"Experimental Study on Steel Fibre Reinforced Concrete"

A report

Submitted in fulfillment of the requirements for the project of

BACHELOR OF TECHNOLOGY

IN

CIVIL ENGINEERING

Under the supervision of

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To

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CERTIFICATE

This is to certify that the work which is being presented in the project report titled **"Experimental Study on Steel Fibre Reinforced Concrete"** in fulfillment of the requirements for the award of the degree of Bachelor of Technology in Civil Engineering and submitted to the Department of Civil Engineering, Jaypee University of Information Technology, Waknaghat is an authentic record of work carried out by Gaurav singh (131617) and Rajat soni (131647) during a period from August 2016 to May 2017 under the supervision of **Mr. Saurav** Assistant Professor, Department of Civil Engineering, Jaypee University of Information Technology, Waknaghat.

The above statement made is correct to the best of our knowledge.

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The topic **"Experimental Study on Steel Fibre Reinforced Concrete"** was very beneficial for us in giving the necessary background information and inspiration in choosing this topic for the project. Our sincere thanks to our Project Guide **Mr.Saurav,** Assistant professor of Civil Engineering Department for having supported the work related to this project. His contributions and technical guidance in preparing this report is greatly acknowledged.

ASBTRACT

In previous years there is lots of research on fibre Reinforced concrete. In this project we make M 60 and replace steel fibre with volume of concrete. In addition we also replace volume of cement with silica fume, fly ash and rice husk ash.

This project shows various mix design with different ratios of steel fibre, silica fume, fly ash and rice husk ash. We perform compression test, split tensile test and flexural test. The objective of this project was to understand the behavior of steel fibre reinforced concrete with different additives such as silica fume, fly ash and rice husk ash with different percentage of steel fibre.

Compressive strength, split tensile strength and flexural strength was tested on cubes, cylinder and beams. In this project we make 27 cubes,21 cylinder and 14 beams.

Keywords:

Steel fibre reinforced concrete, Silica fume, Fly ash, Rice husk ash, Compression test, Split tensile test, flexural test.

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INTRODUCTION

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INTRODUCTION

1.1 General

The most important building material in construction is concrete. Concrete could be built in any size or shape from rectangular beam to circular water storage. The advantages of using concrete are following:

a) Its compressive strength is high
b) It is good in fire resistance.
c) It has high water resistance.
d) It has low cost of maintenance.
e) It has long service of life.
f) It is easily available in today world.
g) It can be molded into any shape.
h) It resistant to wind water and insect.

The disadvantages of using concrete are following

a) It has poor tensile strength of concrete.
b) Its low strain of fracture.
c) Formwork requirement leading to increase cost.
d) During curing there is formation of micro cracks which develop tension in concrete due to which tensile strength is low.

So, low these disadvantages like tensile strength, toughness, post crack behavior, impact resistance, flexural strength fiber is added. Steel fibre is extensively used everywhere form pavements to machine foundation, form deck of bridge to offshore structure.

Fibres are used in every form of life from space shuttle to human muscles. They are used in every where there is a strain. The Space shuttle used it for temperature control and to control the effect of thermal expansion. The fibre has a ability to increase the material strain resistance nature.

Thus, SFRC exhibits better performance not only under static and quasi-statically applied loads but also under fatigue, impact, and impulsive loading.

1.2 Historical Reinforced Concrete

He found that flexural strength is 7% to 14% of its compressive strength of concrete. This drawback has been dealt with over many years by using a system of reinforcing bars (steel rebars) to create reinforced concrete; so that concrete primarily resists compressive stresses and rebars resist flexural and shear stresses. The longitudinal steel rebar in a beam resists flexural (tensile stress) whereas the stirrups, wrapped around the longitudinal steel bar, resist shear stresses. In a column, vertical bars resist compression load and buckling stresses while ties resist shear load and provide confinement to vertical bars. Use of reinforced concrete (RCC) makes for a good composite material with extensive applications.

Steel bars reinforce concrete against tension only locally and Cracks in reinforced concrete members can extend freely until they encountered a rebar. The need for multidirectional and closely spaced steel reinforcement arises in construction industry which is practically not possible. Steel fibre reinforcement gives the solution for this problem

1.3 Chemistry inside Fibre Matrix

Tensile cracking strain of cement matrix is very much small than the ultimate strain of steel fibres. So when a fibre composite is under load, the matrix will crack long before the fibres can be fractured.

As the matrix is crack the fibre composite continues to carry more tensile stress means the peak stress, the peak strain of the fibre composite are greater than the matrix alone and during the inelastic range between first cracking and the peak, multiple cracking of matrix occurs as in the Figure 1.1

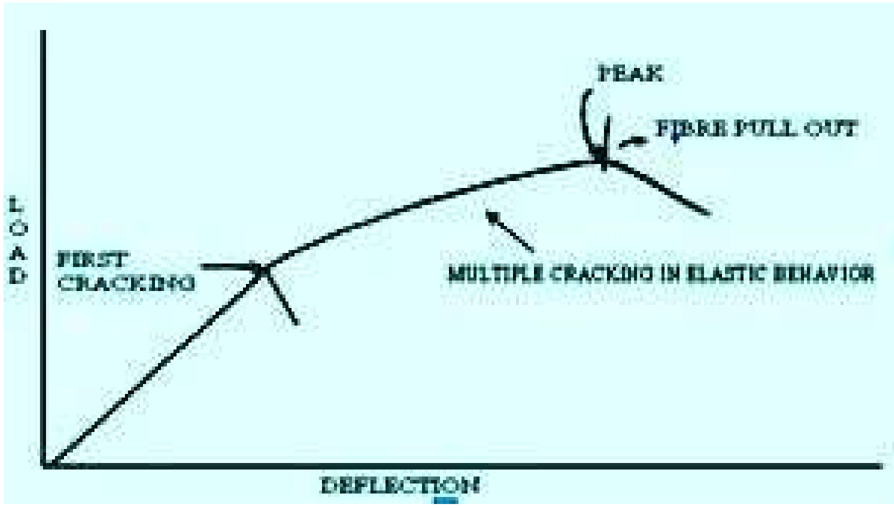

Fig. 1.1 Fibre mechanisms

1.4 Bridging Action

Pullout resistance is very important for efficiency of steel fibre. Pullout strength improves the post-cracking tensile strength of fibre reinforced concrete. So when an SFRC beam or other structural element is loaded; steel fibres bridge the cracks, as shown in Figure 1.2. This bridging action improves greater ultimate tensile strength, larger toughness and better energy absorption.

The important benefit of SFRC is material damage tolerance. Bayasi and Kaiser (2001)[18] performed a study in which damage tolerance factor is defined as the ratio of flexural resistance to ultimate flexural capacity. According to Bayasi and Kaiser at 2% steel fibre volume damage tolerance factor was determined as 93%

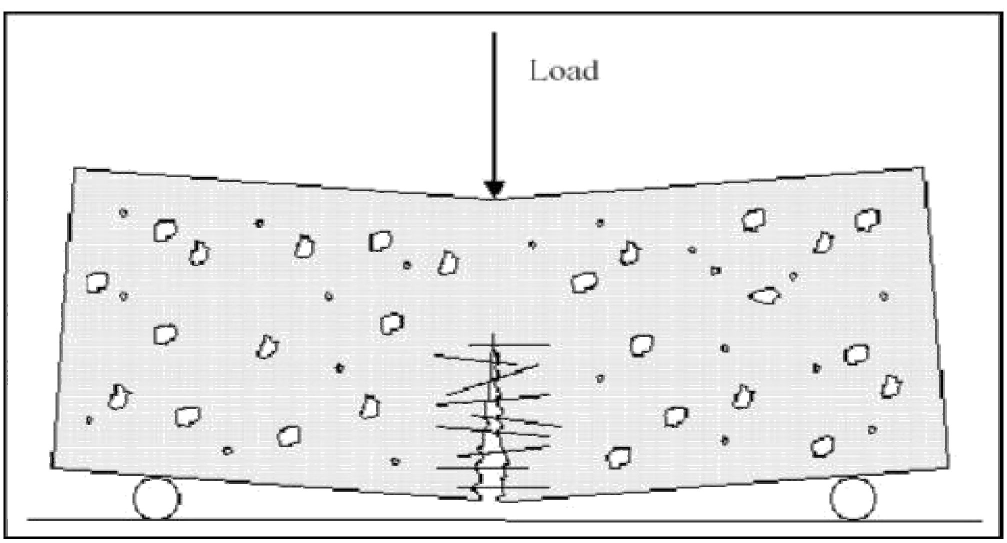

Fig. 1.2 Fibre pull-out

1.5 Workability

On addition of fibre there is reduction in workability. Workability of SFRC is affected by fibre aspect ratio and volume fraction as well the workability of plain concrete.

With the increases in fibre content in concrete, workability decreases. In most of research paper volume of steel fibre is limited to 2.0% and l/d to 100 to avoid unworkable mixes.

In addition, some researchers have limited the fibre reinforcement index to 1.5 for the same reason. Some of researcher use additive to overcome workability problem.

1.6 Advantage of SFRC

The advantages of SFRC are

i. It eliminates storage, handling, manufacturing and positioning of reinforcement cages.

ii. It Reduce the production cycle time which resulting in increased productivity.

iii. Important time savings due to the elimination of the manufacturing, transport, handling and positioning of the conventional reinforcement.

iv. It Improve impact resistance during erection, handling.

v. It Increase load bearing capacity and also less spalling damage.

vi. It Enhance durability.

vii. There is no damage to sealing due to reinforcement.

viii. It increases corrosion resistance quality and spalling is totally excluded.

ix. It increases crack control, the fibres control and distribute the cracks.

x. It gives resistance to tensile stresses at any point in the concrete layer.

xi. Reinforces against the effect of shattering forces.

xii. Reinforces against material loss from abrading forces.

xiii. Reinforces against water migration.

1.7 Applications of SFRC

i. It is use in Rock slope stabilization and support of excavated foundations, also in conjunction with rock and soil anchor systems.

ii. It is use in road pavements, Industrial floorings, warehouses, Foundation slabs because it increases load capacity of structure.

iii. It is use in protect bridge abutments, Channel linings.

iv. It is use in rehabilitation of deteriorated marine structures such as dry docks piers, bulkheads, light stations and sea walls.

v. It is use in rehabilitation of reinforced concrete in structures such as chemical processing, handling plants and bridges.

vi. It is also in Supports of underground openings in tunnels and mines

1.8 Examples of SFRC

- Chamera hydroelectric project, HP
- Uri dam, J&K
- Sirsisilam project, AP
- Tehri Dam project, UK
- Ranganadi Hydroelectric project, AP
- NH Bombay Pune, MH

1.9 Organization of thesis

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2. Literature review.
3. Experiment study.
4. Test, result and discussion.
5. Conclusion.
6. References.

CHAPTER 2

LITERATURE REVIEW

CHAPTER 2

LITERATURE REVIEW

2.1 Steel fibre

A.M. Shende et al[12] makes M-40 concrete with a mix proportion of 1:1.43:3.04 with a water cement ratio of 0.35. He tested various properties of concrete such as compressive strength, split tensile strength, flexural strength of SFRC. He observed that all the strength of concrete mentioned above have a higher value as % of steel fibre in steel fibre reinforced concrete increase and is maximum at 3% fibre content. The compressive strength of concrete increase by 11-24% on addition of fibre. Flexure strength increase from 12-49% with addition of fibre and split tensile strength increase about 3-41% with addition of steel fibre.

Nguyen van chanh[15] said that flexural strength has a greater effect than any other strength of concrete on steel fibre reinforced concrete (SFRC) with increase of more than 100%. The increase in flexural strength is sensitive to fibre volume, aspect ratio with higher aspect ratio leading to larger strength increase. Tensile strength also increases as much as high as 133% but steel fibre does not affect much the compressive strength of concrete increase from nil to 25%.

S.Mindess[26] said that there has been enough research on FRC and his research is majorly based on better way of characterizing the effects of fibres on the toughness of concrete, the properties of FRC under impact loading, the use of hybrid fibre systems. Hybrid fibre is the combination of two or more different type of fibre. This is becoming more common phenomenon. He said the performance of hybrid system is more than that of individual fibre.

2.2 Silica fume

D. Dutta[8] is using M45 grade of concrete and again silica fume is replaced by 5%, 10%, 15% and 20% of OPC and maintaining water-cementitious materials W/C ratio for 0.40. He is using OPC of 43grade.Fine aggregate of natural sand having bulk density of 2610 kg/m^3, specific gravity of 2.65, fineness modulus of 3.10 and grading zone ÎÎ. Coarse aggregate having crushed aggregates of size

12.5 mm of specific gravity 2.83 and fineness modulus 6.28 were used and same silica fume (grade 920 D) is used. And the result shows that when we replace 10% of silica then maximum compacting factor of 0.814 and slump of 20, 20, and 20 is obtained. And when silica fume is replaced by 15% it gives maximum compression value of 65.67 MPa.

K.G. Raveendran et al[10] is using M30 grade of concrete and again same procedure with silica fume. In this paper he gives us information that as we add silica fume by 10% then it gives maximum compressive strength and maximum split tensile strength. But as we increase replacement of silica fume to 15% its flexural strength is maximum.

Subhro Chakraborty et al[1] they use 16 sample having different value of W/B (water/binder ratio) 0.30,0.34,0.38,0.42 and different value of silica fume 5%,10%,15%,20% to take result about the quality, consistency and uniformity of the mix and also measuring the value of workability, slump and CF. In these sample cement of 43 grade OPC was used . Aggregate of Zone II sand was used and course aggregate of 12.5mm aggregates and 20mm aggregates should be used in the ratio of 50:50 was used. And the shows that

1. For all water cement and binder content, the workability of the concrete mix reduced dramatically with the increase in the silica fume replacement percentage.
2. As the amount of silica fume used in a mix increases, the cohesiveness of the mix increases and the mix becomes sticky.
3. Super plasticizer dosage was kept constant (2.5%). Hence no effect of SP dosage on slump variation.

Silica Fume incorporation in concrete:

1. Increases the water demand and reduces the workability.
2. Increases the cohesiveness of the mix. At higher silica fume contents, the mix becomes sticky.
3. Reduces bleeding.
4. Prevents segregation.

5. Reduces the fresh density of concrete.
6. Large replacement percentage can cause a change in the colour of the mix.

Prashant Y.Pawade et al[11] is using M35 concrete in which he replaces silica fume by 0,4,8 and 12% and also add steel fibre of diameter of 0.5 mm and length of 30mm at percentage of 0,0.5,1.0 and 1.5% by volume. So result shows that the workability of sample decreases with adding of silica fume so we have to add super plasticizer. And the compressive strength and flexural strength of sample maximum at add 1.5% of fibre and 8%of silica fume.

2.3 Fly ash

S Suman et al[13] uses fly ash which satisfy all the limit of IS 3812-2003. In this M20 grade with nominal mix as per IS 456-2000 was used. The concrete mix proportion is 1: 1.5: 3 by volume and a water cement ratio of 0.5 is taken. The fly ash is blended in cement at a rate of 5 to 25% by weight of cement in steps of 5% and the result shows about compressive strength .This shows that at earlier age compressive strength of sample with fly ash is less but later it increases. At 90 days the strength of sample with 20%and 10% fly ash relative same so we will use 20% fly ash because it makes concrete more economical.

D.K. Soni and Jasbir Saini[7] discussed about the behaviour of concrete mix with fly ash at higher temperature in which he replaces the F-class fly ash by 30%, 40%, 50% and the temperature variation is normal, 80,100 and 120^0C.He use M20 in his experiment and the result shows that with the percentage of F-class fly ash increases the compressive, tensile strength and elasticity modulus of concrete is decreases. And also with the increase in temperature compressive, tensile strength and elasticity modulus again decreases.

T.S. Butalia et al[25] uses to do Chloride Ion Permeability to determine how much amount of chloride / CO_2 is present in the sample which reduce the amount of pH. As the pH decreases chances of rust increases and rust increase the volume of steel and crack occur and decrease strength of concrete. So the result shows that with the increase in fly ash quantity in concrete it also reduces the chlorine and CO_2 amount which reduces the risk of corrosion attack. It also gives that at

45% replacement of fly ash gives highest compressive strength on after 300 days and also have minimum air void. At 50% it again decreases compressive strength.

Saravana Raja Mohan and K. Parthiban[14] in his paper researcher combine fly ash and steel fiber in M20 concrete at 0.45 of W/C ratio. He uses 43 grade of cement, C-class type of fly ash at the replacement of 10, 15, 20, 25, 30% and fibre of 1mm dia of tensile strength of 300MPa of length 20mm, 40mm, 60mm and 80mm And the result shows that 15%replacement of fly ash and 40 mm length with the fibre content of 0.15% by weight gives highest compressive strength. Steel fibre composites show better performance upto 20% fly ash and 60mm fibre length and 0.6% of fibre content. And the tensile strength is maximum at 10% of fly ash and 0.6% of fibre content.

2.4 Alccofine

Dr H.S Patel[9] research paper contains the effect on high performance concrete when Alccofine and fly ash are added to it in different proportion. Cement used was OPC 53 grade, fine & coarse aggregate both was present. ALCCOFINE 1203 was used which is produced from the slag of high glass content with high reactivity. Super plasticizer GLENIUM SKY 784 was used to improve workability. ALCCOFINE 1203 and GLENIUM SKY 784 proportion are 8% and 20% respectively. The various tests was performed on it such as compression test, chloride resistance test, sea water test, rapid chloride penetration test, accelerated corrosion test. From the test we concluded that durability of concrete improves by the use of it. Permeability of concrete decrease as it converts leachable $Ca(OH)_2$ into soluble non leachable cementious product. It's also possible to make M70 concrete having RPCT value lower than 500 coulombs. As penetration decrease chance of corrosion also decrease so normal cover is sufficient to protect steel from corrosion.

Siddharth P.Upadhyay and M.A Jamnu[5] write a paper on alccofine is a new generation, micro fine material of particle size much finer than other hydraulic materials like cement, fly ash, silica etc being manufactured in India. It gives smooth finish. Use of alccofine is also economical as compared to without it. It can reduce the water cement ratio up to 70% for same workability. It increases both the compressive strength and tensile strength of concrete. He used ALCCOFINE 1203, OPC 53 grade. Fly ash used in it is obtained from Gujarat state electricity department. The maximum compressive strength is obtained using 10% & 30% of alccofine and fly ash. The strength gained till 7 days is fast and after that the rate of gain of strength of concrete is slow. Due to change in water cement ratio from 0.45 to 0.50 a very significant increase in compressive strength is noticed. At 3 days test concrete having higher water cement ratio will show higher strength.

Rajesh Kumar et al[2] in this paper mechanical properties of alccofine (Alccofine 1203) is especially processed product based on high glass content with high reactivity obtained through the process of controlled granulation are considered. The mechanical properties studied here are compressive strength on concrete cubes at 3,7,14 and 28 days of water curing and flexural strength on prisms at 7 and 28 days of water curing. The author concluded that-The results of alccofine material increases the strength (both in compression and in flexure) to a large extent at 10% replacement level of cement. The cement replacement by 10% of alccofine gives higher values of all other mix. The strength development of concrete is carried out at all ages of curing and it is observed that the strength increasing suddenly at the initial stage but after that it is increasing gradually. It is seen that the 7 days' compressive strength when compared between control mix and cement replaced by 10 % alccofine an increase of 25.5 % is observed. When 28 days curing has been done it is found that the flexural strength increased by 27.6% when control mix (0% alccofine) is compared with 10% cement replaced by alccofine. It is clear from the results that the alccofine material increases the strength only at the addition of 10% replacement of cement. If the percentage level of alccofine is increased beyond that level it acts as a filler material and yields good workability to the concrete.

2.5 Rice husk ash

M.Vyas et al[3] Rice husk ash is an agriculture waste product produced in large quantity globally. India alone produces 120 million tons of rice paddies per year, giving around 24 million ton of rice husk every year and 6 million ton of rice husk ash every year. As the rick hush is a waste product and there is a pressure on rice industry to find its solution of disposal. The author performs compressive and flexure strength. The result of the experiment was that water cement ratio is increase respectively compressive strength and flexural strength of previous concrete in use. The compressive strength of pervious concrete is increased up to 10% replacement of cement with RHA beyond than it is starting to decrease. The flexural strength of pervious concrete is increase up to 10% replacement of cement with RHA beyond than it is starting to decrease. It's possible alternative solution to safe disposal of RHA.

Obilade[6] he need to reduce the high cost of ordinary Portland cement in order to provide accommodation for the populace has intensified research into locally available material that could be used as partial replacement for ordinary Portland cement in civil engineering and building works. OPC was replaced by weight at 0%, 5%, 10%, 15%, 20%, and 25%. 0% replacement served as the control. Compaction factor test was carried out on fresh concrete and compressive strength test on cube of size 15 cm after 7, 14, 21 days curing in water. From the study the optimum addition of RHA as partial replacement for cement is in the range of 0-20%. The compaction factor value of the concrete reduced as the percentage of RHA increase. The bulk density of concrete reduced as proportion of rice husk ash increase on mixture. The compressive strength of concrete reduced as proportion of RHA increased.

I. Frank, el al[4] he demonstrate paper how abundant available cheap agriculture waste can be transformed into a useful resource. The result shows that 150-day strength of 10% replacement RHA is higher than the control specimen. The strength of cement blended with pozzolanas normally improves after the age of 28 days because pozzolanas react more slowly but can match characteristics of normal concrete after 28 days. The compressive strength of sample is increase with the increase in hydration period. Water adsorption and simultaneous loss in material result in the reduction of density of sample although, a linear pattern for the slightly loss in density was recorded due to saturation of all concrete specimen over the entire extended hydration period. Over the extended period, considerable drop in compressive strength of sample cured for 56-90 days was noticed in association with RHA content not utilized in pozzolanic reaction. Hence extended hydration period of up-to 150 days can produce RHA/OPC concrete with sufficient strength for structural works.

CHAPTER 3

EXPERIMENTS STUDY

CHAPTER 3

EXPERIMENTAL STUDY

3.1 Experiment overview

For compression test 27 cubes was casted respectively. We also performed split tensile test and 4 point flexure test. We designed the concrete for M60 strength. We construct 21 cylinder of size 20×10cm and 14 beams of size 10×10×50 cm. 27 cubes casted 9 cubes are without fibre and rest are with 2%, 2.5%, 3% fiber. We checked the strength on 14 and 28 day for compressive test.

3.2 Experiments

3.2.1 Compression Test

This test was done in accordance with IS 516-1959.The cubes of standard size 150×150×150mm and 100×100×100mm were used to find the compressive strength of concrete. Cubes were placed on the bearing surface of compression testing machine, of capacity 200 tones and a uniform rate of loading of 140 Kg/cm^2 per minute was applied till the crack appear on the cube. The maximum load was noted and the compressive strength was calculated. The results are tabulated in table 3.1

Fig. 3.1 Compression testing machine

Procedure: -

i. Prepare the specimen of size 15×15×15cm in size.
ii. The concrete should be filled in specimen in layer of 5 cm with proper compaction of each layer either vibration machine or hand tamping.
iii. The mould should be keep at damp condition for 24 hours.
iv. After that the cube should be put in bath tub at a standard temperature of 27±2 ^{o}C.
v. The cubes should be tested immediately on removal from water.
vi. The load should be applied slowly without any shock at a rate of approximately 140Kg/cm^2/min.
vii. The max load applied to the specimen should be noted for each cube.

Calculation: -

Compressive strength in MPa = P/A

Here P = applied load

A = cross sectional area

3.2.2 Split Tensile Strength Test

Concrete is brittle in nature and therefore tensile strength plays an important role for structure safety purposes. This test is also performed on CTM machine. In this test we constructed 21 cylinder out of which 3 cylinder are for each 0, 2, 2.5, 3 % steel fibre and 3 each for rice husk ash, fly ash, silica fumes.

Procedure: -

- The cylinder of size 20×10 cm size is made.
- Centre line shall be drawn on the two opposite faces of the cube which will ensure that they are in same axial plane.
- The mass and dimension of cylinder should be measured before the testing.
- The rate of loading should be smooth and should not be shock loading.
- The rate of loading should be maintained within the range of 1.2N (mm^2/min) to 2.4 N (mm^2/min).
- Maintain the rate once applied until failure.

- Note the maximum reading.

Calculation: -

Splitting tensile strength f_{ct} =2P/πld

Where P = max load applied in Newton applied

l = length of cylinder (mm)

d = cross-section dimension of cylinder (mm)

3.2.3 Four Point Flexure Test

The four point bending flexural test provides values for the modulus of elasticity in bending, flexural stress, flexural strain, and the flexural stress-strain response of the material. This test is very similar to the three point bending flexural test but this method is superior to this because more beam area is exposed to stress. There are several advantages of four-point bending test over uniaxial tensile test are following: -

- Simple geometries of sample
- Sample machining is minimum required
- Simple text fixture
- Possibility to use as-fabricated materials

And disadvantage is that stress distribution is more complex throughout the beam.

3.3 Materials Used

3.3.1 Cement

We use OPC cement and its specific gravity of OPC was 3.14. We use OPC 53 grade cement of ACC.

3.3.2Water

Tape water was used.

3.3.3 Steel Fibre

3.3.3.1 Corrugated Steel Fibres

Corrugated steel fibers from Walia & Company as shown in fig 3.2 were used those length is 35-45 mm and dia of 0.55-0.73mm having aspect ratio of about 61. The tensile strength of fibre is 1200 N/mm^2.

Fig. 3.2 Steel fibre used in project

3.3.4 Fine Aggregate

We were using River sand in testing according to IS 2386 (PART I) whose Specific gravity is 2.63.

Absorption of water is -1%.

Zone of fine aggregate is zone IV.

3.3.5 Coarse Aggregate

We use Crushed stone aggregates having maximum size 20 mm in our tests as per IS 2386 (part III) of 1963.and specific gravity is 2.57.

Absorption of water is 0.8%.

3.3.6 Casting of mould

The materials were weighed accurately using a digital weighing instrument. For plain concrete, fine aggregates, coarse aggregate, cement, water were added to the mixture machine and mixed thoroughly for three minutes. Steel fibres were mechanically sprinkled inside the mixture machine after thorough mixing of the ingredients of concrete as shown in fig. 3.3.

Fig. 3.3 Casting of specimen

The cubes of 15×15 cm were prepared. Before mixing the concrete the moulds were kept ready. The sides and the bottom of the all the mould were properly oiled for easy demoulding.

3.5 Curing

Cubes were at a stable ground and kept at a temperature of 27±2˚C for 24 hours as shown in fig. 3.4. After this, the cubes and cylinder was marked and removed from the moulds and after that the cubes was submerged in clean fresh water for duration until it was used the testing day. The cubes were allowed to become dry before testing.

Fig. 3.4 Curing of cubes

3.6 Mix Design of Concrete

We have designed our mix by IS 10262:2009

Step 1**: <u>Characteristic Strength of concrete</u>**:

$$f_{ck}' = f_{ck} + 1.65s$$

From IS 456, s= 5 for M60

$= 60+1.65\times5$

$=$ **68.25 MPa**

Step 2: **<u>Selection of water/cement or cementations ratio:</u>**

Form IS 456,

W/c= 0.24

Step 3: **<u>Selection of water content:</u>**

From IS 456, at w/c = 0.50 and angular aggregates having maximum nominal size of 20mm

Suggestive water content = 186 kg/m^3

2% super plasticizer by weight of cement is used that result in 30% reduction in water content.

So, Final water content $= 186 \times 0.30$

$= \mathbf{130.2\ kg/m^3}$

Step 4: **Selection of cement content:**

Cement content = water content/water to cement ratio

=130.2/0.22

=**591.82kg/m^3**

Step 5: **Estimation of Coarse Aggregate Proportion in Total Aggregate:**

For w/c=0.50 and zone IV and max nominal size of aggregate=20mm

Coarse aggregate proportion in total aggregate = 0.66

Since there is a decrease in the w/c ratio (0.50-0.22=0.28) this proportion is increased according to the code recommendation by (0.28/0.05=5.6%)

Corrected coarse aggregate proportion in total aggregate = 0.66+5.6/100

= 0.72

Fine aggregate proportion in total aggregate = 1-0.72

= 0.28

Step 6: **Mix design calculations:**

(a) Volume of concrete = 1m^3

(b) Volume of cement = (Mass /Specific gravity) ×(1/1000)

= (591.82/3.15) × (1/1000)

= 0.187m^3

(c) Volume of water = (Mass /Specific gravity) ×(1/1000)

= (130/1) × (1/1000)

= 0.130 m^3

(d) Volume of super plasticizer = (Mass of super plasticizer/Specific gravity of water) × (1/1000)

= (2×591.8/1.1×100) ×(1/1000)

=10^{-2} m^3

(e) Volume of all in aggregate = 1-(b+ c + d)

= 1-(0.187+0.130+10^{-2})

= **0.673 m^3**

(f) Mass of coarse aggregate = (e)×(CA)×(specific gravity of coarse aggregate)×(1000)

= 0.673 ×0.72 ×2.57 ×1000

= 1245.31 kg/m^3

(g) Mass of fine aggregate = e × FA × specific gravity of fine aggregate ×1000

= 0.67 ×0.5 ×2.63 × 1000

= 495.5kg/m^3

Final result:

Cement = 591.82 kg/m^3

Water = 130.2 kg/m^3

Fine aggregate = 495 kg/m^3

Coarse aggregate =1245.31 kg/m^3

Super plasticizer =11.83kg/m^3

Final Ratio:

C: W: FA: CA: SP = 1:0.22:0.83:2.1:0.02

TABLE 3.1 MIX DESIGN FOR STEEL FIBRE

% Replacement	Concrete content(kg/m^3)	Steel fibre(kg/m^3)
0	C: 591; W: 130; F: 495; CA: 1245	0
2	C: 579; W:127; F: 485.1; CA: 1220.1	156
2.5	C: 576; W:126.7; F: 482.6; CA: 1214	195
3	C: 573; W: 126; F: 480; CA: 1208	234

Table 3.1 shows the ratio of concrete design at different percentage of steel fibre.

TABLE 3.2 MIX DESIGN FOR STEEL FIBRE PER (15×15×15) cm^3 CUBE

%Replacement	Concrete content per cube (grams)	Steel fibre per cube (grams)
0	C: 133; W: 29.3; F: 111.4; CA: 280	0
2	C: 130; W: 28.575; F: 109; CA: 275	35.1
2.5	C: 129.6; W: 28.5; F: 109; CA: 273	43.9
3	C: 129; W: 28.35; F: 108; CA: 272	52.6

Table 3.2 shows the amount of constituents of concrete design at different percentage of steel fibre for cube of 15cm×15cm×15cm.

TABLE 3.3 MIX DESIGN FOR SILICA FUME AND STEEL FIBRE

%Replacement of silica fume and steel fibre	Concrete content(kg/m^3)	Steel fibre(kg/m^3)
Silica: 0; steel: 0	C: 591; W: 130; F: 495; CA: 1245; silica: 0	0
Silica: 15; steel: 0	C: 503; W: 130; F: 495; CA: 1245; silica: 62	0
Silica:15; steel: 2	C: 492; W: 127.4; F: 485; CA: 1220; silica: 60.7	156

Table 3.3 shows the ratio of concrete design at different percentage of steel fibre and silica fume.

TABLE 3.4 MIX DESIGN FOR SILICA FUME AND STEEL FIBRE PER (10×10×10) cm^3 CUBE

%Replacement of silica fume and steel fibre	Concrete content per cube (grams)	Steel fibre per cube (grams)
Silica: 0; steel: 0	C: 59.1; W: 13.0; F: 49.5; CA: 124.5; silica: 0	0
Silica: 15; steel: 0	C: 50.3; W: 13; F: 49.5; CA: 124.5; silica: 6.2	0
Silica: 15; steel: 2	C: 49.2; W: 12.7; F: 48.5; CA: 122; silica: 6	15.6

Table 3.4 shows the amount of constituents of concrete design at different percentage of steel fibre and silica fume for cube of 10cm×10cm×10cm.

TABLE 3.5 MIX DESIGN FOR FLY ASH AND STEEL FIBRE

%Replacement of fly ash and steel fibre	Concrete content(kg/m^3)	Steel fibre(kg/m^3)
Fly ash: 0; steel: 0	C: 591; W: 130; F: 495; CA: 1245; fly ash: 0	0
Fly ash: 10; steel: 0	C: 532; W: 130; F: 495 ; CA: 1245; fly ash: 48.8	0
Fly ash: 10; steel: 2	C: 521; W: 127.4; F: 485; CA: 1220; fly ash:47.8	156

Table 3.5 shows the ratio of concrete design at different percentage of steel fibre and fly ash.

TABLE 3.6 MIX DESIGN FOR FLY ASH AND STEEL FIBRE PER (10x10x10) cm^3 CUBE

%Replacement of fly ash and steel fibre	Concrete content per cube(grams)	Steel fibre per cube (grams)
Fly ash: 0; steel: 0	C: 59.1; W: 13.0; F: 49.5; CA: 124.5; fly ash: 0	0
Fly ash: 10; steel: 0	C: 53.2; W: 13; F: 49.5 ; CA: 124.5; fly ash: 4.9	0
Fly ash:10; steel:2	C: 52.1; W: 12.7; F: 48.5; CA: 122; fly ash:4.8	15.6

Table 3.6 shows the amount of constituents of concrete design at different percentage of steel fibre and fly ash for cube of 10cm×10cm×10cm.

TABLE 3.7 MIX DESIGN FOR RICE HUSK ASH AND STEEL FIBRE

%Replacement of fly ash and steel fibre	Concrete content(kg/m^3)	Steel fibre(kg/m^3)
RHA: 0; steel: 0	C: 591; W: 130; F: 495; CA: 1245; fly ash: 0	0
RHA: 10; steel: 0	C: 532; W: 130; F: 495 ; CA: 1245; fly ash: 43.2	0
RHA:10; steel:2	C: 521; W: 127.4; F: 485; CA: 1220; fly ash:42.14	156

Table 3.7 shows the ratio of concrete design at different percentage of steel fibre and rice husk ash.

TABLE 3.8 MIX DESIGN FOR RICE HUSK ASH AND STEEL FIBRE PER (10X10X10) cm^3 CUBE

%Replacement of fly ash and steel fibre	Concrete content per cube (grams)	Steel fibre per cube(grams)
RHA: 0; steel: 0	C: 59.1; W: 13; F: 49.5; CA: 124.5; fly ash: 0	0
RHA: 10; steel: 0	C: 53.2; W: 13; F: 49.5 ; CA: 124.5; fly ash: 4.3	0
RHA:10; steel:2	C: 52.1; W: 12.7; F: 48.5; CA: 122; fly ash:4.2	15.6

Table 3.8 shows the amount of constituents of concrete design at different percentage of steel fibre and rice husk ash for cube of 10cm ×10cm × 10cm.

CHAPTER 4

DISCUSSIONS OF TEST RESULTS

CHAPTER 4

RESULTS AND DISCUSSIONS

4.1 Results and discussion

4.1.1 Compressive Strength

Compressive strength of concrete= P/A

Here,

P= Load applied at the time of failure

A= Area of cross section

Compressive strength of concrete= 1202 kN/225cm^2

$=1202\times10^3 /225 \times 100$

$= 53.4$ N/mm^2

TABLE 4.1 COMPRESSIVE STRENGTH

Type of Specimen	**Compressive Strength. N/mm^2**			
	14 days		**28 days**	
OPC	55.1	55.5	62.2	64.2
	55.5		64.8	
	56		65.8	
HSFRC (3%)	57.2	57.9	63.7	65
	58.1		65.2	
	58.4		66.1	
HSFRC (2.5%)	56.6	56.1	61.1	63.8
	55.7		63.9	
	56.1		66.5	
HSFRC (2%)	52.1	54.9	62.7	64.23
	55.7		65.6	
	57.1		64.4	

The result in table 4.1 shows that when we add steel fibre there is marginally increased in compressive strength with variation around 1% to -1% at 28 days.

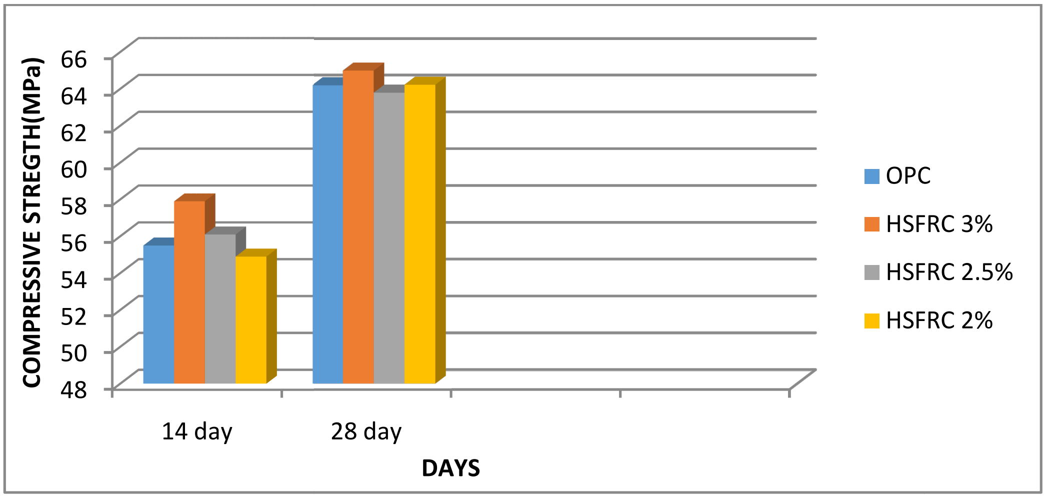

Fig. 4.1 Bar chart for compression testing machine

In this fig. 4.1 we can see that cube having 3% replacement show maximum compressive strength in comparison to other cube. This increase in strength is due to the fact that addition of steel fibre reduces the brittleness of concrete. Cubes for compression testing machine are shown in fig. 4.2 and fig. 4.3 shows the failure pattern of cube after testing.

Fig. 4.2 Cubes for CTM testing

Fig. 4.3 Crack pattern

TABLE 4.2 COMPRESSIVE STRENGTH FOR SILICA FUME AND STEEL FIBRE

Type of Specimen	Compressive Strength. N/mm^2			
	14 days		28 days	
SILICA FUME (15%)	58.5	58.03	66.5	65.56
	57.9		64.9	
	57.7		65.3	
SILICA FUME (15%) + 2% SFRC	57.2	57.73	66.5	66
	57.8		65.9	
	58.2		65.7	

Fig. 4.4 and table 4.2 shows that on replacing OPC with 15% of silica fume than there is increase in compressive strength by comparing it with OPC. After that we replace 2% steel fibre in same concrete mix of silica fume then its compression strength increases.

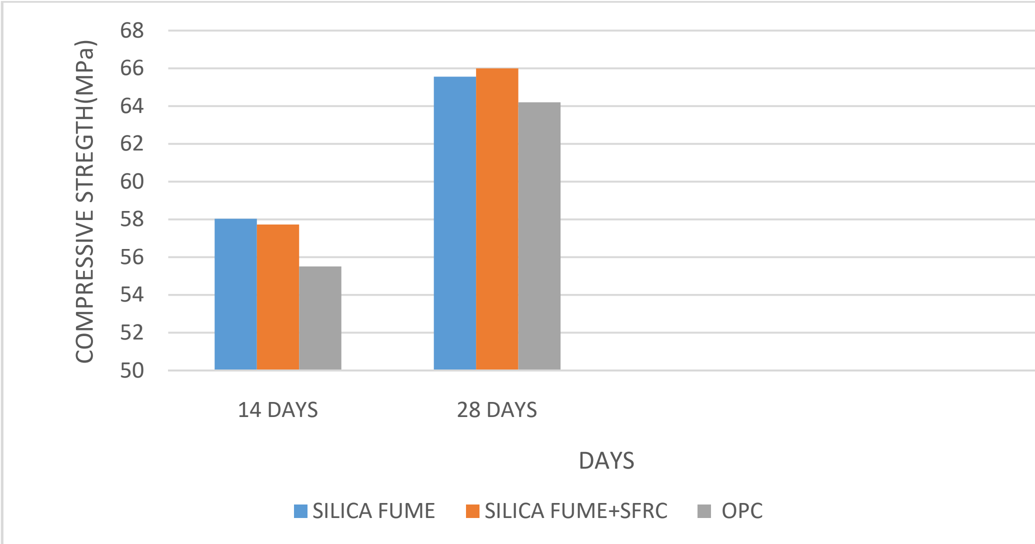

Fig. 4.4 Bar chart for compressive strength

TABLE 4.3 COMPRESSIVE STRENGTH OF FLY ASH AND STEEL FIBRE

Type of Specimen	Compressive Strength. N/mm^2			
	14 days		28 days	
FLY ASH (10%)	53.4	53.8	63.5	63.23
	54.1		62.5	
	53.9		63.7	
FLY ASH (10%) + 2% SFRC	54.4	53.73	64.5	65
	53.1		65.6	
	53.7		64.9	

Fig. 4.5 and table 4.3 show that on replacing OPC with 10% of fly ash than there is increase in compressive strength by comparing it with OPC. After that we replace 2% steel fibre in same concrete mix of fly ash then its compressive strength increases.

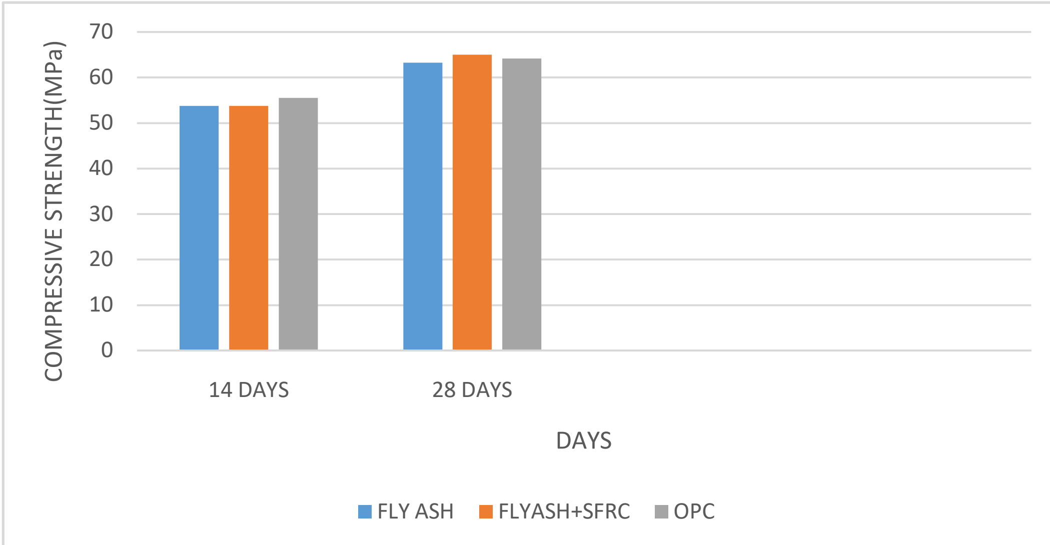

Fig. 4.5 Bar chart for compressive strength

TABLE 4.4 COMPRESSIVE STRENGTH OF RICE HUSK AND STEEL FIBRE

<table>
<tr><th rowspan="2">Type of Specimen</th><th colspan="4">Compressive Strength. N/mm²</th></tr>
<tr><th colspan="2">14 days</th><th colspan="2">28 days</th></tr>
<tr><td rowspan="3">RICE HUSK ASH (10%)</td><td>55.1</td><td rowspan="3">55.75</td><td>64.7</td><td rowspan="3">64.4</td></tr>
<tr><td>56.2</td><td>63.5</td></tr>
<tr><td>55.9</td><td>65</td></tr>
<tr><td rowspan="3">RICE HUSK ASH (10%)
+
2% SFRC</td><td>54.9</td><td rowspan="3">55.2</td><td>64.2</td><td rowspan="3">65.13</td></tr>
<tr><td>55.5</td><td>65.7</td></tr>
<tr><td>55.2</td><td>65.5</td></tr>
</table>

Fig. 4.6 and table 4.4 shows that on replacing OPC with 10% of rice husk ash than there is increase in compressive strength by comparing it with OPC. After that we add 2% steel fibre in same concrete mix of rice husk ash than its compressive strength increases.

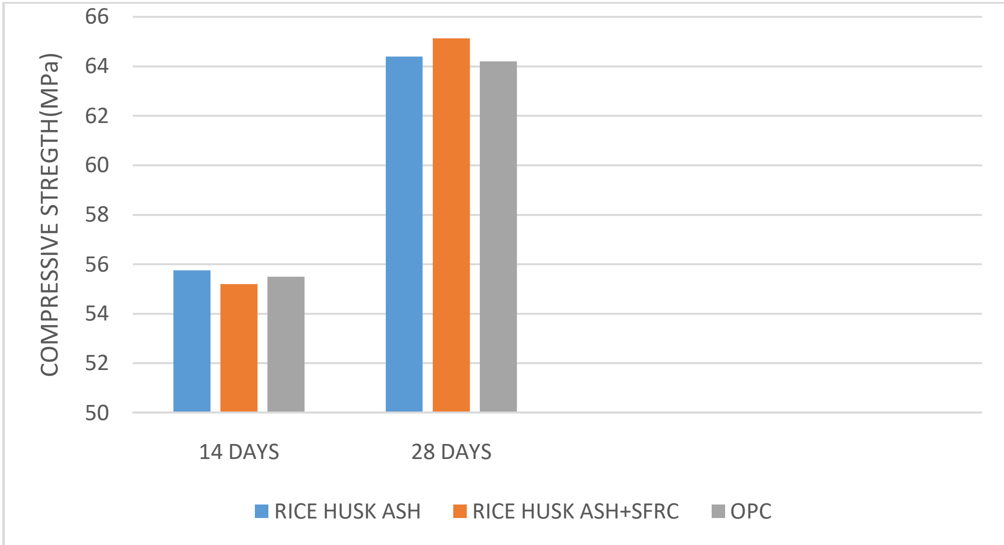

Fig. 4.6 Bar chart for compressive strength

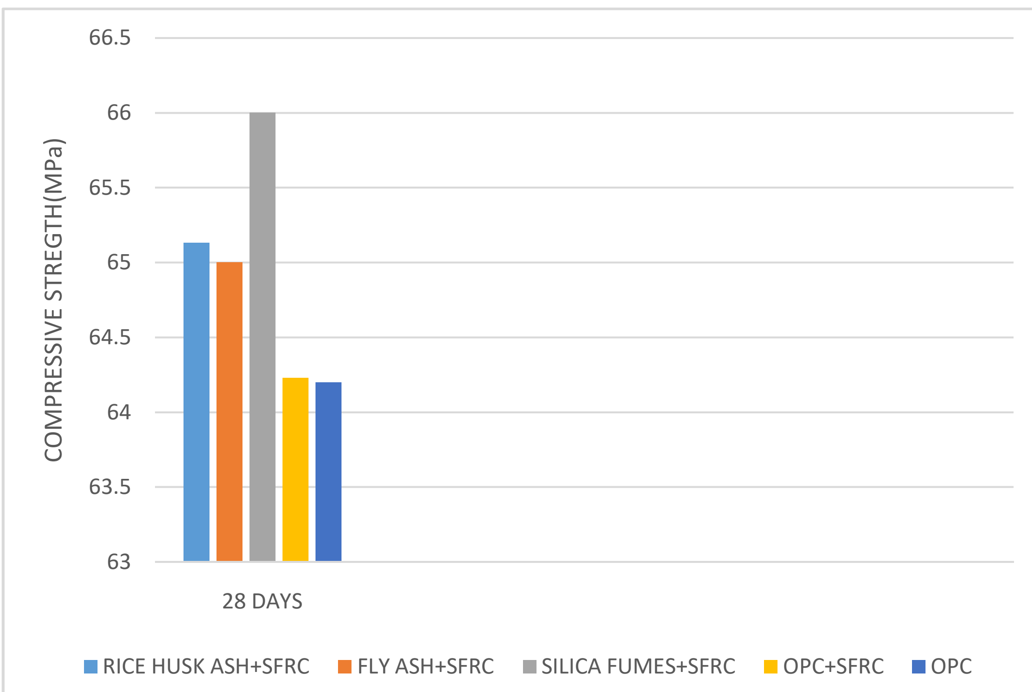

Fig. 4.7 Bar chart for compressive strength

Fig. 4.7 clearly shows that silica fume at 15% replacement show a greater compressive strength than any other additive with SFRC.

4.1.2 Split tensile strength

Spilt tensile strength = $2P/\pi ld$

Here P = Load applied at the time of failure

l = length of cylinder.

D = diameter of cylinder

Spilt tensile strength = $\frac{2\times 147.65}{\pi \times 20\times 10}$

$= 4.7\ N/mm^2$

Fig. 4.8 Mould of Cylinder

Fig. 4.8 clearly shows that mould of cylinder we casted in lab with one beam.

TABLE 4.5 SPLIT TENSILE STRENGTH OF STEEL FIBRE

<table>
<tr><th rowspan="2">Type of Specimen</th><th colspan="2">Split Tensile Strength.
N/mm^2</th></tr>
<tr><th colspan="2">28 days</th></tr>
<tr><td rowspan="3">OPC</td><td>4.7</td><td rowspan="3">5</td></tr>
<tr><td>5</td></tr>
<tr><td>5.3</td></tr>
<tr><td rowspan="3">OPC
+
2% SFRC</td><td>11.5</td><td rowspan="3">11.6</td></tr>
<tr><td>10.9</td></tr>
<tr><td>12.5</td></tr>
</table>

Fig. 4.9 Brittle failure of cylinder without fibre

Fig. 4.10 and table 4.5 shows that on replacing of concrete with 2% steel fibre the result show that the split tensile value increases more than double. And in Fig. 4.9 shows that brittle failure of concrete in split tensile test cylinder without steel fibre.

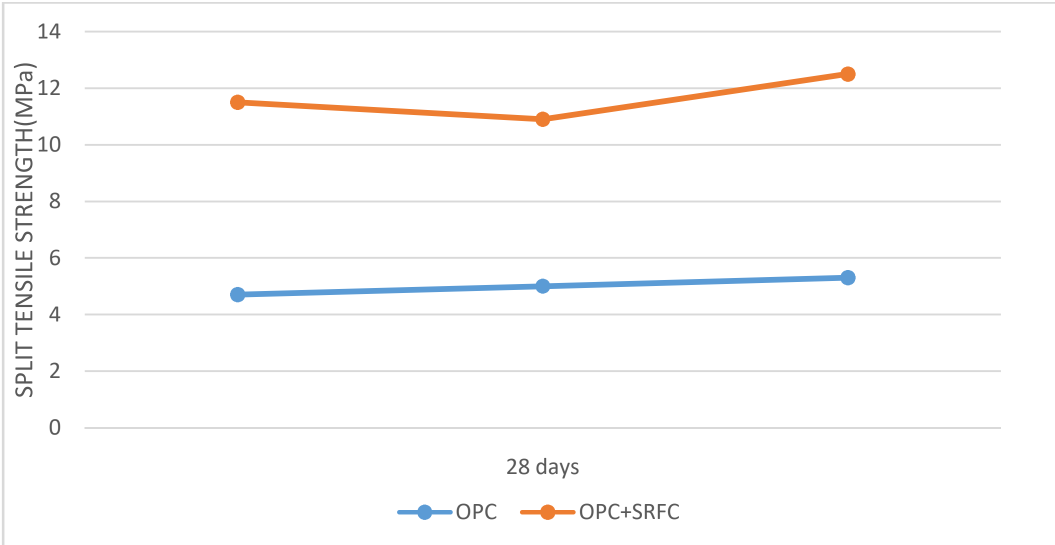

Fig. 4.10 Chart for Variation of Split Strength

TABLE 4.6 SPLIT TENSILE STRENGTH OF SILICA FUME AND STEEL FIBRE

Type of Specimen	Split Tensile Strength. N/mm^2 28 days	
SILICA FUME	6.7	7.1
	7.1	
	7.5	
SILICA FUME + 2% SFRC	14.5	14
	15.1	
	14.2	

Fig. 4.11 and table 4.6 shows that on replacing OPC with 15% of silica fume than there is increase in split tensile strength by comparing it with OPC. After that we replace 2% steel fibre in same concrete mix of silica fume than its split tensile strength increases by double.

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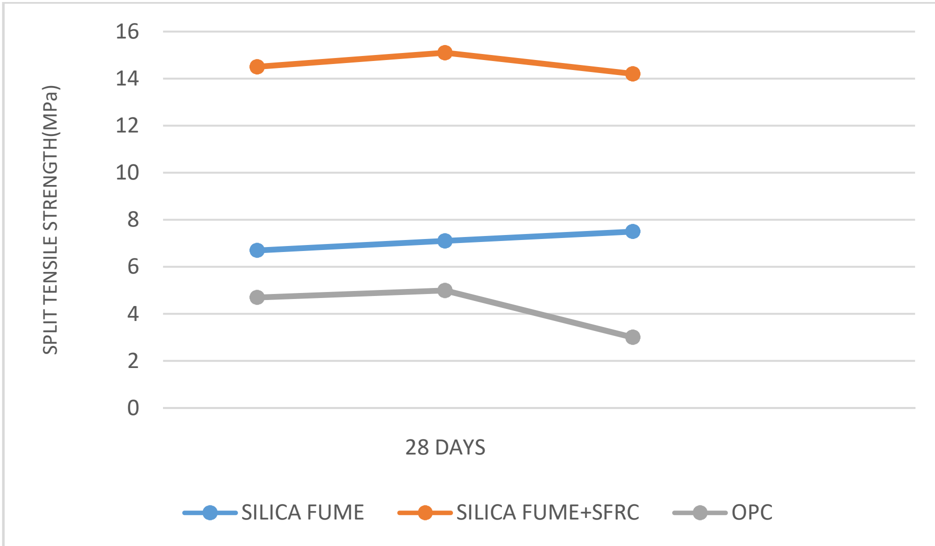

Fig. 4.11 Chart for variation of split strength

TABLE 4.7 SPLIT TENSILE STRENGTH OF FLY ASH AND STEEL FIBRE

Type of Specimen	**Split Tensile Strength. N/mm²**	
	28 days	
FLY ASH	4.9	5.6
	5.7	
	6.2	
FLY ASH + 2% SFRC	13.2	12.76
	12.2	
	12.9	

Fig. 4.12 and table 4.7 show that on replacing OPC with 10% of fly ash than there is increase in split tensile strength by comparing it with OPC. After that we replace 2% steel fibre in same concrete mix of fly ash than its split tensile strength increases more than double.

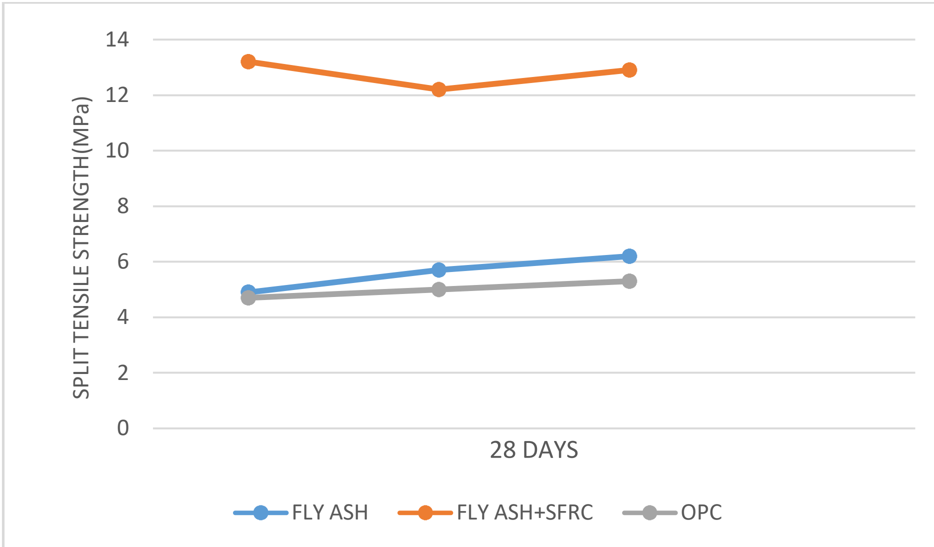

Fig. 4.12 Chart for variation of split strength

TABLE 4.8 SPLIT TENSILE STRENGTH OF RICE HUSK AND STEEL FIBRE

Specimen Type	Split Tensile Strength. N/mm^2	
	28 days	
RICE HUSK ASH	6.5	6
	5.4	
	6.1	
RICE HUSK ASH + 2% SFRC	14.1	14.2
	13.6	
	14.9	

Fig. 4.14 and table 4.8 shows that on replacing OPC with 10% of rice husk ash than there is increase in compressive strength by comparing it with OPC. After that we replace 2% steel fibre in same concrete mix of rice husk ash than its compressive strength increases.

And also fig. 4.13 shows that failure pattern of cylinder with steel fibre.

Fig. 4.13 Failure of cylinder with fibre

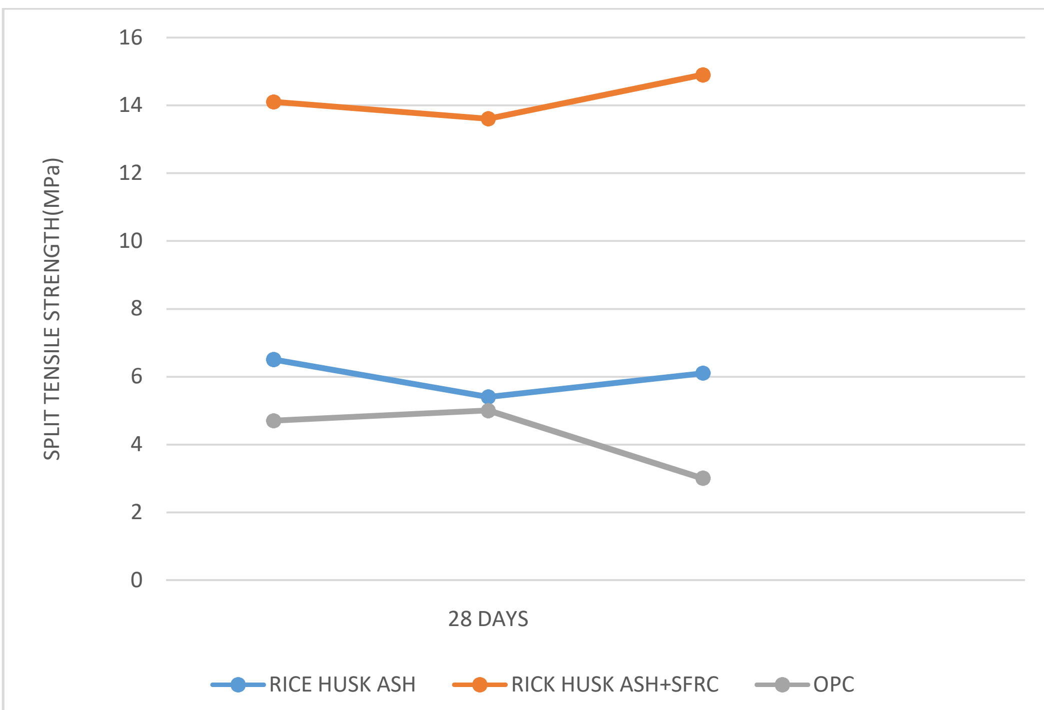

Fig. 4.14 Chart for variation of split strength

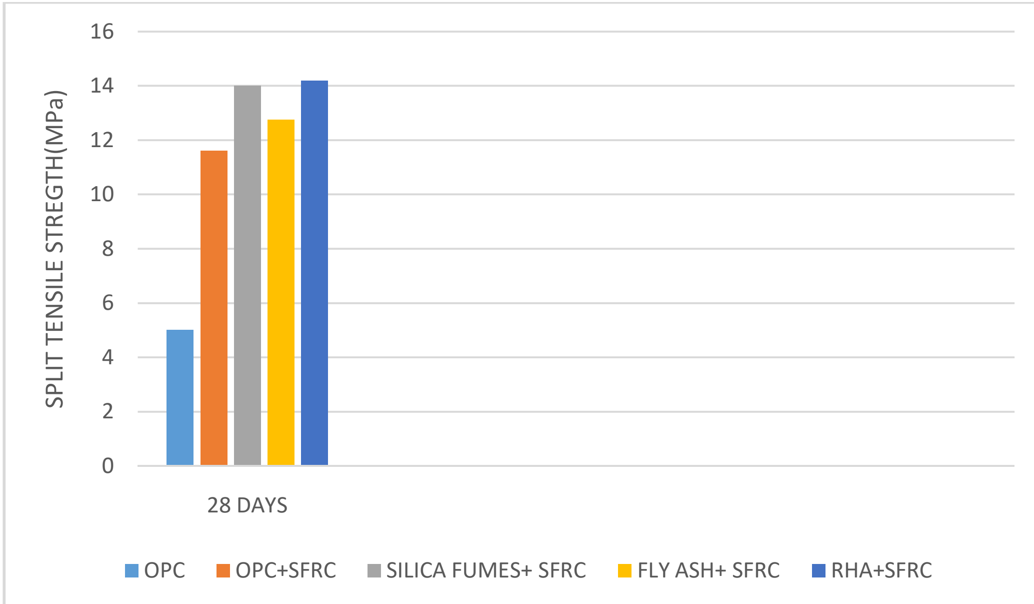

Fig. 4.15 Chart for variation of split strength

Fig. 4.15 clearly shows that rice husk ash of 10% replacement show a greater split tensile strength than any other additive with SFRC.

4.1.3 Flexural Strength

Fig. 4.16 Casting of slab

Fig. 4.17 Slabs before testing

Fig. 4.18 Slab testing

Fig. 4.16 shows how we cast our beam, in fig. 4.17 shows that to dry beam before testing and in fig. 4.18 shows how to put a beam in four point test.

TABLE 4.9 FLEXURAL STRENGTH OF STEEL FIBRE

Type of Specimen	Flexural Strength. N/mm^2	
	28 days	
OPC	8.5	8.33
	8.7	
	7.8	
OPC + 2% SFRC	12.5	12.6
	11.9	
	13.4	

Fig. 4.19 and table 4.9 shows that on replacing 2% steel fibre with concrete the result show that the flexural strength value increase more than 50%.

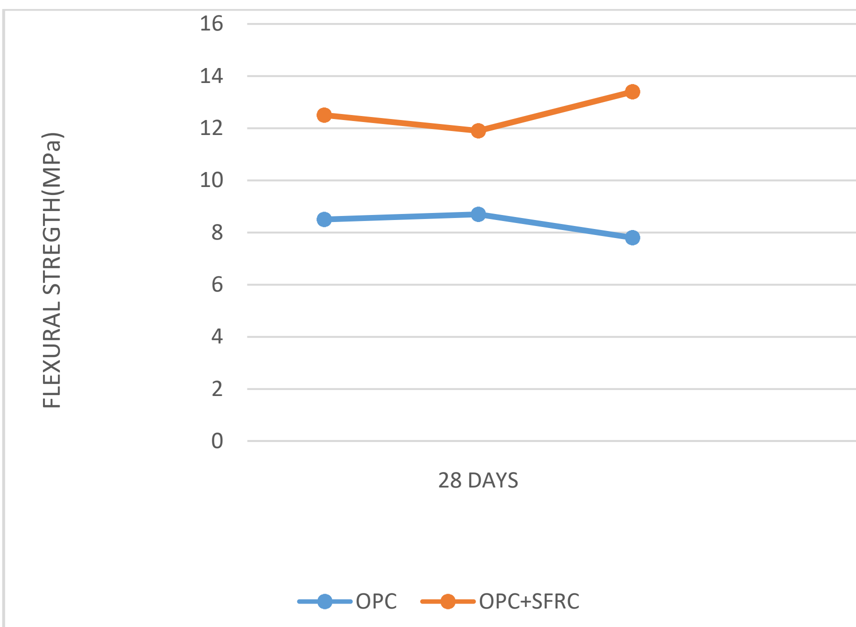

Fig. 4.19 Variation of flexural strength

TABLE 4.10 FLEXURAL STRENGTH OF SILICA FUME AND STEEL FIBRE

Specimen Type	Flexural Strength. N/mm^2	
	28 days	
SILICA FUME (15%)	10.5	10.5
	11.3	
	9.7	
SILICA FUME (15%) + 2% SFRC	14.4	14.86
	15.3	
	14.6	

Fig. 4.20 and table 4.10 shows that on replacing OPC with 15% of silica fume than there is increase in flexural strength by comparing it with OPC. After that we replace 2% steel fibre in same concrete mix of silica fume than its flexural strength increases by more than 40%.

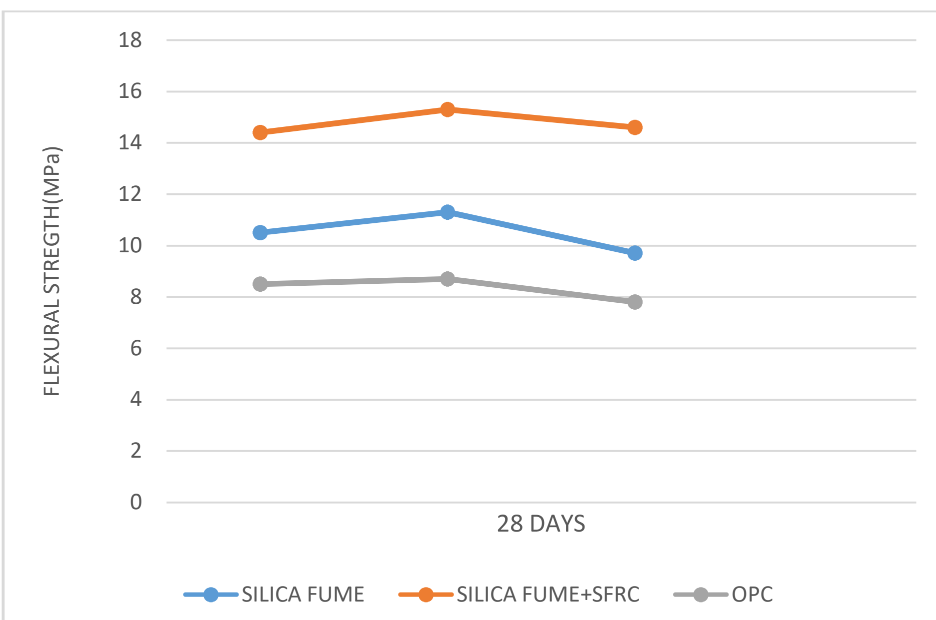

Fig. 4.20 Variation of flexural strength

TABLE 4.11 FLEXURAL STRENGTH OF FLY ASH AND STEEL FIBRE

Type of Specimen	Flexural Strength. N/mm^2	
	28 days	
FLY ASH (10%)	8.5	9.16
	9.3	
	9.7	
FLY ASH (10%) + 2% SFRC	13.5	13.9
	14.3	
	13.9	

Fig. 4.21 and table 4.11 show that on replacing OPC with 10% of fly ash than there is increase in flexural strength by comparing it with OPC. After that we replace 2% steel fibre in same concrete mix of fly ash than its flexural strength increases by more than 40%.

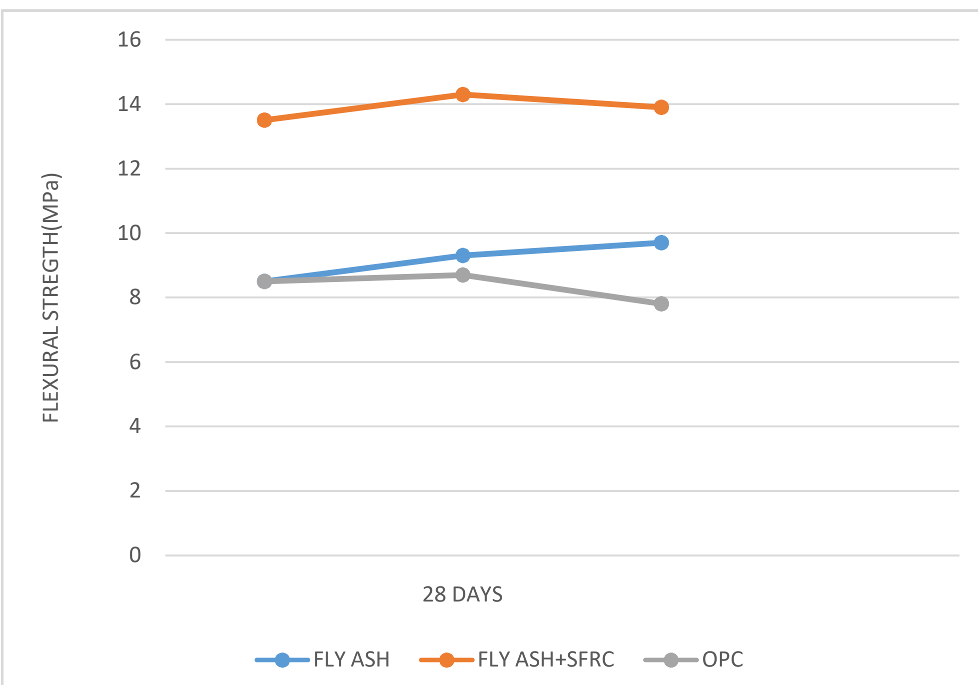

Fig. 4.21 Variation of flexural strength

TABLE 4.12 FLEXURAL STRENGTH OF RICE HUSK AND STEEL FIBRE

Type of Specimen	Flexural Strength. N/mm²	
	28 days	
RICE HUSK (10%)	9.6	9.16
	9.7	
	10.4	
RICE HUSK (10%) + 2% SFRC	14.5	15.0
	15.2	
	15.5	

Fig. 4.22 and table 4.12 shows that on replacing OPC with 10% of rice husk ash than there is increase in flexural strength by comparing it with OPC. After that we replace 2% steel fibre in same concrete mix of rice husk ash than its flexural strength increases by more than 50%.

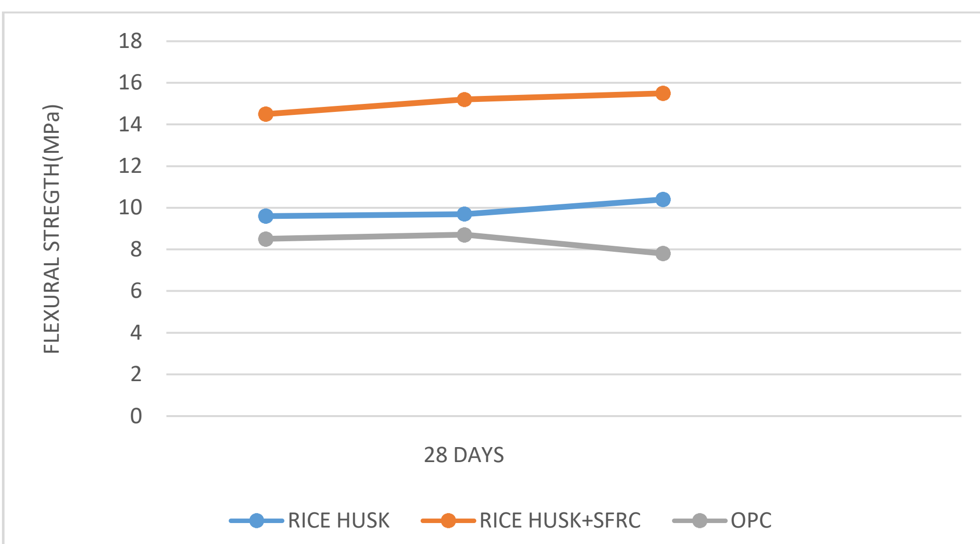

Fig. 4.22 Variation of flexural strength

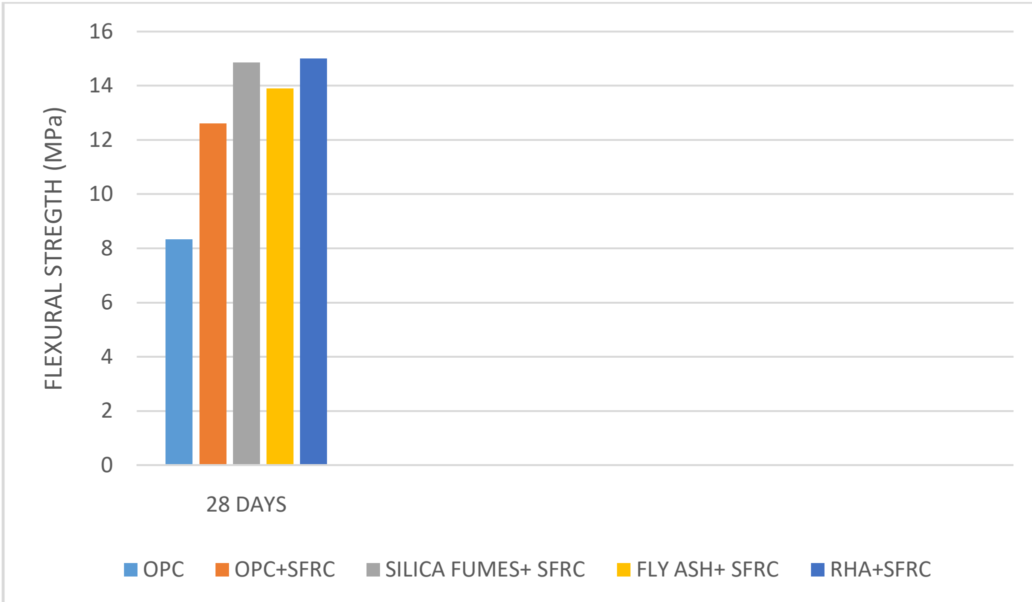

Fig. 4.23 Variation of flexural strength

Fig 4.23 clearly shows that rice husk ash of 10% replacement show a greater flexural strength than any other additive with SFRC.

CHAPTER 5

CONCLUSIONS

CHAPTER 5

CONCLUSION

5.1 Conclusion

On the basis of experiments we done in our lab and we conclude different things on the basis of result are as following:

1. The result shows that when we add steel fibre there is marginally increase in compressive strength and split tensile and flexural strength of concrete increase considerably.
2. Maximum compressive strength arrives at 3% fibre replacement.
3. In experiment we use 2%fibre replacement instead of 3% because workability reduces considerably as percentage of fibre increase.
4. Maximum compressive strength is arrived on adding 2% steel fibre and 15% replacement of silica fume whereas compressive strength of 2% steel fibre and 10% Rice husk as his little bit less but it is more eco friendly and cheaper which is good for builders.
5. Maximum split tensile strength and flexural strength is arrived on adding 2% steel fibre and 10% of rice husk.
6. Addition of rice husk ash is the best additive material that we can add in concrete due to

    - Greater performance than any other material.
    - Easy availability.
    - Eco friendly.
    - Cheap material as it is a waste material.
    - Good workability then other.

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