e-ISSN:2582-7219

INTERNATIONAL JOURNAL OF MULTIDISCIPLINARY RESEARCH IN SCIENCE, ENGINEERING AND TECHNOLOGY

Volume 7, Issue 3, March 2024

INTERNATIONAL STANDARD SERIAL NUMBER INDIA

Impact Factor: 7.521

| ISSN: 2582-7219 | www.ijmrset.com | Impact Factor: 7.521| Monthly Peer Reviewed & Referred Journal |

| Volume 7, Issue 3, March 2024 |

| DOI:10.15680/IJMRSET.2024.0703027 |

Analysis of Unidirectional Kevlar-Epoxy Laminar Composite

Mr. R B Gunale[1], Dr. S. P. Joshi[2], Jagtap Bhushan Arun[3], Jadhav Ajinkya Dadasaheb[4]

Associate Professor, Department of Mechanical Engineering, JSPM's Imperial College of Engineering and Research, Wagholi, Pune, Maharashtra, India[1,2]

U.G. Student, Department of Mechanical Engineering, JSPM's Imperial College of Engineering and Research, Wagholi, Pune, Maharashtra, India [3,4]

ABSTRACT: Properties of laminas are the function of several parameters such as its thickness, fibre orientation, fibre and matrix volume percentage etc. set of required properties can be obtained by varying this percentage in plus and minus range. Paper discussing similar aspects of parameters dependency where change occurred in fibre orientation greatly affects lamina's mechanical properties, this change or variation in properties is noted cyclic and regular in the case of few parameters, and in some cases this change is difficult to recognize. Aim of writing this paper the researchers to let know about effect of parameter change on strength of lamina, so choosing an appropriate set of parameters for standard range one would design and manufacture the lamina for said property configuration and performance.

KEYWORDS: Lamina, composite, elastic properties, orientation etc

I. INTRODUCTION

Industrial designer are eager to investigate new material in order to invent product manufacturing at minimum affordable price, aspect not ends here but going beyond that performance of product for its entire life time is also studied centric to this material selection and replacement proposed. Industrial designer more reply on tested material, it would save time on R & D of studying material various properties and their applicability to recommend for specific application, and thus composite material, a new name in the material domain has raised its head and fetched popularity in short span of time. Though use of composite is not new, several examples such as use of composite in bricks making, bow making and many other applications have justified it was popularly used in olden days too. In current scenario it is also admitted in various fields such as medical, construction, aerospace, navy, marine, sports etc. Research are still going on to find utmost capacity of material in various regards to promote its best and net level use in the time to come ahead.

Fibre volume fraction, matrix volume fraction, percentage of resin are few of the basic elements whose presence in right proportion affects the lamina and laminate properties, behaviour to great extent. Fibre are stiff ad contributes approximately 75% of total load sharing on the structure, where matrix though do not possess that strength as that of fibres but they have good damping capacity which retains the structure safe under the action of sudden or impact load which cannot be done by fibres alone otherwise. Resin bonds the fibre with matrix and enable load transfer from matrix to fibre in better way which otherwise not possible and in the practice of load transfer failure might have happened between fibre-matrix interface.

Few authors have studied impact of lamina thickness on its strength. Fibre orientation and stacking sequence also affects the strength of individual lamina and strength of laminate which was proven by research and investigation already.

Lamina properties determined through uniaxial testing of lamina on UTM (Universal testing Machine) are tabulated below,

| ISSN: 2582-7219 | www.ijmrset.com | Impact Factor: 7.521| Monthly Peer Reviewed & Referred Journal |

| Volume 7, Issue 3, March 2024 |

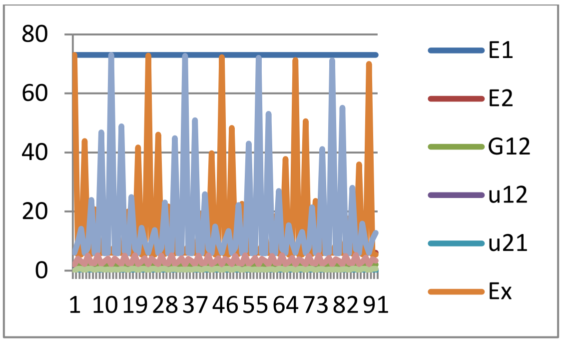
| DOI:10.15680/IJMRSET.2024.0703027 |

Kevlar/Epoxy				
Lamina elastic properties	**E1**	**E2**	**G12**	**U12**
Value	73	6	2	0.32
Off-Axis strain	**ex**	**ey**	**es**	
Value	0.0026	0.0017	0.00010	

Table (1.1): Lamina properties obtained via Uni-axial material testing on UTM (Universal Testing Machine, Static/Gradual loading)

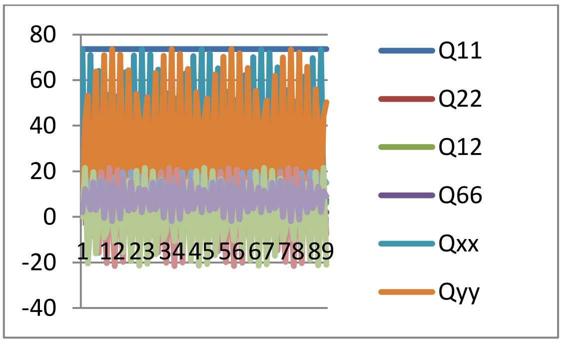
II. Uni-Directional Lamina Analysis

Uni-Directional Lamina Analysis: Impact of orientation change on various elastic properties, stress and strain components are depicted through several graphs obtained and pasted below,



Graph (2.1): Effect of change of orientation on laminas on axis and off-axis engineering elastic properties

Changed orientation of lamina do not affects laminas on axis elastic properties but off axis properties have got considerable impact of such change as depicted in the graph above. The cyclic change in value is the effect centric to off-axis lamina stiffness components which is not the case of online stiffness component and shows straight, linear graphs throughout the orientation change.



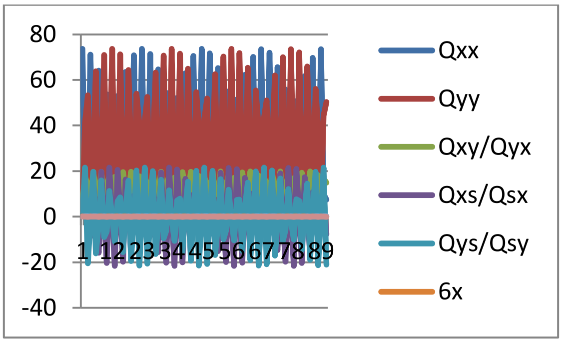
Graph (2.2): Effect of change of orientation on laminas on axis and off-axis stiffness components

Like the elastic constant value change with change in orientation the similar effects have also noted in the case of stiffness components. Value of stiffness components defined for that respective plane noted maximum where its impact seems lowering in the plane which is located at some inclination with respect to original plane or either placed exactly mutually perpendicular. Similarly values of transverse engineering elastic constants noted less in longitudinal direction and plane.

| ISSN: 2582-7219 | www.ijmrset.com | Impact Factor: 7.521| Monthly Peer Reviewed & Referred Journal |

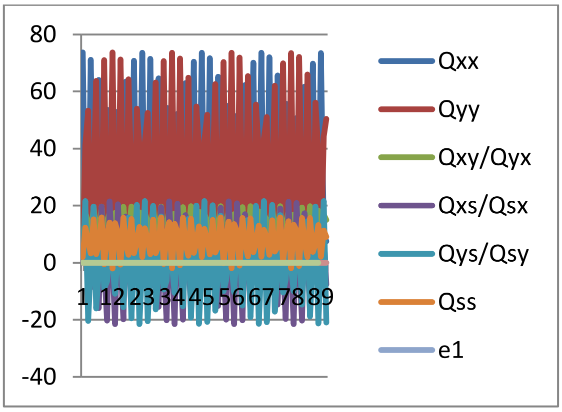
| Volume 7, Issue 3, March 2024 |

| DOI:10.15680/IJMRSET.2024.0703027 |



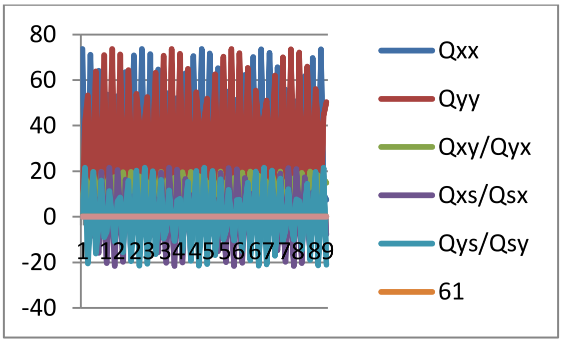
Graph (2.3): Effect of stiffness component on off-axis stress

Stiffness change occurred with respect to orientation, maxim stiffness leads to induce maximum stress and less deformation in lamina.



Graph (2.4): Effect of stiffness components on on-axis strain

Maximum stiffness leads lamina to deform less thus value of longitudinal or planer strains noted also less.



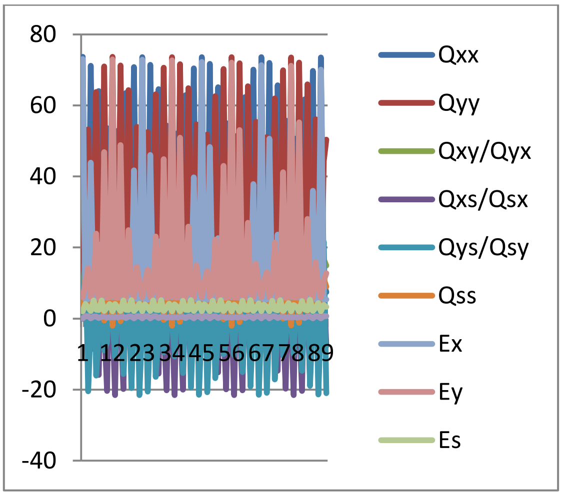
Graph (2.5): Effect of stiffness components on on-axis stress

Maximum vale of stiffness leads to produce maximum value of stress too, or it can also be state that, stress and stiffness components exhibits proportioned relationship between them.

| ISSN: 2582-7219 | www.ijmrset.com | Impact Factor: 7.521| Monthly Peer Reviewed & Referred Journal |

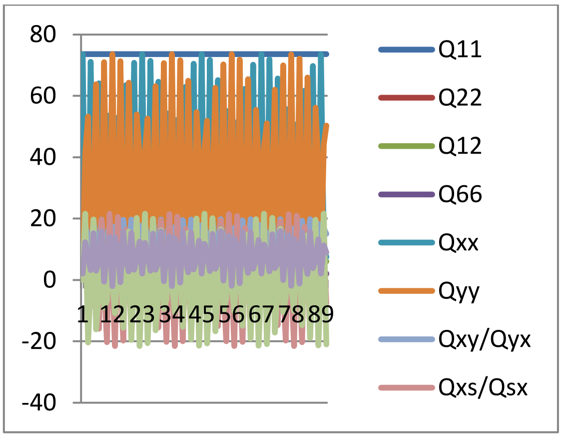
| Volume 7, Issue 3, March 2024 |

| DOI:10.15680/IJMRSET.2024.0703027 |



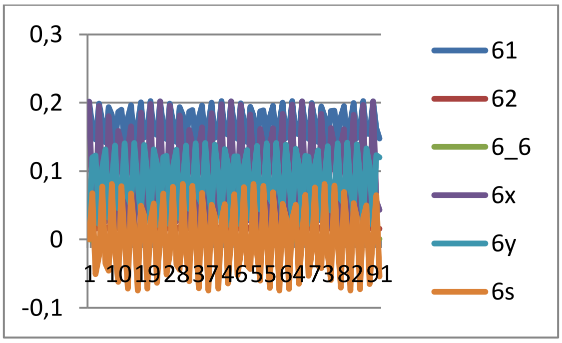
Graph (2.6): effect of stiffness components on off-axis engineering elastic constants.

Directional strength of lamina is defined by means of value of engineering elastic constants so the laminar strength is the function of stiffness and compliance components defined in various planer directions. Stiffness components are affected by value of elastic constants defined in respective direction, it can also be says that strength of lamina in planer direction virtue of stiffness components is the function of lamina engineering elastic constants.



Graph (2.7): Comparing effect of fibre orientation change on off-axis and on-axis lamina stiffness components

Off axis stiffness of lamina changes with change in fibre orientation but on axis stiffness components which are the function of laminas basic engineering elastic properties do not affected by such orientation changes happened.



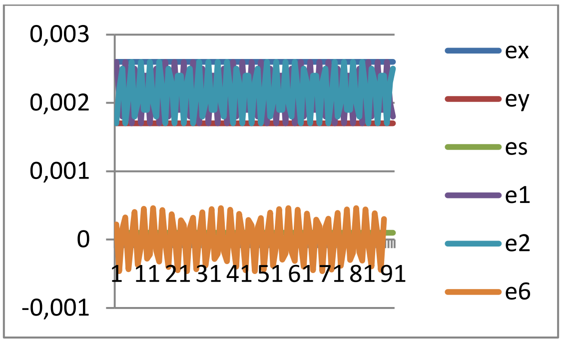
Graph (2.8): Comparing effect of fibre orientation change on off-axis and on-axis stress components

| ISSN: 2582-7219 | www.ijmrset.com | Impact Factor: 7.521| Monthly Peer Reviewed & Referred Journal |

| Volume 7, Issue 3, March 2024 |

| DOI:10.15680/IJMRSET.2024.0703027 |

Stress is the function of stiffness, and stiffens is the function of fibre orientation, thus change in fibre orientation affects the magnitude of stress too.



Graph (2.9): Comparing effect of fibre orientation change on off-axis and on-axis strain components

Strain is the function of stress, which is further function of stiffness and is the further function of orientation. High stiffness components leads to produce less deformation in lamina and thus it exhibits very less value of strain in respective directions.

III. RESULT

Parameters	Maximum value	Minimum value	Orientation (Degrees), Respectively
Q_{xx}, GPa	73.61	1.93	0 & 11
Q_{yy}, GPa	73.61	1.93	11 & 0
Q_{xy}, GPa	19.83	6.5	84 & 0
Q_{xs}, GPa	21.57	-21.57	10 & 56
Q_{ys}, GPa	21.57	-21.50	45 & 21
Q_{ss}, GPa	15.91	-1.9987	73 & 11
e_1	0.0026	0.0026	[0,3,16,19,22,25,38,41,44,47,60,63,66,69,82,85,88] & [5,8,11,14,27,30,33,36,49,52,55,58,71,74,77,80]
e_2	0.0026	0.0026	[5,8,11,14,27,30,33,36,49,52,55,58,71,74,77,80] & [0,3,16,19,22,25,38,41,44,47,60,63,66,69,82,85,88]
e_6	4.6*10^-4	-4.6*10^-4	[56,78] & [45,67]
σ_1, GPa	0.2023	0.1402	8 & [19,41]
σ_2, GPa	0.0191	0.0153	[19,41,63,85] & [8,11,30,33,52,55,74,77]
σ_6, GPa	9.22*10^-4	-9.22*10^-4	[59,81] & 70
σ_x, GPa	0.2019	0.0153	[66,68] & [11,33]
σ_y, GPa	0.1414	0.019	80 & 0
σ_s, GPa	8.12*10^-2	-7.4*10^-2	[7,29] & [15,37,59]
E_x, GPa	73	5.356	0 & 89
E_y, GPa	5.823	5.823	11 & 75
E_s, GPa	5.2387	2	84 & 0
μ_{yx}, GPa	0.673	0.0263	2 & 0

IV. DISCUSSION & CONCLUSION

1. Strain/Deformation along various planes of lamina indicates most sensitive zone of fibre matrix-interface leads to produce considerable deformation which probably brings the failure at such interfacial locations too.

| ISSN: 2582-7219 | www.ijmrset.com | Impact Factor: 7.521| Monthly Peer Reviewed & Referred Journal |

| Volume 7, Issue 3, March 2024 |

| DOI:10.15680/IJMRSET.2024.0703027 |

2. Longitudinal properties contributes good in longitudinal direction and planes defined in such direction, contribution of such properties in load and stress sustaining noted less as direction change happened from longitudinal to transverse, the assumption is also valid when direction change happened from transvers to longitudinal.
3. Value of strain in linear direction is maximum than strain produced in planer or shear direction, still failure probability along plane of shear is more than that of failure probability in longitudinal direction.
4. Stiffness components contribute towards load sustaining, lamina safety against failure; depletes and holds the value of stress within permissible limit, controls the value of strain/deformation etc.
5. Linear strength of lamina is the function of engineering elastic constants where laminar strength is the function of stiffness components derived for different planes.
6. Stiffness components are the function of engineering elastic constants which turn to define overall strength of lamina against linear failure, shear failure, failure due to bending or out of plane loading etc.
7. Analysis of lamina with said mechanical elastic properties and stiffness components is only for in plane an shear loading, when concern of out of loading comes in to picture surprisingly, such loads converted in to in plane loading and analysis continues like it was for in plane loading so far.
8. For analysis purpose, linear load considered directional and acting alone, also considered alone and unique in the calculation of stress and strain, for planer analysis, linear loads considered acting in pair, and thus considered in the form of shear to analyze and predicts its impact in terms of deformation or failure.

REFERENCES

1. Madhujit Mukhopadhaya, 2005, 'Mechanics of Composite Material & Structure', Text book, ISBN 9788173714771.
2. Daniel, "Mechanics of Composite Material (1994)" Text Book, Online ISBN-256-256
3. Valery V Vasiliev & Evgeny V Morozov, 2001, ' Mechanics & Analysis of Composite Materials', text book, ISBN 0-08-042702-2.
4. Rahul B Gunale (June 2018), "A Review paper on study of progressive damage of composites structure under tri-axial loadings by using Macro-Mechanical based failure theories" International journal of trends in scientific research and development, 2(4), pp 2036.
5. Effect of Fibre Orientation on Mechanical Properties of Sisal Fibre Reinforced Epoxy Composites, Journal of Applied Science and Engineering, Vol. 18, No. 3, pp. 289_294 (2015), Kumaresan. M, Sathish. S and Karthi. N.
6. Effects of Polypropylene Fibres on Physical and Mechanical Properties of Concretes, 3rd International Conference on Concrete & Development / 1075, M. Najimi, F.M. Farahani and A.R. Pourkhorshidi.
7. Effect of glass wool fibres on mechanical properties of concrete, International Journal of Engineering Trends and Technology (IJETT) - Volume4 Issue7- July 2013, R. Gowri, M. Angeline Mary.

INNO SPACE
SJIF Scientific Journal Impact Factor
Impact Factor
7.521

INTERNATIONAL
STANDARD
SERIAL
NUMBER
INDIA

निस्केयर
NISCAIR

INTERNATIONAL JOURNAL OF MULTIDISCIPLINARY RESEARCH IN SCIENCE, ENGINEERING AND TECHNOLOGY

| Mobile No: +91-6381907438 | Whatsapp: +91-6381907438 | ijmrset@gmail.com |

www.ijmrset.com