Unbraced and Braced Frames

- The AISC code approximate the effect by using two amplification factors B1 and B2

$$M_u = B_1 M_{nt} + B_2 M_{lt}$$

AISC Equation

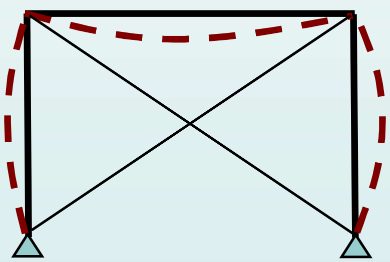
$$P_r = P_{nt} + B_2 P_{lt}$$

AISC Equation

- **Where**
  - **B_1 amplification factor for the moment occurring in braced member**
  - **B_2 amplification factor for the moment occurring from sidesway**
  - **M_{nt} and P_{nt} is the maximum moment and axial force assuming no sidesway**
  - **M_{lt} and P_{lt} is the maximum moment and axial force due to sidesway**
  - **P_r is the required axial strength**

Unbraced and Braced Frames

- Braced frames are those frames prevented from sidesway.
- In this case the moment amplification equation can be simplified to:



$$M_{ux} = B_{1x} M_{ntx}$$

$$M_{uy} = B_{1y} M_{nty}$$

$$B_1 = \frac{C_m}{1 - \left(\frac{P_u}{P_e}\right)} \geq 1$$

AISC Equation

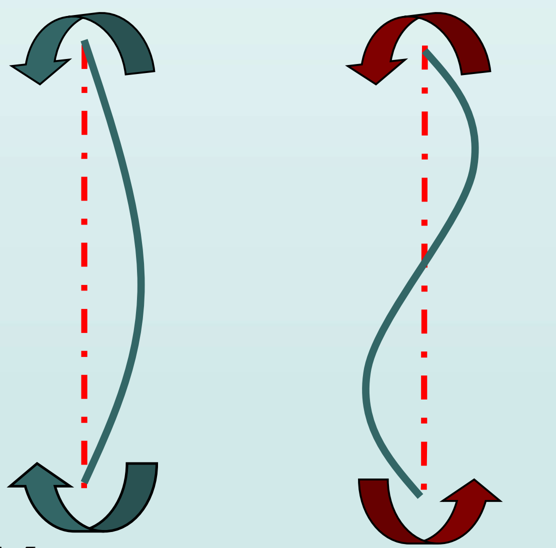
$$P_e = \frac{\pi^2 E A_g}{(KL/r)^2}$$

- KL/r for the axis of bending considered
- $K \leq 1.0$

Unbraced and Braced Frames

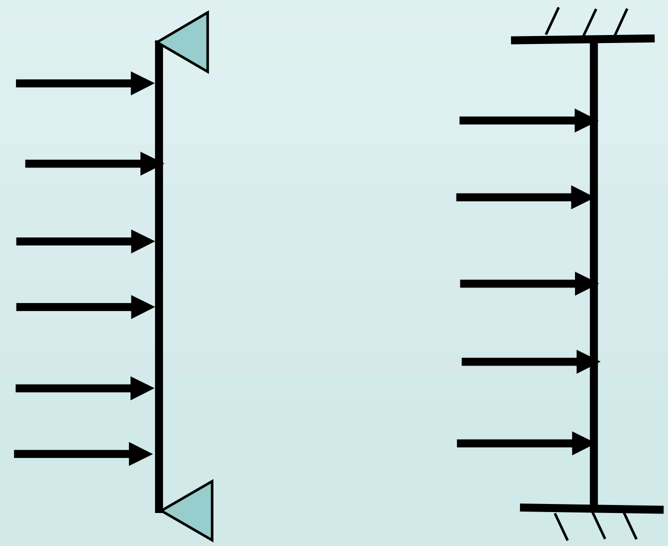
- The coefficient C_m is used to represent the effect of end moments on the maximum deflection along the element (only for braced frames)

$$C_m = 0.6 - 0.4\left(\frac{M_1}{M_2}\right)$$



$$\frac{M_1}{M_2} = -ve \qquad \frac{M_1}{M_2} = +ve$$

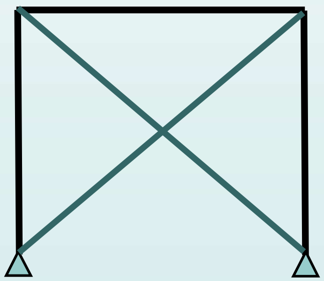
- When there is transverse loading on the beam either of the following case applies



Conservatively $C_m = 1.00$

Unbraced and Braced Frames

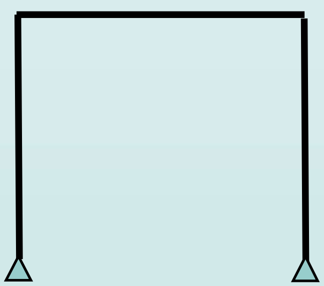
- AISC requires stability bracing to have
  - Specific strength to resist the lateral load
  - Specific axial stiffness to limit the lateral deformation.



$$P_{br} = 0.004 \sum P_u$$

$$\beta_{br} = \frac{2 \sum P_u}{\phi L}$$

Braced Frames



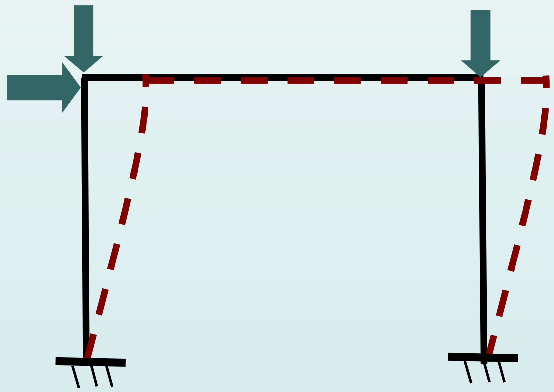
$$\beta_{br} = \frac{3 \sum P_u}{L}$$

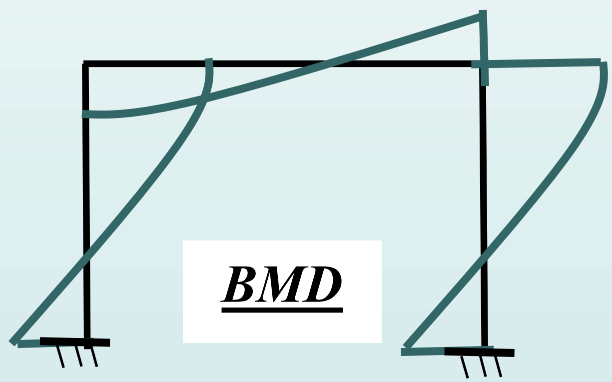
Unbraced Frames

- Where P_u is the sum of factored axial load in the braced story
- P_{br} is bracing strength and β_{br} is braced or unbraced frame stiffness (ϕ = 0.75)

Unbraced and Braced Frames

- Unbraced frames can observe loading + sidesway
- In this case the moment amplification equation can be simplified to:





$$M_u = B_1 M_{nt} + B_2 M_{lt}$$

$$B_1 = \frac{1.0}{1 - \left(\frac{P_u}{P_e}\right)} \geq 1$$

AISC Equation

$$B_2 = \frac{1.0}{1 - \frac{\sum P_u}{R_M \sum H}\left[\frac{\Delta_{oh}}{L}\right]}$$

Unbraced and Braced Frames

- A minimum lateral load in each combination shall be added so that the shear in each story is given by:

$$H_u = 0.0042 \sum P_u$$

Analysis of Unbraced Frames

$\sum P_u$ is the sum of factored axial loads on all columns in floor

Δ_{oh} is the drift due to the unfactored horizontal forces

L is the story height

$\sum H$ story shear produced by unfactored horizontal forces

$\left[\frac{\Delta_{oh}}{L}\right]$ is the drift index (is generally between 1/500 to 1/200)

P_e is the sum of Euler buckling loads of all columns in floor

P_u is the factored axial load in the column

R_M can be conservatively taken as 0.85

Ex. 5.1- Beam-Columns in Braced Frames

A 3.6-m W12x96 is subjected to bending and compressive loads in a braced frame. It is bent in single curvature with equal and opposite end moments and is not loaded transversely. Use Grade 50 steel. Is the section satisfactory if P_u = 3200 kN and first-order moment M_{ntx} = 240 kN.m

Step I: From Section Property Table

W12x96 (A = 18190 mm^2, I_x = 347x10^6 mm^4, L_p = 3.33 m, L_r = 14.25 m, Z_x = 2409 mm^3, S_x = 2147 mm^3)

Ex. 5.1- Beam-Columns in Braced Frames

Step II: Compute amplified moment

- For a braced frame let K = 1.0

$K_xL_x = K_yL_y = (1.0)(3.6) = 3.6$ m

- From Column Chapter: $\phi_c P_n = 4831$ kN

$P_u/\phi_c P_n = 3200/4831 = 0.662 > 0.2$ $\therefore$ Use eqn.

- There is no lateral translation of the frame: $M_{lt} = 0$

$\therefore M_{ux} = B_1 M_{ntx}$

$C_m = 0.6 – 0.4(M_1/M_2) = 0.6 – 0.4(-240/240) = 1.0$

$P_{e1} = \pi^2 EI_x/(K_xL_x)^2 = \pi^2(200)(347x10^6)/(3600)^2 = 52851$ kN

Ex. 5.1- Beam-Columns in Braced Frames

$$B_1 = \frac{C_m}{1 - \frac{P_u}{P_{e1}}} = \frac{1.0}{1 - \frac{3200}{52851}} = 1.073 > 1.0 \quad (OK)$$

$M_{ux} = (1.073)(240) = 257.5$ kN.m

Step III: Compute moment capacity

Since $L_b = 3.6\ m$ $\quad L_p < L_b < L_r$

$$\phi_b M_n = 739\ kN.m$$

Ex. 5.1- Beam-Columns in Braced Frames

Step IV: Check combined effect

$$\frac{P_u}{\phi_c P_n} + \frac{8}{9}\left(\frac{M_{ux}}{\phi_b M_{nx}} + \frac{M_{uy}}{\phi_b M_{ny}}\right) = \frac{3200}{4831} + \frac{8}{9}\left(\frac{257.5}{739} + 0\right) = 0.972 < 1.0$$

$\therefore$ Section is satisfactory