CE 415
DESIGN OF STEEL STRUCTURES

LECTURE 14
COMPRESSION MEMBER

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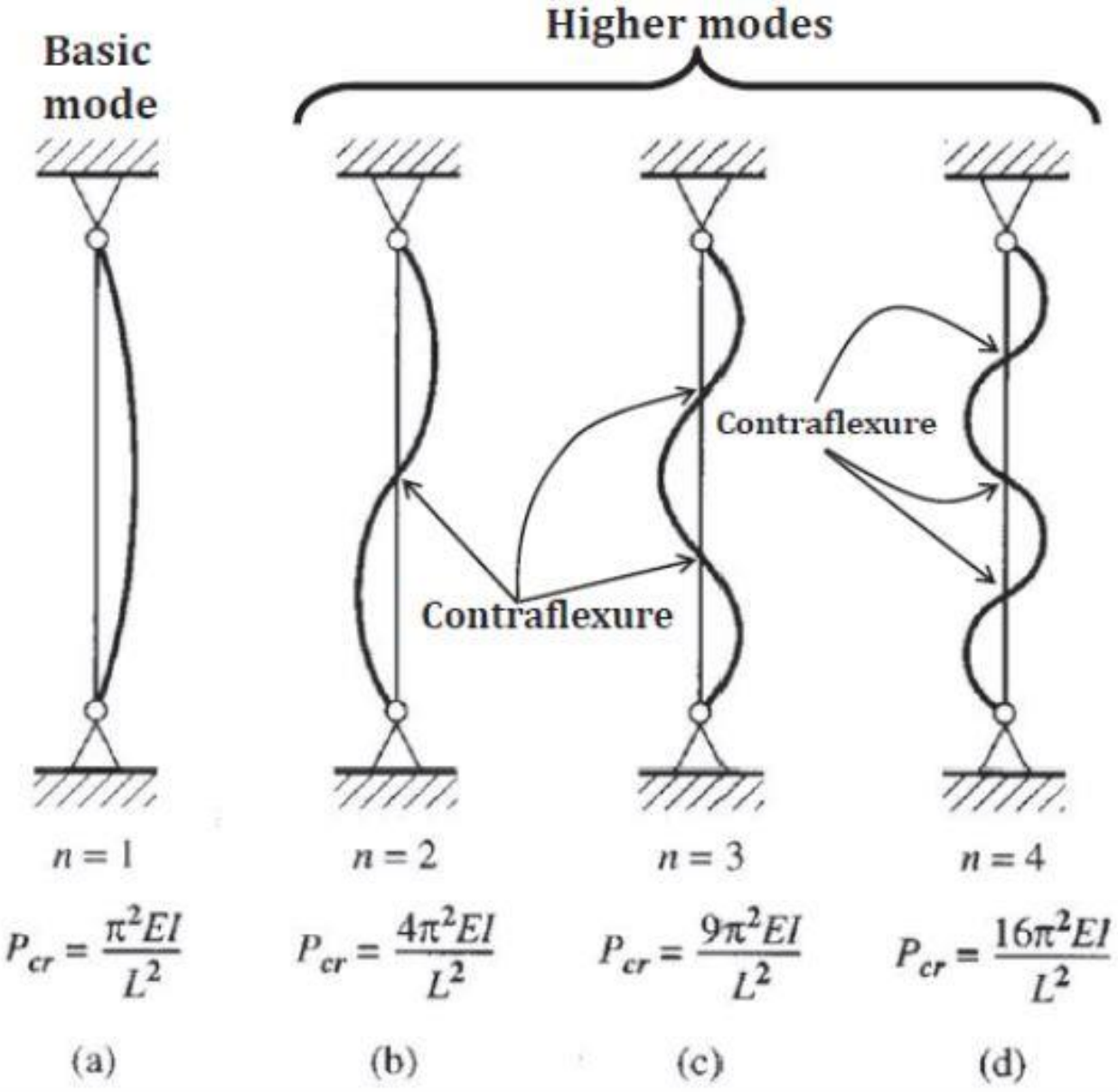
OUTLINE

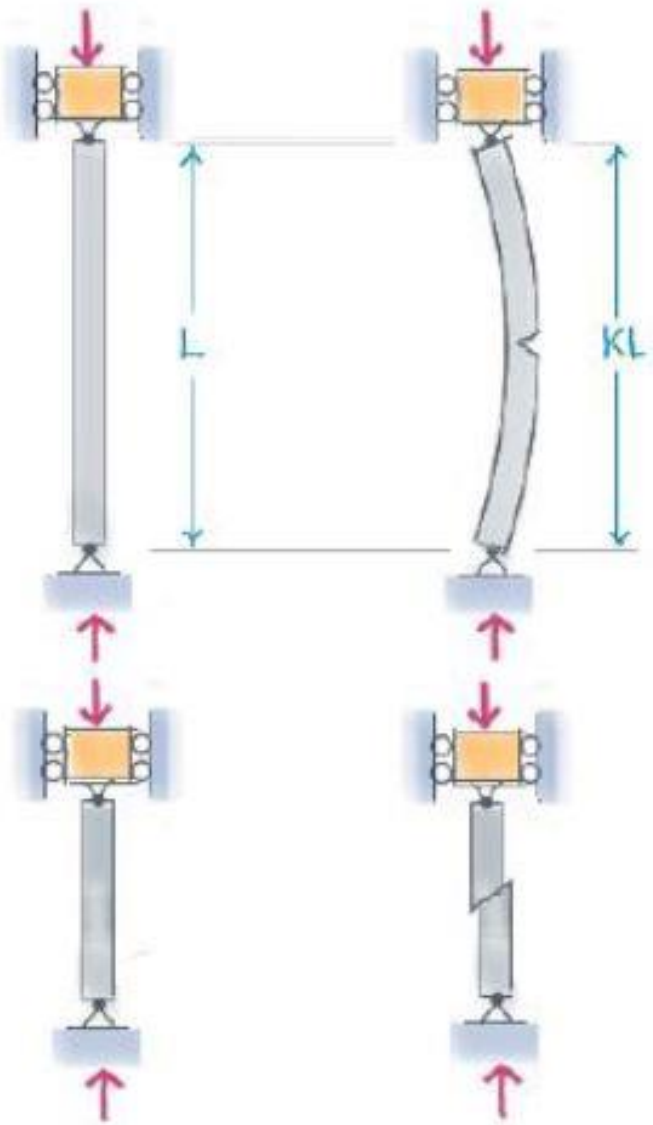
- Buckling mode N
- End constrains k
- Buckling failure math problem

Meaning of *n*

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



Meaning of K, L, KL

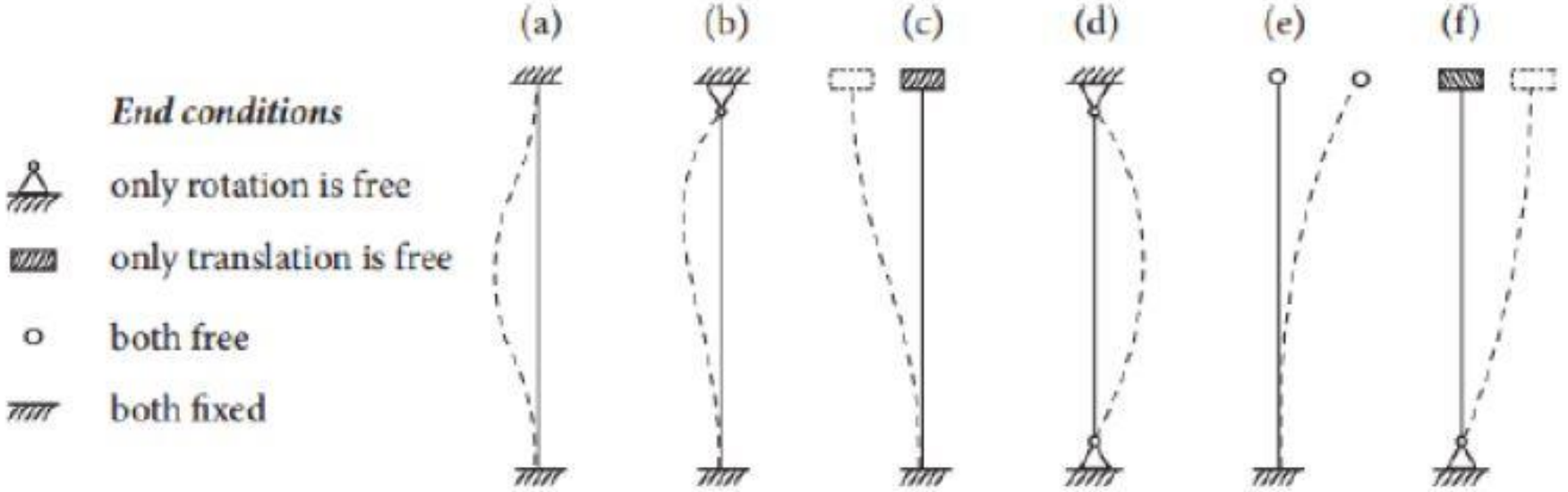


Buckling
Buckling is the sudden lateral instability of a slender structural member induced by the action of an axial load before the yield stress of the material is reached.

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

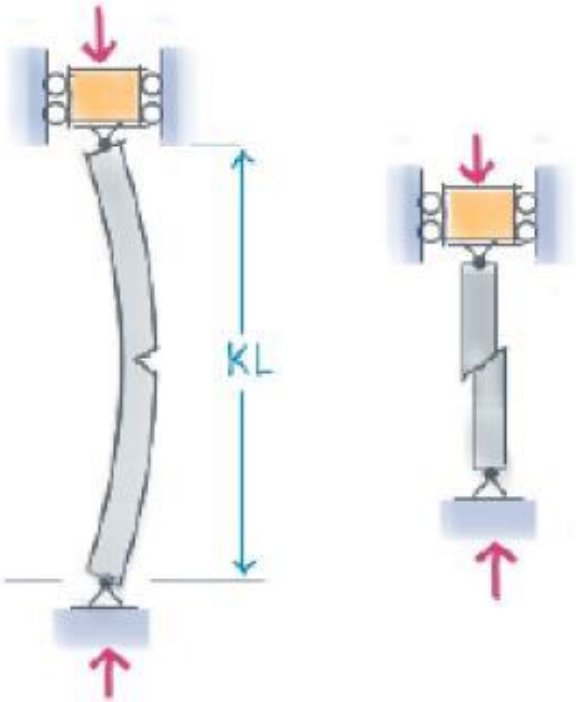


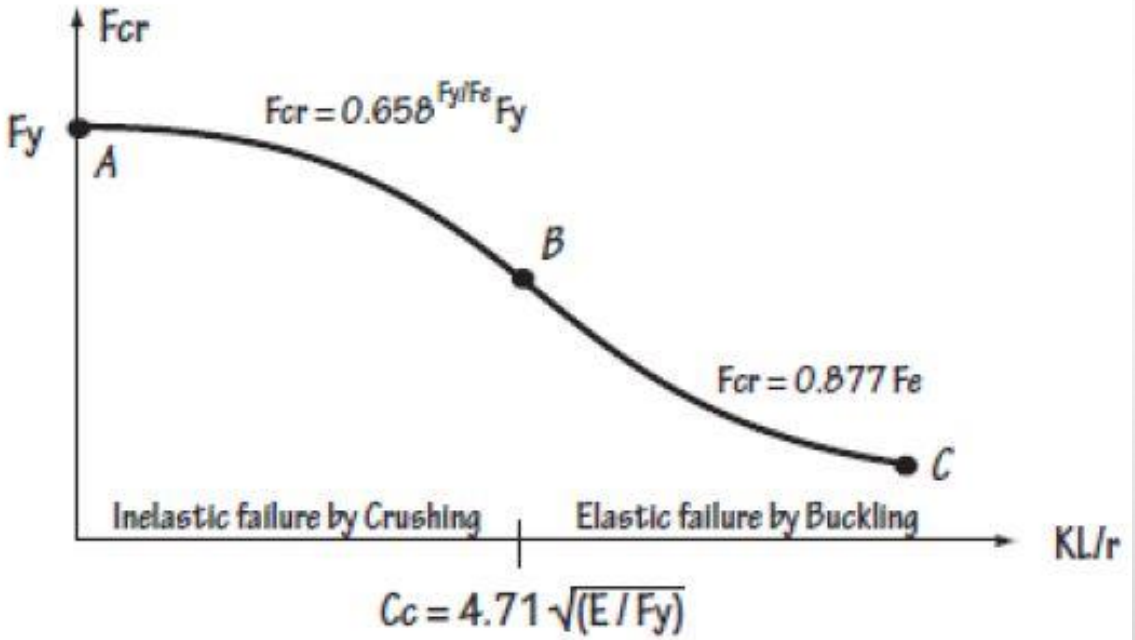
	(a)	(b)	(c)	(d)	(e)	(f)
theoretical value	0.50	0.707	1.0	1.0	2.0	2.0
design value	0.65	0.80	1.2	1.0	2.1	2.0

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
Fy	Yield stress
E	Modulus of elasticiy
C_c	Critical coefficents





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

AISC LRFD Capacity of Compression Members

$$\phi_c P_n \geq P_u$$

where ϕ_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

Ω = 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, $A_g = 17.90$ in^2 and $r_y = 2.45$ in.

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

Soltuion.

$$K = 0.80 \quad \text{(for fixed-hinge joint)}$$
$$L = 35 \text{ ft}$$
$$F_y = 50 \text{ ksi}$$

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