EXPERIMENTAL INVESTIGATION ON MECHANICAL PROPERTIES OF HYBRID FIBRE-REINFORCED CONCRETE

NAGURU BABAVALI [1], Dr C. SASHIDHAR[2]

[1]PG Student, JNTUA College of Engineering(Autonomous),Anantapur, India
[2]Professor & Registrar, JNTUA University, Anantapur, India

Abstract - *In conventional concrete micro cracks develop before structure is loaded because of drying shrinkage and other causes of volume changes. At the point when a design is stacked the micro cracks airs out up and spread, in light of improvement of such micro cracks breaks, bring about elastic twisting in concrete. Fiber supported cement is establishing concrete built up blend with more or arbitrarily disseminated little fibers. In the fiber supported cement various little fibre are scattered and conveyed randomly in concrete at the hour of blending and consequently, work on substantial properties every which way. A fiber is a little discrete supporting material delivered from different materials like steel, plastic, glass, carbon, and regular materials in different shapes and sizes. Fiber supported cement will be concrete based composite that has been created lately. It has been effectively utilized in development with its amazing flexural-rigidity, impervious to parting, impact resistance, and protection from plastic shrinkage breaking of the mortar. These fibers have many advantages. Steel fibers can work on the primary solidarity to diminish in the weighty steel support necessity. Freeze defrost opposition of the substantial is improved. Strength of the substantial is improved to lessen in the break widths. Normal filaments like Sisal are utilized to further develop sway opposition. A mathematical boundary depicting a fiber as its angle proportion. This is characterized as the length of the fiber isolated by the same fiber measurement. Commonplace perspective proportion seethes from 30 to 150 for length aspects of 0.1 to 7.62 cm ordinary fiber widths are 0.25 to 0.76 mm for steel and 0.02 to 0.5 mm for plastic. The plain substantial bombs startlingly when the redirection connecting with a conclusive flexural strength is outperformed, on the other hand fiber upheld concrete to help great loads even at evasions broadly in wealth of the break redirection of the plain concrete. The principle objective of this undertaking is to work on the elasticity and decrease the miniature breaks which are created in plain concrete. The natural substances utilized in the venture are OPC 53 grade, coarse and fine totals, strands as steel and Sisal. Substantial 3D squares were arranged utilizing the blend plan of IS code. The*

mechanical not really set in stone for 28 days and 56 days of restoring. Finally the results compared with conventional concrete and mono fiber in the form of graphs.

Key Words: (Steel, Sisal, compressive strength, Split Tensile Strength, Flexural strength and Impact resistance)

1.INTRODUCTION

Where cement is used as binding material in concrete and it is called as cement concrete. It is one of the seemingly simple but actually complicated materials. Though speedy advances were created throughout previous few decades within the usage and information of concrete, the improved and advanced methods of mix design of concrete, examination and testing are probably resulting in quality control of concrete with in more defined range of limits as per the necessity on the required job.

A few cementitious materials were at that point utilized in old developments of Egyptians and Romans and it is referred to that the gypsum is utilized as concrete in early Egyptians development where as Romans and Greeks utilized lime material which was made by warming limestone. Substantial utilizing in development work was begun at 12,000,000 BC. In 3000 BC, Egyptians have the propensity to utilize the mud blended in with straw to tie the dried blocks. Further they designed lime and gypsum mortar blend is utilized as a limiting specialist for building the Pyramids development.

The fragile material like cement is solid in pressure however feeble in strain. Because of shortcoming at elastic end, the substantial constructions get breaks. These breaks slowly reached out to the pressure end lastly complete part breaks. Now and again because of shrinkage likewise the primary individuals gets disappointment. These breaks are fundamentally minor breaks. These breaks expansion in size and extent as the time slips by and ultimately makes the substantial to come up short. The arrangement of breaks is that piece is the primary justification behind the disappointment of the substantial.

Analysts have been made many endeavors to build the rigidity of cement. To expand the rigidity of cement another method, i.e.., presentation of filaments in concrete is being executed. The filaments fill in as break arrestors and it keeps the part from disappointment condition. These strands are consistently conveyed just as arbitrarily organized in cement and it is known as Fiber Reinforced Concrete (FRC).

1.1 FIBRE REINFORCED CONCRETE (FRC)

Fibres mainly control the extension of crack length and limit the crack width and thickness. The energy absorption capacity and ductility of concrete material is extended by implementation of fibres in concrete. The combination of cement and aggregates of various sizes, incorporating discrete, discontinuous fibres is known as fibre reinforced concrete. Steel and glass, synthetic fibres such as polypropylene, nylon etc are considered as conventional fibres. Cellulose, sisal, jute etc are considered as natural fibres and these are used in fibre reinforced concrete FRC.

Type of fibres varies considerably both in properties, effectiveness and cost.

The making of Fibre reinforced concrete (FRC) is made by mixing of hydraulic cements with or without aggregates and adding discrete fibre reinforcements. If aggregates are not placed then the materials is called Fibre cement in analogy to the well- framed 'asbestos cement'. The modulus of rupture, impact , fatigue strengths and toughness of concrete is improved by utilization of fibres in conventional concrete. Asbestos, glass, steel and carbon fibres can be applied to reinforce cement matrices.

1.2 Fibre being used in concrete:

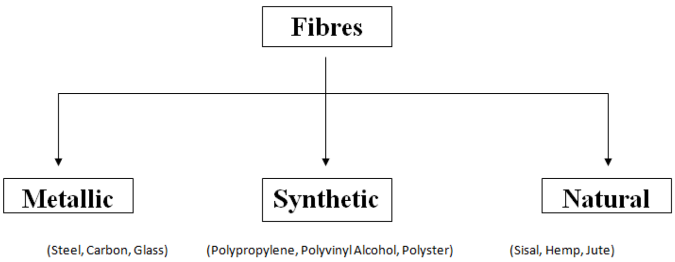

Fig 1.1 Various types of fibres being used

The addition of non-metallic fibres results in good fresh concrete properties and limits early age cracking. The valuable effects of non-metallic fibres could be attributed to their high aspect ratios and increased fibre availability at a given volume fraction.

Fig 1.2 Steel and Sisal fibre

Table 1: Properties of various fibres

Fibre	Diameter (μm)	Specific Gravity	Modulus of Elasticity (GPa)	Tensile Strength (GPa)	Elongation at break (%)
Steel	5-500	7.84	200	0.5-2.0	0.5-3.5
Sisal	10-50	1.5	-	0.8	3

2. LITERATURE REVIEW

YEOLCHOIA (2005) revealed the aftereffect of trial of examination concerning the connection between parting pliable and compressive strength of glass fiber built up concrete (GFRC) and polypropylene fiber supported cement (PFRC). The parting elasticity and compressive strength of GFRC&PFRC has been acquired at 7, 28, 90 days. The parting rigidity of PFRC&GFRC went from 9% to 13% of its compressive strength. The expansion of glass and polypropylene strands in substantial expands the parting elasticity by roughly 20-50%.

MURAHARI & RAM MOHN RAO examinations saw that there isn't a lot of critical obstruction of strands on the split elasticity. The split elasticity acquired strength at early age of 28 days contrasted with 56 days.

3. MATERIALS AND EXPERIMENTAL SET UP

The proportion of length fiber to distance across of the fiber is called as perspective proportion of fiber. It assumes significant part in impacting the designing properties of FRC. Sisal strands were obtained from Reliance Industries, India. These sisal fibres have density of 7.85 g/cm3 and minimum tensile strength of 345 MPa. Fibers with different dosages of 0.50%, 1.00%, 1.25% and 1.50% by volume of concrete were randomly placed into concrete. Required workability was maintained by adding super plasticizer.

3.1 Mix proportions for FRC

Concrete, fine total and coarse total amounts are figured and are blended appropriately in a drum type blender for a base span of 2 mints. At first half of determined water was added, blended completely and reaming half of water alongside fitting measurements of super plasticizer was added to cement to keep up with the usefulness. Sisal filaments were physically scattered into concrete cautiously for uniform dissemination of strands on cement and proceed with the blending for the term of 5 mints. At the point when fiber measurements expanded from 1.25% to 1.50% without super plasticizer we can notice balling impact in fiber supported cement

Table 3.1: Content of mix proportions used

Constituents	Content KG/ m³ of concrete
Cement	395.32
Fine aggregate	624.45
Coarse aggregate	1098.81
Water content	195.16
Fibre dosage	
0.5%	12.21
1%	22.13
1.5%	35.70
Super plasticizer	9.38

3.2 Details of specimen preparation

The standard shapes of size 150 mm x 150mm were utilized to gauge the compressive strength and bond strength of Sisal FRC. Split rigidity of cement was estimated by utilizing standard Cylinders of size 150 mm x 300 mm. Flexural strength of Sisal FRC was estimated by considering a standard bean of size 100 mm x 100 mm x 500mm. Steel moulds are usually utilized for projecting the substantial examples. For appropriate compaction of cement in form, concrete is poured three layers in each shape and after each layer was vibrated for 15 s in the wake of putting it on the vibrating table or manual compaction by utilizing tapping bar. Appropriate evening out of surface for the example was done to get smooth completing of surface on top the shape. After 24 hrs of projecting, example were taken out from shape and drenched in clean water for 28 days. Examples were ready for different fiber measurements of 0.50%, 1.00% and 1.50% of volume of cement notwithstanding tests of control blend. Three examples were ready for each test and normal worth was acquired.

3.3 Equipment used for test

Standard cube of size 150cm X 150cm X150cm was tested on universal testing machine shown in fig to find the compressive strength of fibre reinforced concrete under different dosages of fibres.

Fig 3.1 Cubes testing for compressive strength

Standard cylinder of size 150cm X 300cm is tested on universal testing machine placing mould in longitudinal direction shown in fig.4 to find the split tensile strength of fibre reinforced concrete different dosages of fibre

Fig 3.2 Testing for split tensile strength

Concrete beam of size100mm X100mmX500mm was tested under three point loading method as shown in fig.5 to find the flexural strength of fibre reinforced concrete.

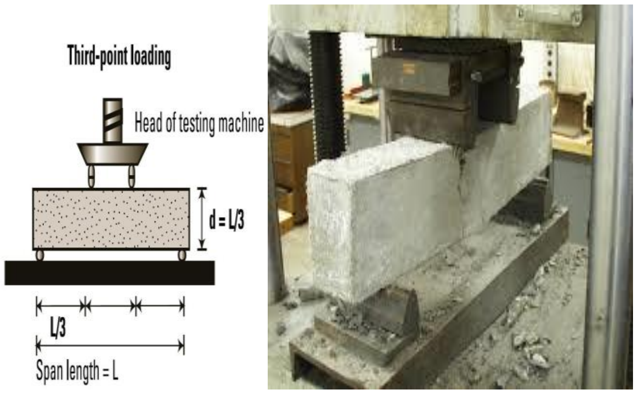

Fig 3.3 Testing for flexural strength

3.4 Impact resistance

Experimental set up is shown in Figure 2. A 4.54 kg drop weight was allowed to fall freely from a height of 457 mm on a steel ball of diameter of 64 mm. This steel ball was in constant contact with the top surface of the specimen. The number of blows was counted until appearance of initial crack. The test was continued until complete fracture was observed and recorded the number of blows.

3.4 Drop weight test set up

Impact energy for each fibre dosage is computed as explained below.

Impact Energy (E imp) = $(0.5mv^2)$ n -------------------- (1)

Where m =mass of the hammer

n= no of blows

V= Impact velocity of hammer

4. RESULTS AND DISCUSSIONS

4.1 COMPRESSIVE STRENGTH:

The limit of concrete material to with remain against loads having a tendency to lessen its size is known as compressive strength of cement. The compressive strength of cement is determined by utilizing a substantial solid shape of size (150mmx150mmx150mm) for measurement of fiber 0.5%, 1%, 1.5% is given by following table 4.1 for the restoring time of 28 days and 56 days.

Fibre dosage (%)	compressive strength SFRC 28 DAYS	compressive strength SFRC 56 DAYS	compressive strength Sisal FRC 28 DAYS	compressive strength Sisal FRC 56 DAYS	compressive strength Steel+Sisal FRC 28 DAYS	compressive strength Steel+Sisal FRC 56 DAYS
PCC	40.02	42.77	40.02	42.77	40.02	42.77
0.50%	43.23	45.46	40.67	41.78	44.23	45.12
1.00%	44.82	46.79	41.34	42.86	46.42	47.34
1.50%	46.18	47.92	42.06	43.12	47.88	48.17

Table 4.1 compressive strength of HFRC at 28 and 56 days

Fig 4.1 Graphical representation of compressive strength

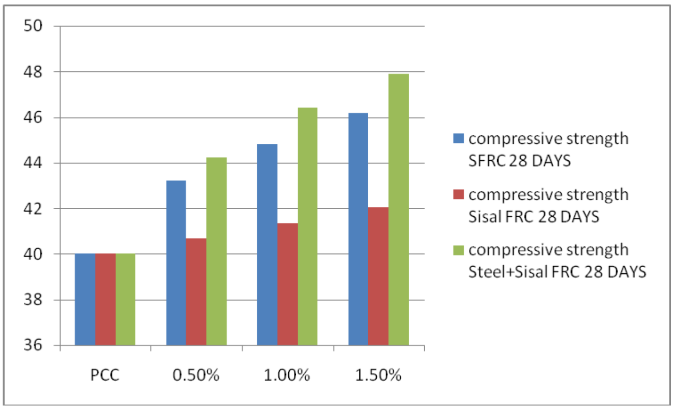

Fig 4.2 Comparison of compressive strength at 28 days curing period

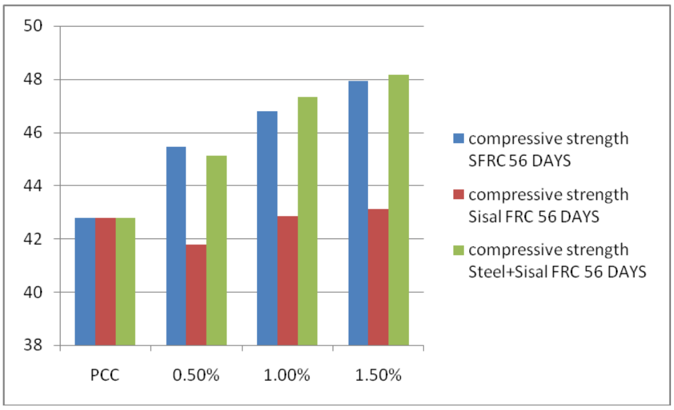

Fig 4.3 Comparison of compressive strength at 56 days curing period

The table outcomes and graphical representation shows compressive strength of hybrid fibre and furthermore correlation with the mono fiber of steel and Sisal.

As it very well may be seen that the compressive strength expanded by expanding in the Hybrid fiber volume. Greatest compressive strength happens for most extreme measurements of 1.5% with 47.88MPa and 48.17MPa for both 28 days and 56 days.

Cross breed fiber shows high compressive strength when it contrast with mono fiber as steel and Sisal. From fig 4.2 compressive strength was continuously expanded with expanding the Hybrid fiber volume contrast with mono strands for 28 days restoring period,but 56 days relieving period shows strength was expanded from 1% of fiber measurement when contrasted with mono fiber

4.2 SPLIT TENSILE STRENGTH

Tensile strength of the concrete is assessed by utilizing Split elasticity of cement. It is one of the disappointment state of cement at which the substantial gets break after use of burden and it is determined by utilizing standard tube shaped example which gets the longitudinal breaks after utilization of burden in testing and the experimental outcomes are set in table3 for 28 days and 56 days relieving period for various measurements of fiber content that is 0.5%, 1.0% and 1.5%.

Table no 4.2

Fibre dosage (%)	Split tensile strength SFRC 28 DAYS	split strength SFRC 56 DAYS	Split tensile strength Sisal FRC 28 DAYS	Split tensile strength Sisal FRC 56 DAYS	Split tensile strength Steel+ Sisal FRC 28 DAYS	Split tensile strength Steel+Sisal FRC 56 DAYS
PCC	3.42	3.78	3.42	3.78	3.42	3.78
0.50 %	3.56	3.63	3.26	3.32	3.56	3.85
1.00 %	3.79	3.87	3.34	3.41	3.68	3.98
1.50 %	4.37	4.56	3.45	3.52	4.48	4.64

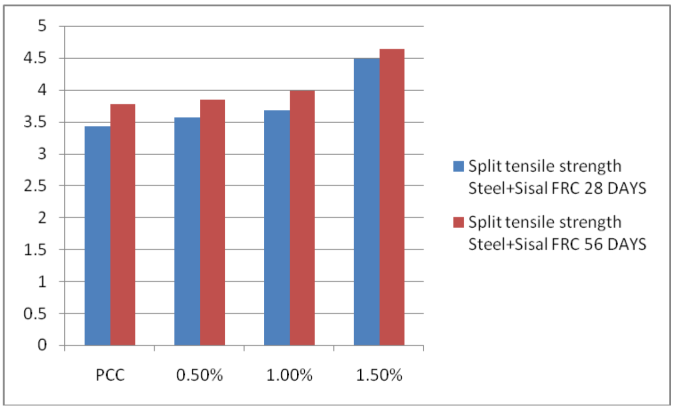

Fig 4.4 Graphical representation of split tensile strength

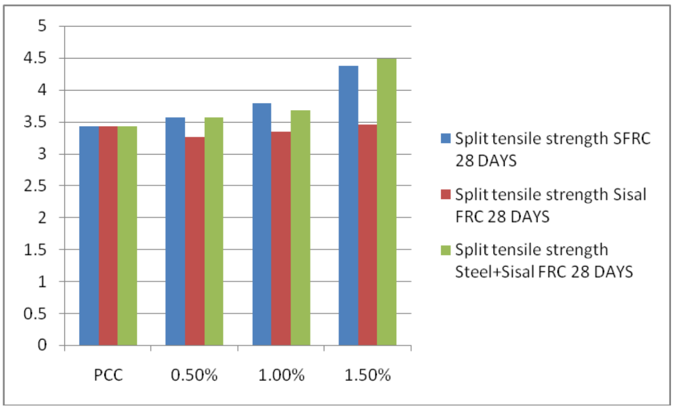

Fig 4.5 comparison of split tensile strength 28 days curing period

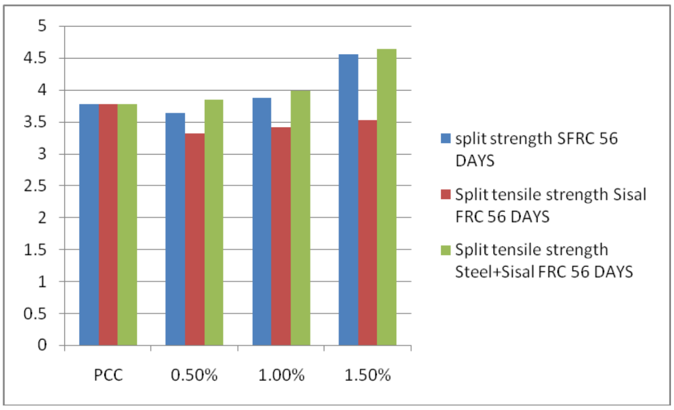

Fig 4.6 comparison of split tensile strength 56 days curing period

The table outcomes and graphical representation shows split tensile of hybrid fibre and furthermore correlation with the mono fiber of steel and Sisal. As it tends to be seen that the split rigidity expanded by expanding in the Hybrid fiber volume. Greatest split rigidity happens for most extreme dose of 1.5% with 4.48MPa and 4.64MPa for both 28 days and s56 days.

From Fig; 4.5 it has been seen that the split elasticity of steel fiber supported cement is step by step expanded while expanding the fiber content at the same time, when comes to the split rigidity of Sisal fiber built up concrete was not bit by bit expanded. As the worth of parted rigidity for PCC is 3.42 and it was diminished to 3.26 for 0.5% of fiber measurements and from here the split elasticity was progressively increments with the expanding fiber dose for 28 days relieving period

From Fig; 4.6 it has been seen that the split elasticity of steel fiber supported cement is step by step expanded while expanding the fiber content at the same time, when comes to the split rigidity of sisal fiber built up concrete was not bit by bit expanded. As the worth of parted rigidity for PCC is 3.39 and it was diminished to 3.26 for 0.5% of fiber measurements and from here the split elasticity was progressively increments with the expanding fiber dose for 56 days relieving period.

4.3 FLEXURAL STRENGTH

Tensile strength of fibre reinforced concrete is assessed by utilizing flexural strength of fiber built up concrete. It computes an unreinforced cement footer or section to oppose disappointment happened under bowing. Flexural strength is communicated as modulus of burst. The test results for Flexural strength of Sisal FRC are given in table 4 at different measurements of fiber content 0.5%,1.0%&1.5% for a restoring time of 28 days and 56 days.

Table no 5.3

Fibre dosage (%)	Flexure strength SFRC 28 DAYS	flexure strength SFRC 56 DAYS	flexure strength Sisal FRC 28 DAYS	flexure strength Sisal FRC 56 DAYS	flexure strength Steel+Sisal FRC 28 DAYS	flexure strength Steel+Sisal FRC 56 DAYS
PCC	4.42	4.78	4.42	4.78	4.42	4.78
0.50%	4.71	4.92	4.32	4.74	4.92	4.95
1.00%	5.02	5.27	4.72	4.86	5.15	5.21
1.50%	5.81	5.87	4.8	4.95	5.65	5.72

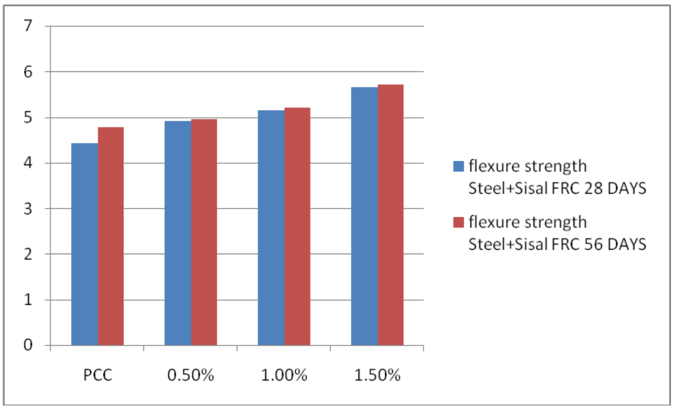

Fig 4.7 Graphical representation of Flexural strength

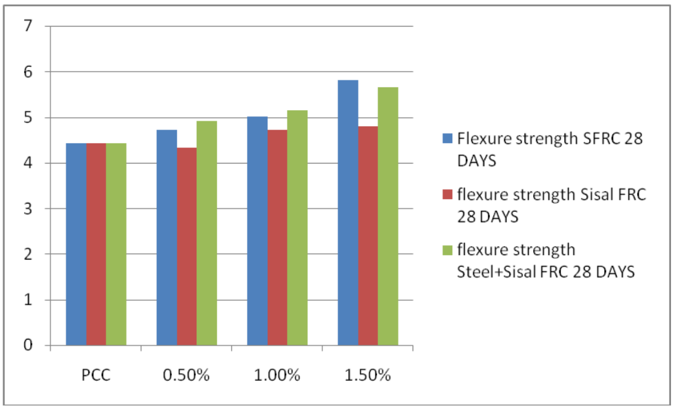

Fig 4.8 comparison of split Flexural strength 28 days curing period

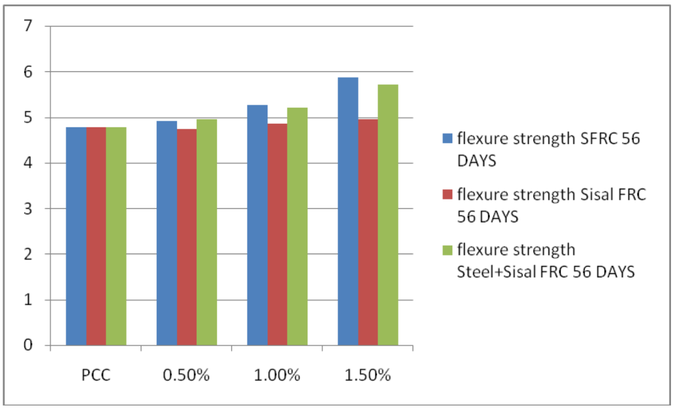

Fig 4.9 comparison of split Flexural strength 56 days curing period

The table outcomes and graphical shows flexure strength of hybrid fibre and furthermore correlation with the mono fiber of steel and Sisal. As it tends to be seen that the flexure strength expanded by expanding in the Hybrid fiber volume. Most extreme flexure strength happens for greatest measurements of 1.5% with 5.65 MPa and 5.72 MPa for both 28 days and 56 days.

Fig:4.8 shows that the flexure strength of mono strands was bit by bit expanded by expanding the fiber measurement and it is likewise seen that Hybrid fiber shows high flexure strength when it contrast with mono fiber as steel and Sisal for 28 days relieving period.

Fig:4.9 shows that there is a slowly expanded flexure strength with the expanding the fiber measurements both mono and mixture fiber concrete however the half breed fiber built up substantial invigorates high flexure when contrast with mono filaments as steel and Sisal

4.4 Impact resistance of Hybrid FRC

Impact opposition as far as number of blows needed for introductory break development and complete crack are displayed in Table 4.4 Additionally, impact energy needed for starting break arrangement and break are referenced

Table 4.4: Impact resistance of Hybrid FRC(28 days)

Fibre dosage	Number of blows for Intial crack	Impact energy(KN-mm)	% Increase in impact energy	Fibre dosage	Number of bows for final crack	Impact energy(KN-mm)	% Increase in impact energy
PCC	23	467.94	-	PCC	31	630.70	-
0.50 %	115	2339.68	400.00	0.50 %	148	3011.06	377.42
1.00 %	273	5554.19	1086.96	1.00 %	305	6205.23	883.87
1.50 %	342	6957.99	1386.96	1.50 %	470	9562.15	1416.13

As it very well may be seen from figure 4.10 and 4.11 that expansion in fiber measurements brought about increment of number blows needed for development of starting break and complete crack. Greatest number of blows was viewed as 342 and 470 for starting and last break and complete crack individually for a fiber measurement of 1.50%.

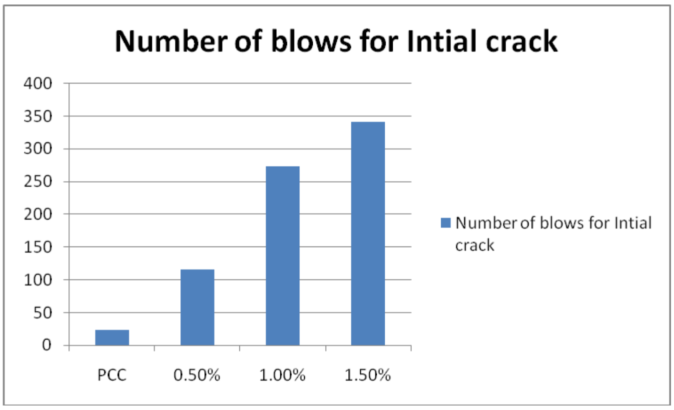

Fig. 4.10: Number of blows for initial crack during 28 days

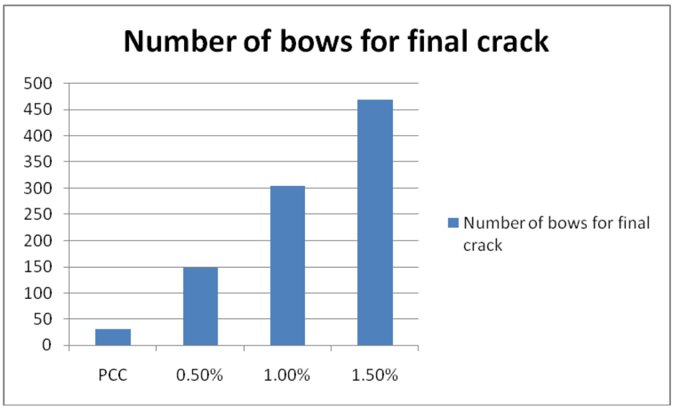

Fig. 4.11: Number of blows for final crack during 28 days

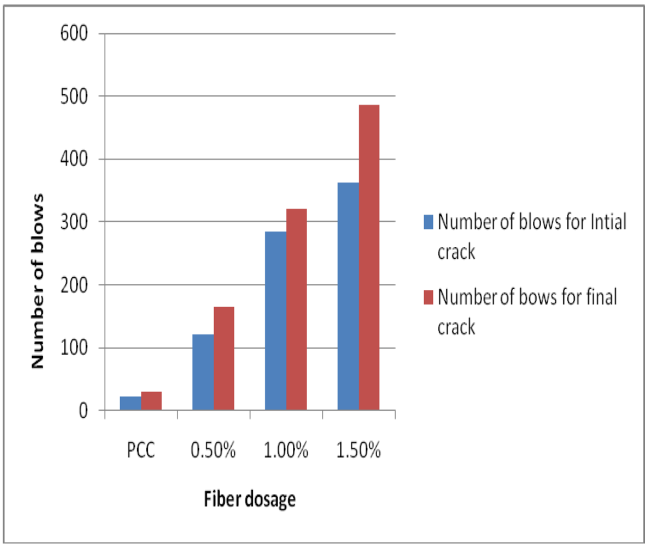

Fig. 4.12: Comparison between number of blows for initial crack and final crack during 28 days

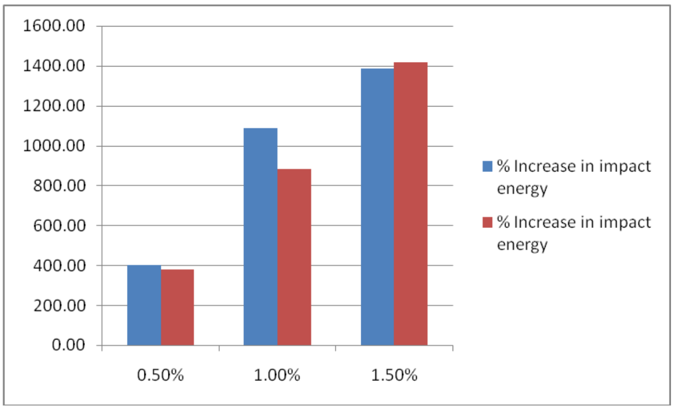

Fig. 4.13: Percentage increase in impact energy

The graphical representation shows that the relationship between the fiber and the cracks of a concrete specimen of size 150X64mm, as we observe the above figures the number of blows increases with the increase of fiber dosage and the maximum number of blows is at the dosage of 1.5% i.e.,342 and 470 as initial and final cracks respectively.

From fig;4.10 the number of blows was increased with increasing he fiber dosage. The maximum number of blows was at the dosage of 1.5% i.e,342 no's.

From fig;4.11 From fig;4.10 the number of blows was increased with increasing he fiber dosage. The maximum number of blows was at the dosage of 1.5% i.e,470 no's.

From fig;4.12 it shows that the comparison of number of blows for initial crack and final crack of concrete during the period of 28 days.

The contrast between number blows for definite break and starting break expanded with expansion in fiber dose as displayed in figure 4.12. Most extreme contrast was seen for the fiber measurement of 1.50%. As effect energy is straightforwardly connected with the quantity of blows, Impact energy expanded with expansion in fiber measurement for both starting break and crack. As it tends to be seen from Figure 4.13 that more rate expansion in sway energy was noticed for introductory break when contrasted with conclusive break for all the fiber doses.

5. CONCLUSIONS

Based on the results of this experimental investigation, the following conclusions can be drawn:

1. Hybrid fibres are more effective in improving the mechanical properties of concrete compared to conventional concrete and also mono fibres (steel & Sisal).

2. Compressive strength of cement expanded with expanding the fiber measurement for both 28 days and 56 days restoring period and furthermore from beginning dose of 0.5% shows increase in compressive strength. For measurements 1.5% shows 47.88 MPa and 48.17MPa as it contrasted with mono strands Hybrid fiber shows great protection from compressive strength.

3. Hybrid fibre shows better protection from split elasticity for both 28 days and 56 days restoring period contrasted with regular cement for dose of 1.5% gives MPa. At the point when it contrasted with mono filaments there is less opposition at measurements of 0.5% of steel fiber then after it abruptly increments.

4. The flexure strength of cement is increment with expanding the fiber dose in both 28 days and 56 days restoring period. The Hybrid fiber shows great protection from flexure when contrast with mono fiber (steel and Sisal) and regular cement. Most extreme strength gives at the dose of 1.5% as 5.65 MPa and 5.72 MPa for 28 days and 56 days restoring period.

5. As we observe the impact energy increases with the increasing the fibre dosage. The maximum resistance in terms of number of blows was found at the fibre dosage of 1.5% as 470 and 497 for 28 days curing period when compared to conventional concrete.

7. Generally concrete having brittle property, when after adding fibres to concrete changes to ductility property it observes in crack patterns of concrete failure.

However, further study is suggested to understand the effect of on the strength of the concrete.

6. REFERENCES

1. "Normal Concrete of strength using Metallic and Synthetic Fibres", S.Vairagade,S.Kene (2013). Elsevier, Procedia Engineering, 51,132 – 140.

2. "Properties of concrete steel fibrous containing mixed fibers in fresh and hardened state", Mohammadi Y, Singh S.P (2008).Elsevier, Construction and Building Materials, 22,956–965.

3. "Stress-strain curve for fibre steel reinforced concrete in compression", by M.CNataraja, N Dhang, and Gupta, A. P (1999),in Cement and Concrete Composites,21(5/6), pp 383- 390.

4. "Historic concrete, A special issue of structures and Buildings" given by Institution of Civil Engineering in August/November (1996).

5. "Studies on Steel Fiber reinforced Concrete- A sustainable approach", Journal of Research and Applied science given by RVasudev (2013) in Vol-4, 1941-1944.

6."Correlations among mechanical properties of steel fibre reinforced concrete" given by B.W.XU, H.S.SHI at Elsevier Journal- Construction and Building materials-23,3468 to 3474.

7. Experimental evaluation of strength properties of steel fibre reinforced concretegiven by SrinivasRao N, RamamohanRao P and Jagadeesh P (2015) at Asian journal of Civil Engineering vol17, no-4, 487-494.

8. Experimental study on steel fibre reinforced concrete for M40 Grade given by Shende A.M, Pande A.M, Gulfan Pathan M at International Refereed Journal of Engineering and Science, Volume-1, Issue1, 2012, 43-48.

9. "Some of the studies on Steel fibre Reinforced concrete "given by Amit Rana, (2013) at International Journal of Advanced Engineering and Engineering technology, Vol-3, Issue-1,120-127.

10. "Study of Flexural Strength in Steel Fibre reinforced Concrete", given by Patil Shweta (2014) at International journal of Recent development in Engineering and Technology, vol-2, Issue-5, 13-16

11." Studies on the Properties of Steel and Polypropylene Fibre without any admixture", given by Selvi.M.T (2013) at International Journal of Engineering and innovative technology,Vol-3,issue-1,411-416.

12. "Addition of fibres and its effect on concrete Strength", given by Aiswarya Sukumar, Elson john (2014) at International journal of Innovative research in advanced Engineering, vol-1, issue-8,144-149.

13. "High Strength Concrete matrix Mechanical properties with Fibre Combination", given by Sivakumar A, Sountharajan V.M and Thirumurugan S (2013) in World Applied Sciences Journal, 26,126-137.

14. Indian standard concrete mix proportioning – guidelines taken from IS 10262-2009 from BIS, New Delhi, 2009.

15. Indian standard plain and reinforced concrete code of practice in IS 456-2000 from BIS, New Delhi, 2000.

16. Indian standard ordinary Portland cement, 43 Grade – specification given by,I.S-8112 from BIS, New Delhi, 2013.

17. Indian standard specification for coarse aggregates and fine aggregates from natural sources for concrete in IS 383-1970 (Reaffirmed 2002) from BIS, New Delhi, 2002.

18. IS 516-1959 (Reaffirmed 2004). Methods of tests for strength of concrete (BIS),New Delhi, 2006.