

- ① Alignment chart or Nomograph detailing \rightarrow Effective Length Factor
- ② Condition of non-antisymmetric curvature For unbraced Frame ELF
- ③ Portal Frame approximate method. Posts 17,18

④ m value For end condition For girders of Unbraced Frame
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ALIGNMENT CHARTS OR NOMOGRAPHS

As already discussed in this chapter, the alignment charts, or nomographs (see Figures 5-10 and 5-11 or see *AISC* Figure C-A-7.2), is an alternate method to Figure 5-4 that can be used to determine the effective length factor, K , for columns. These nomographs account for the moment or rotational restraints provided at the ends of the column by the beams or girders framing into the columns. They provide more accurate K values, but require knowledge of the sizes of the beams, girders, and columns, and are more cumbersome to use. Two charts are presented in the *AISC*: sidesway inhibited (i.e., buildings with braced frames or shear walls), reproduced in Figure 5-10, and sidesway uninhibited (i.e., buildings with moment frames), reproduced in Figure 5-11. The following assumptions have been used in deriving these alignment charts, or nomographs [1]:

1. The behavior of the frame is purely elastic; that is, elastic buckling of the columns is assumed.
2. All members have prismatic or constant cross section.
3. All the beam-to-column or girder-to-column joints are "rigid" or fully restrained (FR) moment connections.
4. For columns in buildings with braced frames or shear walls as the lateral force resisting system (i.e., sidesway *inhibited* frames), but which have "rigid" beam-to-column and girder-to-column connections, the rotations at opposite ends of the restrained beams or girders are equal in magnitude and opposite in direction, resulting in single-curvature bending in the beams and girders.
5. For columns in buildings with moment resisting frames as the lateral force resisting system (i.e., sidesway *uninhibited* frames), the rotations at opposite ends of the restraining beams or girders are equal in magnitude and direction, resulting in double-curvature bending in the beams and girders.

5. For columns in sidesway-uninhibited frames, rotations at opposite ends of the restraining beams or girders are equal in magnitude and direction, producing double- or reverse-curvature bending.
6. The stiffness parameters, $L\sqrt{P/EI}$, of all columns are equal.
7. Joint restraint is distributed to the column above and below the joint in proportion to EI/L for the two columns.
8. All columns buckle simultaneously.
9. No significant axial compression force exists in the beams or girders.

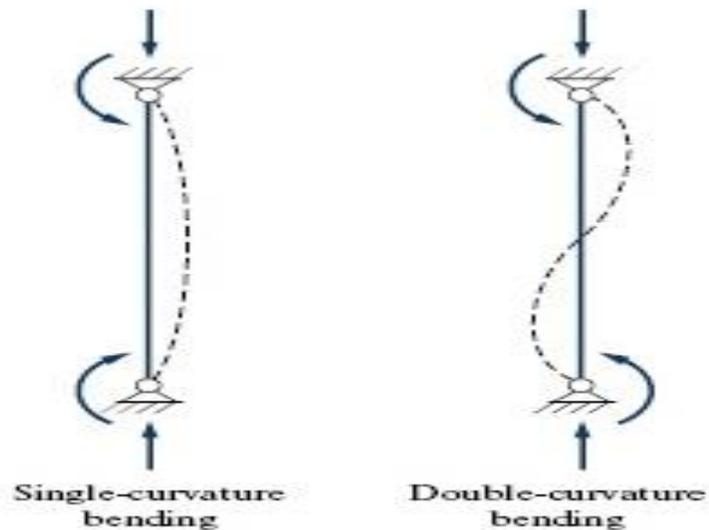


FIGURE 9.31 Column curvature.

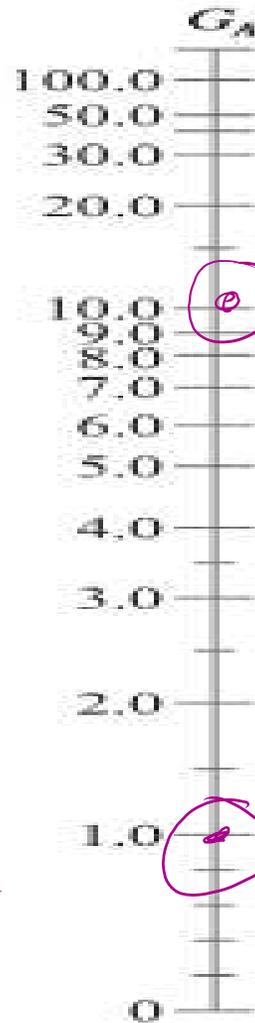
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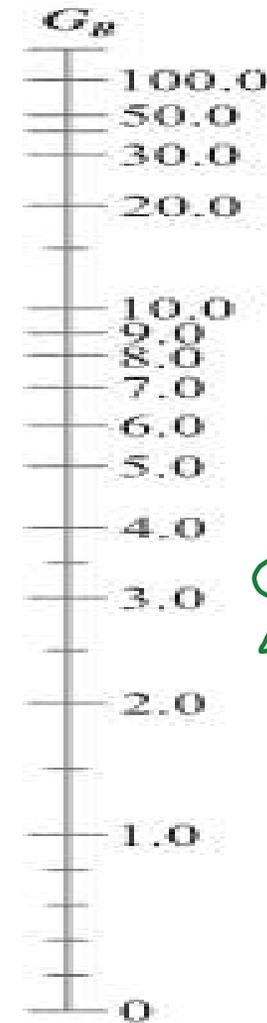
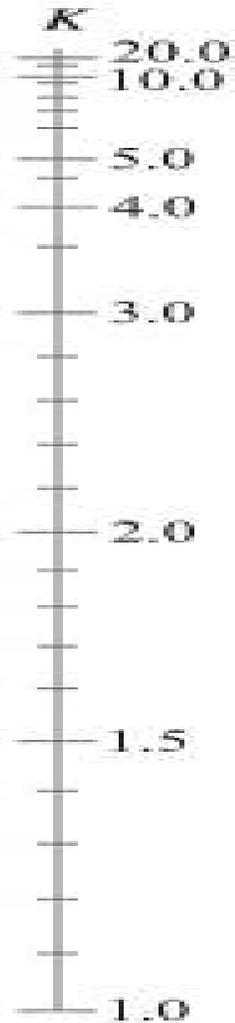
$G = 1$
For Fixed support

$G = 10$
For hinged support

Fixed support



hinged support



Unbraced Frame

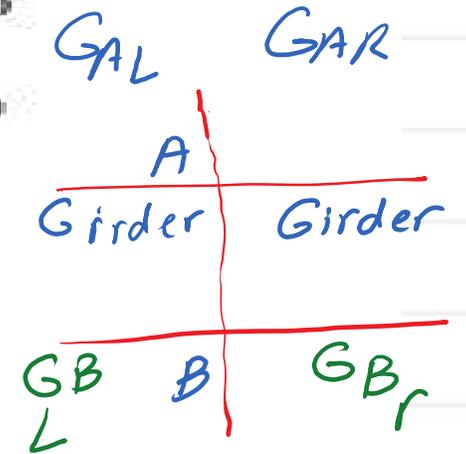


Figure 5-10 Alignment chart: Sidesway uninhibited (i.e., moment frames). [1]

AISC - Commentary

16.1-572

EFFECTIVE LENGTH METHOD

[Comm. 7.2.]

where

$$G = \frac{\Sigma(E_{col}I_{col} / L_{col})}{\Sigma(E_g I_g / L_g)} = \frac{\Sigma(EI / L)_{col}}{\Sigma(EI / L)_g} \quad (C-A-7-3)$$

G-equation

The subscripts *A* and *B* refer to the joints at the ends of the column being considered. The symbol Σ indicates a summation of all members rigidly connected to that joint and located in the plane in which buckling of the column is being considered. E_{col} is the elastic modulus of the column, I_{col} is the moment of inertia of the column, and L_{col} is the unsupported length of the column. E_g is the elastic modulus of the girder, I_g is the moment of inertia of the girder, and L_g is the unsupported length of the girder or other restraining member. I_{col} and L_g are taken about axes perpendicular to the plane of buckling being considered. The alignment charts are valid for different materials if an appropriate effective rigidity, EI , is used in the calculation of G .

It is important to remember that the alignment charts are based on the assumptions of idealized conditions previously discussed—and that these conditions seldom exist in real structures. Therefore, adjustments are often required.

16.1-568

APPENDIX 7 ALTERNATIVE METHODS OF DESIGN FOR STABILITY

Adjustment for Columns

Comm. 7.2.]

EFFECTIVE LENGTH METHOD

16.1-573

Adjustments for Columns With Differing End Conditions. For column ends supported by, but not rigidly connected to, a footing or foundation, G is theoretically infinity but unless designed as a true friction-free pin, may be taken as 10 for practical designs. If the column end is rigidly attached to a properly designed footing, G may be taken as 1.0. Smaller values may be used if justified by analysis.

Adjustments for Girders With Differing End Conditions. For sidesway inhibited frames, these adjustments for different girder end conditions may be made:

- (a) If rotation at the far end of a girder is prevented, multiply $(EI/L)_g$ of the member by 2.
- (b) If the far end of the girder is pinned, multiply $(EI/L)_g$ of the member by 1.5.

For sidesway uninhibited frames and girders with different boundary conditions, the modified girder length, L_g' , should be used in place of the actual girder length, where

$$L_g' = L_g (2 - M_F/M_N) \quad (\text{C-A-7-4})$$

M_F is the far end girder moment and M_N is the near end girder moment from a first-order lateral analysis of the frame. The ratio of the two moments is positive if the girder is in reverse curvature. If M_F/M_N is more than 2.0, then L_g' becomes negative, in which case G is negative and the alignment chart equation must be used. For sidesway uninhibited frames, the following adjustments for different girder end conditions may be made:

- (a) If rotation at the far end of a girder is prevented, multiply $(EI/L)_g$ of the member by $2/3$.
- (b) If the far end of the girder is pinned, multiply $(EI/L)_g$ of the member by $1/2$.

Basic structural analysis

Reddy

3rd

Edition

9.2.4 Portal Frames

Laterally loaded portal frames can also be analysed by the approximations employed in Sec. 9.2.3 for mill bents. Consider, for example, a fixed base portal frame of Fig. 9.11a. Note that the deflected shape of a portal frame depends on the relative stiffness of columns and girder. Two extreme cases are considered. In Fig. 9.11b the deflected shape of the frame when the girder is very stiff in comparison with the columns is given. The points of contra-flexure lie at about mid-height of the columns. The deflected shape of the frame when the girder is flexible in comparison with the columns is given in Fig. 9.11c. The points of

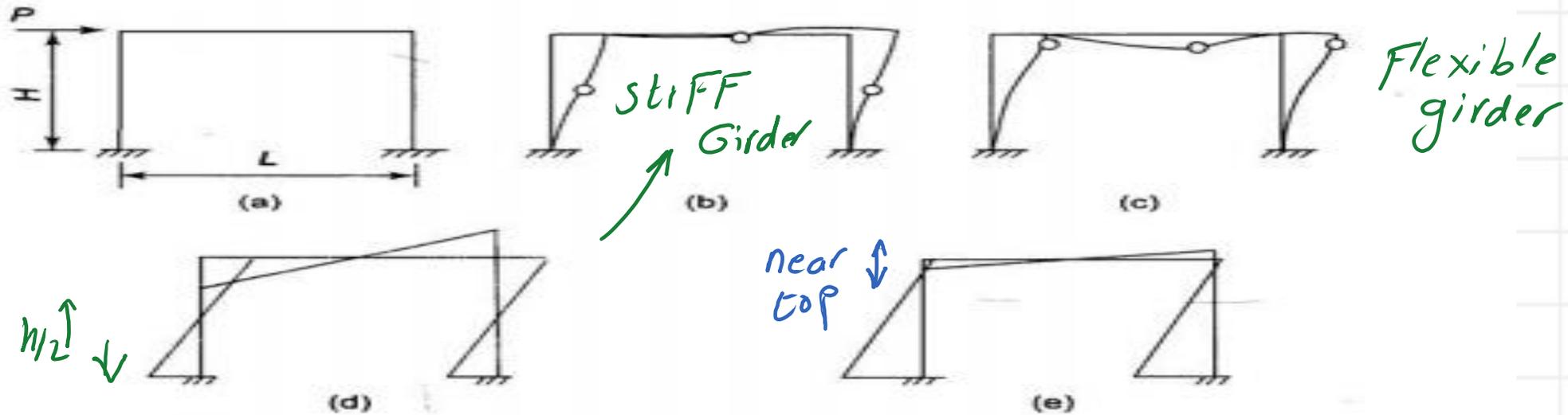
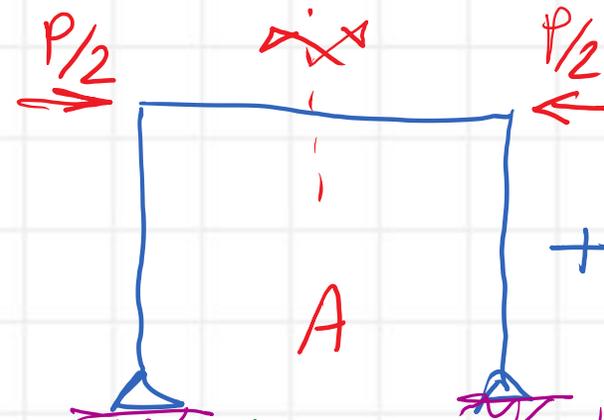
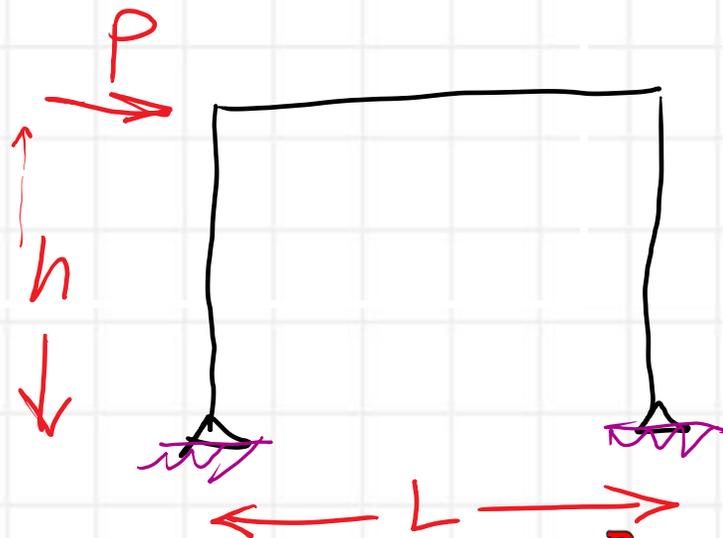


Fig. 9.11 (a) Portal frame, (b) Frame with stiff girder, (c) Frame with flexible girder, (d) Moment diagram for frame with stiff girder, (e) Moment diagram for frame with flexible girder.

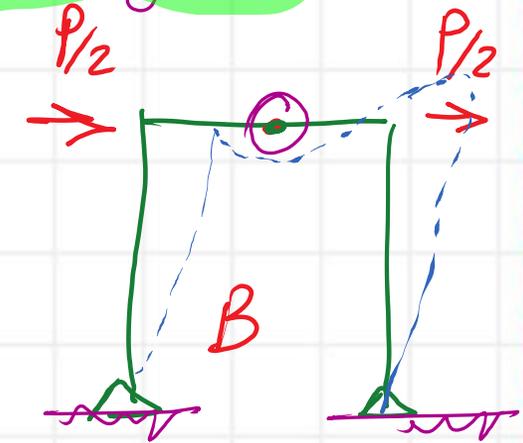
Unbraced Frame

$$G = \frac{\sum \left(\frac{EI}{L} \right)_{\text{columns}}}{\sum \left(m \frac{EI}{L} \right)_{\text{girders}}}$$

First Case
Two hinged
supports
at the
base



NO B.M symmetric Loading



assume roller hinge

Approximate method For analysis

For other conditions include a correction factor "m" to account for actual rotational stiffness of the girder at the joint.

of Frame

Sidesway Uninhibited (Sway)
Assumption: reverse curvature bending of girder.

R.C Hibbler Structural analysis

Prepared by Eng. Maged Kamel.