To Investigate the Impact of Steel and Aramid Fibers on Enhancing the Mechanical Properties of Concrete

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Abstract - Hybrid fiber reinforced concrete is a revolutionary approach that involves the incorporation of two or more types of filaments into a single concrete matrix. This thing significantly enhances the overall properties of the concrete, particularly its strength. Unlike plain concrete, which frequently exhibits low strength characteristics, fiber reinforced concrete offers superior durability and performance. By excercising this advanced construction material, you can ensure the life and structural integrity of your projects.

Keywords: Steel Fibers, Aramid Fibers, Compessive test, Tensile test, Flexular Test.

I. IINTRODUCTION:

By incorporating various types of fibers into concrete, the strain parameter can be significantly improved. This combination of different fiber admixtures not only enhances the strength characteristics of the concrete but also contributes to its sustainable development.Concrete possesses numerous desirable properties such as high compressive strength, stiffness, and durability. A special type of concrete known as fiber reinforced concrete (FRC) takes these advantages even further by incorporating small and continuous fibers dispersed uniformly throughout the mixture. Reinforced concrete is a versatile construction material that can be enhanced with various types of fiber reinforcement. These include steel, carbon, glass, aramid (synthetic fiber), polypropylene, and even natural fibers like jute. Each type of fiber brings its own unique properties to strengthen and reinforce the concrete structure. This project incorporates the use of both Steel fiber and Aramid Fiber (a synthetic fiber) in various proportions. These include plain cement concrete, as well as mixtures containing 1.5% Steel fiber + 0.5% Aramid Fiber, and 1% Steel Fiber + 1% Aramid Fiber. By combining these fibers, we aim to enhance the performance and durability of the concrete structures in this project.

II. LITERATURE SURVEY:

Todd Clarke, Sam Fragomeni, Matt Ghiji, Maurice Guerrieri. et al [1] have been found that,the current infrastructure boom combined with the latest outcomes from 26thUN Climate Change Conference of the Parties (COP 26) seeking a carbon neutral society by 2050 have driven the increasing need for sustainable alternatives to be considered in construction. One such alternative is macro synthetic fibers, which have been gaining acceptance on major infrastructure projects. However, only limited uptake has occurred in permanent structures, due to a lack of knowledge around the behavior of macro synthetic fiber reinforced concrete (MSFRC) when exposed to elevated temperatures. Existing Australian and international design standards do not take into account the loss of strength for MSFRC after exposure to elevated temperatures. Hence, this systematic review sets out to combine all the existing knowledge on the mechanical properties of MSFRC and lay the groundwork for determining acceptable relationships between relative strengths and elevated temperatures.

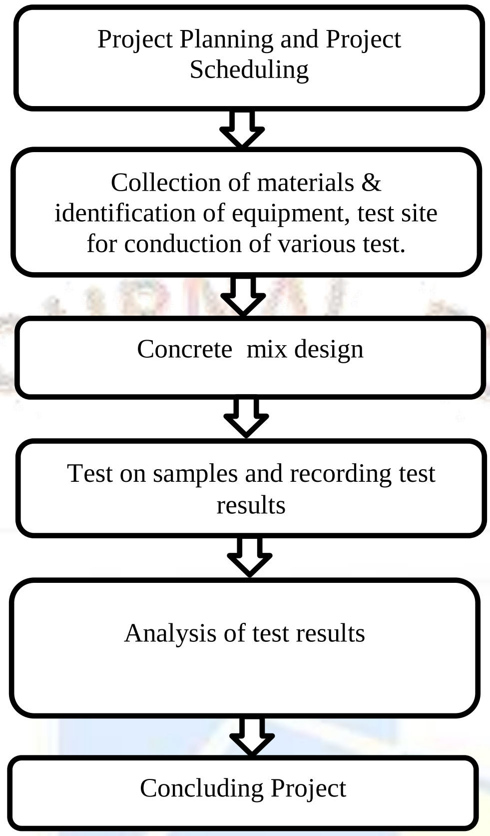
Sagi Murali,Sagar Varma,Ponnada Markandeya Raju et al [2] have been found that, Fibers are materials with axial resistance to load that can withstand tensile stresses also when they are mixed in concrete. Recent research shows that the use of fibers improves the mechanical properties in terms of tensile strength and use of hybrid fibers, the mechanical properties further get improved.

Promod Kawde,Abhijit Warudkar et al [3] have been found that, ordinary cement concrete possesses very low tensile strength, limited ductility and less resistance to cracking. The concrete shows the brittle behaviour and fails to handle tensile loading hence leads to Internal micro cracks which are mainly responsible for brittle failure of concrete. In this era, RCC constructions have their own structural and durability requirements, every structure has its own intended purpose and hence to meet this purpose, modification in traditional cement concrete has become mandatory.

S.Kumaravel,N.Veeragurunath,D.Anandram,E.Vairavi rt al [4] have been found that, the fiber reinforced concrete can improve the strength properties of hardened. Cement concrete is week in tension, to increase tensile strength by addition of fibers in concrete. Investigation is to find the mechanical properties of Hybrid Fiber Reinforced Concrete with steel (hooked end) and polypropylene fiber in various volume fractions. The steel fiber of various ratio (0.5 to 1.25%) and polypropylene fiber of various ratios (0.05 to 0.125) are mixed in based on volume of concrete.

III. METHODOLOGY:

The main objective of the present work to study of mechanical properties of hybrid fiber reinforced concrete as addition of hybrid fiber in concrete to study mechanical properties of concrete. to achieve this objective, experimental program was prepared and materials used, testing procedures are discussed in subsequent sections.



1) Materials Used for Concrete Mix:

Sr.No.	Name of Material	Specifications
1.	Cement	Ultra-tech 43 Grade Cement
2.	Fine Aggregates	River Sand
3.	Coarse Aggregates	Size - 20 mm Shape - Angular
4.	Fibers	Steel Fibers- Hook End 50mm Fibers Aramid Fibers - High Strength 12mm raw

Table3.1: Materials Used.

Fig 3.1 Steel Fibers

Fig 3.2 Aramid Fibers

2) Tests Going to be Conducted:

a) Specific gravity of fine and coarse aggregates
b) Compressive test .
c) Tensile test .
d) Flexural test .

3) Procedure for specific gravity determination for fine aggregate :

- Clean dry pycnometer is taken and its empty weight is determined.
- About 1000g of clean sample is taken into the pycnometer and is weighted.
- Water at 27°c is filled up in the pycnometer with aggregates sample to just immerse sample.
- Immediately after immersion the entrapped air is removed from the sample by shaking pycnometer placing a finger on the hole at top of the sealed pycnometer.
- Now the pycnometer is completely field up with water till the hole at the top and after confirming that there is no more entrapped air in it it is the weighed.
- The content of the pycnometer are discharged and it is cleaned.
- Water is filled it up to the top of the pycnometer without any entrapped air. It then weighed.
- For minerals filler specific gravity is used and the material is filled upto one third of the capacity of bottle the rest of the process of determining specific gravity is similar to the one description for aggregate finer.

4) Procedure for specific gravity determine for course aggregate

- About 1kg of aggregate sample is taken washed to remove fines and than placed in the wire bucket. The wire bucket is then immersed in water which is at a temperature of 22°C to 32°C.
- Immediately after immersed the entrapped air is removed from the sample by lifting the basket 25 mm above the base of the tank and the allowing it to drop 25 time at a rate of about one drop per second.
- The basket and aggregate are weighted while suspended in water. which is at a temperature of 22°to 32°
- The basket and aggregate are remove from water and dried with dry absorbent cloth.
- The aggregate is placed in a shallow tray and headed to about 110°C in the oven for 24 hours later it is cooled in an airtight container and weighed.

IV. CONCRETE MIX DESIGN:

i) Characteristics Compressive strength required in the field at 28 Days = **20 MPa**
ii) Maximum size of aggregate = **20 mm**
iii) Degree of work-ability = **0.90 compacting factor**
iv) Degree of quality control = **Good**
v) Type of exposure = **Mild**

b)Test Data for materials:

i) specific gravity of cement = **3.15**
ii) Compressive strength of Cement at 7 Day = **satisfies the requirement of IS 269 :1989**
iii) 1. Sp.Gravity CA = **2.87**
2.Sp .Gravity FA = **2.64**
iv)Water absorption
1.Coarse aggregate = **0.48%**
2.Fine aggregate = **0.80%**
v) Free (Surface moisture)
1. Coarse aggregate = **Nil**
2. Fine Aggregate = **2.0%**

c) For target mean strength of concrete:

Fck =fck + F.S
= 20 +1.64 x 4
= **26.16 Mpa**

d) Selection of water cement ratio:

W/ C = **0.5**

e) Water Contet = 186

f) Cement Content:

W/C = 0.5
186 /c = 0.5
186 /0.5 = c
C= 372 Kg / m^3

g)Determination of C.A and F.A content assuming 2% entrapped air:

0.98 = [186 + 372/3.15 + 1 / 0.315 x fa / 2.64] 1/1000
fa = 563 .25 kg /m^3
ca =1- 0.315 / 0.315 x 563.25x 2.87 / 2.64
ca = 1331.55 kg /m^3

The mix proportion then becomes

water	:	cement	:	F.A	:	C.A
186.	**:**	**372.**	**:**	**563**	**:**	**1331**
0.5	**:**	**1.**	**:**	**1.513**	**:**	**3.57**

The volume of
Cube = (0.15 x 0.15 x 0.15) x 3 = **0.0101 Cu.m**
Cylinder = (150 x 300) x 3 = **0.135 Cu.m**
Beam = (100 x 100 x 500) x 3 = **0.018 Cu.m**

W/C	Cement	F.A.	C.A.
186	**372**	**563**	**1331**
0.5	**1**	**1.573**	**3.57**

Table 3.2. Final Mix proportion

V. TEST RESULTS:

1) Material Test Results:

i. **Table 5.1 - Specific Gravity Determine for Fine Aggregates:**

Sr.No.	Description	Observed Values
1	Weight of sample	**1000gm**
2	Weight of pycnometer in air W1	**669gm**
3	Weight of aggregate and pycnometer W2	**1668gm**
4	Weight of aggregate,pycnometer and water W3	**2134gm**
5	Weight of water and pycnometer in air W4	**1531gm**
6	Specific Gravity[W2-W1]/[(W4-W1)-(W3-W2)]	**2.64**

ii. **Table 5.2 -Specific Gravity Determine for Fine Aggregates:**

Sr.No.	Description	Observed Values
1	Weight of sample	**1000gm**
2	Weight of saturated aggregate and basket in waterW1	**4737gm**
3	Weight of basket in water W2	**4293gm**
4	Weight of saturated aggregate in air W3	**7325gm**
5	Weight of oven dry aggregate air W4	**884.5gm**
6	Specific Gravity [W2-W1]/[(W4-W1)-(W3-W2)]	**2.87**

2) Table 5.3 -Results of Compressive Test:

Sr. No.	Name of Test	Type of Fibre with Volume in %	No. of Samples	No. of Days	Results
1.	Compression Test on Concrete Cubes	Plain	03	07	Sample -1) 17.72 MPa Sample -2) 16.53 MPa Sample -3) 15.25 MPa
2.		Plain	03	14	Sample -1) 17.87 MPa Sample -2) 18.82 MPa Sample -3) 20.25 MPa
3.		Plain	03	28	Sample -1) 24.13 MPa Sample -2) 25.48 MPa Sample -3) 26.37 MPa
4.		1.5% Steel Fiber + 0.5% Aramid Fiber	03	07	Sample -1) 16.08 MPa Sample -2) 14.47 MPa Sample -3) 16.16 MPa
5.		1.5 % Steel Fiber+ 0.5 % Aramid Fiber	03	14	Sample -1) 17.42 MPa Sample -2) 17.04 MPa Sample -3) 18.03 MPa
6.		1.5 % Steel Fiber +	03	28	Sample -1) 22.31 MPa

		0.5% Aramid Fiber			Sample -2) 22.87 MPa Sample -3) 25.19 MPa
7.		1 % Steel Fibre + 1% Aramid Fiber	03	07	Sample -1) 19.28 MPa Sample -2) 20.20 MPa Sample -3) 21.00 MPa
8.		1 % Steel Fiber+ 1 % Aramid Fiber	03	14	Sample -1) 25.14 MPa Sample -2) 26.96 MPa Sample -3) 27.31 MPa
9.		1 % Steel Fiber+ 1 % Aramid Fiber	03	28	Sample -1) 29.20 MPa Sample -2) 30.58 MPa Sample -3) 28.88 MPa

3) Table 5.4 - Results of Tensile Test:

Sr. No.	Name of Test	Type of Fibre with Volume in %	No. of Samples	No. of Days	Results
1.	Tensile Test on Concrete Cylinders	Plain	03	07	Sample -1) 3.45 MPa Sample -2) 4.20 MPa Sample -3) 6.26 MPa
2.		Plain	03	14	Sample -1) 5.67 MPa Sample -2) 6.67 MPa Sample -3) 7.34 MPa
3.		Plain	03	28	Sample -1) 7.80 MPa Sample -2) 9.98 MPa Sample -3) 10.45 MPa
4.		1.5 % Steel Fiber+ 0.5 % Aramid Fiber	03	07	Sample -1) 4.50 MPa Sample -2) 3.34 MPa Sample -3) 2.45 MPa
5.		1.5 % Steel Fiber+ 0.5 % Aramid Fiber	03	14	Sample -1) 4.67 MPa Sample -2) 3.35 MPa Sample -3) 4.45 MPa
6.		1.5 % Steel Fibre + 0.5 % Aramid Fibre	03	28	Sample -1) 6.56 MPa Sample -2) 7.56 MPa Sample -3) 8.90 MPa
7.		1% Steel Fiber + 1 % Aramid Fiber	03	07	Sample -1) 6.67 MPa Sample -2) 8.56 MPa Sample -3) 9.89 MPa
8.		1 % Steel Fiber + 1 % Aramid Fiber	03	14	Sample -1) 7.89 MPa Sample -2) 9.97 MPa Sample -3) 10.34 MPa
9.		1 % Steel Fiber + 1 % Aramid Fiber	03	28	Sample -1) 10.56 MPa Sample -2) 12.56 MPa Sample -3) 15.00 MPa

4) Table 5.5 -Results of Flexure Test:

Sr. No.	Name of Test	Type of Fibre with Volume in %	No. of Samples	No. of Days	Results
1.	Flexural Test on Concrete Beams	Plain	03	07	Sample -1) 4.56 MPa Sample -2) 6.65 MPa Sample -3) 7.76 MPa
2.		Plain	03	14	Sample -1) 5.67 MPa Sample -2) 6.65 MPa Sample -3) 7.90 MPa
3.		Plain	03	28	Sample -1) 9.87 MPa Sample -2) 12.98 MPa Sample -3) 14.45 MPa
4.		1.5 % Steel Fibre + 0.5 % Aramid Fibre	03	07	Sample -1) 4.56 MPa Sample -2) 3.34 MPa Sample -3) 4.89 MPa
5.		1.5 % Steel Fibre + 0.5 % Aramid Fibre	03	14	Sample -1) 5.67 MPa Sample -2) 4.67 MPa Sample -3) 5.90 MPa
6.		1.5 % Steel Fibre + 0.5 % Aramid Fibre	03	28	Sample -1) 6.78 MPa Sample -2) 9.89 MPa Sample -3) 8.87 MPa
7.		1 % Steel Fibre +	03	07	Sample -1) 8.78 MPa

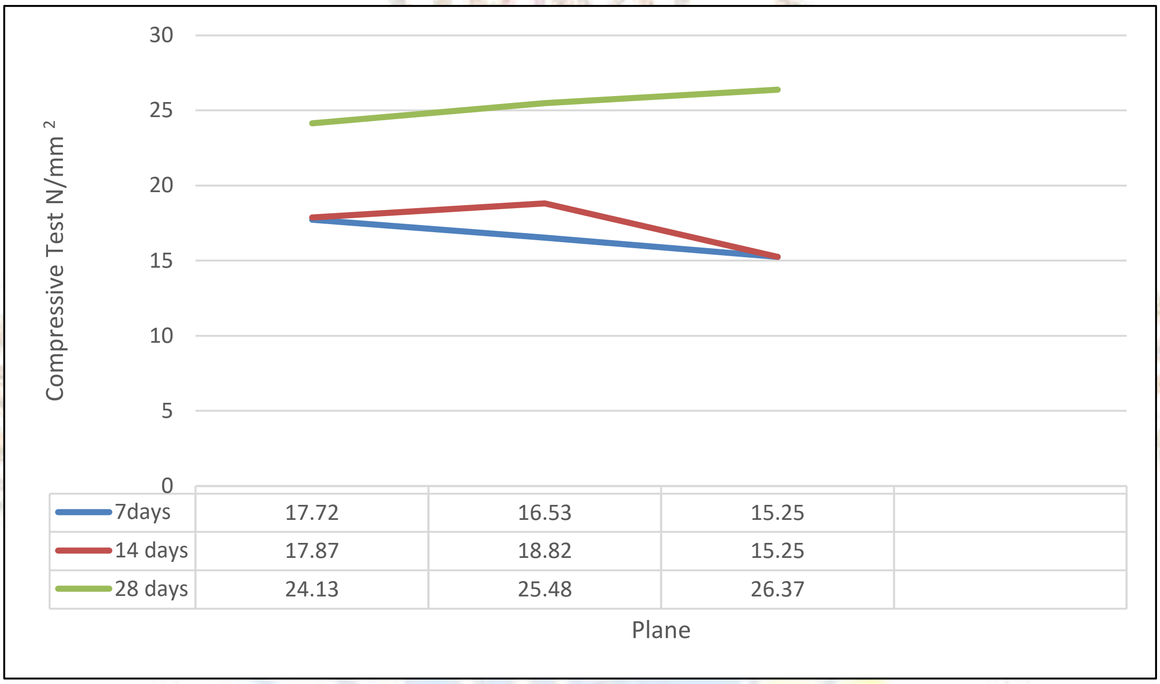
		1 % Aramid Fibre			Sample -2) 10.23 MPa Sample -3) 9.45 MPa
8.		1 % Steel Fibre + 1 % Aramid Fibre	03	14	Sample -1) 9.87 MPa Sample -2) 10.45 MPa Sample -3) 11.78 MPa
9.		1% Steel Fiber +1% Aramid Fiber	03	28	Sample -1) 12.45 MPa Sample -2) 14.34 MPa Sample -3) 15.56 MPa

VI. TEST RESULTS ANALYSIS:

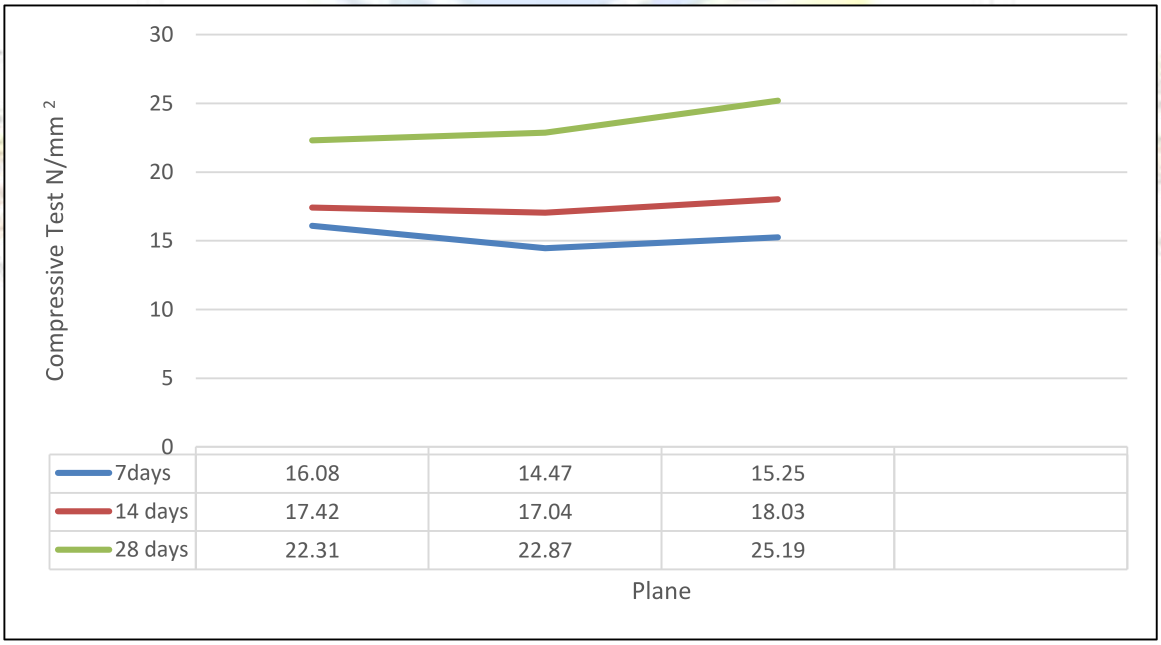
The analysis of results obtained from various test are as following:

1) -Compressive Strength of cube for 7,14 & 28 days:

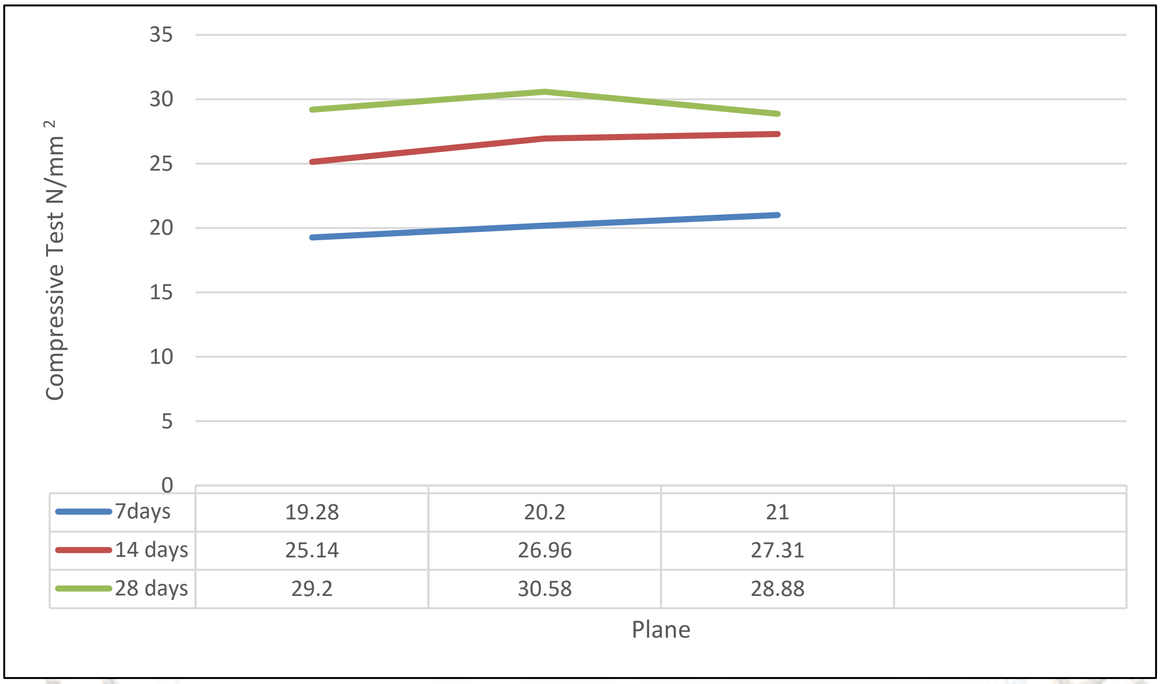
i. Graph 5.1-Plain Concrete:



ii. Graph 5.2-1.5%Steel Fibers & 0.5 % Aramid Fibers Cube:

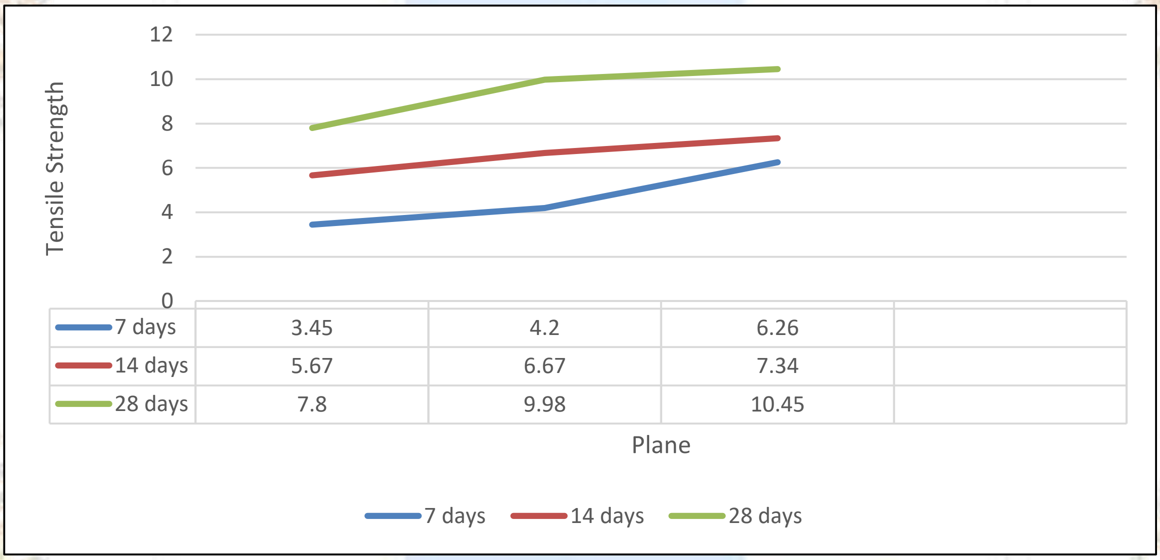


iii. **Graph 5.3-1 % Steel Fibers & 1% Aramid Fibers Cube:**

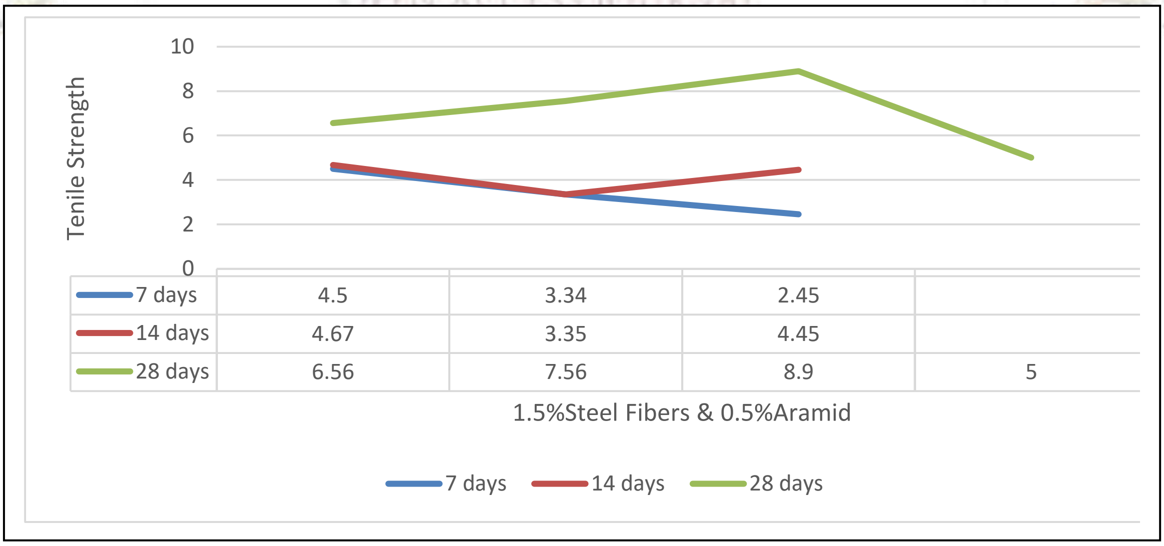


2) Tensile strength of concrete cylinder for 7, 14 & 28 days:

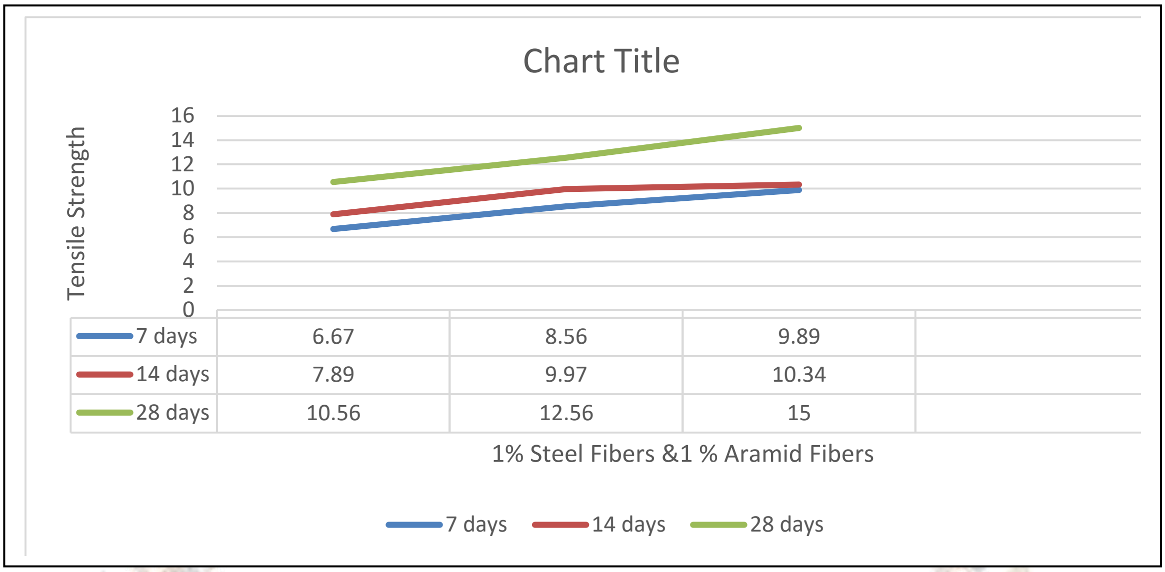
i. **Graph 5.4-Plain Concrete:**



ii. **Graph 5.5-1.5%Steel Fibers & 0.5 % Aramid Fibers Cube:**

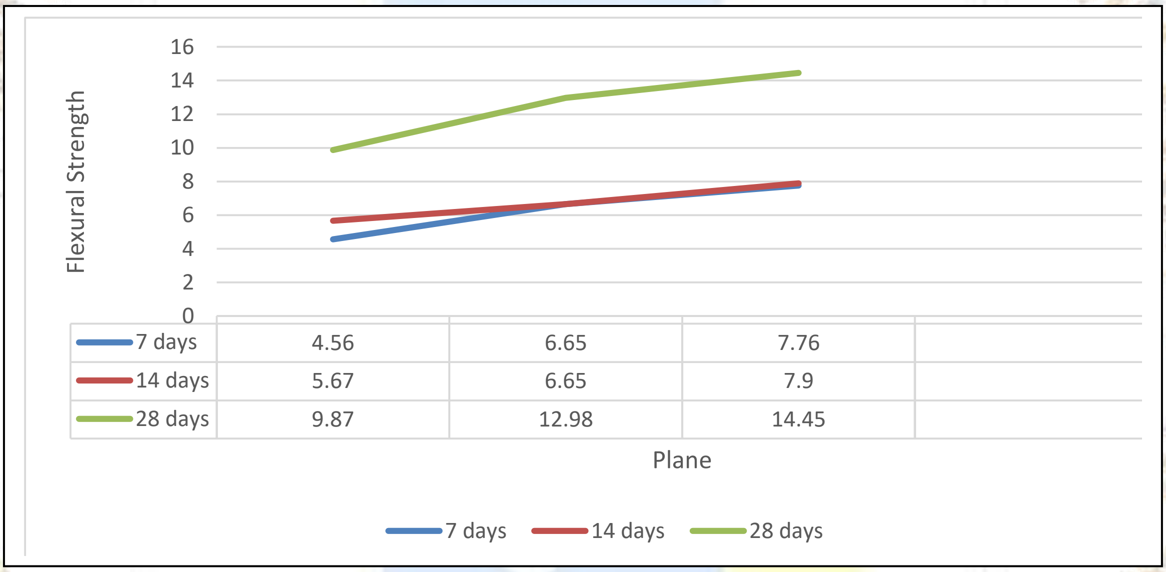


iii. Graph 5.6-1%Steel Fibers &1 %Aramid Fibers Cylinders:

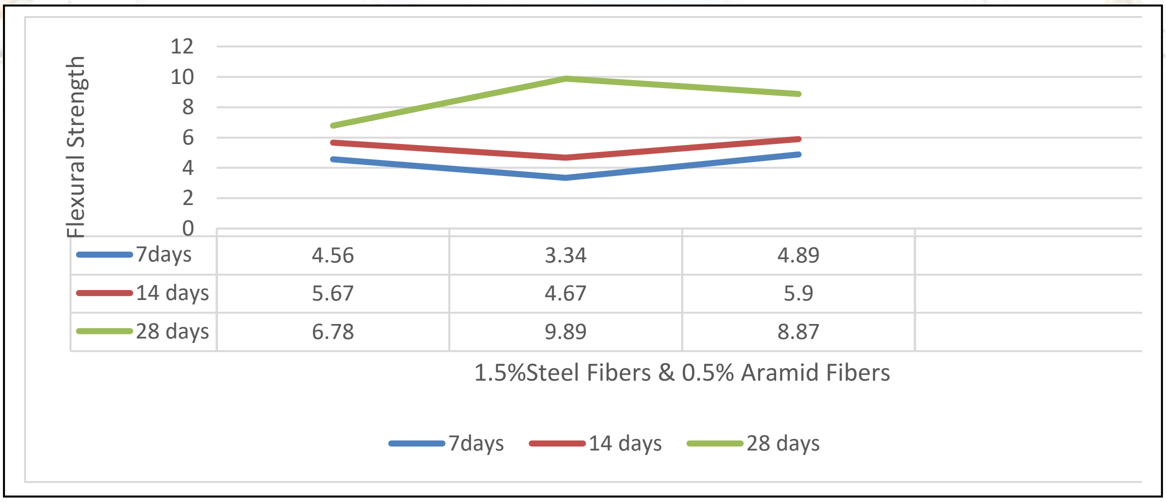


3) Flexural strength of concrete beam for 7, 14 & 28 days:

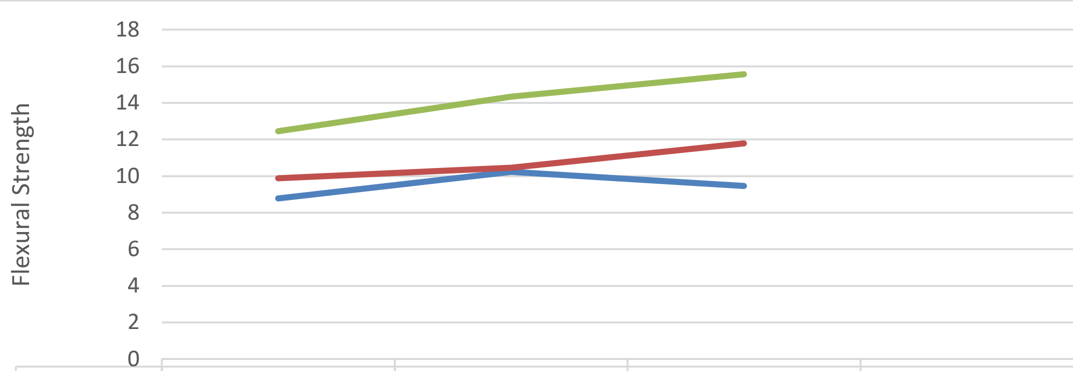
i. Graph 5.7-Plain Concrete:



ii. Graph 5.8-1.5%Steel Fibers & 0.5 % Aramid Fibers Cube:



iii. **Graph 5.9-1%Steel Fibers &1%Aramid Fibers Beam:**



7 days	8.78	10.23	9.45
14 days	9.87	10.45	11.78
28 days	12.45	14.34	15.56

VII. TEST RESULT CONCLUSION:

Based on the experimental studies analysis of test results, the following conclusions were drawn:

1) Improved the overall mechanical properties of concrete.(compressive,tensile,flexural).
2) When we add 1.5 %steel fibers & 0.5 % aramid fibers in concrete mix, the compressive ,tensile & flexural strength are decreases.
3) When we add 1% steel fibers & 1% aramid fibers in concrete mix, the compressive , tensile &flexural strength are increases.

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