March - April 2020
ISSN: 0193-4120 Page No. 5197 - 5203

Performance of Concrete Partially Replaced with Seashells and Coconut Shells as Coarse Aggregates

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Abstract

This study involves partially replacing seashells and coconut shells as coarse aggregates in varying proportions individually and testing their properties like Compressive Strength and Tensile Strength. Various properties of the sea shells and coconut shells were determined. The study involved preparation of 5 samples for each sea shell and coconut shell of varying proportion. The 28 days compressive strength and tensile strength were tested using the Compressive Strength test and Split Tensile test, and an optimum percentage of replacement was determined. The 7 days compressive strength and split tensile strength were studied for the optimum percentage replacement to determine the early strength developed. As a result of these tests, it was determined that 20% replacement was the optimum replacement ratio for sea shells and 10% replacement was the optimum replacement ratio for coconut shells. Graphs were plotted to compare the strength variations of both the shells and a detailed comparative analysis was carried including cost analysis and analysis of variation in strengths.

Keywords; *Seashells, Coconut shells, Compressive Strength, Tensile Strength.*

I. INTRODUCTION

Concrete have the capability of forming into any shape and size for the construction purpose. Using this mouldable nature of the material, concrete has made its progress rapid in the construction industry. The basic constituents of concrete are cement, water and aggregate (and selected additives). Aggregates are the inert "filler" material of concrete. Aggregate tends to represent a relatively high volume percentage of concrete. To reduce the cost of the materials, alternatives have been used for the conventional materials. Recent examination of Indian sea shells has recommended greater extent for their usage as a construction material. Usage of seashells will helps in saving construction material and also aids in solving the problem of disposal of this waste product. In addition to sea shells, the concrete with ground coconut shell will make the concrete more durable against water, acidic, alkaline and salty environment. Coconut shell is a hard and not easily degradable material if it is compressed to the size of sand, it will be a potential material to substitute sand. As modern engineering practices become more demanding, there is a corresponding need for special types of materials with novel properties. For minimizing the cost of concrete, large amount of pozzolanic materials like fly ash and blast furnace slag was suggested for the cement. While sea shells, glass and ceramic material were used instead of fine aggregates and palm kernel shells, coconut shells and sea shells were used as a replacement for coarse aggregate.

When the disposed solid waste materials are used in the concrete instead of conventional material, the

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March - April 2020
ISSN: 0193-4120 Page No. 5197 - 5203

disposal problem will get reduced and simultaneously the required strength of concrete is achieved. In the present investigation sea shells and coconut shells has been used individually as partial replacement of coarse aggregate. Almost all over the world various methods have been adopted to reduce the waste and reuse and recycling methodology have been introduced. As a result, in developing countries like India, reuse of solid wastes has come into existence.

Coconut Shell

One of the major pollution problems as a solid waste in our nation is coconut shells. The chemical composition of the coconut shell is similar to wood. It contains cellulose, lignin, 29.27% and ash. In developing countries, these coconut shell wastes can be used as a construction material in the industry.

Properties of Coconut Shell

Coconut shell has high strength and durable properties. The composites are more weather resistant due to high lignin content. Cellulose content in the coconut shell makes the concrete to absorb less moisture. Coconut shells have good durability characteristics, high toughness and abrasion resistant properties. By utilizing the coconut shells as coarse aggregate a new structural Light Weight Concrete (LWC) can be developed.

1.2 Seashell

1.2.1 Properties of Seashells

It has high content of Calcium Carbonate so it contributes to the strength properties in concrete. It makes the concrete hard and a naturally available and non-bio degradable material.

II. METHODOLOGY

The following steps were carried out in the experiment.

2.1 Initial Testing

To arrive at mix design as per IS 10262 – 2009, the following tests were carried out. Tests conducted on fine aggregates are Water Absorption Test (by IS 2386 Part III – 1963), Sieve Analysis (by IS 2386 Part I – 1963) and Specific Gravity Test (IS 2386 Part III – 1963). Tests conducted on coarse aggregate are Water Absorption Test and Specific Gravity test as per IS 2386.

By using the results obtained in the above mentioned test, design mix for 0% is obtained as 1:1.57:2.58.As per design mix, the concrete is prepared. The water cement ratio was kept as 0.45. Concrete cubes and cylinders were casted and cured and then the strength tests were conducted.

2.2 Compression Test

Compression test is carried out to find the compressive strength of the concrete. The compression test is carried out using a standard compression testing machine (CTM). Many standard codes recommend concrete sample cubes of size 150mm x 150mm x 150mm.The compressive strength of the cube is calculated and given by the following equation:

$$F_C=P/A$$

Where,

P is the Failure load of the Cube (N)

A is the loaded surface area of the cube (⟦mm⟧^2)

The average value of the compressive strength of the three cubes is taken.

2.3 Split Tensile Test

Tensile strength is the one of the important property of concrete as it very much affects the effect of size of cracking. The tensile strength of the concrete can be calculated as follows: $T=2P/\pi DL$

Where, T is the splitting tensile strength (MPa)

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March - April 2020
ISSN: 0193-4120 Page No. 5197 - 5203

P is the maximum applied load indicated by the testing machine (N)

D is the Diameter of the specimen (mm)

L is the Length of the specimen (mm)

III. RESULTS AND DISCUSSION

The use of naturally occurring shells as partial replacement in course aggregates has been gaining popularity over the years. Considering factors like low cost, easy availability and an effective means of waste disposal, the only point of contention was the strength factor of the shells studied. This

study shows that the strength increases with increase in the proportion of sea shells up to certain limit. Beyond that limit the strength decreases as the bond formation becomes tougher owing to the slippery surface of the sea shells. Its compatibility as a coarse aggregate in concrete increases and it reaches an optimum concentration and then decreases with increase in the proportion further.

The optimum proportion of sea shells was observed to be 20%.On the other hand, the strength in Coconut shells concrete decreased. However it turned out to be an essential adoption when employed for low strength concrete scenarios. Coconut Shell concrete is economical and light weight and suffices where high strength in concrete is not required.

The optimum proportion of coconut shells was observed to be 10%.

IV. COMPRESSION TEST RESULTS

Five cube specimens of size 150mm * 150 mm of grade M25 were tested.

4.1 28 days compressive strength for sea shell concrete

The cube compressive strength results of M25 grade mix at 28days made with various proportions of seashells were noted. Table 4.1 depicts the compressive strength of seashell concrete with respect to 28days. Test results were plotted in the form of graphs and shown in Fig 4.1.

Table 4.1 28days Average Compressive test results for sea shell concrete

Percentage of Seashells (%)	Average Compressive Stress(N/mm^2)
0	26.07
10	27.11
20	29.06
30	23.47
40	21.31

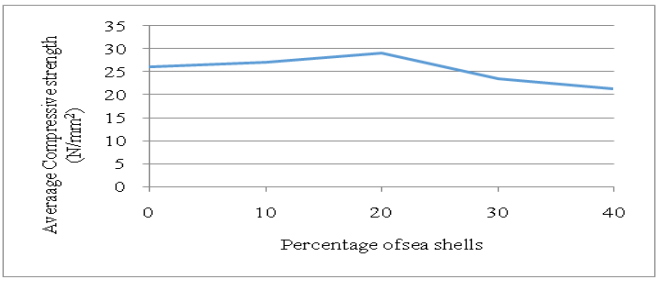

Fig. 4.1 Average Compressive Stress Analysis for Seashells

It is seen that compressive strength for M25 grade concrete was gradually increases from 26.07 to 29.06 for replacement of seashells up to 20%. After that compressive strength decreases with increase in percentage of seashells. So that the optimum proportion of seashell was found to be 20%.

4.2 7 days Compressive Strength of Seashell Concrete

Considering the 28 days compressive strength for seashell concrete, we find that 20% sea shell replacement is the optimum replacement ratio. Hence the 7 day strength is also checked for 20% replacement, to determine the early in the seashell concrete in comparison with the early strength developed in conventional concrete.

Table 4.2 7 days average compressive test results for sea shell concrete

Percentage of Sea Shells (%)	Average Compressive Stress(N/mm^2)
0	17.48
20	16.88

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March - April 2020
ISSN: 0193-4120 Page No. 5197 - 5203

4.3 28 days Compressive Strength for Coconut Shell Concrete.

The cube compressive strength results of M25 grade mix at 28days made with various proportions of coconut shells were noted. Table 4.3 depicts the compressive strength of coconut shell concrete with respect to 28days. Test results were plotted in the form of graphs and shown in Fig 4.2.

Table 4.3 28days Average Compressive test results for coconut shell concrete

Percentage of Coconut shells (%)	Average Compressive Stress(N/mm^2)
0	26.07
10	24.29
20	20.15
30	18.81
40	15.85

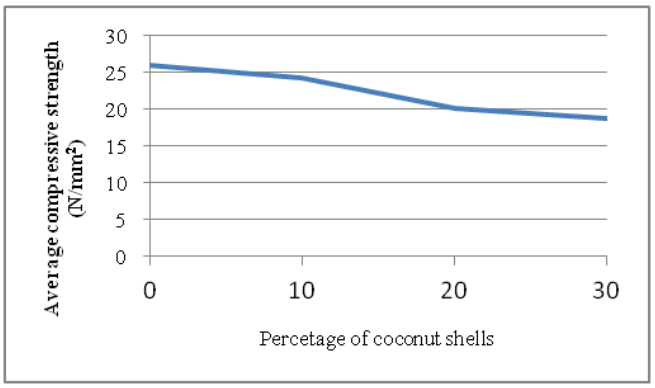

Fig 4.2 Average Compressive Stress Analysis for Coconut shell

It is seen that compressive strength for coconut shell concrete were gradually reduces with rise in percentage of coconut shell, so that optimum mix percentage is reduced to 10% in case of coconut shells.

4.4 7 days compressive strength for coconut shell

Considering the 28 days compressive strength for coconut shell concrete, we find that 10% coconut shell replacement is the optimum replacement ratio. Hence the 7 day strength is also checked for 10% replacement, to determine the early strength developed in the coconut shell concrete in comparison with the early strength developed in conventional concrete.

Table 4.4 7 days Average Compressive Test Results for Coconut Shell Concrete

Percentage of Coconut shells (%)	Average Compressive Stress(N/mm^2)
0	17.48
10	14.96

V. SPLIT TENSILE TEST RESULTS

Five cylinder specimens of diameter = 150mm and height = 100 mm of grade M25 were tested for the tensile strength in the Universal Testing Machine. The specimens had sea shell and coconut shell respectively in ratio of 0%, 10%, 20%, 30% and 40%.

5.1 28 Days Tensile Strength for Seashell Concrete

The splitting tensile strength results of M25 grade mix at the age of 28days made with various proportions of seashells were observed. Table 5.1 depicts the tensile strength of seashell concrete at 28days. Test results were plotted in the form of graphs and shown in Fig 5.1.

Table 5.1 28 Days Average Tensile Test Results for Seashell Concrete

Percentage of Seashells (%)	Average Tensile Stress (N/mm^2)
0	3.20
10	2.31
20	2.58
30	2.16
40	1.83

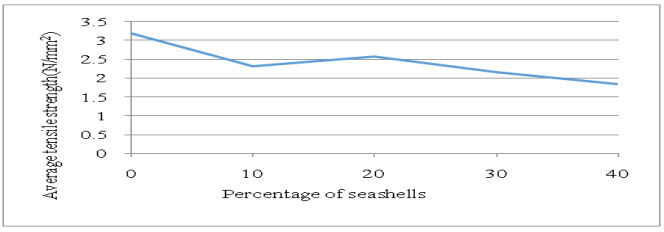

Fig 5.1 Average Tensile Stress Analysis for Seashell

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March - April 2020
ISSN: 0193-4120 Page No. 5197 - 5203

It is observed from the graph that the splitting tensile strength for M25 concrete was decreased initially and increased at 20% replacement and again decreased with increase in percentage of seashell, so that the Optimum replacement of seashell was found to be 20% from the graph.

5.2 7Days Tensile Strength for Seashell Concrete

Considering the 28 days tensile strength for seashell concrete, we find that 20% is the optimum replacement ratio of sea shell. Hence the 7 days strength is also checked for 20% replacement, to determine the early in the seashell concrete in comparison with the early strength developed in conventional concrete.

Table5.2 7 Days Average Tensile Test Results for Sea Shell Concrete

Percentage of Seashells (%)	Average Tensile Stress (N/mm^2)
0	2.07
20	1.69

5.3 28 Days Tensile Strength for Coconut Shell Concrete

The splitting tensile strength results of M25 grade mix at 28days made with various proportions of coconut shells were noted. Table 5.3 depicts the tensile strength of coconut shell concrete with respect to 28days. Test results were plotted in the form of graphs and shown in Fig 5.2.

Table 5.3 28 Average Tensile test results for Coconut shell concrete

Percentage of Coconut Shells (%)	Average Tensile Stress (N/mm^2)
0	3.20
10	2.45
20	2.213
30	1.84
40	1.65

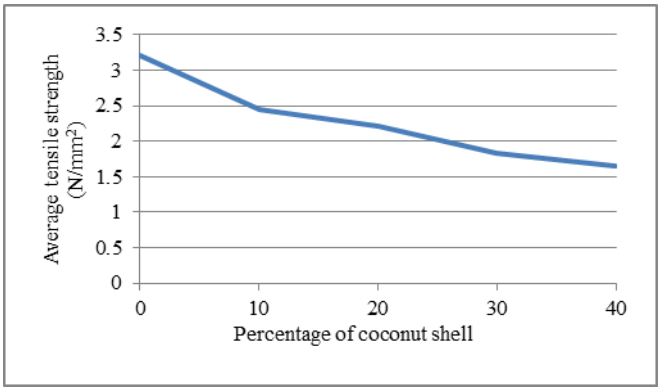

Fig 5.2 Average Tensile Stress Analysis for Coconut Shell

It is seen that tensile strength for coconut shell concrete were gradually reduces with rise in percentage of coconut shell, so that optimum mix percentage is reduced to 10% in case of coconut shells.

5.4 7 Days Tensile Strength for Coconut shell Concrete

Considering the 28 days tensile strength for coconut shell concrete, we find that 10% coconut shell replacement is the optimum replacement ratio. Hence the 7 days strength is also checked for 10% replacement, to determine the early in the seashell concrete in comparison with the early strength developed in conventional concrete.

Table 5.4 7 days average tensile test results for coconut shell concrete

Percentage of Coconut Shells (%)	Average Tensile Stress (N/mm^2)
0	2.07
10	1.64

VI. COMPARATIVE ANALYSIS

A detailed comparative analysis was carried including cost analysis and analysis of variation in strengths for both Seashell and Coconut shell concrete.

Published by: The Mattingley Publishing Co., Inc.

March - April 2020
ISSN: 0193-4120 Page No. 5197 - 5203

Table 6.1 Comparison of Properties of Concrete with coconut shell and sea shell

Concrete with Sea shell	Concrete with Coconut shell
Average cost of sea shells = Rs. 100/30kgs	Average cost of coconut shells = Rs.150/ 20kgs
Optimum mix percentage = 20%	Optimum mix percentage = 10%
Highest 28 days compressive strength= 29.06 N/mm^2	Highest 28 days compressive strength =24.29 N/mm^2
Highest 28 days tensile strength = 2.58 N/mm^2	Highest 28 days tensile strength =2.45N/mm^2
Highest 7 days tensile strength =1.69N/mm^2	Highest 7 days tensile strength =1.64N/mm^2
Total cost for pe	Total cost for pe
Difficult to procure sea shell	Easy to procure coconut shell
Can be used as partial replacement for high strength concrete structures in optimal mix	Can be used as partial replacement for unimportant low strength concrete structures and light weight structures in optimal mix
Usage of sea shells does not have any major effect on the overall weight of the structure	Usage of coconut reduces the overall

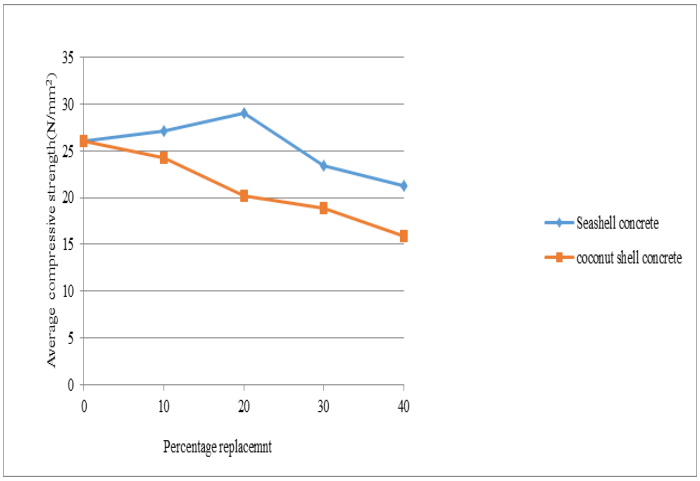

Fig 6.1 Comparison of 28days Compressive strength

VII. CONCLUSION

1. From the test results obtained, it was determined that 20 % was the optimum proportion for sea shells with an average compressive stress of 29.06 N/mm2 and average tensile stress of 2.58 N/mm2

2. From the test results obtained, it was determined that 10 % was the optimum proportion for coconut shells with an average 28 day compressive stress of 24.29 N/mm2 and average tensile stress of 2.45 N/mm2

3. The possible reason for the lower strength in concrete with partial replacement with coconut shell is the lower density of coconut shells as compared to the density of sea shells. Hence, as the strength obtained for sea shell is greater than that of conventional concrete it can be used as a partial replacement for heavy weight structures thus reducing the dependency on blue stone metal, and also providing an efficient method of marine waste disposal.

4. Coconut shell, though do not provide adequate strength help to reduce the cost and weight of the concrete and thus prove to be an efficient replacement for light weight and unimportant low strength structure.

5. Usage of M – Sand also helps reduce the cost of the structure without considerably affecting the strength of the structure as compared with concrete prepared using river sand.

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