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EFFECT OF THE STRENGTH PROPERTIES BY PARTIAL REPLACEMENT OF STEEL FIBERS AND COCONUT SHELLS IN CONCRETE

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Abstract - In this research there are many experimental works conducted to improve the properties of the concrete by adding new materials, weather it is natural materials or recyclable materials or synthetic materials in the concrete mix. Concrete is the most commonly used construction material around the world and most widely used in all types of construction works. It is a man-made product and essentially consists of a mixture of cement, aggregates and water. Granular materials such as sand, crushed stone or gravel from the major part of the aggregates. At present aggregates are readily available at economic prices. But the continued extensive use of these aggregates leads to the depletion of primary aggregates and greater awareness of environmental protection. To reduce the use of this natural aggregates different waste materials and industry by-products are replaced with natural aggregates and properties of the concrete are investigated. Coconut shell is one of the waste materials and can be used as aggregate in concrete. From various research papers, it has been found that, using different types of fibers in concrete improve the mechanical properties, durability, and serviceability of the structure. Steel Fiber Reinforced Concrete (SFRC) containing cement, water, fine aggregate, coarse aggregate and uniformly dispersed fibers. The mixture of concrete and fibrous materials called as "Fiber Reinforced Concrete". Fibers can be in different forms like steel fibers, glass fibers, natural fibers and synthetic fibers etc., among all these types of fibers, steel fibers are used in this project and to produce Steel Fiber Reinforced Concrete (SFRC). Here hooked steel fibers having the aspect ratio is 50 (35 mm length and 0.7 mm diameter) are used to determine the mechanical properties of concrete. Limited research has been conducted on mechanical properties of concrete with coconut shell as aggregate replacement. However further research is needed for better understanding the behavior of coconut shell as aggregate in concrete. The aim of this work is to provide more information on strength of coconut shell at different percentages of coconut shells replacements. Furthermore in this study the effect of steel fibers are cement replacement on properties of coconut shells replaced concrete was also investigated. In this experimental investigation, the coconut shell used as light weight aggregate in concrete, the properties of coconut shell concrete examined, control concrete with normal aggregate and coconut shell were made. The main aim of using steel fibers in concrete is to improve the compressive strength of concrete and ductility nature of concrete structure. In this research, M30 grade of concrete have been considered and casting the specimens with the different percentages of coconut shells and steel fiber content of CC, CS 5, CS 10 and CS 10 & SF 2 to examine the strength properties of concrete. Different shapes of specimen's likes cubes, cylinders and beams are carried out and having their sizes 150×150×150 mm, 150×300 mm and 500×100×100 mm respectively. At last we will present an overview of mechanical properties of Steel Fiber Reinforced Concrete. Several tests will be conducted for specimens such as Slump cone test, Compressive strength test, Split tensile strength test and Flexural strength test. The project aims at analyzing flexural, slump cone, split tensile strength and compressive strength with partial replacement using M30 grade of concrete. This project also aims to show that coconut shell is a potential construction material and simultaneously reduces the solid waste problem in the environment.

Index Terms – Coconut Shells, Steel Fiber Reinforced Concrete (SFRC), Steel Fibers, Compressive Strength, Flexural Strength, Workability.

I. INTRODUCTION

The use of lightweight concrete (LWC) with materials like coconut shells (CS) as aggregates can offer a sustainable solution to the construction industry's ecological challenges. The increasing demand for conventional aggregates, such as gravel and granite, has contributed to environmental degradation and depletion of natural resources, as you've outlined. By integrating agricultural waste like coconut shells as an alternative to conventional coarse aggregates, the industry can reduce the environmental footprint while finding a more sustainable resource. The reliance on normal weight aggregates has strained natural resources and disturbed ecological balance, motivaing the need for alternative materials In developed countries, various lightweight aggregates (LWA) have replaced conventional ones, facilitating the construction of high-rise buildings using LWC. This is less common in Asia, where the construction industry has yet to fully embrace the benefits of LWC. Coconut shells, typically discarded as agricultural waste, have potential as a low-strength lightweight aggregate in concrete production. Although not commonly used, studies have shown that they could be suitable for specific applications, particularly in low-strength concrete. The study investigates the properties of concrete using coconut shells, including compressive strength and bond properties through a pull-out test, comparing results to theoretical standards. The introduction of CS as a substitute for coarse aggregates could support more eco-friendly construction practices, especially for regions rich in agricultural by-products like Asia. The low strength of the material makes it more suitable for specific, non-structural applications or low-load-bearing structures. Concrete, while strong in compression, is weak in tension and prone to cracking. The introduction of steel fibers helps to mitigate this weakness, significantly improving the tensile strength, ductility, and flexural toughness of the concrete. The addition of randomly distributed steel fibers improves the tensile properties and mechanical performance of concrete, controlling the onset and propagation of cracks. SFRC exhibits greater energy absorption capacity, meaning it can deform more before failing. This is particularly important for structures subjected to dynamic loads or requiring high durability. The improved strength properties of SFRC allow for thinner slabs, which translates to reduced material costs and weight, especially useful in high-rise structures. SFRC enhances the concrete's resistance to shrinkage, cracking, and wear, contributing to longer service life and lower maintenance costs. SFRC is commonly used in industrial flooring, pavements, precast concrete, and structures where enhanced performance is required. The use of natural or artificial lightweight aggregates, like coconut shells (CS), is another sustainable approach aimed at reducing the environmental impact of concrete production. Coconut shells, typically an agricultural waste product, offer a promising alternative to conventional aggregates like gravel and granite.

Fig.1 Steel Fibers concrete

Fig.2 Coconut Shells

II. LITERATURE SURVEY

Kabir usman rago (2010) Have studied that coconut shell has full replacement of coarse aggregate in the concrete for nominal mix of M20 (1:1.5:3) achieve 55% strength of the compressive strength of the control concrete and which can be used for the plain cement concrete. The flakiness is six times greater for coconut shell when compared with gravel.

J.P.Ries (2011) have investigated that light weight aggregate plays important role in todays move towards sustainable concrete. Light weight aggregate contributes to sustainable development by lowering transportation requirements, optimizing structural efficiency that results in a reduction in the amount of overall building material being use, conserving energy, reducing labor demands and increasing the service life of structural concrete.

Gopal charan behra and Ranjan kumar behra (2013) Abundant availability of natural resources have become a dream for present day engineering society due to large scale consumptions. The unaccountable growth rate population make problem of availability of coarse aggregate for construction for more severe. Due to rapid urbanization and industrialization, consumption of aggregates increased to manifold. So the research has must find the alternatives for the coarse aggregate. The increase in population also increases the industrial by-products domestic wastes etc.

Vishwas P. kulakarni and sanjay kumar, B. Gaikwad (2013) have said that concrete is the widely used number one structural material in the world today. The demand to make this material lighter has been the subject of study that has challenged scientists and engineers alike. The challenge in making a light weight concrete is decreasing the density while maintaining strength and without adversely affecting the cost. Introducing new aggregates into the mix design is a common way to lower a concrete density.

K. Gunasegaram etal ., (2011) have studied that, the impact resistance of coconut shell aggregate concrete is high when compared with conventional concrete. So it can be used as flexural members. The experimental bond strength bond strength of coconut shell aggregate concrete is much higher compared to the theoretical bond strength as stipulated by IS 456-2000.

Soulioti et. al, has worked on Effects of Fiber Geometry and Volume Fraction on the Flexural Behaviour of Steel-Fiber Reinforced Concrete. The compressive strength, flexural strength were studied and compared with unreinforced concrete. The effect of fiber on workability and air content properties of fresh concrete was also evaluated.

MohdMuzammilahmed and **Mohdmajiduddin** Flexural Behaviour Ofternary Blended Steel Fiber Reinforced Concrete Beams Using Crimped Fibers has worked on the flexural behaviour of beams have improved by adding fibers. The flexural strength of the beam increased nearly by 21.58%. The moment carrying capacity of beams with 0.5% of fiber is 7.16%, 0.75% of fiber is 12.60% and 1.25% is -6.65%. On adding of 1% crimped steel fiber the moment carrying capacity of beam is increased by 21.58%. Specimens with more percentage of fibers shown greater elastic properties.

Shireesha has worked on Experimental studies on steel fiber reinforced concrete. The effects of steel fiber reinforcement in concrete. The design mix of M40 grade was taken and steel fiber of aspect ratio 80 was added. It is observed that the compressive strength increases from 8-21% and 6-12% for 7and 28 days, Split tensile strength increases from 14-36% and 15-39% for 7 and 28 days. Adding 1.5% of fiber the absorbed energy by specimen was 8 and 10 for 7 days and 28 days.

Raghunath and **k. Suguna** has worked on Flexural behaviour of high strength steel fiber reinforced concrete beams by In this study total 4 beams of 3m length and 150mmx250mm in cross section were casted and tested in laboratory. Three different steel fibers volume were taken i.e. 0.5%, 1% and 1.5%. All beams were tested under two point load condition in a loading frame of 750 KN capacity.

Avinash.S and **Parekar Suresh.R** has worked on Steel Fiber Reinforced Concrete Beams under Bending Shear and Torsion without Web Reinforcement. The results for 6 bending, shear and torsion tests on steel fiber reinforced concrete beams without web reinforcement are discussed.

Sudheer et. al, has worked on Experimental Investigation on Strength and Durability Properties of Hybrid Fiber Reinforced Concrete. The compressive strength of high fiberd reinforced concrete is more when compared to conventional concrete. The increase in compressive strength by addition of 0.5%, 1.0% and 1.5% of fiber is 10.75%, 27.26% and 33.79% respectively. Adding 0.5% of fibers may decrease the tensile strength but 1.5% of fiber gives maximum strength when compared to other proportion.

Ghosni et. al, has worked on Flexural behaviour of high strength concrete composite incorporating long hooked end steel fibers. In this research long hooked steel fibers have been added to mix and compressive strength, flexural strength of concrete have been found out for 7, 28 and 56 and 14, 28, and 56 days.

Eethar Thanon Derwood Investigations were conducted on the development of gypsum plaster used naturally by adding 1% of admixture (Super plasticizer) and reinforcing it with bar chip fibers. Different percentages of bar chip as 0, 0.5, 0.75, 1, 1.25 and 1.5% were used. In this paper, they have been considered the Barchip fiber for producing fiber reinforced concrete. The compressive and flexural strength of such gypsum plaster are discussed.

III. OBJECTIVES

As the models proposed for normal concrete may not readily be applicable for CSC, establishing simple and accurate generalized monotonic stress-strain relationships of coconut shell concrete in tension and compression that take into account the coconut shell and content is essential.

- To study the effects of Coconut shell content on compression behaviour of Coconut shell concrete are systematically investigated.
- To study the effects of Coconut shell content on tensile behaviour of Coconut shell concrete are systematically investigated.
- The main objective of this research work is to examine the strength behaviour of Coconut shell concrete.

- To analyze the variation of the compressive strength of concrete, flexural strength of concrete with different percentages of Coconut shells.
- To find out the maximum compressive strength of concrete at which percentage of coconut shell.
- To prepare light weight concrete the grade by using the Coconut shells in concrete.
- The variation of compressive, split tensile and flexural strength is also analyzed when steel fibers also added in addition to coconut shells.
- Shell replacement as coarse aggregate in different proportions of 5%, 10%, and 10% coconut shells and 2% steel fibers.

IV. METHODOLOGY

Nomenclature:

Nomenclature is the name or symbols to mention on the specimens to identified the difference percentages of coconut shell replacement in concrete specimens.

- **CC:** Where CC refers to conventional concrete (without any replacement) with "0 % " replacement of coarse aggregate by coconut shell.
- **CS 5 :** Where CS refers to conventional concrete with partial replacement of coconut shells as coarse aggregate, " 5 " refers to percentage replacement of coarse aggregate by coconut shells.
- **CS 10 :** Where CS refers to conventional concrete with partial replacement of coconut shells as coarse aggregate, " 10 " refers to percentage replacement of coarse aggregate by coconut shells.
- **CS 10 and SF 2 :** Where CS refers to conventional concrete with partial replacement of coconut shells as coarse aggregate, " 10 " refers to percentage replacement of coarse aggregate by coconut shells and SF refers to Steel fibers with partial replacement of steel fibers, " 2% " refers to percentage replacement of cement by steel fibers.

Details of specimen:

Details of cube specimens:

- Size of cube specimens 150x150x150 mm.
- Mix proportion 1:1.453:2.11
- Water/Cement Ratio: 0.48
- No.of specimens 18No.(6-0%,6-5%,6-10%,6-10% CS & 2% SF)
- Curing period for cube specimens 7, 14 and 28 days.

Table 1: Details of different cube specimens (7, 14 and 28 days curing)

S.No	**Identification**	**No.of specimens**	**Size of specimen**	**Mix proportion**	**W/C Ratio**
1.	CC	6	150×150×150 mm	1:1.453:2.11	0.45
2.	CS 5	6	150×150×150 mm		
3.	CS 10	6	150×150×150 mm		
4.	CS 10 & SF 2	6	150×150×150 mm		

Details of beam specimens:

- Size of cube specimens 500x100x100 mm.
- Mix proportion 1:1.453:2.11
- Water/Cement Ratio: 0.45
- No.of specimens 18No.(6-0%,6-5%,6-10%,6-10% CS & 2% SF)
- Curing period for cube specimens 7, 14 and 28 days.

Table 2: Details of different beam specimens (7, 14 and 28 days curing)

S.No	**Identification**	**No.of specimens**	**Size of specimen**	**Mix proportion**	**W/C Ratio**
1.	CC	6	500×100×100 mm	1:1.453:2.11	0.45
2.	CS 5	6	500×100×100 mm		
3.	CS 10	6	500×100×100 mm		
4.	CS 10 & SF 2	6	500×100×100 mm		

Details of cylindrical specimens:

- Size of cylindrical specimens 150 mm diameter and 300 mm height.
- Mix proportion 1:1.453:2.11
- Water/Cement Ratio: 0.45
- No.of specimens 18No.(6-0%,6-5%,6-10%,6-10% CS & 2% SF)
- Curing period for cube specimens 7, 14 and 28 days.

Table 3: Details of different cylindrical specimens (7, 14 and 28 days curing)

S.No	Identification	No.of specimens	Size of specimen	Mix proportion	W/C Ratio
1.	CC	6	150×300 mm	1:1.453:2.11	0.45
2.	CS 5	6	150×300 mm		
3.	CS 10	6	150×300 mm		
4.	CS 10 & SF 2	6	150×300 mm		

In this project, 18 specimens are prepared by using only coarse aggregate in concrete ie..,conventional concrete 36 specimens are prepared by using partial replacement of coconut shells in different percentages (5% and 10%) in concrete mixture and that concrete is called as coconut shell partial replacement concrete. And another 18 specimens are prepared by using 10% coconut shells as partial replacement and 2 % steel fibers. The prepared specimens are used for testing the compressive strength, flexural strength and split tensile strength of concrete.

Table 4: Properties of cement

Properties	Values
Type of Cement	OPC 53 grade
Specific Gravity	3.15
Fineness of cement	4.52%
Normal consistency	31%
Initial setting time	105 minutes
Final setting time	315 minutes

Table 5: Properties of Coarse Aggregates

Properties	Values
Water Absorption	0.6%
Specific Gravity	2.68
Bulk Density (Rodded)	1565 kg/m^3
Bulk Density (Loose)	1472 kg/m^3
Elongation Index	13.5%
Flakiness Index	12.2%
Impact Value	14.5%

Table 6: Sieve Analysis of Coarse Aggregate (20mm)

IS Sieve size, mm	Percentage of passing	Limits as per IS:383
40	100.00	100
20	92.17	85-100
10	9.64	0-20
4.75	0.0	0-5

Table 7: Properties of Fine Aggregate (Sand**)**

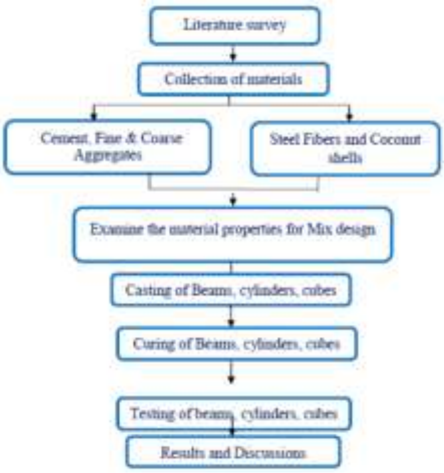
Properties	Values
Fineness modulus	2.76
Specific Gravity	2.66
Bulk Density (Rodded)	1539 kg/m^3
Bulk Density (Loose)	1462 kg/m^3
Silt Content	1.24%
Zone of Sand	II

Table 8: Properties of Steel Fibers

Property	Values
Diameter	0.70 mm
Length of Fiber	35 mm
Appearance	Bright in clean wire
Average Aspect ratio	50
Deformation	Hooked at both ends
Tensile Strength	1050 Mpa
Modulus of Elasticity	200 GPa
Specific Gravity	7.8

Fig.3 Hooked Steel Fibers and Coconut Shells

Steps involved to produce Coconut shell Concrete



V. RESULTS

This study describes the analysis carried out for coconut shell Concrete (CSC). Several tests were conducted on CSC specimens and plotted graphs for different percentages of coconut shells. The analysis is carried out for different percentages of Coconut shell such as 0%, 5%, 10% and 10% CS with coarse aggregate and 2% SF with volume of cement. The graphs were plotted between percentage of Coconut shells and strength and studied in detail.

Table 9: Slump Value of Concrete for different percentages of Coconut shell

S.No	Grade of concrete	Percentage of coconut shell	Percentage of steel fiber	Average slump value (mm)	Percentage of variation.
1	M30	0%	0%	125	-
2		5%	0%	105	16
3		10%	0%	90	14.28
4		10%	2%	65	27.78

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Table 10: Compressive Strength of Concrete for 7 days

S.No	Grade of concrete	Percentage of coconut shell	Percentage of steel fiber	Average compressive strength (N/mm^2)	Percentage of variation.
1	M30	0%	0%	20.35	-
2		5%	0%	15.11	-5.56
3		10%	0%	14.33	-14.69
4		10%	2%	18.67	7.73

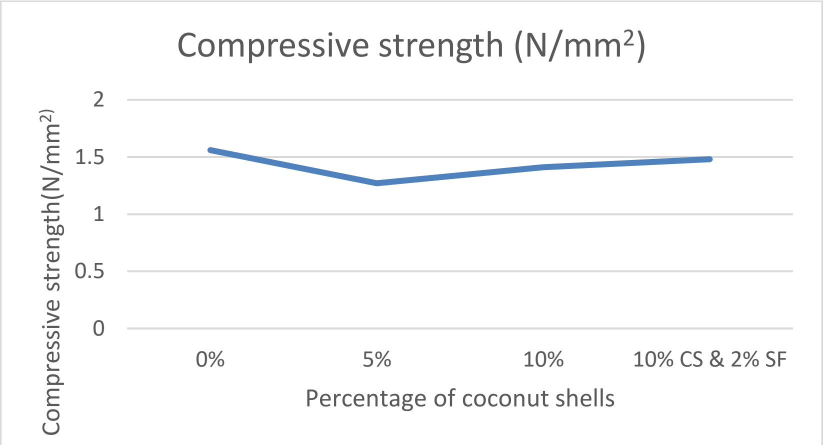

Fig.4 Compressive Strength of Concrete for 7 Days

Table 11: Compressive Strength of Concrete for 28 days

S.No	Grade of concrete	Percentage of coconut shell	Percentage of steel fiber	Average compressive strength (N/mm^2)	Percentage of variation.
1	M30	0%	0%	28.3	-
2		5%	0%	21.3	-34.82
3		10%	0%	19.5	-6.76
4		10%	2%	25.2	22.6

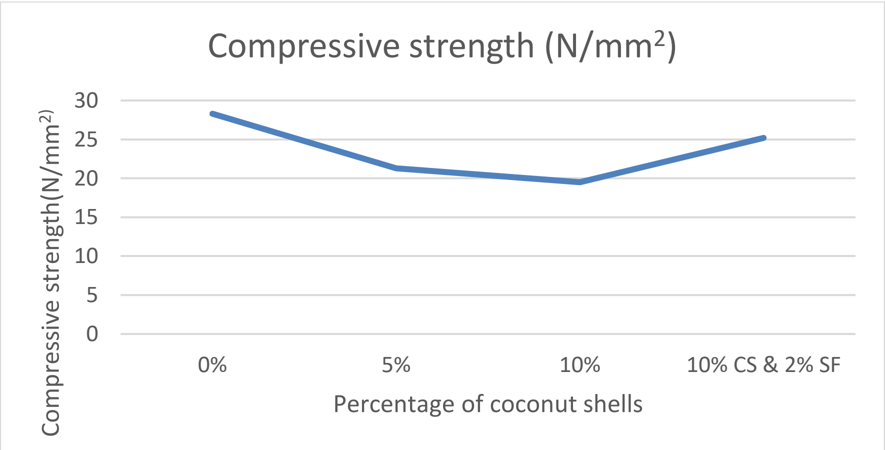

Fig.5 Compressive Strength of Concrete for 28 Days

Table 13: Split Tensile strength of Concrete for 7 Days

SI. No	Grade of concrete	Percentage of coconut shell	Percentage of steel fiber	Average split tensile strength (N/mm^2)	Percentage of variation.
1	M30	0%	0%	1.27	-
2		5%	0%	1.20	-5.51

3		10%	0%	1.16	-3.44
4		10%	2%	1.23	5.69

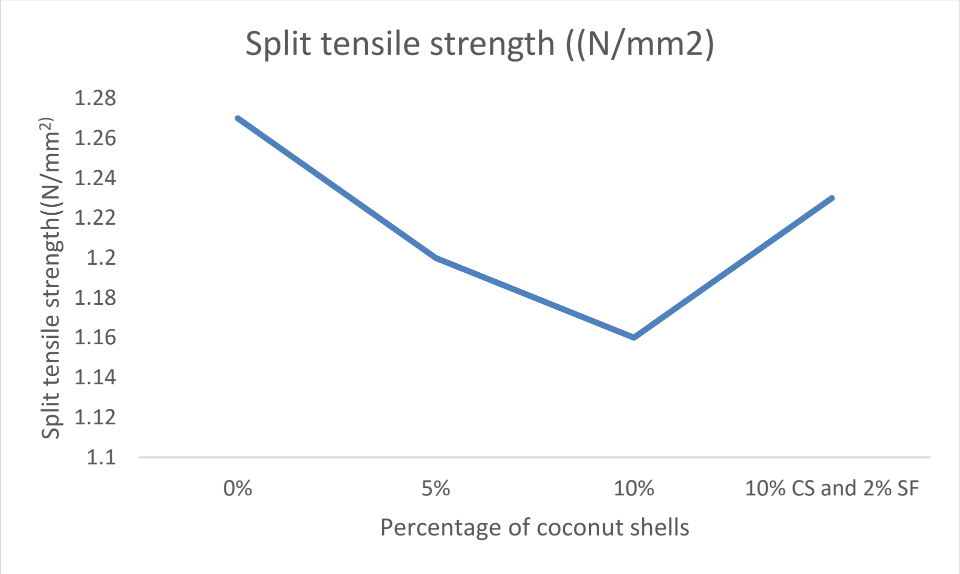

Fig.6 Split tensile Strength of Concrete for 7 Days

Table14: Split Tensile Strength of Concrete for 28 Days

SI. No	Grade of concrete	Percentage of coconut shell	Percentage of steel fiber	Average split tensile strength (N/mm^2)	Percentage of variation.
1	M30	0%	0%	1.56	-
2		5%	0%	1.27	-6.89
3		10%	0%	1.41	-5.25
4		10%	2%	1.48	4.96

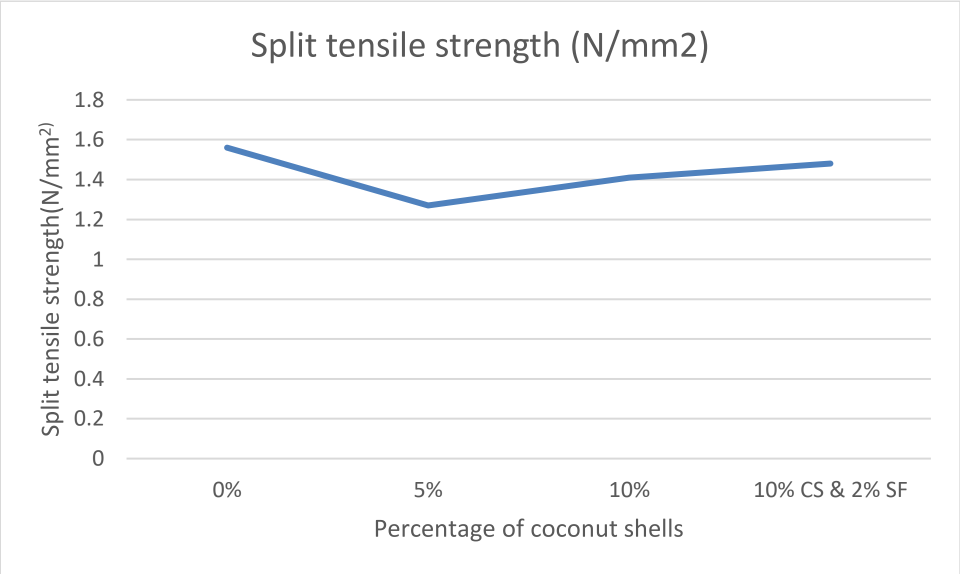

Fig.7 Split tensile Strength of Concrete for 28 Days

VI. CONCLUSIONS

This study explains the structural and strength behaviour of Coconut shell concrete under the different percentages of coconut shell by volume of coarse aggregate. The compressive strength, flexural strength, split tensile strength and slump value of concrete under the different percentages of coconut shell are carried out and presented. The mainly focused on compressive strength variations for each case to understand the performance of coconut shells in concrete. The following conclusions were obtained from the present study.

- On increasing the percentage of coconut shells it is observed that the strength variation tends to be decreased and with addition of coconut shell the strength again tends to be increased with addition of steel fiber.
- With the adding of coconut shells in concrete then the ductility nature of concrete is improved.
- The coconut shells has shown the greater influence on the strength behaviour of concrete and workability of concrete.
- With the adding of coconut shell content in concrete then the workability of concrete got unchanged and that indicates strength is getting decreased.
- The maximum value of slump obtained at 0% of coconut shells is 125 mm and the minimum value of slump is obtained at 10% of coconut shell and 2% of steel fibers 65mm. these results concluded that high workability is observed at 0% of coconut shells and low workability is observed at 10% of coconut shell and 2% of steel fibers
- From the results of compressive strength, we observed that by adding of Coconut shell in concrete then the compressive strength of concrete tends to be slightly decreased.
- The maximum value of compressive strength attains at 0% of Coconut shell in concrete is 28.3 N/mm^2 for M30 grade of concrete. And the minimum value of compressive strength of concrete attains at 10% of Coconut shell in concrete is 19.5 N/mm^2.
- From the results of split tensile strength, we observed that by adding of coconut shells in concrete then the split tensile strength of concrete tends to be slightly decreased.
- The maximum value of split tensile strength attains at 0% of steel fibers in concrete is 1.56 N/mm^2 for M30 grade of concrete. And the minimum value of split tensile strength of concrete attains at 10% of steel fibers in concrete is 1.48 N/mm^2.
- By adding the coconut shells in concrete, light weight concrete can be prepared and solid waste can be reduced successfully.
- Finally, this study concluded that the strength is getting continuously decreased with the increase of coconut shell content in concrete.

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