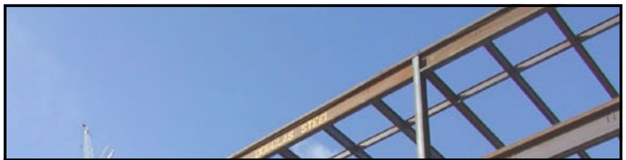


Chapter 4
Compression Members

1

Chapter 4 – More on Effective Length

- For isolated columns that are not part of a continuous frame, **Table C-A-7.1** in ***the Commentary to Specification Appendix 7*** will usually suffice.

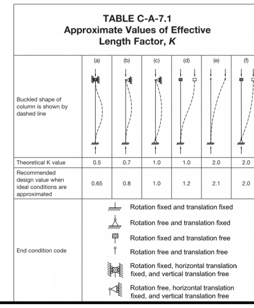


TABLE C-A-7.1
Approximate Values of Effective Length Factor, *K*

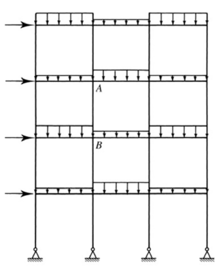
	(a)	(b)	(c)	(d)	(e)	(f)
Buckled shape of column is shown by dashed line						
Theoretical K value	0.5	0.7	1.0	1.0	2.0	2.0
Recommended design value when ideal conditions are approximated	0.65	0.8	1.0	1.2	2.1	2.0

End condition code:
- Rotation fixed and translation fixed
- Rotation free and translation fixed
- Rotation fixed and translation free
- Rotation free and translation free
- Rotation fixed, horizontal translation fixed, and vertical translation free
- Rotation free, horizontal translation fixed, and vertical translation free

2

Chapter 4 – More on Effective Length

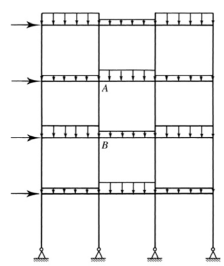
- Consider, however, this rigid frame.
- The columns in this frame are not independent members but part of a continuous structure.



3

Chapter 4 – More on Effective Length

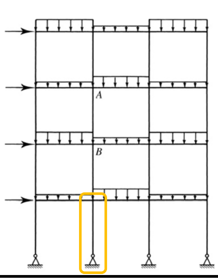
- The columns are restrained at both ends by their connection to beams and other columns.
- This frame is also unbraced, meaning that ***horizontal sideway*** displacements are possible.



4

Chapter 4 – More on Effective Length

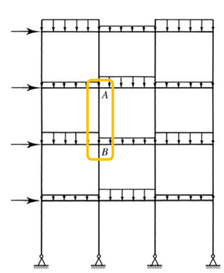
- If ***Table C-A-7.1*** is used for this frame, the lower-story columns are best approximated by ***condition (f)***, and a value of ***K*** = 2.



5

Chapter 4 – More on Effective Length

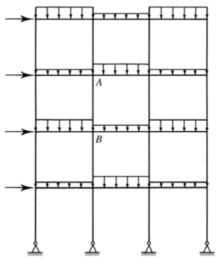
- For a column such as *AB*, a value of ***K*** = 1.2, corresponding to ***condition (d)***, could be selected.



6

Chapter 4 – More on Effective Length

- A more rational procedure, however, will account for the degree of restraint provided by connecting members.

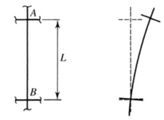


7

Chapter 4 – More on Effective Length

- The rotational restraint provided by the beams, or girders, at the end of a column is a function of the ***rotational stiffnesses*** of the ***members intersecting at the joint***.
- The rotational stiffness of a member is proportional to ***EI/L***, where ***I*** is the moment of inertia of the cross section with respect to the axis of bending.
- The ***effective length factor K*** depends on the ratio of column stiffness to girder stiffness at each end of the member, which can be expressed as:

$$G = \frac{\sum E_{col} I_{col} / L_{col}}{\sum E_g I_g / L_g} = \frac{\sum I_{col} / L_{col}}{\sum I_g / L_g}$$

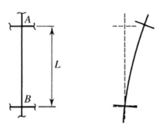


8

Chapter 4 – More on Effective Length

- If a very ***slender column*** is connected to ***girders having large cross-sections***, the girders will effectively prevent rotation of the column.
- The ends of the column are approximately ***fixed***, and ***K*** is relatively small.
- This condition corresponds to small values of ***G***.

$$G = \frac{\sum E_{col} I_{col} / L_{col}}{\sum E_g I_g / L_g} = \frac{\sum I_{col} / L_{col}}{\sum I_g / L_g}$$

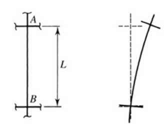


9

Chapter 4 – More on Effective Length

- If ***stiff columns*** are connected to ***flexible beams***, then the ends can more freely rotate.
- The column ends approaches the ***pinned condition***, giving relatively large values of ***G*** and ***K***

$$G = \frac{\sum E_{col} I_{col} / L_{col}}{\sum E_g I_g / L_g} = \frac{\sum I_{col} / L_{col}}{\sum I_g / L_g}$$



10

Chapter 4 – More on Effective Length

- The relationship between ***G*** and ***K*** has been quantified in the Jackson–Mooreland Alignment Charts (Johnston, 1976), which are reproduced in ***Table C-A-7.2 in the Commentary***.

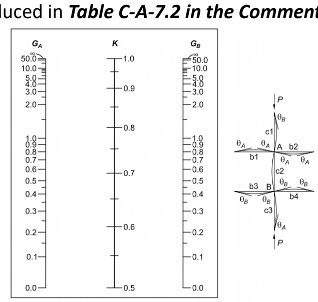


Fig. C-A-7.1. Alignment chart—sidesway inhibited (braced frame).

11

Chapter 4 – More on Effective Length

- The relationship between ***G*** and ***K*** has been quantified in the Jackson–Mooreland Alignment Charts (Johnston, 1976), which are reproduced in ***Table C-A-7.2 in the Commentary***.

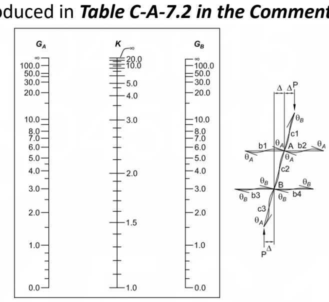


Fig. C-A-7.2. Alignment chart—sidesway uninhibited (moment frame).

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Chapter 4 – More on Effective Length

- To obtain a value of ***K*** from one of these nomograms, first calculate the value of ***G***.
- At each end of the column, let one value be G_A and the other be G_B.
- Connect G_A and G_B with a straight line and ***read the value of on the middle scale***.
- The ***effective length factor*** obtained with respect to the axis of bending, which is the axis perpendicular to the plane of the frame.

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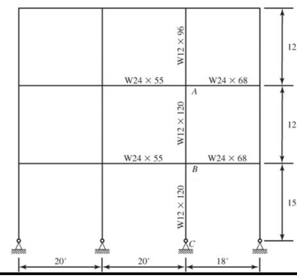
Chapter 4 – More on Effective Length

- **Example 4-13**: The rigid frame below is unbraced. Each member is oriented so that its web is in the plane of the frame. Determine the effective length factor K_x for columns AB and BC.



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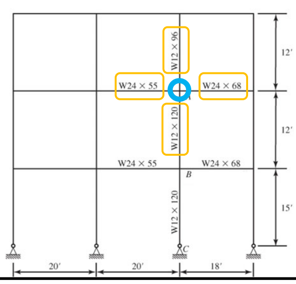
Chapter 4 – More on Effective Length

- **Example 4-13**: Column ***AB***, joint ***A***:

From Table 1-1 (**1**-20): $I_{W24x55} = 1{,}350 in^4$ $I_{W24x68} = 1{,}830 in^4$

From Table 1-1 (**1**-26): $I_{W12x120} = 1{,}070 in^4$ $I_{W12x96} = 833 in^4$



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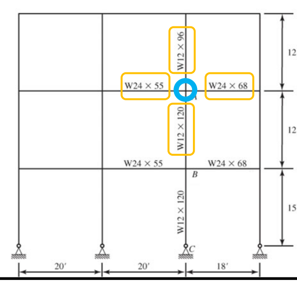
Chapter 4 – More on Effective Length

- **Example 4-13**: Column ***AB***, joint ***A***:

$$G_A = \frac{\sum I_{col}/L_{col}}{\sum I_g/L_g} = \frac{\sum\left(833 in^4/12 ft\right) + \left(1{,}070 in^4/12 ft\right)}{\sum\left(1{,}350 in^4/20 ft\right) + \left(1{,}830 in^4/18 ft\right)} = 0.937$$



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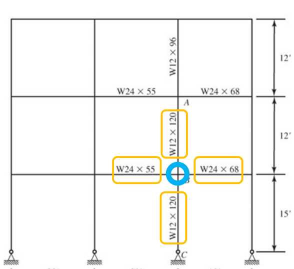
Chapter 4 – More on Effective Length

- **Example 4-13**: Column ***AB***, joint ***B***:

From Table 1-1 (**1**-20): $I_{W24x55} = 1{,}350 in^4$ $I_{W24x68} = 1{,}830 in^4$

From Table 1-1 (**1**-26): $I_{W12x120} = 1{,}070 in^4$



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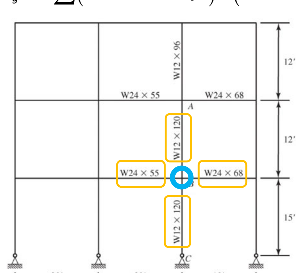
Chapter 4 – More on Effective Length

- **Example 4-13**: Column ***AB***, joint ***B***:

$$G_B = \frac{\sum I_{col}/L_{col}}{\sum I_g/L_g} = \frac{\sum\left(1{,}070 in^4/12 ft\right) + \left(1{,}070 in^4/15 ft\right)}{\sum\left(1{,}350 in^4/20 ft\right) + \left(1{,}830 in^4/18 ft\right)} = 0.949$$



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Chapter 4 – More on Effective Length

- **Example 4-13**: From ***AISC Figure C-A-7.2*** for sidesway uninhibited, with G_A = 0.937 and G_B =0.949.

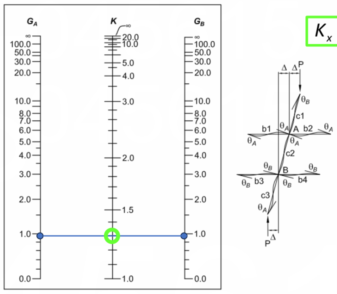

Fig. C-A-7.2. Alignment chart—sidesway uninhibited (moment frame).

$K_x \cong 1.3$

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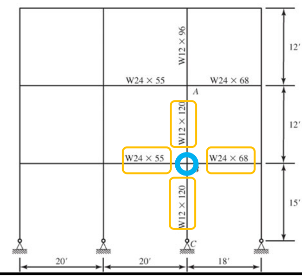
Chapter 4 – More on Effective Length

- **Example 4-13**: Column ***BC***, joint ***B***:

From Table 1-1 (**1**-20): $I_{W24x55} = 1{,}350 in^4$ $I_{W24x68} = 1{,}830 in^4$

From Table 1-1 (**1**-26): $I_{W12x120} = 1{,}070 in^4$



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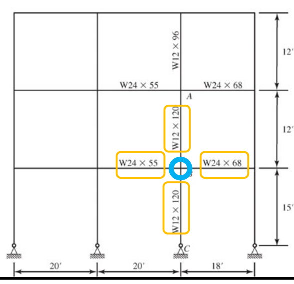
Chapter 4 – More on Effective Length

- **Example 4-13**: Column ***AB***, joint ***B***:

$$G_B = \frac{\sum I_{col}/L_{col}}{\sum I_g/L_g} = \frac{\sum\left(1{,}070 in^4/12 ft\right)+\left(1{,}070 in^4/15 ft\right)}{\sum\left(1{,}350 in^4/20 ft\right)+\left(1{,}830 in^4/18 ft\right)} = 0.949$$



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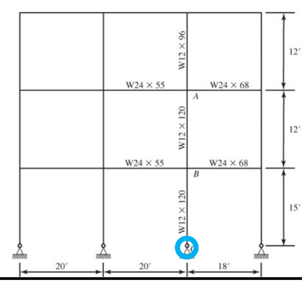
Chapter 4 – More on Effective Length

- **Example 4-13**: Column ***AB***, joint ***C***:

For joint ***C***, a pin connection, the situation is analogous to that of a very stiff column attached to infinitely flexible girders.



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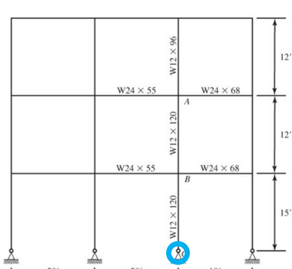
Chapter 4 – More on Effective Length

- **Example 4-13**: Column ***AB***, joint ***C***:

The ratio of column stiffness to girder stiffness would therefore be infinite for a perfectly frictionless hinge.



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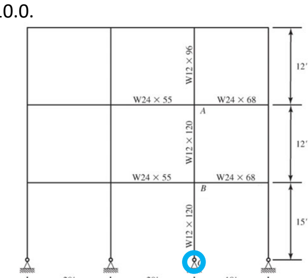
Chapter 4 – More on Effective Length

- **Example 4-13**: Column ***AB***, joint ***C***:

This end condition can only be approximated in practice, so the discussion accompanying the alignment chart recommends that ***G*** = 10.0.



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Chapter 4 – More on Effective Length

- **Example 4-13**: From ***AISC Figure C-A-7.2*** for sidesway uninhibited, with G_A = 0.949 and G_B = 10.

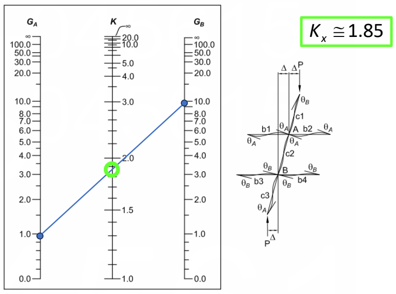

Fig. C-A-7.2. Alignment chart—sidesway uninhibited (moment frame).

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Chapter 4 – More on Effective Length

- As pointed out in **Example 4.13**, for a pinned support, ***G*** should be taken as 10.0; for a fixed support, ***G*** should be taken as 1.0.
- The latter support condition corresponds to an infinitely stiff girder and a flexible column, corresponding to a theoretical value of ***G*** = 0.
- The discussion accompanying the alignment chart in the ***Commentary*** recommends a value of ***G*** = 1.0 because true fixity will rarely be achieved.

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Chapter 4 – More on Effective Length

Let's work on some problems

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Chapter 4 – More on Effective Length

Any questions?

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