



McGILL UNIVERSITY

MECHANICS OF COMPOSITE MATERIALS

MECH 530

Assignment 5

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Ply orientation list

Orientation [degrees] :
[0, 0, 25, -25, 0, 0, 0, 0, -25, 25, 0, 0]

Number of plies

12

Material properties

Graphite/Thermoplastic

ID :	5	[-]
'fiber/matrix :	AS4/PEEK	[-]
'name :	Graphite/Thermoplastic	[-]
'ex :	134.0000	[GPa]
'ey :	8.9000	[GPa]
'es :	5.1000	[GPa]
'nux :	0.2800	[-]
'xt :	2130.0000	[MPa]
'xc :	1100.0000	[MPa]
'yt :	80.0000	[MPa]
'yc :	200.0000	[MPa]
'sc :	160.0000	[MPa]
'h0 :	0.1250	[mm]
'nuy :	0.0186	[-]

Thickness

Total thickness : 0.011500 [m]
Ply thickness : 0.001500 [m]

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

S_on [1/GPa] :
[[0.0075 -0.0021 0.0000]
[-0.0021 0.1124 0.0000]
[0.0000 0.0000 0.1961]]

U's for S [1/GPa]

U1 : 0.0689
U2 : -0.0524
U3 : -0.0090
U4 : -0.0111
U5 : 0.1600

Q_on [GPa] :
[[134.7014 2.5050 0.0000]
[2.5050 8.9466 0.0000]
[0.0000 0.0000 5.1000]]

U's for Q [GPa]

U1 : 57.0443
U2 : 62.8774
U3 : 14.7797
U4 : 17.2848
U5 : 19.8797

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

A [GN/m] :
[[0.1821 0.0124 0.0000]
[0.0124 0.0160 0.0000]
[0.0000 0.0000 0.0163]]

a [m/GN] :
[[5.7979 -4.5109 -0.0000]
[-4.5109 66.0994 -0.0000]
[0.0000 0.0000 61.2628]]

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

D [kNm] :
[[5.2718 0.3594 0.0130]
[0.3594 0.4622 0.0032]
[0.0130 0.0032 0.4720]]
d [1/MNm] :
[[200.3143 -155.6995 -4.4529]
[-155.6995 2284.5488 -11.2113]
[-4.4529 -11.2113 2118.8941]]

Loads

M [N] :
[-1159.09, 0, 0]

N [N/m] :
[4545.45, 0, 0]

Curvature and average strain

K [1/m] :
[-0.2322 0.1805 0.0052]
e0 [-] :
[2.635394e-05 -2.050421e-05 0.000000e+00]

Results

Strains and stresses

See Appendix A

Safety Factors

See Appendix B

Maximum stress failure criteria

	Mode	Lowest R	Ply
0	FT	11.8	1 (0) - B
1	FC	6.3	12 (0) - T
2	MT	13.7	12 (0) - T
3	MC	33.0	1 (0) - B
4	S	17.5	3 (25) - B

Lowest R is 6.3 and occurs at top of ply number 12.
The load vectors R(M) and R(N) which cause failure are:
R(M) [N] :
[-7338.76, 0, 0]
R(N) [N/m] :
[28779.46, 0, 0]

Quadratic Failure Criteria

Lowest R is 4.7 and occurs at top of ply number 12.
The load vectors R(M) and R(N) which cause failure are:
R(M) [N] :
[-5406.56, 0, 0]
R(N) [N/m] :
[21202.21, 0, 0]

Hashin Failure Criteria

	Mode	Lowest R	Ply
0	FT	11.8	1 (0) - B
1	FC	6.3	12 (0) - T
2	MT	13.7	12 (0) - T
3	MC	15.9	3 (25) - B

Lowest R is 6.3 and occurs at top of ply number 12.

The load vectors R(M) and R(N) which cause failure are:

R(M) [N] :

[-7338.76, 0, 0]

R(N) [N/m] :

[28779.46, 0, 0]

A 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 (0°) - B	0.00136	-0.00106	-0.00003	0.00136	-0.00106	-0.00003	0.18073	-0.00606	-0.00015
1 (0°) - T	0.00133	-0.00104	-0.00003	0.00133	-0.00104	-0.00003	0.17688	-0.00593	-0.00015
2 (0°) - B	0.00133	-0.00104	-0.00003	0.00133	-0.00104	-0.00003	0.17688	-0.00593	-0.00015
2 (0°) - T	0.00130	-0.00101	-0.00003	0.00130	-0.00101	-0.00003	0.17303	-0.00580	-0.00014
3 (25°) - B	0.00130	-0.00101	-0.00003	0.00088	-0.00059	-0.00179	0.11690	-0.00306	-0.00914
3 (25°) - T	0.00127	-0.00099	-0.00003	0.00086	-0.00058	-0.00175	0.11429	-0.00300	-0.00894
4 (-25°) - B	0.00127	-0.00099	-0.00003	0.00088	-0.00060	0.00172	0.11710	-0.00313	0.00876
4 (-25°) - T	0.00125	-0.00097	-0.00003	0.00086	-0.00058	0.00168	0.11443	-0.00306	0.00856
5 (0°) - B	0.00125	-0.00097	-0.00003	0.00125	-0.00097	-0.00003	0.16532	-0.00554	-0.00014
5 (0°) - T	0.00122	-0.00095	-0.00003	0.00122	-0.00095	-0.00003	0.16147	-0.00541	-0.00013
6 (0°) - B	0.00122	-0.00095	-0.00003	0.00122	-0.00095	-0.00003	0.16147	-0.00541	-0.00013
6 (0°) - T	0.00119	-0.00092	-0.00003	0.00119	-0.00092	-0.00003	0.15761	-0.00528	-0.00013
7 (0°) - B	-0.00113	0.00088	0.00003	-0.00113	0.00088	0.00003	-0.15062	0.00505	0.00013
7 (0°) - T	-0.00116	0.00090	0.00003	-0.00116	0.00090	0.00003	-0.15447	0.00518	0.00013
8 (0°) - B	-0.00116	0.00090	0.00003	-0.00116	0.00090	0.00003	-0.15447	0.00518	0.00013
8 (0°) - T	-0.00119	0.00093	0.00003	-0.00119	0.00093	0.00003	-0.15832	0.00531	0.00014
9 (-25°) - B	-0.00119	0.00093	0.00003	-0.00082	0.00056	-0.00161	-0.10965	0.00293	-0.00819
9 (-25°) - T	-0.00122	0.00095	0.00003	-0.00084	0.00057	-0.00165	-0.11232	0.00301	-0.00839
10 (25°) - B	-0.00122	0.00095	0.00003	-0.00082	0.00055	0.00168	-0.10951	0.00287	0.00857
10 (25°) - T	-0.00125	0.00097	0.00003	-0.00084	0.00056	0.00172	-0.11211	0.00294	0.00878
11 (0°) - B	-0.00125	0.00097	0.00003	-0.00125	0.00097	0.00003	-0.16603	0.00556	0.00014
11 (0°) - T	-0.00128	0.00099	0.00003	-0.00128	0.00099	0.00003	-0.16988	0.00569	0.00015
12 (0°) - B	-0.00128	0.00099	0.00003	-0.00128	0.00099	0.00003	-0.16988	0.00569	0.00015
12 (0°) - T	-0.00131	0.00102	0.00003	-0.00131	0.00102	0.00003	-0.17374	0.00582	0.00015

B Safety Factors

Ply	Maximum Stress					Quadratic		Hashin			
	FT	FC	MT	MC	S	(+)	(-)	FT	FC	MT	MC
1 (0) - B	11.8	0.0	0.0	33.0	1057.1	10.2	-4.5	11.8	0.0	0.0	33.0
1 (0) - T	12.0	0.0	0.0	33.7	1080.6	10.4	-4.6	12.0	0.0	0.0	33.7
2 (0) - B	12.0	0.0	0.0	33.7	1080.6	10.4	-4.6	12.0	0.0	0.0	33.7
2 (0) - T	12.3	0.0	0.0	34.5	1105.2	10.6	-4.7	12.3	0.0	0.0	34.5
3 (25) - B	18.2	0.0	0.0	65.3	17.5	13.1	-6.6	12.6	0.0	0.0	15.9
3 (25) - T	18.6	0.0	0.0	66.8	17.9	13.4	-6.8	12.9	0.0	0.0	16.3
4 (-25) - B	18.2	0.0	0.0	63.9	18.3	13.2	-6.6	12.9	0.0	0.0	16.5
4 (-25) - T	18.6	0.0	0.0	65.3	18.7	13.6	-6.8	13.2	0.0	0.0	16.9
5 (0) - B	12.9	0.0	0.0	36.1	1157.8	11.1	-4.9	12.9	0.0	0.0	36.1
5 (0) - T	13.2	0.0	0.0	37.0	1186.0	11.4	-5.0	13.2	0.0	0.0	36.9
6 (0) - B	13.2	0.0	0.0	37.0	1186.0	11.4	-5.0	13.2	0.0	0.0	36.9
6 (0) - T	13.5	0.0	0.0	37.9	1215.7	11.7	-5.1	13.5	0.0	0.0	37.8
7 (0) - B	0.0	7.3	15.8	0.0	1215.7	5.4	-12.2	0.0	7.3	15.8	0.0
7 (0) - T	0.0	7.1	15.5	0.0	1186.0	5.2	-11.9	0.0	7.1	15.5	0.0
8 (0) - B	0.0	7.1	15.5	0.0	1186.0	5.2	-11.9	0.0	7.1	15.5	0.0
8 (0) - T	0.0	6.9	15.1	0.0	1157.8	5.1	-11.6	0.0	6.9	15.1	0.0
9 (-25) - B	0.0	10.0	27.3	0.0	19.5	7.1	-14.2	0.0	10.0	15.9	0.0
9 (-25) - T	0.0	9.8	26.6	0.0	19.1	6.9	-13.8	0.0	9.8	15.5	0.0
10 (25) - B	0.0	10.0	27.9	0.0	18.7	7.1	-14.0	0.0	10.0	15.5	0.0
10 (25) - T	0.0	9.8	27.2	0.0	18.2	6.9	-13.6	0.0	9.8	15.2	0.0
11 (0) - B	0.0	6.6	14.4	0.0	1105.2	4.9	-11.1	0.0	6.6	14.4	0.0
11 (0) - T	0.0	6.5	14.1	0.0	1080.6	4.8	-10.8	0.0	6.5	14.1	0.0
12 (0) - B	0.0	6.5	14.1	0.0	1080.6	4.8	-10.8	0.0	6.5	14.1	0.0
12 (0) - T	0.0	6.3	13.7	0.0	1057.1	4.7	-10.6	0.0	6.3	13.7	0.0