

# CE 415

# DESIGN OF STEEL STRUCTURES

## LECTURE 12

## COMPRESSION MEMBER

SEMESTER: SUMMER 2021

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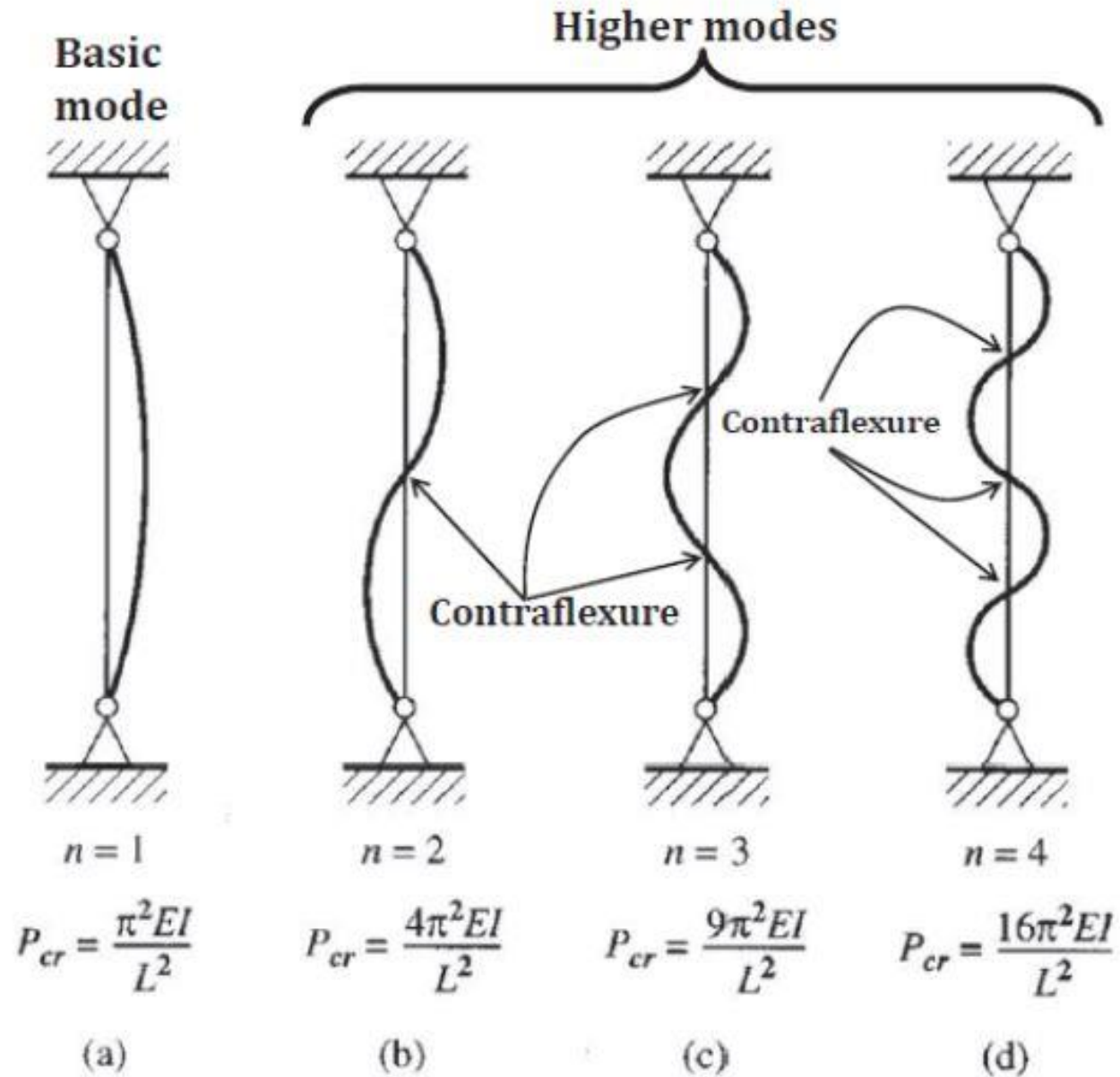
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# OUTLINE

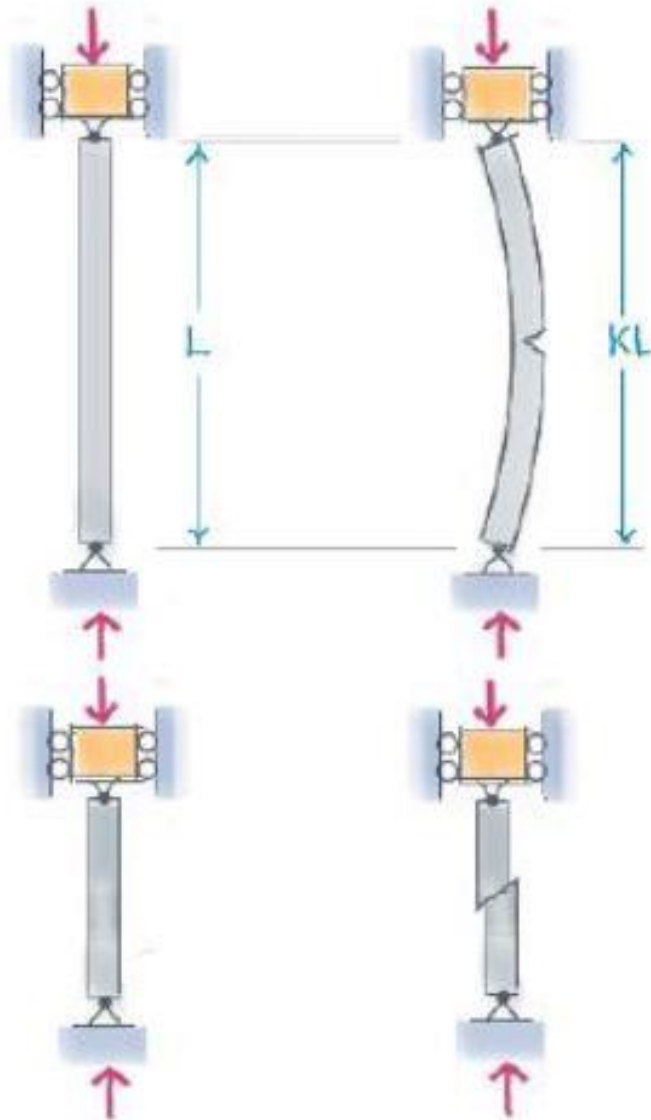
- Buckling mode N
- End constrains k
- Buckling failure math problem

# Meaning of $n$

In order to produce higher modes of buckling, lateral supports are needed at points of contraflexure.



## Meaning of K, L, KL



### Buckling











Buckling is the sudden lateral instability of a slender structural member induced by the action of an axial load before the yield stress of the material is reached.

- $L$  Physical length of column
- $K$  Effective length factor
- $KL$  Effective length

### Crushing

Crushing occurs when the direct stress from an axial load exceeds the compressive strength of the material available in the cross section.

## Values of K

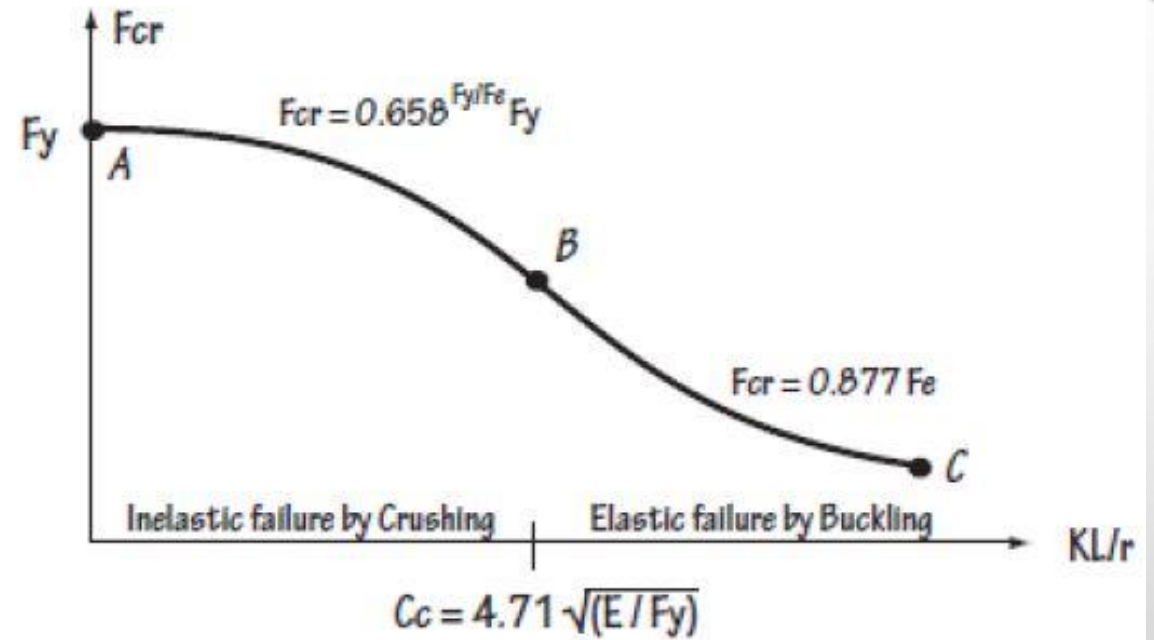
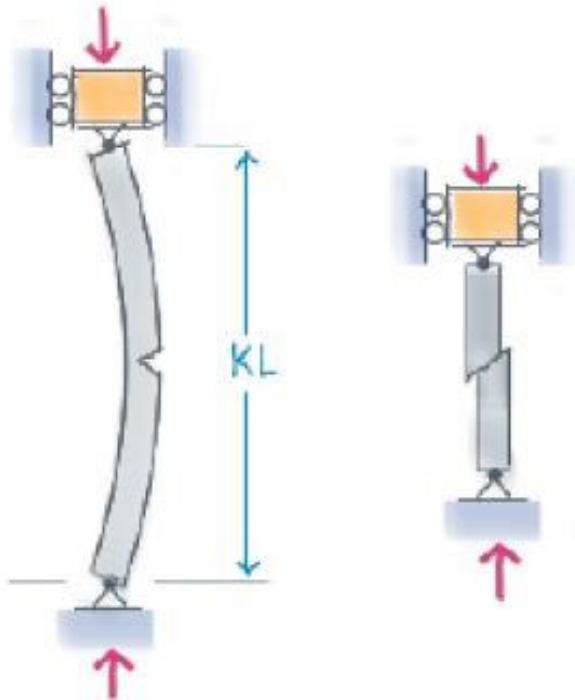
	(a)	(b)	(c)	(d)	(e)	(f)
<b>End conditions</b>						
 only rotation is free						
 only translation is free						
 both free						
 both fixed						
<i>theoretical value</i>	0.50	0.707	1.0	1.0	2.0	2.0
<i>design value</i>	0.65	0.80	1.2	1.0	2.1	2.0

### Summary:

Fixed-Free=2.0  
 Pinned-Pinned=1  
 Pinned-Fixed= 0.8  
 Fixed-Fixed=0.65

## Main formula: AISC 2005

$L$	Physical length of column
$K$	Effective length factor
$KL$	Effective length
$r$	Radius of gyration
$KL/r$	Slenderness ratio
$F_{cr}$	Critical stress
$F_y$	Yield stress
$E$	Modulus of elasticity
$C_c$	Critical coefficient



$$F_{cr} = \begin{cases} 0.658 F_y / F_e F_y & \text{if } KL/r < C_c \\ 0.877 F_e & \text{if } KL/r > C_c \end{cases}$$

## AISC LRFD Capacity of Compression Members

$$\phi_c P_n \geq P_u$$

where  $\phi_c$  = resistance factor = 0.90

$P_n$  = nominal strength =  $F_{cr} A_g$

$F_{cr}$  = Eqs. 6.7.7 and 6.7.8

$P_u$  = factored service load

## AISC ASD Capacity of Compression Members

$$\frac{P_n}{\Omega} \geq P_a$$

where  $P_a$  = maximum compressive load using ASD load combination

$P_n$  = nominal strength

$\Omega$  = safety factor equal to 1.67

**Here, nominal strength  $P_n = F_{cr} A_g$**



**Ques.** A steel column of 25 ft length is made of W 14 × 61 shape which is supported by a fixed-hinge joint. Determine the axial capacity of the section. Steel is A992.

From [Table 1-7](#) of AISC Manual,  $A_g = 17.90 \text{ in}^2$  and  $r_y = 2.45 \text{ in}$ .

**Ques.** If the same column is changed to a length of 35 ft, then determine its capacity.

**Solution.**

$$K = 0.80 \quad (\text{for fixed-hinge joint})$$

$$L = 35 \text{ ft}$$

$$F_y = 50 \text{ ksi}$$

**Check Failure Mode**

$$KL = 0.8 \times 35 = 28 \text{ ft}$$

$$\frac{KL}{r} = \frac{28 \times 12}{2.45} = 137.1$$

$$C_c = 113.4$$

Since,  $KL/r > C_c$ , failure is by buckling.

**Determine Capacity**

$$F_e = \frac{\pi^2 E}{(KL/r)^2} = \frac{\pi^2 \times 29000}{137.1^2} = 15.22 \text{ ksi}$$

$$F_{cr} = 0.877 F_e = 0.877 \times 15.22 = 13.35 \text{ ksi}$$

$$\Phi_c P_n = \Phi_c F_{cr} A_g = 0.9 \times 13.35 \times 17.9 = 215.1 \text{ kip}$$

**Ans.** 215.1 kip