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EXPERIMENTAL STUDY ON PARTIAL REPLACEMENT OF COARSE AGGREGATE BY SEASHELL & PARTIAL REPLACEMENT OF CEMENT BY FLYASH

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ABSTRACT: The growing concern of resource depletion and global pollution has lead to the development of new materials relying on renewable resources. Many by- products are used as aggregate for concrete. Seashell waste which is a major financial and operational burden on the shellfish industry is used as an ingredient in concrete thus offering alternatives to preserve natural coarse aggregate for future generation. Seashell is mainly composed of calcium and the rough texture make it suitable to be used as partial coarse aggregate replacement which provides an economic alternative to the conventional materials such as gravel. Experimental studies were performed on conventional concrete and mixtures of seashell with concrete. The percentage of seashell, is varied from 3% to 11%. Also the cement is replaced for 25% of flyash. The mechanical properties of concrete such as compressive strength, tensile strength, flexural strength, and workability are evaluated. This research helps to access the behaviour of concrete mixed with seashell and determination of optimum percentage of combined mixture which can be recommended as suitable alternative construction material in low cost housing delivery especially in coastal areas and near fresh water where they are found as waste.

KEY WORDS: Seashell, compressive strength, tensile strength, flexural strength, workability, coastal areas.

I. INTRODUCTION

Civil engineering practice and construction works in India depend to a very large extent on concrete. Concrete is one of the major building materials that can be delivered to the job site in a plastic state and can be moulded insitu or precast to virtually any form or shape. Concrete basic constituents are cement, fine aggregate (sand), coarse aggregate (granite chippings) and water. Hence, the overall cost of concrete production depends largely on the availability of the constituents (and selected additives). Water reacts chemically with cement to form the cement paste, acts as binder holding the aggregate together which is an exothermic hydration reaction. Aggregates are usually described as inert "filler" material of either the fine (sand) or coarse (gravel) variety. It tends to represent a relatively high volume percentage of concrete, to minimize costs of the material. In present generation as the population is increasing rapidly along with the increase in construction work, to replace the old process, the new bricks like fly ash bricks came into field replacing the old lime bricks, whereas the cementing material like mud, lime paste and gums is replaced by the cement of different kinds in different construction. The continuously growing construction industry has posed the possibility on depletion of natural aggregates in the future that would increase the cost of concrete material. So the need for replacement of present aggregates is a growing concern to meet the demand for aggregates in the structures. Thus alternative options are adopted for non-load bearing walls and non-structural floors in buildings. Recent studies focuses on the locally available waste to be used as aggregates. One such waste is the seashells obtained from coastal areas, freshwater lakes, and riverine areas.

Seashell is a hard, protective layer, a calcareous exoskeleton which encloses, supports and protects the soft parts of an animal (molluscs). As they grow, the shells increases in size which becomes a strong compact casing for the mollusc inside. The major molluscan seashell includes, bivalves such as clams, scallops, and cockle. The hard shells are regarded as waste, which are accumulated in many parts of the country, when dumped and left untreated may cause unpleasant odour and disturbing view to the surrounding. Also the aggregate surface texture influences the bond between aggregate and cement paste in hardened concrete. Thus it opens an investigation into its potential as a partial replacement of coarse aggregate.

II. LITERATURE REVIEW

Many researchers have studied the engineering properties of sea shell, crushed sea shell aggregates and seashell ash in the recent past.

A. P. Adewuyi and T. Adegoke et al (2008) concluded that the strength of periwinkle shell concrete is determined based on the properties of the shells and various percentage replacements; Concrete with 35.4% and

42.5% periwinkle shells inclusion can still give the minimum 28-day cube strength values of 21 N/mm2 and 15 N/mm2 expected for concrete mixes 1:2:4 and 1:3:6, respectively. Osarenmwinda et al (2009) investigated the potential of periwinkle shell as coarse aggregate for concrete. The results showed that concretes produced with ratio (1:1:2, 1:2:3 and 1:2:4) mixes indicated compressive strengths of 25.67 N/mm2, 19.5 N/mm2 and 19.83 N/mm2 at 28 days curing age respectively. These strength values met the ASTM-77 recommended minimum strength of 17 N/mm2 for structural light weight concrete while the mixes with compressive strengths of 14 N/mm2 and 16.5 N/mm2 respectively did not meet the standard values. Falade, Ikponmwosa and Ojediran (2010) investigated the behaviour of lightweight concrete containing periwinkle shells at elevated temperature and found that the compressive strength decreased with increase in water/cement ratio and temperature. Festus, Oriyomi Olatunji (2012) conducted experiments to assess the suitability of periwinkle shell ash as partial replacement for Ordinary Portland cement and found that that the crushing strength decreases as the percentage of Periwinkle Shell Ash (PSA) increases and the crushing strength increases as the age of curing increases for each of the percentage replacement. Also the initial and final setting time of the OPC/PSA mixes (at 5% and 10%) was found to increase with increasing replacement, this means that PSA concrete is not susceptible to the problem of flash and false set .O.Ettu, O. M. Ibearugbulem, J. C. Ezeh, and U. C. Anya et al(2013) concluded that the density of the concrete decreased with increase in the percentage of periwinkle shells, from 2466.67 Kg/m for 25% periwinkle shell replacement at a mix ratio of 1: 1.5: 3 to 2103.33 Kg/m3 for 75% periwinkle shell replacement at a mix ratio of 1: 2.5: 3. Values of 28-day compressive strength ranged from 24.15 N/mm2 for 75% periwinkle shell replacement to 33.63 N/mm2 at 25% replacement. Most of these values hardly satisfy the minimum 25 N/mm2 requirement. Gurikini Lalitha, C. Krishna Raju (2014) studied the performance of M30 concrete with partial replacement of seashells and coconut shells. They found that the compressive strength of the concrete cubes has gradually decreased from addition of 10% (5% + 5%) of coconut shells and sea shells. Whereas comparing to traditional concrete, compressive strength of 10% (5% + 5%) of coconut shells (5%) and sea shells (5%) increased.

It can be observed that very few experimental studies have been reported in the literature. Hence, a detailed experimental investigation has been carried out on mechanical properties of concrete by varying the percentages of seashell. Recommendations on the optimum seashell content as a coarse aggregate is made based upon experimental results. The present proposed study is expected to produce results to enhance the understanding of the seashell as a coarse aggregate in concrete along with partial replacement of cement by flyash of 25%. Further it was planned to extend the studies into workability characteristics while using seashell as partial replacement. This can be effectively used for the improved concrete construction with local materials.

III. OBJECTIVE AND SCOPE

The objective of the research proposal is to study the influence of percentage of seashell as partial replacement of coarse aggregate and percentage of flyash as partial replacement of cement on mechanical properties of concrete to establish the optimum percentage of seashell and flyash, for the chosen size and type of seashell aggregate especially in coastal and riverine areas.

The detailed scope of the study is summarized as below:

- Conducting experimental studies of mechanical properties of seashell coarse aggregate.
- Experimenting the concrete mixes containing 0%, 3%, 5%, 7%, 9% and 11% of seashell as partial replacement of coarse aggregate along with partial replacement of cement by fly ash of about 25%, to evaluate the mechanical properties of concrete such as compressive strength, tensile splitting strength, and flexural strength characteristics.
- Analysing and studying the effect of varying percentages of seashell and fly ash and comparing the results with normal concrete without any replacements.
- Performing the slump test and analyzing the variation of slump for different percentages of seashell to obtain the workability characteristics of the concrete with partially replaced seashell as coarse aggregate.
- Obtaining the optimum percentage of seashells and flyash based upon the test results.

IV. MATERIALS

4.1 Cement

The most common cement used is Ordinary Portland Cement (OPC).The OPC is of 53 grade confirming to IS: 12269-1987 is been used. The properties of the cement are specific gravity of 2.89, normal consistency of 28%, initial and final setting time of 27 min and 535 min respectively.

4.2 Fine Aggregate
The sieve analysis for fine aggregate expressed a fineness modulus of 2.36. Specific gravity of fine aggregate is 2.59.

4.3 Coarse Aggregate
The coarse aggregate used in concrete mix is of nominal size of 20 mm aggregates with aspecific gravity of 2.6.

4.4 Fly ash
Fly ash is a black finely divided residue resulting from the combustion of powdered coal and transported by the flue gases and collected by the electrostatic precipitator (Fig. 1(a)). It is obtained from a nearby thermal power plant situated at Sriharikota. Specific gravity of fly ash is 2.2

4.5 Seashell
Seashell is a waste obtained from Gummidipoondi at Sunambukulam which is near Pulicat lake, formed 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 seashell, it has the strength nearly equal to coarse aggregate. The seashells of 20 mm size were sieved and used (Fig. 1(b)).

4.6 Water
Normal tap water was used to mix the concrete with a water cement ratio of 0.5 obtained from slump test.

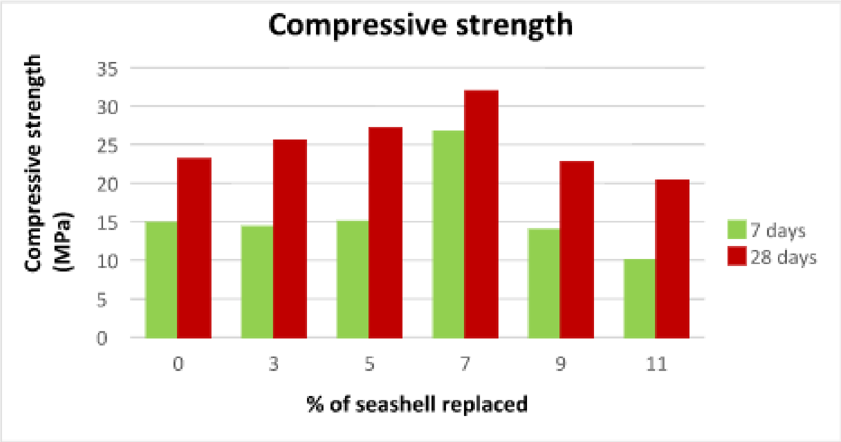
V. EXPERIMENTAL INVESTIGATION
The following tests were conducted on conventional concrete and concrete with partially replaced seashell as coarse aggregate of different percentages and partially replaced cement for fly ash with constant percentage. These tests are carries out as per IS: 516-1959.

i. Compressive strength test
ii. Split Tensile strength test
iii. Flexural strength test
iv. Slump cone test

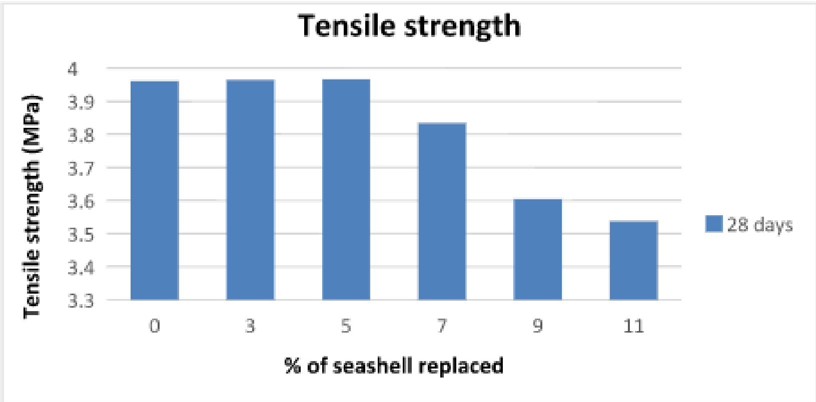
The moulds were cast as per the standards for various tests in the form of cubes, cylinders, prisms. The concrete mix ratio of 1:1.5:3 was used for casting the moulds. Batching operation of weight batching was adopted in the study. The raw materials are first weighed according to their ratio. The cement and fly ash are first mixed to form a uniform colour. Sand is then poured into the mix which is mixed by hand with the aid of a shovel. Coarse aggregate is added which consists of both gravel and seashell which when mixed thoroughly forms a dry mix. Water is now poured to its required amount and mixed well to form a thorough mix. Water should be added little by little after short time of mixing. The whole constituent was mixed until an even paste was obtained. The coarse aggregate for this study was a mixture of gravel and seashell at percentages of 0%, 3%, 5%, 7%, 9% and 11%. Remoulding of the cubes was done between 18 to 24 hours after casting. The hardened concrete was transferred immediately into the curing tank. Curing was done at normal temperature at 270+/-20C. The cubes were removed at the end of 7 days and 28 days from the day of casting and dried at room temperature for 2 hours before testing.

Compressive strength test includes the testing of concrete cubes of 150 mm X 150 mm X 150 mm size on a compressive testing machine with a constant loading rate. Similarly, the cylinders of size 150mm X 75mm was used and prisms of 100mm X 100mm X 500mm were tested. The slump test is performed for varying percentage with water cement ratio of 0.5 and the workability characteristics is found.

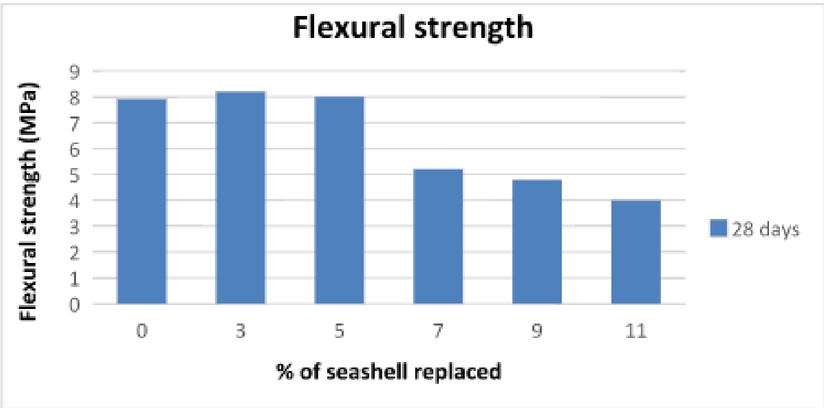
VI. RESULTS AND DISCUSSION
The laboratory tests (Compressive strength test, Split Tensile strength test, Flexural strength test, workability) were carried out on concrete with replacement of seashell and flyash. The mechanical behaviour of concrete with varying percentage (0 to 11%) of seashell and 25% of flyash are studied by repeating the procedure. The tests performed are presented in (Fig. 2).



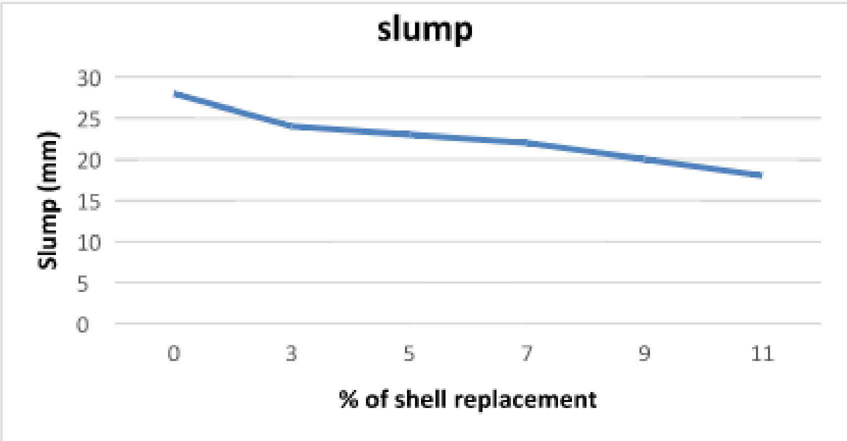
Graph (a)



Graph (b)



Graph (c)



Graph (d)

6.1 Compressive strength of concrete

This test is to determine the cube strength of concrete mix prepared. It is conducted on the 7th day and the 28th day and its observation are listed in table1 and in the form of a graph (a). It is found that the compressive strength of conventional concrete was 23.14 MPa and as the replacement of seashell is increased by 3%, there is a gradual increase in strength upto 7% which gives the maximum compressive strength of 31.95 MPa which is higher than the conventional concrete for 28 days. Further replacement of seashell results in lower compressive strength. The 7 day strength also increases gradually upto 7% which gives 26.71 MPa however further replacement shows the same results. Hence the optimum percent of seashell for compressive strength is 7%. The surface texture of cockle shell which is rougher than natural aggregate which improves bonding and increases inter particle friction which is turn enhances the compressive strength of the concrete.

6.2 Tensile strength of seashell concrete

This test is done to determine the tensile strength of concrete mix prepared. 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. It is conducted on 28th day and its observation are listed in table2 and in the form of a graph (b). It is found that the 28 day strength of cylinder for conventional concrete is 3.961 MPa and as the seashell replacement is increased by 3%, there is a gradual increase in tensile strength of 3.966 MPa at 5%. Further replacement has a lower tensile strength. Hence the optimum percent of seashell for tensile strength is 5%

6.3 Flexural strength of seashell concrete

This test is done to determine the flexural strength of concrete mix prepared to resist bending. The beam is given a two point loading and the values are listed in table3 and in the form of a graph (c). It is found that the seashell replaced gives a lower flexural strength.

6.4 Workability

Graph (d) shows that the concrete workability reduces as the percentage of seashell added as partial coarse aggregate replacement become higher. At the replacement of 11% of cockle shell, the concrete mixture which consistency is very low and difficult to be mixed exhibit very low slump. As the amount of cockle shell added is increased, this rough textured material causes the mix become harsher, more difficult to be mixed thus exhibit lower slump value. This is probably credited to the variation in the texture of cockle shell which is rough than natural aggregate due to the symmetrically radial ribs running on the outer shell. The rough surface creates more friction thus decrease the fluidity of the mix containing higher percentage of cockle shell.

VII. CONCLUSION

The mechanical behaviour of concrete with partial replacement of seashell as coarse aggregate and cement by flyash were investigated and presented. The following conclusions can be drawn based on the analysis of results.

- The addition of seashell as partial replacement for coarse aggregate and partial replacement of cement by flyash increases the compressive strength of concrete for both 7 days and 28 days.
- The optimum seashell content is 7% of coarse aggregate shows good results of high compressive strength of 31.95 MPa than conventional concrete of 23.14 MPa.
- The tensile strength of concrete with replaced seashell and flyash increases at maximum of 5% of coarse aggregate as 3.966 MPa than conventional concrete of 3.961MPa.
- The flexural strength lowers with replacement of seashell.
- The use of flyash has contributed to the increased strength at early stages due to its fineness which makes it to form a dense pack.
- The workability reduces as the seashells are replaced due to their rough texture.
- This reduces the construction cost by reducing the cost of cement and coarse aggregate and it also reduces the environmental pollution due to flyash and seashell.

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Table 1: Compressivestrength in (MPa)

%ofseashell replaced	**7 days**	**28 days**
0	14.88	23.14
3	14.38	25.55
5	15.04	27.15
7	26.71	31.95
9	13.96	22.71
11	10.04	20.4

Table 2: Tensilestrengthin (MPa)

%ofseashell replaced	**28 days**
0	3.961
3	3.964
5	3.966
7	3.834
9	3.605
11	3.537

Table 3: Flexural strength in (MPa)

%ofseashell replaced	**28 days**
0	7.2
3	6.9
5	6.5
7	6.1
9	5.8
11	5.3

Fig 1(a)

Fig 1(b)

Fig 2(a)

Fig 2(b)

Fig 2(c)

Fig 2(d)

Fig.1 (a) Fly ash (b) seashells
Fig.2(a) Compressivestrength test (b) Tensilestrength test (c)Flexural strengthtest (d) Slump test