دانشکده مهندسی مکانیک

درس مکانیک کامپوزیت پیشرفته

تمرین:تمرین دوم

نام و نام خانوادگی: صبا عباس‌زاده منتظری

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1 Question 1

1.Given two pieces of a unidirectional composite material joined in a manner shown in Figure below determine the deformed shape under uniaxial stress. Is deformed shape a,b or c? what principle is involved?

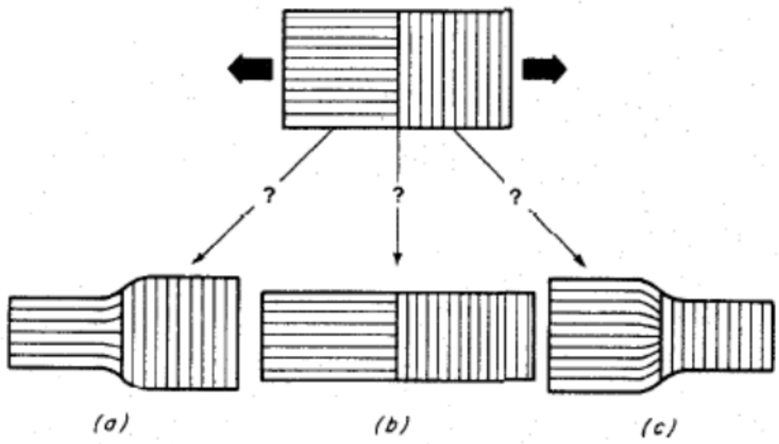

Figure 1: Possible deformed shapes of a 0/90 composite

For a 0 degree composite in on axis coordinate:

$$\begin{aligned} \varepsilon_x &= \frac{1}{E_x}\sigma_x \\ \varepsilon_y &= -\frac{\nu_x}{E_x}\sigma_x = -\nu_x\varepsilon_x \end{aligned} \tag{1}$$

For a 90 degree composite in on axis coordinate: he strain equations in the y-direction are:

$$\begin{aligned} \varepsilon_y &= \frac{1}{E_y}\sigma_y \\ \varepsilon_x &= -\frac{\nu_y}{E_y}\sigma_y = -\nu_y\varepsilon_y \end{aligned} \tag{2}$$

Now, in the global coordinate system along the y-direction, the strain for the intersection line is calculated as:

$$\begin{aligned} \varepsilon_{y0,\text{global}} &= -\frac{\nu_x}{E_x}\sigma \\ \varepsilon_{y90,\text{global}} &= -\frac{\nu_y}{E_y}\sigma \end{aligned} \tag{3}$$

The compliance matrix in 2D (without shear loading) is:

$$\begin{bmatrix} \varepsilon_x \\ \varepsilon_y \end{bmatrix} = \begin{bmatrix} \frac{1}{E_x} & -\frac{\nu_{xy}}{E_x} \\ -\frac{\nu_{yx}}{E_y} & \frac{1}{E_y} \end{bmatrix} \begin{bmatrix} \sigma_x \\ \sigma_y \end{bmatrix} \tag{4}$$

By symmetry of the compliance matrix:

$$\frac{\nu_x}{E_x} = \frac{\nu_y}{E_y}$$

From this, it can be concluded that the strains along theglobal y-direction are the same. Therefore, the correct deformed shape is **(b)**.

2 Question 2

2. Write a computer program to calculate the stiffness and compliance matrices of T300/5208 unidirectional ply.

First we compute stiffness(Q) and compliance(S) matrices for Transversely isotropic materials and save it into a file to load it whenever we want:

```
clc;
clear all;
syms Ex Vx Ey Vy Es
S=[1/Ex,-Vy/Ey,0;-Vx/Ex,1/Ey,0;0,0,1/Es]
save('compliance','S')
Q=[Ex/(1-Vx*Vy),(Vy*Ex)/(1-Vx*Vy),0;(Ey*Vx)/(1-Vx*Vy),(Ey)/(1-Vx*Vy),0;0,0,Es]
save('stiffness','Q')
% Confirmation message
disp('Matrices saved successfully!')
```

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

Now we should load the code and substitute:

```
load('compliance')
load('stiffness')
%%properties of the composite
T300_5208=struct('Ex',181,...
    'Ey',10.3,...
    'Vx',0.28,...
    'Es',7.17);
% Compute Vy dynamically and add it to the structure. It is computed by
% supposing symmetricity.
T300_5208.Vy = T300_5208.Vx * (T300_5208.Ey / T300_5208.Ex);

S_T300_5208=subs(S,fieldnames(T300_5208), struct2cell(T300_5208));
Q_T300_5208=subs(Q,fieldnames(T300_5208), struct2cell(T300_5208));
%%Show S
disp('Numerical Compliance Matrix (S):');
disp(vpa(S_T300_5208, 4));
%%Show Q
disp('Numerical Stiffness Matrix (Q):');
```

```
disp(vpa(Q_T300_5208, 4));
```

Answers:

$$S = \begin{bmatrix} 0.005525 & -0.001547 & 0 \\ -0.001547 & 0.09709 & 0 \\ 0 & 0 & 0.1395 \end{bmatrix}$$

$$Q = \begin{bmatrix} 181.8 & 2.897 & 0 \\ 2.897 & 10.35 & 0 \\ 0 & 0 & 7.17 \end{bmatrix}$$

3 Question 3

3. Write a computer program to find the stress field based on the following strain field for T300/5208 unidirectional ply.

$$\left\{ \begin{array}{c} \varepsilon_x \\ \varepsilon_y \\ \varepsilon_s \end{array} \right\} = \left\{ \begin{array}{c} 0.001 \\ 0.003 \\ 0.002 \end{array} \right\}$$

We multiply Q matrix and given strain:

```
%%define strain
epsilon=[0.001;0.003;0.002]
%%constitutive law
sigma=Q_T300_5208*epsilon,
disp(vpa(sigma, 4));
```

Answer:

$$\left\{ \begin{array}{c} \sigma_x \\ \sigma_y \\ \sigma_s \end{array} \right\} = \left\{ \begin{array}{c} 0.1905 \\ 0.03394 \\ 0.01434 \end{array} \right\}$$