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STUDY OF TORSIONAL BEHAVIOUR OF RECTANGULAR REINFORCED CONCRETE BEAMS WRAPPED WITH GFRP

U.Arun Kumar
Department of civil Engineering, Visakha technical campus, Visakhapatnam
V.Bhargavi
Asst.Professor, Department of civil Engineering, Visakha technical campus, Visakhapatnam
E.V.Raghava Rao
Professor, Department of civil Engineering, Visakha technical campus, Visakhapatnam

ABSTRACT

Today's world is demanding tallest structures; engineering marvels for that we need an material having very good strength. Considering this many times fiber reinforcement polymer (FRP) grade material is used as an external reinforcement extensively. But the major problem is strengthening members are subjected to torsion is exploration started very recently. In earthquake prone areas, concentration at torsion failure is very important. In the experimental step up, behavior and performance of concrete beams rectangular in shape is strengthened with externally bonded GFRP (glass fiber reinforced polymer) for study of torsion.

Experiment was performed on rectangular RC beams bonded with GFRP. This set was under test to identify to detect effect of transferring transfer torque to central part of the beam using cantilever situated at opposite arms. Every arm in the set up was situated under some static load. This was destructive type of testing require and all beams are designed to get produce fail results as far as torsion in considered. Out of eight beams under test one beam is call as control beam and all other beams are strengthened using different types of configuration to verify the effect of different configuration. Moreover, study is only concentrate to continuously wrapper GFRP fabrics.

KEY WORDS- Concrete Beams, Wrapping, GFRP.

I. INTRODUCTION

Every building or structure design in the universe has a problem of degradation over the period of time. The major cause of depreciation is because of changes in the environmental conditions throughout the year. Degradation includes corrosion of steel, strength is lost is steel gradually because of ageing and continuous variation in temperature. Loading of high intensity is another major problem for steel degradation. On all the above major degradation may take place just because of few seconds of earth quake and it will be very destructive. The above problems need to address in designing phase only. The continuous checking of civil structures and best retrofit technologies must be applied on the structure to slow the degration rate of the civil structures. The structure life may be increase in two ways repair or demolish existing one and reconstruct new one. Later technique is very costly, and can be applied to completely degraded structure. Repair of concrete structure by using FRP sheets wrapping has many advantages over traditional technique. E.g. it is having very high tensile strength, extremely low weight, it does have a characteristic of corrosion resistance, and fast installation most important geometry of the structure does not change geometry of the structure.

Most important advantage of using an FRP is structure can be made in a shape that we desire, this type of flexibility is not present in steel structures. Although the FRP is little more costly because of fibers and resins used. But the labor and equipment cost to install FRP systems are lower as compared with the steel structures.

II. EXPERIMENTAL WORK:

Nine numbers of beams were made to carry out experimental study. As described earlier out of nine beams, one beam was designated as controlled beam and other all beams had strengthen with the use of GFRP. There were four series, in series -1, two nos of beams are completely wrapped, one with unidirectional and another one with

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Bidirectional GFRP sheets. Series -2 consists of two beams were wrapped with sheet having thickness of 10cm GFRP sheets, again same unidirectional and bidirectional way. In series-3 two beams were wrapped with smaller thickness GFRP sheets, having thickness of 5cm. and in series -4 beams were wrapped at an angle of 45 degrees having thickness of 5cm GFRP sheets.

Table 1: The characteristics of the specimen

Specimen	Configurations	No of Layers	Concrete cube compressive strength (N/mm^2)	Flexural Strength Of Concrete Prism (N/mm^2)	Split Tensile Strength of Concrete Cylinder (N/mm^2)
Beam No 1	Control beam	None	27.11	6	2.96
Beam No 2	Uni-GFRP Continuous fully wrap	2	31	5.83	2.68
Beam No 3	Bi-GFRP Continuous fully wrap	2	29.34	6.3	3.15
Beam No 4	10cm Uni-GFRP strips wrap	2	30.25	5.65	3.34
Beam No 5	10cm Bi-GFRP strips wrap	2	28.53	6	2.76
Beam No 6	5cm Uni-GFRP strips wrap	2	25.78	5.7	2.87
Beam No 7	5cm Bi-GFRP strips wrap	2	27.36	5.87	2.4
Beam No 8	5cm Uni-GFRP strips wrap(45^0)	2	30	6.1	2.76
Beam No 9	5cm Bi-GFRP strips wrap(45^0)	2	31.5	6.54	3.32

a. REINFORCEMENT

HYSD (High yielding strength deformed bars) of 16mm dia, 10mm dia are used to strengthen longitudinal reinforcement and 6mm dia HYSD bars are used as stirrups. For finding a tensile strength three specimen of each bar are used. After doing all the calculations found tensile strength of each bars are(fy) of bars of 16mm φ bars is 494 N/mm2, 12mm φ bars is 578N/mm2, 10mm φ bars is 429 N/mm2, 8mm φ bars is 523 N/mm2 and of 6mm φ bars is 250N/mm2.

b. REINFORCEMENT DETAILING OF THE BEAMS

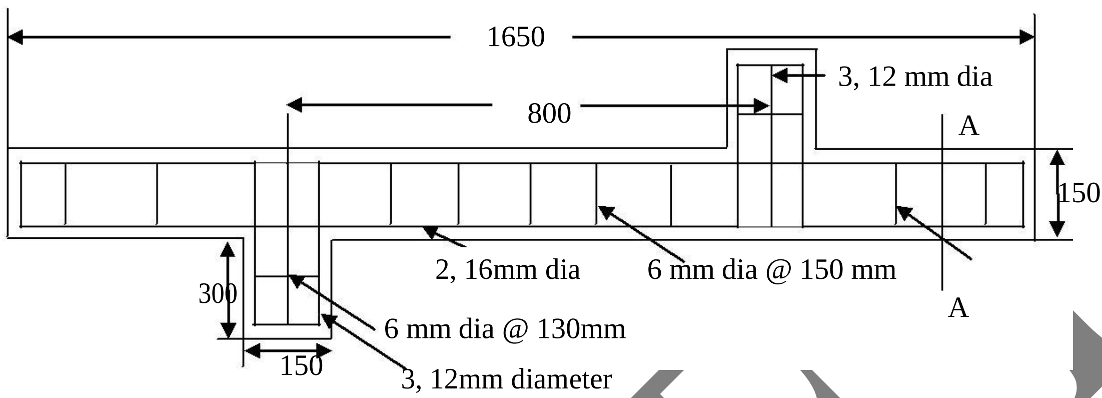

Figure 1: Top view of Torsional Beam

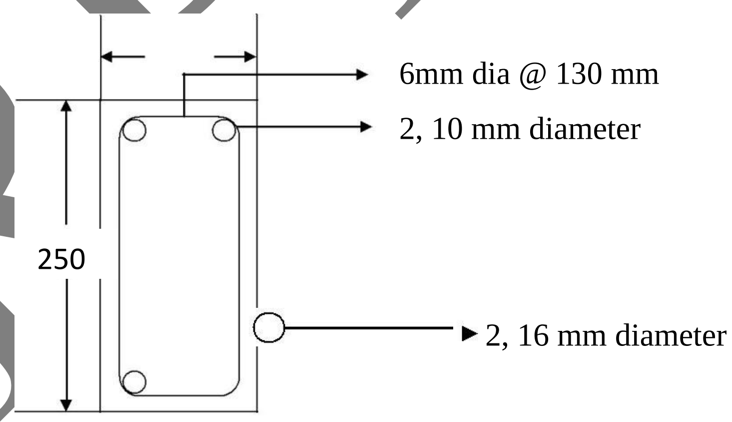

Figure 2: Reinforcement Detailing of Beam

For conducting experiment, nine reinforced concrete Torsion beam specimen of size as Shown in the fig (Length of main beam (L) = 1.65m, Effective length (*l*eff) =1.6m. Breadth of main beam (B) = 0.15m, Depth of main beam (D) = 0.25m, Length of cantilever part (*l*) = 0. 3m, Width of cantilever part= 0.15m, Depth of cantilever part= 0.25m, Distance of cantilever part from end of the beam= 0.35m) and all having the same reinforcement detailing are cast. The mix proportion is 0.5: 1:1.8:3.6 for water, cement, fine aggregate and course aggregate is taken. The mixing is done by using concrete mixture. The beams were cured for 28 days. For each beam three cubes, two cylinders and two prisms were casted to determine the compressive strength of concrete for 28 days.

III. RESULTS

All the experimental results of beams with different types of configurations and orientation of GFRP, their behavior throughout the test is described using recorded data on torsional behavior and the ultimate load carrying capacity. The crack patterns and the mode of failure of each beam are also described in this chapter. All the beams are tested for their ultimate strengths. Beam No-1 is taken as the control beam. It is observed that the control beam had less load carrying capacity and high deflection values compared to that of the externally strengthened

Beams using GFRP sheets. All the eight beams except the control beam are strengthened with GFRP sheets in different patterns. In series -1, two nos of beams are completely wrapped, one with unidirectional and another one with Bidirectional GFRP sheets. Series -2 consists of two beams were wrapped with sheet having thickness of 10cm GFRP sheets, again same unidirectional and bidirectional way. In series-3 two beams were wrapped with smaller thickness GFRP sheets, having thickness of 5cm. and in series -4 beams were wrapped at an angle of 45 degrees having thickness of 5cm GFRP sheets.

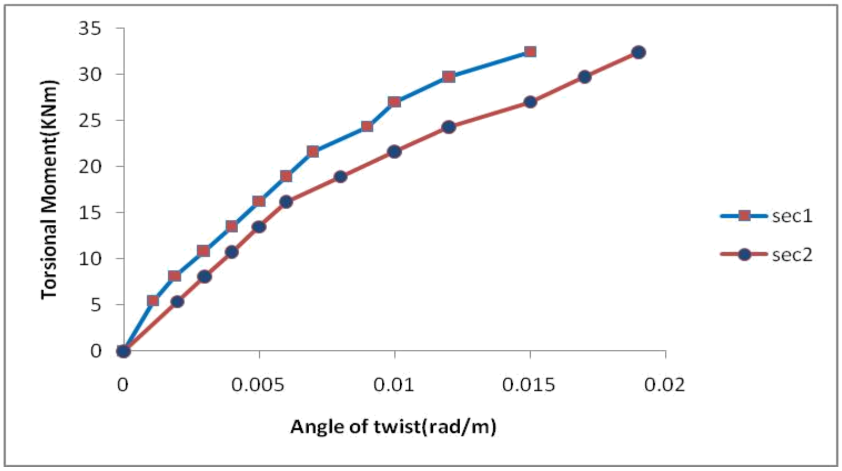

Figure 3: Torsional Moment vs. Angle of Twist Curve for Control Beam-1

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a. ULTIMATE LOAD CARRYING CAPACITY

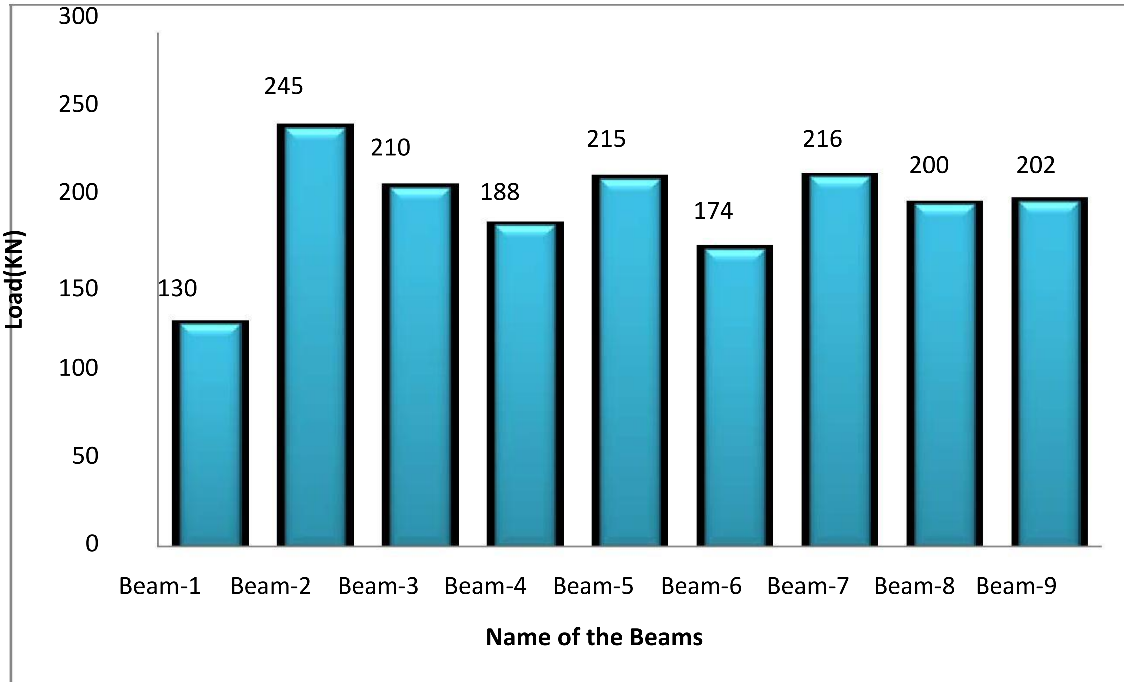
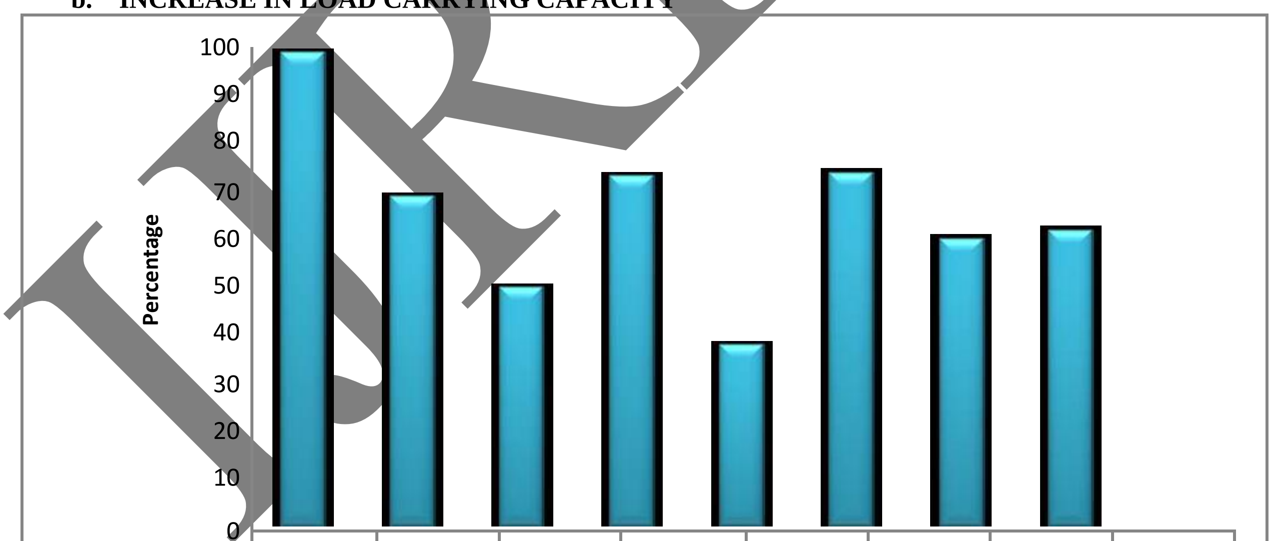


Figure 4: Ultimate Load carrying capacity

In Fig.4 shows the load carrying capacity of the control beams and the strengthen beam are plotted below. It was observed that Beam 2 is having the max load carrying capacity.

b. INCREASE IN LOAD CARRYING CAPACITY



	Beam-2	Beam-3	Beam-4	Beam-5	Beam-6	Beam-7	Beam-8	Beam-9
Percentage	88.46	61.53	44.61	65.38	33.84	66.15	53.84	55.38

Figure 5: Percentage increase in the Ultimate Carrying capacity w.r.t Control Beam 1

The above figure shows the amount of increase in the Torsional strength for each strengthened beam with respect to the Control Beam.

IV. CONCLUSION:

The present experimental study is made on the torsional behavior of rectangular RC beams strengthened by uni-directional and bi-directional GFRP fabrics. Nine rectangular RC beams having same reinforcement detailing and designed to fail in torsion and are cast and tested till collapse. During testing deflections and strain measurements are observed with the help of dial gauges and strain gauge. Following conclusions are drawn from the test results and calculated strength values:

1. The enhancement in load carrying capacity is observed in other beams as compared to control beam.
2. Torsion of reinforced concrete beams strengthened with GFRP sheets exhibited significant increase in their cracking and ultimate strength as well as ultimate twist deformations.
3. Appearances of cracks were observed for higher loads in case of strengthened beams.
4. The load carrying capacity of the strengthened Beam 2 fully wrapped with unidirectional fiber was found maximum for all the beams. The increase in load carrying capacity is 88.46% compared to control beam.
5. Both fully wrapped beams Beam 2 and Beam 3 had partially collapsed without achieving the ultimate load. The failure occurred in the strengthened part of the specimens.
6. Beam 8 and Beam 9 were giving the best results in terms of load carrying capacity and angle of twist respectively. And both are having same wrapping pattern of GFRP which is bonded in the torsion part at an angle 45^0 with the main beam.

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