Strength Analysis of Concrete using Carbon Fibre and Rice Husk Ash

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Abstract - Rice Husk Ash has been generated in large quantities in countries like India. This by-product can contain non-crystalline silica and thus has a high potential to be used as cement replacement in mortar and concrete. This paper assesses the use of rice husk ash as an admixture and carbon fibers as additive to increase the dynamic properties of concrete. Concrete samples are done for 5% and 10% of replacement with rice husk ash and with 0.5% of replacement with carbon fibre. Concrete samples are done for M20 grade and properties of fresh and hardened concrete are assessed. The strength test for the samples of RHA and Carbon Fibre concrete cured in water for 28 days, is done and the results shows the percentage increase in strength for 5% RHA and 0.5% Carbon Fibre is 88%, 77% and 24% in compressive, flexural and tensile strength respectively than the Conventional concrete.

Keywords - Carbon fibre, Coarse aggregates, Compressive strength, Concrete mix design, Fine aggregate, Flexural strength, Fresh concrete, Harden properties, Methyl Cellulose, Rice husk ash, Water-cement ratio, Workability, Tensile strength.

I. INTRODUCTION

Concrete is a composite man-made material mostly used as building binding material in construction era. Now-a-days concrete is used with advanced and improved technologies such as R.C.C. structures or F.R.C. structures to give extraordinary strength and durability to the structures against sliding, cracking, buckling, overturning, etc. Rice milling generates a by-product known as husk and this husk is converted into ash is known as rice husk ash. This RHA in turn contains around 85-90% silica. As for brittle materials in general concrete is strong under compression and weak under tension or flexure. This problem maybe all levitated by the addition of carbon fibre filament. This paper deals with the impact and effects of carbon reinforced concrete and rice husk ash as partial cement replacement and their strength analysis.

II. METHODOLOGY

2.1 Major Materials Used

2.1.1 Cement

Cement is used in the present experimental study was obtained from local market of Kavaraipettai, Tamilnadu, India. Cement is used in the experimental work is OPC of 53 grades conforming to IS: 12269-1987. Table.1 shows properties of cement.

Table - 1 Properties of Cement

S. No.	Properties	Obtained Values	Requirements as per IS 12269-1987
1.	**Fineness**	2.5%	Not >10%
2.	**Soundness**	1 mm	Not >10 mm
3.	**Setting Time** **(a). Initial** **(b). Final**	 90 Minutes 2665 Minutes	 Not <30 Minutes Not >600 Minutes
4.	**Specific Gravity**	3.15	-
5.	**Standard Consistency**	29%	-
6.	**Compressive Strength** **(a). 7 Days** **(b). 28 Days**	 37.29 N/mm^2 53.35 N/mm^2	 Not <37 N/mm^2 Not <53 N/mm^2

2.1.2 Rice Husk Ash

Rice Husk Ash as shown in Fig. 1 is used in the present experimental study was obtained from the supplier. Rice husk Ash generally referred to agriculture by product of burning husk under controlled temperature of 800°C generally this process produces 25% ash containing 85 to 95% of amorphous silica and 5% of alumina. It is sieved through 425 micron sieve. The portion of ash passing through this sieve size is used. The colour of RHA is grey and specific gravity is 2.3.

Figure 1. Rice Husk Ash

2.1.3 Carbon Fibre

Filament of diameter 1.75 mm is purchased from local shop. The length of carbon fibre used is determined by Aspect ratio of 50. PLA based carbon fibre filament as shown in Fig. 2 is used and can resist up to temperature of 210°C.

Figure 2. Carbon Fibre Filaments

2.2 Mix Proportioning

Table – 2 Mix Design

Mix Design Details	
Grade of Concrete	M 20
Water-Cement Ratio	0.50
Grade of Cement	OPC 53
Maximum Size of Aggregate	20 mm
Fine Aggregate	River Sand
Sample designed according to IS 10262:2009	
Carbon Fibre Length	90 mm
Carbon Fibre Length is assigned from **Aspect Ratio of 0.50**	
According to SHRP-ID/UFR92605, the volume of fraction of fibre is taken as 0.5% of fibre to weight of cement content is taken	
Chemical Admixture	**Dispersion Resistant Agent** – Methyl Cellulose (According to SHRP-ID/UFR92605, the volume of fraction of Chemical Admixture is taken as 0.4% of weight of cement content)
Mineral Admixture	**Rice Husk Ash** (According to IS 9001:2008 the volume fraction of Mineral Admixture is taken as 5% and 10% of Rice Husk Ash to the total weight of cement content used)

Table - 3 Mix Proportion for Standard Concrete (Sample 1)

Specimen	Cement (Kg)	Fine Aggregate (Kg)	Coarse Aggregate (Kg)	Water (Kg)	Total (Kg)
Compressive Strength	1.490	2.331	4.506	0.708	**9.035**
Split Tensile Strength	2.349	3.670	7.097	1.116	**14.232**
Flexural Strength	2.217	3.460	6.699	1.053	**13.429**
Total	**6.056**	**9.461**	**18.302**	**2.877**	**36.696**

Table – 4 Mix Proportion for 5% Rice Husk Ash, 0.5% Carbon Fibre Replacement (Sample 2)

Specimen	Cement (Kg)	RHA (Kg)	Carbon Fibre (g)	Fine Aggregate (Kg)	Coarse Aggregate (Kg)	Water (Kg)	Total (Kg)
Compressive Strength	1.414	0.074	0.004	2.331	4.500	0.708	**9.031**
Split Tensile Strength	2.210	0.117	0.117	3.670	7.007	1.110	**14.231**
Flexural Strength	2.090	0.110	0.110	3.460	6.699	1.060	**13.529**
Total	**5.714**	**0.301**	**0.231**	**9.461**	**18.206**	**2.878**	**36.791**

Table – 5 Mix Proportion for 10% Rice Husk Ash, 0.5% Carbon Fibre Replacement (Sample 3)

Specimen	Cement (Kg)	RHA (Kg)	Carbon Fibre (g)	Fine Aggregate (Kg)	Coarse Aggregate (Kg)	Water (Kg)	Total (Kg)
Compressive Strength	1.340	0.149	7.480	2.331	4.500	0.708	**16.508**
Split Tensile Strength	2.110	0.234	11.740	3.670	7.000	1.110	**25.864**
Flexural Strength	1.960	0.221	11.10	3.460	6.700	1.060	**24.501**
Total	**5.41**	**0.604**	**30.32**	**9.461**	**18.2**	**2.878**	**66.873**

Table - 6 Mix Proportion for 0.5% Carbon Fibre Replacement (Sample 4)

Specimen	Cement (Kg)	Carbon Fibre (g)	Fine Aggregate (Kg)	Coarse Aggregate (Kg)	Water (Kg)	Total (Kg)
Compressive Strength	9.720	0.051	15.960	30.780	5.346	**61.857**
Split Tensile Strength	1.541	0.005	4.175	8.071	0.638	**14.430**
Flexural Strength	2.510	0.012	3.940	7.620	1.380	**15.462**
Total	**13.771**	**0.068**	**24.075**	**46.471**	**7.364**	**91.749**

Table – 7 Mix Proportion for 5% Rice Husk Ash Replacement (Sample 5)

Specimen	Cement (Kg)	RHA (Kg)	Fine Aggregate (Kg)	Coarse Aggregate (Kg)	Water (Kg)	Total (Kg)
Compressive Strength	9.690	0.510	15.960	30.780	5.280	**62.220**
Split Tensile Strength	1.110	0.058	4.175	8.071	0.610	**14.024**
Flexural Strength	2.400	0.126	3.940	7.620	1.320	**15.406**
Total	**13.200**	**0.694**	**24.075**	**46.471**	**7.210**	**91.650**

Table – 8 Mix Proportion for 10% Rice Husk Ash Replacement (Sample 6)

Specimen	Cement (Kg)	RHA (Kg)	Fine Aggregate (Kg)	Coarse Aggregate (Kg)	Water (Kg)	Total (Kg)
Compressive Strength	9.186	1.020	15.960	30.780	5.052	**61.998**
Split Tensile Strength	1.010	0.156	4.175	8.073	0.550	**13.964**
Flexural Strength	2.270	0.252	3.940	7.620	1.250	**15.332**
Total	**12.466**	**1.428**	**24.075**	**46.473**	**6.852**	**91.294**

2.3 Design Mix

Nominal mix design is carried out. Mix design for M20 grade concrete with 5% and 10% replacement of rice husk ash to the weight of cement and 0.5% of carbon fibre filament to the weight of cement is also used. Both the samples are replaced with same amount of carbon fibre filament. Water cement ratio is assigned as 0.5 and it is corrected to 0.55.The conventional sample with no replacement of rice husk ash, carbon and methyl cellulose is also prepared. Another set of samples with carbon fibre replacement and rice husk replacement are used. The samples are cured under moist condition for 28 days.

III. RESULTS AND DISCUSSION

Various tests on Fresh and Hardened Concrete are performed, on all the concrete samples and their results are tabulated and analyzed.

3.1 Results on Fresh Properties

Table – 9 Fresh Concrete Test Results

Sample	Methyl Cellulose (%)	Slump Value (mm)	Flow Table (%)	Compaction Factor
S-1	0	100	71.20	0.94
S-2	0.4	130	86.00	0.97
S-3	0.4	115	76.60	0.95
S-4	0.4	140	65.33	0.95
S-5	0	105	62.50	0.91
S-6	0	110	67.33	0.90

3.2 Discussion on Fresh Properties

- Increase in rice husk ash increases Slump value.
- Addition of methylcellulose makes it highly consistent.
- As a whole fresh properties test indicates the concrete is highly workable.
- A basic comparison has been made in strength (Harden properties) for the different samples.

3.3 Results on Hardened Properties

Table –10 Specimen Details

Description	Compressive strength	Split tensile strength	Flexural strength
Shape of specimen	**Cube**	**Cylinder**	**Beam**
Cross sectional area (Sq.mm)	L = 150 mm B = 150 mm H = 150 mm	L = 300 mm D = 150 mm	L = 500 mm B = 150 mm H = 150 mm
Age of specimen	28 days	28 days	28 days
Curing condition	Moist	Moist	Moist
Weight of specimen (Kg)	8.45 Kg	13.30 Kg	6.12 Kg
Load rate (KN/s)	2.75	2.75	2.75

Figure 3. Compression Test

Figure 4. Split Tensile Test

Figure 5. Flexural Test

Table –11 Strength Test Results of the Samples for 7th day

Sample	Compressive strength (MPa)	Split tensile strength (MPa)	Flexural strength (MPa)
S-1	6.50	0.53	0.72
S-2	**12.30**	**0.66**	**1.28**
S-3	9.60	0.64	1.20
S-4	4.49	0.44	0.58
S-5	4.87	0.47	0.53
S-6	3.80	0.41	0.48

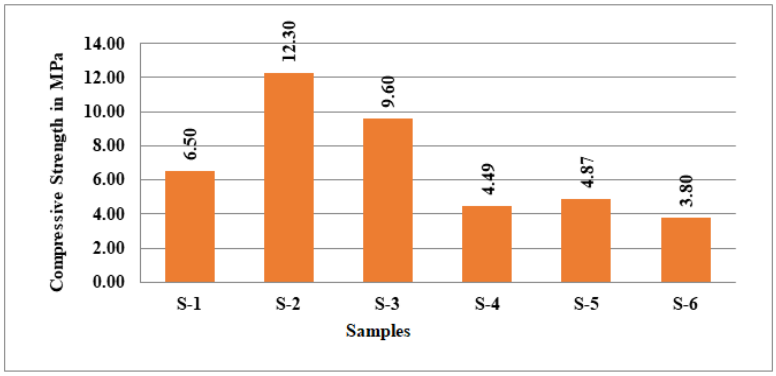

Figure 6. Graph showing Compressive Strength values for different samples on 7th day Test

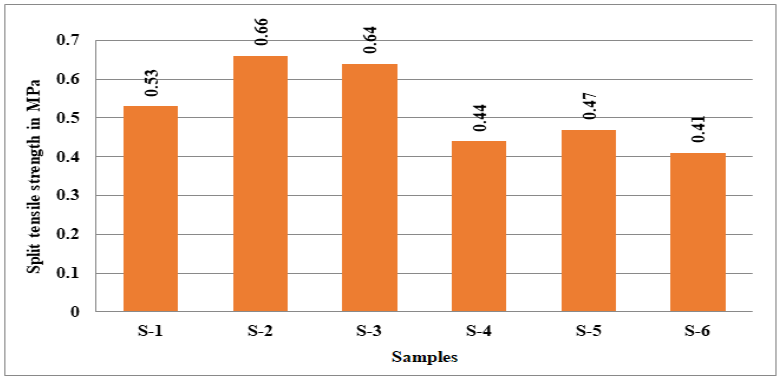

Figure 7. Graph showing Split Tensile Strength values for different samples on 7th day Test

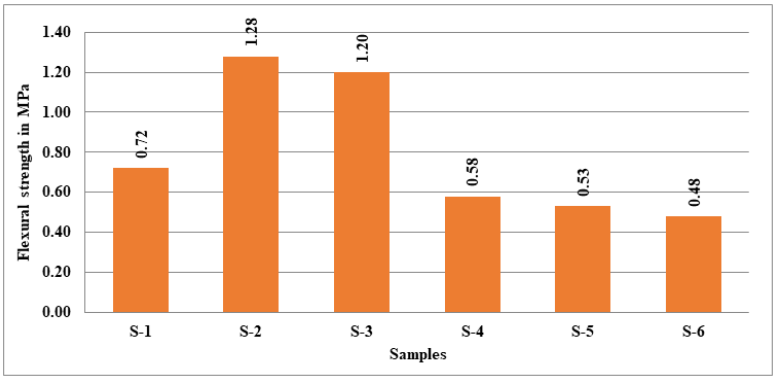

Figure 8. Graph showing Flexural Strength values for different samples on 7th day Test

Table –12 Strength Test Results of the Samples for 14th day

Sample	Compressive strength (MPa)	Split tensile strength (MPa)	Flexural strength (MPa)
S-1	13.00	1.06	1.44
S-2	**24.55**	**1.32**	**2.55**
S-3	19.19	1.28	2.40
S-4	8.98	0.88	1.15
S-5	9.74	0.93	1.06
S-6	7.60	0.81	0.95

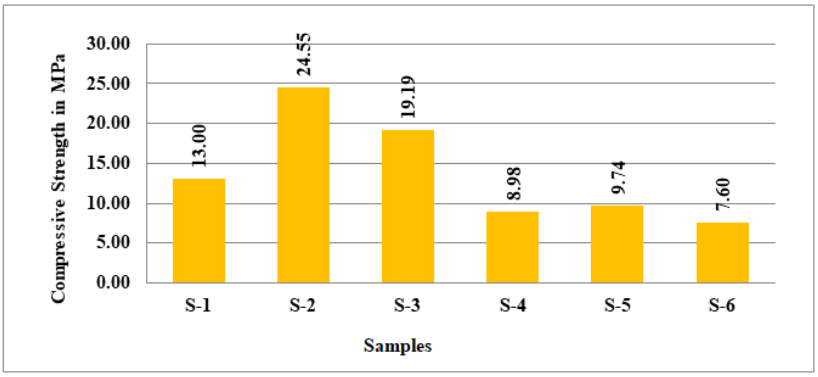

Figure 9. Graph showing Compressive Strength values for different samples on 14th day Test

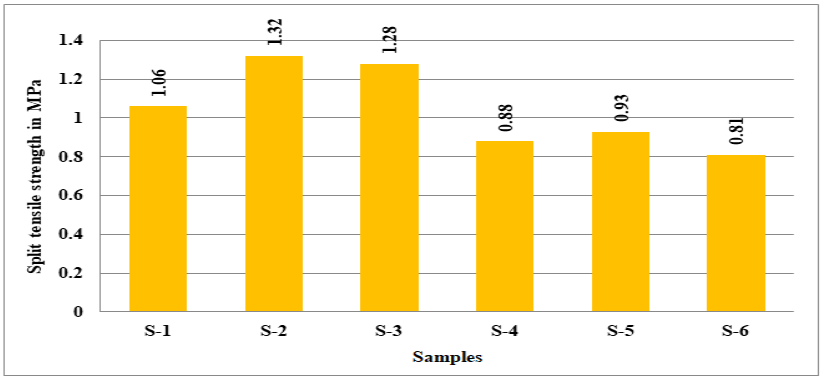

Figure 10. Graph showing Split Tensile values for different samples on 14th day Test

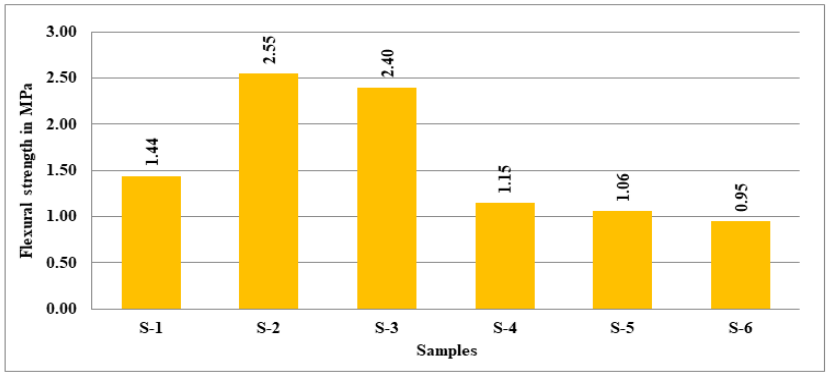

Figure 11. Graph showing Flexural Strength values for different samples on 14th day Test

Table –13 Strength Test Results of the Samples for 28th day

Sample	Compressive strength (MPa)	Split tensile strength (MPa)	Flexural strength (MPa)
S-1	26.00	2.12	2.88
S-2	**49.10**	**2.63**	**5.10**
S-3	38.38	2.58	4.80
S-4	17.98	1.76	2.30
S-5	19.48	1.86	2.12
S-6	15.18	1.62	1.90

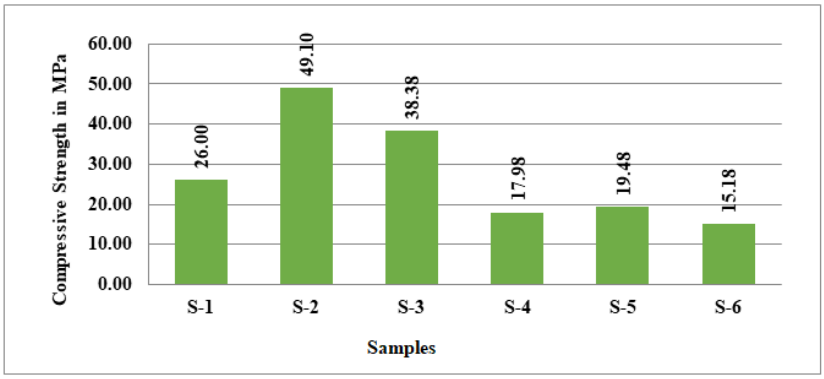

Figure 12. Graph showing Compressive Strength values for different samples on 28th day Test

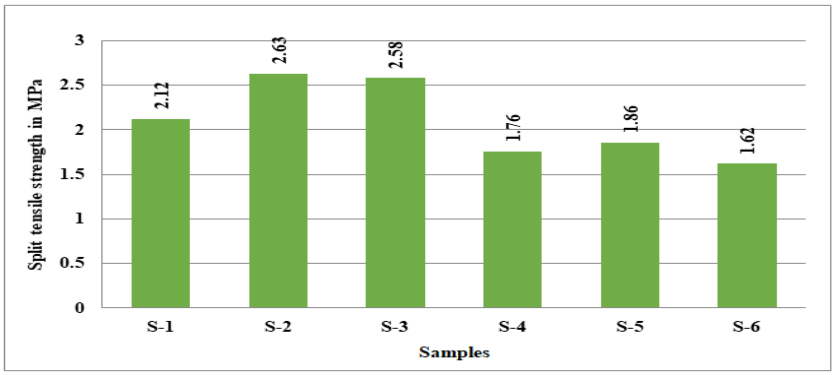

Figure 13. Graph showing Split Tensile values for different samples on 28th day Test

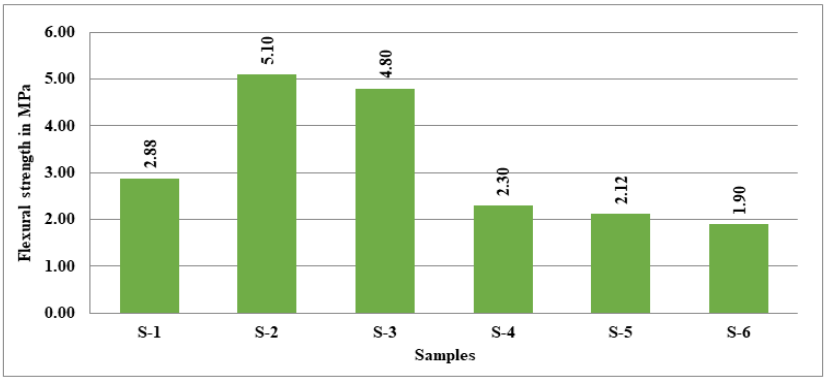

Figure 14. Graph showing Flexural Strength values for different samples on 28th day Test

3.4 Discussion on Hardened Properties

- Compressive strength increases in addition of rice husk ash, Carbon fibre and methyl cellulose. It is noted that 5% replacement of rice husk ash shows rapid increase in its strength when compared to 10% replacement of rice husk ash and conventional sample. It shows that increase of rice husk ash decrease the compressive strength of Concrete 0.5% carbon fibre filament to the weigh to of cement is added to both 5%, 10% replacement of rice husk ash. It is noted that the samples with only rice husk ash (both 5% and 10%) and carbon fibre replacements have shown the less strengths than conventional samples.
- Split tensile strength increases in addition of rice husk ash, carbon fibre and methyl cellulose. It is noted that 5% replacement of rice husk ash shows increase in its flexural strength when compared to conventional and 10% replacement of rice husk ash 0.5% carbon fibre filament to the weight of cement is added to both 5%, 10% replacement of rice husk ash. It is noted that the samples with only rice husk ash (both 5% and 10%) and carbon fibre replacements have shown the less strengths than conventional samples.
- Flexural strength increases in addition of rice husk ash, carbon fibre and methyl cellulose. It is noted that 5% replacement of rice husk ash shows rapid increase in its flexural strength when compared to conventional and 10% replacement of rice husk ash. 0.5% carbon fibre filament to the weight of cement is added to both 5%, 10% replacement of rice husk ash. It is noted that the samples with only rice husk ash (both 5% and 10%) and carbon fibre replacements have shown the less strengths than conventional samples.
- It is found that there is about 88% increase in compressive strength, 77% increase in flexural strength and 24% increase in split tensile strength of Concrete sample when compared to the conventional concrete sample. Its fresh properties test indicates its high workability. It is found that there has been decrease in compressive, flexural and spilt tensile strengths compared to conventional concrete when carbon fibre and rice husk ash are separately casted.

IV. CONCLUSION

In the present study, a simplified experimental study has been proposed and carried out for showing the impact of carbon fibre admixture and rice husk ash in concrete structure. The response of study has been presented in the form of strength of the specimen on 28 days. A comparison study has been carried out one by one with and without Admixture, with and without RHA, Carbon Fibre.

Based on this, the following generalized conclusions can be drawn:

- In this study, maximum strength was obtained in 5 percent replacement of rice husk ash compared to 10 percent replacement of rice husk ash, where increase in compressive strength was 88%, flexural strength was 77% and split tensile strength was 24% after 28 days curing.
- This increase in strength is caused as a result of increase in bond strength by rice husk ash and addition of carbon fiber lead to an increase in tensile strength and reduced cracks in the concrete samples.
- It is found that workability of fresh concrete increases with increase in rice husk ash.
- Cement quantity required is lesser than conventional concrete, hence reducing the greenhouse gases produced due to usage of cement.

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