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Experimental investigation on Stiffness to Load ratio for L-joint Composite in Aerospace Application

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Abstract

In today's growing world composite materials are one type of materials which satisfy the unabated thirst for new materials which has to satisfy the various requirements in various fields. Glass fiber reinforced polymers (GFRPs) is a fiber reinforced polymer made of a plastic matrix reinforced with fine fibers of glass. The present work is undertaken to determine the influence of hollow steel tube reinforced in composites. Experimental investigation on strength of steel tube reinforced of E-glass polyester composite material L-section is carried out to increase the stiffness of glass/polyester composite material. Specimens with tubes will give the higher strength than the specimens without tubes.

Keywords: Composites, Stiffness, Glass fiber polymers, L-Joint, Strength.

1. Introduction

In today's growing world there is an unabated thirst for new materials 7 which has to satisfy the various requirements for applications like electronics, structural, transportation, house-hold, electrical, industrial, medical, aerospace applications, etc. Metals are used in these applications. With the progress in the field of material science and technology have given birth to the fascinating materials called composites. Composites are formed by constituent materials together to form overall structure that is better than the sum of individual components.
The modern-day examples of composites are fiber glass which is widely used today in the applications like building panels, boat hulls, many car bodies and sports equipment. Nowadays carbon composites are used in aircraft industry and some expensive sports equipments like- golf clubs. The world's largest passenger airliner A380 uses more than 20% of modern composites, mainly plastic reinforced with carbon fibers.

2. Objectives

Composites are having major applications in industries, because of their properties such as their adaptability to various situations and their relative combination with the other material, by which the required desired, can be fulfilled. The superior 3 properties of composites such as high strength to weight ratio, biodegradable, low thermal expansion, high tensile strength etc, which made the composite materials attractive to use.
G. Allegri, X. Zhang (et al),(1) This paper presents the damage tolerance capability of laminated T-joint composite structures having through-thickness reinforcement by Z-fibres and the process is called as Z-pinning. P. B. Stickler, (et al), (2) conducted an experimental study transversely stitching and toughened epoxy resin were used for improving the o2ut of plane properties of the composite joint. They studied the effect on joint strength and ultimate strength of the stitch density, web thickness, flange thickness and type of resin. S. Heimbs (et al),(3), failure behaviour of composite T-joints under quasistatic and high-rate dynamic loads is presented, including the investigation of different joint designs to increase damage tolerance and failure resistance. Three different T-joint designs using the same carbon fibre composite base material were used in this study. F.Dharmawan (et al),(4) For a monocoque hull structure, the bulkhead is used to separate the hull into many compartments. A typical joint between the hull and bulkhead used in such structure is known as a T-joint. It consists of composite over laminates over a shaped fillet to allow the transmission of direct and membrane shear stresses. K.Alagarraja (et al), (5) Here the work is done on the fabrication and testing of fiber reinforced polymer composites material. They used the

natural fiber composites such as sisal polymer composites. They combined sisal with glass fiber reinforced epoxy composites and finally evaluated mechanical properties such as tensile strength, impact strength, flexural strength and compression strength.

From the above literature reviews all the research works are carried out for improving the efficiency and overall mechanical strength of glass fiber reinforced plastic composites. Hence the present work is carried to improve the strength of GFRP on the basis of above literature reviews.

3. Methods

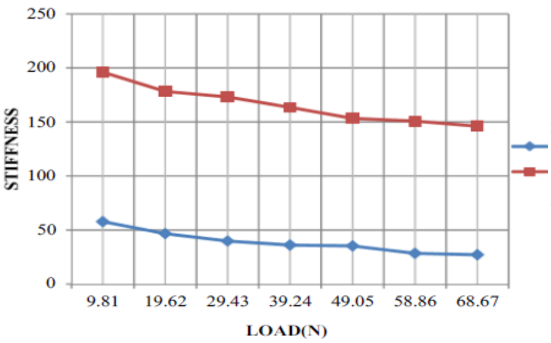
The important points to be considered in selection of the reinforcement consists of density, temperature, compatibility with matrix etc. Glass fibers are the best-known reinforcements in the fiber reinforced composites due its appealing combination of low cost and high strength and stiffness. Low density, insulation capacity, resistance to chemicals and resistance to temperature are the additional properties. Most commonly used in glass fiber reinforcement are unsaturated polyesters dissolved in styrene. These polyesters are produced by reacting an alcohol such as propylene glycol or ethylene glycol with various organic acids. Depending upon type of resin to be produced different types of alcohols and acids are used.

(a) L-Joint Specimen (b) Specimen with Loads (c) Specimen without Loads

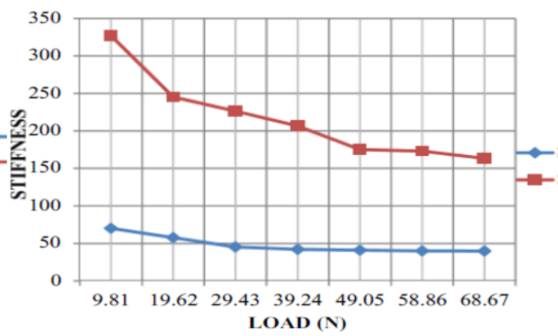
For the specimen with reinforcements the procedure remains same as above only change is that the steel tubes are inserted after third and sixth layer of the glass fiber. Some of the specimens with reinforcements fabricated under loading condition are shown above Figures (a), (b) and (c). In this work the steel tube reinforced composite specimens are compared with the specimens without reinforcement by considering their stiffness to weight ratio. The weight of the specimen is measured by using the standard weighing scale. The stiffness of the specimen is defined as the load by deflection. The load is applied on to the specimen by using the standard weights and the deflection is measured by using the dial gauge. Here two dial gauges are used to measure the deflection on the vertical deflection and the horizontal deflection.

4. Results

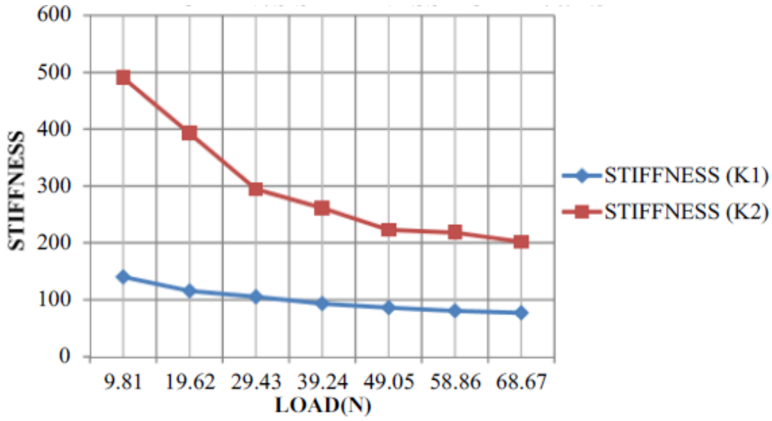
The testing results carried out to measure the deflection for the load applied are represented below. The composite specimen is held to the vice by using the C-clamp. By Using the magnetic base of the dial gauge table, it is fixed to the base and the dial reader is pointed at a suitable point which reads the deflection at that point. Initially the dial gauge readings are noted down only with weighing pan without any weights.



Graph (a): Load v/s stiffness for L-joint without reinforcement for specimen L1/0/0



Graph (b): Load v/s stiffness for L-joint with six number of steel tubes of 1.3mm diameter for specimen L1/6/1.3



Graph (c): Load v/s stiffness for L-joint with six number of steel tubes of 2.3mm diameter for specimen L1/6/2.3

This graph (a) shows the load v/s stiffness for the L-joint without any steel tube reinforcement. The stiffness K1 is the vertical deflection measured by dial gauge for the different dead weights applied. And the stiffness K2 is the horizontal deflection measured by another dial gauge mounted. The load is varied from 1kg to 7kg i.e., 9.81N to 68.67N. The stiffness decreases as the load increases. The stiffness for the vertical deflection is 57.707N/mm for 9.81N. The stiffness for the horizontal deflection is 196.2 N/mm for 9.81N. The stiffness for the horizontal deflection is more than the vertical deflection.

The above graph (b) indicates the load v/s stiffness for the L-joint with six numbers of steel tubes reinforced into the composite. The loads are applied to the specimen at particular point with the other end fixed by using C-clamp. The horizontal and vertical deflections are measured by dial gauges. The vertical stiffness and the horizontal stiffness with respect to the load applied are shown above. The stiffness due to vertical deflection is 70.07142 N/mm for 9.81N load which is higher than the specimen without reinforcement. The stiffness due to horizontal deflection is 327 N/mm for 9.81N which is higher than the vertical deflection. This stiffness is much more than the stiffness than the stiffness without reinforcement.

The above graph (c) indicates the load v/s stiffness for the L-joint with six numbers of steel tubes of 2.3 mm diameter reinforced composite specimen. The loads are applied to the specimen at particular point with the other end fixed by using C-clamp. The horizontal and vertical deflections are measured by dial gauges. The vertical stiffness and the horizontal stiffness with respect to the load applied are shown above. The stiffness due to vertical deflection is 140.142 N/mm for 9.81N load which is higher than the specimen without reinforcement and specimen with reinforcement of 1.3mm diameter tube. The stiffness due to horizontal deflection is 490.5 N/mm for 9.81N which is higher than the vertical deflection.

5. Discussion

Composite L-Joints are used in wings of the aircraft. There will be a weak joint at the intersection of the web and the flange. To increase the strength of this weak joint the fabrication process of the L-joint is changed by inserting the steel tube into the specimen which also increases the strength of the specimen. This work concludes obtained stiffness value is much more than the stiffness without reinforcement as well as with reinforcement of 1.3mm diameter tubes.

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