

FEA and Experimental Analysis of Composite I-Beam Subjected to Tensile Test.

Mr. Londhe A.H.¹,

¹ Professor, Mechanical Engineering Department, Fabtech Engineering College Sangola, Maharashtra,

Abstract - This paper presents experimental analysis of adhesively bonded GFRP I-Beam in pulling load which changes damage occurs, due to alterations in Adhesives used. The use of adhesive bonding in advanced composite structures has potential to reduce weight as compared to mechanical fasteners. Tensile tests were carried out for four composite I-beam specimens with two adhesives. The adhesives used have different properties. Web and flanges of I-Beam specimen is made of material GFRP and for joining web to flanges two different adhesives are used for two separate specimen. The present work is focused on quantifying and enhancing the failure load of GFRP composite I-Beam.

Key Words: Web, Flanges, GFRP, I-Beam, Failure Load, Composite

1. INTRODUCTION

An I-beam, also known as H-beam-beam, Universal Beam, or double-T beam with an I- or H-shaped cross-section. The horizontal elements of the I beam are known as flanges, while the vertical element is termed the web. I-beams are usually made of structural steel and are used in construction and civil engineering. I-beams are widely used in the construction industry and are available in a variety of standard sizes. I-beams may be used both as beams and as columns.

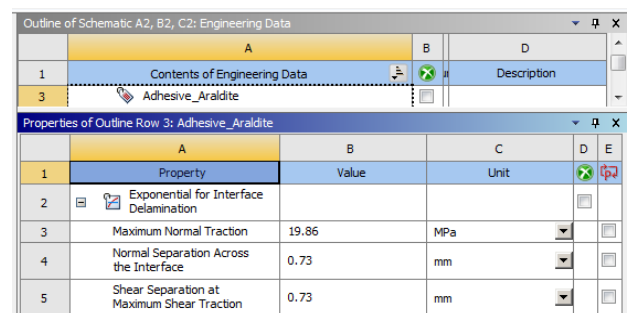
Table -1: Dimensions of I-Beam for FEA & Experimental Work

Sr. No.	Material	Adhesive used	Beam Height (mm)	Flange Width (mm)	Web thickness (mm)	Flange Thickness (mm)
1st	GFRP	Araldite 2015	80	46	5.0	5.0
2nd	GFRP	Hundsman Araldite	80	46	5.0	5.0

Above table-1 shows specification of I-Beam specimen which is selected for project. Specifications are taken as per Indian standard.

2. FEA OF 1ST I-BEAM SPECIMEN WITH ARALDITE 2015 ADHESIVE

Table -2: Properties of Araldite 2015



Property	Value	Unit
Exponential for Interface Delamination		
Maximum Normal Traction	19.86	MPa
Normal Separation Across the Interface	0.73	mm
Shear Separation at Maximum Shear Traction	0.73	mm

Above table-2 gives the properties of adhesive Araldite 2015. By using this adhesive when we done FEA of 1st I-Beam component we got following graph of time Vs force capacity shown in chart 1 In the graph time is taken on x-axis and force capacity is taken on y-axis. This component have taken maximum force of 14945 N

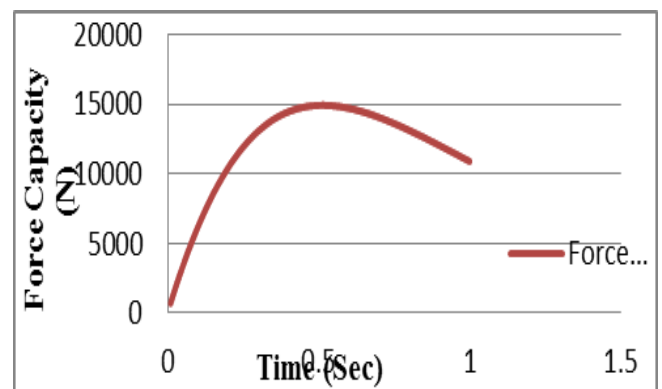


Chart- 1: Force Capacity of I-Beam with Araldite 2015 Adhesive

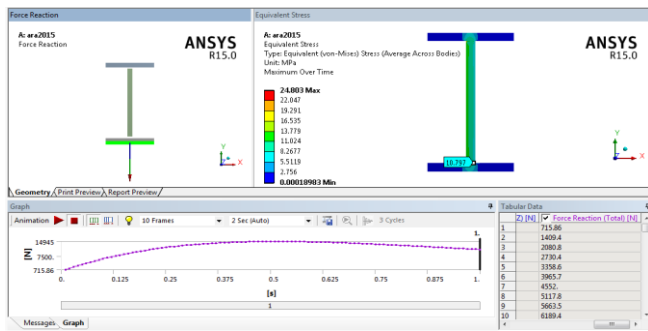


Fig-1: Force Reaction of I-Beam with Araldite 2015 Adhesive

Above fig-1 Shows force reaction, Upper flange of beam is fixed and pulling load is applied along y-axis, as load increases with time one step reached where the beam taken 14945 N load and failed.

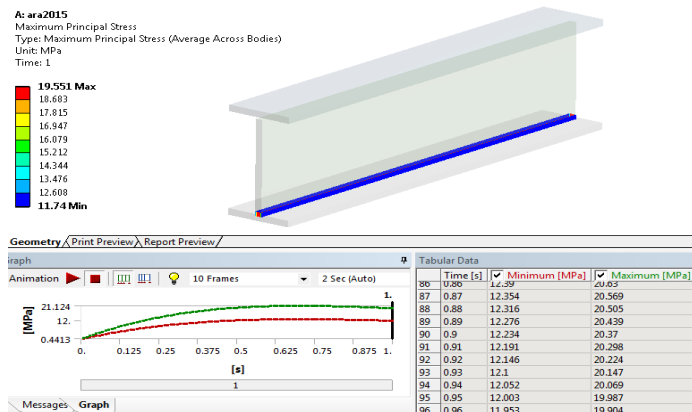


Fig- 2: Max Principal Stress of I-Beam with Araldite 2015 Adhesive

Max principal stress at the bonding area of flange and web junction is 10.797 MPa and it can be seen in above fig-2 The graph of Time Vs Stress for 1st I-Beam specimen is also shown above fig.2 which clearly indicates as time increases stress on junction point increases and it has taken 10.797 MPa stress and failed.

2.1 FEA OF 2nd I-BEAM SPECIMEN WITH HUNDSMAN ARLDITE ADHESIVE

Table -3: Material properties of Huntsman Araldite Adhesive

Outline of Schematic A2, B2, C2: Engineering Data			
	A	B	D
1	Contents of Engineering Data		Description
6	Huntsman Araldite		
Properties of Outline Row 6: Huntsman Araldite			
	A	B	C
1	Property	Value	Unit
2	Exponential for Interface Delamination		
3	Maximum Normal Traction	20.29	MPa
4	Normal Separation Across the Interface	0.82	mm
5	Shear Separation at Maximum Shear Traction	0.82	mm

Above table-3 gives the properties of adhesive Huntsman Araldite. By using this adhesive when we solved FEA of 2nd I-Beam component we got following graph of time Vs force capacity shown in chart-2. In the graph time is taken on x-axis and force capacity is taken on y-axis. This component has taken max force of 15269 N.

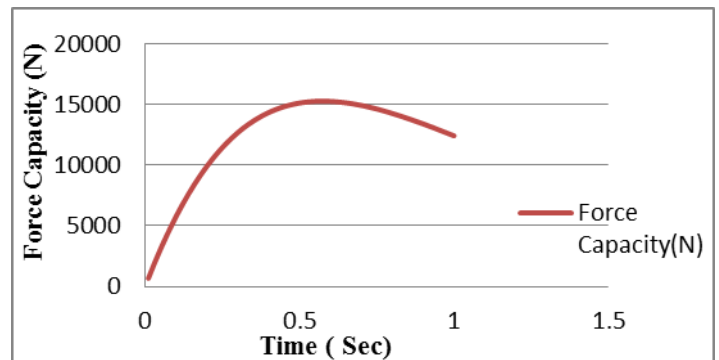


Chart- 2: Force Capacity of I-Beam with Huntsman Araldite Adhesive

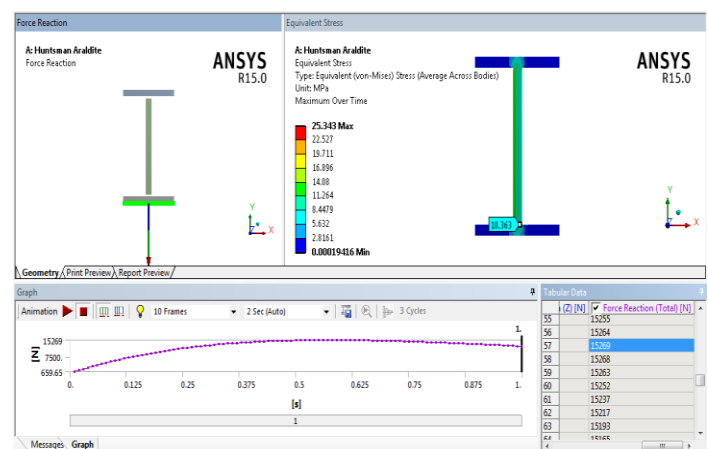


Fig- 3: Force Reaction of I-Beam with Huntsman Araldite Adhesive

Above fig.-3 Shows force reaction, Upper flange of beam is fixed and pulling load is applied along y-axis on flange, as load increases with time one step reached where the beam taken 15269 N load and failed, Above fig.-3 also shows a time Vs load curve, time is taken on x- axis and force is on y-axis.

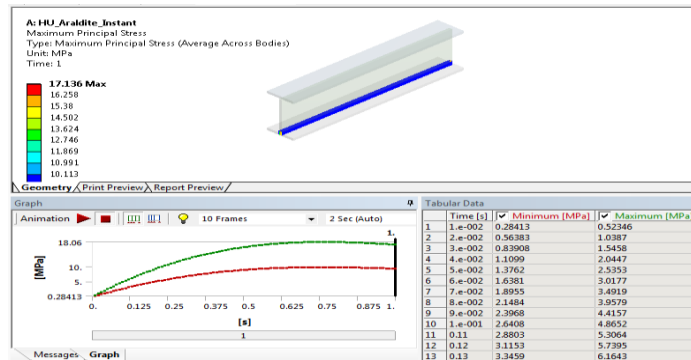


Fig-4: Max Principal Stress of I-Beam with Hundsman Araldite Adhesive.

Max principal stress at the bonding area of flange and web junction for 2nd specimen is 10.363 MPa and it can be seen in above fig.-4. The graph of Time Vs Stress for 2nd I-Beam specimen is also shown in above fig.-4 which clearly indicates as time increased, stress on junction point also increased and it has taken 10.363 MPa stress and failed.

Table -4: Max Principal Stress Sustained By I-Beams

Specimen No.	I-Beam With Adhesive	Stress (MPa)
1 st	Araldite 2015	10.797
2 nd	Hundsman Araldite	10.363

From above result table-4 it is observed that, I-Beam with Araldite 2015 has offered max stress as compared to Hundsman Araldite.

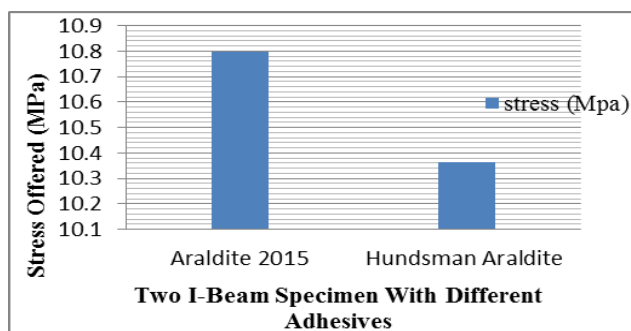


Chart-3: Graph of I-Beam Specimen Vs Stress.

In above plotted chart- 3, two I-Beam specimen are taken on x-axis, stress is taken on y-axis, it is clear that 2nd I-Beam

specimen with Hundsman Araldite as adhesive has taken minimum stress 10.363 MPa.

Table -5: Maximum Force Carrying Capacity of I-Beams Specimens

Specimen No.	I-Beam with adhesive	Force (N)
1 st	Araldite 2015	14945
2 nd	Hundsman Araldite	15269

It is observed from above result table-5; I-Beam with Hundsman Araldite has maximum force carrying capacity as compared to Araldite 2015 specimen.

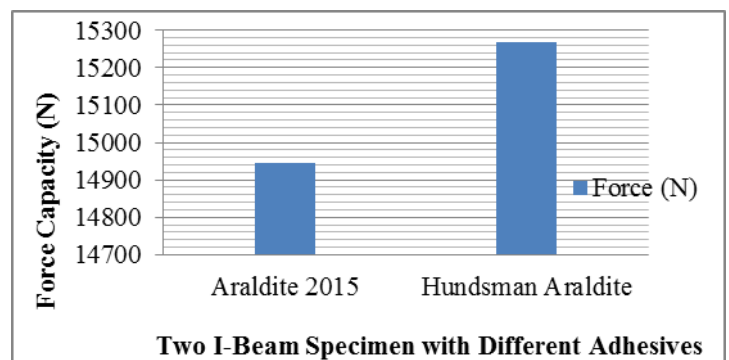


Chart-4: Graph of I-Beam Specimen Vs Force.

In above plotted chart-4, Two I-Beam specimen are taken on x-axis, and force capacity are taken on y-axis, it is clear that 2nd I-Beam specimen with Hundsman Araldite adhesive has taken maximum force as compared to Araldite 2015 specimen. I-Beam specimen with Hundsman Araldite has taken force of 15269 N, where as the specimen with araldite 2015 has taken force of 14945 N. It means Specimen of Hundsman Araldite is stronger than specimen of araldite 2015.

3. EXPERIMENTAL ANALYSIS OF COMPOSITE I-BEAM WITH DIFFERENT ADHESIVES:

In previous chapter we have completed analysis of two specimens of GFRP I-Beam with adhesive as Araldite 2015 and Hundsman Araldite by using ANSYS 15 software. In this chapter we have validated results that we got from ANSYS. Two I-Beam specimens are made from material GFRP and same adhesive as we discussed in last chapter, even we have kept same dimensions.

3.1 EXPERIMENTAL ANALYSIS OF GFRP I-BEAM WITH ARALDITE 2015 AS ADHESIVE:



Fig- 5: Experimental Setup of Composite I-Beam Tensile Testing

Above fig-5 shows a experimental setup for this project work, the computerised universal testing machine of 1000KN capacity and it can be used for compressive as well as tensile testing. The fixture is attached between two jaws of UTM which pulls the flanges in tensile testing. The machine is attached with computer which shows results of load Vs displacement, load Vs time etc.



Fig- 6: 1st I-Beam Specimen with Araldite 2015 Adhesive Before Test

In fig-6 it is shown that 1st I-Beam specimen is properly fixed in fixture, two jaws of UTM pulls the two flanges in opposite direction axially for tensile testing, stress at the joint and force carrying capacity is directly displayed on computer, result of this test is displayed on computer and it is given below.

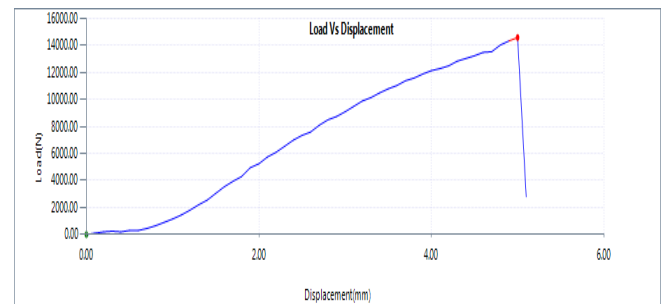


Chart-5: Load Vs Displacement

Above chart-5 shows load Vs displacement curve for 1st specimen with Araldite 2015 adhesive, this specimen has taken maximum force of 14600 N and then it is failed similarly it has offered maximum stress of 9.542 MPa

3.2 EXPERIMENTAL ANALYSIS OF GFRP I-BEAM WITH HUNDSMAN ARALDITE AS ADHESIVE:



Fig- 7: 2nd I-Beam with Hundsman Araldite Adhesive Before Tensile Test

In fig-7 it is shown that 2nd I-Beam specimen is properly fixed in fixture, two jaws of UTM pulls the two flanges in opposite direction for tensile testing, stress at the joint and force carrying capacity is directly displayed on computer screen, result of this test is displayed on computer and it is given below.

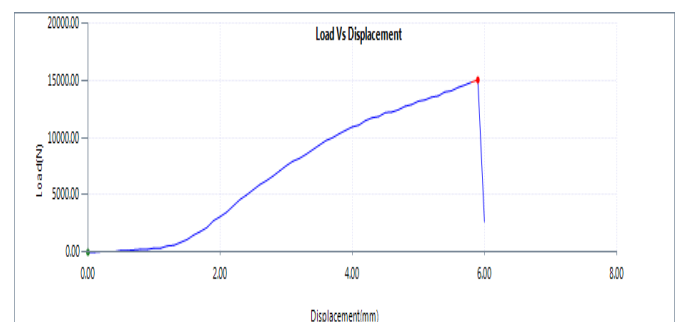


Chart-6: Load Vs Displacement

Above chart-6 shows Load Vs Displacement curve for 2nd I-Beam specimen which clearly shows that it has taken maximum force of 15050 N and then it is failed, 2nd specimen has taken maximum force as compared to 1st specimen with adhesive as Araldite 2015.

Table-6: Maximum stress Sustained by First Two I-Beam

Specimen No	I-Beam specimens with Adhesive	Stress (MPa)
1 st	I-Beam with Araldite 2015	9.542
2 nd	I-Beam With Hundsman Araldite	9.837

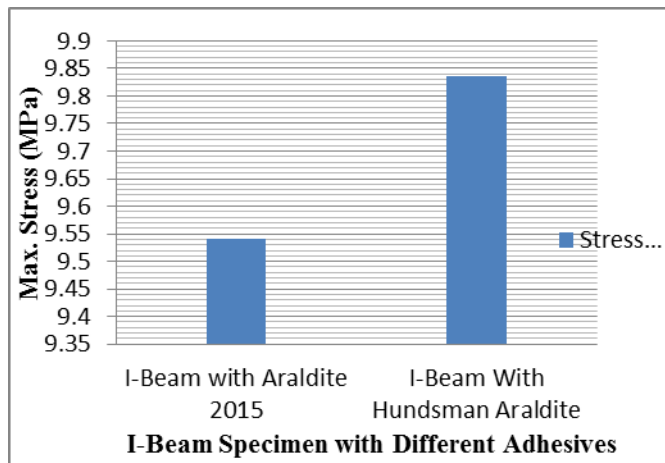


Chart-7: I-Beam Specimen Vs Maximum Stress

Above chart-7 shows a result of stress values for first two specimens, 1st specimen has offered maximum stress of 9.542 MPa and 2nd specimen has offered 9.837 MPa. The above graph clearly shows I-Beam with Hundsman Araldite has offered maximum stress as compared to Araldite 2015.

Table-7: Maximum Force Sustained By First Two I-Beam

Specimen No.	I-Beam with Different Adhesive	Force Capacity (N)
1 st	Araldite 2015	14600
2 nd	Hundsman Araldite	15050

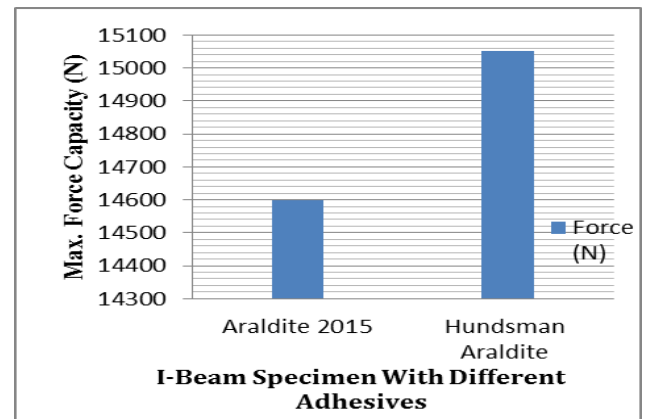


Chart-8: I-Beam Specimen Vs Maximum Force Carrying Capacity

The above chart-8 clearly shows I-Beam with Hundsman Araldite has maximum force carrying capacity as compared to Araldite 2015 therefore it is selected for the next experimental work.

4. CONCLUSIONS

Table-8: Comparison of Force Sustained by 1st and 2nd I-Beam in ANSYS and Experimentally

Specimen No.	I-Beam with Adhesive	ANSYS (Force N)	Experimental (Force N)
1 st	Araldite 2015	14945	14600
2 nd	Hundsman Araldite	15269	15050

Above table-8 gives force capacity of first two I-beam specimens by FEA and experimental method. The specimen with Hundsman Araldite as adhesive has maximum force capacity which is observed by FEA and experimentally.

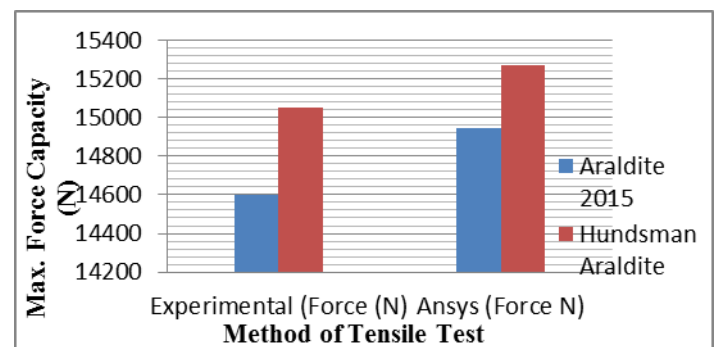


Chart-9: Method of Tensile Test Vs Force Capacity

In above chart-9 we can see when two GFRP I-beam specimens are tested for calculating force capacity by

ANSYS and UTM, in both methods it is found that I-beam specimen with Hundsman Araldite as adhesive has maximum force carrying capacity than Araldite 2015.

REFERENCES

[1] Luciano Feo, Ayman S. Mosallam, Rosa Penna, "Mechanical behavior of web-flange junctions of thin-walled pultruded I-profiles: An experimental and numerical evaluation" Department of Civil Engineering, University of Salerno, 84084 Fisciano SA, Italy, 2013, pp. 18-39.

[2] G. Vasdravellis, B. Uy, E. L. Tan, B. Kirkland, "The effects of axial tension on the hogging-moment regions of composite beams" School of Engineering & Civionics Research Centre, University of Western Sydney, Sydney, Australia, 2012, pp. 20-33.

[3] J. A. B. P. Neto, R.D.S.G.Campilho, L. F. M. daSilva, "Parametric study of adhesive joints with composites", Mechanical Engineering Department, Portugal, 2012, pp. 96-101.

[4] S. Guo, R. Morishima, "Numerical analysis and experiment of composite sandwich T-joints subjected to pulling load" Aerospace Engineering, School of Engineering, Cranfield University, Cranfield, Bedfordshire MK43 0AL, UK, 2011, pp. 229-238