# Study of Torsional Behaviour of Steel I Section Bonded With Fibre Reinforced Polymer Sheet

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**ABSTRACT**

A large number of steel structures need strengthening and retrofitting after some time, as their durability and capacity reduces over time. Conventional strengthening technique for huge steel structures relies on enlarging the original steel section by welding additional elements such as steel plates or channels. The dead load of the enlarged section becomes larger which may result in a reduction in its effectiveness and the added steel plates are susceptible to corrosion in case of strengthening beams placed in a corrosive environment. Due to these reasons, considerable amount of research has been directed to the use of FRP materials for strengthening and retrofitting of steel structures. The conventional method of repairing is usually bulky, heavy, difficult to fix and prone to corrosion and fatigue so there is need for alternative so use of FRP (Fibre Reinforced Polymer) appears to be an excellent solution for these difficulties. In this paper study of torsional effect of steel I section bonded with BFRP and CFRP is studied.

**Key Words:** Torsion, BFRP,CFRP.Steel

## 1. INTRODUCTION

Steel is one of the most widely used for almost every type of structure as it gives the advantages like speedy construction, long durability, cost saving due to recycling and flexibility in construction. Along with these advantages it is subjected to corrosion action due to different environmental conditions. And it is also deteriorated due to aging. These problems effect on the service life of the structure. So as to regain the original strength and to increase the life span, structures are needed to retrofit. The conventional method of repairing or strengthening of steel structures is to cut out the old member and replace it with new one or to attach external steel plates. But these plates or steel parts are generally massive, heavy and difficult to fix and also have tendency to corrode. These conventional methods require considerable time and cost too. So, there is a need to look for an alternative solution. The use of Fibre Reinforced Polymer (FRP) appears to be an excellent solution. It boosts the strength and ductility of these structures

## 2. BASALT FIBRE AND CARBON FIBER

2.1 Basalt fibre

Basalt fibre composites (BFRP) have been receiving increasing attention in civil infrastructures, due to their excellent mechanical and chemical properties and high cost-performance. The research and application of basalt fibres and the FRP composites (BFRP) have been received much more attention in different engineering fields, especially in civil & environmental engineering and automobile industry, due to its excellent mechanical and chemical properties and high cost performance. It is also a typical energy saving, environment-friendly.

2.2 Carbon fiber

Carbon fiber is produced from a petroleum pitch, rayon, or polyacrylonitrile (PAN) precursor filaments of these, PAN-based fiber is the predominate precursor used in CFRP for structural reinforcement and strengthening due to its resulting high quality and strength characteristics. they offer the advantages such as high strength , high fatigue resistance, high strength to weight ratio ,high corrosion resistance etc.

## 3. EXPREMENTAL WORK

Until now limited work has been done on strengthening of steel structures by using FRP and whatever work that has been carried out was on externally bonded GFRP and CFRP strengthening of steel structure. Experimental work is carried out with respect to torsional behavior of rolled steel I sectionbonded with CFRP and BFRP.

**3.1** Experimental Setup

The beams were tested in the Material Testing Laboratory. The procedure of testing for all beams was kept same. The experimental set up is shown in Fig. 1. In test setup, Beams were fixed with lever arm and box type arrangement at both ends. This arrangement was rested over roller support. Roller support was provided at bottom of box. These

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supports ensure that the beam was free to rotate in opposite direction. This setup was installed under Universal Testing Machine (UTM). The central load was applied by UTM on diagonally placed loading spreader beam. Then this central load was distributed over two lever arms as point loads through loading pin. This loading pin was kept at a distance of 300mm over flange of lever arm. Loading was done by UTM (Universal Testing Machine) of capacity 100 KN The angle of twist was measured by using 'Precision Measurement' instrument in degrees.

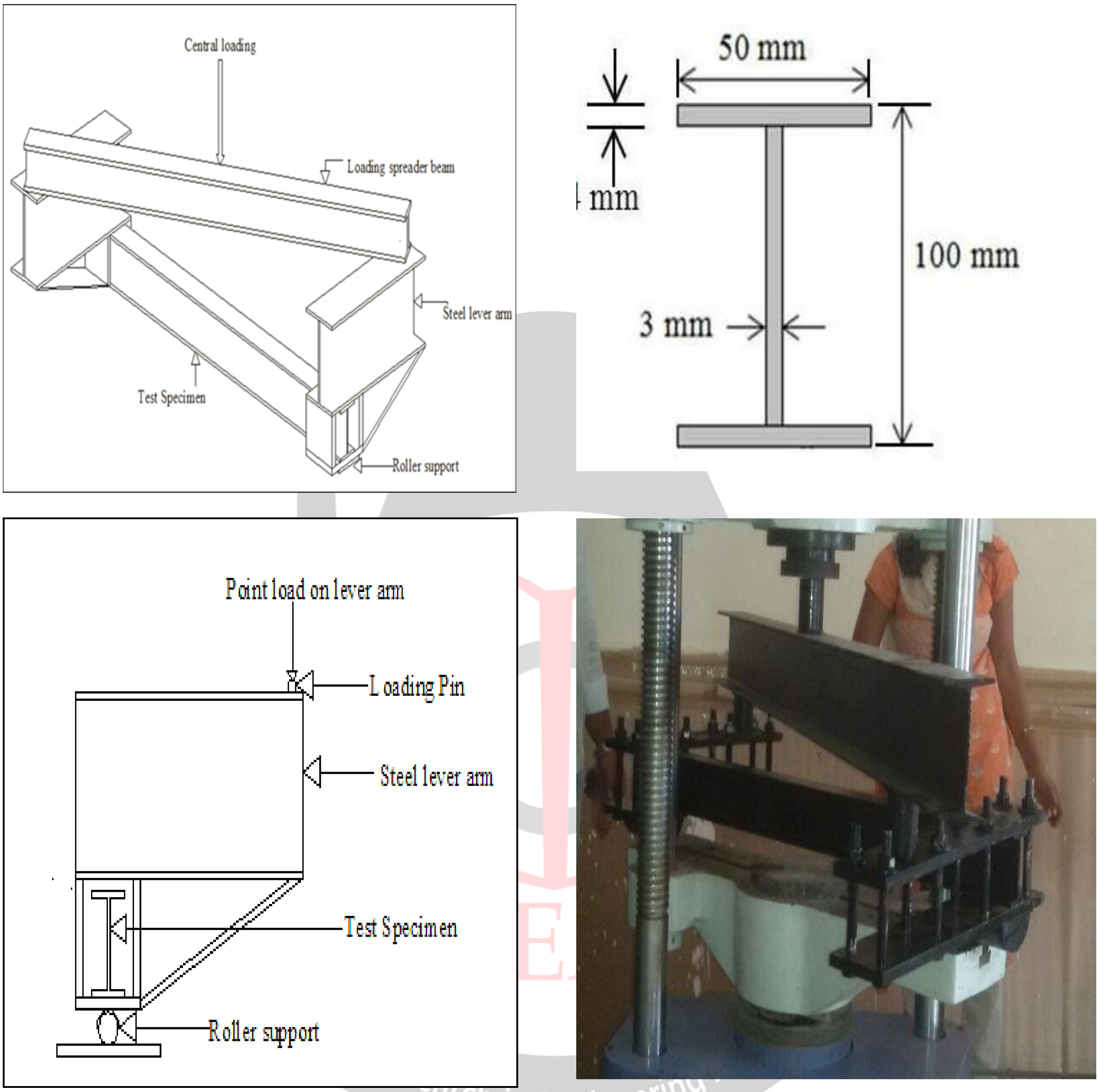


**Figure 1. Torsion assembly details**

## 4.RESULTS AND COMPARISONS OF ANGLE OF TWISTS AND TORSIONAL MOMENTS

Table 1. Comparison of experimental results of Virgin beam, beam with BFRP and beam with CFRP

| Sr. No. | Moment (N-m) | Experimental Results ( Angle Of Twist) | | | | |
|---|---|---|---|---|---|---|
| | | Virgin Section | CFRP All Side Wrapped | CFRP Three side wrapped | BFRP All Side Wrapped | BFRP Three side wrapped |
| 1 | 62.50 | 1.40 | 0.77 | 0.90 | 1.00 | 1.07 |
| 2 | 125.00 | 3.07 | 1.20 | 1.77 | 1.97 | 3.90 |
| 3 | 187.50 | 4.97 | 2.57 | 2.73 | 4.00 | 5.43 |
| 4 | 250.00 | 7.00 | 3.77 | 4.33 | 5.97 | 6.13 |


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| | | | | | | |
|---|---|---|---|---|---|---|
| 5 | 312.50 | 10.00 | 5.57 | 5.37 | 8.03 | 8.00 |
| 6 | 375.00 | 11.33 | 7.00 | 6.43 | 9.93 | 10.40 |
| 7 | 437.50 | 13.00 | 8.30 | 7.63 | 12.10 | 12.00 |
| 8 | 500.00 | 15.03 | 9.48 | 8.43 | 14.00 | 14.97 |
| 9 | 562.50 | 17.13 | 10.81 | 9.75 | 15.53 | 16.80 |
| 10 | 625.00 | 19.03 | 12.14 | 10.87 | 18.10 | 18.27 |
| 11 | 687.50 | 22.10 | 13.47 | 11.99 | 20.10 | 21.40 |
| 12 | 750.00 | 25.01 | 14.80 | 13.11 | 23.00 | 23.80 |
| 13 | 812.50 | 28.10 | 16.13 | 14.23 | 25.07 | 25.40 |
| 14 | 875.00 | 29.93 | 17.45 | 15.35 | 27.07 | 26.90 |
| 15 | 937.50 | 32.03 | 18.78 | 16.48 | 28.03 | 28.27 |
| 16 | 1000.00 | 35.00 | 20.11 | 17.60 | 29.20 | 30.20 |
| 17 | 1062.50 | 36.97 | 21.44 | 18.72 | 30.93 | 31.13 |
| 18 | 1125.00 | 38.97 | 22.77 | 19.84 | 31.90 | 32.37 |
| 19 | 1187.50 | 39.97 | 24.10 | 20.96 | 34.00 | 33.53 |
| 20 | 1250.00 | 41.07 | 25.43 | 22.08 | 35.23 | 35.07 |
| 21 | 1312.50 | 42.03 | 26.76 | 23.20 | 37.20 | 35.90 |
| 22 | 1375.00 | 43.03 | 28.08 | 24.33 | 37.83 | 37.03 |
| 23 | 1437.50 | 45.00 | 29.41 | 25.45 | 39.40 | 38.70 |
| 24 | 1500.00 | 46.80 | 30.74 | 26.57 | 40.97 | 40.73 |
| 25 | 1562.50 | 48.97 | 32.07 | 27.69 | 41.83 | 42.00 |
| 26 | 1625.00 | 50.03 | 33.40 | 28.81 | 43.03 | 43.37 |
| 27 | 1687.50 | 50.47 | 34.73 | 29.93 | 43.93 | 44.43 |
| 28 | 1750.00 | 52.23 | 36.06 | 31.05 | 44.80 | 45.50 |

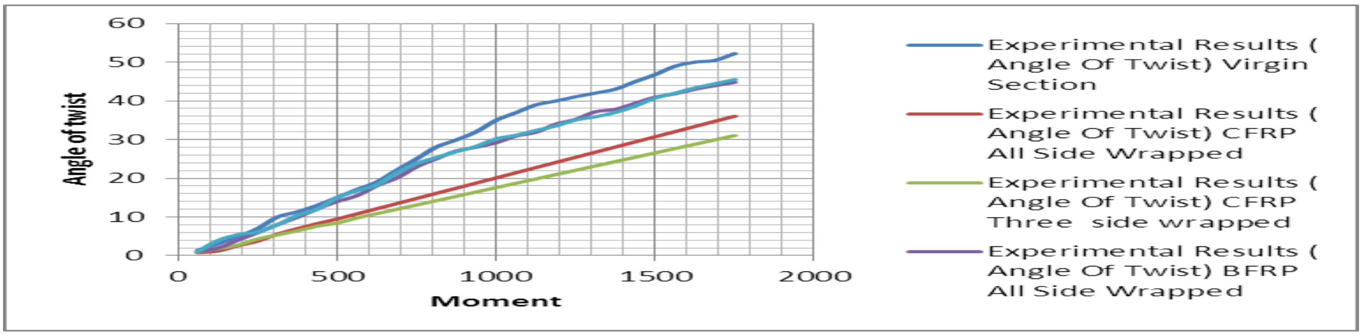
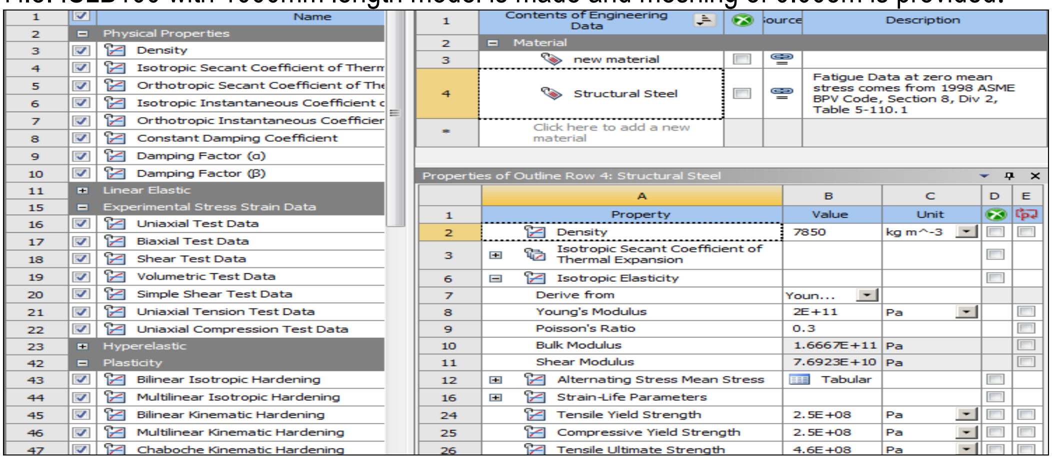



**Figure 2. Graph of angle of twist Vs moment for CFRP and BFRP wrapped Steel I section**

## 5. MODELING IN ANSYS -

Choosing proper axis and providing dimensions to the model is necessary for the best results to be obtained. I-section i.e. ISLB100 with 1000mm length model is made and meshing of 0.005m is provided.

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| | |
|---|---|
| Specification of I section | ISLB100 |
| Length | 1000mm |
| Density | 7850kg/m3 |
| Young's Modulus | 200Gpa |
| Poisson's Ratio | 0.3 |

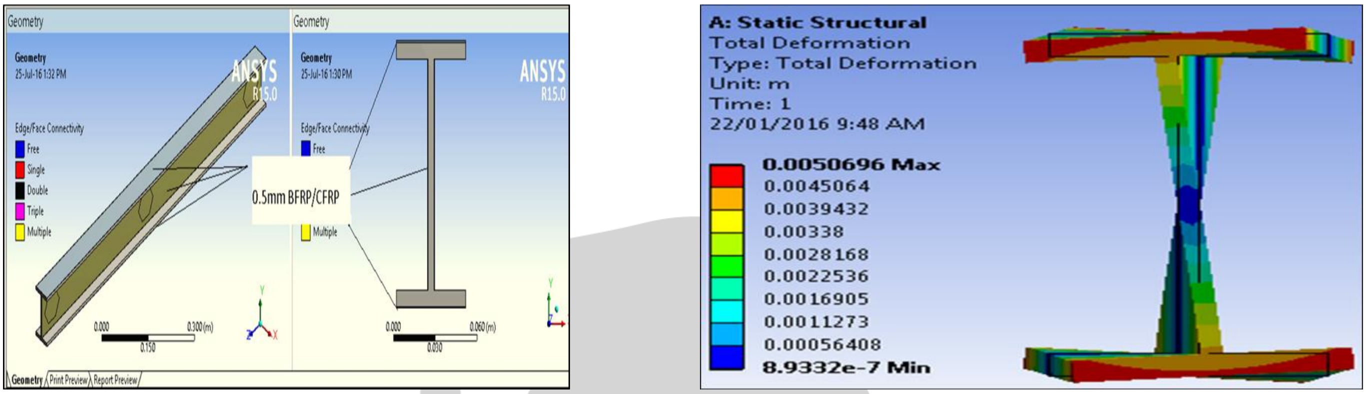


**Figure 3. Details of Ansys modeling**

## 6. CONCLUSIONS

From the experimentation and software analysis, it is clear that bonding of steel structures with different types of FRP's is relevant technique to strengthen the existing steel structures. Experimental and Software results are compared and following conclusions are drawn.

**1.**Torsional strength of BFRP wrapped beam is more than Virgin Beam.Twisting angle for three side wrapped BFRP beam (two web and one flange) is more than all side wrapped beam (two web and two flanges)

**2.** Torsional strength of CFRP wrapped beam is lot more than Virgin Beam. Twisting angle for three side wrapped CFRP beam (two webs and one flange) is more than all side wrapped beam (two web and two flanges).
**3.** Torsional strength of CFRP wrapped beams is more than BFRP wrapped beams.
**4.** All side CFRP wrapped beam is strongest of all the tested sections.

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