Weyerhaeuser

TrusJoist
ENGINEERED WOOD PRODUCTS

Saving a Few Dollars Can End up Costing Thousands

The hazards of deviating from structural frame specifications

When looking for ways to boost the bottom line in construction, it can seem like swapping out a given I-joist, beam or header with a lower-priced alternate is an easy way to reduce costs. But, it is usually not possible to know all the factors that went into the designer's decision to specify a given member. So trying to select an equivalent product at a lower price is a gamble that can often lead to greater liability, additional labor and material costs, and disappointed home and building owners.

What does "specification" really mean?

Although building plans typically allow "equivalent or better" structural members as substitutions, the specified ("spec'd") product has been evaluated in detail by the architects and engineers to ensure the member meets exacting load and performance requirements and will help provide a high-quality, long-lasting structure.

One way to think of the importance of following the specification is to look at the dictionary definition of the word "specific," which is: "something peculiarly adapted to a purpose or use." Similar words to "specific" underscore this point: distinctive, special, particular, exact, dead-on, individual and precise. In short, a material specification tells us which products are uniquely suited to a project's requirements and are known to perform as required.

How substitutions can go wrong

While it is crucial to follow the specs throughout the structure, two applications where using substitute products frequently cause problems for builders are: 1) changing out prefabricated wood I-joists in floors, and 2) installing multi-ply beams in place of solid-section engineered wood beams.

<u>Floor joists</u>

To provide a stable, solid-feeling floor, architects and designers carefully evaluate multiple variables, including the required loads throughout the structure, a room's intended use, the floor covering to be used, as well as the homeowners' expectations. Many of these factors are not apparent just from viewing the plans. For example, a floor

that appears to be overbuilt may potentially reflect an owners' desire to place heavy furniture or equipment in the room or eventually remove an interior load-bearing wall.

The structural members that are specified in a plan are a result of careful analysis of materials and the job-specific conditions. Engineers and designers evaluate many critical design criteria, such as bending, shear, and deflection, for every load and member in the structure.

Additionally, loads must successfully transfer from the roof to the foundation. This involves the design of many connections and blocking and reinforcement elements, each specific to the properties of the member. So even if a joist has a similar span rating, it is difficult to know if the substitute has the same design and performance characteristics and will work in the plan as designed. The substitute may not be "equivalent or better."

Consider a plan that calls for 11⅞″ Trus Joist® TJI® 560 joists, spanning 16′-0″ and spaced 16″ on center. The allowable span for such joists is 23′-8″, based on 40 psf live load, 10 psf dead load and L/480 deflection limit. On the surface, it might seem acceptable to substitute an I-joist with a similar allowable span, but since design properties of products vary widely, there could be a serious compromise in floor system performance.

As seen in the following table, the two I-joists differ widely in some important design properties despite having similar allowable spans. The alternate I-joist has significantly lower design values, even though the allowable spans are similar. These differences could result in a floor system that feels bouncy or soft and could have potential structural problems as well.

11-7/8″ deep joists	Allowable Span*	Bending Moment (ft-lbs)	Vertical Shear (lbs)	EI (stiffness) (in.^{2}-lbs)
Specified Trus Joist® TJI® 560 joist	23'-8"	9,500	2,050	636
Alternate I-joist	22'-8"	6,940	1,420	547

* Based on 40 psf live load, 10 psf dead load, L/480 deflection limit and a 16" o.c. I-joist spacing.

In a real-world example from the eastern U.S., an architect specified TJI 560 joists for a large custom home, and the builder asked his dealer for a lower cost substitute. The dealer, recognizing the potential pitfalls, spoke with the builder and suggested that he stay with the joists that were specified. Ultimately, the builder purchased the less expensive, alternate joists from another dealer.

Once aware of the change, the architect alerted the builder that other builders who had made similar substitutions ended up with homeowner complaints about bouncy floors, plus there was a potential safety and liability issue from compromised structural integrity. To compensate for the decrease in performance of the substituted joists, the architect called for adding a beam and two extra columns.

So instead of saving money, the joist substitution created substantial added costs for the builder including:

- Paying the architect to rework the design
- Purchasing additional materials
- Using additional labor
- Putting the job on hold while a work-around was developed, and
- Losing homeowner satisfaction as a result of the two columns in their large room that was intended to be completely open.

Finally, the builder risked the loss of future business from the architect and homeowner due to the added costs, construction time, and hassle.

Engineered wood beams

Another problematic substitution is the field conversion of wide, solid-section PSL beams to multiple-ply LVL beams. In some regions, it has become common to see a 5¼″ x 16″ Parallam® PSL beam replaced with a three-ply 1¾″ x 16″ field-assembled LVL beam.

Based on the same design considerations stated for I-joists, it is important to remember that LVL and PSL have markedly different design properties. Simple substitutions based on PLF tables alone may have unforeseen structural and performance consequences. And in the case of multiple-ply beams substitutions, there is an additional design consideration. Even if all things were equal, multiple-ply beams differ from solid-section beams in the way they function internally.

A beam must act as one unified member in order to transfer loads correctly. If the LVL plies are not adequately connected to each other, one or two plies will end up carrying more load than the others and may result in a ply exceeding its capacity. This is especially true with side loaded beams when one side is loaded more heavily than the other, or when a point load exists on one side, such as a header framing into the side of the beam.

Inadequate connections between plies can compromise structural integrity. Too often, plies are glued and nailed in an ad-hoc fashion that creates an unreliable assembly. Contacting the architect or engineer to design an appropriate multi-ply beam assembly entails additional time and costs, likely negating any savings from the substitution.

Lesson learned

When considering a change from specs, it is essential to ensure the alternate product is actually “equal or better” for all design considerations. Since the specified materials are determined through careful design and engineering, all considerations may not be apparent from the plans. Simple substitutions based on span or PLF tables may not be adequate or appropriate. It is crucial to contact the original design professional for guidance.

As with other parts of the home—from roofing to windows—cutting corners on structural frame members can result in a cascade of additional work and costs to fix the problems it caused. It is true that you get what you pay for, and a lower price frequently means lower performance. It is simpler, less risky and usually more cost effective to follow the original spec.

Structural frame product specifications account for a multitude of complex loads and other variables, making it virtually impossible to make appropriate substitutions in the field.

The in-field substitution of lower-design value I-joists in this custom home required the costly addition of a beam and support columns, and potentially disappointed homeowners from the loss of clear space in this room.

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