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Performance analysis and comparison of different unidirectional laminate composite material to be used as a suspension system in light weight automobile vehicles

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Abstract: Composite is mixture of multiple materials to gain combine advantage of all those which was otherwise not possible to achieve if added constituents considered alone and independent. Percentage varying of added material if do vary it leads to change lamina property which further effects on laminate properties which can derived from lamina on average basis. The every application is unique and needed to support with best material to perform said task in satisfied manner for expected time span. Designer would have enough number of material choices readily available with him which he choose or reject based on few parameters such as cost, processing easiness, availability, mechanical properties, thermal properties, electrical properties etc. sometime available standard materials are not enough to perform given task satisfactorily and thus designer would think for its replacement and thus role of alternative material comes in to picture. This material performs well on the cost, availability and performance front and thus recognized in to role first time and starts gaining popularity later if consistently gives satisfactory output as required.

Paper describes performance comparison between various composite laminas, laminas behaviour have studied for different fibre orientations, so the strength, stiffness and effect of such change on mechanical properties have studied on each lamina. Current paper describes behaviour of three composite unidirectional lamina in response to change of fibre orientation, it reveals some laminas are less sensitive to such change and its properties remains unchanged till failure but few are very sensitive to such changes happened with respect to orientation or alike parameters such as thickness, fibre, matrix volume fraction and shows rapid change in to properties and behaviour. The industrial designer or researcher would have choice of choosing best material for specific application, or he would fetch an idea about imparting structure with enough strength by varying few basics parameter and that made him either to choose right material for said application through comparative study or upgrading level of performance of material by varying some basic parameters, in both the circumstances, one is capable to pull out choice of best material for said application. The material performance comparison discussed in paper tried to achieve similar objectives.

Keywords: Carbon-epoxy, glass/epoxy, Kevlar/epoxy, composite lamina, orientation, engineering properties etc.

1. Introduction: Selection of material happened based on few parameters such as, its availability, processing easiness, cost, mechanical, thermal and electrical properties etc.

Composite material has widely and satisfactorily recognized by the world of engineering and its uses has initiated in different fields, still researchers are believe to fetch utmost use of it in different fields to the best possible extant which is not happened yet. Specification of idle material to be used for various applications are, its strength, cost, availability, easiness, moulding capacity, performing capacity affectivity by various parameters etc. the set of required properties are determined based on type of environment and nature of loading component will probably subjected to during its operational tenure and thus job of industrial designer is to impart required perfection to address the objectives as framed inline to such operational requirements.

In the paper here, side of side study of performance and properties variation is studied for different laminas. The laminas further process in to laminate which further mould in to components. Ability of lamina and its constituents defines ability of processed components which are recommended to perform various mechanical and semi-mechanical tasks.

Comparison between various materials as an impact of orientation change is discussed throughout paper to determine and select the right lamina configuration with respective material to perform said application in utmost satisfied way.

2. Lamina testing and prediction of various engineering properties:

Following are lamina's engineering elastic properties obtained via Lamina Testing on UTM (Universal Testing Machine), the load applied on sample was uniaxial, gradual, loading magnitude has raisin till failure by fracture. Respective stress-strain graphs plotted were used to determine basic engineering elastic properties of different lamina as tabulated in the table given below.

Glass/Epoxy				
Engineering Elastic Constants	**E1**	**E2**	**G12**	**U12**
Values	**38**	**7**	**4**	**0.24**
Carbon/Epoxy				
Engineering Elastic Constants	**E_1**	**E_2**	**G_{12}**	**μ_{12}**
Values	135	9	5	0.28
Kevlar/Epoxy				
Engineering Elastic Constants	**E1**	**E2**	**G12**	**U12**
Values	73	6	2	0.32

Table (2.1): Material Engineering Elastic properties.

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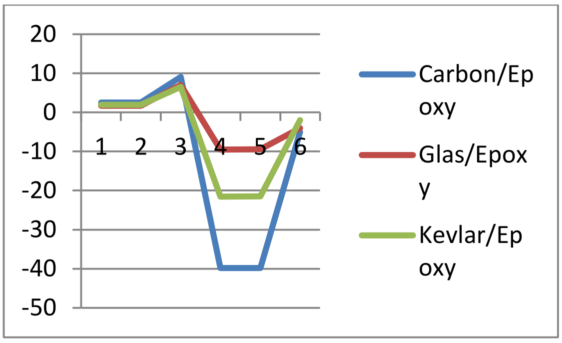
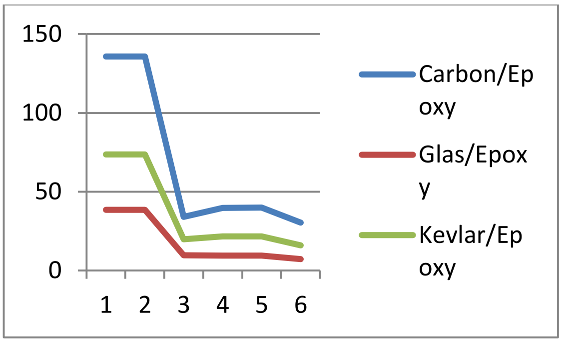
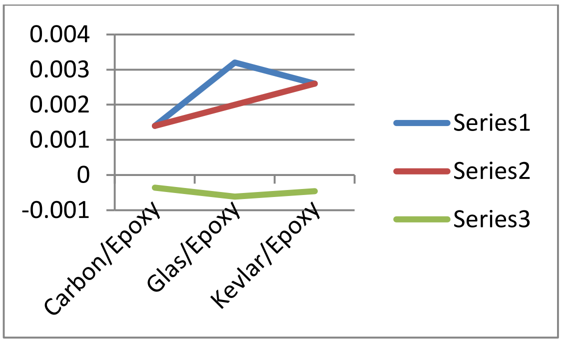
3. Performance analysis and comparison between different laminar composites:



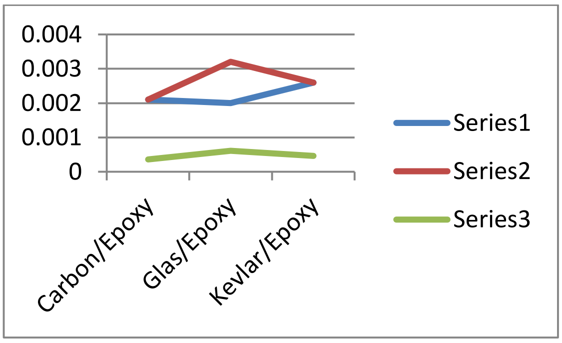
Graph (3.1): Minimum value comparison of laminar stiffness components as a function of changing orientation.



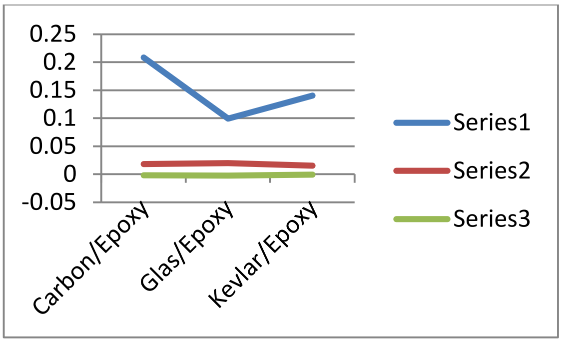
Graph (3.2): Maximum value comparison of laminar stiffness components as a function of changing orientation.



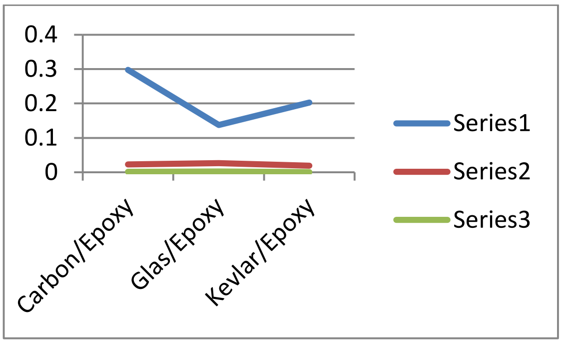
Graph (3.3): Minimum strain value among three different composite



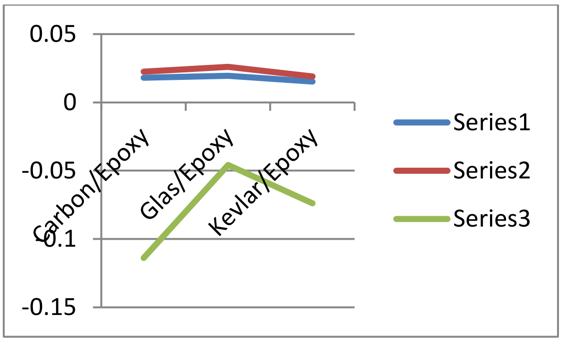
Graph (3.4): Maximum strain value among three different composite



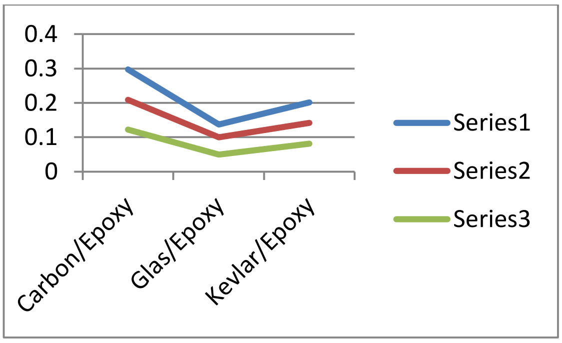
Graph (3.5): Minimum values of on axis- stress value among three different composite



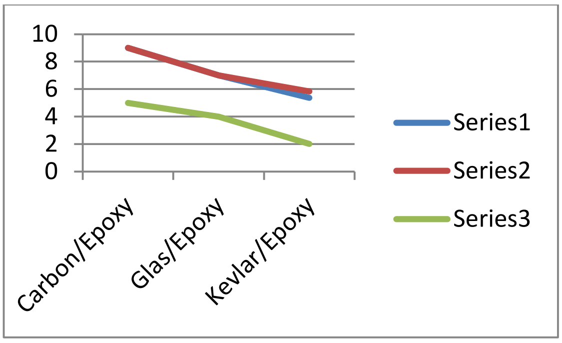
Graph (3.6): Maximum values of on axis- stress value among three different composite



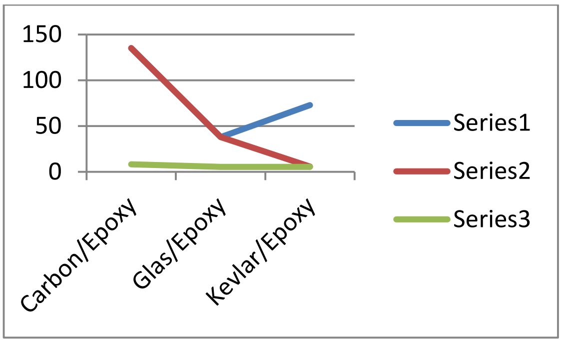
Graph (3.7): Minimum values of off axis stress value among three different composite



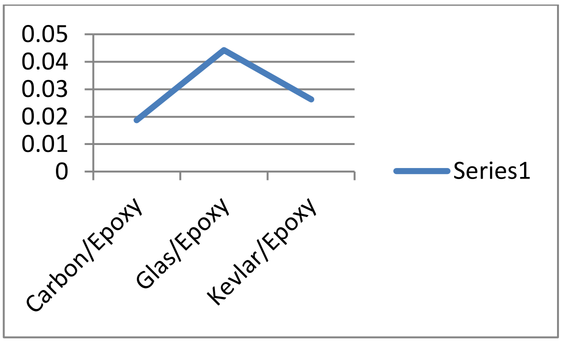
Graph (3.8): Maximum off axis stress value among three different composite



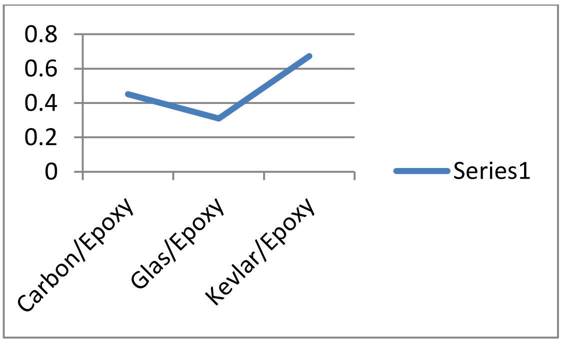
Graph (3.9): Minimum values of engineering elastic constants (E_x, E_y, E_s) in different composite materials.



Graph (3.10): Maximum values of engineering elastic constants (E_x, E_y, E_s) in different composite materials.



Graph (3.11): Minimum values of Poisson’s ratio in different composite materials



Graph (3.12): Maximum values of Poisson’s ratio in different composite materials

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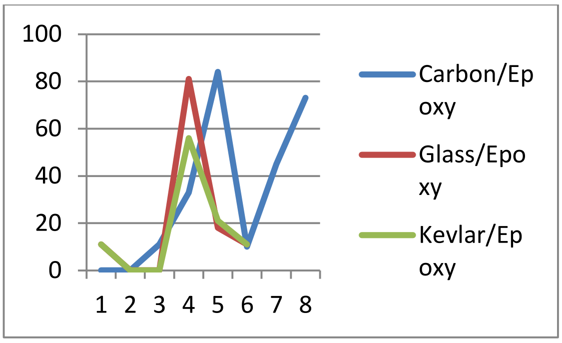
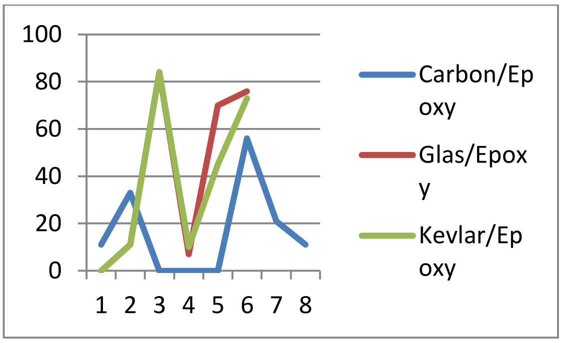
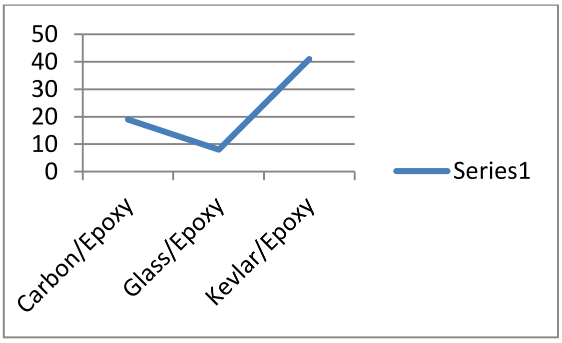


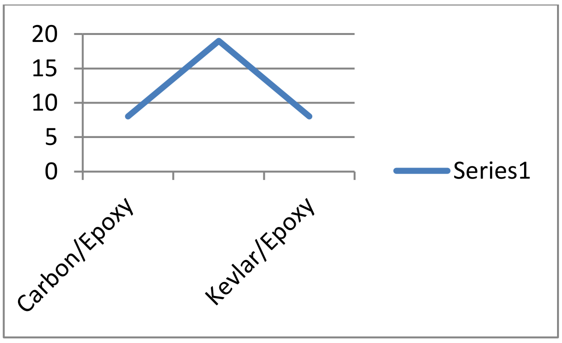
Graph (3.13): Maximum values of lamina stiffness components for different material among different laminas holds different fibre orientations.



Graph (3.14): Minimum values of lamina stiffness components for different material among different laminas holds different fibre orientations.



Graph (3.15): Maximum values of longitudinal stress among different materials for different ply orientations.



Graph (3.16): Minimum values of longitudinal stress among different materials for different ply orientations.

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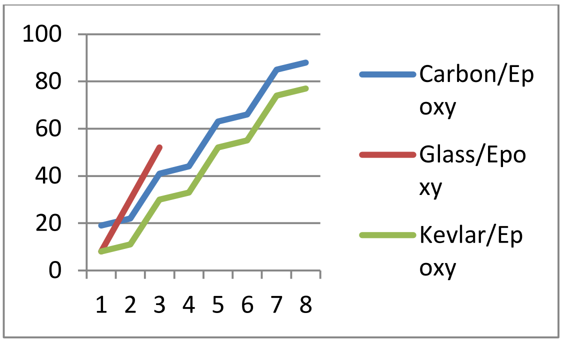
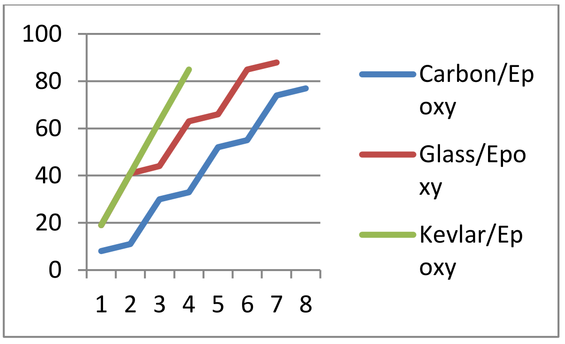
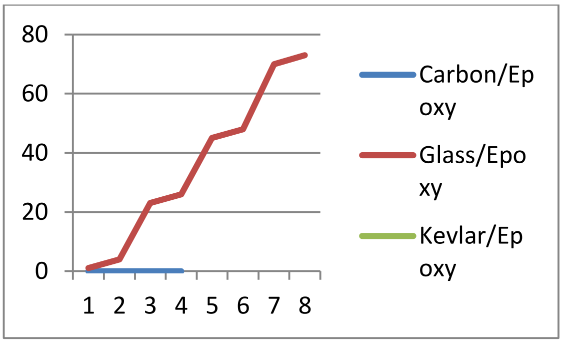


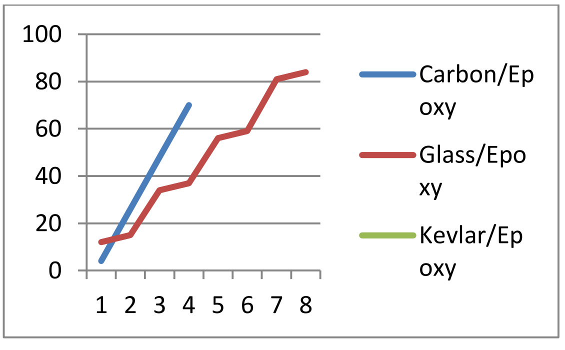
Graph (3.17): Maximum values of transverse stress among different materials for different ply orientations.



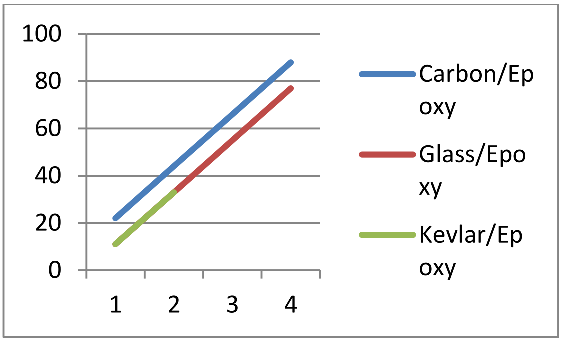
Graph (3.18): Minimum values of transverse stress among different materials for different ply orientations.



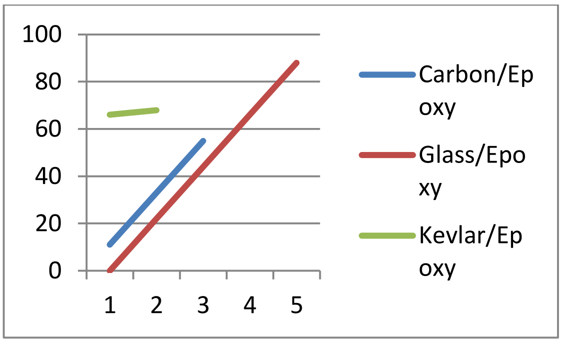
Graph (3.19): Maximum values of shear stress among different materials for different ply orientations.



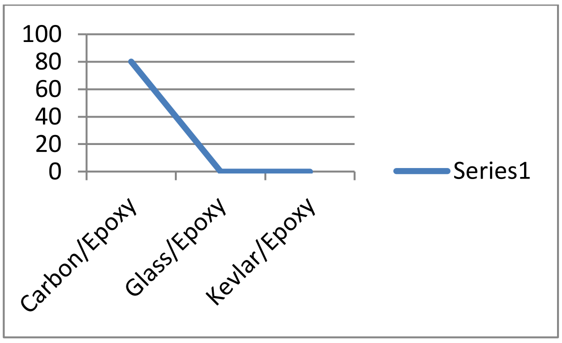
Graph (3.20): Minimum values of shear stress among different materials for different ply orientations.



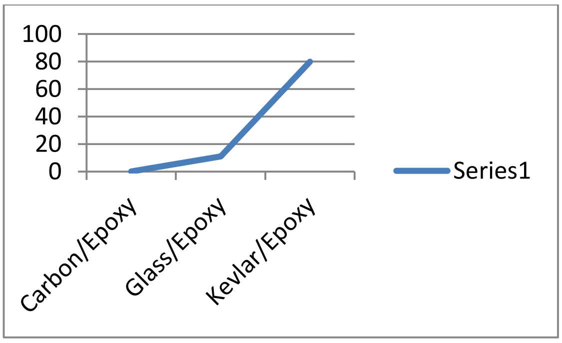
Graph (3.21): Maximum values of longitudinal off axis stress for different material among different ply orientations



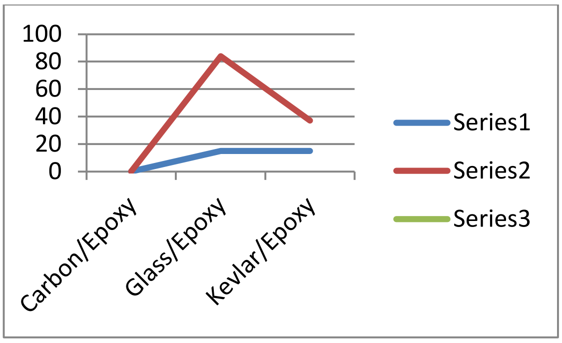
Graph (3.22): Minimum values of longitudinal off axis stress for different material among different ply orientations



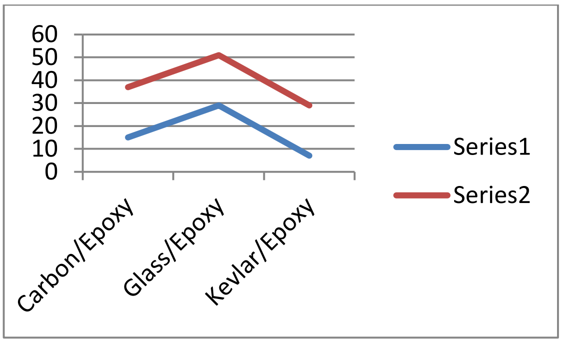
Graph (3.23): Maximum values of transverse off axis stress for different material among different ply orientations



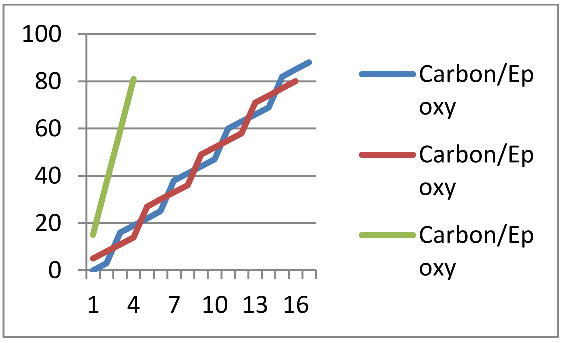
Graph (3.24): Minimum values of transverse off axis stress for different material among different ply orientations



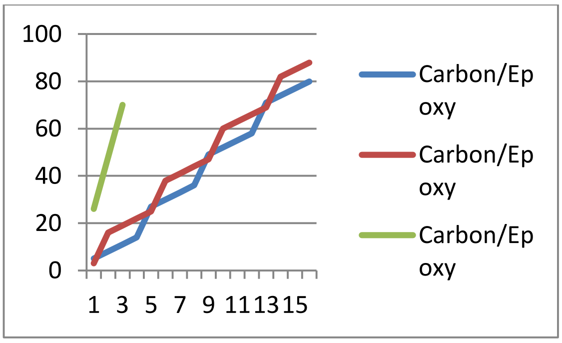
Graph (3.25): Maximum values of Shear stress for different material among different ply orientations



Graph (3.26): Minimum values of shear stress for different material among different ply orientations



Graph (3.27): Maximum values of on axis longitudinal strain for carbon/epoxy among different planes



Graph (3.28): Minimum values of on axis longitudinal strain for carbon/epoxy among different planes

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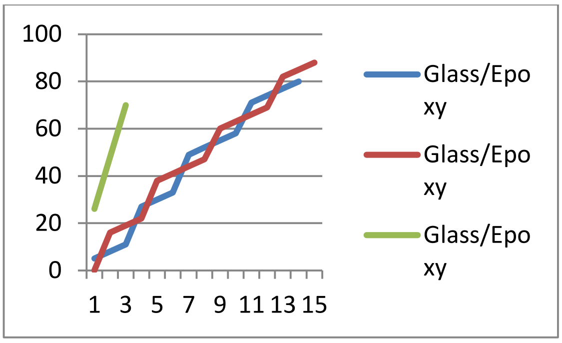
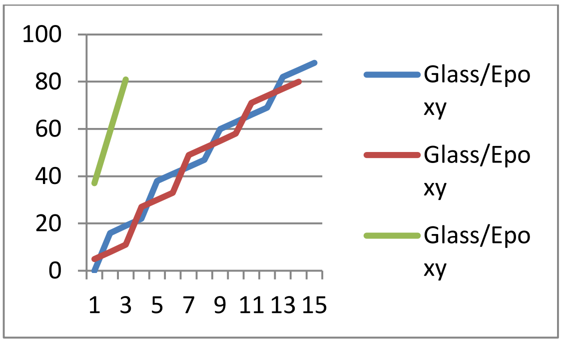
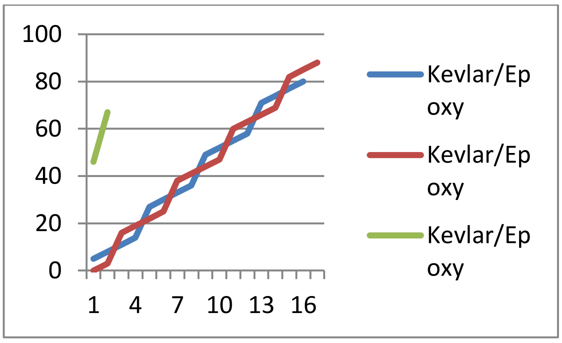


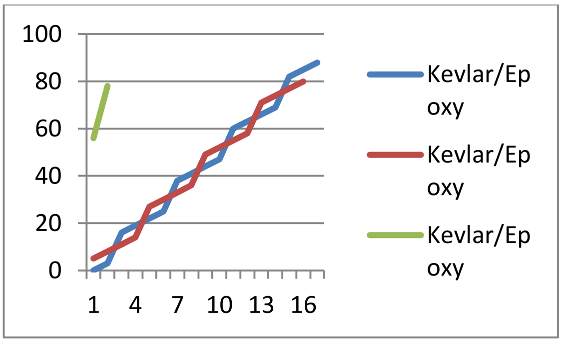
Graph (3.29): Maximum values of on axis longitudinal strain for glass/epoxy among different planes



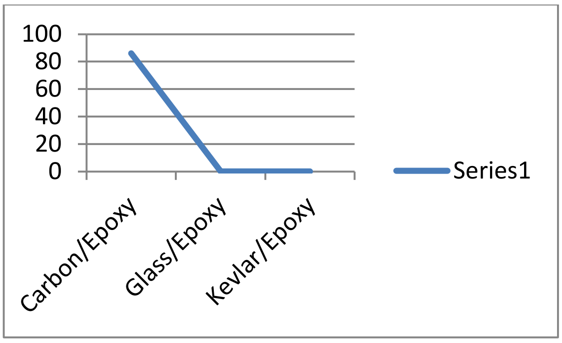
Graph (3.30): Minimum values of on axis longitudinal strain for glass/epoxy among different planes



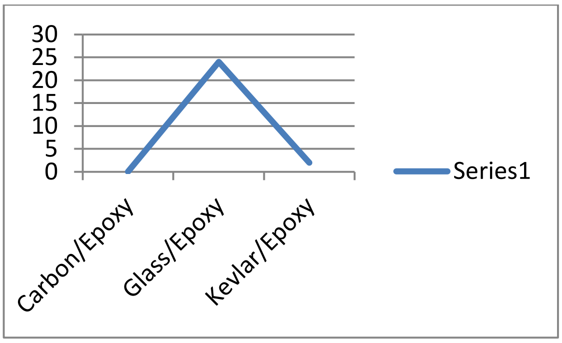
Graph (3.31): Maximum values of on axis longitudinal strain for Kevlar/epoxy among different planes



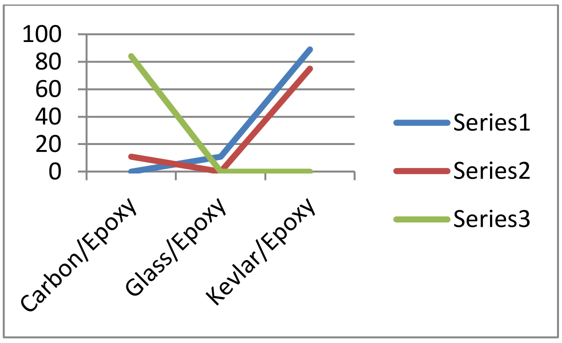
Graph (3.32): Minimum values of on axis longitudinal strain for Kevlar/epoxy among different planes



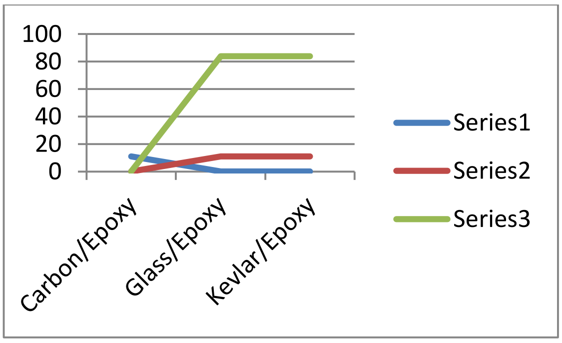
Graph (3.33): Maximum values of poison's ratio for different materials among different planes



Graph (3.34): Minimum values of poison's ratio for different materials among different planes



Graph (3.35): Maximum values of off-axis engineering elastic constants among different materials and different ply orientations.



Graph (3.36): Minimum values of off-axis engineering elastic constants among different materials and different ply orientations.

4. Result :

Sr. No.	Parameter	Minimum value	Material/epoxy	Maximum value	Material/epoxy
1	Q_{xx}, GPa	1.69	Glass	135.7	Carbon
2	Q_{yy}, GPa	1.69	Glass	135	Carbon
3	Q_{xy}, GPa	7.07	Glass	33.94	Carbon
4	Q_{xs}, GPa	-39.79	Carbon	39.72	Carbon
5	Q_{ys}, GPa	-39.79	Carbon	39.79	Carbon
6	Q_{ss}, GPa	-4.99	Carbon	30.24	Carbon
7	6_1, GPa	0.0092	Glass	0.298	Carbon
8	6_2, GPa	0.018	Carbon	0.026	Glass
9	6_3, GPa	-0.0024	Glass	0.0024	Glass
10	6_x, GPa	0.015	Kevlar	0.29	Carbon
11	6_y, GPa	-0.019	Kevlar	0.20	Carbon
12	$6_{xy}/\tau_{xy}$, GPa	-0.074	Kevlar	0.1222	Carbon
13	E_x, GPa	5.356	Kevlar	135	Carbon
14	E_y, GPa	5.82	Kevlar	134.95	Carbon
15	E_s/G_{12}, GPa	2	Kevlar	8.12	Carbon
16	u_{xy}	0.0187	Carbon	0.67	Kevlar

5. Conclusion & Discussion:

1. From strength and performance point of view, carbon/epoxy is best material comparative to glass and Kevlar epoxy.
2. Performance of carbon/epoxy lies at top, followed by performance of glass/epoxy and finally of Kevlar/epoxy.
3. Only strain and stress values shows variations for their maximum and minimum values among multiple planes, where rest of the parameters such as, stiffness, elastic constants, poison’s ratio hardly shows any such variation, even though any variation associated with such parameters exists, it is hardly limited to two to three planes and not more than that.
4. Stiffness and elastic constants component’s holds maximum values in multiple planes in case of carbon epoxy material.
5. Deformation occurs in carbon epoxy is noted less where it is noted highest in the case of Kevlar epoxy material.

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6. Maximum stress value and thus restriction to deformation is noted highest in the case of carbon/epoxy, where it is noted on lowest side in the case of Kevlar epoxy, the performance in such regards is noted average in the case of glass/epoxy material.
7. For less deformation, maximum strength and load sustaining carbon/epoxy is proposed material for the designing of laminate leaf spring to be used in light weight automobile suspension systems.

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