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AN EXPERIMENTAL INVESTIGATION ON THE EFFECT OF SEASHELL COARSE AGGREGATE ON THE MECHANICAL PROPERTIES OF POND-ASH CONCRETE

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Abstract

In this work, it is proposed to study, in concrete the adequacy of seashells as a partial replacement for coarse aggregates. In Countries that are highly developing and where concrete is largely used, the high and ever-increasing cost of concrete has made construction very expensive. The high cost of conventional building materials is a major factor affecting the delivery of homes in the World. This, combined with the adverse effect of concrete production on the environment, has led to studies on various materials that could be used as a partial replacement for coarse aggregates and cement. This necessitated research on alternative building materials and analysis of characteristics of resistance to the traction and compression of concrete produced using seashells as substitutes for conventional coarse aggregates with partial replacement in M30-grade concrete. The main objective is to encourage the use of these products as low-cost building materials. In this work, experiments have been carried out with the collection of the necessary materials, and the data required for the design of the mixture has been obtained by sieve analysis and specific gravity tests. The sieve analysis was conducted from various fine aggregates (FA) and coarse aggregate (CA) samples and the sample that is appropriate for the requirement was selected. Pond ash is the by-product of thermal power plants, which is considered waste whose disposal is a major environmental problem requiring many disposal zones. In fact, there are three types of ashes produced by thermal energy (1) fly ash, (2) bottom ash, and (3) pond ash. Fly ash is collected mechanically or through electrostatic precipitators of combustion gases from power plants, while the chewers are collected from the bottom of the boilers. When these two types of ash are mixed together, transported in the form of manure, and stored in the lagoons as deposits, it is called pond ash. The volume of ash from the pond produced by thermal power plants is very large compared to the other two ashes, namely, fly ash and Clinker. The task of making the most of the ashes of the pond remains a major task problem around the world. To solve the problem, pond ash has been used in the present work as a partial replacement for cement in concrete production.

KEYWORDS: Seashell, Pond ash, Compressive strength, Flexure strength, split tensile strength, coastal areas.

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INTRODUCTION

The practice of civil engineering and construction work in India depends to a very large extent on concrete. Concrete is one of the primary building materials that can be delivered to the job site in a plastic state and can be cast in place or prefabricated into virtually any shape or form. The basic constituents of concrete are cement, fine aggregates (sand), coarse aggregates (granite chips), and water. Therefore, the overall cost of producing concrete largely depends on the availability of constituents (and selected additives). Water reacts chemically with the cement to form the cement paste, and acts as a binder holding the aggregate together, which is an exothermic hydration reaction. Aggregates are generally described as inert "filler" material of the fine (sand) or coarse (gravel) variety. It tends to be a relatively high volume percentage of concrete, in order to minimize material costs. In the current generation, the population is increasing rapidly along with the increase in construction work, to replace the old process, new bricks like fly ash bricks and pond ash bricks have entered the field replacing old lime bricks while cementing material like mud, paste and lime gum is replaced by the cement of different kinds in different constructions. The continuously growing construction industry posed the possibility of a depletion of natural aggregates in the future, which would increase the cost of concrete. The need to replace current aggregates is therefore a growing concern to meet the demand for aggregates in structures. Non-load-bearing walls and non-structural floors in buildings are therefore designed with alternative options. Recent studies focus on locally available wastes for use as aggregates. One such waste is shellfish from coastal areas, freshwater lakes, and river areas.

The shell is a hard protective layer, a calcareous exoskeleton that encloses, supports, and protects the soft parts of an animal (mollusks). As they grow, the shells increase in size, which becomes a compact and sturdy enclosure for the mollusk inside. The main mollusk shell includes bivalves such as clams, scallops, and cockles. Hard shells are considered waste, which accumulates in many parts of the country, when discarded and left untreated, they can cause an unpleasant odor and an annoying view of the environment. The texture of the aggregate surface also influences the bond between the aggregate and the cement paste in the hardened concrete. Thus, it opens an investigation into its potential as a partial replacement for coarse aggregates**.**

LITERATURE REVIEW

Many researchers have studied the engineering properties of seashells, crushed sea shell aggregate, and seashell ash in the recent past in the production of concrete. A brief review of the literature is presented in the following sections

P. Adewuyi and T. Adegoke et al (2008) [1] 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% and42.5% 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.

Falade, Ikponmwosa, and Ojediran (2010) [2] investigated the behaviour of lightweight concrete containing periwinkle shells at elevated temperatures and found that the compressive strength decreased with an increase in water/cement ratio and temperature.

Bharathi Ganesh (2012) [3] The variation in the properties of samples of Pond Ash collected from different locations around the outlet point with respect to its physical properties was not much. This may be due to the fact that the variation in RTPS plant operations is controlled and maintained least due to automation of its operation and also coal is taken from the same source. The results of the characterization of the Pond Ash sample are not very satisfactory when compared to natural sand, but confirm its suitability in concrete as fine aggregate in terms of its strength and durability studies conducted on concrete with Pond Ash as fine aggregate in various replacement levels. Hence effective utilization of Pond Ash as a constituent in various concrete constructions encourage the large-scale utilization of industrial waste, facilitating human habitation, replacing fast-depleting natural resource, so as to contribute to sustainable construction and also helps in conserving the precious topsoil required for growing food contributing to environmental and ecological benefits.

Prof. P. P. Bhangale, Prof. P. M. Nemade [4] investigated the compression strength of concrete at 7, 28 and 126 days age of utilizing pond ash from 0 to 40% in concrete with paste volume 0.32. The strength was gained high when pond ash in concrete due to the smaller pores it was filled.

Gaurav Kantilal Patel, and Prof. Jayesh Kumar Pitroda [5] have assessed the natural sand and pond ash in the Indian situation. The basic properties of pond ash are determined, and the result is compared with natural sand properties as per IS 2386: 1963. Sp. Gravity for Natural Sand was 2.65 & for Pond, ash was 1.89. The fineness Modulus of natural Sand was 2.79 and Pond ash was 1.23 confirming to Zone ll for sand & pond ash ZonelV.

Prashant Kumar Sharma, Himani, Varsha Daba [6] studied experimentally on slump and compression strength of concrete of grade M35 made with partial substitution of fine aggregate from 0 to 25% by pond ash. The slump value of the concrete was decreased due to the size of pond ash particles being coarser as a contrast to fine aggregates. The compression strength at 28days was increased up to 15% of replacement as fine aggregate was 42.87 to 48.72 MPa and further addition decreased the strength from 46.94 to 40.0 MPa when compared to conventional concrete

Arumugam K et al [7] studied the possibility of means of pond ash with different percentages as fine aggregate alternate in cement concrete. The physical properties like specific gravity, bulk density, fineness modulus, and water absorption were studied. Tests such as workability test, compressive, flexure, and tension tests were carried out. The mixes were designed for various percentages of pond ash such as 0, 20, 40, and 60%. It was seen that increase in the accretion of pond ash causes dropping in the slump value of concrete. The compressive, tensile & flexural strength of concrete is augmented with the addition of 20% of pond ash as a substitution for sand.

OBJECTIVE AND SCOPE

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

- To conduct experimental studies on the mechanical properties of seashell coarse aggregate in concrete production.
- to experiment the concrete mixes containing 0%,10%,20%,30%,40%, and 50% of a seashell as partial replacement of coarse aggregate along with partial replacement of cement by Pond ash of about t0%,10%,20%,30%40% to evaluate the mechanical properties of concrete such as workability tests, compressive strength, tensile splitting strength, and flexural strength characteristics.
- Analyzing and studying the effect of varying percentages of seashell and Pond ash and comparing the results with normal concrete without any replacements.
- Performing the slump test and analyzing the variation of a slump for different percentages of a seashell to obtain the workability characteristics of the concrete with partially replaced seashell as coarse aggregate.
- Obtaining the optimum percentage of seashells and Pond ash based on the test results.

4. Materials

Cement:

In this research work, OPC 53 grades manufactured by UltraTech is used.

Fine aggregate:

River sand from the nearby Chitravathi stream which infiltrates a 4.75mm IS sieve is used which validates grading Zone-11 of IS:383-1970[8]

Coarse Aggregate:

Regionally obtainable crushed coarse aggregate of the maximum size of a0 mm which validates to IS:383-1970[8] is used.

Pond ash:

Pondash obtained from AP GENCO Thermal power station, Nellatur, SPSR NELLORE.

Seashell:

Seashell – obtained from Gummidipoondi at Sunambukulam which is near pullicat lake, Sullurpeta, Nellore.

Properties of Cement, fine aggregate and coarse aggregate:

Table 1: Cement and Pond ash properties

TEST PARTICULARS	Cement	Pond ash
Fineness of modulus	4.3	2.94
Specific Gravity	3.1	3.15
Normal consistency	32	42
Initial setting time (min)	32	155
Final setting time (min)	600	230

Table 2: Fine aggregate properties

Test Particulars	Fine aggregate
Specific Gravity	2.64
Fineness modulus	2.46
Water absorption (%)	0.65

Table 3: Coarse aggregate properties

Test Particulars	Coarse aggregate	Sea shells
Specific Gravity	2.78	2.50
Fineness modulus	7.56	4.87
Water absorption (%)	0.62	1.84

MIX PROPORTIONS:

The design of the concrete mix M30 is carried out according to the IS method adopting IS 10262- 2009(7) and IS 456-2000(8), which gives a proportion of 1:1.436:2.36 and w/c ratio of 0.43. In this work the cement is replaced by pond ash 0%,10%,20%,30%and 40% and coarse aggregate with partial replacement of sea shells 0%,10%,20%,30%,40%, and 50% using the above mixing ratio, the concrete is mixed with all the mixes prepared to reveal the workability and strength of the concrete.

5. Results and discussion

Workability tests:

5.1 Slump test:

The purpose of this test is to determine the workability of the cement concrete to be used. The mixture is prepared and placed in a clean sag cone mold and tamped by three layers of about 25 stokes each layer and the top of the cone is leveled. Then the mold is lifted vertically, and the nature of the sag is analyzed to obtain the workability of the given cement concrete.

SLUMP TEST VARIATION IN REPLACEMENT OF POND ASH AND SEASHELL:

TEST RESULTS ARE PRESENTED IN TABLE 4 AND FIG 1

TABLE 4 : TEST RESULTS OF SLUMP CONE TEST

%of pond ash	0% of ss	10% of ss	20% of ss	30% of ss	40% of ss	50% of ss
0%	74	70	68	67	66	63
10%	73	69	67	65	64	62
20%	71	68	65	63	62	60
30%	70	67	64	62	61	59
40%	69	65	63	61	60	57

GRAPH REPRESENTATION:

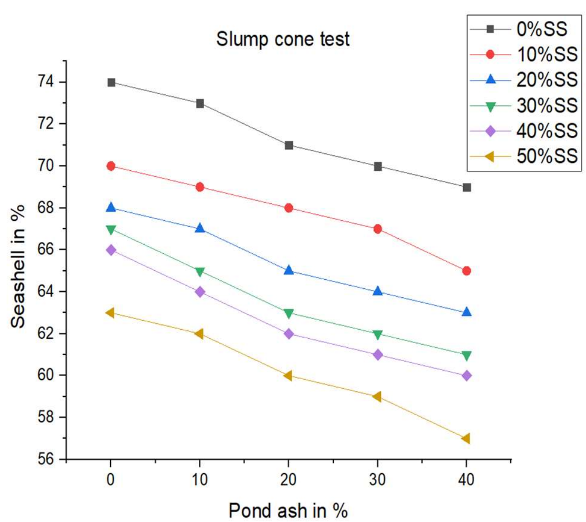

Fig -1 slump test of concrete for 28 days

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

5.2 COMPACTION FACTOR TEST:

The compaction factor test measures the degree of compaction caused by an application of standard work. The test was developed in Great Britain in the late 1940s and was standardized as a British standard 1881-103.

The apparatus, which is commercially available, consists of a rigid frame that supports two conical hoppers aligned vertically one above the other, and mounted above a cylinder. The upper hopper is slightly larger than the lower hopper, while the cylinder is smaller in volume than the two hoppers. . To perform the test, the upper hopper is filled with concrete but not compacted. The door at the bottom of the upper hopper is open and concrete can fall into the lower hopper. After all the concrete has fallen from the upper hopper, the door to the lower hopper is opened to allow the concrete to fall to the lower cylinder. A tamping rod can be used to force particularly cohesive concrete through the hoppers. The excess concrete is carefully scratched from the top of the cylinder and the mass of the concrete in the cylinder is recorded. This mass is compared to the mass of fully compacted concrete in the same cylinder obtained with a manual rod or vibration. The compaction factor is defined as the ratio of the mass of concrete compacted in the compaction factor apparatus to the mass of fully compacted concrete.

COMPACTION FACTOR TEST VARIATION IN REPLACEMENT OF POND ASH AND SEASHELL:

TEST RESULTS ARE PRESENTED IN TABLE 5 AND FIG 2

TABLE 5 : TEST RESULTS OF COMPACTION FACTOR TEST

%of pond ash	0% of ss	10% of ss	20% of ss	30% of ss	40% of ss	50% of ss
0%	0.897	0.835	0.811	0.789	0.746	0.738
10%	0.894	0.832	0782	0.732	0.682	0.632
20%	0.887	0.827	0.767	0.697	0.647	0.596
30%	0.876	0.816	0.766	0.706	0.656	0.586
40%	0.862	0.802	0.752	0.692	0.642	0.582

GRAPH REPRESENTATION

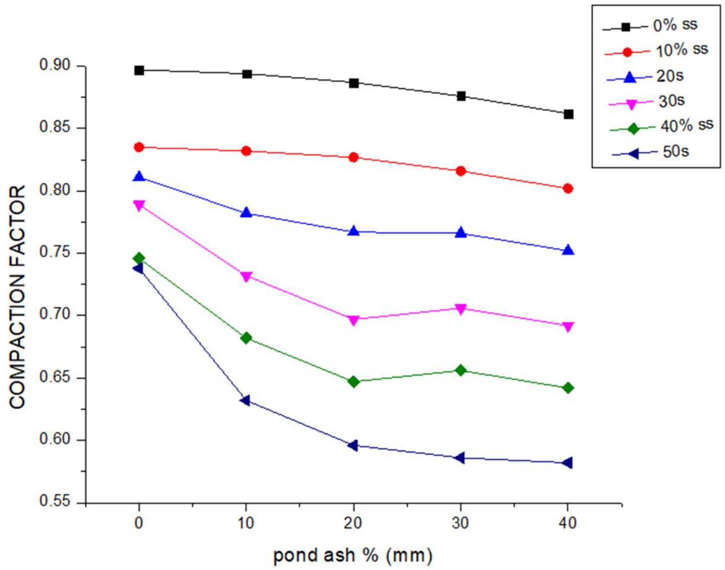

Fig -2 Compaction factor test of concrete for 28 days

5.3 Compressive strength test:

The compressive strength of cubes is obtained by splitting the peak load with the area of the cross-section. In the compressive testing machine, the load is imposed on a constant scale of 14.0N/mm^2/s and the cube is placed so that the total load is taken concentrically by the cube. Then, the compressive strength of the cube (F) was calculated as follows:

F = P/A [Load at failure/ cross-sectional area (N/mm²)]

COMPRESSIVE STRENGTH RESULTS:

TEST RESULTS ARE PRESENTED IN TABLE 6 AND FIG 3

TABLE 6: TEST RESULTS OF COMPRESSIVE STRENGTH

MIX PROPORTIONS	REPLACEMENT OF CEMENT		REPLACEMENT OF COARSE AGGREGATE		COMPRESSIVE STRENGTH IN N/MM2
	CEMENT IN %	**POND ASH %**	**C.A IN %**	**SEA SHELL IN %**	
MIX 1	100	0	100	0	39.6
MIX 2	100	0	90	10	40.3
MIX 3	100	0	80	20	42.6

MIX 4	100	0	70	30	39.3
MIX 5	100	0	60	40	31.3
MIX 6	90	10	100	0	40.3
MIX 7	90	10	90	10	41.6
MIX 8	90	10	80	20	43.3
MIX 9	90	10	70	30	39.6
MIX 10	90	10	60	40	31.6
MIX 11	80	20	100	0	39.8
MIX 12	80	20	90	10	41.2
MIX 13	80	20	80	20	42.8
MIX 14	80	20	70	30	38.4
MIX 15	80	20	60	40	30.8
MIX 16	70	30	100	0	39.2
MIX 17	70	30	90	10	40.2
MIX 18	70	30	80	20	41.8
MIX 19	70	30	70	30	37.8
MIX 20	70	30	60	40	30.8
MIX 21	60	40	100	0	38.4
MIX 22	60	40	90	10	39.8
MIX 23	60	40	80	20	40.8
MIX 24	60	40	70	30	36.4
MIX 25	60	40	60	40	29.4

GRAPH REPRESENTATION:

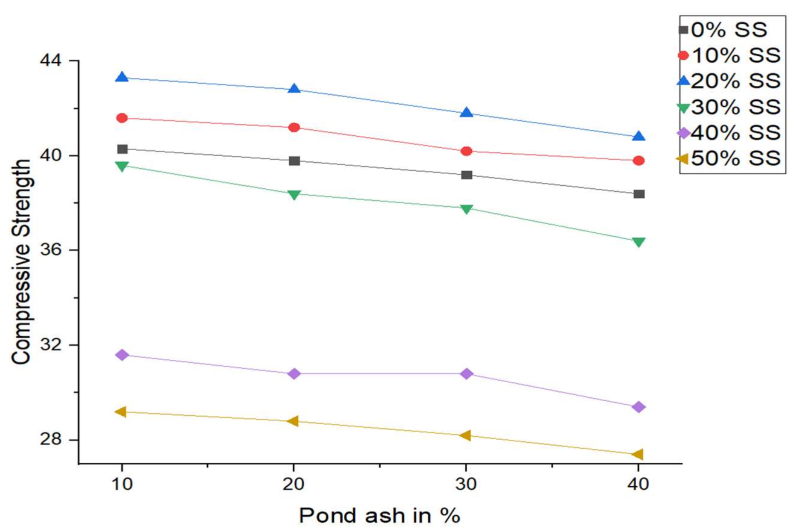

Fig -3 Compressive strength test of concrete for 28 days

The variation of the compressive strength of 0% to 40% replacement of seashells in place of normal coarse aggregate with replacement of cement with pond ash percentages from 0-40%, with steps in 20% and is compared with a conventional mix of M 30 grade of concrete and shown in Fig 2. By observing the test values, it is recognized that compressive strength has improved with 20% seashell replacement of coarse aggregate thereafter strength has decreased. Hence the optimum strength is obtained when pond ash is at a 10% replacement level. Hence M-9 mix gives optimum compressive strength of 43.3 N/mm^2 compared to 39.6 N/mm^2 of conventional mix M-1. When correlated to the nominal mix, the optimum mix has got 15.3 % more compressive strength. By perceiving the compression test outcomes, it is seen that all desired mix proportions are good at compression strength.

5.4 Split Tensile strength

In the split tensile test, the axis of the cylindrical specimen is kept in the direction of the compressive plates of the machine which has an ultimate load of 2000 KN. Until the specimen fails, the load is operated consistently.

Split tensile strength =2P/πdl (N/mm^2)

The changes in Split tensile strength on 0% - 40% substitution of seashells with coarse aggregate and pond-ash replacement in percentages from 0-40% are compared with that of conventional M 30-grade mix. By observing the test results, it is recognized that strength has increased with cement replacement by pond ash up to 40 % and thereafter strength has decreased. Hence the optimum strength is obtained when pod ash is 10% replacement. Hence M-9 mix gave optimum split tensile strength of 3.12N/mm^2 and 3.056 N/mm^2 split tensile strength of conventional mix M-1. It is seen that M-9 mix proportions are higher than the conventional mix, thereafter it gets decreasing.

TEST RESULTS ARE PRESENTED IN TABLE 7AND FIG 4

TABLE 7: TEST RESULTS OF SPLIT TENSILE STRENGTH

MIX PROPORTIONS	REPLACEMENT OF CEMENT		REPLACEMENT OF COARSE AGGREGATE		SPLIT TENSILE STRENGTH IN N/MM^2
	CEMENT IN %	**POND ASH %**	**C.A IN %**	**SEA SHELL IN %**	
MIX 1	100	0	100	0	3.056
MIX 2	100	0	90	10	3.068
MIX 3	100	0	80	20	3.098
MIX 4	100	0	70	30	3.048
MIX 5	100	0	60	40	2.982
MIX 6	90	10	100	0	3.072

MIX 7	90	10	90	10	3.098
MIX 8	90	10	80	20	3.12
MIX 9	90	10	70	30	3.056
MIX 10	90	10	60	40	2.972
MIX 11	80	20	100	0	3.076
MIX 12	80	20	90	10	3.088
MIX 13	80	20	80	20	3.1
MIX 14	80	20	70	30	3.052
MIX 15	80	20	60	40	2.972
MIX 16	70	30	100	0	3.068
MIX 17	70	30	90	10	3.078
MIX 18	70	30	80	20	3.098
MIX 19	70	30	70	30	3.046
MIX 20	70	30	60	40	2.964
MIX 21	60	40	100	0	3.062
MIX 22	60	40	90	10	3.072
MIX 23	60	40	80	20	3.084
MIX 24	60	40	70	30	3.036
MIX 25	60	40	60	40	2.958

GRAPH REPRESENTATION:

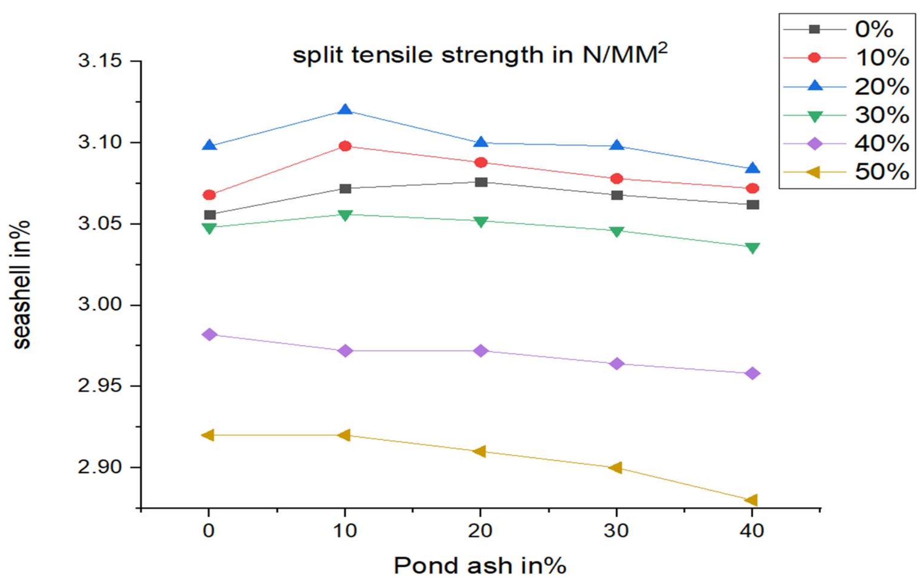

Fig -4 Split tensile strength test of concrete for 28 days

5.5 Flexure strength test:

For the calculation of the flexural strength of concrete, beam samples of dimensions 500X100X100 mm were prepared and dried in the open air after the curing period and a flexural strength test was performed in accordance with IS 5816:1999(reaffirmed 2004).

The flexural strength (F) was obtained using the formula

$F = PL/BD^2$ (N/mm²)

TEST RESULTS ARE PRESENTED IN TABLE 8 AND FIG 5

TABLE 8: TEST RESULTS OF FLEXURE STRENGTH

MIX PROPORTIONS	REPLACEMENT OF CEMENT		REPLACEMENT OF COARSE AGGREGATE		FLEXURE STRENGTH IN N/MM^2
	CEMENT IN %	**POND ASH %**	**C.A IN %**	**SEA SHELL IN %**	
MIX 1	100	0	100	0	6.732
MIX 2	100	0	90	10	6.851
MIX 3	100	0	80	20	7.242
MIX 4	100	0	70	30	6.681
MIX 5	100	0	60	40	5.321
MIX 6	90	10	100	0	6.851
MIX 7	90	10	90	10	7.072
MIX 8	90	10	80	20	7.361
MIX 9	90	10	70	30	6.732
MIX 10	90	10	60	40	5.372
MIX 11	80	20	100	0	6.766
MIX 12	80	20	90	10	7.004
MIX 13	80	20	80	20	7.276
MIX 14	80	20	70	30	6.528
MIX 15	80	20	60	40	5.236
MIX 16	70	30	100	0	6.664
MIX 17	70	30	90	10	6.834
MIX 18	70	30	80	20	7.106
MIX 19	70	30	70	30	6.426
MIX 20	70	30	60	40	5.168
MIX 21	60	40	100	0	6.528
MIX 22	60	40	90	10	6.766
MIX 23	60	40	80	20	6.936

MIX 24	60	40	70	30	6.188
MIX 25	60	40	60	40	4.998

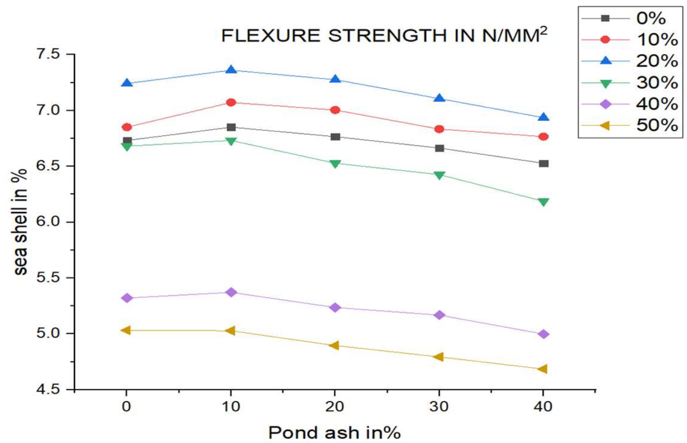

Fig -5 Flexure strength test of concrete for 28 days

By observing the test values, it is recognized that flexural strength has increased with coarse aggregate replacement by seashells 0% to 40%, and thereafter strength has decreased. Hence the optimum strength is obtained when Pond ash is at 10% replacement. Hence M-4 mix gave optimum flexural strength of 7.361N/mm^2 and 6.732 N/mm^2 is the flexural strength of the conventional mix M-1. When correlated to the nominal mix, the optimum mix has got 11.39 % more flexural strength.By noticing the flexural strength test outcomes, it is seen that all desired mix proportions are good in flexure except 30% to 50% replacement of seashell and which gave the lower results when correlated to the nominal mix M-1.

CONCLUSION

1. The addition of seashell as partial replacement for coarse aggregate and partial replacement of cement by Pond ash is feasible in concrete production
2. The optimum seashell content is 20% of coarse aggregate which shows good results of high compressive strength of 43.3MPa than conventional concrete with 39.6MPa.
3. The tensile strength of concrete with seashell aggregate and pond ash increases at maximum of 20% of coarse aggregate at 3.12 MPa than conventional concrete with 3.056 MPa.

- The flexural strength gets peak value at 20% replacement level of seashell and 10% pond ash as cement replacement.
- The use of pond ash has contributed to the increased strength at early stages due to its fineness which makes it to form a dense pack.
- The workability reduces when the seashells are used in place of natural aggregate due to their rough texture.
- The use of Seashells and Pond Ash reduces the construction cost by reducing the cost of cement and coarse aggregate and it also reduces the environmental pollution due to pond ash

and seashell thus making concrete as a sustainable one

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