Mechanics of Composite Materials, Second Edition
with PROMAL Software

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http://www.autarkaw.com/books/composite/index.html

Errors/Typographical Mistakes in Second Edition

Some corrections have already been made in the second print of the book

Page 4: Equation 1.3 should read as

$$M = \frac{PL^2}{u}\frac{1}{E/\rho}$$

Page 84: Figure 2.12 should have a label of C just like in Figure 2.13.

Page 90: Last line Equation 2.48(d) should read as

$$\tau_{23} = \tau_{2'3'}$$

Page 91: Equation 2.50(b).

$C_{1'4}$ should read as C_{14}

Page 93: Line after Equation 2.57 should read as

Similarly, as shown in Figure 2.16b, apply $\sigma_1 = 0$, $\sigma_2 \neq 0$, $\sigma_3 = 0$, $\tau_{23}=0$, τ_{31}

Page 104. Last line should read as

through Equation (~~2.98~~ 2.79) and Equation (2.92) as

Page 96. First line should read as

Inversion of Equation (2.70) would be the (~~compliance~~) stiffness matrix [C] and is

Page 111: Equation 2.99 should have an = sign rather than a – sign. Equation 2.99 should read as

$$\begin{bmatrix} \varepsilon_1 \\ \varepsilon_2 \\ \gamma_{12}/2 \end{bmatrix} = [T] \begin{bmatrix} \varepsilon_x \\ \varepsilon_y \\ \gamma_{xy}/2 \end{bmatrix},$$

Page 112: The last term of $\bar{Q}_{12}$, in Eqn 2.104 (b) should be s^4. The corrected equation is

$$\bar{Q}_{12} = (Q_{11} + Q_{22} - 4\,Q_{66})\,s^2\,c^2 + Q_{12}\,(c^4 + s^4),$$

Page 112: In equation (105) , the last column vector should read as

$$\begin{bmatrix} \sigma_x \\ \sigma_y \\ \tau_{xy} \end{bmatrix},$$

the last element of the vector should have a τ .

Page 113: The second word $\bar{S}_{ij}$ on first line of the page should have a bar on top.

Page 144: Eighth line from top, = sign is missing in

$$\sigma_1 = 0.1714 \times 10^1\,R$$

Page 168. Replace problem#2 by this problem (go to end of this document) as the engineering constants in the problem are not valid.

Page 168. Replace problem#3 by the problem (go to end of this document) as the [C] matrix is not valid.

Page 206: Equation 3.3a-c should have ρ instead of r. It should read as

$$w_c = \rho_c \, v_c ,$$
$$w_f = \rho_f \, v_f \text{ , and}$$
$$w_m = \rho_m \, v_m .$$

Page 210: first line, 0.3 should be 0.7

Page 210: Bottom line ~~0.1896x10^3~~ 1.896×10^3

Page 212: Line 10 from top: "For composites with a certain volume of voids ~~V~~ v_v"

Pg. 217: In the third diagram of Figure 3.3, the thickness of the fiber should be noted as "t_f" instead of "t_r"

Pg. 227: In Figure 3.11(b), the bottom dimension line for t_f should be in line with the bold line of the original shape instead of the dotted line of the deformed shape.

Page 239: Top of page ~~G~~ G_{12}=8.130 *GPa*

Page 282: Eighth line from top: *formula (3.76)* should read as *formula (3.171)*

Problem 3.18: ~~60%~~ unidirectional

Page 313: *28. Shepery* should read as *28. Shapery*

Page 318: Fifth row from top, "A notation of $\mp$45° would indicate the -45° angle ply ...."

Page 400: Line 8 should read as

$$E_b = 10.3 \times 10^6 \frac{1}{12}(4)(1)^3$$

Page 400: Line 17 should read as

$$3.433 \times 10^6 = 26.25 \times 10^6 \frac{1}{12} 4 \, h^3$$

Page 402: **Footnote**: The number *0.0004921 in*. should read as *0.004921 in*.

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Errors in First Edition

Page 62: Eqn 2.8. should read as

$$\varepsilon_x = \frac{\partial u}{\partial x},$$

Page 71: "*stiffness matrix (Equation 2.36)*" should read as "*compliance matrix (equation (2.36))*"

Page 73: "*stiffness matrix (Equation 2.36)*" should read as "*compliance matrix (equation (2.39))*"

Page 74: 5th line from top - spelling mistake "*monoclic*" should read as "*monoclinic*"

Page 93: The second last matrix should read as

$$[\bar{Q}] = \begin{bmatrix} 0.8053\times10^{-10} & -0.7878\times10^{-11} & -0.3234\times10^{-10} \\ -0.7878\times10^{-11} & 0.3475\times10^{-10} & -0.4696\times10^{-10} \\ -0.3234\times10^{-10} & -0.4696\times10^{-10} & 0.1141\times10^{-9} \end{bmatrix}^{-1}$$

Page 105: Equation (2.132b) should have "Q_{22}" instead of "Q_{12}". It should read as

$$U_2 = \frac{1}{2}(Q_{11} - Q_{22}),$$

Page 119: Units of S are MPa

Page 121: Units of S are MPa

Page 124: Eqn 2.159 - Put "2" in front of H_{12}

$$(H_1 + H_2)\sigma + (H_{11} + H_{22} + 2H_{12})\sigma^2 = 1.$$

Page 124: In eqn 2.160, put "-" instead of "+" in front of $(H_{11} + H_{22})\sigma^2$. The eqn should read as

$$H_{12} = \frac{1}{2\sigma^2}[1 - (H_1 + H_2)\sigma - (H_{11} + H_{22})\sigma^2].$$

Page 138: Problem 2.38 - Line 1, Add "*$\sigma > 0$*" after "*$\sigma_x = -\sigma$, $\sigma_y = -\sigma$.*"

Page 141: Matrix C should be

$$[C] = \begin{bmatrix} 9 & 33 & 38 & 54 \\ 12 & 45 & 48 & 69 \\ 23 & 90 & 82 & 121 \\ & & & \end{bmatrix}.$$

Page 183: An = sign is missing after τ_{yz}

Footnote should read as

…….. Hydrostatic stress is defined as

$$\sigma_{xx} = \sigma_{yy} = \sigma_{zz} = p,\ \tau_{xy} = 0, \tau_{yz} = 0, \tau_{zx} = 0$$

Page 213: Equation 3.108 should read as

$$\beta_2 = \frac{V_f(1+\nu_f)\Delta C_f \beta_f + V_m(1+\nu_m)\Delta C_m \beta_m}{(V_m \rho_m \Delta C_m + V_f \rho_f \Delta C_f)} \rho_c - \beta_1 \nu_{12},$$

The change is in the first symbol of the numerator on the right hand side

Page 256: The units for fictitious thermal moments are *Pa-m^2*

Page 260: α instead of σ in last matrix equation. It should read as

$$\begin{bmatrix} \alpha_x \\ \alpha_y \\ \alpha_{xy} \end{bmatrix} = \begin{bmatrix} 5.353 \times 10^{-10} & -2.297 \times 10^{-11} & 0 \\ -2.297 \times 10^{-11} & 9.886 \times 10^{-10} & 0 \\ 0 & 0 & 9.298 \times 10^{-9} \end{bmatrix} \begin{bmatrix} 1.852 \times 10^{3} \\ 2.673 \times 10^{3} \\ 0 \end{bmatrix}$$

Page 265: Problem 4.12: put '*transformed*' in front of '*reduced stiffness matrix*'

Page 265: Problem 4.14: Line 3 from top Replace "*glass/epoxy*" by "*graphite/epoxy*"

Page 272: Examples of quasi-isotropic laminates include [0/36/72/-36/-72]. The last two angles in book are wrong!

Page 276: Equation (5.18) should read as

$$[A^*] = \frac{1}{h} \begin{bmatrix} \frac{U_1}{U_1^2 - U_4^2} & -\frac{U_4}{U_1^2 - U_4^2} & 0 \\ -\frac{U_4}{U_1^2 - U_4^2} & \frac{U_1}{U_1^2 - U_4^2} & 0 \\ 0 & 0 & \frac{2}{U_1 - U_4} \end{bmatrix}$$

Page 278-282:

First ply failure

$$\frac{N_x}{h} = \frac{7.277 \times 10^6}{0.015}$$
$$= 0.4851 \times 10^9 \; Pa$$

The normal strain in the x-direction at this load is

$$(\varepsilon_x^0)_{\text{first ply failiure}} = (5.353 \times 10^{-10})(7.277 \times 10^{6})$$

$$= 3.895 \times 10^{-3}$$

Last ply failure

$$\frac{N_x}{h} = \frac{1.5\times 10^7}{0.015}$$
$$= 0.1\times 10^{10}\ Pa$$

$$(\varepsilon_x^0)_{\text{last ply failiure}} = (5.525\times 10^{-10})(1.5\times 10^7)$$

$$= 8.288\times 10^{-3}$$

Page 284. Figure 5.1 does not show the strains correctly.

Page 288: Example 5.5. Properties of aluminum are given in Table 3.4.

Page 289: Missing *"t="* in

$$t = \sqrt{\frac{6(13000)2}{4(40.02)\ 10^3}}$$
$$= 0.9872\ in.$$

Page 299: Problem 5.10. Both parts of the problem are about the given laminate

Page 300: Problem 5.18. Change 'stiffness' by 'modulus'

REVISED PROBLEM 2.2 AND 2.3

2.2 The engineering constants for an orthotropic material are found to be

$$E_1 = 21.7\ Msi,\ E_2 = 1.74\ Msi,\ E_3 = 1.74\ Msi,$$
$$\nu_{12} = 0.25,\ \nu_{13} = 0.25,\ \nu_{23} = 0.43,$$
$$G_{12} = 0.61\ Msi,\ G_{23} = 0.45\ Msi,\ G_{31} = 0.61\ Msi$$

Find the stiffness matrix [C] and the compliance matrix [S] for the above orthotropic material.

Answers

$$[S] = \begin{bmatrix} 0.046083 & -0.011521 & -0.01152 & 0 & 0 & 0 \\ -0.011521 & 0.57471 & -0.24713 & 0 & 0 & 0 \\ -0.011521 & -0.24713 & 0.57471 & 0 & 0 & 0 \\ 0 & 0 & 0 & 2.2222 & 0 & 0 \\ 0 & 0 & 0 & 0 & 1.6393 & 0 \\ 0 & 0 & 0 & 0 & 0 & 1.6393 \end{bmatrix} Msi^{-1}$$

$$[C] = \begin{bmatrix} 22.088 & 0.77682 & 0.77682 & 0 & 0 & 0 \\ 0.77682 & 2.162 & 0.94524 & 0 & 0 & 0 \\ 0.77682 & 0.94524 & 21.62 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0.45 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0.61 & 0 \\ 0 & 0 & 0 & 0 & 0 & 0.61 \end{bmatrix} Msi$$

2.3 Consider an orthotropic material with the stiffness matrix given by

$$[C] = \begin{bmatrix} 152.68 & 5.3571 & 5.3571 & 0 & 0 & 0 \\ 5.3571 & 14.91 & 6.5185 & 0 & 0 & 0 \\ 5.3571 & 6.5185 & 14.91 & 0 & 0 & 0 \\ 0 & 0 & 0 & 3.1 & 0 & 0 \\ 0 & 0 & 0 & 0 & 4.2 & 0 \\ 0 & 0 & 0 & 0 & 0 & 4.2 \end{bmatrix} GPa$$

Find

a) the stresses in the principal directions of symmetry if the strains in the principal directions of symmetry at a point in the material are

ε_1 = 1 μm/m, ε_2 = 3 μm/m, ε_3 = 2 μm/m,

γ_{23} = 0, γ_{31} = 5 μm/m, γ_{12} = 6 μm/m,

b) the compliance matrix [S]

c) the engineering constants E_1, E_2, E_3, ν_{12}, ν_{23}, ν_{31}, G_{12}, G_{23}, G_{31}.

d) the strain energy per unit volume at the point where strains are given in part

(a)

Answers

(a) [179460 63124 54733 0 21000 25200] Pa

$$\text{(b)}\ [S] = \begin{bmatrix} 0.0066667 & -0.0016667 & -0.0016667 & 0 & 0 & 0 \\ -0.0016667 & 0.083333 & -0.035833 & 0 & 0 & 0 \\ -0.0016667 & -0.035833 & 0.083333 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0.32258 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0.2381 & 0 \\ 0 & 0 & 0 & 0 & 0 & 0.2381 \end{bmatrix} GPa^{-1}$$

(c) E_1=150GPa, E_2=12GPa, E_3=12GPA, ν_{12}=0.25, ν_{23}=0.43, ν_{31}=0.02, G_{12}=4.2 GPa, G_{23}=3.1GPa, G_{31}=4.2 GPa.

(d) 0.37625 N-m/m^3