ACI 318-08 Slender Column Requirements in Sway Frames

1. Design information

Units:  \[ \text{kips} = 1000\text{lbf} \]

Geometry:

Width along X:  \[ b := 18\text{-in} \]

Width along Y:  \[ h := 18\text{-in} \]

\[ A_g := b \cdot h \]

\[ A_g = 324\text{-in}^2 \]

Reinforcement:  \[ 4 \cdot \#10, \text{All Sides Equal} \]

\[ l_{se} := 214\text{.0in}^4 \]

\[ I_x := \frac{b \cdot h^3}{12} \]

\[ I_x = 8748\text{-in}^4 \]

\[ r := \frac{I_x}{A_g} \]

\[ r = 5.1962\text{-in} \]

Clear height:  \[ l_u := 16.00\text{-ft} \]

\[ l_u = 192\text{-in} \]

Concrete:

\[ f'_c := 5\text{-ksi} \]

\[ w_c := 150\text{lbf/ft}^3 \]

\[ E_c := 57000\text{psi} \]

\[ E_c = 4031\text{-ksi} \] (ACI 318. 8.5.1)

Reinforcing Steel:

\[ f_y := 60\text{ksi} \]

\[ E_s := 29000\text{ksi} \]

\[ 0.2 \cdot E_c \cdot I_x + E_s \cdot l_{se} = 1.326 \times 10^7\text{-kip-in}^2 \]

2. Loading Information

<table>
<thead>
<tr>
<th>Load Type</th>
<th>Load Factors</th>
<th>Axial Load</th>
<th>Story Shear</th>
<th>Bending Moment (Top &amp; Bottom)</th>
<th>Sustained Load Ratio</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dead Load, D</td>
<td>[ f_D := 1.2 ]</td>
<td>[ P_D := 380.0\text{-kips} ]</td>
<td>[ \Sigma V_D := 0\text{-kips} ]</td>
<td>[ M_{D,\text{top}} := 32.0\text{-ft-kips} ]</td>
<td>[ St_D := .635 ]</td>
</tr>
<tr>
<td></td>
<td></td>
<td>[ M_{D,\text{bot}} := 54.0\text{-ft-kips} ]</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Live Load, L</td>
<td>[ f_L := 0.5 ]</td>
<td>[ P_L := 140.0\text{-kips} ]</td>
<td>[ \Sigma V_L := 0\text{-kips} ]</td>
<td>[ M_{L,\text{top}} := 20.0\text{-ft-kips} ]</td>
<td>[ St_L := 0 ]</td>
</tr>
<tr>
<td></td>
<td></td>
<td>[ M_{L,\text{bot}} := 36.0\text{-ft-kips} ]</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Snow Load, S</td>
<td>[ f_S := 0.0 ]</td>
<td>[ P_S := 0.0\text{-kips} ]</td>
<td>[ \Sigma V_S := 0\text{-kips} ]</td>
<td>[ M_{S,\text{top}} := 0\text{-ft-kips} ]</td>
<td>[ St_S := 0 ]</td>
</tr>
<tr>
<td></td>
<td></td>
<td>[ M_{S,\text{bot}} := 0\text{-ft-kips} ]</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Wind Load, W</td>
<td>[ f_W := 1.6 ]</td>
<td>[ P_W := 0.0\text{-kips} ]</td>
<td>[ \Sigma V_W := 0\text{-kips} ]</td>
<td>[ M_{W,\text{top}} := 50.0\text{-ft-kips} ]</td>
<td>[ St_W := 0 ]</td>
</tr>
<tr>
<td></td>
<td></td>
<td>[ M_{W,\text{bot}} := 50.0\text{-ft-kips} ]</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Seismic Load, EQ</td>
<td>[ f_{EQ} := 0.0 ]</td>
<td>[ P_{EQ} := 0.0\text{-kips} ]</td>
<td>[ \Sigma V_{EQ} := 0\text{-kips} ]</td>
<td>[ M_{EQ,\text{top}} := 0\text{-ft-kips} ]</td>
<td>[ St_{EQ} := 0 ]</td>
</tr>
<tr>
<td></td>
<td></td>
<td>[ M_{EQ,\text{bot}} := 0\text{-ft-kips} ]</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Column loads:
\[ P_u := f_D P_D + f_L P_L + f_S P_S + f_W P_W + f_{EQ} P_{EQ} \]
\[ P_{u.st} := f_D P_{D.st} + f_L P_{L.st} + f_S P_{S.st} + f_W P_{W.st} + f_{EQ} P_{EQ.st} \]

\[ P_u = 526 \text{-kips} \]
\[ P_{u.st} = 289.56 \text{-kips} \]

Factored end moments due to loads that cause no appreciable sidesway
\[ M_{ns.top} := f_D M_{D.top} + f_L M_{L.top} + f_S M_{S.top} \]
\[ M_{ns.bot} := f_D M_{D.bot} + f_L M_{L.bot} + f_S M_{S.bot} \]
\[ M_{ns.top} = 48.4 \text{-ft kips} \]
\[ M_{ns.bot} = 82.8 \text{-ft kips} \]

Factored end moments due to loads that cause appreciable sidesway
\[ M_{s.top} := f_W M_{W.top} + f_{EQ} M_{EQ.top} \]
\[ M_{s.bot} := f_W M_{W.bot} + f_{EQ} M_{EQ.bot} \]
\[ M_{s.top} = 80 \text{-ft kips} \]
\[ M_{s.bot} = 80 \text{-ft kips} \]

Factored total end moments
\[ M_{u.top} := M_{ns.top} + M_{s.top} \]
\[ M_{u.bot} := M_{ns.bot} + M_{s.bot} \]
\[ M_{u.top} = 128.4 \text{-ft kips} \]
\[ M_{u.bot} = 162.8 \text{-ft kips} \]

Story loads for all columns:
The total factored vertical story load:
\[ \Sigma P_u := 27.333 P_u \]
\[ \frac{\Sigma P_u}{P_u} = 27.333 \]
\[ \Sigma P_u = 14377.16 \text{-kips} \]

\[ \Sigma V_u := f_D \Sigma V_D + f_L \Sigma V_L + f_S \Sigma V_S + f_W \Sigma V_W + f_{EQ} \Sigma V_{EQ} \]
\[ \Sigma V_{u.st} := f_D \Sigma V_{D.st} + f_L \Sigma V_{L.st} + f_S \Sigma V_{S.st} + f_W \Sigma V_{W.st} + f_{EQ} \Sigma V_{EQ.st} \]
\[ \Sigma V_u = 0 \text{-kips} \]
\[ \Sigma V_{u.st} = 0 \text{-kips} \]

3. Determine column designation as sway/nonsway and slenderness considerations

Columns and stories within a structure are designated sway or nonsway in accordance with the stability index for a story, Q, per ACI 318 10.10.5. Consider a column in a sway frame/story.

Determine \( k_{ns} \) (nonsway frames) and \( k_s \) (sway frames) from the alignment charts [ACI 318 Fig. 10.10.1.1. (a) and (b)] respectively or alternate simplified equations used in spColumn Software.

\[ k_{ns} := 0.800 \]
\[ k_s := 1.370 \]
\[ \frac{k_s l_u}{r} = 50.622 \]

Slenderness effects must be considered in sway frames if \( k_s l_u / r > 22 \) (ACI 318-08 10.10.1.a)
4. Moment magnification at ends of compression member (Sway) ACI 318-08 10.10.7

Magnify column moments per 10.10.7 for second order effects at ends of member as required by 10.10.5

\[ \beta_{ds} := \frac{\Sigma V_{u, st}}{\Sigma V_u} \quad \beta_{ds} = 0.000 \quad (ACI \ Cl. \ 10.10.4.2) \]

\[ EI_s := \left[ \frac{0.2 E_c I_x + E_s I_{se}}{1 + \beta_{ds}} \right] \quad EI_s = 1.33 \times 10^7 \text{-kip} \cdot \text{in}^2 \quad (ACI \ Eq. \ 10-14) \]

Critical Load: \[ P_{c,s} := \frac{\pi^2 EI_s}{(k_s lu)^2} \quad P_{c,s} = 1891.15 \text{kip} \quad (ACI \ Eq. \ 10-13) \]

The sum of critical load in all columns in the story considered:

\[ \Sigma P_{c,s} := 28.649 \cdot P_{c,s} \quad \frac{\Sigma P_{c,s}}{P_{c,s}} = 28.649 \quad \Sigma P_{c,s} = 54179.67 \text{-kips} \]

\[ \delta_s := \frac{1.0}{1 - \frac{0.75 \cdot \Sigma P_{c,s}}{\Sigma P_u}} \quad \delta_s = 1.548 \quad (ACI \ Eq. \ 10-21) \]

Magnify column moments \( M_1 \) and \( M_2 \) due to second order effects at the ends:

\[ M_{u, top, second} := M_{ns, top} + \delta_s \cdot M_{s, top} \quad M_{u, top, second} = 172.203 \text{-ft kips} \]

\[ M_{u, bot, second} := M_{ns, bot} + \delta_s \cdot M_{s, bot} \quad M_{u, bot, second} = 206.603 \text{-ft kips} \]

Set \( M_2 \) to the larger of the absolute value of top and bot second order magnified moments.

\[ M_{2, second} := \max \left( \left| M_{u, top, second} \right|, \left| M_{u, bot, second} \right| \right) \quad M_{2, second} = 206.603 \text{-ft kips} \]

\[ M_{1, second} := \min \left( \left| M_{u, top, second} \right|, \left| M_{u, bot, second} \right| \right) \quad M_{1, second} = 172.203 \text{-ft kips} \]

Determine the first order factored moment, \( M_{2, \text{first}} \) at the end at which the larger second order end moment, \( M_{2, \text{second}} \) acts.

\[ M_{2, \text{first}} := \text{if} \left( \left| M_{u, top, second} \right| \geq \left| M_{u, bot, second} \right|, \left| M_{u, top} \right|, \left| M_{u, bot} \right| \right) \quad M_{2, \text{first}} = 162.8 \text{-ft kips} \]

\[ M_{1, \text{first}} := \text{if} \left( \left| M_{u, top, second} \right| \geq \left| M_{u, bot, second} \right|, \left| M_{u, top} \right|, \left| M_{u, bot} \right| \right) \quad M_{1, \text{first}} = 128.4 \text{-ft kips} \]

The ratio of second order moments to first order moments after moment magnification at column ends (sway effect) is:

\[ \frac{M_{2, second}}{M_{2, \text{first}}} = 1.269 \quad \frac{M_{1, second}}{M_{1, \text{first}}} = 1.341 \]

The next step in this calculation was not required in earlier codes unless the parameter \( k''l u/r \) exceeded 35 as previously given in 318-05 10.13.5. This condition amplified the design moment but no stability check was required except for 318-05 10.13.6.
5. Moment magnification along length of compression member (nonsway) ACI 318-08 10.10.6

Continue to magnify column moments per 10.10.6 for second order effects along the length of member as required by 10.10.2.2.

Determine stiffness reduction factor for sustained axial load

\[ \beta_{\text{dns}} := \min \left( \frac{P_{\text{u, st}}}{P_{\text{u}}}, 1.0 \right) \]

\[ \beta_{\text{dns}} = 0.550 \]  

(ACI 10.10.6.2)

\[ E_{\text{Ins}} = \left( \frac{0.2E_c I_x + E_s I_{\text{se}}}{1 + \beta_{\text{dns}}} \right) \]

\[ E_{\text{Ins}} = 8.55 \times 10^6 \text{kip} \cdot \text{in}^2 \]  

(ACI Eq. 10-14)

\[ P_{\text{c,ns}} := \frac{\pi^2 E_{\text{Ins}}}{(k_{\text{ns}} l_u)^2} \]

\[ P_{\text{c,ns}} = 3576.99 \text{kips} \]  

(ACI Eq. 10-13)

Determine and select whether the column is bent in single (1) or double (2) curvature due to second order moments.

Curve := 1

If column is bent in single curvature, \( M_1 \), the smaller of top and bot second order magnified moment is to be taken as positive. Otherwise, \( M_1 \) is to be taken as negative.

\[ M_{1, \text{second}} := \text{if}(\text{Curve} = 1, M_{1, \text{second}}, -M_{1, \text{second}}) \]

\[ M_{1, \text{second}} = 172.203 \text{ft-kips} \]

(ACI Eq. 10-16)

Set \( C_m \) to 1.0 if \( M_2 \), or \( M_1 \) and \( M_2 \) are equal to zero.

\[ C_m := \text{if}(M_{2, \text{second}} = 0, 1, 0.6 + 0.4 \frac{M_{1, \text{second}}}{M_{2, \text{second}}}) \]

\[ C_m = 0.933 \]

(ACI Eq. 10-16)

\[ C_m := \max(C_m, 0.4) \]

\[ C_m = 0.933 \]

\[ C_m := \min(C_m, 1) \]

\[ C_m = 0.933 \]

\[ \delta := \max \left(1, \frac{C_m}{1 - \left( \frac{P_u}{0.75 \cdot P_{\text{c,ns}}} \right)} \right) \]

\[ \delta = 1.161 \]  

(ACI Eq. 10-12)

Check factored moment \( M_2 \) is not less than required by 10.10.6.5 equation 10-17 for minimum moment:

\[ M_{\text{min}} := P_u (0.6\text{in} + 0.03\text{-h}) \]

\[ M_{\text{min}} = 49.97 \text{ft-kips} \]

Determine final moment value amplified per equation 10-11:

\[ M_c := \delta M_2 \]

\[ M_c = 239.88 \text{ft-kips} \]

Check the ratio of second order moment including further moment magnification effects along the length of compression member (ACI 318-08 10.10.2.2) to first order moments. ACI 318-08 10.10.2.1. requires the ratio not exceed 1.40.

6. Check column strength based on spColumn output

\[ \phi P_{\text{n, max}} := 863.3 \text{kips} \]

\[ \frac{P_u}{\phi P_{\text{n, max}}} = 0.609 \]  

OK

\[ \phi M_{nx} := 239.75 \text{ft-kips} \]

\[ \frac{M_c}{\phi M_{nx}} = 1.001 \]  

NG
Code: ACI 318-08
Units: English
Run axis: About X-axis
Run option: Investigation
Slenderness: Considered
Column type: Structural
Bars: ASTM A615
Date: 06/24/10
Time: 13:37:26

f'c = 5 ksi
fy  = 60 ksi
Ag = 324 in^2
As  = 5.08 in^2
rho = 1.57%
fcc = 4.25 ksi
Es = 29000 ksi
Xo  = 0.00 in
Yo  = 0.00 in
lx = 8748 in^4
ly = 8748 in^4
Beta1 = 0.8
Min clear spacing = 11.71 in
Clear cover = 1.88 in
Confinement: Tied
kx(nonsway) = 0.8
kx(sway) = 1.37

phi(a) = 0.8, phi(b) = 0.9, phi(c) = 0.65
General Information:

File Name: C:\Users\mdeger\Documents\spColumn v4.60 - ACI 318-08 Cl 10.10.2.2 Implementation\Or...\CASE B.col
Project: Hassoun 4th Ed Ex 12.4
Column: Engineer: SP
Code: ACI 318-08 Units: English
Run Option: Investigation Slenderness: Considered
Run Axis: X-axis Column Type: Structural

Material Properties:

- $f'c = 5 \text{ ksi}$
- $f_y = 60 \text{ ksi}$
- $E_c = 4030.51 \text{ ksi}$
- $E_s = 29000 \text{ ksi}$
- Ultimate strain = 0.003 in/in
- $\beta_1 = 0.8$

Section:

- Rectangular: Width = 18 in Depth = 18 in
  - Gross section area, $A_g = 324 \text{ in}^2$
  - $I_x = 8748 \text{ in}^4$
  - $I_y = 8748 \text{ in}^4$
  - $r_x = 5.19615 \text{ in}$
  - $r_y = 5.19615 \text{ in}$
  - $X_o = 0 \text{ in}$
  - $Y_o = 0 \text{ in}$

Reinforcement:

Bar Set: ASTM A615

<table>
<thead>
<tr>
<th>Size Diam (in)</th>
<th>Area (in^2)</th>
<th>Size Diam (in)</th>
<th>Area (in^2)</th>
<th>Size Diam (in)</th>
<th>Area (in^2)</th>
</tr>
</thead>
<tbody>
<tr>
<td>3</td>
<td>0.38</td>
<td>4</td>
<td>0.50</td>
<td>5</td>
<td>0.63</td>
</tr>
<tr>
<td>6</td>
<td>0.75</td>
<td>7</td>
<td>0.88</td>
<td>8</td>
<td>1.00</td>
</tr>
<tr>
<td>9</td>
<td>1.13</td>
<td>10</td>
<td>1.27</td>
<td>11</td>
<td>1.41</td>
</tr>
<tr>
<td>14</td>
<td>1.69</td>
<td>18</td>
<td>2.26</td>
<td></td>
<td>4.00</td>
</tr>
</tbody>
</table>

Confinement: Tied; #3 ties with #10 bars, #4 with larger bars.

phi(a) = 0.8, phi(b) = 0.9, phi(c) = 0.65

Layout: Rectangular

Pattern: All Sides Equal  (Cover to transverse reinforcement)

Total steel area: $A_s = 5.08 \text{ in}^2$ at $\rho = 1.57\%$

Minimum clear spacing = 11.71 in

4 #10 Cover = 1.5 in

Service Loads:

<table>
<thead>
<tr>
<th>Load</th>
<th>Axial Load</th>
<th>Mx @ Top</th>
<th>Mx @ Bot</th>
<th>My @ Top</th>
<th>My @ Bot</th>
</tr>
</thead>
<tbody>
<tr>
<td>No. Case</td>
<td>kip</td>
<td>k-ft</td>
<td>k-ft</td>
<td>k-ft</td>
<td>k-ft</td>
</tr>
<tr>
<td>1</td>
<td>380.00</td>
<td>32.00</td>
<td>-54.00</td>
<td>0.00</td>
<td>0.00</td>
</tr>
<tr>
<td>Dead</td>
<td>140.00</td>
<td>20.00</td>
<td>-36.00</td>
<td>0.00</td>
<td>0.00</td>
</tr>
<tr>
<td>Live</td>
<td>0.00</td>
<td>50.00</td>
<td>-50.00</td>
<td>0.00</td>
<td>0.00</td>
</tr>
<tr>
<td>Wind</td>
<td>0.00</td>
<td>0.00</td>
<td>0.00</td>
<td>0.00</td>
<td>0.00</td>
</tr>
<tr>
<td>EQ</td>
<td>0.00</td>
<td>0.00</td>
<td>0.00</td>
<td>0.00</td>
<td>0.00</td>
</tr>
<tr>
<td>Snow</td>
<td>0.00</td>
<td>0.00</td>
<td>0.00</td>
<td>0.00</td>
<td>0.00</td>
</tr>
</tbody>
</table>

Sustained Load Factors:

<table>
<thead>
<tr>
<th>Load</th>
<th>Factor</th>
</tr>
</thead>
<tbody>
<tr>
<td>Case (%)</td>
<td></td>
</tr>
<tr>
<td>Dead</td>
<td>64</td>
</tr>
<tr>
<td>Live</td>
<td>0</td>
</tr>
<tr>
<td>Wind</td>
<td>0</td>
</tr>
<tr>
<td>EQ</td>
<td>0</td>
</tr>
<tr>
<td>Snow</td>
<td>0</td>
</tr>
</tbody>
</table>

Load Combinations:

- $U_1 = 1.200*\text{Dead} + 0.500*\text{Live} + 1.600*\text{Wind} + 0.000*\text{EarthQuake} + 0.000*\text{Snow}$

Slenderness:

- Sway Criteria:
  - X-axis: Sway column. $\text{SumPc} = 28.65 * \text{Pc}$ $\text{SumPu} = 27.33 * \text{Pu}$
  - Second-order effects along length considered
### Column Axis Details

<table>
<thead>
<tr>
<th>Height</th>
<th>Width</th>
<th>Depth</th>
<th>I</th>
<th>f'c</th>
<th>Ec</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

- **Design X**: 16 ft, 8748 in^4, 4030.51 ksi
- **Above X**: (no column specified...)
- **Below X**: (no column specified...)

### X-Beams Details

<table>
<thead>
<tr>
<th>Location</th>
<th>Length</th>
<th>Width</th>
<th>Depth</th>
<th>I</th>
<th>f'c</th>
<th>Ec</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

- **Above Left**: (no beam specified...)
- **Above Right**: (no beam specified...)
- **Below Left**: (no beam specified...)
- **Below Right**: (no beam specified...)

### Effective Length Factors

<table>
<thead>
<tr>
<th>Axis</th>
<th>Psi(top)</th>
<th>Psi(bot)</th>
<th>k(Nonsway)</th>
<th>k(Sway)</th>
<th>klu/r</th>
</tr>
</thead>
<tbody>
<tr>
<td>X</td>
<td>0.000</td>
<td>0.000</td>
<td>0.800</td>
<td>1.370</td>
<td>50.62</td>
</tr>
</tbody>
</table>

### Moment Magnification Factors

#### 0.2*Ec*Ig + Es*Ise (X-axis) = 1.33e+007 kip-in^2

### Factored Moments due to First-Order and Second-Order Effects

Minimum eccentricity, $E_{x,min} = 1.14$ in

#### First line - at column top

#### Second line - at column bottom

### Factored Loads and Moments with Corresponding Capacities

**NOTE**: Each loading combination includes the following cases:

#### First line - at column top

#### Second line - at column bottom

### Magnified (second-order) moment exceeds 1.4 times first-order moment. Revise column!

# Section capacity exceeded. Revise column!

*** End of output ***
General Information:

File Name: C:\Users\mdeger\Documents\spColumn v4.60 - ACI 318-08 Cl 10.10.2.2 Im...
Project: Hassoun 4th Ed Ex 12.4
Column: Engineer: SP
Code: ACI 318-08 Units: English
Run Option: Investigation Slenderness: Not considered
Run Axis: X-axis Column Type: Structural

Material Properties:

f'c = 5 ksi fy = 60 ksi
Ec = 4030.51 ksi Es = 29000 ksi
Ultimate strain = 0.003 in/in
Beta1 = 0.8

Section:

Rectangular: Width = 18 in Depth = 18 in
Gross section area, Ag = 324 in^2
Ix = 8748 in^4 Iy = 8748 in^4
rx = 5.19615 in ry = 5.19615 in
Xo = 0 in Yo = 0 in

Reinforcement:

Bar Set: ASTM A615

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<tbody>
<tr>
<td># 3</td>
<td>0.38</td>
<td>0.11</td>
<td># 4</td>
<td>0.50</td>
<td>0.20</td>
</tr>
<tr>
<td># 6</td>
<td>0.75</td>
<td>0.44</td>
<td># 7</td>
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<td>0.60</td>
</tr>
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<td># 14</td>
<td>1.69</td>
<td>2.25</td>
<td># 18</td>
<td>2.26</td>
<td>4.00</td>
</tr>
</tbody>
</table>

Confinement: Tied; #3 ties with #10 bars, #4 with larger bars.
phi(a) = 0.8, phi(b) = 0.9, phi(c) = 0.65
Layout: Rectangular
Pattern: All Sides Equal (Cover to transverse reinforcement)
Total steel area: As = 5.08 in^2 at rho = 1.57%
Minimum clear spacing = 11.71 in

4 #10 Cover = 1.5 in

Control Points:

<table>
<thead>
<tr>
<th>Bending about</th>
<th>Axial Load P kip</th>
<th>X-Moment k-ft</th>
<th>Y-Moment k-ft</th>
<th>NA depth in</th>
<th>Dt depth in</th>
<th>eps_t</th>
<th>Phi</th>
</tr>
</thead>
<tbody>
<tr>
<td>X @ Max comp</td>
<td>1079.1</td>
<td>-0.00</td>
<td>-0.00</td>
<td>49.91</td>
<td>15.49</td>
<td>-0.00207</td>
<td>0.65</td>
</tr>
<tr>
<td>@ Allowable comp.</td>
<td>863.3</td>
<td>129.29</td>
<td>0.00</td>
<td>18.76</td>
<td>15.49</td>
<td>-0.00052</td>
<td>0.65</td>
</tr>
<tr>
<td>@ fs = 0.0</td>
<td>708.2</td>
<td>193.76</td>
<td>0.00</td>
<td>15.49</td>
<td>15.49</td>
<td>-0.00000</td>
<td>0.65</td>
</tr>
<tr>
<td>@ fs = 0.5*fy</td>
<td>500.7</td>
<td>244.29</td>
<td>0.00</td>
<td>11.52</td>
<td>15.49</td>
<td>0.00103</td>
<td>0.65</td>
</tr>
<tr>
<td>@ Balanced point</td>
<td>357.7</td>
<td>265.43</td>
<td>0.00</td>
<td>9.17</td>
<td>15.49</td>
<td>0.00207</td>
<td>0.65</td>
</tr>
<tr>
<td>@ Tension control</td>
<td>286.0</td>
<td>308.02</td>
<td>0.00</td>
<td>5.81</td>
<td>15.49</td>
<td>0.00500</td>
<td>0.65</td>
</tr>
<tr>
<td>@ Pure bending</td>
<td>-0.0</td>
<td>165.69</td>
<td>0.00</td>
<td>2.50</td>
<td>15.49</td>
<td>0.01557</td>
<td>0.65</td>
</tr>
<tr>
<td>@ Max tension</td>
<td>-274.3</td>
<td>0.00</td>
<td>0.00</td>
<td>0.00</td>
<td>15.49</td>
<td>9.99999</td>
<td>0.65</td>
</tr>
</tbody>
</table>

-X @ Max comp  | 1079.1           | -0.00         | -0.00         | 49.91       | 15.49       | -0.00207 | 0.65 |
| @ Allowable comp. | 863.3           | -129.29       | 0.00          | 18.76       | 15.49       | -0.00052 | 0.65 |
| @ fs = 0.0    | 708.2            | -193.76       | 0.00          | 15.49       | 15.49       | -0.00000 | 0.65 |
| @ fs = 0.5*fy | 500.7            | -244.29       | 0.00          | 11.52       | 15.49       | 0.00103  | 0.65 |
| @ Balanced point | 357.7           | -265.43       | 0.00          | 9.17        | 15.49       | 0.00207  | 0.65 |
| @ Tension control | 286.0           | -308.02       | 0.00          | 5.81        | 15.49       | 0.00500  | 0.65 |
| @ Pure bending | -0.0            | -165.69       | 0.00          | 2.50        | 15.49       | 0.01557  | 0.65 |
| @ Max tension | -274.3          | 0.00          | 0.00          | 0.00        | 15.49       | 9.99999  | 0.65 |

*** End of output ***