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FEA and Experimental Investigation of Sandwich Composite Material Made by Aluminium Composite with Nylon

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Abstract: Aluminium and nylon composite panels are advanced materials combining the lightweight and corrosion-resistant properties of aluminium with the high strength and flexibility of nylon. These composites are increasingly used in aerospace, automotive, and construction industries due to their excellent mechanical properties, durability, and cost-effectiveness. This report explores the fabrication methodology, mechanical performance, and potential applications of aluminium-nylon composite panels. The study highlights the bonding techniques, material characterization, and comparative advantages over traditional materials. The findings suggest that aluminium-nylon composites offer superior strength-to-weight ratios and enhanced fatigue resistance, making them suitable for high-performance applications. FEA results are analyzed for deformation and equivalent stress, static stress test conducted, and experimental test also conducted.
Keywords: Sandwich Composite, Aluminium, Nylon, FEA.

I. INTRODUCTION

A. Introduction Of Composite Material

The word composite in the term composite material signifies that two or more materials are combined on a macroscopic scale to form a useful third material. The key is the macroscopic examination of a material wherein the components can be identified by the naked eye. Different materials can be combined on a microscopic scale, such as in alloying of metals, but the resulting material is, for all practical purposes, macroscopically homogeneous, i.e., the components cannot be distinguished by the naked eye and essentially act together.

B. Structure of A Sandwich Panel

Sandwich structured composites are a special class of composite materials which have become very popular due to high specific strength and bending stiffness. Low density of these materials makes them especially suitable for use in aeronautical, space and marine applications

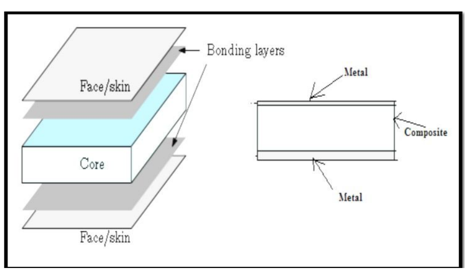

Figure 1.2 Structure Of Sandwich Composite.

C. Objective

- Evaluate the mechanical properties.
- Compare numerical (FEA) results with experimental data.
- Examine stress distribution and deformation patterns.
- Identify failure modes and assess the durability of the sandwich structure.
- Determine the suitability of the aluminum–nylon composite sandwich for structural or lightweight applications in industries such as aerospace, automotive, or construction.

II. FABRICATION PROCESS

The composite panel was fabricated using the following steps:

1) Aluminium Surface Treatment.
2) Chemical Etching.
3) Anodization.
4) Plasma Setup And Surface Treatments.

III.INTRODUCTION TO SOFTWARE

It is a robust application that enables you to create rich and complex designs? The goals of the SOLIDWORKS course are to teach you how to build parts and assemblies in SOLIDWORKS, and how to make simple drawings of those parts and assemblies. This course focuses on the fundamental skills and concepts that enable you to create a solid foundation for your designs.

ANSYS is a complete FEA simulation software package developed by ANSYS Inc. USA. It is used by engineers worldwide in virtually all fields of engineering.

1) Structural.
2) Thermal.
3) Fluid (CFD, Acoustics, and other fluid analyses).
4) Low-and High-Frequency Electromagnetic.

A. *Tensile Testing*

A finite element model of a specimen subjected to tensile loading.The geometry of the specimen appears elongated along the horizontal axis, which is typical in tensile tests.The simulation setup includes meshing, evident from the structured grid on the specimen.

The model details show: Nodes: 1790 ,Elements: 766.

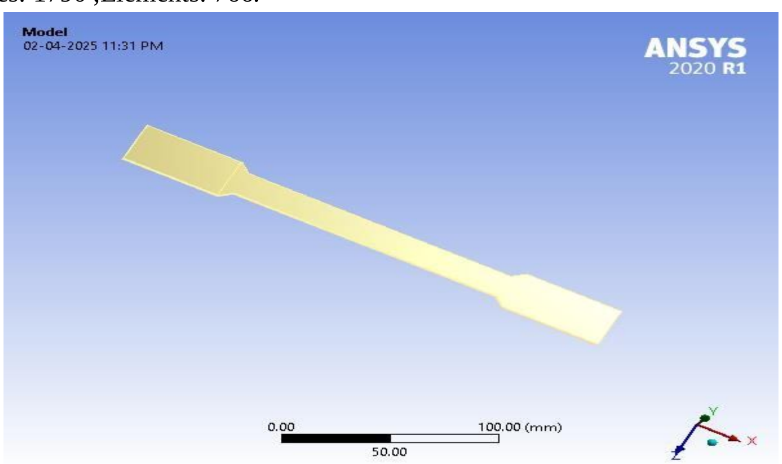

Figure No 3.1 Tensile Testing.

B. *Iges Model*

Nodes	1790
Elements	766

C. *Bounary Condition*

A boundary condition setup for a tensile test simulation in ANSYS 2020 R1, as described in section 5.2.3 Boundary Condition (though "Boundary" is misspelled as "Bounary" in both the heading and caption).In the figure, a 3D model of a specimen is presented. One end (marked B) is assigned a Fixed Support, indicating that this side is completely restrained and cannot move in any direction. The other end (marked A) is subjected to Displacement, simulating the application of tensile force along a specific direction likely the X-axis.

This setup mimics a typical tensile test where one side of the material is held stationary while the other is pulled.This boundary condition is essential to analyze the deformation and stress distribution in the material during tensile loading using Finite Element Analysis (FEA) in ANSYS.

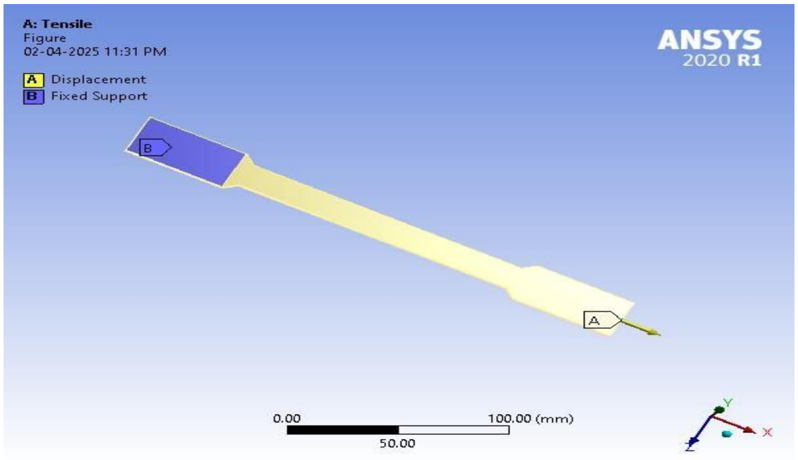

Figure No 3.3 Boundary Condition.

D. Compression Analysis

The model is displayed with a mesh grid, indicating that it has been discretized into smaller elements for numerical simulation.
This setup is typically used to study how a material or structure behaves under compressive loading. The mesh pattern allows the software to calculate stress, strain, and deformation across the body with high precision. The visual shows the initial state of the model, before the application of boundary conditions or loads, setting the foundation for further compression simulations to evaluate the structural response under compressive forces.

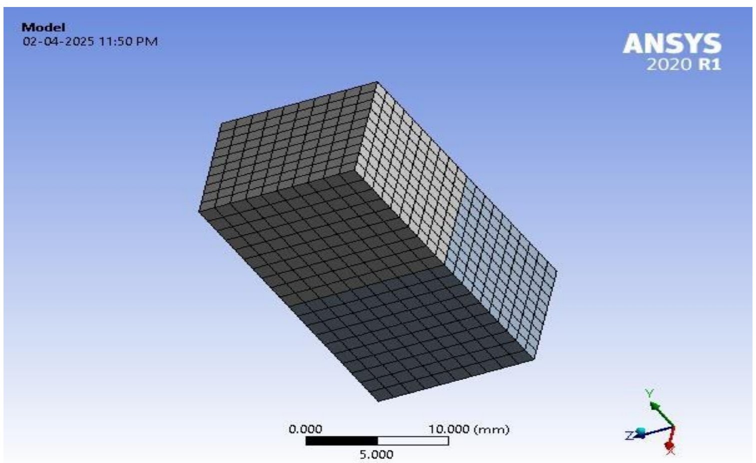

Figure No 3.4 Compression Analysis.

E. Total Deformation

The total deformation experienced by a solid block under compressive loading conditions, analyzed using ansys 2020 r1. the deformation is represented using a color scale ranging from blue (minimum deformation) to red (maximum deformation). according to the legend, the maximum deformation recorded is approximately 0.30346 mm, while the minimum is 0 mm, indicating no displacement at the fixed end. this gradient distribution suggests that the deformation increases progressively from the constrained base to the top surface where the compressive force is applied.

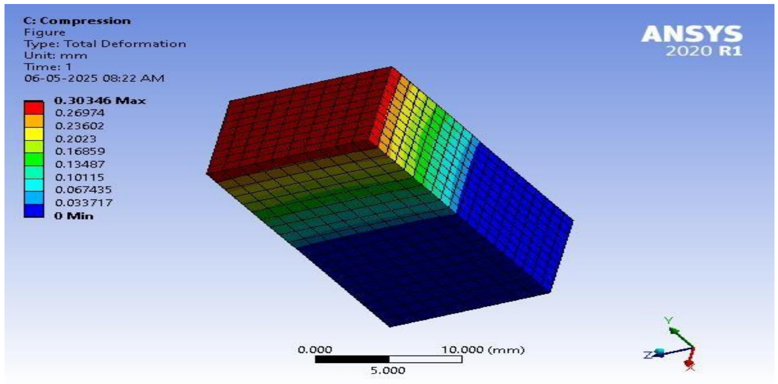

Figure No 3.5 Total Deformation.

F. *Equivalent Strain*

The equivalent strain distribution obtained from a simulation conducted in ANSYS 2020 R1. The model appears to represent a 3D solid element subjected to compression, as indicated in the legend. The color contour plot illustrates the magnitude of equivalent strain across the geometry, with values ranging from 22.964 to 216.536, suggesting regions of varying deformation intensity. The analysis provides insight into the mechanical response of the material under loading conditions.

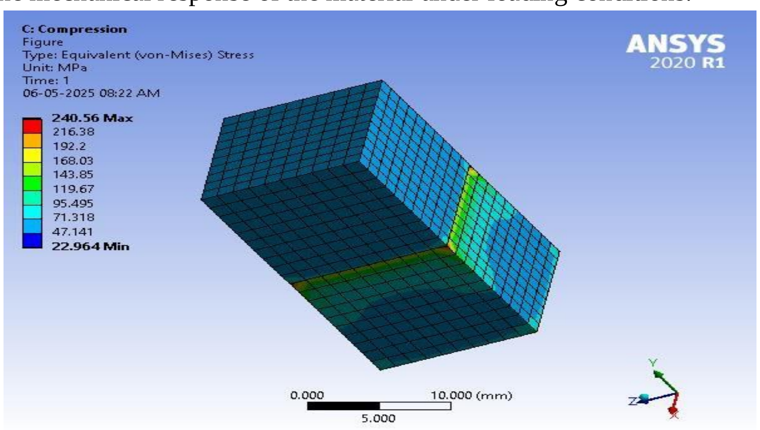

Figure No 3.6 Equivalent Strain

IV. TESTING AND CHARACTERIZATION

A. *Mechanical Testing*

Sample Dimensions

- Tensile Specimen: 250 mm × 25 mm (Dog bone shape, ASTM D638 Type V)
- Compression Specimen: 50 mm × 50 mm × 1.7 mm (Rectangular prism)

Test Setup

Figure No 4.1 Mechanical Testing

B. Tensile Test Results

Table No 4.2 Tensile Test Results

Property	Value	Unit
Ultimate Tensile Strength (UTS)	145.3	MPa
Young's Modulus (E)	3.2	GPa
Elongation at Break	12.5	%
Failure Mode	Nylon ductile rupture → Epoxy delamination → Aluminum necking	

C. Compression Test Results

Table No 4.3 Compression Test Results

Property	Value	Unit
Compressive Strength	210.7	MPa
Modulus in Compression	4.8	GPa
Failure Mode	Epoxy shear cracking → Aluminum microbuckling	

D. Comparative Analysis

Table No 4.4 Comparative Analysis

Aspect	Tensile Behavior	Compression Behavior
Dominant Layer	Nylon (ductile)	Aluminum (stiffness)
Weakest Link	Epoxy delamination	Epoxy shear failure
Strain Capacity	High (12.5%)	Low (3.2% before buckling)

V. CONCLUSION

The aluminium-nylon composite panel demonstrated superior mechanical properties, including high tensile strength, excellent impact resistance, and improved fatigue life compared to pure aluminium or nylon alone. The thermal lamination method provided better interfacial bonding than adhesive bonding, ensuring long-term durability.

Key advantages of this composite include:

1) Lightweight yet strong, making it ideal for aerospace and automotive applications.
2) Corrosion-resistant, suitable for harsh environments.
3) Cost-effective compared to carbon fiber composites.

Table No 5 Conclusion

Result	Testing Name	Values	Pure Aluminum	Pure Nylon
Experimental Result	Ultimate Tensile Strength (UTS)	145.3 Mpa	110 Mpa	26.5 Mpa
	Compressive Strength	210.7	90 Mpa	85.5 Mpa
Analytical Result	Von-mises Stress(Tensile)	144.1 Mpa	90 Mpa	80 Mpa
	Equivalent Stress(Compression)	240.5	230 Mpa	90 Mpa

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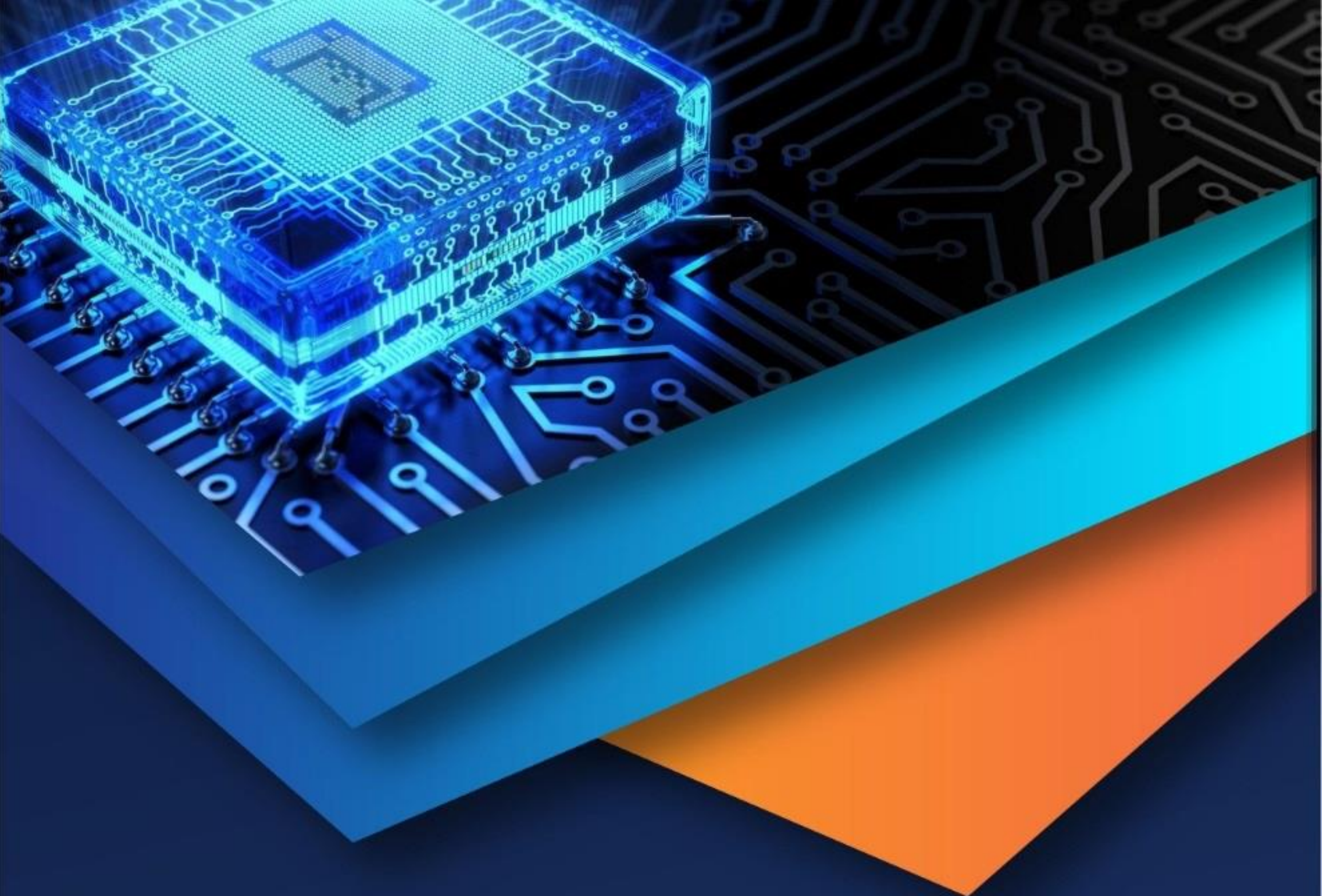

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