Build Bigger by Starting Smaller

Engineered Wood Products Solve Design Challenges in Large Residences

By Chris Brandt, P.E.

In the 1300s, the New College, Oxford fellows planted a grove of oak trees. According to legend, they planned to use them centuries later to replace the dining hall's massive timber beams when they became beetle infested. Then, as now, large sawn structural timbers were hard to obtain.

Fortunately, engineered wood products have eliminated the need to use large trees for high-load carrying structural frame members. For large custom homes and wood-framed multi-family units, these materials can meet stringent structural demands without compromising architectural features.

Manufacturers can take trees apart into individual strands and bond these small pieces with high-strength resins to form stiff, straight, and consistent framing members. Engineers can specify materials such as laminated strand lumber (LSL) and parallel strand lumber (PSL) for beams, headers, columns, studs and other members. The manufacturing process allows for long lengths – up to 60 feet for some products.

High-strength and available in long lengths, PSL beams are well suited for open floor plans.

Structural Challenges

While the push for green construction will likely slow demand for mega-size suburban homes, the large custom-home market remains strong. Such homes – as well as townhomes, apartments, and condominiums – create many structural challenges.

Open Floor Plans

Large residential structures often have expansive interior spaces. Examples include great rooms in single-family homes, and common-use areas such as recreation rooms in multi-family buildings. Historically, designs incorporated numerous columns or interior load bearing walls to handle loads from upper stories and roofs. Absent massive timbers, sawn beams were often not up to the task due to insufficient length or girth. In some cases, meeting load requirements called for building up beams on site from multiple members.

PSL solves this challenge. For example, a 5.25 inch by18 inch 2.0E grade PSL ridge beam can support 1,000 plf (at 115% DOL) while spanning 24 feet between columns. Assuming a 40/15 loading condition and L/240 LL and L/180 TL deflection criteria, the resulting permissible building width is 36 feet and, in non-snow regions governed by a 20 psf roof live load, it can be upwards of 50 feet. Given that designers can use PSL beams in single spans, as well as cantilever and multi-span applications with no additional concerns in negative moment regions, the flexibility provided by PSL is significant.

For certain long-span floor or roof applications, LSL beams are also a good choice. When the demands of the application do not require the high strength of PSL, LSL is often a more economical option. Using the same example as above, a smaller 3.5 inch by 16 inch 1.55E grade LSL ridge beam can support the same 1,000 plf while spanning approximately 16 feet between columns. It is important to note that both PSL and LSL are proprietary products, and capacities vary by manufacturer.

Recent refinements to some LSL beams also further expand the options for engineers to meet architectural demands. For example, one type of beam can accommodate holes up to 4.625-inch diameter (in a 14-inch deep beam). Such LSL beams also have capacity for multiple holes. This feature provides engineers with a new way to address the challenge of accommodating the building trades, who often drill a hole in a beam for routing pipes, wires, or conduits without consideration for the potential impact on structural integrity. It also permits the designer to place utilities within the floor or roof cavity, without compromising the architectural appeal, with soffits and other methods for diverting penetrations around beams.

Tall Walls

Walls taller than 10 feet with many windows provide another design challenge in large single-family and multi-family homes. Residential designs increasingly include such walls in great rooms and entry foyers.

In many markets, tall wall designs use stacked walls since conventional studs are not readily available in lengths longer than 20 feet. A critical flaw with this approach is that stacking creates a hinge point susceptible to drywall cracks and leaks around windows. In some instances, window companies void their warranties in applications where the wall has not been engineered to provide the necessary strength and stiffness to protect the window assemblies from damage.

Using LSL studs, designers can incorporate single-length framing members in walls up to 30 feet high or higher, depending on the lengths stocked in local lumberyards. These long-length continuous pieces give engineers a readily available solution for avoiding the hinge point. They are straight along their entire length, resulting in clean wall lines and minimal culling at the jobsite. Going beyond long lengths and uniformity, LSL studs are also available with a high allowable bending strength and stiffness, which is important when designing for out of plane wind loads. Some manufacturers even provide software, enabling efficient and quick product specification to meet code requirements for strength and deflection.

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Parallel Strand Lumber (PSL) is one of the strongest wood products available for structural applications.

Lateral Bracing

Another issue is providing an adequate lateral-force resisting system that is compatible with the architectural layout of the structure. In either engineered or prescriptive solutions, engineered wood products can help balance cost and the ability to meet the structural and architectural demands of the building.

For wall segments four-feet wide or greater, it is usually most cost effective to design a wood structural panel shear wall. For narrower wall segments created by numerous window and door openings, a pre-built panel can provide the solution without necessitating changes in window or door sizes and locations to accommodate traditional shear walls. For example, in a prescriptively braced structure, a 12-inch wide pre-fabricated panel may be counted as 4 feet of bracing – meaning that it provides a one-for-one substitution for a 4-foot by 8-foot wall section sheathed with OSB or plywood. In engineered applications, design strengths are comparable to 4-foot wood structural panel shear walls. When mixing pre-built panels with site-built shear walls, the engineer must apportion loads between pre-built and site-built walls based on relative stiffness, since the site-built wall is typically stiffer than the narrow pre-built panel.

Some pre-built panels can also be used in a stacked configuration for multi-story applications. For tall walls or balloon framing, designers can incorporate single-piece panels up to 20 feet high.

Although many designs specify steel shear panels, builders typically prefer wood panels because they are accustomed to working with wood framing, and appreciate the flexibility and compatibility with the rest of the structure that a wood panel provides. For example, builders can trim some manufacturer's wood panels to size in the field and do not need to provide additional framing around the panel to facilitate attachment of gypsum, sheathing, siding, etc.

Conclusion

In many technologies, small elements combine to form a greater whole. Engineered wood products follow this trend with strand-based framing members solving design challenges in large residential structures.▪

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