EXPERIMETAL STUDY ON TORSIONAL BEHAVIOR OF RC FLANGED BEAMS STRENGTHENED WITH GLASS FIBRE REINFORCED POLYMERS

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Abstract

Environmental degradation, increased service loads, reduced capacity due to aging, degradation owing to poor construction materials and workmanships and conditional need for seismic retrofitting have demanded the necessity for repair and rehabilitation of existing structures. Fibre reinforced polymers has been used successfully in many such applications for reasons like low weight, high strength and durability. Many previous research works on torsional strengthening were focused on solid rectangular RC beams with different strip layouts and different types of fibres. Various analytical models were developed to predict torsional behavior of strengthened rectangular beams and successfully used for validation of the experimental works. But literature on torsional strengthening of RC T- beam is limited. In the present work experimental study was conducted in order to have a better understanding the behavior of torsional strengthening of solid RC Flanged T-beams. An RC T-beam is analysed and designed for torsion like an RC rectangular beam; the effect of concrete on flange is neglected by codes. In the present study effect of flange part in resisting torsion is studied by changing flange width of controlled beams. The other parameters studied are strengthening configurations and fiber orientations.The objective of present study is to evaluate the effectiveness of the use of epoxy-bonded GFRP fabrics as external transverse reinforced to reinforced concrete beams with flanged cross sections (T-beam) subjected to torsion. Torsional results from strengthened beams are compared with the experimental result of the control beams without FRP application. The study shows remarkable improvement in torsional behavior of all the GFRP strengthens beams.

KEYWORDS –Torsion, Gfr Polymers, Flange Beam, Twist Curves

INTRODUCTION

Modern civilization relies upon the continuing performance of its civil engineering infrastructure ranging from industrial buildings to power stations and bridges. For the satisfactory performance of the existing structural system, the need for maintenance and strengthening is inevitable. During its whole life span, nearly all engineering structures ranging from residential buildings, an industrial building to power stations and bridges faces degradation or deteriorations.The main causes for those deteriorations are environmental effects including corrosion of steel, gradual loss of strength with ageing, variation in temperature, freeze-thaw cycles, repeated high intensity loading, contact with chemicals and saline water and exposure to ultra-violet radiations. Addition to these environmental effects earthquakes is also a major cause of deterioration of any structure. This problem needs development of successful structural retrofit technologies.Early efforts for understanding the response of plain concrete subjected to pure torsion revealed that the material fails in tension rather than shear. Structural members curved in plan, members of a space frame, eccentrically loaded beams, curved box girders in bridges, spandrel beams in buildings, and spiral stair-cases are typical examples of the structural elements subjected to torsional moments and torsion cannot be neglected while designing such members.

Structural members subjected to torsion are of different shapes such as T-shape, inverted L–shape, double T-shapes and box sections. These different configurations make the understanding of torsion in RC members of complex task. In addition, torsion is usually associated with bending moments and shearing forces, and the interaction among these forces is important. Thus, the behaviour of concrete elements in torsion is primarily governed by the tensile response of the material, particularly its tensile cracking characteristics. Spandrel beams, located at the perimeter of buildings, carry loads from slabs, joists, and beams from one side of the member only. This loading mechanism generates torsional forces that are transferred from the spandrel beams to the columns.

OBJECTIVES OF THE STUDY

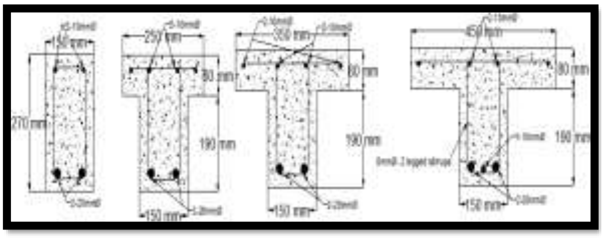
The objective of present study is to evaluate the effectiveness of the use of epoxy-bonded GFRP fabrics as external transverse reinforced to reinforced concrete beams with flanged cross sections (T-beam) subjected to torsion. Torsional results from eight strengthened beams are compared with the experimental result of 3 control beams without FRP applications. The following FRP configurations are examined

a) Completely wrapped T-beams with discrete FRP strip around the cross section making $90^0$with longitudinal axis of beam

b) Completely wrapped T-beams with discrete FRP strip around the cross section making 45^0 with longitudinal axis of the beam

c) U-jacketed T- beam with discrete FRP strip bonded on web of the beam and bottom sides of the flange

d) U-jacketed T- beam with discrete FRP strip



bonded on web to bottom sides of the flange and anchored with the FRP strirs on top of the flange

An RC T-beam is analyzed and designed for torsion like an RC rectangular beam, the effect of concrete on flange is neglected by codes. In the present study effect of flange part in resisting torsion is studied by changing flange width of controlled beams. Three beams with varying flange widths designed to fail in torsion are cast and tested to complete failure. Their performances are compared with respect to a rectangular beam of same depth and web thickness.

RESULTS

Torsional moment and Angle of twist Analysis of all Beams. Here the angle of twist of each beam is analysed Angle of twist of each beam is compared with the angle of twist of control beam. Also the torsional behaviors compared between different wrapping schemes having the same reinforcement. Same type of load arrangement was done for all the beams. All the beams were strengthened by application of GFRP in four layers over the beams. It was noted that the behavior of the beams strengthen with GFRP sheets are better than the control beams. The deflections are lower when beam was wrapped externally with GFRP strips. The use of GFRP strips had effect in delaying the growth of crack formation. When all the wrapping schemes are considered it was found that the Beam with GFRP strips fully wrapped and 45° orientation over full a length of 0.8m in the middle part had a better resistant to torsional behavior as compared to the others strengthened beams with GFRP

Figure 3-1. Detailing of Reinforcement

Table 4.1 Relation between angle of twist and Torsional moment (Control Bear

Twisting moment T in kN-m	**Angle of twist in section 1 (rad/m)**	**Angle of twist in section 2 (rad/m)**	**Remarks**
0.00	0.000	0.000	
1.88	0.001	0.004	
3.75	0.001	0.007	
5.63	0.002	0.010	
7.50	0.002	0.014	
9.38	0.004	0.020	
11.25	0.007	0.027	First Hair line Crack appeared @80kN
12.75			Ultimate load @ 90kN

This beam has same reinforcement detail and dimensions. This is included into the present study to compare the effect of concrete in flange on torsional behavior of RC beams.

Figure 3-16.T-beam without GFRP and 450mm width of Flange, Control beam

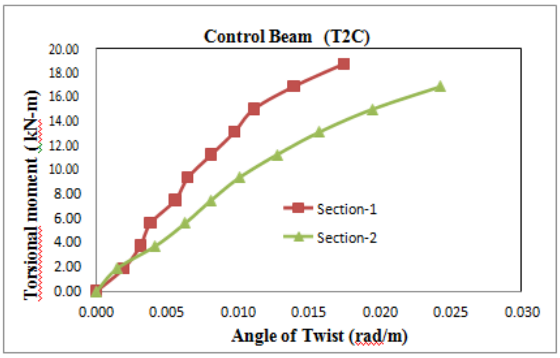


Fig 4.4 Torsional moment Vs Angle of Twist for Beam T2C

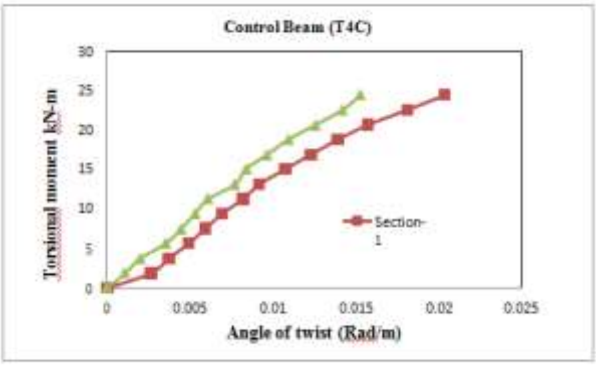


Fig 4.16 Torsional moment Vs Angle of Twist curve (T3C)

CONCLUSIONS

Experimental program of this study consists of eleven numbers of reinforced concrete T- beams with different flange widths tested under torsion. Based on presented experimental measurements and analytical predictions, the following conclusions were reached

1) Experimental results shows that the effect of flange width on torsional capacity of GFRP strengthened RC T-beams are significant.

Torsional strength increases with increase in flange area irrespective of beam strengthening with GFRP following different configurations schemes.

2)With 250 mm wide flange width increase in strength was 13%, with 350mm wide flange was 29% and for 450mm wide flange was found to be 69%. This is due to increase in area enclosed inside the critical shear path.

The use of continuous FRP strips that wrapped around the cross-section of T-beams caused a significant increase on the ultimate torsional strength. It is concluded that full wrapping with continuous strips is far more efficient for torsional upgrading than the use of wrapping with the discrete strips

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