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What is a 10d common nail? AGAIN

Contributed by Williston L. Warren, IV – S.E., SECB, Treasurer

Recently, I have had several discussions about how code requirements are not code requirements. One specific discussion included the generation of structural calculations for an existing building where the construction does not comply with the permitted construction drawings and in some cases with specific code requirements. The justification usually includes the excuse that structural engineers are commonly overly conservative and that the buildings described in the construction documents exceed the minimum requirements of the Building Code.

Now a little review of the non-negotiable points ……

The Building Code in Section 101.2 states "The purpose of this code is to provide minimum standards to safeguard life or limb, health, property and public welfare by regulating and controlling the design, construction, quality of materials, use and occupancy, location and maintenance of all buildings and structures within this jurisdiction and certain equipment specifically regulated herein."

Section 101.3 states "Scope. The provisions of this code shall apply to the construction, alteration, moving, demolition, repair, maintenance and use of any building or structure within this jurisdiction, except work located primarily in a public way, public utility towers and poles, mechanical equipment not specifically regulated in this code, and hydraulic flood control structures." This Section continues in the third paragraph "Where, in any specific case, different sections of this code specify different materials, methods of construction or other requirements, the most restrictive shall govern."

The Administration chapter of the code also describes what constitutes violations of the code, that the Powers of the Building Official is that of a law enforcement officer, and that the Building Official is not liable for any omission or injury resulting from an omission in the construction when acting in good faith and without malice. This liability section states "This code shall not be construed to relieve from or lessen the responsibility of any person owning, operating or controlling any building or structure for any damages to persons or property caused by defects, nor shall the code enforcement agency or its parent be held as assuming any such liability by reason of the inspection authorized by this code or any permits or certificates issued under this code."

The Code in Section 104.2.1 Powers and Duties of Building Official. General, also states that "The building official is hereby authorized and directed to enforce the provisions of this code. The building official shall have the authority to render interpretations of this code and to adopt policies and procedures in order to clarify the application of its provisions. Such interpretations, policies and procedures shall be in compliance with the intent and purpose of this code. Such policies and procedures shall not have the effect of waiving requirements specifically provided for in this code."

Section 106.4.1 Permits Issuance. Issuance states “When the building official issues the permit where plans are required, the building official shall endorse in writing or stamp the plans and specification APPROVED. Such approved plans and specifications shall not be changed, modified or altered without authorizations from the building official, and all work regulated by this code shall be done in accordance with the approved plans.”

Once the Code is adopted by city, county, or state ordinances or laws the following apply to the design and construction of every building:

1. The Code is the minimum standard for building design and construction.
2. The most restrictive section of the Code shall govern.
3. That any construction omissions or defects are not the building official’s responsibility.
4. That inspections do not lessen builder’s responsibility for defects in construction.
5. That the building official is a law enforcement officer.
6. That interpretations of the Code must be consistent with the intent and purpose of the Code.
7. The construction is required to comply with the permitted drawings unless noted by the building official.

I do not see a lot of wiggle room in these 7 requirements, and I believe that this is intentional to take the creativeness out of the design and construction process.

Those that defend poor or deficient construction regularly claim that “there is testing that shows” and justify their design based on test results and reporting that is incomplete or inconclusive. For example: After the 1994 Northridge Earthquake, testing of timber-framed buildings were performed by universities across the country to examine not only component but system behavior during cyclic loadings. These investigations included the determination of the performance of stucco and drywall covered framed walls, subjected to cyclic loads and cyclic testing, to force transfer behavior of anchor bolted sill plates of shear panels. One finding for the sill plate testing is that the behavior and capacity for the sill plate configurations without nuts on the anchor bolts is similar to tested configurations with tightly installed anchor bolt nuts.

These findings are brought up regularly in discussions of the Code requirements for anchor bolt nuts and are used to justify a myriad of conditions that are not allowed by the Code. This justification dismisses the fact that, when this issue has been brought up during the code development process, it was rejected and states that nuts on anchor rods are necessary. Perhaps what our profession really needs is an extensive discussion on construction tolerances and the Code provided minimum requirements.

If you investigate 2 out of 10 shearwalls, and you find problems at those locations, is that an indication of non-compliant construction? If you specify concrete reinforcement spacing of 5 inches on center, is 6 inches on center acceptable? Remember, all construction is required to be Code compliant, so it is hard to justify that anything else is sufficient.

I believe that we as a profession really do not understand the effects construction tolerances have on the engineering behind the drawings.

Our profession is continuing to strive to understand material performance under loadings in an attempt to economize and provide for the safety of the occupants and protect the investments made by the building owners. I question whether the constructors of these buildings understand that the engineering design of today is not that of twenty years ago. The loadings are better understood and now have less of a "confusion factor" in them, and this is especially true for those infrequent but high demand loadings such as lateral loads resulting from ground motion and winds.

Another issue we should be concerned with is whether a structural component designed 25 plus years ago going to perform the same or in a similar fashion compared to one designed today? I am not sure they would perform similarly based on the advances in the understanding of expected loading conditions, material behavior, and, in the case of timber, the actual material changes over the past 30 years when subjected to loading and material changes. I do believe these differences would also vary across the materials and loadings, but do the constructors understand the differences in 25-plus year-old designs versus now in the construction, or do they see them as the same. Is a reinforced concrete element designed using Allowable Stress method versus one designed using Ultimate Strength, going to perform the same?

Let me demonstrate this point: A 10d common nail nailing a timber sheathing panel to framing to resist lateral loads. The NCSEA Basic Education Committee has identified timber engineering design as a subject not frequently available in a large section of universities and, as a result, is, in too many cases, the practitioners learn-by-doing. The example of a nail attaching two pieces of wood would appear to be a simple example, and it is, since almost everyone has used a nail to attach two pieces of wood.

In the 1997 UBC, Table 23-II-I-1, "Allowable Shear for Wind or Seismic Forces …… for Wood Structural Panel Shear Walls ……", the value for 15/32" Structural I sheathing with 10d common nails vary by the spacing of the nails, and the table has a column "Minimum Nail Penetration in Framing" value of 1-5/8 inches. The 1997 UBC Table 23-II-C-2 in 3 locations defines a 10d common nail as having a 0.148-inch Nail Diameter (D) and a 3-inch Nail Length (L).

Table 23-II-I-1 also includes the nail and spacing shearwall values for sheathing installed over up to 5/8 of an inch of gypsum sheathing, where a 3-inch-long nail installed in 15/32-inch-thick over 5/8-inch gyp board gives you a penetration of that nail of 1.91 inches, a little more than a quarter of an inch of penetration over the noted minimum. With a nail spacing of 2 inches and using 15/32 thick sheathing without gyp board the allowable shear is 870 plf. The same nail, spacing and sheathing thickness over gyp board is 730 plf, a 16% reduction. When the spacing is changed to 6 inches on center there is a reduction of 17% in the allowable shear.

Using the same table, it is interesting to note that when you attach 7/16 inch Structural I sheathing with nails at 6 inches on center with the sheathing applied directly to framing of the allowable shear of 255 plf. If the sheathing is applied over 5/8 gypsum the allowable shear is 280 plf. But the "directly applied" requires the use of 8d common nails and the gyp board application requires a 10d nail. Section 2818.3 Nails and Spikes subsection 2318.3.3 Spacing and penetration has a provision "Nails and spikes for which the gages or lengths are not set forth in Tables 23-III-C-1 and Tables 23-III-C-2 shall have a minimum required penetration of not less than 11 diameters and loads may be interpolated."

The Fastening Schedule in table 2304.9.1 of the 2006 IBC defines in multiple locations that a 10d nail has a diameter of 0.148 and a length of 3 inches. The specific diameter and length is included in this table every time a 10d common nail is mentioned. The 2006 IBC Table 2306.4.1 Allowable Shear for Wood Structural Panel Shear Walls ….." and again every mention of a 10d common nail include a "(3" x 0.148 common, 3" x 0.128 galvanized box)". When looking at the 2006 shearwall tables, strangely, the load values are the same for different nail spacing for each sheathing thicknesses.

Other resources also define a 10d nail. In ASTM F-1667 Standard Specifications for Driven Fasteners: Nails, Spikes, and Staples, Table 15 Type I, Style 10 – Common Nails, steel wire, defines a 10d common nail as a length of 3 inches and a diameter of 0.148 inches. Reviewing my American Institute of Timber Construction Timber Construction Manual Second Edition 1974, page 5-65, Table 5.19 describes a 10d common nail has having length of 3 inches and a wire diameter of 0.148 inches.

OK, I am sure many of you are saying, "Can't you calculate this using the NDS". Sure you can – but with care. Consider the following: First, 2005 NDS Table 11Q which provides the common wire nail, single shear (two members) with wood structural panel side members with a specific gravity of 0.50. Using the NDS Z from 11Q and comparing it to the nail forces from the code shear panel table noted above, the table values for sheathing with 15/32" thickness, 3" long 10d common nails vary between 121.8% and 142.8% for the table values, versus Z with the table values larger. So the tables are using larger nail loads than you can calculate using the general dowel expressions for nails, and the differences are not predictable.

More times than I like to think of, I am asked "What is the capacity" of a given configuration versus the specified configuration on the permitted drawings. With many materials, this is fairly direct for assemblies consisting of various components as in with concrete where the variables are considered in the analysis, but what about that of an assembly that uses table values out of the code. Often this discussion is about a shear panel specified to have 10d common nails spaced at 4 inches on center on the boundaries and edges, and was observed to have 2-1/8 inches long 0.148 inches in diameter nails with one boundary having an average spacing of 3.2 inches on center of a 24-inch-long distance, edge nailing condition of 4.3 inches on center and yet another boundary nailing found to be an average of 1.65 inches on center. In addition, the boundary nailing into the pressure-treated sill plate is not corrosive resistant, as required by the Code.

So what is the capacity of this assembly? My response is that this is one of hundreds of thousands of incorrectly constructed shearwalls that has not been tested, because the Code requires the builder to comply with the requirement from Section 106.4.1. I believe that is why this section of the Code exists to eliminate the re-Engineering of work performed by licensed Engineers by constructors that most likely lack the perspective, knowledge and experience to understand the situation.

The discussions do involve a lot of non-technical individuals, but they have retained Structural Engineering consultants, they make a circular discussion due to the belief that nail sizes choices are made in the field by adding the sheathing thickness to the minimum penetration. There have been tests performed on timber sheathed panels subjected to cyclic lateral loads, and it was observed that withdrawal of the nail is a significant response component. And according to the codes, the withdrawal capacity is a function of its length and shorter nails would have less withdrawal capacity to draw on then the required length.

So which is it? If you make a trip to the building supplier and look at nails, you will also find that nails, independent of diameter, come in lengths of a quarter to an eighth of an inch increments. Due to the number of times we observe short nails, just due to the probability, my suggestion is that any engineer designing timber buildings with timber shear panel to resist lateral load, you need to check nail lengths if you specify 10d common nails and, as the current code does, clearly specify the diameter and length of all fasteners. Now looking back at my reinforced concrete example of varying spacing of that reinforcing, current understanding and analysis tools for reinforced concrete allows for considering these differences, where assemblies such as timber sheathed shearwalls do not, the capacities in the Code are a result of testing specific configurations.

Another thought, and you will not like it, a new cottage industry of engineers, or perhaps not engineers, has grown to review your submittal and submit a report to the building owner or whomever paid you. That report could conclude that the design is overly conservative and requires the building owner to spend more money to build the building that it should and you should help pay the difference because it was because of you that there is a difference.

If it is acceptable to have the judicial process accept construction that does not comply with 106.4.1, and the variation is subject to interpretation by those not educated in the profession or by those who built this condition, then why do building departments require a responsible licensed engineering professional and that that responsible engineer remain responsible for that design? Also, why do we then have to endure plan review processes that vary in both quality and depth? Why are so many of use volunteering time in Code development, reviewing proposals and attending hearings?

So is the “safeguard life or limb, health, property and public welfare” purpose of the Code so important? And yes my discussion has been about items that are only included just to make engineers happy, correct? And yes many of these components are included in the construction to allow the building to resist loading it may never see in its life time. Then the components designed to resist gravity loads get tested often and it is within the understanding of the builders because, if not, it fails when they walk on it. However, the lateral force resisting system is different and, unfortunately, can be a source of “savings” for the builders.