Nailed-Plywood Gusset Roof Trusses

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NAILED-PLYWOOD GUSSET ROOF TRUSSES

4/12 AND GREATER SLOPES

MAXIMUM SPAN - 28 FEET 8 INCHES

Hugh D. Angleton
Forestry Department

To provide a substitute when these disadvantages are insurmountable, an all nailed plywood gusset plate roof truss was designed. This truss is similar in most respects to its nail-glued counterpart, but it requires more labor and material. It is strongly recommended that whenever possible, truss designs with nail-glued connections be used. However, when their use is not feasible due to inclement weather or other conditions, the truss design presented here will prove adequate although more costly.

DESIGN AND TESTING PROCEDURES

Nailed plywood gusset trusses have been designed for a minimum roof slope of 4/12 and a maximum span of 28 feet 8 inches. Any span lengths less than 28 feet 8 inches and roof slopes greater than 4/12 are permissible. Peak and heel gusset plate sizes may be reduced in direct proportion to any span length reduction or reduction in design loads. No reduction in gusset plate sizes is allowed for higher roof slopes. Maximum design roof load, live plus dead, regardless of truss-spacing, slope, or span, is 80 pounds per linear foot of horizontal projection of the upper chord. Figure 1 is a plan view of a typical truss of this design.

Three 4/12 slope, 28 foot 8 inch span trusses were built according to this design procedure and tested to obtain their performance characteristics. One truss with a 5/12 slope and the same span was also tested. The testing set-up is shown in Figure 2. Each oil hydraulic cylinder along the upper chord applies pressure at two points spaced one foot apart. The cylinder spacing is two feet, consequently, an evenly distributed load is simulated by point loads at one-foot intervals over the top chord. The horizontally placed steel channels supply lateral restraint much as the roof sheathing in an actual roof would. The oil hydraulic pressure is applied by a hand pump shown in the center of the photo. A more complete description of this testing apparatus is given by Suddarth (11).

*These numbers refer to citations in the bibliography.
Figure 1a. 28 foot 6 inch nailed plywood gusset roof truss with 1/12 slope.

Notes:
1. All members 2" x 4" construction grade Douglas fir or equivalent.
2. All gussets and splice plates are 3/8" C-D Plywood. (NFSA graded marked)
3. Overhang not shown on drawing but optional.
4. Plywood gussets and splice plates both sides.

Figure 1b. Suggested plywood cutting schedule. Includes all gusset and splice plates for one truss of this design.

Bill of materials for (1) truss
- 3# 2" x 4" x 15' Const. grade D fir
- 1 # 2" x 4" x 14' Const. grade D fir
- 1 # 3/4" x 8' sheet -- 3/8" C-D Plywood (NFSA graded marked)
- 3# 6d common wire nails

*The length of two of these pieces will vary with the amount of desired overhang.

Figure 1c. Detail nailing pattern for heel gussets.

Notes:
1. Use 6d common wire nails throughout.
2. Use same nail spacing, end and edge distances for all gussets and splice plates.
3. If there is a tendency to split the wood, stagger nails within rows.
In the lower load ranges, midspan deflections were made using a 0.001 inch dial gauge. At higher loads, a thin line was stretched along the lower chord and was read against a machinist’s scale.

The first two 4/12 trusses and the 5/12 truss were built of 2 x 4 inch construction grade Douglas fir with moisture contents ranging from 13 to 16 percent. Moisture contents were about the same when trusses were tested the following day.

Due to the possible loss in efficiency when nailed joints are made with relatively wet lumber and are loaded when dry, the final 4/12 truss was fabricated of 2 x 4 inch construction grade Douglas fir and Western hemlock lumber which ranged from 19 to 24 percent moisture content, Table 1. This truss was then suspended close to the ceiling of a heated building to dry the lumber before testing. At the time of the test, the moisture content ranged from 7 to 10 percent. This range of moisture content, from over 20 percent to less than 10 percent, simulated actual service conditions and was considered a fair test for the nailed joints.

**PERFORMANCE REQUIREMENTS AND RESULTS**

Performance requirements for the truss designs were taken from "Perfor-

Table 1. Moisture content changes in 4/12 slope roof truss from fabrication to testing.

<table>
<thead>
<tr>
<th>Member</th>
<th>Truss built Feb. 13, 1959</th>
<th>Truss tested March 3, 1959</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>24</td>
<td>8</td>
</tr>
<tr>
<td>B</td>
<td>20</td>
<td>8</td>
</tr>
<tr>
<td>C</td>
<td>22</td>
<td>7</td>
</tr>
<tr>
<td>D</td>
<td>20</td>
<td>10</td>
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<tr>
<td>E</td>
<td>22</td>
<td>7</td>
</tr>
<tr>
<td>F</td>
<td>23</td>
<td>7</td>
</tr>
<tr>
<td>G</td>
<td>24</td>
<td>8</td>
</tr>
<tr>
<td>H</td>
<td>19</td>
<td>7</td>
</tr>
</tbody>
</table>
mance Standards, Structural and Insulation Requirements for Houses" published by the Housing and Home Finance Agency (3):

1. Under the design load of 80 pounds per linear foot of horizontal projection of the upper chord, midspan deflection must not exceed 1/360 of the span.

2. Under $2\frac{1}{4}$ times the design load, the unit must sustain the load. After this load is removed, the residual midspan deflection must not exceed 25 percent of the maximum deflection observed.

Table 2 gives a listing of each truss built and tested, its ultimate load at failure and type of failure observed. Truss No. 4 was built with wet lumber and tested when dry.

Figure 3 shows the failure of the plywood lower chord splice plate in truss No. 4. This truss exhibited the lowest of the observed failure values, 3.75 times design load.

Figure 4 shows the deflection patterns of each truss during the critical loadings. Although the "Performance Standards" require the unit to sustain two and one quarter times design load, deflection readings were taken on all trusses up to two and one half times the design load. It may be readily seen in Figure 5 that allowable residual deflections would not have been exceeded in any case had the total applied load been only $2\frac{1}{4}$ times the design load of 80 pounds per linear foot; consequently, the designs presented here are considered to be adequate.

<table>
<thead>
<tr>
<th>Truss Number</th>
<th>Slope</th>
<th>Span</th>
<th>Failing load, pounds per linear foot of span</th>
<th>Type of failure observed</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>5/12</td>
<td>28'8&quot;</td>
<td>485</td>
<td>Buckled upper chord</td>
</tr>
<tr>
<td>2</td>
<td>4/12</td>
<td>28'8&quot;</td>
<td>400</td>
<td>Buckled upper chord</td>
</tr>
<tr>
<td>3</td>
<td>4/12</td>
<td>28'8&quot;</td>
<td>383</td>
<td>Bending in upper chord</td>
</tr>
<tr>
<td>4</td>
<td>4/12</td>
<td>28'8&quot;</td>
<td>300</td>
<td>Tension failure in plywood lower chord splice</td>
</tr>
</tbody>
</table>
Figure 4. Load deflection patterns for the four nailed-plywood gusset plate trusses.
BIBLIOGRAPHY


10. __________, 1959, King-Post Nailed Trussed Rafters, Bulletin No. 36, Wood Research Laboratory, Virginia Polytechnic Institute, Blacksburg, Va.