Construction Issues

discussion of construction issues and techniques

Good Design Should Consider Poor Execution

By John Bouldin and John "Buddy" Showalter, P.E.

An implicit assumption in the design of wood framed structures is that proper construction methods are followed during the implementation of these designs. It is not appropriate to suggest that designers are responsible for anticipating all the different ways that framing can be incorrectly installed, nor should sloppy installation techniques become a design criterion of light-frame wood construction. However, there are several general categories of construction defects of which designers should be aware. First (and most prevalent) are material handling, installation, and remodeling errors; second are system design oversights. These defects may affect serviceability and structural integrity, but may not manifest symptoms at all when exposed to below-design-load conditions. While many of these issues exist with traditional "stick-frame" construction, the consequences are often more serious with engineered wood products (EWP) designed to span greater distances or carry greater loads. Also, layouts and rooflines are just more complicated than they used to be, and contractors with experience building "stick-frame" may try to apply that experience incorrectly to EWP framing.

This article aims to explore several issues commonly found in light-frame construction. Among the many problems commonly found, the only types that will be addressed in this article include improper installation of EWP's, insufficient bearing, poorly planned load paths, and hanger/connector problems.

Quality Control (…but I've been doing it this way for 20 years)

In Virginia, builders are generally required to provide a one year warranty on most aspects of the home, although this can be waived if done so in the proper form in the sales contract. This could mean that a builder's risk horizon for most homes is only one year. Certain builders may take this into consideration when deciding what installation procedures to follow, what quality control protocols are enforced, and when and how repairs are actually made when deficiencies are identified. Very few jurisdictions require licensure or certification of the framers who actually build light-frame construction, and there seems to be little incentive for the average framer to seek out and learn updated framing techniques to properly install today's framing materials. In fact, relatively few construction workers are even conversant in the terminology of EWPs. It has been the author's experience that most job-site superintendents, who are in a position to wield influence over installations, are more adept at project management than at quality control.

Figure 1.

Many municipal code inspectors do a good job with the limited resources available to them, but few would claim that existing inspection procedures are technically exhaustive and find all existing defects. Even significant structural deficiencies can go unnoticed during the normal inspection process. In the end, much of the quality control function falls to the builder or subcontractors, who must rigorously enforce code and installation compliance upon themselves.

Common Installation Issues

Generally, a building code is in effect in most jurisdictions, but not all, as evidenced by pre-Katrina Louisiana. In addition, EWPs and wood trusses have individual specifications that must be adhered to, and local jurisdictions may add ordinances on top of it all. Prescriptive codes do not always match the manufacturer's minimum installation requirements. EWPs and wood trusses are normally designed by different individuals than the persons who design the overall structures and, in some cases, plans may not be rendered in sufficient detail to prevent confusion as to proper installation methods, especially when there appear to be competing priorities (e.g. the need to run pipes, etc. through I-joists and trusses is one priority, and not damaging them is another).

Figure 1 shows a live-load bearing truss system with a plumbing drain pipe installed through the bottom chords of adjacent trusses. While these bottom chords strongly

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Figure 2.

Figure 3.

Figure 4.

Figure 5.

Figure 6.

Figure 7.

resemble dimension lumber floor joists, they are not that simple. In this example, we must consider at least three possibilities: 1) the plumber erred in the installation by treating truss chords like dimension lumber joists; 2) the truss designer allowed for the reduction of cross section in the original truss design and thus there is no problem; or, 3) the system designer did not take into consideration that a plumbing drain had to be installed in this location, and the plumber had little choice as to where the pipe had to go. Each of these possibilities plays a role in the design, inspection, and performance of the completed framing system. Designers are encouraged to think beyond the structural skeleton to anticipate and provide solutions for accommodating HVAC, plumbing, and electrical systems.

Figure 2 shows a laminated veneer lumber (LVL) beam that has been end-notched above a bearing point. EWP manufacturer specifications prohibit notching of EWP beams to prevent misapplication. While industry standards such as the *National Design Specification® (NDS®) for Wood Construction* permit notching up to ⅖ the depth of the member on the compression side of the beam, it is important that the designer clearly indicate if a condition like this is permitted on the design drawings.

A serious example of LVL modification can be seen in *Figure 3*, where the entire header across a garage door opening has been notched. When this issue was raised with the builder, his comment was that the remaining depth was sufficient to carry the load. Either the designer didn't consider the effect of a deeper header on the available opening height, or the plans were detailed poorly and the header was misplaced within the wall elevation. But most likely, the builder simply made a mistake and decided it was too expensive to consult a design professional regarding the adequacy of the beam.

Figure 4 shows a series of I-joist rafters that were installed like dimension lumber rafters. As can be seen, each I-joist is improperly notched in a 'bird's mouth' fashion, which so weakened the roof system that it had to be replaced. Proper specifications exist to create a bird's mouth, but no I-joist manufacturer allows this type of installation. Including the proper detail on the plans would have been a good approach by the building designer. The cost of replacement could have fallen on the designer had the detailing not been clearly called out. This also raises an interesting dilemma for the project manager – if this was the last house in the subdivision to be built, how many other built and delivered homes may harbor this same defect?

Figure 5 shows a bearing condition that is common to all types of framing. The joists properly bear the minimum required 1.5 inches on the sill plate, but the sill plate itself overhangs the inside of the foundation wall by 1.5 inches. This subjects the sill plate to cross-grain bending stresses – one of the weakest properties of wood. This condition may be adequate depending on cross grain bending stresses, but the design or product literature would have to clearly indicate that the material (typically only an EWP) can handle these stresses. It is interesting to note that the International Residential Code (IRC) requires a bearing length of 1.5 inches for sawn lumber joists resting on a wooden surface, but is silent on whether that surface must be fully supported. It's also worth noting that many I-joist manufacturers require 1.75 inches of bearing.

A problem situation is shown in *Figure 6*, where an EWP rim board is properly doubled across the top of the foundation window so as to create a header to support the joists. An obvious problem is that point load blocking is resting on top of the vinyl window directly. It is generally agreed that vinyl window jambs are insufficient to bear structural loads. This happens more often than might be expected, and may be due to mis-location of the window opening in the foundation wall by

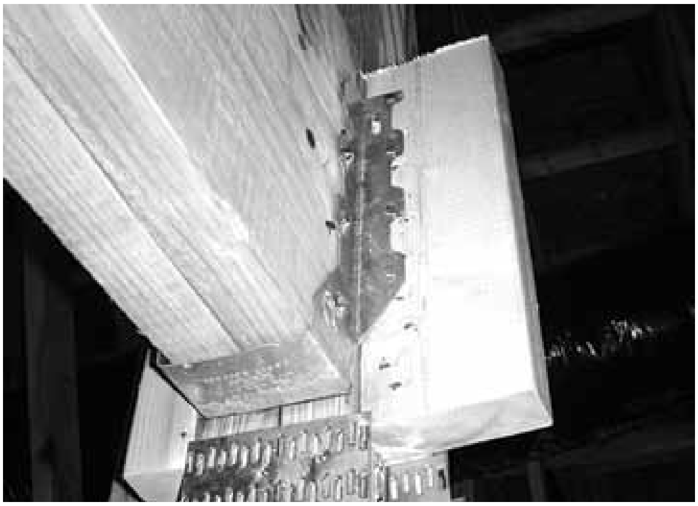

Figure 8.

Figure 9.

the foundation contractor, but could also be due to an oversight in the original design of that load path.

Figure 7 (page 31) highlights an issue that may be more often associated with a design problem than with an installation issue. There is a vertical floor offset in two adjacent rooms, and the installer used an improper support strategy to handle this. Sixty percent of the holes in the joist hanger are empty because there is no structural member into which they can be properly nailed. Another type of dubious solution, in cases where the joists are lower than the beam, is to install a plywood sheet nailed to the beam, but dropped below it, to accommodate the holes in the joist hangers. Perhaps this can be suitably designed, but in the many instances the authors have encountered this situation, it appears to have been an after-thought accommodation. Designers are encouraged to give consideration to changes in framing elevations such as these, and to provide details as needed so that adequate support for framing and hangers is provided.

Figure 8 demonstrates another very common deficiency – that of the incorrect use of a joist hanger. In this example, the outside flanges of the hanger have nothing structural to attach to, so the framers rather creatively added some 'rabbit ears' on the sides of the supporting truss member to hold the beam up. A concealed flange hanger is the proper hanger for this situation, but was not used here.

In the last example, *Figure 9* shows a common retrofitted installation of an I-joist header where the original I-joist encountered an obstruction and had to be cut. The primary support is provided by top flange hangers that must be secured to the tops of the adjacent joist flanges. In each of the two cases in this photo, the installers attempted to force the top tabs of the hanger in between the bottom of the existing subfloor and the top of the I-joist flange after the subfloor had been glued and screwed in place. Clearly, a face-mounted hanger would have been more appropriate.

Future Needs

This brief discussion fails to capture the depth and breadth of the ramifications of construction defects in light-frame wood construction. But the patterns presented do point to the following needs that can be influenced by the designer:

a) A deeper consideration of component installation problems at the system design level;
b) Consideration of utilities and trades in system design;
c) Need for proper and adequate detailing of both standard and non-standard framing conditions to help prevent jobsite creativity to solve the problems created by the lack of clear guidance;
d) Need to find and fix problems so the structure performs as designed;
e) A need to design components such that their installation specifications are sensitive to the realities of in-the-field conditions and limitations.

Conclusion

As stated earlier, it is not appropriate to suggest that designers are responsible for anticipating all the different ways that framing can be incorrectly installed, nor should sloppy installation techniques become a design criterion of light-frame wood construction. The design community cannot, however, afford to assume that the average framing crew is familiar enough with appropriate framing practices to figure out complex framing conditions or to appropriately field-modify a component system to produce as-designed performance. In the authors' experience, few (if any) wood-framed buildings actually meet all code and manufacturer requirements. It is important to remember that building codes are **minimum** safety standards for light-frame construction – they are not lofty goals to which builders aspire. End users and owners of these buildings have a right to assume that the framing meets structural and serviceability minimums as articulated in the codes.

Designers are encouraged to give greater consideration to the needs of HVAC, plumbing, and electrical systems in their designs to provide adequate opportunities for mechanical and electrical runs. Additionally, greater emphasis on clearly detailing the framing at more complicated framing conditions such as changes in framing elevation or after-the-fact repairs, as well as ensuring that the load path is complete and free from obstructions is warranted and can save both time and money for all involved.

The implications of these common defects are important aspects in the design of light frame wood structural systems, but the solutions are not simple, nor readily apparent. Further research should be done to enhance understanding of the causes and scope of these issues, and the magnitude of hidden potential defects.▪

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