MEMORIAL UNIVERSITY

Newfoundland & Labrador, Canada

Structural Steel Design
Beam-Columns

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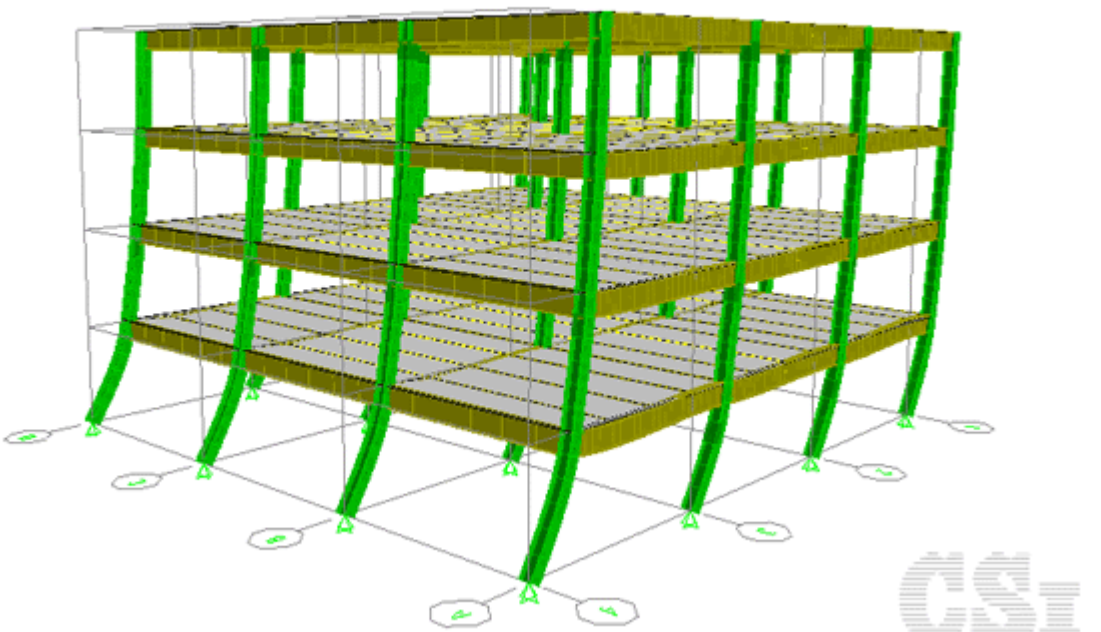
FACULTY OF ENGINEERING & APPLIED SCIENCE

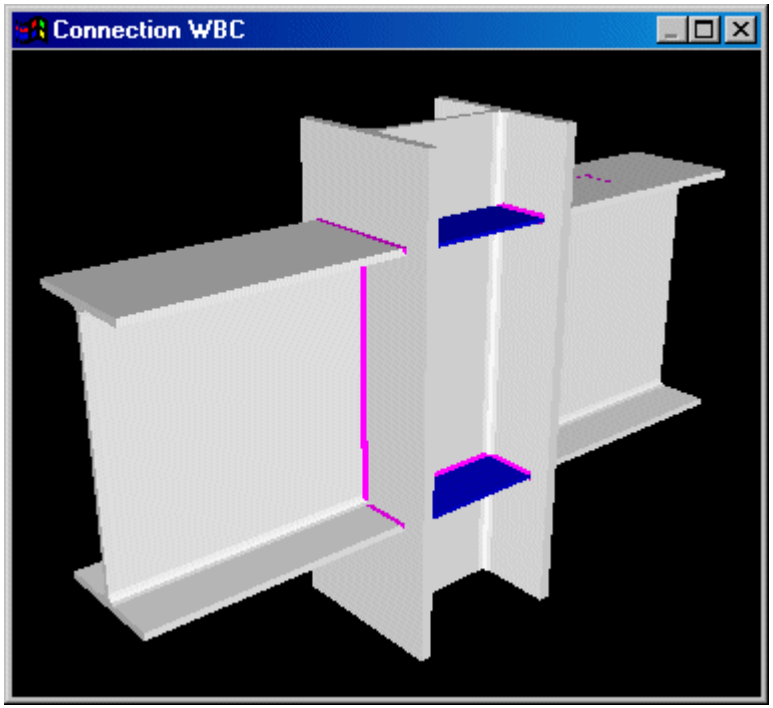
Columns in Buildings

- Subject to moments and axial load transferred from beams

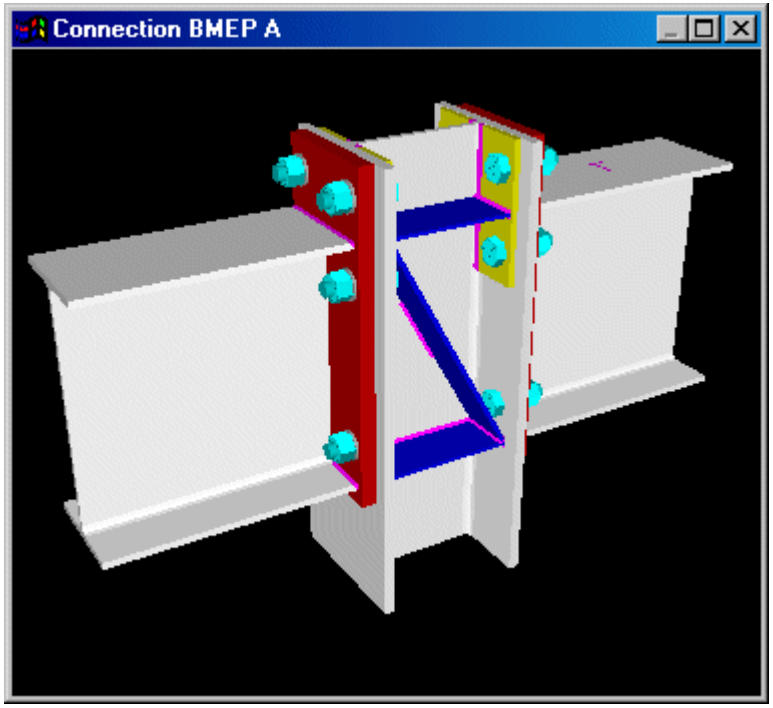


R.C. Hibbeler, Mechanics of Solids, 7th Ed. Prentice-Hall; ETABS software

Moment connection for columns



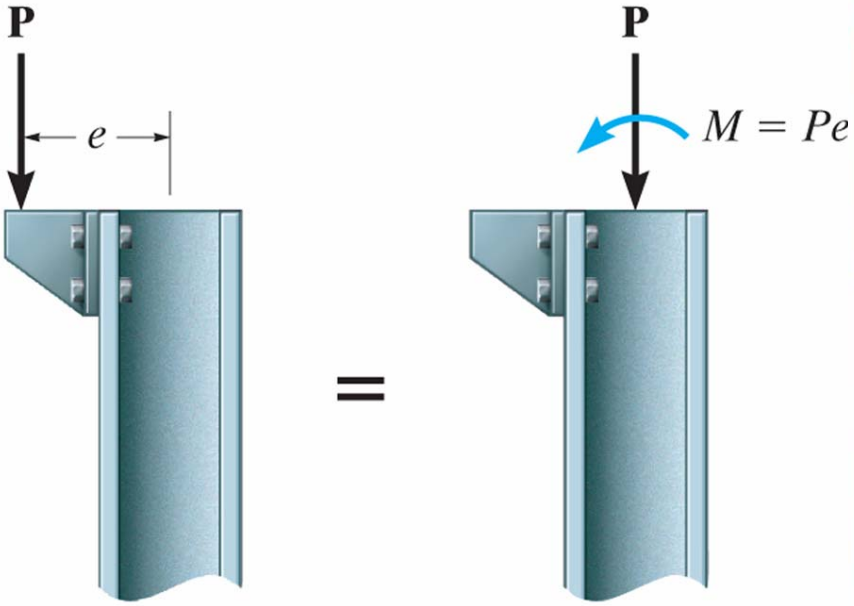
Welded Beam/Column Connection



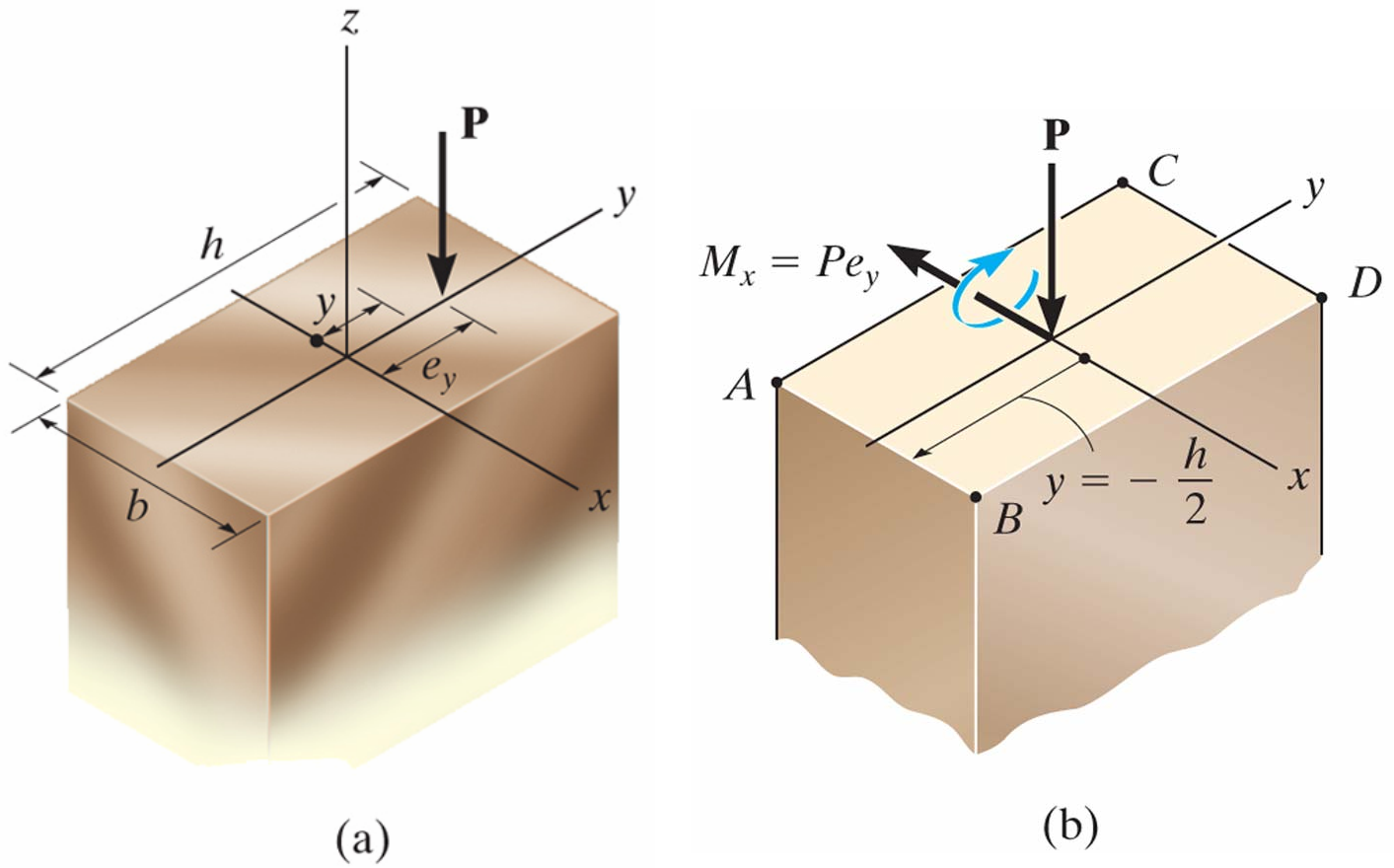
Bolted Moment End Plate Connection

http://www.steel-connections.com/lmc_wbc.htm

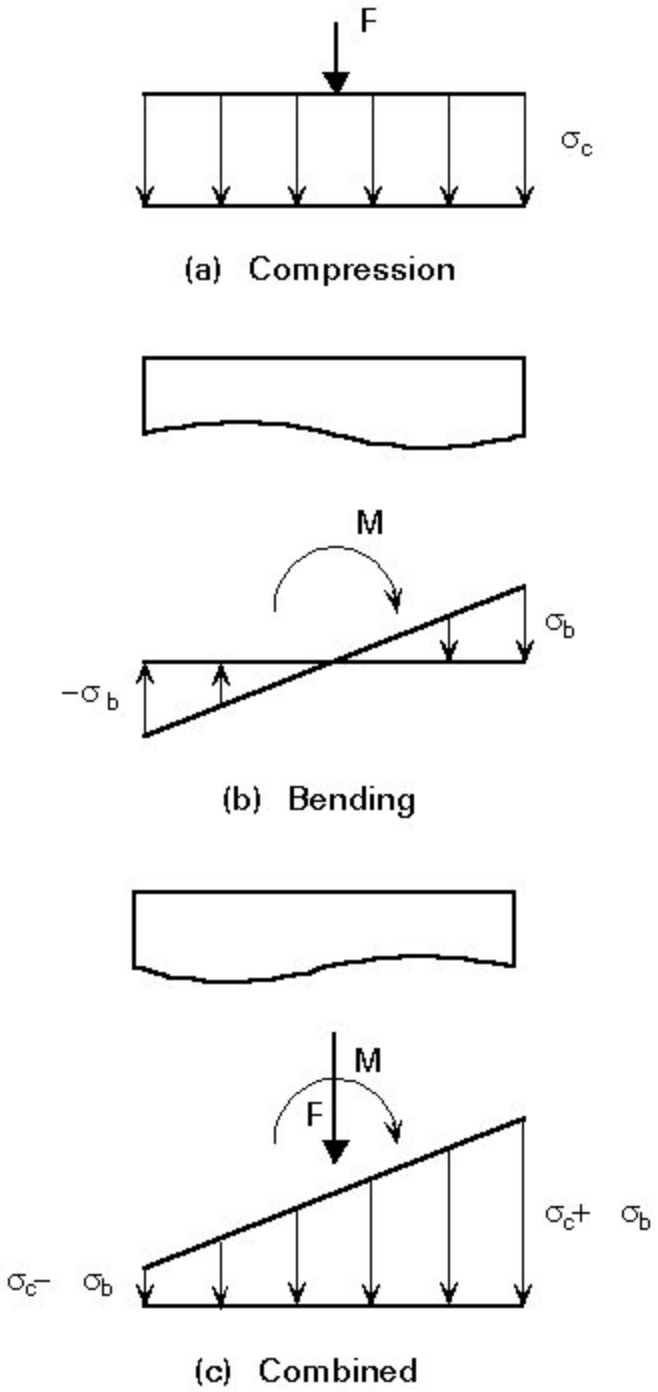
Eccentric Loads

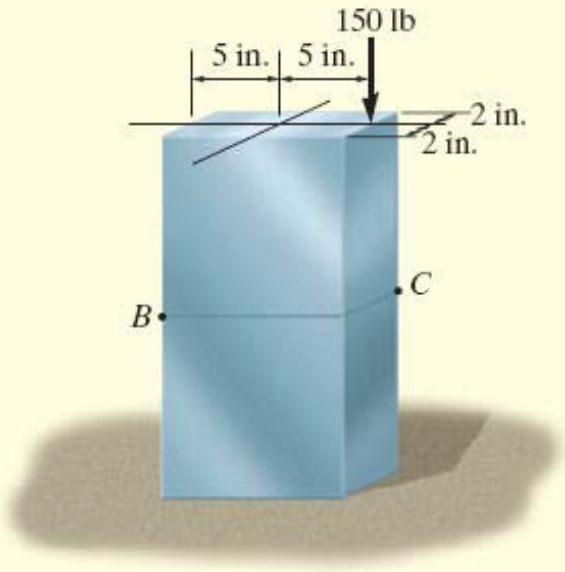


Eccentric Loads



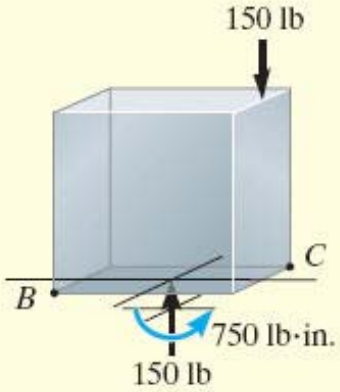
Eccentric Loads





(a)

Fig. 8–3



(b)

A force of 150 lb is applied to the edge of the member shown in Fig. 8–3*a*. Neglect the weight of the member and determine the state of stress at points *B* and *C*.

SOLUTION

Internal Loadings. The member is sectioned through *B* and *C*. For equilibrium at the section there must be an axial force of 150 lb acting through the centroid and a bending moment of 750 lb · in. about the centroidal or principal axis, Fig. 8–3*b*.

Stress Components.

Normal Force. The uniform normal-stress distribution due to the normal force is shown in Fig. 8–3*c*. Here

$$\sigma = \frac{P}{A} = \frac{150\ \text{lb}}{(10\ \text{in.})(4\ \text{in.})} = 3.75\ \text{psi}$$

Bending Moment. The normal-stress distribution due to the bending moment is shown in Fig. 8–3*d*. The maximum stress is

$$\sigma_{\max} = \frac{Mc}{I} = \frac{750\ \text{lb} \cdot \text{in.}(5\ \text{in.})}{\frac{1}{12}(4\ \text{in.})(10\ \text{in.})^3} = 11.25\ \text{psi}$$

Superposition. If the above normal-stress distributions are added algebraically, the resultant stress distribution is shown in Fig. 8–3*e*. Although it is not needed here, the location of the line of zero stress can be determined by proportional triangles; i.e.,

Eccentric Loads

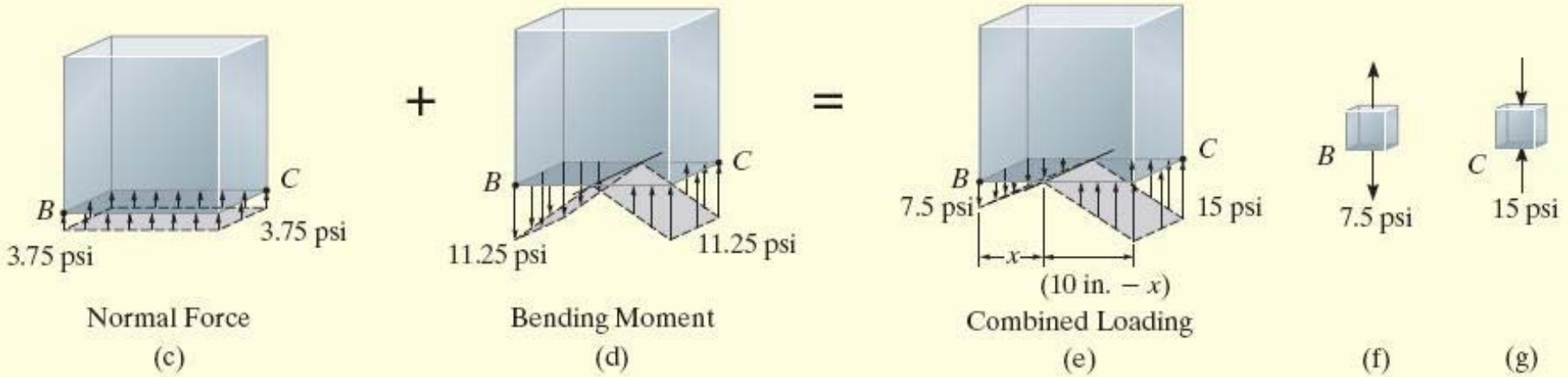
$$\frac{7.5 \text{ psi}}{x} = \frac{15 \text{ psi}}{(10 \text{ in.} - x)}$$

$$x = 3.33 \text{ in.}$$

Elements of material at B and C are subjected only to normal or *uniaxial stress* as shown in Figs. 8–3*f* and 8–3*g*. Hence,

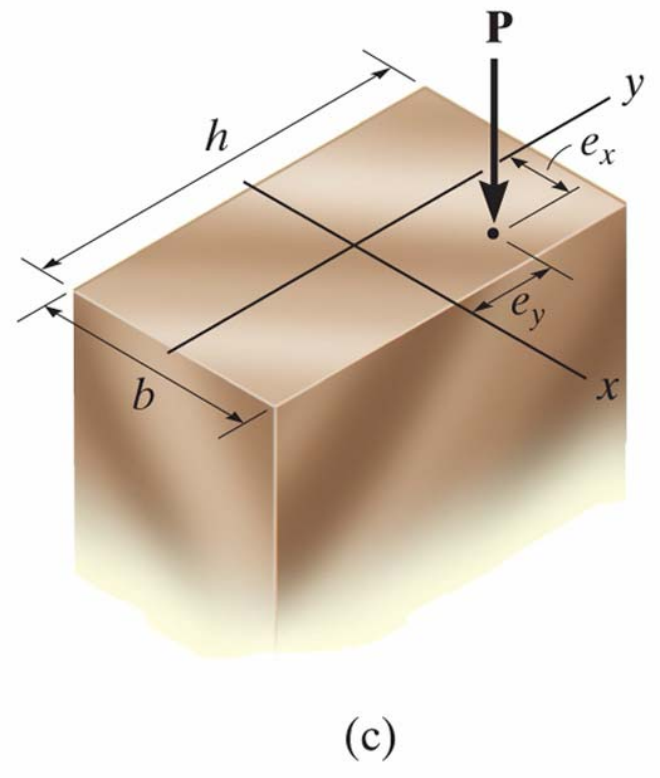
$\sigma_B = 7.5$ psi (tension) *Ans.*

$\sigma_C = 15$ psi (compression) *Ans.*

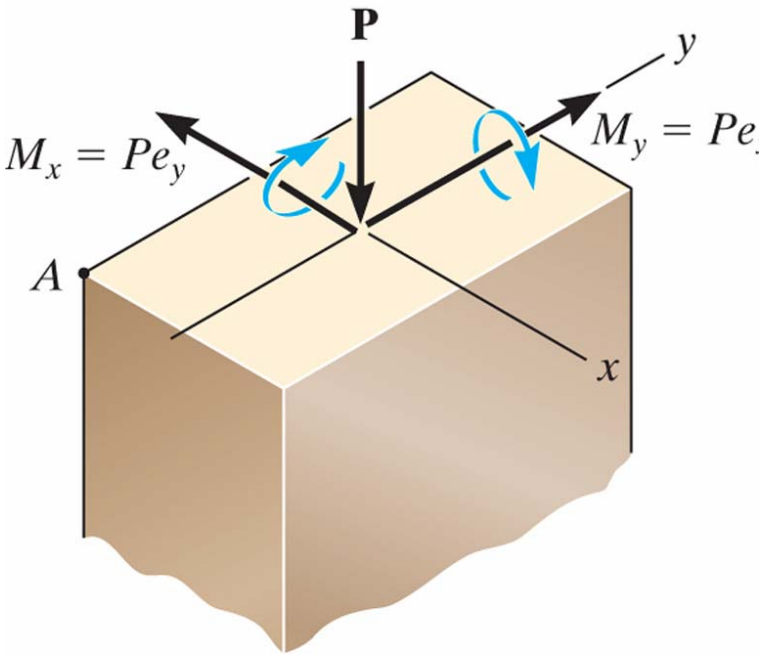


Normal Force (c) + Bending Moment (d) = Combined Loading (e) (f) (g)

Eccentric Loads

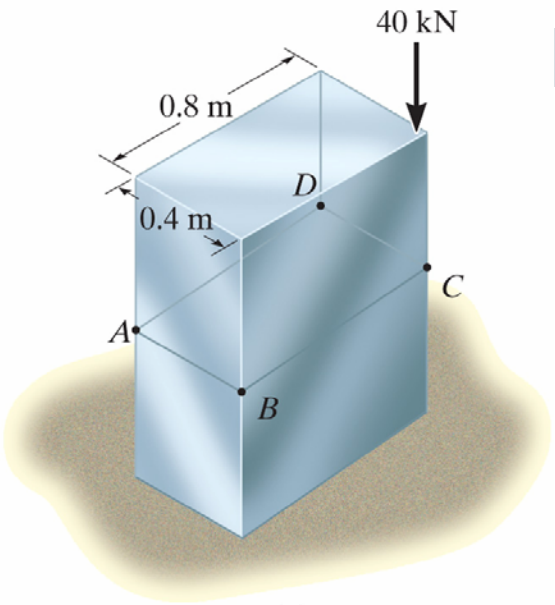


(c)

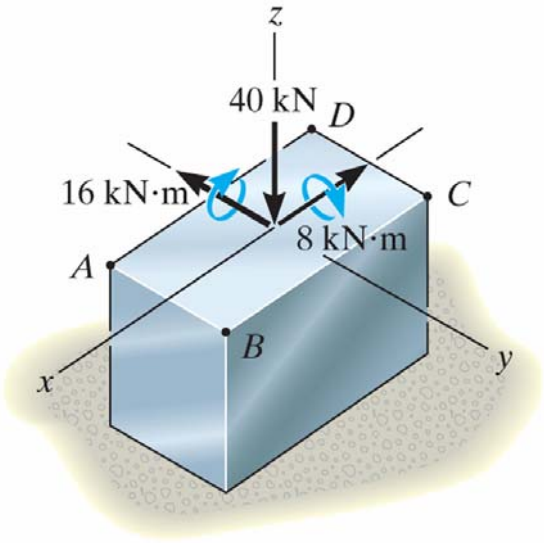


(d)

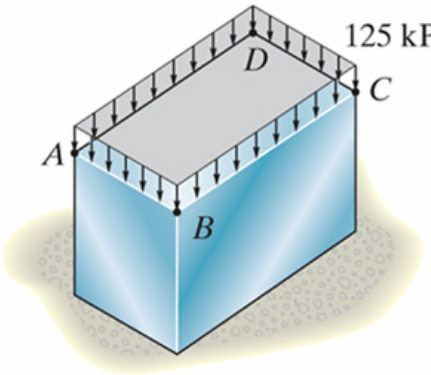
Eccentric Loads



(a)



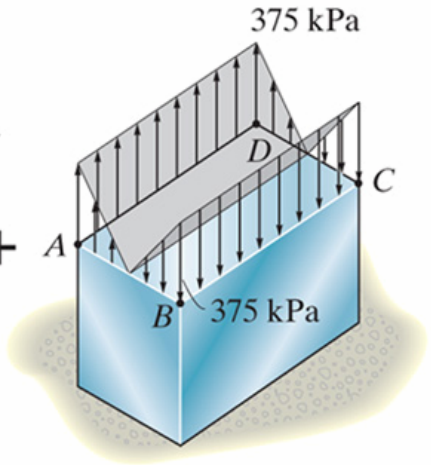
(b)



Normal force
(40 kN)

(c)

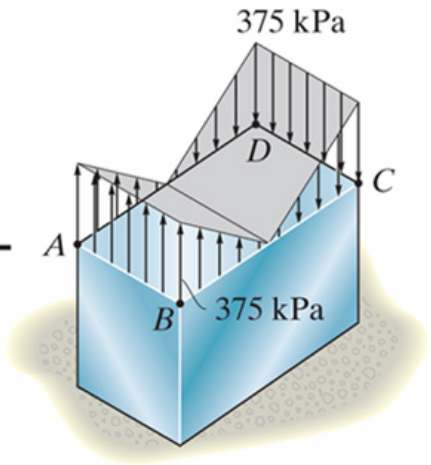
+



Bending moment
(8 kN·m)

(d)

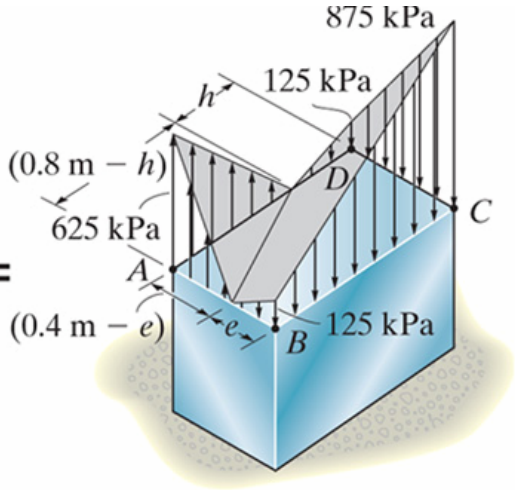
+



Bending moment
(16 kN·m)

(e)

=



Combined loading

(f)

Eccentric Loads

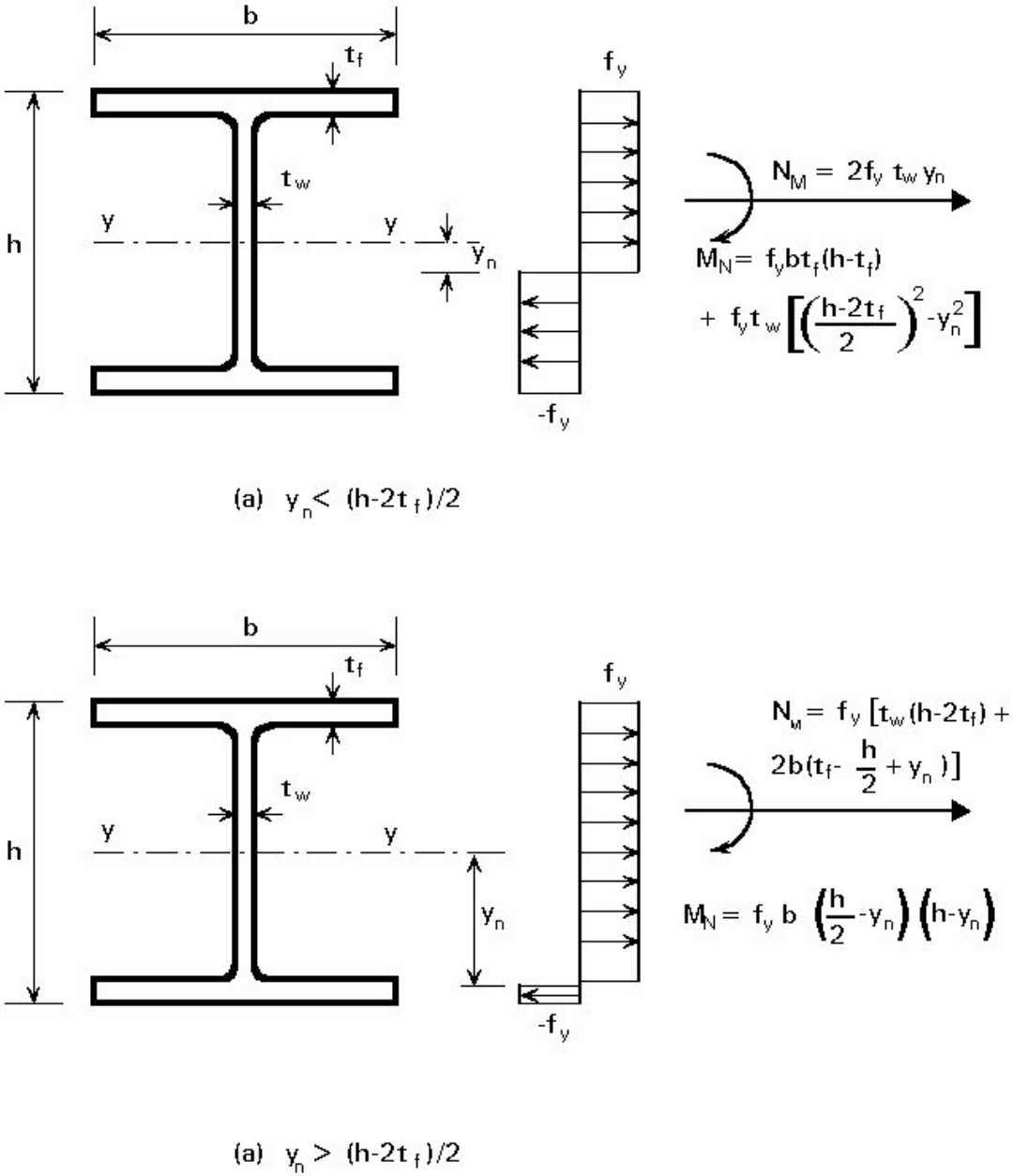


Figure 2 Full plasticity under axial load and moment

Eccentric Loads

- Section behaviour
  - Interaction of Moment and axial force

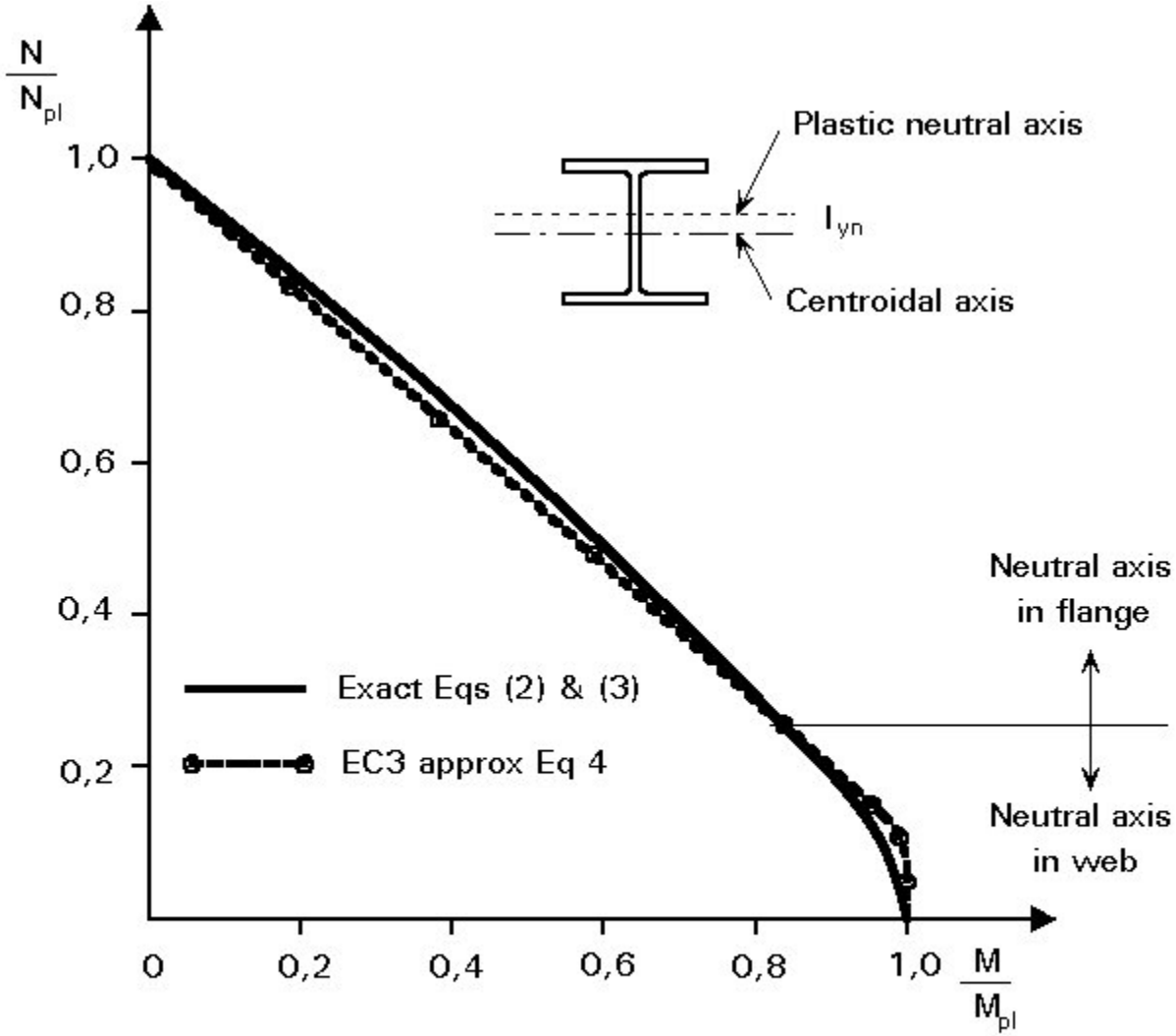


Figure 3 Full plasticity interaction-major axis bending of HEA 450 section

Eccentric Loads

- Moment amplification due to the addition of axial force on top of existing moment

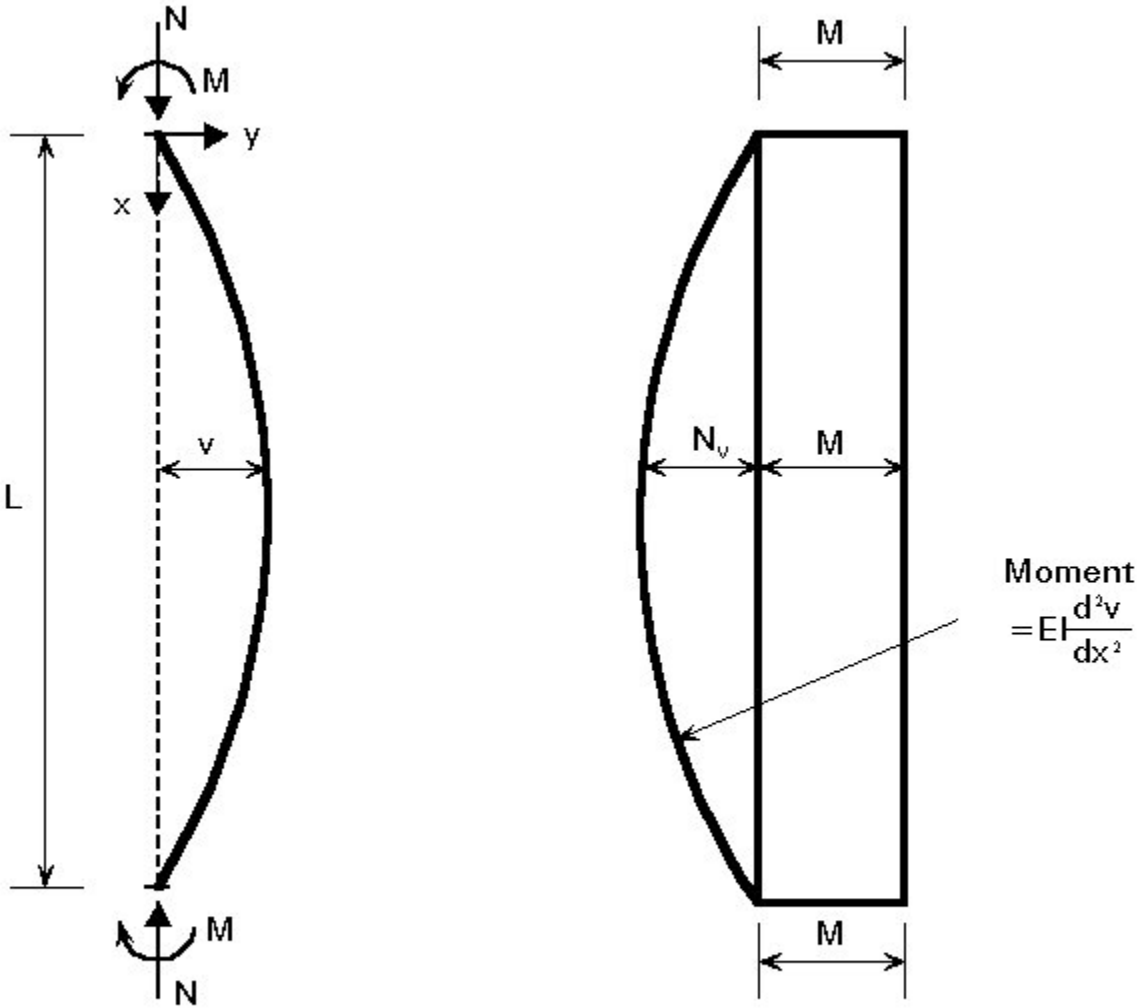


Figure 4 Primary and secondary moments

Eccentric Loads

- Moment amplification due to the addition of axial force on top of existing moment

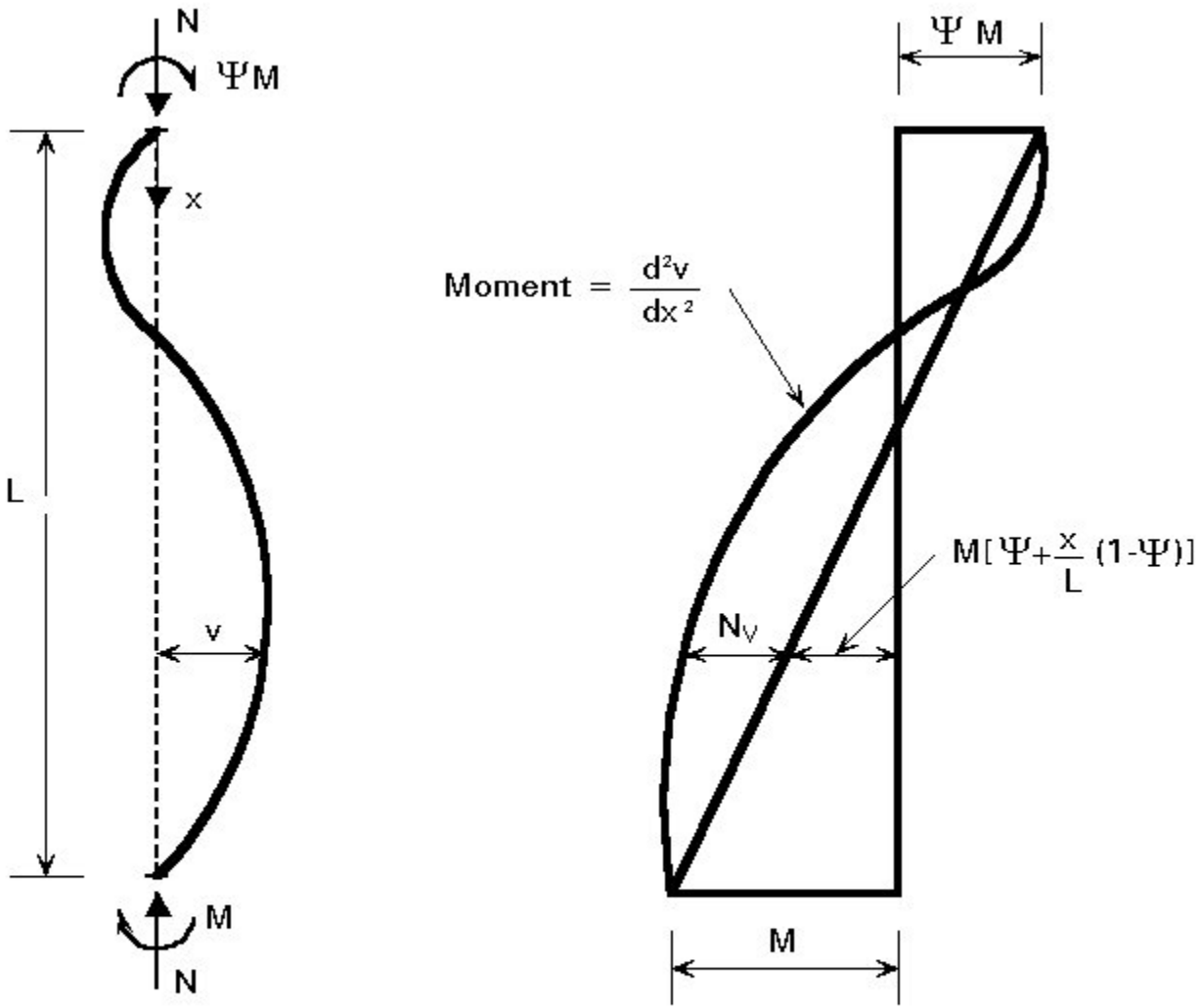
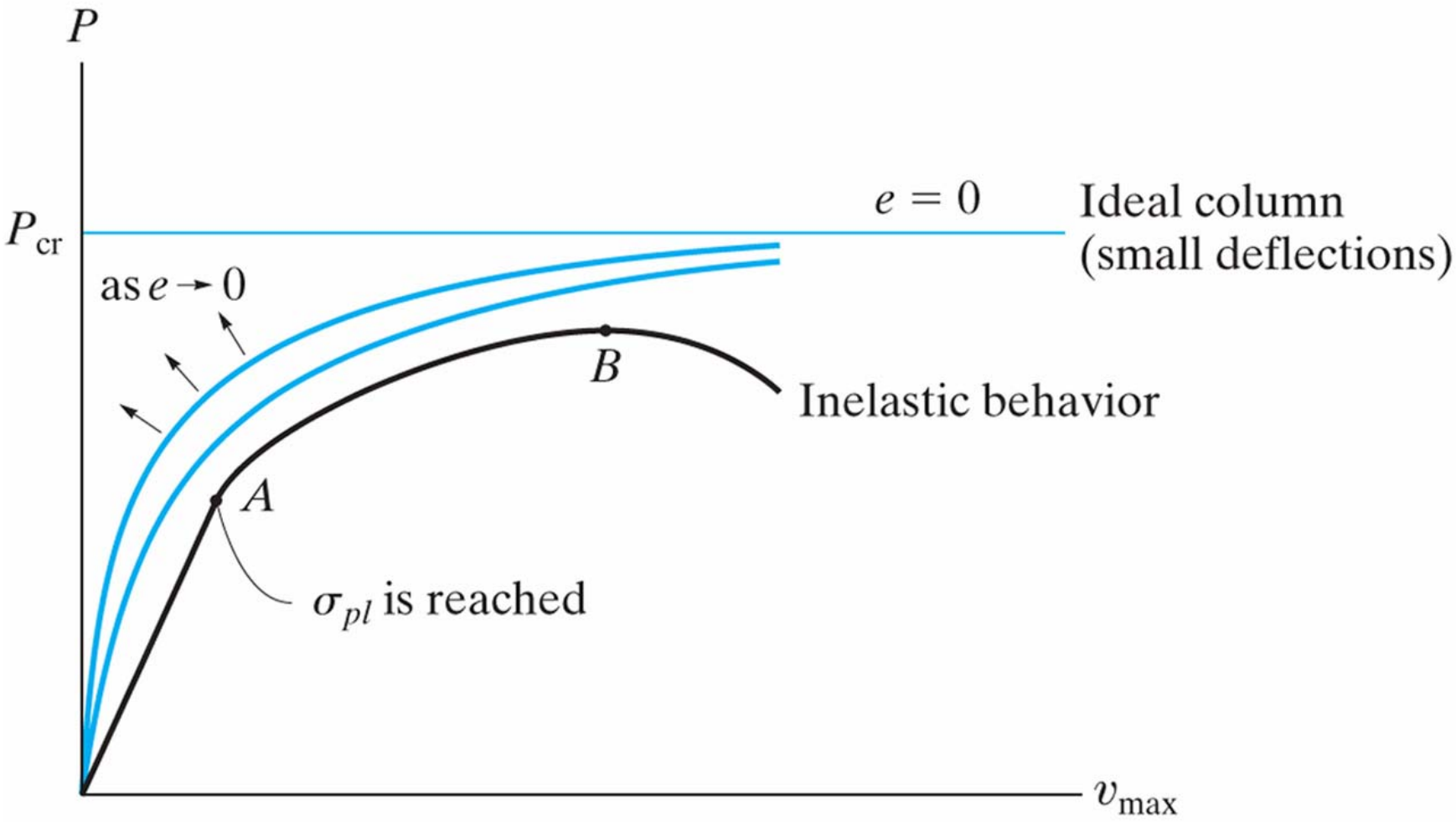


Figure 11 Non-uniform moment case

Eccentric Loads –column behaviour



Over-all behaviour of beam-columns

- Interaction formula
- Cross-sectional strength
- Moment amplification factor
- In-plane bending
- Out-of-plane behaviour
- Special provisions

Beam-Columns

- **Steel beam-columns**
  - Bldg columns with moment connection
  - Exposed columns subject to wind
  - Columns with eccentric loads
  - Beams subject to axial forces and moments
- **Design Clauses: CAN/CSA-S16**
  - Classify, strength check (4 checks)
  - Over-all strength interaction formula- Cl.13.7, 13.8
  - Local buckling check: Clause 11 (Table 2)