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CHARACTERSTICS OF STEEL FIBRE REINFORCED CONCRETE

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ABSTRACT: ***Concrete is probably the most extensively used construction material in the world. The main ingredient in the conventional concrete is Portland cement. The amount of cement production emits approximately equal amount of carbon dioxide into the atmosphere. Cement production is consuming significant amount of natural resources. That has brought pressures to reduce cement consumption by the use of supplementary materials. Availability of mineral admixtures marked opening of a new era for designing concrete mix of higher and higher strength. For the development of high strength concrete with addition of steel fibers. The study focuses on the compressive strength performance of the blended concrete containing different percentage of steel fiber as a partial replacement of OPC. The cement in concrete is replaced accordingly with the percentage of 0.00%, 0.5%, 1%, 1.5%, and 2% by weight of steel fiber. Concrete cubes are tested at the age of, 7, and 28 days of curing. Finally, the strength performance of fiber reinforced concrete is compared with the performance of conventional concrete. From the experimental investigations, it has been observed that, the optimum replacement of steel fiber without changing much the compressive strength is 20%&1.5 % respectively for M30 grade respectively***

Keywords: Steel Fibers, Ordinary Portland cement, Compressive Strength, Tensile Strength.

I. INTRODUCTION

Now a day's human requirement is much higher than shelter, with the advancement of human societies, structure has to be more confined in space occupation, spacious and Stronger than before. Modern structures are developed not only with pleasant appearance but also for long life and durability. In the present work we also experimented with steel fibers and other ingredients (Steel fibre). Sample with different concentration and different size of fiber, were prepared and tested for the compressive strength against conventional concrete.Fibre reinforced concrete (FRC) is Portland cement concrete reinforced with more or less randomly distributed fibres. In FRC, thousands of small fibres are dispersed and distributed randomly in the concrete during mixing, and thus improve concrete properties in all directions. FRC is cement- based composite material that has been developed in recent years. It has been successfully used in construction with its excellent flexural-tensile strength, resistance to spitting, impact resistance and excellent permeability and frost resistance. It is an effective way to increase toughness, shock resistance and resistance to plastic shrinkage cracking of the mortar. Fibre is a small piece of reinforcing material possessing

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certain characteristics properties. They can be circular, triangular or flat in cross-section. The fire is often described by a convenient parameter called aspect ratio. The aspect ratio of the fibre is the ratio of its length to its diameter. The principle reason for incorporating fibres into a cement matrix is to increase the toughness and tensile strength and improve the cracking deformation characteristics of the resultant composite. For FRC to be a viable construction material, it must be able to compete economically with existing reinforcing system.

The strength and durability of concrete can be changed by making appropriate changes in its ingredients like cemetitious material, aggregate and water and by adding some special ingredients. Hence concrete is very well suitable for a wide range of applications. However concrete has some deficiencies as listed below: Low tensile strength, Low post cracking capacity, Brittleness and low ductility, Limited fatigue life, Incapable of accommodating large deformations and Low impact strength. Christo Ananth et al.[6] discussed about amplifier power relation, impedance , T π and microstripline matching networks.

STEEL FIBER REINFORCED CONCRETE

Steel fiber reinforced concrete is a composite material having fibers as the additional ingredients, dispersed uniformly at random in small percentages, i.e. between 0.3% and 2.5% by volume in plain concrete SFRC products are manufactured by adding steel fibers to the ingredients of concrete in the mixer and by transferring the green concrete into moulds. The product is then compacted and cured by the conventional methods. Segregation or balling is one of the problems encountered during mixing and compacting SFRC. This should be avoided for uniform distribution of fibers. The energy required for mixing, conveying, placing and finishing of SFRC is slightly higher. Use of pan mixer and fiber dispenser to assist in better mixing and to reduce the formation of fiber balls is essential. Additional fines and limiting maximum size of aggregates to 20mm occasionally, cement contents of 350 kg to 550 kg per cubic meter are normally needed.

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. Plain, straight and round fibers were found to develop very weak bond and hence low flexural strength. For a given shape of fibers, flexural strength of SFRC was found to increase with aspect ratio (ratio of length to equivalent diameter). Advantages of Steel Fiber Reinforced Concrete are Fast and perfect mixable fibers and High performance and crack resistance, Optimize costs with lower fiber dosages, Steel fibres reinforced concrete against impact forces thereby improving the toughness characteristics of hardened concrete, Steel fibres reduce the permeability and water migration in concrete, which ensures protection of concrete due to the ill effects of moisture

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EFFECTS OF STEEL FIBRES IN CONCRETE

Fibres are usually used in concrete to control cracking due to both plastic shrinkage and drying shrinkage. They also reduce the permeability of concrete and thus reduce bleeding of water. Some types of fibres produced greater impact, abrasion and shatter resistance in concrete. Generally fibres do notIncrease the flexural strength of concrete and so cannot replace moment resisting or structural steel reinforcement. Indeed, some fibres actually reduce the strength of concrete. The amount of fibres added to the concrete mix is expressed as a percentage of total volume of the composite (concrete and fibres), termed volume fraction (Vf). Vf typically ranges from 0.1 to 3%. Aspect ratio (l/d) is calculated by dividing fiber length (l) by its diameter (d). fibres with a non circular cross section use an equivalent diameter for the calculation of aspect ratio. If the modulus of elasticity of the fibre is higher than the matrix (concrete or mortar binder), they help to carry the load by increasing the tensile strength of the material. Increase in the aspect ratio of the fibre usually segments the flexural strength and the toughness of the matrix. However, fibres which are too long tend to ―ball‖ in the mix and create workability problems. Some recent research indicated that using fibres in concrete has limited effect on the impact resistance of the materials. This finding is very important since traditionally, people think that the ductility increases when concrete is reinforced with fibres. The results also indicated out that the use of micro fibres offers better impact resistance compared with the longer fibres.

OBJECTIVE OF STUDY

Today it is steel fiber which is mainly used to reinforce concrete and overcome the problem of brittleness. This paper describes the most interesting applications of steel fiber reinforced concretes (SFRC) all over the world. Firstly, the author presents the evolution of steel fibers and SFRC. Secondly, the paper covers the contemporary importance of SFRC in civil engineering.

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II. LITERATURE REVIEW

A.M. Shende , A.M. Pande , M. Gulfam Pathan (2012)

Critical investigation for M-40 grade of concrete having mix proportion 1:1.43:3.04 with water cement ratio 0.35 to study the compressive strength, flexural strength, Split tensile strength of steel fibre reinforced concrete (SFRC) containing fibers of 0%, 1%, 2% and 3% volume fraction of hook Stain. Steel fibers of 50, 60 and 67 aspect ratio were used. A result data obtained has been analyzed and compared with a control specimen (0% fiber). A relationship between aspect ratio vs. Compressive strength, aspect ratio vs. flexural strength, aspect ratio vs. Split tensile strength represented graphically. Result data clearly shows percentage increase in 28 days Compressive strength, Flexural strength and Split Tensile strength for M-40 Grade of Concrete. It is observed that compressive strength, split tensile strength and flexural strength are on higher side for 3% fibres as compared to that produced from 0%, 1% and 2% fibres. All the strength properties are observed to be on higher side for aspect ratio of 50 as compared to those for aspect ratio 60 and 67. It is observed that compressive strength increases from 11 to 24% with addition of steel fibres. It is observed that flexural strength increases from 12 to 49% with addition of steel fibres. It is observed that split tensile strength increases from 3 to 41% with addition of steel fibres.

Amit Rana et al,. (2013)

Fibres are generally used as resistance of cracking and strengthening of concrete. In this project, I am going to carry out test on steel fibre reinforced concrete to check the influence of fibres on flexural strength of concrete. According to various research papers, it has been found that steel fibres give the maximum strength in comparison to glass and polypropylene fibres. Hence, in this project I was interested in finding out the optimum quantity of steel fibres required to achieve the maximum flexural strength for M25 grade concrete. From the exhaustive and extensive experimental work it was found that with increase in steel fibre content in concrete there was a tremendous increase in Flexural strength. Even at 1 % steel fibre content flexural strength of 6.46 N/mm2 was observed against flexural strength 5.36 N/mm2 at 0% hence increase of 1.1% flexural strength was obtained.

Mr.Nikhil A.Gadge, Prof. S.S.Vidhale (2013)

Concrete is probably the most extensively used construction material in the world. The main ingredient in the conventional concrete is Portland cement. The amount of cement production emits approximately equal amount of carbon dioxide into the atmosphere. Cement production is consuming significant amount of natural resources. That has brought pressures to reduce cement consumption by the use of supplementary materials. Availability of mineral admixtures marked opening of a new era for designing concrete mix of higher and higher strength. Ground Granulated Blast Furnace Slag (GGBS) is a new mineral admixture, whose potential is not fully utilized. Moreover only limited studies have been carried out in India on the use of slag for the development of high strength concrete with addition of steel fibers. The study focuses on the compressive strength performance of the blended concrete containing different percentage of slag and steel fiber as a partial replacement of OPC. The cement in concrete is replaced accordingly with the percentage of 10 %, 20%, 30%, and 40% by weight of slag and 0.5%, 1%, 1.5%, 2% by weight of steel fiber. Concrete cubes are tested at the age of 3, 7, and 28 days of curing. Finally, the strength performance of slag blended fiber reinforced concrete is compared with the performance of conventional concrete. From the experimental investigations, it has been observed that, the optimum replacement of Ground Granulated Blast Furnace Slag Powder to cement and steel fiber without changing much the compressive strength is 20 % & 1.5 % respectively for M20, M30&M40 grade respectively. The optimum dosage for partial replacement of cement by ground granulated blast furnace slag is 20% the optimum dosage for addition of steel fibred is 1.5%. The percentage of increase in compressive strength for M20,M30 & M40 grade for partial replacement of cement by GGBS (20%) + addition of steel fibred (1.5%) are nearly same for M20,M30 & 2.4% for M40 respectively for 28 days of curing. The percentage of increase in flexural strength for M20, M30& M40 grade for partial replacement of cement by GGBS (20%) + addition of steel fibred (1.5%) are 20.37%, 25.37% & 56.39% respectively for 28 days of curing. The percentage of increase in split tensile strength for M20,M30 & M40 grade for partial replacement of cement by GGBS (20%) + addition of steel fibred (1.5%) are 60.19%,58.73% & 66.27% respectively for 28 days of curing . The rate of gain of compressive strength of GGBS concrete is slow in the initial Stage i.e. up to 14 days & as the curing period increases strength also increases. Test results reveal that higher fiber content has brought about increased compressive strength, flexural strength, abrasion resistance, and fiber crack-control effect. Hence the addition of steel fiber within FRC is more helpful for the flexural strength than the compressive strength.

III. METHODOLGY

MATERIALS

The materials used for this experimental work are cement, sand, water, steel fibres, and super plasticizer.

A. CEMENT

Ordinary Portland cement of 53 grade was used in this experimentation conforming to I.S. – 12269- 1987. 53 Grade OPC Cement can be used for High-rise buildings, All types of R.C.C. works, Industrial works,Pre-stressed concrete work like bridges, silos, etc. and Pre-cast elements such as Railway sleepers and concrete pole.

B. FINE AGGREGATES :

Locally available sand zone II with specific gravity 2.65, water absorption 2% and fineness modulus 2.92, conforming to I.S. – 383-1970. It is the aggregate most of which passes 4.75 mm IS sieve and contains only so much coarser as is permitted by specification.

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C. COARSE AGGREGATE:

Crushed granite stones of 10 mm size having specific gravity of 2.70, fineness modulus of 2.73, conforming to IS 383-1970 Aggregates are inert granular materials such as sand, gravel or crushed stone that are an end product in their own right. They are also the raw materials that are an essential ingredient in concrete. For a good concrete mix, aggregates need to be clean, hard, strong particles free of absorbed chemicals or coatings of clay and other fine materials that could cause the deterioration of concrete.It is the aggregate most of which is retained on 4.75 mm IS sieve and contains only so much finer material as is permitted by specification.

D. WATER:

Generally potable water ought to be used. This is to make sure that the water is cheap unfastened from such impurities as suspended solids, organic depend and dissolved salts, which may additionally adversely affect the residences of the concrete, especially the placing, hardening, energy, sturdiness, pit fee, and many others**.**

E. SUPERPLASTICIZER:

To impart additional workability a super plasticizer (Rheobuild 1100) 0.6 % to 0.8% by weight of cement was used. It is based on sulphonated naphthalene polymers with following properties as per I.S. – 9103-1999.

F. STEEL FIBRE

Stainless steel wire of 0.5 mm diameter has been used in the preparation of SFRC. The steel fibre of length 40 mm and of aspect ratio 80 has been used in this experimental work. All the steel fibres are straight in shape.
The typical diameter lies in the range of 0.25-0.75 mm hook end steel fibres are being used in this project. Length of these fibres is 30 mm and the aspect ratio of 55. Density of steel fibre is 7900 kg/cum.

MIX DESIGN AND SAMPLE PREPARATION

Concrete mix design is a procedure of selecting the suitable ingredients of concrete and their relative proportions with an objective to prepare concrete of certain minimum strength, desired workability and durability as economically (value engineered) as possible.
Firming to Zone I of Table 4 IS – 383

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Mix Design of M30 Grade Concrete

Final trial mix for M30 Grade Concrete is 1:1.86:2.89 at w/c of 0.50

Material	Cement	Fine Aggregates	Coarse Aggregates	Water
Density	394 kg/m^3	732 kg/m^3	1139 kg/m^3	197 kg/m^3
Proportions	1	1.86	2.89	0.50

IV. RESULTS

MATERIAL PROPERTIES:

A. CEMENT:

Sl.no	Test	Results	IS code used	Acceptable limit
1	Specific gravity of cement	3.160	IS:2386:1963	3 to 3.2
2	Standard consistency of cement	6mm at 34% w/c	IS:4031:1996	w/c ratio 28%-35%
3	Initial and final setting time	45 mins and 10 hours	IS:4031:1988	Minimum 30mins and should not more than 10 hours
4	Fineness of cement	3.00%	IS:4031:1988	<10%

B.COARSE AGGREGATES:

Sl.no	Test	Results	Is code used	Acceptable limit
1	Fineness modulus	6.5	IS:2386:1963	6.0 to 8.0mm
2	Specific gravity	2.90	IS:2386:1963	2 to 3.1mm
3	Porosity	46.83%	IS:2386:1963	Not greater than 100%
4	Voids ratio	0.8855	IS:2386:1963	Any value
5	Bulk density	1.50g/cc	IS:2386:1963	-
6	Aggregate impact value	37.5	IS:2386:1963	Less than 45%
7	Aggregate crushing value	26.6%	IS:2386:1963	Less than 45%

C.FINE AGGREGATES:

Sl.no	Test	Result	Is code used	Acceptable limits
1	Fineness modulus	4.305	IS:2386:1963	Not more than 3.2 mm
2	Specific gravity	2.43	IS:2386:1963	2.0 to 3.1
3	Porosity	36.6%	IS:2386:1963	Not greater than 100%
4	Voids ratio	0.577	IS:2386:1963	Any value
5	Bulk density	1.5424	IS:2386:1963	-
6	Bulking of sand	3.0%	IS:2386:1963	Less than 10%

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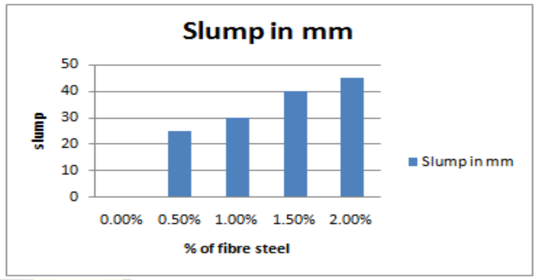
II. CONCRETE TESTS

A. TESTS ON FRESH CONCRETE:

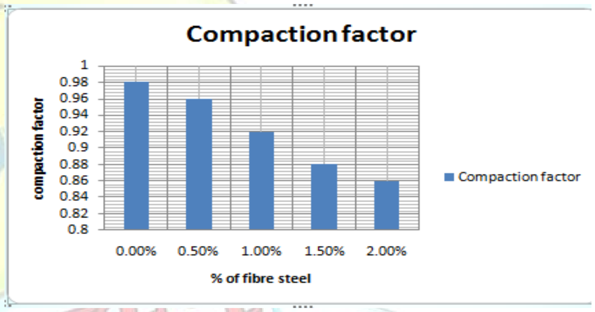
SLUMP CONE TEST:

S.no	% of fibre steel	Slump in mm
1	0.00%	0
2	0.50%	25
3	1.00%	30
4	1.50%	40
5	2.00%	45



COMPACTION FACTOR TEST

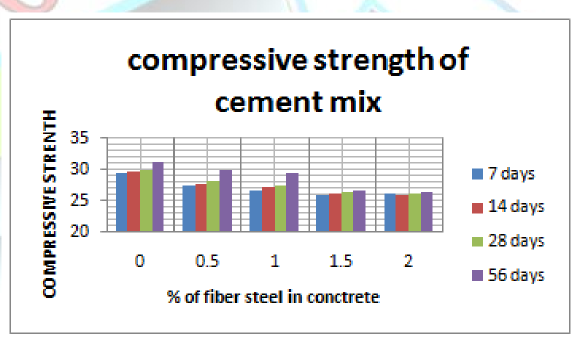
S.no	% of fibre steel	Compaction factor
1	0.00%	0.98
2	0.50%	0.96
3	1.00%	0.92
4	1.50%	0.88
5	2.00%	0.86



B. TESTS ON HARDENED CONCRETE:

i. COMPRESSIVE STRENGTH

s.no	% of steel fibre	compressive strength			
		7 days	14 days	28 days	56 days
1	0	29.6	29.72	29.96	31.2
2	0.5	27.46	27.8	28.2	30.1
3	1	26.84	27.2	27.4	29.6
4	1.5	26	26.2	26.4	26.8
5	2	26.2	26.1	26.2	26.6



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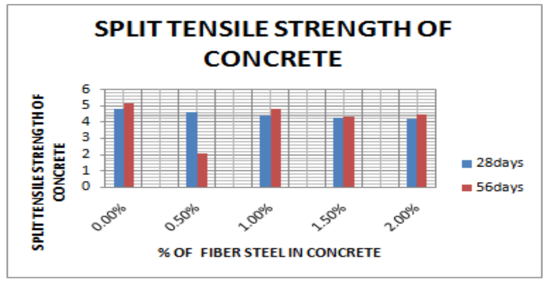
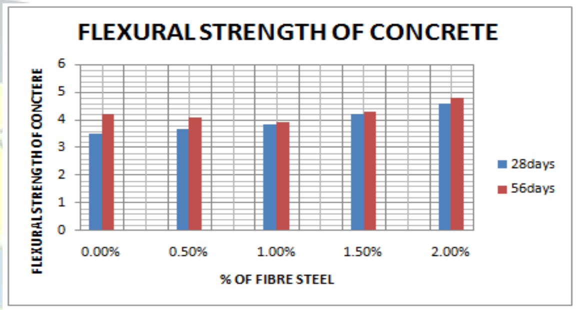
ii. SPLIT TENSILE STRENGTH OF CONCRETE

S.no	% OF STEEL FIBRE	Split Tensile Strength Of Concrete	
		28days	56days
1	0.00%	4.84	5.2
2	0.50%	4.62	2.1
3	1.00%	4.4	4.8
4	1.50%	4.3	4.36
5	2.00%	4.2	4.46



iii. FLEXURAL STRENGTH

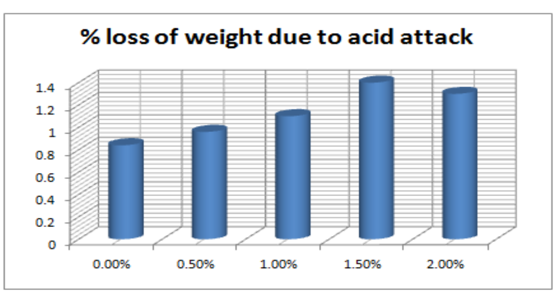
S.no	% OF FIBRE STEEL IN CONCRETE	`Flexural Strength Of Concrete	
		28days	56days
1	0.00%	3.5	4.2
2	0.50%	3.65	4.1
3	1.00%	3.85	3.9
4	1.50%	4.2	4.3
5	2.00%	4.6	4.8

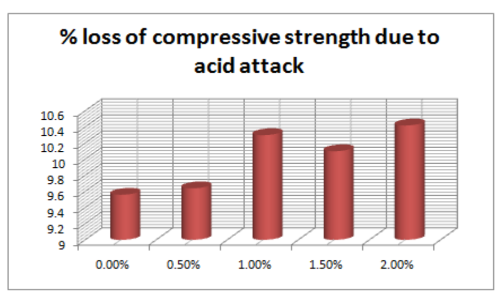


III. DURABILITY TESTS

1. ACID ATTACK

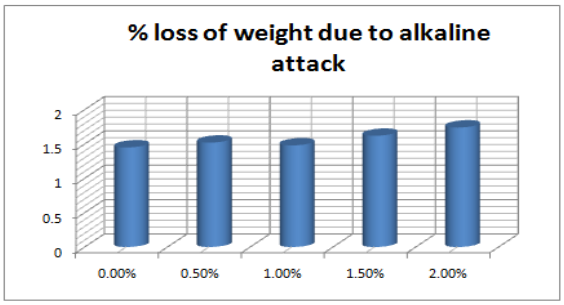
Sl.no	% FIBRE STEEL	Initial weight of cube after 28days curing in grams	Final weight of cubes after 90days curing in grams	% loss of weight due to acid attack	Compressive strength of cube after 28days curing	Compressive strength of cubes after 90days curing	% loss of compressive strength due to acid attack
1	0.00%	2365	2345	0.84	29.96	27.1	9.56
2	0.5%	2340	2318	0.96	28.2	25.5	9.64
3	1.0%	2330	2304	1.1	27.4	24.6	10.3
4	1.50%	2265	2233	1.4	26.4	23.74	10.1
5	2.00%	2394	2363	1.3	26.2	23.5	10.42

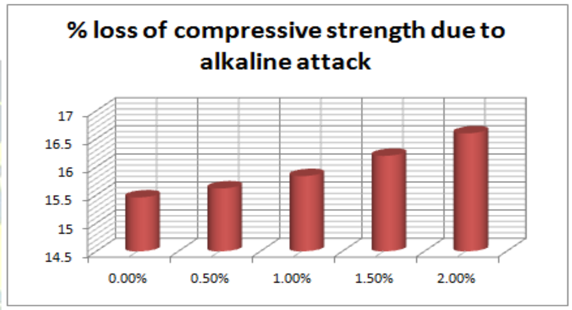




2. ALKANINE ATTACK

Sl. No	% OF FIBRE STEEL	Initial weight of cube after 28days curing in grams	Final weight of cubes after 90days curing in grams	% loss of weight due to alkaline attack	Compressive strength of cube after 28days curing	Compressive strength of cubes after 90days curing	% loss of compressive strength due to alkaline attack
1	*0.00%*	2386	2350	1.45	29.96	25.33	15.46
2	*0.5%*	2340	2305	1.52	28.2	23.8	15.62
3	*1.0%*	2310	2275	1.48	27.4	23	15.84
4	*1.50%*	2270	2235	1.62	26.4	22.12	16.2
5	*2.00%*	2296	2255	1.74	26.2	21.85	16.6

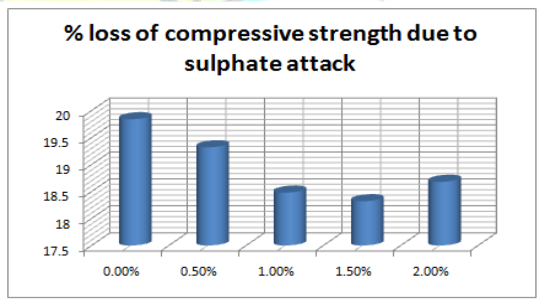




SULPHATE ATTACK

Table 10 : Sulphate Attack Test

Sl.no	*% of FIBRE STEEL*	Compressive strength of cube after 28days curing	Compressive strength of cubes after 90days curing	% loss of compressive strength due to sulphate attack
1	*0.00%*	29.96	24	19.84
2	*0.50%*	28.2	22.75	19.32
3	*1.00%*	27.4	22.33	18.48
4	*1.50%*	26.4	21.56	18.32
5	*2.00%*	26.2	21.3	18.68



CONCLUSIONS

1. The material properties of the cement, fine aggregates and coarse aggregates are within the acceptable limits as per IS code recommendations so we will use the materials for research.
2. Slump cone value for the steel fiber concrete increases with increasing in the percentage of steel fiber so the concrete was not workable by increasing in the percentage.
3. Compaction factor value of steel fiber reinforced concrete decreases with increase in the percentage of steel fibers and the maximum values of compaction factor was observed at 2% of steel fibers.
4. The compressive strength of concrete is maximum at 0% of steel fibers and is the optimum value for 7days curing, 28days curing, 56days curing, 90days curing.
5. Split tensile strength for the cylindrical specimens is maximum at 0% of steel fibers for 28days curing, 56days curing, 90days curing.
6. The flexural strength of copper slag concrete is also maximum at 2% of steel fibers for 28days curing, 56days curing, 90days curing.

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7. The percentage loss of weight and percentage loss of compressive strength due to acid attack is increases with increase in the percentage of steel fibers.
8. The percentage loss of weight and percentage loss of compressive strength due to alkalinity attack is increases with increase in the percentage of steel fibers.
9. The percentage loss of compressive strength due to sulphate attack is decreases with increase in the percentage of steel fibers.

So the replacement of 2% of steel fibers is generally useful for better strength values in M30 grade of concrete.

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