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Numerical Analysis of Hybrid Natural Fiber Reinforced Polymer Composites using FEM

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Abstract

Over the last thirty years composite materials such as polymer, alloys and ceramics have been the dominant emerging materials. The volume and number of applications of Composite materials have grown steadily, penetrating and conquering new markets relentlessly. Polymeric Materials Reinforced with Synthetic Fibers such as glass, carbon, and aramid provide advantages of high stiffness and high strength to weight ratio as compared to conventional materials, i.e. wood, concrete, and steel. Despite these advantages, the widespread use of synthetic Fiber-reinforced polymer composite has a tendency to decline because of their high-initial costs, their use in non-efficient structural forms and most importantly their adverse environmental impact. On the other hand, the increase in interest of using Natural Fibers as Reinforcement in plastics to substitute conventional synthetic fibers in some automobile applications has become one of the main concerns to study the potential of using natural Fibers as reinforcement for polymers. In the light of this, researchers have focused their attention on natural fiber composite (i.e., bio-composites) which are composed of natural or synthetic resins, reinforced with natural fibers. Accordingly, manufacturing of high-performance Engineering Materials from renewable resources has been pursued by researchers across the world owing to renewable raw materials are environmentally sound and do not cause health problem. The present work includes the Analysis of Hemp Fiber Reinforced Polypropylene and Kenaf Fiber Reinforced Epoxy Composites using FEM with various fiber volume fractions and to evaluate the best Tensile Property of the Composites under tensile load. This work is carried out to introduce a new class of polymer composite that might find many engineering applications.

Keywords: Natural fiber, Polypropylene (PP), Epoxy, Biocomposite, mechanical property

Introduction

A composite is a structural material that consists of two or more combined constituents that are combined at a macroscopic level and are not soluble in each other[1]. One constituent is called the reinforcing phase and the one in which it is embedded is called the matrix. The reinforcing phase material may be in the form of fibers, particles, or flakes[2]. The most common advanced composites are polymer matrix composites (PMCs) consisting of a polymer (e.g., epoxy, polyester, polypropylene, urethane) reinforced by thin diameter fibers (e.g., graphite, aramids, boron). For example, graphite/epoxy composites are approximately five times stronger than steel on a weight-for-weight basis. The reasons why they are the most common composites include their low cost, high strength, and simple manufacturing principles[3-6]. This project mainly deals with analysis of mechanical properties of Hemp Reinforced Polypropylene composite that is suitable for automobile application. First, the property for orthotropic material is obtained on the basis of some assumptions (Rule of Mixture) and is modeled with reference to ASTM D638 [6-7]. Here the simulation is carried out under different fiber volume fraction and orientation. Of these the optimal mechanical properties can be found. This work is carried out to introduce a new class of polymer composite that might find many engineering applications.

Material Selection and Properties

The Hemp reinforced polypropylene composite is selected because of its superior strength than other natural fibers .so it is used for Manufacturing of automotive panels and some domestic appliances. The material properties were shown in the table.

Table 1 Properties of fibers and resins

	Density, ρ (g/cc)	Elastic Modulus, E (MPa)	Poisson's ratio, ν	Shear Modulus, G MPa)
Hemp	1.4	4140	0.221	930
PP	1.1	2600	0.39	1000
Kenaf	1.5	4300	0.342	350
Epoxy	1.2	4000	0.41	570

Analytical Procedure

Longitudinal Tensile Modulus along X direction, E_T (MPa)

$E_L = E_f V_f + E_m V_m$

Transverse Tensile Modulus along Y direction, E_T (MPa)

$1/E_T = V_f/E_f + V_m/E_m$

Longitudinal Elastic Modulus along fiber direction, E1=E3 (MPa)

$E_1 = E_L (\cos^4\theta + (E_L/E_T)(\sin^4\theta) + (1/4)((E_L/G_{LT}) - 2\nu_{LT})(\sin^2(2\theta)))^{-1}$

Transverse Elastic Modulus perpendicular to fiber direction, E2 (MPa)

$E_2 = E_L (\sin^4\theta + (E_L/E_T)(\cos^4\theta) + (1/4)((E_L/G_{LT}) - 2\nu_{LT})(\sin^2(2\theta)))^{-1}$

Poisson ratio along XY direction, ($\nu_{12} = \nu_{31}$)

$\nu_{12} = \nu_f V_f + \nu_m V_m$

Poisson ratio along YZ direction, (ν_{23})

$\nu_{23} = \nu_{12} (E_2/E_1)$

Shear Modulus along XY direction, ($G_{12} = G_{13}$) (MPa)

$G_{12} = E_1/2(1+\nu_{12})$

Shear Modulus along YZ direction, ($G_{12} = G_{13}$) (MPa)

$G_{23} = E_2/2(1+\nu_{23})$

Mass Density of the Material, ρ (g/mm3)

$\rho_C = \rho_f v_f + \rho_m v_m$

Where,

θ =orientation of fiber
ε_c = Strain in composite plate
σ c= Stress in composite plate
E c= Young's Modulus of plate
V_f= volume fraction of fiber
V_m = volume fraction of matrix

Sample Calculation For Material Property

At θ =30°& V_f =10% for Hemp Reinforced PP Composite

Calculation of Young's Modulus in Longitudinal direction

$E_L = (E_m * V_m) + (E_f * V_f)$
$= (2600*0.9) + (4140*0.1)$
$= 3370$ N/mm^2

$1/E_T = V_f/E_f + V_m/E_m$
$= (0.1/4140) + (0.9/2600)$
$= 3194.06/2$ N/mm^2
$=1597.03$ N/mm^2

Longitudinal Elastic Modulus along fiber direction, E1=E3 (MPa):

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$$E_1=E_L(\cos^4\theta+(E_L/E_T)(\sin^4\theta)+(1/4)((E_L/G_{LT})-2\nu_{LT})(\sin^2(2\theta)))^{-1}$$

$$E_1=2573.25\ N/mm^2$$

<u>Transverse Elastic Modulus perpendicular to fiber direction, E2 (MPa) :</u>

$$E_2=E_L(\sin^4\theta+(E_L/E_T)(\cos^4\theta)+(1/4)((E_L/G_{LT})-2\nu_{LT})(\sin^2(2\theta)))^{-1}$$

$$E_2=1731.912\ N/mm^2$$

<u>Calculation of Poisson's Ratio:</u>

$\upsilon_{LT}=\upsilon_{12}=(\upsilon_f*V_f)+(\upsilon_m*V_m)$
$=(0.221*0.1)+(0.39*0.9)$
$=0.3055$

$\upsilon_{23}=\upsilon_{12}(E_2/E_1)$
$=0.3055(1731.912/2573.25)$
$=0.2511$

<u>Calculation of Shear Modulus:</u>

$G_{12}=E_1/2(1+\upsilon_{12})$
$=2573.25/2(1+0.3055)$
$=937.022$ N/mm2

$G_{23}=E_2/2(1+\upsilon_{23})$
$=1731.912/2(1+0.2511)$
$=692.155$ N/mm2

<u>Calculation of Density:</u>

$\rho_c=(\rho_f*V_f)+(\rho_m*V_m)$
$=(1400*0.1)+(1100*0.9)$
$=1130$ g/cc

Methodology

The tensile load on laminated composite plates was performed with static mode using the finite element analysis software "ANSYS 11.0". The dimension of the laminated composite plate is taken for analysis having dimensions length, width, thickness, are 203.2mm, 25.4mm, 3mm respectively. The composite model and property were shown in figure 1 and table (1.2.a).

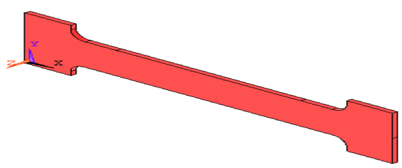

Figure.1 Specimen modeled with Reference to ASTM D638

Evaluation of Orthotropic Material Property

The material properties of the Hemp Fiber Reinforced Polypropylene and Kenaf Fiber Reinforced Epoxy Composites are evaluated by analytical method and is shown in below tables

Properties	V_f at 0˚ Fiber orientation										
	0	0.1	0.2	0.3	0.4	0.5	0.6	0.7	0.8	0.9	1
E_1, (MPa)	2600	2754	2908	3062	3216	3370	3524	367	383	3986	414
E_2, (MPa)	1200	1350	1404	1463	1527	1500	1673	155	185	1954	207
E_3, (MPa)	2600	2754	2908	3062	3216	3370	3524	367	383	3986	414
G_{12},	1088	1003	1072	1143	1216	1291	1472	144	152	1610	169
G_{23},	592	571	599	630	662	698	479	778	824	875	932
G_{31},	1088	1003	1072	1143	1216	1291	1472	144	152	1610	169
ν_{12}	.195	.373	.356	.339	.322	.195	.288	.271	.254	.238	.221
ν_{23}	.098	.183	.172	.162	.153	.097	.137	.129	.123	.116	.110
ν_{31}	.195	.373	.356	.339	.322	.195	.288	.271	.254	.238	.221
ρ, g/cc	1.3	1.13	1.16	1.19	1.22	1.25	1.28	1.31	1.34	1.37	1.4

Table 2 orthotropic Material Property of Hemp fiber at 0˚ Fiber orientation

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	V_f at 30˚ Fiber orientation										
	0	0.1	0.2	0.3	0.4	0.5	0.6	0.7	0.8	0.9	1
E_1, (MPa)	250	2573	2615	2656	2692	2727	2760	2792	2821	2849	2876
E_2, (MPa)	160	1732	1765	1801	1840	1882	1926	1973	2023	2077	2134
E_3, (MPa)	250	2573	2615	2656	2692	2727	2760	2792	2821	2849	2876
G_{12},	900	937	1072	991	1018	1044	1071	1097	1124	1151	1177
G_{23},	641	692	712	732	735	777	802	828	855	885	917
G_{31},	900	937	1072	991	1018	1044	1071	1097	1124	1151	1177
ν_{12}	0.39	.373	.3562	.3393	.3224	.3055	.2886	.2717	.2548	.2379	.221
ν_{23}	.249	.251	.2405	.2302	.2204	.2108	.2013	.1920	.1827	.1734	.164
ν_{31}	0.39	.373	.3562	.3393	.3224	.3055	.2886	.2717	.2548	.2379	.221
ρ, g/cc	1.3	1.13	1.16	1.19	1.22	1.25	1.28	1.31	1.34	1.37	1.4

Table 3 Orthotropic Material Property of Hemp fiber at 30˚ Fiber orientation

	V_f at 45˚ Fiber orientation										
	0	0.1	0.2	0.3	0.4	0.5	0.6	0.7	0.8	0.9	1
E_1, (MPa)	2085	2173	2190	2208	2228	2248	2269	2291	2314	2337	236
E_2, (MPa)	2085	2173	2190	2208	2228	2248	2269	2291	2314	2338	236
E_3, (MPa)	2085	2173	2190	2208	2228	2248	2269	2291	2314	2337	236
G_{12},	750	1003	1072	1143	1216	1290	1360	1446	1527	1610	169
G_{23},	750	1003	1072	1143	1216	1290	1360	1446	1527	1610	169
G_{31},	750	1003	1072	1143	1216	1290	1360	1446	1527	1610	169
ν_{12}	0.39	0.3731	0.356	0.339	0.322	0.305	0.288	0.271	0.254	0.238	0.22
ν_{23}	0.39	0.3731	0.356	0.339	0.322	0.305	0.288	0.271	0.254	0.238	0.22
ν_{31}	0.39	0.3731	0.356	0.339	0.322	0.305	0.288	0.271	0.254	0.238	0.22
ρ, g/cc	1.3	1.13	1.16	1.19	1.22	1.25	1.28	1.31	1.34	1.37	1.4

Table 4 Orthotropic Material Property of Hemp fiber at 45˚ Fiber orientation

	V_f at 60˚ Fiber orientation										
	0	0.1	0.2	0.3	0.4	0.5	0.6	0.7	0.8	0.9	1
E_1, (MPa)	1602	1732	1765	1801	1840	1882	1926	1973	2024	2077	2134
E_2, (MPa)	2502	2573	2616	2655	2744	2772	2761	2792	2821	2849	2876.
E_3, (MPa)	1602	1732	1765	1801	1840	1882	1926	1973	2024	2077	2134
G_{12},	576	631	651	673	696	721	747	776	806	839	875
G_{23},	777	827	856	885	926	956	976	1008	1041	1074	1108
G_{31},	576	631	651	673	696	721	747	776	806	839	875
ν_{12}	0.39	0.373	0.356	0.339	0.322	0.305	0.288	0.271	0.254	0.237	0.221
ν_{23}	0.608	0.554	0.527	0.500	0.480	0.45	0.413	0.384	0.355	0.326	0.297
ν_{31}	0.39	0.373	0.356	0.339	0.322	0.305	0.288	0.271	0.254	0.237	0.221
ρ, g/cc	1.3	1.13	1.16	1.19	1.22	1.25	1.28	1.31	1.34	1.37	1.4

Table 5 Orthotropic Material Property of Hemp fiber at 60˚ Fiber orientation

	V_f at 90˚ Fiber orientation										
	0	0.1	0.2	0.3	0.4	0.5	0.6	0.7	0.8	0.9	1
E_1, (MPa)	1300	1351	1404	1464	1528	1597	1673	1758	1851	1954	2070
E_2, (MPa)	2600	2754	2908	3062	3216	3370	3524	3678	3832	3986	4140
E_3, (MPa)	1300	1351	1404	1464	1528	1597	1673	1758	1851	1954	2070
G_{12},	544	492	518	546	578	612	649	691	737	789	848
G_{23},	935	782	837	895	958	1096	1095	1172	1254	1341	1435
G_{31},	544	492	518	546	578	612	649	691	737	789	848
ν_{12}	.195	.3731	.3562	.3393	.3224	.3055	.2886	.2717	.2548	.2379	.221
ν_{23}	.39	.7607	.7375	.7098	.6786	.644	.6077	.5685	.5275	.4852	.442
ν_{31}	.195	.3731	.3562	.3393	.3224	.3055	.288	.2717	.2548	.2379	.221
ρ, g/cc	1.3	1.13	1.16	1.19	1.22	1.25	1.28	1.31	1.34	1.37	1.4

Table 6 Orthotropic Material Property of Hemp fiber at 90˚ Fiber orientation

	V_f at 0˚ Fiber orientation										
	0	0.1	0.2	0.3	0.4	0.5	0.6	0.7	0.8	0.9	1
E_1, (MPa)	4000	4030	4060	4090	4120	4150	4180	4210	4240	4270	4300
E_2, (MPa)	2000	2014	2028	2043	2057	2072	208	2103	2118	2134	2150

E_3, (MPa)	4000	4030	4060	4090	4120	4150	4180	4210	4240	4270	4300
G_{12},	1418	1436	1454	1472	1489	1508	1526	1545	1564	1583	1602
G_{23},	830	838.1	846.53	855	863	828	881	890	899	908	918
G_{31},	1418	1436	1454	1472	1489	1508	1526	1545	1564	1583	1602
ν_{12}	.41	.403	.3964	.3896	.3828	.376	.3692	.362	.355	.348	.342
ν_{23}	.205	.2015	.1980	.1945	.1911	.1877	.1843	.181	.177	.174	.171
ν_{31}	.41	.403	.3964	.3896	.3828	.376	.3692	.362	.355	.348	.342
ρ, g/cc	1.2	1.23	1.26	1.29	1.32	1.35	1.38	1.41	1.44	1.47	1.5

Table 7 Orthotropic Material Property of Kenaf fiber at 0˚ Fiber orientation

	V $_f$ at 30˚ Fiber orientation										
	0	0.1	0.2	0.3	0.4	0.5	0.6	0.7	0.8	0.9	1
E_1, (MPa)	2163	2072	238	1911	1839	177	1711	1654	1600	1549	1502
E_2, (MPa)	2540	1648	184	1548	1503	146	1420	1382	1346	1311	1279
E_3, (MPa)	2163	2072	238	1911	1839	177	1711	1654	1600	1549	1502
G_{12},	767	739	853	687	665	644	625	607	590	575	560
G_{23},	857	624	184	588	573	557	543	530	518	506	495
G_{31},	767	739	853	687	665	644	625	607	590	575	560
ν_{12}	.41	.4032	.396	.3896	.3828	.376	.369	.3624	.3556	.347	.342
ν_{23}	.481	.320	.306	.315	.3128	.309	.3062	.3028	.299	.2937	.291
ν_{31}	.41	.4032	.396	.3896	.388	.376	.369	.3624	.3556	.347	.342
ρ, g/cc	1.2	1.23	1.26	1.29	1.32	1.35	1.38	1.41	1.44	1.47	1.5

Table 8 Orthotropic Material Property of Kenaf fiber at 30˚ Fiber orientation

	V $_f$ at 45˚ Fiber orientation										
	0	0.1	0.2	0.3	0.4	0.5	0.6	0.7	0.8	0.9	1
E_1, (MPa)	1740	166	1588	1522	1447	1405	1352	1303	1259	1217	117
E_2, (MPa)	1740	166	1588	1522	1447	1405	1352	1303	1259	1217	117
E_3, (MPa)	1740	166	1588	1522	1447	1405	1352	1303	1259	1217	117
G_{12},	617	592	569	548	545	510	494	478	464	451	439
G_{23},	617	592	569	548	545	510	494	478	464	451	439
G_{31},	617	592	569	548	545	510	494	478	464	451	439
ν_{12}	.41	.403	.396	.3896	.328	.376	.369	.3624	.3556	.348	.342
ν_{23}	.41	.403	.396	.3896	.328	.376	.369	.3624	.3556	.348	.342
ν_{31}	.41	.403	.396	.3896	.328	.376	.369	.3624	.3556	.348	.342
ρ, g/cc	1.2	1.23	1.26	1.29	1.32	1.35	1.38	1.41	1.44	1.47	1.5

Table 9 Orthotropic Material Property of Kenaf fiber at 45˚ Fiber orientation

	V $_f$ at 60˚ Fiber orientation										
	0	0.1	0.2	0.3	0.4	0.5	0.6	0.7	0.8	0.9	1
E_1, (MPa)	1702	1648	1597	1548	1503	1623	1420	1381	1346	1312	1279
E_2, (MPa)	2163	2072	1989	1911	1839	2019	1704	1654	1600	1549	1502
E_3, (MPa)	1702	1648	1597	1548	1503	1623	1420	1381	1346	1312	1279
G_{12},	604	587	572	557	543	589	518	507	497	486	476
G_{23},	711	688	666	645	626	688	591	577	563	549	536
G_{31},	604	587	572	557	543	589	518	507	497	486	476
ν_{12}	.41	.4032	.396	.3896	.3828	.376	.3692	.362	.3556	.3488	.342
ν_{23}	.52	.5068	.492	.4807	.4684	.467	.442	.4332	.42	.412	.4017
ν_{31}	.41	.4032	.396	.3896	.3828	.376	.3692	.362	.3556	.3488	.342
ρ, g/cc	1.2	1.23	1.26	1.29	1.32	1.35	1.38	1.41	1.44	1.47	1.5

Table 10 Orthotropic Material Property of Kenaf fiber at 60˚ Fiber orientation

	V $_f$ at 90˚ Fiber orientation										
	0	0.1	0.2	0.3	0.4	0.5	0.6	0.7	0.8	0.9	1
E_1, (MPa)	2000	2015	2029	2043	2058	2073	2088	2103	2118	2134	2150
E_2, (MPa)	4000	4030	3730	4090	4120	4150	4120	4210	4240	4270	4300
E_3, (MPa)	2000	2015	2029	2043	2058	2073	2088	2103	2118	2134	2150
G_{12},	709	718	727	735	744	75	762	772	781	792	801
G_{23},	1099	116	1080	1150	1168	1184	1192	1221	1239	1260	1277
G_{31},	709	718	727	735	744	75	762	772	781	792	801
ν_{12}	.41	.403	.3964	.389	.382	.376	.369	.362	.3556	.347	.342
ν_{23}	.82	.806	.727	.778	.764	.752	.728	.274	.7119	.694	.684

ν_{31}	.41	.403	.3964	.389	.382	.376	.369	.362	.3556	.347	.342
ρ, g/cc	1.2	1.23	1.26	1.29	1.32	1.35	1.38	1.41	1.44	1.47	1.5

Table 11 Orthotropic Material Property of Kenaf fiber at 90˚ Fiber orientation

Meshed Specimen

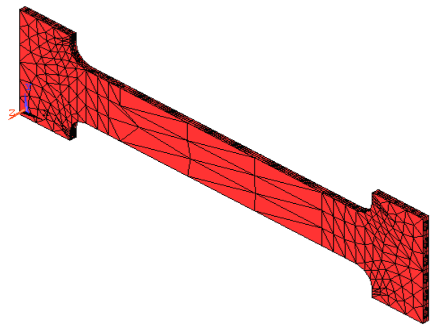

Figure.2 Meshed Specimen

Results And Discussions

This chapter describes the details of Analysis of the composites are evaluated. The raw materials used in this analysis are

1. Hemp fiber.
2. Polypropylene resin

Tensile Strength

The tensile test is generally performed on flat specimens. The commonly used specimens for tensile test are the dog-bone type and the straight side type with end tabs. During the test a uni-axial load is applied through both the ends of the specimen. The ASTM standard test method for tensile properties of fiber resin composites has the designation D638. The length of the test section should be 203.2mm. The tensile test results are analyzed to calculate the tensile strength of composite samples.

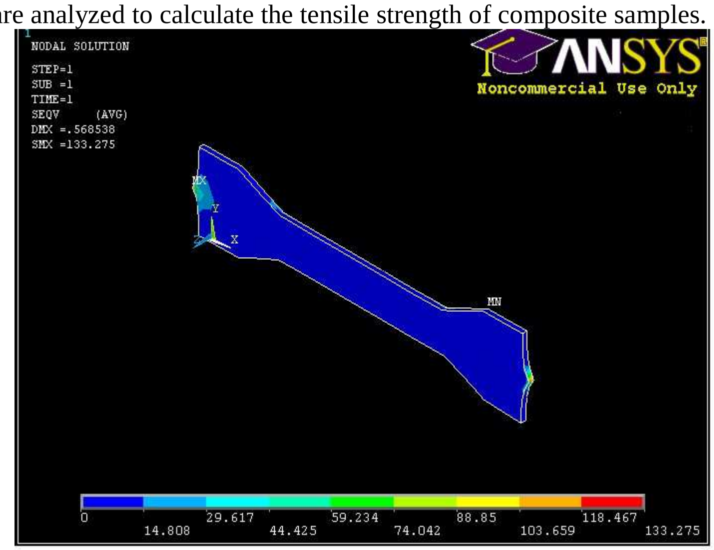

Figure.3 Stress Distributions on Laminated Composite Plate at V_f =60%

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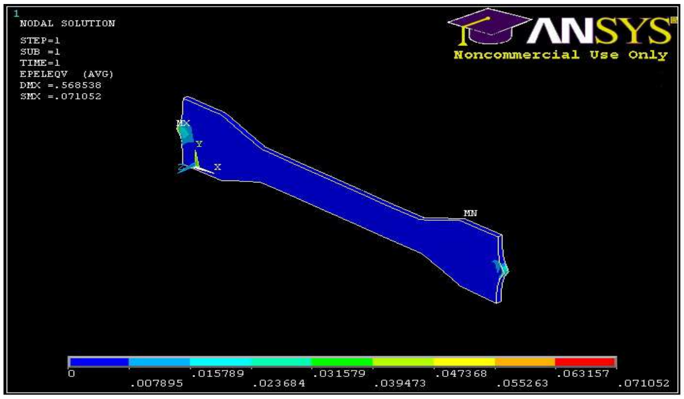

Figure.4 Strain Distributions on Laminated Composite Plate at V_f =60%

Finite Element Analysis Of Hemp Fiber Reinforced Polypropylene Composite Plate

Static analysis is performed on the Laminated Composite Plate by varying the fiber orientation and volume fraction of fiber. The results of Hemp Fiber Reinforced Polypropylene Composite are shown in below tables

Fiber Volume fraction (Vf)	0° fiber orientation			30° fiber orientation		
	Stress, σ(N/mm2)	Strain, ε	Displacement, x(mm)	Stress, σ(N/mm2)	Strain, ε	Displacement, x(mm)
0	135.063	0.093494	0.754104	137.186	0.087327	0.705715
0.1	133.67	0.091504	0.722072	137.782	0.082334	0.67266
0.2	133.303	0.088355	0.692355	137.24	0.079309	0.648279
0.3	133.28	0.08283	0.658028	137.723	0.079168	0.650644
0.4	133.501	0.079197	0.629007	137.773	0.077638	0.640112
0.5	133.305	0.080006	0.618663	137.868	0.076132	0.629775
0.6	133.275	0.071052	0.568538	138.005	0.074642	0.619589
0.7	133.924	0.068526	0.549348	138.176	0.073196	0.609685
0.8	134.178	0.065138	0.524974	138.387	0.071757	0.599792
0.9	134.485	0.061916	0.501484	138.629	0.070339	0.590063
1	134.848	0.058903	0.478761	138.902	0.068938	0.580419

Table 12 Stress, Strain, & Displacement of Hemp fiber at 0° & 30° fiber orientation

Fiber Volume fraction	45° fiber orientation			60° fiber orientation		
	Stress, σ(N/mm2)	Strain, ε	Displacement, x(mm)	Stress, σ(N/mm2)	Strain, ε	Displacement, x(mm)
0	144.745	0.064915	0.592195	151.214	0.073455	0.766613
0.1	142.852	0.072965	0.643397	149.833	0.070622	0.725515
0.2	143.454	0.056378	0.505014	149.245	0.069446	0.714487
0.3	141.929	0.070709	0.624642	148.677	0.068386	0.703395
0.4	141.529	0.069604	0.615709	148.387	0.066427	0.687624
0.5	141.169	0.068516	0.607027	147.828	0.065677	0.676943
0.6	140.871	0.067504	0.599098	147.136	0.065669	0.669228
0.7	140.557	0.066392	0.591107	146.684	0.064884	0.657506
0.8	140.302	0.065358	0.583788	146.263	0.064146	0.645617
0.9	140.079	0.064343	0.576524	145.875	0.063439	0.633548
1	141.697	0.038565	0.34772	145.519	0.062799	0.621307

Table 13 Stress, Strain, & Displacement of Hemp fiber at 45° & 60° fiber orientation

Fiber Volume fraction (Vf)	90° fiber orientation		
	Stress, σ(N/mm2)	Strain, ε	Displacement, x(mm)
0	148.769	0.08638	0.887562
0.1	154.459	0.073082	0.829051
0.2	153.889	0.070489	0.79719
0.3	153.295	0.068027	0.765984
0.4	152.697	0.065703	0.73564
0.5	152.104	0.063496	0.706119
0.6	151.515	0.061364	0.676956

0.7	150.936	0.059281	0.648168
0.8	150.372	0.057229	0.619682
0.9	149.825	0.055184	0.591434
1	149.295	0.053123	0.563357

Table 14 Stress, Strain, & Displacement of Hemp fiber at 90° fiber orientation

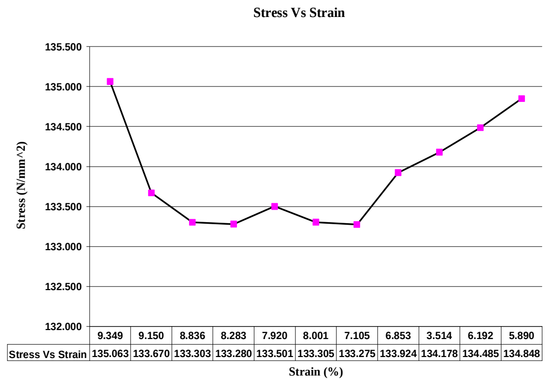

Figure 5 Stress-Strain Curve for Hemp fiber at 0° fiber orientation

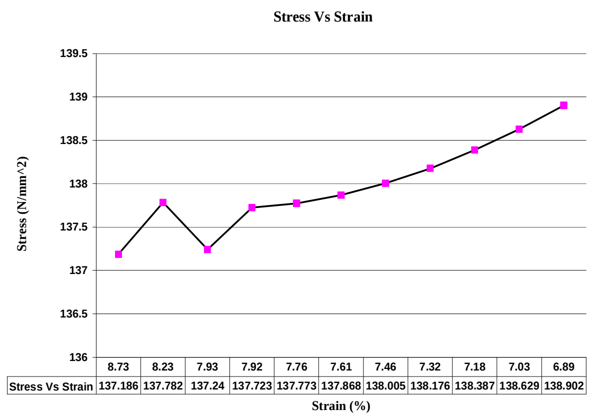

Figure 6 Stress-Strain Curve for Hemp fiber at 30° fiber orientation

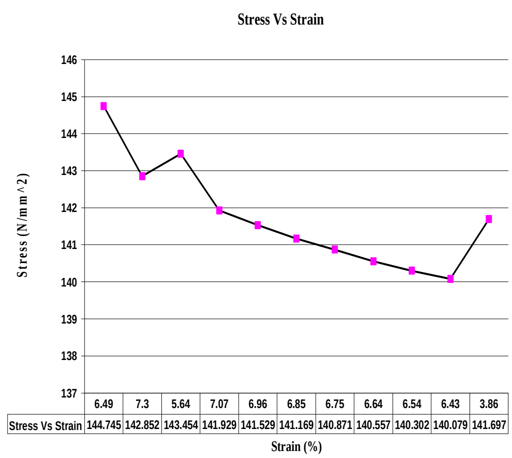

Figure 7 Stress-Strain Curve for Hemp fiber at 45° fiber orientation

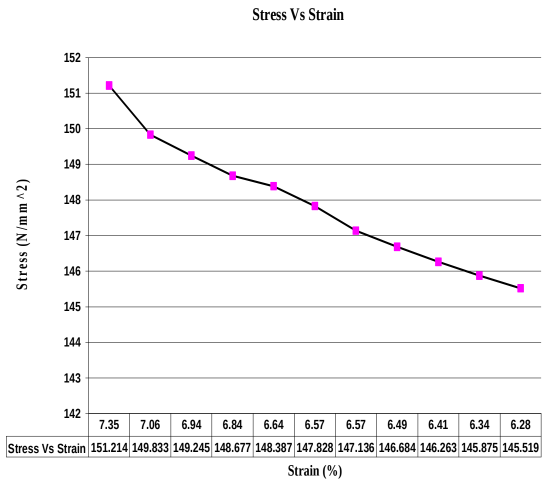

Figure 8 Stress-Strain Curve for Hemp fiber at 60° fiber orientation

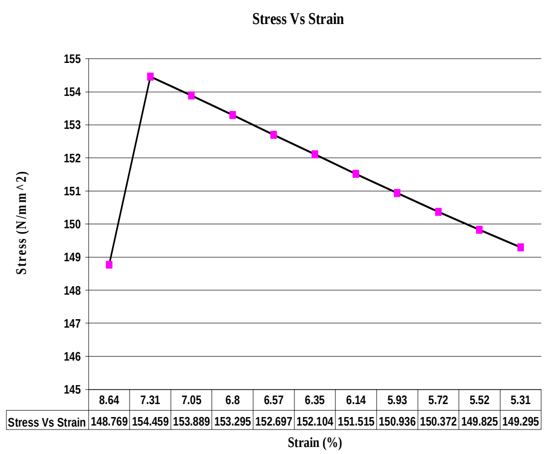

Figure 9 Stress-Strain Curve for Hemp fiber at 90° fiber orientation

From the **fig 5** it is found that the stiffness increases at 0˚ fiber orientation and after 60% fiber volume fraction the von mises stress increases.

From the **fig 7** it is found that the stiffness increase gradually at 30% fiber volume fraction with 45˚ fiber orientation and after 20% fiber volume fraction the von mises stress decreases.

From the **fig** 8 it is found that the stiffness increase gradually at 0% fiber volume fraction with 60˚ fiber orientation and after 0% fiber volume fraction the von mises stress decreases.

From the **fig 9** it is found that the stiffness increase gradually at 0% fiber volume fraction with 90˚ fiber orientation and after 10% fiber volume fraction the von mises stress decreases.

Finite Element Analysis Of Kenaf Fiber Reinforced Epoxy Composite Plate

Static analysis is performed on the Laminated Composite Plate by varying the fiber orientation and volume fraction of fiber using ANSYS11.0. The results of Kenaf Fiber Reinforced Epoxy Composites are shown in below tables:

Table 15 Stress, Strain, & Displacement for Kenaf fiber at 0° & 30° fiber orientation

Fiber Volume fraction	0° fiber orientation			30° fiber orientation		
	Stress, σ (N/mm^2)	Strain, ε	Displacement, x(mm)	Stress, σ(N/mm^2)	Strain, ε	Displacement, x(mm)
0	134.008	0.062755	0.496598	147.242	0.067586	0.634187
0.1	133.988	0.062235	0.493104	140.587	0.09236	0.77331
0.2	133.972	0.06172	0.489631	140.062	0.081783	0.683255
0.3	133.962	0.031157	0.48618	140.669	0.098891	0.831255
0.4	133.957	0.030703	0.482749	140.697	0.102155	0.859932
0.5	133.957	0.060201	0.479338	140.723	0.105388	0.88859
0.6	133.961	0.059704	0.475948	140.74	0.108623	0.91721
0.7	133.97	0.059213	0.472577	140.756	0.111854	0.945706
0.8	133.984	0.058725	0.469226	140.771	0.115051	0.974004
0.9	134.002	0.05824	0.465894	140.762	0.118342	1.003
1	134.025	0.057761	0.46258	140.786	0.12156	1.031

Table 16 Stress, Strain, & Displacement for Kenaf fiber at 45° & 60° fiber orientation

Fiber Volume fraction (Vf)	45° fiber orientation			60° fiber orientation		
	Stress, σ(N/mm2)	Strain, ε	Displacement, x(mm)	Stress, σ(N/mm2)	Strain, ε	Displacement , x(mm)
0	144.466	0.09433	0.834811	148.55	0.080968	0.777069
0.1	144.292	0.09880	0.874112	148.142	0.084275	0.805658
0.2	144.126	0.103257	0.913114	147.748	0.087557	0.834565
0.3	143.977	0.10772	0.9520260	147.405	0.090944	0.863701
0.4	142.92	0.11325	1.004	147.072	0.094252	0.892367
0.5	147.296	0.060878	0.47188	147.156	0.086222	0.824074
0.6	143.546	0.121143	1.069	146.397	0.101172	0.951275
0.7	143.419	0.125714	1.108	146.173	0.104237	0.978452
0.8	143.295	0.130115	1.146	145.904	0.107501	1.007
0.9	141.331	0.125781	1.086	145.67	0.110885	1.035
1	143.065	0.139065	1.223	145.441	0.114242	1.064

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Figure 10 Stress-Strain Curve for Kenaf fiber at 0° fiber orientation

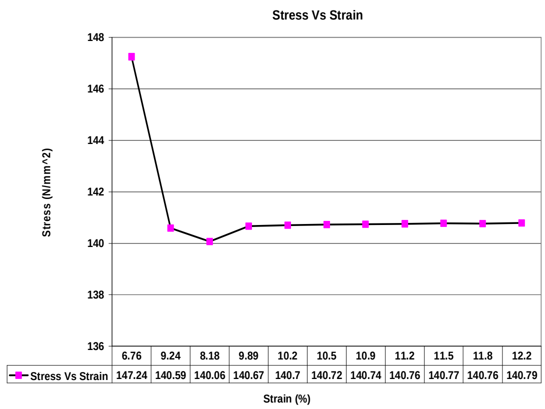

Figure 11 Stress-Strain Curve for Kenaf fiber at 30° fiber orientation

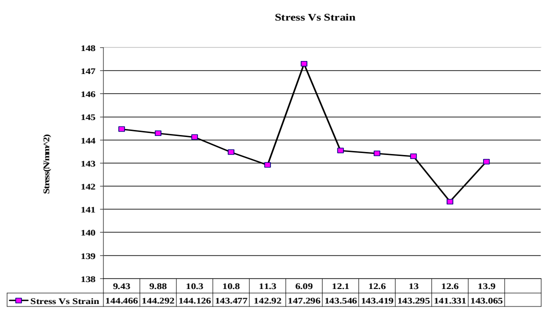

Figure 12 Stress-Strain Curve for Kenaf fiber at 45° fiber orientation

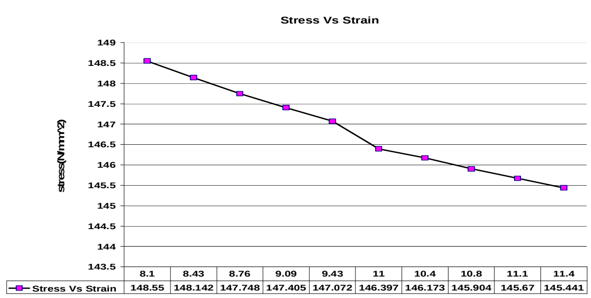

Figure 13 Stress-Strain Curve for Kenaf fiber at 60° fiber orientation

From the **fig 10** it is found that the stiffness increases at 0˚ fiber orientation and after 70% fiber volume fraction the von mises stress increases.
From the **fig 11** it is found that the stiffness decreases gradually at 20% fiber volume fraction with 30˚ fiber orientation and after 30% fiber volume fraction the von mises stress increase.
From the **fig 12** it is found that the stiffness decreases gradually at 0% fiber volume fraction with 45˚ fiber orientation and after 40% fiber volume fraction the von mises stress decreases.
From the **fig 13** it is found that the stiffness increase at 50% fiber volume fraction with 60˚ fiber orientation and after 0% fiber volume fraction the von mises stress decreases.

Conclusion

The Laminated composite Plate was analyzed by Finite Element Method. From the analysis it is found that the ply orientation greatly influences the tensile load of three ply laminates. The Tensile behavior for various ply orientations illustrates that the Stress decreases gradually at one point it reaches to critical Level. The stress, strain and displacement are obtained by analyzing the plate with Hemp Fiber Reinforced Polypropylene and Kenaf Fiber Reinforced Epoxy Composites at different fiber Volume fraction. From the result, it is clear that the laminated plate of Kenaf Fiber Reinforced Epoxy Composites withstand good tensile Property at 60% Fiber Volume Fraction. The results will be useful to predict the tensile properties of the Hemp Fiber Reinforced Polypropylene and Kenaf Fiber Reinforced Epoxy Composites during their usage in automotive application. This work shows the successful Analysis of a Hemp fiber reinforced Polypropylene and Kenaf Fiber Reinforced Epoxy Composites.

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