LRFD Axially Loaded Compression Members

**AISC E3: Compressive Strength for Flexural Buckling of Members without slender elements**

Factored Compression Load $\leq$ Design Compressive Strength

$$P_u \leq \varphi_c P_n \leq \varphi_c A_g F_{cr}$$

Where

$P_u =$ Required axial compressive strength based on factored nominal loads (kips)

$P_n =$ Nominal axial compressive strength (kips)

$\varphi_c =$ Resistance factor for compression members (0.90)

$A_g =$ gross cross-sectional area (sq.in)

$F_{cr} =$ Flexural Buckling stress (Critical compressive stress) (ksi)

*For members designed on the basis of compression, the slenderness ratio $KL/r$ preferably should not exceed 200.*

(a) When $(KL/r) \leq 4.71 \sqrt{(E/Fy)}$ (or $F_y / F_e \leq 2.25$)

$$F_{cr} = [0.658 \left( \frac{F_y}{F_e} \right) ] F_y \quad \text{............(AISC Eq. E3-2)}$$

(b) When $(KL/r) > 4.71 \sqrt{(E/Fy)}$ (or $F_y / F_e > 2.25$)

$$F_{cr} = 0.877 F_e \quad \text{............................(AISC Eq. E3-3)}$$

Where, $F_e =$ elastic critical buckling stress,

$$F_e = \pi^2 E / (KL/r)^2 \quad \text{............................(AISC Eq. E3-4)}$$

Where

$K =$ Effective length factor

$L =$ laterally un-braced length of member (in)

$r =$ Governing radius of gyration about the axis of buckling (in)

$F_y =$ specified minimum yield stress (ksi)

$E =$ modulus of elasticity (29,000 ksi)
For $F_y = 50$ ksi
KL/r > 113
AISC Eq. E3-3
Elastic Buckling

For $F_y = 50$ ksi
KL/r ≤ 113
AISC Eq. E3-2
Inelastic Buckling

For $F_y = 36$ ksi
KL/r > 134
AISC Eq. E3-3
Elastic Buckling

For $F_y = 36$ ksi
KL/r ≤ 134
AISC Eq. E3-2
Inelastic Buckling
COLUMN BUCKLED SHAPE FOR DIFFERENT END CONDITIONS
(Theoretical K Values are shown in Black; AISC Recommended design value (shown in Blue) when ideal conditions are approximated)
Example 1: Check whether W12X72 A992 ($F_y=50$ ksi) is Non-Slender in Compression.

AISC Table 1-1  For W12X72  $A= 21.1$, $b_f/(2t_f) = 8.99$; $h/w = 22.6$

AISC Table B4.1a Case 1:
Flange: $b/t = 0.5b_f/(t_f) = b_f/(2t_f) = 8.99 < 0.56\sqrt{(E/F_y)} = 0.56\sqrt{(29000/50)} = 13.49$  Yes.
Therefore, Non-slender un-stiffened flange element.

AISC Table B4.1a Case 5:
Web: $h/w = 22.6 < 1.49\sqrt{(E/F_y)} = 1.49\sqrt{(29000/50)} = 35.88$  Yes.
Therefore, Non-slender stiffened web element.

Therefore, W12X72 A992 ($F_y=50$ ksi) is a **Non-Slender** Element in Compression.

Example 2: Check whether W12X35 A992 ($F_y=50$ ksi) is Non-Slender in Compression.

AISC Table 1-1  For W12X35  $A= 10.3$, $b_f/(2t_f) = 6.31$; $h/w = 36.2$

AISC Table B4.1a Case 1:
Flange: $b/t = 0.5b_f/(t_f) = b_f/(2t_f) = 6.31 < 0.56\sqrt{(E/F_y)} = 0.56\sqrt{(29000/50)} = 13.49$  Yes.
Therefore, Non-slender un-stiffened flange element.

AISC Table B4.1a Case 5:
Web: $h/w = 36.2 < 1.49\sqrt{(E/F_y)} = 1.49\sqrt{(29000/50)} = 35.88$  NO.
Therefore, slender stiffened web element.

Therefore, W12X35 A992 ($F_y=50$ ksi) is a **Slender** Element in Compression.

[ NOTE: AISC Table 1-1, Footnote (c):  W12X35 is Slender for compression with $F_y=50$ ksi]