

Effectiveness Bonding of CFRP Sheet

Aman Dangi

Master of Technology (Civil Engg.), M.R.I.E.M, Rohtak

ABSTRACT

Many old structures became structurally insufficient to carry the new loading conditions requirements. Moreover, they suffer from structural degradation, reinforcement steel bars corrosion, bad weather conditions...etc. Many official authorities in several countries had recognized many old bridges and buildings as structurally deficient by today's standards. Due to these reasons, structural strengthening became an essential requirement and different strengthening techniques appeared in market. The strength and mode of failure were found to depend on the crack pattern. For U wraps, increasing the fiber reinforced polymer (FRP) laminate thickness resulted in reduced web cracking and increased cracking near the free edge of the laminate

INTRODUCTION

In recent years, there is a challenge in civil engineering industry that rehabilitation need is increasing due to the environment and the change of uses. The concrete structure repair techniques now adopted in construction involve replacing the existing element, external prestressing, adding the external reinforcement. The most important consideration is to ensure the adequate connection and composite action between the reinforcement and the existing structures. Strengthening and repairing of RC element by means of steel plate bonding had been widely used in the last decades because of the simple, inexpensive, rapid nature.

The Carbon Fiber Reinforced Polymer (CFRP) materials are well suited to the rehabilitation of civil engineering structures due to their corrosion resistance, high strength, high modulus, light weight, and workability. As the price of CFRP goes down, more and more investigators devote their efforts to the test and analysis of the properties of the structural members strengthening with CFRP materials. In recent years, the design guidelines are developed in many nations, such as Japan, Canada, and the Great Britain. All these Design Codes or Recommendations become the basis of the application of CFRP to strengthen the concrete structures.

Reinforced Concrete (RC) Rectangular Beams:

It is critically important to examine the shear capacity of RC beams which are intended to be strengthened in flexure. As the amount of steel increases, additional strength provided by the carbon decreases. Compared to a beam reinforced heavily with steel only, the beams reinforced with both steel and carbon have adequate deformation capacity in spite of their brittle mode of failure. Clamping or wrapping of the ends of the CFRP laminate combined with adhesive bonding was effective in anchoring the laminate.

The general and regional behaviors of concrete beams with bonded carbon-fiber-reinforced plastic sheets are studied with the help of strain gauges. The appearance of the first cracks and the crack propagation in the structure up to the failure is monitored

EXPERIMENTAL PROGRAM

Concrete

For the experimental program, 9 concrete cylinders of dimensions 4×8in(101.6×203mm) were fabricated from a normal density concrete mix with a maximum aggregate size of 12 mm. The mean compressive strength for all the specimens was 5540Psi(38.8MPa), and according to the ACI formula, tensile strength 3.73 MPa . The Young's modulus of the concrete, estimated from the concrete compressive strength, was found to be $E_c = 33.5$ MPa.

Composite Fabrics

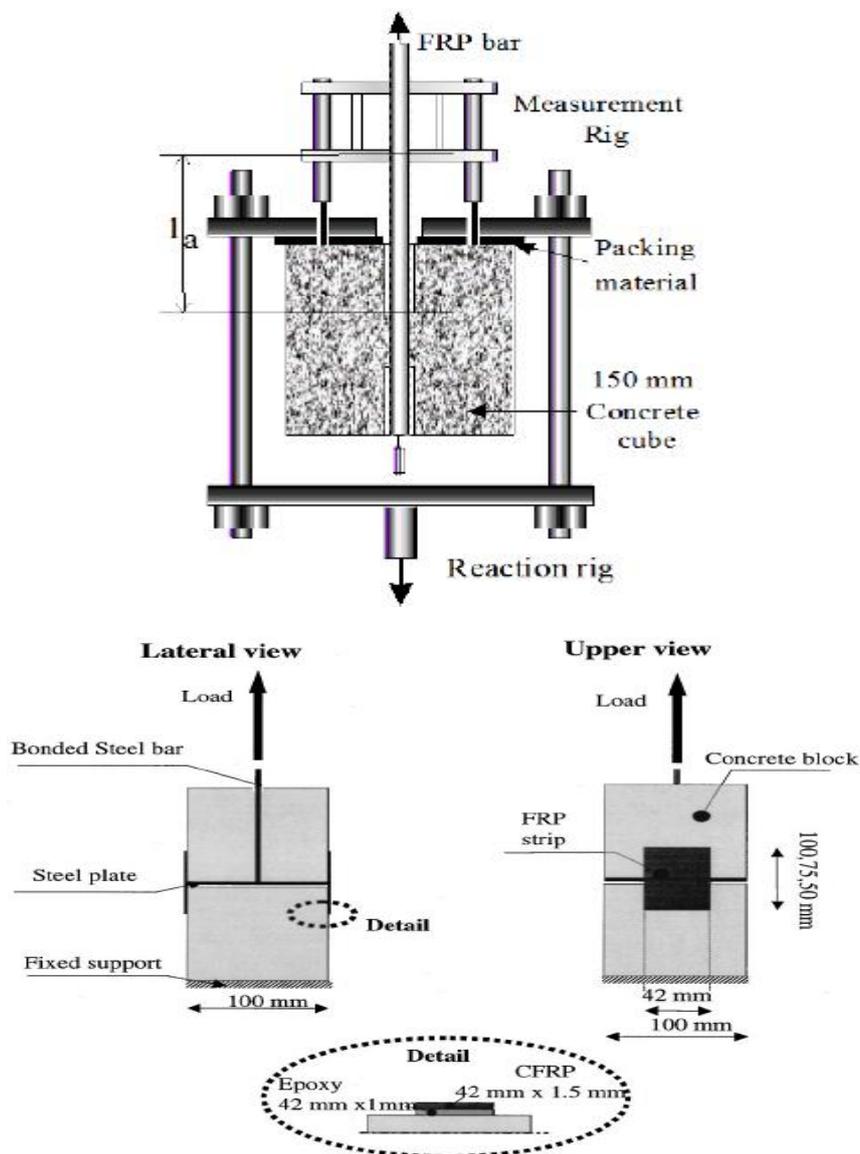
The SikaWrap 103C CFRP sheets made by Sika Corp. were used in this investigation. The composite system was prepared in accordance with the manufacturers' specifications. The unidirectional fabrics were each cut into strips 80 mm wide and were bonded to the concrete blocks. From the data provided by the producer, the values of tensile strength and Young's modulus were 960MPa and 73100MPa respectively. The SikaDur 330 in two components are used as the glue materials. The tensile strength is 30MPa, and the elastic modulus is 2000MPa.

Test of Concrete Blocks

The method used to bond the composite laminates to the concrete blocks consisted of the in-place bonding and curing of the CFRP sheets directly on the concrete. The concrete surface was first sandblasted and then cleaned by air blasting. The thickness of the SikaDur 330 is 1mm. The specimens were cured for 7 days before the bond tests were performed.

Test Device

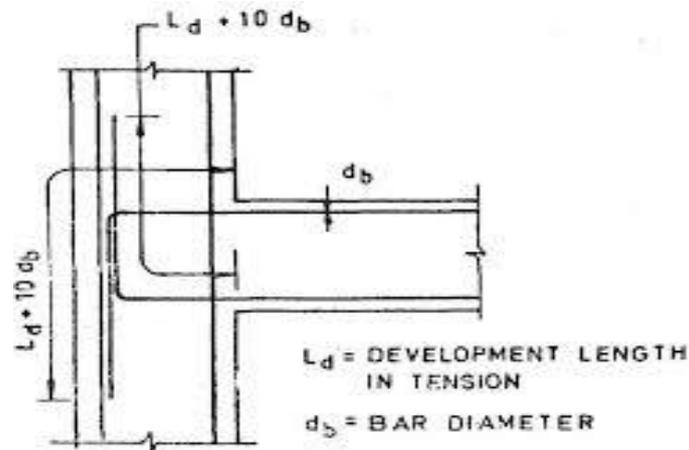
As for the design of the test device, the most important factor should be considered is that to insure the uniform tensile force to apply on the FRP sheet. We use a pin and a loading roller to form a two dimensional flexible device to apply tension force. Considering the difficulty of holding the CFRP sheet, the holding device is not used in our test system. The test setup is shown schematically in Fig. . The test system consists essentially of a FRP sheet bonded to a concrete block, which is then holding to the MTS actuator. A roller is introduced in this test for pulling the FRP sheet to avoid using the holding device which could easily damage the FRP sheet and causing the premature failure of the FRP sheet. The roller is linked to the load cell which is fixed to the loading frame



THE DEVELOPMENT LENGTH

The bond between concrete and CFRP sheet or fabrics is essential for a concrete member retrofitted by external application of a CFRP material as reinforcement. Good bond may help FRP sheet to achieved sufficient tension force at necessary section. The test results show that the failure is mainly caused by the shear failure of concrete block while the adhesive layer never failure. This means that the development length of CFRP sheet mainly depends on the strength of concrete strength. From the calculation in the above section, we know that the main portion of the resistance to the applied tension force is the shear resistance of concrete. Using the same idealized method to simplify the analysis, the linear distribution of the shear resistance of concrete is adopted, and we assume that the resistance from the linear region is negligible.

Specimen	ρ_c (MPa)	l(mm)	b _p (mm)	2P _u (kN)	L _d (mm)	L _d /L
Sp-1	5.6	80	80	37.173	83.0	1.04
Sp-2	5.6	80	80	33.814	75.5	0.94
Sp-3	5.6	120	80	54.276	121.2	1.01
Sp-4	5.6	120	80	50.853	113.5	0.95
Sp-5	5.6	160	80	47.043	105.0	0.66
Sp-6	5.6	160	80	54.603	121.9	0.76



CONCLUSIONS

Providing information on the effectiveness of bonding configurations of CFRP strengthening of the shear-deficient RC beams subjected impact loads.

Observations and experimental data analyses have led to the following conclusions:

A new testing system is developed in this paper, which is very convenient to use for the testing of the bonding properties of concrete and FRP sheet. An analytical model for the prediction of the strain and shear stress distribution is developed in this paper. The test values coincide with the predicted values. The calculation method of the development length of FRP-concrete joint is also given in this paper. The formulation is simple and accurate, which can be used for practical design. From this investigation, we can also conclude that if the bonding length is larger than the development length, there will no contributions to bond strength for the longer part. So it is suggested to limit the stress level of the FRP at the edge of the bond zone.

ADVANTAGES FOR FUTURE WORK

Based on the finding and conclusions of the current study the following recommendations are made for future research in CFRP shear strengthening:

- Study of the bond mechanism between CFRP, AFRP and BFRP and concrete strate.
- CFRP strengthening of RC T-beams with different types of fibers such as carbon, aramid & basalt.
- Strengthening of RC L-beams with CFRP composite.

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