EXPERIMENTAL INVESTIGATION ON BEHAVIOUR OF STEEL FIBRE REINFORCED CONCRETE (SFRC) WITH FLY ASH

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Abstract— **This paper deals with Experimental investigation for M_{30} grade of concrete having mix proportion 1:1.3:2.29 with water cement ratio 0.4 to study the compressive strength, flexural strength and tensile strength of steel fiber reinforced concrete (SFRC) containing fibers of 0.5%, 1.0% and 1.5% volume fraction of hook end Steel fibers of 71 aspect ratio were used. The percentage of Fly Ash by weight is to be from 0%, 10% and 20%. A result data obtained has been analyzed and compared with a control specimen (0.0% fiber and 0.0% fly ash). A relationship between workability, compressive strength, flexural strength and split tensile strength represented mathematically and graphically. Result data clearly shows percentage increase in 28 days Compressive strength, Flexural strength and spilt tensile strength for M_{30} Grade of Concrete.**

Keywords - **Concrete mix, fly-ash, Steel fiber reinforced concrete, Strength, Workability.**

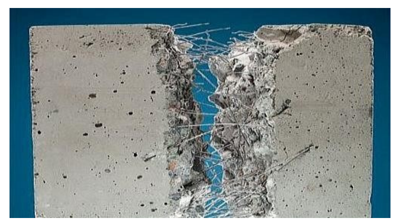
I. INTRODUCTION

Concrete is one of the most widely used construction material. It has good compressive strength, durability, fire resistance and can be cast to fit any structural shape. It also replaces old construction materials such as brick and stone masonry. 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 Low tensile strength, Low post cracking capacity ,Brittleness and low ductility, Limited fatigue life ,Incapable of accommodating large deformations Low impact strength

The presence of micro cracks in the mortar-aggregate interface is responsible for the inherent weakness of plain concrete. The weakness can be removed by inclusion of fibres in the mixture. Different types of fibres, such as those used in traditional composite materials can be introduced into the concrete mixture to increase its toughness, or ability to resist crack growth. The fibres help to transfer loads at the internal micro cracks. Such a concrete is called fibre-reinforced concrete (FRC). Thus fibre-reinforced concrete is a composite material essentially consisting of conventional concrete or mortar reinforced by fine fibres.

STEEL FIBRE REINFORCED CONCRETE (SFRC)

Steel Fibre Reinforced Concrete (SFRC) is a concrete made of hydraulic cements containing fine and coarse aggregate and discontinuous discrete steel fibres.its superior resistance to cracking and crack propagation. As a result of this ability to arrest cracks, fibre composites possess increased extensibility and tensile strength, both at first crack and at ultimate, particular under Flexural loading; and the fibres are able to hold the matrix together even after extensive cracking.



The net result of all these is to impart to the fibre composite pronounced post – cracking ductility which is unheard of in ordinary concrete. The transformation from a brittle to a ductile type of material would increase substantially the energy absorption characteristics of the fibre composite and its ability to withstand repeatedly applied, shock or impact loading.

Classification of Steel Fibre:

ASTM and 820 provides a classification of four general types of steel fibres.

Type I - Cold-drawn wire
Type II - Cut sheet
Type III – Melt-extracted
Type IV – Other fibres

The Japanese society of civil engineers (JSCE) has classified steel fibres based on the shape of their cross-section.

Type I – Square section
Type II – Circular Section
Type III – Crescent Section

Composition of Steel Fibre:

The composition of steel fibres generally includes carbon steel or stainless steel The length dimension ranges from 6.4mm to 76mm while the diameter ranges from 0.25mm to 0.75mm. The steel fibres are described by a convenient parameter “Aspect Ratio”. The aspect ratio is determined by length to diameter ratio. It varies from 20 to 100.

Essential Properties of Steel Fibres

- Fibres should have a relatively high strength and modulus of elasticity.

- Fibres should have the property of "surface roughness" to enhance bonding with the matrix.
- In different environments the compositions of fibres should be varied. I.e. In high temperature stainless steel fibres should be used.
- According to **ASTM A 820** standards, the minimum yield strength of steel fibres should be **50,000 psi (345 Mpa)** while it should be **80,000 psi (552 MPa)** according to **JSCE** standard.

Properties of Concrete Improved by Steel Fibres:

Compressive strength:

In compression the ultimate strength is only slightly affected by the presence of Steel Fibres. The presence of steel fibres increases compressive strength from 0 to 15% for up to 2% of volume of fibres.

Tensile strength:

In direct tension, the improvement in strength is reported from 30-40% for addition up to 2% by total volume of fibres. It is observed that the split tensile strength increases from 10-45% for addition up to 3% by total volume of fibres.

Flexural Strength:

Increase in the flexural strength of SFRC is much greater than in tension or compression because of ductile behavior. The changed elastic distribution is importantly plastic in the tension zone and elastic in the compression zone, which poses a shift of neutral axis towards the compression zone. It changes from 20-100% for addition up to 3% by total volume of fibres.

Fatigue:

For a given type of fibre there is a significant increase in flexural fatigue strength with increasing percentage of steel fibres. Almost 1 1/2 times increase in fatigue strength due to the increasing use of steel fibres.

Impact:

Under flexural impact loading, the peak load for SFRC is 40 percent higher than the normal concrete. So, increased use of steel fibres increase the impact resistance of the concrete.

Advantages of steel fibres :

- Creates more ductile concrete with reduced cracking.
- Reduce the effect of shrinkage curling.
- More economical than conventional steel solutions.
- Easy material handling.
- Supported by large manufactures.
- Very durable.
- Does not interfere with guide wire signals.
- Can replace wire mesh in most elevated slabs

Limitations of Steel Fibre Reinforced Concrete:

- Unless steel fibres are added in adequate quantity, the desired improvements cannot be obtained. As the quantity of fibres is increased, the workability of the concrete is decreased.
- If proper techniques and proportions are not used, the fibres may also cause a finishing problem, with the fibres coming out of the concrete.
- Another problem is the corrosion of the surface which may influence the appearance of the surface.
- Steel fibres are not cost effective. Due to the addition of 1% steel fibre of the total volume, there will be a massive change in the total cost of the construction.

Applications of Steel Fibre Reinforced Concrete:

- SFRC has been tried on overlays of air-field, road pavements, industrial floorings, bridge decks, canal lining, explosive resistance structures, refractory linings etc.
- It can also be used for the fabrication of precast products like pipes, boats, beams, stair case steps, wall panels, roof panels, manhole covers etc.
- SFRC is also being tried for the manufacture of prefabricated formwork molds of "U" shape for casting lintels and small beams.

REVIEW OF LITERATURE:

1).An experimental investigation on structural performance of steel fibre reinforced concrete beam .Jyoti Narwal, Ajay Goel, Devender Sharma, D.R. Kapoor, Bhupinder Singh

Conventional concrete loses its tensile resistance after the formation of multiple cracks. However, fibreous concrete can sustain a portion of its resistance following cracking to resist more loading. The Steel Fibre Reinforced Concrete (SFRC) has enhanced resistance against cracking and a better micro-crack arrest mechanism. Further, fibre reinforced concrete is found to have improved strengths against shear, flexure, tension and increased resistances against impact, fatigue, wear and enhanced toughness and ductility over that of RCC. In the present study an attempt has been made to investigate the effect of percentage of steel fibres on structural behavior of beams measured in terms of Load Deflection behavior, Ultimate load carrying capacity, Cracking Pattern and Mode of Failure and to investigate the effect of aspect ratio of steel fibres on structural performance of RC beams measured in terms of above parameter sand also to investigate the effect of mixed fibres (two types of fibres with different aspect ratios) on structural performance of RC beams.

2).Experimental study and prediction of tensile strength for steel fibre reinforced concrete.Shende.A.M.1, Pande.A.M2

Results of an investigation conducted to study the tensile strength of steel fibre reinforced concrete (SFRC) containing fibres of 0%, 1%, 2% and 3% volume fraction of Hook stain steel fibres of 50, 60 and 67 aspect ratio are presented. Cylinder specimens of size 150 mm diameter and 300 mm length were tested under compression testing machine as per I.S. 516-1959. A result data obtained has been analyzed and compared with control beam (0% fibres). A relationship aspect ratio vs. Tensile strength represented graphically and governing equation of graphs and prepared Mathematical model for Tensile strength can be used to predict Tensile strength of SFRC by using appropriate values of percentage of fibres (Vf) and aspect ratio (A).

MATERIAL COLLECTION

In developing the concrete mix for steel fibre reinforced concrete, it is important to select proper ingredients, evaluate their properties and understand the interaction among different material for optimum usage. The ingredients used for this investigation were cement, fine aggregate, manufactured sand, coarse aggregate, water, chemical and mineral admixtures

Effective production of steel fibre reinforced concrete is achieved by carefully selecting, controlling and proportioning all ingredients. In order to achieve high strength concrete, optimum proportion must be selected, considering the characteristics of cementitious materials, aggregate quality, paste proportion, aggregate paste interaction, admixtures type, dosage and meticulous care in mixing and handling.

CEMENT

Cement is the most important ingredient in concrete. One of the important criteria for the selection of cement is its ability to produce improved microstructure in concrete. Unlike conventional cement concrete (CCC), the high strength concrete incorporates chemical or mineral admixtures or both. Moreover, the effect of characteristics of cement on water demand is more noticeable in HSC. Some of the important factors which play vital role in selection cement are compressive strength at various ages, fineness heat of hydration, alkali content, tricalcium aluminate (C_3A) content, tricalcium silicate (C_3S) content, dicalcium silicate (C_2S) content etc. it is also necessary to ensure compatibility of the chemical and mineral admixtures with cement.

Different brands of cement have been found to possess different strength development characteristics due to the variations in the compound composition and fineness. Hence it was decided to use cement from a single supplier. Portland Pozzolana cement (PPC) is available in three grades namely 53 grades, the number indicating the compressive strength of standard cement sand mortar cubes in MPa at 28 days curing.

FLY ASH

Ash produced in small dark flecks by the burning of powdered coal or other materials and carried into the air. Fly ash is a by-product from burning pulverized coal in electric power generating plants. During combustion, mineral impurities in the coal (clay, feldspar, quartz, and shale) fuse in suspension and float out of the combustion chamber with the exhaust gases. Two types of fly ash are commonly used in concrete: Class C and Class F. Class C are often high-calcium fly ashes with carbon content less than 2%; whereas, Class F are generally low-calcium fly ashes with carbon contents less than 5% but sometimes as high as 10%.

AGGREGATES

Aggregates are important constituents of concrete. It gives body to the concrete, reduce shrinkage. Aggregate occupy 70 to 80 percent of volume of the concrete. The aggregates combine with the binder (cement and pozzolana) and water to produce concrete. Basically there are two types of aggregates, the fine aggregate and the coarse aggregate.

FINE AGGREGATE

Fine aggregate used for high strength concrete should be properly graded to give minimum void ratio and be free from deleterious materials like clay, silt content and chloride contamination etc. high strength concrete contains large quantity of fine cementitious materials. Hence, the grading of river sand is relatively different from that in CCC. The optimum gradation of river sand for high strength concrete is determined more by its effect on water requirement than on physical packing. Indian Standard (IS) committee reports that sand with fineness modulus below 2.5 gives concrete sticky consistency, making it difficult to compact and sand with fineness modulus of about 3 gives the best workability and compressive strength. Properties such as void ratio, gradation, specific gravity, fineness modulus, free moisture content, specific surface and bulk density have to be assessed to design a dense high strength concrete mix with optimum cement content and reduced mixing water.

For this present investigation, river sand was used as fine aggregate. The sand was washed and screened at site to remove deleterious materials and tested as per the procedure given in BIS: 2386-1968.

COARSE AGGREGATE

The coarse aggregate is the strongest and the least porous component of concrete. It is also a chemically stable material. Presence of coarse aggregate reduces the drying shrinkage and other dimensional changes occurring on account of movement of moisture. Coarse aggregate contributes to impermeability concrete provided that it is properly graded and the mix is suitably designed. Coarse aggregate in cement concrete contributes to the heterogeneity of the cement concrete and there is a weak interface between cement matrix and aggregate surface in cement concrete. These two factors result in lower strength of cement concrete. But in high strength concrete, by restricting the maximum size of aggregate and also by making the transition zone stronger by usage of mineral admixtures, the cement concrete becomes more homogeneous and there is a marked enhancement in the strength properties as well as durability characteristics of concrete.

Properties such as crushing strength, durability, modulus of elasticity, maximum size, gradation, shape and surface texture characteristics, percentage of deleterious materials as well as flakiness and elongation indices need special consideration while selecting the coarse aggregate for high strength concrete. The aggregate should be sound, free from deleterious materials and must have crushing strength at least 1.5 times that of concrete.

Considering all the above aspects, blue granite crushed stone aggregates of 20 mm maximum size and typical particle shapes “average and cubic” were used as the coarse aggregates for this investigation.

WATER

Water is an important ingredient of concrete as it actively participates in the chemical reactions with cement to form the hydration product, calcium-silicate-hydrate (C-S-H) gel. The strength of the cement concrete depends mainly from the binding action of the hydrated cement paste gel. A higher water-cement (w/c) ratio will decrease the strength, durability, water-tightness and other related properties of the concrete. The quantity of water added should be the minimum requirement for chemical reaction of unhydrated cement, as the excess water would end up only in the formation of undesirable voids (capillary pores) in the hardened cement paste of concrete. The strength of cement paste is inversely proportional to the dilution of the paste. Hence, it is essential to use a little paste as possible, consistent with the requirement of workability and chemical combination with cement.

From high strength concrete mix design considerations, it is important to have the compatibility between the given cement and the chemical and mineral admixtures along with the water used for mixing. The water used for making concrete should be from undesirable salts that may react with cement and admixtures and reduce their efficiency. Silts and suspended particles are undesirable as they interfere with setting, hardening and bond characteristics. Algae in mixing water may cause marked reduction in strength of concrete either by combining with cement to reduce the bond or by causing large amount of air entrainment in concrete.

STEEL FIBRES

Steel fibres used for reinforcing concrete are defines as short, discrete length of steel having an aspect ratio (ratio of length to diameter) from about 20 to 100 with any of several cross sections and that are sufficiently small to be randomly dispersed in a unhardened concrete mixture using usual mixing procedures. The composition of steel fibres generally includes carbon steel or stainless steel .The length dimension ranges from 6.4mm to 76 mm while the diameter ranges from 0.25mm to 0.75mm.The steel fibres are described by a convenient parameter “aspect ratio “.the aspect ratio is determined by length to diameter ratio, it varies from 20 to 10

MATERIAL TESTING

TESTS FOR CEMENT

FINENESS TEST

S.No	Description	Trial No.1	Trial No.2	Trial No.3
1	Wt of Cement taken	100g	100g	100g
2	Wt of Cement Retained	2g	2g	2g
	Percentage of residue left on 90µ sieve	2%	2%	2%

Fineness of cement

Fineness of cement = (weight retained/weight taken) x 100
Fineness of cement = 2%

NORMAL CONSISTENCY

Trial No.	Wt of cement (g)	% of Water	Amount of water (ml)	Reading of pointer from bottom
1	400	26	104	37
2	400	28	112	34
3	400	30	120	15
4	400	31	124	11
5	400	31.25	125	6

Consistency of cement = 31.25%

INITIAL SETTING TIME TEST

Initial setting time of cement = 36 minutes.

FINAL SETTING TIME TEST

Final setting time of cement = 590 minutes.

SPECIFIC GRAVITY

S.No	Description	Trial No.1	Trial No.2	Trial No.3
1	Weight of empty bottle (W_1) g	44	44	44
2	Weight of bottle + water (W_2) g	101	101	101
3	Weight of bottle + kerosene (W_3) g	90	90	90
4	Weight of bottle + kerosene + cement (W_4) g	105	104	105
5	Weight of cement + bottle g	64	63	64
6	Weight of cement (W_5) g	20	19	20
7	Specific gravity of cement	3.2	3.04	3.2

Specific gravity of cement = 3.15

TESTS FOR FINE AGGREGATE
SIEVE ANALYSIS

S. No	IS Sieve (mm)	Weight retained (kg)	% of wt retained	Cumulative % of wt retained	Cumulative % of passing	Sand Conforming Zone
1	4.75	0.033	1.067	1.067	98.933	I, II, III
2	2.36	0.105	3.500	4.567	95.433	IV
3	1.18	0.358	11.930	16.497	83.503	III
4	0.600	0.627	20.900	37.397	62.603	I, II
5	0.30	1.450	48.330	85.727	14.273	I, II, III
6	0.15	0.319	10.630	96.357	3.643	I, III, IV
7	Pan	0.108	3.600	100	0	

Fineness Modulus of sand = Total percentage of cumulative/100

Fineness Modulus of sand = 3.18 & Sand conforming to zone III.

SPECIFIC GRAVITY TEST

S. No.	Observations	Trial No 1	Trial No 2	Trail No 3
1	Wt of empty container	644	644	644
2	Wt of container+sample (W_2 g)	1201	1097	1109
3	Wt of container+sample+water (W_3 g)	1876	1810	1820
4	Wt of container+water (W_4g)	1531	1531	1531
5	Specific Gravity	2.627	2.603	2.642

Specific Gravity of Fine Aggregate =2.624

MOISTURE CONTENT TEST

S. No.	Observations	Trial No 1	Trial No 2	Trial No 3
1	Wt of empty container	790	842	1026
2	Wt of container+sample (W_2 g)	2790	2842	3026
3	Wt of container+ dry sample (W_3 g)	2746	2791	2978
4	% of moisture content of fine aggregate	2.2	2.6	2.4

% of Moisture Content of Fine Aggregate = $[(W_2-W_3)/(W_3-W_1)]$x100

% of Moisture content of fine aggregate = 2.4%

WATER ABSORPTION TEST

Observations

Wt of sample taken (W_1) = 1000g
Wt of sample in SSD state (W_2) = 1008g
Water absorption = $\{(W_1-W_2)/W_1)\}$ x 100
Water absorption =0.8%

TESTS FOR COARSE AGGREGATE

SIEVE ANALYSIS

S.No	IS Sieve (mm)	Weight retained (g)	% of wt retained	Cumulative % of wt retained	Cumulative % of passing
1	40	0	0	0	100
2	20	2065	51.62	51.62	48.48
3	12.5	1790	44.75	96.37	3.63
4	10	103	2.57	98.94	1.01
5	4.75	42	1.05	100	0

Fineness Modulus of coarse aggregate = 3.46.

SPECIFIC GRAVITY TEST

S. No	Observations	Trial No 1	Trial No 2	Trial No 3
1	Wt of empty container	1252	1252	1252
2	Wt of container +sample (W_2 g)	2996	2808	2900
3	Wt of container + sample + water (W_3 g)	3984	3856	3970
4	Wt of container + water (W_4 g)	2881	2881	2881
5	Specific Gravity	2.720	2.678	2.686

Specific Gravity of Coarse Aggregate =2.695

MOISTURE CONTENT TEST

Observations

Weight of sample taken (W_1) = 3000g
Weight of sample after dried process (W_2) = 2993g
% of free moisture content =$\{(W_1-W_2)/W_1)\}$ x 100
% of free moisture content of Coarse Aggregate = 0.25%

BULK DENSITY TEST
Observations

Dimensions of Mould
Diameter of mould = 0.15 m
Height of mould = 0.17 m
Volume of mould = 0.003002625 m^3

Loose state
Wt of sample taken = 4.362 kg
Density = mass/volume = 1452kg/m^3

Compacted state
Wt of sample taken = 4.846 kg
Density = 1613 kg/m^3

WATER ABSORPTION TEST

Observations
Wt of sample taken (W_1) = 3000 g
Wt of sample in SSD state (W_2) = 3005 g
Wt of oven-dried sample (W_3) = 2993 g
Water absorption of coarse aggregate = $\{(W_2-W_3/W_3)\}$ x 100
Water absorption of coarse aggregate = 0.4%

FLY ASH

Specific gravity of fly ash

S.No	Description	Values
1	Weight of empty bottle(W_1)(g)	26.8
2	Weight of bottle + water(W_2)(g)	75
3	Weight of bottle +kerosene(W_3)(g)	65.5
4	Weight of bottle+ fly ash +kerosene(W_4)(g)	67.5
5	Weight of fly ash (W_5)(g)	10

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$$\text{Specific gravity of fly ash (G)} = \frac{(W_3 - W_1) \times W_5}{(W_5 + W_3 - W_4) \times (W_2 - W_1)}$$

$$= \frac{(65.5-26.8) \times 10}{(10+65.5-67.5) \times (75-26.8)}$$

Fineness of fly ash

S.No	Description	Trial No.1	Trial No.2	Trial No.3
1	Wt of Fly ash taken	100g	100g	100g
2	Wt of Fly ash Retained	6g	6g	6g
3	Percentage of residue left on 90μ sieve	6	6	6

Fineness of cement = (weight retained/weight taken) x 100
Fineness of cement = 6%

PROPERTIES OF FRESH CONCRETE

TEST FOR FRESH CONCRETE

SLUMP CONE TEST

This test is carried out with a mould called slump cone whose top diameter is 10cm, bottom diameter is 20 cm and height is 30 cm. the test may be performed in the following steps:

1. Place the slump mould on a smooth flat and non-absorbent surface.

2. Mix the dry ingredients of the concrete thoroughly till a uniform colour is obtained and then add the required quantity of water.

3. Place the mixed concrete in the mould to about one-fourth of its height. Compact the concrete 25 times with the help of a tamping rod uniformly all over the area.

4. Place the concrete in the mould about half of its height and compact it again.

5. Place the concrete up to its three fourth height and then up to its top. Compact each layer 25 times with the help of tamping rod uniformly. For the second subsequent layers, the tamping rod should penetrate into underlying layers.

6. Strike off the top surface of mould with a trowel or tamping rod so that the mould is filled to its top.

7. Remove the mould immediately, ensuring its movement in vertical direction.

8. When the settlement of concrete stops, measure the subsidence of the concrete in millimeters which is the required slump of the concrete.

SLUMP VALUE = 68mm

PROPERTIES OF HARDENED CONCRETE

COMPRESSIVE STRENGTH OF CUBE

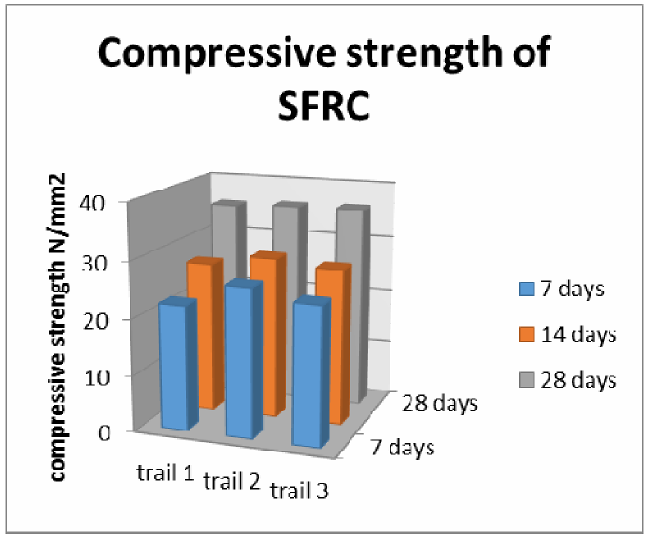
Compression test is the most common test conducted on hardened concrete, partly because it is an easy test to perform, and partly because most of the desirable characteristic properties of concrete are qualitatively related to its compressive strength.

The compression test is carried out on specimens cubical or cylindrical in shape.

PROCEDURE

1. Not e t he date of casting.
2. Measur e t he dimensions of t he concr et e cub e
3. Place the concr ete cube, in the compr ession t esting ma chine.
4. Apply the load to the specimen unifor mly.
5. Apply further load until t he specime n fails. Note down t he loa d at fai lur e.
6. Repeat the procedure for remaining specimens

Compressive strength of SFRC



Compressive Strength of Cube

Sample	7 days (N/mm^2)	14 days (N/mm^2)	28 days (N/mm^2)
1	22.32	26.95	35.52
2	26.45	28.79	35.95
3	24.56	27.77	36.11
Average	**24.44**	**27.83**	**35.86**

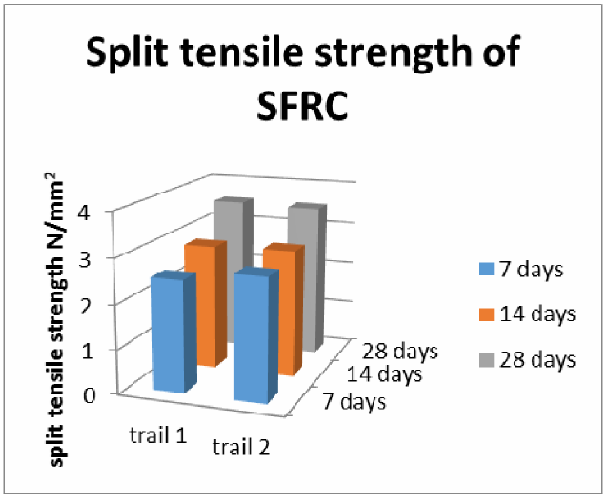
SPLIT TENSILE STRENGTH OF CYLINDER

Generally concrete is used in the compressive members and seldom expected to take up tensile stresses. However, tension is significant with respective to cracking. Hence the knowledge of tensile strength is required. Tensile strength is one of the basic and important properties of concrete. It is difficult to determine the tensile strength directly. An indirect test to determine the tensile strength is the splitting tensile strength test and the direct tensile strength is calculated there by.

PROCEDURE

1. Cure the concrete cylinder for required no of days say 7 or 24 days.
2. Take out concrete cylinder from curing tank.
3. Wipe out the surface of concrete.
4. Measure the dispersion of concrete of cylinder.
5. Keeping the top surface.
6. Place the wooden spring on to or bottom of concrete.
7. Apply load gradually at made of 140kg/cm3 till specimen fault.
8. Note down ultimate load taken by specimen.
9. Split tensile strength = $\frac{2P}{\Pi LD}$, P = applied load.
10. Test at least 3 specimen of each curing days and calculate the average value of flexural strength of concrete at coming bonding days.

Split tensile strength of SFRC



Split Tensile Strength of Cylinder

Sample	7 days (N/mm^2)	14 days (N/mm^2)	28 days (N/mm^2)
1	2.52	2.85	3.56
2	2.75	2.89	3.52
Average	**2.64**	**2.87**	**3.54**

FLEXURAL STRENGTH OF PRISM

Concrete as we know is relatively strong in compression and weak in tension. In reinforced concrete members, little dependence is placed on the tensile strength of concrete since steel reinforcing bars are provided to resist all tensile forces .Therefore the knowledge of tensile strength of concrete is of importance.

Procedure

1. Test specimens are stored in water at a temperature of 24oC to 30oC for 48 hours before testing. They are tested immediately on removal from the water whilst they are still wet condition.

2. The dimension of each specimen should be noted before testing.

3. The bearing surface of the supporting and loading rollers is wiped and clean, and any loose sand or other material removed from the surfaces of the specimen where they are to make contact with the rollers.

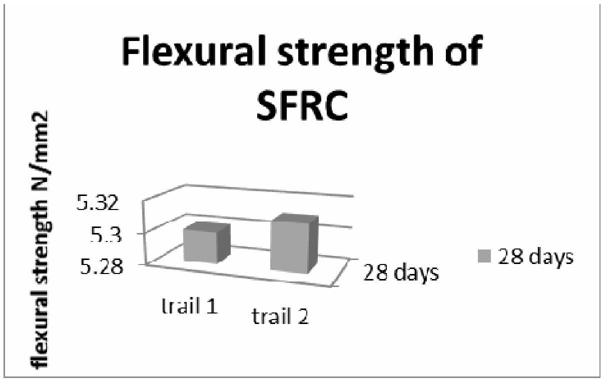
4. The specimen is then placed in the machine in such manner that the load is applied to the upper most surface as cast in the mould.

5. The axis of specimen is carefully aligned with the axis of the loading device. No packing is used between the bearing surfaces of the specimen and rollers.

6. The load is applied without shock and increasing continuously at a rate of the specimen. The rate of loading is 4kN/min for the 15cm specimen and 18 kN /min for the 10cm specimen.

7. The load is increased until the specimen fails and the maximum load applied to the specimen during the test is recorded.

Flexural Strength of SFRC



Flexural Strength of Prism

Sample	7 days (N/mm^2)	28 days (N/mm^2)
1	4.75	5.30
2	4.82	5.31
Average	**4.78**	**5.31**

CONCLUSION

- The detailed literature review on SFRC (Steel fibre reinforced concrete).
- To use economical steel fibre and fly ash are added in order to improve the performance of fibre reinforced concrete.
- From the properties of materials, the mix ratio for M_{30} is found and then various trail mixes are done from that specific mix ratio for M_{30} is found.
- Workability and behaviour of hardened concrete of conventional concrete has been observed and to be investigated postly achieving the results of SFRC

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