Revision and Errata List
May 1, 2003 (Second Printing)
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AISC Design Guide 14: Staggered Truss Framing Systems

The editorial corrections dated May 1, 2003 have been made in the Second Printing, December 2002. Those editorial corrections dated December 1, 2002 apply to the First Printing, December 2001. To facilitate the incorporation of these corrections, this booklet has been constructed using copies of the revised pages, with corrections noted. The user may find it convenient in some cases to hand-write a correction; in others, a cut-and-paste approach may be more efficient.
### 2.4 Diaphragm Chords

The perimeter steel chords are used as diaphragm chords. The chord forces are calculated approximately as follows:

\[ H = \frac{M}{D} \]  

(2-7)

where

- \( H \) = chord tension or compression force
- \( M \) = moment applied to the diaphragm
- \( D \) = depth of the diaphragm

The plank to spandrel beam connection must be adequate to transfer this force from the location of zero moment to the location of maximum moment. Thus observing the moment diagrams in Fig. 2.4, the following chord forces and shear flows needed for the plank-to-spandrel connection design are calculated:

With +5% additional eccentricity:

\[ H = \frac{5,223}{64 \times 0.75} = 61 \text{ k} \]
\[ f_H = 61 / 72 = 0.85 \text{ k/ft} \]
\[ H = \frac{5,223}{64 \times 0.75} = 61 \text{ k} \]
\[ f_H = 61 / 17 = 3.59 \text{ k/ft} \]
\[ H = 12,024 / 64 \times 0.75 = 141 \text{ k} \]
\[ f_H = 141 / 103 = 1.37 \text{ k/ft} \]
\[ f_H = 141 / 72 = 1.96 \text{ k/ft} \]

where constant 0.75 is applied for wind or seismic loads. The calculated shear flows, \( V_{\text{TORS}} \), are shown in Fig. 2.4(a). For -5% additional eccentricity, similar calculations are conducted and the results are shown in Fig. 2.4(b). The shear flows of the two cases are combined in Fig. 2.4(c).
where a value with * indicates the larger shear flow that governs. These shear forces and shear flows due to service loads on the bottom floor are then multiplied by the height adjustment factors for story shear to obtain the final design of the diaphragms up to the height of the building as shown in the table in Fig. 2.5. The table is drawn on the structural drawings and is included as part of the construction contract documents. Forces given on structural drawings are generally computed from service loads. In case factored forces are to be given on structural drawings, they must be clearly specified.

The perimeter steel beams must be designed to support the gravity loads in addition to the chord axial forces, \( H \).

The connections of the beams to the columns must develop these forces \( (H) \). The plank connections to the spandrel beams must be adequate to transfer the shear flow. \( H_v \). The plank connections to the spandrel are usually made by shear plates embedded in the plank and welded to the beams (Fig. 1.2 and Fig. 2.6). Where required, the strength of plank embedded connections is proven by tests, usually available from the plank manufacturers. All forces must be shown on the design drawings. The final design of the diaphragm is shown in Fig. 2.5.
3.6 Vertical and Diagonal Members

The detailed calculations for the design of diagonal member \( d_1 \) in truss T1F of each floor using load coefficients are shown in Table 3.1, where load coefficients \( \phi_{d1} \) and \( \phi_{d2} \) are applied to different load combinations. Truss T1F rather than typical truss T1B is intentionally selected as an example here for explanation of how the load coefficients are applied. Five load combinations as specified in ASCE 7 are considered in this table. A 50% live load reduction is used in the design of the diagonal members. Numbers in boldface in the table indicate the load case that governs. The governing tensile axial forces of the diagonal members range from 412 k to 523 k for different floors. HSS 10x6x \( \frac{1}{2} \) is selected per AISC requirements for all the diagonal members.

3.7 Truss Chords

The designer must investigate carefully all load cases so as to determine which load case governs. For this design example for truss chords, it is found that the load combination of \( 1.2D + 1.6W + 0.5L \) governs. The steel design must comply with AISC Equation H1-1a.

\[
P_a/(\phi P_a) + (8/9) \times [M_{ax}/(\phi_h M_{nx})] \times 1.0
\]

where
\[
\phi = 0.90 \quad \text{Tension}
\]
\[
\phi = 0.85 \quad \text{Compression}
\]
\[
\phi_h = 0.90 \quad \text{Bending}
\]

Calculations for gravity and wind loads are made separately and then combined.

a. Gravity

It is assumed that the chords are loaded with a uniformly distributed load. Using a 50% live load reduction, the following are calculated for the chords of truss T1F on the second story:

\[
\phi_w = 1.0 \quad \text{for truss T1F}
\]
\[
M = 4.93 \times 9.5^2 / 10 = 44 \text{ ft-k (member end moments at joints)}
\]
\[
P = 525 \text{ k (from Fig. 3.3)}
\]
\[
M_u = \phi_L M = \left(\frac{\phi\text{, sum of all lateral loads}}{97 + 40}\right) \times 44 = 41 \text{ ft-k}
\]
\[
P_u = \phi_L P = \left(\frac{\phi\text{, sum of all lateral loads}}{97 + 40}\right) \times 525 = 484 \text{ k}
\]

b. Wind

The maximum wind moment in the chords occurs in the Vierendeel panel.

\[
M = 86.87 \text{ ft-k (from Section 3.4 for typical truss T1B)}
\]
\[
\phi_{occ} = 1.89 \times 86.87 = 164 \text{ ft-k}
\]
\[
M_u = 164 \times 1.3 = 213 \text{ ft-k}
\]

The axial force applied to the chord due to the wind load can be neglected as will be explained in Section 3.8. The above moment is also applied to the adjacent span, which has a span length of 9.5 ft same as the span length used for the gravity load moment calculation. The member forces of the chords on the second story due to gravity and wind loads are then combined as follows:

\[
P_u = 484 \text{ k}
\]
\[
M_u = 41 + 213 = 254 \text{ ft-k}
\]

It is observed that while wind loads vary with building heights, gravity loads do not. Thus, Table 3.2 is created and the chord moments are calculated using coefficient \( f \) of each story as shown. The designed wide-flange sections per AISC Equation H1-1a are also shown in the table. To facilitate the design calculations, the axial force and bending moment strengths of possible W10 members are calculated first and listed in Table 3.3.

3.8 Computer Modeling

When designing staggered truss buildings using computer models (stiffness matrix solutions), the results vary with the assumptions made regarding the degree of composite action between the trusses and the concrete floor. The design results are particularly sensitive to modeling because a bare truss is more flexible than a truss modeled with a concrete floor. Upon grouting, the truss chords become composite with the concrete floor and thus the floor shares with the truss chords in load bearing. Yet, a concrete floor, particularly a concrete plank floor, may not effectively transmit tensile stresses. Also, there is limited information on plank and steel composite behavior. In addition, lateral loads are assumed to be distributed to the trusses by the concrete floor diaphragm and the participation of the truss chords in distributing these forces may be difficult to quantify.

A reasonable approach to this problem is the assumption that the diaphragm is present when solving for lateral loads, but is ignored when solving for gravity loads. This requires working with two computer models—one for gravity loads...
Table 3.1 Design of Diagonal Member d1 of Truss T1F

<table>
<thead>
<tr>
<th>Floor</th>
<th>( \Phi_s )</th>
<th>( \Phi_w \Phi_s F_w )</th>
<th>( \Phi_r )</th>
<th>( \Phi_w \Phi_r F_r )</th>
<th>(1)</th>
<th>(2)</th>
<th>(3)</th>
<th>(4)</th>
<th>(5)</th>
<th>Member Sizes</th>
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<tbody>
<tr>
<td></td>
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<td></td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>Roof</td>
<td>9%</td>
<td>12</td>
<td>13%</td>
<td>10</td>
<td>377</td>
<td>412</td>
<td>366</td>
<td>361</td>
<td>HSS 10×6×1/2</td>
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<tr>
<td>12</td>
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<td>24</td>
<td>26</td>
<td>20</td>
<td>377</td>
<td>412</td>
<td>382</td>
<td>370</td>
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</tr>
<tr>
<td>11</td>
<td>27</td>
<td>36</td>
<td>39</td>
<td>29</td>
<td>377</td>
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<td>397</td>
<td>380</td>
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</tr>
<tr>
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<td>36</td>
<td>48</td>
<td>51</td>
<td>38</td>
<td>377</td>
<td>412</td>
<td>413</td>
<td>389</td>
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<tr>
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<td>377</td>
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<td>3</td>
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<td>98</td>
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<tr>
<td>2</td>
<td>100%</td>
<td>133</td>
<td>100</td>
<td>75</td>
<td>377</td>
<td>412</td>
<td>352</td>
<td>426</td>
<td>HSS 10×6×1/2</td>
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<tr>
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</table>

F in d1 of Typical Truss T1B

<table>
<thead>
<tr>
<th>F in d1 of Typical Truss T1B</th>
<th>70.2(^a)</th>
<th>39.9(^b)</th>
<th>380(^c)</th>
</tr>
</thead>
</table>

\( \Phi_s \) = 1.0 (see Section 3.5)
\( \Phi_w = 1.89 \) (from Table 2.3)

Note:

- a. \( F_s = 70.2 \) k (from Fig. 3.4)
- b. \( F_w = 70.2 \times 652/1,148 = 39.9 \) k (refer to Table 1.2)
- c. \( F_o = 380 \) k (refer to Fig. 3.3)
- d. \( \Phi_s \) values are from Table 1.2
- e. Numbers in boldface indicate the load case governs

\( \Phi_{t1} \) (for load combination 1.4D) = 1.4 \times 97 / (97 + 40) = 0.991

\( \Phi_{t2} \) (for load combination 1.2D + 1.6L) = (1.2 \times 97 + 1.6 \times 20) / (97 + 40) = 1.083

\( \Phi_{t3} \) (for load combination 1.2D + 0.5L) = (1.2 \times 97 + 0.5 \times 20) / (97 + 40) = 0.923

Load combination (1): 1.4D = \( \Phi_{t1} F_o \)
Load combination (2): 1.2D + 1.6L = \( \Phi_{t2} F_o \)
Load combination (3): 1.2D + 1.3W + 0.5L = \( \Phi_{t3} F_o + 1.3 \Phi_w \Phi_s F_w \)
Load combination (4): 1.2D + 1.0E + 0.5L = \( \Phi_{t4} F_o + \Phi_w \Phi_r F_r \)
Load combination (5): 0.9D + (1.3W or 1.0E)
Chapter 7
FIRE PROTECTION OF STAGGERED TRUSSES

Fire safety is a fundamental requirement of building design and construction and fire resistance is one of the most vital elements of all components of a structure.

Qualifying criteria to meet these requirements are included in various building codes of national stature. These are used as standards in different areas of the country and which may or may not be further regulated by the local authorities having jurisdiction. The codes (and publishing organization) are:

- Standard Building Code (SBCCI)
- Uniform Building Code (ICBO)
- National Building Code (BOCA)

These code regulations are based on performance achieved through the standard ASTM E119 test (Alternative Test of Protection for Structural Steel Columns). Due to the dimensional constraints imposed by the fire testing chambers, specific fire tests for steel trusses that simulate actual conditions have not been performed. Therefore, individual truss members are regarded as columns for the purpose of rating their fire resistance and the applicable code requirement will be applied for each member.

By definition, a staggered truss spans from floor slab to floor slab. Slabs are typically pre-cast concrete and have a fire resistance rating. The truss and columns are other elements of this assembly requiring fire protection. There are basically two methods of providing fire protection for steel trusses in this type of assembly:

- Encapsulating it, in its entirety, with a fire-rated enclosure.
- Providing fire protection to each truss member.

In the former, enclosure can be any type of fire-rated assembly. Local regulation, however, might reference different testing laboratories as accepted standards for a particular fire rating.

For economy in materials and construction time, gypsum board and metal stud walls are preferred. Gypsum board type "X" and light-gage metal studs in any of the approved configurations for a particular rating is acceptable. However, removals of portions of the wall, renovations or additions with non-rated assemblies are issues that need to be considered to avoid possible future violations of fire rating integrity when choosing this method.

The other option is to protect each truss member with one of the following methods:

- If the truss is to be enclosed and/or protected against damage and without regard to aesthetics, gypsum-based, cementitious spray-applied fireproofing is often the most economical option.
- Intumescent paint films can be used where aesthetics are of prime concern, and visual exposure of the steel truss design is desired. In addition this product is suitable for interior and exterior applications. Nevertheless, this method is often one of the most expensive at the present time.
- For exterior applications and for areas exposed to traffic, abrasion and impact, a medium- or high-density cement-based formulation is suitable and can be trowel-finished for improved aesthetics.

Whatever method is chosen, the designer must work in close consultation with the product manufacturer by sharing the specifics of the project and relating the incoming technical information to the final design. Final approval must be obtained from the local authorities having jurisdiction over these regulations.