midas Gen

Advanced Webinar

- Steel Structure Design
Why midas Gen

Integrated Design System for buildings and General Structures

Versatility

→ Stadiums
→ Power Plants
→ Hangar
→ Airport
→ Transmission
  Towers
→ Cranes
→ Pressure Vessels
→ Machine Structures
→ Underground
  Structures …

Specialty Structures Applications

Beijing National Stadium
Beijing National Aquatic Center
Beijing Olympic Basketball Gymnasium
Seoul World Cup Stadium
JeonJu World Cup Stadium
DeaJeon World Cup Stadium
USA Pavilion
China Pavilion
German Pavilion
Contents

1. Introduction of Design Features
2. Introduction of Steel Design
3. Design for Steel Structure Building
4. Steel Optimal Design
5. Q & A
1. Introduction of Design Features

**Design Features**

- **Steel**
  - Steel Code Check... Ctrl+6
  - Steel Optimal Design... Ctrl+Shift+6
  - Steel Strong Column-Weak Beam

- **RC**
  - Concrete Code Design
  - Concrete Code Check
  - RC Strong Column-Weak Beam
  - SRC Code Check
  - SRC Optimal Design... Ctrl+Shift+8

- **Footing**
  - Footing Design... Ctrl+9
  - Displacement Optimal Design...

**Design Type**

- **Steel**: Steel code check
  - Steel Optimal Design / Displacement Optimal Design

- **Concrete**: Concrete code design
  - Concrete code check
  - RC Capacity Design
  - Meshed Slab/Wall Design

- **Footing**: design
## Available Design Code

### Gen 2010 (v2.1)

<table>
<thead>
<tr>
<th>RC Design</th>
<th>Steel Design</th>
<th>SRC Design</th>
</tr>
</thead>
<tbody>
<tr>
<td>ACI318</td>
<td>AISC-LRFD</td>
<td>SSRC79</td>
</tr>
<tr>
<td>Eurocode 2, Eurocode 8</td>
<td>AISC-ASD</td>
<td>JGJ138</td>
</tr>
<tr>
<td>BS8110</td>
<td>AISI-CFSD</td>
<td>CECS28</td>
</tr>
<tr>
<td>IS:456 &amp; IS:13920</td>
<td>Eurocode 3</td>
<td>AUJ-SRC</td>
</tr>
<tr>
<td>CSA-A23.3</td>
<td>BS5950</td>
<td>TWNSRC</td>
</tr>
<tr>
<td>GB50010</td>
<td>IS:800</td>
<td>AIK-SRC</td>
</tr>
<tr>
<td>AIJ-WSD</td>
<td>CSA-S16-01</td>
<td>KSSC-CFT</td>
</tr>
<tr>
<td>TWN-USD</td>
<td>GBJ17, GB50017</td>
<td>Footing Design</td>
</tr>
<tr>
<td>AIK-USD, WSD</td>
<td>AIJ-ASD</td>
<td>ACI318</td>
</tr>
<tr>
<td>KSCE-USD</td>
<td>TWN-ASD, LSD</td>
<td>BS8110</td>
</tr>
<tr>
<td>KCI-USD</td>
<td>AIK-ASD, LSD, CFSD</td>
<td></td>
</tr>
</tbody>
</table>

### Slab Design

- Eurocode 2
- Eurocode 3
- KSSC-ASD

### Footing Design

- Eurocode 2 (L, interted T)

### Gen 2011 (v1.1)

<table>
<thead>
<tr>
<th>RC Design</th>
<th>Steel Design</th>
<th>Composite Design</th>
</tr>
</thead>
<tbody>
<tr>
<td>Eurocode 2 (Irregular Section)</td>
<td>Eurocode3(Irregular Section)</td>
<td>Eurocode 4 (Irregular Section)</td>
</tr>
<tr>
<td>Footing Design</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Eurocode 2 (L, interted T)</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
**Steel Design Features**

- Gen provides code checking for beams, columns and bracings
- Both Ultimate and Serviceability limit states are checked.
- Load combinations are automatically generated.
- Static wind loads can be automatically assigned
- Static seismic loads and response spectrum function are available
- Available Section profiles include:
  - Angle, Channel, I-Shape, T-Shape, Box, Pipe, Double L, Double C
- Joint Connection design is not currently available.
- Second-order effects can be considered.
- Internal forces and moments are determined using elastic global analysis.
- Composite beam design is provided in midas Civil.
- Capacity design is available.
Steel Design in Gen; EC3

I. Ultimate Limit State Check
   • Material Properties
   • Section table for the application of Ultimate Limit State Check
   • Resistance of cross-sections
   • Buckling resistance of members

II. Serviceability Limit State Check
   • Vertical deflections
   • Horizontal deflections
1. Ultimate Limit State Check
### Material Properties

- The nominal values of the yield strength ($f_y$) and the ultimate strength ($f_u$) for structural steel are given in the following table:

<table>
<thead>
<tr>
<th>Steel Grade</th>
<th>$t \leq 40\text{mm}$</th>
<th>$t &gt; 40\text{mm}$</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>$f_y$ (N/mm$^2$)</td>
<td>$f_u$ (N/mm$^2$)</td>
</tr>
<tr>
<td>S235</td>
<td>235</td>
<td>360</td>
</tr>
<tr>
<td>S275</td>
<td>275</td>
<td>430</td>
</tr>
<tr>
<td>S355</td>
<td>355</td>
<td>510</td>
</tr>
<tr>
<td>S450</td>
<td>440</td>
<td>550</td>
</tr>
</tbody>
</table>

- Modulus of Elasticity = 210,000 N/mm$^2$
- Poisson’s Ratio $\nu = 0.3$
- Thermal Coefficient = $12 \times 10^{-6}$ /°C
- Weight Density = 76.98 kN/m$^3$
## Section table for the application of Ultimate Limit State Check

<table>
<thead>
<tr>
<th>Cross section</th>
<th>Limit States</th>
<th>Yielding</th>
<th>FB (1)</th>
<th>SB</th>
<th>LTB</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Strong axis</td>
<td>Weak axis</td>
</tr>
<tr>
<td>I section</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Doubly Symmetric</td>
<td></td>
<td>√</td>
<td>√</td>
<td>√</td>
<td>N/A</td>
</tr>
<tr>
<td>Singly Symmetric</td>
<td></td>
<td>√</td>
<td>√</td>
<td>√</td>
<td>N/A</td>
</tr>
<tr>
<td>Box</td>
<td></td>
<td>√</td>
<td>√</td>
<td>√</td>
<td>√ (2)</td>
</tr>
<tr>
<td>Angle</td>
<td></td>
<td>√</td>
<td>√</td>
<td>N/A</td>
<td>N/A</td>
</tr>
<tr>
<td>Channel</td>
<td></td>
<td>√</td>
<td>√</td>
<td>N/A</td>
<td>N/A</td>
</tr>
<tr>
<td>Tee</td>
<td></td>
<td>√</td>
<td>√</td>
<td>N/A</td>
<td>N/A</td>
</tr>
<tr>
<td>Double Angle</td>
<td></td>
<td>√</td>
<td>√</td>
<td>N/A</td>
<td>N/A</td>
</tr>
<tr>
<td>Double Channel</td>
<td></td>
<td>√</td>
<td>√</td>
<td>N/A</td>
<td>N/A</td>
</tr>
<tr>
<td>Pipe</td>
<td></td>
<td>√</td>
<td>√</td>
<td>N/A</td>
<td>N/A</td>
</tr>
<tr>
<td>Solid Rectangle</td>
<td></td>
<td>√</td>
<td>√</td>
<td>N/A</td>
<td>N/A</td>
</tr>
<tr>
<td>Solid Round</td>
<td></td>
<td>√</td>
<td>√</td>
<td>N/A</td>
<td>N/A</td>
</tr>
<tr>
<td>U-Rib</td>
<td></td>
<td>N/A</td>
<td>N/A</td>
<td>N/A</td>
<td>N/A</td>
</tr>
</tbody>
</table>

**Note:**

1. Torsional Buckling and Torsional-Flexural Buckling are not evaluated.
2. The thickness of two webs should be identical, and the member type should be “column” for the weak axis shear buckling check.
3. FB: Flexural Buckling, SB: Shear Buckling, LTB: Lateral-Torsional Buckling
Resistance of Cross-Sections

- **Tension**

  Design tension resistance

  \[ N_{pl,Rd} = \frac{A f_y}{\gamma_{M0}} \]

  The design ultimate resistance of the net cross-section at holes for fasteners is not considered in midas Gen.

- **Compression**

  Design compression resistance

  \[ N_{c,Rd} = \frac{A f_y}{\gamma_{M0}} \] for class 1, 2 or 3 cross-sections

  \[ N_{c,Rd} = \frac{A_{eff} f_y}{\gamma_{M0}} \] for class 4 cross-sections

  In the case of unsymmetrical Class 4 sections, the additional moment due to the eccentricity of the centroidal axis of the effective section is considered in midas Gen.
### Resistance of Cross-Sections

#### Bending moment

**Design bending resistance**

\[
M_{c,Rd} = M_{pl,Rd} = \frac{W_{pl} f_y}{\gamma_{M0}} \quad \text{for class 1 or 2 cross sections}
\]

\[
M_{c,Rd} = M_{el,Rd} = \frac{W_{el,min} f_y}{\gamma_{M0}} \quad \text{for class 3 cross sections}
\]

\[
M_{c,Rd} = \frac{W_{eff,min} f_y}{\gamma_{M0}} \quad \text{for class 4 cross sections}
\]

#### Shear

**Design shear resistance in the absence of torsion**

\[
V_{pl,Rd} = \frac{A_v \left( f_y / \sqrt{3} \right)}{\gamma_{M0}}
\]

The shear area \( A_v \) is calculated based on the clause 6.2.6 (3) as per EN1993-1-1

Rolled I and H sections, load parallel to web: \( A - 2bt_f + (t_w + 2r)t_f \) but not less than \( \eta h_w t_w \)

Design elastic shear resistance is not applied.

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Resistance of Cross-Sections

● Shear Buckling

✓ The shear buckling resistance for webs without intermediate stiffeners is calculated, according to section 5 of EN 1993-1-5, if

$$\frac{h_w}{t_w} > 72 \frac{\varepsilon}{\eta} \quad \varepsilon = \sqrt[3]{\frac{235}{f_y \text{[N/mm}^2\text{]}}}$$

✓ For steel grades up to and including S460. \( \eta = 1.20 \)

✓ For higher steel grades \( \eta = 1.00 \)

✓ Design resistance

$$V_{b,Rd} = V_{bw,Rd} + V_{bf,Rd} \leq \frac{\eta f_{yw} h_w t}{\sqrt{3} \gamma_{M1}}$$

$$V_{bw,Rd} = \frac{X_w f_{yw} h_w t}{\sqrt{3} \gamma_{M1}} \quad V_{bf,Rd} = \frac{b_f t_f^2 f_{xf}}{c \gamma_{M1}} \left(1 - \left(\frac{M_{Ed}}{M_{f,Rd}}\right)^2\right)$$

✓ Stiffener design to resist shear buckling is not provided in midas Gen.

✓ Stiffener type for end supports is assumed as a non-rigid end post.

✓ It is assumed that the length of an unstiffened plate, \( a \) is the same as the unbraced length.
2. Introduction of Steel Design

**Resistance of Cross-Sections**

- **Torsion**
  - ✓ The torsional resistance is not checked.

- **Bending and Shear**
  - ✓ The effect of shear force on the moment resistance is considered.
  - ✓ Where the shear force is less than half the plastic shear resistance, its effect on the moment resistance is neglected.
  - ✓ Where \( V_{ED} \geq 0.5V_{pl,Rd} \)

  \[ M_{y,V,Rd} = \frac{W_{pl,y} - \frac{\rho A_w^2}{4 t_w}}{\gamma_{M0}} f_y \]
  \[ \text{but } M_{y,V,Rd} \leq M_{y,c,Rd} \]
  \[ \rho = \left( \frac{2 V_{Ed}}{V_{pl,Rd}} - 1 \right)^2 \]

  Torsion is not considered when calculating \( \rho \).

For the other cases

\[ M_{V,Rd} = (1 - \rho)M_{c,Rd} \]
2. Introduction of Steel Design

Resistance of Cross-Sections

- Bending and Axial Force

  ✓ The effect of axial force on the moment resistance is considered.
  ✓ Class 1 and 2 cross sections

For doubly symmetrical I- and H-sections, allowance is not made for the effect of the axial force on the plastic resistance moment about the y-y axis when both the following criteria are satisfied:

\[ N_{Ed} \leq 0.25 N_{pl,Rd} \]
\[ N_{Ed} \leq \frac{0.5 h_w t_w f_y}{\gamma_{M0}} \]

For doubly symmetrical I- and H-sections, allowance is not made for the effect of the axial force on the plastic resistance moment about the z-z axis when:

\[ N_{Ed} \leq \frac{h_w t_w f_y}{\gamma_{M0}} \]

The following equations are used for standard rolled I or H sections and for welded I or H sections with equal flanges.

\[ M_{N,y,Rd} = M_{pl,y,Rd} \left( 1-n \right)/(1-0.5a) \quad \text{but} \quad M_{N,y,Rd} \leq M_{pl,y,Rd} \]

for \( n \leq a \):

\[ M_{N,z,Rd} = M_{pl,z,Rd} \left[ 1 - \left( \frac{n - a}{1-a} \right)^2 \right] \]

where \( n = \frac{N_{Ed}}{N_{pl,Rd}} \)

\[ a = \frac{A-2bt_f}{A} \quad \text{but} \quad a \leq 0.5 \]
**Resistance of Cross-Sections**

- **Bending and Axial Force (contd.)**

  For bi-axial bending both the following criteria are used:

  a) \[
  \left( \frac{M_{y,Ed}}{M_{N,y,Rd}} \right)^{\alpha} + \left( \frac{M_{z,Ed}}{M_{N,z,Rd}} \right)^{\beta} \leq 1
  \]
  for Class 1 & 2 sections

  I and H sections:
  \[
  \alpha = 2; \quad \beta = 5n \quad \text{but } \beta \geq 1 \quad n = \frac{N_{Ed}}{N_{pl,Rd}}
  \]

  b) \[
  \frac{N_{Ed}}{N_{Rd}} + \frac{M_{y,Ed}}{M_{y,Rd}} + \frac{M_{z,Ed}}{M_{z,Rd}} \leq 1
  \]
  for Class 1, 2, 3 & 4 sections

- **Bending, Shear and Axial Force**

  ✓ Where the shear force exceeds 50% of the plastic shear resistance, its effect on the moment of resistance is reflected in the formula above.

  ✓ \(M_{pl,y,Rd}\) and \(M_{pl,z,Rd}\) are replaced by \(M_{y,v,Rd}\) and \(M_{z,v,Rd}\) respectively in the following equations to consider shear effect in the above criterion a).

  \[
  \begin{align*}
  M_{N,y,Rd} &= M_{pl,y,Rd} \left( 1 - n \right) / \left( 1 - 0.5a_w \right) \\
  M_{N,z,Rd} &= M_{pl,z,Rd} \left( 1 - n \right) / \left( 1 - 0.5a_f \right)
  \end{align*}
  \]

  ✓ \(M_{y,Rd}\) and \(M_{z,Rd}\) are replaced by \(M_{y,v,Rd}\) and \(M_{z,v,Rd}\) respectively in the above criterion b) to consider shear effect.
• **Uniform members in compression**

  ✓ For slenderness \( \bar{\lambda} \leq 0,2 \) or for \( \frac{N_{Ed}}{N_{cr}} \leq 0,04 \) the buckling effects are ignored.

  \[
  \bar{\lambda} = \sqrt{\frac{A f_y}{N_{cr}}} \quad \text{for Class 1, 2 and 3 cross-sections} \\
  \bar{\lambda} = \sqrt{\frac{A_{eff} f_y}{N_{cr}}} \quad \text{for Class 4 cross-sections}
  \]

  \( N_{cr} \) is the elastic critical force for the relevant buckling mode based on the gross cross sectional properties.

  \[
  N_{cr} = \frac{\pi^2 E I}{L_e^2}
  \]

  ✓ Flexural buckling is checked for the L, C, I, T, Box, Pipe, Double L, and Double C section.

  ✓ Torsional and torsional-flexural buckling is not checked.

  ✓ Design buckling resistance

  \[
  N_{b,Rd} = \frac{\chi A f_y}{\gamma_{M1}} \quad \text{for Class 1, 2 and 3 cross-sections} \\
  N_{b,Rd} = \frac{\chi A_{eff} f_y}{\gamma_{M1}} \quad \text{for Class 4 cross-sections}
  \]

  \[
  \chi = \frac{1}{\phi + \sqrt{\phi^2 - \bar{\lambda}^2}} \quad \text{but} \quad \chi \leq 1,0 \quad \phi = 0,5 \left[ 1 + \alpha (\bar{\lambda} - 0,2) + \bar{\lambda}^2 \right]
  \]

---

**Buckling curve**

<table>
<thead>
<tr>
<th>Imperfection factor ( \alpha )</th>
<th>( a_0 )</th>
<th>( a )</th>
<th>( b )</th>
<th>( c )</th>
<th>( d )</th>
</tr>
</thead>
<tbody>
<tr>
<td>0,13</td>
<td>0,21</td>
<td>0,34</td>
<td>0,49</td>
<td>0,76</td>
<td></td>
</tr>
</tbody>
</table>
2. Introduction of Steel Design

**Buckling Resistance of Members**

● Uniform members in bending
  
  ✓ For the uniform and doubly symmetric I cross-sections only, the lateral torsional buckling check is provided.

  ✓ It is assumed that the section is loaded through its shear center, and the boundary conditions at each end are both restrained against lateral movement and restrained against rotation about the longitudinal axis.

  ✓ For slenderness \( \lambda_{LT} \leq \lambda_{LT,0} \) or for \( \frac{M_{Ed}}{M_{cr}} \leq \lambda_{LT,0}^2 \) the lateral torsional buckling effects are ignored.

\[
\lambda_{LT} = \sqrt{\frac{W_y f_y}{M_{cr}}} \quad \lambda_{LT,0} = 0.4
\]

\( M_{cr} \) is the elastic critical moment for lateral-torsional buckling. The value of \( C_1 \) depends on the moment distribution along the member, which is calculated based on the table in the following page.

\[
M_{cr} = C_1 \frac{\pi^2 EI_z}{L_{cr,LT}^2} \sqrt{\frac{I_w}{I_z} + \frac{L_{cr,LT}^2 GI_i}{\pi^2 EI_z}}
\]

\( G = \frac{E}{2(1 + \nu)} \)

\( I_w = \frac{I_z (h - t_f)^2}{4} \): Warping constant
### Uniform members in bending (Continued)

If the member type is column, $C_1$ is calculated based on the table below. EN 1993-1-1: 1992 Annex F

**Table: Uniform members in bending (Continued)**

<table>
<thead>
<tr>
<th>$\psi$</th>
<th>$k$</th>
<th>$C_1$</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>1.0</td>
<td>1.879</td>
</tr>
<tr>
<td></td>
<td>0.7</td>
<td>2.092</td>
</tr>
<tr>
<td></td>
<td>0.5</td>
<td>2.150</td>
</tr>
<tr>
<td>-1/4</td>
<td>1.0</td>
<td>2.281</td>
</tr>
<tr>
<td></td>
<td>0.7</td>
<td>2.538</td>
</tr>
<tr>
<td></td>
<td>0.5</td>
<td>2.609</td>
</tr>
<tr>
<td>-1/2</td>
<td>1.0</td>
<td>2.704</td>
</tr>
<tr>
<td></td>
<td>0.7</td>
<td>3.009</td>
</tr>
<tr>
<td></td>
<td>0.5</td>
<td>3.093</td>
</tr>
<tr>
<td>-3/4</td>
<td>1.0</td>
<td>2.927</td>
</tr>
<tr>
<td></td>
<td>0.7</td>
<td>3.009</td>
</tr>
<tr>
<td></td>
<td>0.5</td>
<td>3.093</td>
</tr>
<tr>
<td>-1</td>
<td>1.0</td>
<td>2.752</td>
</tr>
<tr>
<td></td>
<td>0.7</td>
<td>3.063</td>
</tr>
<tr>
<td></td>
<td>0.5</td>
<td>3.149</td>
</tr>
</tbody>
</table>
• Uniform members in bending (Continued)

If the member type is beam, C1 is calculated based on the table below.

<table>
<thead>
<tr>
<th>Conditions</th>
<th>Bending moment diagram</th>
<th>k</th>
<th>C1</th>
</tr>
</thead>
<tbody>
<tr>
<td>Case 1</td>
<td></td>
<td>1.0</td>
<td>1.132</td>
</tr>
<tr>
<td></td>
<td></td>
<td>0.5</td>
<td>0.972</td>
</tr>
<tr>
<td>Case 2</td>
<td></td>
<td>1.0</td>
<td>1.285</td>
</tr>
<tr>
<td></td>
<td></td>
<td>0.5</td>
<td>0.712</td>
</tr>
<tr>
<td>Case 3</td>
<td></td>
<td>1.0</td>
<td>Same as Case 1</td>
</tr>
<tr>
<td></td>
<td></td>
<td>0.5</td>
<td></td>
</tr>
<tr>
<td>Case 4</td>
<td></td>
<td>1.0</td>
<td>Same as Case 2</td>
</tr>
<tr>
<td></td>
<td></td>
<td>0.5</td>
<td></td>
</tr>
<tr>
<td>Case 5</td>
<td></td>
<td>1.0</td>
<td>Same as Case 1</td>
</tr>
<tr>
<td></td>
<td></td>
<td>0.5</td>
<td></td>
</tr>
</tbody>
</table>
2. Introduction of Steel Design

Buckling Resistance of Members

- Uniform members in bending (Continued)

Design buckling resistance

\[ M_{b,Rd} = \chi_{LT} \frac{W_y f_y}{\gamma_{M1}} \]

\[ W_y = W_{pl,y} \quad \text{for Class 1 or 2 cross-sections} \]

\[ W_y = W_{el,y} \quad \text{for Class 3 cross-sections} \]

\[ W_y = W_{eff,y} \quad \text{for Class 4 cross-sections} \]

\[ \chi_{LT} = \frac{1}{\Phi_{LT} + \sqrt{\Phi_{LT}^2 - \lambda_{LT}^2}} \] but \( \chi_{LT} \leq 1,0 \)

\[ \Phi_{LT} = 0,5 \left[ 1 + \alpha_{LT} \left( \lambda_{LT} - 0,2 \right) + \lambda_{LT}^2 \right] \]

<table>
<thead>
<tr>
<th>Buckling curve</th>
<th>a</th>
<th>b</th>
<th>c</th>
<th>d</th>
</tr>
</thead>
<tbody>
<tr>
<td>Imperfection factor ( \alpha_{LT} )</td>
<td>0,21</td>
<td>0,34</td>
<td>0,49</td>
<td>0,76</td>
</tr>
</tbody>
</table>

The method in the Clause 6.3.2.3 and 6.3.2.4 of EC3 are not considered.
Uniform members in bending and axial compression

For members which are subjected to combined bending and axial compression, the resistance to lateral and lateral-torsional buckling is verified by the following criteria.

\[
\frac{N_{Ed}}{\chi_y N_{Rk}} + k_{yy} \frac{M_{y,Ed} + \Delta M_{y,Ed}}{\chi_{LT} M_{y,Rk}} + k_{yz} \frac{M_{z,Ed} + \Delta M_{z,Ed}}{\chi_{LT} M_{z,Rk}} \leq 1
\]

\[
\frac{N_{Ed}}{\chi_z N_{Rk}} + k_{zy} \frac{M_{y,Ed} + \Delta M_{y,Ed}}{\chi_{LT} M_{y,Rk}} + k_{zz} \frac{M_{z,Ed} + \Delta M_{z,Ed}}{\chi_{LT} M_{z,Rk}} \leq 1
\]

\(k_{yy}, k_{yz}, k_{zy}, k_{zz}\) are the interaction factors. These values are obtained from Annex A in EN 1993-1-1: 2005.

\(C_{my}, C_{mz}\) and \(C_{mLT}\) in Annex A can be either user-defined or auto-calculated.

### Table 6.7: Values for \(N_{Rk} = f_y A_i, M_{i,Rk} = f_y W_i\) and \(\Delta M_{i,Ed}\)

<table>
<thead>
<tr>
<th>Class</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
</tr>
</thead>
<tbody>
<tr>
<td>(A_i)</td>
<td>(A)</td>
<td>(A)</td>
<td>(A)</td>
<td>(A_{eff})</td>
</tr>
<tr>
<td>(W_y)</td>
<td>(W_{pl,y})</td>
<td>(W_{pl,y})</td>
<td>(W_{el,y})</td>
<td>(W_{eff,y})</td>
</tr>
<tr>
<td>(W_z)</td>
<td>(W_{pl,z})</td>
<td>(W_{pl,z})</td>
<td>(W_{el,z})</td>
<td>(W_{eff,z})</td>
</tr>
<tr>
<td>(\Delta M_{y,Ed})</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>(e_{N,y} N_{Ed})</td>
</tr>
<tr>
<td>(\Delta M_{z,Ed})</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>(e_{N,z} N_{Ed})</td>
</tr>
</tbody>
</table>

When the design axial force, \(N_{Ed}\) is larger than \(N_{cr,z}\) or \(N_{cr,TF}\), the criteria above are not applied.

General method of the clause 6.3.4 is not considered.
ii. Serviceability Limit State Check
**Vertical deflections**

- Vertical deflection can be checked for beam members.
- Remaining total deflection \( w_{\text{max}} \) caused by the **permanent and variable actions** is automatically checked based on the serviceability load combinations.
- The default limit value is set to L/250.
- The deflection due to the **variable actions** can be checked manually by adding load combination consisting of variable actions and changing the limit value.

![Image of vertical deflections](image.png)

*Figure A1.1 - Definitions of vertical deflections*
**Horizontal deflections**

- Horizontal deflection can be checked for column members.
- Horizontal displacement over a story height $H_i$ is automatically checked based on the serviceability load combinations.
- The default limit value is set to $H_i/300$.
- Overall horizontal displacement over the building height $H$ should be checked separately.

**Dynamic effects**

- The vibration of structures is not checked.
Design of Multi-Story Steel Building
Design Methods

midas Gen provides the following two methods:

1. The program finds optimal sections for gravity loads (Design > Steel Optimal Design) and also finds optimal sections for lateral loads (Design> Displacement Optimal Design). With the combined use of the two, the user should find optimal sections.

2. The program checks strength and serviceability based on the sections defined by the user and the design code selected by the user (Design > Steel Code Check). Also, the program searches and proposes sections which satisfy the design conditions entered by the user. Then the user can update the sections referring to the sections proposed by the program.

In this tutorial, method 2 is presented.
3. Design for Steel Structure Building

**Details of the example building**

Figure 1. Elevation (unit: mm)

Figure 2. Structural Plan (2~Roof) (unit: mm)
Applied Codes

- Steel Design Code: Eurocode 3 (2005)

Structural System

- Bracing System

Unit Load Cases

<table>
<thead>
<tr>
<th>Load</th>
<th>Name</th>
<th>Details</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Self Weight</td>
<td>Self Weight</td>
</tr>
<tr>
<td>2</td>
<td>SID</td>
<td>Superimposed Dead Load</td>
</tr>
<tr>
<td>3</td>
<td>Live Load</td>
<td>Live Load</td>
</tr>
<tr>
<td>4</td>
<td>Wind X-dir</td>
<td>Wind Load (in the global X-direction)</td>
</tr>
<tr>
<td>5</td>
<td>Wind Y-dir</td>
<td>Wind Load (in the global Y-direction)</td>
</tr>
<tr>
<td>6</td>
<td>RX</td>
<td>Seismic Load (in the global X-direction)</td>
</tr>
<tr>
<td>7</td>
<td>RY</td>
<td>Seismic Load (in the global Y-direction)</td>
</tr>
</tbody>
</table>
### Applied Sections

These are the sections assumed before design updates.

- **Beam**

<table>
<thead>
<tr>
<th>Section ID</th>
<th>DB</th>
<th>Section Size</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>UNI</td>
<td>IPE 500</td>
</tr>
<tr>
<td>2</td>
<td>UNI</td>
<td>IPE 600</td>
</tr>
<tr>
<td>3</td>
<td>UNI</td>
<td>IPE 450</td>
</tr>
</tbody>
</table>

- **Column**

<table>
<thead>
<tr>
<th>Section ID</th>
<th>DB</th>
<th>Section Size</th>
</tr>
</thead>
<tbody>
<tr>
<td>4</td>
<td>UNI</td>
<td>HEB 240</td>
</tr>
<tr>
<td>5</td>
<td>UNI</td>
<td>HEB 300</td>
</tr>
</tbody>
</table>

- **Brace**

<table>
<thead>
<tr>
<th>Section ID</th>
<th>DB</th>
<th>Section Size</th>
</tr>
</thead>
<tbody>
<tr>
<td>6</td>
<td>UNI</td>
<td>HEA 260</td>
</tr>
</tbody>
</table>
Demonstration
As shown in the *Optimal Design Result (Average Ratio)* graph, the average ratio of column members is about 0.4 since all the sections within ±5% of the entered dimensions are examined for strength verification. Therefore, we will *reduce the section dimension* and re-perform *Steel Optimal Design*.

By performing *Steel Optimal Design*, we can check that the total weight of each section is significantly reduced.

All the sections within ±5% of the entered dimensions are examined for strength verification. If the entry is "0", all dimensions are searched.
Thank you