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Enhancement in the Structural Stability of Concrete by Effective Utilization of Coconut Coir Fibre and Coconut Shell

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ABSTRACT
The effective disposal of waste material is a challenge to the mankind. So many researches are being introduced for effective disposal of waste material in the production of the concrete. The production of concrete consumes lots of natural resources and is a major cause of natural resource depletion and also it is a source of pollution to the environment. As a part of concern study emphasis on the effective disposal & reuse of Coconut waste which is generated from different temples it falls in the category of agricultural waste. The study predicts the effective use of coconut coir and coconut waste in the production of concrete as partial replacement of aggregates and cement. Experimental investigations reveals that the use of CS and CF provides a cost effective, environment friendly solution to the waste disposal problem. Also, it enhances the structural stability of concrete an optimum dosage by enhancing the compressive strength and flexural stability of the concrete.

***Keywords*: CF: Coir Fibre, Coconut Shell:CS**

1.INTRODUCTION

1.1GENERAL

Cement, aggregates, water and admixtures in definite proportion makes worlds most utilized material named as concrete. It is known for its power of making robust, sturdy, elegant structures which contribute in the development of the nation. Huge quantity of material such as cement, sand, aggregates (coarse and fines), water are required for effective concrete generation. Almost 66to 78 percent of concrete volume is contributed by aggregates [Shetty, 2009]. Ecological imbalance is being created by the use of traditional material such as ground aggregates like granite which is natural stone deposit, large scale production of concrete requires huge number of natural resources and can result in natural imbalances. For sustainable development the use of natural resources shall be restricted to ascertain the natures balance. The use of recycle waste is now a days demand throughout the world in order to reduce the demand of natural resources. So, in order to reduce the utilization of aggregates in the world throughout the measures are being taken to substitute the aggregates use by waste material or material which is being dumped. Today's scenario encourages the use of waste material as boon for the effective production of concrete. As per [S.P. Ahirrao et. al. 2013] the use of construction demolition waste, CKD, BKD, Plastic waste, shells of coconut, oil palm shell, fly ash, slag from industries, waste rubber tires, marble waste residue, broken glass pieces, glass powder use is being encouraged in concrete. The use of coconut shell in the concrete production can be advantageous at some stage to reduce the use of natural aggregates in the concrete which can be a environmental friendly solution to the issue. Works on the use of coconut shell in the concrete is going on as follows:

Coconut shell waste of around 4.6b million tons is approximately produced annually which is increasing day by day [Sangeetha G., 2016]. Aggregates replacement with coconut waste in the form of coir fibre, shell of coconut, powder, husk of coconut is being used in the production of concrete and comparison of the properties is being made. Engineering properties of coconut shell and by-product are being studied in order to resolve the issue of natural resource use in the concrete and probably it can help in the reduction of the use by certain percentage.

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2.LITERATURE REVIEW

2.1GENERAL

The starting milestone of the work was taken as the previously done work in the field of utilization of waste material to replace the conventional coarse aggregate. Studies in huge numbers are being carried out for the effective use of waste material in the concrete as partial replacement of aggregates with fibres and other wastes. Partial replacement of coarse aggregates by alternative waste material such as coconut shell and coir fibre are being taken as centre of literature review in the present study.

2.2 APPLICATION OF WASTE COCONUT SHELL

E.A. Olanipekun, (2006), In the manufacturing of concrete coconut shell and palm kernel shell was being used as coarse aggregates at a rate of 0%,25%,75% and 100% respectively. Water/Cement proportion of 0.75 and 0.50 was utilized, for mix proportion 1:2:4 and 1:1:2 for cement: sand: aggregate, individually. The physical properties of coconut shell and palm kernel shell - moisture content, water retention capacity, strength, thickness, and specific gravity were resolved. The study revealed that the as the percentage of shell substitution was enhanced the compressive strength was decreased.
K. Gunasekaran, (2011), analysed the use of coconut shell as a replacement in the concrete as lightweight aggregate was being performed. The properties such as compressive strength, flexural strength etc was being determined and studied. Emphasis on the bonding strength of the coconut shell was being made in order to check compatibility with the concrete. The results demonstrated that coconut shell performance was satisfying to be used as light weight aggregate in the concrete.
Amarnath Yerramala, (2012) study revealed the use of coconut shell as replacement of coarse aggregates in the concrete production and its transportation at respective sites. The substitution of fly ash in the concrete for cement and CS as aggregate was further being studied. The functionally or workability of the concrete enhanced by the use of fly ash and CS in the concrete.

2.3 APPLICATION OF COIR FIBRE

Ralf Winterberg (2010), study reveals the use of fibre reinforced concrete and use of fibrous material in the concrete in modern scenario is very useful in reducing the cost of concrete production and is ecofriendly and sustainable solution. The paper depicted the cost-effective production of concrete using fibre reinforcement.
Majid Ali, (2012) investigations were being carried out the study on the damping ratio and the basic frequency of the simply supported Coir Fibre Reinforced Concrete (CFRC) beams were
K. Gunasekaran., (2013) studied and observed that the flexural strength of RCC beam was significantly enhanced by the use of Coconut shell as partial replacement with the coarse aggregates and suggested the partial replacement in the concrete significantly reduced the cost of concrete production.
Vishwas P. Kulkarni (2013) conduced study for the use of coconut shell as replacement of coarse aggregates in the concrete. Replacement of coarse aggregates as 0%, 10%, 20%, 30% by coconut shell in the production of M20 grade concrete was carried out. The compressive strength of the concrete enhanced drastically and no bond issue was observed.
Dewanshu Ahlawat (2014) coconut shell's suitability was being studied as a replacement to coarse aggregates in the concrete. Investigations suggested that as the coconut shell content was enhanced the compressive strength reduced but workability enhanced drastically.
Parag S, (2014) In the study M 20, M35, M50 grade concrete mix design was being carried out. Percentage variation as 0%,10%,20%,30%,40% was being taken and used. The coconut shell substitution was being taken as 0%,10%,20%,30%,40% respectively. Study revealed that coconut shell can be used as low-quality concrete as light weight concrete in low-cost projects
Sangeetha G, (2016) used coconut shell and clay as replacement of coarse aggregates and cement in the concrete. Studies revealed decrease in the compressive strength as the content of clay and coconut shell was being enhanced in the concrete.
provisionally fixed about the mechanical characteristics' use proved out be best at fibre length of 5 cm and at 5% fibre content.
Saravana Raja Mohan, (2012) studied the suitability of coir fibre in fly ash concrete and found that fly ash-based coconut fibre enhanced the concrete strength and found out to be superior execution of work and workability by using CFR.
Onkar V. (2018), Ground nut shell and coir fibres were being used partial replacement in the concrete, the results suggested that the coir fibres are more efficient than the ground nut shell to be used in concrete.

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2.4 APPLICATION OF DIFFERENT FIBRES IN CONCRETE

[Vasudev R, 2013] compared the ordinary reinforced concrete and steel fibre reinforced concrete. The compressive and tensile conduct of composite concrete with different percentages of such fibres have been investigated in experimental studies and analysed. The M20 and M30 concrete mixes with fibre ranging in percentage from 0.25 percent, 0.5 percent, 0.75 percent, and 1 percent were used. In comparison with standard steel fibre concrete, the evaluation of the experimental outcomes showed enhanced efficiency with steel fibre concrete.

[Padmanabhan Iyer et. al. 2015] in this experimental study, in order to investigate feasible improvements in 28 days, compressive strength and modulus of rupture, a FRC material called the basalt fibre reinforced concrete, the sliced basalt fibres were used in filament shape. The basalt fibre specimens were cast in three different lengths (12, 36, and 50 mm) and three different quantities (4, 8, and 12 kg/m³) by using basalt filament fibres. This study found that, in cases where both CS and MOR enhancement is required, the optimum length and optimal amount of basalt fibre are 36 mm and 8 kg/m³.

[Satyashiva Prasad et. al. 2017] researched steel fibres interacting with concrete under compression strength testing and split tension strength testing. The experimental investigation was conducted on concrete grade M30. The steel fibres were added in 0 percent, 0.25 percent, 0.50 percent, 0.75 percent, 1.0 percent, and 1.25 percent volume fractions. Experimental findings showed that steel fibre addition increases the ability of concrete to hold cracks.

Previous researchers addressed the multiple benefits and disadvantages of using waste products instead of the conventional coarse concrete aggregate. In addition to these waste products, numerous other waste products have been explored and recorded for concrete manufacturing such as fly ash, agricultural slag, oil palm shell, marble waste dust, rice husk, gypsum by-product, blast furnace slag, silica fume etc.

MATERIAL & METHODOLOGY

3.1 AVAILABILITY OF COCONUT SHELL

As an alternate CS (Coconut shell) can be utilized in place of crushed stone. Mainly composition of CS is Wood & comprise of 33.61% cellulose, 36.51% lignin, and 0.61% ash and it retains less moisture due to presence of less cellulose content. Coconut Shell-solid composite is immaculate & null necessity for pre-treatment and the shell of coconut is suited with cement.

Image 3.1 Coconut waste

Image 3.2 Waste Coconut Shells

3.2 PROPERTIES OF COCONUT SHELL

Following are main characteristics of Coconut shell makes it fit for the use of coarse concrete composite.

- Coconut shell has high strength and modulus features.
- High lignin content advantage has been introduced. High lignin material increases the weather resistance of the composites.
- As it absorbs less humidity than other industrial landfills, it has low cellulose content.
- The shells of coconut are non -biodegradable, as available in natural existence, they can easily be used in concrete that can meet almost all the characteristics of the initial concrete.
- The presence of sugar content in coconut shell does not affect the concrete structure and endurance as soon as it is not in a free sugar type.
- Once they are embedded in concrete matrix tough wood-based organic materials will not contaminate or drain to produce toxic materials.

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3.3 COIR FIBRE

External shell of coconut is the source of coir fibre. Coir filaments observed are of 2 types darker /brown produced from natural coconut and other one is white filament removed from youth coco nut. Engineering importance of dark filament is high. Nearly 7.50 million tons annually is the estimated quantity of coir fibre waste.

RESULTS AND DISCUSSION

4.1 GENERAL

Firstly, Conduction of mix design of m20 grade is being done for the substitution of the coconut shell by conventional coarse aggregate and the addition of coir fibre by cement content & as per design mix cubes were being prepared .For exploring the impact of partially replacing the coarse aggregate with waste coconut shell and adding coir fibre by cement content, 126 cubes are cast in coarse aggregate by volume to increase the amount of waste Coconut Shell (CS) and adding Coir Fibre (CF) by cement content.

Comparison of outcomes of mix of concrete with crushed coarse aggregate and waste coconut shell and coir fibre in distinct percentages is produced with regard to multiple parameters such as density and compressive strength.

4.2 VARIATION IN THE WORKABILITY OF CONCRETE DUE TO WASTE COCNUT AND COIR FIBRE

Table 4.1 and figure 4.1 offer workability check results of fresh concrete when coconut shell and coir fibre is accessorial. Workability is checked by the slump cone test. By check result, it been ascertained that workability of the concrete slashed with inflated within the percentage of coconut shell and coir fibre in concrete.

Table 4.1 Slump Cone value (in mm) of concrete

		Coconut Shell				
		0%	**5%**	**10%**	**15%**	**20%**
Coir Fibre	**0%**	83	-	-	-	-
	1%	-	76	69	64	55
	2%	-	69	67	61	52
	3%	-	67	65	58	48
	4%	-	66	64	54	45
	5%	-	63	60	51	42

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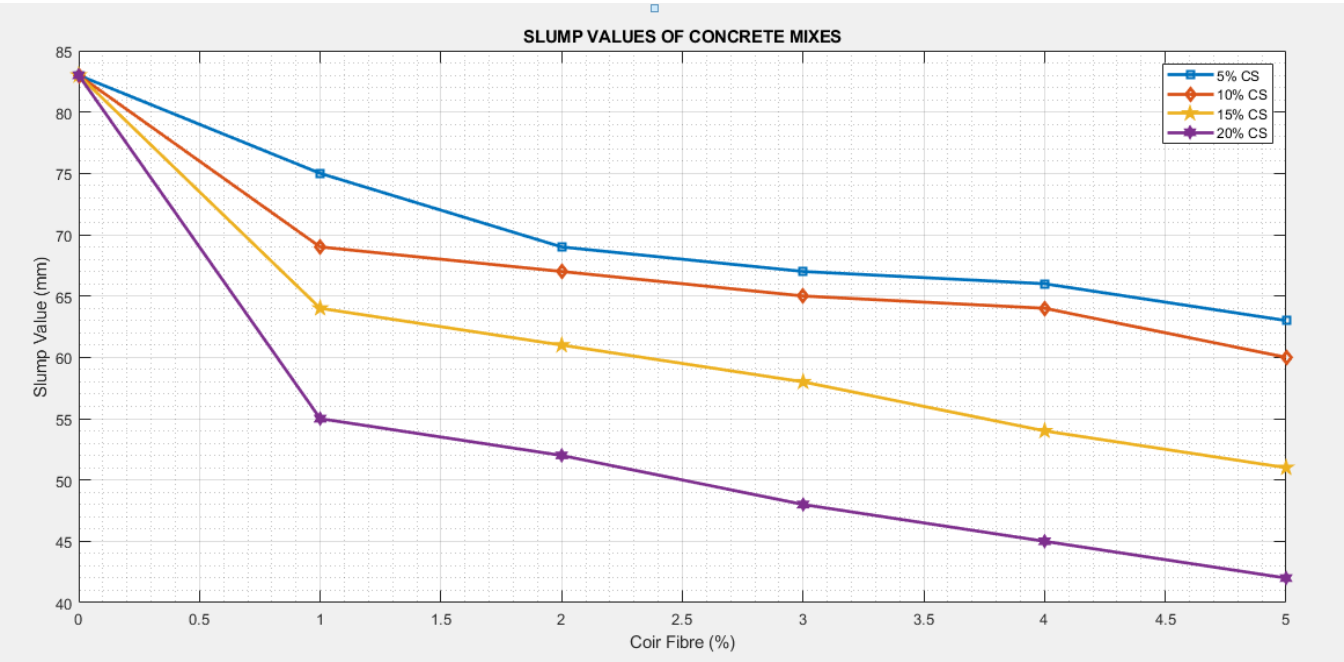

Figure 4.1 Slump Cone test result of concrete

4.3 EFFECT OF WASTE COCONUT SHELL & COIR FIBRE ON COMPRESSIVE STRENGTH OF CONCRETE

Table 5.2 depicts 7 days compressive strength for variable quantity of coir fibre and coconut shell. Figure 5.2 shows graph between concrete compressive strength at 7 days and Coir Fibre percentages (1 , 2 , 3 , 4 &5). Gradual deduction in the compressive strength of CS & CF fibre substituted concrete is observed on enhancing the CS & CF amount. The & 7 days compressive strength maintains up to 5 percent CS & 1 percent CF addition and 10 percent CS & 1 percent CF addition

Table 4.2 Variation of compressive strength at different CS & CF percentage

7 DAYS COMPRESSIVE STRENGTH (MPa)						
		Coconut Shell (CS)				
		0%	5%	10%	15%	20%
Coir Fibre (CF)	0%	24.18	-	-	-	-
	1%	-	23.07	23.40	19.40	16.07
	2%	-	22.09	20.92	18.37	15.56
	3%	-	21.29	17.40	16.03	12.74
	4%	-	19.40	15.92	14.67	11.14
	5%	-	17.78	14.07	12.03	10.37

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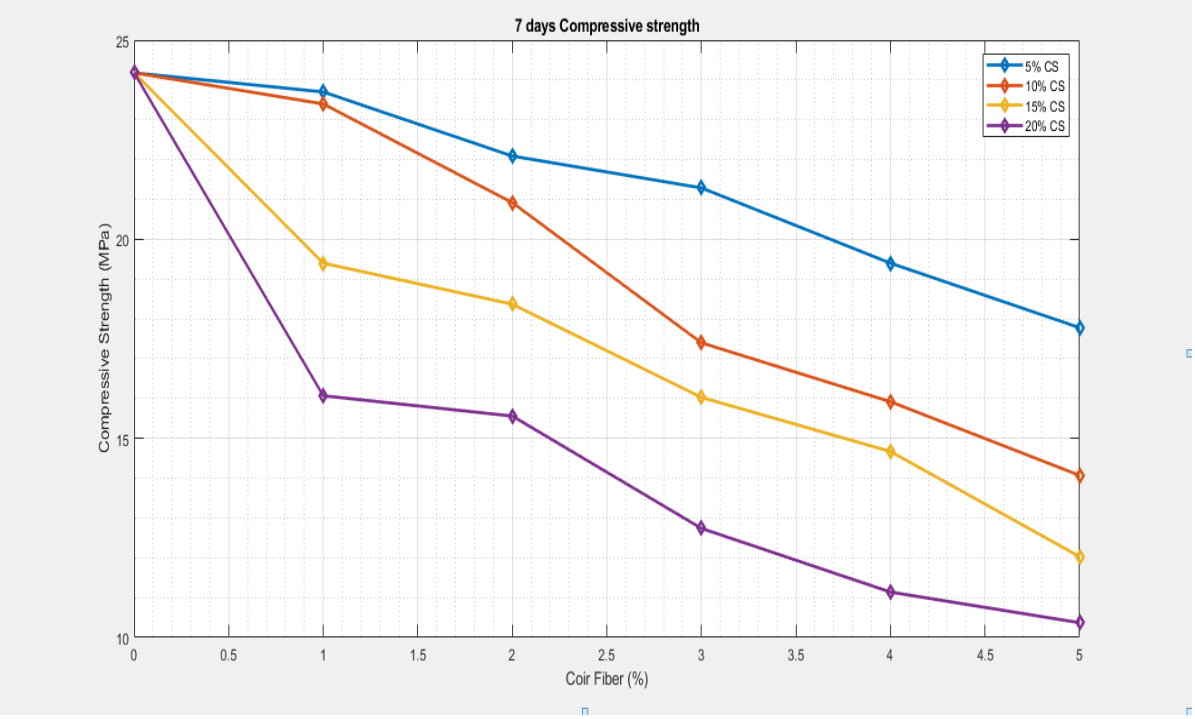

Figure4.2 Compressive Strength of concrete (7 days)

Table 4.3 depicts 28 days compressive strength of varied proportions of CS and CF. Figure 4.3 depicts 28 days compressive strength graph at Coir Fibre percentages (1 percent, 2 percent, 3 percent, 4 percent, and 5 percent). The reduction in the compressive strength is being observed gradually as the amount of CS and CF is enhanced .It is analysed that 28 days compressive strength is highest at 5 % CS with 1& 2% CF and it is ideal mix and cost effective solution.

Table 4.3 Variation of compressive strength at different CS & CF percentage

28 DAYS COMPRESSIVE STRENGTH (MPa)						
		Coconut Shell (CS)				
		0%	**5%**	**10%**	**15%**	**20%**
Coir Fibre (CF)	**0%**	28.29	-	-	-	-
	1%	-	29.50	28.50	23.60	19.85
	2%	-	28.65	26.12	20.50	16.50
	3%	-	24.30	20.50	17.30	14.65
	4%	-	22.20	18.50	15.58	12.20
	5%	-	20.10	15.68	13.83	11.65

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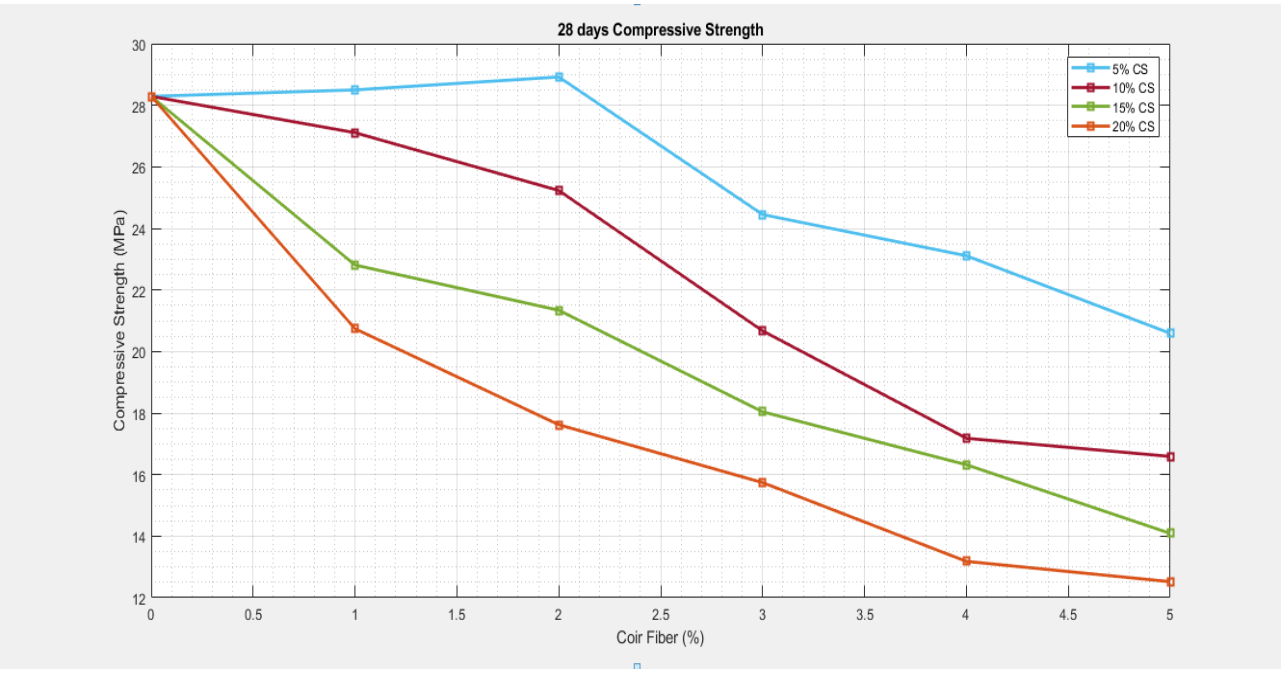

Figure 4.3 Compressive strength of concrete (28 days)

4.4 EFFECT OF WASTE COCONUT SHELL & COIR FIBRE ON CONCRETE DENSITY

Concrete cubes ready for concrete control & with distinct percentages of standard aggregate substitution by coconut shell and addition of coir fibre by cement material are weighted just before being tested for strength under compression. The concrete density is now evaluated to assess the impact of the substitution of standard aggregate by coconut shell and the addition of coir fibre The findings are provided in Figure 4.4, which demonstrates that density reduces as the proportion of coconut shell increases. Table 5.4 indicates a reduction of about 3.14 percent for the substitute of 20 percent coconut shell and 5 percent coir fibre.

Table 5.4 Density of Concrete

S. No.	Coconut shell	Coir Fibre	Demould Density (kg/m³)	% decrease in density w.r.t. control concrete
1.	0%	0%	2561.07	NIL
2.	5%	1%	2540.74	0.80
		2%	2537.41	0.93
		3%	2535.47	1.00
		4%	2534.30	1.05
		5%	2532.18	1.14
3.	10%	1%	2528.04	1.30
		2%	2525.77	1.39
		3%	2522.74	1.51
		4%	2520.49	1.61
		5%	2518.45	1.69
4.	15%	1%	2512.56	1.93
		2%	2511.32	1.98
		3%	2509.48	2.05
		4%	2504.77	2.24
		5%	2503.86	2.28
5.	20%	1%	2495.25	2.63
		2%	2493.88	2.69
		3%	2489.87	2.85
		4%	2486.48	2.99
		5%	2482.97	3.14

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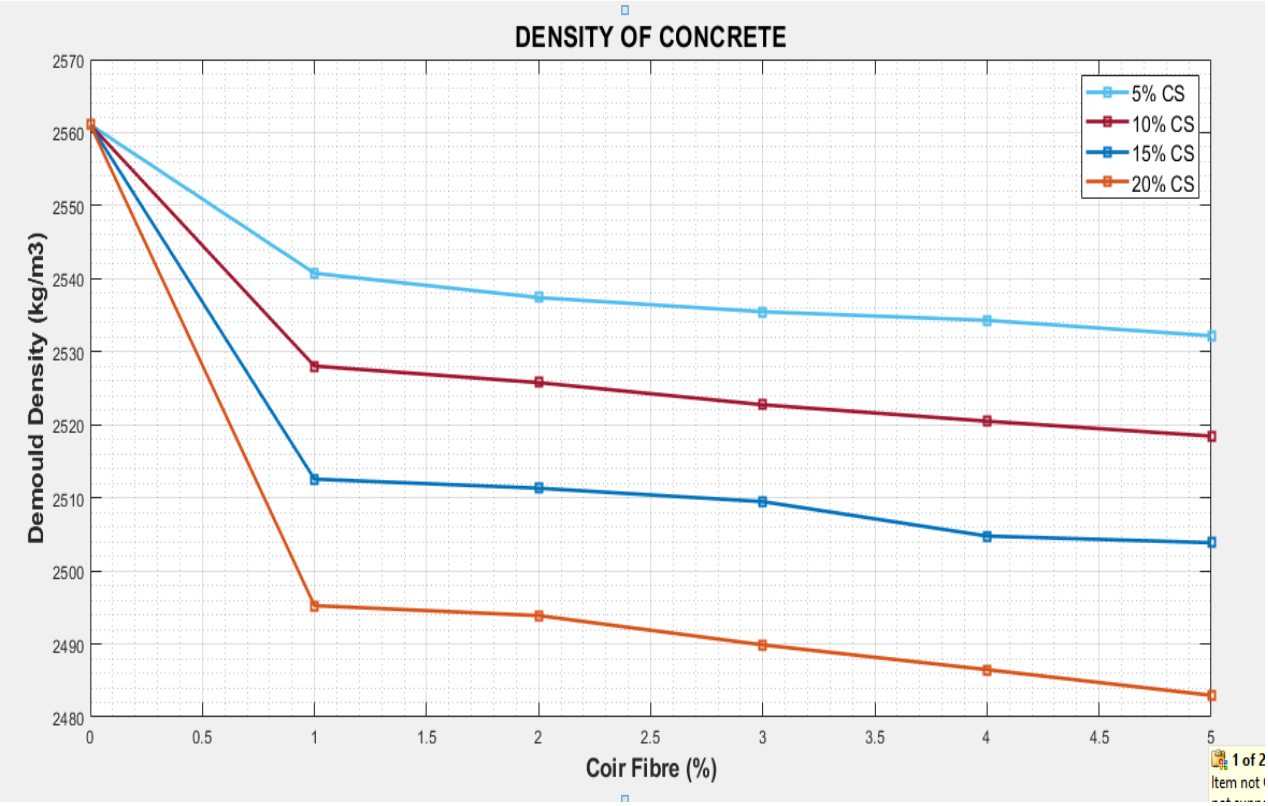

Figure 4.4 Density of concrete

4.5 EFFECT OF COIR FIBRE REINFORCED CONCRETE (CFRC) ON FLEXURAL STRENGTH

Table 4.5 provides a flexural strength of 100x100x500 mm3 CFRC beam for 7 days and 28 days for distinct coir fibre proportions. Figure 5.5 indicates a plot of CFRC flexural strength between 7 days and 28 days and Coir Fibre percentages (0 , 2 , 4 , 6 & 8). The addition of coir fibre upto 6 % enhance the flexural strength for 7 days and 28 days of curing .

Table 4.5 Flexural strength of CFRC with different Quantity of Coir Fibre

S. No.	Coir Fibre (added by cement content)	Flexural Strength (MPa)	
		7 days	28 days
1.	0%	1.00	1.40
2.	2%	1.50	2.25
3.	4%	2.50	3.75
4.	6%	2.75	4.25
5.	8%	2.00	3.00

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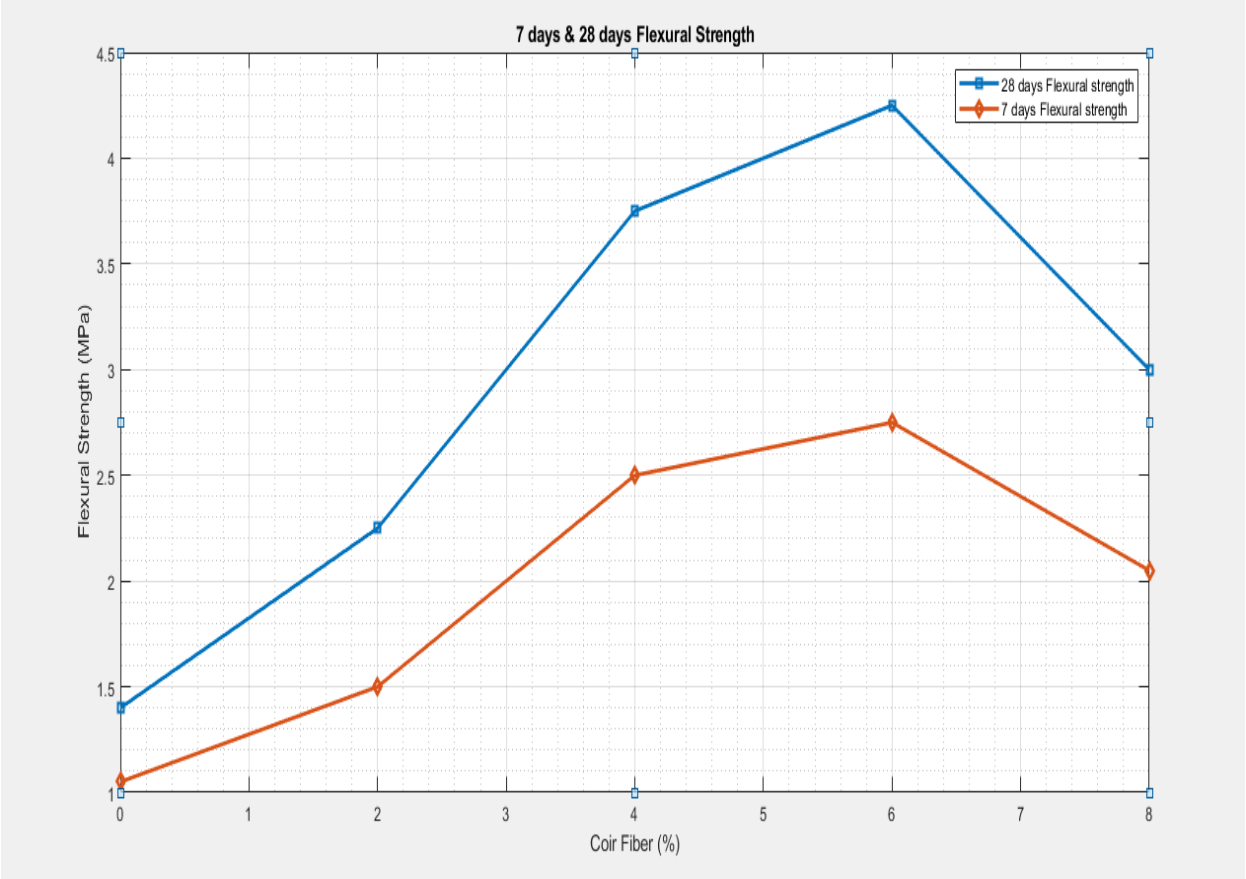

Figure 4.5 Flexural strength of CFRC (7 days and 28 days)

5 CONCLUSIONS

As per conclusion of literature survey and Experiments, the findings are as follows:

- Coconut waste has got non decaying properties which makes issues for its disposal. The issue of efficient disposal can be resolved by the use of cocnut shell in the concrete manufacturing as its properties enhance the compressive strength and flexural strength of the concrete to an extent.
- Coir fibre and coconut shell introduction in the concrete reduces its workability. Reduction in the density of concrete is observed as increment of coconut shell and coir fibre is done hence making it as light weight concrete. For the substitution of 5 % coir fibre and 20 % coconut shell density is reduced about 3.14 %.
- Upto 5% CS and 1 percent CF addition compressive strength for 7 days is maintained. The optimum mix for 28 days compressive strength is 5% CS replacement and 1& 2% CF replacement at which the compressive strength of the concrete is enhanced.
- The optimum use of coir fibre upo 6 % improves the flexural strength of the concrete and is cost effective solution to the making of concrete and disposal of the waste. Its use is cost friendly as compared to other FRP materials and its use is environment friendly.
- Mechanical characteristics of the concrete is being enhanced by the use of coir fibre in the concrete manufacturing. Hence Coconut shells can be used to build low-cost residential societies providing cost effective solutions

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