FlowChart for Determining Column Slenderness Effects

spColumn

1st Order Analysis

1st order analysis
R6.6.4.1

Sidesway Consideration

Sway or Nonsway?

Nonsway if:

$M_{2nd} \leq 0.05 \times M_{1st}$ 6.6.4.3(a)

or

$EI_{bracing\ elements} \geq 12 \times EI_{story\ columns}$ 6.2.5

or

$Q = \dfrac{\Sigma P_u \times \Delta_o}{V_{us} \times l_c} \leq 0.05$ 6.6.4.3(b)

6.6.4.4.1

Sway

Nonsway

Slenderness Consideration

Neglect Slenderness?

Neglect slenderness if:

$\dfrac{k \times l_u}{r} \leq 22$ 6.2.5a

Yes

Only 1st order analysis required
6.6

Neglect Slenderness?

Neglect slenderness if:

$\dfrac{k \times l_u}{r} \leq 34 + 12\left(\dfrac{M_1}{M_2}\right)$ 6.2.5b

$\dfrac{k \times l_u}{r} \leq 40$ 6.2.5c

No

No

Slenderness Effects at Column Ends

Slenderness Effects at Column Ends

1. Moment Magnification Method:

$M_1 = M_{1ns} + \delta_s M_{1s}$ 6.6.4.6.1a

$M_2 = M_{2ns} + \delta_s M_{2s}$ 6.6.4.6.1b

$$\delta_s = \left\{ \begin{array}{c} \dfrac{1}{1-Q} \\ \dfrac{1}{1 - \dfrac{\Sigma P_u}{0.75 \Sigma P_c}} \end{array} \right\}$$ 6.6.4.6.2

$$Q = \frac{\Sigma P_u \times \Delta_o}{V_{us} \times l_c}$$ 6.6.4.3(b)

$$P_c = \frac{\pi^2 (EI)_{eff}}{(k l_u)^2}$$ 6.6.4.4.2

$$(EI)_{eff} = \left\{ \begin{array}{c} \dfrac{0.4 E_c I_g}{1+\beta_{ds}} \\ \dfrac{0.2 E_c I_g + E_s I_{se}}{1+\beta_{ds}} \\ \dfrac{E_c I}{1+\beta_{ds}} \end{array} \right\}$$ 6.6.4.4.4

$$\beta_{ds} = \frac{V_{u,sustained}}{V_u}$$ 6.6.3.1.1

2. Elastic 2nd Order Analysis 6.7

3. Inelastic 2nd Order Analysis 6.8

Slenderness Effects at Column Ends

Not Applicable

$M_1 = lesser\ first\ order\ factored\ end\ moment$

$M_2 = greater\ first\ order\ factored\ end\ moment$

Slenderness Effects along Column Length

Slenderness Effects along Column Length

1. Moment Magnification Method:

$M_c = \delta M_2 \geq \delta M_{2,min}$ 6.6.4.5.1

$$\delta = \frac{C_m}{1 - \dfrac{P_u}{0.75 P_c}} \geq 1.0$$ 6.6.4.5.2

$$P_c = \frac{\pi^2 (EI)_{eff}}{(k l_u)^2}$$ 6.6.4.4.2

$$(EI)_{eff} = \left\{ \begin{array}{c} \dfrac{0.4 E_c I_g}{1+\beta_{dns}} \\ \dfrac{0.2 E_c I_g + E_s I_{se}}{1+\beta_{dns}} \\ \dfrac{E_c I}{1+\beta_{dns}} \end{array} \right\}$$ 6.6.4.4.4

$$\beta_{dns} = \frac{P_{u,sustained}}{P_u}$$ 6.6.4.4.4

$$C_m = \left\{ \begin{array}{c} 0.6 - 0.4\dfrac{M_1}{M_2} \\ 1 \end{array} \right\}$$ 6.6.4.5.3

2. Elastic 2nd Order Analysis R6.7.1.2

3. Inelastic 2nd Order Analysis R6.8.1.3

Lateral Stability

Lateral Stability

The column is laterally stable if:

$M_c \leq 1.4 \times M_2^*$ 6.2.6

Yes

Design Column for 2nd Order Moment

No

Revise Structural System

* M_2 used in lateral stability is the larger first order factored end moment

Reference: ACI 318-14