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Comparative Experimental Study on Torsional Behavior of RC beam using CFRP and GFRP Fabric Wrapping

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Abstracts

Fiber reinforced polymer (FRP) as an external reinforcement is used extensively to enhance the strength requirement related to flexure and shear in structural systems. But the strengthening of members subjected to torsion is yet to be explored as Torsion failure is a brittle form of failure. In present experimental study deals with the torsional strengthening of Reinforced Concrete beams using epoxy bonded Fiber-Reinforced Polymer (FRP) fabric. Total Thirty nine rectangular beams of size 150mm × 300 mm and 1200 in length are casted. Out of which, three beams are control beam and remaining thirty six beams are classified into two groups. One with CFRP fabric wrapping and another with GFRP fabric wrapping. With various wrapping patterns. The applied CFRP and GFRP configurations are U-jacketed, vertical strips with spacing, and edge strips along with vertical strips along its entire length. Torsional capacity of beams of two groups is compared with control specimen with respect to torsional moment, angle of twist and ductility factor and it was observed that CFRP fabric bonded beam shows more torsional strength than the GFRP bonded beam.

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Keywords: Torsion, CFRP fabrics, GFRP fabrics, Torsional capacity, angle of twist, ductility.

Nomenclature

CFRP	Carbon fibre reinforced polymer
GFRP	Glass fibre reinforced polymer
FRP	Fibre reinforced polymer
FB1	Fibre reinforced Beam 1
CFB1	Carbon Fibre reinforced Beam 1
GFB1	Glass Fibre reinforced Beam

1. Introduction

Structural members curved in plan, members of 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 moment. and torsion cannot be neglected while designing these members structural members subjected to torsion are of different shape such as T-shape ,inverted L-shape, double T-Shapes and box sections .

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These different configurations make the understanding of torsion in RC members a complex task . In case of torsion, the cracks follow the spiral crack pattern and failure of structural member occurs.

Therefore, strengthening becomes necessary for the achievement of satisfactory strength and serviceability
The load carrying capacity of structural member damaged by deterioration and overloads have been needed the effective techniques. The different strengthening and upgrading procedures are available, out of which, application of FRP is the best solution for torsional strengthening. In the last previous decades, the research has been conducted on the strengthening of Reinforced Concrete beam using epoxy bonded fabric and laminates. The advantages of this technique of FRP bonding are decreased due to construction limitation of structural members and de-bonding of FRP fabrics and laminates. Due to presence of slab, complete wrapping of FRP fabrics and laminates are not possible practically around the cross section of R.C.member.

2. Review of liturature

Previous studies on the torsional strengthening conducted on different parameters such as different configurations of FRP, various thickness of FRP, different epoxy resin used as bonding material etc. Some of the literature studies shown below:
A. Deifalla et al were focused on the experimental study of behavior and analysis of inverted T- shaped RC beams under shear and torsion (Elsevier 2014) that the flange stirrups is more efficient in resisting torsion moment over shear force. Sure Naveen et al were conducted their study on torsional behavior of RC T- beams strengthened with GFRP (ISC 2014) that GFRP proved more effective in strengthening of RC. T- beam when applies to flange at different configurations and fiber orientation. A Deifalla et al shows in effectiveness of externally bonded CFRP strips for strengthening flanged beams under torsion (Elsevier 2013) that full wraps, anchored U- jackets and extended U-jacketed strips found to be more effective compare to the un-anchored U-jackets. Therefore, the objective of the present experimental study is to evaluate and compare the effectiveness of the use of epoxy-bonded carbon and glass FRP fabrics with different configuration as external reinforcement to rectangular Reinforced Concrete beams subjected to torsion. The applied CFRP and GFRP configurations are U-jacked, vertical strips with different spacing, edge strips with vertical strips along its entire length. Torsional capacity of beams of two groups will compare before and after strengthening with twists and ductility factor.

Table 1 -FRP fabric properties

FRP	Young's modulus Gpa	Tensile strength Mpa	Strain at failure (%)	Density (gm/cm2)
GFRP	390-760	3000-4800	3.5 -5.5	2.5-2.6
CFRP	70-90	2400-5100	0.5-1.73	1.85-1.9

3. Experimental work
4.

In the experimental program total thirty nine rectangular RC beams were casted , out of which three are controlled specimens and remaining thirty six are grouped in two categories one with GFRP fabric and another with CFRP fabric with six different bonding patterns as shown in fig-3 and each pattern is having average of three test specimens .

3.1 *Specimen characteristics*

The thirty nine Reinforced Concrete rectangular beam of cross section of 150 × 300 mm and 1200 mm long were casted by using, 2 No's-12 mm and 1 No-10 mm diameter reinforcing bar at bottom and 2 No's-8mm diameter bars at top (Fe500) with 6mm stirrups at spacing 100 mm c/c. (Fe250)

3.2 Material properties

1].Concrete properties : All the RC beams were casted using M30 grade of concrete with 53 grade Ultra tech OPC cement , 20 mm maximum size of coarse aggregate with sp. Gravity 2.66 and river sand having sp. gravity 2.71 with water cement ratio of 0.45 mix proportion ratio by using I.S 10262-2009 is 1: 1.76:2.77. The clear concrete cover to the outer side of stirrup was 20 mm. And these beams were cured in water for 28 days. As the size of beams is considerably bulky, beams are cured in the artificially prepared pond cum tank at the site where all beams were casted.

2] FRP material properties

1. 12k carbon UD fabric - HinFab™ HCU202
2. Glass UD Fabric - HinFab™ HGU900
3. HinPoxy C Epoxy Saturant- Resin + Hardener

Mixing Ratio-
HinPoxy C Resin: HinPoxy C hardener = 100:300 (w/w), Gel time at 30˚ C- 120 minutes.

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