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 (e.g., pneumatic nail gun) 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 (Chart 1) 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-ft. by 8-ft. shear walls utilizing 7/16-inch-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 inch, the estimated reduction in the shear capacity is only approximately 3%. If 100% of the fasteners are overdriven up to 1/16 inch, the estimated reduction in shear capacity is approximately 9%. Similarly, if 20% of the fasteners are overdriven by up to 1/8 inch, 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. A common approach for developing required design shear capacity for the case of overdriven fasteners is to add staples which are less likely to induce splitting in the framing. The staples specified are based on design capacities provided in building code evaluation reports, such as ICC-ES ESR-1539.

The values in Chart 1 can be used to estimate the reduction in shear capacity if fasteners are overdriven by varying percentages and depths.

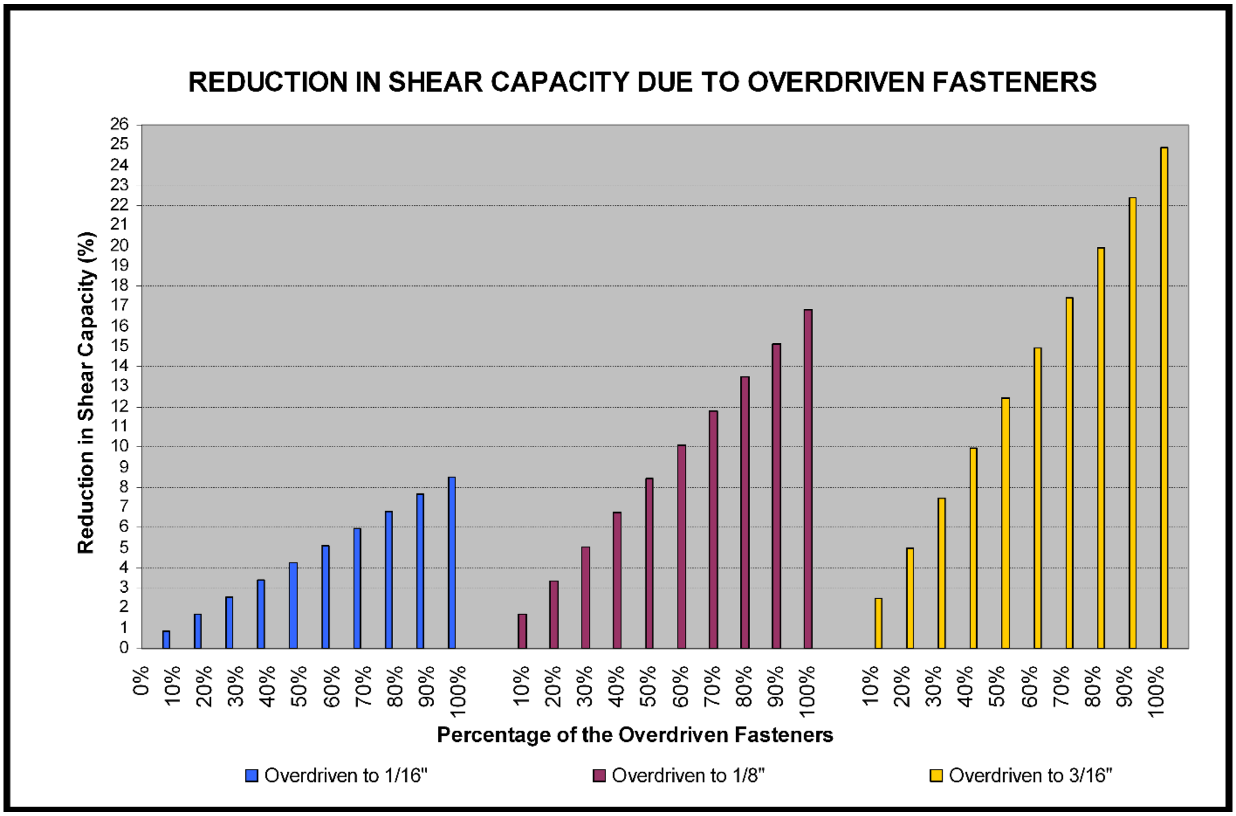

Chart 1. Effect of Overdriven Fasteners on Lateral (Shear) Capacity

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 and up to 1/16 inch overdriven,
- 40% overdriven between 1/16 inch up to 1/8 inch, and
- 10% overdriven between 1/8 inch up to 3/16 inch.

Using the chart, an estimate of the reduction in shear capacity based on the number and magnitude of overdriven nails would be:

• 20% flush	= 0% reduction
• 30% overdriven up to 1/16”	≈ 2.6% reduction
• 40% overdriven between 1/16” up to 1/8”	≈ 6.7% reduction
• 10% overdriven between 1/8” up to 3/16”	≈ 2.5% reduction
	≈ **11.8% total reduction**

To restore the shear capacity to within approximately 3% of the design capacity, additional fasteners are required to take the place of all the fasteners that have been overdriven by more than 1/16 inch. Care should be taken to ensure that the additional fasteners are driven flush and are not overdriven.

Additional Considerations

The allowable shear capacity of diaphragms and shear walls depends on several other factors including fastener type, size, spacing, and amount of penetration into the framing members. In addition, wood species, width of framing members, panel grade, thickness, layout, and presence or absence of panel edge framing support influence the allowable shear capacity. Each of these factors must be considered when evaluating the effects of overdriven fasteners.

For instance, if the required shear capacity is based on a fastener spacing of 6 inches at the supported edges of the panels but the actual nail spacing is 4 inches, the effective shear capacity may still be adequate even with a portion of the fasteners overdriven. Similarly, if the required shear capacity is based on a sheathing grade panel, but a Structural I sheathing grade panel has been installed instead, the effective shear capacity may still be adequate even with a portion of the fasteners overdriven.

Another factor to consider is whether the panels have been exposed to moisture causing the fastener heads to become embedded in the panel due to thickness swell as opposed to being overdriven. If the nail embedment is due to panel swelling and not overdriving, no shear strength reduction of the panels needs to be considered.

References

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Additional Information

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[2] Karacabeyli, E., Ceccotti, A. (1998). "Nailed wood-framed shear walls for seismic load: Test results and design considerations". *Proceedings of the Structural Engineers World Congress. San Francisco, paper No. T207-6*

[3] Monique C. Hite and Harry W. Shenton III. (2002). "Modeling the Non-Linear Behavior of Wood Frame Shear Walls." *Proceedings of the 15th ASCE Engineering Mechanics Conference, Columbia University, June 2-5, New York, NY*

[4] Zacher, E. G., Gray, R.G. (1989). "Lessons learned from dynamic tests of shear panels." *Proceedings of the Sessions Related to Design, Analysis and Testing at Structural Congress, A. H-S Ang, ed., ASCE, New York, 134-142*