A STUDY ON THE HARDENED PROPERTIES OF M25 GRADE CONCRETE WITH HYBRID FIBRE REINFORCEMENT

[1] Dr.B.MADHUSUDANA REDDY, [2]G.CHANDRA BABU
[1]Assistant Professor, Department of Civil Engineering, Sri Venkateswara University College of Engineering, Tirupati, Andhra Pradesh, India
[2]M.Tech Student, Department of Civil Engineering, Sri Venkateswara University College of Engineering, Tirupati, Andhra Pradesh, India

Abstract : In the present investigation a detailed experimental study is carried out on hardened properties of M25 grade concrete with reinforcing steel fibre (SF) and polypropylene fibre (PPF) at various volume proportions. Initially the cube (150mmx150mmx150mm) compressive strength was tested for different proportions of steel fibre i.e. 0%, 0.75%, 1%, 1.25%, 1.5%, 1.75% and 2% of volume of the concrete. It is noticed that the optimum dosage of steel fibre is found to be at 1% volume proportion of concrete when tested at 28 days. The concrete mix design for M25 grade is done as per IS:10262-2009 and the proportions obtained are cement=350kg, fine aggregate=583.93kg, coarse aggregate(12.5mm & 20mm) =1235.3kg and water = 168kg. By keeping SF dosage at 1% of volume proportion constant then to it PPF is added to the concrete mix at varying volume proportions (0.3%, 0.4%, 0.5%, 0.6%, 0.7%) and different physical tests were conducted. The various properties studied with these different combinations of SF and PPF (Hybrid fibre) are Compressive strength, Split tensile strength, Modulus of elasticity and Flexural strength. Water absorption is also conducted for assessing the durability. The shape of SF used is End hooked having the aspect ratio of 50 whereas PPF is straight with aspect ratio of 1600. Based on the results obtained, it is noticed that the maximum value of strengths for the above mentioned physical tests is found at 1% SF and 0.4% PPF together. The reinforcement of hybrid fibre in the concrete doesn't showed the considerable effect on the durability parameter.

Index Terms **- M25 Grade concrete, Steel fibre(SF), Polypropylene fibre(PPF) , End hooked, Compressive strength, Split tensile strength, Modulus of elasticity, Flexural strength and Durability parameter.**

I. INTRODUCTION

Though concrete posses high compressive strength ,stiffness ,low thermal and electrical conductivity, low combustibility and toxicity but two characteristics limited its usage are it is brittle and weak in tension. However the developments of Fibre reinforced composites have provided a technical basis for improving these deficiencies. Fibre are small pieces of reinforcing materials added to a concrete mix which normally contains Cement, Water, Fine aggregate and coarse aggregate. Among all the available fibres the most commonly used fibres are steel, glass, asbestos and polypropylene. Fibre reinforced concrete comprises the benefits of plain concrete and properties of fibre. One of the greatest disadvantage of using cementitious material is its vulnerability to cracking, so fibre are used which acts as crack arrester. Adding two or more fibres to the concrete mix enhances the strength of the concrete and it is known as Hybrid Fibre Reinforced Concrete (HFRC). The fractured properties of concrete gets increased upon the addition of fibres. The average Compressive Strength, Split tensile strength, Modulus of elasticity and Flexural strength is higher when hybrid (SF and PPF) fibres are used. Addition of Steel fibre improves the Flexural strength as well as the deflection capacity. Cracking behaviour is gradual and it is more ductile when Polypropylene fibre is used. The process of destruction of concrete under high temperature variations can be delayed by addition of the polypropylene fibre. Both crack propagation and crack width are observed to be reduced .

II . SIGNIFICANCE OF THIS STUDY

The main objective of this work is to find out the optimum dosage of steel fiber and to study the hardened properties of M25 grade concrete with reinforcing Hybrid fibre (SF and PPF). There is an adequate availability of literature about the reinforcement hybrid fibre in self compacting concrete but there is no sufficient literature for reinforcement of hybrid fibre in plain concrete . Hence ,an attempt is made on this work. The mechanical properties included in this study are compressive strength, split tensile strength, flexural strength and modulus of elasticity..The durability test such as water absorption is also conducted for all the mixes .The results of the tested specimens are compared with the control mix.

III . MATERIALS

Cement :

The cement used throughout the experimental investigation was Ordinary Portland Cement (OPC) of 43 grade conforming to IS : 8112:1989 specifications. Normal consistency and fineness values are found to be 31% and 4% respectively.The specific gravity of the cement was 3.12. The initial and final setting times were found as 52 minutes and 336 minutes respectively.

Fine aggregate :

Locally available river sand passing through 10.0 mm size conforming to Zone – II as per IS :383 -1970, has been used. Specific gravity and Fines modulus are 2.56 and 2.77 respectively. Bulk density was observed to be 1536 kg/m^3**.**

Coarse aggregate :

The graded Coarse aggregate of sizes 20mm and 12.5mm used in this experimental work which was obtained from locally available quarry. Specific gravity and Fines modulus was observed to be 2.72 and 6.96 respectively. Water absorption was 0.4% (20mm) and 0.8% (12.5mm). Bulk density values ware observed to be 1496 kg/m^3 for 20mm aggregate and 1524 kg/m^3 for 12.5mm aggregate.

Steel fibre and Polypropylene fibre :

End hooked steel fibres obtained from Stewols India Pvt. Ltd having the length 30mm and diameter 0.60mm with aspect ratio 50 is used. Polypropylene fibre of length 12 mm and diameter 7.5µm with aspect ratio 1600 is used.

Fig.1 Steel fibre and Polypropylene fibre.

IV.MIX PROPORTION OF MATERIALS

After performing all the required tests on the ingradients of the concrete such as a Cement, Fine aggregate, Coarse aggregate etc..mix design is calculated . Mix design of M25 grade is done as per IS :10262 -2009. Target mean strength of the designed M25 grade concrete is 31.6 MPa. The quantity of ingradient materials and their mix proportions are shown in following table. no.1. The compressive strength observed at 28days for this control mix is 33.9 MPa.

	Cement	Fine Aggregate	Coarse Aggregate	Water
Quantity (kg/m^3)	350	583.93	1235.3	168
Mix proportion	**1**	**1.66**	**3.52**	**0.48**

Table.1.Mix proportion of the materials

V . EXPERIMENTAL INVESTIGATION

In the present investigation initially steel fibre (SF) is added at various volume proportions of volume of concrete in order to find out the optimum dosage. The volume proportions tested are : 0%, 0.75%, 1% , 1.25% , 1.5% , 1.75% , 2% , whose weights are 0, 58.6, 78.5 ,98.12 , 117.75 , 137.37 , 157 kg/m^3 respectively. Then after testing for its compressive strength it is noticed

that at 1% SF maximum compressive strength is noticed. Now the hybrid mixes are prepared by maintaining 1% SF constant with varying volume proportions of polypropylene fibre (PPF). The five volume proportions of PPF are 0.3% , 0.4% , 0.5% , 0.6% , 0.7% which posses the weights 2.7, 3.6 , 4.5 , 5.4 , 6.3 kg/m^3 . Then the optimum results were obtained for the combination of 1% SF with 0.4% PPF (1%SF + 0.4% PPF) .

Tests were performed on cured concrete specimens consisting for Compressive strength, Split tensile strength ,Flexural strength, Modulus of elasticity and Water absorption tests. For each mixture ,Cube specimen were tested at 3,7,28,56 and 90 days and the cylinder , beam specimens were tested at 28 days. For all the tets results were computed from the average of three specimens. Dimensions of the each specimen for Cube : 150mm x 150mm x 150mm , for Beam :500mm x 100mm x 100mm and for Cylinder : 150mm x 300mm.

VI . RESULTS AND DISCUSSIONS

COMPRESSIVE STRENGTH TEST

Intially cube compressive strength test was performed to find out the optimum dosage of Steel fibre (SF) after 3,7,28 days of curing in water and the results are shown in Fig.no.2. Then after finding the Optimum dosage of steel fibre the compression test on cubes were performed for varying dosage of Polypropylene fibre (PPF) at 3,7,28,56,90 days of curing and the values are represented in Fig.no.3.

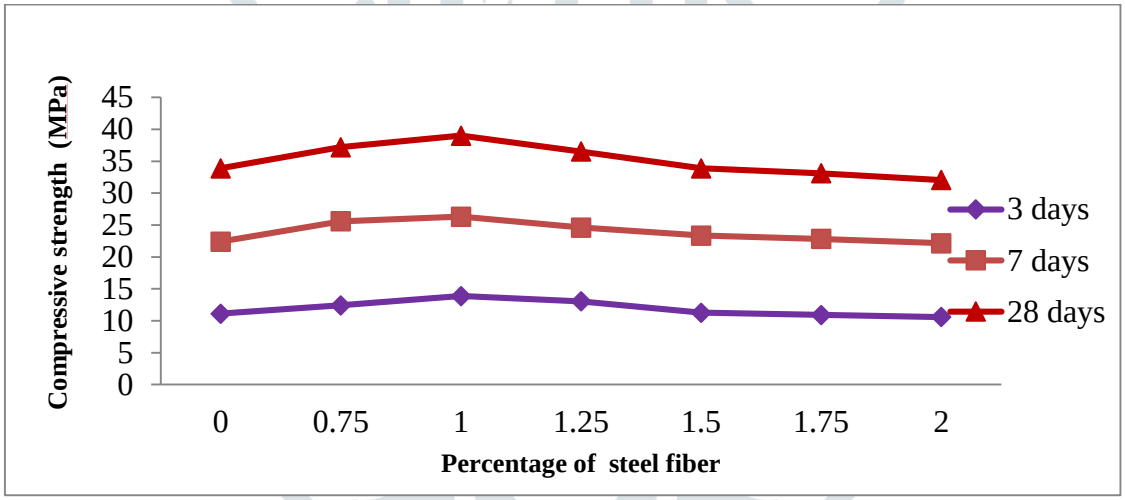

Fig.2.compression test result for Optimum dosage of steel fibre.

From the above graphical representation of the compressive strength results for various dosages of steel fibre, it is noticed that at 1% volume proportion of concrete maximum value of compressive strenth achieved i.e. 39.01 MPa. Then after 1%, as dosage of steel fibre increasing compressive strength is observeved to be gradually decreasing. Hence the optimum dosage of SF is conformed as 1% volume fraction.

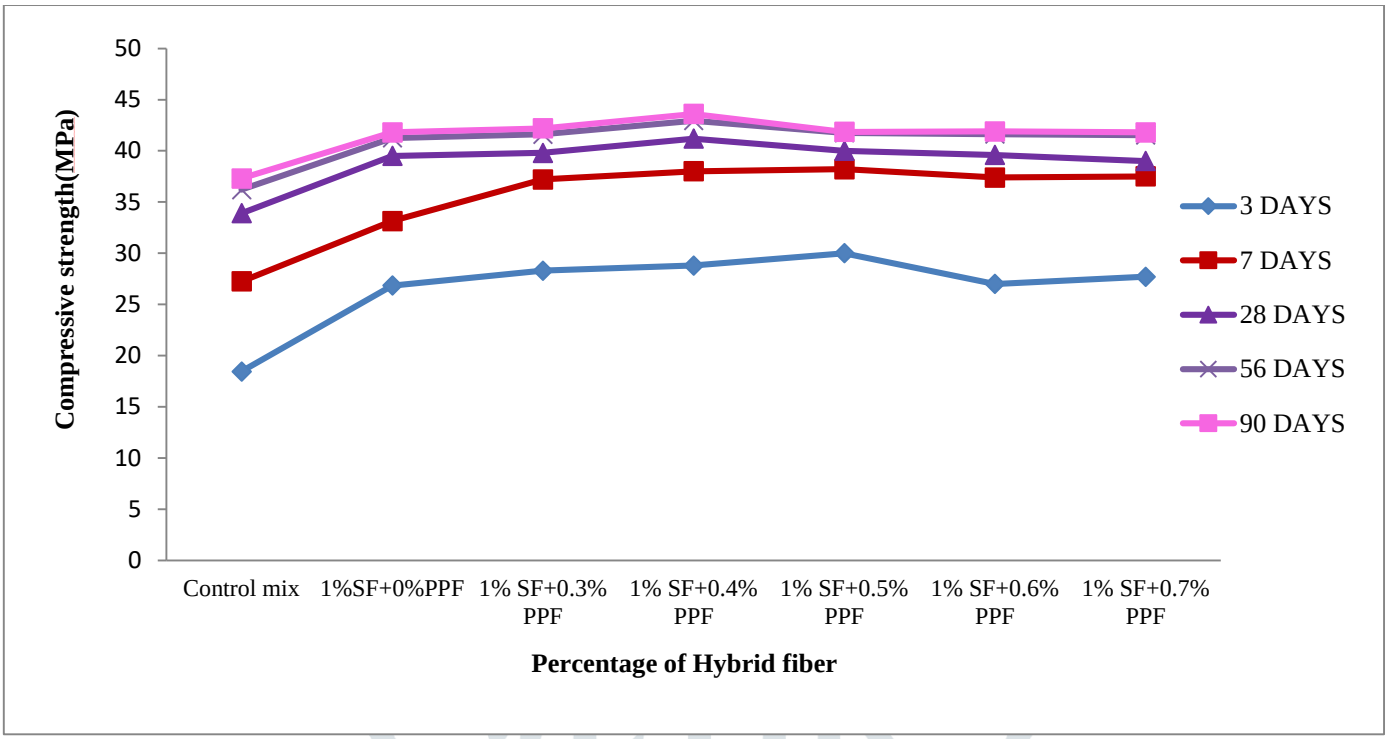

Fig.3.Cube compression test results for Hybrid mixes

Based on the results of compressive strength with hybrid mixes, it is clear that as the dosage of polypropylene increases the compressive strength also increased up to 0.4% and then gradually decreased up to 0.7%. Hence optimum dosage of hybrid fibre mix is 0.4% PPF with the combination of 1% SF and the maximum compressive strength is 43.6 MPa.

SPLIT TENSILE STRENGTH

Split tensile strength of specimens with different hybrid mixes are performed and the results are graphically represented in fig.no.4

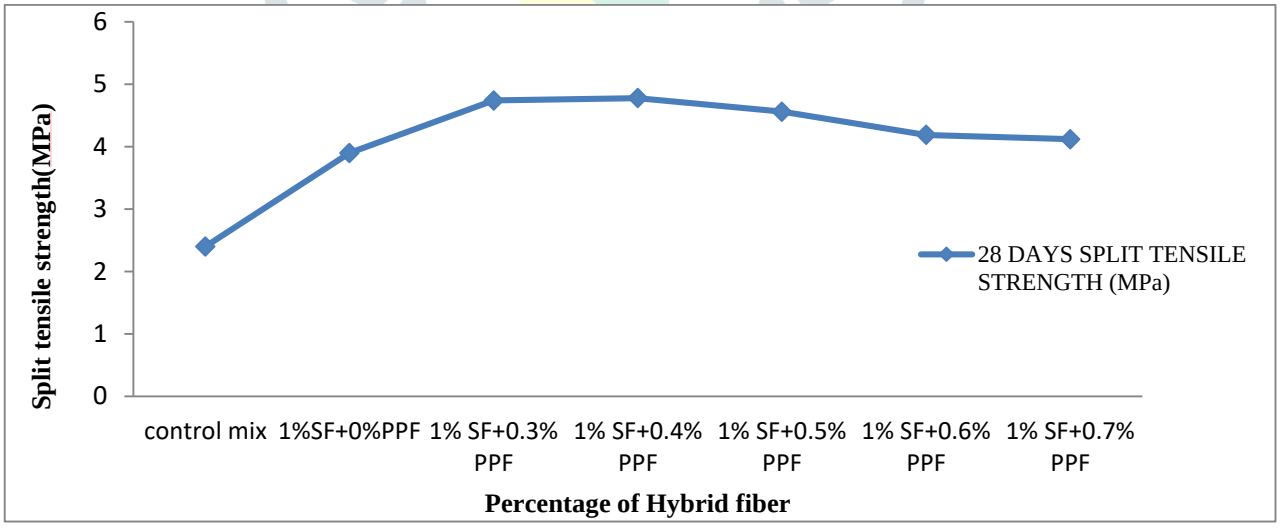

Fig.4. Split tensile strength test results

From the above results it is clear that at 28 days split tensile strength of M25 grade concrete with the addition of hybrid fibre (SF&PPF) at various dosages, it is observed that the split tensile strength is increased up to 0.4% PPF with the combination of 1% SF and then decreased gradually as dosage increases. Reduction in the workability is the major reason for gradual decrease in the split tensile strength. Hence the maximum split tensile strength is found to be 4.78 MPa at 1%SF + 0.4%PPF , whereas for control mix is 2.4 MPa.

FLEXURAL STRENGTH

Flexural strength test results are obtained for different proportions of hybrid fibre mixes and the results are represented in following fig.no 5.

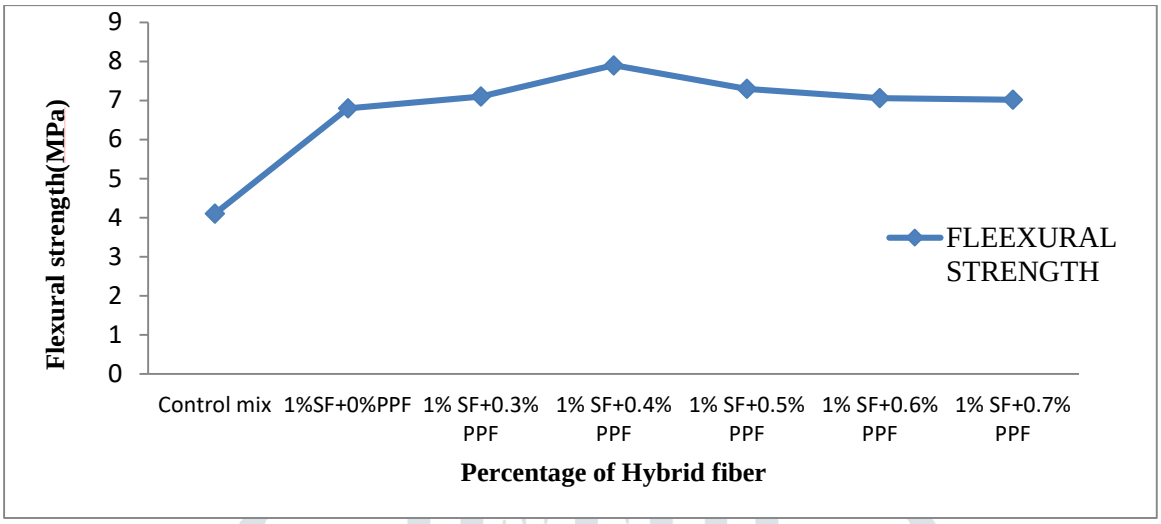

Fig.5.Flexural strength test results with Hybrid mixes.

From the above results it is clear that at 28 days flexural strength of M25 grade concrete with the addition of hybrid fibre (SF&PPF) at various dosages, it is observed that the flexural strength is increased up to 0.4% PPF with the combination of 1% SF and then decreased gradually as dosage increases. Hence the maximum flexural strength is found to be 7.9 MPa at 1%SF + 0.4%PPF and 4.1 MPa for control mix.

MODULUS OF ELASTICITY

Modulus of elasticity test was performed on standard cylinder specimens after 28 days of curing and the results are presented in Fig.no.6

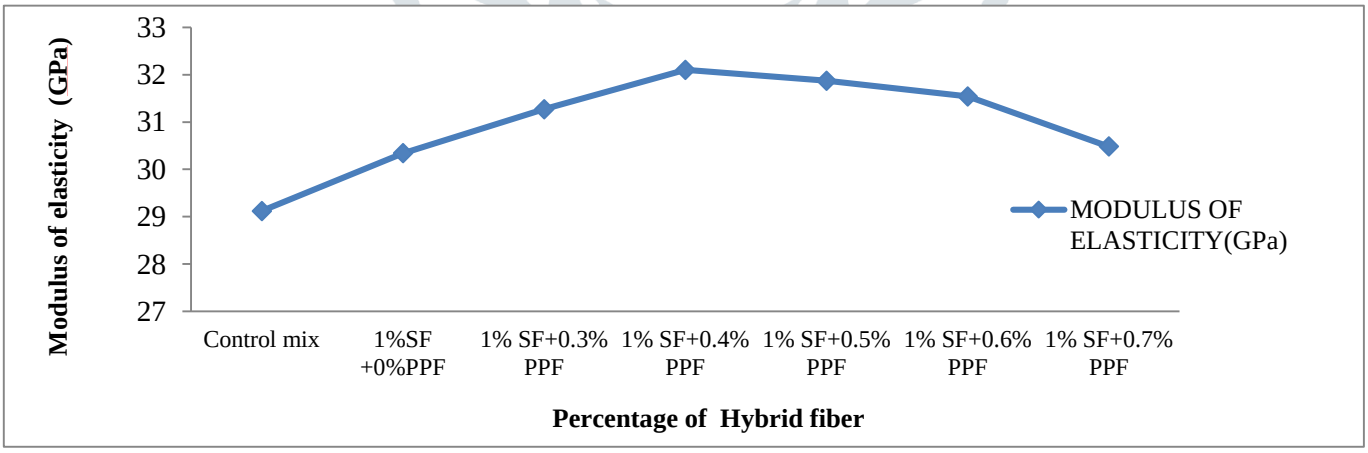

Fig.6 Modulus of elasticity with hybrid mixes.

From the above results, it is inferred that there is a slight increase in the modulus of elasticity of concrete after the reinforcement of hybrid fibre. Numerically the modulus of elasticity at optimum dosage (1% SF + 0.4% PPF) is 32.1 MPa and for control mix is 29.1 MPa. The slight increase observed is 3 MPa.

WATER ABSORPTION

The percentage of water absorption (WA) of standard specimens was conducted for durability check after 28 days of curing and the values are represented in Fig.no7.

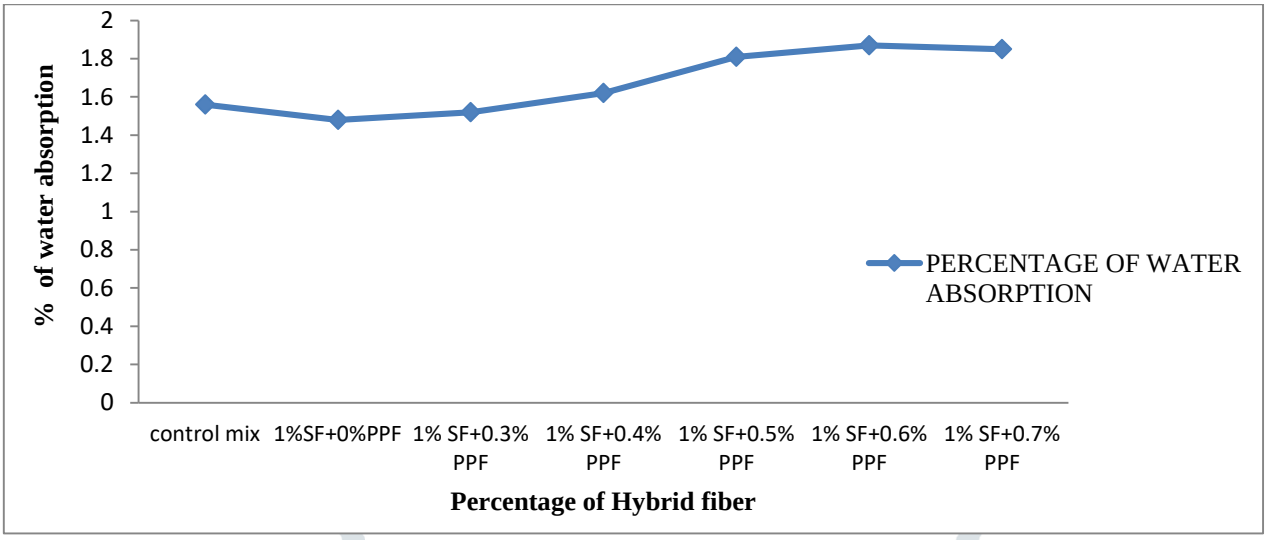

Fig.7. Water absorption test results.

Generally,water absorption of concrete had a close relationship with the characteristics of its pore structure in the cement paste and the intensity of microcracks at the aggregate-cement paste interface as well as within the paste itself. From the above experimental investigations , it is clear that the reinforcement of steel fibre and polypropylene fibre doesn't show any significant effect on the water absorption and it is the indication for enhancement of durability of concrete.

VII . CONCLUSIONS

The following conclusions were drawn after the laboratory investigations:

- The Cube Compressive Strength of M25 Grade obtained is **37.3** MPa.
- The Optimum dosage of Steel Fibre is **1%** by volume fraction of concrete.
- The Optimum dosage of Hybrid Fibre is **1%SF** with the combination of **0.4% PPF.**
- The Cube Compressive Strength with Hybrid fibre mix obtained is **43.6** MPa, which is **16.89%** higher compared to reference mix.
- The Split tensile strength of M25 Grade obtained is **2.4** MPa.
- The Split tensile strength with Hybrid fibre mix obtained is **4.78** MPa, which is nearly **100%** higher compared to reference mix.
- The Flexural strength for M25 Grade obtained is **4.1** MPa.
- The Flexural strength with Hybrid fibre mix obtained is **7.9** MPa, which is **92.68%** higher compared to reference mix.
- The Modulus of Elasticity for M25 Grade design mix is **29.12** GPa.
- The Modulus of Elasticity with Hybrid fibre mix is **32.1** GPa, which is **10.23%** higher compared to reference mix.
- The Reinforcement of Hybrid fibre doesn't showed significant effect on percentage of Water absorption.

References

- V.Bindiganavile and Banthia - "Some studies on the response in the Engineering properties fibre reinforced concrete,ICI journal,PP.671-682."
- Mustafa Sahamaran,Alpheren Yurtseven,I.Ozgur Yaman – "Workability of hybrid fibre reinforced Self Compacting Concrete Building and Environment, Volume 40,PP:1672-1677."

- R.Ramanathan– "Performance of self Compacting Concrete containing Different Mineral admixtures, KSCE journal of civil engineering , volume 17,Issue 2:PP.465-472."
- Agrawal ,R.,Singh,A.K., and Singhal,D.(1996)-"Effect of fiber reinforcing index on compressive strength and bond strength of steel fiber reinforced concrete." Institution of Engineers (India),77(1),37-40.
- Ghosh, S., Battacharya ,C., and Ray, S.P. (1989). "Tensile strength of steel fiber reinforced concrete ." Institution of Engineers (India),69 (1).PP :222-227.
- IS 10262-2009: Indian Standard " Guidelines For Concrete Mix Design Proportioning" code of practice.
- IS 456-2000: Indian Standard " Plain And Reinforced Concrete" –code of practice.
- IS 383-1970: Indian Standard " Specification For Coarse And Fine Aggregates From Natural Sources For Concrete".
- IS 516:1959: Indian Standard "Methods of Tests For Strength of Concrete"
- IS 5816:1999: Indian Standard "Methods of Test Splitting Tensile Strength Of Concrete."
- ASTM C 642-06: "standard method for Percentage of water absorption by oven –drying of concrete ."
- "Concrete Technology"-M.S.SHETTY.