggregate passes 4.75 mm IS sieve and 0 to 15% passes 150 micron IS sieve depending upon its grading zone.

Table 2.3: Physical properties of fine aggregates

Sl.no	Particulars	Obtained values
1	Fineness modulus	2.68
2	Maximum size	2.36mm
3	Specific gravity	2.48
4	Water absorption	1%

Table 2.3 shows the results for various tests such as specific gravity, fineness modulus, water absorption and maximum size for fine aggregates.

D. Coarse Aggregates

Crushed stone aggregates of 20mm size obtained from local quarry site were used for the experiment. The physical properties of coarse aggregates are shown in table below.

Table 2.4: Physical properties of coarse aggregates

Sl.no	Particulars	Obtained Values
1	Specific Gravity	2.7
2	Fineness Modulus	4.406
3	Water Absorption	0.25%

Table 2.4 shows the results for various tests such as specific gravity, fineness modulus and water absorption for coarse aggregates.

E. Coconut Shells

Coconut shell is a natural material that is available abundantly. Waste generated by industrial and agriculture processes, has created disposal and management problems that pose serious issues of

environmental pollution. Coconut shells are reused in many applications and some a considerable amount of its are exported. Therefore, the utilization of these materials in construction will be an important step to improve sustainability and eco-friendly construction. In addition to that, it will help to reduce the self-weight of concrete structures. This study will help to reduce other necessary ingredients in the production of concrete. The current study examines the suitability of the partial replacement of a coarse aggregate with coconut shells in the production of concrete.

Table 2.5: Properties of coconut shells aggregate

Sl.No	Particulars	Obtained values
1	Specific gravity	1.07
2	Impact value	24%
3	Water absorption	14.4%

Table 2.5 shows the various physical properties such as specific gravity, impact value and water absorption of coconut shells.

Fig.1 Coconut Shell

Figure 1 shows the coconut shells as a partial replacement for coarse aggregate in the preparation of concrete for the following experimental study.

F. Coir Fiber

The coconut shell utilized in this study are brought from local temple. They are sundried for five days prior to using being a combination. The coconut shell is broken into smaller pieces up to 20 mm. The breaking of coconut shell is done by using 30kg hammer. The broken pieces are passed through IS 20 mm sieve and those retained on the IS 16 mm sieve are utilized.

Table 2.6: Physical properties of coir fiber sand

Sl.no	Particulars	Obtained Values
1	Specific Gravity	1.66
2	Fineness Modulus	4.49

The basic tests such as specific gravity and fineness modulus test were conducted for coir fiber sand and the results are as shown in table 2.6.

Fig.2 Coir Fibre

Figure 2 shows the coir fiber as a partial replacement for fine aggregates (sand) in the preparation of concrete for the following experimental study.

Mix Proportion by volume = 1: 1.8: 3.02

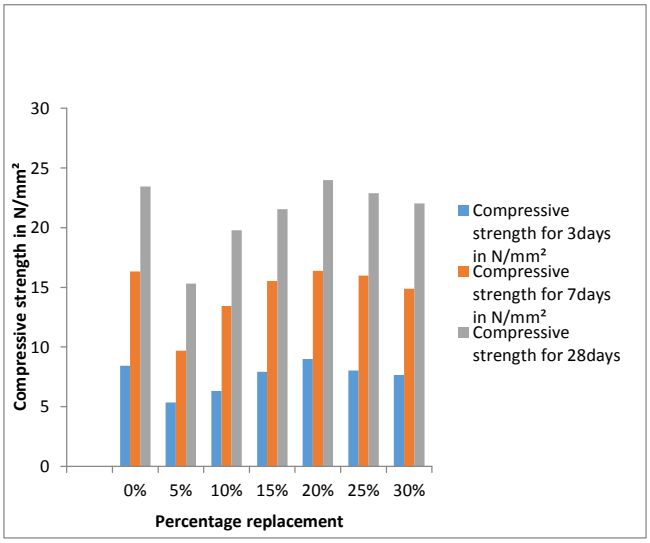
1= cement
1.8= fine aggregate
3.02= coarse aggregate
0.5= Water-cement ratio

A. Compression strength results

Table 2.7 : Test results of M_{20} grade concrete with 0%, 5%, 10%, 15%, 20%, 25% and 30% replacement of coir fiber and coconut shells with fine and coarse aggregates for 3, 7 and 28 days

Sl no	Grade	Percentage replacement of coir fiber & coconut shells	Compressive strength in N/mm² Age in days 3	7	28
1	M_{20}	0%	8.43	16	23
2	M_{20}	5%	5.36	9	15

3	M_{20}	10%	6.321	13	19
4	M_{20}	15%	7.93	15	21
5	M_{20}	20%	8.99	16	23
6	M_{20}	25%	8.03	15	22
7	M_{20}	30%	7.66	14	22



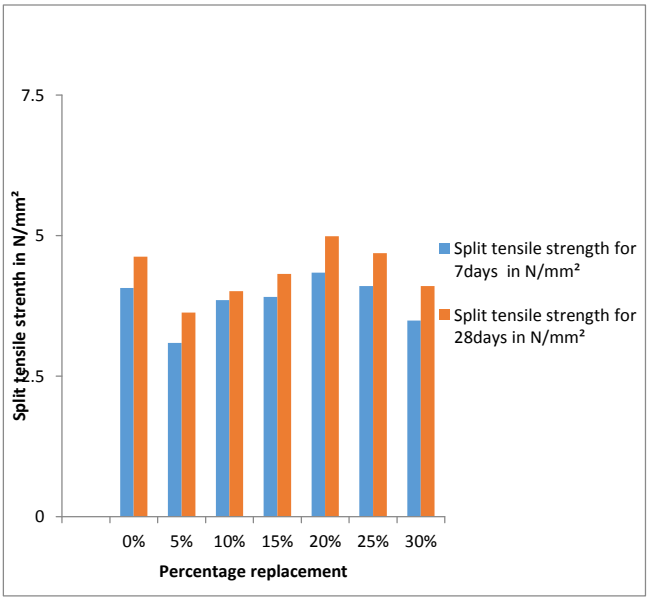
Graph 2.7 M_{20} concrete grade with 0%, 5%, 10%, 15%, 20%, 25% and 30% replacement of coir fiber and coconut shells and their compressive strength at 3,7 and 28 days

The above graph indicates that the compressive strength for 3, 7 and 28 days with 0%, 5%, 10%, 15%, 20%, 25% and 30% replacement of coir fiber and coconut shells with fine and coarse aggregates. The strength increases upto 20% replacement of coir fiber and coconut shells when compared with normal concrete after which the strength decreases with the increase in the percentage replacement.

B. Split tensile strength results

Table 2.8 : Test results of M_{20} grade concrete with 0%, 5%, 10%, 15%, 20%, 25% and 30% replacement of coir fiber and coconut shells with fine and coarse aggregates for 7 and 28 days.

Sl no	Grade	Percentage replacement of coir fiber & coconut shells	Split tensile strength in N/mm² Age in days	7	28
1	M_{20}	0%	-	4.068	4.627
2	M_{20}	5%	-	3.09	3.63
3	M_{20}	10%	-	3.85	4.01
4	M_{20}	15%	-	3.91	4.32
5	M_{20}	20%	-	4.34	4.99
6	M_{20}	25%	-	4.10	4.69
7	M_{20}	30%	-	3.49	4.10



Graph 2.8 : M_{20} concrete grade with 0%, 5%, 10%, 15%, 20%, 25% and 30% replacement of coir fiber and coconut shells and their split tensile strength at 7 and 28 days.

The above graph indicates that the split tensile strength for 7 and 28 days with 0%, 5%, 10%, 15%, 20%, 25% and 30% replacement of coir fiber and coconut shells with fine and coarse aggregates. The strength increases upto20% replacement of coir fiber and coconut shells when compared with normal concrete i.e., 0% replacement of coir fiber and coconut shells after which the strength decreases with the increase in the percentage replacement.

3. CONCLUSIONS

The maximum compressive strength and split tensile strength of the concrete are obtained when 20% of fine and coarse aggregates were replaced with coir fiber and coconut shells respectively. The compressive strength and split tensile strength has decreased for 25% and 30% replacement with coir fiber and coconut shells, however there is little variation in strength compared to conventional concrete. Utilization of coir fiber and coconut shells in concrete mix have the advantage of reduction in cost of construction materials. By using coir fiber and coconut shells in concrete, problems regarding safe disposal is reduced.

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BIOGRAPHIES

Prof. Shruthi H G, a silver medalist in Master of Technology - Computer Aided Design of Structures from PESCE, VTU Belgaum, Karnataka, INDIA and presently working has Assistant Professor in department of civil engineering ATMECE. She is continuously involved in research, development and analysis of new concepts evolving in construction aspects. Aspiring researchers for new horizons of trends in civil engineering.