Equations:

$$\sigma_{Px} = l\sigma_{xx} + m\sigma_{yx} + n\sigma_{zx}$$
$$\sigma_{Py} = l\sigma_{xy} + m\sigma_{yy} + n\sigma_{zy}$$
$$\sigma_{Pz} = l\sigma_{xz} + m\sigma_{yz} + n\sigma_{zz} \qquad \boldsymbol{\sigma}_P = \mathbf{T}\cdot\mathbf{N}$$

$$\sigma_{PN} = l^2\sigma_{xx} + m^2\sigma_{yy} + n^2\sigma_{zz} + mn(\sigma_{yz}+\sigma_{zy}) + nl(\sigma_{xz}+\sigma_{zx}) + lm(\sigma_{xy}+\sigma_{yx})$$
$$= l^2\sigma_{xx} + m^2\sigma_{yy} + n^2\sigma_{zz} + 2mn\sigma_{yz} + 2ln\sigma_{xz} + 2lm\sigma_{xy}$$

$$\sigma_{PS} = \sqrt{\sigma_P^2 - \sigma_{PN}^2} = \sqrt{\sigma_{Px}^2 + \sigma_{Py}^2 + \sigma_{Pz}^2 - \sigma_{PN}^2}$$

$$\sigma_{XX} = l_1^2\sigma_{xx} + m_1^2\sigma_{yy} + n_1^2\sigma_{zz} + 2m_1n_1\sigma_{yz} + 2n_1l_1\sigma_{zx} + 2l_1m_1\sigma_{xy}$$
$$\sigma_{YY} = l_2^2\sigma_{xx} + m_2^2\sigma_{yy} + n_2^2\sigma_{zz} + 2m_2n_2\sigma_{yz} + 2n_2l_2\sigma_{zx} + 2l_2m_2\sigma_{xy}$$
$$\sigma_{ZZ} = l_3^2\sigma_{xx} + m_3^2\sigma_{yy} + n_3^2\sigma_{zz} + 2m_3n_3\sigma_{yz} + 2n_3l_3\sigma_{zx} + 2l_3m_3\sigma_{xy}$$
$$\sigma_{XY} = \boldsymbol{\sigma}_X\cdot\mathbf{N}_2 = \boldsymbol{\sigma}_Y\cdot\mathbf{N}_1$$
$$= l_1l_2\sigma_{xx} + m_1m_2\sigma_{yy} + n_1n_2\sigma_{zz} + (m_1n_2+m_2n_1)\sigma_{yz} + (l_1n_2+l_2n_1)\sigma_{zx} + (l_1m_2+l_2m_1)\sigma_{xy}$$
$$\sigma_{XZ} = \boldsymbol{\sigma}_X\cdot\mathbf{N}_3 = l_1l_3\sigma_{xx} + m_1m_3\sigma_{yy} + n_1n_3\sigma_{zz} + (m_1n_3+m_3n_1)\sigma_{yz} + (l_1n_3+l_3n_1)\sigma_{zx} + (l_1m_3+l_3m_1)\sigma_{xy}$$
$$\sigma_{YZ} = \boldsymbol{\sigma}_Y\cdot\mathbf{N}_3 = l_2l_3\sigma_{xx} + m_2m_3\sigma_{yy} + n_2n_3\sigma_{zz} + (m_2n_3+m_3n_2)\sigma_{yz} + (l_2n_3+l_3n_2)\sigma_{zx} + (l_2m_3+l_3m_2)\sigma_{xy}$$

$$\mathbf{Q}^T\mathbf{T}\mathbf{Q} = \mathbf{T}'$$
$$\mathbf{Q} = \begin{bmatrix} \cos\theta_{Xx} & \cos\theta_{Yx} & \cos\theta_{Zx} \\ \cos\theta_{Xy} & \cos\theta_{Yy} & \cos\theta_{Zy} \\ \cos\theta_{Xz} & \cos\theta_{Yz} & \cos\theta_{Zz} \end{bmatrix} = \begin{bmatrix} l_1 & l_2 & l_3 \\ m_1 & m_2 & m_3 \\ n_1 & n_2 & n_3 \end{bmatrix}$$

$$l(\sigma_{xx}-\sigma) + m\sigma_{xy} + n\sigma_{xz} = 0$$
$$l\sigma_{xy} + m(\sigma_{yy}-\sigma) + n\sigma_{yz} = 0$$
$$l\sigma_{xz} + m\sigma_{yz} + n(\sigma_{zz}-\sigma) = 0$$
$$\begin{vmatrix} \sigma_{xx}-\sigma & \sigma_{xy} & \sigma_{xz} \\ \sigma_{xy} & \sigma_{yy}-\sigma & \sigma_{yz} \\ \sigma_{xz} & \sigma_{yz} & \sigma_{zz}-\sigma \end{vmatrix} = 0$$

$$\sigma^3 - I_1\sigma^2 + I_2\sigma - I_3 = 0$$
$$I_1 = \sigma_{xx} + \sigma_{yy} + \sigma_{zz}$$
$$I_2 = \begin{vmatrix} \sigma_{xx} & \sigma_{xy} \\ \sigma_{xy} & \sigma_{yy} \end{vmatrix} + \begin{vmatrix} \sigma_{xx} & \sigma_{xz} \\ \sigma_{xz} & \sigma_{zz} \end{vmatrix} + \begin{vmatrix} \sigma_{yy} & \sigma_{yz} \\ \sigma_{yz} & \sigma_{zz} \end{vmatrix}$$
$$= \sigma_{xx}\sigma_{yy} + \sigma_{xx}\sigma_{zz} + \sigma_{yy}\sigma_{zz} - \sigma_{xy}^2 - \sigma_{xz}^2 - \sigma_{yz}^2$$
$$I_3 = \begin{vmatrix} \sigma_{xx} & \sigma_{xy} & \sigma_{xz} \\ \sigma_{xy} & \sigma_{yy} & \sigma_{yz} \\ \sigma_{xz} & \sigma_{yz} & \sigma_{zz} \end{vmatrix}$$

$$\sigma_{oct} = \frac{1}{3}(\sigma_{xx} + \sigma_{yy} + \sigma_{zz})$$
$$\tau_{oct} = \frac{1}{3}\sqrt{(\sigma_{xx}-\sigma_{yy})^2 + (\sigma_{yy}-\sigma_{zz})^2 + (\sigma_{zz}-\sigma_{xx})^2 + 6(\sigma_{xy}^2 + \sigma_{yz}^2 + \sigma_{xz}^2)}$$
$$\mathbf{T} = \mathbf{T}_m + \mathbf{T}_d$$
$$\sigma_m = \frac{\sigma_{xx}+\sigma_{yy}+\sigma_{zz}}{3} = \frac{\sigma_1+\sigma_2+\sigma_3}{3} = \frac{1}{3}I_1 \qquad \mathbf{T}_m = \begin{bmatrix} \sigma_m & 0 & 0 \\ 0 & \sigma_m & 0 \\ 0 & 0 & \sigma_m \end{bmatrix}$$
$$\mathbf{T}_d = \begin{bmatrix} \frac{2\sigma_{xx}-\sigma_{yy}-\sigma_{zz}}{3} & \sigma_{xy} & \sigma_{xz} \\ \sigma_{xy} & \frac{2\sigma_{yy}-\sigma_{xx}-\sigma_{zz}}{3} & \sigma_{yz} \\ \sigma_{xz} & \sigma_{yz} & \frac{2\sigma_{zz}-\sigma_{yy}-\sigma_{xx}}{3} \end{bmatrix}$$

$$\sigma_{XX} = \frac{1}{2}(\sigma_{xx}+\sigma_{yy}) + \frac{1}{2}(\sigma_{xx}-\sigma_{yy})\cos 2\theta + \sigma_{xy}\sin 2\theta$$
$$\sigma_{YY} = \frac{1}{2}(\sigma_{xx}+\sigma_{yy}) - \frac{1}{2}(\sigma_{xx}-\sigma_{yy})\cos 2\theta - \sigma_{xy}\sin 2\theta$$
$$\sigma_{XY} = -\frac{1}{2}(\sigma_{xx}-\sigma_{yy})\sin 2\theta + \sigma_{xy}\cos 2\theta$$
$$\tan 2\theta = \frac{2\sigma_{xy}}{\sigma_{xx}-\sigma_{yy}}$$
$$\sigma_1 = \frac{\sigma_{xx}+\sigma_{yy}}{2} + \sqrt{\frac{1}{4}(\sigma_{xx}-\sigma_{yy})^2 + \sigma_{xy}^2}$$
$$\sigma_2 = \frac{\sigma_{xx}+\sigma_{yy}}{2} - \sqrt{\frac{1}{4}(\sigma_{xx}-\sigma_{yy})^2 + \sigma_{xy}^2}$$
$$\tau_{max} = \sigma_{XY(max)} = R = \sqrt{\frac{1}{4}(\sigma_{xx}-\sigma_{yy})^2 + \sigma_{xy}^2}$$

$$\frac{\partial\sigma_{xx}}{\partial x} + \frac{\partial\sigma_{yx}}{\partial y} + \frac{\partial\sigma_{zx}}{\partial z} + B_x = 0$$
$$\frac{\partial\sigma_{xy}}{\partial x} + \frac{\partial\sigma_{yy}}{\partial y} + \frac{\partial\sigma_{zy}}{\partial z} + B_y = 0$$
$$\frac{\partial\sigma_{xz}}{\partial x} + \frac{\partial\sigma_{yz}}{\partial y} + \frac{\partial\sigma_{zz}}{\partial z} + B_z = 0$$

With temperature change (you can always let $\Delta T=0$ for equations without temperature change):

$$\epsilon_{xx} = \frac{1}{E}[\sigma_{xx} - \nu(\sigma_{yy}+\sigma_{zz})] + \alpha\Delta T$$
$$\epsilon_{yy} = \frac{1}{E}[\sigma_{yy} - \nu(\sigma_{xx}+\sigma_{zz})] + \alpha\Delta T$$
$$\epsilon_{zz} = \frac{1}{E}[\sigma_{zz} - \nu(\sigma_{xx}+\sigma_{yy})] + \alpha\Delta T$$
$$\epsilon_{xy} = \frac{(1+\nu)}{E}\sigma_{xy}, \quad \epsilon_{xz} = \frac{(1+\nu)}{E}\sigma_{xz}, \quad \epsilon_{yz} = \frac{(1+\nu)}{E}\sigma_{yz}$$

Without temperature change:

$$\sigma_{xx} = \frac{E}{(1+\nu)(1-2\nu)}[(1-\nu)\epsilon_{xx} + \nu(\epsilon_{yy}+\epsilon_{zz})]$$
$$\sigma_{yy} = \frac{E}{(1+\nu)(1-2\nu)}[(1-\nu)\epsilon_{yy} + \nu(\epsilon_{xx}+\epsilon_{zz})]$$
$$\sigma_{zz} = \frac{E}{(1+\nu)(1-2\nu)}[(1-\nu)\epsilon_{zz} + \nu(\epsilon_{xx}+\epsilon_{yy})]$$
$$\sigma_{xy} = \frac{E}{1+\nu}\epsilon_{xy}, \quad \sigma_{xz} = \frac{E}{1+\nu}\epsilon_{xz}, \quad \sigma_{yz} = \frac{E}{1+\nu}\epsilon_{yz}$$

Plane stress:

$$\sigma_{xx} = \frac{E}{1-\nu^2}(\epsilon_{xx} + \nu\epsilon_{yy})$$
$$\sigma_{yy} = \frac{E}{1-\nu^2}(\nu\epsilon_{xx} + \epsilon_{yy})$$
$$\sigma_{xy} = \frac{E}{1+\nu}\epsilon_{xy}$$
$$\begin{Bmatrix} \varepsilon_{xx} \\ \varepsilon_{yy} \\ \gamma_{xy} \end{Bmatrix} = \frac{1}{E}\begin{bmatrix} 1 & -\nu & \\ -\nu & 1 & \\ & & 2(1+\nu) \end{bmatrix}\begin{Bmatrix} \sigma_{xx} \\ \sigma_{yy} \\ \sigma_{xy} \end{Bmatrix}$$
$$\varepsilon_{zz} = -\frac{\nu}{E}(\sigma_{xx}+\sigma_{yy})$$

Plane strain:

$$\begin{Bmatrix} \sigma_{xx} \\ \sigma_{yy} \\ \sigma_{xy} \end{Bmatrix} = \frac{E(1-\nu)}{(1+\nu)(1-2\nu)}\begin{bmatrix} 1 & \frac{\nu}{(1-\nu)} & \\ \frac{\nu}{(1-\nu)} & 1 & \\ & & \frac{1-2\nu}{2(1-\nu)} \end{bmatrix}\begin{Bmatrix} \varepsilon_{xx} \\ \varepsilon_{yy} \\ \gamma_{xy} \end{Bmatrix}$$
$$\sigma_{zz} = \frac{E\nu}{(1+\nu)(1-2\nu)}(\varepsilon_{xx}+\varepsilon_{yy}) = \nu(\sigma_{xx}+\sigma_{yy})$$

$$SF = h(Y)/g(\sigma_{ij})$$

$$f = \tau_{\max} - Y/2 = 0$$

$$f = \sigma_e - Y = 0$$

$$f = \tau_{oct} - \frac{\sqrt{2}}{3} Y = 0$$

$$\tau_{\text{oct}} = \frac{1}{3}\sqrt{(\sigma_{xx}-\sigma_{yy})^2 + (\sigma_{yy}-\sigma_{zz})^2 + (\sigma_{zz}-\sigma_{xx})^2 + 6(\sigma_{xy}^2 + \sigma_{yz}^2 + \sigma_{xz}^2)}$$

$$\sigma_{\text{e}} = \sqrt{\frac{1}{2}[(\sigma_{xx}-\sigma_{yy})^2 + (\sigma_{yy}-\sigma_{zz})^2 + (\sigma_{zz}-\sigma_{xx})^2] + 3(\sigma_{xy}^2 + \sigma_{yz}^2 + \sigma_{xz}^2)}$$

$$U_0 = \frac{1}{2E}(\sigma_{xx}^2 + \sigma_{yy}^2 + \sigma_{zz}^2) - \frac{\nu}{E}(\sigma_{xx}\sigma_{yy} + \sigma_{yy}\sigma_{zz} + \sigma_{zz}\sigma_{xx}) + \frac{1}{2G}(\sigma_{yz}^2 + \sigma_{zx}^2 + \sigma_{xy}^2) \quad (5.7)$$

$$q_i = \frac{\partial U}{\partial F_i} = \sum_{j=1}^{m}\left(\int \frac{N_j}{E_j A_j}\frac{\partial N_j}{\partial F_i}dz + \int \frac{k_j V_j}{G_j A_j}\frac{\partial V_j}{\partial F_i}dz + \int \frac{M_j}{E_j I_j}\frac{\partial M_j}{\partial F_i}dz + \int \frac{T_j}{G_j J_j}\frac{\partial T_j}{\partial F_i}dz\right)$$

$$\theta_i = \frac{\partial U}{\partial M_i} = \sum_{j=1}^{m}\left(\int \frac{N_j}{E_j A_j}\frac{\partial N_j}{\partial M_i}dz + \int \frac{k_j V_j}{G_j A_j}\frac{\partial V_j}{\partial M_i}dz + \int \frac{M_j}{E_j I_j}\frac{\partial M_j}{\partial M_i}dz + \int \frac{T_j}{G_j J_j}\frac{\partial T_j}{\partial M_i}dz\right)$$

$$U_N = \int_0^L \frac{N^2}{2EA}dz \qquad U_M = \int_0^L \frac{M^2}{2EI}dz$$

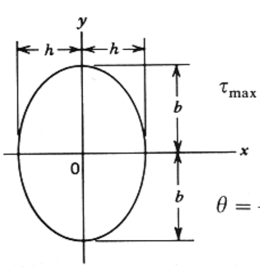
$$U_S = \int_0^L \frac{kV^2}{2GA}dz \qquad U_T = \int_0^L \frac{T^2}{2GJ}dz$$

Beam cross section	k
Thin rectangle[a]	1.20
Solid circular[b]	1.33
Thin-wall circular[b]	2.00
I-section, channel, box-section[c]	1.00

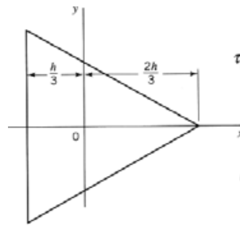
$$\phi = BF(x,y) \qquad \sigma_{zx} = \frac{\partial \phi}{\partial y} \qquad \sigma_{zy} = -\frac{\partial \phi}{\partial x}$$

$$T = 2\iint \phi \, dx\, dy \qquad \frac{\partial^2 \phi}{\partial x^2} + \frac{\partial^2 \phi}{\partial y^2} = -2G\theta$$

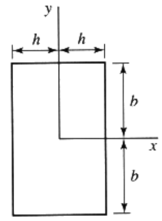
$$\frac{z}{p/S} = \frac{\phi}{2G\theta}, \qquad \phi = \frac{2G\theta S}{p} z$$



$$\tau_{\max} = \frac{2T}{\pi b h^2} \qquad \theta = \frac{T(b^2 + h^2)}{G\pi b^3 h^3} \quad (6.47)$$



$$\tau_{\max} = \frac{15\sqrt{3}T}{2h^3} \qquad \theta = \frac{15\sqrt{3}T}{Gh^4} \quad (6.49)$$



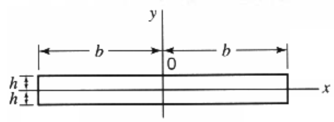
$$T = GJ\theta$$

$$J = k_1(2b)(2h)^3$$

$$\tau_{\max} = \frac{T}{k_2(2b)(2h)^2} = 2G\theta h\frac{k_1}{k_2}$$

TABLE 6.1 Torsional Parameters for Rectangular Cross Sections

b/h	1.0	1.5	2.0	2.5	3.0	4.0	6.0	10	∞
k_1	0.141	0.196	0.229	0.249	0.263	0.281	0.299	0.312	0.333
k_2	0.208	0.231	0.246	0.256	0.267	0.282	0.299	0.312	0.333



$$J = C\frac{1}{3}\sum_{i=1}^{n}(2b_i)(2h_i)^3$$

$$\tau_{\max} = \frac{2Th_{\max}}{J}, \qquad \theta = \frac{T}{GJ} \quad (6.63)$$

$$T = 2\sum_{i=1}^{N} A_i \frac{z_i}{c} = 2\sum_{i=1}^{N} A_i q_i \quad (6.68)$$

$$\theta = \frac{1}{2GA_i}\oint_{l_i} \frac{q_i - q'}{t} dl, \qquad i = 1, 2, \ldots, N \quad (6.69)$$

$$\sigma_{zz} = \frac{M_X Y}{I_X} - \frac{M_Y X}{I_Y} \quad (7.4)$$

$$\sigma_{zz} = -\left(\frac{M_y I_x + M_x I_{xy}}{I_x I_y - I_{xy}^2}\right)x + \left(\frac{M_x I_y + M_y I_{xy}}{I_x I_y - I_{xy}^2}\right)y \quad (7.12)$$

$$M_x = M\sin\phi \qquad M_y = -M\cos\phi, \qquad \sigma_{zz} = \frac{M_x(y - x\tan\alpha)}{I_x - I_{xy}\tan\alpha}$$

$$\tan\alpha = \frac{M_x I_{xy} + M_y I_x}{M_x I_y + M_y I_{xy}}, \qquad \tan\alpha = \frac{I_{xy} - I_x\cot\phi}{I_y - I_{xy}\cot\phi}$$

$$q = \tau t = \frac{V_y A'\bar{y}'}{I_x} = \frac{V_y Q}{I_x}$$

$$\sigma_{\theta\theta} = \frac{N}{A} + \frac{M_x(A - rA_m)}{Ar(RA_m - A)}, \qquad \sigma_{rr} = \frac{AA'_m - A'A_m}{trA(RA_m - A)}M_x$$

$$A = \sum_{i=1}^{n} A_i \qquad A_m = \sum_{i=1}^{n} A_{m_i}, \qquad R = \frac{\sum_{i=1}^{n} R_i A_i}{\sum_{i=1}^{n} A_i}$$

TABLE 9.2 Expressions for A, R, and $A_m = \int \frac{dA}{r}$

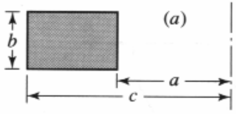
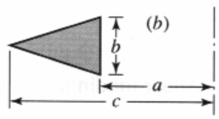
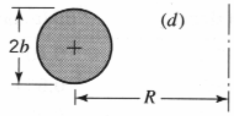
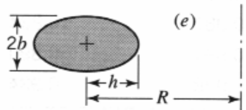
	(a)	$A = b(c-a)$; $R = \frac{a+c}{2}$ $A_m = b \ln\frac{c}{a}$
	(b)	$A = \frac{b}{2}(c-a)$; $R = \frac{2a+c}{3}$ $A_m = \frac{bc}{c-a}\ln\frac{c}{a} - b$
	(d)	$A = \pi b^2$ $A_m = 2\pi\left(R - \sqrt{R^2 - b^2}\right)$
	(e)	$A = \pi bh$ $A_m = \frac{2\pi b}{h}\left(R - \sqrt{R^2 - h^2}\right)$

TABLE 9.3
Table for Calculating the Effective Width and Lateral Bending Stress of Curved I- or T-Beams

$b_p^2/\bar{r}t$	0.2	0.3	0.4	0.5	0.6	0.7	0.8	0.9	1.0
α	0.977	0.950	0.917	0.878	0.838	0.800	0.762	0.726	0.693
β	0.580	0.836	1.056	1.238	1.382	1.495	1.577	1.636	1.677
$b_p^2/\bar{r}t$	1.1	1.2	1.3	1.4	1.5	2.0	3.0	4.0	5.0
α	0.663	0.636	0.611	0.589	0.569	0.495	0.414	0.367	0.334
β	1.703	1.721	1.728	1.732	1.732	1.707	1.671	1.680	1.700

$b'_p = \alpha b_p$, $b' = 2b'_p + t_w$, $\sigma_{xx} = -\beta\bar{\sigma}_{\theta\theta}$

$$\sigma_{rr} = \frac{p_1a^2 - p_2b^2}{b^2 - a^2} - \frac{a^2b^2}{r^2(b^2 - a^2)}(p_1 - p_2)$$

$$\sigma_{\theta\theta} = \frac{p_1a^2 - p_2b^2}{b^2 - a^2} + \frac{a^2b^2}{r^2(b^2 - a^2)}(p_1 - p_2)$$

$$\sigma_{zz} = \frac{p_1a^2 - p_2b^2}{b^2 - a^2} + \frac{P}{\pi(b^2 - a^2)} = \text{constant}$$

Open end:
$$\sigma_{zz} = \frac{P}{\pi\left(b^2 - a^2\right)}$$

$$u_{(\text{closed end})} = \frac{r}{E(b^2 - a^2)}\left[(1 - 2\nu)(p_1a^2 - p_2b^2) + \frac{(1+\nu)a^2b^2}{r^2}(p_1 - p_2) - \nu\frac{P}{\pi}\right] \quad (11.24)$$

$$u_{(\text{open end})} = \frac{r}{E(b^2 - a^2)}\left[(1 - \nu)(p_1a^2 - p_2b^2) + \frac{(1+\nu)a^2b^2}{r^2}(p_1 - p_2)\right] \quad (11.25)$$

$$P_n = \frac{n^2\pi^2EI}{L^2}, \qquad n = 1, 2, 3, ..$$

$$P_{cr} = \frac{\pi^2EI}{L^2}, \qquad \sigma_{cr} = \frac{P_{cr}}{A} = \frac{\pi^2E}{(L/r)^2}$$

$r^2 = I/A$

TABLE 12.1
Comparison of Boundary-Condition Effects

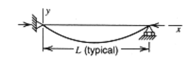
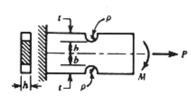
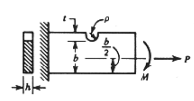
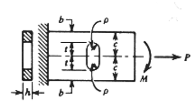
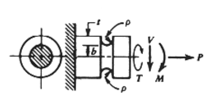
Boundary Conditions	Critical Load	Deflected Shape	Effective Length KL
Simple support-simple support	$\frac{\pi^2EI}{L^2}$		L
Clamped-clamped	$\frac{4\pi^2EI}{L^2}$		$\frac{1}{2}L$
Clamped-simple support	$\frac{2.04\pi^2EI}{L^2}$		$0.70L$
Clamped-free	$\frac{\pi^2EI}{4L^2}$		$2L$
Clamped-guided	$\frac{\pi^2EI}{L^2}$		L
Simple support-guided	$\frac{\pi^2EI}{4L^2}$		$2L$

Table 14.3

Type of Notch	Type of Load	Formula for Nominal Stress	Scale for $\sqrt{\frac{t}{\rho}}$	Curve for Finding S_{cc}
	Tension	$\frac{P}{2bh}$	f	1
	Bending	$\frac{3M}{2b^2h}$	f	2
	Tension	$\frac{P}{bh}$	f	3
	Bending	$\frac{6M}{b^2h}$	f	4
	Tension	$\frac{P}{2bh}$	f	5
	Bending	$\frac{3Mt}{2h(c^3 - t^3)}$	e	5
	Tension	$\frac{P}{\pi b^2}$	f	6
	Bending	$\frac{4M}{\pi b^3}$	f	7
	Direct shear	$\frac{1.23V}{\pi b^2}$	e	8
	Torsional shear	$\frac{2T}{\pi b^3}$	e	9

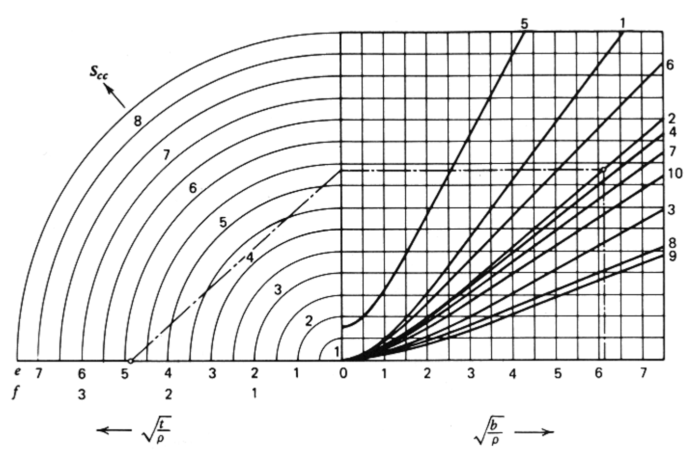
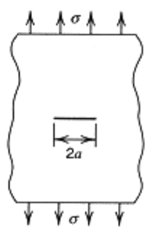


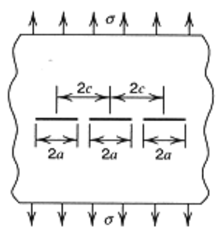
TABLE 15.2
Stress Intensity Factors K_I

Case 1. Infinite Sheet with Through-Thickness Crack and Uniform Tension at Infinity. Griffith's Crack



$$K_I = \sigma\sqrt{\pi a}$$

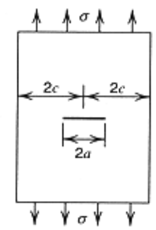
Case 2. Periodic Array of Through-Thickness Cracks in Infinite Sheet with Uniform Tension at Infinity



$$K_I = \sigma\sqrt{\pi a}\, f(\lambda);\ \lambda = \frac{a}{c}$$

λ	$f(\lambda)$
0.1	1.00
0.2	1.02
0.3	1.04
0.4	1.08
0.5	1.13
0.6	1.21

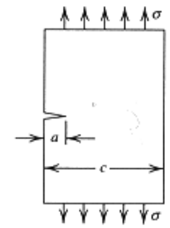
Case 3. Central Crack in Finite-Width Strip Subjected to Uniform Tension at Infinity



$$K_I = \sigma\sqrt{\pi a}\, f(\lambda);\ \lambda = \frac{a}{c}$$

λ	$f(\lambda)$
0.1	1.01
0.2	1.03
0.3	1.06
0.4	1.11
0.5	1.19
0.6	1.30

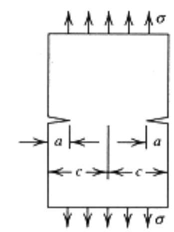
Case 4. Single-Edge Crack in Finite-Width Sheet



$$K_I = \sigma\sqrt{\pi a}\, f(\lambda);\ \lambda = \frac{a}{c}$$

λ	$f(\lambda)$
$0 (c \to \infty)$	1.12
0.2	1.37
0.4	2.11
0.5	2.83

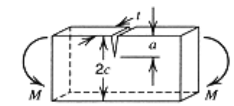
Case 5. Double-edge Crack in Finite-Width Sheet



$$K_I = \sigma\sqrt{\pi a}\, f(\lambda);\ \lambda = \frac{a}{c}$$

λ	$f(\lambda)$
$0 (c \to \infty)$	1.12
0.2	1.12
0.4	1.14
0.5	1.15
0.6	1.22

Case 6. Edge Crack in Beam in Bending



$$K_I = \sigma\sqrt{\pi a}\, f(\lambda)$$

$$\lambda = \frac{a}{2c}$$

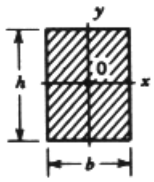
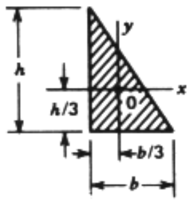
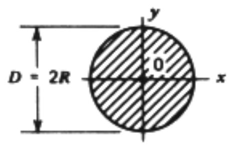
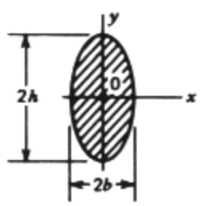
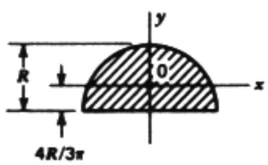
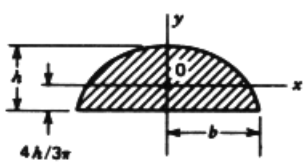
$$\sigma = \frac{3M}{2tc^2}$$

λ	$f(\lambda)$
0.1	1.02
0.2	1.06
0.3	1.16
0.4	1.32
0.5	1.62
0.6	2.10

TABLE 15.1
K_{IC} Critical Stress Intensity Factor (Fracture Toughness) (Room Temperature Data)

Material	σ_u (MPa)	Y (MPa)	K_{IC} (MPa$\sqrt{m}$)	Minimum Values for B, a, t (mm)
Alloy Steels				
A533B	—	500	175	306.0
2618 Ni Mo V	—	648	106	66.9
V1233 Ni Mo V	—	593	75	40.0
124 K 406 Cr Mo V	—	648	62	22.9
17-7PH	1289	1145	77	11.3
17-4PH	1331	1172	48	4.2
Ph 15-7Mo	1600	1413	50	3.1
AISI 4340	1827	1503	59	3.9
Stainless Steel				
AISI 403	821	690	77	31.1
Aluminum Alloys				
6061-T651	352	299	29	23.5
2219-T851	454	340	32	22.1
7075-T7351	470	392	31	15.6
7079-T651	569	502	26	6.7
2024-T851	488	444	23	6.7
Titanium Alloys				
Ti-6Al-4Zr-2Sn-0.5Mo-0.5V	890	836	139	69.1
Ti-6Al-4V-2Sn	852	798	111	48.4
Ti-6.5Al-5Zr-1V	904	858	106	38.2
Ti-6Al-4Sn-1V	889	878	93	28.0
Ti-6Al-6V-2.5Sn	1176	1149	66	8.2

TABLE B.1
Moments of Inertia of Common Plane Areas

Rectangle		$I_x = bh^3/12$ $I_y = hb^3/12$ $J_0 = (bh^3 + hb^3)/12$ $I_{xy} = 0$
Right Triangle		$I_x = bh^3/36$ $I_y = hb^3/36$ $J_0 = (bh^3 + hb^3)/36$ $I_{xy} = -b^2h^2/72$
Circle		$I_x = \pi D^4/64 = \pi R^4/4$ $I_y = \pi D^4/64 = \pi R^4/4$ $J_0 = \pi D^4/32 = \pi R^4/2$ $I_{xy} = 0$
Ellipse		$I_x = \pi bh^3/4$ $I_y = \pi hb^3/4$ $J_0 = \pi bh(h^2 + b^2)/4$ $I_{xy} = 0$
Semicircle		$I_x = \pi R^4(1/8 - 8/9\pi^2)$ $I_y = \pi R^4/8$ $J_0 = \pi R^4(1/4 - 8/9\pi^2)$ $I_{xy} = 0$
Semiellipse		$I_x = \pi bh^3(1/8 - 8/9\pi^2)$ $I_y = \pi hb^3/8$ $J_0 = \pi bh(h^2/8 - 8h^2/9\pi^2 + b^2/8)$ $I_{xy} = 0$