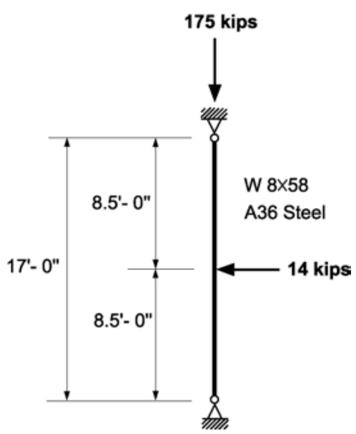
AISC-LRFD93-1

Title

Design of Beam-Column

Description

The beam-column in Figure is pinned at both ends and subjected to the factored loads shown. Bending is about the strong axis. Investigate the acceptability of a W8×58 of A36 steel used as a beam-column.



Beam-Column

Theoretical Results (AISC-LRFD93)

The axial compressive design strength of a W8 $\times$ 58 of A36 steel with an effective length of $K_y L = 1.0 \times 17 = 17$ ft is

$$\phi_c P_n = 318 \text{ kips}$$

For an unbraced length $L_b = 17$ ft

$$\phi_b M_n = 151.5 \text{ ft-kips}$$

For the end conditions and loading of this problem, $C_b = 1.32$

$$\phi_b M_n = 1.32(151.5) = 200.0 \text{ ft-kips}$$

But this is larger than $\phi_b M_p = 161.5$ ft-kips , so the design moment must be limited to $\phi_b M_p$.

$$\phi_b M_p = 161.5 \text{ ft-kips}$$

The maximum bending moment occurs at midheight

$$M_u = \frac{14(17)}{4} = 59.5 \text{ ft-kips}$$

$$\frac{P_u}{\phi_c P_n} + \frac{8}{9}\left(\frac{M_u}{\phi_b M_n}\right) = \frac{175}{318} + \frac{8}{9}\left(\frac{59.5}{161.5}\right) = 0.878 < 1.0 \qquad \text{OK}$$

Results by MIDAS/Gen

```
--------------------------------------------------------------------------------
 MIDAS/Gen - Steel Code Checking   [ AISC-LRFD93 ]
================================================================================

*.DEFINITION OF LOAD COMBINATIONS WITH SCALING UP FACTORS.
------------------------------------------------------------------------------------------------------------
   LCB  C    Loadcase Name(Factor) + Loadcase Name(Factor) + Loadcase Name(Factor)
------------------------------------------------------------------------------------------------------------
     1  0          DL( 1.400)
------------------------------------------------------------------------------------------------------------

*. LOADCOMB NO =    1,                         *. UNIT SYSTEM : kip, ft

*. SECTION PROPERTIES : Designation = W8x58
```

*. DESIGN PARAMETERS FOR STRENGTH EVALUATION :
Ly = 1.70000e+001, Lz = 1.70000e+001, Lu = 1.70000e+001
Ky = 1.00000e+000, Kz = 1.00000e+000

==
[[[*]]] COMPUTE MOMENT MAGNIFICATION FACTORS AND MAGNIFIED MOMENTS.
==

( ). Factored force/moments caused by unit load case.
*.Load combination ID = 1

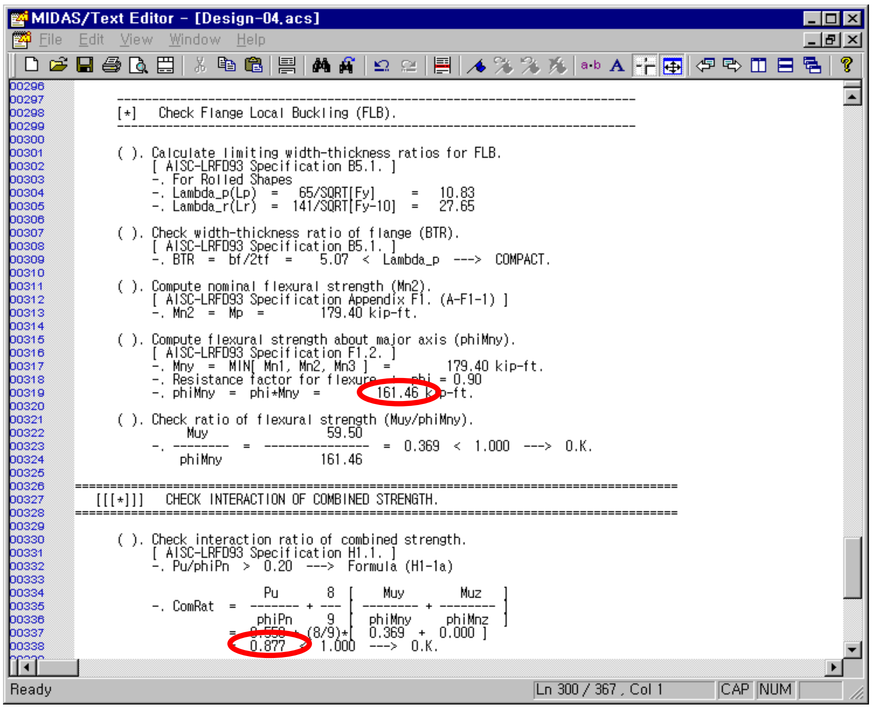
( ). Compute moment magnification factors(B1y,B1z).
-. Pu = Pu(DL+LL) + Pu(WL(EL)) = 175.00 kip.
-. About major(Local-y) axis.
Cmy(User Defined or Default Value) = 0.85
SLENy = Ky*Ly / Roy = 55.89
Lambda = (SLENy/pi)*SQRT(Fy/Es) = 0.6268
Pey = (Area*Fy)/Lambda^2 = 1566.82 kip.
B1y = Cmy / (1-Pu/Pey) = 0.96
B1y < 1.0 ---> B1y = 1.00
-. About minor(Local-z) axis.
Cmz(User Defined or Default Value) = 0.85
SLENz = Kz*Lz / Roz = 97.14
Lambda = (SLENz/pi)*SQRT(Fy/Es) = 1.0895
Pez = (Area*Fy)/Lambda^2 = 518.65 kip.
B1z = Cmz / (1-Pu/Pez) = 1.28

( ). Given factored axial forces and moments at <1/2>.

Load Case	Pu	My	Mz
DL	-175.00	59.50	0.00
LL	0.00	0.00	0.00
DL+LL	-175.00	59.50	0.00
WL or EL	0.00	0.00	0.00
DL+LL+WL(EL)	-175.00	59.50	0.00

( ). Compute magnified moments.
-. Muy = B1y*My(DL+LL) + B2y*My(WL(EL)) = 59.50 kip-ft.
-. Muz = B1z*Mz(DL+LL) + B2z*Mz(WL(EL)) = 0.00 kip-ft.

```
======================================
  [[[*]]]   CHECK AXIAL STRENGTH.
======================================

  ( ). Calculate axial compressive strength (phiPn).
       [ AISC-LRFD93 Specification E2. (E2-1), Appendix E3. (A-E3-1) ]
    -. Fcr      = MIN[ Fcr1,Fcr2 ]     =   3154.3593 kip/ft^2.
    -. Resistance factor for compression  :  phi = 0.85
    -. phiPn  =  phi*Area*Fcr          =         318.39 kip.

  ( ). Check ratio of axial strength (Pu/phiPn).
         Pu               175.00
    -. ---------  =  ---------------  =  0.550  <  1.000  --->  O.K.
       phiPn             318.39

============================================================
  [[[*]]]   CHECK FLEXURAL STRENGTH ABOUT MAJOR AXIS.
============================================================

  ( ). Compute flexural strength about major axis (phiMny).
       [ AISC-LRFD93 Specification F1.2. ]
    -. Mny        =  MIN[ Mn1, Mn2, Mn3 ]     =        179.40 kip-ft.
    -. Resistance factor for flexure  :  phi = 0.90
    -. phiMny   =  phi*Mny                    =        161.46 kip-ft.

  ( ). Check ratio of flexural strength (Muy/phiMny).
          Muy              59.50
    -. ----------  =  ---------------  =  0.369  <  1.000  --->  O.K.
        phiMny           161.46

==========================================================
  [[[*]]]   CHECK INTERACTION OF COMBINED STRENGTH.
==========================================================

  ( ). Check interaction ratio of combined strength.
       [ AISC-LRFD93 Specification H1.1. ]
    -. Pu/phiPn  >  0.20  --->  Formula (H1-1a)

                        Pu       8  [  Muy            Muz   ]
    -. ComRat  =  ------- + --- [ ---------- + ----------- ]
                       phiPn     9  [ phiMny     phiMnz  ]
               =  0.550 + (8/9)*[  0.369  +  0.000 ]
               =  0.877  <  1.000  --->  O.K.
```



Comparison of Results

	Reference	MIDAS/Gen
$\phi_c P_n$ (axial compressive strength)	318 kips	318 kips
C_b (bending coefficient)	1.32	1.32
M_u (maximum bending moment)	59.5 ft-kips	59.5 ft-kips
$\phi_b M_n$ (flexural strength)	161.5 ft-kips	161.5 ft-kips
$\dfrac{P_u}{\phi_c P_n} + \dfrac{8}{9}(\dfrac{M_u}{\phi_b M_n})$ (interaction ratio of Combined strength)	0.878	0.877

Reference

WILLIAM T. SEGUI, “*LRFD Steel Design*”, Example 6.1

AISC-LRFD93-2

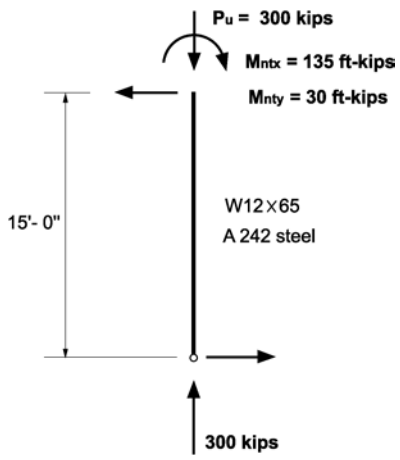
Title

Design of Member in Braced Frames

Description

Investigate the acceptability of a W12×65 of A242 steel used as a beam-column under the loading shown the Figure.

M_{ntx} = 135 ft-kips
M_{nty} = 30 ft-kips
P_u = 300 kips
f_y = 50 ksi



Beam-column in braced frames

Theoretical Results (AISC-LRFD93)

Load Combination ID = 2
1.2D+1.6L

Strong axis bending

$$C_{mx} = 0.6 - 0.4\frac{M_1}{M_2} = 0.6 - 0.4(0) = 0.6$$

$$\frac{K_x L}{r_x} = \frac{15(12)}{5.28} = 34.09$$

$$P_{e1x} = \frac{\pi^2 E A_g}{(K_x L / r_x)^2} = \frac{\pi^2 (29,000)(19.1)}{(34.09)^2} = 4704 \text{ kips}$$

$$B_{1x} = \frac{C_{mx}}{1 - \dfrac{P_u}{P_{e1x}}} = \frac{0.6}{1 - \dfrac{300}{4704}} = 0.641 < 1.0 \qquad \therefore \text{ use } B_{1x} = 1.0.$$

$$M_{ux} = B_{1x} M_{ntx} + B_{2x} M_{ltx} = 1.0(135) + 0 = 135 \text{ ft-kips}$$

This is larger than $\phi_b M_{px}$, $\therefore$ use $\phi_b M_{nx} = \phi_b M_{px} = 357.8$ ft-kips.

Weak-axis bending

$$C_{my} = 0.6 - 0.4\frac{M_1}{M_2} = 0.6 - 0.4(0) = 0.6$$

$$\frac{K_y L}{r_y} = \frac{15(12)}{3.02} = 59.60$$

$$P_{e1y} = \frac{\pi^2 E A_g}{(K_y L / r_y)^2} = \frac{\pi^2 (29,000)(19.1)}{(59.60)^2} = 1539 \text{ kips}$$

$$B_{1y} = \frac{C_{my}}{1 - \dfrac{P_u}{P_{e1y}}} = \frac{0.6}{1 - \dfrac{300}{1539}} = 0.745 < 1.0 \qquad \therefore \text{ use } B_{1y} = 1.0$$

$$M_{uy} = B_{1y} M_{nty} + B_{2y} M_{lty} = 1.0(30) + 0 = 30 \text{ ft-kips}$$

Because the flange of this is noncomopact, the weak-axis bending strength is limited by FLB.

$$\lambda = \frac{b_f}{2t_f} = 9.9$$

$$\lambda_p = \frac{65}{\sqrt{F_y}} = \frac{65}{\sqrt{50}} = 9.19$$

$$\lambda_r = \frac{141}{\sqrt{F_y - 10}} = \frac{141}{\sqrt{50-10}} = 22.29$$

Since $\lambda_p < \lambda < \lambda_r$

$\phi_b M_{ny} = 0.90(179.1) = 161.2$ ft-kips

Interaction of combined strength

$$\frac{P_u}{\phi_b P_n} + \frac{8}{9}\left(\frac{M_{ux}}{\phi_b M_{nx}} + \frac{M_{uy}}{\phi_b M_{ny}}\right) = 0.4792 + \frac{8}{9}\left(\frac{135}{357.8} + \frac{30}{161.2}\right)$$

$$= 0.980 < 1.0 \quad \text{OK}$$

Results by MIDAS/Gen

```
-----------------------------------------------------------------------
 MIDAS/Gen - Steel Code Checking   [ AISC-LRFD93 ]
=======================================================================

=======================================================================
  [[[*]]]   COMPUTE  MOMENT  MAGNIFICATION  FACTORS  AND  MAGNIFIED
            MOMENTS.
=======================================================================

*. UNIT SYSTEM : kip, ft

  ( ). Factored force/moments caused by unit load case.
     *.Load combination ID =   2

     *.Member end moments caused by gravity load(DL+LL).
         M1yG =        0.00,   M2yG =       135.00
         M1zG =        0.00,   M2zG =        30.00

  ( ). Compute moment magnification factors(B1y,B1z).
    -. About major(Local-y) axis.
    -. Single Curvature Bending.
       Cmy      =  0.6 - 0.4*(M1yG/M2yG)          =          0.60
       SLENy    =  Ky*Ly / Roy                    =         34.09
       Lambda   =  (SLENy/pi)*SQRT(Fy/Es)         =        0.4506
       Pey      =  (Area*Fy)/Lambda^2             =     4703.86 kip.
       B1y      =  Cmy / (1-Pu/Pey)               =          0.64
```

B1y < 1.0 ---> B1y = 1.00
-. About minor(Local-z) axis.
-. Single Curvature Bending.

Cmz	= 0.6 - 0.4*(M1zG/M2zG)	=	0.60
SLENz	= Kz*Lz / Roz	=	59.60
Lambda	= (SLENz/pi)*SQRT(Fy/Es)	=	0.7878
Pez	= (Area*Fy)/Lambda^2	=	1538.86 kip.
B1z	= Cmz / (1-Pu/Pez)	=	0.75

B1z < 1.0 ---> B1z = 1.00

( ). Given factored axial forces and moments at <J>.

Load Case	Pu	My	Mz
DL	-108.00	0.00	10.80
LL	-192.00	135.00	19.20
DL+LL	-300.00	135.00	30.00
WL or EL	0.00	0.00	0.00
DL+LL+WL(EL)	-300.00	135.00	30.00

( ). Compute magnified moments.
-. Muy = B1y*My(DL+LL) + B2y*My(WL(EL)) = 135.00 kip-ft.
-. Muz = B1z*Mz(DL+LL) + B2z*Mz(WL(EL)) = 30.00 kip-ft.

===================================
[[[*]]] CHECK AXIAL STRENGTH.
===================================

( ). Calculate axial compressive strength (phiPn).
[AISC-LRFD93 Specification E2. (E2-1), Appendix E3. (A-E3-1)]
-. Fcr = MIN[Fcr1,Fcr2] = 5552.9743 kip/ft^2.
-. Resistance factor for compression : phi = 0.85
-. phiPn = phi*Area*Fcr = 626.06 kip.

( ). Check ratio of axial strength (Pu/phiPn).

$$\frac{Pu}{phiPn} = \frac{300.00}{626.06} = 0.479 < 1.000 \; \text{---> O.K.}$$

===
[[[*]]] CHECK FLEXURAL STRENGTH ABOUT MAJOR AXIS.
===

( ). Compute flexural strength about major axis (phiMny).
[AISC-LRFD93 Specification F1.2.]

-. Mny = MIN[Mn1, Mn2, Mn3] = 397.23 kip-ft.
-. Resistance factor for flexure : phi = 0.90
-. phiMny = phi*Mny = 357.51 kip-ft.

( ). Check ratio of flexural strength (Muy/phiMny).

```
       Muy           135.00
-. ------------  =  ---------------  =  0.378  <  1.000  --->  O.K.
     phiMny          357.51
```

==
[[[*]]] CHECK FLEXURAL STRENGTH ABOUT MINOR AXIS.
==

( ). Compute flexural strength about minor axis (phiMnz).
[AISC-LRFD93 Specification F1.2.]
-. Mnz = 178.52 kip-ft.
-. Resistance factor for flexure : phi = 0.90
-. phiMnz = phi*Mnz = 160.67 kip-ft.

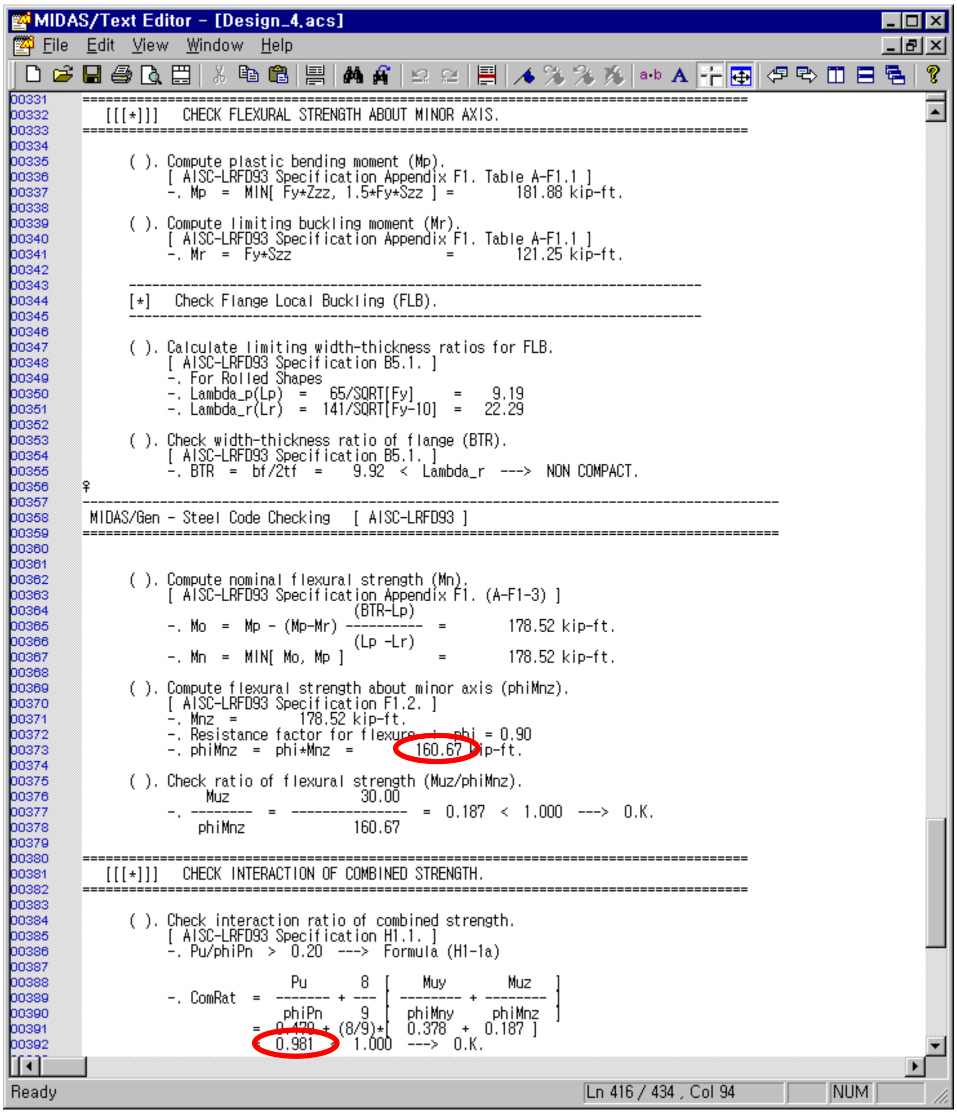
( ). Check ratio of flexural strength (Muz/phiMnz).

```
     Muz           30.00
-. --------  =  ---------------  =  0.187  <  1.000  --->  O.K.
   phiMnz        160.67
```

==
[[[*]]] CHECK INTERACTION OF COMBINED STRENGTH.
==

( ). Check interaction ratio of combined strength.
[AISC-LRFD93 Specification H1.1.]
-. Pu/phiPn > 0.20 ---> Formula (H1-1a)

```
                    Pu       8       Muy          Muz
-. ComRat  =  ------- + --- [ ---------- + ---------- ]
                  phiPn     9    phiMny      phiMnz
           =  0.479 + (8/9)*[  0.378  +  0.187 ]
           =  0.981  <  1.000  --->  O.K.
```



```
MIDAS/Text Editor - [Design_4.acs]
File  Edit  View  Window  Help

=====================================================================================
  [[[*]]]   CHECK FLEXURAL STRENGTH ABOUT MINOR AXIS.
=====================================================================================

      ( ). Compute plastic bending moment (Mp).
           [ AISC-LRFD93 Specification Appendix F1. Table A-F1.1 ]
           -. Mp  =  MIN[ Fy*Zzz, 1.5*Fy*Szz ] =       181.88 kip-ft.

      ( ). Compute limiting buckling moment (Mr).
           [ AISC-LRFD93 Specification Appendix F1. Table A-F1.1 ]
           -. Mr  =  Fy*Szz                    =       121.25 kip-ft.

      -------------------------------------------------------------------------
      [*]   Check Flange Local Buckling (FLB).
      -------------------------------------------------------------------------

      ( ). Calculate limiting width-thickness ratios for FLB.
           [ AISC-LRFD93 Specification B5.1. ]
           -. For Rolled Shapes
           -. Lambda_p(Lp)  =   65/SQRT[Fy]      =    9.19
           -. Lambda_r(Lr)  =  141/SQRT[Fy-10]   =   22.29

      ( ). Check width-thickness ratio of flange (BTR).
           [ AISC-LRFD93 Specification B5.1. ]
           -. BTR  =  bf/2tf  =    9.92  <  Lambda_r  --->  NON COMPACT.

-----------------------------------------------------------------------------------------
 MIDAS/Gen - Steel Code Checking    [ AISC-LRFD93 ]
=========================================================================================


      ( ). Compute nominal flexural strength (Mn).
           [ AISC-LRFD93 Specification Appendix F1. (A-F1-3) ]
                                       (BTR-Lp)
           -. Mo  =  Mp - (Mp-Mr) ----------  =        178.52 kip-ft.
                                       (Lp -Lr)
           -. Mn  =  MIN[ Mo, Mp ]              =        178.52 kip-ft.

      ( ). Compute flexural strength about minor axis (phiMnz).
           [ AISC-LRFD93 Specification F1.2. ]
           -. Mnz  =       178.52 kip-ft.
           -. Resistance factor for flexure : phi = 0.90
           -. phiMnz  =  phi*Mnz  =       160.67 kip-ft.

      ( ). Check ratio of flexural strength (Muz/phiMnz).
                Muz                     30.00
           -. --------  =  ---------------  =  0.187  <  1.000  --->  O.K.
               phiMnz                  160.67

=====================================================================================
  [[[*]]]   CHECK INTERACTION OF COMBINED STRENGTH.
=====================================================================================

      ( ). Check interaction ratio of combined strength.
           [ AISC-LRFD93 Specification H1.1. ]
           -. Pu/phiPn  >  0.20  --->  Formula (H1-1a)

                              Pu        8   [    Muy        Muz    ]
           -. ComRat  =  ------- + --- [ --------- + -------- ]
                             phiPn      9   [  phiMny     phiMnz   ]
                      =  0.429 + (8/9)*[  0.378  +  0.187 ]
                      =  0.981  <  1.000  --->  O.K.

Ready                                   Ln 416 / 434 , Col 94         NUM
```

Comparison of Results

	Reference	MIDAS/Gen
C_{mx} (equivalent moment correction factor)	0.6	0.6
P_{e1x} (elastic Euler buckling load)	4,704 kips	4,704 kips
M_{ux} (service loads about major axis)	135 ft-kips	135 ft-kips
$\phi_b M_{nx}$ (flexural strength about major axis)	357.8 ft-kips	357.5 ft-kips
M_{uy} (service loads about minor axis)	30 ft-kips	30 ft-kips
$\phi_b M_{ny}$ (flexural strength about minor axis)	161.2 ft-kips	160.7 ft-kips
$\frac{P_u}{\phi_b P_n} + \frac{8}{9}\left(\frac{M_{ux}}{\phi_b M_{nx}} + \frac{M_{uy}}{\phi_b M_{ny}}\right)$ (interaction ratio of combined strength)	0.980	0.981

Reference

WILLIAM T. SEGUI, "*LRFD Steel Design*", Example 6.6

AISC-LRFD93-3

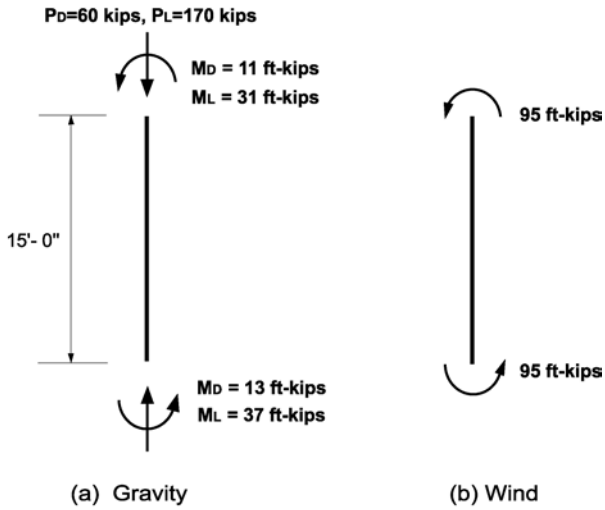
Title

Design of Member in Unbraced Frames

Description

Investigate the acceptability of a W12 × 65 of A36 steel used as a beam-column in unbraced frames. The axial load and end moments obtained from a first order analysis of the gravity loads(dead load and live load) are shown in Figure (a). The frame is symmetric, and the gravity loads are symmetrically placed.

Figure (b) shows the wind load moments obtained from a first-order analysis. All bending moments are about the strong axis. Effective length factors are K_x = 1.0 for the nonsway case, and K_y = 1.0.



Beam-column in unbraced frames

Theoretical Results (AISC-LRFD93)

Load Combination ID = 2
1.2D+1.6L

For this load condition, P_u = 344.0 kips, M_{nt} = 74.80 ft-kips, and M_{lt} = 0 (because of symmetry, there are no sidesway moments).

$$C_{mx} = 0.6 - 0.4\frac{M_1}{M_2} = 0.6 - 0.4(\frac{62.80}{74.80}) = 0.2642$$

For the axis of bending,

$$\frac{KL}{r} = \frac{K_x L}{r_x} = \frac{15(12)}{5.28} = 34.09$$

(Since this is the no-sidesway case, K_x for the braced condition is used.)

$$P_{e1x} = \frac{\pi^2 E A_g}{(KL/r)^2} = \frac{\pi^2 (29,000)(19.1)}{(34.09)^2} = 4,704 \text{ kips}$$

$$B_1 = \frac{C_m}{1 - \frac{P_u}{P_{e1x}}} = \frac{0.2642}{1 - \frac{344.0}{4,704}} = 0.285 < 1.0 \qquad \therefore \text{ use } B_1 = 1.0$$

$$M_u = B_1 M_{nt} + B_2 M_{lt} = 1.0(74.80) + 0 = 74.80 \text{ ft-kips}$$

$$C_b = \frac{12.5 M_{\max}}{2.5 M_{\max} + 3M_A + 4M_A + 3M_C}$$

$$= \frac{12.5(74.80)}{2.5(74.80) + 3(28.40) + 4(6.002) + 3(40.40)}$$

$$= 2.24$$

For C_b = 2.24,

$$\phi_b M_n = 2.24(254.5) > \phi_b M_p = 261.4 \text{ ft-kips}$$

$$\therefore \text{use } \phi_b M_n = 261.4 \text{ ft-kips}$$

Determine the critical axis for axial compressive strength

$$K_y L = 15 \text{ ft}$$

$$\frac{K_x L}{r_x / r_y} = \frac{1.2(15)}{1.75} = 10.29 \text{ ft} < 15 \text{ ft} \qquad \therefore \text{use } KL = 15 \text{ ft}$$

From the Column Load Tables, with $KL = 15$ ft , $\phi_c P_n = 485$ kips.

$$\frac{P_u}{\phi_c P_n} = \frac{344.0}{485} = 0.7903 > 0.2$$

$$\frac{P_u}{\phi_c P_n} + \frac{8}{9}\left(\frac{M_{ux}}{\phi_b M_{nx}} + \frac{M_{uy}}{\phi_b M_{ny}}\right) = 0.793 + \frac{8}{9}\left(\frac{74.80}{261.4} + 0\right) = 0.964 < 1.0 \qquad \text{OK}$$

Results by the MIDAS/Gen

```
-------------------------------------------------------------------------
 MIDAS/Gen - Steel Code Checking   [ AISC-LRFD93 ]
=========================================================================

*.DEFINITION OF LOAD COMBINATIONS WITH SCALING UP FACTORS.
---------------------------------------------------------------------------------------------------------
   LCB  C    Loadcase Name(Factor) + Loadcase Name(Factor) + Loadcase Name(Factor)
---------------------------------------------------------------------------------------------------------
     1  0          DL( 1.400)
     2  0          DL( 1.200) +         LL( 1.600)
     3  0          DL( 1.200) +          W( 1.300) +          LL( 0.500)
     4  0          DL( 0.900) +          W( 1.300)
     5  0          DL( 0.900) +          W(-1.300)
---------------------------------------------------------------------------------------------------------

*. LOADCOMB NO =    2              *. UNIT SYSTEM : kip, ft

*. SECTION PROPERTIES : Designation = W12x65

*. DESIGN PARAMETERS FOR STRENGTH EVALUATION :
   Ly   = 1.50000e+001,  Lz   = 1.50000e+001,  Lu   = 1.50000e+001
   Ky   = 1.00000e+000,  Kz   = 1.00000e+000

=========================================================================
  [[[*]]]  COMPUTE MOMENT MAGNIFICATION FACTORS AND MAGNIFIED
           MOMENTS.
=========================================================================

  ( ). Factored force/moments caused by unit load case.
     *.Load combination ID =   2

----------------------------------------------------
     Load Case              Pu        Myi
----------------------------------------------------
    DL+LL+WL(EL)      -344.00    -74.80
----------------------------------------------------
```

```
*.Member end moments caused by gravity load (DL+LL).
  M1yG    =      62.80,  M2yG     =     -74.80
  M1zG    =       0.00,  M2zG     =       0.00

( ). Compute moment magnification factors(B1y,B1z).
  Cmy      = 0.6 - 0.4*(M1yG/M2yG)      =        0.26
  SLENy    = Ky*Ly / Roy                =       34.09
  Lambda   = (SLENy/pi)*SQRT(Fy/Es)     =      0.3823
  Pey      = (Area*Fy)/Lambda^2         =     4703.86 kip.
  B1y      = Cmy / (1-Pu/Pey)           =        0.29
  B1y  <  1.0  --->  B1y  =  1.00

=====================================
 [[[*]]]   CHECK AXIAL STRENGTH.
=====================================

( ). Calculate axial compressive strength (phiPn).
   [ AISC-LRFD93 Specification E2. (E2-1), Appendix E3. (A-E3-1) ]
 -. Fcr      = MIN[ Fcr1,Fcr2 ]    =   4299.7586 kip/ft^2.
 -. Resistance factor for compression  :  phi = 0.85
 -. phiPn  =  phi*Area*Fcr         =        484.77 kip.

( ). Check ratio of axial strength (Pu/phiPn).
       Pu          344.00
 -. ---------  =  ---------------  =  0.710  <  1.000  --->  O.K.
      phiPn        484.77

=========================================================
 [[[*]]]   CHECK FLEXURAL STRENGTH ABOUT MAJOR AXIS.
=========================================================

( ). Compute plastic bending moment (Mp).
   [ AISC-LRFD93 Specification F1.1. (F1-1) ]
 -. Mp  =  MIN[ Fy*Zyy, 1.5*Fy*Syy ] =       290.40 kip-ft.

( ). Compute limiting buckling moment (Mr).
   [ AISC-LRFD93 Specification F1.1. (F1-7) ]
 -  For rolled shapes : Fr         =             10.0 ksi.
    Fo  =  MIN[ Fyw, Fyf-Fr ]  =   3744.0000 kip/ft^2.
 -. Mr  =  Fo*Syy                  =        190.45 kip-ft.

-------------------------------------------------------------------------
 [*]   Check Web Local Buckling (WLB).
-------------------------------------------------------------------------

( ). Check width-thickness ratio of web (DTR).
```

[AISC-LRFD93 Specification B5.1.]
-. DTR = hc/tw = 27.97 < Lambda_p ---> COMPACT.

( ). Compute nominal flexural strength (Mn3).
[AISC-LRFD93 Specification Appendix F1. (A-F1-1)]
-. Mn3 = Mp = 290.40 kip-ft.

---

[*] Check Lateral-Torsional Buckling (LTB).

( ). Calculate bending coefficient (Cb).
[AISC-LRFD93 Specification F1.2a. (C-F1-3)]
-. Mmax = 74.80 kip-ft. (Maximum moment).
-. MA = 40.40 kip-ft. (Moment at quarter point).
-. MB = 6.00 kip-ft. (Moment at centerline).
-. MC = 28.40 kip-ft. (Moment at three-quarter point).
-. Cb = 12.5*Mmax / (2.5*Mmax + 3*MA + 4*MB + 3*MC) = 2.240

( ). Compute nominal flexural strength (Mn1)
[AISC-LRFD93 Specification F1.2a. (F1-2)]

```
                [                      (Lu-Lp)  ]
-. Mn  =  Cb [ Mp - (Mp-Mr) ----------- ] =       633.63 kip-ft.
                [                      (Lr-Lp)  ]
```

-. Mn1 = MIN[Mn, Mp] = 290.40 kip-ft.

---

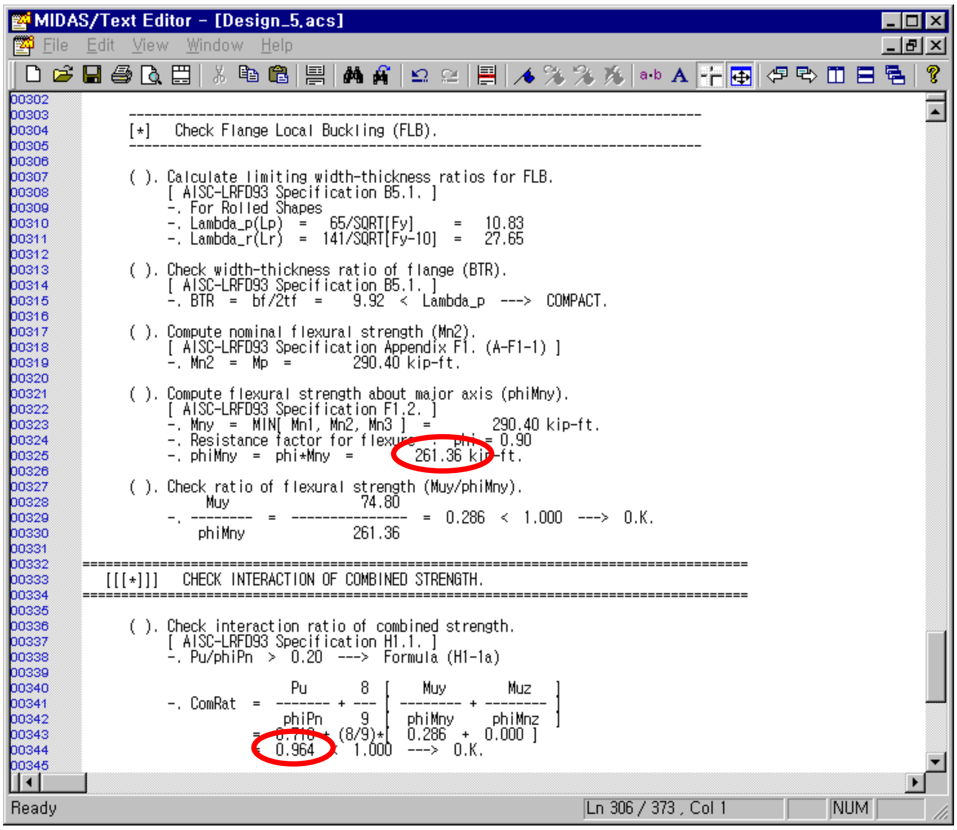
[*] Check Flange Local Buckling (FLB).

( ). Check width-thickness ratio of flange (BTR).
[AISC-LRFD93 Specification B5.1.]
-. BTR = bf/2tf = 9.92 < Lambda_p ---> COMPACT.

( ). Compute nominal flexural strength (Mn2).
[AISC-LRFD93 Specification Appendix F1. (A-F1-1)]
-. Mn2 = Mp = 290.40 kip-ft.

( ). Compute flexural strength about major axis (phiMny).
[AISC-LRFD93 Specification F1.2.]
-. Mny = MIN[Mn1, Mn2, Mn3] = 290.40 kip-ft.
-. Resistance factor for flexure : phi = 0.90
-. phiMny = phi*Mny = 261.36 kip-ft.

```
( ). Check ratio of flexural strength (Muy/phiMny).
         Muy              74.80
  -. ----------- = --------------- = 0.286 < 1.000 ---> O.K.
       phiMny            261.36

====================================================================
 [[[*]]]   CHECK INTERACTION OF COMBINED STRENGTH.
====================================================================

( ). Check interaction ratio of combined strength.
     [ AISC-LRFD93 Specification H1.1. ]
  -. Pu/phiPn > 0.20
                      Pu        8  [    Muy          Muz    ]
  -. ComRat  =  --------- + --- [ ---------- + ---------- ]
                   phiPn       9  [  phiMny     phiMnz  ]
             =  0.710 + (8/9)*[  0.286  +  0.000 ]
             =  0.964  <  1.000  --->  O.K.
```



```
MIDAS/Text Editor - [Design_5.acs]
File  Edit  View  Window  Help

   -----------------------------------------------------------------------
   [*]   Check Flange Local Buckling (FLB).
   -----------------------------------------------------------------------

   ( ). Calculate limiting width-thickness ratios for FLB.
        [ AISC-LRFD93 Specification B5.1. ]
        -. For Rolled Shapes
        -. Lambda_p(Lp)  =   65/SQRT[Fy]      =   10.83
        -. Lambda_r(Lr)  =  141/SQRT[Fy-10]   =   27.65

   ( ). Check width-thickness ratio of flange (BTR).
        [ AISC-LRFD93 Specification B5.1. ]
        -. BTR  =  bf/2tf  =     9.92  <  Lambda_p  --->  COMPACT.

   ( ). Compute nominal flexural strength (Mn2).
        [ AISC-LRFD93 Specification Appendix F1. (A-F1-1) ]
        -. Mn2  =  Mp  =        290.40 kip-ft.

   ( ). Compute flexural strength about major axis (phiMny).
        [ AISC-LRFD93 Specification F1.2. ]
        -. Mny  =  MIN[ Mn1, Mn2, Mn3 ]  =        290.40 kip-ft.
        -. Resistance factor for flexure : phi = 0.90
        -. phiMny  =  phi*Mny  =        261.36 kip-ft.

   ( ). Check ratio of flexural strength (Muy/phiMny).
            Muy                 74.80
        -. --------  =  ---------------  =  0.286  <  1.000  --->  O.K.
           phiMny              261.36

========================================================================
 [[[*]]]   CHECK INTERACTION OF COMBINED STRENGTH.
========================================================================

   ( ). Check interaction ratio of combined strength.
        [ AISC-LRFD93 Specification H1.1. ]
        -. Pu/phiPn  >  0.20  --->  Formula (H1-1a)

                           Pu       8  [   Muy         Muz    ]
        -. ComRat  =  ------- + --- [ -------- + -------- ]
                         phiPn      9  [  phiMny      phiMnz  ]
                   =  0.710 + (8/9)*[  0.286  +  0.000 ]
                   =  0.964  <  1.000  --->  O.K.

Ready                                   Ln 306 / 373 , Col 1      NUM
```

Comparison of Results

	Reference	MIDAS/Gen
C_{mx} (equivalent moment correction factor)	0.26	0.26
M_u (service loads)	74.80 ft-kips	74.80 ft-kips
C_b (bending coefficient)	2.24	2.24
$\phi_b M_n$ (flexural strength)	261.4 ft-kips	261.4 ft-kips
$\phi_c P_n$ (axial compressive strength)	485 kips	485 kips
$\frac{P_u}{\phi_b P_n} + \frac{8}{9}(\frac{M_{ux}}{\phi_b M_{nx}} + \frac{M_{uy}}{\phi_b M_{ny}})$ (interaction ratio of combined strength)	0.964	0.964

Reference

WILLIAM T. SEGUI, *LRFD Steel Design*, Example 6.7