**ME 4210 Composites HW10 Robert Ressler**

clear all

clc

format shortg

% Properties

El = [138e9 9e9 0]; % Gpa = Pa e9

G = [6.9e9 0 0]; % Gpa = Pa e9

v = [.32 0 0];

stack = [30 -60 -30 60]; % degrees

thickness = 1e-3; % m

N = [ 2.5e6 1.5e6 1e6 ]; % kN/mm = N/m e6

M = [ 20e3 15e3 10e3 ]; % Nm/mm = Nm/m e3

[ A,B,D ] = laminaStiffness\_ressler(El,v,G,stack,thickness);

E = [A B; B D];

IPR = [N M]';

[E\_inv,Eps\_mid,Curv\_mid,Eps\_layers,Sig\_layers ] = lamina\_analysis\_ressler (E,IPR,E,G,v,thickness,stack)

8.1428e-09 -4.4119e-09 9.9292e-10 9.0895e-07 -1.3631e-06 4.4523e-06

-4.4119e-09 8.1428e-09 9.9292e-10 1.3631e-06 -9.0895e-07 -4.4523e-06

9.9292e-10 9.9292e-10 1.2918e-08 4.7032e-06 -4.7032e-06 5.3523e-22

-9.0895e-07 -1.3631e-06 -4.7032e-06 0.007447 -0.0033152 -0.0032184

1.3631e-06 9.0895e-07 4.7032e-06 -0.0033152 0.007447 -0.0032184

-4.4523e-06 4.4523e-06 -2.3263e-21 -0.0032184 -0.0032184 0.014306

|  |  |
| --- | --- |
| Eps\_mid =  0.056987  -0.028717  0.040406 | Curv\_mid =  58.008  22.691  25.963 |
| Eps\_layers(:,:,1) =  -0.0010208 -0.030025 -0.059029  -0.051408 -0.062754 -0.0741  0.014442 0.0014609 -0.011521  Eps\_layers(:,:,2) =  0.056987 0.027983 -0.0010208  -0.028717 -0.040063 -0.051408  0.040406 0.027424 0.014442  Eps\_layers(:,:,3) =  0.11499 0.085991 0.056987  -0.006026 -0.017372 -0.028717  0.066369 0.053387 0.040406  Eps\_layers(:,:,4) =  0.173 0.144 0.11499  0.016665 0.0053196 -0.006026  0.092332 0.07935 0.066369 | Sig\_layers(:,:,1) =  2.1423e+08 1.5616e+08 9.8083e+07  -2.2181e+08 -1.7233e+08 -1.2285e+08  -1.2491e+08 -9.6592e+07 -6.8274e+07  Sig\_layers(:,:,2) =  3.2521e+08 2.694e+08 2.1359e+08  -3.2436e+08 -2.7488e+08 -2.2541e+08  -1.8292e+08 -1.5264e+08 -1.2236e+08  Sig\_layers(:,:,3) =  8.3637e+08 7.0204e+08 5.6772e+08  -8.1604e+08 -6.8904e+08 -5.6205e+08  4.7326e+08 3.9896e+08 3.2466e+08  Sig\_layers(:,:,4) =  1.0998e+09 9.6646e+08 8.3313e+08  -1.0646e+09 -9.3887e+08 -8.1315e+08  6.3109e+08 5.5483e+08 4.7856e+08 |

function [E\_inv,Eps\_mid,Curv\_mid,Eps\_layers,Sig\_layers ] = lamina\_analysis\_ressler (El,IPR,E,G,v,t,stack)

% lamina\_analysis\_ressler takes a laminate

A = El(1:3,1:3);

B = El(4:6,1:3);

D = El(4:6,4:6);

A\_star = inv(A);

B\_star = -A\_star \* B;

C\_star = B \* A\_star;

D\_star = D - B\*A\_star\*B;

A\_prime = A\_star - B\_star\*inv(D\_star)\*C\_star;

B\_prime = B\_star \* inv(D\_star);

C\_prime = inv(D\_star)\*C\_star;

D\_prime = inv(D\_star);

% Assemble inverse stiffness matrix

E\_inv = [A\_prime B\_prime; C\_prime D\_prime];

% Mid-plane strains and curvature

Eps\_curv\_mid = E\_inv \* IPR;

Eps\_mid = Eps\_curv\_mid(1:3);

Curv\_mid = Eps\_curv\_mid(4:6);

% Preallocate

Eps\_layers = zeros(3,3,length(stack));

Sig\_layers = zeros(3,3,length(stack));

% Lamina stresses and strains

for i = 1:length(stack)

% Sin, Cos for the layer

s = sind(stack(i));

c = cosd(stack(i));

% Transformation matrix to reference coords

T = [c^2 s^2 2\*c\*s; ...

s^2 c^2 -2\*c\*s; ...

-c\*s c\*s c^2-s^2];

T\_E = [c^2 s^2 c\*s; ...

s^2 c^2 -c\*s; ...

-2\*c\*s 2\*c\*s c^2-s^2];

% Q\_bar, reduced stiffness matrix

Q = [ E(1)/(1-v(1)\*v(2)) v(1)\*E(2)/(1-v(1)\*v(2)) 0; ...

v(1)\*E(2)/(1-v(1)\*v(2)) E(2)/(1-v(1)\*v(2)) 0; ...

0 0 G(1)];

Qbar = inv(T) \* Q \* T\_E;

% Lamina layer depth

z\_k = t \* (i-length(stack)/2);

z\_k1 = z\_k - t;

z = [z\_k (z\_k+z\_k1)/2 z\_k1];

for j = 1:length(z)

% Strain in the layer

Eps\_layers(:,j,i) = (Eps\_mid + z(j)\*Curv\_mid)';

% Stress in the layer

Sig\_layers(:,j,i) = Qbar \* Eps\_layers(:,j,i);

end

end

end