Investigation of Torsional Behavior of RC Flanked Beams Reinforced with Glass Fiber Reinforced Polymers using Experiments.

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Abstract

Existing structures must be repaired and refurbished due to environmental degradation, rising service loads, aging-related capacity loss, deterioration from subpar building materials and craftsmanship, and the conditional requirement for seismic retrofitting. Many of these applications have found success using fiber-reinforced polymers due to their low weight, great strength, and durability. Solid rectangular RC beams with various strip configurations and fiber kinds were the subject of numerous earlier studies on torsional strengthening. A number of analytical models were created to forecast the torsional behavior of reinforced rectangular beams, and they were effectively employed to validate the experimental results. However, there is little research on RC T-beam torsional strengthening. To better understand the behavior of torsional strengthening of solid RC flanged T-beams, an experimental investigation was carried out in this work. Similar to an RC rectangular beam, an RC T-beam is examined and constructed for torsion; codes ignore the impact of concrete on the flange. By altering the flange width of controlled beams, the current study examines the impact of the flange component in preventing torsion. Fiber orientations and strengthening configurations are the other parameters that are being examined. The current study aims to assess the efficacy of using epoxy-bonded GFRP fabrics as external transverse reinforcement for torsion-resistant reinforced concrete beams with flanged cross sections (T-beam). The experimental findings of the control beams without the use of FRP are contrasted with the torsional results of strengthened beams. The torsional behavior of all the GFRP-strengthened beams has significantly improved, according to the study.

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

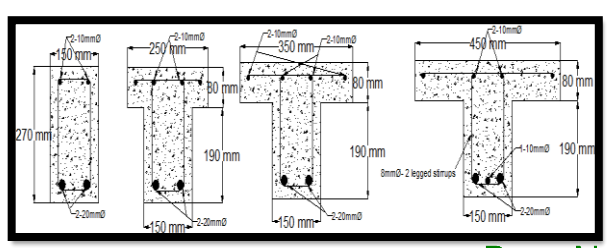
The objective of present study is to evaluate the effectiveness of the use of epoxy-bonded GFRP fabrics as external transverse reinforced to reinforced concrete beams with flanged cross sections (T-beam) subjected to torsion. Torsional results from eight strengthened beams are compared with the experimental 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

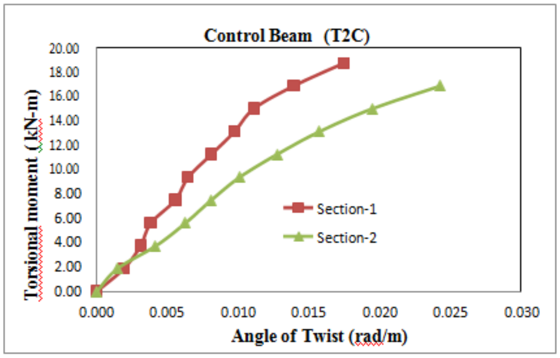


Fig 4.4 Torsional moment Vs Angle of Twist for Beam T2C

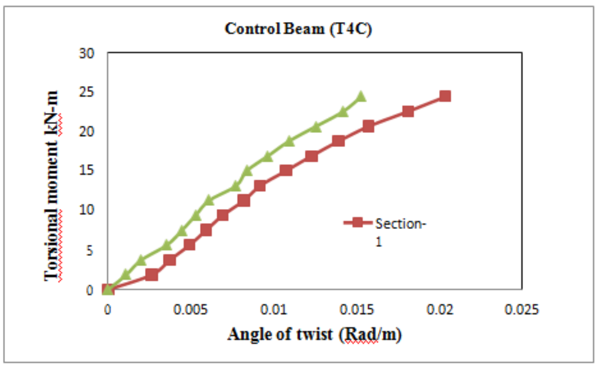


Fig 4.16 Torsional moment Vs Angle of Twist curve (T3C)

CONCLUSIONS

Eleven reinforced concrete T-beams with varying flange widths that are tested under torsion make up the experimental program for this investigation. The following conclusions were drawn from the experimental measurements and analytical predictions that were provided. 1) According to experimental results, flange width significantly affects the torsional capacity of RC T-beams reinforced with GFRP. Regardless of whether the beam is strengthened with GFRP using various arrangement methods, torsional strength rises as the flange area grows. 2) Strength increased by 13% with a flange width of 250 mm, 29% with a flange width of 350 mm, and 69% with a flange width of 450 mm. This is because the crucial shear path's enclosed area has grown. The ultimate torsional strength was significantly increased by using continuous FRP strips that wrapped around the T-beam cross-section. For torsional upgrading, it is determined that full wrapping with continuous strips is significantly more effective than using wrapping with separate strips.

REFERENCES

Ameli, M. and Ronagh, H.R. (2007). “Behavior of FRP strengthened reinforced concrete beams under torsion”,Journal of Composites for Construction, 11(2), 192-200.

Ameli, M., and Ronagh, H. R. (2007), “Analytical method for evaluating ultimate torque of FRP strengthened reinforced concrete beams” ,Journal of Composites for Construction ,11, 384– 390.

Amir, M., Patel, K. (2002).“Flexural strengthening of reinforced concrete flanged beams with composite laminates”,Journal of Composites for Construction, 6(2), 97-103.

Andre, P., Massicotte, Bruno, Eric, (1995). “Strengthening of reinforced concrete beams with composite materials : Theoretical study”, Journal of composite Structures,33,63-75

Arbesman, B. (1975). “Effect of stirrup cover and amount of reinforcement on shear capacity of

ISSN NO: 0005-0601

reinforced concrete beams." MEng thesis, Univ. of Toronto.

Arduini, M., Tommaso, D. A., Nanni, A. (1997), "Brittle Failure in FRP Plate and Sheet Bonded Beams", ACI Structural Journal, 94 (4), 363-370.

Chalioris, C.E. (2006). "Experimental study of the torsion of reinforced concrete members", Structural Engineering & Mechanics, 23(6), 713-737.

Chalioris, C.E. (2007a). "Torsional strengthening of rectangular and flanged beams using carbon fibre reinforced polymers – Experimental study", Construction & Building Materials, in press (available online since 16 Nov. 2006).

Chalioris, C.E. (2007b). "Tests and analysis of reinforced concrete beams under torsion retrofitted with FRP strips", Proceedings 13th Computational Methods and Experimental Measurements (CMEM 2007), Prague, Czech Republic.

Chen, J.F. and Teng, J.G. (2003a). "Shear capacity of fiber-reinforced polymer-strengthened reinforced concrete beams: Fiber reinforced polymer rupture", Journal of Structural Engineering, ASCE, 129(5), 615-625.

Chen, J.F. and Teng, J.G. (2003b). "Shear capacity of FRP-strengthened RC beams: FRP debonding", Construction & Building Materials, 17, 27-41.

Deifalla A. and Ghobarah A.(2010), "Full Torsional Behavior of RC Beams Wrapped with FRP: Analytical Model", Journal of Composites for Construction,14,289-300.

Deifalla and A. Ghobarah (2005) "Simplified analysis for Torsionaly Strengthed RC beams using FRP'Proceedings of the