Shapes of Trusses

- Pratt
- Parker
- K-Truss
- Howe
- Camelback
- Warren
- Fink
- Double Intersection Pratt
- Warren (with Verticals)
- Bowstring
- Baltimore
- Double Intersection Warren
- Waddell “A” Truss
- Pennsylvania
- Lattice

- Scissors
- Polynesian
- Clerestory
- Vaulted Parallel Chord
- Cantilevered Mansard with Parapets
- Gambrel
- Hip
- Vault
- Room-in-Attic
- Dual Pitch
- Flat Vault
- Bowstring
- Mono
- Studio Vault
- Double Cantilever
- Half Scissors
- Tray or Coffer
- Half Hip
- Barrel Vault
- Double Cantilever
- Sloping Flat
- Multi-Piece
- Double Inverted
Types of Structural Steel Sections
Steel structure mainly consist of:

1. Roof Panel.
2. Roof Purlin.
4. Gutter.
5. Frame or Truss.

Types of Actions:

1. Permanent actions (Own weight)
   a. Structural elements.
   b. Roof panel (6 kg/m$^2$) roof thickness = 0.6 mm
   c. Purlin.
   d. Bracing.
2. Variable actions
   a. Imposed Load.
   b. Wind Load.
Design of 2D Truss Steel Structures Based on EuroCode

Truss

Frame

No Max Span For Truss

Max Span For Frames = 30m
Design Example
Members

<table>
<thead>
<tr>
<th>Member Group</th>
<th>Section</th>
<th>Weight (kg/m)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Top Cord</td>
<td>UNA 150X90X15</td>
<td>33.9</td>
</tr>
<tr>
<td>Bottom Cord</td>
<td>UNA 150X75X15</td>
<td>24.8</td>
</tr>
<tr>
<td>Diagonal members</td>
<td>UNA 100X75X12</td>
<td>15.4</td>
</tr>
<tr>
<td>Vertical</td>
<td>UNA 125X75X12</td>
<td>17.8</td>
</tr>
<tr>
<td>Purlin</td>
<td>UKPFC 100X50X10</td>
<td>10.20</td>
</tr>
<tr>
<td>Bracing members</td>
<td>CHS 33.7X2.6</td>
<td>1.99</td>
</tr>
<tr>
<td>Column</td>
<td>UC 152x152x23</td>
<td>23</td>
</tr>
</tbody>
</table>

Loads

- **Permanent actions**
  
  Roof panel weight = 6 kg/m² (roof thickness = 0.6 mm).
  
  Span length=5 m
  
  Metal deck =Area × wt. = (5.00 × 1.00) × 6 = 30 kg
  
  Purlins = length × wt. = (5.00 × 10.20) = 51 kg
  
  Bracing length = 2 ∗ √((2.5² + 0.5²)) = 5.10 m
  
  Bracing = length × wt. = (5.10 × 1.99) = 10.15 kg
  
  Dead load = 30 + 51 + 10.15 = 91.15 kg
  
  Loads at interior joints = D = 91.15 kg = 0.894 KN
  
  Loads at exterior joints = D/2 = 0.894/2 = 0.447 KN

- **Variable actions**
  
  **Imposed Load**
  
  According to EN 1991-1-1

---

Table 6.9 - Categorization of roofs

<table>
<thead>
<tr>
<th>Categories of loaded area</th>
<th>Specific Use</th>
</tr>
</thead>
<tbody>
<tr>
<td>H</td>
<td>Roofs not accessible except for normal maintenance and repair.</td>
</tr>
<tr>
<td>I</td>
<td>Roofs accessible with occupancy according to categories A to D</td>
</tr>
<tr>
<td>K</td>
<td>Roofs accessible for special services, such as helicopter landing areas</td>
</tr>
</tbody>
</table>
Choose category H for not accessible expect for maintenance and repair

Using the recommended value  \( q_k = 0.4 \text{ kN/m}^2 \)

Imposed load =  \( Area \times q_k = (5 \times 1) \times 0.4 = 2 \text{ kN} \)

Loads at interior joints =  \( L = 2 \text{ kN} \)

Loads at exterior joints =  \( L / 2 = 2 / 2 = 1 \text{ kN} \)

### Wind Load

The quantification of the wind actions on the building follows EN 1991-1-4

We will use wind pressure  \( q_w = 0.7 \text{ KN/m}^2 \)

\[
W_{\text{col}} = q_w \times \text{Span length} = 0.7 \times 5 = 3.5 \text{ KN/m} \\
W_{\text{interior joints}} = q_w \times \text{Area} = 0.7 \times 5 \times 1 = 3.5 \text{ KN} \\
W_{\text{exterior joints}} = 3.5 / 2 = 1.75 \text{ KN} \\
\alpha = \text{Roof slope} = \tan^{-1} \left( \frac{1.2}{22/2} \right) = 6.22^\circ
\]
Structural Analysis using Robot 2018
Choose the shape
Design of 2D Truss Steel Structures Based on EuroCode

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Eng. Haya Baker
Load combinations

- Case 1: Permanent $1.35G_k$
- Case 2: Permanent and imposed $1.35G_k + 1.5Q_k$
- Case 3: Permanent and wind right $1.35G_k + 1.5Q_k$
- Case 4: Permanent and wind left $1.35G_k + 1.5Q_k$
- Case 5: Permanent and wind right and imposed $1.35G_k + 1.5Q_{k1} + 0.75Q_{k2}$
- Case 6: Permanent and wind left and imposed $1.35G_k + 1.5Q_{k1} + 0.75Q_{k2}$

Other cases many not be critical
Design of 2D Truss Steel Structures Based on EuroCode

- **Case 1: Permanent**
  
  \[ 1.35G_k \]

- **Case 2: Permanent and imposed**
  
  \[ 1.35G_k + 1.5Q_k \]

- **Case 3: Permanent and wind right**
  
  \[ 1.35G_k + 1.5Q_k \]
• Case 4: Permanent and wind left  
  \[ 1.35G_k + 1.5Q_k \]

• Case 5: Permanent and wind right and imposed  
  \[ 1.35G_k + 1.5Q_{k1} + 0.75Q_{k2} \]

• Case 6: Permanent and wind left and imposed  
  \[ 1.35G_k + 1.5Q_{k1} + 0.75Q_{k2} \]
Select all members of each group separately and enter detailed analysis

Top Cord

1. Choose Fx (Axial Force)
2. Click Apply
3. Do the same for all the groups
The table below summarize the result of the most critical design load for each group

<table>
<thead>
<tr>
<th>Member Group</th>
<th>Section</th>
<th>Length (m)</th>
<th>Design factored load (KN)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Top Cord</td>
<td>UNA 150X90X15</td>
<td>1.01</td>
<td>Comp (+) 171.56, Tension (-) -122.43</td>
</tr>
<tr>
<td>Bottom Cord</td>
<td>UNA 150X75X15</td>
<td>1.00</td>
<td>Comp (+) 159.33, Tension (-) -169.27</td>
</tr>
<tr>
<td>Diagonal members</td>
<td>UNA 100X75X12</td>
<td>2.42</td>
<td>Comp (+) 79.65, Tension (-) -118.05</td>
</tr>
<tr>
<td>Vertical</td>
<td>UNA 125X75X12</td>
<td>2.20</td>
<td>Comp (+) 5.06, Tension (-) -3.72</td>
</tr>
<tr>
<td>Column</td>
<td>UC 152x152x23</td>
<td>7.00</td>
<td>Comp (+) 64.49, Tension (-) -39.74</td>
</tr>
</tbody>
</table>
Design example

We will design based on the maximum load for tension and compression then we will check the member in the other.

The gravity cases make tension load on some members and compression load on others, in opposite with the wind cases.

Bottom cord using section UNA 150X75X15 using S275, \( A = 31.7 \, \text{cm}^2 \)

\[ f_y = 275 \, \text{N/mm}^2 , f_u = 410 \, \text{N/mm}^2 , N_{\text{Ed}} = 169.27 \, \text{KN tension} \]

Check of tension member

Assume welded connection from the long leg, then after design connection recheck on fracture strength.

\[
N_{pL,Rd} = \frac{A f_y}{Y_m} = \frac{31.7 \times 10^2 \times 275}{1.0} \times 10^{-3} = 871.75 \, \text{KN} > 169.27 \, \text{KN}
\]

So, the member is satisfactory.

Check of compression member

\[ N_{\text{Ed}} = 159.33 \, \text{KN} , f_y = 275 \, \text{N/mm}^2 , A = 31.7 \, \text{cm}^2 \]

- Classification of the section

\[
h/t \leq 15\varepsilon \rightarrow 150/15 = 10 < 15 \times 0.92 = 13.8 \rightarrow \text{Class 3}
\]

\[
b + h \leq 11.5\varepsilon \rightarrow \frac{150 + 75}{2 \times 15} = 7.5 < 11.5 \times 0.92 = 10.58 \rightarrow \text{Class 3}
\]

\[
N_{c,Rd} = \frac{A f_y}{Y_m} = \frac{31.7 \times 10^{-4} \times 275 \times 10^3}{1.0} = 871.75 \, \text{KN} > 159.33 \, \text{KN}
\]

- Buckling lengths – assume all connections are pinned connection and support conditions the same in both planes, the buckling lengths are equal in both planes, given by:

Buckling in the plane of the structure - \( L_e = 1.0 \times 1.0 = 1 \, \text{m} \)

- Determination of the slenderness coefficients

\[
\lambda_1 = \pi \sqrt{\frac{210 \times 10^6}{275 \times 10^3}} = 86.8
\]

\[
\lambda_{\text{max}} = \frac{L_e}{l_{\text{min}}} = \frac{1 \times 10^2}{1.58} = 63.29 , \bar{\lambda}_{\text{max}} = \frac{\lambda_{\text{max}}}{\lambda_1} = \frac{63.29}{86.8} = 0.729 < 1
\]

- Calculation of the reduction factor \( x \)

\[
\alpha = 0.34
\]

\[
\varnothing = 0.5[1 + 0.34 \times (0.729 - 0.2) + 0.729^2] = 0.855
\]
\[ x = \frac{1}{0.855 + \sqrt{0.855^2 - 0.729^2}} = 0.768 \]

- Safety verification

\[ N_{b,Rd} = \frac{x A f_y}{Y M_1} = \frac{0.768 \times 31.7 \times 10^{-4} \times 275 \times 10^3}{1.0} = 669.504 \text{ KN} \]

As \( N_{Ed} = 159.33 \text{ kN} < N_{b,Rd} = 669.504 \text{ kN} \)

So, the member is satisfactory and we should select lighter section.

**Design of Connection**