**MECH530 – Assignment 4**

**Philip Becker**

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CHOSEN MATERIAL: graphite\_epoxy\_1

================= GEOMETRY PARAMETERS =================

Layer Number Type Thickness (mm) Orientation (degrees)

-----------------------------------------------------------------

1 ply 0.125 0

2 ply 0.125 0

3 ply 0.125 20

4 ply 0.125 -20

5 ply 0.125 0

6 ply 0.125 90

- core 10.000 N/A

7 ply 0.125 90

8 ply 0.125 0

9 ply 0.125 -20

10 ply 0.125 20

11 ply 0.125 0

12 ply 0.125 0

================= MATRICES =================

[A] Matrix (in N/m):

2.117e+08 1.249e+07 1.055e-10

1.249e+07 6.027e+07 2.519e-09

1.055e-10 2.519e-09 1.890e+07

[a] Matrix (in m/N):

4.783e-09 -9.911e-10 1.054e-25

-9.911e-10 1.680e-08 -2.234e-24

1.054e-25 -2.234e-24 5.291e-08

[D] Matrix (in Nm):

6.268e+03 3.611e+02 1.578e+01

3.611e+02 1.602e+03 2.736e+00

1.578e+01 2.736e+00 5.465e+02

[d] Matrix (in (Nm)^-1):

1.617e-04 -3.642e-05 -4.484e-06

-3.642e-05 6.323e-04 -2.114e-06

-4.484e-06 -2.114e-06 1.830e-03

================= CURVATURES AND OFF-AXIS STRAIN =================

N\_vector (N) = [0.000; 0.000; 0.000]

M\_vector (Nm) = [-2450.000; 0.000; 0.000]

epsilon\_o\_vector = [

0.000e+00

0.000e+00

0.000e+00

]

k\_vector (m^-1) = [

-3.960e-01

8.923e-02

1.099e-02

]

================= PER-LAYER STRESSES AND STRAINS =================

Ply Angle (deg) z\_height (m) Surface Epsilon\_x epsilon\_vector on\_axis\_strain on\_axis\_stress

\_\_\_ \_\_\_\_\_\_\_\_\_\_\_ \_\_\_\_\_\_\_\_\_\_\_\_ \_\_\_\_\_\_\_ \_\_\_\_\_\_\_\_\_\_\_ \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

1 0 0.00575 Top -0.0022773 {'[-2.277e-03, 5.131e-04, 6.317e-05]' } {'[-2.277e-03, 5.131e-04, 6.317e-05]' } {'[-4.125e+02, -1.289e+00, 4.529e-01]' }

1 0 0.005625 Bottom -0.0022278 {'[-2.228e-03, 5.019e-04, 6.180e-05]' } {'[-2.228e-03, 5.019e-04, 6.180e-05]' } {'[-4.036e+02, -1.261e+00, 4.431e-01]' }

2 0 0.005625 Top -0.0022278 {'[-2.228e-03, 5.019e-04, 6.180e-05]' } {'[-2.228e-03, 5.019e-04, 6.180e-05]' } {'[-4.036e+02, -1.261e+00, 4.431e-01]' }

2 0 0.0055 Bottom -0.0021782 {'[-2.178e-03, 4.908e-04, 6.042e-05]' } {'[-2.178e-03, 4.908e-04, 6.042e-05]' } {'[-3.946e+02, -1.233e+00, 4.332e-01]' }

3 20 0.0055 Top -0.0018466 {'[-2.178e-03, 4.908e-04, 6.042e-05]' } {'[-1.847e-03, 1.591e-04, 1.762e-03]' } {'[-3.353e+02, -3.703e+00, 1.263e+01]' }

3 20 0.005375 Bottom -0.0018046 {'[-2.129e-03, 4.796e-04, 5.905e-05]' } {'[-1.805e-03, 1.555e-04, 1.722e-03]' } {'[-3.277e+02, -3.619e+00, 1.235e+01]' }

4 -20 0.005375 Top -0.0018426 {'[-2.129e-03, 4.796e-04, 5.905e-05]' } {'[-1.843e-03, 1.935e-04, -1.631e-03]'} {'[-3.344e+02, -3.336e+00, -1.170e+01]'}

4 -20 0.00525 Bottom -0.0017997 {'[-2.079e-03, 4.685e-04, 5.768e-05]' } {'[-1.800e-03, 1.890e-04, -1.593e-03]'} {'[-3.267e+02, -3.259e+00, -1.143e+01]'}

5 0 0.00525 Top -0.0020792 {'[-2.079e-03, 4.685e-04, 5.768e-05]' } {'[-2.079e-03, 4.685e-04, 5.768e-05]' } {'[-3.767e+02, -1.177e+00, 4.135e-01]' }

5 0 0.005125 Bottom -0.0020297 {'[-2.030e-03, 4.573e-04, 5.630e-05]' } {'[-2.030e-03, 4.573e-04, 5.630e-05]' } {'[-3.677e+02, -1.149e+00, 4.037e-01]' }

6 90 0.005125 Top 0.00045731 {'[-2.030e-03, 4.573e-04, 5.630e-05]' } {'[4.573e-04, -2.030e-03, -5.630e-05]'} {'[7.726e+01, -1.968e+01, -4.037e-01]' }

6 90 0.005 Bottom 0.00044616 {'[-1.980e-03, 4.462e-04, 5.493e-05]' } {'[4.462e-04, -1.980e-03, -5.493e-05]'} {'[7.538e+01, -1.920e+01, -3.939e-01]' }

7 90 -0.005 Top -0.00044616 {'[1.980e-03, -4.462e-04, -5.493e-05]'} {'[-4.462e-04, 1.980e-03, 5.493e-05]' } {'[-7.538e+01, 1.920e+01, 3.939e-01]' }

7 90 -0.005125 Bottom -0.00045731 {'[2.030e-03, -4.573e-04, -5.630e-05]'} {'[-4.573e-04, 2.030e-03, 5.630e-05]' } {'[-7.726e+01, 1.968e+01, 4.037e-01]' }

8 0 -0.005125 Top 0.0020297 {'[2.030e-03, -4.573e-04, -5.630e-05]'} {'[2.030e-03, -4.573e-04, -5.630e-05]'} {'[3.677e+02, 1.149e+00, -4.037e-01]' }

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10 20 -0.005375 Top 0.0018046 {'[2.129e-03, -4.796e-04, -5.905e-05]'} {'[1.805e-03, -1.555e-04, -1.722e-03]'} {'[3.277e+02, 3.619e+00, -1.235e+01]' }

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11 0 -0.0055 Top 0.0021782 {'[2.178e-03, -4.908e-04, -6.042e-05]'} {'[2.178e-03, -4.908e-04, -6.042e-05]'} {'[3.946e+02, 1.233e+00, -4.332e-01]' }

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12 0 -0.005625 Top 0.0022278 {'[2.228e-03, -5.019e-04, -6.180e-05]'} {'[2.228e-03, -5.019e-04, -6.180e-05]'} {'[4.036e+02, 1.261e+00, -4.431e-01]' }

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================= SKATEBOARD RESULTS =================

P = -1960.00 N

L = 0.50 m

b = 0.10 m

M\_1 = (P \* L) / (4 \* b) = -2450.00 Nm

d\_11 = 1.617e-04 Nm^-1

delta\_midpoint = ((P \* L^3) / (48 \* b)) \* d\_11 = -0.82509 cm

The highest magnitude of epsilon\_x is 0.002277 at Ply 12 Bottom – FAIL! (magnitude > 0.002)

The midpoint deflection (delta\_midpoint) is -0.82509 cm – FAIL! (magnitude > 0.5 cm)