ISSN: 2350-0328

International Journal of Advanced Research in Science, Engineering and Technology

Vol. 4, Issue 9 , September 2017

Effect of Fiber Length and Percentage of SISAL on Strength of Concrete

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ABSTRACT: The natural fibres are investigated by different researchers as construction materials that can be used in cement paste/mortar/concrete. The present work is carried out to evaluate the compressive, tensile as well as Flexural strength of concrete using sisal fibres as admixture. By using different fibre Aspect ratio and fibre percentage, effect on compressive strength of concrete cube specimen for various combinations is studied. Fibres used with aspect ratio (50, 75,100) and the percentage of (0.5%, 1%, 1.5%, 2%) were used for the work (M_{40} ,M_{50})grade mix was used for the study. The experimental work was carried out for twelve different combinations. The obtained specimens were subjected to tests aimed to check the compressive strength. An increase in compressive strength by 49.12 % and was observed at 1% of 50 aspect ratio when compared with the normal M40 concrete. M50 mix was used for the study. The experimental work was carried out for twelve different combinations. The obtained specimens were subjected to tests aimed to check the compressive strength. An increase in compressive strength by 72% and was observed at 1.5% of 100 aspect ratio when compared with the normal M_{50} concrete.

I.INTRODUCTION

Sisal fiberis a leaf fiber extracted from the leaves of plant which is scientifically known as Agave sisalana. The Sisal plant is one of the types of perennial shrub which grows in the tropical and subtropical regions of the world. It is one of the most extensively cultivated hard fibers in the world. It grows in very hardy type soils where normal plants may not be grown. Though, the ideal condition in which the plant may be cultivated are in the areas where average temperature is between 20 to 28°C and the average annual rainfall is between 600 to 1500 mm. The main advantage of this plant is that, it can be grown where prolong droughts and high temperature are the problems where other plants cannot be grown.

In the sisal fiber, after decortications only approximately 5% of the whole sisal leaf is used, leaving the remaining 95% as residue, which is separated in a rotating sieve in two types: i) leaf residues that can be used to generate bio energy, animal feed and fertilizers productions or that are accumulated nearby rivers and streams, and ii) field bush which is composed of short sisal fiber and that currently has no application. During the drying process, sisal fibers are visually selected; those fibers which have no damage or impurities are then brushed and packed for export or are used as basic material for sisal-based products. The other fibers, called refuge, are used in construction industry as by-products in the installation of ceiling plaster.

II. METHODOLOGY

A. TEST OF SPECIMENS

In this thesis M_{40} & M_{50} grades of concrete with different percentages of sisal fibers with different aspect ratio are to be considered for the following strength tests:

Compressive strength

- 7 days specimens age
- 28 days specimens age

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Split tensile strength of specimens

- 7 days specimens age
- 28 days specimens age

Flexural strength of specimens

- 7 days specimens age
- 28 days specimens age

compressive strength test procedure:

Totally 72 cubes of size 150 mm x 150 mm x 150 mm were cast to study the compressive strength of sisal fiber reinforced concrete. Standard cast iron moulds were used for casting the test specimens. Before casting, machine oil was smeared on the inner surfaces of moulds. Sisal fiber reinforced concrete with glass fibres was mixed using a horizontal pan mixer machine and was poured into the moulds in layers. Each layer of concrete was compacted using a table vibrator.

Instrumentation and Testing Procedure

For the evaluation of compressive strength, all the GFRGPCC cube specimens were subjected to a compressive load in a digital Compression Testing Machine with a loading capacity of 2000kN. Specimens were tested as per the procedure given in Indian Standards I.S.516. The maximum load applied to the specimen was recorded. The compressive strength of the specimen was calculated by dividing the maximum load applied to the specimen by the cross-sectional area.

B. SPLIT TENSILE STRENGTH

Test Specimens:

Totally 72 cylinders having a diameter of 150 mm and 300 mm length were cast to evaluate the split tensile strength of sisal fiber reinforced concrete. Standard cast iron moulds were used for casting the test specimens. Before casting, machine oil was smeared on the inner surfaces of moulds. Sisal fiber reinforced concrete was mixed using a horizontal pan mixer machine and was poured into the moulds in layers. Each layer of concrete was compacted using a table vibrator.

Instrumentation and Testing Procedure:

In order to evaluate the splitting tensile strength of sisal fibre reinforced concrete composites, all the cylinder specimens were subjected to split tensile test in a 2000 kN digital Compression Testing Machine. Specimens were tested as per the procedure given in Indian Standards I.S.5816. The maximum load applied to the specimen was recorded and the split tensile strength of the specimen was calculated.

C. FLEXURAL STRENGTH

Test Specimens:

Totally eighteen prisms of size 700mmx150mm x150 mm were cast to study the flexural strength of sisal fibre concrete. Standard cast iron moulds were used for casting the test specimens. Before casting, machine oil was smeared on the inner surfaces of moulds. Sisal concrete was mixed using a horizontal pan mixer machine and was poured into the moulds in layers. Each layer of concrete was compacted using a table vibrator.

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Instrumentation and Testing Procedure:

Flexural strength of sisal fibre reinforced concrete composites was determined using prism specimens by subjecting them to two point loading in Universal Testing Machine having a capacity of 1000kN. Specimens were tested as per the procedure given in Indian Standards I.S.516. The maximum load applied to the specimen was recorded and the flexural strength of the specimen was calculated.

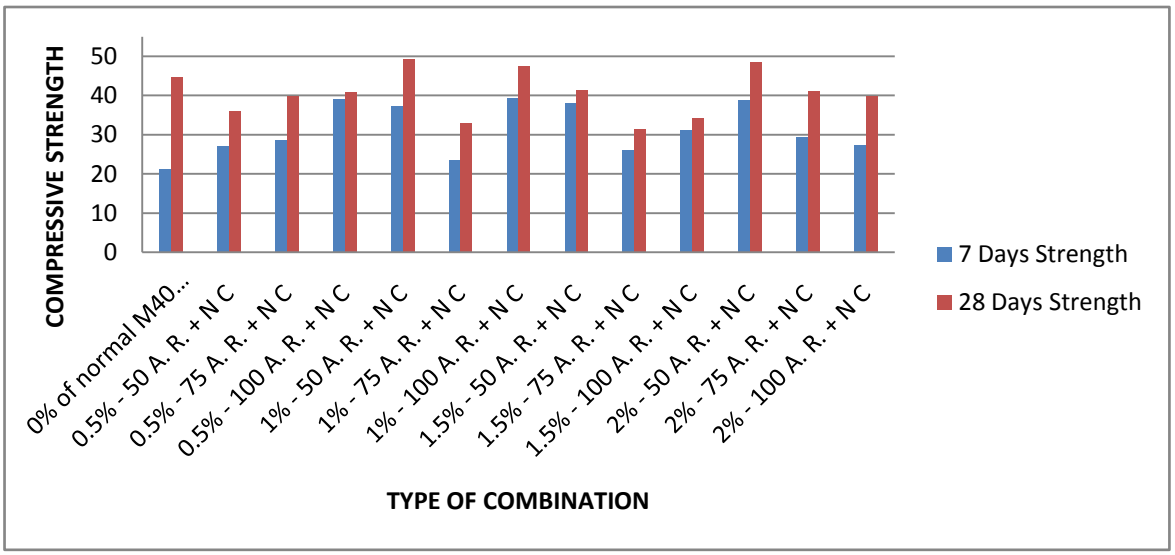
III. EXPERIMENTAL RESULTS

A. Compressive strength of concrete:

There are in total 12 different combinations of fiber dosage. While mixing the concrete, the fibers are randomly spread in the plastic concrete at the time of mixing. The results of compressive strength for 7days and 28days is shown in the following table

Table :1 compressive strength of concrete M40 mix:-

Details of sisal Insertion	7 Days Strength	28 Days Strength
0% of normal M40 concrete	21.1	44.7
0.5% - 50 A. R. + N C	27.03	36
0.5% - 75 A. R. + N C	28.52	39.78
0.5% - 100 A. R. + N C	39.04	40.89
1% - 50 A. R. + N C	37.19	49.12
1% - 75 A. R. + N C	23.41	32.81
1% - 100 A. R. + N C	39.26	47.33
1.5% - 50 A. R. + N C	37.85	41.41
1.5% - 75 A. R. + N C	25.93	31.41
1.5% - 100 A. R. + N C	31.19	34.15
2% - 50 A. R. + N C	38.74	48.52
2% - 75 A. R. + N C	29.26	41.11
2% - 100 A. R. + N C	27.26	39.85



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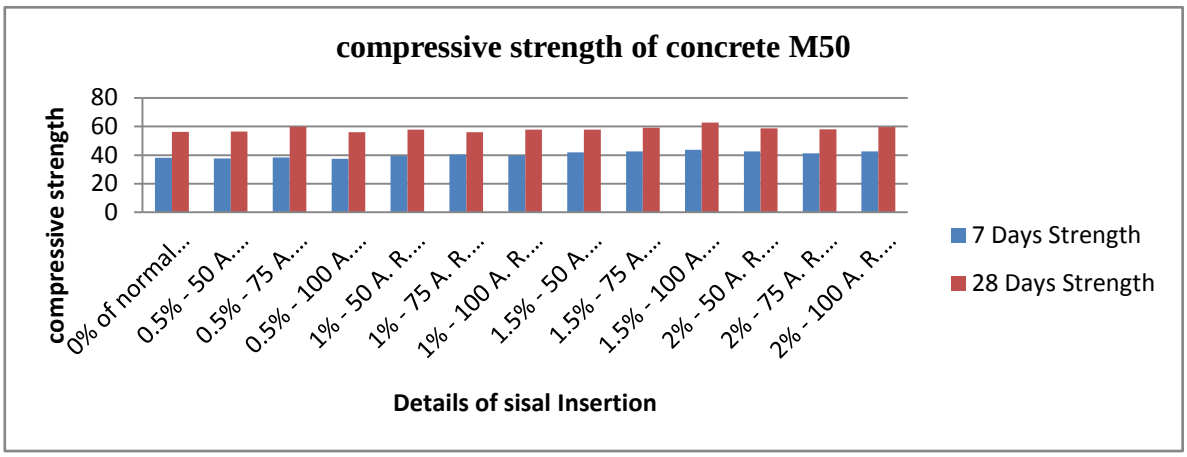
It is to be noted from the above results that, for all the combinations of sisal, the compressive strength is found to be greater than that of the normal concrete (0% insertion) after 28 days curing. From the obtained results that, compressive strengths for 1% sisal insertion are seen to be maximum for 7 and 28 days strength results. Here it is seen that for 7 days strength 1% sisal with Aspect ratio 100 gives the highest strength on 7 days curing. But after 28 days curing sisal fiber 1% with Aspect ratio 50 shows the highest strength.

The strength of concrete is found to be increased by 69 %. From the graphical representation for the strength results cumulatively it is seen that, Strength consistently increases from 0 % to 1% sisal with 50 A. R. and after this the graph shows undulations reflecting the decreasing and increasing results. It suddenly drops down at 1% with A.R. 75. It is considerable that, the results for 2% sisal fiber with 50 A. R. is second highest for the 7 as well as 28 days results.

Table .2 compressive strength of concrete for M50 mix

Details of sisal Insertion	7 Days Strength	28 Days Strength
0% of normal M50 concrete	38	56.25
0.5% - 50 A. R. + N C	37.64	56.5
0.5% - 75 A. R. + N C	38.43	59.8
0.5% - 100 A. R. + N C	37.5	56
1% - 50 A. R. + N C	39.4	57.85
1% - 75 A. R. + N C	40.41	55.95
1% - 100 A. R. + N C	39.75	57.8
1.5% - 50 A. R. + N C	41.85	57.81
1.5% - 75 A. R. + N C	42.65	59.26
1.5% - 100 A. R. + N C	43.7	62.75
2% - 50 A. R. + N C	42.5	58.72
2% - 75 A. R. + N C	41.26	58.1
2% - 100 A. R. + N C	42.6	59.5



Compressive strength of concrete for M50 mix

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B. split tensile strength of concrete:

It has been seen from the obtained results that, tensile strength of concrete is improved by the insertion of sisal in concrete; almost all the strengths are seen to be improved, except the combination of 0.5% -75 A.R., in this particular combination average 28 days strength is slightly below the average 28 days strength of specimen without fiber. It is seen that as like compressive strength, the maximum 28 days strength is seen for 1% sisal insertion with A.R. 100.

Table.3 Split tensile strength of concrete for M40 mix:-

details of sisal insertion	7days strength	28 days strength
0% of normal M40 concrete	1.56	2.85
0.5% - 50 A. R. + Normal Concrete	2.37	3.11
0.5% - 75 A. R. + Normal Concrete	1.86	2.84
0.5% - 100 A. R. + Normal Concrete	1.71	3.02
1% - 50 A. R. + Normal Concrete	3.18	3.55
1% - 75 A. R. + Normal Concrete	2.52	3.28
1% - 100 A. R. + Normal Concrete	3.16	3.68
1.5% - 50 A. R. + Normal Concrete	3.21	3.68
1.5% - 75 A. R. + Normal Concrete	2.8	3.46
1.5% - 100 A. R. + Normal Concrete	3.11	3.66
2% - 50 A. R. + Normal Concrete	2.6	3.15
2% - 75 A. R. + Normal Concrete	2.38	3.05
2% - 100 A. R. + Normal Concrete	2.3	3.21

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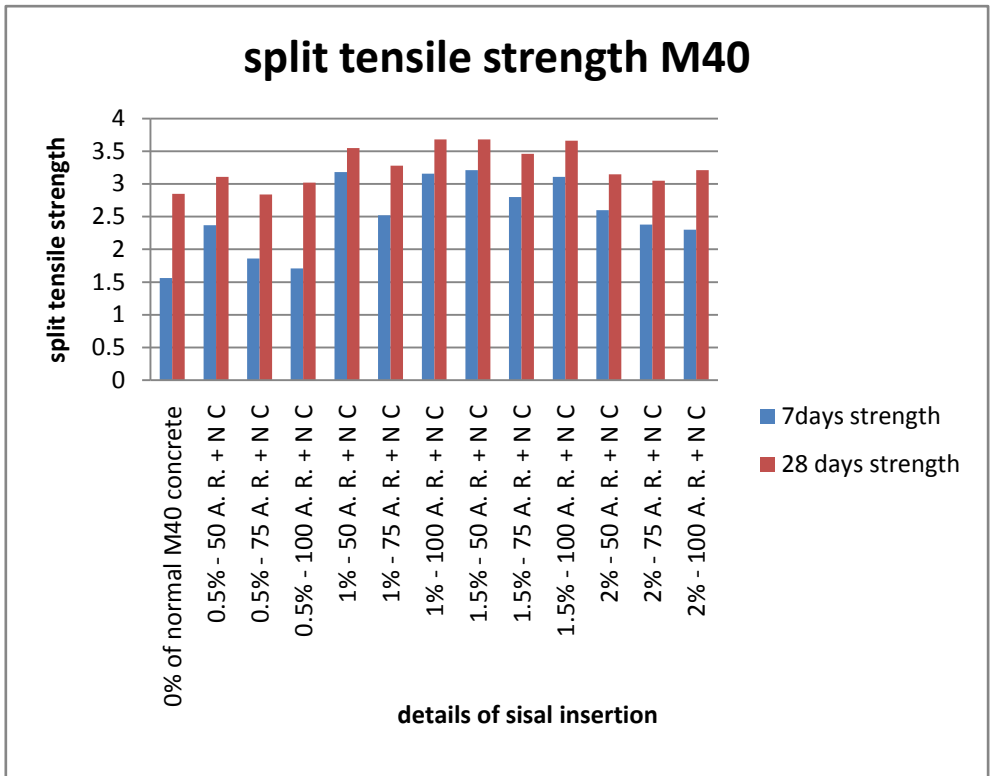

Split tensile strength of concrete for M40 mix

Here it is noted that the same strength is also seen for the combination, 1.5% sisal with A. R 50. For the 1%- A.R. 50 combination however, the strength achieved at early stage of 7 days is high but the strength is later not improved well. If we evaluate results graphically, we may observe that the 7 and 28 days strength of the specimens are seen to be similar. The results are shown graphically in the Figure 6.5. From the below graph it is seen that the tensile strength of the concrete can be improved by insertion of fibers with fiber dose between 1% and 1.5%, the graph shows the steady profile with less undulations for any combination of fiber dosage 1% and 1.5%, for fiber dosage less than 1%, and greater than 1.5% the Tensile strength gradually reduced.

Table : split tensile strength of concrete for M50 mix :-

details of sisal insertion	7days strength	28 days strength
0% of normal M50 concrete	3.8	5.625
0.5% - 50 A. R. + Normal Concrete	3.764	5.65
0.5% - 75 A. R. + Normal Concrete	3.843	5.98

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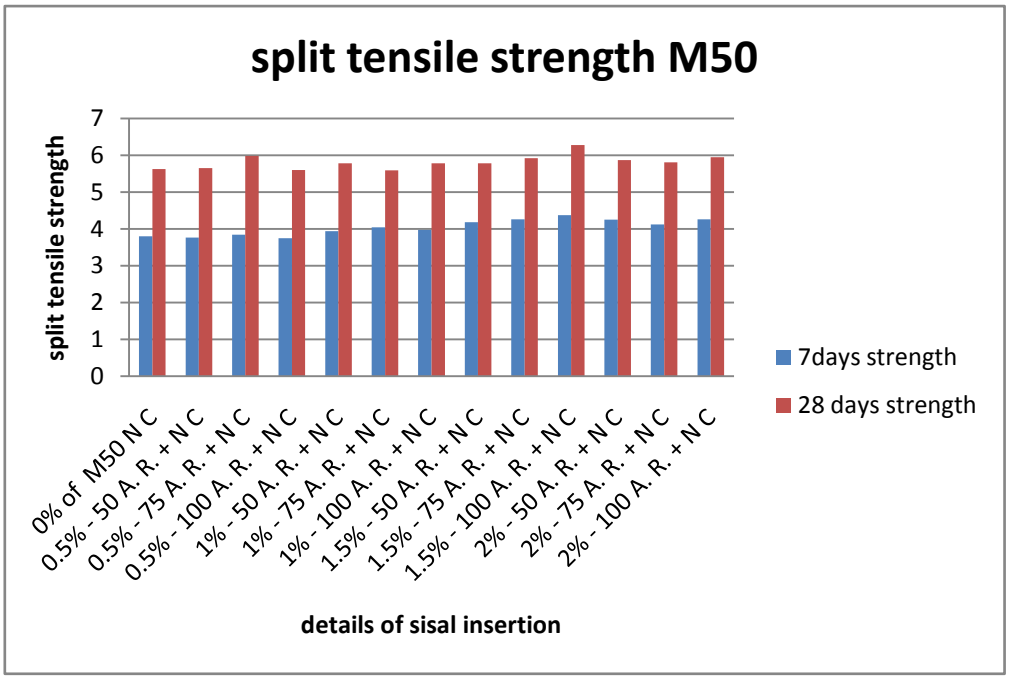
0.5% - 100 A. R. + Normal Concrete	3.75	5.6
1% - 50 A. R. + Normal Concrete	3.94	5.785
1% - 75 A. R. + Normal Concrete	4.041	5.595
1% - 100 A. R. + Normal Concrete	3.975	5.78
1.5% - 50 A. R. + Normal Concrete	4.185	5.781
1.5% - 75 A. R. + Normal Concrete	4.265	5.926
1.5% - 100 A. R. + Normal Concrete	4.37	6.275
2% - 50 A. R. + Normal Concrete	4.25	5.872
2% - 75 A. R. + Normal Concrete	4.126	5.81
2% - 100 A. R. + Normal Concrete	4.26	5.95



Split tensile strength for M50 mix

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C. Flexural Strength of Concrete Beams (150 x 150 x 700 mm):

If we observe average 28 days strength, it is seen that the Flexural strength is directly proportional to the Aspect ratio of the fiber irrespective of the percentage of fiber. This may be because of high pull out strength of the fiber under the action of bending. It is seen in all the four percentage combinations that, the flexural strength increases with the increase in the length of fiber. The highest strength of the 28 days cured samples is observed for the 1.5% sisal with 100 A.R. Also the values for 100 A.R. for all the percentage of fiber are very close strength results.

Flexural strength of concrete for M40 mix:-

details of sisal insertion	7 days strength	28 days strength
0% of normal M40 concrete	2.95	3.95
0.5% - 50 A. R. + Normal Concrete	3.07	3.82
0.5% - 75 A. R. + Normal Concrete	3.25	5.54
0.5% - 100 A. R. + Normal Concrete	3.08	7.23
1% - 50 A. R. + Normal Concrete	4.25	5.87
1% - 75 A. R. + Normal Concrete	3.47	6.64
1% - 100 A. R. + Normal Concrete	2.94	7.13
1.5% - 50 A. R. + Normal Concrete	4.26	5.92
1.5% - 75 A. R. + Normal Concrete	3.52	6.75
1.5% - 100 A. R. + Normal Concrete	3.61	7.41
2% - 50 A. R. + Normal Concrete	2.8	6.89
2% - 75 A. R. + Normal Concrete	3.3	6.48
2% - 100 A. R. + Normal Concrete	3.6	7.03

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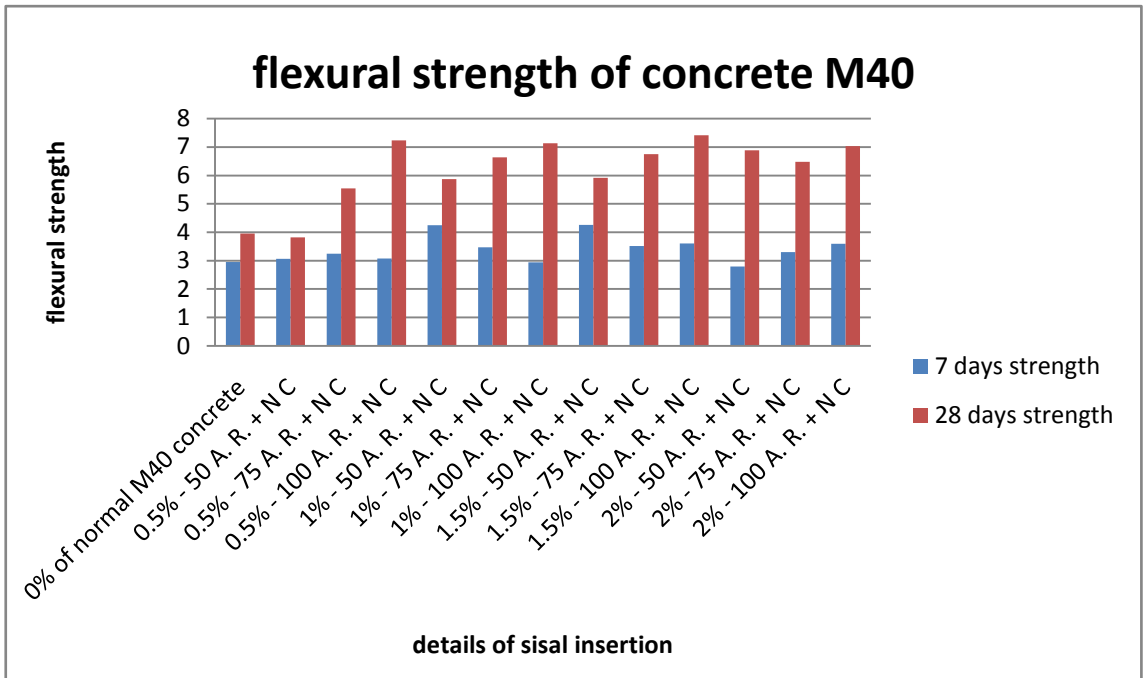

Flexural strength of concrete for M40 mix

The results are shown graphically in the Figure from the below graph it is seen that the strength of beam in flexure under three point bending test on UTM, the concrete strength is improved by insertion of fibers with fiber dose with high A.R. of 100 for all the combination of percentages. The 28 days strength is shown by graph very much comparative values for 100A.R

Flexural strength of concrete for M50 mix

details of sisal insertion	7 days strength	28 days strength
0% of normal M50 concrete	4.31509	5.25
0.5% - 50 A. R. + Normal Concrete	4.294601	5.261654
0.5% - 75 A. R. + Normal Concrete	4.339435	5.413132
0.5% - 100 A. R. + Normal Concrete	4.286607	5.23832
1% - 50 A. R. + Normal Concrete	4.393859	5.324143
1% - 75 A. R. + Normal Concrete	4.44982	5.235981
1% - 100 A. R. + Normal Concrete	4.413332	5.321842

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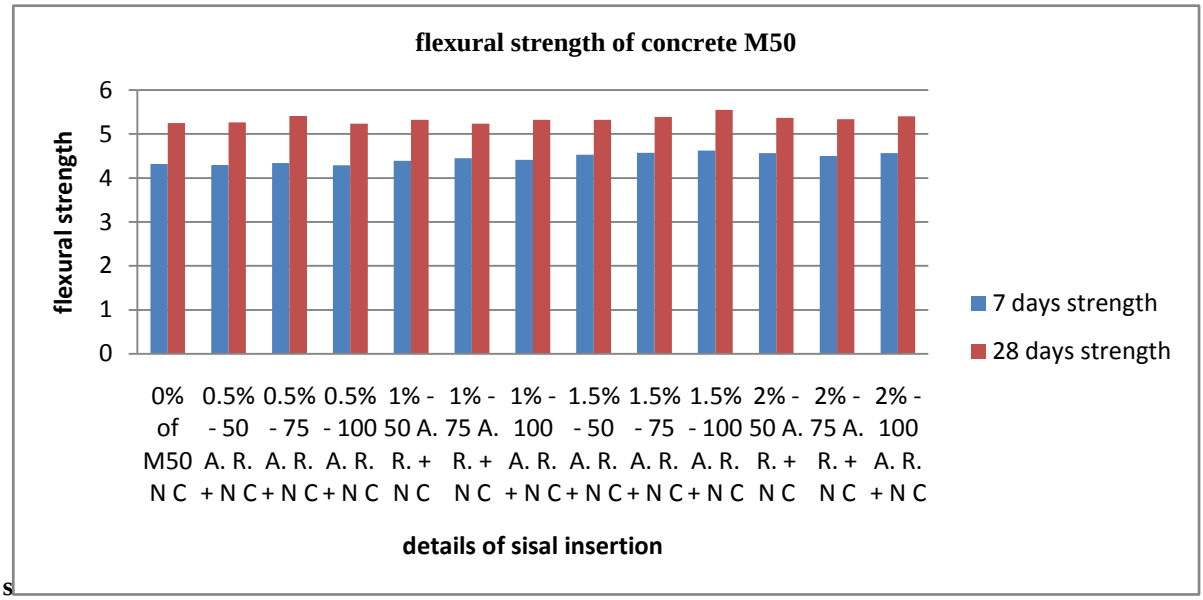
1.5% - 50 A. R. + Normal Concrete	4.52841	5.322302
1.5% - 75 A. R. + Normal Concrete	4.571488	5.388636
1.5% - 100 A. R. + Normal Concrete	4.627418	5.545043
2% - 50 A. R. + Normal Concrete	4.563442	5.364028
2% - 75 A. R. + Normal Concrete	4.496376	5.335635
2% - 100 A. R. + Normal Concrete	4.568807	5.399537

the flexural strength increases with the increase in the length of fiber. The highest strength of the 28 days cured samples is observed for the 1% sisal with 100 A.R. Also the values for 100 A.R. for all the percentage of fiber are very close strength results.



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Flexural strength of concrete for M50 mix

IV. CONCLUSION AND FUTURE WORK

1. The obtained results for various combinations have shown that the compressive strength of the concrete is increases with percentage increase but after 1% fiber dosage the strength is seen to be reduced gradually.

2. To compare the results on the parameters of length of fiber. At low fiber length the compressive strength is seen to be maximum. It reduces as the fiber length increased from A.R. 50 to A.R. 75, and again the strength is seen to be increased for A.R. 100, this shows that the compressive strength is more at low A.R.

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3. The maximum compressive strength is observed at 1 % fiber with aspect ratio 50 which is 49.12 % more than the average compressive strength without fiber.

The tensile strength increased with the increase in fiber percentage, there seen to be gradual increase in the strength from 0.5% to 1.5% and then there is a decrease in the tensile strength.

2. With the variation of fiber length, it is seen that, the moderate aspect ratio of 75 with the sisal fiber percentage of 0.5 gives the very poor results, where as for low and high length fibers there is improvement in the tensile strength.

3. The maximum tensile strength is at 1% fiber with 100 A.R. and 1.5% fiber with 50 A.R. which is 29.14% more than the concrete strength without fiber.

A. FLEXURAL STRENGTH OF CONCRETE:

1. The flexural strength is improved with the increase in the percentage fiber up to 1.5% after that there is a little decrease in the flexural strength. For short fibers however the strength increases continuously from 0.5 to 2% fiber variation.

2. If we analyze the strength results with respect to change in the aspect ratio, the strength is shown to be increased continuously with the increase in the aspect ratio, at aspect ratio 100 strengths for all the percentage of fiber, are very near to each other, while at aspect ratio 50 there is marginable difference in the strength of concrete at various percentages.

3. The maximum flexural strength is at 1.5% fiber with aspect ratio 100 which is 87.71% more than the concrete strength without fiber.

Recommendations for further studies are as mentioned below.

1. Though the problem of the reduction in workability of the fresh fiber reinforced concrete is not influencing the strength pattern if the water absorption of fiber is considered while designing the concrete, by adding chemical admixture such as super plasticizer, silica fume or blast furnace slag etc, this problem may be reduced.
2. More laboratory investigations and tests should be conducted to study on the other Mechanical properties of Sisal fiber reinforced concrete with different grades of concrete.
3. Natural fibers are generally subjected to aging process after certain duration of time, therefore the effect of aging of sisal fiber is to be studied and the strength decrement of fiber reinforced concrete after long term age are to be evaluated.
4. The combination of fibers may tend to provide more efficient mechanical properties of structure. Further investigation can be carried out by combination of different types of fibers into the concrete mix.

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