Steel Beam Design

• Design Method
• hot rolled production
• cold formed steel

Design of Steel Beam – Procedure (zone 1)

1. Use the maximum moment equation, and solve for the ultimate moment, $M_u$.
2. Set $\phi M_n = M_u$ and solve for $M_n$
3. Assume Zone 1 to determine $Z_x$ required
4. Select the lightest beam with a $Z_x$ greater than the $Z_x$ required from AISC table
5. Determine if $h/t_w < 59$ (case 1, most common)
6. Determine $A_w$: $A_w = d \cdot t_w$
7. Calculate $V_n$: $V_n = 0.6 \cdot F_y \cdot A_w$
8. Calculate $V_u$ for the given loading $V_u = w_u \cdot L / 2$ (e.g. unif. load)
9. Check $V_u < \phi V_n$ $\phi$ for $V = 1.0$
10. Check deflection

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**Notes and Equations**

- $M_u = \frac{w_u \cdot L^2}{8}$
- $V_u = \frac{247,500 \cdot 30}{0.90} = 247.5$ kip
Design of Steel Beam

Example - Bending

1. Use the maximum moment equation, and solve for the ultimate moment, $M_u$.

2. Set $\phi M_n = M_u$ and solve for $M_n$

   \[ M_n = \frac{M_u}{\phi} \]

   **Assuming Zone 1**

3. Determine $Z_x$ required (assume zone 1)

   \[ M_n = F_y \cdot Z_x \]

4. Select the lightest beam with a $Z_x$ greater than the $Z_x$ required from AISC table
Design of Steel Beam
Example - Shear

5. Determine if \( h/t_w < 59 \)
   (case 1, most common)

6. Determine \( A_w \):
   \( A_w = d \times t_w \)

7. Calculate \( V_n \):
   \( V_n = 0.6 \times F_y \times A_w \)

8. Calculate \( V_u \) for the given loading
   \( V_u = \frac{w \cdot L}{2} \)  
   (unif. load)

9. Check \( V_u < \phi_v \cdot V_n \)
   \( \phi_v = 1.0 \)

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Table 1-1 (continued)

| Shape | Area | Depth | Web | Flange | Distance | Compact
<table>
<thead>
<tr>
<th></th>
<th></th>
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<th></th>
<th></th>
<th></th>
<th></th>
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</thead>
<tbody>
<tr>
<td></td>
<td>( A )</td>
<td>( d )</td>
<td>( t_w )</td>
<td>( t_f )</td>
<td>( t_s )</td>
<td></td>
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<tr>
<td>Case 1</td>
<td>13.5</td>
<td>18.1</td>
<td>18</td>
<td>0.390</td>
<td>1/4</td>
<td>V4</td>
</tr>
<tr>
<td>Case 2</td>
<td>11.8</td>
<td>17.0</td>
<td>11.8</td>
<td>0.334</td>
<td>1/4</td>
<td>V4</td>
</tr>
<tr>
<td>Case 3</td>
<td>10.3</td>
<td>17.0</td>
<td>10.3</td>
<td>0.425</td>
<td>1/4</td>
<td>V4</td>
</tr>
<tr>
<td>Case 4</td>
<td>9.85</td>
<td>17.0</td>
<td>9.85</td>
<td>0.985</td>
<td>1/4</td>
<td>V4</td>
</tr>
<tr>
<td>Case 5</td>
<td>7.7</td>
<td>17.0</td>
<td>7.7</td>
<td>0.875</td>
<td>1/4</td>
<td>V4</td>
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<tr>
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<td>17.0</td>
<td>6.7</td>
<td>0.760</td>
<td>1/4</td>
<td>V4</td>
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<tr>
<td>Case 7</td>
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<td>17.0</td>
<td>6.05</td>
<td>0.665</td>
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<td>V4</td>
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</tbody>
</table>

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Design of Steel Beam
Example - Shear

5. Determine if \( h/t_w < 59 \)
   (case 1, most common)

6. Determine \( A_w \):
   \( A_w = d \times t_w \)

7. Calculate \( V_n \):
   \( V_n = 0.6 \times F_y \times A_w \)

8. Calculate \( V_u \) for the given loading
   \( V_u = \frac{w \cdot L}{2} \)  
   (unif. load)

9. Check \( V_u < \phi_v \cdot V_n \)
   \( \phi_v = 1.0 \)
Steel Beam Deflection

Deflection limits by application

IBC Table 1604.3

For steel structural members, the DL can be taken as zero (note g)

DL deflection can be compensated for by beam camber

<table>
<thead>
<tr>
<th>CONSTRUCTION</th>
<th>L</th>
<th>S or W</th>
<th>D + L</th>
</tr>
</thead>
<tbody>
<tr>
<td>Roof members:</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Supporting plaster ceiling</td>
<td>l/360</td>
<td>l/360</td>
<td>l/240</td>
</tr>
<tr>
<td>Supporting nonplaster ceiling</td>
<td>l/240</td>
<td>l/240</td>
<td>l/180</td>
</tr>
<tr>
<td>Not supporting ceiling</td>
<td>l/180</td>
<td>l/180</td>
<td>l/120</td>
</tr>
<tr>
<td>Floor members</td>
<td>l/360</td>
<td>—</td>
<td>l/240</td>
</tr>
<tr>
<td>Exterior walls and interior</td>
<td>—</td>
<td>l/240</td>
<td>—</td>
</tr>
<tr>
<td>partitions:</td>
<td>—</td>
<td>l/120</td>
<td>—</td>
</tr>
<tr>
<td>With brittle finishes</td>
<td>—</td>
<td>—</td>
<td>—</td>
</tr>
<tr>
<td>With flexible finishes</td>
<td>—</td>
<td>—</td>
<td>—</td>
</tr>
<tr>
<td>Farm buildings</td>
<td>—</td>
<td>—</td>
<td>l/180</td>
</tr>
<tr>
<td>Greenhouses</td>
<td>—</td>
<td>—</td>
<td>l/120</td>
</tr>
</tbody>
</table>

University of Michigan, TCAUP

Structures II

Beam without Camber

Developed by Scott Civjan
University of Massachusetts, Amherst
For AISC
Results in deflection in floor under Dead Load.
This can affect thickness of slab and fit of non-structural components.

Beam with Camber
Results in deflection in floor under Dead Load. This can affect thickness of slab and fit of non-structural components.

Cambered beam counteracts service dead load deflection.

Hot Rolled Shapes
Cold Form Sections

From:
Building Design Using Cold Formed Steel Sections: Structural Design to BS 5950-5:1998. Section Properties and Load Tables. p. 276

Figure 2.3  Examples of cold formed steel sections
Cold Form Sections

[Images of cold-formed steel sections]

[Image of a construction site with a worker and steel framing]

[Diagram showing structural elements: Studs, Roof Purlins, Sidewall Girts, Weld]