Attachment of Residential Deck Ledger to Metal Plate Connected Wood Truss Floor System

September 18, 2007

Applicability:

The purpose of this Technical Note is to suggest construction details for residential deck ledger attachment to metal plate connected wood truss (MPCWT) floor systems.

Issue:

Numerous field observations of existing decks revealed that a major source of failures are attributable to inadequate connection between the deck ledger and house rim joist, related wood decay and/or corrosion of fasteners, and a failure of single and/or various elements of the guardrail system.

Residential decks are usually supported on one side by a ledger attached to the house. This ledger attachment is critical for ensuring that the deck is safely and securely supported at this location. Deck ledger connection problems are often aggravated by lack of structural redundancy, namely, when the ledger to rim board connection fails, the deck typically collapses catastrophically.

Recommendations:

When the floor system for the house uses MPCWT, the deck ledger shall not be connected to the house by nails alone. In the absence of a lateral bracing system installed on the deck, lag screws or bolts and/or other mechanical connectors must be used, i.e., the deck ledger must be lagged or bolted to the rim joist and/or other structural components of the house which in turn must be securely attached to the framing of the structure and supported on the foundation and/or wall below.

A MPCWT is an engineered, prefabricated structural component designed for each specific application. MPCWT used in residential floors are often installed with a 2x4 lumber “ribbon” at the ends of the trusses (see Figure 1), the purpose of which is to tie the ends of the trusses together. The ribbon board, by itself, is not intended to support the Deck Ledger and deck.

Installing residential decks when the floor system for the house uses MPCWT requires a standard detail provided by the truss designer, a free-standing deck, or a full plan submission.
Any of the five recommended details for connecting deck ledgers to common wood truss floor system configurations (as described in Appendices A - E) can be used for making the connection.

Key Definitions:

**Truss:** An individual metal plate connected wood component manufactured for the construction of a building.

**Deck Ledger:** When building a deck that juts out from a house, the deck is usually tied into the house structurally. To achieve this, a header board or "ledger" is connected to the house. The header board is one end of the deck, and the deck at this end derives support from the house.

Background:

The 2007 Supplement to the 2006 International Residential Code (IRC) has prescriptive provisions for deck ledger connections. IRC Table R502.2.2.1 specifies fastener spacing for $\frac{1}{2}''$ diameter bolts or lag screws. AF&PA’s American Wood Council, in cooperation with the International Code Council, has also developed *Design for Code Acceptance No. 6 (DCA6) – Prescriptive Residential Deck Construction Guide*, available at www.awc.org.

The deck ledger shall not be connected to the house by nails alone. Therefore, in the absence of a lateral bracing system installed on the deck, lag screws or bolts and/or other mechanical connectors for “positive anchorage” are required to design and construct a code-conforming deck. In other words, the deck ledger must be lagged or bolted to the rim joist and/or other structural components of the house which in turn must be securely attached to the framing of the structure and supported on the foundation and/or wall below.

Analysis:

The technical reference for the engineering design of connections in wood construction is the *2005 National Design Specification®* (NDS®) for Wood Construction. However, due to commonly accepted methods of connecting deck ledgers to rim boards, the NDS requirements are

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not applicable. Table 11J of the NDS provides reference lateral design values for lag screws in single shear connections based on the assumption of 8D penetration in the main member or 4 inches for a ½-inch diameter lag screw. Additionally, the minimum penetration depth of four diameters (4D) into the main member when using ½-inch diameter lag screws is not met, when a solid-sawn rim board, which is only 1½ -inches thick, is used.

Because of the specific requirements for deck ledger and rim board connections, an alternative design was needed. An alternative design method is supported in Section 104.11.2 of the 2006 IBC which allows using alternative materials and methods including load testing to derive design values.

**2006 IBC 104.11.2 Tests.** Whenever there is insufficient evidence of compliance with the provisions of this code, or evidence that a material or method does not conform to the requirements of this code, or in order to substantiate claims for alternative materials or methods, the building official shall have the authority to require tests as evidence of compliance to be made at no expense to the jurisdiction. Test methods shall be as specified in this code or by other recognized test standards. In the absence of recognized and accepted test methods, the building official shall approve the testing procedures. Tests shall be performed by an approved agency. Reports of such tests shall be retained by the building official for the period required for retention of public records.

**Recent research and testing of deck-ledger-to-rim-board connection details at Virginia Tech and Washington State University**

The latest research and testing conducted on the deck ledger connection by the Virginia Tech Department of Wood Science and Forest Products and Washington State University Wood Materials and Engineering Laboratory, provided ultimate capacities for lag screws and bolts much higher than allowable capacities derived using the NDS equations. (References 3, 4, and 5) Initially, the researchers used the 2005 NDS to calculate the required on-center spacing of lag screws and bolts for deck ledger to rim board connections for various deck widths. Although the calculated spacing was “per code,” it was impractical. The tight spacing limitation for allowable capacities for lag screws and bolts in NDS is based on small allowable deformations at the design loads.

Three common deck-ledger-to-rim-board connection details were tested, which is allowed and recognized by the code. Test results for this specific application revealed that the “ultimate” loads for lag screws are two to three times higher than the values obtained using the NDS equations. In addition, bolts tested for this specific application proved to be even stronger compared to NDS equations.

The recommended details for attachment of deck ledgers to MPCWT floor systems in IRC Table R502.2.2.1 are based on the latest research and testing conducted jointly by the Virginia Tech Department of Wood Science and Forest Products and Washington State University Wood Materials and Engineering Laboratory. Below is the summary of the minimum requirements and limitations:

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- D.M. Carradine, D. Bender, J. R. Loferski, and F.E. Woeste. 2006. Residential Deck Ledger Connection Testing and Design. Wood Design Focus, AF&PA/AWC: (9-12)
Three common residential deck ledger construction details using \( \frac{1}{2} \)-inch diameter lag screws or bolts were tested. The 2006 IRC specified live load of 40 psf and dead load of 10 psf are used. Note that other loads may control residential deck ledger design such as snow, seismic, wind, and concentrated loads such as planters or tubs.

Solid-sawn lumber rim board with specific gravity of \( G \geq 0.42 \) (includes spruce-pine-fir (SPF), hem-fir, Douglas-fir-larch, and southern pine) or structural composite lumber (SCL) rim board with thickness \( \geq 1" \) and equivalent specific gravity of \( G \geq 0.50 \).

All floor truss members used to connect deck ledger to the floor truss system shall be of minimum specific gravity of \( G \geq 0.42 \) (includes SPF, hem-fir, Douglas-fir-larch and southern pine).

Preservative pressure treated (PPT) deck ledger lumber with \( G \geq 0.42 \) (includes hem-fir, Douglas-fir-larch and southern pine). Deck ledger can be incised and wet. PPT deck ledger should be treated to a retention level of 0.40 lbs/ft\(^3\) of ACQ-B, C and D (Alcaline Copper Quat), which is suitable for ground contact. Other approved preservative treatments per American Wood Preservers’ Association such as CC (Micronized Copper) may be used as well. No wood decay is allowed.

No fastener corrosion is allowed. All fasteners should be hot-dip galvanized per ASTM A153 or “316 stainless steel series,” as determined by the deck designer and approved by the building official.

Lag screws and bolts shall be installed according to 2005 NDS requirements. Lead holes for the lag screws should be equal to the root diameter (or slightly less) of the threaded portion and the clearance holes should be \( \frac{1}{2}" \) in diameter. For a particular box of \( \frac{1}{2}" \) diameter lag screws, a "test" installation into the house is recommended before drilling the lead holes to ensure that the lead holes are neither too small nor too large. Bolts shall be installed with \( \frac{9}{16}" \) or at least \( \frac{17}{32}" \) diameter clearance holes.

Squash and/or blocking panels between the trusses, sill plate, and ribbon board should be cut to fit tightly (i.e., snug-tight) and be attached using deformed shank 8d nails spaced at max. 4" on center.

Each of the five recommended details for connecting deck ledgers to common wood truss floor system configurations are described in Appendices A – E.

**Conclusion:**

From the above discussion it can be concluded that nailing deck ledgers to MPCWT floor systems is not sufficient. The deck ledger must be lagged or bolted to the rim joist and/or other structural components of the house. Various options and connection details for achieving the connection of the deck ledger to the MPCWT floor system are provided in this Technical Note, which may be referred to by the building designer to achieve a code-conforming deck ledger connection.

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**Appendix B**

**General Notes**

- Deck ledger fastening schedule should be provided to structural engineer if Composite Rimboard or 2x Dimensional Lumber is used.

**Table 2: Fastener-Connectors Correlation for PF-P Hem-Fit or Southern Pine Residential**

**Appendix C**

- Structural Composite Lumber (SCL) or 2x Dimensional Lumber Rimboard

**Details 2: Attaching Residential Deck Ledger Directly to Rimboard**

**Wall Section**

*Vertical Rafter* - Spaced at 2" centers with double

*Smart Rafter* - Spaced at 2" centers with double

**Wall Side View**

- Rimboard 1x10 or 2x Dimensional Lumber Rimboard
### General Notes

- Table 2: Fasen steeler spacing for PPT 2x4s at bottom pre-residential deck ledger attached to structural composite lumber (SCL) rimboard or 2x12 dimensional lumber when foam wall sheathing is used.

#### Appendix C

- 2x12 dimensional lumber (SCL) rimboard or structural composite lumber (SCL) rimboard

#### Deck Ledger Fastening Schedule

<table>
<thead>
<tr>
<th>Fastener Type</th>
<th>Fastener Size</th>
<th>Placement</th>
</tr>
</thead>
<tbody>
<tr>
<td>Deck Ledger</td>
<td>1/4&quot; spacer</td>
<td>at each 2'</td>
</tr>
<tr>
<td>Wall Sheathing</td>
<td>3/4&quot;</td>
<td>every 2'</td>
</tr>
</tbody>
</table>

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**Wall Section View**

- Parallel chord floor truss spaced at 2'x2' with double 2x6 SCF or 2x6 dimensional lumber rimboard.
- 2x6 SCF or 2x6 dimensional lumber rimboard.

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**Wall Side View**

- 2x6 SCF or 2x6 dimensional lumber rimboard.