Design Project

UCK236E - Composite Materials
Faculty of Aeronautics and Astronautics
Istanbul Technical University

Due: 19 June 2020

The project will contribute to 40% of your overall grade!

In this project, you are responsible for designing a symmetric stacking sequence satisfying a set of requirements. You will work as groups to design, analyze and potentially optimize your own stacking sequence. A final report, expected to be the order of 10 pages, must be submitted online by the deadline, clearly showing all necessary calculations and justifying the selections of material and ply orientations.

Two groups which designed the stacking sequences with minimum weight and highest in-plane specific modulus will be rewarded with extra credits, 20% each.

For any questions regarding the design problem, you are highly encouraged to discuss the problem with the TA(s) as soon as possible. The design problem will require exhaustive calculations, thus developing a user-friendly program written with a programming language of your choice is recommended!

Problem Definition

Consider a square plate with an edge-length of $a = 0.4$ m, operating as a panel structure on a military jet. The loads acting on the plate are given as follows:

$$\boldsymbol{N} = \begin{bmatrix} N_x & N_y & N_{xy} \end{bmatrix}^T = \begin{bmatrix} 50 & -50 & 1 \end{bmatrix}^T kN/m \tag{1}$$

$$\boldsymbol{M} = \begin{bmatrix} M_x & M_y & M_{xy} \end{bmatrix}^T = \begin{bmatrix} -2 & 7 & 1 \end{bmatrix}^T N.m/m \tag{2}$$

Your task is to design a 6-ply symmetric laminate with a ply thickness of 0.25 mm by selecting appropriate materials and ply orientations, so that your design can sustain the loading conditions described in Equations 1 and 2. You can choose different materials for different plies from Table 1.

The design requirements and restrictions are defined as follows:

- The stresses in individual plies must be lower than the ply strength given in Table 1. Use a factor of safety, $n_s = 2$.
- Magnitudes of global mid-plane strains must be lower than 5×10^{-3} m/m. Use a factor of safety, $n_s = 2$.
- Magnitudes of global mid-plane curvatures must be lower than 4 m^{-1}. Use a factor of safety, $n_s = 2$.

Table 1: Material selection table

Material	$\boldsymbol{E_{11}}$ **[GPa]**	$\boldsymbol{E_{22}}$ **[GPa]**	$\boldsymbol{G_{12}}$ **[GPa]**	$\boldsymbol{\nu_{12}}$	**Density [kg/m³]**	$\boldsymbol{\sigma_{11}}$ **[MPa]**	$\boldsymbol{\sigma_{22}}$ **[MPa]**	$\boldsymbol{\tau_{12}}$ **[MPa]**
Boron/Epoxy	207	19	6.4	0.21	1990	1585	63	131
AS Carbon/Epoxy	128	9	5.7	0.25	1540	1448	62	60
T-300/Epoxy	138	10	6.5	0.21	1550	1448	45	62
HMS Carbon/Epoxy	171	13.8	5.9	0.20	1630	827	86	72
GY-70/Epoxy	262	8.3	4.1	0.25	1690	586	41	97
Kevlar 49/Epoxy	76	5.5	2.1	0.34	1380	1379	28	60
E-Glass/Epoxy	32	4.8	4.8	0.30	1800	1103	97	83

Based on the above design criterion, follow the steps below:

1. Select materials and ply orientations for a symmetric stacking sequence consisting of 6 plies
2. Compute **A**, **B**, **D** matrices and solve the governing equations for mid-plane strains and curvatures
3. Plot the variation of global and local strains and stresses along the thickness
4. Determine in-plane and flexural engineering constants of the laminate
5. Calculate the mass and specific in-plane axial modulus of the laminate