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An Experimental Study On Flexural & Tensile Strength Of Concrete By Using Sugarcane Baggase Ash& Steel Fiber

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ABSTRACT

Generally the concrete is weak in tensile as well as flexural strength which are some basic strength properties of any structure. Steel fiber can be potentially used in the concrete to improve its structural strength. Use of steel fiber in the concrete will also reduce the steel reinforcement requirement at later stage. Concrete was prepared in the present research work in which sugarcane bagasse ash was used to substitute cement to minimize cement use and thereby reduce construction costs. In this work concrete cubes were casted in various proportions of SCBA like 5%, 10%, 15%, and 20%. This combination was further enhanced by adding steel fiber by volume in percentages like 0.5%, 1%, and 1.5%. The cubes were prepared using this combination and tested at different curing ages, such as 7-days, 28-days, 56-days and 90-days. At such ages, concrete properties such as compressive strength, flexural strength and split tensile strength were analyze

1. Introduction

In the field of construction, concrete is the most resourceful, sustainable and environmentally friendly part. It can be casted in any shape and size from cylindrical water tank to beams, columns of any building. Owing to its brittle nature, concrete is essentially very good in compression. It is fairly less ductile therefore its tensile strength is not appreciable. To improve its tensile strength reinforcement is added to the concrete and the most common form of reinforcement which is added to the concrete is steel bars at the time of construction. Concrete has wide advantages such as high compressive strength, fire resistant, low maintenance but on the other hand formwork demand, poor tensile strength, and low strength per unit weight are some of the major disadvantages

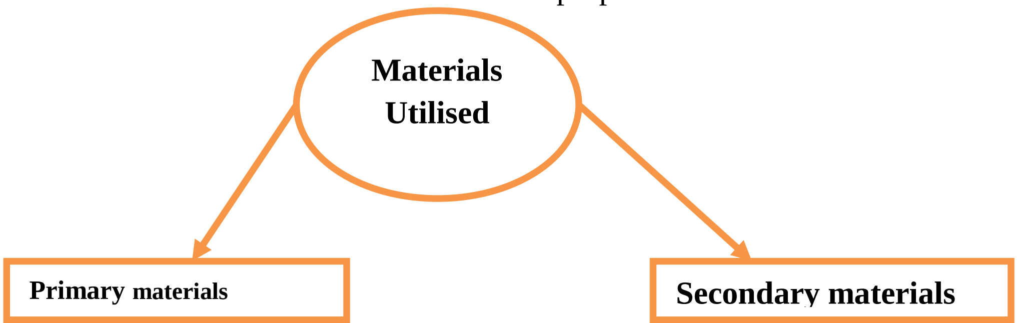
The field of civil engineering is developing constantly where a demand for strong concrete consumption has become necessary. To meet the strength and performance demands the concrete should enhanced by adding some amount reinforcement. Nowadays fiber reinforced concrete has taken a huge lime light in the construction industry to reduce the dependence of steel reinforcement at later stage. Steel fiber is highly manufactured in India and it can be extensively be used in the field of construction. The major role of steel fiber in the concrete is to resist the cracking and fracture in the concrete produced due to external loads coming over it. Addition of steel fiber reduced the crack propagation as it acts as stitch for the cracks if arrived. Owing to this exceptional property in steel fibre reinforced concrete, the cracks are avoided and the concrete's tensile strength is significantly increased. This also imparts ductility to the concrete which is not developed in the ordinary concrete. The transformation of brittle material into the ductile material will substantially increase the property of energy absorption and thereby improve its ability to stand against the impact and cyclic loads which cases fatigue and cracking the concrete.

The fiber reinforced concrete can be defined as the composite mixture of cement, fine aggregate, coarse aggregate, admixture and steel fiber which are randomly oriented. This randomly oriented fibers act a bridge when a crack is being generated. Steel fibers basically improve the toughness of the concrete under any kind of loading thereby improving its resistance for external load. The peak load carrying capacity of the concrete is highly increased with inclusion of steel fibers. These fibres may also be known as aggregates, as the filling content for the cracks and the use of this randomly oriented discrete fibre enhances the concrete's homogeneity and also increases the concrete’s density, which in turn improves the concrete's physical and mechanical properties. To date, several techniques have been developed to research the effect of steel fibre on concrete strength, but a systematic and unified approach has not yet been developed.

The current research work contains not only use of steel fiber but also utilizing sugarcane bagasse ash as cement replacement component. The sugarcane bagasse ash is very rich in silica content which is one of the major ingredients for strength enhancement. The SCBA was used in different percentages along with the steel fibers. The concrete composition was tested for various tests to check the improvement in the properties such as

- Flexural strength
- Compressive strength
- Density
- Split tensile strength

But the extent of improvement of these properties depends on the shape, size, volume and percentage of fiber added to the concrete. Therefore, an optimal dosage of steel fiber reinforcement and SCBA was composed to get enhancement in the above desired properties.



Cement
OPC 53 grade cement was utilized in the project work having specific gravity of 3.16 which confirmed all the tests and standards such as consistency, soundness, fineness etc.

Fine aggregates
River bed sand was obtained from Kanhan river. The specific gravity was 2.69 and it confirmed to zone II Indian Standard codes.

Coarse aggregate
Locally available crushed aggregates were used having specific gravity of 2.68. These aggregates confirmed all the IS standards and tests such as elongation & flakiness index, crushing strength etc.

Water
Normal tap water was used while preparing the design mix whose Ph level was confirmed according to the IS standards.

Sugar-cane bagasse ash
SCBA was obtained from Vainganga Sugar and Power Ltd. Devhara district, Bhandara. SCBA is basically a by-product of sugar factories which is developed by burning sugarcane bagasse.
The SiO_2 content in the SCBA is around 77% and rest it contained the oxides such as CaO, MgO, ZrO etc.

Steel fiber-
These are basically the thin steel fiber thread obtained from market. These are readily available in market as they are pre manufactured from the industry. The dimensions of the steel fiber are as follows.
Nomenclature-7560
Diameter-1mm
Length-60mm
Aspect ratio-80

2. Details of Secondary materials

Sugar-cane bagasse ash

SCBA was obtained from Vainganga Sugar and Power Ltd. Devhara district, Bhandara. In essence, SCBA is a by-product of sugar factories produced by the combustion of sugarcane bagasse.

Fig-1*: sieved sugar cane bagasse ash***.**

Chemical Composition of Sugarcane Bagasse Ash

The analysis showed inclusion of different oxides in addition to silica. The detailed chemical analysis of SCBA is shown in the following table.

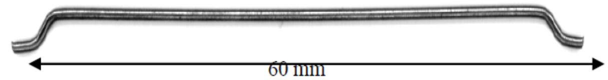
Table-1 *Sugarcane Bagasse ash's Chemical Composition*

Oxides	Percentage	Oxides	Percentage
Na_2O	0.162 %	Rb_2O	0.011 %
MgO	2.905 %	ZrO_2	0.101 %
Al_20_3	1.097 %	SrO	0.018 %
SiO_2	76.667 %	Cr_2O_3	0.008 %
P_2O_5	3.115 %	MnO_2	0.130 %
SO_3	0.118 %	LOI	3.15 %
CI	0.026 %	CaO	3.496 %
TiO_2	0.123 %	K_2O	7.521 %
BaO	0.015 %	Fe_2O_3	1.315 %
CuO	0.021 %		

Steel fibre

Fibre is basically astrand of reinforce substances possess certain reinforcing properties.It could be flat or circular in shape. Fibers are defined by the convenient "Aspect ratio" parameter, which is the ratio of their length to diameter.

Since the early 1900s, steel fibres have been utilised in concrete. The fibres were round and smooth earlier and the wires were chopped into the lengths needed. But now number of steels fibres are available as reinforcement in the market. Diameter range between 0.23 to 1 mm. They generally have rectangular c/s which is created by slicing the sheet of 0.25 mm thick.



(a)

3. Experimentation work

The experiment was carried out in different phases. Firstly, the nominal mix was prepared and its Split Tensile strength & flexural for 7, 28, 56 and 90 days was analysed. On observing these strengths steel fiber was added into it in the proportion of 0.5%, 1%, 1.5%. This combination was further carried forward using SCBA as a replacement for cement in various percentage such as 5%, 10%, 15% and 20%. Every combination was then tested by including the fibers of steel in the proportion of 0.5%, 1%, and 1.5% by volume of the total concrete. The flow charts shows the entire experimentation carried out in the research.

Experiment flow chart

Preparing a nominal mix design for M25 and M30 as per IS standard specifications and thereby assessing it for flexural as well as split tensile strength.

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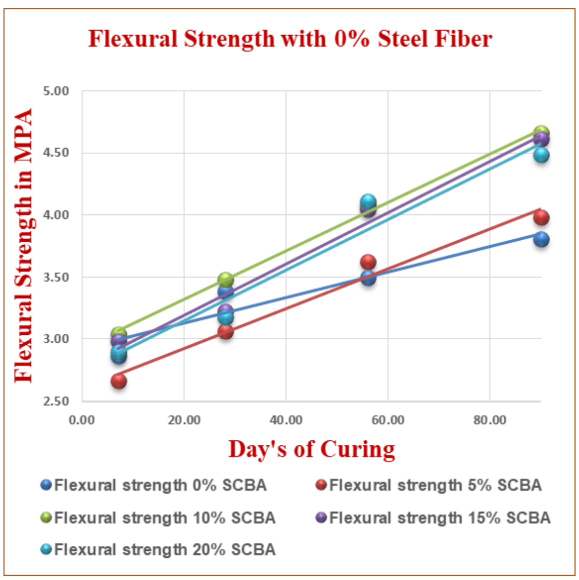
Using the same mix and including steel fiber in it in the proportion of 0.5%, 1% and 1.5% by volume and thereby

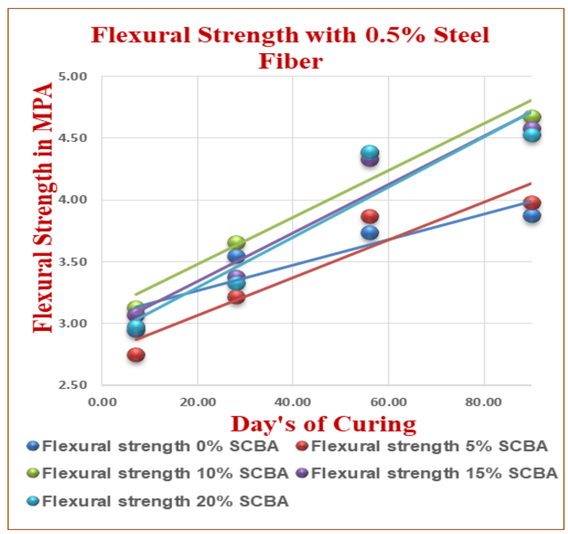
4. Experimentation Results

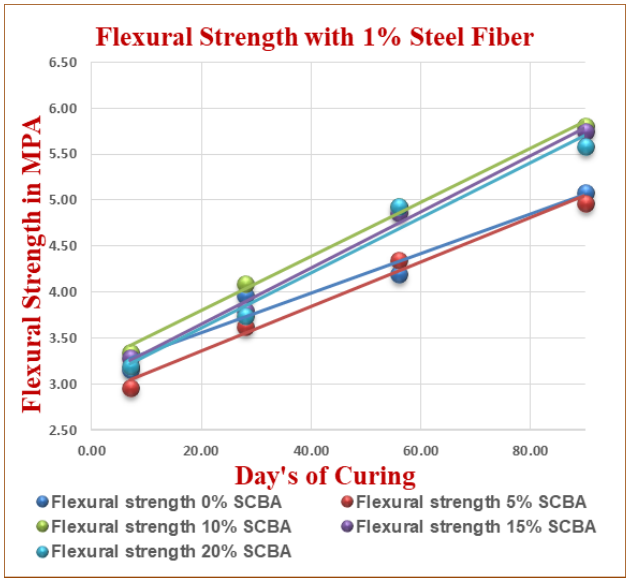
Table-2 *M25 Grade of Concrete in MPA Flexural Test Results*

Days of curing	% of SF	Flexural strength 0% SCBA	Flexural strength 5% SCBA	Flexural strength 10% SCBA	Flexural strength 15% SCBA	Flexural strength 20% SCBA

7.00	0% SF	2.87	2.67	3.04	2.98	2.90
28.00		3.38	3.07	3.48	3.22	3.17
56.00		3.50	3.62	4.08	4.04	4.11
90.00		3.80	3.98	4.66	4.61	4.48
7.00	0.5% SF	2.95	2.75	3.13	3.07	2.98
28.00		3.54	3.22	3.66	3.38	3.33
56.00		3.74	3.87	4.38	4.33	4.39
90.00		3.88	3.98	4.67	4.58	4.53
7.00	1% SF	3.04	2.84	3.22	3.16	3.07
28.00		3.70	3.39	3.82	3.68	3.50
56.00		4.00	4.14	4.69	4.63	4.70
90.00		4.93	4.82	5.64	5.58	5.42
7.00	1.5% SF	3.16	2.95	3.35	3.29	3.19
28.00		3.96	3.62	4.09	3.80	3.75
56.00		4.20	4.35	4.92	4.86	4.94
90.00		5.08	4.96	5.81	5.75	5.58







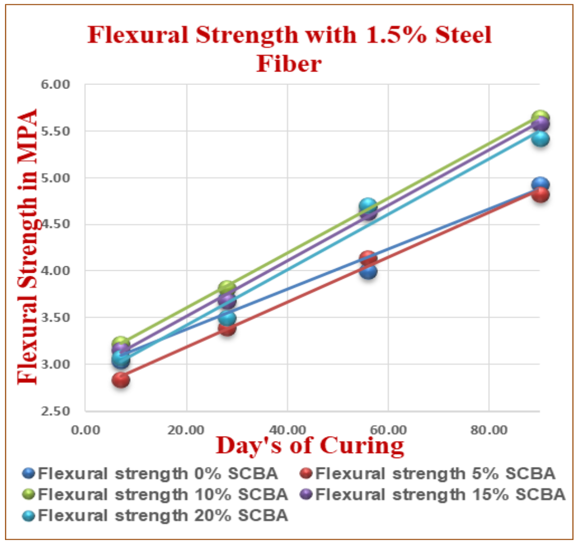
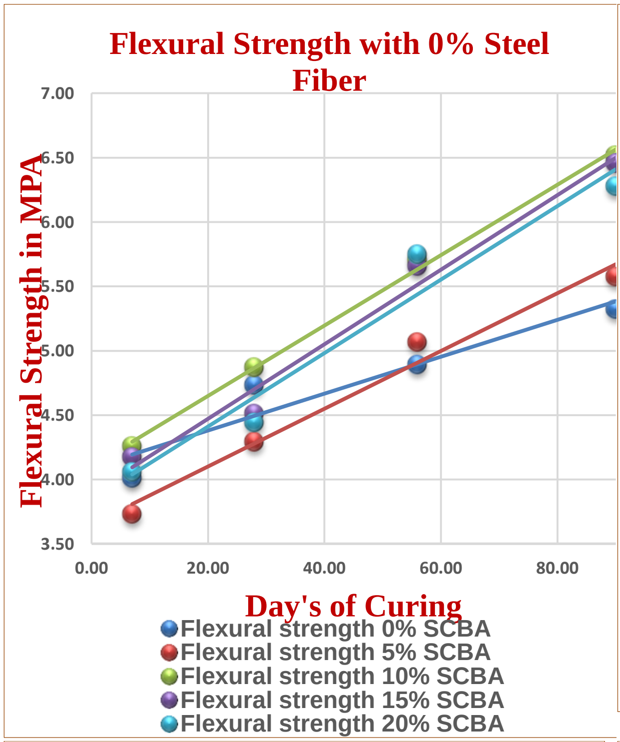
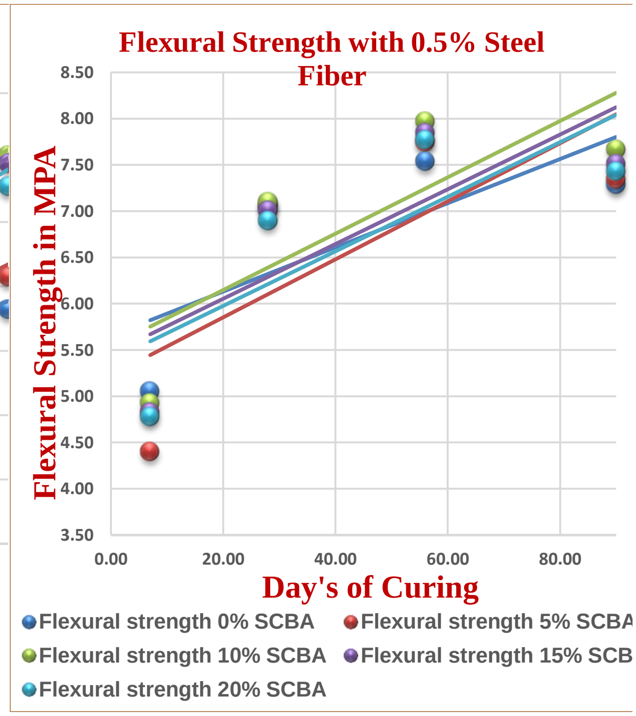


Table-3 *Flexural Test results for M30 Grade of Concrete in MPA*

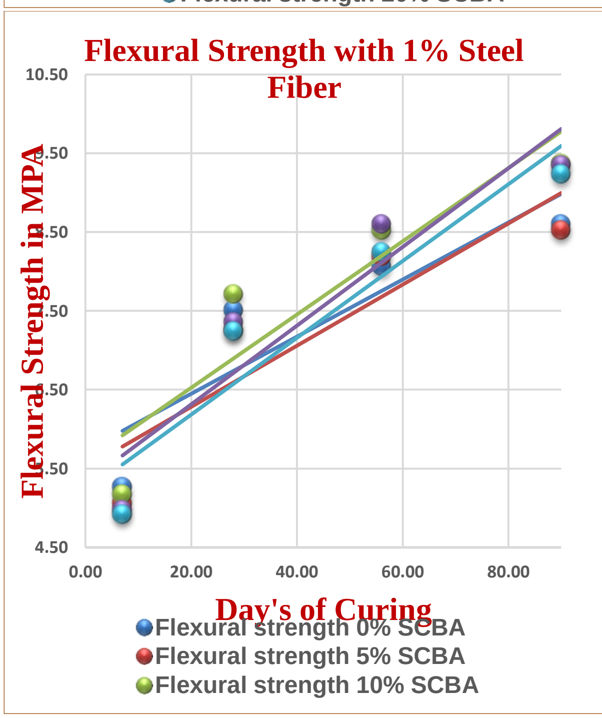
Days of curing	% of SF	Flexural strength 0% SCBA	Flexural strength 5% SCBA	Flexural strength 10% SCBA	Flexural strength 15% SCBA	Flexural strength 20% SCBA
7.00	0% SF	4.01	3.73	4.26	4.18	4.06
28.00		4.74	4.29	4.87	4.51	4.44
56.00		4.90	5.07	5.71	5.66	5.75
90.00		5.32	5.57	6.52	6.46	6.28
7.00	0.5% SF	5.05	4.40	4.93	4.83	4.78
28.00		7.05	7.07	7.10	7.01	6.90
56.00		7.54	7.75	7.97	7.85	7.77
90.00		7.29	7.35	7.67	7.51	7.43
7.00	1% SF	5.27	5.06	5.17	4.98	4.92
28.00		7.51	7.27	7.72	7.36	7.24
56.00		8.07	8.19	8.53	8.60	8.25
90.00		8.60	8.52	9.37	9.35	9.24
7.00	1.5% SF	5.40	5.12	5.44	5.10	5.04
28.00		7.48	7.47	7.62	7.53	7.41
56.00		8.24	8.36	8.75	8.52	8.33
90.00		8.76	9.06	9.55	9.47	9.45



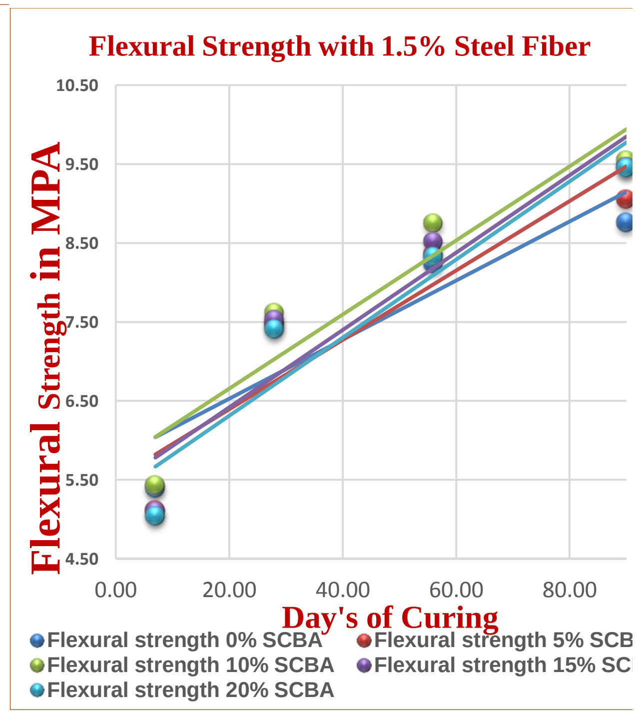
Flexural Strength with 0% Steel Fiber
Flexural Strength in MPA
Day's of Curing
Flexural strength 0% SCBA
Flexural strength 5% SCBA
Flexural strength 10% SCBA
Flexural strength 15% SCBA
Flexural strength 20% SCBA



Flexural Strength with 0.5% Steel Fiber
Flexural Strength in MPA
Day's of Curing
Flexural strength 0% SCBA
Flexural strength 10% SCBA
Flexural strength 20% SCBA



Flexural Strength with 1% Steel Fiber
Flexural Strength in MPA
Day's of Curing
Flexural strength 0% SCBA
Flexural strength 5% SCBA
Flexural strength 10% SCBA



Flexural Strength with 1.5% Steel Fiber
Flexural Strength in MPA
Day's of Curing
Flexural strength 0% SCBA
Flexural strength 10% SCBA
Flexural strength 20% SCBA

Table-4 *M25 Grade of Concrete in MPA Split Tensile Test Results*

Days of curing	% of SF	0% SCBA	5% SCBA	10% SCBA	15% SCBA	20% SCBA
7.00	0% SF	1.46	1.89	1.98	1.38	1.28
28.00		2.44	2.96	3.48	2.11	2.05
90.00		2.92	3.26	4.07	3.27	2.66
7.00	0.5% SF	1.97	2.55	2.68	1.90	1.73
28.00		3.29	4.00	4.69	2.84	2.77
90.00		3.94	4.40	5.50	4.41	3.59
7.00	1% SF	2.12	2.74	2.88	2.84	1.86
28.00		3.53	4.29	5.04	4.09	3.73
90.00		4.23	4.72	5.91	5.40	4.52
7.00	1.5% SF	2.28	2.94	3.09	3.05	2.00
28.00		3.81	4.62	5.43	4.41	4.02
90.00		4.54	5.07	6.34	5.80	4.85

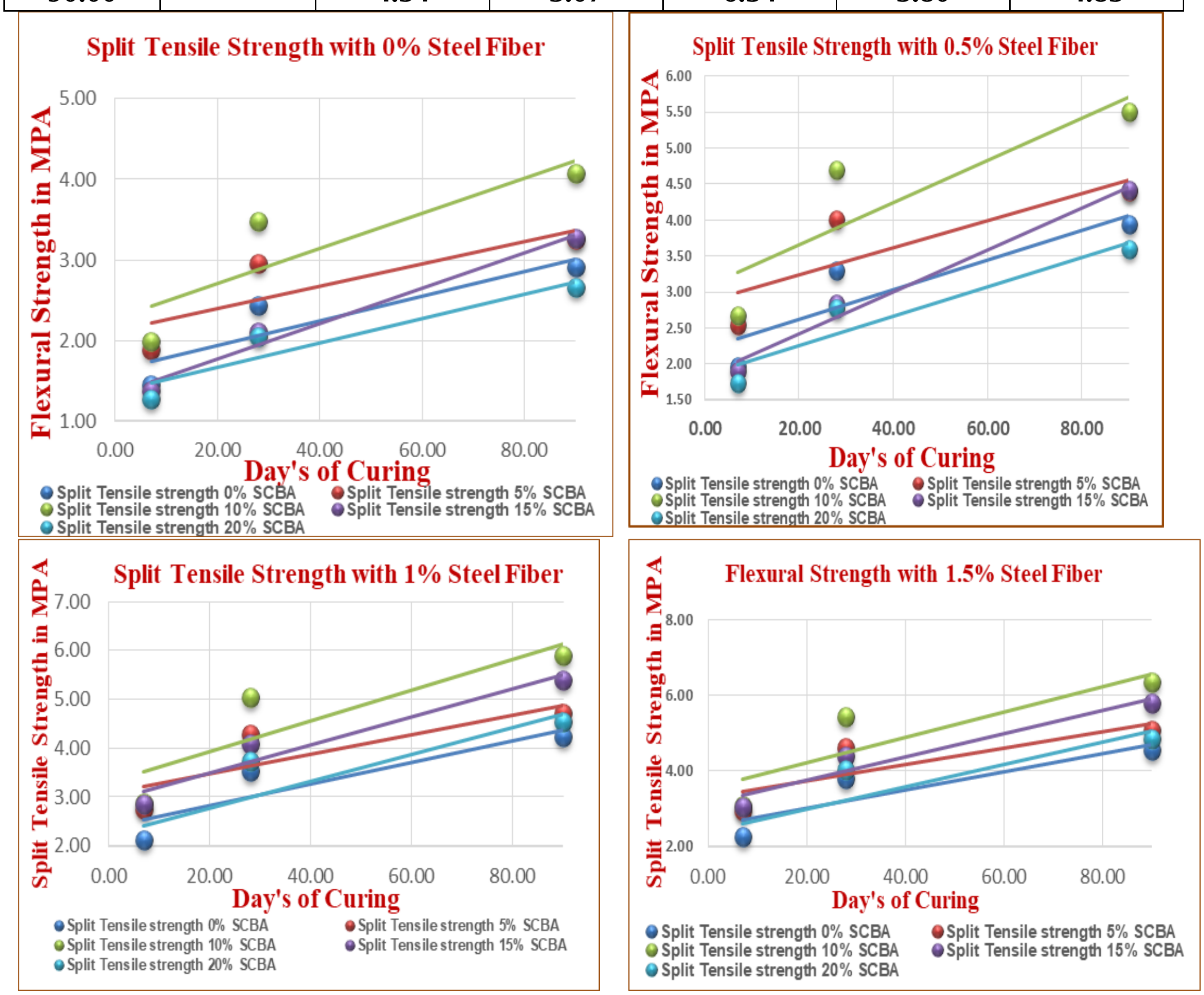
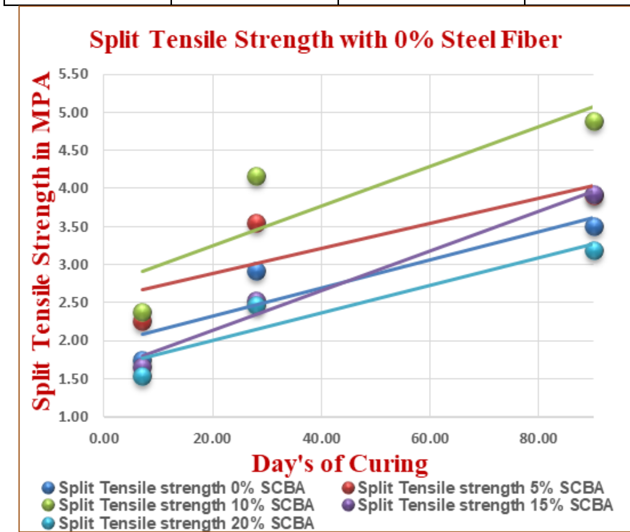
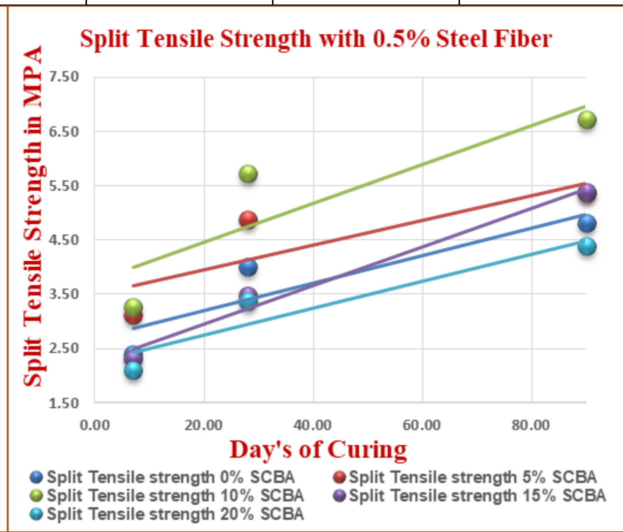
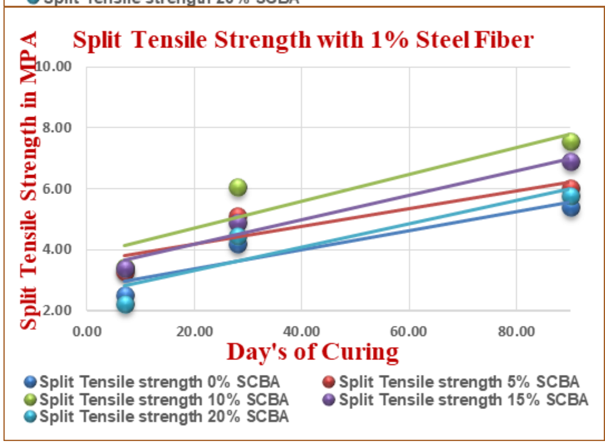


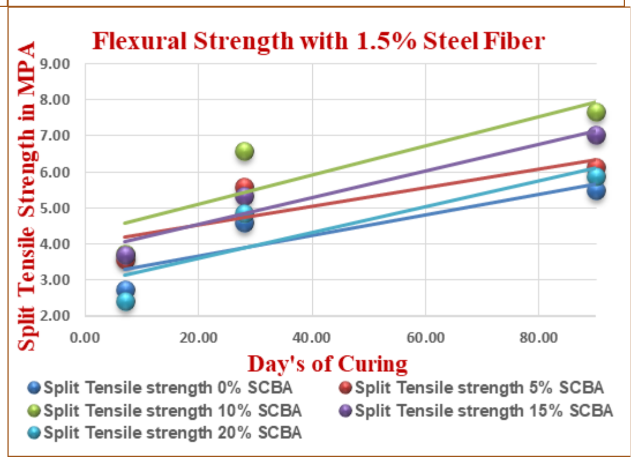
Table-5 *Split Tensile Test results for M30 Grade of Concrete in MPA*

Days of curing	% of SF	0% SCBA	5% SCBA	10% SCBA	15% SCBA	20% SCBA
7.00	0% SF	1.75	2.26	2.38	1.66	1.54
28.00		2.92	3.55	4.17	2.53	2.46
90.00		3.50	3.91	4.89	3.92	3.19
7.00	0.5% SF	2.40	3.11	3.27	2.31	2.11
28.00		4.01	4.88	5.73	3.47	3.38
90.00		4.81	5.36	6.71	5.38	4.38
7.00	1% SF	2.52	3.26	3.42	3.37	2.21
28.00		4.20	5.11	6.04	4.87	4.44
90.00		5.41	6.03	7.54	6.90	5.78
7.00	1.5% SF	2.75	3.56	3.74	3.69	2.42
28.00		4.60	5.59	6.57	5.33	4.87
90.00		5.50	6.13	7.67	7.02	5.87



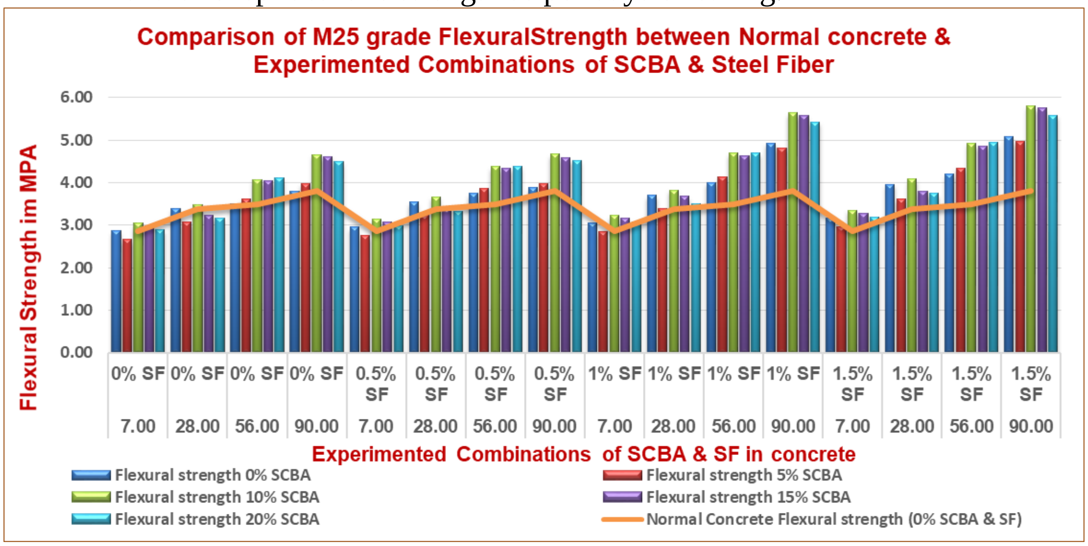


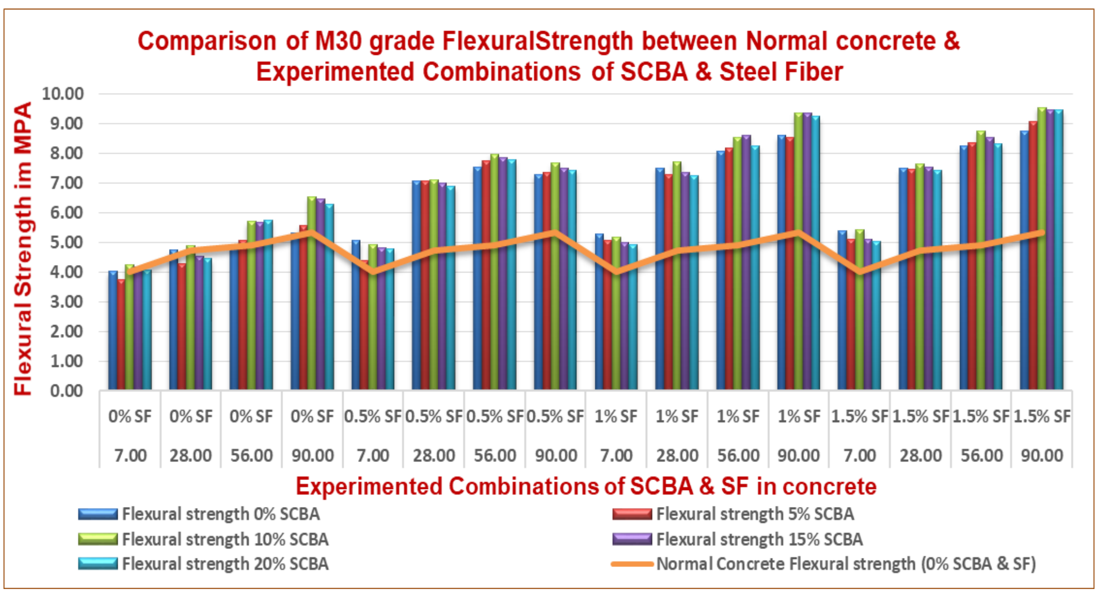


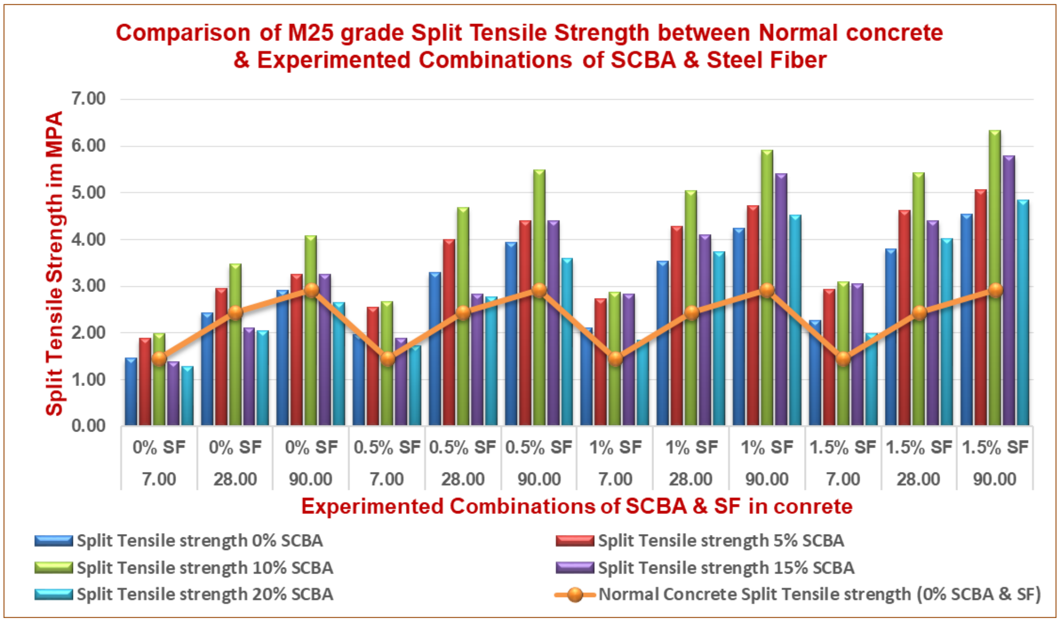


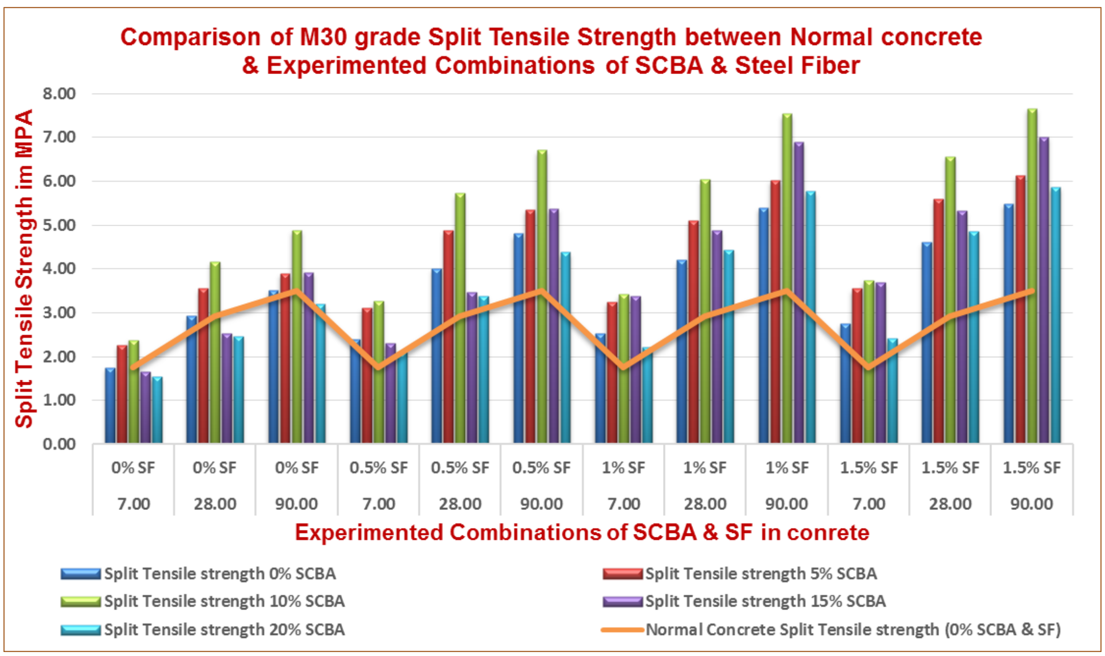
5. Comparison of the Result

To understand the impact of steel fibre addition & cement replacement in concrete with sugarcane baggase ash we compared their strength on the basis of days of curing with the strength of Normal concrete means concrete with same mix without addition of steel fiber & replacement of cement with sugarcane baggase ash. Following graph shows trend & comparison of the flexural & split tensile strength as per days of curing.









From the above all comparisons it is pretty evident that the concrete property did enhance when the SCBA was used along with the steel fiber. Basically a drastic improvement was seen in the tensile and flexural properties. In addition to it the failure pattern also changed as the phenomenon of instant cracking was reduced as the cracks were arrested by the steel fiber. The following lab images provide a better idea regarding the failure pattern of the cubes.

Specimen casted for flexural strength

Failure pattern images

The figure shows the failure pattern of the beam specimen which was casted in the laboratory and has undergone the two point loading test. The beam size was 100x100x500 mm. the loading was initiated through the machine and the loading continued till the failure crack was seen. This sample specimen corresponds to the combination of 10% SCBA with 1% steel fiber. The failure stress was calculate and it showed the value about 5.64 Mpa which was maximum among all the combination. The crack width was about 4mm.

This picture shows actually the cracked beam specimen looked like. The beam was cracked nearly from the center which showed a good sign that the cracks at other locations were arrested due to the steel fiber. This improvises the strength of the beam and allows it fail at the center where the maximum bending moments acts for the simply supported specimen.

The image relates split tensile strength of the cylinder. The specimen dimensions were 150x300mm. The testing was carried to determine the tensile strength of the concrete. The loading was gradually applied to the cylinder and in the meantime the failure was noted. Since it contained steel fiber in it, the fibers acted as reinforcement which improved the tensile strength as the specimen failed at a higher load that it failed when the minimal mix was constructed.

Images of failed specimens

The above specimens are the failed specimen of split tensile strength. These specimen showed a better cracking pattern when the steel fiber was inserted in it. The steel fiber gave a better reinforcing action to the concrete as it lifted the tensile strength of the concrete. The fibers also helped the cracks to get arrest thereby acting a stitched surface to the cracks which were popping out due to tensile failure.

From the entire research performed, the following findings were deduced.

- The concrete mix made by 10% SCBA replacement and 1% steel showed splendid results as compared to the nominal mix of the concrete.
- Steel fiber act as strong reinforcement in the concrete which can be further utilized in high performance concrete.
- It acts a stitching material in the concrete which blocks the cracks coming due to flexural and tensile stresses.
- Addition of steel fiber also reduces the dependence of reinforcement at later stages therefore making the concrete even more economical.
- Secondly addition of SCBA also improves the strength properties and it also suppress the cement consumption thereby leading to economy.
- As far as mass concreting is concerned at lower as well as higher stages this combination can firmly be utilized with proper mix design parameter.
- The study also proved that reducing the cement consumption and steel in the concrete will

also help in conserving the environment by reducing the air pollution in the surrounding produced from steel factories and sugar industries,

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