REDUCTION IN INNER REINFORCEMENT OF BEAM BY REINFORCEMENT WITH CARBON FIBER WRAP REINFORCED POLYMER (CFRP) COMPOSITESPOD

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Abstract- Structural strengthening of civil engineering elements like beams, columns etc in order to effects of degradation has been under immense research. Improvement in material science revealed other alternative materials which could serve as reinforced composites; the one used in our study is Carbon Fiber Reinforced Polymer (CFRP).
The present study focus on the behavior of reinforced concrete beams using by Carbon Fiber Reinforced Polymer (CFRP) subjected to external loading. In the present research, under reinforced beam sections has reduced their inner reinforcement and provide external reinforcement by the application of Carbon Fiber Reinforced Polymer (CFRP) by Wet Layup method. This technique to study the strength characteristics of beam specimens, both control beam condition and with warping of CFRP layers condition.
Hence, experiments will conduct on Reinforced Concrete Beam with and without Carbon Fiber Reinforced Polymer (CFRP) warping

Keywords- Concrete, Non-Destructive Testing, Compressive Strength, Flexural Strength, Rebound Hammer, CFRP Sheet

OBJECTIVES OF RESEARCH WORK

The objective of the research is to evaluate the performance of Carbon Fiber Reinforced Polymer (CFRP) in Civil Engineering Construction work. To achieve this, the effects of Carbon Fiber wrapping in different layers as External Reinforcement in Beam.
The research covers the use of Carbon Fiber Reinforced Polymer (CFRP) as a Reinforcement material in the construction of Beams.

METHODOLOGY WITH RESULTS OBTAINED

The experimental result obtained from previously discussed methodology has been analyzed and discussed under this chapter. The investigation consists of testing of beam for compressive strength and flexural strength test. Beam Specimens are tested for 7 days and 28 days strengths.
Three sets of concrete beam will be tested for their strengths-

In SET-I five concrete beams will be tested without CFRP wrapping. In SET-II five concrete beams will be tested with only single layer of CFRP wrapping. In SET-III five concrete beams will be tested with double layer of CFRP wrapping.
In SET-I concrete beam will be taken as the control concrete beam without CFRP wrapping and minimum weight of steel reinforcement.
In SET-II concrete beam will be providing only single wrap of CFRP sheet on the full dimensions and reduced some amount of steel reinforcement.
In SET-III concrete beam will be providing double wrap of CFRP sheet on the full dimensions and reduced some amount of steel reinforcement.

ANALYSIS OF REBOUND HAMMER TEST

Compressive strength of M-20 grade is 20 N/mm2. 7 days and 28 days characteristic compressive strength of conventional concrete (M-20) is
13.5 N/mm^2 and 20 N/mm^2 respectively. Since, in this research work,

- 7 days and 28 days compressive strength of concrete beam without CFRP sheet is 13.98 N/mm^2 and 22.92 N/mm^2 respectively.
- 7 days and 28 days compressive strength of concrete beam with single Sheet of CFRP layer is 14.24 N/mm^2 and 22.98 N/mm^2 respectively.
- 7 days and 28 days compressive strength of concrete beam with double Sheet of CFRP layer is 14.28 N/mm^2 and 23.01 N/mm^2 respectively.

Compressive strength of concrete beam for 7 days and 28 days is shown in the tables

TABLE NO. 4.1 CONTROL CONCRETE BEAM AVERAGE COMPRESSIVE STRENGTH 7 DAYS (N/MM^2)

S.NO.	Rebound Number	Compressive Strength(N/mm^2)	Steel Weight(Kg)	Average Strength(N/mm^2)
1	11.8	13.19	3.25	13.98
	11.4	14.62	3.25	
	11.8	15.14	3.25	
	12.6	12.17	3.25	
	12.6	14.78	3.25	

TABLE NO. CONTROL CONCRETE BEAM AVERAGE COMPRESSIVE STRENGTH 28 DAYS (N/MM^2)

S.NO.	Rebound Number	Compressive Strength(N/mm^2)	Steel Weight(Kg)	Average Strength(N/mm^2)
2	21.70	23.38	3.25	22.92
	23.80	25.35	3.25	
	21.10	22.55	3.25	
	19.25	19.68	3.25	
	22.50	23.65	3.25	

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TABLE NO. 4.3 COMPRESSIVE STRENGTH OF CONTROL CONCRETE BEAM

Sample No.	Compressive Strength (N/mm^2) at the age of	
	7 Days	28 Days
1	13.19	23.38
2	14.62	25.35
3	15.14	22.55
4	12.17	19.68
5	14.78	23.65

GRAPH NO. 4.1 COMPRESSIVE STRENGTH GRAPHS

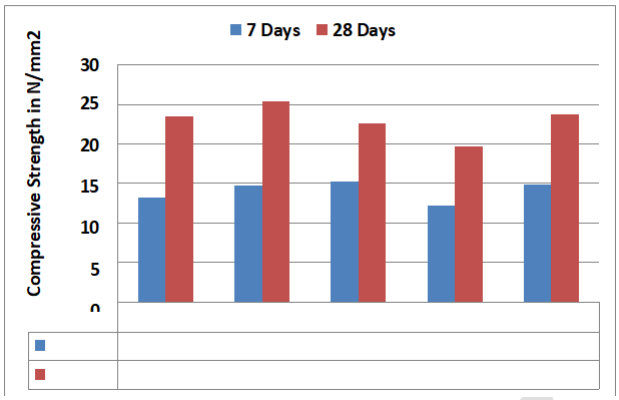


TABLE NO. 4.4 BEAM WITH SINGLE WRAP OF CFRP SHEET AVERAGE COMPRESSIVE STRENGTH 7 DAYS (N/MM^2)

S.NO.	Rebound Number	Compressive Strength(N/mm^2)	Steel Weight(Kg)	Average Strength(N/mm^2)
1	11.8	13.39	3.15	14.24
	11.4	14.82	3.15	
	11.8	15.54	3.15	
	12.6	12.47	3.15	
	12.6	14.98	3.15	

TABLE NO. 4.5 BEAM WITH SINGLE WRAP OF CFRP SHEET AVERAGE COMPRESSIVE STRENGTH 28 DAYS (N/MM^2)

S.NO.	Rebound Number	Compressive Strength(N/mm^2)	Steel Weight(Kg)	Average Strength(N/mm^2)
2	21.70	23.38	3.15	22.98
	23.80	25.35	3.15	
	21.10	22.55	3.15	
	19.25	19.68	3.15	
	22.50	23.95	3.15	

TABLE NO. 4.6 COMPRESSIVE STRENGTH OF BEAM WITH SINGLE WRAP OF CFRP SHEET

Sample No.	Compressive Strength (N/mm^2) at the age of	
	7 Days	28 Days
1	13.39	23.38
2	14.82	25.35
3	15.54	22.55
4	12.47	19.68
5	14.98	23.95

GRAPH NO. 4.2 COMPRESSIVE STRENGTH GRAPHS

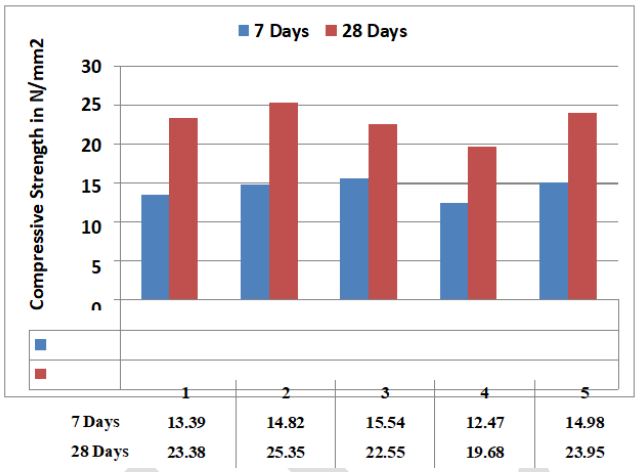


TABLE NO. 4.7 BEAM WITH DOUBLE WRAP OF CFRP SHEET AVERAGE COMPRESSIVE STRENGTH 7 DAYS (N/MM^2)

S.NO.	Rebound Number	Compressive Strength(N/mm^2)	Steel Weight(Kg)	Average Strength(N/mm^2)
1	11.8	13.49	3.08	14.28
	11.4	14.92	3.08	
	11.8	15.64	3.08	
	12.6	12.52	3.08	
	12.6	14.85	3.08	

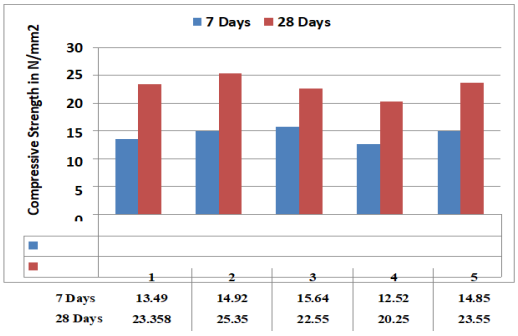
TABLE NO. 4.8 BEAM WITH DOUBLE WRAP OF CFRP SHEET AVERAGE COMPRESSIVE STRENGTH 28 DAYS (N/MM^2)

S.NO.	Rebound Number	Compressive Strength(N/mm^2)	Steel Weight(Kg)	Average Strength(N/mm^2)
2	21.70	23.38	3.08	23.01
	23.80	25.35	3.08	
	21.10	22.55	3.08	
	19.25	20.25	3.08	
	22.50	23.55	3.08	

TABLE NO. 4.9 COMPRESSIVE STRENGTH OF BEAM WITH DOUBLE WRAP OF CFRP SHEET

Sample No.	Compressive Strength (N/mm^2) at the age of	
	7 Days	28 Days
1	13.49	23.38
2	14.92	25.35
3	15.64	22.55
4	12.52	20.25
5	14.85	23.55

GRAPH NO. 4.3 COMPRESSIVE STRENGTH GRAPHS



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ANALYSIS OF FLEXURAL STRENGTH TEST

Flexure strength of concrete is calculated using empirical formula given F= PL/ (bd^2)
Since, in this research work,

- 7 days and 28 days flexural strength of concrete beam without CFRP sheet is 3.46 N/mm^2 and 4.43 N/mm^2 respectively.
- 7 days and 28 days flexural strength of concrete beam with single Sheet of CFRP layer is 3.94 N/mm^2 and 4.88 N/mm^2 respectively.
- 7 days and 28 days flexural strength of concrete beam with double Sheet of CFRP layer is 4.29 N/mm^2 and 5.31 N/mm^2 respectively.

Flexural strength of concrete beam for 7 days and 28 days is shown in the table

TABLE NO. 4.10 CONTROL CONCRETE BEAM AVERAGE FLEXURAL STRENGTH 7 DAYS (N/MM^2)

S.No.	Flexural Strength (N/mm^2)	Steel Weight (kg)	Average Flexural Strength (N/mm^2)
1	3.90	3.25	3.46
	4.25	3.25	
	3.50	3.25	
	3.15	3.25	
	2.50	3.25	

TABLE NO. 4.11 CONTROL CONCRETE BEAM AVERAGE FLEXURAL STRENGTH 28 DAYS (N/MM^2)

S.No.	Flexural Strength (N/mm^2)	Steel Weight (kg)	Average Flexural Strength (N/mm^2)
2	4.90	3.25	4.43
	5.50	3.25	
	4.72	3.25	
	3.90	3.25	
	3.15	3.25	

TABLE NO. 4.12 FLEXURAL STRENGTH OF CONTROL CONCRETE BEAM

Sample No.	Flexural Strength (N/mm^2) at the age of	
	7 Days	28 Days
1	3.90	4.90
2	4.25	5.50
3	3.50	4.72
4	3.15	3.90
5	2.50	3.15

GRAPH NO. 4.4 FLEXURAL STRENGTH GRAPHS

TABLE NO. 4.13 BEAM WITH SINGLE WRAP OF CFRP SHEET AVERAGE FLEXURAL STRENGTH 7 DAYS (N/MM^2)

S.No.	Flexural Strength (N/mm^2)	Steel Weight (kg)	Average Flexural Strength (N/mm^2)
1	4.30	3.15	3.94
	4.85	3.15	
	3.90	3.15	
	3.75	3.15	
	2.90	3.15	

TABLE NO. 4.14 BEAM WITH SINGLE WRAP OF CFRP SHEET AVERAGE FLEXURAL STRENGTH 28 DAYS (N/MM^2)

S.No.	Flexural Strength (N/mm^2)	Steel Weight (kg)	Average Flexural Strength (N/mm^2)
2	5.20	3.15	4.88
	5.95	3.15	
	4.90	3.15	
	4.75	3.15	
	3.60	3.15	

TABLE NO. 4.15 FLEXURAL STRENGTH OF BEAM WITH SINGLE WRAP OF CFRP SHEET

Sample No.	Flexural Strength (N/mm^2) at the age of	
	7 Days	28 Days
1	4.30	5.20
2	4.85	5.95
3	3.90	4.90
4	3.75	4.75
5	2.90	3.60

TABLE NO.4.16 BEAM WITH DOUBLE WRAP OF CFRP SHEET AVERAGE FLEXURAL STRENGTH 7 DAYS (N/MM^2)

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S.No.	Flexural Strength (N/mm^2)	Steel Weight (kg)	Average Flexural Strength (N/mm^2)
1	4.60	3.08	4.29
	5.25	3.08	
	4.30	3.08	
	4.15	3.08	
	3.15	3.08	

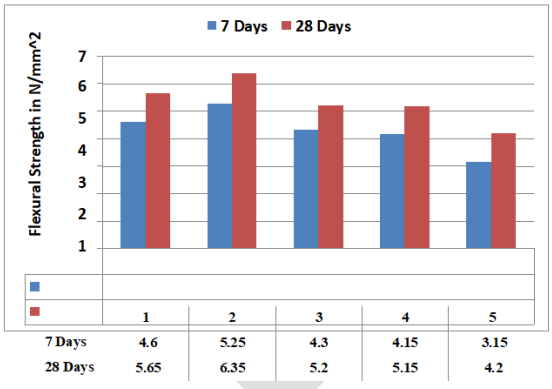
TABLE NO. 4.17 BEAM WITH DOUBLE WRAP OF CFRP SHEET AVERAGE FLEXURAL STRENGTH 28 DAYS (N/MM^2)

S.No.	Flexural Strength (N/mm^2)	Steel Weight (kg)	Average Flexural Strength (N/mm^2)
2	5.65	3.08	5.31
	6.35	3.08	
	5.20	3.08	
	5.15	3.08	
	4.20	3.08	

TABLE NO. 4.18 FLEXURAL STRENGTH OF BEAM WITH DOUBLE WRAP OF CFRP SHEET

Sample No.	Flexural Strength (N/mm^2) at the age of	
	7 Days	28 Days
1	4.60	5.65
2	5.25	6.35
3	4.30	5.20
4	4.15	5.15
5	3.15	4.20

GRAPH NO. 4.6 FLEXURAL STRENGTH GRAPHS



CONCLUSIONS

- The strength properties of concrete beam with CFRP wrapping and reduction in inner reinforcement were investigated for 7 and 28 Days.
- The compressive strength and flexural strength values varied.

In this study compressive strength and flexure strength test is conducted. The conclusions are as follows-

- Compressive strength of concrete beam with single layer of CFRP sheet and double layer of CFRP sheet is found to be higher than control concrete beam. In this research work it has been found compressive strength of concrete beam with CFRP sheet is more than for every sample. The average compressive strength of concrete beam with single wrap of CFRP sheet at 7 days and 28 days is 14.24 N/mm^2 and 22.98 N/mm^2 respectively. The average compressive strength of concrete beam with double wrap of CFRP sheet at 7 days and 28 days is 14.28 N/mm^2 and 23.01 N/mm^2 respectively which is quite satisfactory to be used in construction.
- Flexural strength of concrete beam with single layer of CFRP sheet and double layer of CFRP sheet is found to be higher than control concrete beam. In this research work it has been found flexural strength of concrete beam with CFRP sheet is more than for every sample. The average flexural strength of concrete beam with single wrap of CFRP sheet at 7 days and 28 days is 3.94 N/mm^2 and 4.88 N/mm^2 respectively. The average flexural strength of concrete beam with double wrap of CFRP sheet at 7 days and 28 days is 4.29 N/mm^2 and 5.31 N/mm^2 respectively which is quite satisfactory to be used in construction.

The above results are achieved at ambient temperature curing. Thus, it is concluded that beam with CFRP wrapping can serve as an alternate to beam without CFRP wrapping with certain precautions.

FUTURE SCOPE

This study can be further extended in following areas-

- Larger dimensions of beam can be investigated for flexure.
- The effect of CFRP on beams with larger amounts of steel reinforcement should also be studied.
- A more attention will be taken for finding the fire resistance properties of carbon fiber composites need to be evaluated. Since it is a composite material, it will be also helpful to resist fire.

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