

Errata for Roark's Formulas for Stress and Strain

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CHAPTER 2

Stress and Strain: Important Relationships

The stress transformation formulas for plane stress at a given location, Eqs. 2.3-17 can be rewritten as

$$\begin{aligned}\sigma_{x'} &= \frac{\sigma_x + \sigma_y}{2} + \frac{\sigma_x - \sigma_y}{2} \cos 2\theta + \tau_{xy} \sin 2\theta \\ \tau_{x'y'} &= -\frac{\sigma_x - \sigma_y}{2} \sin 2\theta + \tau_{xy} \cos 2\theta\end{aligned}\tag{2.5-1}$$

CHAPTER 8

Beams; Flexure of Straight Bars

TABLE 8.1 Shear, Moment, Slope, and Deflection Formulas for Elastic Straight Beams

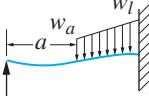
End Restraints, Reference No.	Boundary Values	Selected Maximum Values of Moments and Deformations
2c. Left end simply supported, right end fixed	 <p> $R_A = \frac{w_a}{8l^3}(l-a)^3(3l+a) + \frac{w_l-w_a}{40l^3}(l-a)^3(4l+a)$ $\theta_A = \frac{-w_a}{48EI}l(l-a)^3(l+3a) - \frac{w_l-w_a}{240EI}l(l-a)^3(2l+3a)$ $M_A = 0 \quad y_A = 0$ $R_B = \frac{w_a+w_l}{2}(l-a) - R_A$ $M_B = R_A l - \frac{w_a}{2}(l-a)^2 - \frac{w_l-w_a}{6}(l-a)^2$ $\theta_B = 0 \quad y_B = 0$ </p>	<p>If $a=0$ and $w_l=w_a$ (uniform load on entire span), then</p> $R_A = \frac{3}{8}w_a l \quad R_B = \frac{5}{8}w_a l \quad \text{Max } M = M_B = \frac{-w_a l^2}{8}$ $\text{Max } +M = \frac{9w_a l^2}{128} \text{ at } x = \frac{3}{8}l \quad \text{Max } \theta = \theta_A = \frac{-w_a l^3}{48EI}$ $\text{Max } y = -0.0054 \frac{w_a l^4}{EI} \text{ at } x = 0.4215l$ <p>If $a=0$ and $w_a=0$ (uniformly increasing load), then</p> $R_A = \frac{w_l l}{10} \quad R_B = \frac{2w_l l}{5} \quad \text{Max } -M = M_B = \frac{-w_l l^2}{15}$ $\text{Max } +M = 0.0298w_l l^2 \text{ at } x = 0.4472l \quad \text{Max } \theta = \theta_A = \frac{-w_l l^3}{120EI}$ $\text{Max } y = -0.00239 \frac{w_l l^4}{EI} \text{ at } x = 0.4472l$ <p>If $a=0$ and $w_l=0$ (uniformly decreasing load), then</p> $R_A = \frac{11}{40}w_a l \quad R_B = \frac{9}{40}w_a l \quad \text{Max } -M = M_B = \frac{-7}{120}w_a l^2$ $\text{Max } +M = 0.0422w_a l^2 \text{ at } x = 0.329l$ $\text{Max } \theta = \theta_A = \frac{-w_a l^3}{80EI} \quad \text{Max } y = -0.00304 \frac{w_a l^4}{EI}; \text{ at } x = 0.4025l$

TABLE 8.5 Shear, Moment, Slope, and Deflection Formulas for Finite-Length Beams on Elastic Foundations

	Right End	Free	Guided	Simply Supported	Fixed
Left End	$R_A = 0 \quad M_A = 0$ $\theta_A = \frac{(T_1-T_2)\gamma C_1 C_2 + C_3 C_4 - C_2}{\beta t}$	$R_A = 0 \quad M_A = 0$ $\theta_A = \frac{(T_1-T_2)\gamma C_2^2 + C_4^2}{2\beta^2 t}$	$R_A = 0 \quad M_A = 0$ $\theta_A = \frac{(T_1-T_2)\gamma C_1^2 + C_3 - C_4}{\beta t}$	$R_A = 0 \quad M_A = 0$ $\theta_A = \frac{(T_1-T_2)\gamma C_1 C_2 + C_3 C_1}{2 + C_{11}}$	$R_A = 0 \quad M_A = 0$ $\theta_A = \frac{(T_1-T_2)\gamma 2C_1 C_3 - C_2^2}{2 + C_{11}}$
Free	$y_A = \frac{-(T_1-T_2)\gamma C_4^2 + 2C_1 C_3 - 2C_3}{2\beta^2 t}$	$y_A = \frac{-(T_1-T_2)\gamma C_2 C_3 - C_1 C_4}{2\beta^2 t}$	$y_A = \frac{-(T_1-T_2)\gamma C_1 C_2 + C_3 C_4 - C_2}{2\beta^2 t}$		

CHAPTER 9

Curved Beams

TABLE 9.1 Formulas for Curved Beams Subjected to Bending in the Plane of the Curve

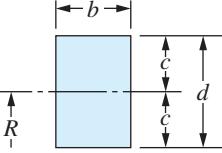
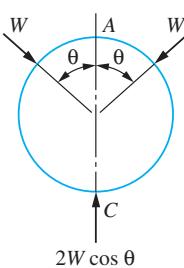
Form and Dimensions of Cross Section, Reference No.	Formulas	Values of $\frac{e}{c}$, k_i , and k_o for Various Values of $\frac{R}{c}$
1. Solid rectangular section 	$\frac{e}{c} = \frac{R}{c} - \frac{2}{\ln \frac{R/c+1}{R/c-1}}$ $k_i = \frac{1}{3e/c} \frac{1-e/c}{R/c-1}$ $k_o = \frac{1}{3e/c} \frac{1+e/c}{R/c+1}$ <p>(Note: e/c, k_i, and k_o are independent of the width b)</p> $\int_{\text{area}} \frac{dA}{r} = b \ln \frac{R/c+1}{R/c-1}$	$\frac{R}{c} = 1.20 \quad 1.40 \quad 1.60 \quad 1.80 \quad 2.00 \quad 3.00 \quad 4.00 \quad 6.00 \quad 8.00 \quad 10.00$ $\frac{e}{c} = 0.366 \quad 0.284 \quad 0.236 \quad 0.204 \quad 0.180 \quad 0.115 \quad 0.085 \quad 0.056 \quad 0.042 \quad 0.033$ $k_i = 2.888 \quad 2.103 \quad 1.798 \quad 1.631 \quad 1.523 \quad 1.288 \quad 1.200 \quad 1.124 \quad 1.090 \quad 1.071$ $k_o = 0.566 \quad 0.628 \quad 0.671 \quad 0.704 \quad 0.730 \quad 0.810 \quad 0.853 \quad 0.898 \quad 0.922 \quad 0.937$

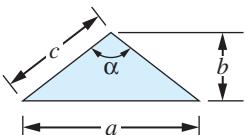
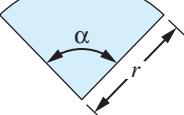
TABLE 9.2 Formulas for Circular Rings

Reference No., Loading, and Load Terms	Formulas for Moments, Loads, and Deformations and Some Selected Numerical Values																																																																		
5.  $L T_M = -WR \sin(x-\theta) \langle x-\theta \rangle^0$ $L T_N = -W \sin(x-\theta) \langle x-\theta \rangle^0$ $L T_V = -W \cos(x-\theta) \langle x-\theta \rangle^0$ $2W \cos \theta$	$M_A = \frac{-WR}{\pi} [s(\pi-\theta) - k_2(1+c)]$ $M_C = \frac{-WR}{\pi} [s\theta - k_2(1+c)]$ $N_A = \frac{-W}{\pi} s(\pi-\theta)$ $V_A = 0$ $\Delta D_H = \begin{cases} \frac{-WR^3}{EI} \left[k_1 \left(\frac{\theta s}{2} - c \right) + 2k_2 c - \frac{2k_2^2(1+c)}{\pi} \right] & \text{if } \theta \leq \frac{\pi}{2} \\ \frac{-WR^3}{EI} \left[\frac{k_1 s(\pi-\theta)}{2} - \frac{2k_2^2(1+c)}{\pi} \right] & \text{if } \theta \geq \frac{\pi}{2} \end{cases}$ $\Delta D_V = \frac{WR^3}{EI} \left[\frac{k_1 (s-\pi c + \theta c)}{2} - k_2 s + \frac{2k_2^2(1+c)}{\pi} \right]$ $\Delta L = \frac{WR^3}{2EI} \left[k_1 \left(\frac{\theta s}{\pi} - \frac{\pi c}{2} \right) - k_2 (1-c) + \frac{2k_2^2(1+c)}{\pi} \right]$ $\Delta L_W = \frac{WR^3}{EI} \left\{ k_1 \frac{s - s^3(1-\theta/\pi) - c(\pi-\theta)}{2} + k_2 \left[\frac{\theta s(1+c)}{\pi} - s \right] + \frac{k_2^2(1+c)^2}{\pi} \right\}$ $\Delta L_{WH} = \frac{-WR^3}{EI\pi} [k_1 s(\pi-\theta)(\theta-sc) + 2\theta c k_2 (1+c) - 2s k_2^2 (1+c)]$ $\Delta \psi = \frac{WR^2}{EI\pi} [\pi s^2 - \theta(1+c+s^2)] k_2$ <p style="text-align: right;"> $\text{Max} + M = M_C \quad \text{if } \theta \leq 60^\circ$ $\text{Max} + M \text{ occurs at the load} \quad \text{if } \theta > 60^\circ \text{ where}$ $M_\theta = \frac{WR}{\pi} [k_2(1+c) - sc(\pi-\theta)]$ $\text{Max} - M = \begin{cases} M_C & \text{if } \theta \geq 90^\circ \\ M_A & \text{if } 60^\circ \leq \theta \leq 90^\circ \end{cases}$ $\text{Max} - M \text{ occurs at an angular position } x_1 = \tan^{-1} \frac{-\pi c}{\theta s} \quad \text{if } \theta \leq 60^\circ$ $\text{If } \alpha = \beta = 0, M = K_M WR, N = K_N W,$ $\Delta D = K_{\Delta D} WR^3/EI, \Delta \psi = K_{\Delta \psi} WR^2/EI, \text{etc.}$ </p> <table border="1" style="margin-left: auto; margin-right: auto;"> <thead> <tr> <th>θ</th> <th>30°</th> <th>60°</th> <th>90°</th> <th>120°</th> <th>150°</th> </tr> </thead> <tbody> <tr> <td>K_{M_A}</td> <td>0.1773</td> <td>-0.0999</td> <td>-0.1817</td> <td>-0.1295</td> <td>-0.0407</td> </tr> <tr> <td>K_{N_A}</td> <td>-0.4167</td> <td>-0.5774</td> <td>-0.5000</td> <td>-0.2887</td> <td>-0.0833</td> </tr> <tr> <td>K_{M_C}</td> <td>0.5106</td> <td>0.1888</td> <td>-0.1817</td> <td>-0.4182</td> <td>-0.3740</td> </tr> <tr> <td>K_{M_θ}</td> <td>0.2331</td> <td>0.1888</td> <td>0.3183</td> <td>0.3035</td> <td>0.1148</td> </tr> <tr> <td>$K_{\Delta D_H}$</td> <td>0.1910</td> <td>0.0015</td> <td>-0.1488</td> <td>-0.1351</td> <td>-0.0456</td> </tr> <tr> <td>$K_{\Delta D_V}$</td> <td>-0.1957</td> <td>-0.0017</td> <td>0.1366</td> <td>0.1471</td> <td>0.0620</td> </tr> <tr> <td>$K_{\Delta L}$</td> <td>-0.1115</td> <td>-0.0209</td> <td>0.0683</td> <td>0.0936</td> <td>0.0447</td> </tr> <tr> <td>$K_{\Delta L_W}$</td> <td>-0.1718</td> <td>-0.0239</td> <td>0.0683</td> <td>0.0888</td> <td>0.0278</td> </tr> <tr> <td>$K_{\Delta L_{WH}}$</td> <td>0.0176</td> <td>-0.0276</td> <td>-0.1488</td> <td>-0.1206</td> <td>-0.0182</td> </tr> <tr> <td>$K_{\Delta \psi}$</td> <td>-0.1027</td> <td>0.0000</td> <td>0.0000</td> <td>0.0833</td> <td>-0.0700</td> </tr> </tbody> </table>	θ	30°	60°	90°	120°	150°	K_{M_A}	0.1773	-0.0999	-0.1817	-0.1295	-0.0407	K_{N_A}	-0.4167	-0.5774	-0.5000	-0.2887	-0.0833	K_{M_C}	0.5106	0.1888	-0.1817	-0.4182	-0.3740	K_{M_θ}	0.2331	0.1888	0.3183	0.3035	0.1148	$K_{\Delta D_H}$	0.1910	0.0015	-0.1488	-0.1351	-0.0456	$K_{\Delta D_V}$	-0.1957	-0.0017	0.1366	0.1471	0.0620	$K_{\Delta L}$	-0.1115	-0.0209	0.0683	0.0936	0.0447	$K_{\Delta L_W}$	-0.1718	-0.0239	0.0683	0.0888	0.0278	$K_{\Delta L_{WH}}$	0.0176	-0.0276	-0.1488	-0.1206	-0.0182	$K_{\Delta \psi}$	-0.1027	0.0000	0.0000	0.0833	-0.0700
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CHAPTER 10

Torsion

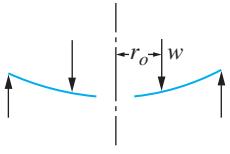
TABLE 10.1 Formulas for Torsional Deformation and Stress

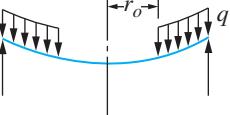
Form and Dimensions of Cross Sections, Other Quantities Involved, and Case No.	Formula for K in $\theta = \frac{TL}{KG}$	Formula for Shear Stress
<p>6. Isosceles triangle</p>  <p>(Note: See also Ref. 21 for graphs of stress magnitudes and locations and stiffness factors.)</p>	<p>For $\frac{2}{3} < a/b < \sqrt{3}$ ($39^\circ < \alpha < 82^\circ$)</p> <p>For $K = \frac{a^3 b^3}{15a^2 + 20b^2}$</p> <p>approximate formula which is exact at $\alpha = 60^\circ$ where $K = 0.02165c^4$.</p> <p>For $\sqrt{3} < a/b < 2\sqrt{3}$ ($82^\circ < \alpha < 120^\circ$)</p> <p>$K = 0.0915b^4 \left(\frac{a}{b} - 0.8592 \right)$</p> <p>approximate formula which is exact at $\alpha = 90^\circ$ where $K = 0.0261c^4$ (errors < 4%) (Ref. 20)</p>	<p>For $39^\circ < \alpha < 120^\circ$</p> <p>$Q = \frac{K}{b[0.200 + 0.309a/b - 0.0418(a/b)^2]}$</p> <p>approximate formula which is exact at $\alpha = 60^\circ$ and $\alpha = 90^\circ$</p> <p>For $\alpha = 60^\circ$ $Q = 0.0768b^3 = 0.0500c^3$</p> <p>For $\alpha = 90^\circ$ $Q = 0.1604b^3 = 0.0567c^3$</p> <p>$\tau_{\max}$ at center of longest side</p>
<p>8. Circular sector</p>  <p>(Note: See also Ref. 21.)</p>	<p>$K = Cr^4$ where C varies with $\frac{\alpha}{\pi}$ as follows:</p> <p>For $0.1 \leq \frac{\alpha}{\pi} \leq 2.0$,</p> <p>$C = 0.0034 - 0.0697 \frac{\alpha}{\pi} + 0.5825 \left(\frac{\alpha}{\pi} \right)^2$</p> <p>$- 0.2950 \left(\frac{\alpha}{\pi} \right)^3 + 0.0874 \left(\frac{\alpha}{\pi} \right)^4 - 0.0111 \left(\frac{\alpha}{\pi} \right)^5$</p>	<p>$\tau_{\max} = \frac{T}{Br^3}$ on a radial boundary. B varies with $\frac{\alpha}{\pi}$ as follows:</p> <p>For $0.1 \leq \frac{\alpha}{\pi} \leq 1.0$,</p> <p>$B = 0.0117 - 0.2137 \frac{\alpha}{\pi} + 2.2475 \left(\frac{\alpha}{\pi} \right)^2$</p> <p>$- 4.6709 \left(\frac{\alpha}{\pi} \right)^3 + 5.1764 \left(\frac{\alpha}{\pi} \right)^4 - 2.2000 \left(\frac{\alpha}{\pi} \right)^5$</p> <p>(Data from Ref. 17)</p>

CHAPTER 11

Flat Plates

TABLE 11.2 Formulas for Flat Circular Plates of Constant Thickness

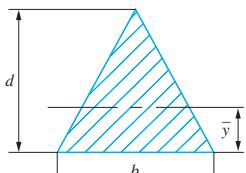
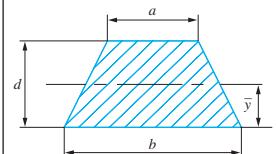
Case No., Edge Restraints	Boundary Values	Special Cases																														
1a. Outer edge simply supported, inner edge free 	$M_{rb} = 0, \quad Q_b = 0, \quad y_a = 0, \quad M_{ra} = 0$ $y_b = \frac{-wa^3}{D} \left(\frac{C_1 L_9}{C_7} - L_3 \right)$ $\theta_b = \frac{wa^2}{DC_7} L_9$ $\theta_a = \frac{wa^2}{D} \left(\frac{C_4 L_9}{C_7} - L_6 \right)$ $Q_a = -w \frac{r_o}{a}$	$y_{\max} = y_b, \quad M_{\max} = M_{tb}$ If $r_o = b$ (load at inner edge), <table border="1"> <thead> <tr> <th>b/a</th><th>0.1</th><th>0.3</th><th>0.5</th><th>0.7</th><th>0.9</th></tr> </thead> <tbody> <tr> <td>K_{y_b}</td><td>-0.0364</td><td>-0.1266</td><td>-0.1934</td><td>-0.1927</td><td>-0.0938</td></tr> <tr> <td>K_{θ_b}</td><td>0.0371</td><td>0.2047</td><td>0.4262</td><td>0.6780</td><td>0.9532</td></tr> <tr> <td>K_{θ_a}</td><td>0.0418</td><td>0.1664</td><td>0.3573</td><td>0.6119</td><td>0.9237</td></tr> <tr> <td>$K_{M_{tb}}$</td><td>0.3374</td><td>0.6210</td><td>0.7757</td><td>0.8814</td><td>0.9638</td></tr> </tbody> </table>	b/a	0.1	0.3	0.5	0.7	0.9	K_{y_b}	-0.0364	-0.1266	-0.1934	-0.1927	-0.0938	K_{θ_b}	0.0371	0.2047	0.4262	0.6780	0.9532	K_{θ_a}	0.0418	0.1664	0.3573	0.6119	0.9237	$K_{M_{tb}}$	0.3374	0.6210	0.7757	0.8814	0.9638
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Case No., Loading, Load Terms	Edge Restraint	Boundary Values	Special Cases																								
10. Uniformly distributed pressure from r_o to a  $LT_y = \frac{-qr^4}{D} G_{11}$ $LT_\theta = \frac{-qr^3}{D} G_{14}$ $LT_M = -qr^2 G_{17}$ $LT_Q = \frac{-q}{24} (r^2 - r_o^2) r - r_o^2$	10a. Simply supported	$y_a = 0, \quad M_{ra} = 0$ $y_c = \frac{-qa^4}{2D} \left(\frac{L_{17}}{1+\nu} - 2L_{11} \right)$ $M_c = qa^2 L_{17}$ $\theta_a = \frac{q}{8Da(1+\nu)} (a^2 - r_o^2)^2$ $Q_a = \frac{-q}{2a} (a^2 - r_o^2)$	$y = k_y \frac{qa^4}{D}, \quad \theta = K_\theta \frac{qa^3}{D}, \quad M = K_M qa^2$ <table border="1"> <thead> <tr> <th>r_o/a</th><th>0.0</th><th>0.2</th><th>0.4</th><th>0.6</th><th>0.8</th></tr> </thead> <tbody> <tr> <td>K_{y_c}</td><td>-0.06370</td><td>-0.05767</td><td>-0.04221</td><td>-0.02303</td><td>-0.00677</td></tr> <tr> <td>K_{θ_a}</td><td>0.09615</td><td>0.08862</td><td>0.06785</td><td>0.03939</td><td>0.01246</td></tr> <tr> <td>K_{M_c}</td><td>0.20625</td><td>0.17540</td><td>0.11972</td><td>0.06215</td><td>0.01776</td></tr> </tbody> </table> <p>Note: If $r_o = 0$, $G_{11} = \frac{1}{64}$, $G_{14} = \frac{1}{16}$, $G_{17} = \frac{(3+\nu)}{16}$</p> $y_c = \frac{-qa^4(5+\nu)}{64D(1+\nu)}, \quad M_c = \frac{qa^2(3+\nu)}{16}, \quad \theta_a = \frac{qa^3}{8D(1+\nu)}$	r_o/a	0.0	0.2	0.4	0.6	0.8	K_{y_c}	-0.06370	-0.05767	-0.04221	-0.02303	-0.00677	K_{θ_a}	0.09615	0.08862	0.06785	0.03939	0.01246	K_{M_c}	0.20625	0.17540	0.11972	0.06215	0.01776
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APPENDIX A

Properties of a Plane Area

TABLE A.2 Moment of Inertia of Sections

Section	\bar{y}	Moment of Inertia I_y	Section	\bar{y}	Moment of Inertia I_y
9.		$\frac{1}{3}d$			
		$\frac{bd^3}{36}$	13.		$\frac{d(2a+b)}{3(a+b)}$