**EXAMPLE 6.1:**

Design the beam column part of a braced frame for the forces shown:

PD=70k, PL=210k Pu=420k

MD=11k-ft, ML=36k-ft Mux\_top=70.8k-ft

KL=14ft

MD=14k-ft, ML=41k-ft Mux\_bot=82.4k-ft

For KL=14ft, select a W shape with ΦcPn greater than Pu. (See Table 4-1).

Select W12x65 with ΦcPn=685k.

$$∴ \frac{P\_{u}}{∅\_{c}P\_{n}}=\frac{420}{685}=0.6131>0.2∴use AISC equation H1-1a$$

Assume Cb=1, For Lb=14ft, for W12x65 (Table 3-10)

ΦbMnx=345k-ft

Actual value of Cb:

$$C\_{b}=\frac{12.5×82.4}{2.5×82.4+3×73.7+4×76.6+3×79.5}=1.06$$

$∴ ∅\_{b}M\_{nx}=1.06×$345=365.7k-ft

But ΦbMp=356k-ft <365.7k-ft

$$∴ use ∅\_{b}M\_{nx}=356 k-ft$$

Mux =max(Mux\_top, Mux\_bot) = 82.4k-ft

AISC Equation H1-1a

$$\frac{P\_{u}}{∅\_{c}P\_{n}}+\frac{8}{9}\left(\frac{M\_{ux}}{∅\_{b}M\_{nx}}+\frac{M\_{uy}}{∅\_{b}M\_{ny}}\right)=0.6131+\frac{8}{9}\left(\frac{82.4}{356}\right)=0.819<1.0$$

OK. The member design works.

**Example 6.2:**  Check the adequacy of a 15ft long A992 W12x65 beam-column. The axial loads and end moments have been obtained from 2nd order analysis of the gravity loads. The frame and loading are symmetric. The wind load moments have also been obtained from 2nd order analysis. For strong axis bending, Kx=1.0.

PD=85k, PL=220k



MD=15k-ft, ML=45k-ft, MW=211.2k-ft

KL=15ft

MD=18k-ft, ML=52kft, MW=211.2k-ft

**Case 1:** 1.2D+1.6L

PU=454k KyL=15ft

Mux\_top=90k-ft $\frac{K\_{x}L}{^{r\_{x}}/\_{r\_{y}}}=(KL)\_{x-eq}=\frac{1.0×15}{1.75}=8.6ft<15ft$

 Table 4-1, For W12x65

 $∅\_{c}P\_{n}=663k$

 Pu= 454 k

 Mux=max(Mux\_top, Mux\_bot) = 104.8 k-ft

 Mux\_bot=104.8k-ft

$$∴ \frac{P\_{u}}{∅\_{c}P\_{n}}=\frac{454}{663}=0.6848>0.2∴use AISC equation H1-1a$$

Assume Cb=1, For Lb=15ft, for W12x65 (Table 3-10)

ΦbMnx=340k-ft

Actual value of Cb:

$$C\_{b}=\frac{12.5×104.8}{2.5×104.8+3×93.7+4×97.4+3×101.1}=1.06$$

$∴ ∅\_{b}M\_{nx}=1.06×$340=360.4k-ft

But ΦbMp=356k-ft <365.7k-ft

$$∴ use ∅\_{b}M\_{nx}=356 k-ft$$

Mux=104.8k-ft

AISC Equation H1-1a

$$\frac{P\_{u}}{∅\_{c}P\_{n}}+\frac{8}{9}\left(\frac{M\_{ux}}{∅\_{b}M\_{nx}}+\frac{M\_{uy}}{∅\_{b}M\_{ny}}\right)=0.6848+\frac{8}{9}\left(\frac{104.8}{356}\right)=0.95<1.0$$

OK.

**CASE 2:** Considering 1.2 D + 1.0 W + 0.5 L

PU=212k



Mux\_top=251.7k-ft

KL=15ft

Mux\_bot=258.8k-ft

$$M\_{ux}=max\left(M\_{ux\_{top}}, M\_{ux\_{bot}}\right)=258.8 k-ft$$

Cb >1.0, but no need to recalculate since Mux is in double curvature.

$$∴ ∅\_{b}M\_{nx}=∅\_{b}M\_{px}=356 k-ft$$

$$∴ \frac{P\_{u}}{∅\_{c}P\_{n}}=\frac{212}{663}=0.32>0.2∴use AISC equation H1-1a$$

$$\frac{P\_{u}}{∅\_{c}P\_{n}}+\frac{8}{9}\left(\frac{M\_{ux}}{∅\_{b}M\_{nx}}+\frac{M\_{uy}}{∅\_{b}M\_{ny}}\right)=0.32+\frac{8}{9}\left(\frac{258.8}{356}\right)=0.966$$

OK.

**PROCEDURE FOR DESIGN OF BEAM COLUMNS:**

Because of too many variables, trial-and-error process.

The procedure is as follows:

* Assume equation H1-1a governs, i.e. :

$$\frac{P\_{r}}{P\_{c}}+\frac{8}{9}\left(\frac{M\_{rx}}{M\_{cx}}+\frac{M\_{ry}}{M\_{cy}}\right)\leq 1.0$$

$$\frac{1}{P\_{c}}\left(P\_{r}\right)+\left(\frac{8}{9M\_{cx}}\right)\left(M\_{rx}\right)+\left(\frac{8}{9M\_{cy}}\right)\left(M\_{ry}\right)\leq 1.0$$

$$p\left(P\_{r}\right)+b\_{x}\left(M\_{rx}\right)+b\_{y}\left(M\_{ry}\right)\leq 1.0$$

Where

$$p=\frac{1}{P\_{c}};$$

$$ b\_{x}=\frac{8}{9M\_{cx}};$$

$$ b\_{y}=\frac{8}{9M\_{cy}}$$

* If $p\left(P\_{r}\right)<0.2, then $

$$0.5p\left(P\_{r}\right)+\frac{9}{8}\left(b\_{x}\left(M\_{rx}\right)+b\_{y}\left(M\_{ry}\right)\right)\leq 1.0$$

If $p\left(P\_{r}\right)\geq 0.2, then $

$$p\left(P\_{r}\right)+b\_{x}\left(M\_{rx}\right)+b\_{y}\left(M\_{ry}\right)\leq 1.0$$

* Table 6-1 gives values of p, bx and by for all W shapes. The values of Cb, B1 and B2 must be calculated independently.
* Select a trial shape from Table 6-1.
* Use (KL)eff to select p, (Lb) to select bx. by is independent of the length. (Assume weak axis buckling and Cb=1.0)
* Calculate pPr and use applicable interaction equation.
* Evaluate interaction equation.
* If the result is not close to 1.0, then try another shape. By examining terms in the equation, you will know.
* Continue till the interaction gives 0.9-1.0.

**EXAMPLE 6.3:**

PD=54k, PL=147k PU=300k

MD=18k-ft, ML=49k-ft

 Mux=100k-ft

KL=Lb=16ft; Cb=1.0

MD=18k-ft, ML=49k-ft

Try a W10 shape. For W10x60;

$$p=1.89×10^{-3};$$

$$ b\_{x}=3.51×10^{-3}$$

$$∴p\left(P\_{r}\right)=1.89×10^{-3}×300=.57>0.2$$

$$∴p\left(P\_{r}\right)+b\_{x}\left(M\_{rx}\right)+b\_{y}\left(M\_{ry}\right)\leq 1.0$$

$$(1.89×10^{-3}×300+3.51×10^{-3}×100)=0.92<1.0$$

OK. But is it the best section? Try a lighter section.

For W10x54

$$p=2.12×10^{-3};$$

$$ b\_{x}=3.97×10^{-3}$$

$$∴p\left(P\_{r}\right)=2.12×10^{-3}×300=.64>0.2$$

$$∴p\left(P\_{r}\right)+b\_{x}\left(M\_{rx}\right)+b\_{y}\left(M\_{ry}\right)\leq 1.0$$

$$\left(2.12×10^{-3}×300+3.97×10^{-3}×100\right)=1.03>1.0$$

No Good.

Use W10x60 section.