DEFLECTION

A structure must be **<u>serviceable</u>** in addition to being safe. A serviceable structure performs satisfactorily without causing any discomfort or perceptions of un-safety for the occupants or users of the structure.

For a beam, being serviceable usually means that the deformation (primarily vertical sag) must be limited.

According to International Building Code (ICB 2000), some of the typical deflection limits are:

| Members | Max. Live Load defl. | Max. dead+live load defl. | Max. Snow or Wind Load defl. |
|--------------------------------|-------------------------|------------------------------|------------------------------------|
| Roof Beam: | | | |
| Supporting plaster ceiling | L / 360 | L / 240 | L / 360 |
| Supporting non-plaster ceiling | L / 240 | L / 180 | L / 240 |
| Not supporting a ceiling | L/180 | L / 120 | L / 180 |
| Floor Beam | L/360 | L / 240 | |
| | | | |

Note: L = Span Length

The limits shown above for deflection due to dead + live loads do not apply to steel beams, because the dead load deflection is usually compensated by <u>cambering</u>. Camber is a curvature in the opposite direction of the dead load deflection curve. When the dead load is applied to a cambered beam, the curvature is removed and beam becomes level. Therefore, the live load deflection is of concern in the completed structure.

EXAMPLE 1: Compute the dead load and live load deflections for the floor beam, W 18X35 as shown in fig. Check whether the floor beam is satisfactory considering deflection criterion according to IBC.



SOLUTION:

$$\Delta = \frac{5}{384} \left(\frac{w_{D} L^{4}}{E I} \right)$$

 $\Delta D = (5/384)[(0.5+0.035)/12](30x12)^4 / (29000x510) = 0.659 \text{ in}$ $\Delta L = (5/384)[0.55/12](30x12)^4 / (29000x510) = 0.678 \text{ in}$

Total deflection = 0.659+0.678 = 1.337 in

The max. permissible live load deflection = L/360 = (30x12)/360 = 1.0 in > 0.678 in. OK

The max. permissible dead+live load deflection = L/240 = (30x12)/240 = 1.5 in > 1.337 in. OK [Note: For a cambered steel beam, no need to check the dead+live load deflection criteria]

The beam satisfies the deflection criterion.

Maximum Deflection for some common loading conditions



EXAMPLE 2: (a) Check whether the floor beam is satisfactory considering deflection criterion according to IBC. (Max. Live Load defl = L/360)



$$\Delta L = (5/384)[0.55/12](30x12)^4 / (29000x510) + 0.0357[5x(30x12)^3] / (29000x510) = 0.659 + 0.563 = 1.222 \text{ in}$$

The max. permissible live load deflection = L/360 = (30x12)/360 = 1.0 in < 1.222 in. NG

The beam DOES NOT satisfy the deflection criterion.

(b) Select a W-shape to satisfy the live load deflection criteria.

Find required moment of inertia, I

1.222 x 510/(I) = 1.0

 $I = 623.22 \text{ in}^4$

Look for I = 623.22 or slightly above in AISC Table,

<u>W 18 X 46</u> (I=712) ;

 $\Delta L = (5/384)[0.55/12](30x12)^4 / (29000x721) + 0.0357[5x(30x12)^3] / (29000x721) = 0.466 + 0.398 = 0.864 in$ The max. permissible live load deflection = L/360 = (30x12)/360 = 1.0 in > 0.864 in. OK