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Strengthening of Shear Deficient RCL and .T- Beams with Externally Bonded FRP Sheet

Aman Dangi

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

ABSTRACT

The rehabilitation of existing reinforced concrete (RC) bridges and building becomes necessary due to ageing, corrosion of steel reinforcement, defects in construction/design, demand in the increased service loads, and damage in case of seismic events and improvement in the design guidelines. Fiber-reinforced polymers (FRP) have emerged as promising material for rehabilitation of existing reinforced concrete structures. The rehabilitation of structures can be in the form of strengthening, repairing or retrofitting for seismic deficiencies. RC T-section is the most common shape of beams and girders in buildings and bridges. Shear failure of RC T-beams is identified as the most disastrous failure mode as it does not give any advance warning before failure.

I.INTRODUCTION

The shear strengthening of RC T-beams using externally bonded (EB) FRP composites has become a popular structural strengthening technique, due to the well-known advantages of FRP composites such as their high strength-to-weight ratio and excellent corrosion resistance. A few studies on shear strengthening of RC T-beams using externally bonded FRP sheets have been carried out but still the shear performance of FRP strengthened beams has not been fully understood. The present study therefore explores the prospect of strengthening structurally deficient T-beams by using an externally bonded fiber reinforced polymer (FRP).This study assimilates the experimental works of glass fiber reinforced polymer (GFRP) retrofitted RC T-beams under symmetrical four-point static loading system. The thirteen number of beams were of the following configurations, (i) one number of beam was considered as the control beam, (ii) seven number of the beams were strengthened with different configurations and orientations of GFRP sheets, (iii) three number of the beams strengthened by GFRP with steel bolt-plate, and (iv) two number of beams with web openings strengthened by U-wrap in the shear zone of the beams. The first beam, designated as control beam failed in shear. The failures of strengthened beams are initiated with the debonding failure of FRP sheets followed by brittle shear failure. However, the shear capacity of these beams has increased as compared to the control beam which can be further improved if the debonding failure is prevented. An innovative method of anchorage technique has been used to prevent these premature failures, which as a result ensure full utilization of the strength

Strengthening of Reinforced Concrete (RC) Rectangular Beams:

When the RC beam is deficient in shear, or when its shear capacity is less than the flexural capacity after flexural strengthening, shear strengthening must be considered. It is critically important to examine the shear capacity of RC beams which are intended to be strengthened in flexure.

Many existing RC members are found to be deficient in shear strength and need to be repaired. Shear failure of RC beams are catastrophic which could occur without any forewarning. Shear deficiencies in reinforced concrete beams may crop up due to factors such as inadequate shear reinforcement, reduction in steel area due to corrosion, use of outdated design codes, increased service load, poor workmanship and design faults. The application of Glass Fiber Reinforced Polymer (GFRP) composite material, as an external reinforcement is a viable technology recently found to be worth for improving the structural performance of reinforced concrete structures.

II.SOME EXPERIMENTALLY RESEARCH

Duthinh and Starnes (2014) tested seven concrete beams reinforced internally with steel and externally with carbon FRP laminate applied after the concrete had cracked under four-point loading. Results showed that FRP was very effective for flexural strengthening. 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 FRP laminate combined with adhesive bonding was effective in anchoring the laminate.

Alex et al. (2015) studied experimentally the effect of shear strengthening of RC beams on the stress distribution, initial cracks, crack propagation, and ultimate strength. Five types of beams with different strengthening carbon-fiber–reinforced plastic sheets are often strengthened in flexure. The experimental results show that it is not necessary to strengthen the entire concrete beam surface. 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 and discussed for five different strengthened beams. In particular, for one of the strengthened RC beams, the failure mode and the failure mechanism are fully analyzed.

III.MIXING OF CONCRETE

Mixing of concrete is done thoroughly with the help of standard concrete mixer machine, to ensure that a uniform quality of concrete is obtained. First coarse and fine aggregates are fed alternately, followed by cement. Then required quantity of water is slowly added into the mixer to make the concrete workable until a uniform colour is obtained. The mixing is done for two minutes after all ingredients are fed inside the mixer as per IS: 456-2000.

Compaction

All specimens were compacted by using 30mm size needle vibrator for good compaction of concrete, and sufficient care was taken to avoid displacement of the reinforcement cage inside the form work. Finally, the surface of concrete was leveled and smoothened by metal trowel and wooden float. After seven hours, the specimen detail and date of concreting was CURING 27 DAYS

Curing of Concrete

Curing is done to prevent the loss of water which is essential for the process of hydration and hence for hardening. Usually, curing starts as soon as the concrete

Concrete

Concrete is a material composed of cement and water combined with sand, gravel, crushed stone, or other inert material such as expanded slag or vermiculite. A strong stone-like mass is formed from chemical reaction of the cement and water. The concrete paste can be easily molded into any form or trowelled to produce a smooth surface.

Fine Aggregate

Fine aggregate/sand is an accumulation of grains of mineral matter derived from disintegration of rocks. It is distinguished from gravel only by the size of the grains or particles, but is distinct from clays which contain organic material. Sand is used for making mortar and concrete and for polishing and sandblasting. Sands containing a little clay are used for making molds in foundries.The grading zone of fine aggregate is zone III as per Indian Standard specifications IS: 383-1970

Coarse Aggregate

Coarse aggregates are the crushed stone is used for making concrete. The commercial stone is quarried, crushed, and graded. Much of the crushed stone used is granite, limestone, and trap rock. The coarse aggregates of two grades are used one retained on 10 mm size sieve and another grade contained aggregates retained on 20 mm size sieve. The maximum size of coarse aggregate was 20 mm and is having specific gravity of 2.88 grading confirming to IS: 383-1970

Water

Water fit for drinking is generally considered good for making the concrete. Water should be free from acids, alkalis, oils, vegetables or other organic impurities. Soft water produces weaker concrete. Water has two functions in a concrete mix. Firstly, it reacts chemically with the cement to form a cement paste in which the inert aggregates are held in suspension until the cement paste has hardened. Secondly, it serves as a vehicle or lubricant in the mixture of fine aggregates and cement. Ordinary clean portable tap water is used for concrete mixing in all the mix.

Reinforcing Steel

High-Yield Strength Deformed (HYSD) bars confirming to IS 1786:1985. The reinforcements used were 20 mm and 10 mm diameter are used for the longitudinal reinforcement and the stirrups are 8 mm diameter. The yield strength of steel reinforcements used in this experimental program is determined by performing the standard tensile test on the three specimens of each bar.

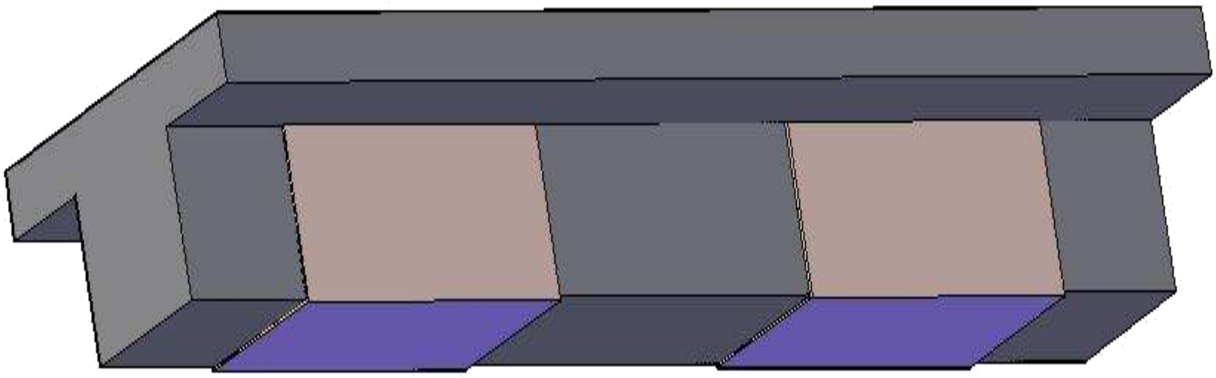

Figure 1: Reinforced T-Beam

IV.CONCLUSIONS

In this experimental investigation the shear behaviour of RC T AND L-beams strengthened by GFRP sheets are studied. The test results illustrated in the present study showed that the external strengthening with GFRP composites can be used to increase the shear capacity of RC T-beams, but the efficiency varies depending on the test variables such as fiber orientations, wrapping schemes, number of layers and anchorage scheme.
Based on the experimental and theoretical results, the following conclusions are drawn:

- Externally bonded GFRP reinforcement can be used to enhance the shear capacity of RC T-beams.
- The test results confirm that the strengthening technique of FRP system can increase the shear capacity of RC T-beams.

The initial cracks in the strengthened beams are formed at a higher load compared to the ones in the control beam.

V.SCOPE FOR FUTURE WORK

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

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

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