What is a 10d Common Nail?

Part 1

By Williston L. Warren, IV, S.E., SECB

After you finish the engineering on a project and it goes out the door, what happens to it? Who is responsible? How will it perform versus the engineering assumptions?

Over the years, the reality of what gets engineered versus what gets constructed has become more concerning. Performing site visits to observe construction configuration and specifics of the contractor's interpretations of the permitted drawings has been, to say the least, enlightening. The author's most significant experiences have been in California, where the majority of the engineering effort is to reduce the seismic hazard of timber-framed buildings. You would think that knowing this, builders would try to comply with the intent of the Structural Engineer. Builders point to the successful inspection by the governing agencies as a testament to the quality of their work. However, in loading conditions other than gravity, shortcomings of the construction are not immediately obvious.

The author's experiences in the investigation of the as-built conditions of buildings have also contributed to these types of observations. Just what is the point? Conversations with some Structural Engineering professionals, as well as builders and their framing subcontractors, reveals there is an amount of "flexibility" in the construction that has not been included in either the code development and the engineering assumptions made by the structural designer. For example, wood structural panel sheathing with nail fasteners to the framing: first of all, what is the tolerance for the fastener spacing and the fastener size? Construction authorities suggest that the fact that there is nailing is a compliant result.

For years, the building code defined a 10d common nail as 0.148 inches in diameter and 3 inches long, and that definition occurred in one location in the code. In the shear panel table of the code, *Figure 1 (page 44)*, *International Building Code* (IBC), the minimum penetration was listed for each of the nail specifications. Upon careful examination, many users conclude that the length of the nail in ⅜-inch thick sheathing is the 1⅝ inches of minimum nail penetration plus the ⅜-inch sheathing thickness to be 2 inches long, even though the code specifically notes a 10d common nail is 3 inches in length. This convenient confusion was addressed in the shear panel table in the 2006 *International Building Code* (IBC) and is reflected in *Figure 2 (page 44)*. This "flexibility" is further supported by the fact that nail manufacturers make 10d common nails, as well as other types, in length increments of ¼ of an inch and in some cases ⅛ inch. The inspection agency typically does not pick up the incorrect nail sizes used, whether it is size or fastener diameter or length.

The Codes have referenced many editions of the *National Design Specification®* (NDS®) *for Wood Construction* and recently referenced editions of the American Wood Council's (AWC) *Special Design Provisions for Wind and Seismic* (SDPWS) which also includes a length specification of nail fasteners into framing. Further, lengths and diameters of common, box, and sinker nails in accordance with ASTM F 1667-00, *Standard Specification for Driven Fasteners: Nails, Spikes and Staples*, are tabulated in SDPWS Appendix Table A1. So how could this still be in question? Structural Engineering professionals use the history of "flexibility" as a justification for current interpretations that allow for what clearly is a misinterpretation. What is the impact of varying interpretations of code requirements? To understand this impact, it is prudent to know the source and intent of the code requirement. What is the source and intent of specific shear panel capacities for the different sheathing thicknesses, nail sizes, and spacing?

What are the nailing capacities for different connections and where do they come from? One can use AWC's NDS® yield limit equations to calculate the capacity of wood structural panels nailed to wood framing. The recent edition of the NDS Table 11Q describes common wire nail lateral design values for sheathing. Everyone should go through this exercise. When you do, you see that the numbers you generate are not those in the code tables for wood structural panel shear walls. How can this be? Then where do the tabulated values come from?

As with many construction materials and types that are used, testing the components and configurations is the basis of allowable requirements in the building code. After the 1994 Northridge earthquake, the City of Los Angeles passed ordinances that required certain building types to be investigated and retrofit, if necessary. There were committees established that included building department members as well as Structural Engineers Association of Southern California (SEAOSC) members who examined many facets of building types subjected to the earthquake and the resultant performance. One specific item examined by a dedicated committee was the performance of wood structural panel sheathed shear walls subjected to cyclic loading.

The City required cyclic testing of components going forward when those components were used in the City of Los Angeles. Much of this required testing was to confirm the component's ability to provide a factor of safety that resulted from static testing. Many hardware and component manufacturers scrambled to test and provide testing documentation; some were required to revise

Williston L. Warren, IV is Principal Structural Engineer, SESOL, Inc., Newport Beach, California. Treasurer of the National Council of Structural Engineering Associations (NCSEA), Member of the NCSEA Code Advisory Committee (CAC), Chair of the CAC Evaluation Service Committee, Member of the Applied Technology Council (ATC) Board of Directors, and ATC Board Representative on the Project Review Panel for ATC 58-2, ATC-110 and ATC-124.

manufacturing or installation guidelines. One specific committee was directed to cyclically test wood structural panel sheathed shear wall assemblies to confirm and document performance and failure modes. This requirement was quickly included in the Evaluation Service criteria for affected components.

Results of the testing can be found in a full report to the City of Los Angeles, *Report of a Testing Program of Light-Framed Walls with Wood-Sheathed Shear Panels*, by the Research and COLA-UCI Light Frame Test Committee of the Structural Engineers Association of Southern California, December 2001 (**www.icclabc.org/uploads/2001-12_COLA-UCI_Shear_Wall_Test_Report.pdf**). This testing specifically used ASTM F 1667-00's descriptions of common nails, which uses the length of 10d common nails as 3 inches long. There are other references that include discussion of a shorter than specified nail length, but it was one test specimen, and the test showed lower values and recommended further testing. Shear wall behavior was observed during the testing with specific notice to the nails. Nails were observed to be withdrawing along with the typical "shear" force resistance. Nails withdrawing during loading leads one to believe that a shorter nail would have a reduced capacity when compared to a nail with the length specified by ASTM F 1667.

All the testing aside, the building code specifies nail diameters and lengths, and some professional Structural Engineers are accepting and excusing non-code conforming nail size and spacing in construction. This extends to litigation, where not only the spacing of the nails but the size of the nails is excused because of the factor of safety used in these materials. Load capacities do have these factors, but stiffness is not one of them. Certainly, fabrication variances need to be considered for nail spacing, but one would think a craftsman would be able to get nailing within a ¼ of an inch to ⅜ of an inch average spacing of that specified over a 24-inch length of nails. Put another way, when an apple is specified, you would not expect that a pear would be used even though you like pears.

Many builders and engineering professionals also excuse closer nailing than specified as acceptable because it provides greater capacity, neglecting any effect that closer spacing has on the stiffness of the wall and how it affects the load distribution throughout the building. Short nails get excused because they seem to meet criteria that were not included in the testing that provided building code requirements for cyclic loadings. The position of builders and framing subcontractors is that any errors or mistakes they make are usually

Figure 1. Portion of 2000 IBC Shear Wall Capacity Table.

Panel Grade	Minimum Nominal Panel Thickness (inches)	Minimum Fastener Penetration in Framing (inches)	Panels Applied Direct to Framing				
			Nail (common or galvanized box) or staple size	Fastener spacing at panel edges (inches)			
				6	4	3	2
Structural I Sheathing	5⁄16	1¼	6d	200	300	390	510
		1	1½ 16 Gage	165	245	325	415
	⅜	1⅜	8d	230	360	460	610
		1	1½ 16 Gage	155	235	315	400
	7⁄16	1⅜	8d	255	395	505	670
		1	1½ 16 Gage	170	260	345	440
	15⁄32	1⅜	8d	280	430	550	730
			10d	340	510	665	870
		1	1½ 16 Gage	185	280	375	475
		1½	10d	340	510	665	870

Figure 2. Portion of 2015 SDPWS Table 4.3A.

Panel Grade	Minimum Nominal Panel Thickness (inches)	Minimum Fastener Penetration in Framing (inches)	Panels Applied Direct to Framing				
			Nail (common or galvanized box) or staple size	Fastener spacing at panel edges (inches)			
				6	4	3	2
Structural I Sheathing	5⁄16	1¼	6d (2 x 0.113″ common, 2″ x 0.099″ galvanized box)	200	300	390	510
		1	1½ 16 Gage	165	245	325	415
	⅜	1⅜	8d (2½″ x 0.131″ common, 2½″ x 0.113″ galvanized box)	230	360	460	610
		1	1½ 16 Gage	155	235	315	400
	7⁄16	1⅜	8d (2½″ x 0.131″ common, 2½″ x 0.113″ galvanized box)	255	395	505	670
		1	1½ 16 Gage	170	260	345	440
	15⁄32	1⅜	8d (2½″ x 0.131″ common, 2½″ x 0.113″ galvanized box)	280	430	550	730
		1	1½ 16 Gage	185	280	375	475
		1½	10d (3″ x 0.148″ common, 3″ x 0.128″ galvanized box)	340	510	665	870

apparent immediately because they are very familiar with construction for resisting gravity loads. They think that distress due to gravity loads occurs during their construction and distress due to lateral loads occurs sometime in the future, if at all.

Some engineers take the position that building inspectors can authorize changes in construction for the specified requirements. Does this extend to the size of nail fastener sizes and spacing specified by the structural engineer? Where is the line? If an engineer specifies nails spaced at 3 inches, can the inspector allow 2-, 4- or 6-inch spacing? What about Section 106-Inspections, "Approval as a result of inspection shall not be construed to be an approval of a violation of the provisions of this code or other ordinances of the jurisdiction."? What about specifying a 16d nail to attach a 2x to a 4x? Does this mean the length of the nail of 3¼ inches can be used? Who in the field performs the addition for nail lengths for each condition, or does the Code provide this by specifying one length of nail for each nail size?

So what does this say about the Structural Engineering profession, where individuals cannot only accept and even excuse non-conformance with building code requirements due to a general lack of understanding? What does this say about the excusing professional, whether or not they are aware of the misinterpretation?

Many structural engineers spend countless hours in building code development, and can appreciate and understand the subject. However, there are those who do not understand and do not appear to care. Investigation after the 1994 Northridge earthquake discovered that in certain applications, small differences in what is provided versus what is required can make a substantial difference. One can encounter this situation in other types of loading cases such as snow, wind and foundation movement, and is usually not seen in gravity design. What this finally ends up as is a question as to the capacity of the existing configuration in an attempt to determine if there is sufficient capacity to call it good. The author has seen some attempts to determine this, however, generally, it becomes a case of "it is OK because I say so" and those left to judge do not understand that there is no basis for this position other than the building has yet to collapse.

Also, the general public does not understand what affects a building and what doesn't. Their experience every day with buildings is that they are hard when you hit your head against them. With this being the case, "how can what I am doing affect or damage a building." The differences between loading cases are not easily understood by those not trained to see the difference. When someone inquires about the existing capacity versus the anticipated demand, the obvious response is that the professional has not tested every combination or permutation of incorrect installation of components to determine their capacity. That is why the building code exists, to establish the minimum criteria for the construction so that testing is not needed.

Currently, many structural engineers in California are working to encourage and assist in the development of retrofit standards and ordinances to increase the safety of certain types of buildings that have proven to be a hazard. Resistance to this in the past came from building owners, but, currently, there is a confluence of forces apparently going to make it happen. So what does it say about our profession when one portion is willing to accept below code required construction while others are working to advance code compliant construction? In the author's opinion, it makes it hard for others to see us as a profession.■

Full 2000 IBC Shear Wall Capacity Table.

PANEL GRADE	MINIMUM NOMINAL PANEL THICKNESS (inches)	MINIMUM FASTENER PENETRATION IN FRAMING (inches)	PANELS APPLIED DIRECT TO FRAMING					PANEL APPLIED OVER 1/2" OR 5/8" GYPSUM SHEATHING				
			Nail (common or galvanized box) or staple size[k]	Fastener spacing at panel edges (inches)				NAIL (common or galvanized box) OR STAPLE SIZE[k]	Fastener spacing at panel edges (inches)			
				6	4	3	2[e]		6	4	3	2[e]
Structural I Sheathing	5/16	1 1/4	6d	200	300	390	510	8d	200	300	390	510
		1	1 1/2 16 Gage	165	245	325	415	2 16 Gage	125	185	245	315
	3/8	1 3/8	8d	230[d]	360[d]	460[d]	610[d]	10d	280	430	550[f]	730
		1	1 1/2 16 Gage	155	235	315	400	2 16 Gage	155	235	310	400
	7/16	1 3/8	8d	255[d]	395[d]	505[d]	670[d]	10d	280	430	550	730
		1	1 1/2 16 Gage	170	260	345	440	2 16 Gage	155	235	310	400
	15/32		8d	280	430	550[f]	730	10d	280	430	550[f]	730
		1 3/8	10d	340	510	665[f]	870	—	—	—	—	—
		1	1 1/2 16 Gage	185	280	375	475	2 16 Gage	155	235	300	400
		1 1/2	10d	340	510	665[f]	870	10d	—	—	—	—
Sheathing, Plywood Siding[g] except Group 5 Species	5/16 or 1/4[c]	1 1/4	6d	180	270	350	450	8d	180	270	350	450
		1	1 1/2 16 Gage	145	220	295	375	2 16 Gage	110	165	220	285
	3/8	1 1/4	6d	200	300	390	510	8d	200	300	390	510
		1 3/8	8d	220[d]	320[d]	410[d]	530[d]	10d	260	380	490[f]	640
		1	1 1/2 16 Gage	140	210	280	360	2 16 Gage	140	210	280	360
	7/16	1 3/8	8d	240[d]	350[d]	450[d]	585[d]	10d	260	380	490[f]	640
		1	1 1/2 16 Gage	155	230	310	395	2 16 Gage	140	210	280	360
	15/32	1 3/8	8d	260	380	490[f]	640	10d	260	380	490[f]	640
		1 1/2	10d	310	460	600[f]	770	—	—	—	—	—
		1	1 1/2 16 Gage	170	255	335	430	2 16 Gage	140	210	280	360
	19/32	1 1/2	10d	340	510	665[f]	870	—	—	—	—	—
		1	1 3/4 16 Gage	185	280	375	475	—	—	—	—	—

Full 2015 SDPWS Table 4.3A.

PANEL GRADE	MINIMUM NOMINAL PANEL THICKNESS (inch)	MINIMUM FASTENER PENETRATION IN FRAMING (inches)	PANELS APPLIED DIRECT TO FRAMING					PANELS APPLIED OVER 1/2″ OR 5/8″ GYPSUM SHEATHING				
			NAIL (common or galvanized box) or staple size[k]	Fastener spacing at panel edges (inches)				NAIL (common or galvanized box) or staple size[k]	Fastener spacing at panel edges (inches)			
				6	4	3	2[e]		6	4	3	2[e]
Structural I Sheathing	5/16	1 1/4	6d (2 × 0.113″ common, 2″ × 0.099″ galvanized box)	200	300	390	510	8d (2 1/2″ × 0.131″ common, 2 1/2″ × 0.113″ galvanized box)	200	300	390	510
		1	1 1/2 16 Gage	165	245	325	415	2 16 Gage	125	185	245	315
	3/8	1 3/8	8d (2 1/2″ × 0.131″ common, 2 1/2″ × 0.113″ galvanized box)	230[d]	360[d]	460[d]	610[d]	10d (3″ × 0.148″ common, 3″ × 0.128″ galvanized box)	280	430	550[f]	730
		1	1 1/2 16 Gage	155	235	315	400	2 16 Gage	155	235	310	400
	7/16	1 3/8	8d (2 1/2″ × 0.131″ common, 2 1/2″ × 0.113″ galvanized box)	255[d]	395[d]	505[d]	670[d]	10d (3″ × 0.148″ common, 3″ × 0.128″ galvanized box)	280	430	550[f]	730
		1	1 1/2 16 Gage	170	260	345	440	2 16 Gage	155	235	310	400
	15/32	1 3/8	8d (2 1/2″ × 0.131″ common, 2 1/2″ × 0.113″ galvanized box)	280	430	550	730	10d (3″ × 0.148″ common, 3″ × 0.1218″ galvanized box)	280	430	550[f]	730
		1	1 1/2 16 Gage	185	280	375	475	2 16 Gage	155	235	300	400
		1 1/2	10d (3″ × 0.148″ common, 3″ × 0.128″ galvanized box)	340	510	665[f]	870	10d (3″ × 0.148″ common, 3″ × 0.128″ galvanized box)	—	—	—	—
Sheathing, plywood siding[g] except Group 5 Species	5/16 or 1/4[c]	1 1/4	6d (2″ × 0.113″ common, 2″ × 0.099″ galvanized box)	180	270	350	450	8d (2 1/2″ × 0.131″ common, 2 1/2″ × 0.113″ galvanized box)	180	270	350	450
		1	1 1/2 16 Gage	145	220	295	375	2 16 Gage	110	165	220	285
	3/8	1 1/4	6d (2″ × 0.113″ common, 2″ × 0.099″ galvanized box)	200	300	390	510	8d (2 1/2″ × 0.131″ common, 2 1/2″ × 0.113″ galvanized box)	200	300	390	510
		1 3/8	8d (2 1/2″ × 0.131″ common, 2 1/2″ × 0.113″ galvanized box)	220[d]	320[d]	410[d]	530[d]	10d (3″ × 0.148″ common, 3″ × 0.128″ galvanized box)	260	380	490[f]	640
		1	1 1/2 16 Gage	140	210	280	360	2 16 Gage	140	210	280	360
	7/16	1 3/8	8d (2 1/2″ × 0.131″ common, 2 1/2″ × 0.113″ galvanized box)	240[d]	350[d]	450[d]	585[d]	10d (3″ × 0.148″ common, 3″ × 0.128″ galvanized box)	260	380	490[f]	640
		1	1 1/2 16 Gage	155	230	310	395	2 16 Gage	140	210	280	360
	15/32	1 3/8	8d (2 1/2″ × 0.131″ common, 2 1/2″ × 0.113″ galvanized box)	260	380	490	640	10d (3″ × 0.148″ common, 3″ × 0.128″ galvanized box)	260	380	490[f]	640
		1 1/2	10d (3″ × 0.148″ common, 3″ × 0.128” galvanized box)	310	460	600[f]	770	—	—	—	—	—
		1	1 1/2 16 Gage	170	255	335	430	2 16 Gage	140	210	280	360
	19/32	1 1/2	10d (3″ × 0.148″ common, 3″ × 0.128″ galvanized box)	340	510	665[f]	870	—	—	—	—	—
		1	1 3/4 16 Gage	185	280	375	475	—	—	—	—	—
			Nail Size (galvanized casing)					Nail Size (galvanized casing)				
	5/16[c]	1 1/4	6d (2″ × 0.099″)	140	210	275	360	8d (2 1/2″ × 0.113″)	140	210	275	360
	3/8	1 3/8	8d (2 1/2″ × 0.113″)	160	240	310	410	10d (3″ × 0.128″)	160	240	310[f]	410