EXPERIMENTAL STUDY ON FIBER (HOOKED STEEL) REINFORCED CONCRETE USING M-20 GRADE

C.Poongodi, Assistant professor, Department Of Civil Engineering, PPG Institute of Technology, Coimbatore ,Tamil Nadu, India.
S.Sathiya, Assistant Professor, Department Of Civil Engineering, St. Mother Theresa Engineering College, Thoothukudi,Tamil Nadu,India.
V. Balakrishnan, Assistant Professor, Department Of Civil Engineering, Hanmuganathan Engineering College, Arasampatti, Puthukkottai, Tamil Nadu, India.
M. Jawahar, Assistant Professor, Department Of Civil Engineering ,Pollachi Institute of Engineering and Technology, Poosaripatti, Pollachi, Tamil Nadu,India.
Prof. Prasoon P P, Assistant Professor, Department Of Civil Engineering , College Of Engineering Trikaripur , Kasaragod, Kerala, India.
Dr.A.Hemalatha, Professor & Head, Department Of Civil Engineering, NPR College Of Engineering Technology, Dindigul,Tamil Nadu, India

ABSTRACT
The most common building material used worldwide is cementing concrete. This is mostly due to cement concrete's excellent workability and ability to assume any shape. Concrete that has internal micro cracks breaks down in a brittle manner. Concrete's durability, serviceability, and reduction of interior micro cracks are all improved by the use of various types of fibres. Here, M20 grade concrete is employed, with fibre percentages of 0%, 1%, 2%, and 3% by weight of concrete, work abilities of fresh concrete test such as compacting factor ,floe table, slump cone and vee-bee consistometre test after that hardened concrete properties like compressive and tensile strength tests for cubes and cylinders like seventh, fourteenth, and twenty-eighth days of curing days.
Keywords: Hooked steel, Concrete, M_{20}, Casting, Fiber, Curing, Opc Cement, Properties of Concrete

1 Introduction
1.1General
Second only to water in terms of usage is concrete. Sand, crushed rock, and water are typically combined with Portland cement to create it. When applying concrete in harsh conditions for a long service life, durability is a crucial factor. Large amounts of cement and particles from the natural world are combined with water to make concrete. Huge amounts of energy are used in cement manufacture, which accounts for 7% of global greenhouse gas emissions. Portland cement is the primary component of traditional concrete. The amount of carbon dioxide released into the atmosphere as a result of cement manufacture is roughly equal. Three billion tonnes of concrete were consumed globally last year, or one tonne for each person on the planet. No material is consumed by man. Except for water, no other substance is used by man in such vast quantities. Concrete is still used at roughly the same rate as it was thirty years ago. According to estimates, the globe currently consumes over 55 billion tonnes of concrete annually. The fact that concrete is frequently the least expensive and most readily available material on the job is another factor contributing to its appeal among engineers.

1.2Literature review
Following are some of research works carried out using different type of fibers,
Avinash Joshi , Pradeep reddy ,Punith kumar and Pramod hatker (2018), conducted experimental study on steel fiber Reinforced concrete for M25, M30, M40 grades of concrete
- Steel fibers decrease the workability so, use of superplasticer improve the workability. As the volume of steel fibers increases from 0.5 to 1.5% the workability decreases that is slump loss.

- The compressive strength of concrete increases considerably as the volume of steel fibers is increased from 2% to 3% and the increase is almost similar to all the grade of normal concrete that is M25, M30, M40.
- The tensile strength increases significantly as the volume of steel fibers is increase is similar to the grade of concrete.
- The shear strength of concrete improves as the volume of fibers is increased.

A.M. Shende, A.M. Pande and M. GulfamPathan (2017), conducted Experimental Study on Steel Fiber Reinforced Concrete for M-40 Grade having mix proportion 1:1.43:3.04 with water cement ratio 0.35. The following conclusions could be drawn from the present investigation.

- It is observed that compressive strength increases from 4 to 5% with addition of steel fibers.
- It is observed that flexural strength increases from 2 to 3% with addition of steel fibers.
- It is observed that split tensile strength increases from 3 to 5% with addition of steel fibers.

2 Materials used

2.1Materials

The materials used for the experimental investigation are as follows**.**

- Cement
- Fine aggregate confirming IS: 2386 (PART-III)-1963.
- Coarse aggregate confirming IS: 2386 (PART-III)-1963.
- Steel fibers(hooked)
- Water

2.2 Cement

The primary basic material utilised in all building is cement. Therefore, cement quality must be examined before it is used as a building material. The cement can be put through the tests below in a lab to determine its quality.

2.3 Cement fineness test

Cement is finned by dry sieving in accordance with IS 4031:(PART)-1996.

The idea behind this is that we calculate the percentage of cement whose size is more than the designated mesh size. For cleaning the sieve, a nylon or pure bristle brush, preferably with 25 to 40mm of bristles, is used together with a balance that can weigh 10g to the nearest 10mg.

2.4 Test Procedure:

1. Weigh approximately 10gm of cement to nearest 0.01g and place it on the sieve.
2. Shake the sieve by swirling, planetary and linear movement, until no more fine material passesthrough it.
3. Weigh the residue and express its mass as a percentage to the nearest of 0.1 %.4. Gently brush all the fine material off the base of the sieve.

Table : 1 Results of sieve analysis

Sl.No	Observations	Sample1	Sample2
1	Weight of cement (Wg)	100	100
2	I.S sieve size (microns)	90	90
3	Weight retained in sieve (W1g)	3	3
4	%retained on sieve(W1/W)*100	3	3
5	% of passed sample	97	97

2.5 Consistency test

This test determines the amount of water that must be mixed to create a paste with a normal consistency. A paste with a normal consistency has a viscosity that allows the Vicat's plunger to penetrate up to a point that is 5 to 7 mm from the mold's bottom. The usual consistency of the cement, which in turn depends on the compound composition and fineness of the cement, determines the amount of water needed for various cement tests.

2.6 Test Procedure

25% water is added to 300 grammes of cement. Vicat's device's mould is filled with the paste, and the surface of the filled paste is levelled and polished. Then, a 10 mm x 10 mm square needle attached to the plunger is slowly lowered across the cement paste surface and immediately released. The cement paste is cut by the plunger. The linked scale's reading is noted. The amount of water injected is thought to be the correct percentage for a typical consistency when the reading is between 7 and 10 mm from the bottom of the mould.

Table No: 2 Normal Consistency

SL. No	Particulars	Requirements asper IS 12269-1987	Test results
1	Normal consistency	25% - 36%	35%

2.7 Initial and final setting time

When water is added to cement, the resulting paste starts to stiffen and gain strength and lose the consistency simultaneously. The term setting implies solidification of the plastic cement paste. Initial and final setting times may be regarded as the two stiffening states of the cement. The beginning of solidification, called the initial set, marks the point in time when the paste has become unworkable. The time taken to solidify completely marks the final set, which should notbe too long in order to resume construction activity within a reasonable time after the placementof concrete.

The initial setting time may be defined as the time taken by the paste to stiffen to such an extent that the Vicat's needle is not permitted to move down through the paste to within 5 ± 0.5 mm measured from the bottom of the mould. The final setting time is the time after which the paste becomes so hard that the angular attachment to the needle, under standard weight, fails to leave any mark on the hardened concrete. Initial and final setting times are the rheological properties of cement.

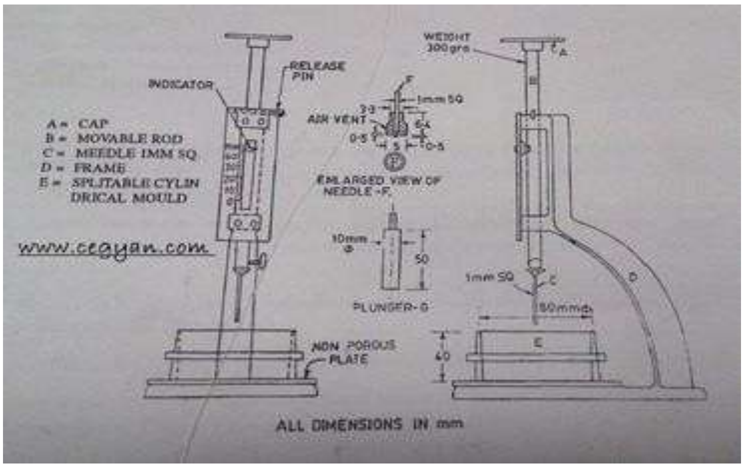

Fig 1: Vicat's Apparatus

2.8 Test procedure

By measuring cement with 0.85 times the amount of water necessary to produce a paste with a specified consistency, smooth cement paste can be made. The moment water is introduced to the cement, the stopwatch is set to begin. The mould, which is set on a nonporous plate, is entirely filled with cement paste, and the paste's top surface is levelled with the top of the mould. The test is carried out at 27 2 °C, or room temperature. The Vicat's equipment is used to hold the mould filled with cement paste. The needle is carefully lowered until it makes contact with the test block, and it is then swiftly released. Thus, the test block is penetrated by the needle, and the reading is recorded on the graded scale of the Vicat equipment. Until the needle is unable to penetrate the block by approximately 5 mm measured from the mold's bottom, the technique is repeated. Once the stop watch has been set, the time is recorded and the initial setting time is obtained. When the attachment fails to leave an impression on the test block surface after gently pressing the needle against it, the cement is said to have finally set

Table No : 3 Results of setting time of cement

SL. No.	Particulars	Requirements as per IS 12269-1987	Test results
1	Initial setting time	30 min	53 min
2	Final setting time	600 (max)	600 min

2.9 Fine Aggregate

Sand plays a very important role in concrete. It manages to fill the voids between the powders and the coarse aggregates. It also imparts flowing characteristics to concrete. The sand used was locally available river sand with specific gravity of 2.52 and conforming to ZONE 2.

Following tests can be performed on fine aggregate in laboratory to check its quality.

- Sieve analysis and fineness modulus.

Table No:4 fineness of sand

IS Sieve size (mm)	Weight retained (gm)	Cumulative weight retained (gm)	Cumulative % weight retained	Cumulative passing	Remarks
4.75	92	92	9.2	90.8	
2.36	164	256	25.6	74.4	
0.6	194	450	45.0	55.0	
0.425	195	645	64.5	35.5	
0.30	183	828	82.8	17.2	
0.075	92	920	92.0	8.0	
Pan	80	000	100	0	
			Total=319.1		Zone II

Fineness modulus =319.1/100= 3.191

2.10 Coarse Aggregate

Coarse aggregates differ in nature and shape depending on their extraction and production. The trials are made keeping maximum aggregate size of 20 mm. The coarse aggregates, obtained from a local source, had a specific gravity of 2.7 for 20 mm down aggregates.

Following tests can be performed on coarse aggregate in laboratory to check its quality.

2.10.1 Sieve analysis and fineness modulus.

Table No: 5 fineness modulus of coarse aggregate

seive size(mm)	Weight retained (gm)	Cumulative weight retained (gm)	Cumulative %weight retained	umulative passing
40	0	0	0	0

32	**0**	**0**	**0**	**0**
26	**22**	**22**	**1.1**	**98.9**
20	**223**	**245**	**12.25**	**87.75**
12.5	**1528**	**1773**	**88.65**	**11.36**
10	**115**	**1888**	**94.4**	**5.6**
4.75	**64**	**1952**	**97.6**	**2.4**
Pan	**48**	**2000**	**100**	**0**
			Total=294	

Fineness modulus = 294/100

= 2.94

2.11 Steel Fibers

In this present study Hook ended Steel Fibers were used. These Steel fibers were obtained from cheerlapally. The mechanical properties and chemical composition of these fibers is as follows

Table 6 Mechanical properties of steel fiber

Mechanical properties of hooked end steel fiber	
Size in dia	0.50 mm
Length	50 mm
Tensile strength	1188 MPa
Tolerance for diameter and length	(+/-)10%(as per ASTM)

Table 7 Chemical composition of steel fibre

Chemical composition of mild steel wire	
C	0.035
Mn	0.310
Si	0.045
P	0.017
S	0.003

Fig 2: Hooked Steel fibers

3 Concrete mix design

Concrete mix design is the process of choosing appropriate concrete materials and figuring out their proportions with the goal of producing concrete with the necessary strength, durability, and workability as cheaply as feasible. The performance requirements for concrete in its two states—plastic and hardened—determine the proportioning of its ingredients. The plastic concrete cannot be properly poured or compacted if it is not workable. As a result, the workability property assumes critical significance.

The quality and quantity of cement, water, and aggregates; batching and mixing; placement, compaction, and curing are only a few of the variables that affect hardened concrete's compressive strength, which is typically regarded as a measure of its other attributes. The cost of the labour, equipment, and supplies goes into the price of the concrete. Because cement is more expensive than aggregate, there are variances in material costs; as a result, it is important to create a mix that is as lean as feasible. Technically speaking, rich mixes may result in high shrinkage and cracking in structural concrete as well as the evolution of high hydration heat in mass concrete, both of which may result in cracking.

The cost of the materials needed to produce a minimum mean strength, or characteristic strength, that is defined by the structure's designer affects the actual cost of concrete. This depends on the quality control procedures, however it is undeniable that these raise the price of concrete. Depending on the size and nature of the task, the level of quality control is frequently a tradeoff in terms of cost. The cost of labour is affected by the mix's workability; for example, a concrete mix with poor workability may require a lot of labour to compact it to the desired level with the equipment at hand.

3.1Mix proportions for concrete

The different mix proportions for M20 grade concrete considering in this experimentare shown in table 8

Table 8 Different Mix Proportions used in this study

S.NO	MIX	STEEL FIBER (%)
1	Mix 1	0 %
2	Mix 2	1 %
3	Mix 3	2 %
4	Mix 4	3 %

Table 9 Mix design specification for M20

Description of items	Mix proportion for cubic meter (kg/m^3)
Cement content	383
Coarse aggregate	546
Fine aggregate	1188
Water content	191.6 liters
Water cement ratio	0.5

3.2 Preparation of Concrete Mixes and Casting of test Specimens

The necessary amounts of ingredients were weighed after the mix proportions were decided upon. To create a uniform mix, cement, coarse and fine aggregates were first combined in a mixer. Superplasticizer and water were then added. The mixing process took roughly 5 minutes in total. After running the tests for new properties, casting was done right away after mixing. To get a smooth finish and remove extra material, the specimens' top surface was scraped. Six 150mm x 150mm x 150mm cubes of each concrete mix were cast. Three layers of specimens for a typical concrete mix were cast before vibration with a tamping rod. After 24 hours, all specimens were remolded, and they were then immediately moved to the curing tank.

4. Fresh Concrete Tests

4.1Slump test

To ascertain the consistency of concrete, utilize a slump test. How stiff the mixture is, or how much water has been added, is determined by its consistency. The stiffness of the concrete mix should correspond to the standards for the caliber of the finished product. The outcome of the slump test serves as an indicator of how a compacted, inverted cone of concrete would behave when subjected to gravity. It gauges the concrete's consistency or moisture content. Every mixture in the experiment listed in the table is subjected to the slump test. The test is repeated until the mix design's expected slump is attained.

4.2 Types of Slump

The slumped concrete takes various shapes, and according to the profile of slumpedconcrete, the slump is termed as;

1. **Collapse Slump**
2. **Shear Slump**
3. **True Slump**
4. **No slump**

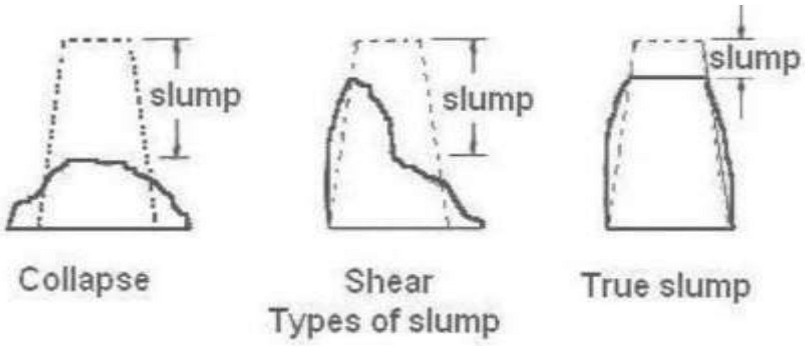

Fig 3: Types of slump

- **Collapse Slump**

In a collapse slump the concrete collapses completely. A collapse slump will generally mean that the mix is too wet or that it is a high workability mix, for which slump test isnot appropriate.

- **Shear Slump**

In a shear slump the top portion of the concrete shears off and slips sideways. (OR) Ifone-half of the cone slides down an inclined plane, the slump is said to be a shear slump.

1. If a shear or collapse slump is achieved, a fresh sample should be taken and the test isrepeated.
2. If the shear slump persists, as may the case with harsh mixes, this is an indication of lackof cohesion of the mix.

- **True slump**

In a true slump the concrete simply subsides, keeping more or less to shape

1. This is the only slump which is used in various tests.

2. Mixes of stiff consistence have a Zero slump, so that in the rather dry range no variation can be detected between mixes of different workability.

4.3 Procedure

1. The mould for the slump test is a frustum of a cone, 300 mm (12 in) of height. The baseis 200 mm (8 in) in diameter and it has a smaller opening at the top of 100 mm (4 inch).
2. The base is placed on a smooth surface and the container is filled with concrete in three layers, whose workability is to be tested.
3. Each layer is temped 25 times with a standard 16 mm (5/8 in) diameter steel rod, roundedat the end.
4. When the mould is completely filled with concrete, the top surface is struck off (levelledwith mould top opening) by means of screening and rolling motion of the temping rod.
5. The mould must be firmly held against its base during the entire operation so that it couldnot move due to the pouring of concrete and this can be done by means of handles or foot- rests brazed to the mould.
6. Immediately after filling is completed and the concrete is levelled, the cone is slowly andcarefully lifted vertically, an unsupported concrete will now slump.
7. The decrease in the height of the centre of the slumped concrete is called slump.
8. The slump is measured by placing the cone just besides the slump concrete and the temping rod is placed over the cone so that it should also come over the area of slumped concrete.

9. The decrease in height of concrete to that of mould is noted with scale**.**

Fig : 4 Cube specimens

4.3.1Compacting by Hand:

When compacting by hand, the standard tamping bar is used and the stroke of the bar should be distributed in a uniform manner. The number of strokes for each layer should not less than

Fig: 5 Compacting by hand

30. The stroke should penetrate in to the underlying layer and the bottom layer should be rodded throughout its depth. After top layer has been compacted, the surface of the concrete should be finished level with the top of the mould, using a trowel and covered with a glass or metal plate to prevent evaporation.

4.3.2 Curing of Specimen:

The test specimen should be stored in a place at a temperature of 27° +/- 2°C for 24 +/- 0.5 hrs. From the time addition of water to the dry ingredients. After this period the specimen should be marked and removed from the moulds and immediately submerged in clean fresh water or saturated lime solution and kept there until taken out just prior to the test. The water or solution in with the specimens are kept should be renewed every seven days and should be maintained

Fig: 6 Curing of samples

5 Hardened Concrete Tests

5.1Compressive strength test

Out of many test applied to the concrete, this is the utmost important which gives an idea about all the characteristics of concrete. By this single test one judge that whether Concreting hasbeen done properly or not.

For cube test two types of specimens either cubes of 15 cm X 15 cm X 15 cm or 10cm X 10 cm x 10 cm depending upon the size of aggregate are used. For most of the works cubical moulds of size 15 cm x 15cm x 15 cm are commonly used.

Procedure

- The concrete mix design has been carried out for M20 grade concrete as per IS: 10262:2009. Three cubes of standard dimensions (150 mm x 150 mm x 150 mm) were cast with plain concrete (M_{20}) using normal ingredients: cement, coarse aggregate and fine aggregate and water is filled by five layers and tampering each layer 10 times and cured for 7,14 and 28days.
- The grade of concrete used was M20. Series of concrete cubes of standard dimensions (150 mm x 150 mm x 150 mm) were casted. Hooked steel fibres of 1%,2% and 3% by weight of concrete were added. Each cube is filled in three layers andtampering was done 25 times for each layer. After 24hrs it is demoulded and kept it in curing for 7, 14 and 28 days.
- The cubes were tested in compression testing machine at 7, 14 and 28 days and the compressive strengths of the cubes are compared with that of cubes 0% steel fibres**.**

5.2 Split tensile strength test

One of the fundamental and crucial characteristics of concrete is its tensile strength. Concrete's tensile strength can be assessed using a splitting tensile strength test on a concrete cylinder. Due to its brittleness, concrete is particularly vulnerable to tension and cannot be expected to withstand direct tension. When concrete is subjected to tensile pressures, fractures form. In order to establish the load at which the concrete members may crack, it is important to determine the tensile strength of concrete.

5.3 Procedure of Splitting Tensile Test:

Take the wet specimen from water after 7 days of curing
Wipe out water from the surface of specimen
Draw diametrical lines on the two ends of the specimen to ensure that they are on thesame axial place.
Note the weight and dimension of the specimen.
Set the compression testing machine for the required range.
Keep are plywood strip on the lower plate and place the specimen.
Align the specimen so that the lines marked on the ends are vertical and centered overthe bottom plate.
Place the other plywood strip above the specimen.
Bring down the upper plate to touch the plywood strip.
Apply the load continuously without shock at a rate of approximately 14-21kg/cm2/minute (Which corresponds to a total load of 9900kg/minute to 14850kg/minute)Note down the breaking load(P)

6 Results and Discussion

6.1 Compressive Strength

After The 3, 7 & 28 days curing, the moulds were tested with compression testingmachine and the results were given in table 10

S.no	Mix	Compressive Strength (N/mm^2)		
		7 Days	14 Days	28 Days
1.	Mix 1	20.3	24.6	27.3

2.	**Mix**	**21.8**	**27.1**	**29.8**
3.	**Mix 3**	**24.3**	**29.5**	**32.3**
4.	**Mix 4**	**24.9**	**29.9**	**32.7**

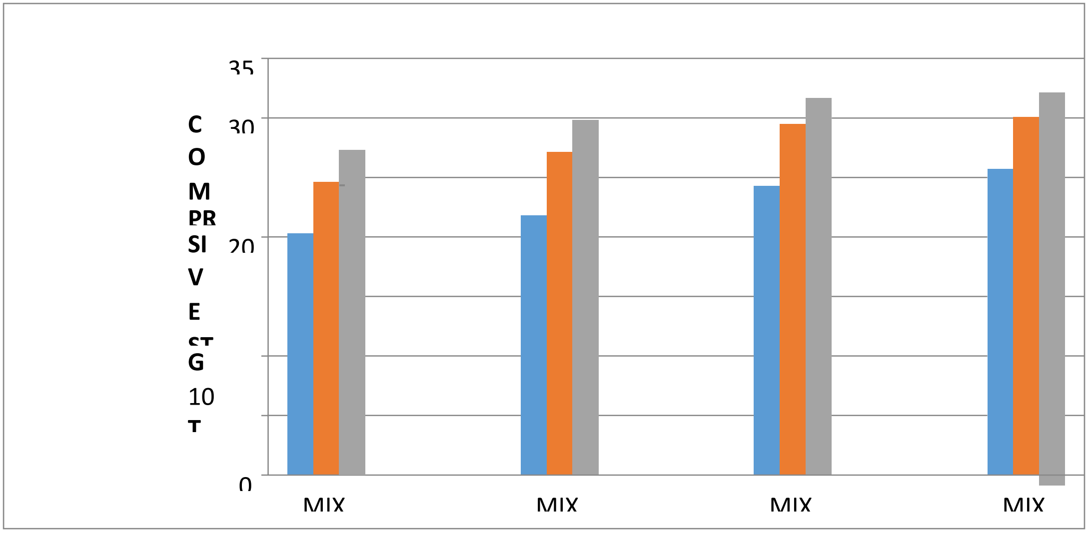

Fig No:7 Comparison of compressive strength

6.2 Split Tensile Strength

After the 3,7 & 28 days curing, the moulds were tested with compression testingmachine and the results were given in table

Table:11 Split tensile strength

s.no	Mix	Split Tensile Strength (N/mm^2)		
		7 Days	14 Days	28 Days
1.	Mix 1	1.65	2.05	2.4
2.	Mix 2	2.6	2.9	3.2
3.	Mix 3	3.1	3.7	3.9
4.	Mix 4	3.36	4.52	4.8

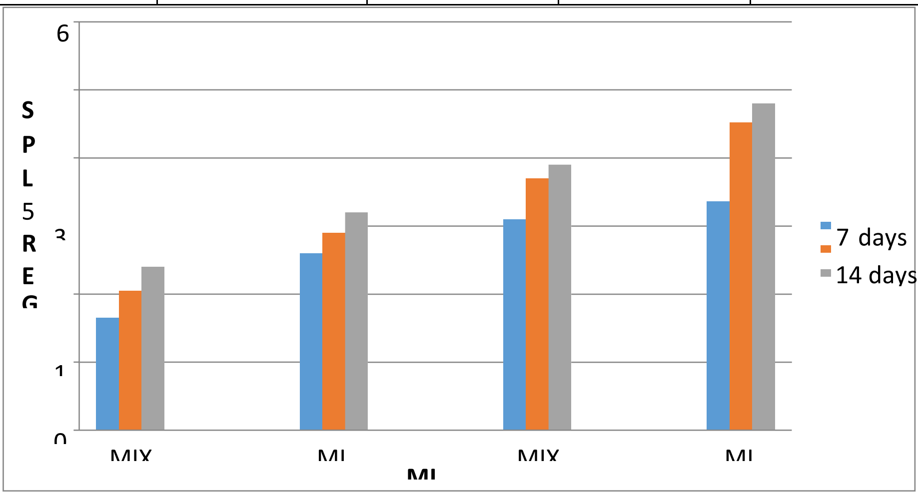

Fig No:8 Comparison of tensile strength

Conclusions

The following conclusions were made by observing the test results of this experimental study.

1. At the 28th day of curing, the compressive strengths of SFRC for the proportions of 0%, 1%,

2%, and 3% are 27.3 MPa, 29.8 MPa, 32.2 MPa, and 32.7 MPa, respectively.

2. At the 28th day of curing, the Split Tensile strength of SFRC for proportions of 0%, 1%, 2%, and 3% is 2.4 MPa, 3.2 MPa, 3.9 MPa, and 4.8 MPa, respectively.
3. Using 3% of steel fibre yields the best compression results, which are 24.9 MPa, 29.9 MPa, and 32.7 MPa at the 7th, 14th, and 28th days of curing, respectively.
4. Using 3% steel fibre yields the highest results in split tensile strength, which are 3.36 MPa, 4.52 MPa, and 4.8 MPa at the 7th, 14th, and 28th days of the experiment curing respectively.
5. Based on the findings, it can be seen that the workability of concrete reinforced with steel fibres declines as the amount of steel fibres rises.
6. The addition of steel fibre to concrete improves the material's tensile and compression strengths as well as its crack resistance.

References

1.ASTM C1018-89, Standard Test Method for Flexural Toughness and First Crack Strength of Fiber Reinforced Concrete (Using Beam with Third-Point Loading), 1991 Book of ASTM Standards, Part 04.02, American Society for Testing and Materials, Philadelphia, pp. 507–513.

2. "Steel Fibrous Shotcrete" by C.H. Henager. An overview of the design and building of the State-of-the-art ConcreteInt. 1981.

3. "Fiber reinforced cements and concretes," by Colin D. Johnston The third volume of advances in concrete technology was published in 2001 by Gordon and Breach Science.

4. MohdZaminJumaat, Kathy KhaiQian Yap, U. Johnson Alengaram, Construction and Building Materials 55 (2014) 20–28,

5."The Effect of Steel Fibers on the Enhancement of Flexural and Compressive Toughness and Fracture Characteristics of Oil Palm Shell Concrete."

6.R.J. Craig, "Structural applications of reinforced steel fibre concrete." Design and construction of concrete worldwide, 1984.

7.The mechanics of crack arrest in concrete, Journal of Engineering and Mechanics Division, ASCE89-147-188, Ramualdi J.P. and Batson G.B. (1983)

8. Vikrants, Vairagada, and Kavitha S. Kne Introduction to steel fibre reinforced concrete in volume 1 issue 4 of the International Journal of Scientific and Technological Research on the engineering performance of concrete (2012).

9.Mohandas, K & Elangovan, G 2016, 'Retrofitting of reinforced concrete beam using different resin bonded GFRP laminates' International Journal of Advanced Engineering Technology, E-ISSN0976-3945, vol. 7 no. 2**,**

10.Mohandas, K & Elangovan, G 2016, 'Retrofitting of reinforced concrete beam using different resin bonded GFRP laminates' International Journal of Advanced Engineering Technology, E-ISSN0976-3945, vol. 7 no. 2,

11.Mohandas, K & Elangovan, G 2015, 'Influence of polymeric resins on the enhancement of strengthening of reinforced concrete beam with phenolic resin bonded FRP'S', International Journal of Applied Engineering Research, ISSN0973-4562 vol. 10, no. 5,

12.Dr.K.Mohan das, Dr.N.Sundar, S Harishankar, A Raj Kumar, SPM Kannan & Dr.K.Ramesh "An experimental study on strength characteristics of replacement of fine aggregate with stone dust and coarse aggregate with demolished concrete waste" YMER.Volume-21;Issue-2,Pages 683-700.

