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1. Definition of Compression - members.
2. Modes of Failure.
3. Where to use different steel sections?
4. Derivation of Euler Formula.
5. Difference between Local buckling and General buckling.
6. Short Columns modes of failure.
7. Torsion buckling.

Summary of the post content

Prepared by Eng.Maged Kamel.

Introduction

Alan Williams

steel structural design

As shown in Fig. 6.1, a compression member is a structural element that supports loads applied along its longitudinal axis. Axially loaded members are compression members that are nominally free from applied bending moments and consist of the several types illustrated. The column in a building frame, as shown in Fig. 6.1*a*, supports the gravity loads applied to the frame. Failure of a column may cause complete collapse of the structure above the failed column. A brace in a braced frame, as shown in Fig. 6.1*b*, provides the lateral restraint to resist the horizontal forces caused by wind or earthquake. A strut in a roof truss, as shown in Fig. 6.1*c*, is a web member that provides the required compression force. Similarly, as shown in Fig. 6.1*d*, the top chord provides the compression members in a truss.

Types of compression members

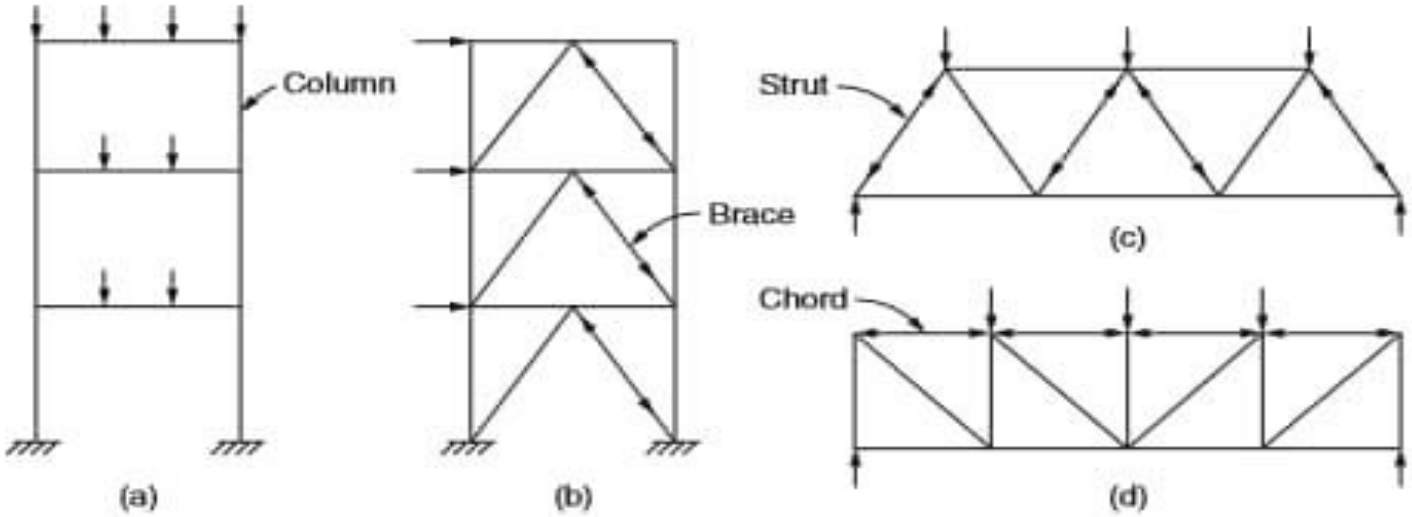

Figure 6.1 Types of compression members.

Prof. Varma

- Compression Members: Structural elements that are subjected to axial compressive forces only are called *columns*. Columns are subjected to axial loads thru the centroid.
- Stress: The stress in the column cross-section can be calculated as

$$f = \frac{P}{A} \tag{2.1}$$

where, f is assumed to be uniform over the entire cross-section.

- This ideal state is never reached. The stress-state will be non-uniform due to:
  - Accidental eccentricity of loading with respect to the centroid
  - Member out-of-straightness (crookedness), or
  - Residual stresses in the member cross-section due to fabrication processes.

Ideal state never reached

- Accidental eccentricity and member out-of-straightness can cause bending moments in the member. However, these are secondary and are usually ignored.
- Bending moments cannot be neglected if they are acting on the member. Members with axial compression and bending moment are called *beam-columns*.

Stress equation for a column

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Single-angle members (a) are satisfactory for use as bracing and compression members in light trusses. Equal-leg angles may be more economical than unequal-leg angles, because their least r values are greater for the same area of steel. The top chord

ⓐ Single angle is suitable as bracing

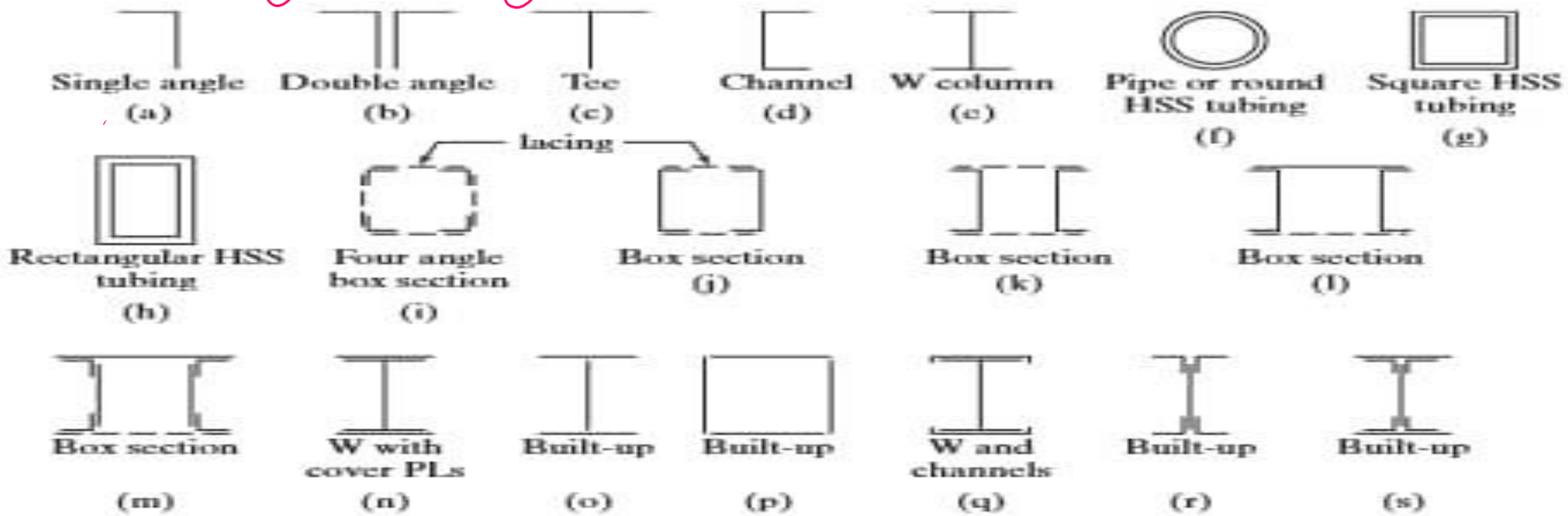

FIGURE 5.2
Types of compression members.

Use a single angle as a lacing

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(b) use double angles bolted roof truss – Top Chord

members of bolted roof trusses might consist of a pair of angles back to back (b). There will often be a space between them for the insertion of a gusset or connection plate at the joints necessary for connections to other members. An examination of this section will show that it is probably desirable to use unequal-leg angles with the long legs back to back to give a better balance between the *r* values about the *x* and *y* axes.

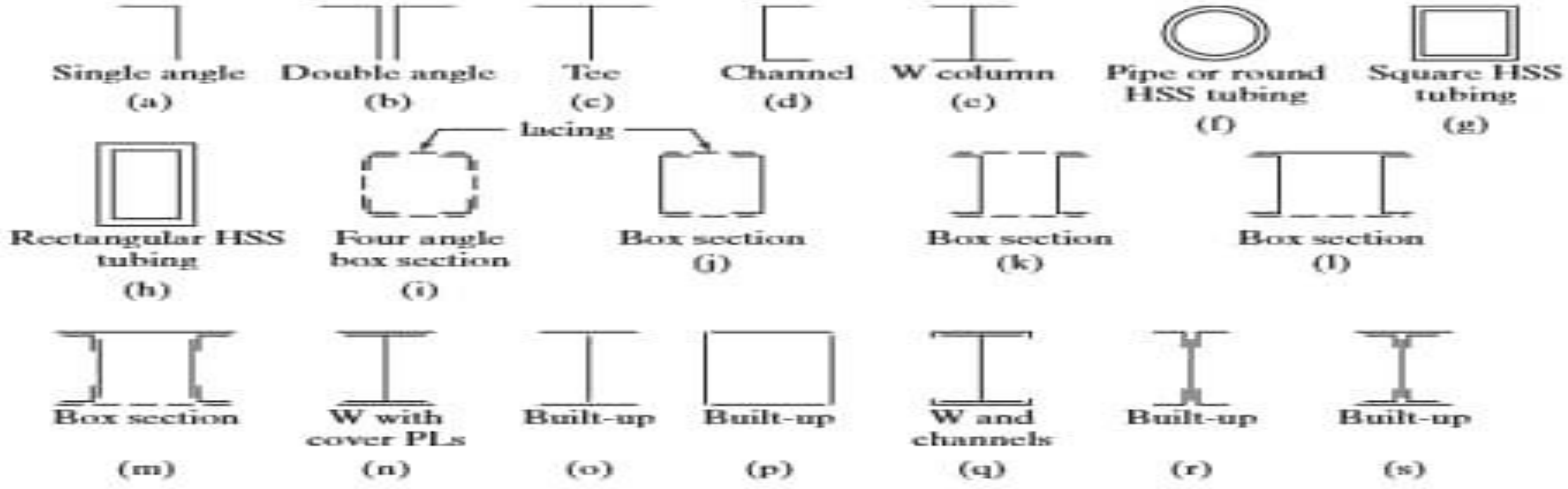

FIGURE 5.2
Types of compression members.

Use a Double-angle as a bolted roof truss.

(c) Use T section for welded connection in place of Gusset Plate. Mccormac

(d) [channel is not adequate due to Low r value.

(e) W section is suitable for steel Columns.

(f) Pipes & HSS sections are valuable sections for buildings

(g)

(h) HSS section

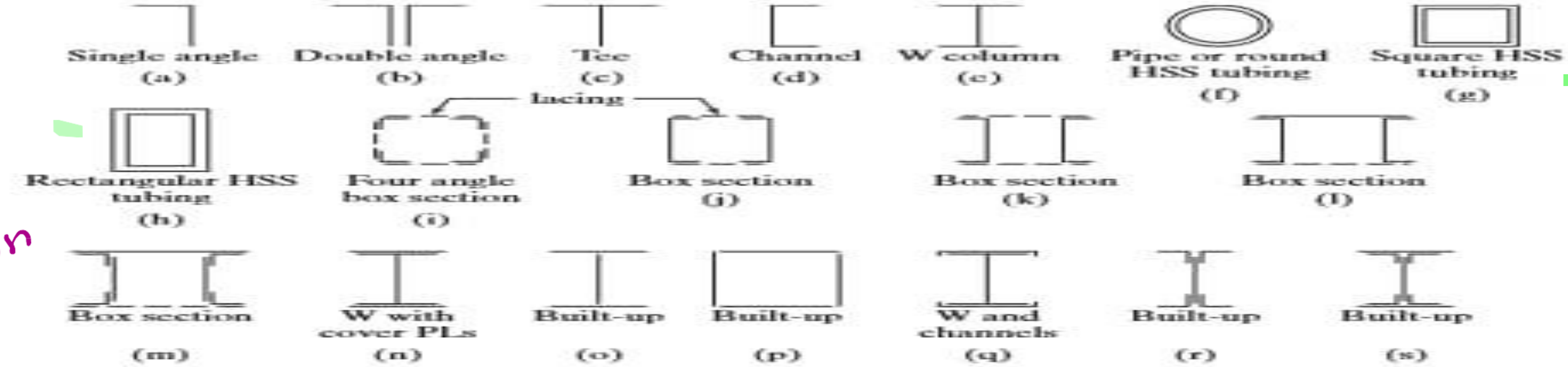

FIGURE 5.2
Types of compression members.

Use a T-section as a welded connection

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(i) Four angle box section and 2[are suitable For Lacing.

Use a T-section as a welded connection

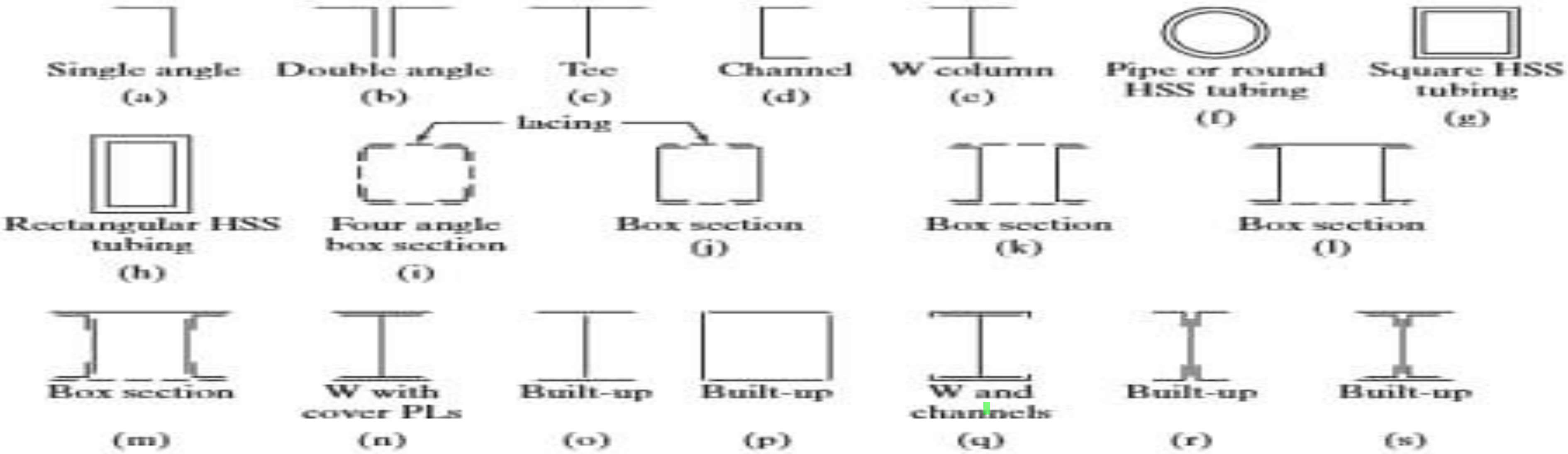

FIGURE 5.2
Types of compression members.

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Modes of Failures

McCormac

There are three general modes by which axially loaded columns can fail. These are flexural buckling, local buckling, and torsional buckling. These modes of buckling are briefly defined as follows:

Long Column Euler

1. *Flexural buckling* (also called Euler buckling) is the primary type of buckling discussed in this chapter. Members are subject to flexure, or bending, when they become unstable.
2. *Local buckling* occurs when some part or parts of the cross section of a column are so thin that they buckle locally in compression before the other modes of buckling can occur. The susceptibility of a column to local buckling is measured by the width–thickness ratios of the parts of its cross section. This topic is addressed in Section 5.7. Table B4.1b
3. *Flexural torsional buckling* may occur in columns that have certain cross-sectional configurations. These columns fail by twisting (torsion) or by a combination of torsional and flexural buckling. This topic is initially addressed in Section 6.10.

A P P E N D I X   A

Derivation of the Euler Formula

Euler -equation part-1

The Euler formula is derived in this section for a straight, concentrically loaded, homogeneous, long, slender, elastic, and weightless column with rounded ends. It is assumed that this perfect column has been laterally deflected by some means, as shown in Fig. A.1 and that, if the concentric load P were removed, the column would straighten out completely.

The x and y axes are located as shown in the figure. As the bending moment at any point in the column is $-Py$, the equation of the elastic curve can be written as

$$EI\frac{d^2y}{dx^2} = -Py$$

For convenience in integration, both sides of the equation are multiplied by $2dy$:

$$EI2\frac{dy}{dx}d\frac{dy}{dx} = -2Pydy$$

$$EI\left(\frac{dy}{dx}\right)^2 = -Py^2 + C_1$$

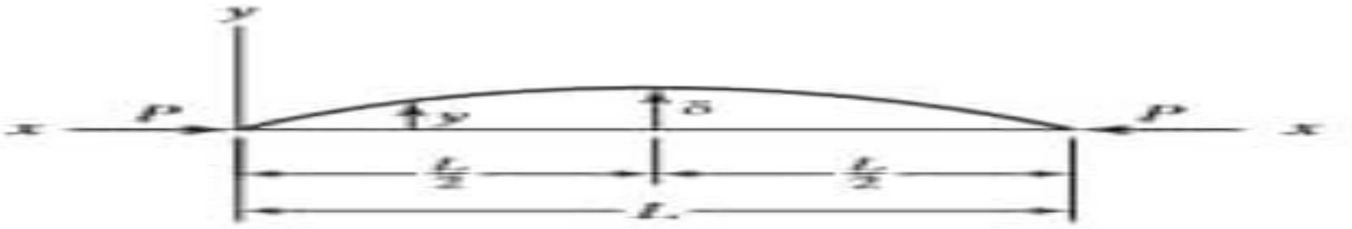

FIGURE A.1

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Euler -equation part-2

$$EI\left(\frac{dy}{dx}\right)^2 = -Py^2 + C_1$$

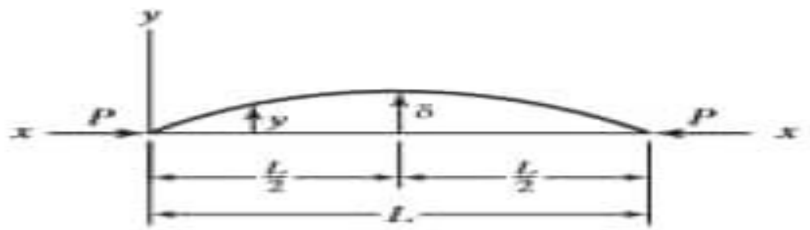

FIGURE A.1

When $y = \delta$, $dy/dx = 0$, and the value of C_1 will equal $P\delta^2$ and

$$EI\left(\frac{dy}{dx}\right)^2 = -Py^2 + P\delta^2$$

The preceding expression is arranged more conveniently as follows:

$$\left(\frac{dy}{dx}\right)^2 = \frac{P}{EI}(\delta^2 - y^2)$$

$$\frac{dy}{dx} = \sqrt{\frac{P}{EI}}\sqrt{\delta^2 - y^2}$$

$$\frac{dy}{\sqrt{\delta^2 - y^2}} = \sqrt{\frac{P}{EI}}dx$$

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Euler -equation part-3

$$EI\left(\frac{dy}{dx}\right)^2 = -Py^2 + C_1$$

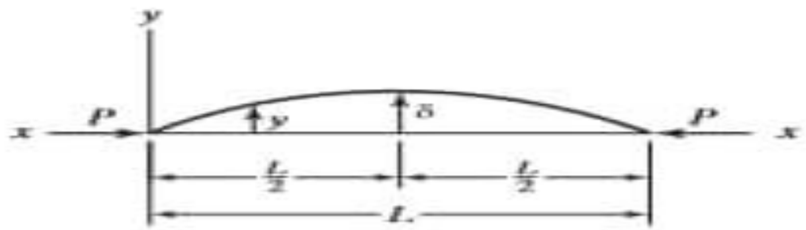

FIGURE A.1

When $y = \delta$, $dy/dx = 0$, and the value of C_1 will equal $P\delta^2$ and

$$EI\left(\frac{dy}{dx}\right)^2 = -Py^2 + P\delta^2$$

The preceding expression is arranged more conveniently as follows:

$$\left(\frac{dy}{dx}\right)^2 = \frac{P}{EI}(\delta^2 - y^2)$$

$$\frac{dy}{dx} = \sqrt{\frac{P}{EI}}\sqrt{\delta^2 - y^2}$$

$$\frac{dy}{\sqrt{\delta^2 - y^2}} = \sqrt{\frac{P}{EI}}dx$$

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Integrating this expression, the result is

$$\arcsin\frac{y}{\delta} = \sqrt{\frac{P}{EI}}\,x + C_2$$

When $x = 0$ and $y = 0$, $C_2 = 0$. The column is bent into the shape of a sine curve expressed by the equation

$$\arcsin\frac{y}{\delta} = \sqrt{\frac{P}{EI}}\,x$$

When $x = L/2$, $y = \delta$, resulting in

$$\frac{\pi}{2} = \frac{L}{2}\sqrt{\frac{P}{EI}}$$

In this expression, P is the *critical buckling load*, or the maximum load that the column can support before it becomes unstable. Solving for P, we have

$$P = \frac{\pi^2 EI}{L^2}$$

Euler Critical buckling load

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This expression is the Euler formula, but usually it is written in a little different form involving the slenderness ratio. Since $r = \sqrt{I/A}$ and $r^2 = I/A$ and $I = r^2A$, the Euler formula may be written as

$$\frac{P}{A} = \frac{\pi^2 E}{(L/r)^2} = F_e$$

Convert Load to stress

The Euler expression may be modified to account for alternative support conditions by using the factor K to give

$$F_e = \pi^2 E/(KL/r)^2$$

where KL/r = slenderness ratio

K = effective length factor

= factor that modifies actual column length and support conditions to an equivalent pin-ended column

Euler -Stress equation

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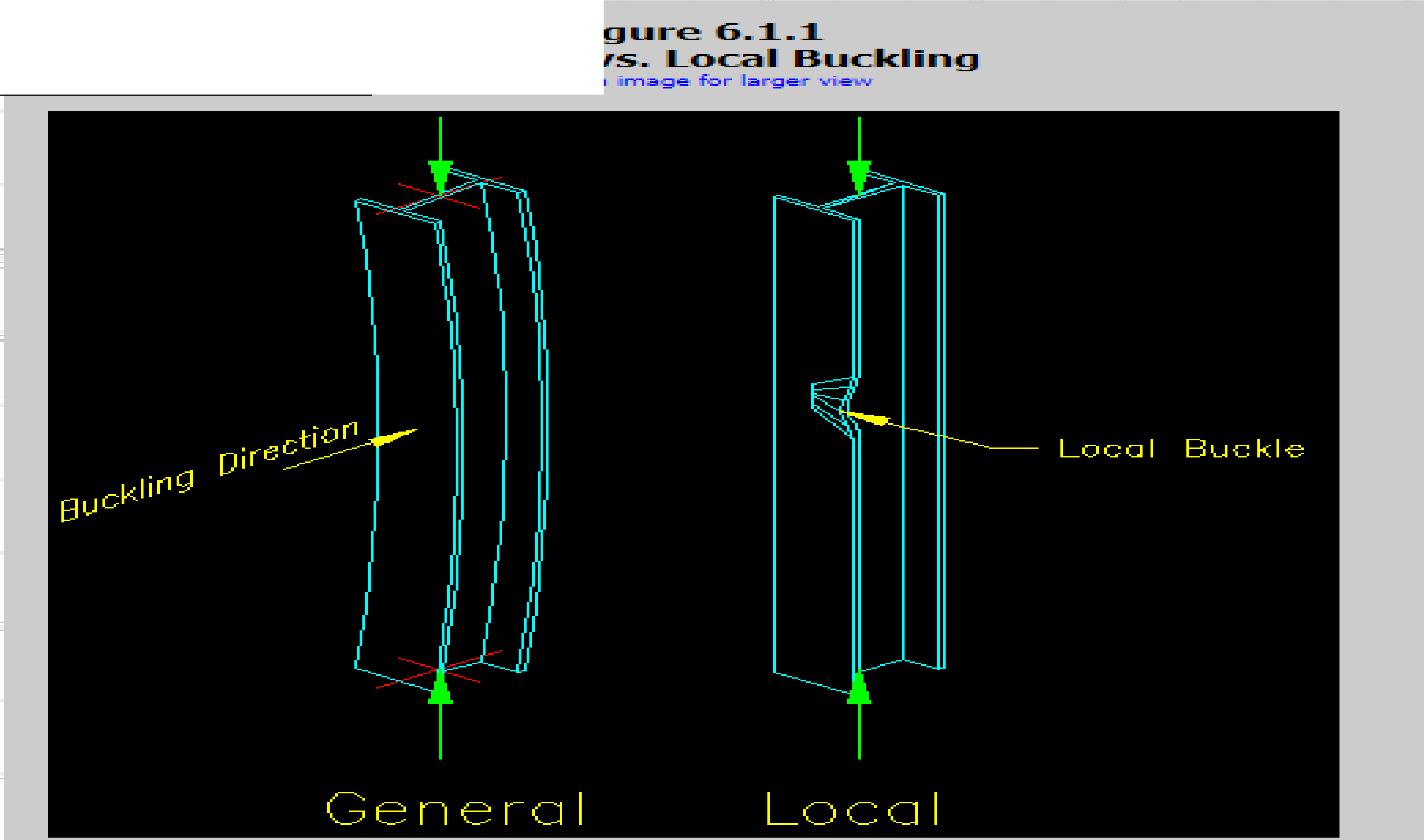
Local buckling versus general buckling

http://www.bgstructuralengineering.com/BGSCM14/BGSCM006/index.htm



Local buckling versus General buckling

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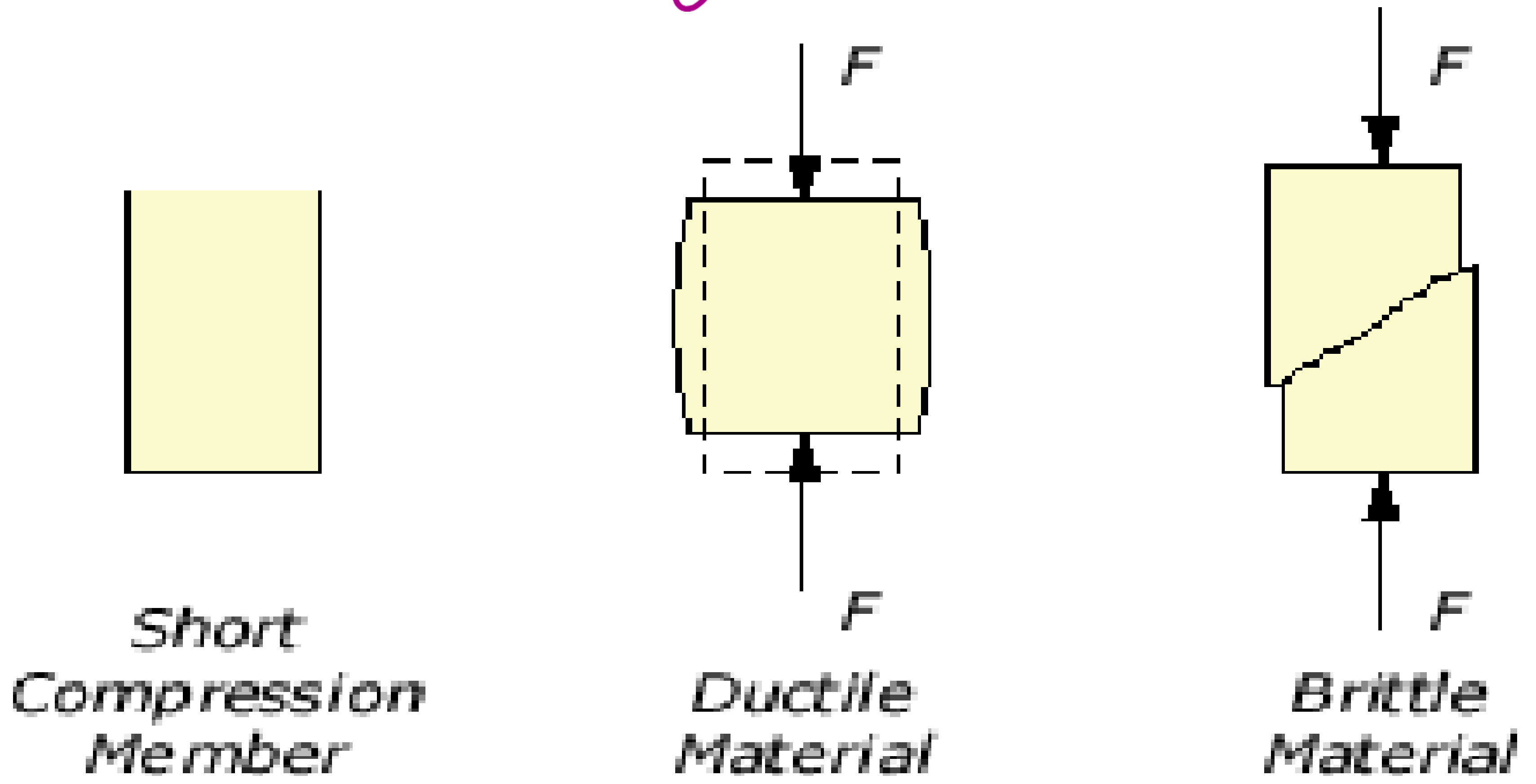
Types of Failure.

Types of failure for columns



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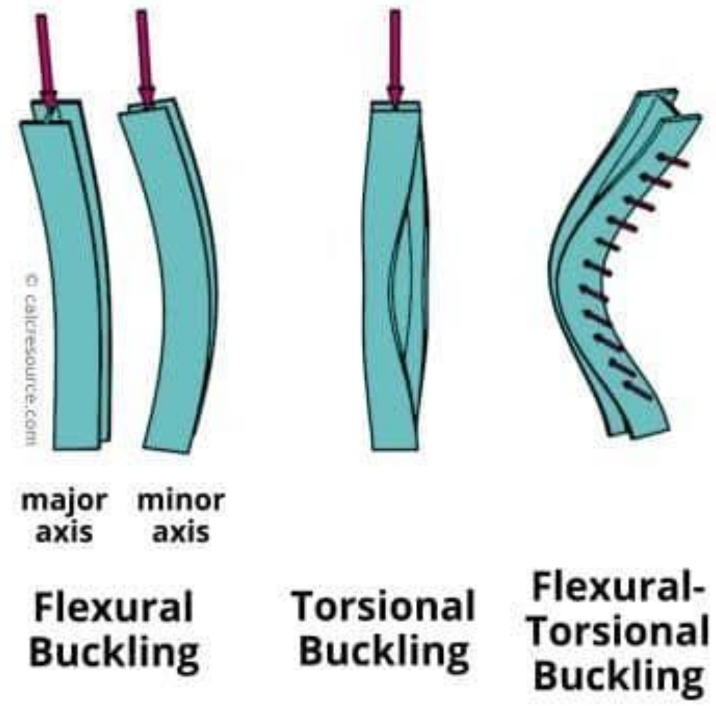
https://calcresource.com/statics-buckling-load.html

From the Source

Except for the buckling of entire members, other types of instability can also occur in a structure. When, the compressive stresses in a local area of a member (either beam or column) become critically high, local instabilities may occur, associated with the slenderness of the plates, the cross-section is built from, rather than the member slenderness. These phenomena are classified as local buckling, shear buckling and crippling.



Member buckling modes

Compression member buckling modes

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