Overdriven Nails in Structural Sheathings

Overview

Revised 3/22/2017

SBCA

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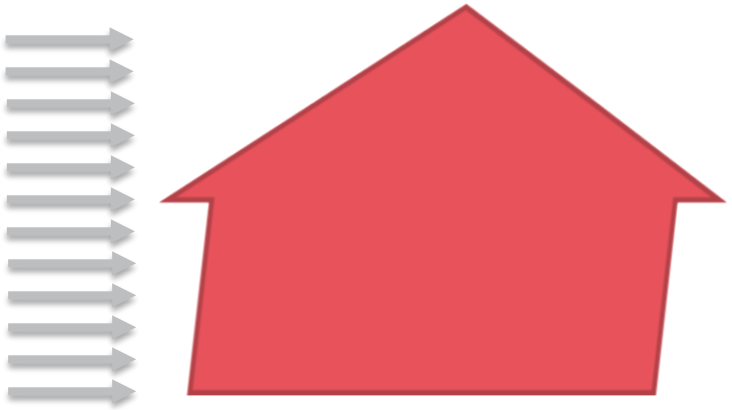
Introduction

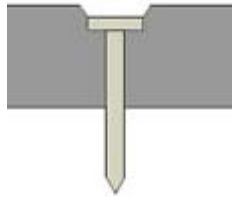
- All building codes provide provisions for the attachment of structural sheathing to wall and roof framing members.
- Structural sheathing connections to building framing are important for *lateral shear resistance*, or the ability of a building to resist wind and seismic loads.

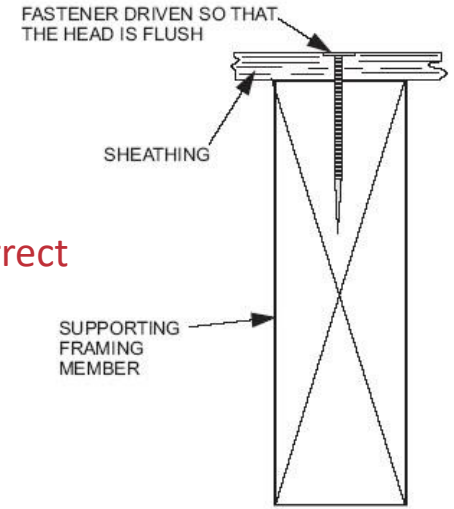


Introduction

- When designing attachment for structural sheathing, designers rely upon published data – whether from the building codes, referenced standards, or proprietary sources
- In almost every case, the published values assume the head of the fastener is flush with the surface of the sheathing, NOT embedded beneath the surface (overdriven)
- Overdriven fasteners reduce the shear strength of the sheathing by reducing the effective thickness of the panel, which then may not be able to resist the intended loads.

Overdriven

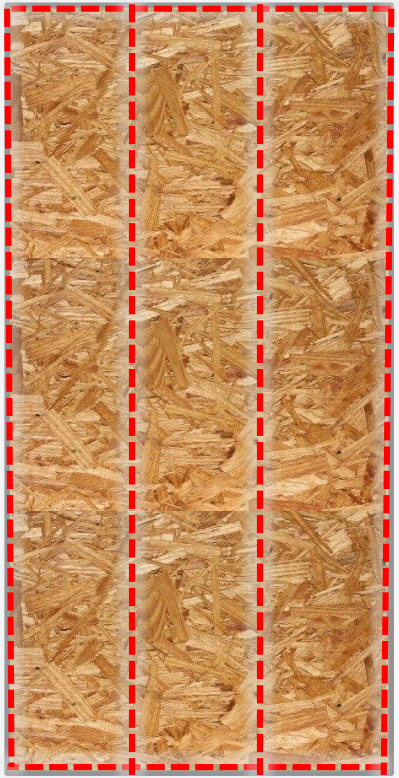


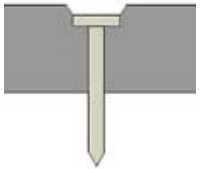


Correct

Introduction

- At panel edges, overdriven fasteners allow for easier pull-through or tear-out due to the reduced thickness of the panel at the fastener head.
- At intermediate framing members, overdriven fasteners provide reduced resistance to panel buckling.





Introduction

- There is no guidance in the International Building Code (IBC), International Building Code (IRC), or National Design Specification for Wood Construction (NDS) as to what the capacity reduction is for overdriven fasteners, nor what corrective action could be taken.
- This presentation will provide guidance on how to ensure shear capacity in cases with overdriven fasteners

Background

- The *IBC* only describes how sheathing fasteners should be installed, but not how to resolve situations where fasteners have been installed improperly.
- This same requirement is not included in the *IRC*.

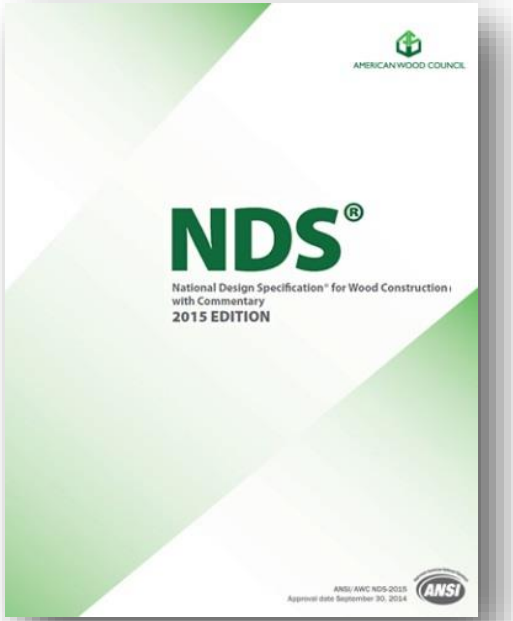
- **2304.9.2 Sheathing fasteners**. Sheathing nails or other *approved* sheathing connectors shall be driven so that their head or crown is flush with the surface of the sheathing.

Background

- However, since the prescriptive requirements are based on testing or calculations that assume the fasteners are driven flush with the surface of the sheathing, it is still necessary to achieve the intended function of the prescriptive requirements.
- Regardless of code requirements for the sheathing fastener (spacing, diameter, length, etc.), the fastener must be driven flush with the sheathing surface to achieve the intended capacity of the wall system.

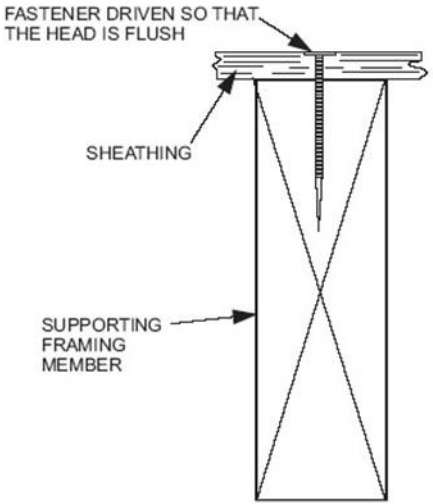
Analysis – NDS

- The 2015 NDS does not address the issue of over-driven nails but does offer design values for dowel-type fasteners in Chapter 12.
- These design values are calculated assuming fasteners are installed correctly.



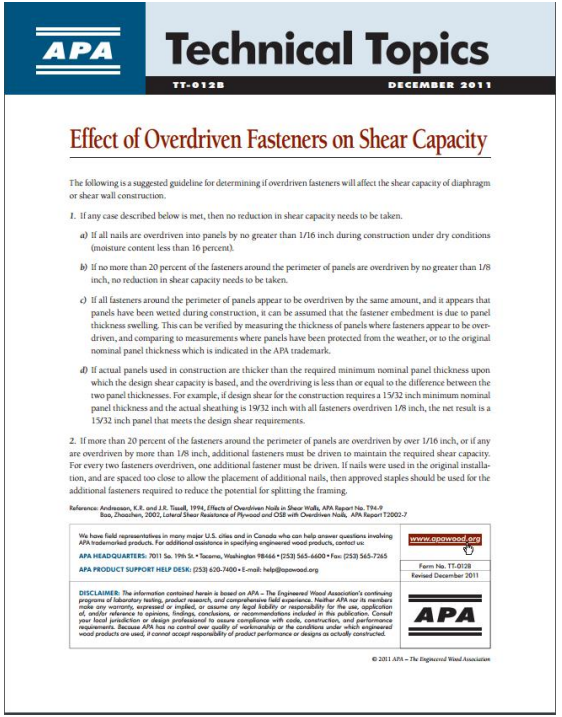
Analysis – IBC

- The 2009 and 2012 *IBC* Commentary for Section 2304.9.2 provide the following information regarding overdriven fasteners:
  - This requirement is a matter of workmanship (see Figure 2304.9.2 for an illustration of a nail driven to fasten sheathing properly). Protruding nails do not provide the intended connecting capacity and could be hazardous. Likewise, nails overdriven into structural sheathing may not perform as expected. Framing installation is often less than perfect and fasteners are overdriven to a point where the top layer of sheathing is crushed beneath the nail head. An occasional overdriven nail may not be significant. As the percentage of overdriven fasteners increases, the issue raised is at what point does this adversely affect the shear capacity of a diaphragm or shear wall element. The APA has recognized that this is a common occurrence and has made a guideline available at no cost on its website (www.apawood.org). Another condition to be aware of in sheathing nailing is where the depth of the supporting member is less than the length of a commonly used fastener, such as in a case where sheathing will be applied over the top of flat decking. Shorter nails are available for these situations, but the holding and shear capacities are typically reduced.



Analysis – Engineered Wood Association (APA)

- Technical Topics: Form TT-012B, *Effects of Overdriven Fasteners on Shear Capacity* offers the following guidelines for determining if overdriven fasteners will indeed affect the shear capacity of a given wall assembly:



APA Technical Topics

TT-012B DECEMBER 2011

Effect of Overdriven Fasteners on Shear Capacity

The following is a suggested guideline for determining if overdriven fasteners will affect the shear capacity of diaphragm or shear wall construction.

1. If any case described below is met, then no reduction in shear capacity needs to be taken.

   a) If all nails are overdriven into panels by no greater than 1/16 inch during construction under dry conditions (moisture content less than 16 percent).

   b) If no more than 20 percent of the fasteners around the perimeter of panels are overdriven by no greater than 1/8 inch, no reduction in shear capacity needs to be taken.

   c) If all fasteners around the perimeter of panels appear to be overdriven by the same amount, and it appears that panels have been wetted during construction, it can be assumed that the fastener embedment is due to panel thickness swelling. This can be verified by measuring the thickness of panels where fasteners appear to be over-driven, and comparing to measurements where panels have been protected from the weather, or to the original nominal panel thickness which is indicated in the APA trademark.

   d) If actual panels used in construction are thicker than the required minimum nominal panel thickness upon which the design shear capacity is based, and the overdriving is less than or equal to the difference between the two panel thicknesses. For example, if design shear for the construction requires a 15/32 inch minimum nominal panel thickness and the actual sheathing is 19/32 inch with all fasteners overdriven 1/8 inch, the net result is a 15/32 inch panel that meets the design shear requirements.

2. If more than 20 percent of the fasteners around the perimeter of panels are overdriven by over 1/16 inch, or if any are overdriven by more than 1/8 inch, additional fasteners must be driven to maintain the required shear capacity. For every two fasteners overdriven, one additional fastener must be driven. If nails were used in the original installation, and are spaced too close to allow the placement of additional nails, then approved staples should be used for the additional fasteners required to reduce the potential for splitting the framing.

Reference: Andreason, K.R. and J.R. Tissell, 1994, *Effects of Overdriven Nails in Shear Walls*, APA Report No. T94-9
Bao, Zhaozhen, 2002, *Lateral Shear Resistance of Plywood and OSB with Overdriven Nails*, APA Report T2002-7

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Form No. TT-012B
Revised December 2011

APA

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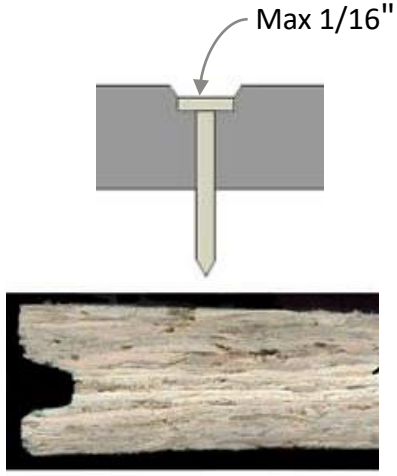
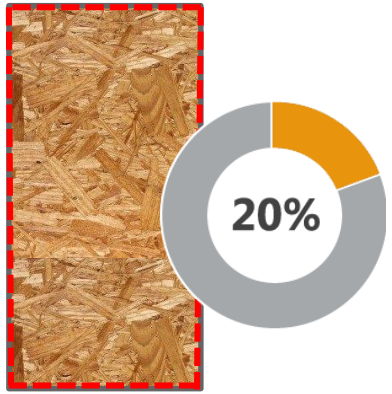
Analysis – Engineered Wood Association (APA)

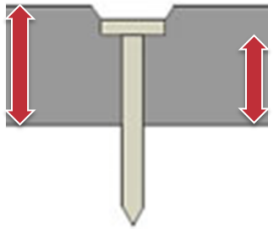
1. If any of the following are met, then <u>no reduction in shear capacity needs to be taken</u>:

- All nails are overdriven into panels by no greater than $^{1}/_{16}$" under dry conditions (moisture content less than 16%)
- No more than 20% of the perimeter fasteners are overdriven by no greater than ⅛“
- If all perimeter fasteners are overdriven by the same amount and it appears that wetting occurred during construction, fastener embedment may be due to panel swelling in thickness.
- If actual panels used in construction are thicker than the required minimum nominal panel thickness upon which the design shear capacity is based, and the overdriving is less than or equal to the difference between the two panel thicknesses.





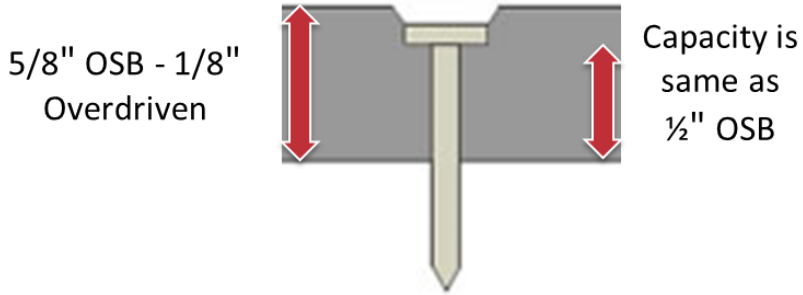
If panel is thicker than necessary



Reduced thickness is OK

Analysis – Engineered Wood Association (APA)

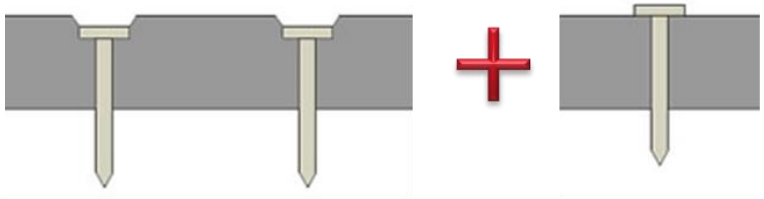
- For example: re-analyze capacity based on average thickness of panel measured from the bottom of the fastener head.
  - i.e. 5/8” panel with fasteners overdriven by 1/8” would have the capacity of ½” panel.
- Adjust nailing schedule accordingly.

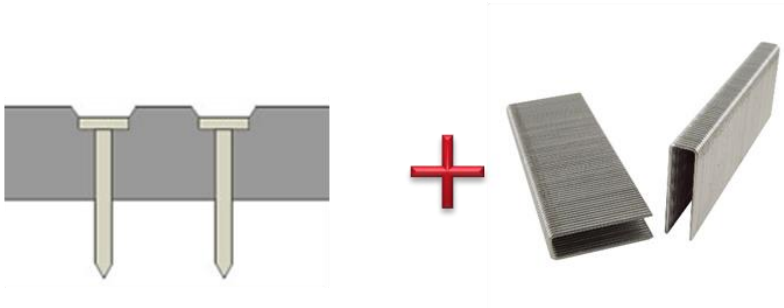


Analysis – Engineered Wood Association (APA)

2. If any of the following are met, then a reduction in shear capacity needs to be taken:

- If > 20% of the fasteners around the perimeter are overdriven by over 1/16”, or if any are overdriven by more than 1/8”:
  - Then add 1 additional fastener for every 2 that are overdriven.
- If the additional nails violate the minimum spacing requirements (3” o.c. for 2 inch lumber for splitting):
  - Use staples for the additional fasteners to reduce the potential for splitting.





Analysis – Timber Engineering Company (TECO)

- TECO's Tech Tip outlines an example of calculating reduction in shear capacity
- It also draws attention to other factors that impact shear capacity including:
  - Fastener type
  - Fastener size
  - Fastener spacing
  - Amount of penetration into the framing members
  - Wood species
  - Width of framing members

TECO BUILDING CONFIDENCE

TECH TIP

Reduction in Shear Capacity Due to Overdriven Fasteners

Diaphragms and shear walls, constructed with wood structural panels such as oriented strand board (OSB) and plywood, provide the primary lateral load resisting system in many types of construction. The ability of these systems to resist and transfer shear load is highly dependent on the strength and behavior of the sheathing fastener connection. The allowable shear loads provided in the building codes for wood-framed diaphragms and shear walls are based on the assumption that the fasteners used to attach the sheathing to the framing members are driven so that their heads or crowns are flush with the surface of the sheathing. During construction of these assemblies, however, it is common to have at least a portion of the fasteners with their heads overdriven below the surface of the panels. This can be especially true when power-driving equipment is used to install the fasteners.

Improper installation of the fasteners may potentially reduce the shear capacity of the shear walls and diaphragms. Recent studies indicate that overdriven nails reduce shear wall strength from 5% to 22% depending on the depth of the overdriven nail-head.

The bar chart on the following page provides an estimate of the percent reduction in shear capacity for various percentages of fasteners overdriven to three different depths. This chart is based on an analytical model developed from research by Judd and Fonseca (1, 2), and Jones and Fonseca (3) involving in part the pseudo-dynamic testing of the 8 by 8' shear walls utilizing 7/16" thick OSB and 8d cooler nails.

Review of the chart indicates that shear capacities are reduced when fasteners are overdriven. The reduction in shear capacity depends on the magnitude of the overdriven depth of the fasteners and the percentage of total fasteners overdriven.

For example, if 30% of the fasteners in a diaphragm or shear wall are overdriven by up to 1/16", the estimated reduction in the shear capacity is only approximately 3%. If 100% of the fasteners are overdriven up to 1/16", the estimated reduction in shear capacity is approximately 9%. Similarly, if 20% of the fasteners are overdriven by up to 1/8", the estimated reduction in the shear capacity is also approximately only 3%. Depending on the design requirements of the diaphragm or shear wall, reductions in shear capacity of up to 5% might be considered negligible and therefore possibly ignored. If the full design shear capacity is required, additional fasteners must be added to take the place of the overdriven fasteners. Care must be taken to ensure that the additional fasteners, together with the original fasteners, do not violate minimum spacing requirements and therefore induce splitting of the framing members.

This chart (see Chart 1) can be used to estimate the reduction in shear capacity if fasteners are overdriven by varying percentages and depths.

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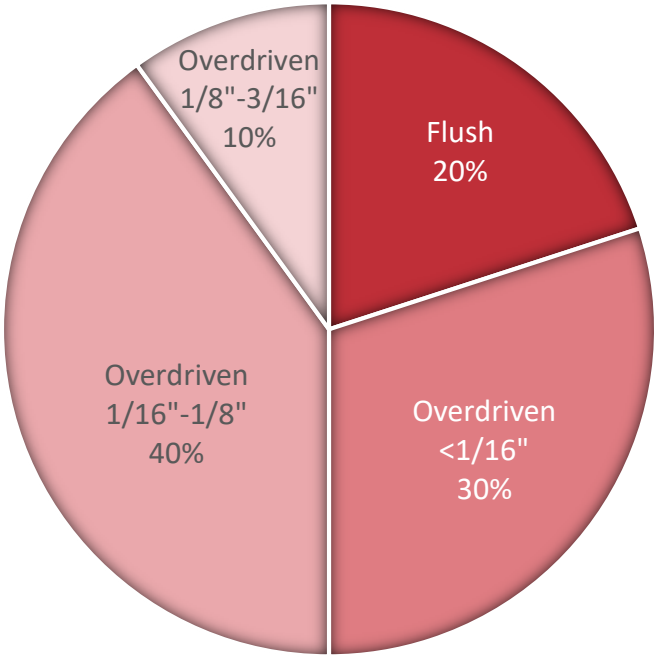
For additional information, contact TECO at (608) 837-2790 or visit www.tecotested.com

Analysis – Timber Engineering Company (TECO)

- Consider the following example:
  - Assume that 20% of the nails in a shear wall are driven flush with the sheathing and the remaining nails are overdriven as follows:
    - 30% between flush up to $^{1}/_{16}$"
    - 40% between $^{1}/_{16}$" up to ⅛" and
    - 10% between ⅛" up to $^{3}/_{16}$".

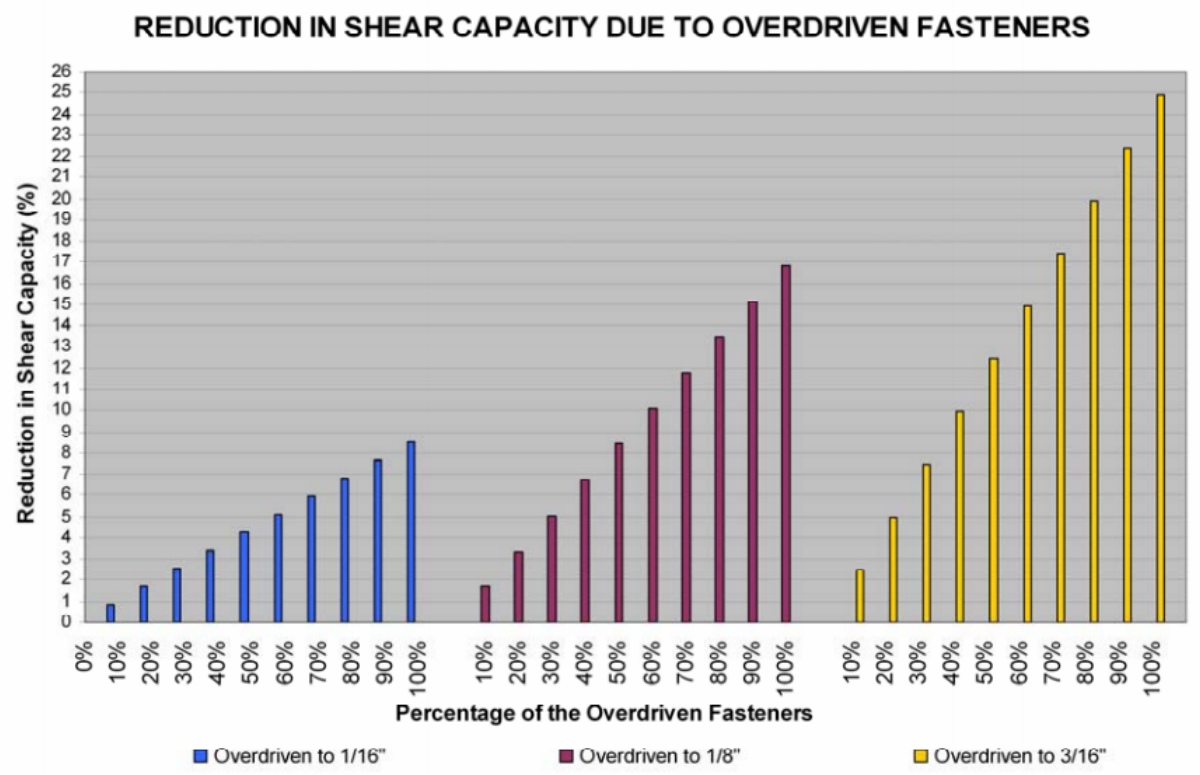


Analysis – Timber Engineering Company (TECO)

- Using the chart (on the following slide) an estimate of the reduction in shear capacity based on the number and magnitude of overdriven nails would be:
  - 20% flush = 0% reduction
  - 30% up to 1/16” ≈ 2.6% reduction
  - 40% between 1/16” up to 1/8” ≈ 6.7% reduction
  - 10% between 1/8” up to 3/16” ≈ 2.5% reduction

Total Reduction ≈ 11.8%

Analysis – Timber Engineering Company (TECO)



Conclusion

- When sheathing fasteners are overdriven, the sheathing panel or structure should be evaluated to determine the impact of the overdriven fasteners on the shear performance of the building.
- If it is determined that a sufficient number of fasteners are overdriven, corrective action per APA or TECO recommendations should be followed.

References

- *ANSI/AWC National Design Specification for Wood Construction*; American Wood Council; 2015.
- *APA – Engineered Wood Association*, 2011, “Effect of Overdrive Fasteners on Shear Capacity,” TT-012B.
- *Timber Engineering Company*, 2008, “Reduction in Shear Capacity Due to Overdriven Fasteners,” V1.0.
- *International Building Code*, International Code Council; 2015