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A Partial Replacement for Coarse Aggregate by Sea Shell and Cement by Lime in Concrete

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***Abstract**: This paper reports the exploratory study on the suitability of the cockle shells as partial replacement for in concrete. In developing countries where concrete is widely used, the high and steadily increasing cost of concrete has made construction very expensive. The high cost of conventional building materials is a major factor affecting housing delivery in world. This has necessitated research into alternative materials of construction and analyzing tensile and compressive strength characteristics of concrete produced using by sea shells as substitutes for conventional coarse aggregate with partial replacement using M20 grade concrete. The main objective is to encourage the use of these products as construction materials in low-cost building. In this research work experiments have been conducted with collection of materials required and the data required for mix design are obtained by sieve analysis and specific gravity test. Sieve analysis is carried out from various fine aggregates (FA) and coarse aggregates (CA) samples and the sample which suits the requirement is selected. Specific gravity tests are carried out for fine and coarse aggregate. In this project, cement is partial replacement with lime powder of about 10%, 20%, 30% .The coarse aggregate is partial replacement with 10 %, 20%, and 30% by sea shell. The water cement ratio is maintained for this mix design is 0.5. Results show that replacement of appropriate cockle shell content able to produce workable concrete with satisfactory strength. Integration of 20% cockle shell enhanced the strength of concrete making it to be the highest as compared to any other replacement level.*

***Keywords**: cockle shell, partial coarse aggregate replacement, concrete, workability, compressive strength, tensile strength.*

1. INTRODUCTION

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. 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. The basic constituents of concrete are cement, water and aggregate (and selected additives). Cement is produced by heating limestone and clay to very high temperatures in a rotating kiln. Cement is produced by grinding the resulting clinker to a fine powder. Water reacts chemically with cement to form the cement paste, which essentially acts as the "glue" (or binder) holding the aggregate together. The reaction is an exothermic hydration reaction. The water cement ratio is an important variable that needs to be "optimized". High ratios produce relatively porous concrete of low strength, whereas too low a ratio will tend to make the mix unworkable. Aggregates are usually described as inert "filler" material of either the fine (sand) or coarse (stone) variety. Aggregate tends to represent a relatively high volume percentage of concrete, to minimize costs of the material.

Recent investigation of Indian sea shells has indicated greater scope for their utilization as a construction material. Greater utilization of sea shells will lead to not only saving such construction material but also assists in solving the problem of disposal of this waste product. So the need for the replacement of the present material that is the concrete manufacturing has to be changed to meet the needs of the structures. So the most economical, ecological, light – weight and increasing the ease of work construction of the structure is important in the present economy. So the role of the light – weight concrete has come into the field. As modern engineering practices become more demanding, there is a corresponding need for special types of materials with novel properties. Scientists, engineers and technologists are continuously on the searching for materials, which can act as substitute for conventional materials or which possess such properties as would enable new designs and innovations resulting in to economy, so that a structure can be built economically. Many attempts have been made to develop new materials, which is the combination of two or more materials. Such materials are called composite materials. Concrete can be concluded as a composite material as it is a mixture of different materials. For reducing the cost of concrete, greater use of pozzolanic materials like fly ash and blast furnace slag was suggested for the cement, sea shells, glass and ceramic material are used in case of fine aggregates, when coming to case of course aggregates palm kernel shells, coconut shells and sea shells. The use of these materials as the substitute material in concrete would reduce the disposal problem now faced by thermal power plants and industrial plants, agricultural areas and at the same time achieving the required strength of concrete. Already many investigations have been going on the partial replacement of coconut shells in place of coarse aggregate. In the present investigation sea shells has been used as partial replacement of coarse aggregate and cement by lime powder. Sea shells are also available in large quantities.

2. EXPERIMENTAL SETUP

In this stage collection of materials required and the data required for mix design are obtained by sieve analysis and specific gravity test. Sieve analysis is carried out from various fine aggregates (FA) and coarse aggregates (CA) samples and the sample which suits the requirement is selected. Specific gravity tests are carried out for fine and coarse aggregate. The various materials used were tested as per Indian standard specifications.

2.1 Materials

Raw materials required for the concreting operations of the present work are cement, fine aggregate, coarse aggregate, lime, seashell and water.

2.2 Cement

The most common cement used is an ordinary Portland cement. The Ordinary Portland Cement of 53 grade conforming to IS: 12269- 1987 is been used. Many tests were conducted on cement; some of them are Specific gravity, setting tests, etc.

S.No.	property test	Results.
1	Normal consistency	28%
2	Specific gravity	3.15
3	Initial setting time	27 min
4	Final setting time	535 min

2.3 lime powder

Although limestone powder is an inert material and can`t react with cement, many fine particles (less than 16μm exist in limestone powder and filled in the interface between cement and aggregate or cement particles, so it can improve the particle gradation of base material and paste workability. The influence of limestone powder on paste compressive strength improvement decreased with increasing paste age. Therefore, limestone powder was helpful to improve the early strength of paste.

Fig: 1 lime powder

2.4 Aggregates

The size of aggregates used is 20mm and the grain size of sand used is of zone 2. The aggregate tests are performed and the results are as follows.

Sieve Analysis**:** The sieve analysis test is performed to obtain a distribution of grain size of the aggregate. The test was performed for 20mm aggregates, river sand and seashell for the project.

Fine Aggregate**:** The sieve analysis for fine aggregate is done to find out the grain size of the sand and its zone. The analysis is done with 500 grams of sand in an automatic sieve shaker for about 5 minutes with the sieve dishes are arranged from 10 mm to 150 microns down the order of sieve shaker. Based on the analysis the fineness modulus obtained is 2.46. Specific gravity of fine aggregate is 2.51.

According to IS 2386 – 1963, Fineness modulus ranges are

Fine sand : 2.2 – 2.6
Medium sand: 2.6 – 2.9
Coarse sand : 2.9 – 3.2

Coarse Aggregate**:** The sieve analysis for coarse aggregate is executed to find out the aggregate size and its zone. The fractions from 80 mm to 4.75 mm are termed as coarse aggregate. The Coarse Aggregates from crushed Basalt rock, conforming to IS 383 – 1970 is been used. The analysis is done with 5 Kg of coarse aggregate by manual sieve shaker for about 15 minutes with the sieve dishes are arranged from 40 mm to 150 microns down the order of sieve shaker. Based on the analysis, the fineness modulus obtained as 7.132 which are in zone – II conforming to IS 383 – 1970. Specific gravity of coarse aggregate is 2.67.

2.5 Sea shells

Sea shell is a waste obtained near the seashore area as the result of disintegration of dead animals. Seashell consists of three layers outer, intermediate and inner layer .Outer layer is made up of calcite material whereas inner layer is otherwise known as nacre which is made up of calcium carbonate. Since 95% of calcium carbonate present in sea shell, it has the strength nearly equal to coarse aggregate. The sieve analysis for seashell is executed to find out its size. The analysis is done with 500 grams of seashell by manual sieve shaker for about 15 minutes with the sieve dishes are arranged from 40 mm to 1.18 mm down the order of sieve shaker. Based on the analysis, the fineness modulus obtained as 7.53.Specific gravity of sea shell is 2.50.

Fig: 2 sea shells

2.6 Water Absorption Test

This test is performed in order to determine the water absorption capacity of the aggregates used. Here about 300 grams of the various aggregates are taken separately and immersed in water for about 24 hours. These aggregates are then kept in oven at a temperature of 100 to 110 C° for a time period of 6 hours and then sample is weighted. The change in weight is noted. As per code the limiting value for the water absorption is 2%. The results of the aggregates tested are 1% for sand, 0.5% for 20mm aggregates and 0% for seashell.

3.0 METHODOLOGY

For each test that was conducted, cubes and cylinders were prepared. Cubes and cylinders were prepared to obtain the compressive strength and splitting tensile strength respectively. The specimens were casted and cured for 28 days. The 28 days cured specimens were subjected to testing and the results were obtained. Due to the compressive force, the cube of size 150 X 150 X 150 mm is subjected to a large magnitude of compressive strength near the loading region. The compressive strength was computed by the standard stress formula P/A, where P is the ultimate load in KN and A is the area in m2. The split tensile strength was conducted by the cylinder specimen 150 X 300 mm and computed by using the expression $ft = 2P/ \pi LD$, where P is the ultimate load in KN, L is the depth of the cylinder in m and D is the diameter of the cylinder in m. The test for modulus of elasticity is done by using the cylinder specimen and modulus of rigidity is done by using the cube specimen.

4.0 RESULTS AND DISCUSSION

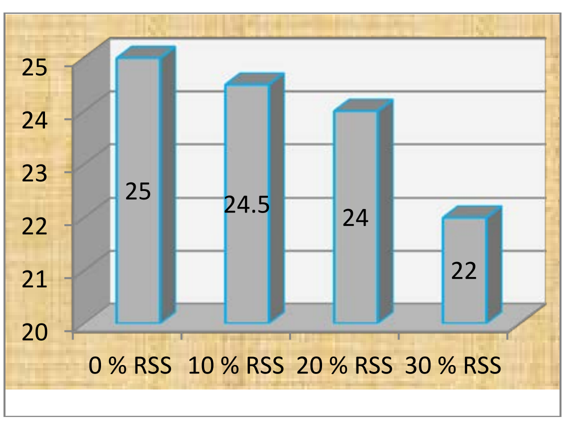
4.1 Slump Test

The aim of this test is to determine the workability of the cement concrete to be used. The mix is prepared and placed in a clean slump cone mould and tamped by three layers of about 25 stokes each layer and the top of the cone is leveled off. Then the mould is lifted up vertically and the nature of slump is analyzed to get the workability of the given cement concrete. For the water cement ratio of 0.5 the slump obtained for each seashell concrete design mix and conventional design mix are given below (in mm):

Conventional concrete - 25 mm
10 % replacement of seashell – 24.5 mm
20 % replacement of seashell - 24 mm
30 % replacement of seashell - 22 mm

The above slump value is within the permissible limit as per IS code 456 and suitable for construction purpose and also has a good workability.

Fig: 3 Slump test

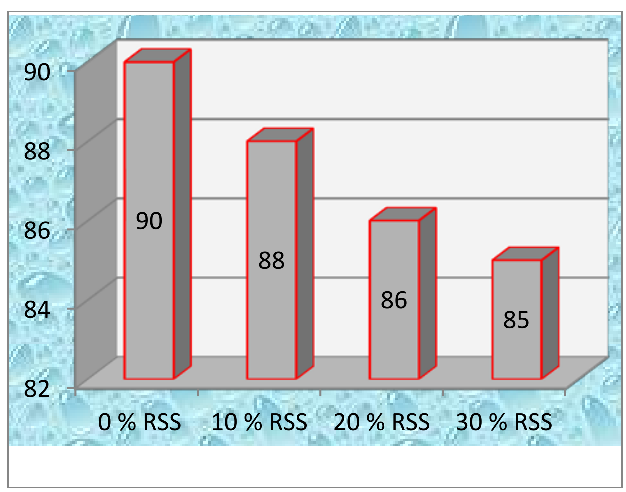


Graph: 1 Representation of Slump Cone Test

4.2 Compaction Factor Test

Compacting factor of fresh concrete is done to determine the workability of fresh concrete by compacting factor test as per IS 1199-1959. This test gives behavior of concrete under the action of external forces. If measures the compact ability of concrete, by measuring the amount of compaction. This test is suitable for mixes having medium and low workability's i.e. compaction factor in between 0.91 to 0.81, but is not suitable for concretes with very low workability's, the compaction factor below 0.71. The apparatus, which is commercially available, consist of a rigid frame that supports two conical hoppers vertically aligned above each other and mounted above a cylinder. The top hopper is slightly larger than the bottom hopper, while the cylinder is smaller in volume than both hoppers.

Fig: 4 Compaction Factor

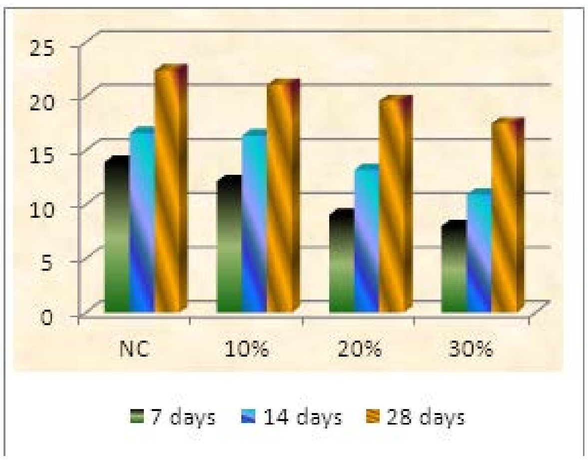


Graph: 2 Representation of compaction factor Test

4.3 Compressive Strength of Concrete Cubes

This test is done to determine the cube strength of concrete mix prepared. The test is conducted on the 7th day and the 28th day and its observation are listed below in the form of a graph. Compressive strength values with replacement for coarse aggregates by seashell with 10%, 20%, 30% and cement by lime powder with 10%, 20%, and 30%.

Fig: 5 compressive testing of cubes



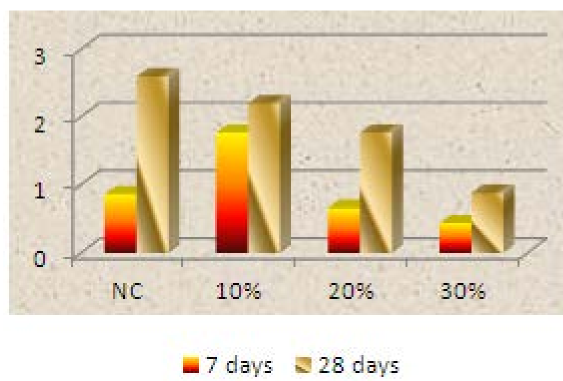
Graph: 3 Representation of Compressive Strength Values.

Table 1: Compressive Strength Results

S.No	% Replacement of lime powder & seashell	Compressive strength N/mm2 (7 days)	Compressive strength N/mm2 (14days)	Compressive strength N/mm2 (28days)
1	0	13.92	16.59	22.37
2	10	12.14	16.37	21.03
3	20	9.03	13.18	19.55
4	30	8.00	10.88	17.48

4.4 Tensile strength of cylinder:

This test is done to determine the tensile strength of the cylinders. The test is conducted on the 7th day and the 28th day and its observation are listed below in the form of a graph. The cylinder is placed in a horizontal position and the load is applied gradually and value is recorded if the cylinder splits into two half or if the cylinder fails while applying the load on it. Tensile strength values with replacement for coarse aggregates by seashell with 10%, 20%, 30% and cement by lime powder with 10%, 20%, 30%.



Graph: 4 Representations of Tensile Strength Values.

5.0 CONCLUSION

In this project we tried to replace the cement and coarse aggregate partially by lime and sea shell (10%, 20%, & 30%) respectively to increase the strength of concrete. But the strength is same with the conventional concrete only at 10% and 20% replacement of aggregate by sea shell .The strength is gradually decreasing at 30% replacement of sea shell. So we conclude that the cement and coarse aggregate replaced with lime and sea shell at 10% in concrete is suitable for construction. Moreover it reduces the construction cost by reducing the cost of cement and coarse aggregate and it also reduces the environmental pollution due to lime and sea shell.

Table 2: **Tensile Strength Results**

S.No	% Replacement of lime powder & seashell	Compressive strength N/mm2 (7 days)	Compressive strength N/mm2 (28days)
1	0	0.86	2.6
2	10	1.77	2.2
3	20	0.66	1.77
4	30	0.44	0.88

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