AERO 516: Quals Review

January 21, 2016

1 Basic Concepts - Week 1

1.1 Properties of Composites

- Out-of-plane properties are generally very weak
- Much manufacturing variability
- Greatest specific stiffness of any material

Figure 1: Sodano's whip

1.2 Fiber Notes

- Types: glass, carbon, SiC, boron, polymer
- Tow is the number of filaments
- Carbon fiber: 225-500 GPa modulus, 3400-6400 MPa strength

2 Lamina Stress-Strain Relationships - Week 1

2.1 Stress-Strain Basics

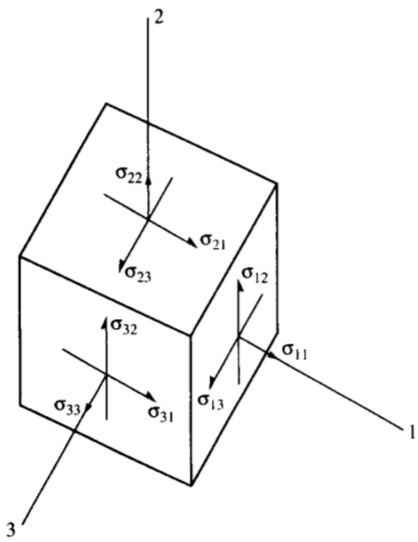


Figure 2: 3D stress representation

Table 1: Elastic coeffs

Material and coord sys	# non-zero coeffs	# ind coeffs
3D aniso	36	21
3D gen ortho (non-princ)	36	9
3D special ortho (princ)	12	9
3D transversely iso	12	5
3D iso	12	2
2D aniso	9	6
2D gen ortho	9	4
2D special ortho (princ)	5	4
2D square sym	5	3
2D iso	5	2

- $\{\boldsymbol{\sigma}\} = [\mathbf{C}]\{\boldsymbol{\epsilon}\}, C$ is the stiffness matrix
- $\{\boldsymbol{\epsilon}\} = [\mathbf{S}]\{\boldsymbol{\sigma}\}, S$ is the compliance matrix
- $\mathbf{S} = \mathbf{C}^{-1}$
- Stress and strain can be averaged over a specimen, such as:
- $\bar{\sigma_i} = \int_V \sigma_i dv/V$ and $\bar{\epsilon} = \int_V \epsilon_i dv/V$
- $\bar{\sigma_i} = C_{ij}\bar{\epsilon_j}$ and $\bar{\epsilon} = S_{ij}\bar{\sigma}$
- $W = \frac{1}{2}C_{ij}\epsilon_i\epsilon_j$
- S, the compliance matrix, contains the simpler terms in regards to engineering terms

TODO: flesh this out, include 6x6 for special cases

2.2 Generally Orthotropic Lamina

3 Effective Moduli of a Continuous Fiber-Reinforced Lamina - Week 2

3.1 Elementary Mechanics of Materials

3.2 Improved Mechanics of Materials

3.3 Micromechanics

4 Strength of a Lamina - Week 3

4.1 Maximum Strength

4.2 Maximum Stress

4.3 Maximum Strain

5 Analysis of Laminates - Week 3

5.1 Basics

5.2 Classical Lamination Theory

5.2.1 Assumptions

5.2.2 Definitions

5.2.3 Special Properties

5.3 Laminate-Force Relations - Week 4

5.3.1 Determining Strain

5.3.2 Determining Engineering Constants

5.4 Hygrothermal Effects

6 Previous Qual Questions - Week 5

6.1 Fall 2015

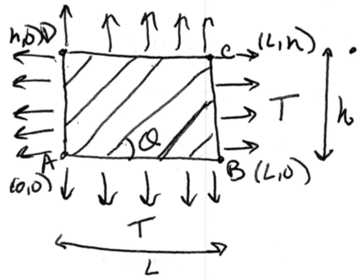
1. By conducting two tests (you can use as many strain sensors you want), determine E_1, E_2, ν_{12}, ν_{21}, G_{12} for a lamina. You cannot apply pure shear - you can only apply normal stress and rotate the lamina with some angle to make it not aligned with the load.

2. Choose a configuration (I chose 90/0/0/90) for a laminate. Perform three tests to obtain E_x, E_y, ν_{12}, ν_{21}, G_{12}.

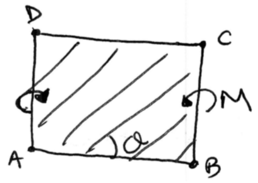
3. Can we determine lamina properties from the laminate properties? (My answer is yes: you can write E_x , ..., G_{xy} as some linear function of E_1 , ..., G_{12} . Then you just solve this linear equations set. But Sodano did not tell me its correct or not.)

6.2 Winter 2015

516 2015



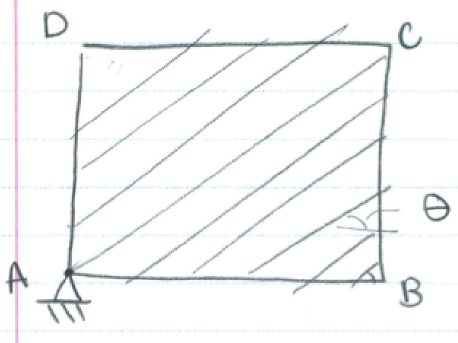
• Calculate the deformed coordinates for C.

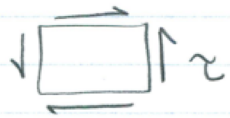


• What is the deformed shape?
(i.e. calculate the strains & curvatures to get eq. for w)

6.3 Winter 2014

AE510 PRELIM - WAAS





find displacements @ pt. C & D

$$\begin{Bmatrix} \varepsilon_x \\ \varepsilon_y \\ \gamma_{xy} \end{Bmatrix} = [\bar{S}] \begin{Bmatrix} \cancel{\sigma_x} \\ \cancel{\sigma_x} \\ \tau_{xy} \end{Bmatrix} \qquad \begin{aligned} \varepsilon_x &= \bar{S}_{16}\tau \\ \varepsilon_y &= \bar{S}_{26}\tau \\ \gamma_{xy} &= \bar{S}_{66}\tau \end{aligned}$$

$$\frac{\partial u}{\partial x} = \bar{S}_{16}\tau \qquad u = \bar{S}_{16}\tau x + f(y) \qquad \frac{\partial v}{\partial x} + \frac{\partial u}{\partial y} = \underbrace{g'(x)}_{\text{must be constant}}^{C_1} + \underbrace{f'(y)}_{\text{must be constant}}^{C_2} = \bar{S}_{66}\tau$$

$$\frac{\partial v}{\partial y} = \bar{S}_{26}\tau \qquad v = \bar{S}_{26}\tau y + g(x)$$

$$g(x) = C_1 x + C_3 \qquad C_1 + C_2 = \bar{S}_{66}\tau$$

$$f(y) = C_2 y + C_4 \qquad u = \bar{S}_{16}\tau x + C_2 y + C_4$$

$$v = \bar{S}_{26}\tau y + C_1 x + C_3$$

BC:s

$u(0,0) = 0 \rightarrow u(0,0) = C_4 \Rightarrow C_4 = 0$

$v(0,0) = 0 \rightarrow v(0,0) = C_3 \Rightarrow C_3 = 0$

$\omega(0,0) = 0$

$$\omega = \frac{1}{2}\left(\frac{\partial u}{\partial y} - \frac{\partial v}{\partial x}\right) = \frac{1}{2}\left(C_2 - C_1\right) = 0 \Rightarrow C_1 = C_2$$

$$2C_1 = \bar{S}_{66}\tau$$

$$C_1 = C_2 = \frac{1}{2}\bar{S}_{66}\tau$$

$$\boxed{\begin{aligned} u &= \bar{S}_{16}\tau x + \tfrac{1}{2}\bar{S}_{66}\tau y \\ v &= \bar{S}_{26}\tau y + \tfrac{1}{2}\bar{S}_{66}\tau x \end{aligned}}$$