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ME599: ADVANCED MECHANICS OF COMPOSITE MATERIALS
TAKEHOME FINAL EXAM SPRING QTR 2003 PROF. M. TUTTLE

Solutions are due by 5PM, Wednesday 11 June

(see Notes on following page)

1. A $[0_2/90/0]_s$ laminate is cured at $175°C$ and then cooled to room temperature ($20°C$). The laminate is trimmed in the shape of a rectangular panel with aspect ratio of 0.75, where the dimension of the plate parallel to the *x*-axis is 150 *mm*. The panel is mounted in a frame that provides type S4 simple supports. The following loads are then applied:

$$q(x,y) = (100N/m^2)\sin(\pi x/a)\sin(\pi y/b)$$
$$N_{xx} = 200kN/m$$
$$Nyy = 100kN/m$$
$$N_{xy} = 0$$

Predict whether the panel will fail under the conditions described, according to a first-ply failure analysis and based on the Maximum Stress Failure Criterion.

2. A $[30_2/90/0]_s$ laminate is cured at $175°C$ and then cooled to room temperature ($20°C$). The laminate is trimmed in the shape of a rectangular panel with aspect ratio of 0.75, where the dimension of the plate parallel to the *x*-axis is 150 *mm*. The panel is then mounted in a frame that provides type S4 simple supports. The following loads are applied:

$$q(x,y) = (100N/m^2)$$
$$N_{xx} = 200kN/m$$
$$Nyy = 100kN/m$$
$$N_{xy} = 0$$

The panel is analyzed using a Ritz analysis with $M = N = 10$. Since the plate is simply-supported, the bending moment M_{xx} should (rigorously speaking) equal zero along the edge $x = a$. However, a finite series has been used (i.e., $M = N = 10$) and therefore (according to the numerical solution) M_{xx} will not equal zero along $x = a$. Plot the value of M_{xx} along the edge $x = a$ that is implied by a Ritz solution in which $M = N = 10$.

Notes:

1. The composite panels are produced using a graphite-epoxy prepreg system that is cured at a temperature of $175°C$ and exhibits the following properties at room temperature:

$E_{11} = 135GPa$ $E_{22} = 10GPa$ $G_{12} = 8GPa$

$\nu_{12} = 0.25$ $\alpha_{11} = -1.5\mu m/m - °C$ $\alpha_{22} = 28.0\mu m/m - °C$

$\sigma_{11}^{fT} = 1500MPa$ $\sigma_{11}^{fC} = 1200MPa$

$\sigma_{22}^{yT} = 50MPa$ $\sigma_{22}^{yC} = 100MPa$

$\tau_{12}^{y} = 75MPa$

ply thickness = 0.125 *mm*

2. Any computer program that can be downloaded from the ME599 website can be used as necessary.

3. Recall that, according to a first-ply failure analysis, the "failure load" is the load that will cause the first ply failure within a structure.

4. Recall that, according to the Maximum Stress Failure Criterion, a ply failure will occur if any of the following conditions exist:

if: $\sigma_{11} = \sigma_{11}^{fT}$ (failure occurs due to tensile fiber fracture)

if: $\sigma_{11} = \sigma_{11}^{fC}$ (failure occurs due to compressive fiber fracture/crushing/microbuckling)

if: $\sigma_{22} = \sigma_{22}^{yT}$ (failure occurs due to matrix yielding in tension)

if: $\sigma_{22} = \sigma_{22}^{yC}$ (failure occurs due to matrix yielding in compression)

if: $|\tau_{12}| = \tau_{12}^{y}$ (failure occurs due to matrix yielding in shear)