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Experimental Investigation of Compressive Strength of Concrete By Using Coconut Fibres"

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Abstract: *Sustainability is a wide accepted concept in modern construction scenario. Even though the construction industry is revolutionizing in a significant manner in terms of both equipment and materials used, the cost of construction has skyrocketed along with the deteriorative impact on environment. This resulted in the adoption of a more balanced approach with the environment as its nerve centre to create a better world to live in. This has led to the adoption of a natural fibre like Coconut for the strength enhancement in concrete Coconut fibre is available in abundance at the test site, which makes it quite viable as a reinforcement material in concrete. Further, it acts as a new source of income for the coconut producer who gets the benefits of the new demand generated by the construction industry. In addition to this, it is an effective method for the disposal of coir mattress waste which will reduce the demand for additional waste disposal infrastructure and decrease the load on existing landfills and incinerators. The problem of high rate of water absorption of the fibre could be reduced by coating the fibres with oil. This experiment describes the behavioral study of coconut fibre in concrete structure. The addition of coconut fibre in concrete improves various engineering properties of concrete. Coconut fibre is treated as natural fiber before using in concrete. Addition of coconut fibre improves the compressive strength, flexural strength and split tensile strength of concrete. The experiment was conducted on high strength concrete with the addition of fiber with 5 mix proportions (1%, 2%, 3%, 4% and 5%) by the weight of cement. The compressive strength and split tensile strength of cured concrete evaluated for 7days and 28days.The study found the optimum fiber content to be at 1%(by the weight of the cement).This results show coconut fiber can be used in construction.*

Keywords: Coconut coir fibre, Compressive Strength.

I. INTRODUCTION

Concrete is the most widely used construction material in all over the world. Concrete is weak in tension and flexure so it is reinforced with steel reinforcing bars. Various types of fibres were used in concrete to it make more strong, durable and economical. Natural fibre such as coconut having physical and mechanical characteristics that can be used in the development of reinforced concrete material. These coconut fibres are easily available in large quantity and are also cheap. The primary goal of this project is to study the properties of concrete by reinforcing with coconut fibres and the following objectives have been founded: To determine the Compressive Strength and Split Tensile Strength of concrete after addition of coconut fibres.To know the performance of coconut fibres in reinforced concrete to reduce cracking. The advantage of using such fibres provides generally a low cost construction and the elimination of the need for waste disposal in landfills. Utilization of these fibres in concrete leads to an effective solid waste management Technique. The introduction of fibres is a solution to develop concrete with enhanced Compressive Strength and Split tensile strength, which is a new form of binder that could combine Portland cement in bonding with cement.
Fibre Reinforced Concrete, there are four categories namely,
SFRC – Steel Fibre Reinforced Concrete
GFRC – Glass Fibre Reinforced Concrete

SNFRC – Synthetic Fibre Reinforced Concrete and NFRC – Natural Fibre Reinforced Concrete In this project we have used natural fibers.

1.1 Need for Study

Coconut fibre with a tensile strength of 21.5 MPa is the toughest among all natural fibres (Munawar et al., 2003). They are capable of taking strains 4–6 times higher than other fibres (Munawar et al., 2003).Although it is a cheap and efficient a major hindrance towards its wide scale use is the high rate of water absorption, which can be reduced by coating it with oil. The advantages of coconut fibre are :low cost, reasonable specific strength, low density, ease of availability, enhanced energy recovery, biodegradability, ability to be recycled in nature in a carbon neutral manner, resistance to fungi moth and rot, excellent insulation to sound, flame, moisture and dampness, toughness, durability, resilience.

1.2 Objectives and Scope

The aim of this study is to investigate the effect of oil coated coir fibre on physical properties of concrete
The objectives of this work are:

1. To find out variation in compressive, tensile and flexural strengths of CFRC using processed fibre strands and raw fibre meshes at varying fibre contents and to compare it with that of conventional concrete
2. To determine the influence of shape of fibres on strength of concrete
3. The scope of this project is limited to rural residential constructions.

1.3 Aim of the Study

Experimental investigation of compressive strength of concrete by using Coconut fibre

II. LITERATURE REVIEW

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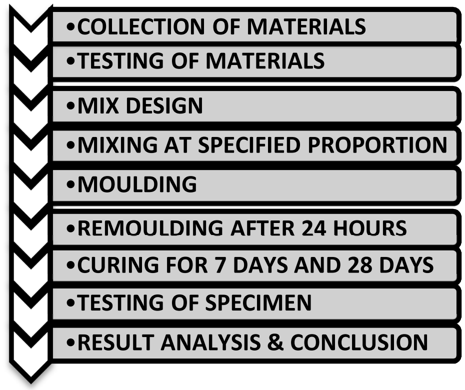
III. MATERIALS AND METHODOLOGY:

Based on the previous research work, a comparison of strength properties of fibre reinforced concrete is made with respect to conventional concrete and the influence of shape of fibres on strength are also studied. Tests are conducted using processed coconut fibres of length 5cm after coating them with coconut oil at varying fibre contents of 1%,2%,3%,4% and 5%.Material tests were carried out initially to determine the suitability of materials to be used in concrete. The mix was designed as per IS 10262 : 2009 at a suitable water content and design mix was obtained. The mixing was carried out according to standard procedure given in IS code with sufficient care to ensure that no bleeding occurred throughout the entire process. Slump tests were carried out to ensure that the mix was workable. The cubes were then cured for 7 and 28 days and were properly dried in sunlight before testing

The primary goal of this project is to conduct experimental studies for enhancement of properties of concrete by reinforcing it with coconut fibers. For checking we cast cube of (150X50X150)mm size with M20 grade of concrete adding with 0%,1%,2%,3%,4% and 5% of coconut fiber on volume basis . We casted total 36 cube of M20 grade of concrete. 18 cube cured for 7 days and 18 cube cured for 28 days to check compressive strength after 7 days and 28 days.

for comparatively study of compressive strength 3 cube with 0%,1%,2%,3%,4% and 5% so total 18 cube for 7 days and 28 days of compressive strength. Same procedure done for M25 grade of concrete cube.



The following materials were used for preparing the concrete mix.
1) Portland pozzolana cement
2) Fine aggregate
3) Coarse aggregate
4) Water
5) Coconut fibre

CEMENT

IS 1489 1991 Part I defines PPC as "An intimately inter ground mixture of Portland clinker and pozzolana with the possible addition of gypsum (natural or chemical) or an intimate and uniform blending of Portland cement and fine pozzolana". Portland-pozzolana cement can be produced either by grinding together Portland cement clinker and pozzolana with addition of gypsum or calcium sulphate, or by intimately and uniformly blending Portland cement and fine pozzolana. The pozzolanic materials generally used for manufacture of PPC are calcined clay or fly ash. Portland-pozzolana cement produces less heat of hydration and offers greater resistance to the attack of aggressive waters than normal Portland cement. Moreover, it reduces the leaching of calcium hydroxide liberated during the setting and hydration of cement.

Figure: Cement

FINE AGGREGATE

Aggregates are the important constituents in concrete. They give body to the concrete, reduce shrinkage and effect economy. They occupy about 70-80 percent of the volume of the concrete. Aggregates shall consist of naturally occurring (crushed or uncrushed) stones, gravel and sand or combination thereof. They shall be hard, strong, durable, clear and free from veins and adherent coating; and free from injurious amounts of disintegrated pieces, alkali, vegetable matter and other deleterious substances. As far as possible, flaky and elongated pieces should be avoided. Aggregates can be mainly classified into fine aggregates and coarse aggregates.

IS 383- 1970 defines fine aggregates as "Aggregate most of which passes 4.75mm IS sieve and contains only so much coarser material as permitted." It may be:

Natural sand: Fine aggregate resulting from the natural disintegration of rock and which has been deposited by streams or glacial agencies.

ii. Crushed stone sand: Fine aggregate produced by crushing hard stone.

iii. Crushed gravel sand: line aggregate produced by crushing natural gravel.
In this research work we use Crushed stone sand or M sand

Figure: M sand

COARSE AGGREGATE

IS 383-1970 defines coarse aggregates as Aggregates most of which is retained on 4.75 mm IS Sieve and containing only so much finer material as is permitted for the various types described in this standard Figure 3.1.4

Coarse aggregates may be described as:

1. Uncrushed gravel or stone which results from natural disintegration of rock,
2. Crushed gravel or stone when it results from crushing of gravel or hard stone, and
3. Partially crushed gravel or stone when it is a product of the blending of uncrushed gravel stone and crushed gravel or stone.

Figure : Coarse aggregate

WATER

According to IS 456 : 2000, water used for mixing and curing shall be clean and free from injurious amounts of oils, acids, alkalis, salts, sugar, organic materials or other substances that may be deleterious to concrete or steel. Potable water is generally considered satisfactory for mixing concrete. The pH value of water shall be not less than 6

COCONUT FIBRE

Coconut fibre both raw and processed are used in this research.

RAW FIBRE

It is the waste material obtained from mattress manufacturing and possess high degree of tensile strength of 21.5 MPa . They are properly washed before use. This will remove dust and other residual particles left on the fibre so as to augment the surface of contact between the fibre and mix resulting in better binding between the reinforcement and concrete and ultimately higher strength. The fibres are then cut into square meshes of size 5cm x 5cm

Figure : Raw coconut fibre obtained from mattress waste

PROCESSED FIBRES

They are properly washed and drawn into strands before use. Treatment of fibres removes dust and other residual particles left on the fibre so as to augment the surface of contact between the fibre and mix resulting in better binding between the reinforcement and concrete and ultimately higher strength. The fibre is washed in tap water for 30 minutes so as to loosen the fibres and to remove the coir dust. Fibres are then washed and soaked again for 30 minutes. This process is to be repeated three times The softened fibres are straightened manually and combed with a steel comb. To accelerate the drying process, the wet long fibres will be then put in oven at 30°C for 10–12 in which most of the moisture will be removed. The fibres are then completely dried in the open air, combed again and finally cut into the required length of 5cm and soaked in oil for 15-20 min and dried in sun for 24 hours.

Figure : Processed fibre

MIX DESIGN

Mix design is defined as the process of selecting suitable ingredients of concrete and determining their relative proportions with the object of producing concrete of certain minimum strength and durability as economically as possible. A Mix design was conducted as per IS 10262-1982 to arrive at M20 and M25 mix concrete.

A	Grade Designation	M20	
B	Type of Cement	PPC 53	
C	Maximum Nominal	20mm	
D	Minimum Cement Content	300kg	Table 5-IS456
E	Maximum Cement Content	450kg	As per clause
F	Maximum W/C ratio	0.55	Table 5-IS456
G	Workability	75mm	For RCC As per code

Mix design of M20 grade of concrete as per Indian Standard code

A. STIPULATIONS FOR PROPORTIONING

Table 5 Minimum Cement Content, Maximum Water-Cement Ratio and Minimum Grade of Concrete for Different Exposures with Normal Weight Aggregates of 20 mm Nominal Maximum Size

(Clauses 6.1.2, 8.2.4.1 and 9.1.2)

Sl No.	Exposure	Plain Concrete			Reinforced Concrete		
		Minimum Cement Content kg/m³	Maximum Free Water-Cement Ratio	Minimum Grade of Concrete	Minimum Cement Content kg/m³	Maximum Free Water-Cement Ratio	Minimum Grade of Concrete
1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
i)	Mild	220	0.60	–	300	0.55	M 20
iii)	Moderate	240	0.60	M 15	300	0.50	M 25
iii)	Severe	250	0.50	M 20	320	0.45	M 30
iv)	Very severe	260	0.45	M 20	340	0.45	M 35
v)	Extreme	280	0.40	M 25	360	0.40	M 40

NOTES

1 Cement content prescribed in this table is irrespective of the grades of cement and it is inclusive of additions mentioned in 5.2. The additions such as fly ash or ground granulated blast furnace slag may be taken into account in the concrete composition with respect to the cement content and water-cement ratio if the suitability is established and as long as the maximum amounts taken into account do not exceed the limit of pozzolona and slag specified in IS 1489 (Part 1) and IS 455 respectively.

2 Minimum grade for plain concrete under mild exposure condition is not specified.

Table 5 Minimum Cement Content, Maximum water-cement Ratio for Mix design of M20 grade concrete – IS456 codebook

B. TEST DATA FOR MATERIALS

Values in this section should be based on the laboratory tests. Here, standard values of different materials are assumed for the mix design of M20 grade concrete.

A	Cement Used	OPC 53	Confirming to IS8112
B	Specific Gravity of Cement	3.15	Test – IS: 2720
C	Specific Gravity of		Test – IS 2386
	Coarse Aggregate	2.74	
	Fine Aggregate	2.74	
D	Water Absorption		Test – IS 2386
	Coarse aggregate	0.5 %	
	Fine aggregate	1 %	
E	Sieve Analysis		Test – IS 2386
	Coarse aggregate		Confirming to Table 2-IS383
	Fine aggregate	Zone II	Confirming to Table 4-IS383

C. TARGET STRENGTH

Apart from mix design, the strength of the concrete also depends on other factors like mixing method, climate etc. Hence Target strength (Fck) of concrete should be more than designed characteristic strength (fck) for safety.

Target strength for m20 grade concrete can be found from the formula given in the codebook.

Fck = = fck.+1.65s

Standard deviation (S) value for the M20 grade concrete is given in table 1 of IS10262.

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Table 1 Assumed Standard Deviation
(*Clauses* 3.2.1.2, A-3 *and* B-3)

Sl No. (1)	Grade of Concrete (2)	Assumed Standard Deviation N/mm² (3)
i)	M 10	3.5
ii)	M 15	
iii)	M 20	4.0
iv)	M 25	
v)	M 30	5.0
vi)	M 35	
vii)	M 40	
viii)	M 45	
ix)	M 50	
x)	M 55	

NOTE — The above values correspond to the site control having proper storage of cement; weigh batching of all materials; controlled addition of water; regular checking of all materials, aggregate grading and moisture content; and periodical checking of workability and strength. Where there is deviation from the above, values given in the above table shall be increased by 1 N/mm².

Table 1 Standard Deviation for M20 grade Concrete – IS10262 Codebook

Fck	= fck.+1.65s	"S" from Table1-IS10262
Fck	= 20+(1.65 x 4)	S = 4
Fck	= 26.6 N/mm2	

After 28 days of curing, concrete should have more than 26.6 N/mm2 of compressive strength when tested in the Direct Compressive Testing Machine (CTM).

D. SELECTION OF WATER-CEMENT RATIO

The maximum water-cement ratio for M20 grade concrete can be found from Table 5-IS456 given above.

Maximum W/C ratio	=0.55	Table 5-IS456
Adopted W/C ratio	=0.55	

You can reduce the water-cement ratio based on your requirements but remember that Water-cement ratio directly affects the strength of the concrete.

E. SELECTION OF WATER CONTENT

Table 2 Maximum Water Content per Cubic Metre of Concrete for Nominal Maximum Size of Aggregate
(*Clauses* 4.2, A-5 *and* B-5)

Sl No. (1)	Nominal Maximum Size of Aggregate mm (2)	Maximum Water Content [1] kg (3)
i)	10	208
ii)	20	186
iii)	40	165

NOTE — These quantities of mixing water are for use in computing cementitious material contents for trial batches.

[1] Water}content corresponding to saturated surface dry aggregate.

Maximum water content to get upto 50mm slump in concrete is given in Table 2 of IS10262.

Table 2 Maximum Water Content per cubic meter – IS10262
For aggregate = 20mm, Slump = 50mm

Maximum Water Content	= 186 L

But we need a 75mm slump in our concrete as per the specification given in section 1. Clause 4.2 suggests an increase of 3% of water content in increase slump by 25mm slump in concrete.
For aggregate = 20mm, Slump = 75mm

Water-content for 75mm Slump	= 186+(0.03*186)	As per Clause 4.2
	= 191.58 L	
Adopted Water Content	= 190 L	

F. CALCULATION OF CEMENT

Weight of cement can be calculated from the water-cement ratio and the water content.

Adopted Water Cement Ratio	= 0.55
Cement required	= Water Content / W-C Ratio = 190/0.55 = 345.45 kg
Adopted Cement Content	= 345 kg

G. COARSE AND FINE AGGREGATE

Coarse aggregate ratios for different Zones of Fine aggregates are given in Table 3 of IS10262. These are ratios are valid for 0.5 Water-cement ratio.

Table 3 Volume of Coarse Aggregate per Unit Volume of Total Aggregate for Different Zones of Fine Aggregate
(*Clauses* 4.4, A-7 *and* B-7)

Sl No.	Nominal Maximum Size of Aggregate mm	Volume of Coarse Aggregate[1)] per Unit Volume of Total Aggregate for Different Zones of Fine Aggregate			
		Zone IV	Zone III	Zone II	Zone I
(1)	(2)	(3)	(4)	(5)	(6)
i)	10	0.50	0.48	0.46	0.44
ii)	20	0.66	0.64	0.62	0.60
iii)	40	0.75	0.73	0.71	0.69

[1)] Volumes are based on aggregates in saturated surface dry condition.

Table 3 Volume of coarse aggregate to total aggregate ratio for Mix Design of M20 concrete – IS10262
For aggregate = 20mm, Fine aggregate= Zone II, Water-cement ratio = 0.50

Coarse Aggregate ratio (For W/C =0.5)	=0.62	Table3-IS10262

But we need C.A ratio for 0.55 water-cement ratio. If the water-cement ratio increase by 0.05 we need to decrease C.A ratio by 0.01 and vice versa. Hence we need to subtract 0.01 from the above C.A ratio.
For aggregate = 20mm, Fine aggregate= Zone II, Water-cement ratio = 0.55

Coarse Aggregate ratio (For W/C =0.5)	=0.62	Table3-IS10262
Coarse Aggregate ratio (For W/C =0.55)	=0.61	(0.62-0.01 = 0.61)
Final Fine Aggregate ratio	= 0.39	(1-0.61) = 0.39

H. MIX CALCULATIONS OF M20 GRADE CONCRETE

This section deals with the calculation of the weight of fine aggregate and coarse aggregate from the aggregate ratio, cement and water.

A	Volume of Concrete	= 1 cu.m
B	Total Volume of Cement	= Cement/(S.G*1000)
		= 345/(3.15*1000)
		= 0.110 cu.m
C	Volume of Water	= Water /(S.G*1000)
		= 190/(1*1000)
		= 0.190 cu.m
D	Total Aggregates requirement	= A – (B+C+D+E)
		= 1 – (0.110+0.190)
		= 0.7 cu.m
E	Coarse Aggregate (C.A)	= F * C.A ratio * S.G * 1000
		= 0.7*0.61*2.74 *1000
		= 1170 kg
F	Fine Aggregate (F.A)	= F * F.A ratio * S.G * 1000

		= 0.7*0.39*2.74 *1000
		= 748 kg

Cement, Fine and Coarse Aggregate needed for M20 grade concrete. Therefore to prepare one cubic meter of m20 grade concrete we need the following quantities of cement, fine aggregate (sand), coarse aggregate(stone) and water.

S.No.	MATERIALS	QUANTITY
1	Cement	345 kg
2	Fine Aggregate	750 kg
3	Coarse Aggregate (20mm)	1170 kg
4	WATER	190 L

To find the design mix ratio, divide the calculated value of all materials by the weight of cement. Therefore Mix Design Ratio of M20 Grade concrete by weight is Cement: F.A: C.A: Water = 1 : 2.17 : 3.4 : 0.55

IV. EQUIPMENTS

Compression Testing Machine

A compression test is any test in which a material experiences opposing forces that push inward upon the specimen from opposite sides or is otherwise compressed , "squashed", crushed, or flattened. The test sample is generally placed in between two plates that distribute the applied load across the entire surface area of two opposite faces of the test sample and then the plates are pushed together by a universal test machine causing the sample to flatten. A compressed sample is usually shortened in the direction of the applied forces and expands in the direction perpendicular to the force. A compression test is essentially the opposite of the more common tension test. Salient feature of compression testing machine are :

- High stability welded assembly
- 500 kN tensile and 1000 Kn compression capacity
- 100 mm piston stroke with safety limit switch
- Upper compression platen with ball seating assembly and lower platen included

Fig: Compreesion testing machine

Set of two tensile grips and jaw faces included

- Platen hardness of min 55 HRC
- Distance pieces included

Tamping Rod

The tamping rod is a round, straight steel rod used with concrete cylinder molds, slump cones and unit weight tests. It measures 5/8″ diameter by 24″ length. Both ends are rounded to a hemispherical tip.

Tamping rods are dimensionally accurate rods used to tamp fresh concrete into concrete cylinder molds and grout sample boxes to eliminate voids and excess air

Fig: Tamping Rod

Trowel:

A hand trowel is a gardening tool which is designed for digging small holes, transplanting seedlings, planting bulbs, and performing similar tasks. Many gardeners find hand trowels immensely useful, and they are quite common in gardening sheds as a result.

Fig: Trowel

Cube mould

These Concrete Cube Mould are use for making Concrete /cement Cubes which are use for preparation of concrete cube specimens of high strength materials for compression testing. The standard size of concrete cube mould is 150 mm. the moulds for the specimens must be made of cast iron or cast steel.

Fig: Cube Mould

Weighing machine:

A weighing balance is an instrument that is used to determine the weight or mass of an object. It is available in a wide range of sizes with multiple weighing capacities and is an essential tool in laboratories, commercial kitchens and pharmacies.

Fig :- Weighing Machine

Vibrating Table

The Vibrating table is entirely constructed of thick steel. The table top is made of thick mild steel plate and has stops along its edges to prevent moulds from walking off the table during operation

Fig :- Vibrating table

MIXING OF CONCRETE:

The all ingredient of concrete mixing in tilting machine with proper proportioning

Fig :- Tilting machine

CASTING AND CURING:

The specimens were removed from the moulds after 24 hours of casting and they are put in a water pond until for testing. Some of the specimens were removed from the water after 7 and 21 days of submersion in water for testing the specimens for 7and 21-days strength.

Fig :- Casting of cube

Fig :- Curing of cube

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TESTING OF SPECIMEN:

Compressive Strength: Compressive strength is defined as resistance of concrete to axial loading. Cubes were placed in Compressive Testing Machine (C.T.M), and load was applied. The readings were recorded up to the final crack of the cube and compressive strength was calculated. The results of Compressive strength are shown in Table. Calculations: Compressive Strength = Maximum load/Cross Sectional Area = P/A

	Compressive strength N/mm^2					
Curing Days	0%	1%	2%	3%	4%	5%
7 days	14	16.30	15.02	13.96	13	12.5
	14.4	16.90	14.96	13.20	12.90	11.91
	14.2	16.50	14.88	13.50	13.2	11.98
Average	14.2	16.56	14.95	13.53	13.03	12.13

	Compressive strength N/mm^2					
Curing Days	0%	1%	2%	3%	4%	5%
28 days	24.88	28.3	26.2	25.70	23.80	22
	25.10	27.79	26	25.79	23.5	22.36
	25.10	27.10	25.90	25	22.88	21.69
Average	25.02	27.3	26.03	25.49	23.39	22.01

Table: Compressive strength of M20 grade of concrete cube after 7 days and 28 days

Fig: Tested cube

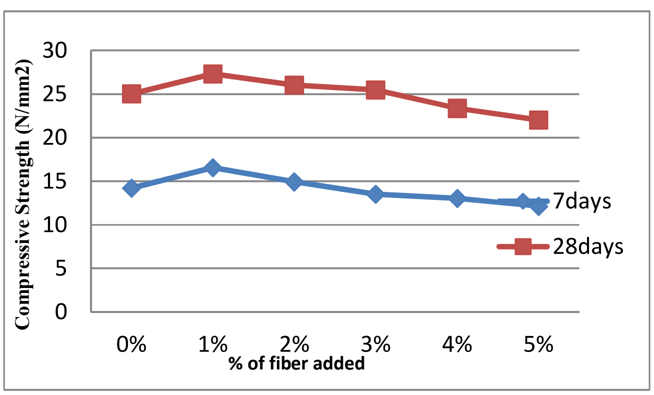

Figure: Compressive strength of M20 grade concrete cubes after 7days and 28 days

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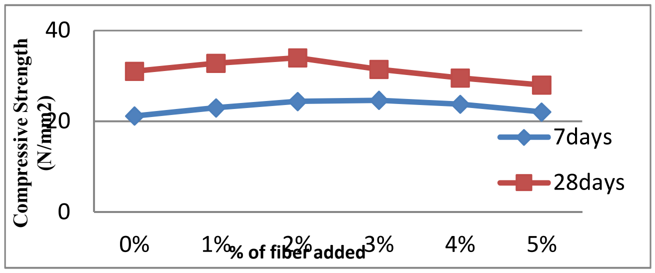

Figure: Compressive strength of M25 grade concrete cubes after 7days and 28 days

V. CONCLUSION

1. Coconut fibre being low in density reduces the overall weight of the fibre reinforced concrete thus it can be used as a structural light weight concrete.
2. By reinforcing the concrete with coconut fibres which are freely available, we can reduce the environmental waste.
3. Flexural strength increases in case of 3% fibre mix. Thus, economy can be achieved in construction.
4. Since, 5% & 4 % fibres do not show favourable results, it can be concluded that fibre content should not be used beyond 3%.

V. FUTURE SCOPE

1. The workability of the concrete with fibres was found to be very less. Hence, it can be improved to have a better slump value. Thus, certain admixtures such as air entraining agents and super plasticizers can be used so as to improve the flow characteristic of concrete.
2. Hand mixing becomes very tedious and leads to formation of a non homogeneous mix. Certain chemicals can be added so as to replace hand mixing by machine mixing.
3. Admixtures can also be used to reduce the number of voids which are formed to the present of fibres in the concrete. It may help improve the strength characteristics of concrete.
4. It was found that the results did not improve by addition of fibres beyond 5% of the weight of cement in the mix. Hence, the optimum increase in the strength of concrete by addition of fibres lies between addition of fibres between 0% and 3% of the weight of cement in the mix.