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Design Investigation of Composite Material Joint for Strength as Replacement to Metal Joint.

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Abstract - *The aim of this project was to evaluate the suitability of E-glass with RTM resin composite material joints as replacements for metal joints. Tensile strength and compressive strength tests were conducted using a Universal Testing Machine (UTM), resulting in values of 410 MPa and 340 MPa, respectively. These findings suggest that the composite material joints exhibit promising mechanical properties comparable to traditional metal joints. The high tensile strength indicates the ability of the joints to withstand pulling forces, while the significant compressive strength demonstrates resistance to crushing forces. This indicates the potential for utilizing E-glass with RTM resin composites in structural applications where high strength and durability are essential, potentially leading to lighter-weight and corrosion-resistant alternatives to metal joints. Overall, this research highlights the feasibility and efficacy of composite material joints as replacements for metal joints in various engineering applications.*

***Key Words*: Composite material, E-glass, RTM resin, tensile strength, compressive strength, metal joint replacement.**

1.INTRODUCTION

In our project, titled "Strength and Replacement of Composite Material Joints as Replacement of Metal Joints," we address the need for alternatives to traditional metal joints in engineering applications. Metal joints often face challenges such as corrosion and weight concerns, prompting the exploration of composite materials as replacements. Composites offer several advantages, including resistance to corrosion, reduced weight, and potentially superior quality. By replacing metal joints with composite alternatives, we aim to mitigate corrosion issues, decrease overall weight, and enhance the quality and performance of joints in various structural applications. This project focuses on evaluating the strength characteristics of composite material joints, aiming to demonstrate their viability as effective substitutes for metal joints in engineering designs. Through this research, we seek to contribute to the advancement of lightweight and corrosion-resistant solutions in engineering practices.

1.1 Problem Statement

The problem we're addressing involves the limitations of traditional metal joints in engineering applications, notably issues such as corrosion susceptibility and excessive weight. Metal joints are prone to corrosion over time, leading to structural degradation and increased maintenance costs. Additionally, their weight can pose challenges in applications where weight reduction is crucial for efficiency and performance. To overcome these challenges, we're investigating the use of composite materials as replacements for metal joints. Composites offer several advantages over metals, including superior corrosion resistance, lighter weight, and the potential for higher quality and durability. By evaluating the strength characteristics of composite material joints, we aim to demonstrate their suitability as reliable substitutes for metal joints in various engineering applications. Through this research, we seek to contribute to the development of lightweight, corrosion-resistant solutions that enhance overall performance and reduce maintenance requirements, thus addressing critical challenges in engineering design and construction.

1.2 Aim & Objectives

1. Evaluate the corrosion resistance of composite material joints to address the limitations of metal joints prone to corrosion.
2. Determine the weight reduction potential of composite material joints compared to metal joints, aiming to improve efficiency and performance.
3. Assess the mechanical properties and durability of composite material joints to ensure reliability and longevity in engineering structures.
4. Investigate the feasibility of integrating composite material joints into various engineering applications to expand their utilization.
5. Contribute to the advancement of lightweight, corrosion-resistant solutions in engineering practices, reducing maintenance costs and enhancing overall performance.

1.3 Scope

The scope of this project encompasses a comprehensive evaluation of composite material joints as replacements for traditional metal joints in engineering applications. We will focus on assessing various aspects, including corrosion resistance, weight reduction potential, mechanical properties, and feasibility of integration into different structures. Through laboratory testing and analysis, we aim to understand the performance characteristics of composite material joints compared to metal joints. Additionally, we will explore the applicability of composite joints in diverse engineering fields such as automotive, aerospace, and infrastructure. This project offers an opportunity to contribute to the development of lightweight, corrosion-resistant solutions that address critical challenges faced by industries. Furthermore, it opens avenues for future research and innovation in the utilization of composite materials for structural applications.

1.4 Methodology

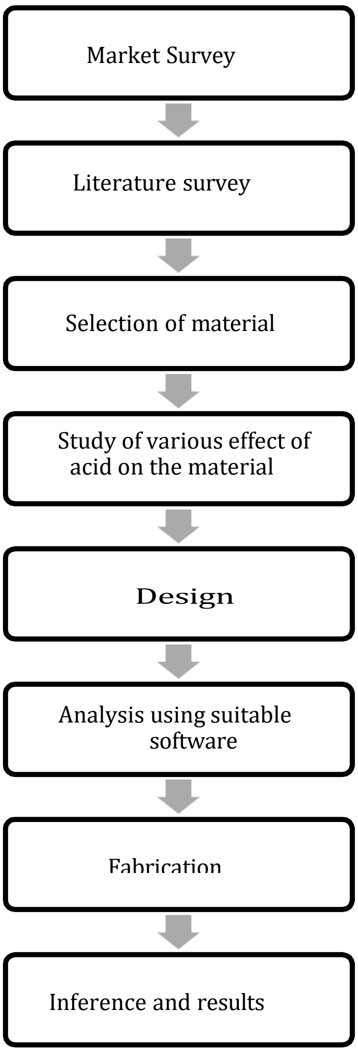

Fig -1: Methodology

2. LITERATURE SURVEY

Ehteram A. Noor, et.al, [4] "Corrosion Behavior of Mild Steel in Hydrochloric Acid Solutions", 2008.
In this paper the authors present study and examination of the corrosion behaviour of mild steel in hydrochloric acid (HCl) solutions through both chemical and electrochemical methods at 25°C. Chemical analysis indicates a corrosion rate increase with rising HCl concentration. Electrochemical results reveal anodically controlled steel dissolution, with a multistep mechanism involving electron release and potential adsorbed groups like [FeOH] and [FeClOH]. Mild steel, commonly used in construction, faces challenges in handling HCl due to its corrosive nature."

Abedin I. Gagani, et.al, [5] "Immersed interlaminar fatigue of glass fiber epoxy composites using the I-beam method", 2018.

In this paper the authors present the study that explores the degradation of interlaminar shear performance in composites exposed to the marine environment. A novel test method, the I-beam short beam shear, is used to determine shear properties and accelerate fluid saturation in glass fiber epoxy specimens. Experimental analysis reveals a change in failure mode between dry and conditioned samples, with dry samples exhibiting creep-dominated failure leading to inter-ply cracks, and conditioned samples showing damage growth-dominated failure resulting in intra-ply failure. Optical micrographs indicate the occurrence of fiber/matrix debonding in conditioned samples before mechanical loading, potentially serving as damage onset points.

Fabio Nardone, et.al, [7] "Tensile behavior of epoxy based FRP composites under extreme service conditions", 2011.

In this paper the authors addresses the mechanical properties of externally bonded (EB) FRP composites used for strengthening reinforced concrete (RC) members in extreme service environments. The focus is on the mechanical properties of glass and carbon FRP (GFRP and CFRP) coupon specimens subjected to temperature extremes and freeze-thaw cycles. Results indicate that GFRP specimens exhibit minimal variation in mechanical properties with different ply numbers and minor reductions in axial tensile strength and strain with increasing temperature. In contrast, CFRP specimens experience a significant reduction in mechanical properties at extreme temperatures, while freeze-thaw cycles have a limited impact on performance.

3. Proposed Material

Our project focuses on the strength and replacement of metal joints with composite materials, specifically E-glass laminate. In our composite, E-glass fibers are mixed with RTM (Resin Transfer Molding) epoxy resin at a ratio of 100:27. The resin is heated to 40 degrees Celsius, and fine hard 972 is melted at 100-105 degrees before being mixed in, ensuring a homogeneous blend. Through testing using a Universal Testing Machine (UTM), we found that our composite exhibits impressive tensile strength of 410 MPa and compressive strength of 340 MPa. This demonstrates the robustness and reliability of our composite material, showcasing its potential as a viable replacement for metal joints in various applications.

3.1 Testing of Proposed Material

3.1.1 Test Set Up

Universal Testing Machines (UTM):

A Universal Testing Machine (UTM) is used to test both the tensile and compressive strength of materials. Universal Testing Machines are named as such because they can perform many different varieties of tests on an equally diverse range of materials, components, and structures. Most UTM models are modular, and can be adapted to fit the customer's needs. A Universal Testing Machine also known as a material testing machine and can be used to test the tensile and compressive properties of materials. This type of machines is called Universal Testing Machine because it can perform all the tests like compression, bending, tension etc. to examine the material in all mechanical properties. These machines generally have two columns but single column types are also available. Load cells and extensometers measure the key parameters of force and deformation which can also be presented in graphical mode in case of computer operated machines. These machines are widely used and would be found in almost all materials testing laboratory. UNIVERSAL TESTING MACHINES can be of different types-based output required like Computer operated Universal Testing Machine and digitally operated Universal Testing Machine.

The main functions of UTM are to test the mechanical properties of materials. The standard tests performed by UTM are:

1) Tensile Test
2) Compression Test

Fig -2: Experimental Setup

3.1.2 Test Samples

The dimension of test samples for the project are selected from the ASTM D 638-14 & ASTM D 695-10 standard table.

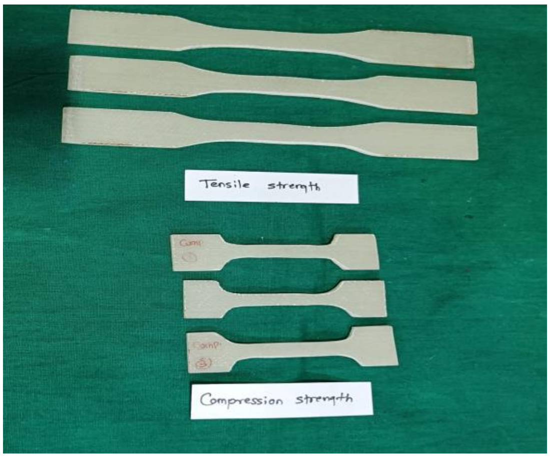

Fig -3: Before Testing

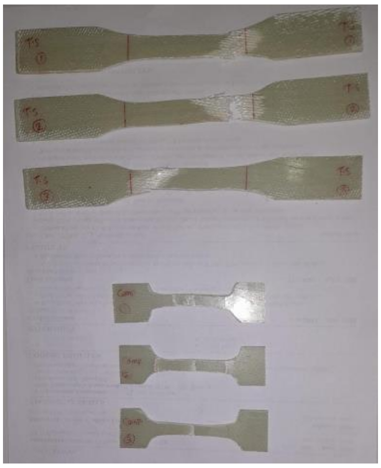

Fig -4 After Testing

3.1.3 Result Table

Sr. No	Tensile Strength (MPa)	Compressive Strength (MPa)
1	394.86	305.10
2	416.08	392.46
3	418.97	323.94
	Avg.= 409.97	340.49

3.1.4 Graphs

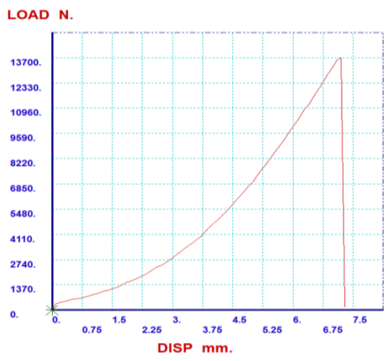

Fig -5 Tensile Test

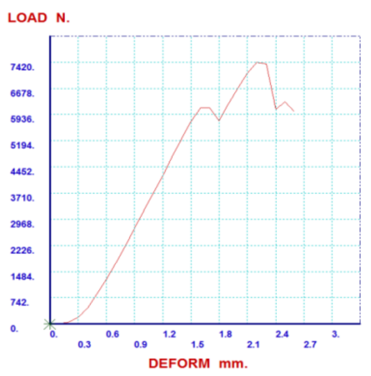

Fig -6 Compression Test

3.2 3D Design Model

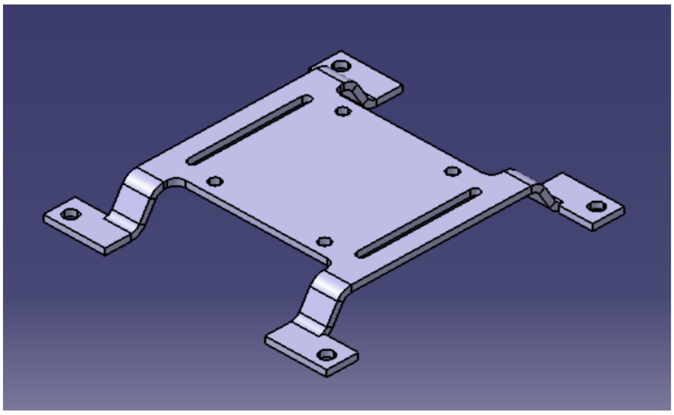

Fig -7: Catia V5 Mounting Bracket

3.3 Calculations

3.3.1 Cross Sectional Area (A)

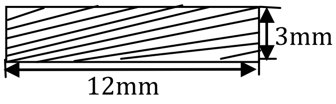

Fig -8: Cross Section

Cross sectional Area(A) = L * B = 12 * 3
= 36 mm^2

3.3.2 Force Calculations (F_t & F_c)

1) **Tensile Strength**

$\sigma_t = F_t / A$
$409.97 = F_t / 36$
$\mathbf{F_t = 14758.92\ N}$

2) **Compressive Strength**

$\sigma_c = F_c / A$
$340.49 = F_c / 36$
$\mathbf{F_c = 12257.64\ N}$

3. CONCLUSIONS

Our project successfully demonstrates the viability of using E-glass laminate with RTM epoxy resin as a replacement for metal joints. By carefully controlling the mixing ratio and temperature during fabrication, we achieved impressive tensile strength of 410 MPa and compressive strength of 340 MPa, as tested under UTM. This composite material offers a durable and reliable alternative to metal joints, offering advantages such as corrosion resistance and lightweight properties. Our findings highlight the potential for widespread adoption of this composite in various industries, contributing to enhanced performance and cost savings in structural applications.

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