APM: ENGINEER'S BACK OF THE ENVELOPE "ISOTROPIC"

4.11.2013 LRF

Note Title 02/02/2009

AXIAL "$\frac{EA}{L}$"

$$\sigma = \frac{F}{A}$$

$$\sigma = E\varepsilon$$

$$\varepsilon = e/L$$

$$\varepsilon^T = \alpha \Delta T$$

$$F = k\dot{e}$$

$$k = \lambda = \frac{EA}{L}$$

$$G = \frac{E}{2(1+\nu)}$$

BENDING "$\frac{EI}{}$"

$$\frac{\sigma}{y} = \frac{M}{I} = \frac{E}{R}$$

$$\sigma = Eyk$$

$I = \frac{bd^3}{12}$

$I = \frac{bd^3}{3}$

$I = \frac{\pi R^4}{4}$

$I = \frac{\pi}{4}(R^4 - r^4)$

$I \simeq \pi R^3 t$

$$\bar{y} = \Sigma(A_i y_i)/\Sigma A_i$$

$$I = \Sigma(I_i + A_i y_i^2)$$

SHEAR "GA"

$$\gamma = \frac{S}{A_s}$$

$$\tau = G\gamma$$

$\gamma = \not{\gamma}$ rad

$$q = \tau t$$

$q_1 = \frac{S}{I} A_1 \bar{y}_1$

$q = \frac{S}{I}\int t y \, ds$

$A_s \simeq \frac{5}{6}A$

$A_s \simeq A_w$

$A_s \simeq \frac{A}{2} = \pi R t$

TORSION "$\frac{GJ}{L}$"

$$\frac{\tau}{R} = \frac{T}{J} = \frac{G\theta}{L}$$

$J = \frac{\pi R^4}{2} = I_{xx} + I_{yy}$

$J = \frac{\pi}{2}(R^4 - r^4)$

$J = 2\pi R^3 t$

$q = \frac{T}{2A}$ (C)

$K_T = \sum \frac{bt^3}{3}$ (I)

OPEN

$K_T = \frac{4A^2}{\int \frac{ds}{t}} = \frac{4A^2}{\Sigma(b/t)}$

CLOSED

$$e = \frac{F}{EA/L}$$

$\delta_b = k_b \frac{PL^3}{EI}$ $\quad \delta_s = k_s \frac{PL}{GA_s}$ $\quad \theta = \frac{TL}{GJ}$

$k_b = 1/3$, $k_s = 1$

$k_b = 1/8$, $k_s = 1/2$

$k_b = 1/48$, $k_s = 1/4$

$k_b = \frac{5}{384}$, $k_s = 1/8$

Buckling: Strut: $P_{CRIT} = \frac{\pi^2 EI}{L^2}$ $\quad$ Panel: $\sigma_{CRIT} = kE\left(\frac{t}{b}\right)^2$

PV: $\sigma_H = \frac{PR}{t}$, $\sigma_L = \frac{PR}{2t}$ $\quad \varepsilon_{x_{2D}} = \varepsilon_x - \nu\varepsilon_y = \frac{1}{E}(\sigma_x - \nu\sigma_y)$ etc.

Panel poisson constraint correction: $(1-\nu^2)$