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DEVELOPMENTANDFLEXURALTESTINGOFCARBON FIBER REINFORCED PLASTIC (CFRP)

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Abstract: *This report aims to assist engineers in understanding and applying their knowledge in replacement of conventional materials. Many structures utilized in Automobile, Aerospace, Naval and other Transportation vehicle structural parts are subjected tovarious sorts of loads. Addedtothesestructures bendingloads, which results in flexural stress in the structures. Structures that are subjected to bending loads are vulnerabletoseveralproblems.Inordertopreventbending,structures'structuralintegrity isessential.Structuressubjectedtopurebendingloadfrequentlyexperiencethespecimen's maximumflexuralstressateithertheouterorinnerfiber,whichcausesfailure.Theneutral axisorintermediateaxiswillexperiencezerostress.WiththehelpofaFlexuralTestsystem, thecurrent studyintendstoexaminetheflexuralcharacteristicsofcarbon fiberreinforced E-poxy composites under static flexural loading. By performing the three-point bend test on a composite specimen in accordance with ASTM D790 standards, the flexural parametersareidentified.Thesetestswillalsobeutilizedtodemonstratehowcarbon fiber reinforced polymer's flexural characteristics are affected by thickness.*

Keywords:Carbonfiber,E-poxy,Flexuralstrength,Compositematerial

1. INTRODUCTION

Current materialsfrequentlyreachtheirpracticallimitsintheongoingsearchforenhanced performance, which can be defined by a variety of factors, including less weight, more strength, and lower cost. Therefore, scientists, engineers, and researchers in the field of materials are constantly driven to develop either new or enhanced versions of existing materials.Compositesareanillustrationofthesecondgroup.Compositematerials,plastics, and ceramics have been the most popular new materials during the past thirty years. The quantityandvarietyofusesfor compositematerialshavegrowncontinuously,persistently entering and dominating new markets. Modern composite materials dominate the market for engineered materials, appearing in a wide range of products and applications, from simple consumer goods to complex machinery.

The keyconcernfor car manufacturers is weight reduction inorder tosave energyand natural resources. The perfect replacement for metallic parts is composite material.

Acomposite materialis describedasa combinationof twoor more materials that exhibits superior qualities than those of the component parts utilized separately.

We are aware that the flexural properties of laminated composites are influenced by thickness, and that various types of loads are applied to the structural components of vehicles used in the automotive, aerospace, naval, and other transportation industries.

Theseconstructionsareadditionallysubjectedtobendingloadsthatputthemunderflexural stress. This study's goal is to conduct an experimental analysis of laminated composites' progressive failure process under flexural loads,

Composites experience stresses due to flexural loading, which vary according on the thickness. These flexural stresses are zero at the neutral axis in the middle and highest at the outer surfaces. Thestress in a singleply is influenced by its stiffness and proximity to the neutral axis of the laminate.

2. OBJECTIVES:

1. TolearntheorthotropicpropertiesofComposites.
2. Tosynthesizematerialandtestforvalidation.
3. Tostudyflexuralpropertiestestsapplying3-Pointbendingtest.
4. Toidentify/establishcharacteristicsStructure–Propertyrelationshipbasedon outputs.
5. Tostudyflexuralproperties ofcompositematerialsatdifferentthickness.

3. LITERATUREREVIEW

[1][Patel and Patel](1993), the researcher detailed about the effect of tetra functionalepoxyresinsonthe mechanicalpropertiesofthecarbon fiber reinforced polymer. Two epoxy resins were going to use for the fabrication of carbon fiber epoxy composites and the comparison takes place. The specimen was made according to ASTM D standard.

[2][Mujikaetal](2002),theresearchexplainedaboutthewovencarbonfiberepoxy compositesdemandswereincreasedintheresearchareasandtheindustriesbecause ofeaseofmanufacturing.Two different epoxieswereusedwiththefillerknownas polysulfide.ThesampleweremadeaccordingtoASTMdstandardthroughvacuum technique.

[3][Solomonetal](2017),surveyoftheresearchpaperexplainedaboutthemixing ratio of the fiber and the matrix contained in it.

In this paper carbon fiber chosen as the fiber and the matrix was epoxy resins araldite. The sample were made according to ASTM D standard through vacuum bagging technique.

[4][Giovedietal](2005),theliteraturesurveyofthepaperinformthattheadhesion between the fiber and the matrix play an important role for the mechanical propertiesofthe composites. Inthispaper two different typesofcarbon fiber were taken to observe the adhesion parameter. The effect of the EB irradiation was analysed on the specimen.

[5][Han-kiyoon](2007), the researcher explained about the effect of the fiber orientationand the volume fraction for hybrid composites. The combinationofthe two reinforcement was Carbon Fiber Reinforced Polymer (CFRP) and the metal.

[6][F.H. et al](2008), the aim of the research paper was to find out the volume fractionofthefiberformthecompositesmaterial.Twodifferenttypesoffiberwere chosen to find out the separate volume fraction. One was the glass fiber and the other was carbon fiber and compare them itself. The sample were made according to ASTM d standard with filament winding method.

[7][Coban et al](2010), the researcher explained about the use of carbon fiber reinforced polymer because of their important mechanical properties. In this research paper one of the important parameters were going to evaluate was viscoelastic properties which were going to be affected by the orientation of the fiber on thermal cycles.

[8][Gururaja and Harirao](2013), the benefits of the hybrid composites drawn a researcher attraction to combine the advanced composites material such as carbon fiber and the glass fiber with three different orientation to obtain the required propertiesofthecomposites.ThesampleweremadeaccordingtoASTMdstandard through vacuum bagging technique.

4. DESIGNCONSIDERATIONS

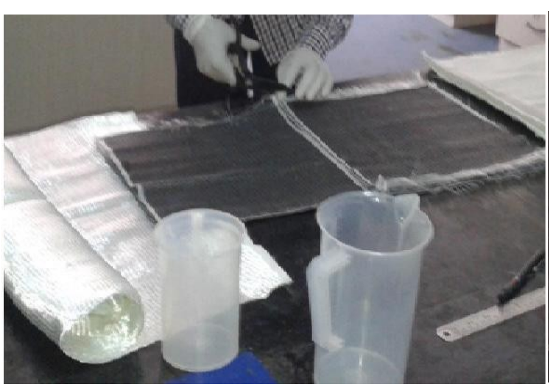
The depth of the specimen for flatwise tests must equal the material's thickness. For edgewise tests, the specimen's breadth must match the sheet's thickness and its depth cannot be greater than its width.

Thesupportspanmustbe16(tolerance1)timesthedepthofthebeamforalltests. Forspecimensdeeperthan 3.2mm (1/8 in), the specimen breadthmustnotbe higher thanone-fourthofthesupport span.Specimenswithadepthof3.2mmorlessmust haveabreadthof12.7mm(1/2inch).Thespecimenmustbelongenoughtoprovide atleast10%ofthesupportspanofoverhangingoneachend,butinnocircumstance less than 6.4 mm (1/4 in.) on each end.

5. MATERIALSANDMETHODS

1. LaminatedFabrication
    - SelectionofCompositeMaterials
    - Reinforcement-Carbon(200GSM)
    - Matrix-EpoxyEpolomresin &Hardener5015

2. Regional resources are first used to gather the carbon fiber that will be used as reinforcement in this investigation. After that, it is carefully cleaned and sized. A calculatedamountofepoxy resinandhardener(ratioof70:30byweight)was thoroughly mixed in a glass jar for various volume fractions offibers. Place a peel layerof plastic on top, followed by a peel layer of fabric. After covering it with glue, add ply after ply of carbon fiber between 00 and 900. Fibers are impregnated with resin.Typically, rollers or brushes are used for this, but roller-type impregnators, which use rotating rollersand a resinbath to force resin into the fabrics, are becomingmore popular. To remove bubbles from production sheets, use a roller. Peel ply of plastics shouldbeplacedafterpeelplyofcloth.Thepressurewasthenappliedfromthetop, anditwasleftto preservefor24hours at room temperature.A small amountof the epoxyandhardenermixtureissqueezedoutwhenpressureisapplied.



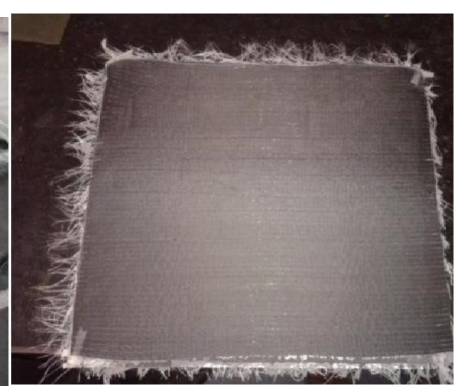


Figure1:SpecimenpreparationandSpecimen

- Propertiescalculate from micromechanicsof composite MaterialsUsed are tabulated as Follows:

Table-1: MaterialProperties(SIUnit)

Material	Properties	Value
CarbonFiber	E_f	242
	ρ_f	1.81
	v_f	0.25
EpoxyResin	E_m	3.7
	ρ_m	1.14
	v_m	0.245
Laminate (Orthotropic)	E_1	134.766
	E_2=E_3	8.701
	ρ_C	1.62
	G12=G13	3.102
	G23	3.241
	v12	0.25
	V_f	0.60

6. TESTING:

Three-point bend test was carried out in an3-Point Bending machine in accordance with ASTM D790 to measuretheflexural strength of thecomposites. Theloading arrangement for the specimen and the photograph of the machine used are shown in figure. Theflexuralstrengthofcompositeswasfoundoutusingthefollowingequation:

$$\sigma = \frac{3PL}{2bh^2}$$

Where, σ is the flexural strength , P is the load, L is the span length ,b is the width and the thickness of the specimen under test.

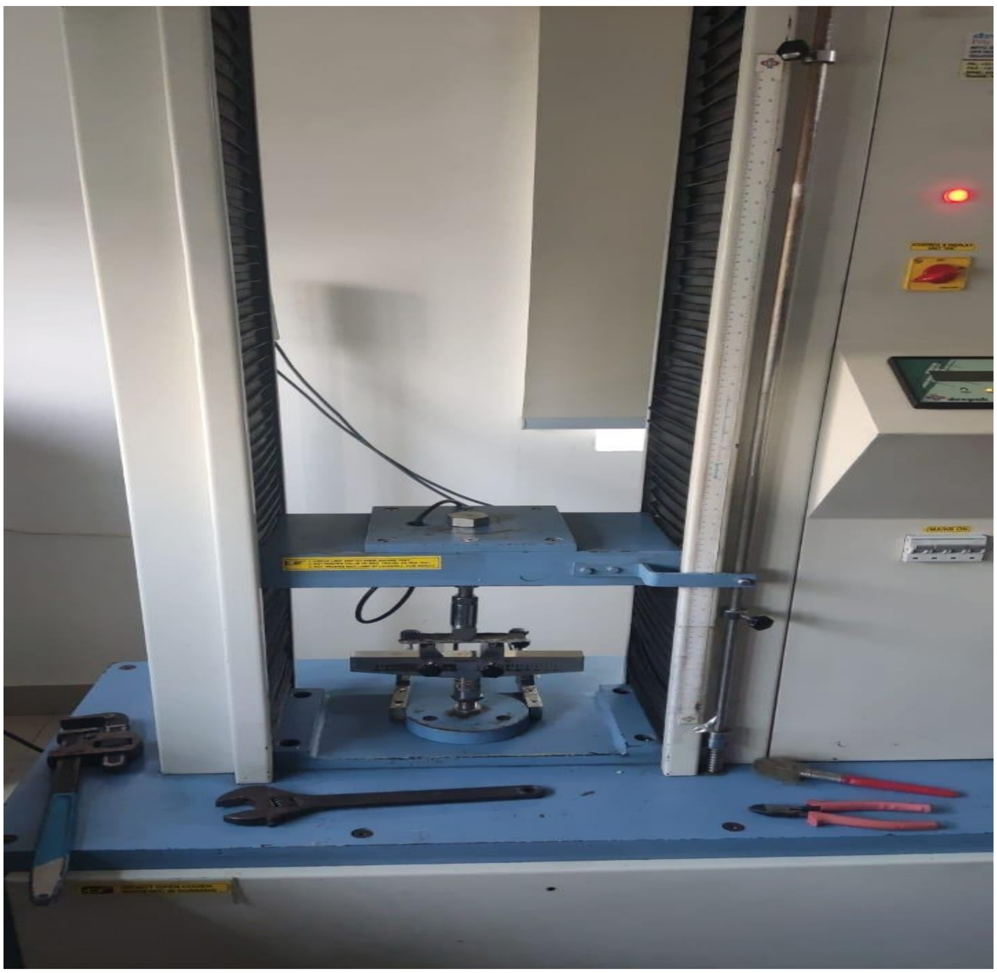
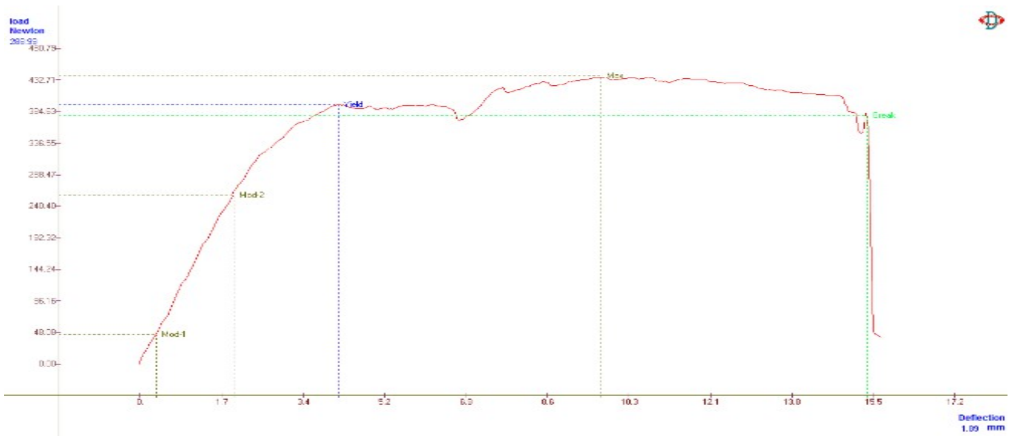


Figure2:3-PointBendingmachineSampleloadedconditionforFlexuraltesting

7. EXPERIMENTALRESULTS:

Three-pointbendingtestswereperformedon $0^0/90^0$lay-up composite specimens. Theload-deflectioncurvewasevaluated.Threetypesoflaminatesweretested withthreedifferentthicknesses.Graphobtainedforspecimensplottedareas follows:



GraphPlottedBetweenLoadandDeflection

- It has been noted that the strength of carbon laminates has significantly improved as test thicknesses have increased. This can be as a result of the carbon fiber and matrix having strong adherence.
- Results for flexural stress calculated using experimental, analytical, and FEA approaches are shown to be in great agreement.
- Thefindingsofthisstudyaresuggestedforthecommunityofcompositesdesignersfor better strengthening of FRP composites.

Experimentalresults obtainedfromtestingthespecimens on3-Point Bendingis tabulated are as follows:

Table-2: Testingresultsofspecimens:

CarbonFiber Specimen	Load(N)	Flexural Strength (MPa)	FlexuralModulus (MPa)
Specimen1	440	44	683
Specimen2	221	12	100
Specimen3	332	21	204
Specimen4	428	53	725
Specimen5	395	64	695
Specimen6	578	67	592
Specimen7	432	13	135
Specimen8	221	69	674
Specimen9	394	54	731

8. CONCLUSIONS

- Thisstudyexaminesthebehaviorofcompositematerialsandlaminates,including anisotropic, quasi-isotropic, orthotropic, and isotropic materials.
- The nature of the matrixand several reinforcingfibertypes,including,carbon, and graphite, are investigated.
- Based on the findings,itisobviousthatflexuralpropertiesare essentialfortesting composite materials.
- Incomponents madeofcompositematerials, delaminationisfoundtobea measureof failure.

9. FUTURESCOPE

Although the current work includes various inquiries, there are still some unanswered questions, such as:

- Thereisahugeamountofroomforfutureacademicstopursuethisfieldofstudy.This research can be expanded upon to investigate further tribological features of the composite, such as abrasion, wear, and hardness behaviour.
- Thereisscopetoinvestigatemoreaspectsofthesecomposites,suchastheuseofother possiblefillers tocreatehybridcomposites, evaluation of their mechanicalbehaviour, and the analysis of the experimental results.
- Additionalresearchcanbedoneusingvariousmatrixmaterialsandfiberkinds.
- Stitching and interleaving techniques are used to investigate composite delamination processes.
- Impact and fatigue tests can be used to gauge the laminated composites' impact andfatigue resistance.
- Vibrationandmodalanalysiscanbeusedtoassessthelaminates'resistanceto vibration.
- It is feasibletostudylaminatedcomposites withcut outsanddeterminethestresses at the bearings.

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