Mid-Term Exam: Smart Materials and Design

Date: April 28 (Mon)
Time: 14:00 – 15:15

1.

We wish to estimate the properties of composites made using a new fiber, (NF). Test data from composites made with this new fiber and 3501-6 matrix resin are available from a 60% V_f composite longitudinal tensile test and a 60% V_f composite transverse tensile test. It is also known that the new fiber geometry (size and surface features) are similar to that of AS4 fibers. The properties of AS4 fibers, 60% Vf AS4/3501-6 composites, and 3501-6 matrix resin are all known, and are given in the table below. With this information, estimate E_{Lf} and E_{Tf} of the new fiber, and E_L and E_T at 50% and 70% V_f for the NF/3501-6 composites.

	E_L (Msi)	E_T (Msi)	ν_{LT}	G_{LT} (Msi)
AS4/3501-6 (60% Vf)	20.6	1.42	0.30	.87
AS4 Fiber	34.0	2.30		
3501-6 matrix	0.5		0.35	
NF/3501-6 (60%)	26.3	1.50		

2.

Consider test specimens 2" wide made of the following layups of AS4/3501-6 plies. The ply thicknesses are all 0.005", and the fiber volume fractions are all 60%.

a) $[0_4]_T$

A 2000 lb. tensile load is applied in the x direction. No transverse or shear loads are applied. Compute the A and a matrices, and find ε_x, ε_y, and ε_{xy} in each case. Sketch the deformation (qualitatively, not to scale) and comment briefly on the key features of the deformation in each case. Please explain what you are doing at each step with clear equations, even if you are having the computer do the math. Show all intermediate steps and results clearly for at least one case.

3.

Compute the $\underset{\sim}{A}$, $\underset{\sim}{B}$, $\underset{\sim}{D}$ matrices for each of the following laminates,

$$[15_2/0_2/-15_2]_t$$

Indicate what type of coupling exists for each of these layups, (i.e.extension-shearing, extension-bending, extension-twisting, bending-twisting, etc.). Note the following definitions,

extension --	$\varepsilon_x, \varepsilon_y$	bending --	κ_x, κ_y
shearing --	γ_{xy}	twisting --	κ_{xy}

The laminates are all made from AS4/3501-6 whose properties are given below. The foam is Rohacell, which is isotropic, has a very small modulus E = .014 Msi, ν = .45, G = .005 Msi, and gives a negligible contribution to the bending stiffness

E_L (Msi)	E_T (Msi)	ν_{LT}	G_{LT} (Msi)	t_{ply}
20.6	1.42	.30	.87	.005"

X_t (Ksi)	X_c (Ksi)	Y_t (Ksi)	Y_c (Ksi)	S (Ksi)
330	-180	7.5	-35	14

4.

Given a $[45_2/0]_s$ laminate plate, 3" by 12" ,which is subjected to a physical bending moment M_o (in-lbs) at its ends. The plate is made of AS4/3501-6 material. Determine the maximum bending moment M_o that causes first-ply failure in the laminate . Use both the Maximum Stress and the Tsai-Wu criteria, and indicate what sort of first-ply failure you would expect . What is the curvature κ_x , and the radius of curvature R_x , when this first-ply failure occurs?