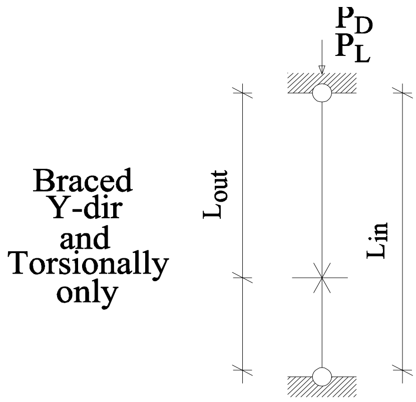
## Design of WT-Shapes Subjected to Compression Axial Force




### Materials

| | | | |
|---|---|---|---|
| Grade: | SEL("Material/ASTM";NAME; ) | = | A992 |
| $F_y$= | TAB("Material/ASTM";$F_y$;NAME=Grade) | = | 50 ksi |
| E= | | | 29000 ksi |
| G= | | | 11200 ksi |

### Buckling Lengths

| | |
|---|---|
| $kL_{in}$= | 20.00 ft |
| $kL_{out}$= | 20.00 ft |
| $k_zL$= | 20.00 ft |

*($kL_{in}$ and $kL_{out}$ are unbraced lengths for the strong- and weak- axes, respectively; $k_zL$ is the torsional unbraced length)*

### Axial Loads

| | |
|---|---|
| Axial dead load, $P_D$= | 6 kips |
| Axial Live load, $P_L$= | 18 kips |

From Chapter 2 of ASCE/SEI 7, the required compressive strength is:

| | | | |
|---|---|---|---|
| Ultimate load, $P_u$= | $1.2*P_D+1.6*P_L$ | = | 36.0 kips |

### Section Details

| | | | |
|---|---|---|---|
| sec.: | SEL("AISC/WT"; NAME; ) | = | WT7X15 |
| Depth, d= | TAB("AISC/WT";d;NAME=sec.) | = | 6.92 in |
| Stem thickness, $t_w$= | TAB("AISC/WT";$t_w$;NAME=sec.) | = | 0.270 in |
| Flange width, $b_f$= | TAB("AISC/WT";$b_f$;NAME=sec.) | = | 6.73 in |
| Flange thickness, $t_f$= | TAB("AISC/WT";$t_f$;NAME=sec.) | = | 0.385 in |
| Gross area, A= | TAB("AISC/WT";A;NAME=sec.) | = | 4.4 $in^2$ |
| $I_x$= | TAB("AISC/WT";$I_x$;NAME=sec.) | = | 19 $in^4$ |
| $I_y$= | TAB("AISC/WT";$I_y$;NAME=sec.) | = | 10 $in^4$ |

*($I_x$ and $I_y$ are the moment of inertia about x-and y-axes, respectively)*

$r_x$= TAB("AISC/WT";$r_x$;NAME=sec.) = 2.07 in

$r_y$= TAB("AISC/WT";$r_y$;NAME=sec.) = 1.49 in

*($r_x$ and $r_y$ are the radius of gyration about x- and y-axis, respectively)*

Torsion constant, J= TAB("AISC/WT";J;NAME=sec.) = 0.19 $in^4$

$Q_s$= TAB("AISC/WT";$Q_s$;NAME=sec.) = 0.61

y= TAB("AISC/WT";y;NAME=sec.) = 1.58 in

($Q_s$ is a reduction factor for unstiffned elements and y is the distance to the N.A.)

**Element Classification**

(1) Flanges:

$b_f/2t_f$, $\lambda_f$= $b_f/(2*t_f)$ = 8.74

Determine the flange limiting slenderness ratio, λrf, from AISC Specification Table B4.1a case 2:

$\lambda_{rf}$= $0.56*\sqrt{(E/F_y)}$ = 13.5

Fl_Class= IF($\lambda_f \le \lambda_{rf}$;"Non-Compact";"Slender") = Non-Compact

(2) Web:

d/tw, $\lambda_w$= $d/t_w$ = 25.6

Determine the slender web limit from AISC Specification Table B4.1a case 4:

$\lambda_{rw}$= $0.75*\sqrt{(E/F_y)}$ = 18.06

Web_Class= IF($\lambda_w \le \lambda_{rw}$;"Non-compact"; "Slender") = Slender

Q= $Q_s$ = 0.610

**Slenderness check:**

For members designed on the basis of compression, the slenderness ratio KL/r preferably should not exceed 200.

$\lambda_x$= $\frac{kL_{in}}{r_x}*12$ = 115.9

$\lambda_y$= $\frac{kL_{out}}{r_y}*12$ = 161.1

$\lambda_{max}$= MAX($\lambda_x$;$\lambda_y$) = 161.1

X-X Axis Critical Elastic Flexural Buckling Stress:

$F_{ex}$= $\frac{\pi^2 * E}{\lambda_x^2}$ = 21.3 ksi

Critical Elastic Torsional and Flexural-Torsional Buckling Stress:

$F_{ey}$= $\frac{\pi^2 * E}{\lambda_y^2}$ = 11.0 ksi

**Torsional Parameters**

The shear center for a T-shaped section is located on the axis of symmetry at the mid-depth of the flange.

$x_o$= 0.0 in

$y_o$= $y-t_f/2$ = 1.39 in

According to the AISC Specification Eqn. E4-11:

$r_o$= $\sqrt{(x_o^2+y_o^2+\frac{I_x+I_y}{A})}$ = 2.92 in

According to the AISC Specification Eqn. E4-10:

H= $1-\frac{x_o^2+y_o^2}{r_o^2}$ = 0.77 in

According to the AISC Specification Eqn. E4-9:

$$F_{ez}=\left(\frac{\pi^2 * E * C_w}{(k_z * L)^2}+GJ\right)\frac{1}{A * r_o^2}$$

Omit term with $C_w$ per User Note at end of AISC Specification Section E4.

$F_{ez}$ = $\frac{G * J}{A * r_o^2}$ = 56.72 ksi

According to the AISC Specification Eqn. E4-5:

$F_{e2}$= $\frac{F_{ey}+F_{ez}}{2 * H} * \left(1-\sqrt{1-\frac{4 * F_{ey} * F_{ez} * H}{(F_{ey}+F_{ez})^2}}\right)$ = 10.5 ksi

**Governed Critical Elastic Buckling Stress**

$F_e$= MIN ($F_{ex}$; $F_{ey}$; $F_{e2}$) = 10.5 ksi

**Buckling Stress for The Section**

Determine whether AISC Specification Equation E7-2 or E7-3 applies.

$F_{er}$= $0.44*Q*F_y$ = 13.4 ksi

$F_{cr}$= IF($F_e \geq F_{er}$; $Q*0.658^{(F_y*Q/F_e)}*F_y$;$0.877*F_e$) = 9.2 ksi

**Nominal Compressive Strength**

$P_n$= $F_{cr}*A$ = 40.5 kips

$\Phi_v$= 0.90

$\Phi_v P_n$= $\Phi_v*P_n$ = 36.5 kips

Compressive stress safety ($S_s$):

$S_s$= IF($\Phi_v*P_n$>Pu;"Safe";"Unsafe") = Safe

Stress_ratio= $\frac{P_u}{\Phi_v * P_n}$ = 0.99

**Design Summary**

| | | | |
|---|---|---|---|
| Ultimate load, $P_u$= | $1.2*P_D+1.6*P_L$ | = | 36.0 kips |
| Design load, $\Phi_v P_n$= | $\Phi_v*P_n$ | = | 36.5 kips |
| Stress_ratio= | $\frac{P_u}{\Phi_v*P_n}$ | = | 0.99 |
| $S_s$= | IF($\Phi_v*P_n>P_u$;"Safe";"Unsafe") | = | Safe |