LRFD Axially Loaded Compression Members

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

Factored Compression Load ≤ 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)
φ_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 $(KL/r) \leq 4.71\sqrt{(E/F_y)}$ (or $F_y / F_e \leq 2.25$)

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

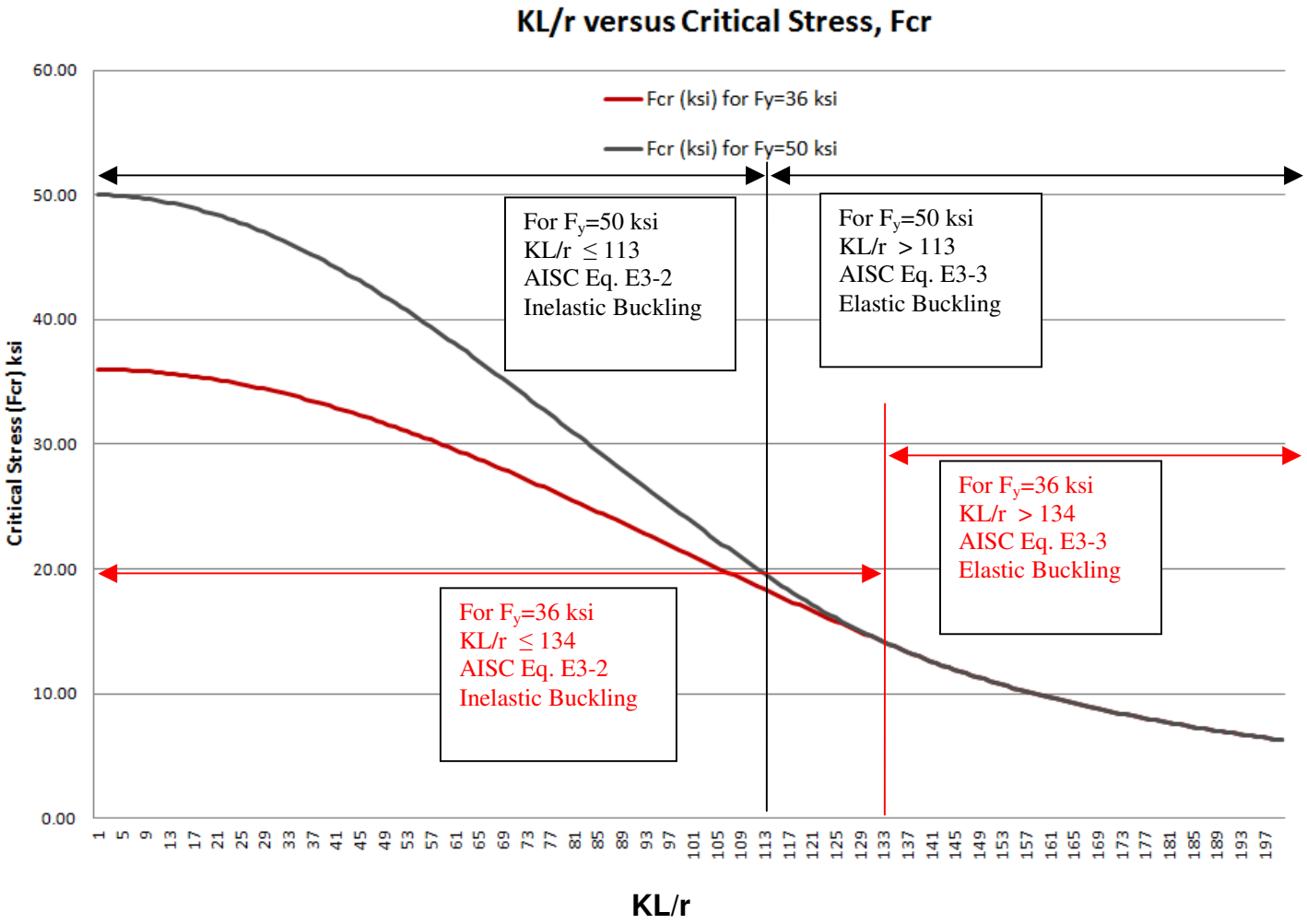
(b) When $(KL/r) > 4.71\sqrt{(E/F_y)}$ (or $F_y / F_e > 2.25$)

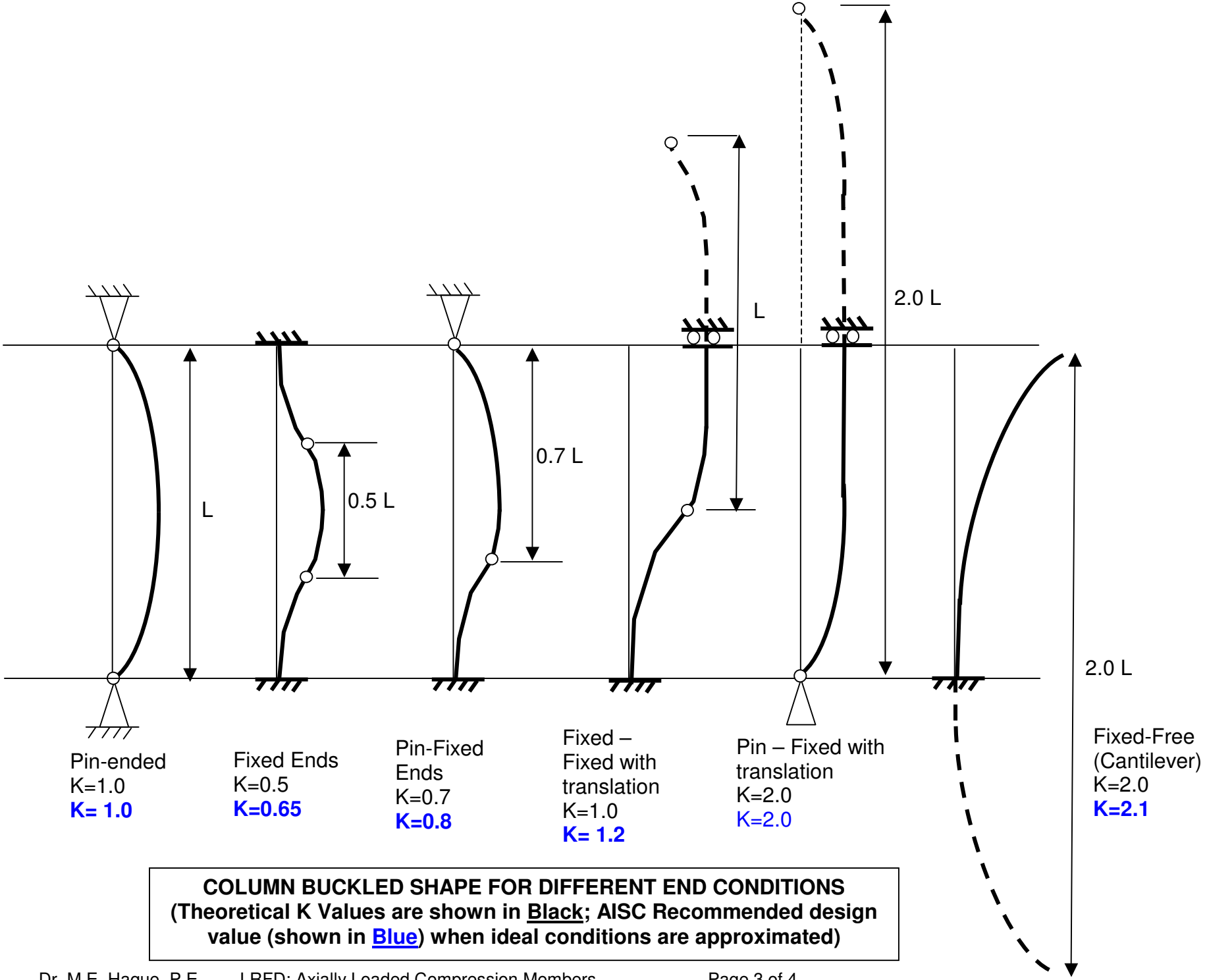
$$F_{cr} = 0.877 F_e \quad \text{.....(AISC Eq. E3-3)}$$

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)


KL/r versus Critical Stress, Fcr
Fcr (ksi) for Fy=36 ksi
Fcr (ksi) for Fy=50 ksi
For Fy=50 ksi
KL/r ≤ 113
AISC Eq. E3-2
Inelastic Buckling
For Fy=50 ksi
KL/r > 113
AISC Eq. E3-3
Elastic Buckling
For Fy=36 ksi
KL/r > 134
AISC Eq. E3-3
Elastic Buckling
For Fy=36 ksi
KL/r ≤ 134
AISC Eq. E3-2
Inelastic Buckling
Critical Stress (Fcr) ksi
60.00
50.00
40.00
30.00
20.00
10.00
0.00
1 5 9 13 17 21 25 29 33 37 41 45 49 53 57 61 65 69 73 77 81 85 89 93 97 101 105 109 113 117 121 125 129 133 137 141 145 149 153 157 161 165 169 173 177 181 185 189 193 197
KL/r



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)

AISC Table B4.1a (AISC Steel Manual 14th Ed. Page 16.1-16)
Width-to-thickness Ratios: Compression Elements-
Members Subjected to Axial Compression

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/t_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: $h/t_w = 22.6 < 1.49\sqrt{(E/F_y)} = 1.49\sqrt{(29000/50)} = 35.88$ 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/t_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: $h/t_w = 36.2 < 1.49\sqrt{(E/F_y)} = 1.49\sqrt{(29000/50)} = 35.88$ 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]