Lecture Notes #7
Design of Truss Structures I

Professor Guowei Ma
Office: 160
Tel: 61-8-6488-3102
Email: ma@civil.uwa.edu.au
Trusses

• Fabricated from various steel sections available, jointed together by welding or by bolting usually via gusset plates.
• Plane trusses and space trusses.
• Bridge trusses and roof trusses.
• Members supporting heavy loads
• Members having longer span.
• Saving in weight.
Type of Trusses

- Roof truss
  - Hipped
  - Lattice
  - Mansard

- Supporting truss
  - N-truss
  - Vierendeel

- Bracing truss
  - Multi-storey building
  - Single-storey building
Truss System

Space truss

Singapore Esplanade theatre
Skidding Truss Information

Expected Load: 14kton (Loading out platform) & 3kton (Skidding truss)
Structure Type: Mega truss with steel tubular and girder members
Dimension: 36m (Width) x 76m (Length)
Function: Support the mega structure loaded on top & launch to the dock
Truss Analysis

- Pin-joint truss analysis
  - method of joint, method of section, numerical simulation
  - several analyses may be needed for different load combinations
- Analysis of load bearing members such as rafters
- Assessment of stresses due to eccentricity of the connections
- Assessment of the effects of joint rigidity and deflections
Roof Truss

- Roof rafters spanning more than 20 m can be designed
- Usual span-to-depth ratio of steep roof trusses is 7.5 to 12
- Panel width should be constant
- Even number of panels avoids cross-braces
- Diagonal web members should be in tension under worst-case loading
- Inclination angle of the diagonals should be between 35° and 50°
- If at all possible, the purlins and verticals should closely coincide
Roof Truss

Usual range of depths of roof trusses
# Approximate mass for roof trusses

<table>
<thead>
<tr>
<th>Diagram</th>
<th>Span, m</th>
<th>Mass, kg</th>
<th>kN</th>
</tr>
</thead>
<tbody>
<tr>
<td><img src="image" alt="Diagram" /></td>
<td>5 – 7</td>
<td>160 – 210</td>
<td>1.6 – 2.1</td>
</tr>
<tr>
<td><img src="image" alt="Diagram" /></td>
<td>8 – 11</td>
<td>210 – 270</td>
<td>2.1 – 2.7</td>
</tr>
<tr>
<td><img src="image" alt="Diagram" /></td>
<td>12 – 14</td>
<td>270 – 400</td>
<td>2.7 – 4.0</td>
</tr>
<tr>
<td><img src="image" alt="Diagram" /></td>
<td>15 – 16</td>
<td>400 – 620</td>
<td>4.0 – 6.2</td>
</tr>
<tr>
<td><img src="image" alt="Diagram" /></td>
<td>17 – 20</td>
<td>620 – 950</td>
<td>6.2 – 9.5</td>
</tr>
<tr>
<td><img src="image" alt="Diagram" /></td>
<td>22 – 30</td>
<td>950 – 1100</td>
<td>9.5 – 11.0</td>
</tr>
</tbody>
</table>
Approximate mass for roof trusses

<table>
<thead>
<tr>
<th>Span (m)</th>
<th>Self-weight (kN/m²), over span × truss spacing</th>
</tr>
</thead>
<tbody>
<tr>
<td>10</td>
<td>0.11</td>
</tr>
<tr>
<td>20</td>
<td>0.12</td>
</tr>
<tr>
<td>30</td>
<td>0.16</td>
</tr>
<tr>
<td>40</td>
<td>0.22</td>
</tr>
</tbody>
</table>
Out-of-Plane Load

- Wind loads acting on the upper half of the end walls
- Frictional drag effects on the roof, and
- Accumulated "lateral" bracing system restraint forces

Notes:
1. Unless special studies are made, lateral forces from rafters should be accumulated at the braced bay.
2. $N_r'$ = compression force in top truss chord, which for illustrative purposes, is assumed to be the same for all roof trusses in the figure.
Design of Tension Members

Cl. 7.1, Design for axial tension

\[ N^* \leq \phi N_t \]

\( \phi = \) the capacity factor, see Table 3.4, \( \phi = 0.9 \)

\( N_t = \) the nominal section capacity in tension

\[ N_t = A_g f_y \quad \text{and} \quad N_t = 0.85 k_t A_n f_u \]

\( A_g = \) the gross area of the cross-section

\( f_y = \) the yield stress used in design

\( k_t = \) the correction factor for distribution of forces

\( A_n = \) the net area of the cross-section

\( f_u = \) the tensile strength used in design
Design of Compression Members

Cl. 6.1, Design for axial compression

\[ N^* \leq \phi N_s \quad \text{and} \quad N^* \leq \phi N_c \]

\[ \phi = \text{the capacity factor, } = 0.9 \]

\( N_s = \text{the nominal section capacity determined in accordance} \)

\[ \text{with Clause 6.2} \]

\( N_c = \text{the nominal member capacity determined in accordance} \)

\[ \text{with Clause 6.3.} \]
Truss Node Connections

- **Direct connections**
  - *Members are welded directly to one another, without the need for gussets or other elements (e.g. tubular joints).*
  - *When the chords are made from large angles or tee-sections, it is possible to connect angle web members directly to the chords.*

- **Gusseted connections**
  - *Predominant when rivets and bolts are used for connections.*
  - *Transfer of forces is indirect and not aesthetically pleasing.*
  - *Advantage: easier to make all members intersect at the theoretical node point—in contrast to direct connections, where some eccentricity is unavoidable.*

- **Pin connections**
  - *Generally used when aesthetics are important*
(a) centre of gravity lines intersect at the node;
(b) eccentric connection can be a practical way of detailing but additional bending stresses are induced
(a) to (f): commonly used in welded construction (though (a), (c), (d) and (e) may be bolted)
(g) to (k): common sections used for chord and web/diagonal members
(a) Gussetless construction using Tee-chords; (b) gussets are required where diagonals carry large forces; (c) Tee-diagonals and chords, gussetless; (d) and (e) node detail for heavy trusswork, and (f) riveted/bolted nodes
Connections of Rolled-Steel Sections

(a) portal-type Pratt truss
(b) Fink truss with large eaves overhang
(c) alternative chord cross-sections
Closed Sections

Splices for Tubular Truss Members

(a) sandwich plate splice; (b) sandwich plate splice at chord reduction; (c) jacket splice; (d) welded butt splice; (e) welded butt splice with reducer, and; (f) flange splice.
Connections for Tubular Sections

(a) Direct contact overlap connection without eccentricity; (b) direct contact overlap connection with eccentricity; (c) direct contact gap connection with/without eccentricity (with chord face reinforcing plate shown—without reinforcing plate is very common); (d) T-joint with chord face reinforcing plate (for very heavy loads—otherwise no reinforcing plate is also popular); (e) connection detail at support (note vertical stub portion with flange splice for lifting onto support); (f) concentric reducer where chord section is stepped down (alternatively, if the overall section is not stepped down then the wall thickness is reduced—the latter applies for RHS/SHS); (g) slotted-gusset connections; (h) flattened end connections, and; (i) slit tube connections.