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An Experimental Investigation On The Strength Characteristics Of Flanged Beams Using Glass Fiber Reinforced Polymer (GFRP) Reinforcement

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Abstract:
The repair and rehabilitation of deteriorating reinforced concrete (RC) structures have become increasingly important due to factors such as environmental degradation, aging, poor construction materials and workmanship, increased service loads, and the need for seismic retrofitting. Among various strengthening techniques, Fibre Reinforced Polymers (FRP) have emerged as an effective solution because of their high strength-to-weight ratio, corrosion resistance, and ease of installation.Previous studies on torsional strengthening have primarily concentrated on solid rectangular RC beams with different fibre types and wrapping configurations. Several analytical models have been developed and validated experimentally for predicting the torsional behavior of such beams. However, limited research has focused on the torsional strengthening of flanged RC T-beams, where the contribution of the flange to torsional resistance is often neglected in design codes.
The present study aims to experimentally investigate the torsional behavior of solid RC flanged (T-section) beams strengthened using externally bonded Glass Fibre Reinforced Polymer (GFRP) fabrics. The influence of flange width, strengthening configurations, and fibre orientations on the torsional performance of beams was examined. Control beams without FRP were tested to compare their performance with GFRP-strengthened specimens.

Keywords: POLYMERS, GGWT, MoRT&H.

I. 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. So it is very important to have a check upon the continuing performance of the civil engineering infrastructures.

TORSIONAL STRENGHTENING OF BEAMS

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.

II. LITERATURE

Externally bonded, FRP sheets are currently being studied and applied around the world for the repair and strengthening of structural concrete members. Strengthening with Fiber Reinforced Polymers (FRP) composite materials in the form of external reinforcement is of great interest to the civil engineering community. FRP composite materials are of great interest to the civil engineering community because of their superior properties such as high stiffness and strength as well as ease of installation when compared to other repair materials. Also, the non-corrosive and nonmagnetic nature of the materials along with its resistance to chemicals made FRP an excellent option for external reinforcement.

Research on FRP material for use in concrete structures began in Europe in the mid 1950's by Rubinsky and Rubinsky, 1954 and Wines, J. C. et al., 1966. The pioneering work of bonded FRP system can be credited to Meier (Meier 1987); this work led to the first on-site repair by bonded FRP in Switzerland (Meier and Kaiser 1991).Japan developed its first FRP applications for repair of concrete chimneys in the early 1980s (ACI 440 1996).By 1997 more than 1500 concrete structures worldwide had been strengthened with externally bonded FRP materials. Thereafter, many FRP materials with different types of fibres have been developed. FRP products can take the form of bars, cables, 2-D and 3-D grids, sheet materials and laminates.

III. EXPERIMENTAL STUDY

To study the most influential strengthening variables on torsional behavior a total of eleven medium scale reinforced concrete beams of 1900 mm long were constructed for this work. T-shaped beams, which are sorted in three groups (T2, T3 and T4) and were tested under combined bending torsion. Three numbers of beams are without torsional reinforcement were the control specimens and eight specimens were strengthened using epoxy-bonded glass FRP fabrics as external transverserein-forcemeat

CASTING OF SPECIMENS.

For conducting experiment, eleven reinforced concrete beam specimen of size as Shown in the fig (Length of main beam (L) = 1900mm, Breadth of main beam(bw) = 150mm, Depth of main beam(D) = 270mm, Length of cantilever parts = 400mm, Width of cantilever part= 200mm, Depth of cantilever part= 270mm, Distance of cantilever part from end of the beam= 350mm) and all having the same reinforcement detailing are cast. The mix proportion is 0.5: 1:1.67:3.3 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.

MATERIALPROPERTIES

Concrete

For conducting experiment, the proportions in the concrete mix are tabulated in Table 3.1 as per IS:456-2000. The water cement ratio is fixed at 0.55. The mixing is done by using concrete mixture. The beams are cured for 28 days. For each beam six 150x150x150 mm concrete cube specimens and six 150x300 mm cylinder specimens were made at the time of casting and were kept for curing, to determine the compressive strength of concrete at the age of 7 days & 28 days

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Table 3.1 Design Mix Proportions of Concrete

Description	Cement	Sand(Fine Aggregate)	Coarse Aggregate	Water
Mix Proportion (by weight)	1	1.67	3.33	0.5

Cement

Cement is a material, generally in powered form, which can be made into a paste usually by the addition of water and, when molded or poured, will set into a solid mass. Numerous organic compounds used for an adhering, or fastening materials, are called cements, but these are classified as adhesives, and the term cement alone means a construction material. The most widely used of the construction cements is Portland cement. It is bluish-gray powered obtained by finely grinding the clinker made by strongly heating an intimate mixture of calcareous and argillaceous minerals. Portland Slag Cement (PSC) Konark Brand was used for this investigation. It is having a specific gravity of2.96.

Fine Aggregate

Fine aggregate 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. Clear sands are employed for filtering water. Here, the fine aggregate/sand is passing through 4.75 mm sieve and having a specific gravity of 2.64. 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

Table 3.3 Tensile Strength of reinforcing steel bars

Sl. no. of sample	Diameter of bar (mm)	0.2% Proof stress (N/mm^2)	Avg. Proof Stress (N/mm^2)
1	20	475	470
2	10	530	529
3	8	520	523

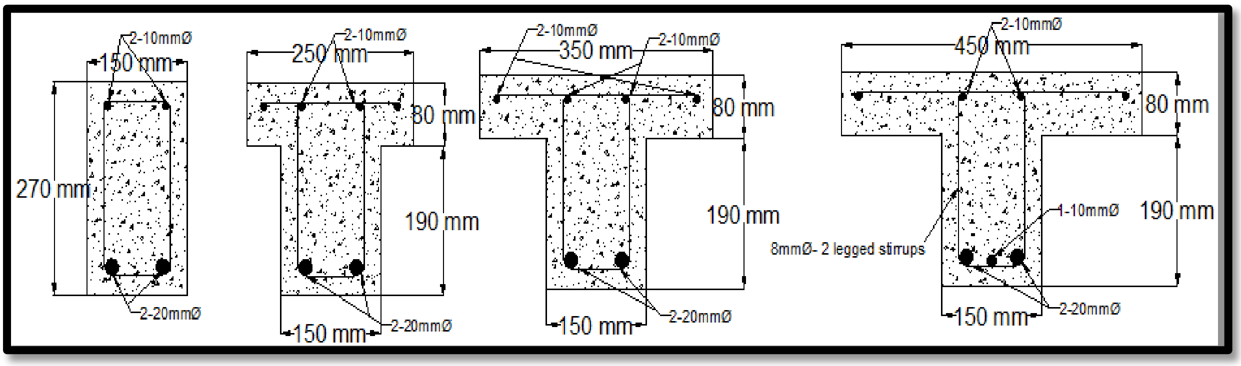

Figure 3-1. Detailing of Reinforcement

STRENGTHENING OFBEAMS

Fig. 3.5 Application of epoxy and hardener on the beam

Fig 3.6 Roller used for the removal of air bubble

Form Work

Fresh concrete being plastic in nature requires good form work to mold it to the required shape and size. So the form work should be rigid and strong to hold the weight of wet concrete without bulging anywhere. The joints of the form work are sealed to avoid leakage of cement slurry. Mobil oil was then applied to the inner faces of form work.

Figure 3-7. Steel Frame Used For Casting of RC T-Beam

EXPERIMENTAL SETUP

The beams were tested in the loading frame of "Structural Engineering" Laboratory of National Institute of Technology, Rourkela. The testing procedure for the all the specimen is same. First the beams are cured for a period of 28 days then its surface is cleaned with the help of sand paper for clear visibility of cracks. The two-point loading arrangement was used for testing of beams.

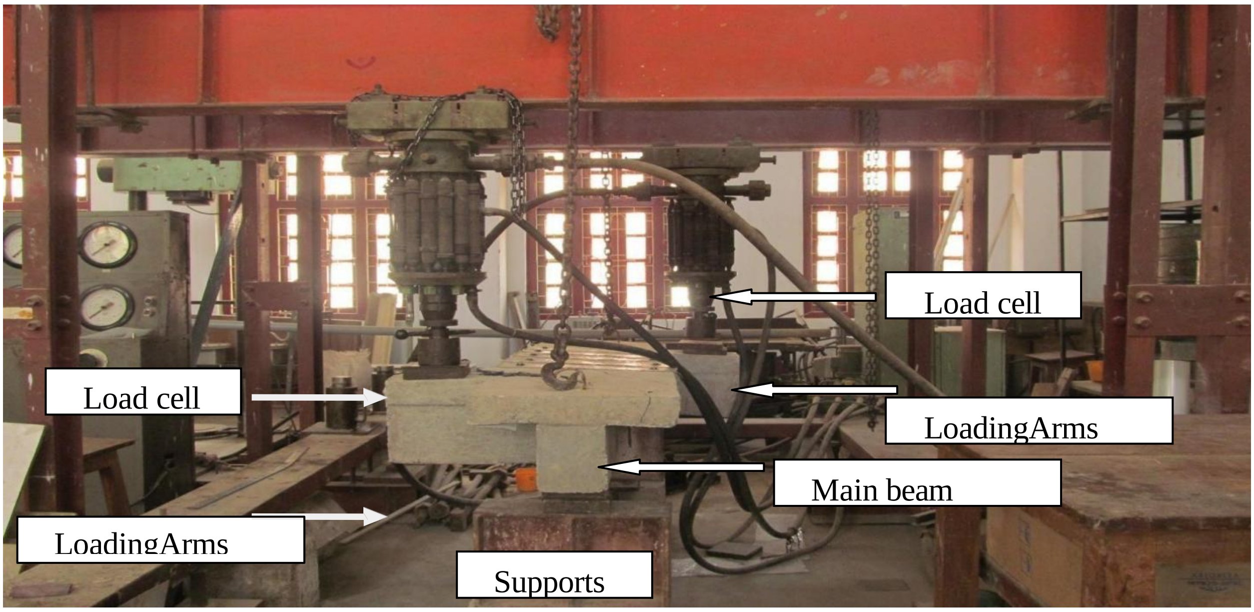

Fig no.3.8 Loading Setup

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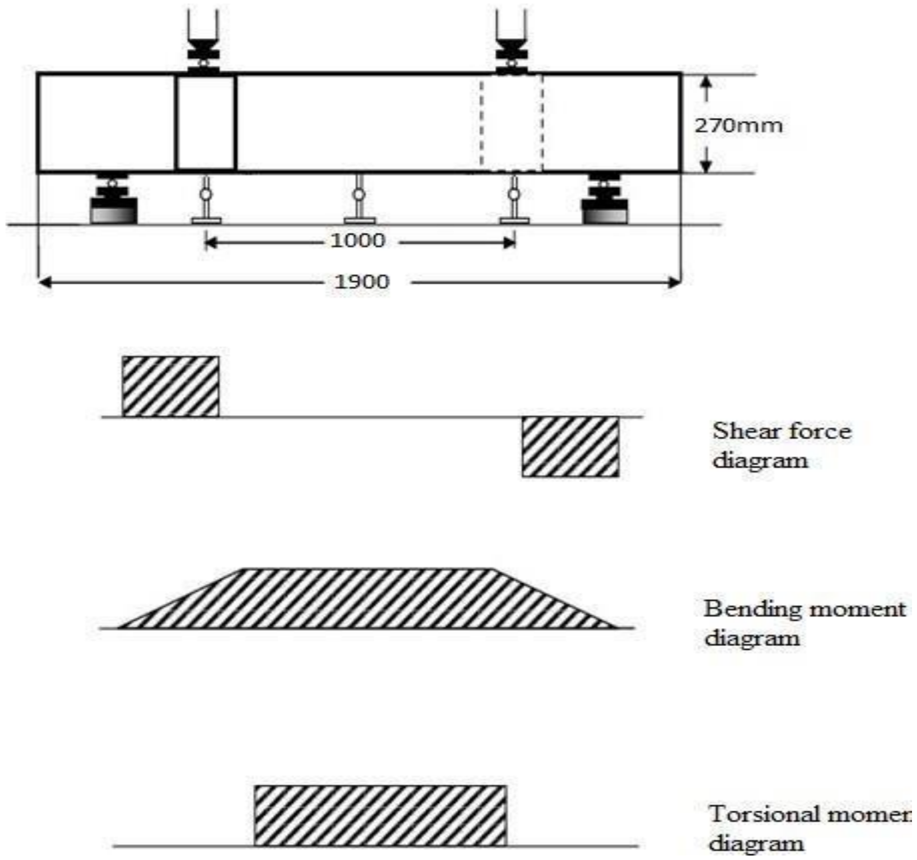

Fig. 3.9 Shear force and bending moment diagram for two point loading

III. ANALYTICAL ANALYSIS

Various analytical models have been proposed for evaluating ultimate torque of FRP Strengthened Reinforced concrete beams. Earlier the FIB model introduced in 2001 was the only available analytical method to evaluate the FRP contribution in the ultimate torsional capacity of the RC beams

Table 5.1 Comparison of Analytical and Experimental Results

Beam Name		tf (mm)	n	θ	B	fc 2 N/mm	Tf,cal kN m	Tfexp= Tult* Tcont* kNm	-
Series- A	T3SU	2.26	5	65°	90°	28.62	28.61	27	1.05
	T3SF	2.51	5	50°	90°	28.69	109.61	114	0.96
	T3S45	2.46	4	55°	45°	28.69	99.69	94	1.060
Series- B	T4SU	2.43	5	55°	90°	30.89	51.3	56	0.91
	T4SF	2.53	5	45°	90°	30.77	149.98	163	0.97
	T4S45	2.28	4	42°	45°	29.83	133.17	145	0.91

V.CONCLUSIONS

i. Experimental results shows that the effect of flange width on torsional capacity of GFRP strengthened RC T-beams aresignificant.
ii. Torsional strength increases with increase in flange area irrespective of beam strengthening with GFRP following different configurationsschemes.
iii. 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.
iv. The cracking and ultimate torque of all strengthen beams were greater than those of the control beams.
v. The increase in magnitude depends on the FRP strengtheningconfigurations.
vi. The maximum increase in torque was obtained for 900fully wrappedconfigurations. Increase of 133.33% to 116.67% in first cracking and 155.55% to 107.23% in ultimate torsion were recorded for series B beams and series C beams respectively.
vii. Beams U wrapped with 900 oriented GFRP stripes showed lowest torsional resisting capacity. Since shear flow stresses take a close path during torsional loading ,torsion would not be well resisted in case of U-jacketingstrengthening.
viii. For U wrapped beams increase of 22.22% to 33.33% in first cracking and 23.27% to 36.84% in ultimate torsion were recorded for series B beams and series C beams respectively
ix. Beams strengthen with U jacketing in web and top of flange and anchored with bolts exhibited increase of 11.11% to 55% in first cracking and 28.33% to 61.84% in ultimate torsion were recorded for series B beams and series C beamsrespectively.

REFERENCES:

1. ACI Committee 440 (1996) State Of Art Report On Fiber ReinforcedPlastic
2. 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.
3. 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.
4. Amir, M., Patel, K. (2002).“Flexural strengthening of reinforced concrete flanged beams with composite laminates”,Journal of Composites for Construction, 6(2), 97-103.
5. Andre, P., Massicotte, Bruno, Eric, (1995). “Strengthening of reinforced concrete beams with composite materials : Theoretical study”, Journal of compositeStructures,33,63-75
6. Arbesman, B. (1975). “Effect of stirrup cover and amount of reinforcement on shear capacity of reinforced concrete beams.” MEng thesis, Univ. ofToronto.
7. Arduini, M., Tommaso, D. A., Nanni, A. (1997), “Brittle Failure in FRP Plate and Sheet Bonded Beams”, ACI Structural Journal, 94 (4),363-370.
8. Belarbi, A., and Hsu, T. T. C. (1995). “Constitutive laws of softened concrete in biaxial tension-compression.” ACI Structural Journal, 92,562-573.