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Improvement of Strength of Concrete with Partial Replacement Of Course Aggregate With Coconut Shell and Coir Fibres

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ABSTRACT

Coconut shell and coir fibres are the natural materials which is abundantly available in tropical regions. Wastes generated by industrial and agricultural processes have created disposal and management problems which pose serious challenges to efforts towards environmental conservation. A considerable amount of coconut shells and fibres remain in the environment as waste, so utilization of these materials for construction will be an important step to improve sustainability and eco-friendly construction. In addition to that it will help to produce light weight and economically profitable materials in construction field. The current study examined the suitability of partial replacing of coarse aggregate with coconut shell and coir fibres. To compare the above, test for compressive strength, splitting tensile strength, temperature resistance, water absorption, electrical resistance, chemical resistance, pH test of sample were performed. The specific gravity, bulk density and water absorption of coconut shell and fibres were analyzed. A study on the economic aspects was also carried out. The addition of fly ash helps to increase the strength and workability of concrete. The results obtained from above will be compared with conventional concrete of same mix.

Keywords: *coconut shell, coir fibres, compressive strength, electrical resistivity, fly ash, pH, splitting tensile strength, temperature resistivity, water absorption.*

INTRODUCTION

General:

Concrete is the widely used first number of structural material in the world today. Infrastructure developed across the world created demand for different construction materials. Different waste materials and industrial by products such as fly ash, recycle aggregates, foundry sand, bottom ash, glass ware and coconut shell were replaced with natural aggregate. In India demand of construction aggregate in 2010 was 2210 million metric tons.(in 2015 it will be expected as 3330 million metric tons and after 2020 it will be more than 5075 million metric tons.

The growing concern of resource depletion and global pollution has challenged many researchers to seek and develop new materials relying on renewable resources. These include the use of by-products and waste materials for building construction. Aggregates categorized under this section are those directly used without the need for processing.

The high cost of conventional building materials is a major factor affecting construction in India. In developing countries where abundant agricultural and industrial wastes are discharged, these wastes can be used for various purposes in construction industry. This will have double the advantages, reduction in the cost of construction material and also as a means of disposal of wastes. Thus the approach is logical, worthy and attributable. Therefore an attempt has been made in this study to utilize the coconut shell and coir fibres as partial replacement of coarse aggregate in the development of light weight concrete. Coir fibres and coconut shells are new materials in the field of construction, so a study on various strength, chemical and durability properties of these materials is required. Also suitable measures have to be adopted for attaining the target strength.

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Fig1.Coconut Shells

Coconut shell is one of the most important natural fillers produced in tropical countries like Malaysia, Indonesia, Thailand, andSri Lanka. Many works have been devoted to use of other natural fillers in composites in the recent past years and coconut shell filler is a potential candidate for the development of new composites because they have high strength and modulus properties along with the added advantage of high lignin content.

Figure 1 Coconut shell (left) and coconut fiber (right)

The chemical compositions of CS contains is 33.61% cellulose, 36.51% lignin, 29.27% pentosans and 0.61% ash. CS has low ash content but high volatile matter, 65-75%3. While CF has the lowest cellulose content, 36 - 43% but with twice amount of lignin (41- 45%) compared to jute and sisal which makes it has greater resistance and hardness. CF will act as stabilizing additives when added into the asphalt mix around 180°C .

The characteristics and properties of coconut fiber are given Table 1.

CF has outstanding moisture absorption because the irregular of crack in the cross section surface provides unique structure. The unique structure also results in better air permeability and moisture conductivity. In addition, the unique structure of the CF will improve the moisture susceptibility, viscoelasticity and rutting resistance as well as ameliorate low temperature anti-cracking properties, durability, material toughness, fatigue life and lowering reflective cracking of asphalt concrete mixtures and pavements.

Table 1 Characteristics and properties of the coconut fiber [14]

Characteristics of granulated	Results
Average length of the granulated one	10-20mm
Average thickness	0.1mm
Amount (percentile in weight)	0.5-0.7%
Ph	5.4
Electric Conductivity	1.8dS/m
Capacity of cationic exchange	92
Relation C/N	132
Specific mass	70g/L
Water retention	538ml/L
Capacity of aeration	45.5%
Porosity	95.6%

Coconut shell as coarse aggregate

The concrete obtained using Coconut Shell aggregates satisfies the minimum necessities of concrete. Coconut Shell concrete has superior workability because of the smooth surface on one side of the shells. The impact resistance of Coconut Shell concrete is high when compared with conventional concrete. Moisture retaining and water absorbing capacity of Coconut Shell are more compared to conventional aggregate. The amount of cement content may be more when Coconut Shell are used as an aggregate in the production of concrete compared to conventional aggregate concrete. The presence of sugar in the CS as long as it is not in a free sugar form, will not affect the setting and strength of concrete. It is found that wood based materials, being hard and of organic.

Present status of coconut shell:

The coconut palm is one of the most useful plants in the world. Coconut is grown in 92 countries in

the world. Global production of coconut is 51 billion nuts from an area of 12 millionhectares. South East Asia is regarded as the origin of coconut. The four major players India, Indonesia, Philippines and Sri Lanka contribute 78% of the world production. According to FAO statistics (Food and Agriculture Organization) 2007, global production of coconuts was 61.5 MT with Indonesia, Philippines, India, Brazil and Sri Lanka as the major contributors to coconut production. The total world coconut area was estimated as approximately 12 million hectares and around 93 percent is found in the Asian and Pacific region. The average annual production of coconut was estimated to be 10 million metric tons of copra equivalents. Of the world production of coconut, more than 50 percent is processed into copra. While a small portion is converted into desiccated coconut 5 and other edible kernel products, the rest is consumed as fresh nuts.

Present use of coconut shell:

Coconut shells have good durability characteristics, high toughness and abrasion resistant properties; it is suitable for long standing use. Coconut shells are mostly used as an ornament, making fancy items, house hold utensils, and as a source of activated carbon from its charcoal. The powdered shell is also used in the industries of plastics, glues, and abrasive materials and it is widely used for the manufacture of insect repellent in the form of mosquito coils and in agarbathis. The purpose of this research work is to develop a concrete with coconut shells as coarse aggregate. The whole entity could be called coconut shell aggregate concrete (CSAC). After the coconut is scraped out, the shell is usually discarded as waste as shown in Figure 1. The vast amount of this discarded coconut shells resource is as yet unutilized commercially; its use as a building material, especially in concrete, on the lines of other LWA is an interesting topic for study. The study of coconut shells will not only provide a new material for construction but will also help in the preservation of the environment in addition to improving the economy by providing new use for the coconut shells.

MATERIALS AND METHODOLOGY

Description of Materials:

Coconut Shell

Coconuts are referred to as "man's most useful trees", "king of the tropical flora" and "tree of life". Global production of coconut is 51 billion nuts from an area of 12 million hectares. South East Asia is regarded as the origin of coconut.

Although the lignin content is higher and the cellulose content is lower, coconut shells are similar in chemical composition to hard wood. Coconut shell has good durability characteristics, high toughness & abrasion resistant properties. Coconut shell which is crushed in appropriate sizes (Fig. 1) can be used in concrete. Literature study shows 10% replacement is optimum.

Coir Fibres

Coconut fibres (Fig. 2) are extracted from the outer shell of a coconut. There are two types of coconut fibres, brown fibres extracted from matured coconuts and white fibres extracted tender coconuts. Brown fibres are thick, strong and have high abrasion resistance, which is used commonly.

There are many advantages of coconut fibreseg. They are moth-proof, fungi and rot resistant, provide excellent insulation against temperature & sound, not easily combustible, unaffected by moisture and dampness,tough, durable, resilient, springs back to shape even after constant use, totally static free and easy to clean. Coir fibres were added 3% by the weight of cement and in 5 cm length.

Fig 1: Crushed Coconut Shell

Fig 2: Coir fibre

Cement:

Ordinary Portland cement grade 53, conforming to I.S.12269-1987 was used. The physical property of cement is shown as per table 1.

Table – 1

Basic Result Of Ordinary Portland Cement (OPC)

TEST	RESULT
Initial setting time	185 min
Final setting time	320 min
Compressive strength 3 days	27.08 N/mm2

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Soundness	4.9 mm
Fineness (90 um sieve)	1.70%
Standard consistency	30.50%

Coarse Aggregate:

As coarse aggregate in concrete consist 35 to 70% of volume of the concrete.an aggregate with specific gravity more than 2.55 and absorption less than 1.5%.the physical properties of coarse aggregate is shown in table 2.

Sieve Analysis Of Coarse Aggregate (20mm) Sieve size (mm)	**Weight retain (gms)**	**Cumulative weight retain (gms)**	**Cumulative percentage weight retain (%)**	**Cumulative percentage weight passing**
40	0.0	0.0	0.0	100
20	315	315	6.3	93.7
10	4475	4790	95.8	4.2
4.75	120	4910	98.2	1.8

Table – 3

Test Value of Coarse Aggregate (20 Mm) Coarse aggregate	
Aggregate Impact value	12.4
Aggregate Crusher Value	14.3
Aggregate Abrasion Value	16.3
Specific Gravity	2.85
Water Absorption	0.94%
Gradation	Falls in 20 mm size
Combined Flakiness Index, Elongation Index	22.9 %

Coconut Shell:

In this work coconut shell was used as partial replacement of coarse aggregate which is crushed granite. Coconut shells were unruffled from the local temple after that it was cleaned, sun dried, removed fibers to evaluate its properties. Coconut shell needs no pre treatment, except for water absorption. Coconut shell has very high water absorption. Due to this property, before use coconut shells were soaked in potable water for 24 hours.

Table – 4

S.N.	**Physical property**	**Test result**
1.	Maximum Size (mm)	20
2.	Fineness modulus	6.48
3.	Specific Gravity	1.56
4.	Bulk Density(kg/m^3)	510-600
5.	Water Absorption (%)	23
6.	Aggregate Crushing Value (%)	2.49
7.	Aggregate Impact Value (%)	8.55
8.	Moisture Content (%)	4.2
9.	Shell Thickness(mm)	3-6

Coir Fiber:

Table – 5

Physical Properties Of Coir Fibre TEST	**RESULT**
Sp. Gravity	0.74
Water absorption (%)	68.69

Fine Aggregate:

The fractions from 4.75 mm to 150 microns are termed as fine aggregate. Locally available natural river sand conforming to grading of IS: 383 1970 with specific gravity 2.77 was used as fine aggregate.

Table – 6.Sieve Analysis of Fine Aggregate.

Sieve size (mm)	**Weight retain (gms)**	**Cumulative weight retain (gms)**	**Cumulative percentage weight retain (%)**	**Cumulative percentage weight passing**
10	0	0	0	100
4.75	118	118	5.9	94.10
2.36	68	186	9.3	90.7
1.18	296	364	24.10	75.9
600 micron	332	694	40.70	59.3
300 micron	874	1568	84.40	15.6
150	146	1714	91.70	8.3

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Table – 7. Test Value Result of Fine Aggregate

Fine aggregate	
Specific gravity	2.55
Gradation	Fall in Zone II
Moisture content	1.4%
Fine modulus	2.56
Silt content	0.78%

Types of tests:

WORKABILITY TESTS

A. Slump Cone Test:

Slump test is the most commonly used method of measuring workability of concrete which can be employed either in laboratoryor at site of work. It is not a suitable method for very wet or very dry concrete. It does not measure all factors contributing toworkability, nor is it always representative of the placability of the concrete. However, it is used conveniently as a control test and gives an indication of the uniformity of concrete from batch to batch. Repeated batches of the same mix, brought to the sameslump, will have the same water content and water cement ratio; provided the weights of aggregate, cement and admixtures areuniform and aggregate grading is within acceptable limits. Additional information on workability and quality of concrete can beobtained by observing the manner in which concrete slumps. Quality of concrete can also be further assessed by giving a fewtamping or blows by tamping rod to the base plate.

TESTS FOR CONCRETE

A. Test for Compressive Strength of Concrete Cubes:

Compression test is the most common test conducted on hardened concrete, partly because it is an easy test to perform, andpartly because most of the desirable characteristic properties of concrete are qualitatively related to its compressive strength. Thecube specimen is the sizes 150x150x150 mm are used for compression test. These specimens are tested by compression testingmachine after 7 days,14 days and 28 days curing. The compressive strength test on hardened concrete will be performed on a2000 KN capacity compression testing machine.

Compressive strength=maximum load/area

= P/A

B. Test for Split Tensile of Concrete Cylinder:

The tensile strength is one of the basic and important properties of the concrete. The tensile strength test on hardened concrete is performed on a 400 KN capacity testing machine. Specimen of concrete cylinder is 150 mm diameter x 300 mm height. In the splitting tension test a 150 mm x 300 mm concrete cylinder is subjected to compression loads along two axial lines which are diametrically opposite. In these tests in general a compressive force is applied to a concrete specimen in such a way that the specimen fails due to tensile stresses developed in the specimen. Direct tension test of concrete are seldom carried out, mainly because the specimen holding devices introduce secondary stresses cannot be ignored.

Test for Flexural Strength of Concrete Beams:

Flexural strength is one measure of the tensile strength of concrete. It is a measure of an unreinforced concrete beam or slab to resist failure in bending size of concrete beam specimen is 100 mm breadth x 100 mm depth x 500 mm length or 150 mm breadth x 150 mm depth x 700 mm length. The flexural strength is expressed as modulus of rupture in Mpa and is determined by standard test methods third point loading or centre point loading. In the central point loading, maximum fibre stress will come below the point where the bending moment is maximum. In case of symmetrical of loading two point loading, the critical crack may appear at any section, not strong enough to resist the stress within the middle third, where the bending moment is maximum.

Test for Durability of Concrete Cube:

The durability of cement concrete is defined as its ability to resist weathering action, chemical attack, fand abrasion. Durability of concrete is the important factor for any structures. Durability of concrete is direct effect the service life of the structure. Along service life is considered synonymous with durability. As

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durability under one set of conditions does not necessarily mean durability under another, it is customary to include a general reference to the environment when defining durability.

TESTING OF MATERIALS

Testing of concrete is done to determine the various properties of concrete when the coarse aggregate is partially replaced by coconut shell and coir. Material properties such as specific gravity, density and water absorption of coconut shell and coir fibres were tested as per IS: 2386 (part III) – 1963. Strength properties were analyzed by conducting compressive strength test as per IS: 516 - 1959 (reaffirmed 1999) and splitting tensile strength test as per IS: 5816 - 1999. Nature of concrete was determined by pH test using pH paper. Durability characteristics such as water absorption, chemical, temperature and electrical resistivity properties were investigated. Also density and feasibility study was conducted. The strength property of concrete having coir fibres and coconut shell was improved by the addition of fly ash as per IS: 3812 (part I) – 2003.

RESULTS AND DISCUSSIONS

Bulk Density Test

The bulk density in compacted state is more as compared to the loose which shows that the bulk density greatly depends on the degree of compaction or how densely it is packed**.**

TABLE 1: Bulk Density of Coconut shell

DESCRIPTION	Quantity
Volume of vessel (A)	1.5000 m^3
Weight of empty vessel (B)	1.9835 kg
Weight of sample + vessel without compaction (C)	2.7568 kg
Weight of sample + vessel with compaction (D)	2.8969 kg

Bulk density of coconut shell, Loose = C-B/A = 515.53 kg/m^3

Bulk density of coconut shell, Compacted= D-B/A = 608.93 kg/m^3

Aggregates with bulk densities less than 1120 kg/m^3 are called Lightweight. From experiment, the bulk density of coconut shell is less than 1120 kg/m^3, so that which helps to produce Light-Weight concrete.

Specific Gravity And Water Absorption Test On Construction Materials

TABLE 2: Specific Gravity and Water Absorption of Coconut shell

DESCRIPTION	Quantity
Weight of sample + vessel + water (A)	5.793 kg
Weight of vessel + water (B)	5.539 kg
Weight of air dried sample (C)	1.068 Kg
Weight of oven dried sample (110ºC) (D)	0.843 Kg

Specific gravity of coconut shell is less than aggregate and the water absorption of coconut shell is greater than aggregate. So the coarse aggregate cannot be fully replaced by coconut shell. Only partial replacement is possible.

TABLE 3: Specific Gravity and Water Absorption of coir fibres

DESCRIPTION	Quantity
Weight of sample + vessel + water (A)	5.5530 kg
Weight of vessel + water (B)	5.5390 kg
Weight of air dried sample (C)	0.0850 Kg
Weight of oven dried sample (110ºC) (D)	0.0496 Kg

Specific gravity of coir fibre is less than aggregate and coconut shell. The water absorption of coir fibre is greater than aggregate and coconut shell. Coir fibres are used for enhancing tensile strength of concrete.

Compressive Strength Test

TABLE 4: Compressive Strength of Cubes

CONCRETE	DESCRIPTION	COMPRESSIVE STRENGTH (N/mm^2)

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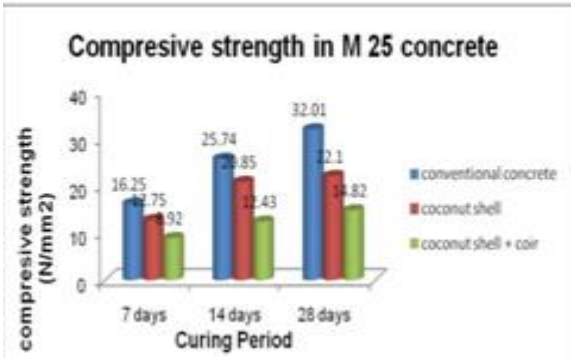
MIX			7 days	14 days	28 DAYS
M 25	Conventional concrete		16.25	25.74	32.01
	Coarse aggregate replaced by	Coconut shell	12.75	20.85	22.1
		Coconut shell + coir	8.92	12.43	14.82
M 30	Conventional concrete		28.45	31.62	36.06
	Coarse aggregate replaced by	Coconut shell	17.34	25.31	27.89
		Coconut shell + coir	11.34	18.38	20.47

Compressive strength is the capacity of a material or structure to withstand loads tending to reduce size. It always increases with age and curing. Strength is the stress required to cause fracture of the material. Compressive strength is affected by the factors such as effect of materials, mix proportions and curing conditions.

Coarse aggregate replaced by 10% coconut shell attains 65% to 80% strength of conventional concrete and coarse aggregate replaced by 10% coconut shell & 3% coir by the weight of cement attains 45% to 60% strength of conventional concrete.



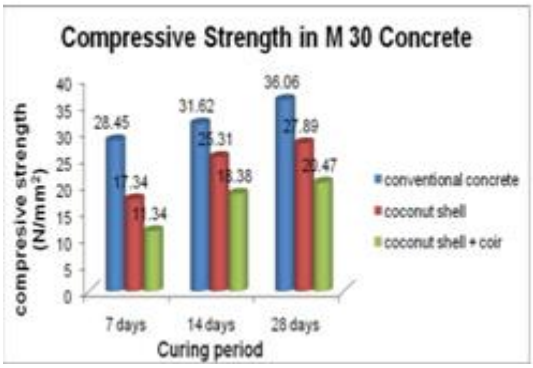


Fig 6: Graph Showing Compressive Strength inM 25& M 30 Concrete

Ph Test

When salt (pH of roughly 6 to 7) or other acids are introduced onto the concrete, they enter into small pores and micro-cracks of the concrete and attack the surrounding materials which lowering their pH. When the pH is lowered, the ability of cement to hold things together is compromised.

Concrete having partial replacement of coarse aggregate with 10% coconut shell and 10% coconut shell + 3% coir in M 25 and M 30 concrete gives pH value 12. This results shows that the concrete is alkaline in nature.

Water Absorption Test

The increase in weight as a percentage of the original weight is expressed as its absorption (%). The average absorption of the test samples shall not be greater than 5% with no individual unit greater than 7%.

TABLE 5: Water Absorption of Cubes

From test results, the addition of coconut shell and coir increases the water absorption property of concrete. Water absorption of concrete having coconut shell + coir is more than concrete with coconut shell, which exceeds limit of 7% water absorption in M 25 and M 30 concrete.

CONCRETE MIX	COARSE AGGREGATE REPLACED BY	WATER ABSORPTION (%)				
		0.5 hr	1 hr	24 hr	72 hr	168 hr
M 25	Coconut shell	4.8	5.28	5.32	5.91	6.42
	Coconut shell + coir	5.91	6.47	6.78	6.93	7.42
M 30	Coconut shell	4.46	4.65	4.76	4.86	6.11

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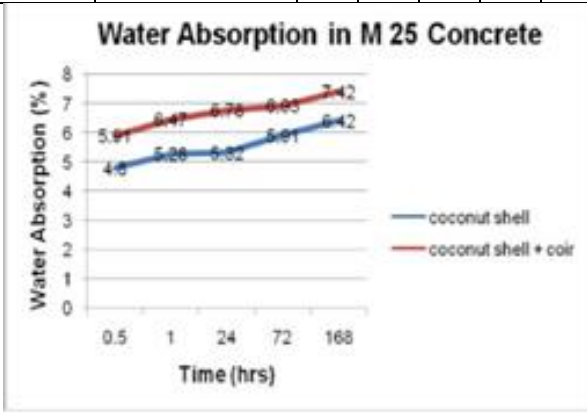
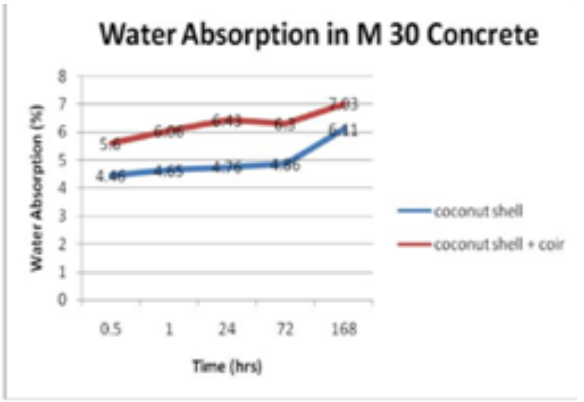
	Coconut shell + coir	5.6	6.06	6.43	6.3	7.03





Electrical Resistivity Test

Conventional concrete is not electrically conductive in nature. The electric resistivity of normal weight concrete ranges between 6.54 – 11 kilo-ohm-meter.

TABLE 6: Electrical Resistivity of Cubes

CONCRETE MIX	COARSE AGGREGATE REPLACED BY	ELECTRICAL RESISTIVITY (kilo-ohm-meter)		
		7 days	**14 days**	**28 days**
M 25	Coconut shell	11.25	11.25	11.25
	Coconut shell + coir	11.25	11.25	7.5
M 30	Coconut shell	11.25	11.25	11.25
	Coconut shell + coir	11.25	11.25	7.5

Electrical resistivity of concrete having coconut shell and coir is 11.25 kilo-ohm-meter, which is nearer to the electrical resistivity of conventional concrete. After 28 days curing concrete with coconut shell + coir having electrical resistivity of 7.50 kilo-ohm-meter. It is comparable with conventional concrete.

7. Temperature Resistivity Test

TABLE 7: Temperature Resistivity of Specimens

CONCRETE MIX	**DESCRIPTION**		**COMPRESSIVE STRENGTH (N/mm^2) After 28 day curing**
M 25	Conventional		10.28
	Coars aggregate replaced by	Coconut shell	4.87
		Coconut shell + coir	4.05
M 30	Conventional		12.92
	Coars aggregate replaced by	Coconut shell	5.50
		Coconut shell + coir	5.11

The rise in temperature causes a decrease in the strength of concrete. However, the rate at which the strength decrease depends on the rate of increase in the temperature of the fire and the insulating properties of concrete. The change in concrete properties due to high temperature depends on the type of coarse aggregate used.

Chloride Test

When chloride present in sufficient amounts, may initiate or accelerate the corrosion of metals such as steel embedded in or contacting a cement system such as mortar, grout or concrete. The rate of ingress of chlorides into concrete depends on the pore structure of the concrete, which is affected by factors including materials used, construction practices and age.

TABLE 8: Chloride Penetration of Cubes

CONCRETE	COARSE AGGREGAT	**CHLORIDE PENETRATION**

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MIX	EREPLACED BY	(%)		
		0-10 mm	10-30 mm	30-50 mm
M 25	Coconut shell	31.6	21.6	19.9
	Coconut shell + coir	31.6	19.9	18.3
M 30	Coconut shell	33.3	24.9	23.3
	Coconut shell + coir	33.3	24.9	19.9

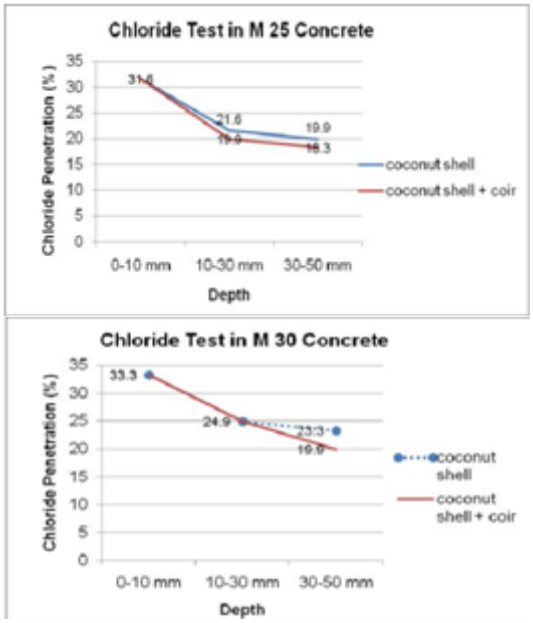

Fig 10: Graph Showing Chloride test in M 25 & M30 Concrete

The permeability of concrete is obviously related to the pore structure of the cement paste matrix. This will be influenced by many factors such as water-cement ratio and type of aggregate

Sulphate Test

Sulphate attack on ordinary Portland cement matrix is generally characterized by sulphate ions with cement hydration products and it causes expansion, cracking and spalling of concrte. The form and extent ofdamage to concrete will depend on the sulphate concentration, the type of cations in the sulphate solution.

TABLE 9: Compressive Strength of Cubes after Sulphate Attack

MIX	AGGREGATE REPLACED BY	After 28 day curing
M 25	Coconut shell	13.85
	Coconut shell + coir	10.28
M 30	Coconut shell	24.43
	Coconut shell + coir	18.34

10. Splitting Tensile Strength Test

Generally concrete is not designed to resist direct tension; the knowledge of tensile strength is of value in estimating the load under which cracking will develop.

TABLE 10: Splitting Tensile Strength of Cylinders

CONCRETE MIX	DESCRIPTION		SPLITTING TENSILE STRENGTH (N/mm^2)		
			7 days	14 days	28 days
M 25	Conventional		1.89	2.34	3.21
	Coarse aggregate replaced by	Coconut shell	1.43	1.89	2.15
		Coconut shell +coir	1.2	1.67	1.94
M 30	Conventional		1.93	2.51	3.71
	Coarse aggregate replaced by	Coconut shell	1.47	2.05	2.5
		Coconut shell + coir	1.23	1.91	2.1

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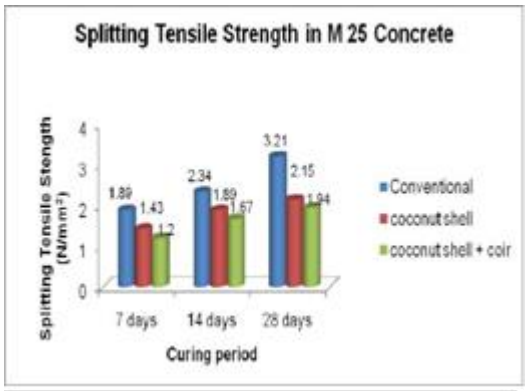

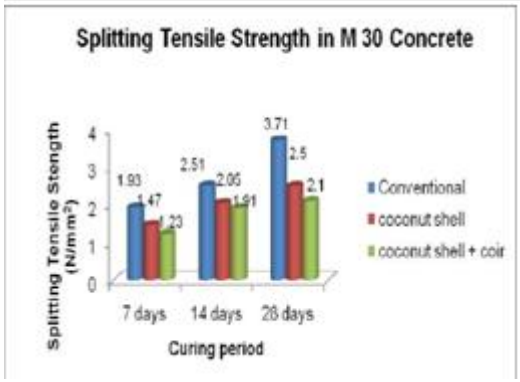

Fig 12: Graph Showing Splitting TensileStrength in M 25&M 30 Concrete

Density of Concrete

Density of normal concrete is in the order of about 2400 kg/m^3. The density of light weight concrete will be less than about density 1900 kg/m^3 and high density concrete have unit weight ranging from about 3360 kg/m^3.

TABLE 11: Density of Concrete

DESCRIPTION		MASS (kg)	VOLUME (m^3)	DENSITY (kg/m^3)
Conventional concrete		8.4	0.00337	2488.89
Coarse aggregate replaced by	Coconut shell	7.9	0.00337	2340.74
	Coconut shell + coir	7.2	0.00337	2133.33

When coconut shell and coir fibres added to the concrete, it reduces the density of concrete. So the material is comparable to light weight concrete.

Improvement of Strength by Using Fly Ash

Fly ash is the modern pozzolona which helps to improving the performance of concrete. This helps to increases the strength properties of concrete.

TABLE 12: Compressive Strength of Cubes Containing Fly Ash

CONCRETE MIX	COARSE AGGREGATE REPLACED BY	COMPRESSIVE STRENGTH (N/mm^2)	
		7 days	28 days
M 25	conventional	16.42	28.74
	Coconut shell	15.2	25.91
	Coconut shell + coir	10.82	23.36
M 30	conventional	20.98	30.17
	Coconut shell	18.43	28.84
	Coconut shell + coir	12.7	27.1
M 35	conventional	23.57	34.84
	Coconut shell	20.76	32.19
	Coconut shell + coir	13.1	29.35
M 40	conventional	25.01	41.47
	Coconut shell	23.96	38.03
	Coconut shell + coir	13.47	35.05
M 45	conventional	27.93	45.67
	Coconut shell	24.63	42.45
	Coconut shell + coir	14.15	37.92
M 50	conventional	31.66	56.13
	Coconut shell	25.01	52.94
	Coconut shell + coir	14.4	45.42

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Addition of fly ash helps to improve the strength of concrete with partial replacement of coarse aggregate with coir fibres and coconut shell. Compressive strength of concrete having coarse aggregate replaced by coconut shell reaches 90 – 95% of conventional concrete and coarse aggregate replaced by coconut shell + coir fibres reaches 80 – 90% of conventional concrete.

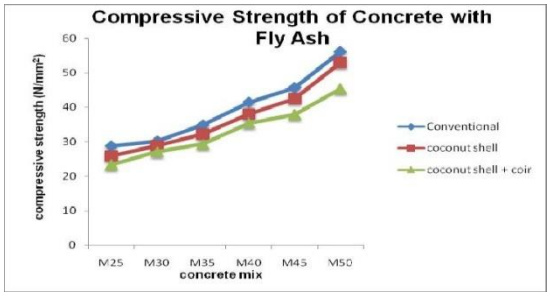

Fig 14: Graph Showing Compressive Strength of Concrete with Fly Ash

TABLE 13: Compressive Strength of Concrete With and Without Fly Ash

CONCRETE MIX	DESCRIPTION		COMPRESSIVE STRENGTH After 28 day curing (N/mm2)	
			WITHOUT FLY ASH	WITH FLY ASH
M 25	Coarse aggregate	Coconut shell	22.1	25.91
	replaced by	Coconut shell + coir	14.82	23.36
M 30	Coarse aggregate	Coconut shell	27.89	28.84
	replaced by	Coconut shell + coir	20.47	27.1

Fly ash having advantages of greater strength, increases durability, increase workability, improve finishing etc. Void filling property of fly ash helps to improve the strength of concrete by reducing the voids in the concrete matrix having coconut shell and coir fibers.Improvements in strength of concrete having coconut shell + coir fibers are found to be more as compared to coconut shell alone. Because of the addition of coir fibers creates more voids in concrete matrix and also reduces the workability of concrete.

TABLE 14: Cost of Conventional Concrete for 1 Cu.m

DESCRIPTION	QUANTITY REQUIRED (m^3)	RATE (Rs/m^3)	TOTAL COST (Rs)
Cement	0.1159	10951.00	1269.22
River sand	0.2476	2648.25	655.71
Aggregate	0.4217	706.20	297.8
Labour	1	3500	3500
Wastage of materials			300
Total			6022.73

TABLE 15: Cost of Concrete Replaced by Coarse Aggregate with 10% of Coconut Shell for 1 Cu.m

DESCRIPTION	QUANTITY REQUIRED (m^3)	RATE (Rs/m^3)	TOTAL COST (Rs)
Cement	0.1159	10951.00	1269.22
River sand	0.2476	2648.25	655.71
Aggregate	0.3795	706.20	268.00
Coconut shell	0.0421	190.02	8.00
Labour	1	3502.50	3502.50
Wastage of materials			300
Total			6003.43

Amount saved
=6022.73-6003.43

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= 19.3 Rs/m^3

TABLE 16: Cost of Concrete Replaced by Coarse Aggregate with 10% of Coconut Shell and 3% of Coir Fibres for 1 Cu.m

DESCRIPTION	QUANTITY REQUIRED (m^3)	RATE (Rs/m^3)	TOTAL COST (Rs)
Cement	0.1159	10951.00	1269.22
River sand	0.2476	2648.25	655.71
Aggregate	0.3760	706.20	265.53
Coconut shell	0.0421	190.02	8.00
Coir fibres	0.0034	882.35	3.00
Labour	1	3506.50	3506.50
Wastage of materials			300

Amount saved
= 6022.73 - 6007.96
= 14.77 Rs/m^3

The usage of coconut shell and coir fibres in construction field initiates low cost construction as well as waste management.

Conclusion

The use of coconut shell and coir fibres as partial replacement of coarse aggregate should be encouraged for sustainable and eco friendly construction. By the utilization of agricultural waste materials in concrete tends to low cost construction and waste management. The results conclude that the concrete with coarse aggregate partially replaced with coconut shell and coir fibres shows lesser strength but can recommended for low cost construction with addition of fly ash. Strength properties of concrete having coconut shell and coir fibres improve to 80% – 95% by the addition of fly ash.

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