Chapter H Design of Members for Combined Forces and Torsion

This chapter addresses members subject to axial force and flexure about one or both axes, with or without torsion, and to members subject to torsion only.

H.1 MEMBERS SUBJECT TO FLEXURE AND AXIAL FORCE

For members subject to flexure and axial force,

$$\frac{P_r}{P_c} + \frac{M_{rx}}{M_{cx}} + \frac{M_{ry}}{M_{cy}} \le 1.0 \qquad \text{(H.1-1)}$$

where all terms are positive, and

x = subscript for major principal axis bending
y = subscript for minor principal axis bending
P_r = required axial strength
P_c = available axial strength determined in accordance with Chapter D for axial tension and Chapter E for axial compression
M_r = required flexural strength
M_c = available flexural strength determined in accordance with Chapter F

H.2 MEMBERS SUBJECT TO TORSION

The available torsional strength of members is the least of the available strengths for the limit states of rupture, yielding, and buckling. The available torsional strength ($\phi_T T_n$ for LRFD and T_n/Ω_T for ASD) shall be determined in accordance with this Section and Sections H.2.1, H.2.2, H.2.3, or H.2.4, where T_n is the nominal torsional strength and

LIMIT STATE	ϕ_T building-type structures	Ω_T building-type structures	Ω_T bridge-type structures
torsional rupture	0.75	1.95	2.20
other torsional limit states	0.90	1.65	1.85

For the limit state of torsional rupture, the shear stress F_s corresponding to the torsional strength is

For unwelded members

$$F_s = F_{su}/k_t \qquad \text{(H.2-1)}$$

For welded members

$$F_s = F_{su}(1 - A_{wz}/A_g)/k_t + F_{suw} A_{wz}/A_g \qquad \text{(H.2-2)}$$

For the limit states of shear yielding and shear buckling, the shear stress F_s corresponding to the torsional strength is

For unwelded members

$$F_s = F_{so} \qquad \text{(H.2-3)}$$

For welded members

$$F_s = F_{so}(1 - A_{wz}/A_g) + F_{sw} A_{wz}/A_g \qquad \text{(H.2-4)}$$

where

F_{so} = shear stress corresponding to the torsional strength for an element determined using Section H.2 if no part of the cross section were weld-affected. Use buckling constants for unwelded metal (Table B.4.1 or Table B.4.2) and F_{sy}.
F_{sw} = shear stress corresponding to the torsional strength for an element determined using Section H.2 if the entire cross section were weld-affected. Use buckling constants for weld-affected zones (Table B.4.1) and F_{syw}.
A_{wz} = cross sectional area of the weld-affected zone
A_g = gross cross sectional area of the element.

H.2.1 Pipes and Round or Oval Tubes

The nominal torsional strength T_n for pipes and round or oval tubes is

$$T_n = F_s J/R \qquad \text{(H.2-5)}$$

For the limit state of torsional rupture, the shear stress F_s corresponding to the torsional strength shall be determined in accordance with Section H.2.

For the limit state of torsional yielding and torsional buckling, the shear stress F_s corresponding to the shear strength is

LIMIT STATE	F_s	λ
yielding	F_{sy}	$\lambda \le \lambda_1$
inelastic buckling	$B_s - 1.25 D_s \lambda$	$\lambda_1 < \lambda < \lambda_2$
elastic buckling	$\dfrac{\pi^2 E}{(1.25\lambda)^2}$	$\lambda \ge \lambda_2$

where

$$\lambda_1 = \frac{B_s - F_{sy}}{1.25 D_s}$$

$$\lambda_2 = \frac{C_s}{1.25}$$

Buckling constants B_s, D_s, and C_s are given in Table B.4.1 or B.4.2.