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An Experimental Study For Strengthening Of Reinforced Concretre Beam Using Carbon Fibre

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Abstract —*This paper explain about use of carbon fibre CFRP for strengthening of structural elements, this experimental study is based on beam. The beams resisting torsion can be strengthened using carbon fibre CFRP. An experimental study for the improvement of the torsional resistance of reinforced concrete beam using CFRP is presented in this paper. Total 18 beams size of 150mm*150mm*1500mm are cast. Beams are strengthened by CFRP with different wrapping configuration. All beams are subjected to torsional moment.*

Keywords- *Carbon fibre reinforced polymer CFRP, Reinforced concrete beam, Torsion*

I. INTRODUCTION

In the world there are many methods for strengthening of reinforced concrete structures. Strengthening of reinforced concrete structures is an important task in the field of structural maintenance. The aim of strengthening is to increase the capacity of an existing structural element. In this topic we discuss about the different types of CFRP laminates and various pattern of wrapping are used in strengthening of reinforced concrete beam, Concrete member can now easily strengthened by CFRP laminates. Strengthening of concrete structure with CFPR lamination is the best method of retrofitting because it offer high strength to weight ratio, anticorrosion and faster installation. Some researcher worked on beam and column retrofitted with CFRP and GFRP for study purpose for some parameters like strengthening, ductility and durability. CFRP strengthening is simple method to give some additional strength and increase life of structure. The carbon fibre reinforced polymer CFRP and glass fibre reinforced polymer GFRP is widely used for structural strengthening.

II. EXPERIMENTAL WORK

In the experimental study total eighteen reinforced concrete beam were casted, out of which three are controlled beam and remaining fifteen beams are grouped of five wrapping pattern, in this study considered three specimen for each wrapping pattern.

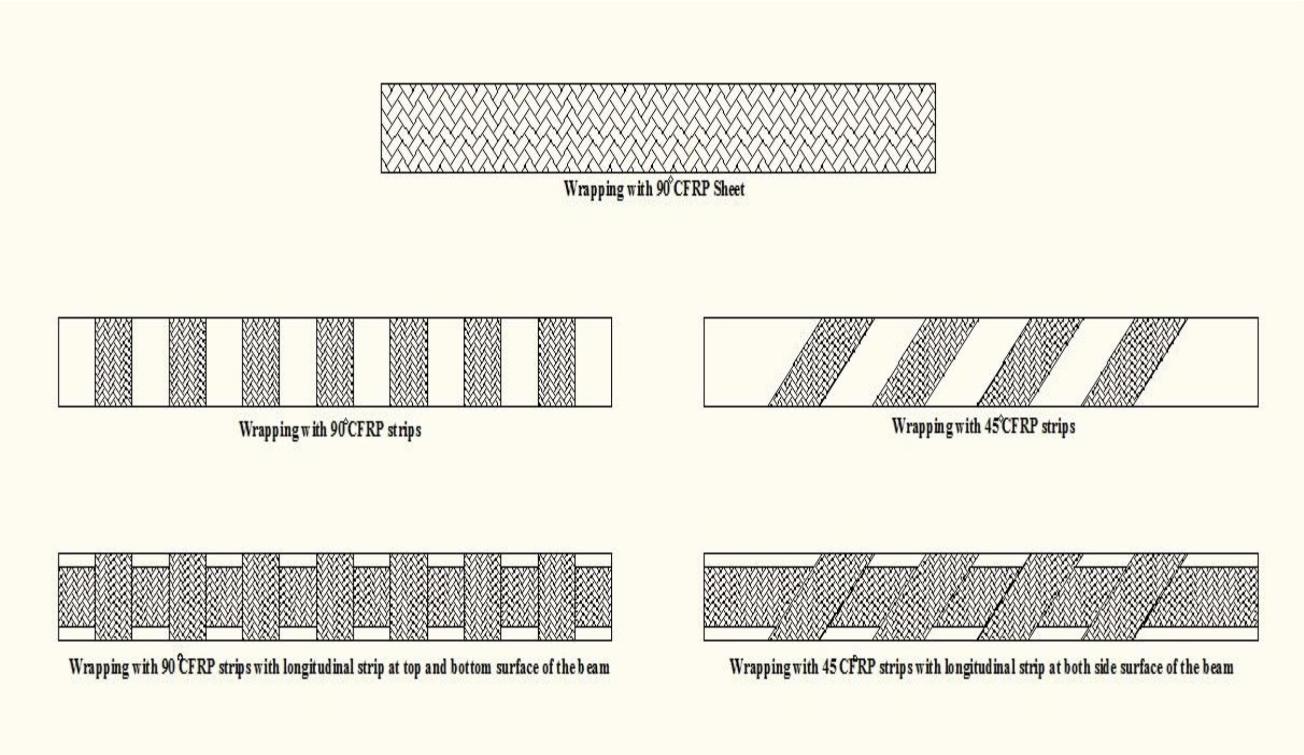
2.1 Specimen Characteristics

Total eighteen RCC beams were casted with M25 grade concrete. The size of beam is 150mm*150mm*1500mm, with providing reinforcement is 3nos -12mmϕ at bottom and 2nos-12mmϕ at top (Fe 415 HYSD), providing 8mm stirrups at spacing 70mm c/c.

2.2 Apply Different Types of Wrapping Pattern

Different types of wrapping patterns are applied on beams with help of CFRP and epoxy resin, various types of wrapping patterns are listed below,

1. Wrapping with 90º CFRP sheet (CFFWP 90º)
2. Wrapping with 90º CFRP strips (CFSWP 90º)
3. Wrapping with 45º CFRP strips (CFSWP 45º)
4. Wrapping with 90º CFRP strips with longitudinal strip at top and bottom surface of the beam (CFSWPLTB 90º)
5. Wrapping with 45º CFRP strip with longitudinal strip at both side surface of the beam (CFSWPLBS 45º)



"Figure 1 Various types of wrapping pattern"

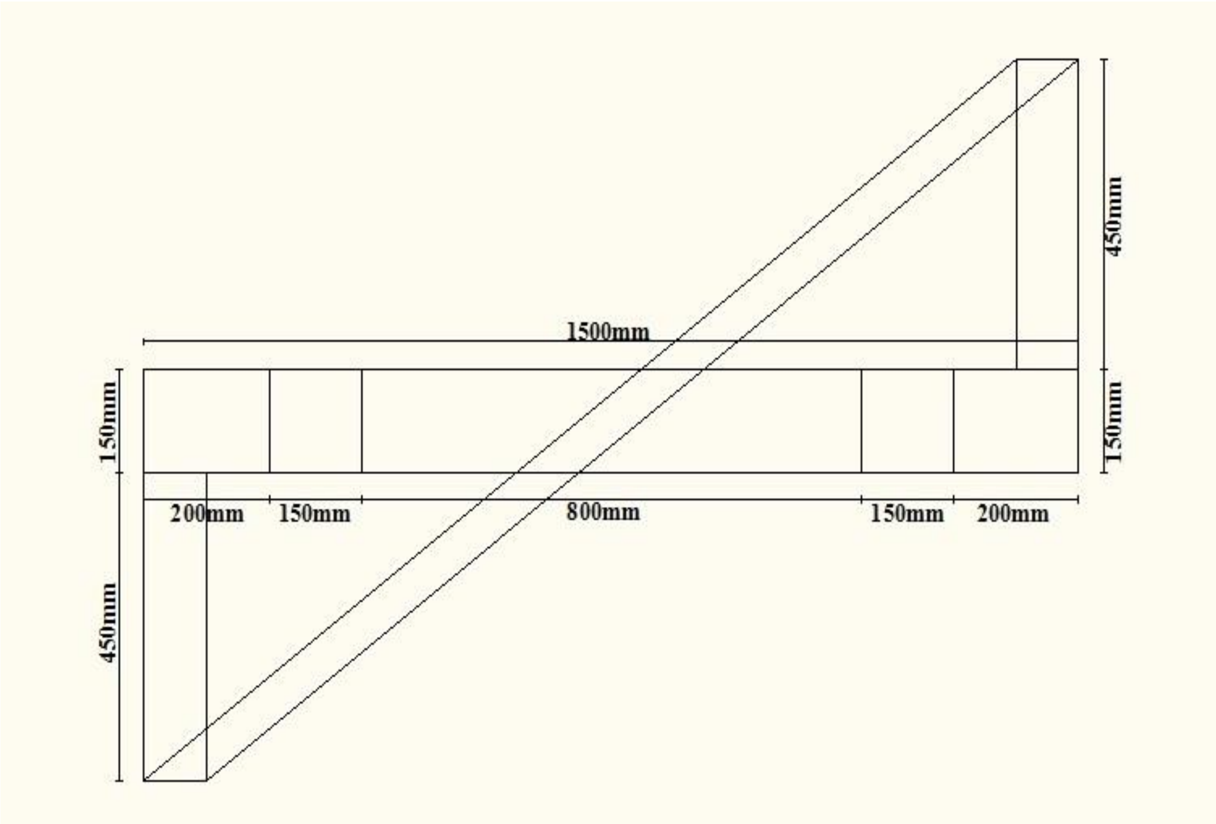
"Table 1 Properties of Fibre"

Laminates thickness	0.129mm
Tensile E-Modulus	2,30,000 N/mm²
Tensile Strength	4000 N/mm²
Elongation at Break	1.7 %
Average Tensile Modulus	225 KN/mm²
Average Tensile Strength	3200 N/mm²

2.3 Instrumentation and Test Setup

Loading capacity of the frame is 500 KN. and beam was tested on loading frame. The load was applied with the help of hydraulic jack of capacity 50 tones. Torsion assembly is specially fabricated. The position of lever arm coincides with support, the beam is subjected to pure torsion. Dial gauge is used for measuring displacement under the lever arm. The load from hydraulic jack is distributed to beam through cross beam resting on the end of lever arm attached to beam. So, half of the applied load will act the end of each lever arm and develop torsion at central zone of beam. To calculate twisting moment, load multiplied by length of lever arm from the centre of beam. The twisting angle at each lever arm is obtained from vertical displacement and length of lever arm. The torsion test setup is shown in figure 2 and 3.

"Figure 2 Torsion Test Setup"



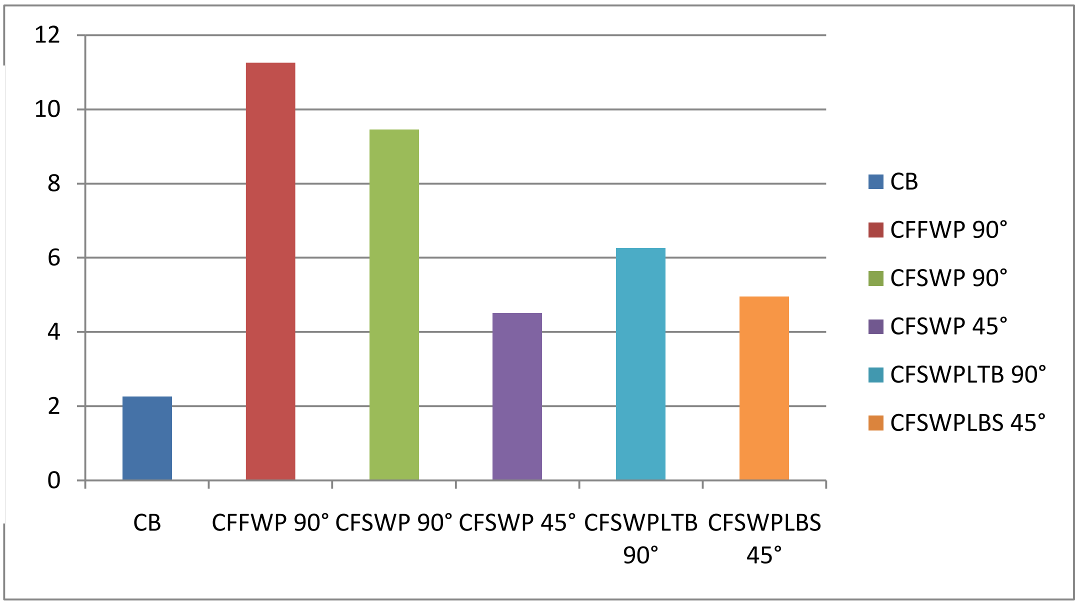
"Figure 3 Schematic Diagram of Torsion Test Setup"

III. TEST RESULTS

The test results are shown in table 2

"Table 2 Test Result"

Beam Specimen	Average Cracking Load (KN)	Average Cracking Twisting Moment (KN·m)	Angle of Twist (Radian)
Control Beam	2.5	2.25	0.0024
CFFWP 90°	12.50	11.25	0.011
CFSWP 90°	10.50	9.45	0.012
CFSWP 45°	5	4.5	0.0051
CFSWPLTB 90°	7.5	6.75	0.0090
CFSWPLBS 45°	5.5	4.95	0.010



"Chart 1 Cracking Twisting Moment"

IV. DISCUSSION & CONCLUSION

4.1 Discussion

1. The strengthening of RCC beam is done by using CFRP.
2. To apply torsion with help of mechanism of torsion test.
3. All beams are check in torsion, not bending and shear.
4. In control beam after applied torsional moment, cracks develop at the centre of beam and cracks develop diagonally on the surface of beam. No one cracks develop near the support of beam. It means pure torsion was applied to all the beams.
5. As per expectation the beam of full wrapping with CFRP sheet gave well performance compared to other wrapped beams.
6. As per experimental results the beam of full wrapping with CFRP sheet is able to take more twisting moment (11.25 KN·m) compared to other beams, but in this beam consumption of material is more.
7. The second pattern is wrapping with 90° CFRP strips at 3inch interval. From the experimental test result the twisting moment capacity of this pattern is near about full wrapping pattern and need of material is less as compare full wrapped beam.

8. The third pattern is wrapping with 45° CFRP strips at 3inch interval, but twisting moment result of this wrapping pattern is less (4.5KN·m) as compare wrapping with 90° strips.
9. Remaining two wrapped beams are wrapping with 90° CFRP strips with longitudinal strip at top and bottom surface of the beam and wrapping with 45° CFRP strips with longitudinal strip at both side surface of the beam take twisting moment is 6.75 and 4.95 KN·m respectively.

4.2 Conclusion

1. All the beams are failed in diagonal cracks developed due to torsion. It can be seen that the assembly designed by the candidate have performed well and applied pure torsion to all the beams.
2. No flexural and shear cracks are observed in any of the beam, beams failed due to torsion only.
3. Cracks developed at central zone of the beam.
4. In the strengthened beams, majority delamination of the CFRP sheets are observed and then cracks developed in the beams.
5. The best performer wrapping pattern amongst all is wrapping with 90° CFRP sheet (CFFWP 90°**)**
6. Wrapping with 90° strips at 3inch interval (CFSWP 90°**)** have performed well, Therefore, this type of wrapping pattern (CFSWP 90°**)** can be considered as the best option for the torsional strengthening.
7. From Experimental study we can conclude that wrapping pattern of with 90° CFRP sheet (CFFWP 90°**)** give more torsional strength than other wrapped beam.

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