IJESRT: 9(4), April, 2020 ISSN: 2277-9655

International Journal of Engineering Sciences & Research Technology

(A Peer Reviewed Online Journal)
Impact Factor: 5.164

IJESRT

Website: www.ijesrt.com Mail: editor@ijesrt.com

IJESRT
INTERNATIONAL JOURNAL OF ENGINEERING SCIENCES & RESEARCH TECHNOLOGY

FLEXURAL BEHAVIOR OF ROLLED STEEL I SECTION BONDED WITH CFRP AND BFRP BY FINITE ELEMENT METHOD

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DOI: 10.5281/zenodo.3778552

ABSTRACT

Present study centered on Experimental with finite component investigation on failure analysis and flexural behavior of basalt Fibre Reinforced polymer (BFRP) and Carbon Fiber reinforced polymer (CFRP) reinforced steel I-beam. The target of this investigation is to review the impact of basalt fiber reinforced polymer, carbon Fiber reinforced polymer (BFRP) on steel I section underneath flexure. To complete this objective, hot rolled section of ISLB 100 used. Total 10 beams are tested. Out of those, 2 beams are control beam. These I sections are strengthen with BFRP and CFRP sheets. The results showed that it's attainable to increase the moment capability of a steel beam with CFRP bonded to its tension flange. In addition, it's potential to predict the degree of increase in capability by mistreatment simplified analytical solutions.

KEYWORDS: Ansys Software, Basalt Fiber Reinforced Polymer, Flexural Strength, Carbon Reinforced Polymer.

1. INTRODUCTION

Steel is that the world's most important engineering and construction material. Steel is associate alloy of iron and carbon and different components. Due to its high strength and low value, it's a significant element utilized in housing industry for nearly each form of structure like multi-storey buildings, bridges, industrial shades, towers etc. Steel structures are advantageous because it offers high strength, ductility, long durability, speedy construction, flexibility and might be recycled thus reduces the price. Despite of getting these blessings steel structure has some disadvantages like high maintenance, condition to buckling, corrosion action thanks to completely different environmental conditions, fatigue, tiny resistance against hearth and it's additionally deteriorated because of aging. These factors weaken the structure and scale back its life.

A large range of steel structures, like buildings, offshore platforms, massive mining instrumentation and bridges get broken attributable to varied reasons and need repairing. Therefore to regain the strength and to increase the lifespan, structures are required to be re-strengthened. Typical ways of strengthening and rehabilitation of existing steel components are supported adding steel plates to the current member either by fastening or bolting. These plates are sometimes large, heavy, and tough to repair and at risk of corrosion and fatigue. Though attachment is taken under consideration a convenient because of add the additional plates, it's always associated with fatigue issues. On the other hand, bolting will not be a fascinating different due to its high price and an enormous space district regional locality vicinity section of the cross-sectional area may be lost as a results of drilling for holes.

The ways of retrofitting that utilizes steel plates has some disadvantages like use of elevating work instrumentation to lift the plates and because of this extra loading are on the structure. The employment of steel in buildings' retrofitting usually will be often thought of economical and efficient because: Steel structures are significantly effective design performance-based style. Due to ductile behavior of steel members raise elastic limit, it dissipates on the far side quantity of energy before damages occur.

Buildings attract less base shear below associate earthquake because of higher strength-to-weight and stiffness-to-weight ratios of steel members, a better-quality control will be achieved within the production of the fabric additionally as a result of the fabrication and erection of them, whereas guaranteeing results almost the theoretical predictions It potential to use steel to retrofit all sorts of structures while not increasing the dead weight dramatically, creating the works less annoying and time intense. Considering all the positive and negative factors of steel members, the requirement for an alternate technique and/or material has been continually advantageous. Fiber reinforced polymer (FRP) materials are established as alternatives to steel in several infrastructure applications.

In recent years, the use of fiber reinforced polymer (FRP) composite materials has been speedily growing across various industries, for example the aerospace, automobile, marine, and construction industries [1]. Currently, associate large proportion of economic product and mechanical components are created of FRP composite materials as against Al or steel. Additional specifically, the appliance of FRP is gaining acceptance, primarily because of its non-corrosive nature, high specific strength, high specific stiffness, and lower specific weight relative to straightforward steel [1].Fiber may be a natural or artificial substance that's considerably longer than it's wide. Fibers are usually utilized in the manufacture of alternative material. The strongest engineering materials usually incorporate fibers, as an example carbon fibre. The common FRP materials chiefly in the main carbon fibre strengthened reinforced (CFRP), glass fiber reinforced polymer (GFRP) and aramid fibre reinforced polymer (AFRP). On the premise of fibers differing kinds of FRPs are classified.

1.1 Need for Basalt Fibre Reinforced Polymer

Basalt fibre is a new construction material to fibre reinforced polymers (FRPs) and structural composites. Basalt fibre has a similar chemical composition as glass fibre. It has better strength characteristics than glass fibre, and unlike most glass fibres is highly resistant to alkaline, acidic and salt attack making it a good alternative for steel, concrete, bridge and shoreline structures. Compared to carbon and aramid fibre, basalt fibre has the features of wider application temperature range -452° F to 1,200° F (-269° C to +650° C), higher oxidation resistance, higher radiation resistance, higher compression strength, and higher shear strength. (Note that application temperatures of FRPs are limited by the glass transition temperature of the matrix, which is lower than the application temperature of the fibres.)Producing fibres from basalt was started during the cold war by the old Soviet Union and limited commercial research and production was done in the U.S. during the same period. The Soviets researched basalt as a source of fiber for ballistic resistant textiles. Basalt fibers have higher tensile strength than E-glass fibers but lower than S-glass, however, its cost is near the cost of E-glass. It has much better resistance than E- and S-glass to the alkalis in concrete

1.2 Conclusions from the Previous Research

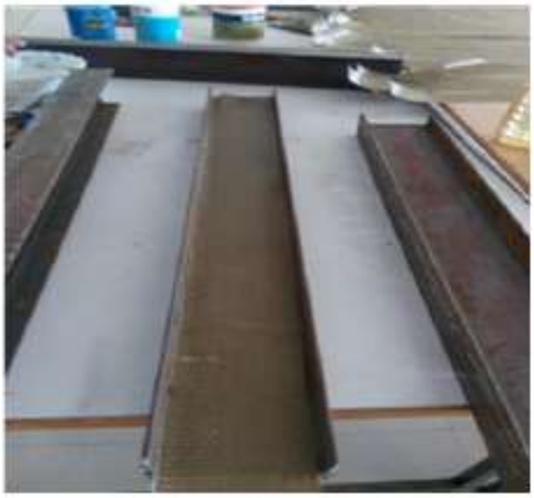
The numerical analysis assisted by previously valuable experimental results found in the literature succeeded to predict the critical CFRP plate length at which, full efficiency of the adhesively bonded plate is achieved. An analytical model to predict the linear and nonlinear behavior of steel beams rehabilitated using FRP The tested specimen failed when the FRP sheet reached its maximum tensile strength. Experimental program proved that the flexural load carrying capacity of a steel girder can be increased significantly by adhesively bonding carbon fiber polymer (CFRP) composites to its tension flange. Tapering of laminates end to reduce the interfacial stress. The results showed that it is possible to increase the moment capacity of a steel beam with CFRP bonded to its tension flange.

They summarized and concluded along with view of, research work is needed on this subject especially for strengthened steel members where there is an inconstancy between the thermal expansion properties of steel and composite laminates

2. MATERIALS AND METHODS

Present study focused on Experimental investigation on failure analysis and flexural behavior of Basalt Fibre Reinforced polymer (BFRP) strengthened steel I-beam. The objective of this investigation is to study the effect of basalt fibre reinforced polymer on steel I section under flexure. ISLB 100 is used as main beam or control beam with thickness of web is 4 mm and flange having dimension as 50mm legth and 4mm thick Total ten beams were tested. Out of these, 3 beam was control beam. These I sections were strengthened with BFRP sheets.

Figure 1:



Cross sectional details of the I-beam

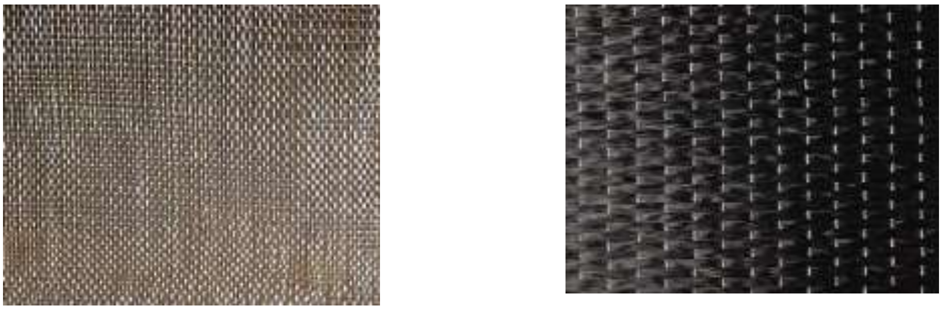
2.1 FRP strips

The beam specimens which are explained above were strengthened by BFRP an strips. These strips were adhered to both flanges and layers (single and double). Width of strip is CFRP same (46 mm) for all strengthened beams. The BFRP and CFRP strip had following characteristics shown in table. (Data is provided by the company)

Table 1.CFRP and BFRP polymer Sheet Properties

Properties	**BFRP**	**CFRP**
Density	2.7 Kg/m3	1.8 Kg/m3
Modulus of elasticity	89Gpa	230 Gpa
Tensile strength	4.84Gpa	2.28 Gpa
Elongation at break	3.15%	1.1%
Poisson’s ratio	0.26	0.2
Maximum temperature	650ºc	860 ºc

Figure 2:



Basalt Fibre Reinforced Polymer (BFRP) Strips

Carbon fiber Polymer (CFRP) Strips

2.2 Testing of Beams-

All the 10 beams were tested one by one, one beam was control beam, three beams were bonded for different length and with single layer of BFRP and CFRP sheet on tension flange, three beams were bonded for different length and with double layer of BFRP and CFRP sheet on tension flange and three beams were bonded for different length and with double layer of BFRP and CFRP sheet on both tension and compression flange.

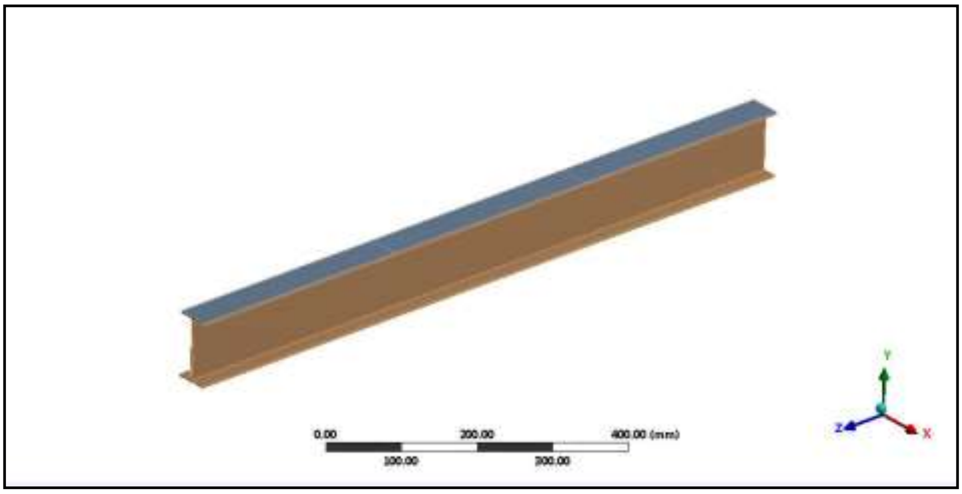
Figure 3:

Test set up of I beam

2.3 Development of finite element model using ANSYS software:

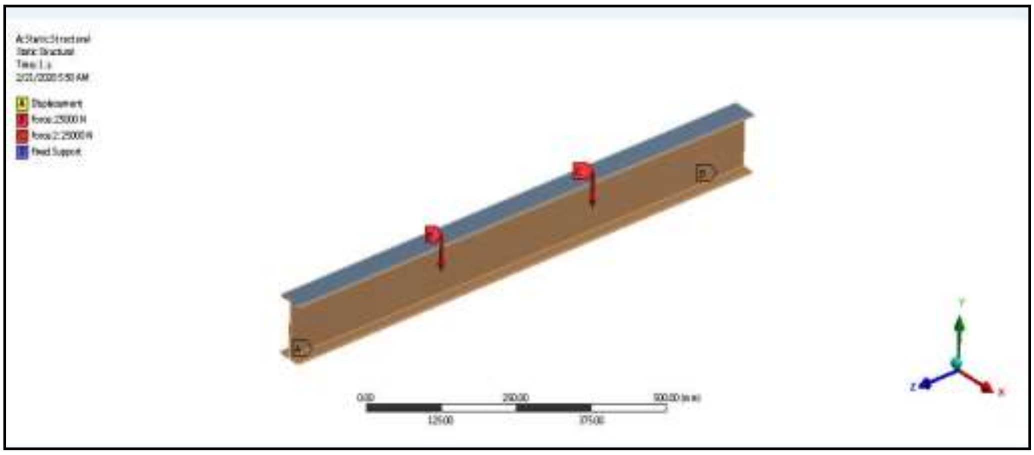
In the present study finite element program (ANSYS v.13.0) used to build three dimensional model of steel beam. Two type of element were used to represent the beam namely SOLID185 and SOLSH190. To develop precise model, the actual boundary conditions as well as loads were applied on 3D finite element model. Deformations at the mid-span of beam in finite element model are found to be similar as that of actual tested beam.

Figure 4:



Finite Element model of I-beam in ANSYS

Figure 5:



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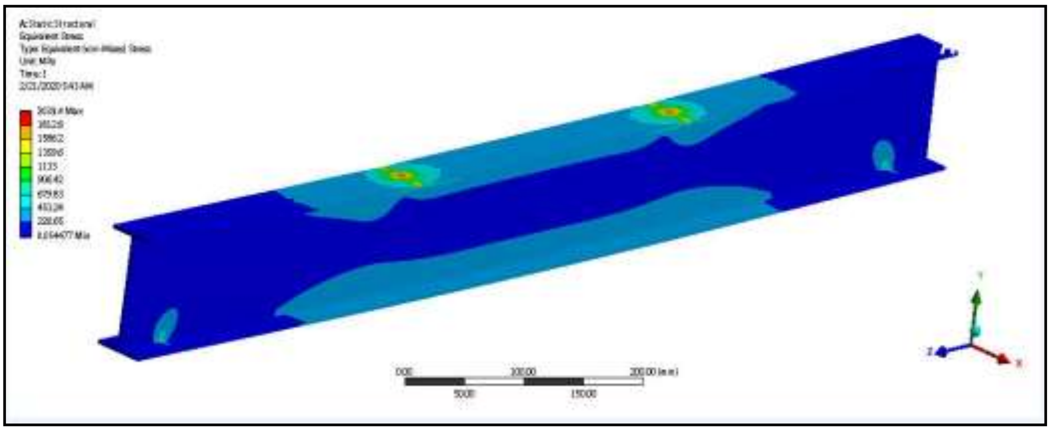
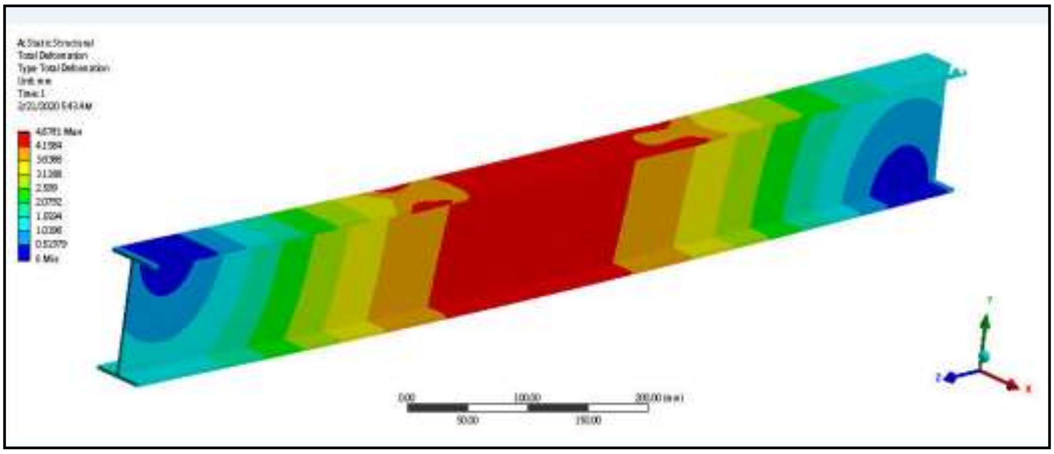
Finite Element model of I-beam in ANSYS with Support condition

Figure 6:



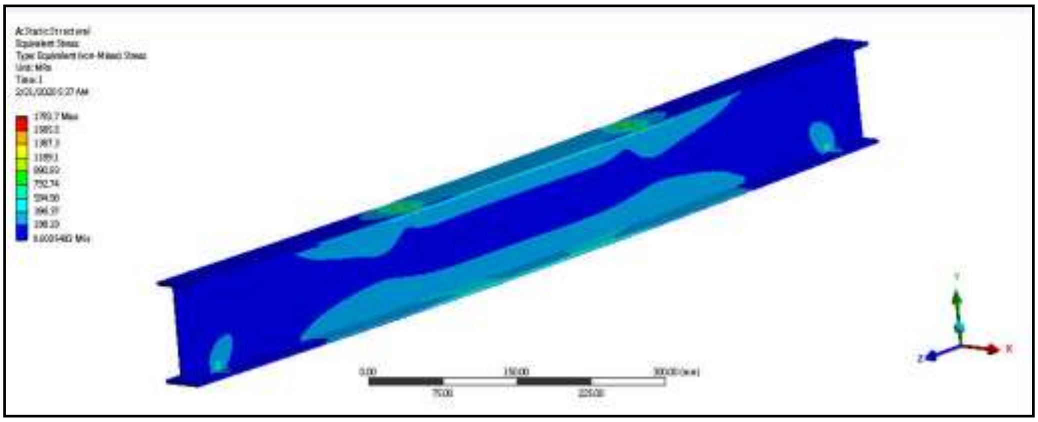
Equivalent stress distribution of I-Beam

Figure 7:



Deformation on I Beam in FE model

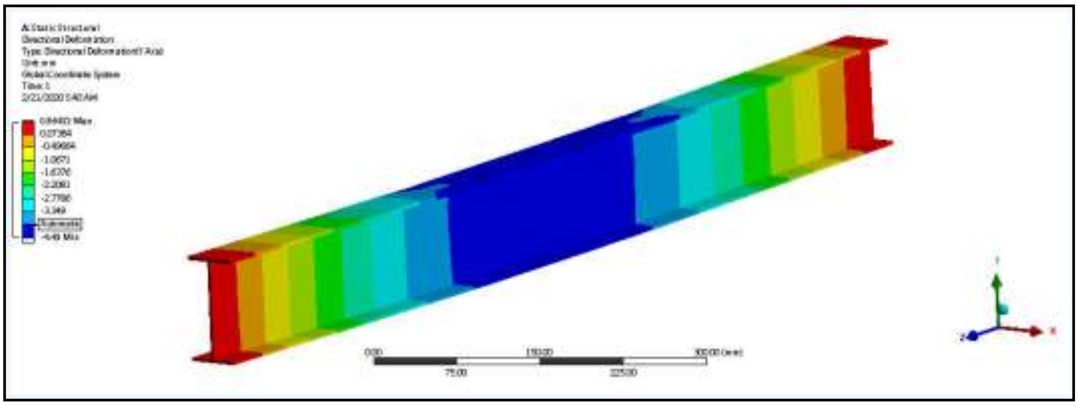
Figure 8:



Stress distribution Fiber sheet bonded on tension and comp. flange in FE model

ISSN: 2277-9655
Impact Factor: 5.164
CODEN: IJESS7

Figure 9:



Deformation Fiber sheet bonded on tension flange in FE model

3. RESULTS AND DISCUSSION

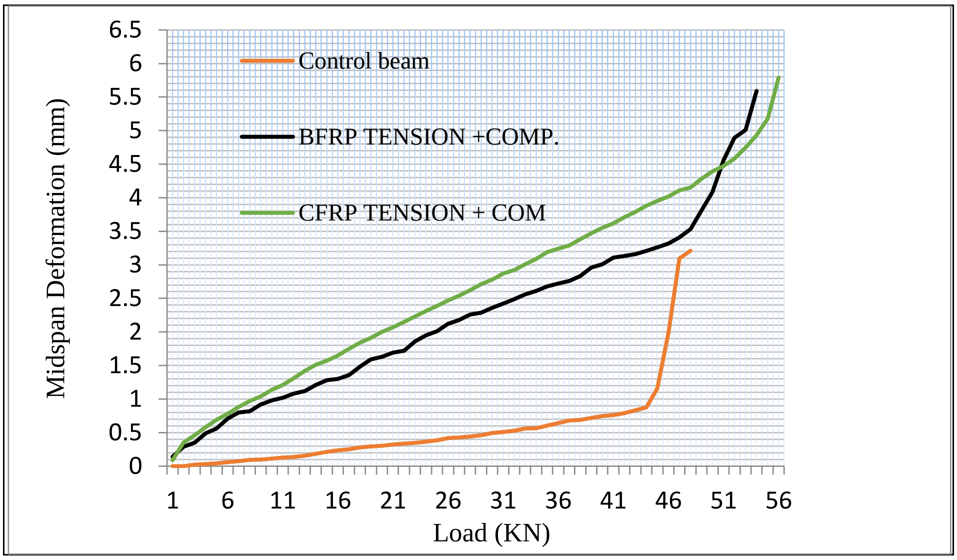
Results obtained in four point bending test for two control beams are listed in table Fig. shows Load vs. Deformation graphs.

Table 2. Midspan deflections of control beam, BFRP on tension side, CFRP on tension side

	Control beam	**BFRP on tension side**	**CFRP on tension side**
LOAD (KN)	**Deformation (mm)**	**Deformation (mm)**	**Deformation (mm)**
1	0	0.62	0.15
2	0	0.65	0.36
3	0.02	0.75	0.49
4	0.03	0.91	0.59
5	0.04	1.01	0.75
6	0.06	1.07	0.88
7	0.075	1.15	1.01
8	0.095	1.18	1.1
9	0.1	1.27	1.2
10	0.115	1.37	1.31
11	0.125	1.45	1.39
12	0.135	1.54	1.5
13	0.155	1.66	1.65
14	0.185	1.72	1.78
15	0.215	1.75	1.8
16	0.235	1.8	1.9
17	0.25	1.86	1.99
18	0.28	1.92	2.09
19	0.295	1.97	2.18
20	0.305	2.04	2.29
21	0.325	2.1	2.36
22	0.335	2.14	2.45
23	0.345	2.18	2.54

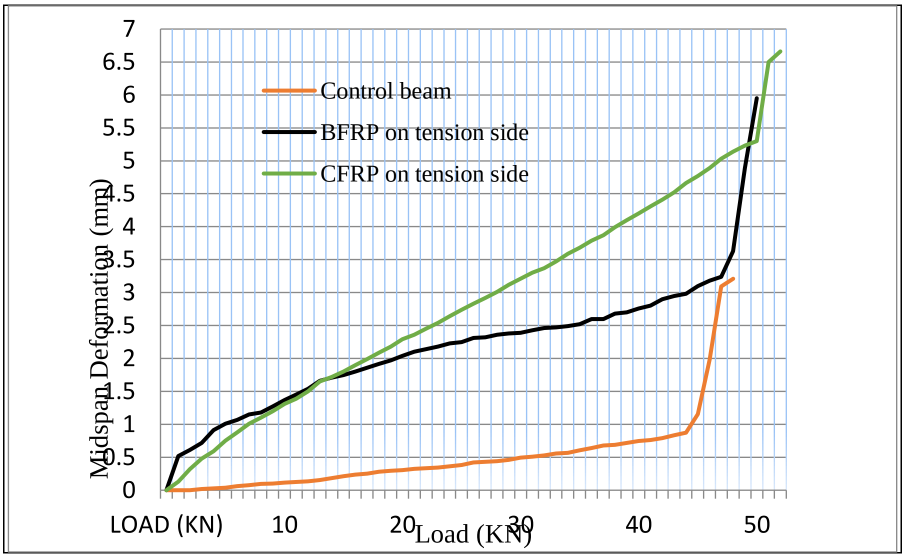
24	0.365	2.23	2.64
25	0.385	2.25	2.74
26	0.42	2.31	2.83
27	0.43	2.32	2.92
28	0.44	2.36	3.01
29	0.46	2.38	3.12
30	0.495	2.39	3.21
31	0.51	2.43	3.3
32	0.53	2.46	3.37
33	0.56	2.47	3.47
34	0.565	2.49	3.59
35	0.605	2.52	3.68
36	0.64	2.6	3.79
37	0.68	2.6	3.87
38	0.69	2.68	3.99
39	0.72	2.7	4.1
40	0.745	2.76	4.2
41	0.76	2.8	4.31
42	0.79	2.9	4.41
43	0.835	2.95	4.52
44	0.875	2.98	4.66
45	1.155	3.1	4.77
46	1.985	3.18	4.89
47	3.095	3.24	5.03
48	3.21	3.63	5.14
49		4.89	5.19
50		5.95	5.2
51			6.45
52			6.6

Graph 1:



Comparative Load vs. deflection plot for beams bonded with FRPs (at Compression flange)

Graph2:



Comparative Load vs. deflection plot for beams bonded with FRPs (at tension flange)

4. CONCLUSION

The numerical analysis assisted by previously valuable experimental results found in the literature succeeded to predict the critical CFRP plate length at which, full efficiency of the adhesively bonded plate is achieved. an analytical model to predict the linear and nonlinear behavior of steel beams rehabilitated using FRP The tested specimen failed when the FRP sheet reached its maximum tensile strength. Experimental program proved that the flexural load carrying capacity of a steel girder can be increased significantly by adhesively bonding carbon fiber polymer (CFRP) composites to its tension flange. Tapering of laminates end to reduce the interfacial stress. The results showed that it is possible to increase the moment capacity of a steel beam with CFRP bonded to its tension flange.

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