

Comparison of Artificial Fiber with Steel and Natural Fiber Embedded in Concrete for its Mechanical Properties

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ABSTRACT: This study is investigate the response of conventional steel reinforced concrete, artificial fiber reinforced concrete(FRP POLYPROPYLENE) and natural fiber(COCONUT FIBER) reinforced engineered cementitious composites members on their flexural load- deformation behavior, compressive strength and behavior of concrete. The behavior of flexural load- deformation and compressive strength of conventional reinforced concrete member are briefly reviewed and compared with fiber reinforced engineered cementitious composites .Compatible deformations of reinforcement and matrix leads to low interfacial bond stress and prevent the composite disintegration by bond splitting and lower spalling. Furthermore flexural strength as well as crack deformation and widths in fiber reinforced engineered cementitious composites members are found effectively independent of interfacial bond properties due to the tensile deformation characteristics of the compendious matrix. We can study the basic mechanical properties and behavior of different materials under embedded concrete. And find out that artificial made fiber are more capable of bearing both flexural and compression. By using this higher bond matrix we can use as an highly engineer made material to resist deformation and crack formation and propagation under high load such as load caused by heavy machineries such as milling, shaping machine and reciprocating compressors.

KEYWORDS: Concrete block, Ordinary Portland cement, Steel, Polypropylene, Coconut fiber, compressive strength ,flexural strength.

1. INTRODUCTION

Fiber glass reinforced plastic, commonly known as fiber glass, was developed commercially after World War II. Since that time, the use of fiber glass has grown rapidly. Thermo set plastic resin that is reinforced with glass fiber. In this manual, the more general terms Fiber Reinforced Plastic/Composites or FRP/Composites will be used to describe these extremely useful material systems. Plastic resins come in two different classes – thermo sets and thermoplastics. From a practical perspective, it's easy to remember that thermo sets maintain their molded at higher temperatures and cannot be melted and reshaped. Thermoplastics will melt at a given temperature and can be solidified into new shapes by cooling to ambient temperatures. Thermo sets and thermoplastics are described with more detail in the Resin Systems section of this document. Reinforcing fiber include glass, carbon, aramid and other man-made and natural materials that are further described in the Reinforcement section of this document.

II. LITREATURE REVIEW

M. A. Erki et al used Coconut fiber which is an abundant, versatile, renewable, cheap, lingo cellulosic fiber and more resistant to thermal conductivity. The aim of investigation is to study the possibilities to use the coconut fiber in addition to the other constituents of concrete . The testing of various material constituents of concrete was carried out according to the Indian Standard specifications. L. C. Bank et al proposed a method to increase the Energy absorption capacity and toughness of the material, but also increase tensile and flexural strength of concrete. Fiber of various

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shapes and sizes produced from steel, plastic, glass, and natural materials are being used; however, for most structural and nonstructural purposes, steel fiber is the most commonly used of all the fiber. B. Benmokrane et al presented a fiber reinforced concrete (FRC) is a new structural material which is gaining increasing importance. Addition of fiber reinforcement indiscrete form improves many engineering properties of concrete. Currently, very little research work is being conducted within the Kingdom Using this new material. They described the different types of fiber and the application of FRC in different areas. F. Micelli investigated the response of conventional reinforced concrete and fiber reinforced engineered cementations composites members on their flexural load- deformation behavior, compressive strength and split tensile strength behavior of concrete. The behavior of flexural load- deformation, split tensile strength and, compressive strength of conventional reinforced concrete member are briefly reviewed and compared with fiber reinforced engineered cementations composites. F. M. Wegian et al presented the results of an experimental investigation of the performance characteristics of concrete members reinforced with basalt fiber reinforced polymer (BFRP) bars along with polypropylene fiber. The primary objective of the research is the identification of the stress-strain relationship which ensures the determination of the load-strain behavior and maximum load capacity of the basalt FRP reinforced slabs reinforced with or without polypropylene. A. F. Ashour, discussed that for the polypropylene fiber reinforced concrete slabs, an average of 8% difference was observed in the predicted values of maximum load obtained using the proposed model, an average of 9% difference using the Decay and Krishnan curve for plain concrete, an average of 8% difference using the Hognestad's Model and an average of 20% difference using the ACI 440.1R method with failure loads being greater than the predicted strengths. M. Guadagnini et al developed a fiber reinforced concrete (FRC) which is a composite material made of hydraulic cement or cements; water; fine and coarse aggregate; and short, uniformly dispersed discontinuous fiber. Fiber may be of steel, glass, polymeric materials, carbon, cellulose, and so forth, and their lengths vary from 3 to 64 mm (0.12 to 2.52 in.). The diameters may vary from a few μm to about 1 mm (0.04 in.). The sections may be round, oval, polygonal, triangular; crescent shaped, or even square depending on the manufacturing process and the raw material used. G. Razaqpur et al presented test results of simply supported concrete beams longitudinally reinforced either by steel or glass fiber -reinforced polymer (GFRP). A total of sixteen large-scale concrete beams with steel stirrups were constructed and tested under four-point monotonic loading till failure. Half of the beams were longitudinally reinforced with GFRP bars, while the other half was reinforced with conventional steel bars as control specimens. To examine the shear behavior of the GFRP reinforced concrete (RC) beams, the main parameters investigated in the study included shear span-effective depth ratios, longitudinal reinforcement ratios and stirrup ratios. A. K. El-Sayed et al presented a behavior of reinforced concrete beams strengthened with various types of fiber reinforced polymer (FRP) laminates is presented in this paper. The experimental program included strengthening and testing 14 simply supported rectangular cross section beams. Each beam was initially loaded above its Cracking load. The cracked beams were strengthened with FRP laminates and then tested until complete failure. The Effects of strengthening on deflection, failure load and failure mode, strain, and beam ductility are discussed.

III. PROBLEM IDENTIFICATION

From the previous papers we have identified that although the steel posses higher value of youngs modulus than fiber reinforced plastics posses higher value of load bearing capacity. Some of properties that was undesirable in steel,

- Less load bearing capacity.
- High corrosion properties.
- Low flexural properties.
- Less compression strength.

But it is obvious that fiber reinforced plastic posses high value load bearing value and less corrosion and wear properties. it can be opted for high load bearing application and compression and flexural applications. The main parameters investigated in the study included shear span-effective depth ratios, longitudinal reinforcement ratios and stirrup ratios. Two modes of failure, namely flexure and shear were observed. Due to low modulus elasticity of FRP bars, it was found that lesser shear strength resulted in concrete beams reinforced with FRP bars compared to beams reinforced with steel bars. Moreover, then fluency of the shear span-effective depth ratios and longitudinal

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reinforcement ratios significantly affect the distribution of internal forces in FRP reinforced concrete beams. The test results correlated well with the prediction values provided by standard codes and design guidelines except in the case of FRP reinforced concrete beams failed on shear. Due to this reason artificial fiber (fiber reinforced plastic) and artificial fiber (coconut fiber) are used in case of steel for high compressive load, flexural load, and vibrating and fluctuating loads.

IV. PROCESS METHODOLOGY

The process of selecting suitable ingredients of concrete and determining their relative amounts with the objective of producing a concrete of required, strength, durability, and workability as economically as possible, is termed the concrete mix design. The proportioning of ingredients of concrete is governed by the required performance of concrete in 2 states, namely the plastic and the hardened states. If the plastic concrete is not workable it cannot be properly placed and compacted. The property of workability, therefore becomes of vital importance.

The compressive strength of hardened concrete which is generally considered to be an index of its properties, depends upon many factors, e.g. quality and quantity of cement, water and aggregates; batching and mixing; placing, compaction and curing. The cost of concrete is made of the cost of materials, plant and labor. The variations in the cost of the material arise from the fact that the cement is several times costly than aggregates, thus the aim is to produce as lean mixture as possible. From technical point of view the rich mixes may lead to high shrinkage and cracking in structural concrete, and to evolution of high heat of hydration in mass concrete which may cause cracking.

The actual cost of concrete is related to the cost of materials required for producing a minimum mean strength called characteristic strength that is specified by the designer of the structure. This depends on the quality control measures, but there is no doubt that the quantity control adds to the cost of concrete. The extent of the quality control is often an economic compromise and depends on the size and size and type of job. The cost of labor depends on the workability of mix, e.g., a concrete mix of an inadequate workability may result in a high cost of labor to obtain a degree of compaction with available equipment.

4.1 Experimental Procedure

4.1.1 Raw material

Ordinary Portland cement, locally available sand, aggregates, potable water and brown coir fiber, polypropylene rod, steel rod were used for preparation of plain concrete (PC) and CFRC beams. The maximum size of aggregates was 12mm (passing through sieve 12mm and retained at sieve 10mm). The diameter and tensile strength of coir rope was 1 cm.

4.1.2 Material preparation

Ordinary steel rod, polypropylene rod are to be purchased. And coir fiber is to be taken from fiber ropes it is to be done by coir fiber were loosed and soaked in water for 30 minutes to soften the fiber and to remove coir dust. Fiber were then straightened manually and combed with a steel comb. Wet long fiber were put in an oven where approximately 70-80% moisture was removed.

4.1.3 Mix design and casting procedure

For the plain concrete, the mix design ratio for cement, sand and aggregates was 1, 2 and 2, respectively with water cement ratio of 0.48. The mix design for coir fiber reinforced concrete was the same as that of the plain concrete except that the water cement ratio was 0.56 because of the addition of fiber to make CFRC workable and 7.5 cm long coir fiber of 3% by weight of cement were added and the same amount (weight) of aggregates were deducted from the total weight of aggregates. All materials were taken by weight of cement. The pan type concrete mixer, shown in Figure 1, was used in preparing concrete. All materials were put in the mixer pan along with the water, and the mixer was rotated for three minutes. The slump test was 50mm. For preparing CFRC, a layer of coir fiber was spread in the pan, followed by spreading of aggregates, sand and cement. The first layer of fiber was hidden under the dry concrete

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materials with the help of a spade. Then, another layer of coir fiber followed by layers of aggregates, sand and cement were spread. The second layer of fiber over the dry concrete materials. This process is repeated until the rest materials were put into the mixer pan. Approximately, three quarters of the water (according to a water cement ratio of 0.48 which was the same as that of plain concrete) was added, and the mixer was rotated for two minutes. Then the remaining water was added and the mixer was again rotated for two minutes. The CFRC was not workable at this stage, so more water was added twice with an increment of 0.04 water cement ratio to make the CFRC workable. Finally, the mixer was rotated for three minutes to get mix the CFRC well. A slump test for the CFRC was also performed before pouring it into moulds. This test was performed in the same manner as performed for that of plain concrete. The slump test for CFRC was 12mm, but the CFRC was workable using a new pouring technique. It may be noted that more water could not be added to avoid bleeding. CFRC was poured into the moulds and the moulds were lifted up to a height of approximately 200 – 300 mm and then dropped to the floor for self-compaction of the fiber concrete and to remove air voids from the CFRC. Figure 3 shows partially filled CFRC beam with rope. A clear concrete cover below the rope was ensured. It may be noted that the rope was pre-tensioned so that there was no sagging while pouring the CFRC, and knots were provided at both ends just to provide anchorage. All specimens were cured for 14 days before testing.

4.2 Specimens

4.2.1 Compressive strength

Standard cube specimens are casted and tested for compressive strength after 14 days. For preparing the specimens, the permanent steel moulds size of 150mmx150mmx150mm were used. Before mixing the concrete, the moulds were kept ready. After pouring concrete into the mould, Table vibrator was used to compact the concrete and then the top surface was given a smooth finish. The test specimens were stored in a place free from vibration and kept at a temperature of $27^{\circ}\pm 2^{\circ}\text{C}$ for 24 hours $\pm \frac{1}{2}$ hour from the time of addition of water to the dry ingredients. After this period, the specimen were marked and removed from the moulds and immediately submerged in clean fresh water and kept there until taken out prior to test. The specimens dried for testing. This test was conducted as per IS 516-1959. The cubes of standard size 150mm x150mm x150 mm were used to find the compressive strength of concrete. Specimens were placed on the bearing surface of Compression Testing Machine (CTM) of capacity 40 tones without eccentricity and a uniform rate of loading was applied till the failure of the cube. The maximum load was noted and the compressive strength was calculated. The experimental result shows that the Compressive Strength of Steel Reinforced Concrete was greater than Recon Fiber Reinforced Concrete from of mix from respectively. The compression strength of concrete is a vital parameter as it decides the other parameters like tension, flexure etc. The effect of polypropylene fiber on the compressive strength of concrete has been discussed in many literatures and observed that polypropylene fiber either decreases or increases the compressive strength of concrete, but the overall effect is negligible in many cases.

4.2.2 Flexural strength

The Specimen of size 500mm x100mm x 100mm is placed on the bed of the testing machine (i.e.) on two Steel Rollers of 38mm diameter. The Specimen is placed such that the Span between two supports is 40 cm. The load is applied using the Flexural Strength Machine. The load at failure was noted. The results of these flexural tests have been presented in and table respectively. From the graph it is revealed that the performance fiber reinforced concrete increased from compared to the conventional concrete. he specimens dried for testing. This test was conducted as per IS 516-1959. The cubes of standard size 150mm x150mm x150 mm were used to find the compressive strength of concrete. Specimens were placed on the bearing surface of Compression Testing Machine (CTM) of capacity 40 tones without eccentricity and a uniform rate of loading was applied till the failure of the cube. The maximum load was noted and the compressive strength was calculated. The experimental result shows that the Compressive Strength of Steel Fiber Reinforced Concrete was greater than Recon Fiber Reinforced Concrete from of mix from respectively. The compression strength of concrete is a vital parameter as it decides the other parameters like tension, flexure etc. The effect of polypropylene fiber on the compressive strength of concrete has been discussed in many literatures and observed that polypropylene fiber either decreases or increases the compressive strength of concrete, but the overall effect is negligible in many cases. In fact, the effect of a low volume of polypropylene fiber on the compressive strength of concrete may be concealed by the experimental error.

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V. TEST RESULT AND DISCUSSION

5.1 Compression Test

This test was conducted as per IS 516-1959. The cubes of standard size 150mm x150mm x150 mm were used to find the compressive strength of concrete. Specimens were placed on the bearing surface of Compression Testing Machine (CTM) of capacity 40 tones without eccentricity and a uniform rate of loading was applied till the failure of the cube. The maximum load was noted and the compressive strength was calculated. The experimental result shows that the Compressive Strength of Steel Fiber Reinforced Concrete was greater than Recon FIBER Reinforced Concrete from of mix .

Table `1.1 Compression Test on Steel

S.No	Material	Days Of Curing	Compressive Stress=P/A (N/Mm ²)
1	Steel	14	6.49
2	Concrete	14	1.305

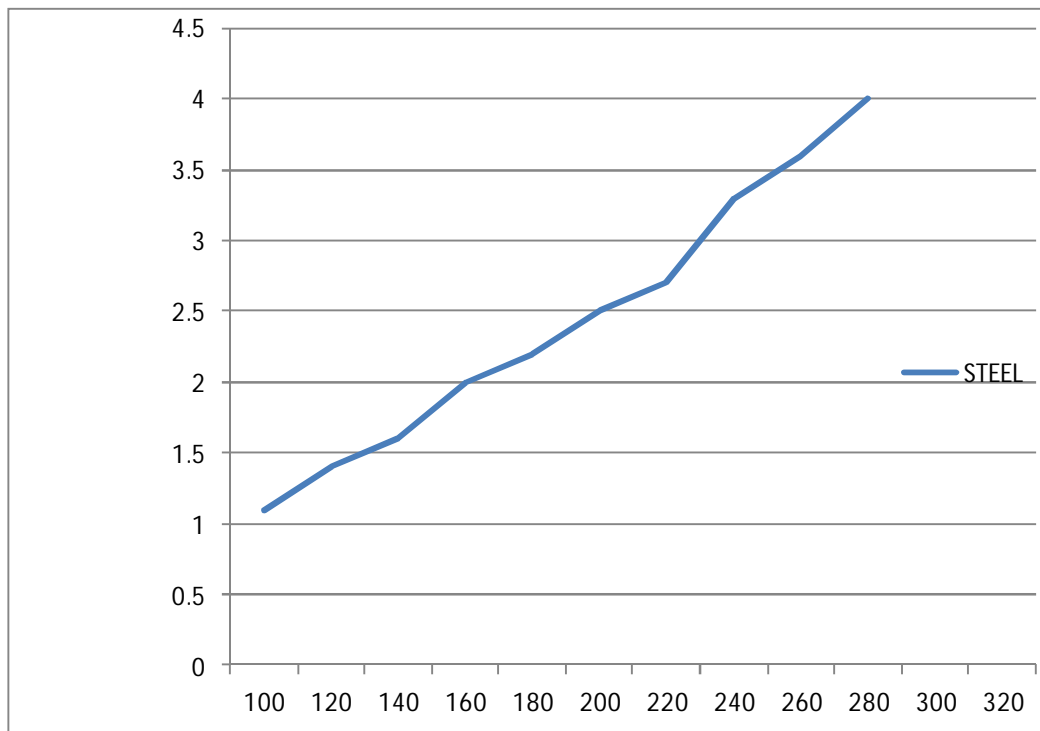


Figure 1.1 Parameter: load(x-axis) vs deformation(y-axis)

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Table 1.2 Compressive Test on Artificial Fiber

S.No	Material	Days Of Curing	Compressive Stress(N/Mm ²)
1	Polypropylene	14	6.587
2	Concrete	14	1.55

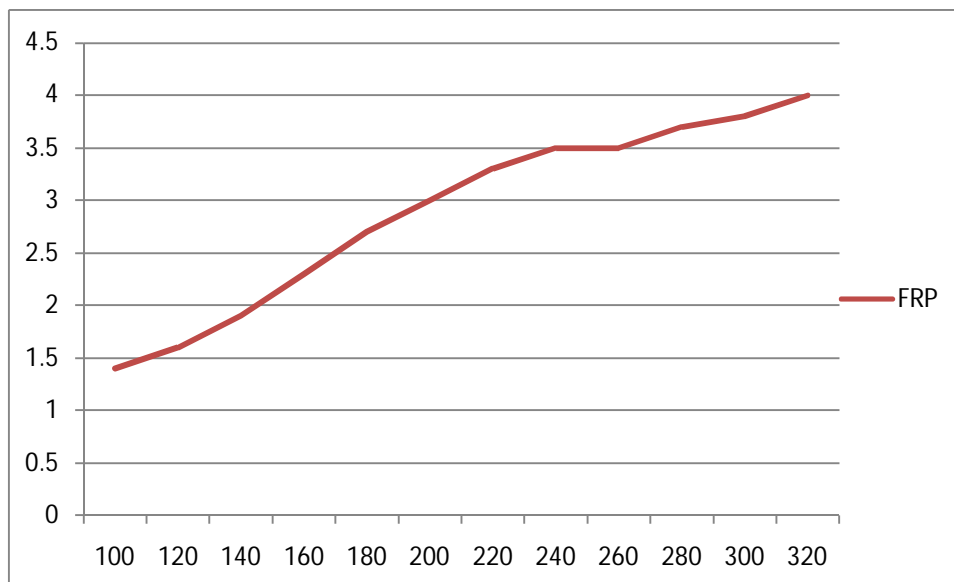


Figure 1.2 Parameter: load(x-axis) vs deformation(y-axis)

Compressive Test on Natural Fiber

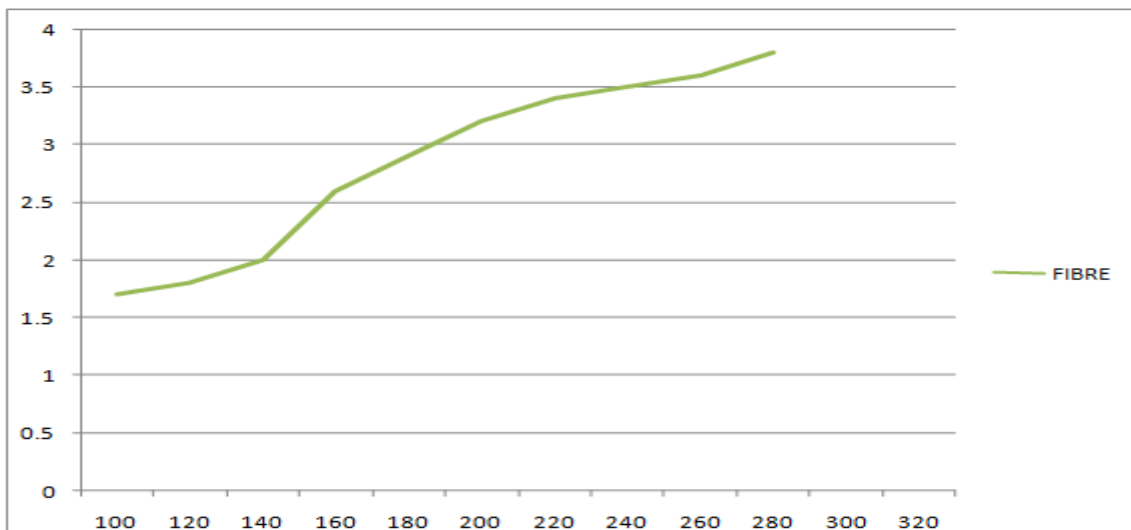


Figure 1.3 Parameter: Load(x-axis) vs deformation(y-axis)

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Comparison Graph On Compressive Strength On Steel,Artificial Fiber And Natural Fiber:

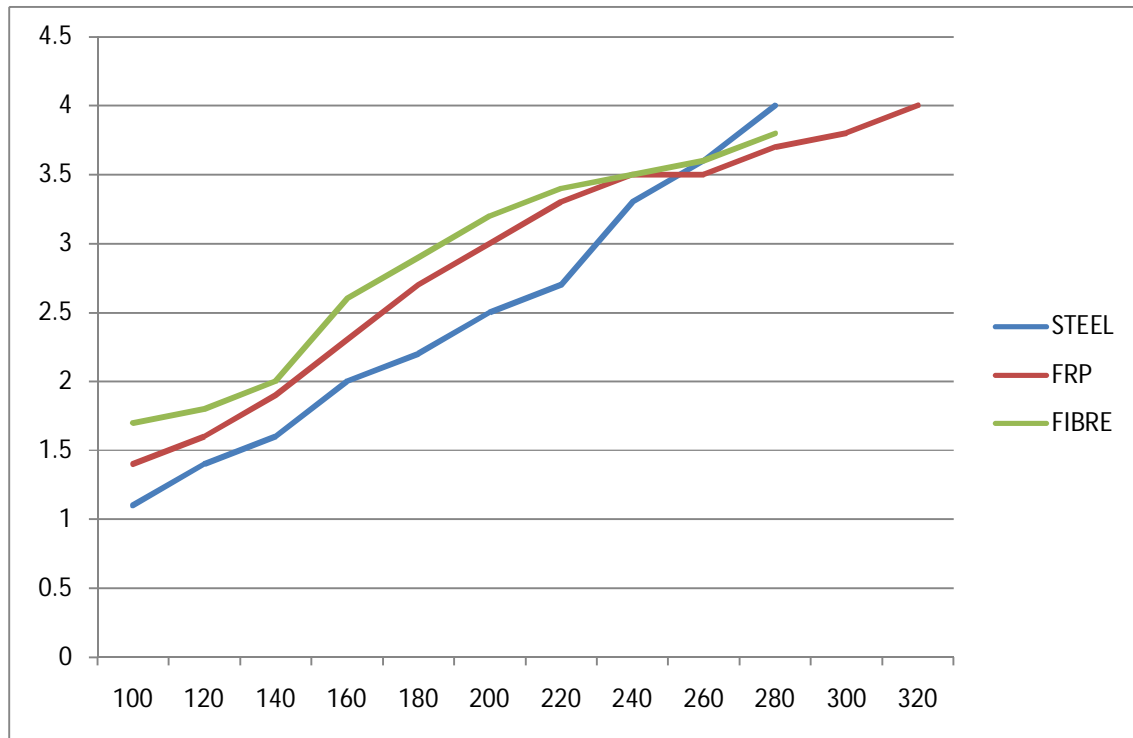


Figure 1.4 Parameter: Load(x-axis) vs deformation(y-axis)

Inference:

In starting condition up to certain load limit steel poses much more resistant to deform (up to 3.5mm) but after certain point artificial fiber (pp) surpasses the value of steel and coconut fiber and possess very great resistant to deform after 280KN(from the graph).coconut fiber in case poses value lower than remaining two. Hence polypropylene can be chosen as an optimum material to substituent for heavy loads.

5.2 FLEXURAL TEST:

The Specimen of size 500mm x100mm x 100mm is placed on the bed of the testing machine (i.e.) on two Steel Rollers of 38mm diameter. The Specimen is placed such that the Span between two supports is 40 cm. The load is applied using the Flexural Strength Machine. The load at failure was noted. The results of these flexural tests have been presented in respectively. From the graph it is revealed that the performance of fiber reinforced concrete .

FLEXURAL STRENGTH:

$$\text{Formula} = PL/BD^2$$

P-Failure load of prism.

L- lenth of prism.

B- breath of prism.

D- depth of prism.

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Table 1.3 Flexural Strength Of Steel

S.NO	DAYS OF CURING	FAILURE LOAD(KN)	FLEXURAL STRENGTH(N/MM ²)
1	14	6.5	3.25

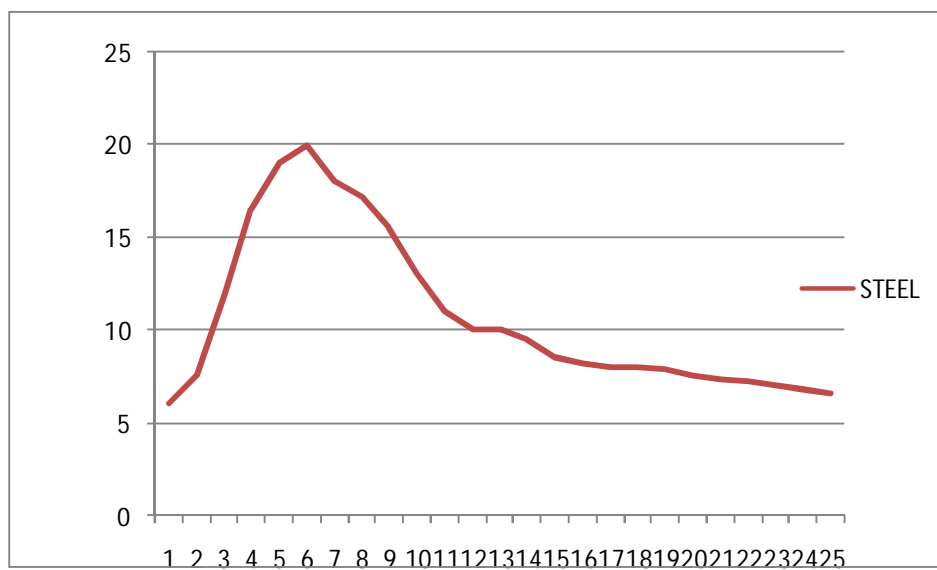


Figure 1.5 Parameter : load (X-axis) vs deformation(Y-axis).

Table 1.4 Flexural Test for Artificial Fiber

S.NO	DAYS OF CURING	FAILURE LOAD(KN)	FLEXURAL STRENGTH(N/MM ²)
1	14	7.4	3.7

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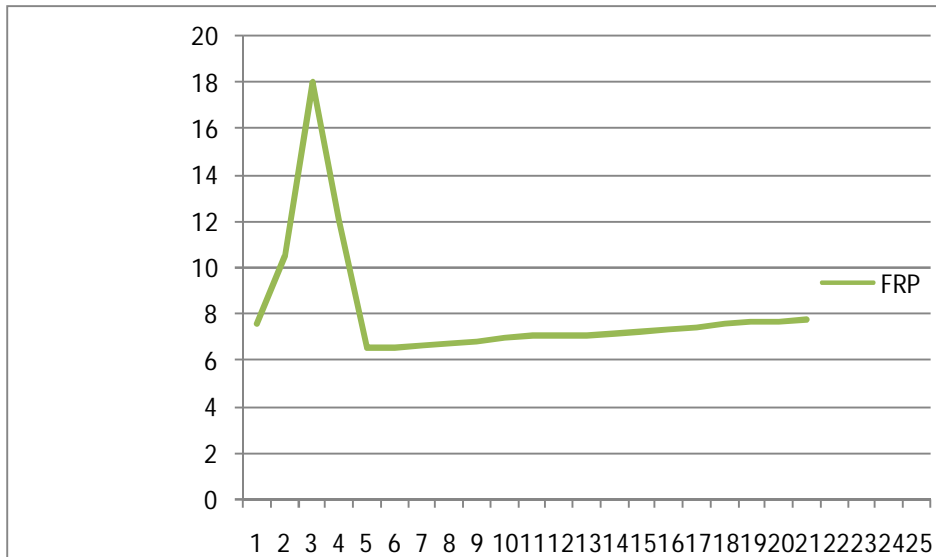


Figure 1.6 Parameter : load (X-axis) vs deformation(Y-axis).

Table 1.5 Flexural Test For Natural Fiber

S.No	Days Of Curing	Failure Load(KN)	Flexural Strength(N/Mm ²)
1	14	6.8	3.4

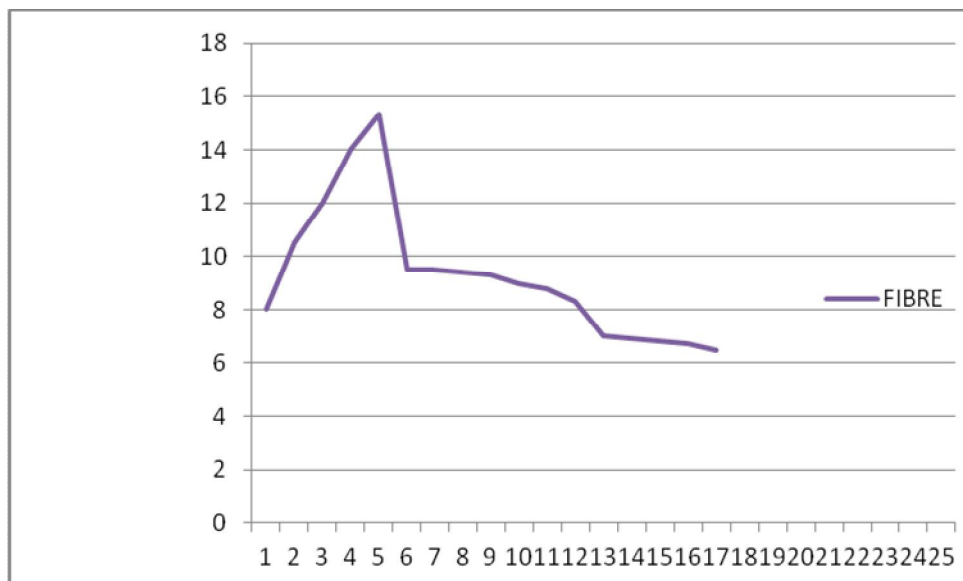


Figure 1.7 Parameter : load (X-axis) vs deformation(Y-axis).

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COMPARISON GRAPH ON FLEXURAL STRENGTH

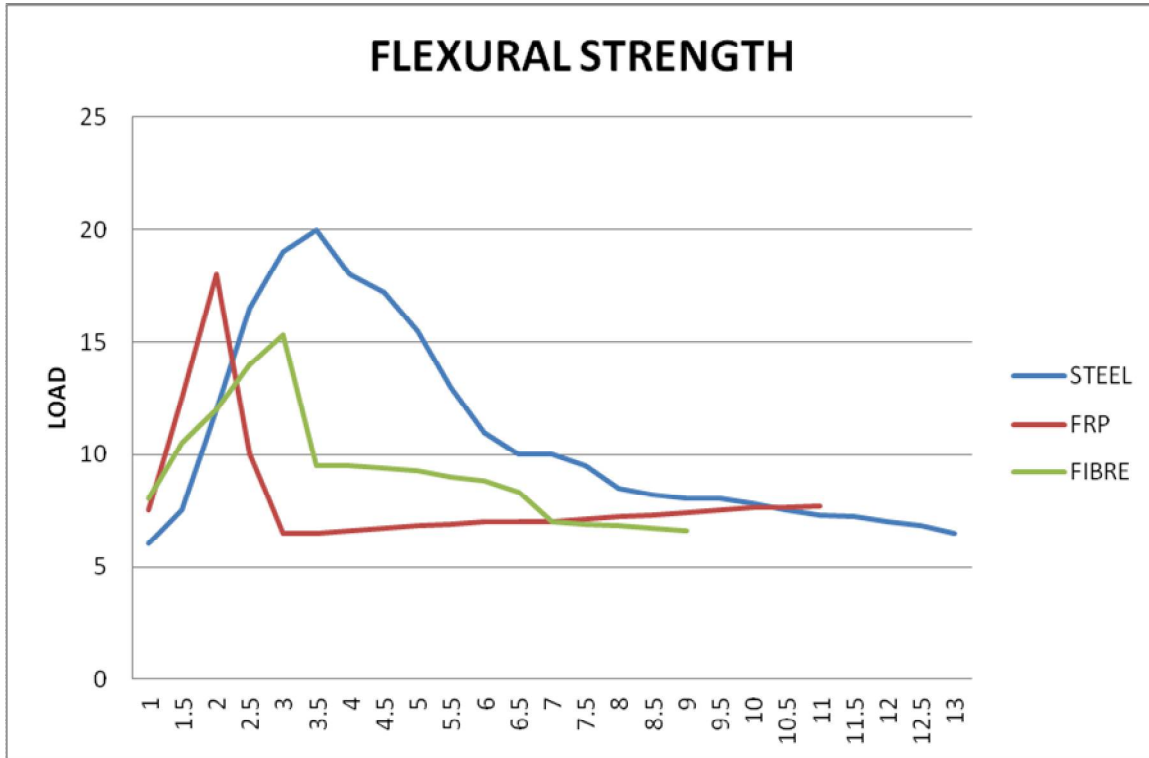


Figure 1.8 Parameter : load (X-axis) vs deformation(Y-axis).

Inference:

Steel possesses higher value of breaking point and also high load bearing capacity. But in case of artificial fiber (PP) it possesses less resistance to deformation which is the desired property of flexural and also from calculation it is obvious that artificial fiber possesses higher value of flexural strength. Natural fiber has much lesser value of breaking point than PP and steel. Hence artificial fiber can be opted for heavy load bearing application.

VI. RESULT AND DISCUSSIONS

There are three types of tests used with accuracy by the metals industry; they are the Brinell hardness test, the Rockwell hardness test, and the Vickers hardness test. Since the definitions of metallurgical ultimate strength and hardness are rather similar, it can generally be assumed that a strong metal is also a hard metal. The way the three of these hardness tests measure a metal's hardness is to determine the metal's resistance to the penetration of a non-deformable ball or cone. The tests determine the depth which such a ball or cone will sink into the metal, under a given load, within a specific period of time.

Table 1.6 Hardness Value of Before Welding

MATERIAL	HARDNESS VALUE
EN36	85

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Table 1.7 Hardness Value of After Welding

Materials	TEST PLATE	AVG HRB
EN36	S1	90
	S2	104
	S3	95
	S4	94
	S5	96
	S6	96
	S7	107
	S8	76
	S9	108

Table 1.8 Impact strength

Materials	TEST PLATE	Average in Joules
SS409	S1	28
	S2	20
	S3	30
	S4	24
	S5	22
	S6	26
	S7	18
	S8	24
	S9	20

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6.1 Taguchi Optimization Through Minitab -16 Impact Strength

Table 1.9 S/N ratios values for the Impact strength

T.NO.	Designation	AMPS	VOLT	Gas Pr Lit/min	IMPACT STRENGTH	S/NRATIO
1	A1B1C1	140	22	4	28	28.9432
2	A1B2C2	140	24	5	20	26.0206
3	A1B3C3	140	26	6	30	29.5424
4	A2B1C2	160	22	5	24	27.6042
5	A2B2C3	160	24	6	22	26.8485
6	A2B3C1	160	26	4	18	25.1055
7	A3B1C3	180	22	6	26	28.2995
8	A3B2C1	180	24	5	24	27.6042
9	A3B3C2	180	26	4	20	26.0206

Table 2.0 Response Table for Signal to Noise Ratios

LEVELS	AMPS	VOLT	GAS PR
1	28.17	28.26	26.69
2	26.82	26.52	27.08
3	27.31	26.89	28.23
Delta $\Delta_{\max-\min}$	1.65	1.46	1.54
Rank	1	3	2

Table 2.1 Analysis of Variance (ANOVA) results for the Roughness

Source	DF	Seq SS	Adj SS	Adj MS	F	P	% of contribution
AMP S	2	32.89	32.89	15.11	0.93	0.519	26
VOL T	2	27.56	30.22	15.11	0.85	0.541	22
GAS PR	2	30.22	30.22	17.18	0.85	0.541	24
Error	2	35.56	35.56				28
Total	8	126.22	16.14				100

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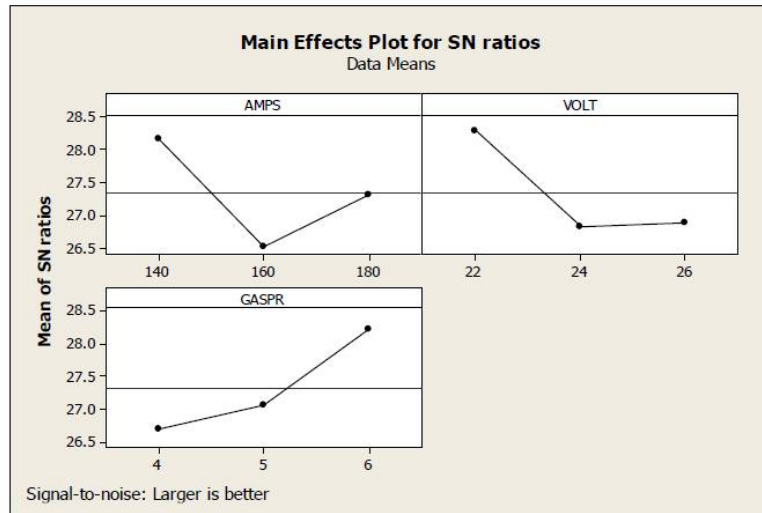


Fig. 1.9 Main effectsplot for S\N Ratio

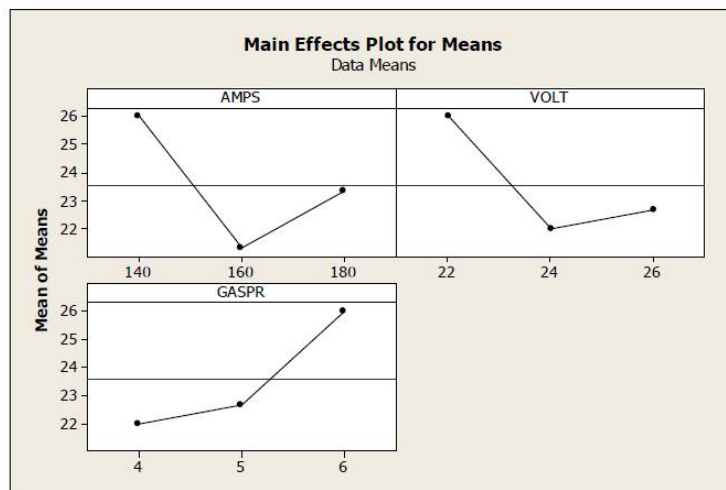


Fig. 1.10 Main effectsplot for Means Ratio

Table 2.2 Various Sizes Of Bead Width(BW), Depth Of Penetration(DOP) And Heat Affected Zone-En36 Fcaw

Test Sample	Location	Area	Mean	Min	Max	Angle	Length
Sample-1	BW	0.6	116.413	37.496	180.345	-2.793	14.034
	DOP	0.313	151.336	42.05	247.467	86.947	6.419
Sample-2	BW	0.51	136.293	113.49	207.421	-3.691	13.275
	DOP	0.249	170.289	111.407	220.232	88.512	6.583
Sample-3	BW	0.531	97.065	46.887	138.422	-0.905	16.241
	DOP	0.292	105.5	55.549	120	89.215	6.24

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Sample-4	BW	0.698	110.581	19.707	164.766	-0.682	14.36
	DOP	0.337	123.722	60.618	148.667	88.652	7.267
Sample-5	BW	0.506	114.088	35.333	181	0.418	11.71
	DOP	0.377	86.576	24.489	155.4	93.489	7.022
Sample-6	BW	0.53	108.535	77.28	162.69	-0.694	14.104
	DOP	0.263	105.531	33.396	155.396	91.809	8.124
Sample-7	BW	0.569	153.884	112.953	188.667	-1.697	11.544
	DOP	0.398	216.282	158	234.256	89.182	5.984
Sample-8	BW	0.499	99.125	43.826	123.873	-2.862	13.692
	DOP	0.364	104.479	50.333	132.333	88.363	5.985
Sample-9	BW	0.671	184.613	119.244	211.759	0.455	10.77
	DOP	0.304	214.453	176	233.667	90	5.726

IX. CONCLUSION

In starting condition up to certain load limit steel poses much more resistant to deform (up to 3.5mm) but after certain point artificial fiber (PP) surpasses the value of steel and coconut fiber and possess very great resistant to deform after 280KN(from the graph) . It attain its deformation of 4mm when its attain the load of 320KN(from the graph).Coconut fiber in case poses value lower than remaining two. Hence fiber reinforced plastic polypropylene can be chosen as an optimum material to substituent for heavy loads. Hence polypropylene fiber can be used along with concrete to achive maximum load condition.

Steel poses higher value of breaking point and also high load bearing capacity .But in case of artificial fiber (PP) it poses less resistant to deform which is the desired property of flexural and also from calculation it is clear that artificial fiber poses higher value of flexural strength . Natural fiber has much lesser value of breaking point than PP and steel. Hence artificial fiber can be opted for heavy load bearing application and various fluctuating and vibrating loads.

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