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Experimental Study on Strength Parameters of Steel Fiber Reinforced Concrete using GI Wire & Fly Ash

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Abstract - *In this paper an attempt is made to present the results of an experimental investigation carried out on steel fiber reinforced concrete. GI wires used as a fibres with aspect ratio 50. In this present Investigation the fiber are randomly oriented and range from 0.1%, to 0.4% at 0.1% interval by weight of cement. The results show the maximum compressive strength is obtained at 0.3% of fiber at 3 and 7 days and at 0.2% of fiber at 28 days. The maximum split tensile strength and flexural strength are found to be at 0.2% of fiber for 7and 28 days. And workability and strength decreases with partially replacement of cement by fly ash with addition of steel fibers.*

Key Words: Steel Fibres, Fly ash, Aspect Ratio

1. Introduction

Concrete is most widely used construction material in the world due to its ability to get cast in any form and shape. In the present days civil engineering constructions have their own structural and durability requirements related with concrete to better suit the intended functions of the structure.

1.1 Fibre Reinforced Concrete

Fiber reinforced concrete can be defined as a composite material consisting of mixture of cement, mortar or concrete and discontinuous, discrete, suitable fibers. Incorporation of fiber in concrete has found to improve several properties like tensile strength, cracking resistance, impact and wear resistance, ductility and fatigue resistance. As a result of these different formulations, four categories of fiber reinforcing have been created. These include steel fiber, synthetic fibers, glass fibers and natural fibers. Within these different fibers that character of fiber reinforced concrete changes with varying concrete's, fiber materials, geometries, distribution, orientation and densities. In this project galvanized iron (GI) wire is used as a steel fibers because for the reasons to improve strength of the concrete.

1.2 1 Advantages of SFRC

- SFRC distributes localized stresses.
- Reduction in maintenance and repair cost.
- Provides tough and durable surface.
- Reduce surface permeability, dusting and wear.
- Cost saving.
- They act as a crack arrestor.
- Increase tensile strength and toughness.
- Resistance to impact.
- Resistance to freezing and thawing.be used. Other font types may be used if needed for special purposes.

1.2.2 Disadvantages of SFRC

- Increase in specific gravity of the concrete. This means that the concrete will be heavier than normal concrete in case some fibers.
- Proportioning the exact amount of fibers in the batch of concrete. Test has shown that a slight variation in fibers creates tremendous changes in concrete strength.
- Higher cost because of its control issues (production issues) as well as the cost of raw material is high.
- Corrosion of steel fibers. Use of fibers to increase the tensile strength and stiffness and in order to get higher performance of concrete but corrosion of fiber will reduce the performance level.

1.3 Applications of SFRC

- Replacement slabs or overlays to resist cavitations damage.
- Airport and highway paving and overlays- particularly where thinner-than-normal slab is desired.
- Industrial floors- for impact resistance and resistance to thermal shock.
- Foundations slabs for residential buildings.
- Bridge decks- as an overlay or topping where primary structural support is provided by and underlying reinforced concrete deck.

2 Methodology and Materials

The objective of this experimental investigation is to determine the strength parameters such as compressive strength, split tensile strength & flexural strength of concrete and designed to meet the requirements of M25 grade of concrete.

- In first stage, properties of various materials used in mix are studied.
- In second stage, mix design is carried out for preparation of the mould.
- Investigate the strength characteristics (compressive, split tensile and flexural strength) of concrete modified with addition of variable proportions of steel fibers (0.1%, 0.2%, 0.3%, and 0.4%).
- Compare the effect of various type of fibers for efficient performance interests of strength and workability.
- Final stage is about comparing the results.

3. Materials

The materials used in the experimental program and basic tests performed on them. The materials used in this study are tested for their properties as per Indian standards.

3.1 Cement

Ordinary Portland cement of 53 grade (ultra tech cement) confirming to Indian standard IS 8112:1989 has been used in the present study.

3.2 Fine aggregate

Natural river sand from Krishna river Karnataka, is used as a fine aggregate. Advantage of natural sand is that particles are cubical rounded with smooth surface texture and gives good workability.

3.2 Coarse aggregate

Locally available coarse aggregate having the maximum size of 20mm was used in the present work.

3.3 Water

Generally, portable water can be used for concrete mixing. The amount of water in concrete controls many fresh and hardened properties in concrete including workability, compressive strengths, permeability and water tightness, durability and weathering.

3.4 Admixture

Super plasticizer constitutes a relatively new category and improved version of plasticizers. In this present study master rheobuild SP11 is used as a super plasticizer and it is composed of synthetic polymers specially designed to impart rheoplastic qualities to concrete

3.5 Steel Fibres

In Present study 0.5mm G.I. Wires used as a steel fibres and GI wires are coated with zink and in size range 0.37 mm to 5 mm in market.

Figure 1: Galvanizes Iron Wire

4. Tests on Materials

Following tests are conducted on materials to know the quality of materials.

4.1 Tests on Cement

The cement is tested for its various properties as per IS code. The results on cement are shown in table.1

Table -1 Properties of Portland cement

Sl.No	Properties	Results
1	Normal consistency	32
2	Specific gravity	3.12
3	Initial setting time	80 min
4	Final setting time	550 min

4.2 Tests on Aggregates

Table -2: Properties of fine aggregate

Sl.No	Property	Results
1	Specific gravity	2.58
3	Fineness Modulus	2.58

Table -3: Properties of Coarse aggregate

S.NO	Property	Results
1	Specific gravity	2.68
3	Fineness Modulus	3.12

5. Mix Design

The mix design is carried for M25 grade concrete as per IS: 10262-2009.

Cement	Fine aggregate	Coarse aggregate
1	2.36	3.27

6. Experimental Investigation

6.1 Tests on Fresh Concrete

The behavior of fresh concrete from mixing up to compaction depends mainly on the property called workability, is the ease with which concrete mixes can be compacted as completely as possible while using the lowest possible water/cement ratio. A workable mix should not segregate. Workable concrete is the one which exhibits very little internal friction between the partials and it can be consolidated with minimum compacting effort.

6.1 Production of cement concrete

Mixing

Mixing in the present investigation is carried by using a Pan Mixer. All the materials are dumped in the pan and the mixing was done for about 3-4 minutes by the addition of water obtained in the mix design.

Placing and Compaction

After the completion of mixing, concrete is placed in number of layers in to the moulds & compacted by tamping rod.

Curing

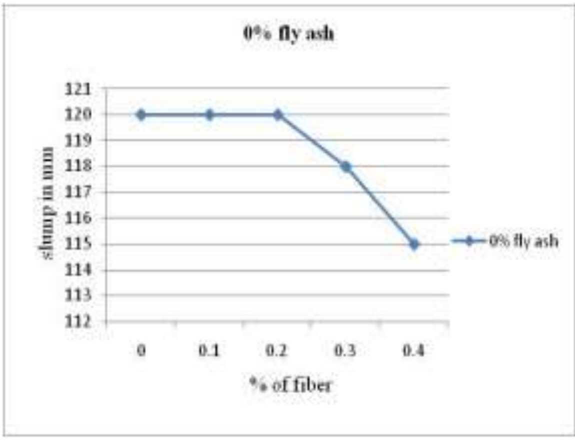
After casting of specimens moulds were de-molded after 24 hours of casting and specimens kept for curing.

7. Results & Discussions

7.1 Workability

Table 4: Slump Values of Different Mixes

Sl.No.	Fiber content in concrete	W/c	Slump value (mm)
1	0%	0.45	120
2	0.1%	0.45	120
3	0.2%	0.45	120
4	0.3%	0.45	118
5	0.4%	0.45	115

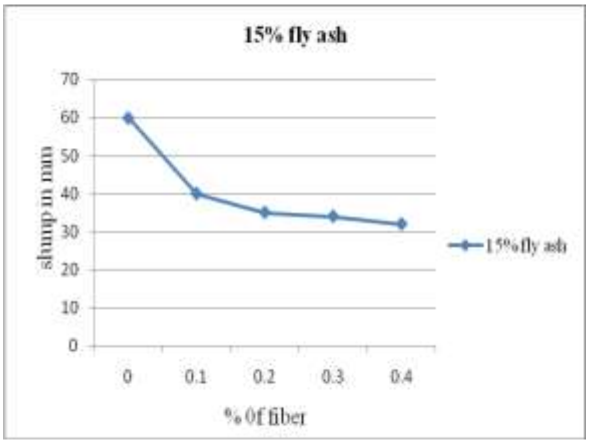


Graph 1: slump value VS % of fiber

From graph 1 it is observed that use of super plasticizer in concrete the slump value is more than assumed slump value. As percentage of fibers up to 0.2% the workability is almost same as percentage increases after 0.2% the workability of concrete is slightly decreases.

Table 5: Slump Values of Different Mixes with fly ash

Sl.No.	Fibers in	W/c	Slump (mm)
1	0%	0.45	60
2	0.1%	0.45	40
3	0.2%	0.45	35
4	0.3%	0.45	34
5	0.4%	0.45	32



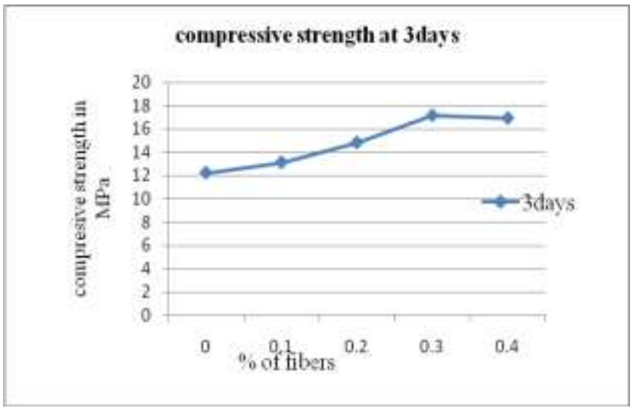
Graph 2: study of comparison of slump in (mm) in % of fiber

From graph 1 it is observed that use of fly ash & super plasticizer in concrete the slump value is lower than assumed slump value. As percentage of fibers increases the workability of the concrete is decreases.

7.2 Compressive strength

Table 6: Compressive Strength concrete at 3 days

SL.NO	ASPECT RATIO	MIX	READING OF SPECIMENS			STRENGTH (N/mm²)
			S1	S2	S3	
1	50	0% fiber	270	280	275	12.22
2	50	0.1% fiber	290	300	295	13.11
3	50	0.2% fiber	350	320	330	14.81
4	50	0.3% fiber	395	385	378	17.15
5	50	0.4% fiber	382	376	358	16.53

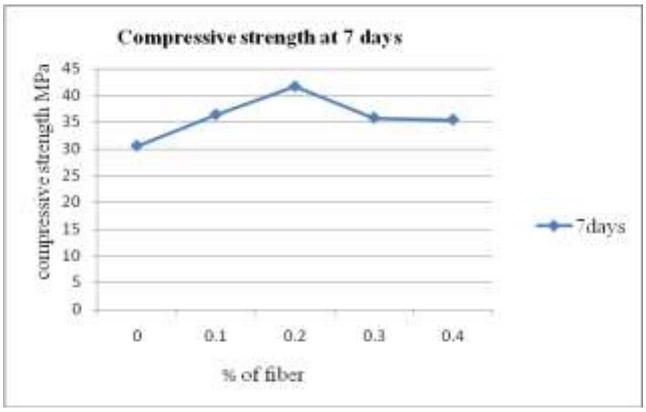


Graph 3: Study Comparison of Compressive strength VS % of fiber for 3 days

From the above graph, it is observed that compressive strength of fiber reinforced concrete composed with steel fiber is found to maximum at 0.3% of total fiber content by weight of cement.

Table 7: Compressive Strength concrete at 7 days

SL.NO.	ASPECT RATIO	MIX	READING OF SPECIMENS			STRENGTH (N/mm²)
			S1	S2	S3	
1	50	0% fiber	680	672	709	30.53
2	50	0.1% fiber	641	894	919	36.35
3	50	0.2% fiber	944	1005	861	41.60
4	50	0.3% fiber	742	852	796	35.40
5	50	0.4% fiber	742	832	840	35.76

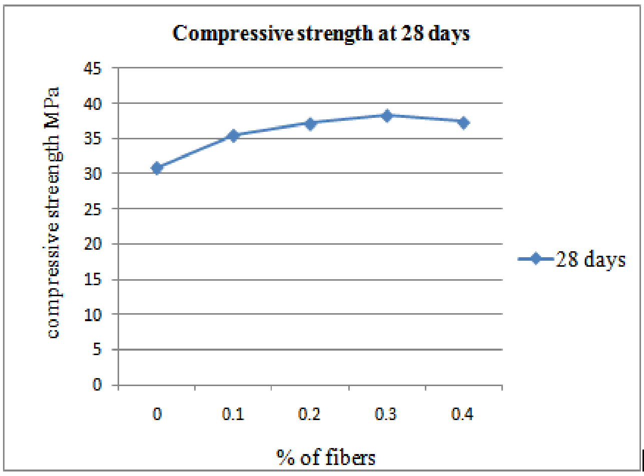


Graph 4: Study Comparison of Compressive strength VS % of fiber for 7 days

From the graph 4, it is observed that maximum compressive strength is to be obtained at 0.2% of fiber (by weight of cement), beyond 0.2% compressive strength gradually decreases.

Table 8: Compressive Strength concrete at 28 days

SL.NO.	ASPECT RATIO	MIX	READING OF SPECIMENS			STRENGTH (N/mm²)
			S1	S2	S3	
1	50	0% fiber	674	689	720	30.85
2	50	0.1% fiber	776	807	813	35.49
3	50	0.2% fiber	835	826	846	37.14
4	50	0.3% fiber	892	820	873	38.296
5	50	0.4% fiber	998	719	803	37.33

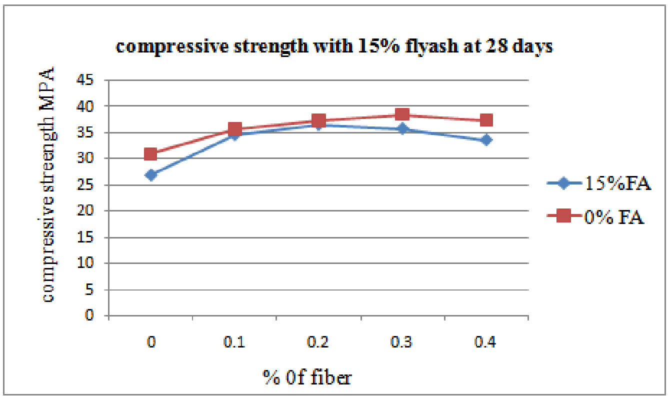


Graph 5: Study Comparison of Compressive strength VS % of fiber for 28 days

From the graph 5, it is observed that maximum compressive strength obtained at 0.3% of fiber, beyond that this compressive strength slightly reduces as compare 0.3% fibers.

Table 8: Compressive Strength concrete at 28 days with fly ash.

SL.NO	ASPECT RATIO	MIX	READING OF SPECIMENS			STRENGTH (N/mm²)
			S1	S2	S3	
1	50	0% fiber	605	618	591	26.87
2	50	0.1%fiber	669	756	909	34.57
3	50	0.2%fiber	662	1034	766	36.47
4	50	0.3%fiber	756	882	696	35.76
5	50	0.4%fiber	630	787	850	33.58



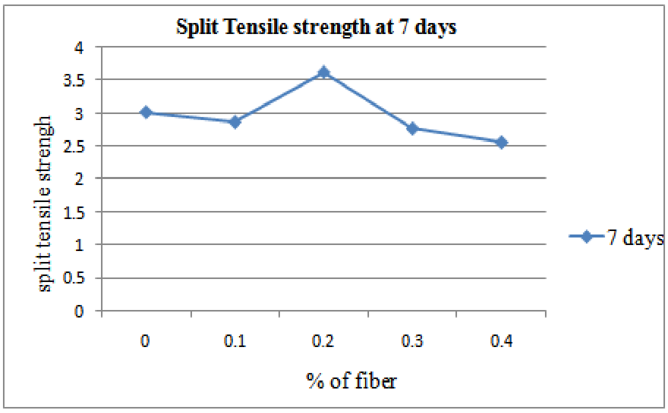
Graph 6: Study Comparison of Compressive strength VS % of fiber for 28 days with fly ash

From the above graph, it is observed that maximum compressive strength at 0% fly ash obtained to be 0.3% of fiber and for 15% fly ash it is obtained at 0.2% fiber, but by comparing both the results maximum compressive strength at 0% fly ash is more than 15% fly ash.

7.3 Split Tensile Strength

Table 9: Split tensile Strength at 7 days.

S.NO.	ASPECT RATIO	MIX	READING OF SPECIMENS			STRENGTH (N/mm²)
			S1	S2	S3	
1	50	0% fiber	218	193	231	3.02
2	50	0.1% fiber	203	206	201	2.87
3	50	0.2% fiber	242	289	241	3.63
4	50	0.3% fiber	205	184	198	2.77
5	50	0.4% fiber	169	171	204	2.56

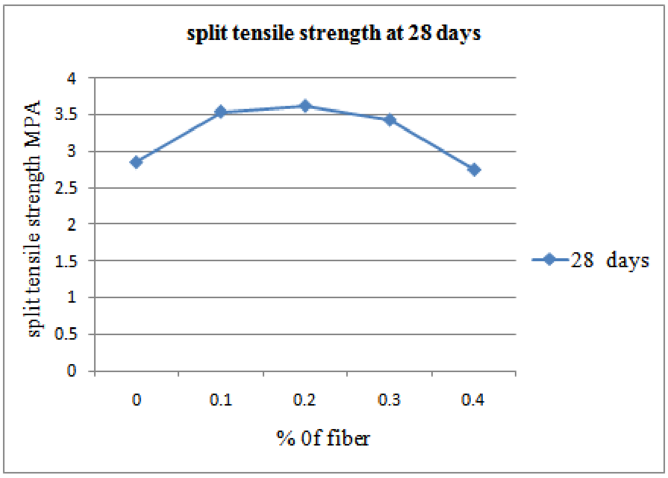


Graph 7: Study of Comparison of split tensile strength in % of fiber at 7 days

From the above graph, it is observed that the tensile strength of concrete increases up to 0.2% of fiber and as percentage increases beyond 0.2% it is goes on decreases.

Table 10: Split tensile Strength at 28 days

S.NO.	ASPECT RATIO	MIX	READING OF SPECIMENS			STRENGTH (N/mm²)
			S1	S2	S3	
1	50	0% fiber	224	192	191	2.85
2	50	0.1% fiber	260	254	238	3.54
3	50	0.2% fiber	180	125	20	3.62
4	50	0.3% fiber	276	215	237	3.43
5	50	0.4% fiber	192	201	191	2.75



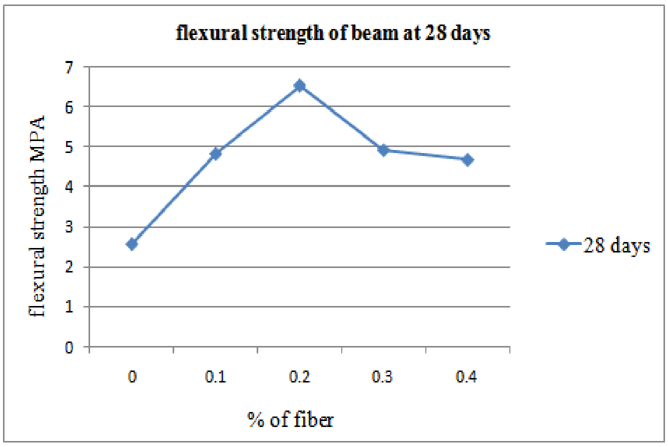
Graph 8: Study of Comparison of split tensile strength in % of fiber at 28 days

From the above graph, it is observed that maximum tensile strength was found to be at 0.2%of fiber and as increase in percentage of fiber after 0.2% the tensile strength gradually decreases

7.4 Flexural strength

Table 11: Flexural Strength at 28 days

S.NO.	ASPECT RATIO	MIX	READING OF SPECIMENS			STRENGTH (N/mm²)
			S1	S2	S3	
1	50	0% fiber	8.5	8	12.5	2.58
2	50	0.1% fiber	17.5	19.5	20	4.62
3	50	0.2% fiber	1.5	21.5	20	6.52
4	50	0.3% fiber	20	16.5	18	4.67
5	50	0.4% fiber	16	17.5	19.5	4.91



Graph 9: Study of Comparison of flexural strength in % of fiber at 28 days

From above graph, it is observed that flexural strength of concrete is increases with increase in fiber content up to 0.2% and as increases in fiber percentage the flexural strength gradually decreases

8. CONCLUSION

Based on the experimental and analytical results the following conclusions are drawn

- The compressive strength of fiber reinforced concrete composed with steel fibers is found maximum at 0.3% of total fiber content by weight of cement at 3days and 28 days, at 0.2% of total fiber content by weight of cement at 7days.
- The compressive strength of fiber reinforced concrete with fly ash composed with steel fiber is less than as compared with compressive strength of fiber reinforced concrete without fly ash
- The split tensile strength of fiber reinforced concrete composed with steel fibers is found to be maximum at 0.2% of total fiber content by weight of cement at the age of 7days and 28 days.
- The flexural strength of fiber reinforced concrete composed with steel fiber is found to be maximum at 0.2% of total fiber content by weight of cement at 28 days.
- Incorporation of steel fibers decreases the workability considerably.
- Workability and strength decreases with partially replacement of cement by fly ash.

Scope for future study

- In this present study, the strength parameters such compressive strength, split strength and flexural strength with percentage of steel fiber up to 0.4% was adopted with aspect ratio of 50. For further study different types of fibers can use with different percentages and with different aspect ratios.
- Water cement ratio were adopted 0.45 for this present study, can also adopt different range of water cement ratios for future study.
- Present study shows only compressive strength of concrete with constant percentage of fly ash. For further can be study other strength parameters such as tensile strength and flexural strength along with fibers.

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