Project (#3): In-Plane Loaded Composite Laminate

Due Date: Upload zip folder to TED by 11:58 PM, Friday March 13, 2020

<u>Files in your MATLAB Folder:</u>
Download from TED: SE160A_3_Composites_Input.xlsx
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<u>Your created (m) file:</u>
For Undergraduate Students: SE160A_3_LastName_FirstName.m
For Graduate Students: SE260A_3_LastName_FirstName.m

<u>Analytical Study answers are saved in a (pdf):</u>
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Laminated composite materials offer improved performance and reduced weight. The properties of these materials are highly dependent upon the fibers, the resin, and most importantly the manufacturing methods. Variations in the manufacturing methods can lead to changes in the fiber volume fraction (V_f) or even worse internal delaminations that result in lower laminate strength. In this MATLAB project, you will begin with the fiber and resin properties and then combine them to form a composite lamina. These lamina will be stacked to form a symmetric laminate (12-ply maximum). The equivalent stiffness properties will be determined. Finally, laminate will be subjected to in-plane loads (Nx, N_y, N_{xy}) to determine the in-plane laminate strains and ply stresses.

Although it is beyond the class expectations, interested students can easily apply one of the laminated composite failure theories to determine the margin of safety of the overall laminate. To accomplish this task, first the stresses (σ_{11}, σ_{22}, τ_{12}) in each ply are determined, then the three margins of safety (fiber, matrix, shear) are determined for each ply, and finally the overall lowest margin of the laminate is determined. Knowing the lowest margin of safety will identify the critical ply and the associated failure mode.

ANALYTICAL STUDY (Use your MATLAB code to answer questions and submit using pdf file)

1.) **QUASI-ISOTROPIC LAMINATES**. Consider carbon/epoxy laminates fabricated with (IM7) carbon fibers and (3501-6) epoxy with an areal fiber weight of (150 g/m^2) and (RC=30%).

a.) Compare (A_{11}, A_{12}, A_{66}) and (E_x, G_{xy}, ν_{xy}) for the following:
t_{ply} = 0.050 inch, $[0/60/-60]_{2S}$
t_{ply} = 0.050 inch, $[0/120/30/90/60/-30]_S$
t_{ply} = 0.075 inch, $[0/45/-45/90]_S$
t_{ply} = 0.075 inch, $[20/65/-25/110]_S$

b.) Applying an in-plane load (N_x = 5,000 lb/in, N_y = N_{xy} = 0 lb/in) to the four laminates of part (a.), calculate the strain (ε_{xx}, ε_{yy}, γ_{xy}) in the four laminates. Calculate the stress (σ_{xx}) in each ply. Calculate the fiber stress (σ_{11}) in each ply. Is there a best laminate? Which one, why?

c.) Applying an in-plane shear load (N_x = N_y = 0 lb/in, N_{xy} = 5,000 lb/in) to the four laminates of part (a.), calculate the strain (ε_{xx}, ε_{yy}, γ_{xy}) in the four laminates. Calculate the shear stress (τ_{xy}) in each ply. Calculate the fiber stress (σ_{11}) and the matrix shear stress (τ_{12}) in each ply. Is there a best laminate? Which one, why?

2.) **OFF-ANGLE SYMMETRIC LAMINATES**. An aerospace structures engineer has developed an invention. The design will only work with a material having a large negative extension-shear coupling ($\eta_{x,xy}$). The engineer considers using a thick (t_{ply} = 0.10 inch) single ply of carbon/epoxy laminate that is fabricated with (IM7) carbon fibers and (3501-6) epoxy with an areal fiber weight of (150 g/m^2) and (RC=30%). If the engineer can only cut material in 5-degree increments, what orientation angle (θ) between (0) and (90) degrees, will provide the largest negative ($\eta_{x,xy}$).