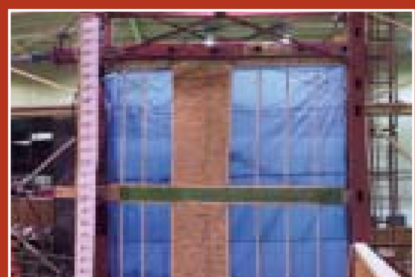
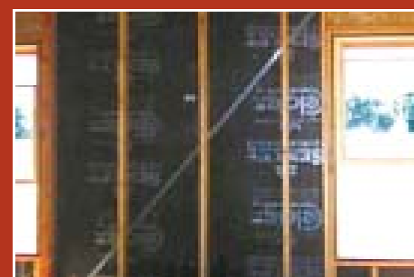
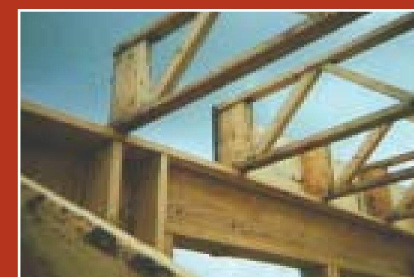
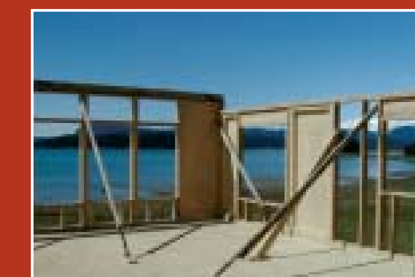
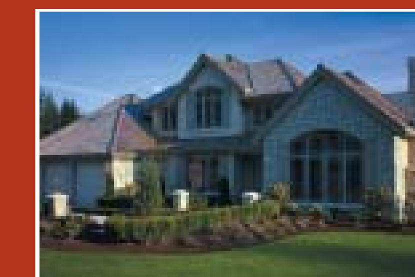
Optimizing Wood Framing

by Peter Yost and Ann Edminster

We have a 400-year history of building with wood in this country. We have stacked logs, hewn and fitted heavy timbers, nailed light frames, and finally even glued up engineered wood systems. With each step, we have used this elegant resource more efficiently, haven't we?

The answer is: not entirely. Research conducted by the National Association of Home Builders (NAHB) and the NAHB Research Center shows that 87.7 percent of the 1.7 million homes built in the U.S. in 1999 were stick-framed, that a "typical" home consumes just over 13,100 board feet of framing lumber (about three-quarters of an acre of forest) and that the wood scrap pile for the construction of this "typical" home is pushing 2 tons.

How did this happen? A combination of factors have worked to drive up our consumption of wood in home building.

- **Single-family detached units.** Realizing the American dream of owning one's own home uses more wood per household than multi-family housing. According to NAHB, single-family detached units went from about 71 percent of overall housing starts to nearly 80 percent just between 1978 and 2001.
- **Home size.** In the last 40 years, the median new U.S. home size has increased from 1,365 square feet to well over 2,000 square feet, this despite the fact that household size has actually decreased by 20 percent.
- **Complexity.** Not many of today's homes are simple in form. Jogs, dormers, vaulted ceilings, convoluted roof lines and elaborate staircases abound.
- **Safety standards.** We require more of our structures today, particularly in regions with seismic and wind considerations. Re-engineering for these loads has resulted in some increase in wood use requirements, but has also spawned site practices that simply "throw more wood" at the problem.
- **Lumber versus labor.** Just as the relative value of materials versus labor seems to have reversed (today, materials are "cheap—it's the labor that is "dear"), the typical skills set of both designers and framers has diminished, leading to waste at the front and tail ends of wood construction.[1]
- **The nature and structure of the industry.** Home building is like no other production process in the 21st century. Nearly all of the 1.7 million homes built each year are site-built, making home building one of the most fragmented of U.S. industries. It is journeymen framers—not architects, engineers or even general contractors—who control what and how much wood goes where on the job site. And most training occurs informally, by word-of-mouth, during production.

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This article is really about the last three of these factors, why optimized framing makes so much sense and how building code officials can work with builders to use less wood (and build a better house, too).

WHY OPTIMIZED FRAMING?

There are a number of substantial advantages to optimized framing: it saves time and money up front, it improves home buyer satisfaction, its saves money and energy over the long term, and it improves builder image.

- **Reduced wood purchase and disposal costs.** Actual field counts for a production builder in California have found a 40-percent reduction in the cost of a wall-framing package after implementing optimized framing methods: a purchase savings for the builder of over $1,100 on each house. Another builder in Maryland reduces total wood waste disposal by 15 percent using efficient framing. Note that neither of these examples takes into account the labor savings from handling less wood and wood waste.
- **Fewer callbacks.** A Chicago builder reports drywall callbacks dropping from more than $1,200 to only $150 per house with the switch to optimized framing.
- **Improved thermal performance.** The R-value for a "typical" eave wall (framed 2x4, 16 inches on-center, with oriented strand board sheathing) goes from R-11 to R-20 with optimized framing (framed 2x6, 24 inches on-center, with 1-inch rigid insulating sheathing).
- **Reduced environmental impact.** The annual toll for residential construction in the U.S. is 2 billion board feet of framing lumber and nearly 2.5 million tons of wood waste. That translates into 1.1 million acres of clearcut forest and 30-yard dumpsters lined up end-to-end from Phoenix to Chicago! Clearly, builders can achieve and claim significantly reduced global and local environmental impact with optimized framing.

Under the Department of Energy's "Building America" program, 7,000 homes built by Building Science Consortium production builders have achieved the results listed above. These gains are the products of "systems-thinking" and a breakdown of age-old myths about how wood framing works.

BREAKING DOWN THE MYTHS

To convince builders (and building code officials) that optimized framing not only works but is a better way to build, some pretty entrenched ways of thinking about construction and how houses work must be tackled head-on.

MYTH #1: "THE CODES DON'T ALLOW ME TO USE ADVANCED FRAMING TECHNIQUES."

Following are all of the major optimized framing techniques, with support from the *International Residential Code*® (IRC®), if applicable, cited in brackets.

- **Frame at 24 inches on center**. The prevailing practice among builders is to frame walls, floors and often roofs at 16-inch centers. However, 24-inch centers are structurally adequate for most residential applications. Even when the stud size must be increased from 2x4 to 2x6, changing spacing from 16 to 24 inches can reduce framing lumber significantly. [IRC Table R602.3(5).]
- **Align framing members and use a single top plate.** Double top plates are used principally to distribute loads from framing members that are not aligned above studs and joists. By aligning framing members vertically throughout the structure, the second plate can be eliminated. Plate sections are cleated together using flat plate connectors. For multistory homes that are framed with 2x4s, this may increase the stud size on lower floors to

2x6; however, there is still typically a net decrease in lumber used. [In IRC Section R602.3.2, a single top plate is listed as an acceptable option for in-line framing and with properly tied joints.]

- **Size headers for actual loading conditions**. Headers are often oversized for the structural work that they do. Doubled-up 2x6 (or 4x6) headers end up in nonload-bearing walls. Doubled-up 2x12 (or 4x12) headers end up in all load-bearing walls, regardless of specific loading conditions. "Load-tuned" headers should be in the vocabulary and practice of all engineers, architects, builders and framers. [Section R602.7.2 states that nonbearing walls do not need structural headers.]
- **Ladder block exterior wall intersections.** Where interior partitions intersect exterior walls, three-stud "partition post" or stud-block-stud configurations are typically inserted. Except where expressly engineered, these are unnecessary. Partitions can be nailed either directly to a single exterior wall stud or to flat blocks inserted between studs. This technique is called "ladder blocking" or "ladder framing." This also creates room for more insulation.
- **Use two-stud instead of three-stud corners.** Exterior wall corners are typically framed with three studs. The third stud generally only provides a nailing edge for interior gypsum board and can be eliminated. Drywall clips, a 1x nailer strip or a recycled plastic nailing strip can be used instead. Using drywall clips also reduces opportunities for drywall cracking and nail popping, frequent causes of builder callbacks. [IRC Figure R602.3(2) shows let-in 1x4 bracing in place of sheathing and has a note at the bottom of the page for two-stud corners and drywall clips. The figure also shows "optimized" cripples (on spacing pattern, with no sill support cripples at the jack studs).]
- **Eliminate redundant floor joists.** Double floor joists are often installed unnecessarily below nonload-bearing partitions. Nailing directly to the subfloor provides adequate attachment and support. Partitions parallel to overhead floor or roof framing can be attached to 2x3 or 2x4 flat blocking.
- **Use 2x3s for partitions.** Interior, nonload-bearing partition walls can be framed with 2x3s at 24 inches on-center or 2x4 "flat studs" at 16 inches on-center. [Section R602.5.]

Myth #2: "The frame is just a frame."

Most of us think of the framing in a building envelope as just structural, so the more wood and support that goes in the better. However, since a building is a system, the framing is involved in a lot more than just its structure. The frame is also a key part of the thermal envelope. Every stick or skin of wood (which has an R-value of about 1 per inch) that you can take out and replace with cavity or sheet insulation (with R-3.5+ per inch) represents more than a three-fold improvement in resistance to heat loss or gain. The techniques listed under Myth #1 do not compromise the structural integrity of a home, but yield significant thermal gains, particularly in cold climates.

Myth #3: "The more I attach drywall to wood, the better."

Wrong—since wood and drywall behave quite differently under different thermal and moisture conditions, they do best together if they are attached only where necessary. This is why drywall clips and slotted truss anchors reduce rather than increase the potential for drywall cracking callbacks.

Myth #4: "Wider stud spacing and insulating sheathing make the walls wavy."

Using structural sheathing and tighter stud spacing to try to correct a lumber-quality problem is just throwing good money after bad. Use straight studs to get straight walls (2x6s tend to be much straighter than 2x4s, as do finger-jointed and oriented strand board studs), instead of wasting structural materials to try to hide bad lumber.

Myth #5: "You just can't do optimized framing in high wind and seismic zones."

Building Science Corporation (BSC), in collaboration with the U.S. Army Corps of Engineers Construction Engineering Research Laboratory and Pulte Homes, is developing an innovative new shear panel design that accommodates 24-inch on-center stud spacing, a single top plate and insulated sheathing to provide a resource-efficient, optimized framing solution.

In BSC's basic shear panel configuration, the walls are framed with 2x6s at 24 inches on-center, then a shear panel is fabricated to be inset within a double-stud bay where one stud is omitted, leaving a 4-foot nominal space. The panel is a nominal 4-foot by 8-foot frame made of 2x4s, sheathed in oriented strand board and nailed at the panel perimeter with 8d nails at 4 inches on-center. The frame, which is predrilled at each end of the top and bottom 2x4s, is inserted in the wall framing void over sill-plate anchor bolts. A wall-height threaded rod is then coupled to each anchor bolt with a coupling nut and run up through the top plate and a flat steel bearing plate. Above the plate, the rods are secured with nuts, developing 6,000 to 8,000 pounds of post-tensioning in the rods.

This panel provides 650 pounds per linear foot in 8-foot-high panels or 500 pounds per linear foot in 10-foot-high panels, and dramatically reduces the amount of wood needed to address high lateral-loading conditions.

WHAT CAN CODE OFFICIALS DO?

We need more builders and code officials who are students of building science. Lake County, Illinois, provides a great example. During the development of an early Building America project at Prairie Crossing (near Chicago), the local code prohibited several systems-integrated strategies, including optimized framing. After hearing the systems engineering logic behind the building details and seeing how they were all part of a comprehensive approach to a high-performance home, local officials called for an alternate code to be drawn up. The new code permitted the package of optimized strategies, so long as they were all used.[2] This ensured that the integrity of the systems-thinking inherent in the alternate code was protected.

A building inspector can become a resource for (as much as a regulator of) builders by actively contributing to their education, and code officials can be instrumental in elevating optimized framing from the "exceptions" and "footnotes" currently in the codes to the "better way to build."

The building code community is singularly positioned to be a green light rather than a stop sign for an approach to framing that offers benefits to the builder, the home buyer and the community, both local and global. Use the technical resources listed below to become a local hero—saving builders on their construction costs, improving the local housing stock and conserving natural resources. ◆

Notes

1. Ironically, this is the market economic "reality," whereas the world resource situation is the opposite: we have an ever-increasing abundance of human labor at our disposal while materials grow ever-scarcer and more precious.
2. *Lake County Building Code*, Section 326: "Advanced Energy Efficient and Resource Efficient Single Family Residence Code."

Resources

Building America, *www.eere.energy.gov/buildings/building_america*.

Efficient Wood Use in Residential Construction: A Practical Guide to Saving Wood, Money, and Forests. Ann Edminster and Sami Yassa. National Resources Defense Council, 1998. *www.nrdc.org*.

Energy and Environmental Building Association Builder's Guides. Joseph Lstiburek and Betsy Pettit. *www.eeba.org/mall/builder_guides.asp*.

"Using Wood Efficiently: From Optimizing Design to Minimizing the Dumpster." Stephen Baczek, Peter Yost and Stephanie Finegan. Building Science Corporation, 2002. *www.buildingscience.com/resources/misc/wood_efficiency.pdf*.

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