CHAPTER

5a

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Prentice Hall Structural Steel Design
LRFD Method

Third Edition

INTRODUCTION TO AXIALLY LOADED COMPRESSION MEMBERS

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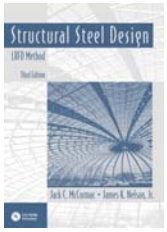
Part II – Structural Steel Design and Analysis



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ENCE 355 - Introduction to Structural Design

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Introduction

- Axial Compression
  - Columns are defined as members that carry loads in compression.
  - Usually they carry bending moments as well, about one or both axes of the cross section.
  - The bending action may produce tensile forces over a part of the cross section.
  - Despite of the tensile forces or stresses that may be produced, columns are

Introduction

- Axial Compression
  - Generally referred to as: "compression members" because the compression forces or stresses dominate their behavior.
  - In addition to the most common type of compression members (vertical elements in structures), compression members include:
    - Arch ribs
    - Rigid frame members inclined or otherwise
    - Compression elements in trusses
    - shells

Introduction

Steel Columns

Introduction

Introduction

Introduction

Introduction

- General
  - Columns include top chords of trusses and various bracing members.
  - In many cases, many members have compression in some of their parts. These include:
    - The compression flange
    - Built-up beam sections, and
    - Members that are subjected simultaneously to bending and compressive loads.

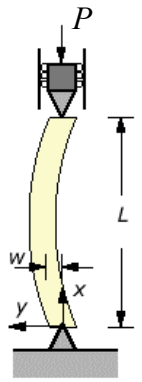
Introduction

- General
  - Mode of Failures for Columns
    1. **Flexural Buckling** (also called Euler buckling) is the primary type of buckling. Members are subject to flexure or bending when they become unstable.
    2. **Local Buckling:** This type 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 ratio of the parts of the cross section

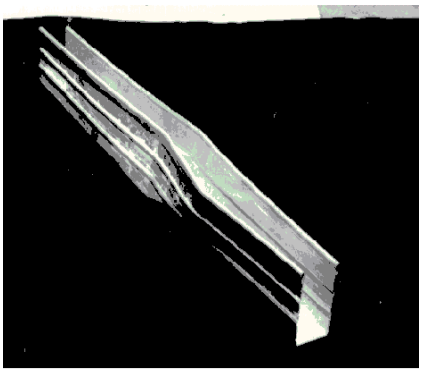
Introduction

- General

Euler Buckling

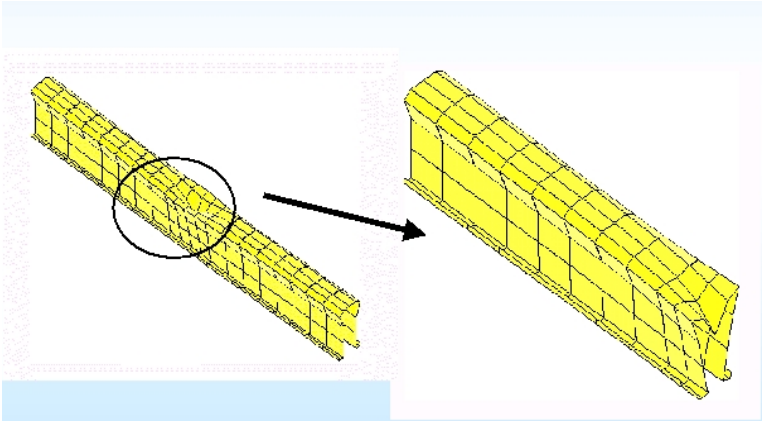


Simply supported column subjected to axial load ***P***



Introduction

- General
  - Local Buckling



Introduction

- General
  - Mode of Failures for Columns (cont'd)
    3. **Torstional 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.

Introduction

- Slenderness Ratio
  - The longer the column becomes for the same cross section, the greater becomes its tendency to buckle and the smaller becomes the load it will carry.
  - The tendency of a member to buckle is usually measured by its slenderness ratio, that is

$$\text{Slenderness Ratio} = \frac{L}{r} \qquad (1)$$

$$\text{where } r = \sqrt{\frac{I}{A}} = \text{radius of gyration}$$

Introduction

- Effect of Material Imperfections and Flaws
  - Slight imperfections in tension members and beams can be safely disregarded as they are of little consequences.
  - On the other hand, slight defects in columns may be of major significance.
  - A column that is slightly bent at the time it is put in place may have significant bending moment resulting from the load and the initial lateral deflection.

Introduction

- Why is a column more critical than a beam or a tension member?
  - A column is a more critical member in a structure than is a beam or tension members because minor imperfections in materials and dimensions mean a great deal.
  - This fact can be illustrated by a bridge truss that has some of its members damaged by a truck.

Introduction

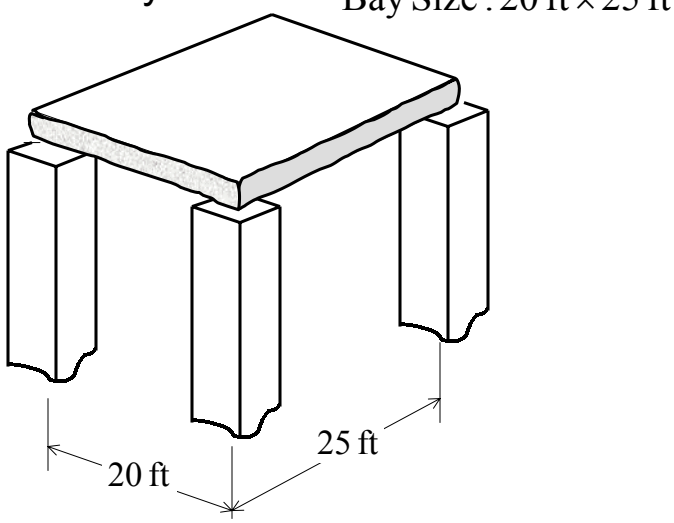
- Why is a column more critical than a beam or a tension member? (cont'd)
  - The bending of tension members probably will not be serious as the tensile loads will tend to straighten those members; but the bending of any compression members is a serious matter, as compressive loads will tend to magnify the bending in those members.

Introduction

- Columns Bay
  - The spacing of columns in plan establishes what is called a ***Bay***.
  - For example, if the columns are 20 ft on center in one direction and 25 ft in the other direction, the bay size is 20 ft $\times$ 25 ft.
  - Larger bay sizes increase the user's flexibility in space planning.

Introduction

- Columns Bay



Residual Stresses

- Residual stresses are stresses that remain in a member after it has been formed into a finished product.
- Causes:

1. Uneven cooling that occurs after hot rolling of structural shapes.
2. Cold bending or cambering during fabrication.
3. Punching of holes during fabrication.
4. Welding.

Residual Stresses

- Residual Stresses in Rolled Sections
  - In wide-flange or H-shaped sections, after hot rolling, the flanges, being the thicker parts, cool more slowly than the web region.
  - Furthermore, the flange tips having greater exposure to the air cool more rapidly than the region at the junction of the flange and the web.
  - Consequently, compressive residual stress exists at flange tips and mid-depth of the web, while tensile residual stress exists in the flange and the web at the regions where they join.

Residual Stresses

- Residual Stresses in Rolled Sections

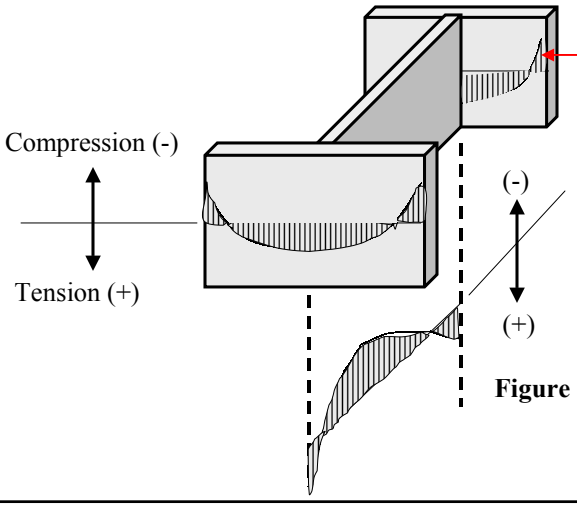


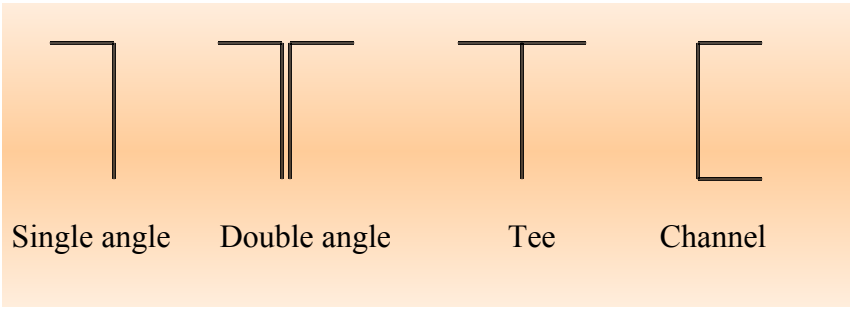
Figure 1. Typical residual stress pattern on rolled shapes

Sections Used for Columns

- In theory, numerous shapes can be used as columns to resist given loads.
- However, from practical viewpoint, the number of possible solutions is severely limited by section availability, connection problems, and type of structure in which the section is to be used.

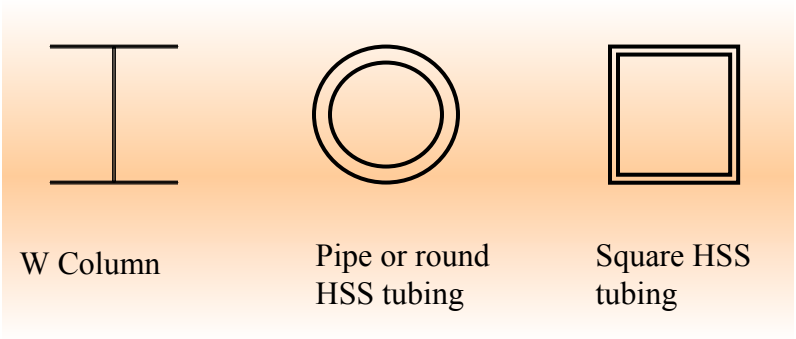
Sections Used for Columns

Figure 1. Types of Compression Members



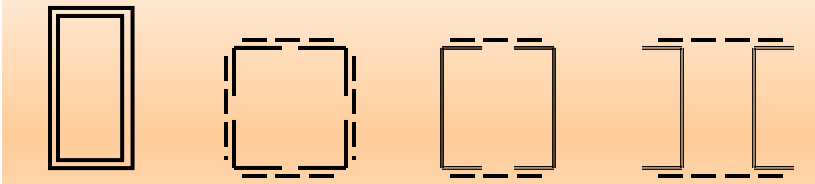
Sections Used for Columns

Figure 1. (cont'd)Types of Compression Members



Sections Used for Columns

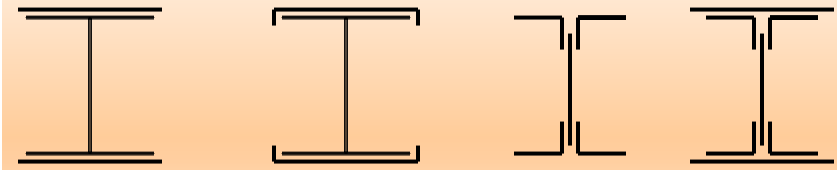
Figure 1. (cont'd)Types of Compression Members



Rectangular HSS tubing | Four angle box section | Box section | Box section

Sections Used for Columns

Figure 1. (cont'd)Types of Compression Members



W with Cover Plats | W and channels | Built-up | Built-up