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تمرین:تمرین سوم

نام و نام خانوادگی: صبا عباس‌زاده منتظری

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1 Question 1

1.Write a computer program to calculate the off-axis stress field of T300/5208 unidirectional ply based on the following off-axis strain:

$$\left\{\begin{array}{c}\varepsilon_x\\ \varepsilon_y\\ \varepsilon_s\end{array}\right\}=\left\{\begin{array}{c}0.001\\ -0.003\\ 0.004\end{array}\right\}$$

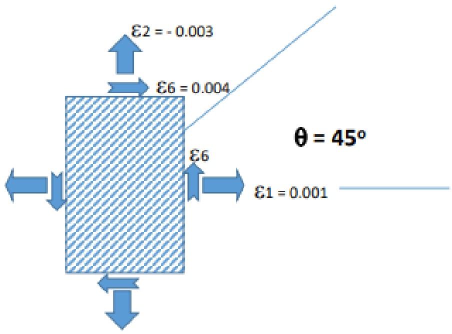

Figure 1: Schematic of problem

Following formula is used for the calculations:

$$\{\sigma_i\}_{1,2,6}=\left[T_\sigma^-\right]\left[Q_{ij}\right]_{x,y,s}\left[T_\varepsilon^+\right]\{\varepsilon_j\}_{1,2,6} \tag{1}$$

The code below implements the equation above. It loads On-axis stiffness matrix from the code of the last exercise. All of the explanations are written as a comment in the code. The values are extracted from the table below: Then we substitute the numbers given in the table below into the matrices:

Type	Material	E_x (GPa)	E_y (GPa)	ν_x	E_s (GPa)	v_f	Specific gravity
T300/5208	Graphite /Epoxy	181	10.3	0.28	7.17	0.70	1.6
B (4)/5505	Boron /Epoxy	204	18.5	0.23	5.59	0.5	2.0
AS/3501	Graphite /Epoxy	138	8.96	0.30	7.1	0.66	1.6
Scotchply 1002	Glass /Epoxy	38.6	8.27	0.26	4.14	0.45	1.8
Kevlar 49 /Epoxy	Aramid /Epoxy	76	5.5	0.34	2.3	0.60	1.46

Table 1: Properties of composite materials

```
clc;
clear all;
%%loading On-axis Stiffness matrix
load('stiffness');
syms teta
m=cos(teta);
n=sin(teta);
%%Positive strain transformation matrix
T_strain_positive=[m^2,n^2,m*n;n^2,m^2,-m*n;-2*m*n,2*m*n,(m^2-n^2)];
%%Negative stress transformation matrix
T_stress_negative=[m^2,n^2,-2*m*n;n^2,m^2,2*m*n;m*n,-m*n,(m^2-n^2)];
```

```
12 %%properties of the composite
13 T300_5208=struct('Ex',181,...
14     'Ey',10.3,...
15     'Vx',0.28,...
16     'Es',7.17);
17 % Compute Vy dynamically and add it to the structure. It is computed by
18 % supposing symmetricity.
19 T300_5208.Vy = T300_5208.Vx * (T300_5208.Ey / T300_5208.Ex);
20 %%Calculation of on-axis stiffness for T300_5208
21 Q_T300_5208=subs(Q,fieldnames(T300_5208), struct2cell(T300_5208));
22 %%Calculation of Positive strain transformation matrix for 45 degree
23 TP=subs(T_strain_positive,[teta],deg2rad(45));
24 %%Calculation of Negative stress transformation matrix for 45 degree
25 TN=subs(T_stress_negative,[teta],deg2rad(45));
26 %%Calculation of off-axis stiffness for T300_5208
27 Q_off=TN*Q_T300_5208*TP;
28 %%Given off-axis strain
29 offaxisstrain=[0.001; -0.003; 0.004];
30 %%Calculation of off-axis stress
31 Sigma_off=Q_off*offaxisstrain;
32 disp(vpa(Sigma_off , 3));
33 %%Saving transformation tensors in case we need it later
34 T_strain_negative=[m^2,n^2,-m*n;n^2,m^2,m*n;2*m*n,-2*m*n,(m^2-n^2)];
35 T_stress_positive=[m^2,n^2,2*m*n;n^2,m^2,-2*m*n;-m*n,m*n,(m^2-n^2)];
36 save('Transformations.mat', 'T_strain_positive', 'T_strain_negative',...
37 'T_stress_positive', 'T_stress_negative');
```

Lines 34 to 37 are written for saving the transformation matrices to use it in the next codes.

The answer calculated by the mentioned code:

$$\begin{Bmatrix} \varepsilon_1 \\ \varepsilon_2 \\ \varepsilon_6 \end{Bmatrix} = \begin{Bmatrix} 0.101 \\ 0.044 \\ 0.101 \end{Bmatrix} \tag{2}$$

2 Question 2

2. How does a [45] deform under uniaxial tensile stress: A,B or C?.

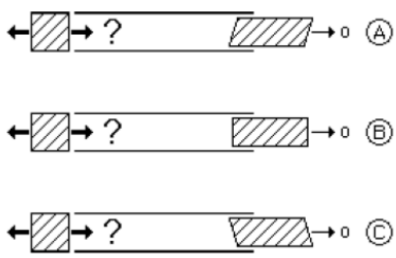

Figure 2: Schematic of problem

We write a code with the assumption that an Off-axis stress with magnitude of one and direction of 1-axis is applied to the composite.

$$\{\varepsilon_i\}_{1,2,6} = \left[T_{\varepsilon}^{-}\right] \left[S_{ij}\right]_{x,y,s} \left[T_{\sigma}^{+}\right] \{\sigma_j\}_{1,2,6} \tag{3}$$

```
%%We load the On-axis compliance matrix and transformation matrices
load('compliance')
load('Transformations')
S_T300_5208=subs(S,fieldnames(T300_5208), struct2cell(T300_5208));
%%Calculation of Positive stress transformation matrix for 45 degree
TP=subs(T_stress_positive,[teta],deg2rad(45));
%%Calculation of Negative strain transformation matrix for 45 degree
TN=subs(T_strain_negative,[teta],deg2rad(45));
%%Calculation of off-axis compliance for T300_5208
S_off=TN*S_T300_5208*TP;
%%Given off-axis stress
offaxisstress=[1; 0; 0];
%%Calculation of off-axis strains
strain_off=S_off*offaxisstress;
disp(vpa(strain_off, 3));
```

The answer shows:

$$\begin{Bmatrix} \varepsilon_1 \\ \varepsilon_2 \\ \varepsilon_6 \end{Bmatrix} = \begin{Bmatrix} 0.060 \\ -0.010 \\ -0.046 \end{Bmatrix} \tag{4}$$

Negative shear strain shows that the answer is **(c)**.

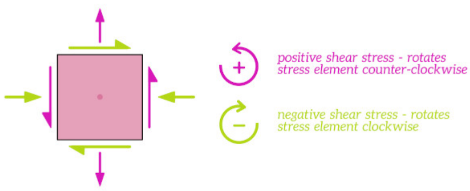

Figure 3: Positive and negative shear loading

3 Question 3

3.If a positive torque is applied to a [45] tube, what will be the resulting length: A,B or C?

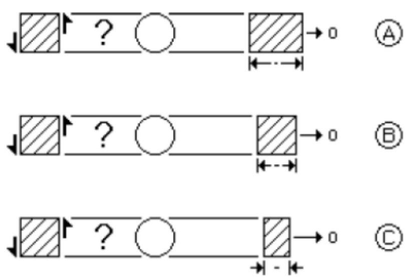

Figure 4: Schematic of problem

We assume that a positive torque with magnitude of one is applied to composite. With the off-axis compliance the off-axis strains can be deriven.

```
%%Given off-axis strain
torque=[0; 0; 1];
%%Calculation of off-axis strain
strain=S_off*torque;
disp(vpa(strain, 3));
```

strain:

$$\begin{Bmatrix} \varepsilon_1 \\ \varepsilon_2 \\ \varepsilon_6 \end{Bmatrix} = \begin{Bmatrix} -0.046 \\ -0.046 \\ +0.106 \end{Bmatrix} \tag{5}$$

Therefore the element becomes shorter due to negative strains in 1 and 2 directions and the answer is **(c).**

4 Question 4

4.Under a torque loading of [-45] and [+45] tubes are conneted by a butt joint, what is the final shape: A,B or C?

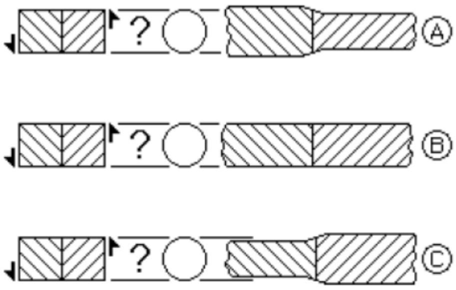

Figure 5: Schematic of problem

The strains for +45 degree are calculated in the previous problem and the answer is equation 5. The strains for -45 degree composite are calculated by the code below:

```
%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%
%%Given off-axis strain
torque=[0; 0; 1];
%%Calculation of off-axis strain for positive 45
strain=S_off*torque;
disp(vpa(strain, 3));
%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%
%%Calculation of Positive stress transformation matrix for 45 degree
TP_minus45=subs(T_stress_positive,[teta],deg2rad(-45));
%%Calculation of Negative strain transformation matrix for 45 degree
TN_minus45=subs(T_strain_negative,[teta],deg2rad(-45));
%%Compliance for -45
S_off_minus45=TN_minus45*S_T300_5208*TP_minus45;
%%strains for negative 45 degree
strain_minus45=S_off_minus45*torque;
disp(vpa(strain_minus45, 3));
```

$$
\left\{ \begin{array}{c} \varepsilon_1 \\ \varepsilon_2 \\ \varepsilon_6 \end{array} \right\} = \left\{ \begin{array}{c} +0.046 \\ +0.046 \\ +0.106 \end{array} \right\} \tag{6}
$$

Therefore the element at the left side [-45] expands and the element at the right side becomes smaller so the asnwer is **(a).**