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EXPERIMENTAL INVESTIGATION OF COCONUT SHELL AS PARTIAL REPLACEMENT OF COARSE AGGREGATE AND ADDING STEEL FIBRE IN CONCRETE

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ABSTRACT

Concrete is one of the most widely used construction materials in the world Lightweight aggregate concrete (LWAC) is an important and versatile material in modern construction. It has gained popularity due to its lower density and superior thermal insulation properties many architects, engineers, and contractors recognize the inherent economies and advantages offered by this material, as evidenced by the many impressive light weight concrete (LWC) structures found throughout the world. Lightweight concrete has strengths comparable to normal concrete; yet is typically 25–35% lighter .Structural LWC offers design flexibility and cost savings due to self-weight reduction, improved seismic structural response, and lower foundation costs. This coconut shell can be crushed and used as a coarse aggregate in the production of LWC. Coconut Shell Concrete (CSC) could be used in rural areas and places where coconut is abundant and may also be used where the conventional aggregates are costly. And also adding a steel fibre of certain amount for increasing the strength in concrete and by improve its crack resistance, ductility, energy absorption and impact resistance characteristics. An attempt has been made to examine the suitability of partial replacing 10%, 20% and 30% of coconut shell as for coarse aggregate in *concrete of grade M20 and also adding a steel fiber at a certain amount in the concrete. The results found were comparable with that of conventional mix.*

Key words: Light weight concrete, Coconut Shell Concrete, Steel fibre.

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1. INTRODUCTION

Waste management should be an integral part of a project's development. Each of the principal project participants the Owner, their Architectural and Engineering services (or Construction Management consultant), the Contractor, and Subcontractors will engage in waste management to some degree throughout the project. Initially, the Owner and their A/E must establish waste reduction goals and define what levels of diversion are achievable and reasonable under the project's conditions.

Utilization of agricultural wastes in construction industry has been investigated for many years but the impacts have been found to be varying degrees of success. In countries where abundant agricultural wastes are discharged, these wastes can be used as potential material or replacement material in construction industry. The coconut shell is one of the agricultural wastes, produced in abundance has the potential to be used as coarse aggregate in concrete. Eight of the ten largest producers are in the Asia Pacific region. The three main producers, Indonesia, the Philippines and India account for 75% of world production. India is the third largest coconut producing country, with an area of 1.9 million hectare and annual production of 2.74 million tones copra equivalent Within India, 90% of the total production of coconut is concentrated in South India. The average annual reduction of coconut is estimated at about 15 billion nuts in India. After the coconut is carped out, the shell is usually discarded as waste. The vast amount of this discarded CS resource is yet unutilized commercially; its use as a building material, especially in concrete, on the lines of other lightweight aggregates is an interesting topic for furth

This coconut shell can be crushed and used as a coarse aggregate in the production of LWC. Coconut Shell Concrete (CSC) could be used in rural areas and places where coconut is abundant and may also be used where the conventional aggregates are costly. In this study, the important mechanical properties of CSC, namely compressive, flexural, splitting tensile strengths and impact resistance have been measured to assess its suitability as a lightweight aggregate

2. SCOPE OF THE PROJECT

- By complete replacement of coarse aggregate by coconut shell the densities of concrete gets reduced.
- By introducing coconut shell a light weight concrete can be achieved. Coconut shells are economic since it is an agricultural waste.
- By using coconut shell as aggregate in concrete a proper method for reducing natural wastages can be achieved.

3. OBJECTIVE OF THE PROJECT

- To study the waste minimize techniques
- Introduction of new construction material
- To find mix ratio which gives good strength while replaced with coconut shell.
- To study the coconut shell concrete and its effect as waste management in constructions.
- To compare the mechanical properties of normal concrete and coconut shell replaced concrete.

4. METHODOLOGY

4.1. General

Materials required for making conventional concrete and coconut shell concrete are collected from the nearby source; the various material required are cement, fine aggregate, coarse aggregate and coconut shell. The various materials collected are prepared and batched for casting.

The coconut shell is surface cleaned and soaked in water for a day for SSD. The term SSD means saturated surface dry condition of coconut shells which are immersed in water for a day and dry it in atmospheric temperature to attain the state not to observe water from the concrete.

Materials that are used for making concrete were tested before casting the specimens. The properties obtained from the tests were used in mix design. The preliminary tests were conducted for the following materials.

- Cement
- Fine Aggregate(River sand)
- Coarse aggregate
- Coconut shell
- Steel fibre

5. COLLECTION AND PREPARATION OF MATERIALS

5.1. Cement

Portland cement produced by Sankar Company has been used throughout this investigation. Cement is the most widely used cementations Ingredient in present day concrete. The function of cement is first, to find the fine aggregate together and second to fill the voids in between fine aggregate and coarse particles to form a compact mass. Although cement constitutes only about 10 % of the volume of the concrete mix it is the active portion of the binding medium and the only scientifically controlled ingredient of concrete. Ordinary Portland Cement (OPC) 53 Grade conforming to Indian Standard IS 12269:1987 was used as a binder

5.2. Fine Aggregate

River sand (from Nagercoil) was used throughout the investigation as the fine aggregate conforming to grading zone III as per IS 383:1970. Natural sands and gravels are the product of weathering and the action of wind or water, while manufactured crushed fine aggregate and crushed stone coarse and fine aggregate are produced by crushing natural stone. Crushing, screening, and washing may be used to process aggregates from either sand and gravel deposits or stone quarries.

5.3. Coarse Aggregate

The natural coarse aggregates obtained from the locally available quarries with maximum size of 20 mm and satisfying the grading requirements of BIS (IS: 383-1970) is used in both normal and recycled aggregate concretes. The specific gravity of coarse aggregate is 2.5 and the fineness modulus of 2.88. the crushing value of the coarse aggregate used as 31.25% , the ideal aggregates should be clean, cubical, angular, cent present crushed with a minimum of large enlarged surface.

5.4. Coconut Shell

The freshly discarded shells (CS) were collected from the local oil mills and they were well seasoned. The seasoned CS is crushed by manually. The crushed edges were rough and spiky and the lengths were restricted to a maximum of 12.5 mm. The surface texture of the shell was fairly smooth on concave and rough on convex faces. CS aggregates used were in saturated surface dry (SSD) condition.

5.5. Steel Fibre

Steel fibres mixed into the concrete can provide an alternative to the provision of conventional steel bars or welded fabric in some applications. Today, industrial floors are major applications for steel-fibre-reinforced concrete. In the United Kingdom, several million m^2 of steel-fibre-reinforced slabs have been installed over the past ten years, both for ground-supported and pile-supported floors. Other major applications for fibre-reinforced concrete include external paved areas, sprayed concrete, composite slabs on steel decking and precast elements. Steel fibres are increasingly being used in suspended ground floor slabs on piles to replace much, and in many case all, of the reinforcement. There may also be health and safety benefits resulting from the reduced handling of reinforcement.

6. MIX DESIGN

Table 1 Properties of selected trial mixes of CSC at 28 days.

Sl.no	Cement content (Kg/m)	Water cement ratio	Mix ratio	Harden density (Kg/m^3)
1	510	0.42	1:1.4:0.6	1970

Actual Quantities Required for the Conventional Concrete Mix

Mix ratio 1:1.5:3

Water/cement = 0.55

Add 15% wastage

For on cube (150mm x 150mm x 150mm)

Water =760ml

Cement =1.525Kg

Fine aggregate =2.300Kg

Coarse aggregate =4.575Kg

For one cylinder (dia =150mm, h=300mm)

Water =1200ml

Cement =2.4Kg

Fine aggregate =3.6Kg

Coarse aggregate =7.2Kg

For one beam (700mm x150mm x150mm)

Water =3720ml

Cement =7.44Kg

Fine aggregate =11.16Kg

Coarse aggregate =22.32Kg

Actual quantities required for the coconut shell concrete mix:

Mix ratio 1:1.47:0.65

Water/cement = 0.42

Add 10% wastage

For on cube (150mm x 150mm x 150mm)

Water =985ml

Cement =2.343Kg

Fine aggregate =3.445Kg

Coarse aggregate =1.532Kg

For one cylinder (dia =150mm, h=300mm)

Water =1540ml

Cement =3.682Kg

Fine aggregate =5.412Kg

Coarse aggregate =2.393Kg

For one beam (700mm x150mm x150mm)

Water =4950ml

Cement =10.939Kg

Fine aggregate =16.080Kg

Coarse aggregate =7.110Kg

7. TESTING OF PLASTIC CONCRETE FOR WORKABILITY

The concrete which is made for casting is tested for slump; both the conventional concrete and coconut shell concrete are tested for the slump value. The obtained slump value is shown in the

Table 1 Slump value of the plastic concrete

Type of concrete	Slump value
Conventional concrete	180mm
Coconut shell concrete	270mm

8. RESULT AND DISCUSSION

8.1. Testing of Mechanical Properties of Concrete

The experimental program involves casting and testing of concrete specimens with and without coconut shell. The different specimens considered in this study include 3 cubes for compressive strength and 3 cylinders for tensile strength after 7 days curing for both conventional concrete and coconut shell concrete. And 2 set beams for flexural strength for both type of concretes. And the above tests are carried out for 28 days curing also. All the concrete specimens reported in this study were cast as per the mix design.

8.2. Compressive Strength Test

Procedure

Specimen stored in water shall be tested immediately on removal from the water and while they are still in the wet conditions. Surface water and grit shall be wiped of the specimens and any projecting fins removed. Specimens when received dry shall be kept in water for 24 hours before they are taken for testing. The dimensions of the specimens to the nearest 0.2 mm and their weight shall be noted before testing.

Bearing surfaces of the testing machine shall be wiped clean and any loose sand or other material removed from the surfaces of the specimen which are to be in contact with the compression platens. In the case of cubes, the specimen shall be placed in the machine in such a manner that the load shall be applied to opposite sides of the cubes as cast, that is, not to the top and bottom. The axis of the specimen shall be carefully aligned with the center of the thrust of the spherically seated platen. No packing shall be used between the faces of the test specimen and the steel platen of the testing machine. As spherically seated block is brought to bear on the specimen, the moveable portion shall be rotated gently by hand so that uniform seating may be obtained.

The load shall be applied without shock and increased continuously at the rate of approximately 140 Kg / Sq. cm/ min until the resistance of the specimen to the increasing load breaks down and no greater load cab be sustained. The maximum load applied to the specimen shall then be recorded and the appearance of the concrete and any usual features in the type of failure shall be noted. Testing of specimen is shown in fig.4.1

The measured compressive strength of the specimen is calculated by dividing the maximum obtained load (P) during the test by cross sectional area (A), calculated from the mean dimensions of the section.

P_c=P/A

Three numbers of cubes are taken for 7thand 28th day from casting for strength test.

8.3. Conventional Concrete

Table 2 Compressive strength of conventional concrete at 7 days

Sl No	Wt (Kg)	Density (Kg/m^3)	Load (KN)	Strength (N/mm^2)
1	8.75	2592.59	360	16
2	8.85	2622.20	335	14.88
3	8.65	2562.90	340	15.11

Average compressive strength of conventional concrete at 7 days =15.33N/mm^2

Table 3 Compressive strength of conventional concrete at 14 days

Sl no	Wt (Kg)	Density (Kg/m^3)	Load (KN)	Strength (N/mm^2)
1	8.75	2592.59	360	19.54
2	8.85	2622.20	335	20.88
3	8.65	2562.90	340	21.11

Average compressive strength of conventional concrete at 14 days =20.51N/mm^2

Table 4 Compressive strength of conventional concrete at 28 days

Sl no	Wt (Kg)	Density (Kg/m^3)	Load (KN)	Strength (N/mm^2)
1	8.60	2548.14	710	31.5
2	8.60	2548.14	675	30
3	8.50	2518.51	630	28.2

Average compressive strength of conventional concrete at 28 days=29.86N/mm^2

8.4. Compressive Strength of Coconut Shell Concrete

Table 5 Compressive strength of coconut shell concrete at 7 days

Sl no	Wt (Kg)	Density (Kg/m^3)	Load (KN)	Strength (N/mm^2)
1	6.55	1940.74	250	11.11
2	6.50	1925.92	230	10.22
3	6.55	1940.74	230	10.22

Average compressive strength of coconut shell concrete at 7 days =10.51N/mm^2

Table 6 Compressive strength of coconut shell concrete at 14 days

Sl no	Wt (Kg)	Density (Kg/m^3)	Load (KN)	Strength (N/mm^2)
1	6.55	1940.74	250	13.11
2	6.50	1925.92	230	12.22
3	6.55	1940.74	230	12.22

Average compressive strength of coconut shell concrete at 14 days =12.55N/mm^2

Table 7 Compressive strength of coconut shell concrete at 28 days

Sl no	Wt (Kg)	Density (Kg/m^3)	Load (KN)	Strength (N/mm^2)
1	6.55	1940.74	250	16.5
2	6.50	1925.92	230	17
3	6.55	1940.74	230	16.2

Average compressive strength of coconut shell concrete at 28 days =16.87N/mm^2

8.5. Split Tensile Strength Test

Specimen stored in water shall be tested immediately on removal from the water and while they are still in the wet condition. Surface water and grit shall be wiped off the specimens and any projecting fins removed. Specimens when received dry shall be kept in water for 24 hours before they are taken for testing. The dimension of the specimens to the nearest 0.2mm and their weights shall be noticed before testing.

Bearing surface of testing machine shall be wiped clean and any loose and or other material removed from the surface of the specimen which is to be in contact with the compression platens. The concrete cylinders shall be placed in the machine in such a manner the load shall be applied on the curved surface of the cylinder as cast. The load shall be applied without shock and increase at a constant rate until the resistance of the specimen to the increasing loads breaks down the no greater load can be sustained .the maximum load applied to the specimen shall be recorded and the appearance of any unusual cracks shall be noted. The measured strength of the specimen shall be calculated by dividing the maximum obtained load (P) to the specimen during the test by circumferential area. $P_t = 2P / (\pi \times D \times L)$ Three numbers of cylinders are taken for 7thand 28th day from casting.

8.6. Split Tensile Strength of Conventional Concrete

Table 8 Split tensile strength of conventional concrete at 7 days

Sl No	Wt (Kg)	Density (Kg/m^3)	Load (KN)	Strength (N/mm^2)
1	11.9	2249.50	110	1.56
2	11.9	2249.50	105	1.484
3	12.1	2287.30	110	1.56

Average split tensile strength of conventional concrete at 7 days=1.534N/mm^2

Table 9 Split tensile strength of conventional concrete at 28 days

Sl No	Wt (Kg)	Density (Kg/m^3)	Load (KN)	Strength (N/mm^2)
1	12.1	2287.30	155	2.192
2	12.0	2268.43	180	2.546
3	12.1	2296.78	150	2.286

Average split tensile strength conventional of concrete at 28 days =2.286N/mm^2

8.7. Split Tensile Strength of Coconut Shell Concrete

Table 10 Split tensile strength of coconut shell concrete at 7 days

Sl No	Wt (Kg)	Density (Kg/m^3)	Load (KN)	Strength (N/mm^2)
1	10.2	1928.16	90	1.27
2	10.2	1928.16	90	1.27
3	10.2	1928.16	85	1.20

Average split tensile strength of coconut shell concrete at 7 days =1.24N/mm^2

Table 11 Split tensile strength of coconut shell concrete at 28 days

Sl no	Wt (Kg)	Density (Kg/m^3)	Load (KN)	Strength (N/mm^2)
1	9.80	1852.55	110	1.556
2	9.80	1852.55	105	1.485
3	9.70	1833.64	110	1.556

Average split tensile strength of coconut shell concrete at 28 days =1.532N/mm^2

8.8. Flexural Strength Test

Specimen stored in water shall be tested immediately on removal from the water and while they are still in the wet condition. Surface water and grit shall be wiped off the specimens and any projecting fins removed. Specimens when received dry shall be kept in water for 24 hours before they are taken for testing. The dimension of the specimens to the nearest 0.2mm and their weights shall be noticed before testing.

Bearing surface of testing machine shall be wiped clean and any loose and or other material removed from the surface of the specimen which is to be in contact with the compression platens. The concrete cylinders shall be placed in the machine in such a manner the load shall be applied on the curved surface of the cylinder as cast. The load shall be applied without shock and increase at a constant rate until the resistance of the specimen to the increasing loads breaks down the no greater load can be sustained .the maximum load applied to the specimen shall be recorded and the appearance of any unusual cracks shall be noted. The measured strength of the specimen shall be calculated by using the formula $P_b = PL / (b \times d^2)$

Two numbers of beams are taken for 7thand 28th day from casting.

8.9. Flexural Strength of Conventional Concrete

Table 12 Flexural strength of conventional concrete at 7 days

Sl No	**Wt (Kg)**	**Density (Kg/m^3)**	**Load (KN)**	**Strength (N/mm^2)**
1	37.5	2380.95	43	7.64
2	37.6	2387.30	42	7.46

Average flexural strength conventional of concrete at 7 days =7.55N/mm ^{2}

Table 13 Flexural strength of conventional concrete at 28 days

Sl no	**Wt (Kg)**	**Density (Kg/m^3)**	**Load (KN)**	**Strength (N/mm^2)**
1	37.3	2371.42	63	11.2
2	37.4	2374.60	52	9.24

Average flexural strength conventional of concrete at 28 days =10.22N/mm ^{2}

8.10. Flexural Strength of Coconut Shell Concrete

Table 14 Flexural strength of coconut shell concrete at 7 days

Sl no	**Wt (Kg)**	**Density (Kg/m^3)**	**Load (KN)**	**Strength (N/mm^2)**
1	28.8	1828.57	28	4.97
2	28.7	1825.39	26	4.62

Average flexural strength coconut shell concrete at 7 days =4.795N/mm ^{2}

Table 15 Flexural strength of coconut shell concrete at 28 days

Sl No	**Wt (Kg)**	**Density (Kg/m^3)**	**Load (KN)**	**Strength (N/mm^2)**
1	28.7	1825.39	33	5.86
2	28.6	1819.04	34	6.04

Average flexural strength coconut shell concrete at 28 days=5.95N/mm ^{2}

9. COMPARISON

The coconut shell concrete is compared with the conventional concrete for the compression, split tensile strength and flexural strength for 7 and 28 days are plotted below. The split tensile strength of coconut shell concrete is 11.79% for 7 days and 9.08% for 28 days from its compressive strength, and the flexural strength is 45.62% for 7 days and 35.26% for 28 days from its compressive strength,

9.1. Compressive Strength at 7 days

Conventional concrete=15.33 N/mm^2

Coconut shell concrete=10.51N/mm^2

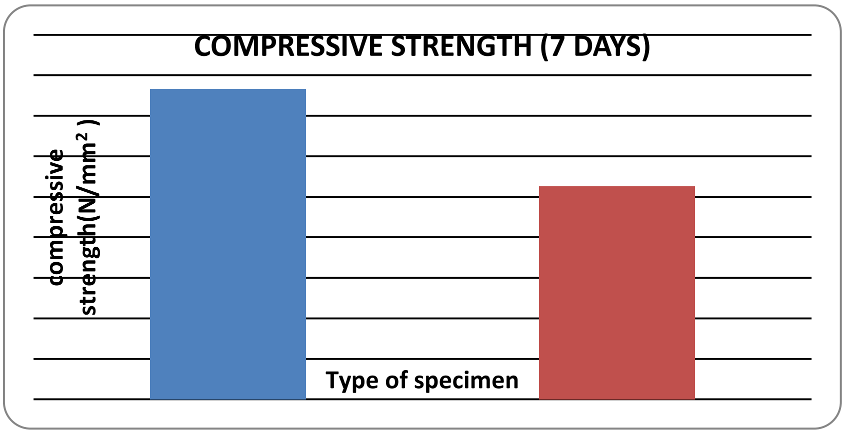

Figure 1 Compressive strength at 7 days

9.2. Compressive Strength at 14 days

Conventional concrete=20.55 N/mm^2

Coconut shell concrete=12.51N/mm^2

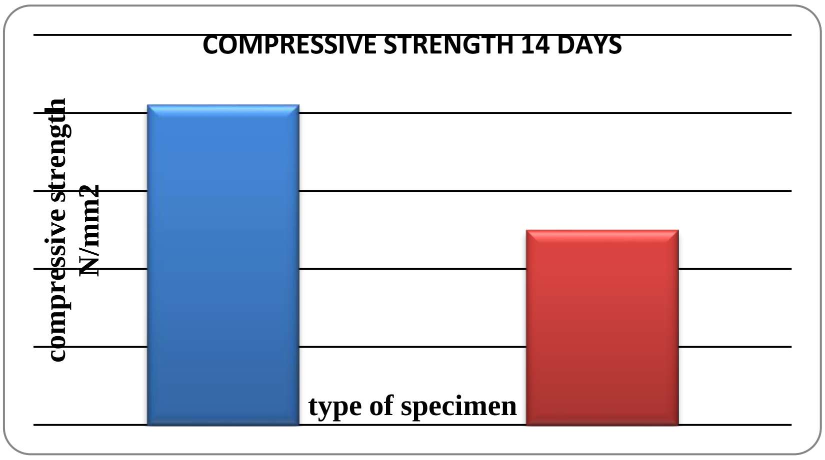

Figure 2 Compressive strength at 14 days

9.3. Compressive Strength at 28 days

Conventional concrete=29.86 N/mm^2

Coconut shell concrete=16.87N/mm^2

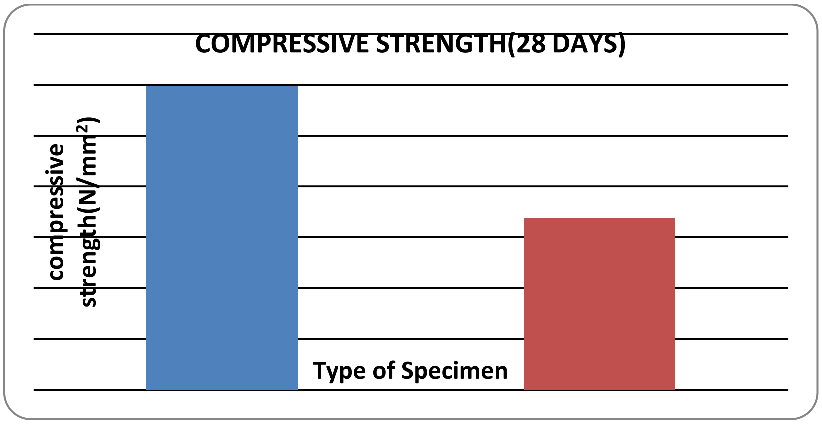

Figure 3 Compressive strength at 28 days

9.4. Split tensile Strength at 7 days

Conventional concrete=1.53 N/mm^2

Coconut shell concrete=1.24N/mm^2

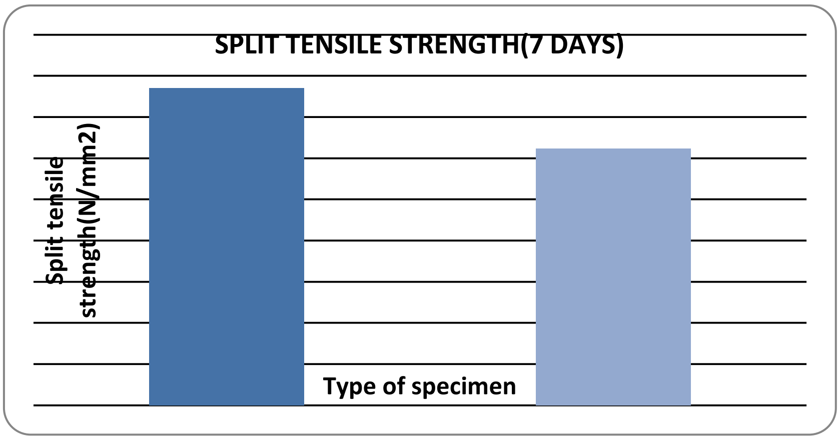

Figure 4 Split tensile strength at 7 days

9.5. Split Tensile Strength at 28 days

Conventional concrete=2. 286N/mm^2

Coconut shell concrete=1.532N/mm^2

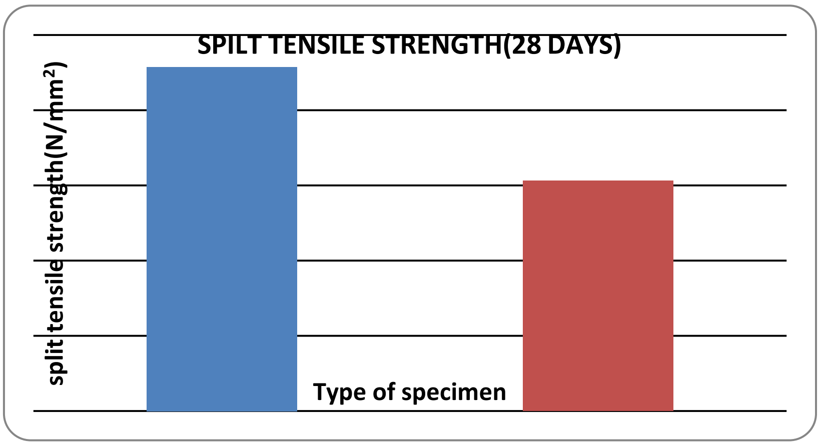

Figure 5 Split tensile strength at 28 days

9.6. Flexural Strength at 7 days

Conventional concrete=7.55N/mm^2

Coconut shell concrete=4.795N/mm^2

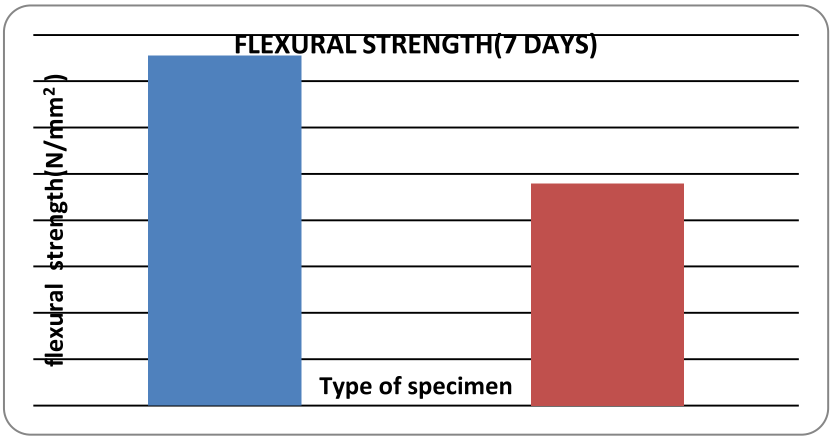

Figure 6 Flexural strength at 7 days

9.7. Flexural Strength at 28 days

Conventional concrete=10.22 N/mm^2

Coconut shell concrete=5.95N/mm^2

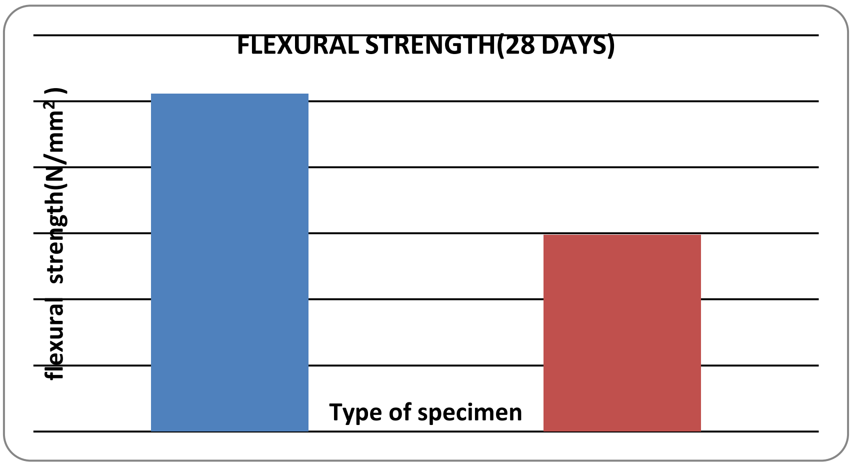

Figure 7 Flexural strength at 28 days

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