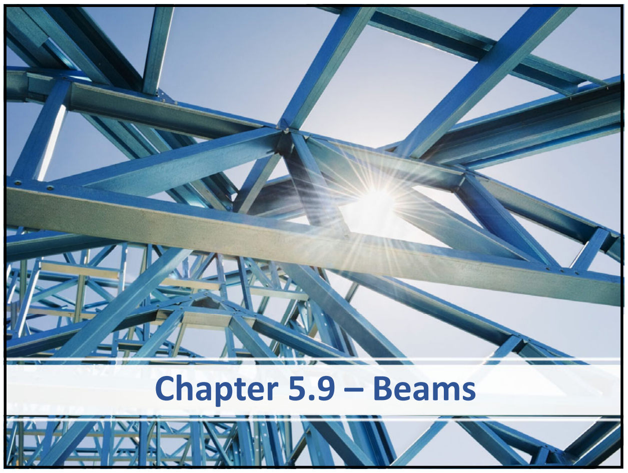

1

Chapter 5 – Deflection

- In addition to being safe, a structure must be ***serviceable***.
- A ***serviceable structure*** is one that ***performs satisfactorily***, not causing any ***discomfort or perceptions of unsafety*** for the occupants or users of the structure.
- For a beam, being serviceable usually means that the ***deformations***, primarily the vertical sag or deflection, ***must be limited***.
- ***Excessive deflection*** is usually an indication of a ***very flexible*** beam, which can lead to problems with vibrations.

2

Chapter 5 – Deflection

- The deflection itself could cause problems if elements attached to the beam can be ***damaged by small distortions***.
- In addition, users of the structure may view large deflections negatively and wrongly ***assume that the structure is unsafe***.
- For the common case of a simply supported, uniformly loaded beam, the ***maximum vertical deflection*** is:

$$\Delta = \frac{5wL^4}{384EI}$$

- Deflection formulas for a variety of beams and loading conditions can be found in **Table 3-22**, Part 3, "Design of Flexural Members," of the Manual.

3

Chapter 5 – Deflection

- The appropriate limit for the ***maximum deflection*** depends on the function of the beam and the likelihood of damage resulting from the deflection.
- The ***AISC Specification*** furnishes ***little guidance*** other than a statement in **Chapter L**, "Design for Serviceability," that deflections should not be excessive.
- There is, however, a more detailed discussion in the **Commentary to Chapter L**.

Historically, common deflection limits for horizontal members have been 1/360 of the span for floors subjected to reduced live load and 1/240 of the span for roof members. Deflections of about 1/300 of the span (for cantilevers, 1/150 of the length) are visible and may lead to general architectural damage or cladding leakage. Deflections greater than 1/200 of the span may impair operation of moveable components such as doors, windows, and sliding partitions.

4

Chapter 5 – Deflection

- Appropriate ***limits for deflection*** can usually be found from the governing building code, expressed as a fraction of the span length ***L***, such as ***L/360***.
- Sometimes a ***numerical limit***, such as 1 inch, is appropriate.

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Chapter 5 – Deflection

- The limits given in the ***International Building Code*** (ICC, 2021) are typical.

TABLE 1604.3DEFLECTION LIMITS[a, b, c, h, i]

CONSTRUCTION	L or L_r	S or W^f	$D + L^{d,g}$
Roof members:[e]			
Supporting plaster or stucco ceiling	l/360	l/360	l/240
Supporting nonplaster ceiling	l/240	l/240	l/180
Not supporting ceiling	l/180	l/180	l/120
Floor members	l/360	—	l/240
Exterior walls:			
With plaster or stucco finishes	—	l/360	—
With other brittle finishes	—	l/240	—
With flexible finishes	—	l/120	—
Interior partitions:[b]			
With plaster or stucco finishes	l/360	—	—
With other brittle finishes	l/240	—	—
With flexible finishes	l/120	—	—
Farm buildings	—	—	l/180
Greenhouses	—	—	l/120

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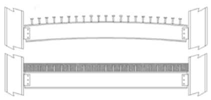
Chapter 5 – Deflection

- The limits shown in the ***IBC Table*** for deflection due to dead load plus live load ***do not apply*** to steel beams, because the dead load deflection is usually compensated for by some means, such as ***cambering***.
- ***Camber*** is a curvature in the opposite direction of the dead load deflection curve and can be accomplished by bending the beam, with or without heat.
- When the ***dead load*** is applied to the ***cambered beam***, the curvature is removed, and the beam becomes level.




7

Chapter 5 – Deflection

- The limits shown in the ***IBC Table*** for deflection due to dead load plus live load ***do not apply*** to steel beams, because the dead load deflection is usually compensated for by some means, such as ***cambering***.
- ***Camber*** is a curvature in the opposite direction of the dead load deflection curve and can be accomplished by bending the beam, with or without heat.

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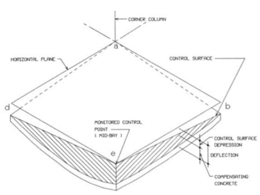
Chapter 5 – Deflection

- Therefore, ***only the live load deflection*** is of concern in the completed structure.
- Dead load deflection can also be accounted for by pouring a ***variable-depth slab*** with a level top surface, the variable depth being a consequence of the deflection of the beam (this is referred to as ***ponding of the concrete***).



9

Chapter 5 – Deflection

- **Example 5.9**: Compute the dead load and live load deflections for the **W16** × **40** beam shown. If the maximum permissible live load deflection is ***L/360***, is the beam satisfactory?

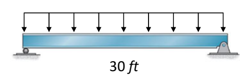
From Table 1-1 (**1**-22):

$w_D = 0.6\ k/ft$

$w_L = 0.85\ k/ft$

$I_x = 518 in^4$

The dead load deflection is:



$$\Delta_D = \frac{5wL^4}{384EI}$$

$$= \frac{5(0.6k/ft)(1ft/12in)(360in)^4}{384(29{,}000ksi)(518in^4)} = 0.728in$$

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Chapter 5 – Deflection

- **Example 5.9**: Compute the dead load and live load deflections for the **W16** × **40** beam shown. If the maximum permissible live load deflection is ***L/360***, is the beam satisfactory?

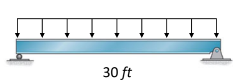
From Table 1-1 (**1**-22):

$w_D = 0.6\ k/ft$

$w_L = 0.85\ k/ft$

$I_x = 518 in^4$

The live load deflection is:



$$\Delta_L = \frac{5wL^4}{384EI}$$

$$= \frac{5(0.85k/ft)(1ft/12in)(360in)^4}{384(29{,}000ksi)(518in^4)} = 1.031in$$

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Chapter 5 – Deflection

- **Example 5.9**: Compute the dead load and live load deflections for the **W16** × **40** beam shown. If the maximum permissible live load deflection is ***L/360***, is the beam satisfactory?

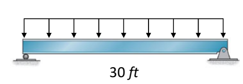
From Table 1-1 (**1**-22):

$w_D = 0.6\ k/ft$

$w_L = 0.85\ k/ft$

$I_x = 518 in^4$

The max deflection is:



$$\frac{L}{360} = \frac{360in}{360} = 1.0in$$

$\frac{L}{360} > \Delta_D$ **O.K.**

$\frac{L}{360} < \Delta_L$ **N.G.**

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Chapter 5 – Beams

Any questions?

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