Construction Issues

discussion of construction issues and techniques

What is a 10d Common Nail? AGAIN

Part 2

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Have you ever been in a discussion, adversarial or entertaining, with a non-engineer or even an engineer, about what code requirements exist for construction activities? For example, a discussion about 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.

What follows is a review of what should be considered non-negotiable points.

The 2012 *International Building Code* (IBC), in Section 101.3, states "The purpose of this code is to establish the minimum requirements to provide a reasonable level of safety, public health, and general welfare through structural strength, means of egress facilities, stability, sanitation, adequate light and ventilation, energy conservation, and safety to life and property from fire and other hazards attributed to the built environment and to provide a reasonable level of safety to firefighters and emergency responders during emergency operations."

IBC Section 101.2 states "Scope. The provisions of this code shall apply to the construction, alteration, relocation, enlargement, replacement, repair, equipment, use and occupancy, location, maintenance, removal and demolition of every building or structure or any appurtenances connected or attached to such buildings or structures."

The administration chapter of the code also describes what constitutes violations of the code, that the power of the building official is that of a law enforcement officer, and that the building official is not liable for any injury resulting from an omission in the construction when acting in good faith and without malice. This liability section states, "The building official, member of the board of appeals or employee charged with the enforcement of this code, while acting for the jurisdiction in good faith and without malice in the discharge of the duties required by this code or other pertinent law or ordinance, shall not thereby be civilly or criminally rendered liable personally and is hereby relieved from personal liability for any damage accruing to persons or property as a result of any act or by reason of an act or omission in the discharge of official duties."

IBC Section 104.1, Powers and Duties of Building Official, 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."

IBC Section 107.3, Examination of Documents: "The building official shall examine or cause to be examined the accompanying submittal documents and shall ascertain by such examination whether the construction indicated and described is in accordance with the requirements of this code and other pertinent laws or ordinances."

Once the code is adopted by city, county, or state ordinances or laws, the following apply to 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 governs.
3) Any construction omissions or defects are not the building official's responsibility.
4) Inspections do not lessen the builder's responsibility for defects in construction.
5) The building official is responsible for determining if the construction is in accordance with the code.
6) 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.

There doesn't seem to be a lot of wiggle room in these seven requirements. In the author's opinion, this looks to be intentional in order to take contractors' creativeness out of the design documents and construction process.

The engineering professionals that defend poor and deficient construction regularly claim that "there is testing that shows…" This claim is used to justify the construction based on these test results, even knowing that these reports are incomplete or inconclusive. For example, after the 1994 Northridge Earthquake, testing of timber-framed buildings was performed by universities across the country to examine not only component performance 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, and 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 are similar to tested configurations with tightly installed anchor bolt nuts.

These findings are brought up regularly in discussions of 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 the code still states that nuts on anchor rods are necessary. Perhaps what our profession needs is an extensive discussion on construction tolerances and the code provided minimum requirements.

If you investigate two out of 10 shear walls, and you find problems at those shear wall 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.

As a profession, we 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 occupants, and protect the investments made by building owners. We can 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, 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 is going to perform the same or in a similar fashion compared to one designed today. Are we 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? These differences would also vary across the materials and loadings. But, do the constructors understand the differences in 25-plus-year-old designs versus current designs in construction or do they see them as the same? Is a reinforced concrete element designed using the allowable stress method versus one designed using ultimate strength going to perform the same?

The NCSEA Basic Education Committee has identified timber engineering design as a subject not frequently available in a significant number of universities and as a result, in too many cases, practitioners learn-by-doing. The example of a nail attaching two pieces of wood would appear to be a simple example because almost everyone has used a nail to connect two pieces of wood. The previous article on this subject discussed the point of connecting wood structural panels to framing to resist lateral loads with a 10d common nail. The building code and current AWC *Special Design Provisions for Wind and Seismic* (SDPWS) clearly define the length of a 10d common nail as 3 inches long and the minimum penetration of that 3-inch long nail.

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 American Institute of Timber Construction *Timber Construction Manual*, Second Edition 1974, page 5-65, Table 5.19 describes a 10d common nail as having a length of 3 inches and a wire diameter of 0.148 inches.

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OK, you are probably saying, "Can't you calculate this using the NDS?" Sure you can – but with care. First, you need to consider that the information in the shear wall tables is a product of testing versus the results you get from the calculations, and there is a difference.

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 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? Frequently, this discussion is about a wood structural panel shear wall specified to have 10d common nails spaced at 4 inches on center on the boundaries and edges. This example was observed to have 2⅛-inch long by 0.148-inch 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. Also, 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? This is one of the hundreds of thousands of incorrectly constructed shear walls that have not been tested because the code requires the builder to comply with the requirement of Section 107.4 which states: "**Amended construction documents**. Work shall be installed in accordance with the *approved construction documents,* and any changes made during construction that are not in compliance with the *approved construction documents* shall be resubmitted for approval as an amended set of *construction documents*." (Emphasis added by author.) Is this 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 size choices are made in the field by adding the sheathing thickness to the minimum penetration. There have been tests, by various sources, performed on wood structural panel shear walls subjected to cyclic lateral loads and it was observed that withdrawal of the nail is a significant response component. Moreover, according to the codes, the withdrawal capacity is a function of its length. Shorter nails would have less withdrawal capacity to draw on than the required length.

So which is it? If you make a trip to the building supplier and look at nails, you find that nails, independent of diameter, come in lengths of a quarter to 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 wood structural panel shear walls to resist lateral loads needs to check nail lengths if 10d common nails are specified and, as the current code does, clearly specify the diameter and length of all fasteners. Now consider a reinforced concrete example of varying spacing of reinforcing bars. With the current understanding of reinforced concrete, analysis tools are available that allow for such variation and determination of constructed capacities. Assemblies such as timber sheathed shear walls do not have these tools. Also remember that the capacities in the code are a result of testing specific configurations, and do not include all combinations and permutations.

Another thought, and you may 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 whoever paid you. That review report could conclude that the original design is overly conservative, requires the building owner to spend more money to build than it should, and you (the Engineer) 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, involving judges, juries, lawyers and other "experts," accept construction that does not comply with 107.4, and the variation is subject to interpretation by those not educated in the profession or by those who improperly build, then why do building departments require that a responsible licensed engineering professional 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 us volunteering time in code development, reviewing proposals, and attending hearings?

So is the "*reasonable level of safety, public health, and general welfare*" purpose of the code so important? Many will say that this is important to engineers and, yes, my discussion has been about items that are only included just to make engineers happy, correct? Moreover, yes, many of these components are included in construction to allow the building to resist loading it may never see in its lifetime. Also, components designed to resist gravity loads get tested often and they are within the understanding of the builders because, if not, they fail when walked on. However, the lateral force resisting system is different and, unfortunately, can be a source of "savings" for builders.

Most evening news programs include a story about some natural loading conditions on structures such as floods, tornadoes, and occasionally earthquakes; many of us work actively to reduce the "loss of life" aspects of these loadings. With this confusion, it could come down to one of the following:

1) The building code is a collection of recommendations and happy wishes. Adoption of the code by ordinance is merely a pro forma measure. What nail size to be used in all the construction underway nationally is an individual exercise in simple math performed multiple times a day. Nail spacing of shear wall panels does not need to be as described by the drawings – whatever is provided is good enough because the panels really will not ever see the lateral loads for which they are designed. Use of corrosion resistive nails in pressure treated lumber is also unnecessary because, even though the code requires pressure treated lumber on concrete slabs due to water, we all know there really will not be any water ever. And just so you can sleep at night, remember, there is a ten-year statute on construction litigation for the project.
2) OR, is the building code the minimum requirement for construction as it states? And, when it notes that the heads of nails shall be installed with the crown of the nail flush with the sheathing, it means it. Any other requirement that accepts some over-driven nails and some under-driven would require an engineer be observing with calipers to measure each installation when they vary from flush. As for nail lengths, that only one length should be used for each nail size, so the framer does not need someone to oversee the minimum penetration and sheathing thicknesses. Moreover, that nail spacings be installed as specified, not accepting just what ends up in the field.

Is there a specific and uniform construction standard, or is it non-standard or non-uniform? Which is it?▪

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