McGill University

Mechanics of Composite Materials

MECH 530

Assignment 6

Student Name:
Selim Belhaouane

Student ID:
260450544

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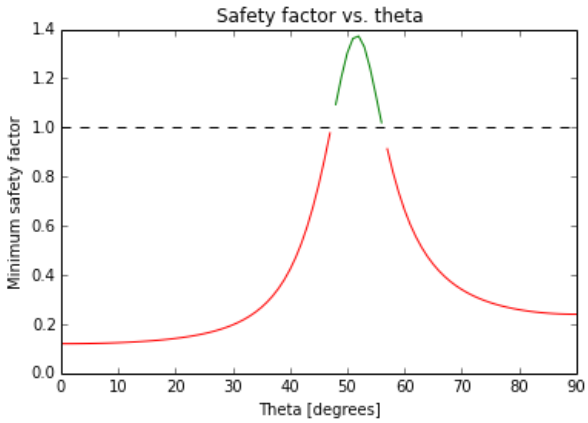
Design #1




```
Maximum R (1.37) occurs for theta = 52 degrees
```

Complete output

** Ply orientation list **

```
Orientation [degrees] :
[52, -52, -52, 52]
```

Number of plies

```
4
```

Material properties

```
'          ID :            4  [-]'
'fiber/matrix :  Kev49/Epoxy  [-]'
'        name : Kevlar/Epoxy  [-]'
'          ex :      76.0000  [GPA]'
'          ey :       5.5000  [GPA]'
'          es :       2.3000  [GPA]'
'         nux :       0.3400  [-]'
'          xt :    1400.0000  [MPA]'
'          xc :     235.0000  [MPA]'
'          yt :      12.0000  [MPA]'
'          yc :      53.0000  [MPA]'
'          sc :      34.0000  [MPA]'
'          h0 :       0.1250  [mm]'
'         rho :       1.4600  [g/cm3]'
'         nuy :       0.0246  [-]'
```

Thickness

```
Total thickness : 0.000500 [m]
Ply thickness   : 0.000500 [m]
```

On-axis Modulus and Compliance matrices -- [Q] and [S]

```
S_on [1/GPa] :
[[   0.0132   -0.0045    0.0000]
 [  -0.0045    0.1818    0.0000]
 [   0.0000    0.0000    0.4348]]
U's for S [1/GPa]
U1 :  0.1263
U2 : -0.0843
```

```
U3 : -0.0289
U4 : -0.0333
U5 :  0.3194

Q_on [GPa] :
[[  76.6412    1.8858    0.0000]
 [   1.8858    5.5464    0.0000]
 [   0.0000    0.0000    2.3000]]
U's for Q [GPa]
U1 : 32.4418
U2 : 35.5474
U3 :  8.6520
U4 : 10.5378
U5 : 10.9520
```

In-plane Modulus and Compliance -- [A] and [a]

```
A [GN/m] :
[[   0.0081    0.0091    0.0000]
 [   0.0091    0.0167    0.0000]
 [   0.0000    0.0000    0.0093]]
a [m/GN] :
[[ 316.9010 -172.4533   -0.0000]
 [-172.4533  153.7231    0.0000]
 [   0.0000    0.0000  107.5774]]
```

Flexural Modulus and Compliance -- [D] and [d]

```
D [kNm] :
[[   0.0002    0.0002    0.0001]
 [   0.0002    0.0003    0.0002]
 [   0.0001    0.0002    0.0002]]
d [1/MNm] :
[[15530371.6619 -7642652.2161 -1690461.2187]
 [-7642652.2161 8642673.4179 -3364279.7092]
 [-1690461.2187 -3364279.7092 8954671.2946]]
```

Loads

```
N [kN/m] :
[  25.0000   50.0000    0.0000]


e0 [-] :
[-0.00070 0.00337 0.00000]
```

See Appendix A for stresses/strains and safety factors.

Design #2

Chosen layup

[-55/-25/55/25]s

Complete output

Ply orientation list

```
Orientation [degrees] :
[-55, -25, 55, 25, 25, 55, -25, -55]
```

Number of plies

```
8
```

Material properties

```
'          ID :          3  [-]'
'fiber/matrix : E-glass/Epoxy  [-]'
'        name : Fiberglass  [-]'
'          ex :    38.6000  [GPA]'
'          ey :     8.2700  [GPA]'
'          es :     4.1400  [GPA]'
'         nux :     0.2600  [-]'
'          xt :  1062.0000  [MPA]'
'          xc :   610.0000  [MPA]'
'          yt :    31.0000  [MPA]'
'          yc :   118.0000  [MPA]'
'          sc :    72.0000  [MPA]'
'          h0 :     0.1250  [mm]'
'         rho :     1.8000  [g/cm3]'
'         nuy :     0.0557  [-]'
```

Thickness

```
Total thickness : 0.001000 [m]
Ply thickness   : 0.001000 [m]
```

On-axis Modulus and Compliance matrices -- [Q] and [S]

```
S_on [1/GPa] :
[[   0.0259   -0.0067    0.0000]
 [  -0.0067    0.1209    0.0000]
 [   0.0000    0.0000    0.2415]]
U's for S [1/GPa]
U1 :  0.0836
U2 : -0.0475
U3 : -0.0102
U4 : -0.0169
U5 :  0.2009

Q_on [GPa] :
[[  39.1673    2.1818    0.0000]
 [   2.1818    8.3915    0.0000]
 [   0.0000    0.0000    4.1400]]
U's for Q [GPa]
U1 : 20.4500
U2 : 15.3879
U3 :  3.3294
U4 :  5.5112
U5 :  7.4694
```

In-plane Modulus and Compliance -- [A] and [a]

```
A [GN/m] :
[[   0.0212    0.0071    0.0000]
 [   0.0071    0.0166    0.0000]
 [   0.0000    0.0000    0.0090]]
a [m/GN] :
[[  55.0092  -23.4870   -0.0000]
 [ -23.4870   70.3723   -0.0000]
 [  -0.0000   -0.0000  110.6965]]
```

Flexural Modulus and Compliance -- [D] and [d]

```
D [kNm] :
[[   0.0015    0.0006   -0.0004]
 [   0.0006    0.0016   -0.0004]
 [  -0.0004   -0.0004    0.0008]]
d [1/MNm] :
[[858067.0903 -250207.2728 316679.9763]
 [-250207.2728 811552.9001 310409.5587]
 [316679.9763 310409.5587 1612611.0848]]


The ratio of D11 to D22 is :
0.94461988227
```

Design #3

In a Nutshell

```
Material Chosen :
T300/N5208

Orientation [degrees] :
[10, 20, -13, -16, -18, 29, 31, 27, 27, 31, 29, -18, -16, -13, 20, 10]

Number of layers :
16

Weight :
9.6 gram

Minimum safety factor for load I / load II :
2.26 / 2.28
```

Complete output

Ply orientation list

```
Orientation [degrees] :
[10, 20, -13, -16, -18, 29, 31, 27, 27, 31, 29, -18, -16, -13, 20, 10]
```

Number of plies

```
16
```

Material properties

```
'          ID :          1  [-]'
'fiber/matrix : T300/N5208  [-]'
'        name : Graphite/Epoxy  [-]'
'          ex :   181.0000  [GPA]'
'          ey :    10.3000  [GPA]'
'          es :     7.1700  [GPA]'
'         nux :     0.2800  [-]'
'          xt :  1500.0000  [MPA]'
'          xc :  1500.0000  [MPA]'
'          yt :    40.0000  [MPA]'
'          yc :   246.0000  [MPA]'
'          sc :    68.0000  [MPA]'
'          h0 :     0.1250  [mm]'
'         rho :     1.6000  [g/cm3]'
'         nuy :     0.0159  [-]'
```

Thickness

```
Total thickness : 0.350000 [cm]
Ply thickness   : 0.200000 [cm]
```

On-axis Modulus and Compliance matrices -- [Q] and [S]

```
S_on [1/GPa] :
[[   0.0055   -0.0015    0.0000]
 [  -0.0015    0.0971    0.0000]
 [   0.0000    0.0000    0.1395]]
U's for S [1/GPa]
U1 :  0.0555
U2 : -0.0458
```

```
U3 : -0.0042
U4 : -0.0058
U5 :  0.1226

Q_on [GPa] :
[[ 181.8111    2.8969    0.0000]
 [   2.8969   10.3462    0.0000]
 [   0.0000    0.0000    7.1700]]
U's for Q [GPa]
U1 : 76.3682
U2 : 85.7325
U3 : 19.7104
U4 : 22.6074
U5 : 26.8804
```

In-plane Modulus and Compliance -- [A] and [a]

```
A [GN/m] :
[[   0.2830    0.0403    0.0293]
 [   0.0403    0.0323    0.0129]
 [   0.0293    0.0129    0.0489]]
a [m/GN] :
[[   4.3731   -4.9306   -1.3251]
 [  -4.9306   40.1686   -7.6278]
 [  -1.3251   -7.6278   23.2757]]
```

Flexural Modulus and Compliance -- [D] and [d]

```
D [kNm] :
[[   0.4936    0.0553    0.0335]
 [   0.0553    0.0473    0.0129]
 [   0.0335    0.0129    0.0694]]
d [1/MNm] :
[[2359.0757 -2575.6152 -660.3018]
 [-2575.6152 25064.6523 -3420.3223]
 [-660.3018 -3420.3223 15371.9932]]
```

Load Case 1

```
N [N/m]:
[-22400  -3000  -2000]
M [N]:
[-1000  -100  -100]


e0 [-] :
[-0.00008 0.00001 0.00001]
k [-] :
[-2.03548405  0.41118216 -0.53486525]
```

See Appendix B for stresses/strains and safety factors.

Load case 2

```
N [N/m]:
[-20800  -2800  -2200]
M [N]:
[-980  -98 -110]


e0 [-] :
[-0.00007 0.00001 -0.00000]
k [-] :
[-1.98685075  0.44400239 -0.70863186]
```

See Appendix C for stresses/strains and safety factors.

A Design 1

A.1 Stresses and Strains

Table 1: Stresses are in [GPa].

Ply	ϵ_1	ϵ_2	ϵ_6	ϵ_x	ϵ_y	ϵ_s	σ_x	σ_y	σ_s
1 (52°) - B	-0.00070	0.00337	0.00000	0.00183	0.00084	0.00395	0.14187	0.00813	0.00909
1 (52°) - T	-0.00070	0.00337	0.00000	0.00183	0.00084	0.00395	0.14187	0.00813	0.00909
2 (-52°) - B	-0.00070	0.00337	0.00000	0.00183	0.00084	-0.00395	0.14187	0.00813	-0.00909
2 (-52°) - T	-0.00070	0.00337	0.00000	0.00183	0.00084	-0.00395	0.14187	0.00813	-0.00909
3 (-52°) - B	-0.00070	0.00337	0.00000	0.00183	0.00084	-0.00395	0.14187	0.00813	-0.00909
3 (-52°) - T	-0.00070	0.00337	0.00000	0.00183	0.00084	-0.00395	0.14187	0.00813	-0.00909
4 (52°) - B	-0.00070	0.00337	0.00000	0.00183	0.00084	0.00395	0.14187	0.00813	0.00909
4 (52°) - T	-0.00070	0.00337	0.00000	0.00183	0.00084	0.00395	0.14187	0.00813	0.00909

A.2 Safety Factors

	Maximum Stress					Quadratic		Hashin			
Ply	FT	FC	MT	MC	S	(+)	(-)	FT	FC	MT	MC
1 (52) - B	9.87	0.00	1.48	0.00	3.74	2.45	-2.60	3.50	0.00	1.37	0.00
1 (52) - T	9.87	0.00	1.48	0.00	3.74	2.45	-2.60	3.50	0.00	1.37	0.00
2 (-52) - B	9.87	0.00	1.48	0.00	3.74	2.45	-2.60	3.50	0.00	1.37	0.00
2 (-52) - T	9.87	0.00	1.48	0.00	3.74	2.45	-2.60	3.50	0.00	1.37	0.00
3 (-52) - B	9.87	0.00	1.48	0.00	3.74	2.45	-2.60	3.50	0.00	1.37	0.00
3 (-52) - T	9.87	0.00	1.48	0.00	3.74	2.45	-2.60	3.50	0.00	1.37	0.00
4 (52) - B	9.87	0.00	1.48	0.00	3.74	2.45	-2.60	3.50	0.00	1.37	0.00
4 (52) - T	9.87	0.00	1.48	0.00	3.74	2.45	-2.60	3.50	0.00	1.37	0.00

B Design 3 – Load Case I

B.1 Stresses and Strains

Table 4: Stresses are in [GPa].

Ply	ϵ_1	ϵ_2	ϵ_6	ϵ_x	ϵ_y	ϵ_s	σ_x	σ_y	σ_s
16 (10°) - T	-0.00364	0.00072	-0.00093	-0.00367	0.00075	0.00062	-0.66506	-0.00285	0.00444
16 (10°) - B	-0.00339	0.00067	-0.00086	-0.00341	0.00070	0.00058	-0.61855	-0.00266	0.00414
15 (20°) - T	-0.00339	0.00067	-0.00086	-0.00319	0.00048	0.00195	-0.57869	-0.00432	0.01398
15 (20°) - B	-0.00313	0.00062	-0.00080	-0.00295	0.00044	0.00180	-0.53513	-0.00401	0.01294
14 (-13°) - T	-0.00313	0.00062	-0.00080	-0.00277	0.00026	-0.00236	-0.50272	-0.00536	-0.01694
14 (-13°) - B	-0.00288	0.00057	-0.00073	-0.00254	0.00024	-0.00217	-0.46200	-0.00493	-0.01554
13 (-16°) - T	-0.00288	0.00057	-0.00073	-0.00242	0.00012	-0.00245	-0.44036	-0.00583	-0.01754
13 (-16°) - B	-0.00262	0.00052	-0.00066	-0.00221	0.00010	-0.00223	-0.40158	-0.00532	-0.01597
12 (-18°) - T	-0.00262	0.00052	-0.00066	-0.00213	0.00002	-0.00238	-0.38717	-0.00592	-0.01709
12 (-18°) - B	-0.00237	0.00047	-0.00060	-0.00192	0.00002	-0.00215	-0.34980	-0.00535	-0.01542
11 (29°) - T	-0.00237	0.00047	-0.00060	-0.00196	0.00005	0.00209	-0.35546	-0.00511	0.01499
11 (29°) - B	-0.00212	0.00042	-0.00053	-0.00175	0.00005	0.00187	-0.31713	-0.00459	0.01339
10 (31°) - T	-0.00212	0.00042	-0.00053	-0.00168	-0.00002	0.00199	-0.30509	-0.00509	0.01425
10 (31°) - B	-0.00186	0.00036	-0.00046	-0.00147	-0.00002	0.00175	-0.26822	-0.00450	0.01254
9 (27°) - T	-0.00186	0.00036	-0.00046	-0.00159	0.00009	0.00153	-0.28873	-0.00364	0.01097
9 (27°) - B	-0.00161	0.00031	-0.00040	-0.00137	0.00008	0.00132	-0.24905	-0.00317	0.00948
8 (27°) - T	0.00145	-0.00030	0.00041	0.00125	-0.00011	-0.00118	0.22700	0.00251	-0.00843
8 (27°) - B	0.00170	-0.00035	0.00047	0.00147	-0.00012	-0.00138	0.26667	0.00298	-0.00992
7 (31°) - T	0.00170	-0.00035	0.00047	0.00136	-0.00002	-0.00159	0.24805	0.00376	-0.01141
7 (31°) - B	0.00195	-0.00041	0.00054	0.00157	-0.00002	-0.00183	0.28493	0.00435	-0.01313
6 (29°) - T	0.00195	-0.00041	0.00054	0.00163	-0.00008	-0.00172	0.29601	0.00389	-0.01230
6 (29°) - B	0.00221	-0.00046	0.00061	0.00184	-0.00009	-0.00194	0.33433	0.00442	-0.01391
5 (-18°) - T	0.00221	-0.00046	0.00061	0.00178	-0.00002	0.00206	0.32285	0.00490	0.01476
5 (-18°) - B	0.00246	-0.00051	0.00067	0.00198	-0.00003	0.00229	0.36022	0.00547	0.01644
4 (-16°) - T	0.00246	-0.00051	0.00067	0.00206	-0.00010	0.00215	0.37409	0.00489	0.01540
4 (-16°) - B	0.00272	-0.00056	0.00074	0.00227	-0.00011	0.00237	0.41288	0.00540	0.01696
3 (-13°) - T	0.00272	-0.00056	0.00074	0.00239	-0.00023	0.00210	0.43383	0.00453	0.01508
3 (-13°) - B	0.00297	-0.00061	0.00081	0.00261	-0.00025	0.00230	0.47455	0.00496	0.01647
2 (20°) - T	0.00297	-0.00061	0.00081	0.00281	-0.00045	-0.00168	0.51016	0.00347	-0.01208
2 (20°) - B	0.00323	-0.00066	0.00088	0.00305	-0.00049	-0.00183	0.55372	0.00378	-0.01312
1 (10°) - T	0.00323	-0.00066	0.00088	0.00326	-0.00070	-0.00051	0.59060	0.00225	-0.00364
1 (10°) - B	0.00348	-0.00071	0.00094	0.00352	-0.00075	-0.00055	0.63711	0.00244	-0.00394

B.2 Safety Factors

	Maximum Stress					Quadratic		Hashin			
Ply	FT	FC	MT	MC	S	(+)	(-)	FT	FC	MT	MC
16 (10) - T	0.00	**2.26**	0.00	86.31	15.30	2.46	-2.15	0.00	**2.26**	0.00	17.63
16 (10) - B	0.00	2.43	0.00	92.44	16.41	2.65	-2.31	0.00	2.43	0.00	18.91
15 (20) - T	0.00	2.59	0.00	56.93	4.86	2.65	-2.14	0.00	2.59	0.00	5.29
15 (20) - B	0.00	2.80	0.00	61.35	5.26	2.87	-2.31	0.00	2.80	0.00	5.72
14 (-13) - T	0.00	2.98	0.00	45.90	4.02	2.88	-2.18	0.00	2.98	0.00	4.37
14 (-13) - B	0.00	3.25	0.00	49.91	4.37	3.14	-2.37	0.00	3.25	0.00	4.77
13 (-16) - T	0.00	3.41	0.00	42.19	3.88	3.16	-2.28	0.00	3.41	0.00	4.24
13 (-16) - B	0.00	3.74	0.00	46.24	4.26	3.47	-2.50	0.00	3.74	0.00	4.65
12 (-18) - T	0.00	3.87	0.00	41.56	3.98	3.48	-2.43	0.00	3.87	0.00	4.36
12 (-18) - B	0.00	4.29	0.00	45.98	4.41	3.86	-2.70	0.00	4.29	0.00	4.84
11 (29) - T	0.00	4.22	0.00	48.09	4.54	3.85	-2.73	0.00	4.22	0.00	4.97
11 (29) - B	0.00	4.73	0.00	53.65	5.08	4.32	-3.05	0.00	4.73	0.00	5.56
10 (31) - T	0.00	4.92	0.00	48.36	4.77	4.34	-2.97	0.00	4.92	0.00	5.24
10 (31) - B	0.00	5.59	0.00	54.70	5.42	4.95	-3.37	0.00	5.59	0.00	5.96
9 (27) - T	0.00	5.20	0.00	67.53	6.20	4.89	-3.56	0.00	5.20	0.00	6.78
9 (27) - B	0.00	6.02	0.00	77.61	7.18	5.68	-4.12	0.00	6.02	0.00	7.85
8 (27) - T	6.61	0.00	15.93	0.00	8.07	4.64	-6.14	5.11	0.00	7.20	0.00
8 (27) - B	5.62	0.00	13.40	0.00	6.85	3.94	-5.23	4.35	0.00	6.10	0.00
7 (31) - T	6.05	0.00	10.64	0.00	5.96	3.73	-5.29	4.24	0.00	5.20	0.00
7 (31) - B	5.26	0.00	9.20	0.00	5.18	3.24	-4.60	3.69	0.00	4.51	0.00
6 (29) - T	5.07	0.00	10.29	0.00	5.53	3.34	-4.58	3.74	0.00	4.87	0.00
6 (29) - B	4.49	0.00	9.05	0.00	4.89	2.95	-4.06	3.31	0.00	4.30	0.00
5 (-18) - T	4.65	0.00	8.17	0.00	4.61	2.88	-4.08	3.27	0.00	4.01	0.00
5 (-18) - B	4.16	0.00	7.32	0.00	4.14	2.58	-3.66	2.93	0.00	3.60	0.00
4 (-16) - T	4.01	0.00	8.18	0.00	4.42	2.65	-3.64	2.97	0.00	3.89	0.00
4 (-16) - B	3.63	0.00	7.41	0.00	4.01	2.40	-3.30	2.69	0.00	3.53	0.00
3 (-13) - T	3.46	0.00	8.84	0.00	4.51	2.50	-3.28	2.74	0.00	4.02	0.00
3 (-13) - B	3.16	0.00	8.07	0.00	4.13	2.29	-3.00	2.51	0.00	3.67	0.00
2 (20) - T	2.94	0.00	11.52	0.00	5.63	2.45	-2.99	2.61	0.00	5.06	0.00
2 (20) - B	2.71	0.00	10.57	0.00	5.18	2.26	-2.75	2.40	0.00	4.65	0.00
1 (10) - T	2.54	0.00	17.79	0.00	18.67	2.43	-2.75	2.52	0.00	12.88	0.00
1 (10) - B	2.35	0.00	16.41	0.00	17.25	2.26	-2.55	2.33	0.00	11.89	0.00

C Design 3 – Load Case II

C.1 Stresses and Strains

Table 7: Stresses are in [GPa].

Ply	ϵ_1	ϵ_2	ϵ_6	ϵ_x	ϵ_y	ϵ_s	σ_x	σ_y	σ_s
16 (10°) - T	-0.00355	0.00078	-0.00124	-0.00363	0.00087	0.00032	-0.65801	-0.00157	0.00226
16 (10°) - B	-0.00330	0.00073	-0.00115	-0.00338	0.00080	0.00029	-0.61194	-0.00147	0.00211
15 (20°) - T	-0.00330	0.00073	-0.00115	-0.00320	0.00063	0.00171	-0.58037	-0.00278	0.01224
15 (20°) - B	-0.00305	0.00067	-0.00107	-0.00296	0.00058	0.00158	-0.53664	-0.00258	0.01133
14 (-13°) - T	-0.00305	0.00067	-0.00107	-0.00263	0.00025	-0.00259	-0.47788	-0.00503	-0.01858
14 (-13°) - B	-0.00281	0.00062	-0.00098	-0.00242	0.00023	-0.00238	-0.43911	-0.00463	-0.01705
13 (-16°) - T	-0.00281	0.00062	-0.00098	-0.00229	0.00010	-0.00264	-0.41557	-0.00561	-0.01895
13 (-16°) - B	-0.00256	0.00056	-0.00089	-0.00209	0.00009	-0.00241	-0.37890	-0.00512	-0.01725
12 (-18°) - T	-0.00256	0.00056	-0.00089	-0.00200	0.00000	-0.00255	-0.36341	-0.00576	-0.01830
12 (-18°) - B	-0.00231	0.00051	-0.00080	-0.00181	0.00000	-0.00230	-0.32827	-0.00520	-0.01650
11 (29°) - T	-0.00231	0.00051	-0.00080	-0.00199	0.00018	0.00196	-0.36066	-0.00386	0.01408
11 (29°) - B	-0.00206	0.00045	-0.00071	-0.00177	0.00016	0.00175	-0.32172	-0.00346	0.01257
10 (31°) - T	-0.00206	0.00045	-0.00071	-0.00171	0.00010	0.00188	-0.31036	-0.00393	0.01351
10 (31°) - B	-0.00181	0.00040	-0.00062	-0.00150	0.00008	0.00166	-0.27279	-0.00348	0.01188
9 (27°) - T	-0.00181	0.00040	-0.00062	-0.00161	0.00019	0.00142	-0.29204	-0.00268	0.01019
9 (27°) - B	-0.00156	0.00034	-0.00053	-0.00139	0.00016	0.00123	-0.25185	-0.00233	0.00880
8 (27°) - T	0.00142	-0.00033	0.00053	0.00127	-0.00018	-0.00110	0.23054	0.00181	-0.00787
8 (27°) - B	0.00166	-0.00038	0.00062	0.00149	-0.00021	-0.00129	0.27074	0.00215	-0.00926
7 (31°) - T	0.00166	-0.00038	0.00062	0.00139	-0.00011	-0.00152	0.25317	0.00288	-0.01087
7 (31°) - B	0.00191	-0.00044	0.00071	0.00160	-0.00013	-0.00174	0.29074	0.00334	-0.01250
6 (29°) - T	0.00191	-0.00044	0.00071	0.00166	-0.00018	-0.00162	0.30124	0.00290	-0.01160
6 (29°) - B	0.00216	-0.00049	0.00079	0.00187	-0.00021	-0.00183	0.34018	0.00330	-0.01311
5 (-18°) - T	0.00216	-0.00049	0.00079	0.00167	-0.00001	0.00220	0.30433	0.00479	0.01579
5 (-18°) - B	0.00241	-0.00055	0.00088	0.00187	-0.00001	0.00245	0.33947	0.00535	0.01759
4 (-16°) - T	0.00241	-0.00055	0.00088	0.00195	-0.00009	0.00232	0.35437	0.00473	0.01661
4 (-16°) - B	0.00266	-0.00060	0.00097	0.00215	-0.00010	0.00255	0.39103	0.00522	0.01830
3 (-13°) - T	0.00266	-0.00060	0.00097	0.00228	-0.00023	0.00230	0.41380	0.00427	0.01652
3 (-13°) - B	0.00291	-0.00066	0.00106	0.00249	-0.00025	0.00252	0.45257	0.00467	0.01804
2 (20°) - T	0.00291	-0.00066	0.00106	0.00283	-0.00058	-0.00148	0.51282	0.00217	-0.01061
2 (20°) - B	0.00315	-0.00071	0.00115	0.00307	-0.00063	-0.00161	0.55654	0.00236	-0.01152
1 (10°) - T	0.00315	-0.00071	0.00115	0.00323	-0.00079	-0.00024	0.58572	0.00115	-0.00174
1 (10°) - B	0.00340	-0.00077	0.00124	0.00349	-0.00086	-0.00026	0.63179	0.00125	-0.00189

C.2 Safety Factors

	Maximum Stress					Quadratic		Hashin			
Ply	FT	FC	MT	MC	S	(+)	(-)	FT	FC	MT	MC
16 (10) - T	0.00	**2.28**	0.00	156.82	30.09	2.40	-2.23	0.00	**2.28**	0.00	34.87
16 (10) - B	0.00	2.45	0.00	167.57	32.20	2.58	-2.39	0.00	2.45	0.00	37.33
15 (20) - T	0.00	2.58	0.00	88.40	5.55	2.59	-2.25	0.00	2.58	0.00	5.92
15 (20) - B	0.00	2.80	0.00	95.17	6.00	2.80	-2.43	0.00	2.80	0.00	6.40
14 (-13) - T	0.00	3.14	0.00	48.89	3.66	2.83	-2.18	0.00	3.14	0.00	3.95
14 (-13) - B	0.00	3.42	0.00	53.17	3.99	3.08	-2.37	0.00	3.42	0.00	4.30
13 (-16) - T	0.00	3.61	0.00	43.87	3.59	3.10	-2.27	0.00	3.61	0.00	3.89
13 (-16) - B	0.00	3.96	0.00	48.09	3.94	3.40	-2.49	0.00	3.96	0.00	4.27
12 (-18) - T	0.00	4.13	0.00	42.71	3.72	3.43	-2.42	0.00	4.13	0.00	4.05
12 (-18) - B	0.00	4.57	0.00	47.27	4.12	3.80	-2.69	0.00	4.57	0.00	4.49
11 (29) - T	0.00	4.16	0.00	63.79	4.83	3.74	-2.88	0.00	4.16	0.00	5.21
11 (29) - B	0.00	4.66	0.00	71.13	5.41	4.20	-3.22	0.00	4.66	0.00	5.84
10 (31) - T	0.00	4.83	0.00	62.57	5.03	4.22	-3.13	0.00	4.83	0.00	5.45
10 (31) - B	0.00	5.50	0.00	70.74	5.72	4.80	-3.56	0.00	5.50	0.00	6.20
9 (27) - T	0.00	5.14	0.00	91.94	6.68	4.76	-3.76	0.00	5.14	0.00	7.18
9 (27) - B	0.00	5.96	0.00	105.54	7.73	5.53	-4.35	0.00	5.96	0.00	8.32
8 (27) - T	6.51	0.00	22.13	0.00	8.64	4.86	-5.95	5.20	0.00	8.04	0.00
8 (27) - B	5.54	0.00	18.58	0.00	7.34	4.13	-5.08	4.42	0.00	6.83	0.00
7 (31) - T	5.92	0.00	13.87	0.00	6.25	3.91	-5.12	4.30	0.00	5.70	0.00
7 (31) - B	5.16	0.00	11.98	0.00	5.44	3.40	-4.46	3.74	0.00	4.95	0.00
6 (29) - T	4.98	0.00	13.79	0.00	5.86	3.50	-4.44	3.79	0.00	5.39	0.00
6 (29) - B	4.41	0.00	12.13	0.00	5.18	3.09	-3.93	3.36	0.00	4.77	0.00
5 (-18) - T	4.93	0.00	8.35	0.00	4.31	2.85	-4.00	3.24	0.00	3.83	0.00
5 (-18) - B	4.42	0.00	7.48	0.00	3.87	2.56	-3.59	2.91	0.00	3.43	0.00
4 (-16) - T	4.23	0.00	8.46	0.00	4.09	2.63	-3.56	2.94	0.00	3.69	0.00
4 (-16) - B	3.84	0.00	7.67	0.00	3.72	2.39	-3.23	2.67	0.00	3.34	0.00
3 (-13) - T	3.62	0.00	9.37	0.00	4.12	2.49	-3.21	2.72	0.00	3.77	0.00
3 (-13) - B	3.31	0.00	8.56	0.00	3.77	2.28	-2.94	2.49	0.00	3.45	0.00
2 (20) - T	2.93	0.00	18.46	0.00	6.41	2.57	-2.90	2.66	0.00	6.06	0.00
2 (20) - B	2.70	0.00	16.92	0.00	5.90	2.36	-2.68	2.45	0.00	5.57	0.00
1 (10) - T	2.56	0.00	34.80	0.00	38.97	2.51	-2.68	2.56	0.00	25.96	0.00
1 (10) - B	2.37	0.00	32.00	0.00	35.92	2.33	-2.48	2.37	0.00	23.89	0.00