Comparison between Experimental Value and Finite Element Analysis value of Glass Fiber Reinforced Polymer Composite

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Abstract - *Composite materials offer higher specific strength and stiffness than other conventional materials. The utilization of fiber glass is increase in recent years particularly in the aerospace industry due to its excellent properties such as light weight, high specific strength, high specific modulus of elasticity, good corrosion resistances. Glass fiber reinforced polymer (GFRP) composites are also used in passenger compartments, storage room doors due to their high mechanical properties. Composites were prepared with different wt% of chopped E-glass fiber mixed with epoxy resin.*

Tensile strength, bending test and impact test were conducted to find out the significant effect of glass percentage on mechanical characteristics of glass fiber reinforced composites. FEA analysis can be done to save time and compare the experimental data with FEA analysis data . Ansys software is used for FEA analysis . Finally check any difference in experimental data with FEA analysis

The experimental values are more than the FEA values. Decrease value in mechanical testing may result of the presence of inhomoginites such as, mixture of matrix and reinforced material thoroughly, air bubbles presence in the specimens

1.INTRODUCTION

The field of composite materials has progressed considerably over the last few decades .Properties like low density, high strength and stiffness, chemical and corrosion resistance, etc. make composite materials an attractive alternative to metals and alloys. Use of fibre glass is increase in recent years particularly in the aerospace industry Because of its excellent i.e light weight and high specific strength, high specific modulus of elasticity, good corrosion resistances etc [2]. Compared with pure plastic specimen, adding glass fibre into plastic materials could increase tensile strength and hardness. Specimen with 10 wt% glass fibre had largest ultimate tensile strength value 78.2 N/mm^2 and specimen with 12.5wt% glass fibre had smallest value of tensile strength compare to all reinforced specimen. [1]

Finite element analysis, also called the finite element method, is a method for numericalsolution of field problems. A field problem requires determination of the spatial distribution of one or more dependent variables. Mathematically, a field problem is described by differential equations or by an integral expression. Either description may be used to formulate finite elements. Elements are connected at points called nodes and the assemblage of elements is called a finite element structure. The particular arrangement of elements is called a mesh.

2. EXPERIMENTAL SET-UP

The engineering data and materials properties are required to analyze the prepared composite specimens so that we can create one model and use it for the analysis purpose. In UG-NX software the parameters for analysis purpose chosen were based on the matrix material and the reinforcement. Static structure and NX NASTRAN tools were also selected for the purpose.

Ansys software is used for analysis .Various specimen are prepared Contents of composite materials:

a) E-glass as reinforced material

b) Epoxy Araldite LY556 as resin

4. Stiffness behavior: Flexible

Part Size (for tensile) : ASTM D638-V standard

Part Size (compressive) : ASTM D638-V standard(12.7*12.7*25)

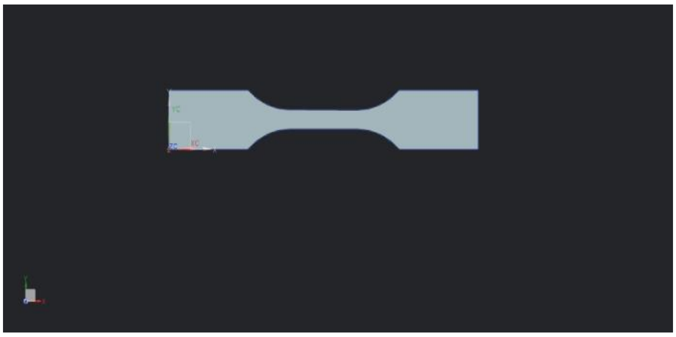
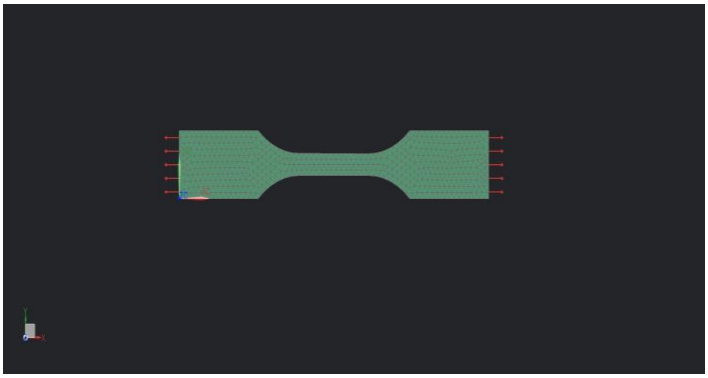


Fig 2.1 .(a)Model of a tensile specimen ASTM Standard



(b) Load applie don tensile specimen

Fig 2.2. Tensile specimen

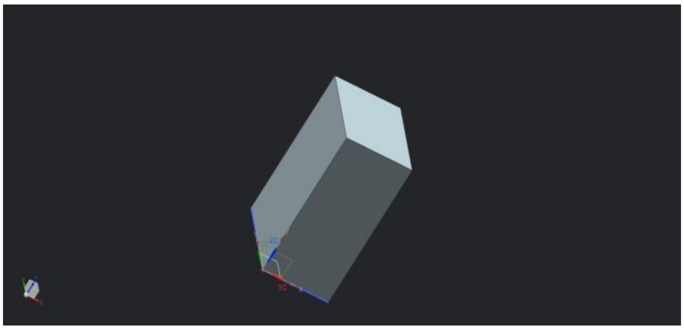


Fig 2.3 Compression modeling Specimen

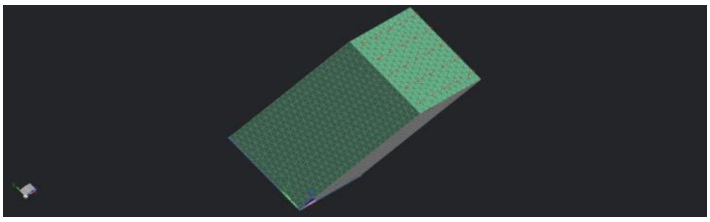


Fig 2.4.Compression modeling Specimen load applied

3. Measurement Techniques

ASTM D638-V standard and ASTM D256, standard were followed for tensile and impact test respectively [5]. Five specimen of GFR composite were prepared with different wt% of fibre separately for both tensile and impact test. The mass values of the specimens were measured by a precision balance weighting machine

Finite element Analysis is a numerical method of a complex system into very small pieces called elements. The software uses equations that generate the behavior of these elements and solves them all. The parts were assumed to be transversely isotropic in nature. G2, Poisson's ratio was calculated using information and equations available in Materials for engineering [] some of the value used was based on the ratio of"typical" material property values provided by NX **Material**

ANSYS software is used for analysis

Table 3.1 Glass Epoxy Material Properties

þ	Density (g/cc)	1900
E11	Young's modulus along fiber direction 1(Gpa)	80
E22	Young's modulus along matrix direction 2 (Gpa)	4
v12	Poisson's ratio	0.35
v13	Poisson's ratio	0.34
G12	Shear modulus in 1-2 plane (psi)	3.80E+05
G13	Shear modulus in 1-3 plane (psi)	3.80E+05
G23	Shear modulus in 2-3 plane (psi)	431720
X2t	Tensile failure stress in direction 1 (transverse to fiber direction) (Mpa)	490
X2c	Compressive failure stress in direction 1 (transverse to fiber direction) (Mpa)	244.76
S12	Shear strength in 1-2 plane (Mpa)	160.64
S13	Shear strength in 1-3 plane (Mpa)	155.43
S23	Shear strength in 2-3 plane (psi)	14000

Table 3.2.properties of epoxy material

Material Type	Isotropic Material
Mass Density	1.2 g/cc
Young Modules(E)	3000000mN/mm^2(kPa)
Poisson's Ratio (NU)	0.37
Yield Strength	27000mN/mm^2(kPa)
Thermal Expansion Coefficient (A)	6e-0051/C
Thermal Conductivity (K)	2250microW/mm-C
Specific Heat (CP)	938000000microJ/kg-K

Part Size (for tensile) : ASTM D638-V standard

Part Size (compressive) : ASTM D638-V standard

4. Result and Analysis

4.1 Tensile Test Result

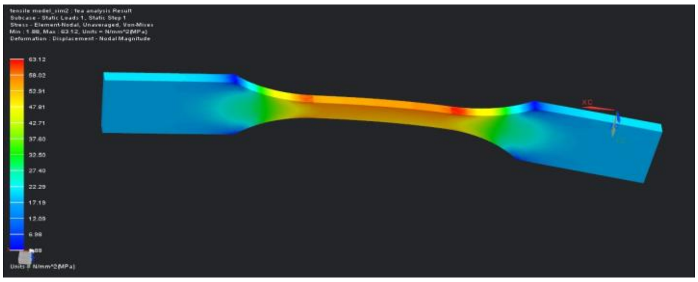


Fig 4.1 Von-misses Stress in pure epoxy

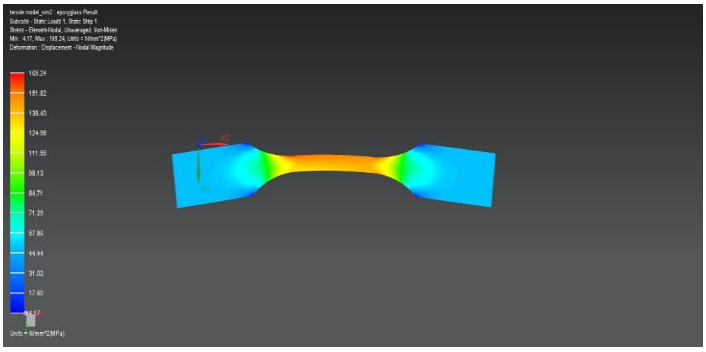


Fig: 4.2. Von Misses stress of 10 wt%5 glass fiber epoxy

Above fig 4.1 and fig 4.2 shows that the Adding fiber to to epoxy resin increase the stress property of composite material part .Under 1050 N load the max stress in pure epoxy material is 63.13 Mpa while in 10 % glass fiber composite it was 165.24 Mpa . The same effect can see regarding elastic strain of epoxy polymer. Fiber volume fraction also increase the value of elastic strain in material.

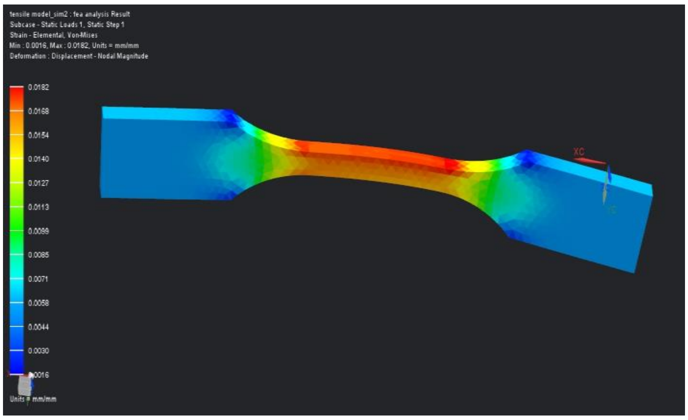


Fig:4.3 Elastric strain value of pure epoxy

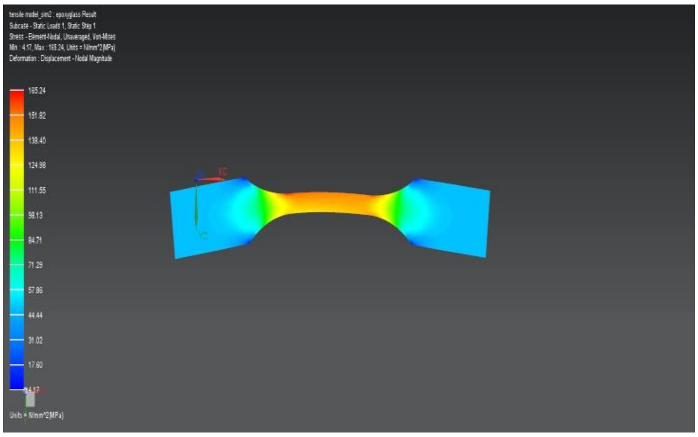


Fig 4.4: Elastic strain value of 10% glass fiber epoxy composite

4.2. Compressive test result

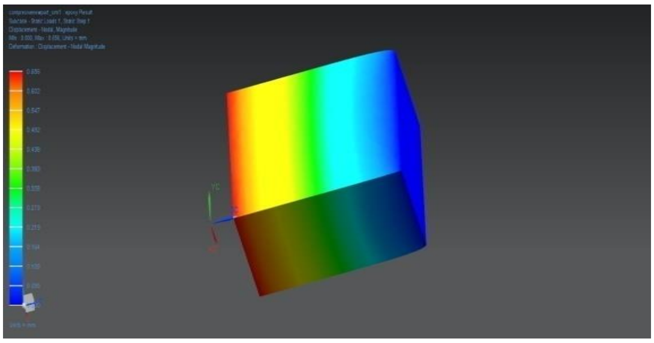


Fig 4.5. total Displacement in Pure epoxy

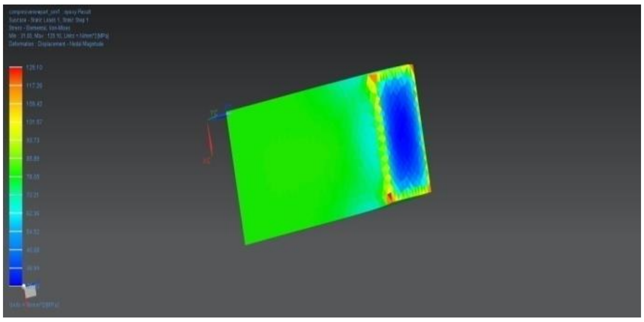


Fig 4.6. Von-misses Stress in pure epoxy

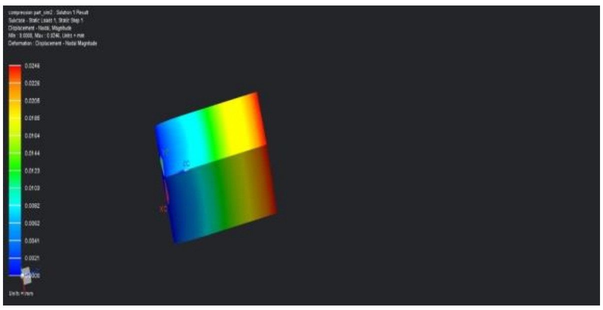


Fig 4.7. Displacement in 10%glass epoxy part

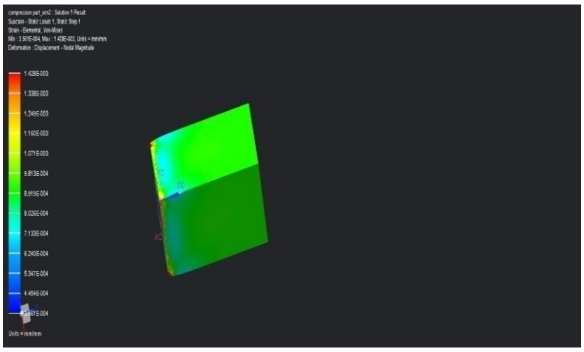


Fig 4.8. Strain in 10%glass

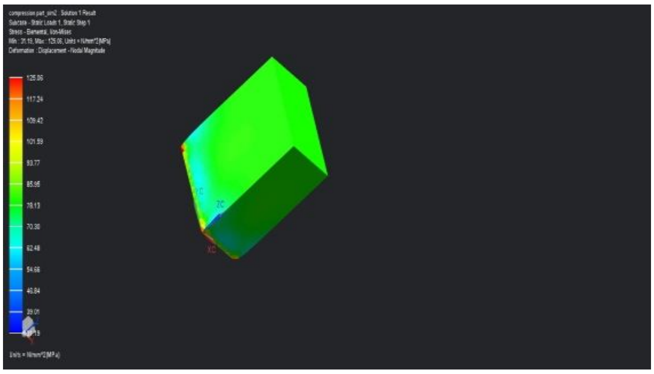


Fig 4.9 Strain in 10%glass epoxy part epoxy part

From the above Fig. 4.5 and fig 4.6. shows the total displacement for pure epoxy is 0.656mm under the 12.9 KN load while with the same load applied on glass fiber reinforced epoxy composite it shown very less value of displacement as .0246mm.Fig 4.7 and fig 4..8. shows the Elastic strain 0% epoxy and 10% of glass fiber reinforced epoxy composite respectively as 0.381mm and 1.428 mm . Von misses stress for glass reinforced epoxy is maximum 125.06 MPa

5 CONCLUSIONS

5.1. Validation of Experimental and ANSYS Results

Specimen	Load (KN)	Result from experiment Stress (MPA)	Result from analysis Stress (MPA)	Error in Result
Pure epoxy	1050	61.90	63.12	1.32
10% Glass fiber	1880	163.93	165.24	1.31

Table 5.1. : Comparison of FEA and experimental deformation for Tensile test

Above table 4.2. shows that the stress value obtained from Mechanical test is less than the stress value obtained from the FEA analysis result. If we see the tensile value of 0% epoxy specimen is 61.90 Mpa in case of mechanical testing while in case of FEA analysis of the same specimen give a value of 63.12 Mpa i.e. error showing approx 1.32 Mpa. This different in result value may reason of in homogeneities present in the composite test specimen such as air bubbles or void present during fabrication and also improper mixture of reinforcement and matrix.

The experimental values are more than the FEA values. Decrease value in mechanical testing may result of the presence of inhomoginites such as, mixture of matrix and reinforced material thoroughly, air bubbles presence in the specimens

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