Experimental Investigation on Coir Fibre Reinforced Concrete with Partial Replacement of Cement by Rice Husk Ash

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Abstract— **In present day constructions, the use of admixtures has increased for achieving various properties which cannot be achieved by conventional concrete. Rice husk ash is a waste product of the rice mills. This research was experimentally carried more natural, local and affordable material like RHA will out to investigate the properties of Rice Husk Ash (RHA) not only take care of waste management but will also when used as a partial replacement for Ordinary reduce the problem of high cost of concrete and housing. Coconut fire is strong in tension, hence it can be used a fibre reinforced material. Hardened concrete tests like compressive strength, split-tensile strength and Flexural strength test were undertaken showing a remarkable increase in strength of concrete as a percentage of rice husk ash replacement and addition of coir as fibre reinforcement.**

Index Terms—: **Rice Husk Ash, Coconut Fibre, Admixtures, Compressive Strength, Split-Tensile Strength and Flexural Strength.**

I. INTRODUCTION

Concrete is one of the crucial materials for infrastructure development due to its versatile application, globally its usage is second to water. Due to increase in the cost of conventional building materials and environmental hazard, the designers and developers are looking for 'alternative materials' to reduce the use of cement in civil engineering constructions. For this objective, the researchers are trying to use various waste products in concrete technology. The objective of this investigation is to study the effect of partial replacement of cement by Rice husk Ash as a Mineral admixture in concrete and also adding Natural fiber (Coir) to increase the tensile strength of concrete.

II. MATERIALS USED AND METHODOLOGY

Coconut Fibers

Coconut fibre is one of the natural fibres abundantly available in tropical regions, and is extracted from the husk of coconut fruit. The aim of this review is to spread awareness of coconut fibres as a construction material in civil engineering .Coconut fibers are added to the concrete in terms of volume fraction of 0.25% and 0.5%.

Table 1- Properties of Coconut Fibre

Properties	Value
Fiber length (mm)	50-110
Fiber diameter (mm)	0.1- 0.406
Average tensile strength(N/mm2)	150
Specific gravity	1.12-1.15
Elongation (%)	10-25

Rice Husk Ash (RHA)

Rice husk ash is produced by burning rice husk and contains large proportion of silica. To achieve amorphous state, rice husk was burnt at controlled temperature. It is necessary to evaluate the product from a particular source for performance and uniformity since it can range from being as deleterious as silt when incorporated in.

Table 2- Physical Properties of Rice Husk Ash

Physical properties	Value
Specific gravity	2.19
Fineness passing through 45μm sieve in (%)	99.5
Color	Grey

Table 3- Chemical Properties of Rice Husk Ash

Chemical properties	Value
Silicon dioxide(SiO2)	88.32
Silicon dioxide(SiO2)	0.46
Ferric oxide(Fe2O3)	0.67
Calcium oxide(CaO)	0.51
Magnesium oxide(MgO)	0.44
Sodium oxide(Na2O3)	0.12
Potassium oxide(K2O)	2.91

III. EXPERIMENTAL INVESTIGATION

Mix Design

Mix design is the process of selecting suitable ingredients of concrete and determines their relative proportions with the object of producing concrete of certain minimum strength and durability as economically as possible. The first object is to achieve the stipulated minimum strength. The second object is to make the concrete in the most economical manner.

Table 4- Design of Concrete Mix for M 20 Grade

Water content, W	Cement content, C	Fine Aggregate, F.A	Coarse Aggregate, C.A
210.6 kg/m3	402 kg/m3	614.46 kg/m3	1158.96 kg/m3
0.52	1	1.53	2.89

IV. TEST PROCEDURE

The experimental investigations carried out on the test specimens to study the strength-related properties of concrete using Rice husk ash and coir. Here, an attempt was made to study the strength development at different replacement levels at different ages with Rice husk ash and coir the results were compared. Concrete were produced with 10 and 20 % of the RHA as cement replacement (in mass) and coir is added with 0.25 and 0.5 % (by volume). Totally thirteen different proportions of concrete mixes are used. Ratio for M20 Grade as per IS 10262:2009. The strength-related properties such as compressive strength, splitting tensile strength, flexural strength were studied. Minimum three specimens were tested for each mix for each test. The entire tests were conducted as per specifications required.

V. CASTING AND TESTING OF SPECIMENS

All the ingredients were first mixed in dry condition in the concrete mixer. The concrete mix proportion is already shown in table. The calculated amount of water added to the dry mix and mixed thoroughly to get uniform mix. Before casting machine oil was smeared on the inner surface of the mould and the concrete was poured in to the mould. After 24 hours of casting, the specimens were demoulded and cured for 28 days using water tank. After the curing period was over, the specimens were white washed and kept ready for testing. For each mix, six cube specimens, three cylinder specimens and three beam specimens of size 100 x 150 x 1000 mm. Cube and specimens were tested on 7 days and 28 days.

Cube Compressive Strength Test

The compressive strength is one of the most important properties of concrete. Concrete specimens of 150 x 150 x150 mm cubes were cast with coconut fibre in various percentages such as 0.25 and 0.5% along with 10 and 20% replacement levels of RHA. After 24 hours the specimens were demoulded and subjected to cure for 28 days in ordinary tap water. After 28 days of curing, the cubes are then allowed to become dry for some hours. For each system triplicate specimens were cast .The cubes are tested in the compression-testing machine. The ultimate load at which the cube fails was taken. Compressive strength was calculated using the following formula.

$$\mathbf{f_{cu} = load\ at\ failure\ /\ cross\ sectional\ area (N/mm^2)}$$

Figure 1- Compression Test in Progress

Figure 2- Split Tensile Test in Progress

Split Tensile Test

Concrete cylinder of size 150 mm diameter and 300 mm height. During casting, the cylinders were mechanically vibrated using a table vibrator. After 24 h, the specimens were removed from the mould and subjected to water curing for 28 days. After the specified curing period was over, the concrete cylinders were subjected to split tensile test. Tests were carried out on triplicate specimens and average split tensile strength values were recorded.

$$f_{sp} = 2P/\pi dl (N/mm^2)$$

Where,

P = load at failure (N)
d = diameter of specimen (mm)
l = length of specimen (mm)

Flexural Strength (PCC Beam)

Toughness is defined as the amount of energy required to break a material (area under the load deformation curve).The test specimen of size 500mm x 100 mm x 100 mm beam is subjected to two point loading. The load is applied to the specimen gradually until the specimen fails. The deflection is noted at the centre point of the specimen. The crack will appear when the specimen fails.

Figure 3- Flexure Test in Progress

Flexural Strength (RCC Beam)

Two point loading system was adopted for the tests. A Data Acquisition System was used to store the data such as load and corresponding vertical deflection. The beams were mounted over two pedestals and the concentrated loads were applied by means of 40T Universal Testing machine (UTM). The load at which the concrete has started to rupture, the failure load of the specimens and also the nature of failure modes were noted for each beam. The experimental setup is shown in Figure 4.13.

Figure 4 - Loading Set-Up

VI. SPECIMEN DETAILS

Table 5 – Specimen Details

Type of specimen	% of RHA added	% of CF added	28 days			
			Cubes	cylinders	PCC beams	RCC Beams
conventional	0	0	3	3	3	1
S1	10	0.25	3	3	3	1
S2	10	0.5	3	3	3	1
S3	20	0.25	3	3	3	1
S4	20	0.5	3	3	3	1

VII. RESULT AND DISCUSSION

Cube Compressive Strength

The concrete cube specimens are made as fibre reinforced concrete by adding coir fibres. The compressive strength on coir fibre reinforced concrete are given in table 6

Table 6: Compressive Strength of Concrete

CUBE SPECIMENS	AVERAGE LOAD (KN)	AVERAGE COMPRESSIVE STRENGTH (N/MM^2)
Control	444.82	19.77
OPC+0.25%CF+10%RHA	928.12	41.25
OPC+0.5%CF+10%RHA	812.02	36.09

OPC+0.25%CF+20%RHA	866.05	38.49
OPC+0.5%CF+20%RHA	665.55	29.58

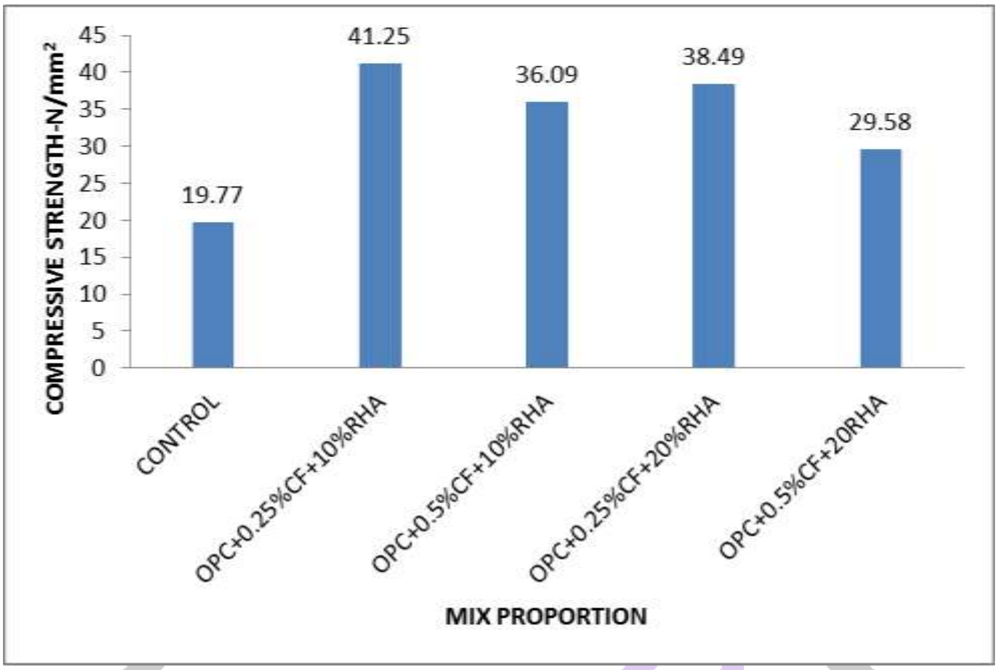

Figure 5 - Variation of Compressive Strength of Concrete

Split Tensile Strength

The concrete cylinder specimens are made as fibre reinforced concrete by adding coir fibres. The split tensile strength on coir fibre reinforced concrete are given in table 7

Table 7 - Split tensile Strength Of Concrete

CYLINDER SPECIMENS	AVERAGE LOAD (KN)	AVERAGE SPLIT TENSILE STRENGTH (N/MM^2)
Control	89.77	1.27
OPC+0.25%CF+10%RHA	159.04	2.25
OPC+0.5%CF+10%RHA	187.32	2.65
OPC+0.25%CF+20%RHA	171.05	2.42
OPC+0.5%CF+20%RHA	112.68	1.58

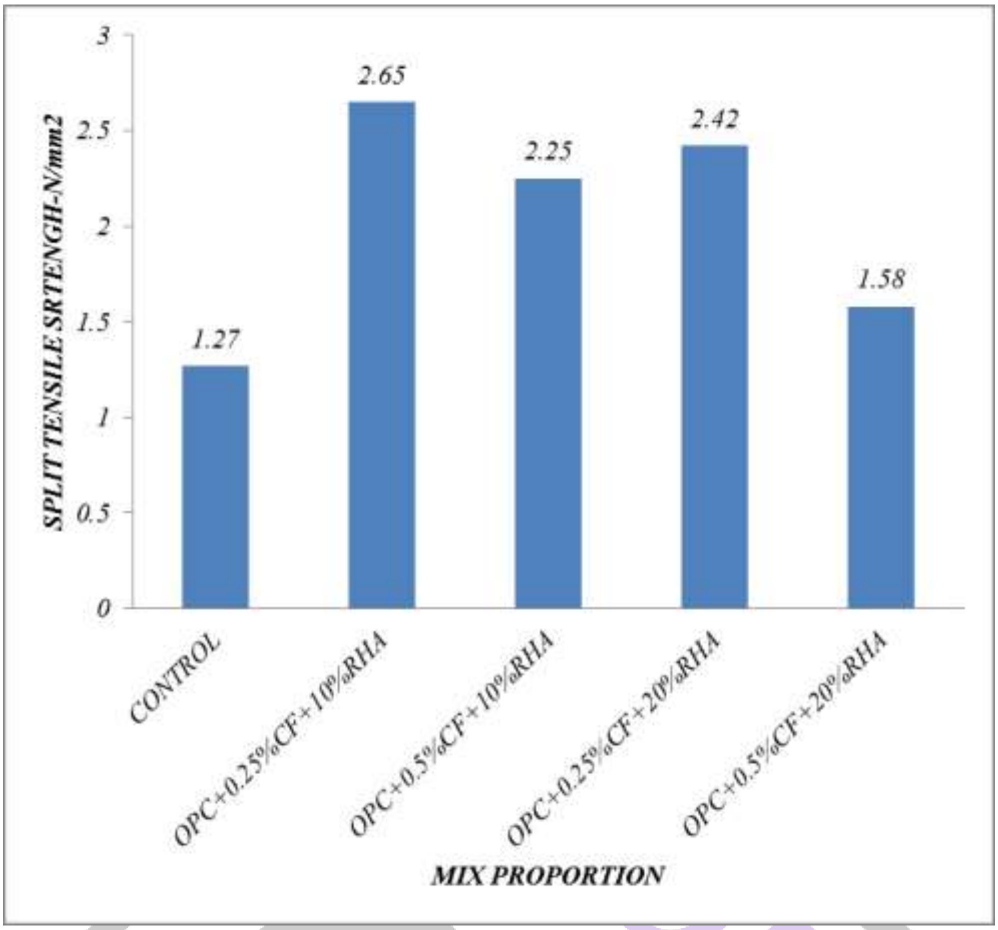

Figure 6 - Variation of Split Tensile Strength Of Concrete

Flexural Strength of PCC Beams

The concrete prism specimens are made as fibre reinforced concrete by adding both coir fibres and by adding fibres in each specimen. The flexural strength on coir fibre reinforced concrete is given in table 5.3.

Table 8- Flexural Strength of Concrete (PCC Beam)

BEAM SPECIMENS	LOAD (KN)	FLEXURAL STRENGTH (N/MM^2)
Control	14.12	7.4
OPC+0.25%CF+10%RHA	17.62	8.6
OPC+0.5%CF+10%RHA	17.02	8.51
OPC+0.25%CF+20%RHA	16.54	8.27
OPC+0.5%CF+20%RHA	16.21	8.10

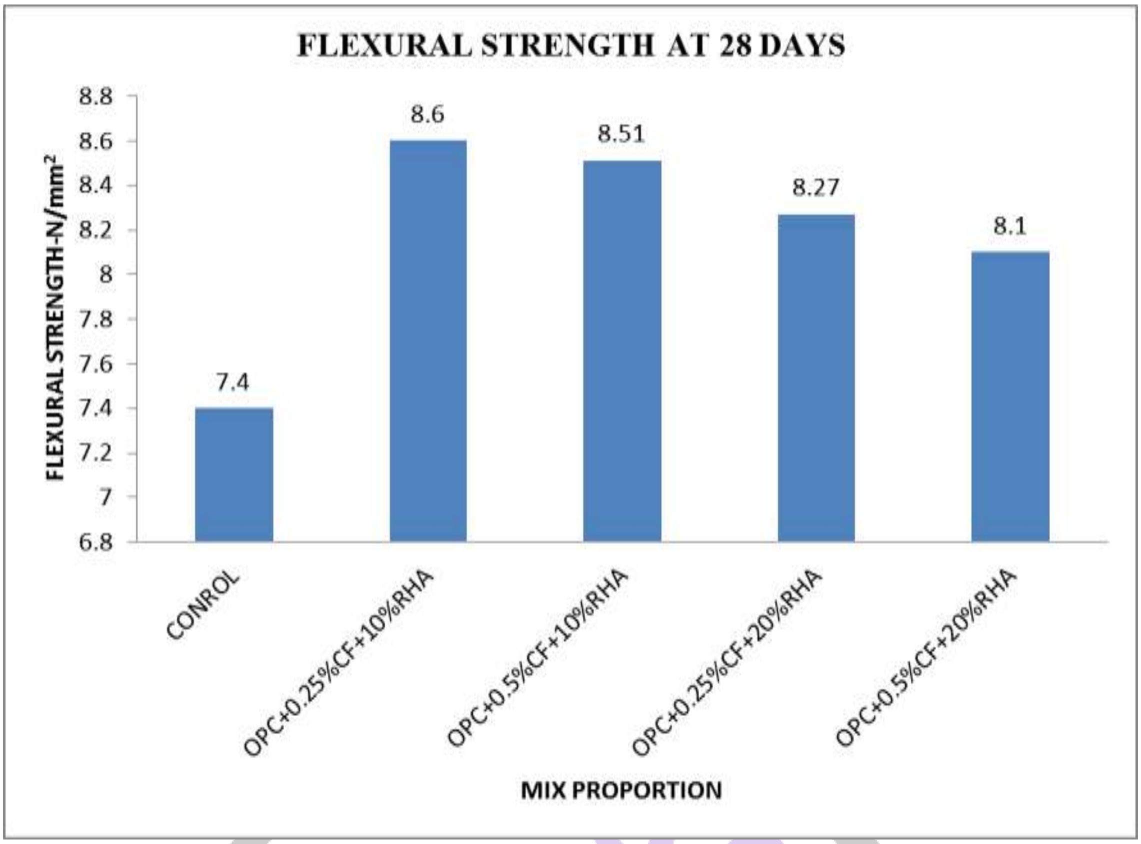

Figure 7 - Variation of Flexural Strength of Concrete

Load-Deflection Behaviour

Load-deflection behavior of CFRC strengthened beams with respect to control specimen is shown in Fig 8 to 10. Until reach the failure load of control beam, all the strengthened beams with exhibited linear elastic behavior, followed by inelastic behavior when increasing the load. The beams strengthened by fibres improve the ductile mode of the beam and it controls the mid-span deflection compared to that of control beam.

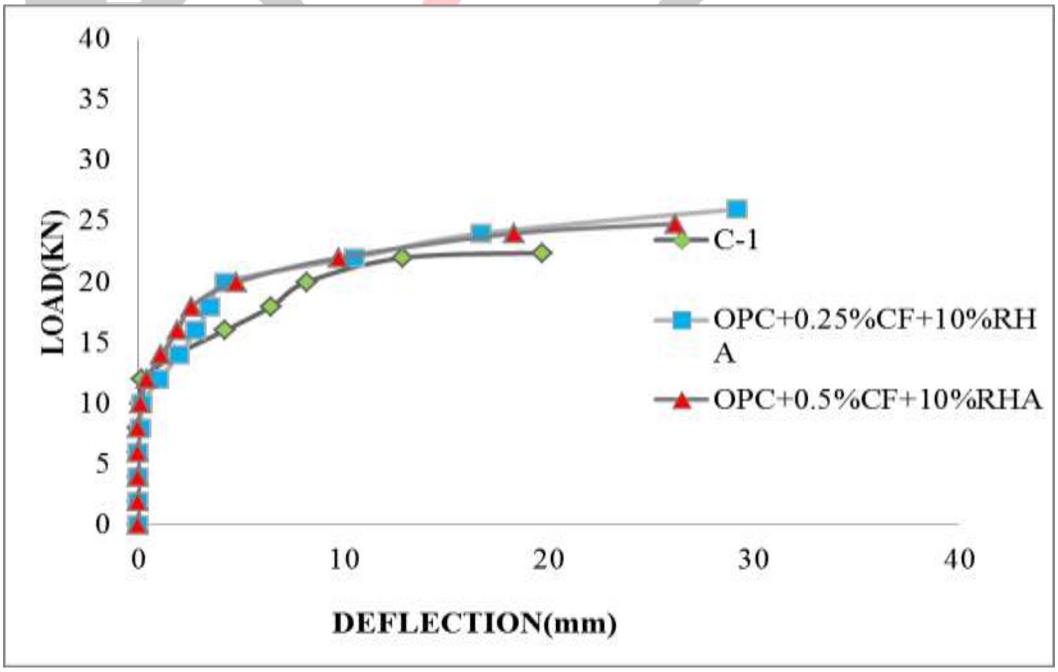

Figure 8 - Load-Deflection Behaviour of C-1, OPC+0.25%CF+10%RHA, OPC+0.5%CF+10%RHA -Comparison

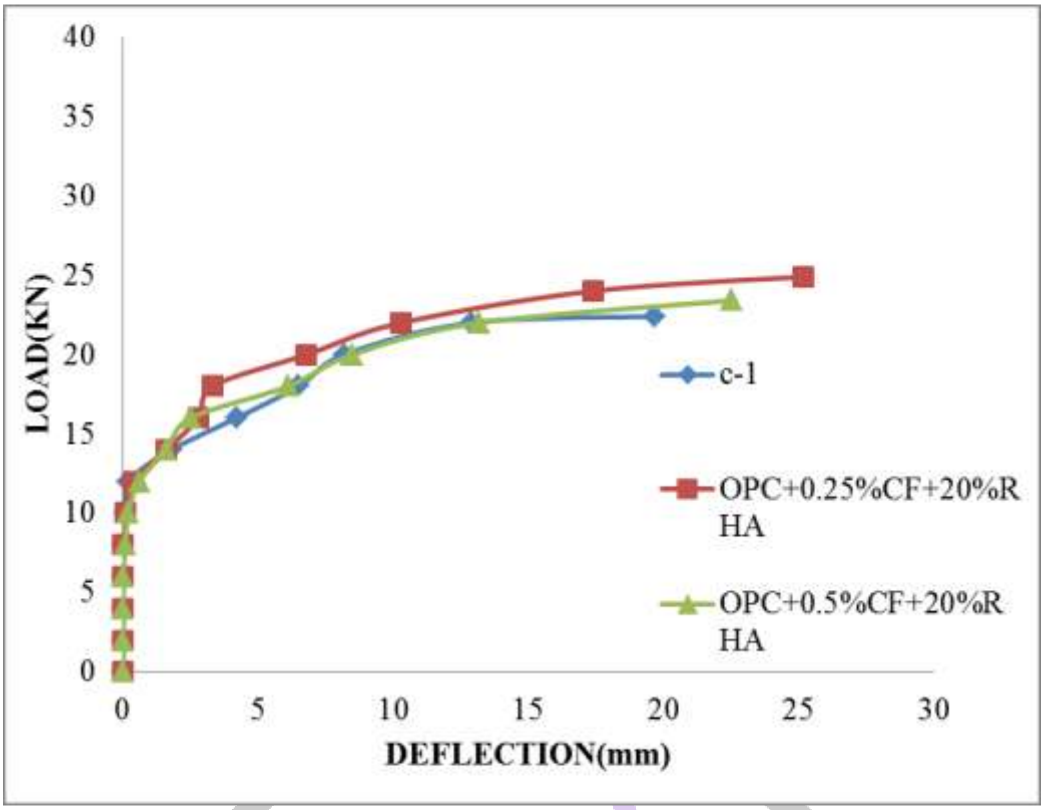

Figure 9 - Load-Deflection behaviour of C-1, OPC+0.25%CF+20%RHA, OPC+0.5%CF+20%RHA - Comparison

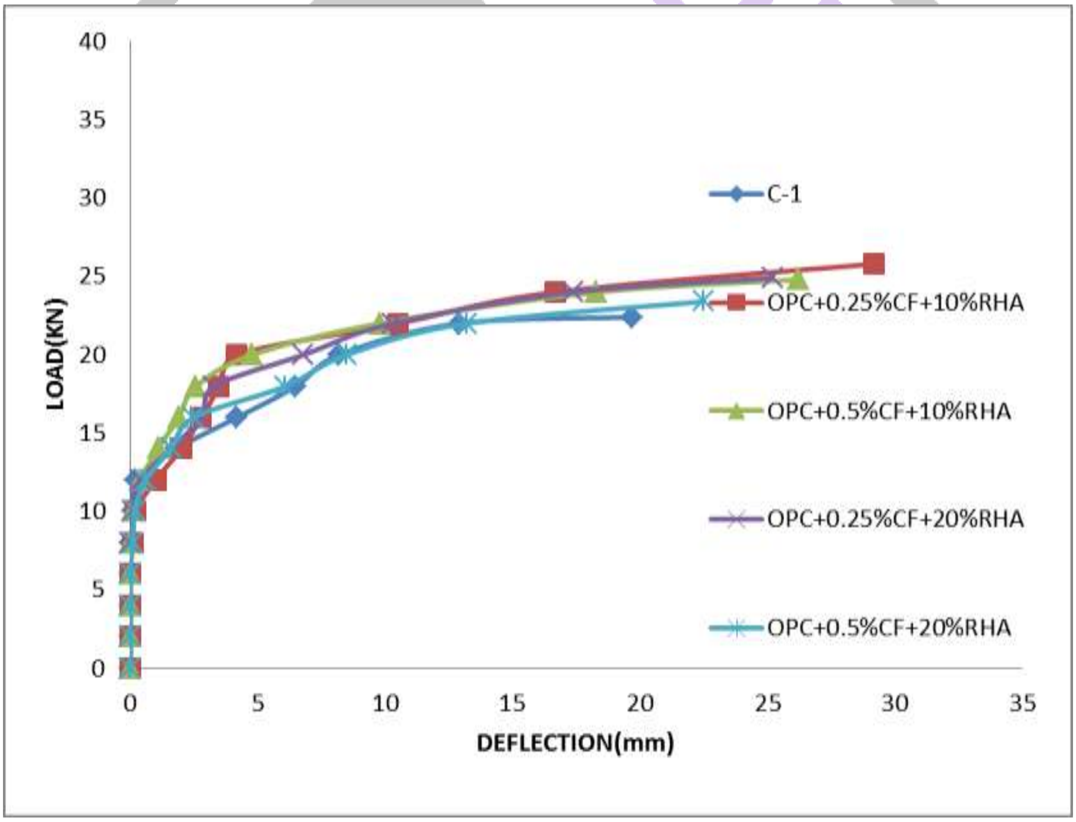

Figure 10 - Load-Deflection behaviour of all beams - Comparison

Flexural Strength of RCC Beams

The concrete RCC specimens are made as fibre reinforced concrete by adding coir fibres and by adding fibres in each specimen. The flexural strength on coir fibre reinforced concrete is given in table 5.4.

Table 9 - Flexural Strength Of Concrete (RCC Beam)

BEAM SPECIMENS	LOAD (KN)	FLEXURAL STRENGTH (N/MM^2)
Control	19.7	14
OPC+0.25%CF+10%RHA	29.2	20.76
OPC+0.5%CF+10%RHA	26.2	18.63
OPC+0.25%CF+20%RHA	25.8	18.35
OPC+0.5%CF+20%RHA	22.5	16.21

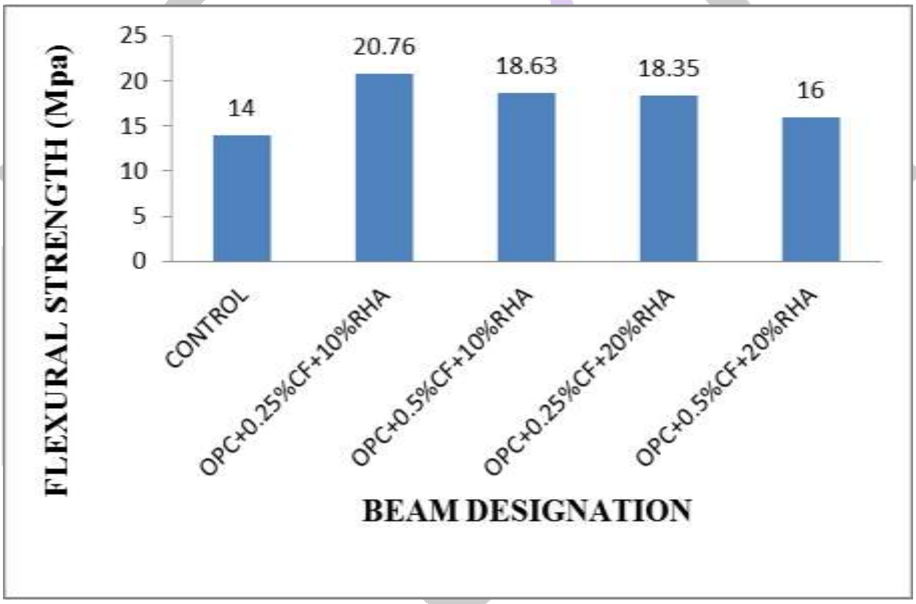

Figure 11 - Variation of Flexural Strength of Concrete (RCC beam)

VIII. CONCLUSION

When compared to control system, all the fiber added systems have shown higher compressive strength. It is observed that OPC+0.25% CF+10% RHA system is found to have higher compressive strength when compared to all the other systems. Compressive strength decreases with increase in fibre content.The maximum compressive strength was achieved for 0.25% coir fibre. Thereafter increase in fibre content has marginally reduced the compressive strength. CFRC shows an increase in split tensile strength as compared to the conventional concrete. The maximum split tensile strength was achieved for 0.25% coir fibre. Thereafter increase in fibre content has marginally reduced the split tensile strength. The maximum flexural strength was achieved for 0.25% coir fibre. Thereafter increase in fibre content has marginally reduced the flexural strength. The optimum percentage of coir fiber to increase the strength of a conventional concrete was obtained at 0.25%.

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