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EXPERIMENTAL STUDY ON EFFECT OF STEEL FIBERS AND GLASS FIBERS ON PROPERTIES OF CONCRETE

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Abstract -This Concrete requires some form of tensile reinforcement to compensate its brittle behaviour. To increase the toughness and resistance to cracks can be introduced into the concrete mixture. In this thesis a comparative study is carried out on the properties of steel fiber reinforced concrete and glass fiber reinforced concrete with conventional concrete. Specimens of M30 and M40 grade concrete with different percentages of fibers are casted and tested. After the casting of cubes, beams and cylinder with the above stated quantity fractions we can carry out specific test which include compressive strength, tensile strength and flexural strength respectively. After the completion of this work we compare the results of glass fiber strengthened concrete with that of the normal concrete. From evaluating those two we are able to see that how the addition of the fibers will have an effect on the mechanical properties of conventional concrete and we check that the addition of fibers improves the strength of concrete or not.

Key Words: compressive strength, glass fibers, tensile strength, flexural strength, steel fibers,

1. INTRODUCTION

Cement mortar and concrete are the most extensively used building materials and their consumption is mounting swiftly in almost all countries. The only drawback of cement concrete is its brittleness, with comparatively low tensile strength and low resistance to crack opening and proliferation and trivial elongation at break. To overwhelm these discrepancies, reinforcement with discrete fibers might play a significant role. Fiber reinforced concrete (FRC) reduces the bleeding of water in concrete and thus also reduces the porous nature of concrete. Some forms of fibers produce shatter resistance and extra abrasion in concrete.

Steel fibers are added to concrete to improve the structural properties, particularly tensile and flexural strength. The extent of improvement in the mechanical properties achieved with SFRC over those of plain concrete depends on several factors, such as shape, size, volume, percentage and distribution of fibers.

Glass fiber-reinforced concrete uses fiberglass, much like you would find in fiberglass insulation, to reinforce the concrete. The glass fiber helps insulate the concrete in addition to making it stronger. Glass fiber also helps prevent the concrete from cracking over time due to mechanical or thermal stress. In addition, the glass fiber does not interfere with radio signals like the steel fiber reinforcement does.

2. LITERARTURE REVIEW

[1] Samprati Mishra [2017], "Glass Fiber Reinforced Concrete":

In the present study alkali resistance glass fiber is used. Glass fiber falls under the economical class i.e. without any extra expenditure (out of the total cost of concrete) it can be used. The glass fiber used here are 12mm in length and the diameter of each fiber is 14micron. A total of 10 mixes were prepared by varying the percentage of glass fiber and grade of concrete mixes. Firstly a trial test was done by adding different percentages of glass fiber to M25 grade concrete. The compressive strength test was done at 7days and 28days. The results were finally compared.

[2] K.I.M.Ibrahim [2016], "Mechanical Properties of Glass Fiber Reinforced Concrete (GFRC)":

In this project, cube, cylinders and beams specimens have been designed with glass fiber reinforced concrete (GFRC) containing glass fibers of 0% ,0.1% ,0.3%and 0.5% volume fraction . Comparing the results of GFRC with plain concrete, this paper validated the positive effect of glass fibers with percentage increase in compression, splitting and flexure improvement of specimens at 7 and 28 days.

[3] J.D.Chaitanya kumar, G.V.S. Abhilash, P.Khasim Khan, G.Manikanta sai, V.Taraka ram [2016], "Experimental Studies on Glass Fiber Reinforced Concrete":

The main aim of the study is to study the effect of glass fibre in the concrete. Glass fibre has the high tensile strength and fire resistant properties thus reducing the loss of damage during fire accidents. The addition of these fibres into concrete can dramatically increase the compressive strength, tensile strength and split tensile strength of the concrete. In this study, tests have done for the concrete with glass fibre of 0.5%, 1%, 2% and 3% of cement by adding as an admixture. They observed that the workability of concrete increases at 1% with the addition of glass fiber and the increase in compressive strength, flexural strength, split tensile strength for M-20 grade concrete at 7 and 28 days are observed to be more at 1%.

[4] Abdul Ghaffar, Amit S. Chavhan, Dr.R.S.Tatwawadi [2014], "Steel Fiber Reinforced Concrete":

The purpose of this research is based on the investigation of the use of steel fibers in structural concrete to enhance the mechanical properties of concrete.. This investigation was carried out using several tests, compressive test and flexural test. A total of eleven mix batches of concrete containing 0% to 5% with an interval of 0.5% by wt. of cement. 'Hooked' steel fibers were tested to determine the enhancement of mechanical properties of concrete. The workability of concrete significantly reduced as the fiber dosage rate increases.

[5] Amit Rana [2013], "Some Studies on Steel Fiber Reinforced Concrete":

Fibers are generally used as resistance of cracking and strengthening of concrete. In this project, I am going to carry out test on steel fiber reinforced concrete to check the influence of fibers on flexural strength of concrete. According to various research papers, it has been found that steel fibers give the maximum strength in comparison to glass and polypropylene fibers. From the exhaustive and extensive experimental work they found that with increase in steel fiber content in concrete there was a tremendous increase in Flexural strength. Even at 1 % steel fiber content flexural strength of 6.46 N/mm^2 was observed against flexural strength 5.36 N/mm^2 at 0% hence increase of 1.1% flexural strength was obtained.

3. MATERIALS CHARACTERIZATION

(a) Cement

The cement used in casting all specimens is Ordinary Portland Cement (OPC 53 Grade).The physical and chemical properties of cement is complied with IS: 12269-1987.

(b) Fine Aggregate

Fine aggregates are essentially any natural sand particles won from the land through the mining process. Fine aggregates consist of natural sand or any crushed stone particles that are ¼" or smaller. Fine aggregate i.e. Sand confirming to Zone-III of IS: 383-1970, is used for concrete.

(c) Coarse Aggregate

Coarse aggregate i.e. crushed stone chips of size 4.75 - 20 mm confirming to IS: 383-1970. Coarse aggregate are generally obtained by blasting in stone quarries or by breaking them by hand or by crushers. machine – crushed stones consist of stones of various sizes whereas hand – broken aggregates consist of only ingle size stones.

(d) Water

Potable water free from impurities and deleterious materials was used for mixing and curing in this thesis.

(e) Steel Fibers

Steel fibers transforms the concrete which is brittle in to ductile, robust and durable. Steel fibers are available in different length and shape. In this thesis Hooked Steel Fibers are used.

Hooked Steel Fibers

These steel fibers can be used with any concrete mix. The length to diameter ratio typically rangesfrom 30 to 100 mm.

(f) Glass Fibers

Glass Fibers are numerous fine strands of extremely fine glass. They are light weight, extremely strong and robust. They are less brittle and the raw materials are less expensive. Chopped strands of glass were used.

4. METHODOLOGY

The aim of this investigation is to compare the basic properties of control concrete with concrete made of steel fibers and concrete made with glass fibers for M30 & M40 grade of concrete.

Nine concrete types were tested for each grade of concrete mix.

(a) The first concrete sample was prepared with 0% addition of fiber i.e, control mixture.
(b) The second concrete sample was made with 0.5% addition of steel fiber.
(c) The third concrete sample was made with 1.0% addition of steel fiber.
(d) The fourth concrete sample was made with 1.5% addition of steel fiber.
(e) The fifth concrete sample was made with 2.0% addition of steel fiber.
(f) The sixth concrete sample was made with 0.5% addition of glass fiber.
(g) The seventh concrete sample was made with 1.0% addition of glass fiber.
(h) The eighth concrete sample was made with 1.5% addition of glass fiber.
(i) The ninth concrete sample was made with 2.0% addition of glass fiber.

S.NO	PROPERTY OF CEMENT	VALUES OBTAI NED
1.	Standard Consistency (%)	20%
2.	Initial Setting Time (mins)	62 mins
3.	Final Setting Time (mins)	370 mins
4.	Fineness (%)	4%
5.	Soundness	4mm
6.	Specific Gravity	3.15
7.	Compressive Strength (N/mm^2)	47 N/mm^2
		66 N/mm^2

5. MATERIAL PROPERTIES

Table-1: Properties of OPC 53 Grade Cement

S.No.	PROPERTY OF FINE AGGREGATE	VALUES OBTAINED
1.	Specific Gravity	2.71
2.	Water Absorption (%)	3.0%
3.	Grading Zone	III
4.	Fineness Modulus	2.89

Table-2: Properties of Fine Aggregate

Table-3: Properties of Coarse Aggregate

S.No.	PROPERTY OF COARSE AGGREGATE	VALUES OBTAI NED
1.	Particle Shape	Angular
2.	Specific Gravity	2.73
3.	Water Absorption	0.27%
4.	Fineness Modulus	8.43

Table-4: Mechanical Properties of Steel Fibers

S.No.	PROPERTIES	VALUES
1.	Type	Hooked
2.	Length	50mm
3.	Diameter	1mm
4.	Aspect Ratio	50

Table-5: Mechanical Properties of Glass Fibers

S.No	PROPERTIES	VALUES
1.	Length	50mm
2.	Diameter	0.5 mm
3.	Aspect Ratio	100

6. EXPERIMENTAL WORK

In present experimental work, various concrete mix batches have been prepared such as, normal concrete i.e. 0% fiber content, 0.5%, 1.0%, 1.5% and 2% addition of hooked steel fiber, 0.5%, 1.0%, 1.5% and 2% addition of glass fiber, . The testing of mechanical properties were conducted on Universal Testing machine for 3 days, 7 days and 28 days.

(a) Evaluation of Compressive Strength:

Compressive strength is the most common test conducted on hardened concrete, partly because itis an easy test to perform, and partly because most of the desirable characteristic properties of concrete are qualitatively related to its compressive strength. To evaluate the compressive strength cubes of size 150 mm x 150 mm x 150 mm were casted using C.I. mould.

(b) Evaluation of Split Tensile Strength:

Generally the split tensile strength will be predicted by using cylinders of diameter 150mm and depth or height of 300m placing longitudinally and applying force by machine. This work is carried out for grades of M40 & M60 at 3days, 7days and 28 days.

(c) Evaluation of Flexural Strength:

Modulus of rupture was tested by prisms with dimension of (100x100x500) mm. When tested the prisms we put the loadin two points on them (two point load).

7. RESULTS & DISCUSSIONS

Table 6: Compressive Strength for varying % of Steel and Glass Fibers for M_{30} Grade Concrete

TYPE	FIBER CONTENT	AVERAGE COMPRESSIVE STRENGTH (N/mm^2)		
		3 DAYS	7 DAYS	28 DAYS
Plain	0%	12.10	22.48	32.89
Steel Fiber	0.5%	13.58	23.41	33.56
	1.0%	14.12	24.03	34.11
	1.5%	14.91	24.81	34.97
	2.0%	14.03	24.01	34.07
Glass Fiber	0.5%	12.88	22.89	33.04
	1.0%	13.67	23.58	33.89
	1.5%	14.12	24.01	34.22
	2.0%	13.55	23.12	33.67

Table 7: Compressive Strength for varying % of Steel and Glass Fibers for M_{40} Grade Concrete

TYPE	FIBER CONTENT	AVERAGE COMPRESSIVE STRENGTH (N/mm^2)		
		3 DAYS	7 DAYS	28 DAYS
Plain	0%	16.45	28.34	42.56
Steel Fiber	0.5%	17.32	29.41	43.35
	1.0%	18.09	30.12	44.10
	1.5%	18.89	30.88	44.89
	2.0%	18.08	30.06	44.01
Glass Fiber	0.5%	16.89	28.94	42.93
	1.0%	17.67	29.47	43.56
	1.5%	18.22	30.05	44.22
	2.0%	17.12	29.00	43.09

Table 8: Split Tensile Strength for varying % of Steel and Glass Fibers for M_{30} Grade Concrete

TYPE	FIBER CONTENT	AVERAGE SPLIT TENSILE STRENGTH (N/mm^2)	
		7 DAYS	28 DAYS
Plain	0%	3.60	4.53
Steel Fiber	0.5%	3.96	4.99
	1.0%	4.20	5.15
	1.5%	4.34	5.38
	2.0%	4.12	5.08
	0.5%	3.86	4.84

Glass Fiber	1.0%	4.06	5.04
	1.5%	4.23	5.14
	2.0%	4.00	4.96

Table 9: Split Tensile Strength for varying % of Steel and Glass Fibers for M_{40} Grade Concrete

TYPE	FIBER CONTENT	AVERAGE SPLIT TENSILE STRENGTH (N/mm^2)	
		7 DAYS	28 DAYS
Plain	0%	3.96	4.70
Steel Fiber	0.5%	4.45	5.12
	1.0%	4.89	5.38
	1.5%	5.01	5.56
	2.0%	4.77	5.10
Glass Fiber	0.5%	4.38	5.03
	1.0%	4.67	5.13
	1.5%	4.87	5.33
	2.0%	4.41	5.04

Table 10: Flexural Strength for varying % of Steel and Glass Fibers for M_{30} Grade Concrete

TYPE	FIBER CONTENT	AVERAGE FLEXURAL STRENGTH (N/mm^2)	
		7 DAYS	28 DAYS
Plain	0%	2.56	3.83
Steel Fiber	0.5%	2.89	4.01
	1.0%	3.12	4.29
	1.5%	3.49	4.45
	2.0%	3.06	4.15
Glass Fiber	0.5%	2.76	3.94
	1.0%	3.01	4.16
	1.5%	3.32	4.34
	2.0%	2.96	4.07

Table 11: Flexural Strength for varying % of Steel and Glass Fibers for M_{40} Grade Concrete

TYPE	FIBER CONTENT	AVERAGE FLEXURAL STRENGTH (N/mm^2)	
		7 DAYS	28 DAYS
Plain	0%	2.97	4.45
Steel Fiber	0.5%	3.12	4.96
	1.0%	3.43	5.19
	1.5%	3.67	5.37
	2.0%	3.35	5.11
Glass Fiber	0.5%	3.01	4.75
	1.0%	3.19	4.89
	1.5%	3.46	4.94
	2.0%	3.06	4.67

Chart-1: Compressive Strength of M30 Grade Concrete Using DifferentPercentages of Steel Fibers

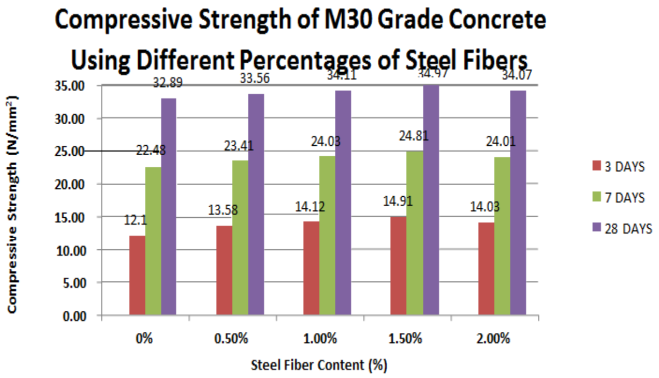


Chart-2: Compressive Strength of M30 Grade Concrete Using DifferentPercentages of Glass Fibers

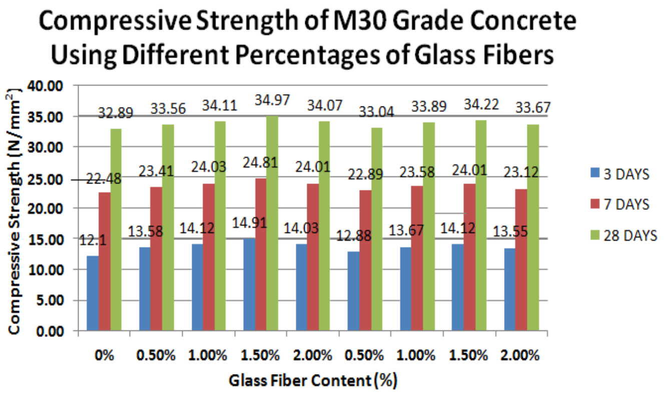


Chart-3: Compressive Strength of M40 Grade Concrete Using DifferentPercentages of Steel Fibers

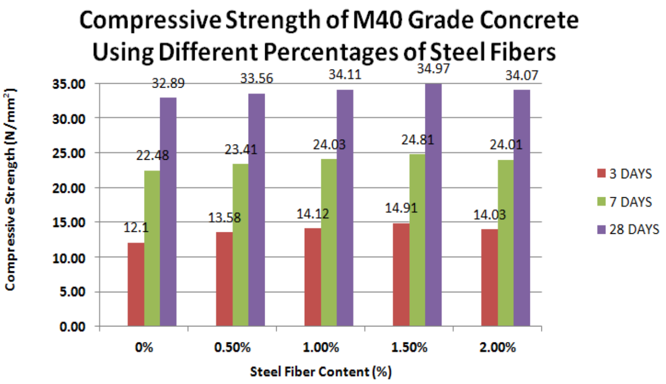


Chart-4: Compressive Strength of M40 Grade Concrete Using DifferentPercentages of Glass Fibers

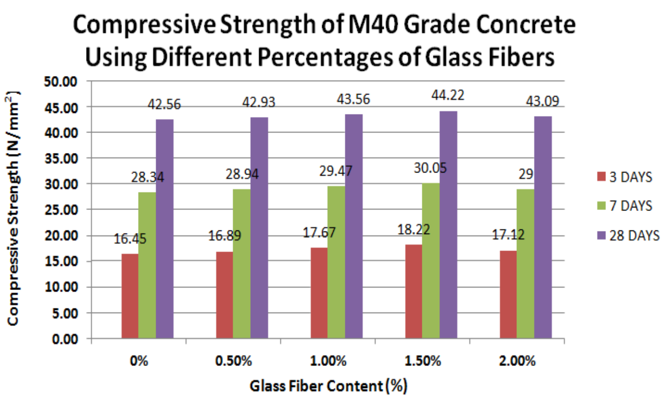


Chart-5: Split Tensile Strength of M30 Grade Concrete Using DifferentPercentages of Steel Fibers

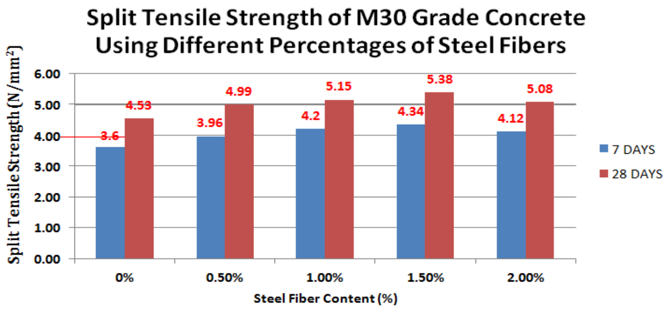


Chart-6: Split Tensile Strength of M30 Grade Concrete Using DifferentPercentages of Glass Fibers

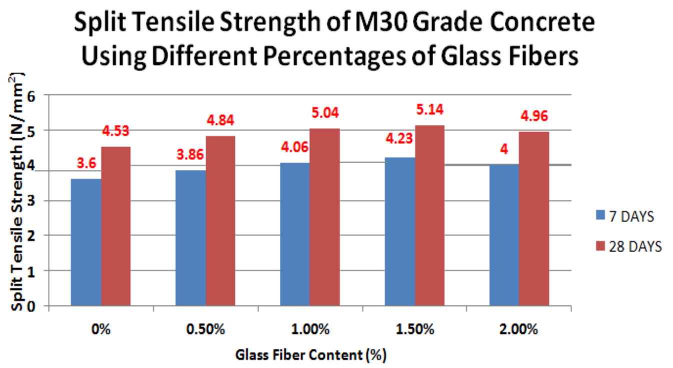


Chart-7: Split Tensile Strength of M40 Grade Concrete Using DifferentPercentages of Steel Fibers

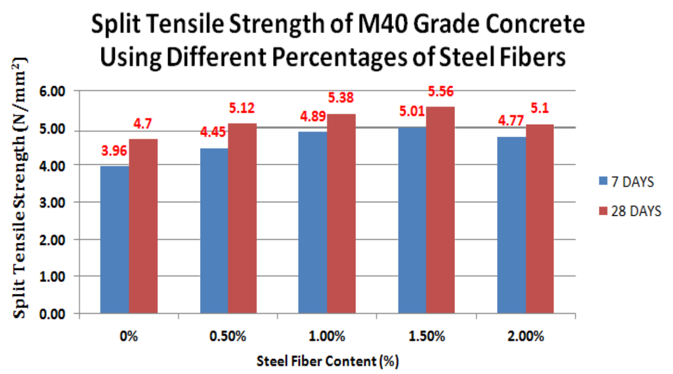


Chart-8: Split Tensile Strength of M40 Grade Concrete Using DifferentPercentages of Glass Fibers

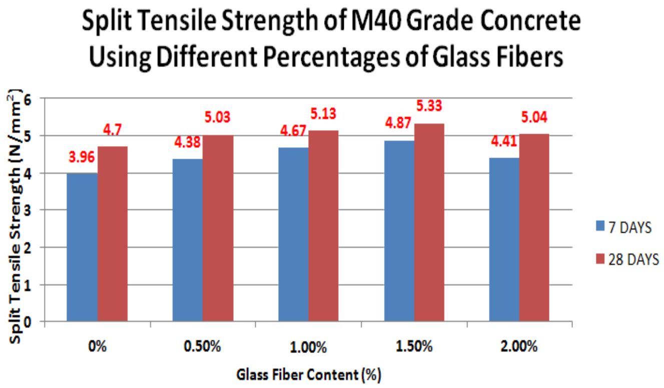


Chart-9: Flexural Strength of M30 Grade Concrete Using DifferentPercentages of Steel Fibers

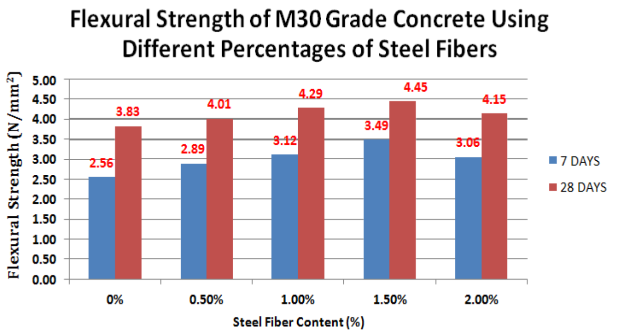


Chart-10: Flexural Strength of M30 Grade Concrete Using DifferentPercentages of Glass Fibers

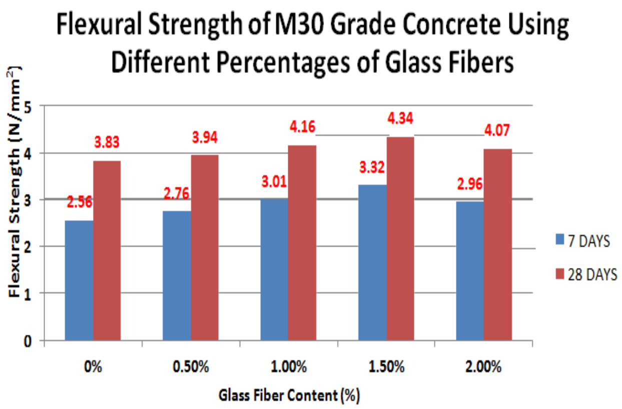


Chart-11: Flexural Strength of M40 Grade Concrete Using DifferentPercentages of Steel Fibers

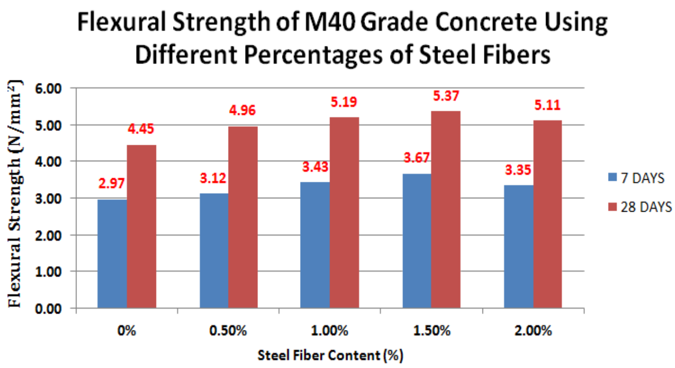
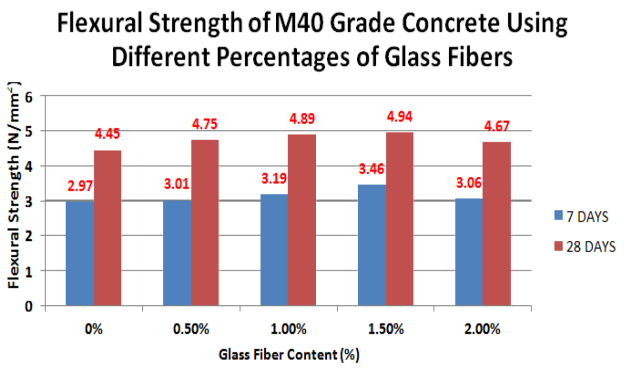


Chart-11: Flexural Strength of M40 Grade Concrete Using DifferentPercentages of Glass Fibers



8. CONCLUSIONS

In this study, steel fibers and glass fibers were used to produce fiber reinforced concrete. A strict mixing procedure is followed in this study, in terms of mixing, addition of components and sequence of material addition. From the above results and comparison following points are observed:

1) The compressive strength of steel fiber reinforced concrete of grade M30 by using 0.5% steel fibers at 28 days is 33.56N/mm2, by using 1.0% is 34.11N/mm2, by using 1.5% is 34.97N/mm2 and by using 2.0% is 34.07N/mm2. When compared to all percentages steel fibers optimizes 1.5%.

2) The compressive strength of steel fiber reinforced concrete of grade M30 by using 0.5% steel fibers at 28 days is 33.04N/mm2, by using 1.0% is 33.89N/mm2, by using 1.5% is 34.22N/mm2 and by using 2.0% is 33.67N/mm2. When compared to all percentages glass fibers optimizes 1.5%.

3) The split tensile strength of steel fiber reinforced concrete of grade M30 by using 0.5% steel fibers at 28 days is 4.99/mm2, by using 1.0% is 5.15N/mm2, by using 1.5% is 5.38N/mm2 and by using 2.0% is 5.08N/mm2. When compared to all percentages steel fibers optimizes 1.5%.

4) The split tensile strength of steel fiber reinforced concrete of grade M30 by using 0.5% steel fibers at 28 days is 4.84/mm2, by using 1.0% is 5.04N/mm2, by using 1.5% is 5.14N/mm2 and by using 2.0% is 4.96N/mm2. When compared to all percentages glass fibers optimizes 1.5%.

5) The flexural strength of steel fiber reinforced concrete of grade M30 by using 0.5% steel fibers at 28 days is 4.01 N/mm2, by using 1.0% is 4.29N/mm2, by using 1.5% is 4.45N/mm2 and by using 2.0% is 4.15N/mm2. When compared to all percentages steel fibers optimizes 1.5%.

6) The flexural strength of steel fiber reinforced concrete of grade M30 by using 0.5% steel fibers at 28 days is 3.94 N/mm2, by using 1.0% is 4.16N/mm2, by using 1.5% is 4.34N/mm2 and by using 2.0% is 4.07N/mm2. When compared to all percentages glass fibers optimizes 1.5%.

7) Similarly the compressive Strength, Split Tensile Strength and Flexural Strength for M40 grade concrete also the strength increases with addition of steel and glass fibers upto 1.5% thereafter the strength starts decreasing. So we can conclude that the optimum percentage of addition of steel fibers or glass fibers is upto 1.5% for M30 and M40 Grade of concrete.

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