LAB REPORT NO: 1

CS50P - MICROMECHANICS LAB

Date: 2024-07-02

Test performed by:	Test certified by:
Name:	Name:
Data:	Date:

HALPIN-TSAI MICROMECHANICS COMPARISON ANALYSIS

SECTION 1: UD COMPOSITE CONSTITUENT'S ELASTIC PROPERTIES

Table 1-1: CARBON-EPOXY

Constituent	Axial Young's Modulus, E1 (GPa)	Transverse Young's Modulus, E2 (GPa)	Axial Shear Modulus, G12 (GPa)	Transverse Shear Modulus, G23 (GPa)	Major Poisson's Ratio, v12	Plane-strain Bulk Modulus, K23 (GPa)
Carbon	250.000	25.000	20.000	10.000	0.280	17.023

Constituent	Young's Modulus, E (GPa)	Poisson's Ratio, v	Shear Modulus, G (GPa)	Plane-strain Bulk Modulus, K (GPa)
Epoxy	2.800	0.300	1.077	2.692

Table 1-2: FIBERGLASS-EPOXY

Constituent	Young's Modulus, E (GPa)	Poisson's Ratio, v	Shear Modulus, G (GPa)	Plane-strain Bulk Modulus, K (GPa)
Fiberglass	120.000	0.290	46.512	110.742
Epoxy	2.800	0.300	1.077	2.692

Table 1-3: CARBON-GRAPHITE

Constituent	Axial Young's Modulus, E1 (GPa)	Transverse Young's Modulus, E2 (GPa)	Axial Shear Modulus, G12 (GPa)	Transverse Shear Modulus, G23 (GPa)	Major Poisson's Ratio, v12	Plane-strain Bulk Modulus, K23 (GPa)
Carbon	250.000	25.000	20.000	10.000	0.280	17.023
Graphite	180.000	20.000	15.000	10.000	0.290	10.190

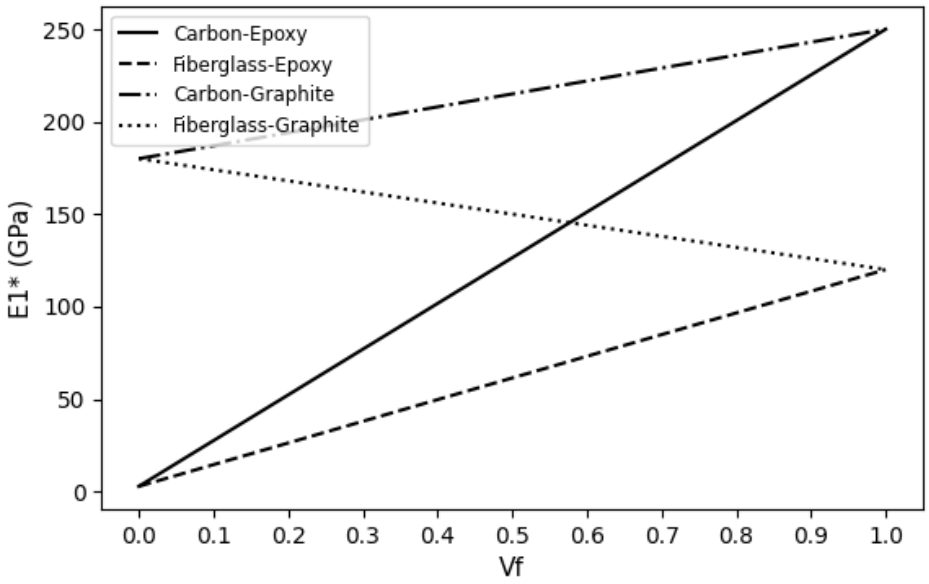
Table 1-4: FIBERGLASS-GRAPHITE

Constituent	Young's Modulus, E (GPa)	Poisson's Ratio, v	Shear Modulus, G (GPa)	Plane-strain Bulk Modulus, K (GPa)
Fiberglass	120.000	0.290	46.512	110.742

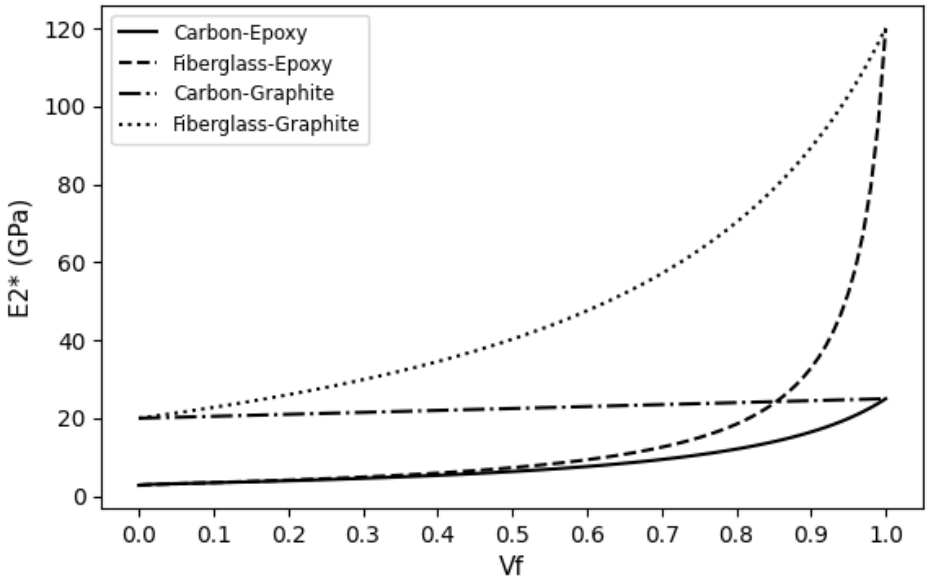
Constituent	Axial Young's Modulus, E1 (GPa)	Transverse Young's Modulus, E2 (GPa)	Axial Shear Modulus, G12 (GPa)	Transverse Shear Modulus, G23 (GPa)	Major Poisson's Ratio, v12	Plane-strain Bulk Modulus, K23 (GPa)
Graphite	180.000	20.000	15.000	10.000	0.290	10.190

HALPIN-TSAI MICROMECHANICS COMPARISON ANALYSIS

SECTION 2: UD COMPOSITES - GRAPHS ON EFFECTIVE ELASTOC PROPERTIES



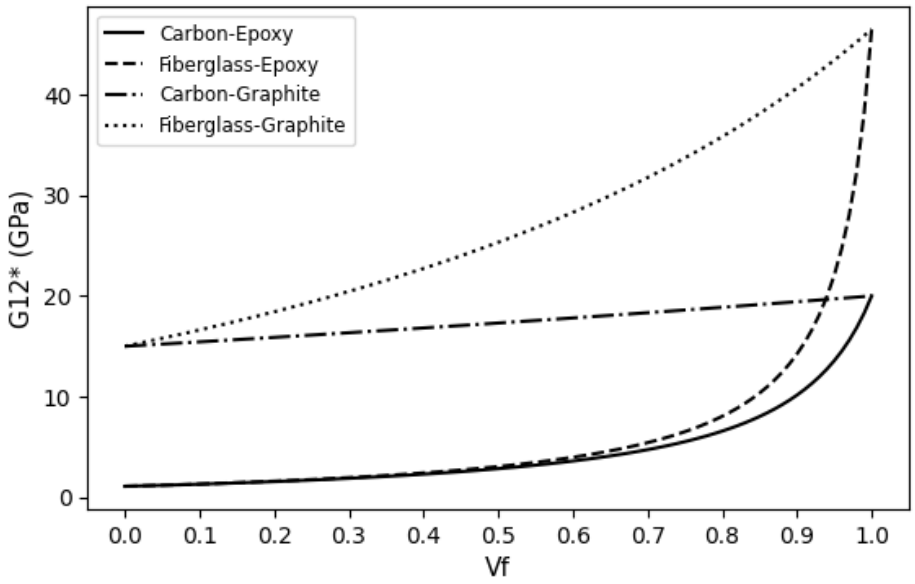
2-A) Effective axial Young's modulus



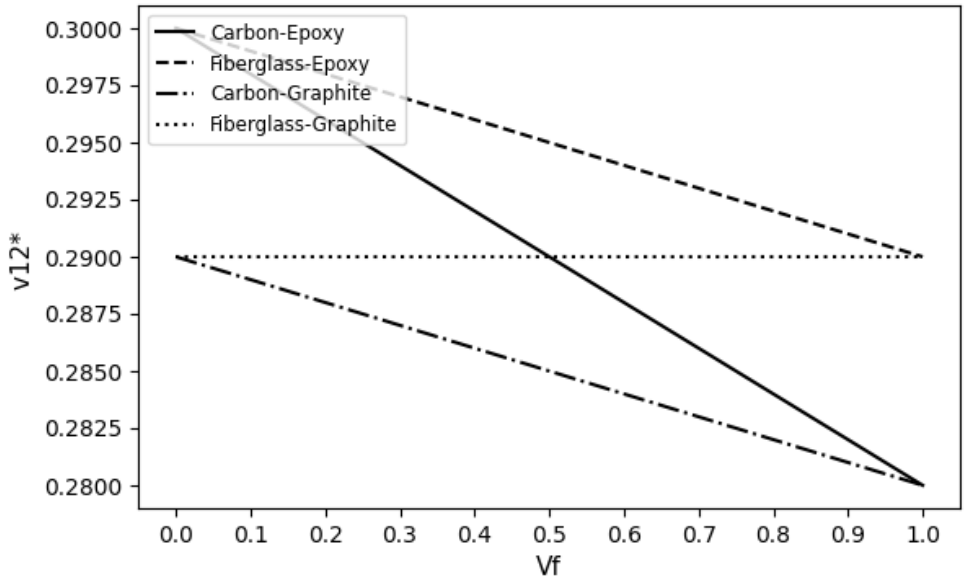
2-B) Effective transverse Young's modulus

HALPIN-TSAI MICROMECHANICS COMPARISON ANALYSIS

SECTION 2: UD COMPOSITES - GRAPHS ON EFFECTIVE ELASTOC PROPERTIES (CONT.)

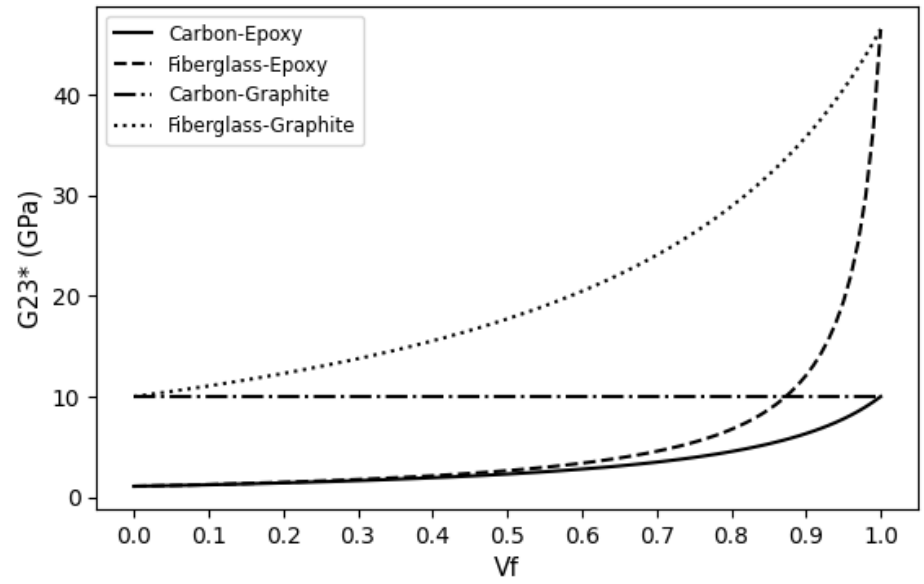


2-C) Effective axial shear modulus

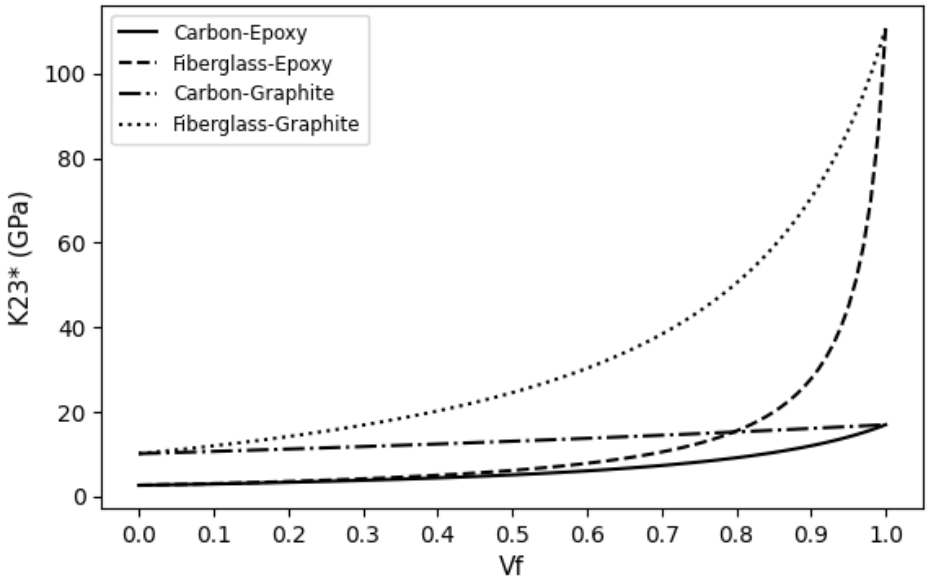


2-D) Effective major Poissons' ratio

SECTION 2: UD COMPOSITES - GRAPHS ON EFFECTIVE ELASTOC PROPERTIES (CONT.)



2-E) Effective transverse shear modulus



2-F) Effective plane-strain bulk modulus

HALPIN-TSAI MICROMECHANICS COMPARISON ANALYSIS

SECTION 3-A: COMPARISON ON EFFECTIVE AXIAL YOUNG'S MODULI

[1] - Carbon-Epoxy
[2] - Fiberglass-Epoxy
[3] - Carbon-Graphite
[4] - Fiberglass-Graphite

Vf	[1] E1* (GPa)	[2] E1* (GPa)	[3] E1* (GPa)	[4] E1* (GPa)
0	2.800	2.800	180.000	180.000
0.01	5.272	3.972	180.700	179.400
0.02	7.744	5.144	181.400	178.800
0.03	10.216	6.316	182.100	178.200
0.04	12.688	7.488	182.800	177.600
0.05	15.160	8.660	183.500	177.000
0.06	17.632	9.832	184.200	176.400
0.07	20.104	11.004	184.900	175.800
0.08	22.576	12.176	185.600	175.200
0.09	25.048	13.348	186.300	174.600
0.1	27.520	14.520	187.000	174.000
0.11	29.992	15.692	187.700	173.400
0.12	32.464	16.864	188.400	172.800
0.13	34.936	18.036	189.100	172.200
0.14	37.408	19.208	189.800	171.600
0.15	39.880	20.380	190.500	171.000
0.16	42.352	21.552	191.200	170.400
0.17	44.824	22.724	191.900	169.800
0.18	47.296	23.896	192.600	169.200
0.19	49.768	25.068	193.300	168.600
0.2	52.240	26.240	194.000	168.000
0.21	54.712	27.412	194.700	167.400
0.22	57.184	28.584	195.400	166.800
0.23	59.656	29.756	196.100	166.200
0.24	62.128	30.928	196.800	165.600
0.25	64.600	32.100	197.500	165.000
0.26	67.072	33.272	198.200	164.400
0.27	69.544	34.444	198.900	163.800
0.28	72.016	35.616	199.600	163.200
0.29	74.488	36.788	200.300	162.600
0.3	76.960	37.960	201.000	162.000
0.31	79.432	39.132	201.700	161.400
0.32	81.904	40.304	202.400	160.800
0.33	84.376	41.476	203.100	160.200
0.34	86.848	42.648	203.800	159.600
0.35	89.320	43.820	204.500	159.000

HALPIN-TSAI MICROMECHANICS COMPARISON ANALYSIS

Vf	[1] E1* (GPa)	[2] E1* (GPa)	[3] E1* (GPa)	[4] E1* (GPa)
0.36	91.792	44.992	205.200	158.400
0.37	94.264	46.164	205.900	157.800
0.38	96.736	47.336	206.600	157.200
0.39	99.208	48.508	207.300	156.600
0.4	101.680	49.680	208.000	156.000
0.41	104.152	50.852	208.700	155.400
0.42	106.624	52.024	209.400	154.800
0.43	109.096	53.196	210.100	154.200
0.44	111.568	54.368	210.800	153.600
0.45	114.040	55.540	211.500	153.000
0.46	116.512	56.712	212.200	152.400
0.47	118.984	57.884	212.900	151.800
0.48	121.456	59.056	213.600	151.200
0.49	123.928	60.228	214.300	150.600
0.5	126.400	61.400	215.000	150.000
0.51	128.872	62.572	215.700	149.400
0.52	131.344	63.744	216.400	148.800
0.53	133.816	64.916	217.100	148.200
0.54	136.288	66.088	217.800	147.600
0.55	138.760	67.260	218.500	147.000
0.56	141.232	68.432	219.200	146.400
0.57	143.704	69.604	219.900	145.800
0.58	146.176	70.776	220.600	145.200
0.59	148.648	71.948	221.300	144.600
0.6	151.120	73.120	222.000	144.000
0.61	153.592	74.292	222.700	143.400
0.62	156.064	75.464	223.400	142.800
0.63	158.536	76.636	224.100	142.200
0.64	161.008	77.808	224.800	141.600
0.65	163.480	78.980	225.500	141.000
0.66	165.952	80.152	226.200	140.400
0.67	168.424	81.324	226.900	139.800
0.68	170.896	82.496	227.600	139.200
0.69	173.368	83.668	228.300	138.600
0.7	175.840	84.840	229.000	138.000
0.71	178.312	86.012	229.700	137.400
0.72	180.784	87.184	230.400	136.800
0.73	183.256	88.356	231.100	136.200
0.74	185.728	89.528	231.800	135.600
0.75	188.200	90.700	232.500	135.000
0.76	190.672	91.872	233.200	134.400
0.77	193.144	93.044	233.900	133.800
0.78	195.616	94.216	234.600	133.200
0.79	198.088	95.388	235.300	132.600
0.8	200.560	96.560	236.000	132.000

HALPIN-TSAI MICROMECHANICS COMPARISON ANALYSIS

Vf	[1] E1* (GPa)	[2] E1* (GPa)	[3] E1* (GPa)	[4] E1* (GPa)
0.81	203.032	97.732	236.700	131.400
0.82	205.504	98.904	237.400	130.800
0.83	207.976	100.076	238.100	130.200
0.84	210.448	101.248	238.800	129.600
0.85	212.920	102.420	239.500	129.000
0.86	215.392	103.592	240.200	128.400
0.87	217.864	104.764	240.900	127.800
0.88	220.336	105.936	241.600	127.200
0.89	222.808	107.108	242.300	126.600
0.9	225.280	108.280	243.000	126.000
0.91	227.752	109.452	243.700	125.400
0.92	230.224	110.624	244.400	124.800
0.93	232.696	111.796	245.100	124.200
0.94	235.168	112.968	245.800	123.600
0.95	237.640	114.140	246.500	123.000
0.96	240.112	115.312	247.200	122.400
0.97	242.584	116.484	247.900	121.800
0.98	245.056	117.656	248.600	121.200
0.99	247.528	118.828	249.300	120.600
1	250.000	120.000	250.000	120.000

HALPIN-TSAI MICROMECHANICS COMPARISON ANALYSIS

SECTION 3B: COMPARISON ON EFFECTIVE TRANSVERSE YOUNG'S MODULI

[1] - Carbon-Epoxy
[2] - Fiberglass-Epoxy
[3] - Carbon-Graphite
[4] - Fiberglass-Graphite

Vf	[1] E2* (GPa)	[2] E2* (GPa)	[3] E2* (GPa)	[4] E2* (GPa)
0	2.800	2.800	20.000	20.000
0.01	2.958	2.916	20.049	20.261
0.02	3.045	3.002	20.100	20.526
0.03	3.108	3.075	20.149	20.793
0.04	3.163	3.140	20.199	21.066
0.05	3.216	3.203	20.250	21.342
0.06	3.265	3.263	20.300	21.622
0.07	3.314	3.321	20.350	21.907
0.08	3.362	3.380	20.400	22.196
0.09	3.409	3.438	20.450	22.488
0.1	3.458	3.497	20.500	22.786
0.11	3.506	3.556	20.550	23.088
0.12	3.555	3.614	20.600	23.395
0.13	3.605	3.675	20.650	23.706
0.14	3.655	3.738	20.700	24.023
0.15	3.705	3.799	20.750	24.344
0.16	3.758	3.863	20.800	24.672
0.17	3.810	3.929	20.850	25.004
0.18	3.863	3.994	20.900	25.341
0.19	3.917	4.061	20.950	25.684
0.2	3.972	4.129	21.000	26.035
0.21	4.030	4.199	21.050	26.389
0.22	4.087	4.272	21.100	26.751
0.23	4.144	4.346	21.150	27.117
0.24	4.204	4.422	21.200	27.492
0.25	4.266	4.497	21.250	27.872
0.26	4.326	4.577	21.300	28.260
0.27	4.391	4.658	21.350	28.655
0.28	4.456	4.741	21.400	29.055
0.29	4.521	4.825	21.450	29.466
0.3	4.588	4.913	21.500	29.882
0.31	4.658	5.002	21.550	30.307
0.32	4.728	5.095	21.600	30.741
0.33	4.800	5.190	21.650	31.181
0.34	4.873	5.286	21.700	31.632
0.35	4.949	5.388	21.750	32.091

HALPIN-TSAI MICROMECHANICS COMPARISON ANALYSIS

Vf	[1] E2* (GPa)	[2] E2* (GPa)	[3] E2* (GPa)	[4] E2* (GPa)
0.36	5.026	5.490	21.800	32.559
0.37	5.104	5.595	21.850	33.037
0.38	5.184	5.705	21.900	33.524
0.39	5.267	5.818	21.950	34.022
0.4	5.353	5.934	22.000	34.530
0.41	5.438	6.054	22.050	35.048
0.42	5.527	6.178	22.100	35.578
0.43	5.619	6.305	22.150	36.119
0.44	5.712	6.437	22.200	36.673
0.45	5.808	6.574	22.250	37.238
0.46	5.907	6.714	22.300	37.818
0.47	6.008	6.860	22.350	38.409
0.48	6.111	7.010	22.400	39.014
0.49	6.217	7.167	22.450	39.633
0.5	6.328	7.329	22.500	40.268
0.51	6.441	7.498	22.550	40.917
0.52	6.558	7.672	22.600	41.581
0.53	6.676	7.855	22.650	42.262
0.54	6.800	8.044	22.700	42.961
0.55	6.926	8.241	22.750	43.678
0.56	7.055	8.444	22.800	44.411
0.57	7.191	8.657	22.850	45.165
0.58	7.331	8.882	22.900	45.938
0.59	7.474	9.114	22.950	46.732
0.6	7.621	9.357	23.000	47.546
0.61	7.775	9.612	23.050	48.384
0.62	7.932	9.879	23.100	49.244
0.63	8.095	10.158	23.150	50.130
0.64	8.265	10.453	23.200	51.041
0.65	8.441	10.761	23.250	51.978
0.66	8.622	11.086	23.300	52.942
0.67	8.811	11.427	23.350	53.936
0.68	9.007	11.790	23.400	54.959
0.69	9.208	12.171	23.450	56.015
0.7	9.419	12.577	23.500	57.102
0.71	9.639	13.007	23.550	58.226
0.72	9.868	13.463	23.600	59.385
0.73	10.105	13.948	23.650	60.582
0.74	10.353	14.467	23.700	61.821
0.75	10.610	15.021	23.750	63.101
0.76	10.881	15.615	23.800	64.426
0.77	11.163	16.252	23.850	65.798
0.78	11.458	16.938	23.900	67.218
0.79	11.766	17.680	23.950	68.692
0.8	12.090	18.484	24.000	70.220

HALPIN-TSAI MICROMECHANICS COMPARISON ANALYSIS

Vf	[1] E2* (GPa)	[2] E2* (GPa)	[3] E2* (GPa)	[4] E2* (GPa)
0.81	12.430	19.357	24.050	71.807
0.82	12.789	20.310	24.100	73.454
0.83	13.165	21.354	24.150	75.168
0.84	13.562	22.504	24.200	76.953
0.85	13.979	23.774	24.250	78.808
0.86	14.422	25.186	24.300	80.743
0.87	14.890	26.764	24.350	82.761
0.88	15.386	28.541	24.400	84.867
0.89	15.914	30.555	24.450	87.069
0.9	16.475	32.857	24.500	89.374
0.91	17.073	35.514	24.550	91.786
0.92	17.711	38.618	24.600	94.314
0.93	18.397	42.287	24.650	96.969
0.94	19.131	46.694	24.700	99.757
0.95	19.923	52.086	24.750	102.692
0.96	20.778	58.834	24.800	105.782
0.97	21.702	67.525	24.850	109.044
0.98	22.707	79.138	24.900	112.489
0.99	23.801	95.441	24.950	116.135
1	25.000	120.001	25.000	120.001

HALPIN-TSAI MICROMECHANICS COMPARISON ANALYSIS

SECTION 3-C: COMPARISON ON EFFECTIVE AXIAL SHEAR MODULI

[1] - Carbon-Epoxy
[2] - Fiberglass-Epoxy
[3] - Carbon-Graphite
[4] - Fiberglass-Graphite

Vf	[1] G12* (GPa)	[2] G12* (GPa)	[3] G12* (GPa)	[4] G12* (GPa)
0	1.077	1.077	15.000	15.000
0.01	1.097	1.098	15.043	15.154
0.02	1.116	1.119	15.086	15.311
0.03	1.137	1.141	15.129	15.468
0.04	1.157	1.163	15.172	15.628
0.05	1.178	1.185	15.216	15.789
0.06	1.200	1.208	15.259	15.951
0.07	1.221	1.231	15.303	16.116
0.08	1.244	1.255	15.347	16.282
0.09	1.266	1.279	15.391	16.450
0.1	1.289	1.304	15.435	16.620
0.11	1.313	1.330	15.479	16.792
0.12	1.337	1.356	15.523	16.965
0.13	1.362	1.382	15.568	17.140
0.14	1.387	1.409	15.612	17.318
0.15	1.412	1.437	15.657	17.497
0.16	1.438	1.465	15.702	17.679
0.17	1.465	1.494	15.747	17.862
0.18	1.492	1.524	15.792	18.047
0.19	1.520	1.554	15.837	18.235
0.2	1.548	1.585	15.882	18.425
0.21	1.577	1.617	15.928	18.616
0.22	1.607	1.650	15.973	18.811
0.23	1.638	1.683	16.019	19.007
0.24	1.669	1.717	16.065	19.206
0.25	1.700	1.752	16.111	19.407
0.26	1.733	1.788	16.157	19.610
0.27	1.766	1.825	16.204	19.816
0.28	1.800	1.863	16.250	20.024
0.29	1.835	1.902	16.297	20.235
0.3	1.871	1.942	16.343	20.448
0.31	1.908	1.983	16.390	20.664
0.32	1.945	2.025	16.437	20.882
0.33	1.984	2.068	16.484	21.104
0.34	2.023	2.112	16.532	21.327
0.35	2.064	2.158	16.579	21.554

HALPIN-TSAI MICROMECHANICS COMPARISON ANALYSIS

Vf	[1] G12* (GPa)	[2] G12* (GPa)	[3] G12* (GPa)	[4] G12* (GPa)
0.36	2.106	2.205	16.627	21.784
0.37	2.148	2.254	16.674	22.016
0.38	2.192	2.303	16.722	22.252
0.39	2.238	2.355	16.770	22.490
0.4	2.284	2.408	16.818	22.732
0.41	2.332	2.463	16.866	22.977
0.42	2.381	2.519	16.915	23.224
0.43	2.431	2.577	16.963	23.476
0.44	2.484	2.637	17.012	23.730
0.45	2.537	2.700	17.061	23.988
0.46	2.592	2.764	17.110	24.249
0.47	2.649	2.830	17.159	24.514
0.48	2.708	2.899	17.209	24.782
0.49	2.769	2.971	17.258	25.055
0.5	2.832	3.044	17.308	25.330
0.51	2.896	3.121	17.357	25.610
0.52	2.963	3.201	17.407	25.894
0.53	3.032	3.283	17.457	26.181
0.54	3.104	3.369	17.508	26.473
0.55	3.178	3.459	17.558	26.769
0.56	3.255	3.552	17.609	27.069
0.57	3.335	3.649	17.659	27.373
0.58	3.417	3.750	17.710	27.682
0.59	3.503	3.855	17.761	27.995
0.6	3.592	3.966	17.812	28.313
0.61	3.685	4.081	17.864	28.636
0.62	3.781	4.202	17.915	28.964
0.63	3.882	4.328	17.967	29.296
0.64	3.986	4.461	18.019	29.634
0.65	4.096	4.600	18.071	29.977
0.66	4.210	4.747	18.123	30.325
0.67	4.329	4.901	18.175	30.678
0.68	4.453	5.064	18.228	31.038
0.69	4.584	5.235	18.281	31.402
0.7	4.721	5.417	18.333	31.773
0.71	4.864	5.610	18.386	32.150
0.72	5.015	5.814	18.439	32.532
0.73	5.174	6.031	18.493	32.921
0.74	5.341	6.262	18.546	33.317
0.75	5.517	6.509	18.600	33.719
0.76	5.704	6.773	18.654	34.127
0.77	5.901	7.056	18.708	34.543
0.78	6.110	7.360	18.762	34.966
0.79	6.332	7.688	18.816	35.396
0.8	6.568	8.042	18.871	35.833

HALPIN-TSAI MICROMECHANICS COMPARISON ANALYSIS

Vf	[1] G12* (GPa)	[2] G12* (GPa)	[3] G12* (GPa)	[4] G12* (GPa)
0.81	6.819	8.426	18.926	36.278
0.82	7.088	8.844	18.981	36.731
0.83	7.376	9.300	19.036	37.192
0.84	7.685	9.801	19.091	37.661
0.85	8.017	10.352	19.146	38.139
0.86	8.375	10.962	19.202	38.626
0.87	8.763	11.640	19.258	39.122
0.88	9.183	12.400	19.314	39.626
0.89	9.642	13.256	19.370	40.141
0.9	10.143	14.228	19.426	40.665
0.91	10.694	15.342	19.483	41.199
0.92	11.301	16.631	19.539	41.744
0.93	11.974	18.139	19.596	42.299
0.94	12.725	19.928	19.653	42.865
0.95	13.567	22.084	19.711	43.443
0.96	14.519	24.734	19.768	44.032
0.97	15.604	28.069	19.826	44.633
0.98	16.850	32.392	19.884	45.246
0.99	18.298	38.222	19.942	45.873
1	20.000	46.512	20.000	46.512

HALPIN-TSAI MICROMECHANICS COMPARISON ANALYSIS

SECTION 3-D: COMPARISON ON EFFECTIVE MAJOR POISSON'S RATIO

[1] - Carbon-Epoxy
[2] - Fiberglass-Epoxy
[3] - Carbon-Graphite
[4] - Fiberglass-Graphite

Vf	[1] v12*	[2] v12*	[3] v12*	[4] v12*
0	0.3000	0.3000	0.2900	0.2900
0.01	0.2998	0.2999	0.2899	0.2900
0.02	0.2996	0.2998	0.2898	0.2900
0.03	0.2994	0.2997	0.2897	0.2900
0.04	0.2992	0.2996	0.2896	0.2900
0.05	0.2990	0.2995	0.2895	0.2900
0.06	0.2988	0.2994	0.2894	0.2900
0.07	0.2986	0.2993	0.2893	0.2900
0.08	0.2984	0.2992	0.2892	0.2900
0.09	0.2982	0.2991	0.2891	0.2900
0.1	0.2980	0.2990	0.2890	0.2900
0.11	0.2978	0.2989	0.2889	0.2900
0.12	0.2976	0.2988	0.2888	0.2900
0.13	0.2974	0.2987	0.2887	0.2900
0.14	0.2972	0.2986	0.2886	0.2900
0.15	0.2970	0.2985	0.2885	0.2900
0.16	0.2968	0.2984	0.2884	0.2900
0.17	0.2966	0.2983	0.2883	0.2900
0.18	0.2964	0.2982	0.2882	0.2900
0.19	0.2962	0.2981	0.2881	0.2900
0.2	0.2960	0.2980	0.2880	0.2900
0.21	0.2958	0.2979	0.2879	0.2900
0.22	0.2956	0.2978	0.2878	0.2900
0.23	0.2954	0.2977	0.2877	0.2900
0.24	0.2952	0.2976	0.2876	0.2900
0.25	0.2950	0.2975	0.2875	0.2900
0.26	0.2948	0.2974	0.2874	0.2900
0.27	0.2946	0.2973	0.2873	0.2900
0.28	0.2944	0.2972	0.2872	0.2900
0.29	0.2942	0.2971	0.2871	0.2900
0.3	0.2940	0.2970	0.2870	0.2900
0.31	0.2938	0.2969	0.2869	0.2900
0.32	0.2936	0.2968	0.2868	0.2900
0.33	0.2934	0.2967	0.2867	0.2900
0.34	0.2932	0.2966	0.2866	0.2900
0.35	0.2930	0.2965	0.2865	0.2900

HALPIN-TSAI MICROMECHANICS COMPARISON ANALYSIS

Vf	[1] v12*	[2] v12*	[3] v12*	[4] v12*
0.36	0.2928	0.2964	0.2864	0.2900
0.37	0.2926	0.2963	0.2863	0.2900
0.38	0.2924	0.2962	0.2862	0.2900
0.39	0.2922	0.2961	0.2861	0.2900
0.4	0.2920	0.2960	0.2860	0.2900
0.41	0.2918	0.2959	0.2859	0.2900
0.42	0.2916	0.2958	0.2858	0.2900
0.43	0.2914	0.2957	0.2857	0.2900
0.44	0.2912	0.2956	0.2856	0.2900
0.45	0.2910	0.2955	0.2855	0.2900
0.46	0.2908	0.2954	0.2854	0.2900
0.47	0.2906	0.2953	0.2853	0.2900
0.48	0.2904	0.2952	0.2852	0.2900
0.49	0.2902	0.2951	0.2851	0.2900
0.5	0.2900	0.2950	0.2850	0.2900
0.51	0.2898	0.2949	0.2849	0.2900
0.52	0.2896	0.2948	0.2848	0.2900
0.53	0.2894	0.2947	0.2847	0.2900
0.54	0.2892	0.2946	0.2846	0.2900
0.55	0.2890	0.2945	0.2845	0.2900
0.56	0.2888	0.2944	0.2844	0.2900
0.57	0.2886	0.2943	0.2843	0.2900
0.58	0.2884	0.2942	0.2842	0.2900
0.59	0.2882	0.2941	0.2841	0.2900
0.6	0.2880	0.2940	0.2840	0.2900
0.61	0.2878	0.2939	0.2839	0.2900
0.62	0.2876	0.2938	0.2838	0.2900
0.63	0.2874	0.2937	0.2837	0.2900
0.64	0.2872	0.2936	0.2836	0.2900
0.65	0.2870	0.2935	0.2835	0.2900
0.66	0.2868	0.2934	0.2834	0.2900
0.67	0.2866	0.2933	0.2833	0.2900
0.68	0.2864	0.2932	0.2832	0.2900
0.69	0.2862	0.2931	0.2831	0.2900
0.7	0.2860	0.2930	0.2830	0.2900
0.71	0.2858	0.2929	0.2829	0.2900
0.72	0.2856	0.2928	0.2828	0.2900
0.73	0.2854	0.2927	0.2827	0.2900
0.74	0.2852	0.2926	0.2826	0.2900
0.75	0.2850	0.2925	0.2825	0.2900
0.76	0.2848	0.2924	0.2824	0.2900
0.77	0.2846	0.2923	0.2823	0.2900
0.78	0.2844	0.2922	0.2822	0.2900
0.79	0.2842	0.2921	0.2821	0.2900
0.8	0.2840	0.2920	0.2820	0.2900

HALPIN-TSAI MICROMECHANICS COMPARISON ANALYSIS

Vf	[1] v12*	[2] v12*	[3] v12*	[4] v12*
0.81	0.2838	0.2919	0.2819	0.2900
0.82	0.2836	0.2918	0.2818	0.2900
0.83	0.2834	0.2917	0.2817	0.2900
0.84	0.2832	0.2916	0.2816	0.2900
0.85	0.2830	0.2915	0.2815	0.2900
0.86	0.2828	0.2914	0.2814	0.2900
0.87	0.2826	0.2913	0.2813	0.2900
0.88	0.2824	0.2912	0.2812	0.2900
0.89	0.2822	0.2911	0.2811	0.2900
0.9	0.2820	0.2910	0.2810	0.2900
0.91	0.2818	0.2909	0.2809	0.2900
0.92	0.2816	0.2908	0.2808	0.2900
0.93	0.2814	0.2907	0.2807	0.2900
0.94	0.2812	0.2906	0.2806	0.2900
0.95	0.2810	0.2905	0.2805	0.2900
0.96	0.2808	0.2904	0.2804	0.2900
0.97	0.2806	0.2903	0.2803	0.2900
0.98	0.2804	0.2902	0.2802	0.2900
0.99	0.2802	0.2901	0.2801	0.2900
1	0.2800	0.2900	0.2800	0.2900

HALPIN-TSAI MICROMECHANICS COMPARISON ANALYSIS

SECTION 3-E: COMPARISON ON EFFECTIVE TRANSVERSE SHEAR MODULI

[1] - Carbon-Epoxy
[2] - Fiberglass-Epoxy
[3] - Carbon-Graphite
[4] - Fiberglass-Graphite

Vf	[1] G23* (GPa)	[2] G23* (GPa)	[3] G23* (GPa)	[4] G23* (GPa)
0	1.077	1.077	10.000	10.000
0.01	1.091	1.093	10.000	10.099
0.02	1.106	1.110	10.000	10.199
0.03	1.120	1.127	10.000	10.300
0.04	1.135	1.144	10.000	10.403
0.05	1.151	1.162	10.000	10.508
0.06	1.166	1.180	10.000	10.614
0.07	1.182	1.198	10.000	10.722
0.08	1.198	1.217	10.000	10.832
0.09	1.214	1.236	10.000	10.943
0.1	1.231	1.256	10.000	11.056
0.11	1.248	1.276	10.000	11.171
0.12	1.265	1.296	10.000	11.288
0.13	1.283	1.317	10.000	11.406
0.14	1.301	1.339	10.000	11.527
0.15	1.319	1.360	10.000	11.649
0.16	1.338	1.383	10.000	11.774
0.17	1.357	1.406	10.000	11.901
0.18	1.376	1.429	10.000	12.029
0.19	1.396	1.453	10.000	12.160
0.2	1.416	1.477	10.000	12.294
0.21	1.437	1.502	10.000	12.429
0.22	1.458	1.528	10.000	12.567
0.23	1.479	1.555	10.000	12.707
0.24	1.501	1.582	10.000	12.850
0.25	1.524	1.609	10.000	12.995
0.26	1.546	1.638	10.000	13.143
0.27	1.570	1.667	10.000	13.294
0.28	1.594	1.697	10.000	13.447
0.29	1.618	1.727	10.000	13.604
0.3	1.643	1.759	10.000	13.763
0.31	1.669	1.791	10.000	13.925
0.32	1.695	1.825	10.000	14.091
0.33	1.722	1.859	10.000	14.259
0.34	1.749	1.894	10.000	14.431
0.35	1.777	1.931	10.000	14.606

HALPIN-TSAI MICROMECHANICS COMPARISON ANALYSIS

Vf	[1] G23* (GPa)	[2] G23* (GPa)	[3] G23* (GPa)	[4] G23* (GPa)
0.36	1.806	1.968	10.000	14.785
0.37	1.835	2.006	10.000	14.967
0.38	1.865	2.046	10.000	15.153
0.39	1.896	2.087	10.000	15.343
0.4	1.928	2.129	10.000	15.537
0.41	1.960	2.173	10.000	15.734
0.42	1.993	2.218	10.000	15.936
0.43	2.028	2.264	10.000	16.142
0.44	2.063	2.312	10.000	16.353
0.45	2.099	2.362	10.000	16.568
0.46	2.136	2.413	10.000	16.789
0.47	2.174	2.466	10.000	17.014
0.48	2.213	2.521	10.000	17.244
0.49	2.253	2.578	10.000	17.479
0.5	2.295	2.637	10.000	17.720
0.51	2.338	2.699	10.000	17.966
0.52	2.382	2.762	10.000	18.218
0.53	2.427	2.829	10.000	18.476
0.54	2.474	2.898	10.000	18.741
0.55	2.522	2.970	10.000	19.012
0.56	2.571	3.044	10.000	19.289
0.57	2.623	3.122	10.000	19.574
0.58	2.676	3.204	10.000	19.866
0.59	2.731	3.289	10.000	20.165
0.6	2.787	3.378	10.000	20.472
0.61	2.846	3.471	10.000	20.788
0.62	2.906	3.569	10.000	21.111
0.63	2.969	3.671	10.000	21.444
0.64	3.034	3.779	10.000	21.786
0.65	3.102	3.892	10.000	22.137
0.66	3.172	4.011	10.000	22.498
0.67	3.245	4.136	10.000	22.870
0.68	3.321	4.269	10.000	23.252
0.69	3.399	4.409	10.000	23.646
0.7	3.481	4.558	10.000	24.051
0.71	3.567	4.716	10.000	24.469
0.72	3.656	4.884	10.000	24.900
0.73	3.749	5.062	10.000	25.344
0.74	3.846	5.253	10.000	25.803
0.75	3.947	5.457	10.000	26.276
0.76	4.054	5.676	10.000	26.765
0.77	4.165	5.911	10.000	27.271
0.78	4.282	6.164	10.000	27.793
0.79	4.404	6.438	10.000	28.334
0.8	4.533	6.735	10.000	28.894

HALPIN-TSAI MICROMECHANICS COMPARISON ANALYSIS

Vf	[1] G23* (GPa)	[2] G23* (GPa)	[3] G23* (GPa)	[4] G23* (GPa)
0.81	4.669	7.058	10.000	29.474
0.82	4.813	7.411	10.000	30.075
0.83	4.964	7.798	10.000	30.699
0.84	5.124	8.225	10.000	31.347
0.85	5.293	8.697	10.000	32.019
0.86	5.473	9.223	10.000	32.718
0.87	5.664	9.811	10.000	33.445
0.88	5.867	10.475	10.000	34.202
0.89	6.085	11.229	10.000	34.991
0.9	6.317	12.093	10.000	35.814
0.91	6.566	13.093	10.000	36.673
0.92	6.833	14.265	10.000	37.570
0.93	7.122	15.655	10.000	38.509
0.94	7.433	17.333	10.000	39.491
0.95	7.771	19.397	10.000	40.521
0.96	8.139	21.998	10.000	41.601
0.97	8.540	25.377	10.000	42.736
0.98	8.980	29.945	10.000	43.929
0.99	9.464	36.461	10.000	45.186
1	10.000	46.512	10.000	46.512

HALPIN-TSAI MICROMECHANICS COMPARISON ANALYSIS

SECTION 3-F: COMPARISON ON EFFECTIVE PLANE-STRAIN BULK MODULI

[1] - Carbon-Epoxy
[2] - Fiberglass-Epoxy
[3] - Carbon-Graphite
[4] - Fiberglass-Graphite

Vf	[1] K23* (GPa)	[2] K23* (GPa)	[3] K23* (GPa)	[4] K23* (GPa)
0	2.692	2.692	10.190	10.190
0.01	2.722	2.729	10.241	10.360
0.02	2.753	2.766	10.293	10.532
0.03	2.784	2.805	10.344	10.707
0.04	2.815	2.844	10.396	10.886
0.05	2.847	2.883	10.449	11.067
0.06	2.880	2.924	10.501	11.252
0.07	2.913	2.965	10.554	11.440
0.08	2.947	3.008	10.607	11.631
0.09	2.981	3.051	10.660	11.826
0.1	3.016	3.095	10.714	12.024
0.11	3.052	3.140	10.768	12.226
0.12	3.088	3.186	10.822	12.432
0.13	3.124	3.233	10.876	12.641
0.14	3.162	3.282	10.931	12.855
0.15	3.200	3.331	10.986	13.072
0.16	3.239	3.381	11.041	13.294
0.17	3.278	3.433	11.097	13.520
0.18	3.318	3.486	11.153	13.750
0.19	3.359	3.540	11.209	13.985
0.2	3.401	3.595	11.265	14.225
0.21	3.444	3.652	11.322	14.469
0.22	3.487	3.710	11.379	14.719
0.23	3.531	3.769	11.437	14.973
0.24	3.576	3.830	11.494	15.233
0.25	3.622	3.892	11.552	15.499
0.26	3.669	3.957	11.611	15.770
0.27	3.717	4.022	11.669	16.047
0.28	3.766	4.090	11.728	16.329
0.29	3.815	4.159	11.788	16.619
0.3	3.866	4.231	11.847	16.914
0.31	3.918	4.304	11.907	17.216
0.32	3.971	4.379	11.967	17.525
0.33	4.025	4.457	12.028	17.841
0.34	4.080	4.536	12.089	18.165
0.35	4.137	4.618	12.150	18.496

HALPIN-TSAI MICROMECHANICS COMPARISON ANALYSIS

Vf	[1] K23* (GPa)	[2] K23* (GPa)	[3] K23* (GPa)	[4] K23* (GPa)
0.36	4.195	4.702	12.212	18.835
0.37	4.254	4.789	12.274	19.182
0.38	4.314	4.879	12.336	19.537
0.39	4.376	4.971	12.399	19.902
0.4	4.439	5.067	12.462	20.275
0.41	4.504	5.165	12.525	20.658
0.42	4.570	5.266	12.589	21.051
0.43	4.638	5.371	12.653	21.453
0.44	4.707	5.480	12.717	21.867
0.45	4.778	5.592	12.782	22.291
0.46	4.851	5.708	12.848	22.727
0.47	4.926	5.828	12.913	23.175
0.48	5.003	5.952	12.979	23.635
0.49	5.081	6.081	13.045	24.108
0.5	5.162	6.215	13.112	24.595
0.51	5.245	6.354	13.179	25.096
0.52	5.330	6.498	13.247	25.611
0.53	5.417	6.649	13.314	26.142
0.54	5.507	6.805	13.383	26.689
0.55	5.599	6.967	13.451	27.253
0.56	5.694	7.137	13.521	27.834
0.57	5.792	7.313	13.590	28.434
0.58	5.893	7.498	13.660	29.053
0.59	5.996	7.690	13.730	29.693
0.6	6.103	7.892	13.801	30.353
0.61	6.213	8.103	13.872	31.036
0.62	6.326	8.324	13.944	31.743
0.63	6.443	8.557	14.016	32.474
0.64	6.564	8.801	14.088	33.232
0.65	6.689	9.057	14.161	34.017
0.66	6.817	9.328	14.234	34.831
0.67	6.950	9.613	14.308	35.675
0.68	7.088	9.914	14.382	36.552
0.69	7.231	10.233	14.457	37.464
0.7	7.378	10.570	14.532	38.411
0.71	7.531	10.929	14.608	39.398
0.72	7.690	11.310	14.684	40.425
0.73	7.854	11.716	14.760	41.496
0.74	8.025	12.150	14.837	42.614
0.75	8.202	12.615	14.915	43.781
0.76	8.387	13.113	14.993	45.001
0.77	8.579	13.648	15.071	46.278
0.78	8.779	14.226	15.150	47.615
0.79	8.987	14.851	15.230	49.018
0.8	9.204	15.529	15.310	50.490

HALPIN-TSAI MICROMECHANICS COMPARISON ANALYSIS

Vf	[1] K23* (GPa)	[2] K23* (GPa)	[3] K23* (GPa)	[4] K23* (GPa)
0.81	9.431	16.268	15.390	52.038
0.82	9.669	17.075	15.471	53.667
0.83	9.917	17.961	15.553	55.384
0.84	10.177	18.938	15.635	57.197
0.85	10.449	20.020	15.717	59.112
0.86	10.735	21.226	15.801	61.140
0.87	11.036	22.579	15.884	63.291
0.88	11.352	24.106	15.968	65.575
0.89	11.685	25.845	16.053	68.007
0.9	12.037	27.841	16.138	70.601
0.91	12.408	30.156	16.224	73.372
0.92	12.801	32.875	16.311	76.342
0.93	13.218	36.112	16.398	79.530
0.94	13.661	40.032	16.485	82.963
0.95	14.132	44.875	16.573	86.670
0.96	14.634	51.011	16.662	90.684
0.97	15.170	59.039	16.751	95.047
0.98	15.744	69.993	16.841	99.805
0.99	16.360	85.828	16.932	105.014
1	17.023	110.742	17.023	110.742