FAILURE STRENGTH ANALYSIS OF COMPOSITE I-BEAM FOR EFFECTIVE DESIGN

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Abstract

In most of the acidic environments in the industry, the steel equipment parts are coated with Polyurethane (PU, which indicates chemical reaction after some time of use. This is a prevalent and persisting problem of the industries. Prevention of this rust and extend the life of steel parts is a challenge to the equipment designers and users. This problem can be minimized or prevented by use of reinforced epoxy glass fiber composite material. In the present research work, the results have revealed that, 2015 araldite indicates, better resistance to the reaction with maximum stress as 10.797 MPa. This is comparable to maximum stress value of 10.363 MPa with Huntsman Araldite adhesive. This shows improved failure strength on th Web Flange Joint (WFJ). The numerical analysis clearly shows there is no reaction effect on the immersed, in the acidic solution, reinforced epoxy glass fiber for a certain period of time. Hence the sample has shown much improved behavior in the subjected environment.

Keywords: *Chemical Industry, Steel parts, Polyurethane, Reinforced epoxy glass fiber, Huntsman Araldite*

INTRODUCTION

The I-beam is made by two different section horizontal element is called as flange and the vertical element is called as web. I – beam is known by variety of commercial names in the application industries, with an H or I shape cross section. The flanges resist the bending moment and the web resists shear forces experienced by the beam. As suggested by the beam theories, the I beams are very efficient in case of shear forces and bending moments. However, the cross section of these beams is inefficient in case of torsional stresses or twisting moments. Hence hollow sections are suggested in such loading conditions for these beams to get improved strengths.

There are two different processes used to make the I-beam sections. 1. Plate girder made by welding plates. 2. Rolled I-beam, made by extrusion, cold rolling, hot rolling. The major application areas of these beams are construction work in civil engineering work, mechanical industry, chemical, and automobile. In the present proposed work, I-beam which is used in chemical factory for stirrer mounting mechanism, is subjected to study. Fig.1 shows that the geometry of I-beam is taken from ISMB 80 standard for using the sample of stirrer mounting mechanism. Height of the I-beam is 80 mm, flange width 50 mm and Web and Flange thickness is 5 mm.

Construction work, chemical industry, aircraft industry, automobile bodies are the major application areas where I beam are the structural members. In larger sections this I-beam is made up of steel with PU coating Web-flange junction of that beam is joining by welding or nut bolt joint. This I beam is completely immersed into the acid, named benzoinic acid. After certain duration, the PU coating shows rusting, as a result of reaction of the acidic environment with the base steel. This affected beam loses its utility and becomes a waste, cannot be used for any other application in future. Hence, as an alternative to this, the I-Beam with composite beam,made up of epoxy glass fiber material. However, the failure is mostly observed at the Web Flange Joint.

Two standard I-beam sections are designed as follows:

1. Plate girder, made by welding (or sometimes riveting or bolting) plates.
2. Rolled I-beam, made by extrusion, cold rolling, hot rolling (contingent on material).

Potter et al. studied that the use of adhesive bonding in advanced composite structures which offers the potential for considerable weight and cost saving compared to the use of mechanical fasteners. Conversely, the ability to design and analyses like structures and in their production to appropriate eminence quality standards are developed [1]. Experimental tests were accomplished that to examine the effect of bending moments and axial compression loads on composite I-beams. The effect of the aspect ratio on the first crushing load, the energy absorption and the initial crushing bending moments have also been studied. Woven fabric glass fiber was used as the fiber material while the matrix was of an epoxy resin and hardener mixture. Even though, the fabrication process for the composite I-beams have been done with great care in this project, some thickness variations have been foundeven along the same model [2].

Trahair N.S. et. al., have analysed the effect of restraints on elastic lateral buckling (no any deformation) of tracks loaded at the flange of bottom, and shows the which one to be excused for in design of the strength [3]. Most prone of stainless steel to fighting the corrosion, which was predictable of this purpose type of steel reason for its chemical composition? These corrosion specimens had excessive damage in strain and strength, along with the major weight defeat. Pitting was also most prevalent on these samples [4]. At that time this beam is used in acid factory the material of beam is steel with PU coating such as high elasticity, high chemical resistance, ultraviolet durability, and good transparency. In the field of engineering PU has been widely used in various domains, like tires, high- performance sealants, wheels, hard plastic parts seals, gaskets andautomotive suspension bushes. In spite of, the PU is not suitable abrasive wear resistance properties. PU specimens submerged in the 1 M HCl chemical solutions for various time-periods, in which the effect of weight of the PU has become a more substantial with longer involvement. The involvement of the PU in the chemical permits the immersion of water molecules so that the quantity of riveted water in the PU rises with improved immersion period, subsequent in dissimilar weight losses of the PU with altered immersion periods through evaporation of the engrossed water. On the other hand, the reduced weight of the PU with longer immersion time should be correlated to the lowered thermal stability of the polymer because the polymer structure can be degraded by the prolonged immersion in the highly acidic solution [5].

Geometry of I Beam

Figure 1 show that the geometry of I-beam is taken from ISMB 80 standard for using the sample of stirrer mounting mechanism. The height of the I-beam is 80 mm, the width of flange is 50 mm and thickness of the web and flange is 5 mm.

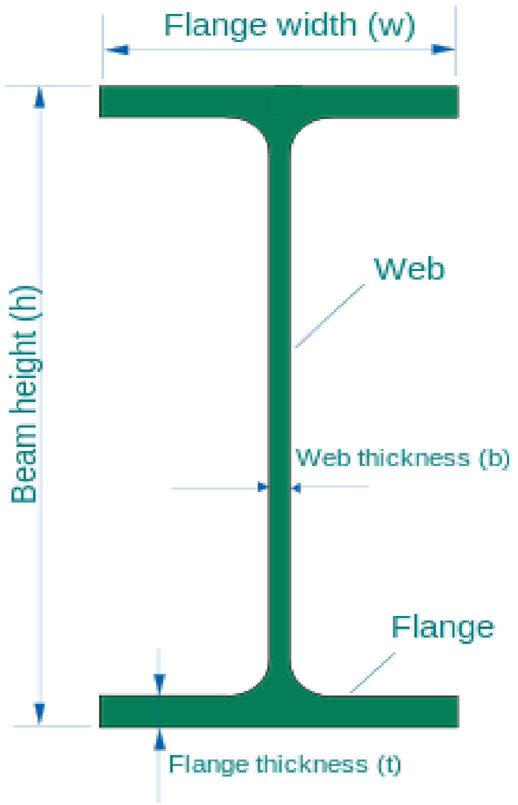

Figure 1: Geometry of I Beam.

Problem Statement

As understood from the design principles, web is resisting the shear forces and flage resists most of the bending moments experienced by an I Beam. The failure occurs at the web – flange joint (WFJ). Hence proper bonding of the web and flange is necessary to get strength to the I beam. The Chemical reaction between steel part coated with PU with acidic solution reduces the beam's life considerably. The beam also gets rusted. Hence the present study is carried out to improve the life of beam with reducing the rusting of the beam.

Objectives

1. To design the composite, I beam with material of reinforced epoxy glass fiber.
2. To analyse the stress and forces experienced by the composite I beam at WFJ with the help of FEA.
3. To carry out the improvement in failure strength of I beam with application of Araldite adhesive at WFJ.

MODELLING USING ANSYS

Following Step are used in ANSYS

To solve any ANSYS problem mainly following steps are used. These steps are common in all ANSYS problem except material properties and type of analysis used.

Preliminary Decisions

a) Analysis type
b) Model
c) Element type

Pre-processing

a) Material
b) Create or import the model geometry
c) Mesh the geometry

Solution

a) Apply loads
b) Solve

Post Processing

a) Review results
b) Check the validity of the solution

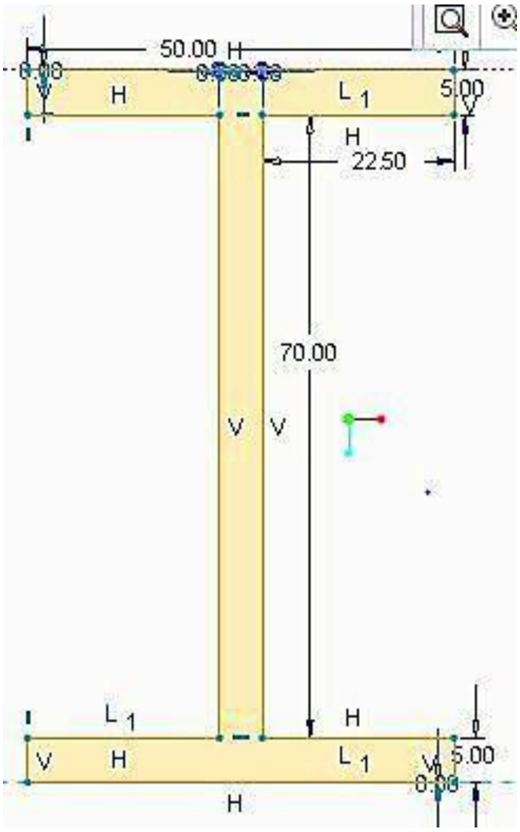

Figure 2: *Creo Design of I Beam.*

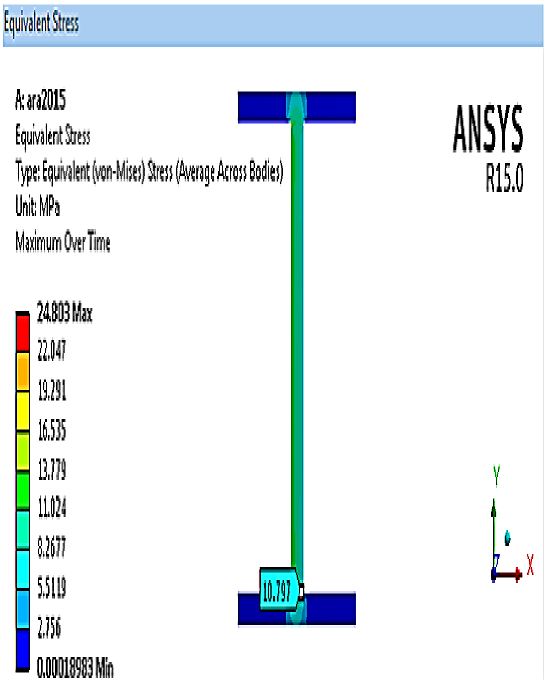

Figure 3: *Von-Mises Stress of araldite 2015.*

Maximum stress at the bonding area of flange and web junction is 10.797 MPa and it can be seen in above Figure 3. This clearly indicates as time increases stress on junction point increases and it has taken 10.797 MPa stress and then failed.

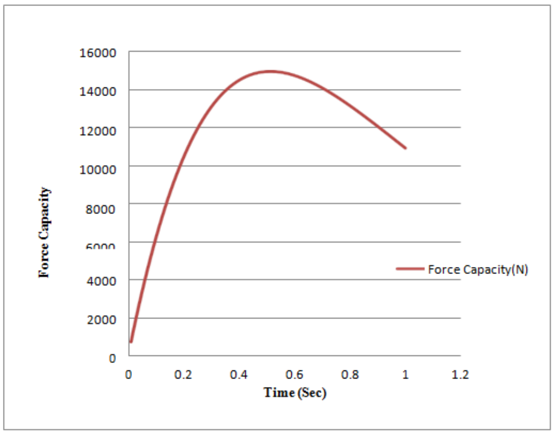

Figure 4: Force Capacity of I-Beam with Araldite 2015 Adhesive.

By using this adhesive when we done FEA of I-Beam component we got following graph of time Vs force capacity shown in Figure 4.

In the graph time is taken on x-axis and force capacity is taken on y-axis. This component has taken maximum force of 14945 N.

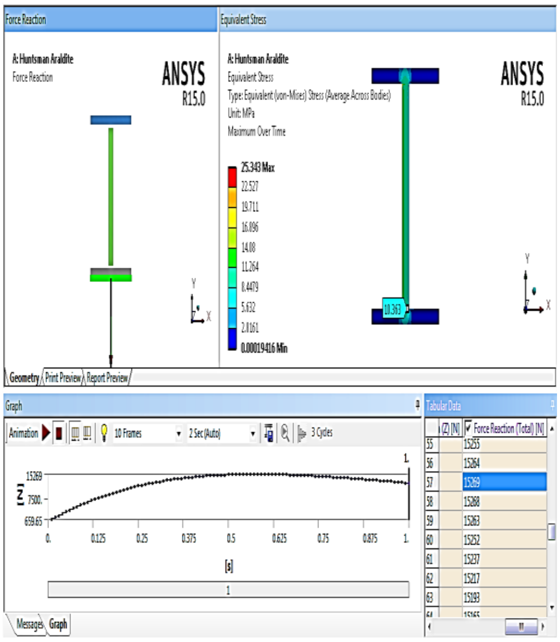

Figure 5: ***Von-Mises Stress Huntsman Araldite Adhesive.***

Figure 5 shows a time Vs load curve, time is taken on x- axis and force is on y-axis. The 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. Max principal stress at the bonding area of web- flange junction (WFJ) for specimen is 10.363 MPa. The I-Beam specimen which clearly indicates that the time increases, stress on junction point also increased and it has taken 10.363 MPa stress and then failed.

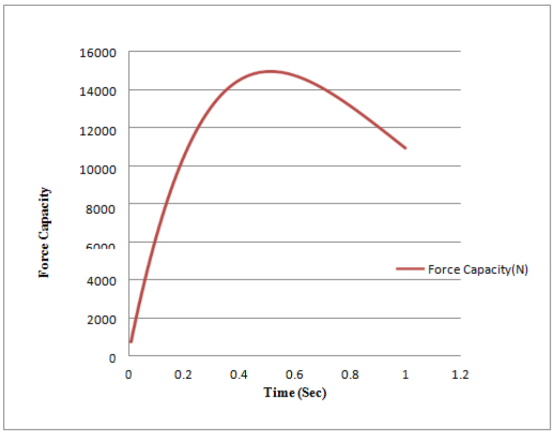

Figure 6: Force Capacity of I-Beam with Huntsman Araldite Adhesive.

By using this adhesive when we solved FEA of I-Beam component we got following graph of time Vs force capacity shown in Figure 6. 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.

PROPERTIES OF MATERIAL

Table 1: Properties of Glass Fiber-Reinforcement Materials.

Fiber Property	Glass Fibers
Diameter (μm)	8-14
Density (kg/m^3)	2560
Longitudinal Modulus of Elasticity (GPa)	76
Transverse Modulus of Elasticity (GPa)	76
Tensile Strength (GPa)	1.4-2.5
Elongation at Fracture (%)	1.8-3.3

Table 2: Properties of Epoxy Matrix

Matrix Property	Epoxy
Density (kg/m^3)	1100-1400
Modulus of Elasticity (GPa)	3-6
Tensile Strength (GPa)	0.035-0.10
Compressive Strength (GPa)	0.1-0.2
Elongation at Fracture (%)	1-6

RESULTS AND DISCUSSION

Table 3: *Max Stress Sustained by I-Beams at Joint*

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

From above result Table 3 it is observed that,I-Beam with Araldite 2015 has offered max stress as compared to Huntsman Araldite. It is clear that 2nd I-Beam specimen with Huntsman Araldite as adhesive has taken minimum stress 10.363 MPa.

Table 4: Maximum Force Carrying Capacity of I-Beams Specimens

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

Table 4, shows the results obtained with I-Beam joined with Huntsman Araldite at WFJ has maximum force carrying capacity as compared to Araldite 2015 specimen. It is clear that 2nd I-Beam specimen with Huntsman Araldite adhesive has resisted larger force value as compared to Araldite 2015 specimen. I-Beam specimen with Huntsman Araldite has taken force of 15269 N, whereas the specimen with araldite 2015 has taken force of 14945 N. The results prove that the second specimen, i.e. specimen prepared eith Huntsman Araldite has improved failure strength, hence preferred for replacement at actual area of application.

CONCLUSION

1. The I -Beam manufactured with composite materials and with use of Huntsman Araldite is the better option.
2. This beam also carries an advantage of less weight compared to the steel beams,
3. The larger force carrying capacity of Huntsman Araldite specimen proves that it's a better option compared to the specimen prepared with Araldite 2015.

REFERENCES

1. *Potter K.D. et al. Heavily loaded bonded composite structure: design, manufacture and test of `I' beam specimens. Department of Aerospace Engineering, Bristol University, University Walk, Queen's Building, Bristol BS8 1TR, UK, BAE Systems,Airbus, Ltd., Filton, UK. 2001: pp. 389-399.*
2. *Khalid Y.A. et al. Performance of composite I-beams under axial compression and bending load modes. Department of Mechanical Engineering and Manufacturing Engineering, Faculty of Engineering, University Putra Malaysia, Serdang, 43400 Selangor, Malaysia. 2005: pp. 127-135.*
3. *Trahair N.S. Lateral buckling of monorail beams. The University of Sydney, NSW, 2006, Australia. 2008:pp. 3213-3218.*
4. *Caitlin O'Brien et al. Mechanical Behavior of Stainless-Steel Fiber-Reinforced Composites Exposed to Accelerated Corrosion. 2017.*
5. *Naywin Khun & Erjia Liu. Tribological Behavior of Polyurethane Immersed in Acidic Solution. 2012.*