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Properties of Concrete partially replaced with Coconut Shell as Coarse aggregate and Steel fibres in addition to its Concrete volume

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Properties of Concrete partially replaced with Coconut Shell as Coarse aggregate and Steel fibres in addition to its Concrete volume

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Abstract. Cement is a binder material with various composition of Concrete but instantly it posses low tensile strength. The study deals with mechanical properties of that optimized fiber in comparison with conventional and coconut shell concrete.The accumulation of fibers arbitrarily dispersed in the composition increases the resistance to cracking, deflection and other serviceability conditions substantially. The steel fiber in extra is one of the revision in coconut shell concrete and the outcome of steel fiber in coconut shell concrete was to investigate and compare with the conventional concrete. For the given range of steel fibe from 0.5 to 2.0% , 12 beams and 36 cylindrical specimens were cast and tested to find the mechanical properties like flexural strength, split tensile, impact resistance and the modulus of elasticity of both conventional and coconut shell concrete has been studied and the test consequences are compared with the control concrete and coconut shell concrete for M25 Grade. It is fulfilled that, the steel fibers used in this venture has shown significant development in all the properties of conventional and coconut shell concrete while compared to controlled conventional and coconut shell concrete like, Flexural strength by 6.67 % for 1.0 % of steel fiber in conventional concrete and by 5.87 % for 1.5 % of steel fiber in coconut shell concrete.

1. Introduction

Concrete is a complex substance containing the multiple components in various composition. Even though, coarse aggregate constitutes the major volume and capacity of concrete, material remains a sky scraping claim. From the stand point of energy cutback and protection of natural wealth, the use of different constituents which should be light in mass to reduce the self weight of concrete in building supplies is now a worldwide fear. However, plain concrete possesses very low tensile strength, partial ductility and modest opposition to cracking. This absence has been eliminated by using fibers into the concrete. It will help in safeguarding and repairing of concrete structures.

1.1: Light weight concrete

The demand to make concrete as lighter is of quite important. LWC is made by diminishing the compactness while maintaining the strength and without unfavourably affecting the price. Introducing a new aggregate into the mix design is a familiar way to subordinate concrete mass. LWC is characteristically deals with reusing waste as aggregates towards economical growth.

1.2: Coconut shell concrete

The budding of waste coconut shell are used as a alternative for coarse aggregate in concrete. After the coconut is tattered out, the shell is regularly discharged. The bulk density of coconut shell is about 500 to 600 kg/m3, producing concrete of about less than 2000 kg/m3 in density, which makes them lightweight.The coconut shell concrete straight forwardly attains the strength around 17 N/mm2. For the past 10 years light weight concrete getting a maximum hold in the construction industry

1.3: Steel fiber reinforced concrete

Steel fibers used in concrete are of limited volume fraction. The fibers of various cross sections are used. Hooked and deformed ends of fibers improve the fatique or impact strength. For high temperature applications up to 1650 deg.-C, like in refractory structures, stainless steel fibres are used. Corrosion of steel fibers in concrete with a high water to cement ratio may cause deterioration. When fibers were exposed on a surface, they showed evidence of corrosion; however, internal fibers showed no corrosion.

1.4: Need for the project

The needs for this project are as follows:

To recover the tensile strength of the plain cement concrete with coconut shell steel fibers are to be used and to judge the results with conservative concrete with steel fibers.

1.5: Objectives of the project

The main objectives of this project are as follows:

To optimize the volume fraction of the selected aspect ratio of steel fiber in coconut shell concrete.

To study the mechanical properties of that optimized fiber in comparison with conventional and coconut shell concrete.

1.5: Scope of the project- The scope of this learning is to analyse the mechanical properties of coconut shell concrete added with steel fibres and increasing the ductile property in the manufacturing of concrete. Steel fiber is added in different percentage from 0.5 % to 2 % to coconut shell concrete and compared to conventional concrete.

2. Methodology

To study the behaviour of coconuts shell with various volume fraction of steel fibre in concrete was studied through the following methodology is shown in the figure 1 .

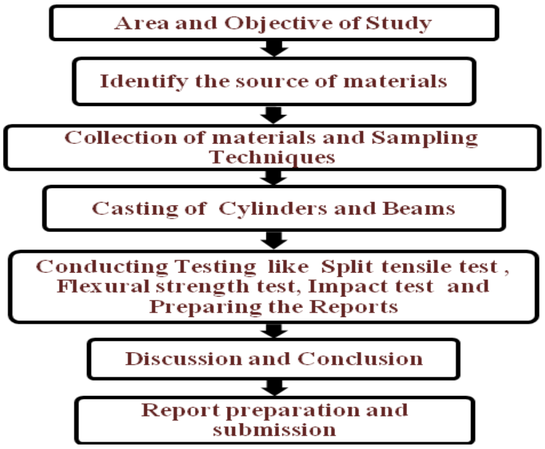

Figure 1. Methodology

3. Materials

In this experimental study the composition of concrete materials like cement, crushed granite stone, coconut shell, fine aggregate, steel fiber and water used were described as follows:

3.1 Cement

The cement used in this study is Ordinary Portland Cement (OPC) and is conforming to IS: 12269-1987. The cement properties are listed in then table1.

Table 1 Properties of cement

Description	Test Results	As per IS: 12269-1987
Fineness, %	4.12	Maximum 10%
Normal consistency, %	31	27 – 33
Initial setting time, min.	76	Not less than 30
Final setting time, min.	430	Not more than 600
Specific gravity	3.1	3.10 – 3.15

3.2 Crushed Granite Stone

The stone aggregate of size around 12.5mm is chosen as coarse aggregate for control concrete chosen by shape as per IS: 2386 (Part 1)-1963 and surface quality description of the aggregate are classified as per IS: 383-1970. The properties of crushed granite stone were shown in table 2.

Table 2 Properties of crushed granite stone

Description	Test Results	As per IS: 383-1970
Fineness modulus	6.94	5.00 – 7.00
Specific gravity	2.82	2.60 – 2.90

3.3 Coconut Shell Aggregate

The freshly unused coconut shell collected from industries was second-handed. The various size of coconut shells are used. The figure 2 shows coconut shell aggregate before crush and Figure 3 shows coconut shell after crush. The properties of coconut shell were shown in table 3.

Table 3 Properties of coconut shell

Description	Test Results
Fineness modulus	6.26
Specific gravity	1.05

Figure 2. Coconut shell before crush

Figure 3. Coconut shell after crush

3.4 Fine Aggregate

The sand used for the research programme was taken from nearby river sand and conformed to grading II as IS: 383-1970. The sand was first passed in 4.75mm sieve to eliminate any particles superior than 4.75mm. The properties of fine aggregate were shown in table 4.

Table 4 Properties of fine aggregate

Description	Test Results
Fineness modulus	2.56
Specific gravity	2.57

3.5 Steel Fiber

Steel fibers are added at various proportions from 0.5 % to 2.0 % to find the optimum level both in control concrete and coconut shell aggregate concrete by volume fraction. The properties of steel fiber used were shown in able 5.

Table 5 Properties of steel fiber

Parameters	Value
Length, mm	50
Diameter, mm	1
Aspect ratio (l/d)	50
Tensile strength, N/mm2	1225
Elastic modulus, N/mm2	210000

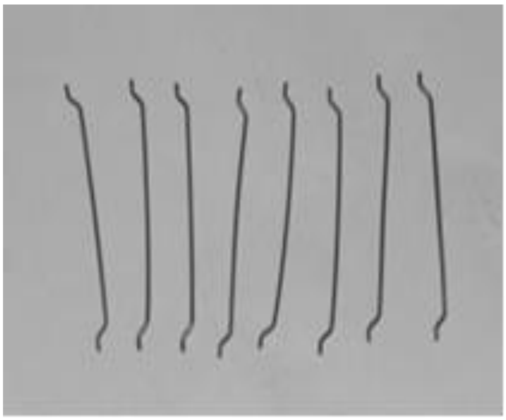

Figure 4. Hooked end steel fibers

Figure 5. Fresh concrete specimens

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3.6 Water

Potable water is mostly initiated in fresh concrete and curing of specimens which remain free of charge from all impurities.

3.7 Specimen details

Rectangular cast of size 100 mm × 100 mm × 500 mm were used to prepare the concrete specimens for the determination of flexural strength. Cylindrical mould of size 200 mm height and 100 mm diameter were used to prepare the concrete specimens for the determination of split tensile strength and modulus of elasticity and cylindrical mould of size 63.5 mm height and 152.4 mm diameter were used to prepare the concrete specimens for the determination of impact resistance.

3.8 Modulus of Elasticity of Concrete

The test specimens used for determining elastic modulus were 100 mm diameter and 200 mm height. During this test, deflection at each 5000 N load was recorded. Figure 4 shows the fresh concrete cube, beam and cylindrical specimens. Figure 5 shows the fresh concrete specimens

3.9 Recent studies on Concrete replacement

Tomas and Ucol-ganiron [1] the study remains about the design a technical specification of concrete hollow block using coconut shell and fiber as aggregates that will meet the ASTM requirements in order to help contribute to the industry in saving the environment. A conventional concrete hollow block was compared to concrete hollow blocks with coconut shells and fibers of the same proportions. Observations from the tests performed were conducted in the laboratory where precise data are gathered and completely attained. Vishwas P and Kukarni [2] the three different concrete mixes with different combination of natural material content namely 0 %, 10 %, 20 %, and 30 %. Three sample specimen will be prepared for each concrete mixes. The aim behind this is to use low cost material like coconut shell and thus taking close to the concept of low cost housing. All precaution is taken to maintain serviceability, strength and durability of the members.

Sivakumar A and Manu Santhanam [3] the review shows addition of steel fibers generally contributed towards the energy absorbing mechanism (bridging action) whereas, the non-metallic fibers resulted in delaying the formation of micro-cracks. Compared to other hybrid fiber reinforced concretes, the flexural toughness of steel-polypropylene hybrid fiber concretes was comparable to steel fiber concrete. Increased fiber availability in the hybrid fiber systems (due to the lower densities of non-metallic fibers), in addition to the ability of non-metallic fibers to bridge smaller micro cracks, are suggested as the reasons for the enhancement in mechanical properties. Gunasekaran K and Annadurai R[4] investigated the effects of three types of curing on coconut shell aggregate have been studied for long term performance. The freshly discarded coconut shell collected from local oil mill was used in this study since the different species of coconut shell were processed together, the shells are found to have varying thickness of 2-8 mm. the pore structure of coconut shell has been studied through scanning electron microscope (SEM). The pore structures in coconut shell behave like a reservoir. Coconut shell specimens has very closely spaced discrete cells and also has some long continuous chain linked cells with different widths. There is no bond failure in coconut shell aggregate concrete even at the later ages and maintained good quality for the long-term performance. Song P S and Hwang S [5] investigated that the marked brittleness with low tensile strength and strain capacities of high-strength concrete (HSC) can be overcome by the addition of steel fibers. This paper investigated the mechanical properties of high-strength steel fiber-reinforced concrete. The properties included compressive and splitting tensile strengths, modulus of rupture, and toughness index. The steel fibers were added at the volume fractions of 0.5 %, 1.0 %, 1.5 %, and 2.0 %. The compressive strength of the fiber-reinforced concrete reached a maximum at 1.5 % volume fraction, being a 15.3 % improvement over the HSC.

4. Results and Discussion

The results of cube, cylinder and beam specimens are analysed for the comparison between the conventional concrete (CC) and coconut shell concrete (CSC) specimens and presented.

4.1 Fresh Concrete Properties

Coconut shell aggregate concrete M25 grade has better workability because of smooth measures. The various percentages of steel fibers are added to improve the strength. Fresh concrete properties for conventional concrete and coconut shell concrete added with various percentage of steel fiber are shown in the table 6 respectively.

Table 6 Fresh concrete properties for CC and CSC with various % of steel fiber

% of steel fiber	Conventional concrete		Coconut shell concrete	
	Slump (mm)	Density (kg/m3)	Slump (mm)	Density (kg/m3)
0	10	2503	5	1976
0.5	10	2530	5	1982
1.0	10	2538	5	2039
1.5	10	2546	5	2087
2.0	12	2558	8	2127

4.2 Hardened Concrete Properties

The mechanical properties like flexural strength, split tensile strength, impact resistance and elastic modulus of control concrete and coconut shell concrete along with optimized percentage of steel fiber was studied.

4.3 Flexural Strength

Flexural strength for conventional and coconut shell concrete with optimized percentage of steel fiber are 1.0 % and 1.5 % respectively. The flexural strength was computed from the following equation.

Modulus of rupture = $\frac{PL}{bd^2}$ N/mm^2

where,

P = maximum load applied (N)
L = supported length of the specimen (mm)
b = breath of the section (mm)
d = depth of the section (mm)

The flexural strength test results of conventional concrete and coconut shell concrete without addition of steel fiber and with addition of optimized percentage of steel fibers are shown in table 7.

Maximum flexural strength for conventional and coconut shell concrete without addition of steel fiber is 5.73 N/mm2 and 4.67 N/mm2 respectively. The maximum flexural strength for conventional and coconut shell concrete with addition of optimized percentage of steel fiber is 6.67 N/mm2 and 5.87 N/mm2 respectively. The figure 6 shows the flexural strength of conventional concrete and coconut shell concrete without addition of steel fiber and with addition of optimized percentage of steel fiber at 28 days.

Table 7 Flexural strength of CC and CSC with and without steel fiber

Type of concrete	% of steel fiber added	Flexural strength (N/mm^2)
CC	0	5.73
CSC	0	4.67
CC	1.0	6.67
CSC	1.5	5.87

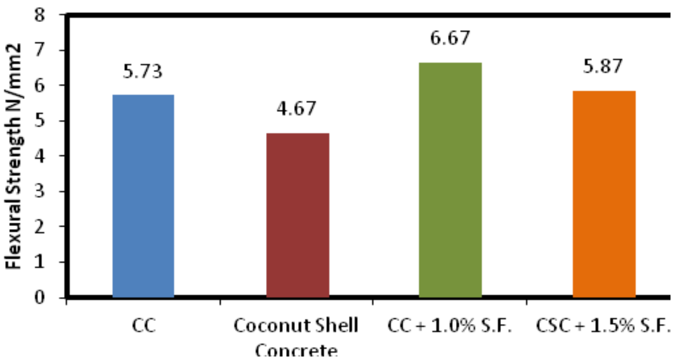

Figure 6. Flexural strength of CC and CSC with and without steel fiber

4.4 Split Tensile Strength

Split tensile strength test for conventional and coconut shell concrete with an optimized percentage of steel fiber are 1.0 % and 1.5 % respectively. Shear and bond strength between aggregate and cement paste and crack resistance are related to tensile strength of coarse aggregate and cement paste.

The splitting tensile strength was computed from the following equation.

$Fsp = \frac{2P}{\pi DL}$ N/mm^2

Where,

Fsp = Split tensile strength (N/mm^2)

P = Load at Failure (N)

D = Diameter of the specimen (mm)

L = Length of the specimen (mm)

The split tensile strength test results of conventional concrete and coconut shell concrete without addition of steel fiber and with addition of optimized percentage of steel fibers are shown in table 8.

Table 8 Split tensile strength of CC and CSC with and without steel fiber

Type of concrete	% of steel fiber added	Split tensile strength (N/mm^2)
CC	0	3.40
CSC	0	2.65
CC	1.0	4.17
CSC	1.5	3.07

Maximum split tensile strength for conventional and coconut shell concrete without addition of steel fiber is 3.40 N/mm2 and 2.65 N/mm2 respectively. Maximum split tensile strength for conventional and coconut shell concrete with addition of optimized percentage of steel fiber is 4.17 N/mm2 and 3.07 N/mm2 respectively. The figure7 shows the split tensile strength of conventional concrete and coconut shell concrete without addition of steel fiber and with addition of optimized percentage of steel fiber at 28 days.

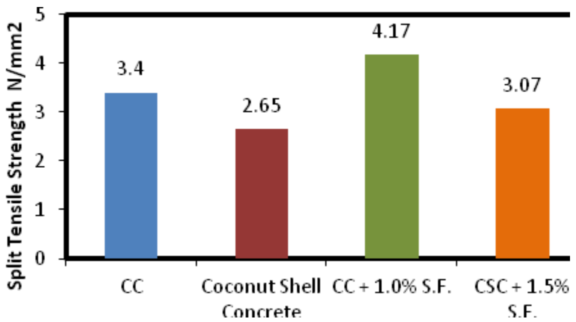

Figure 7. Split tensile strength of CC and CSC with and without steel fiber

4.5 Impact Resistance

Impact test for conventional and coconut shell concrete with optimized percentage of steel fiber is 1.0 % and 1.5 %. The test specimens used for the impact tests were 152.4 mm in diameter and 63.5 mm thick. The number o blows are listed initially or First crack and listed also for the final crack. The impact test results are presented table 9.

Table 9 Impact resistance of CC and CSC with and without steel fiber

Type of concrete	% of steel fiber added	Compressive strength (N/mm2)	Average number of blows for initial crack	Average number of blows for fractured pieces
CC	0	31.40	19	22
CSC	0	25.83	23	28
CC	1.0	37.25	38	42
CSC	1.5	29.12	45	50

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The impact resistance of coconut shell concrete is more compared to conventional concrete both for initial and for failure. For conventional concrete without addition of steel fiber an average number of blows observed for making an initial crack is 19 and for making failure is 22 and with addition of optimized percentage of steel fiber for making an initial crack is 38 and for making final crack is 42. For coconut shell concrete without addition of steel fiber an average number of blows observed for making an initial crack is 23 and for making failure is 28 and with addition of optimized percentage of steel fiber for making an initial crack is 45 and for making final crack is 50. Compared to conventional concrete, coconut shell concrete offered impact resistance 20 % more approximately, this increase in impact resistance may be due to the fibrous nature of the coconut shell aggregate and its high impact resistance.

4.6 Modulus of Elasticity of Concrete

The test was carried out conforming to IS: 516-1959 to obtain the stress-strain curve and modulus of elasticity of the concrete. Stress-Strain graph for conventional concrete is shown in figure 8 and for coconut shell concrete is shown in figure 9.

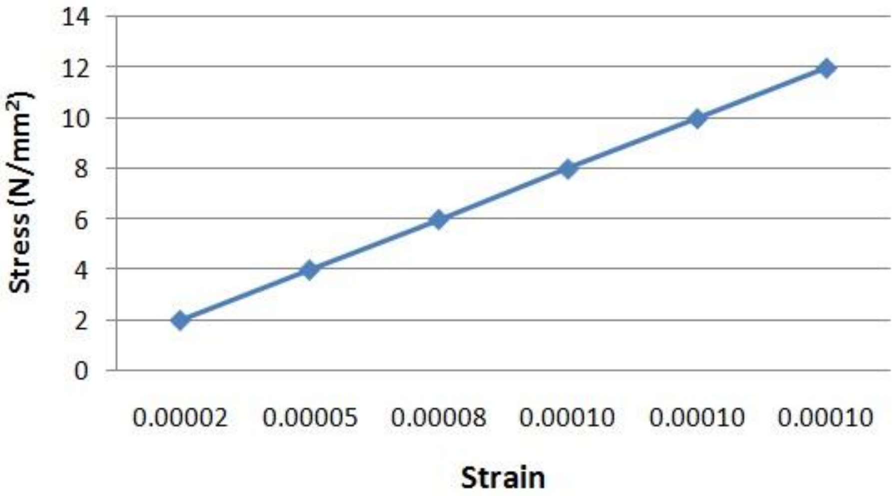

Figure 8. Stress-strain curve for CC

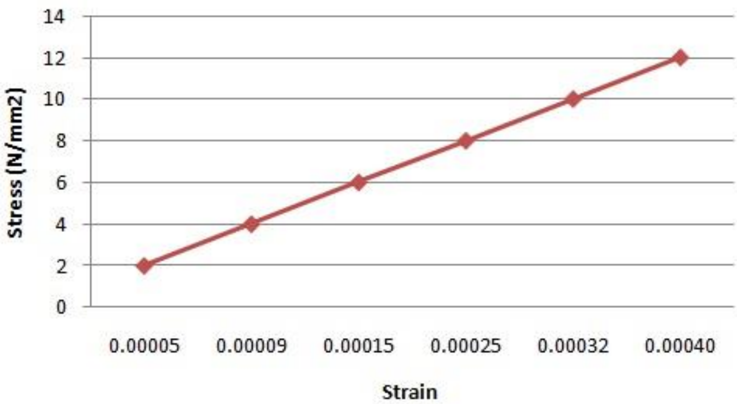

Figure 9. Stress-strain curve for CSC

Stress-Strain graph for optimized percentage of steel fiber in conventional concrete is shown in figure 10 and for coconut shell concrete is shown in figure 11.

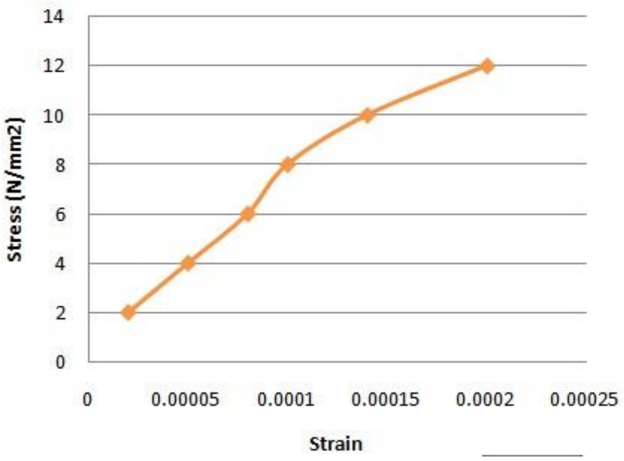

Figure 10. Stress-strain curve for CC with 1.0 % steel fiber

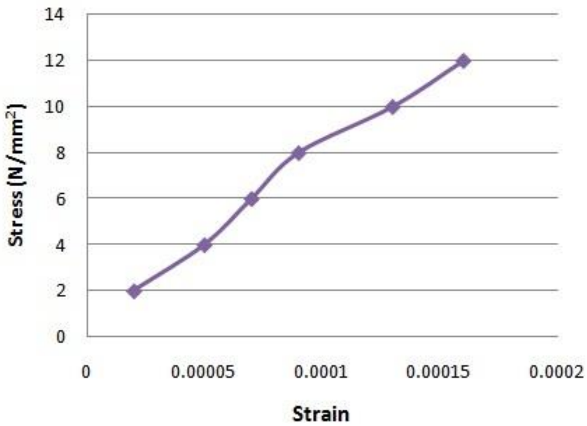

Figure 11. Stress-strain curve for CSC with 1.5 % steel fiber

The figure 12 shows comparison of stress-strain curve for conventional and coconut shell concrete without steel fiber.

From figure 12 it is noted that stress-strain diagram of coconut shell concrete is slightly below that of conventional concrete for a constant stress the strain is more in conventional concrete. Thus the young's modulus of conventional concrete will be more than that of coconut shell concrete.

The modulus of elasticity for conventional concrete and coconut shell concrete are 32608 N/mm2 and 11300 N/mm2 respectively.

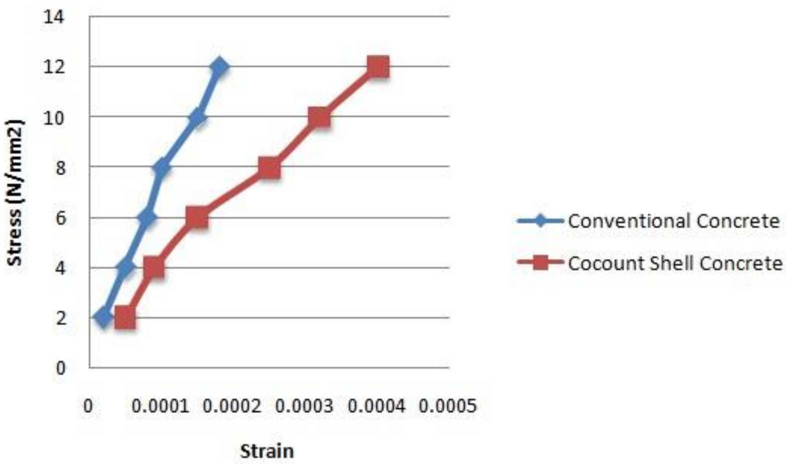

Figure 12. Comparison of stress-strain curve for CC and CSC

The figure 13 shows comparison of stress-strain curve for conventional and coconut shell concrete with optimized percentage of steel fiber.

From figure 13 it is noted that stress-strain diagram of coconut shell concrete is slightly below that of conventional concrete for a constant stress the strain is more in conventional concrete. Thus the young's modulus of conventional concrete will be more than that of coconut shell concrete.

The modulus of elasticity for conventional concrete and coconut shell concrete with optimized steel fiber are 36450 N/mm2 and 12280 N/mm2 respectively.

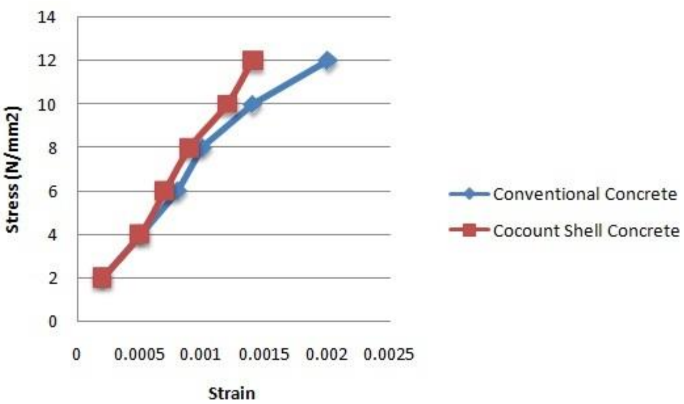

Figure 13. Comparison of stress-strain curve for CC and CSC with optimized % of steel fiber

5. Conclusions

The following conclusions have been drawn from the experimental results of this study.
The addition of steel fibers increases the strength of concrete. The optimized percentage of steel fiber used in conventional concrete is 1.0 % of the total volume of concrete and in coconut shell concrete is 1.5 % of the total volume of concrete.
For the optimized percentage of steel fiber, flexural strength of conventional concrete and coconut shell concrete is 6.67 N/mm2 and 5.87 N/mm2 at an age of 28 days. The flexural strength increased by 16.40 % in conventional concrete and 25.70 % in coconut shell concrete for optimized steel fiber

compared to without addition of steel fiber respectively
For the optimized percentage of steel fiber, split tensile strength of conventional concrete and coconut shell concrete is 4.17 N/mm2 and 3.07 N/mm2 at an age of 28 days. The split tensile strength increased by 22.64 % in conventional concrete and 15.85 % in coconut shell concrete for optimized steel fiber compared to without addition of steel fiber respectively
The impact resistance of coconut shell aggregate concrete is high when compared with conventional concrete. The impact resistance increased by 90.90 % in conventional concrete and 78.57 % in coconut shell concrete for optimized steel fiber compared to without addition of steel fiber respectively.
The modulus of elasticity for conventional concrete and coconut shell concrete with optimized steel fiber are 36450 N/mm2 and 12280 N/mm2 respectively.

5.1: Scope for future study
Effect of different fibers on coconut shell concrete can be studied
Structural behavior of coconut shell concrete with different fiber can be studied.
Making high strength of coconut shell concrete using different fibers can be studied.

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