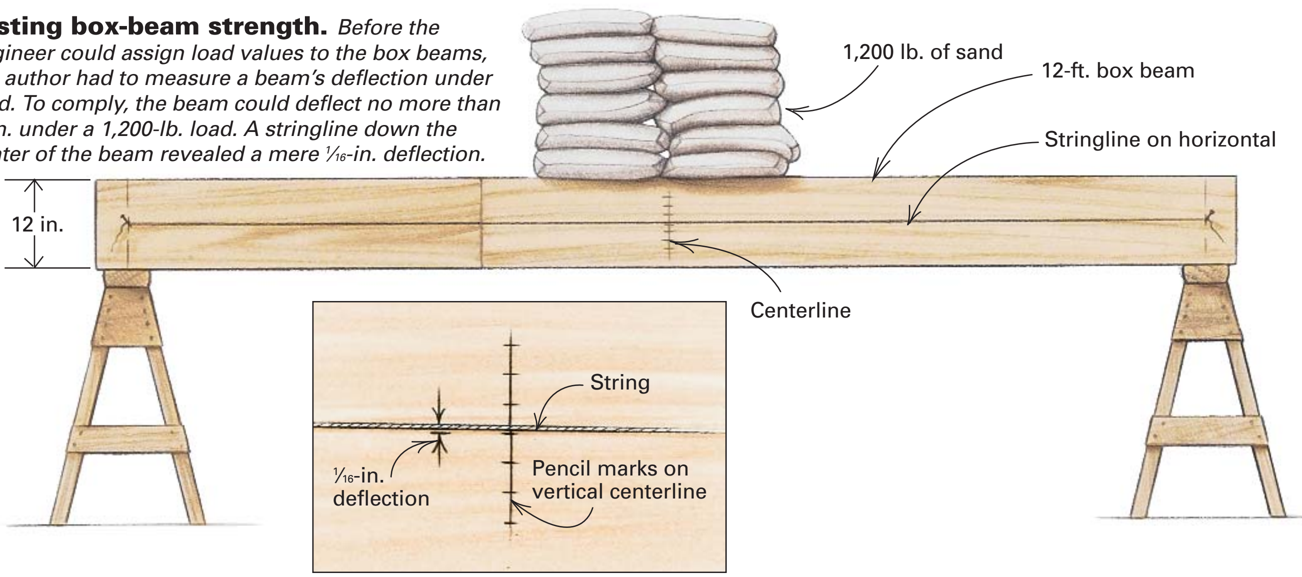
**Testing box-beam strength.** *Before the engineer could assign load values to the box beams, the author had to measure a beam's deflection under load. To comply, the beam could deflect no more than ¼ in. under a 1,200-lb. load. A stringline down the center of the beam revealed a mere ¹⁄₁₆-in. deflection.*



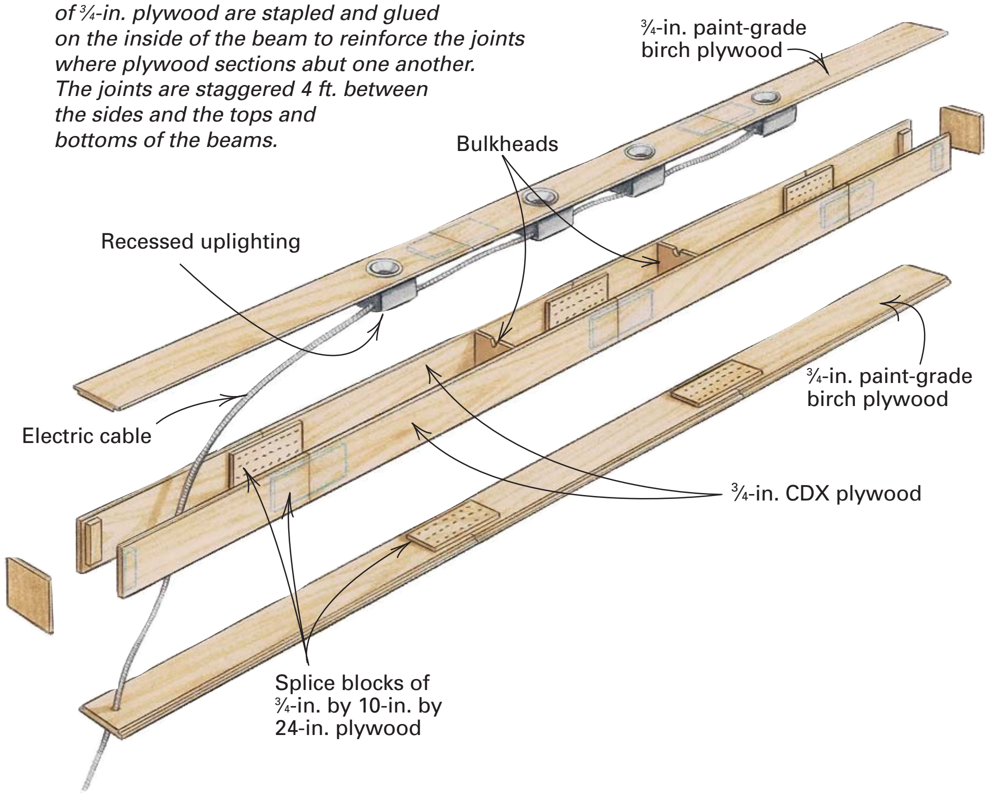



Drawings: Bob La Pointe

Prefabricated parts become a unified structure. Plywood bents composed of hollow trusses, beams and columns are bolted to the foundation and stitched together with stud walls and a plywood skin. Before the plywood shear walls are installed, you can see the access holes in the columns and beams for making bolted connections.

# Making Plywood Box Beams

## Glue, staples and a little engineering turn sheets of plywood into trusses and columns




**Inside the basic box beam.** *Splice blocks made of ¾-in. plywood are stapled and glued on the inside of the beam to reinforce the joints where plywood sections abut one another. The joints are staggered 4 ft. between the sides and the tops and bottoms of the beams.*

by Roger Fleck

Here's a paradox for you: Just as the last great stands of old-growth timber disappear, the venerable craft of timber framing enters a renaissance. It makes a kind of perverse sense. A lot of people are tired of unrelieved gypboard boxes. They want to see the structure of their buildings because there is an honest, I-feel-sheltered atmosphere in a house when you can see big beams, posts and trusses that are holding up the roof.

When I built my own house (*FHB* #73, pp. 76-81), I fully expected to use heavy timbers to make the ceiling trusses. A session with a calculator, however, sent me off in another direction. I quickly learned that good-quality 10x10s and 12x12s were very costly, and that the custom metal hardware required to meet California's seismic standards would have upped the ante even further.

I eventually built that house of steel components. But another construction technique was on my mind at the same time, and I got to try it out a few years later when I built a contemporary spec house on a neighboring parcel of land in Nicasio, California. My colleagues and I called this project the Meadow House. During the construction of the Meadow House, I used a technique that I call the hollow box beam to create a signature look that emphasized structure (photo p. 111).

**Lessons adapted from the exhibit business—**The shapes of the trusses, beams and columns are visible everywhere in the house, throughout the foyer, master bedroom, great room, porch and kitchen. Because of their predominance and structural duties, these elements required a practical and cost-effective building method. To make them, I modified some details that I had learned making exhibits for trade shows.

In the exhibit industry, structural elements are prefabricated in shops and then shipped to convention facilities across the country, where they are assembled to create larger structures. With tight deadlines, budgets and shipping restrictions, the exhibit components have to be lightweight, strong and durable, and they must be made from readily available materials. Hollow beams and columns fill this bill exactly. In essence, the Meadow House presented the same challenge as an exhibit project: Create an impressive image through structure while being practical with the use of materials.

A similar effect could have been achieved with solid lumber, but there were numerous design and cost advantages to the hollow-box technique. First, the structural components that we created were strong and lightweight, which made them relatively easy to handle. Second, we built them of common materials—plywood and MDF (medium-density fiberboard)—that are much less expensive and more readily available than quality solid lumber of this size. And because we built the components in a shop out of dimensionally stable materials, the beams, trusses and columns were precise, with none of the shrinking, twisting and checking of big timbers.

Mechanical details such as lighting and wiring were preinstalled in the beams while they were at a convenient working height. Multiples were made using templates and jigs to save time. Finally, the components were brought to the site preprimed, which allowed us to achieve high-quality finishes efficiently.

**Plywood splice blocks act like tenons. The angled connection where the top chord of a truss meets a bottom chord is reinforced with a pair of plywood splice blocks that tuck into the bottom chord (photo below). Glue and staples complete the union.**

**The sides are covered with MDF. A paint-grade skin of MDF covers the rough plywood sides of the trusses. After applying liberal amounts of glue (photo above) with special attention to the edges, the author's crew used brad nailers to hold the MDF in place while the glue set up (photo below).**

**Big assemblies from smaller components—**The basic building block of the hollow box structure is the hollow box beam—in our case, 12-in. by 12-in. box beams. We used them in the trusses, the beams, the columns and the combo truss/columns that were raised as single units, a la timber-frame bents (top photo, p. 110). A box beam has four plywood sides, which are attached to one another by way of glued-and-stapled rabbet joints (drawing p. 107).

After ripping the plywood to the correct width, my crew and I milled the rabbeted edges with a shaper. The rabbets are deep—½ in. by ¾ in.—which allowed us to glue and staple the corners in both directions. We used our shaper because its power feed made the work go more smoothly. But lacking a shaper, you could also use a big router to cut the rabbets.

There are several truss variants in the house, and we made ¼-in. thick MDF templates for all of them. Using the shop floor as our worktable, we laid out the trusses at full scale and then transferred the dimensions to the MDF sheets. We used the templates to establish the length and angles of each subassembly and to locate items such as access holes and cutouts for recessed light fixtures.

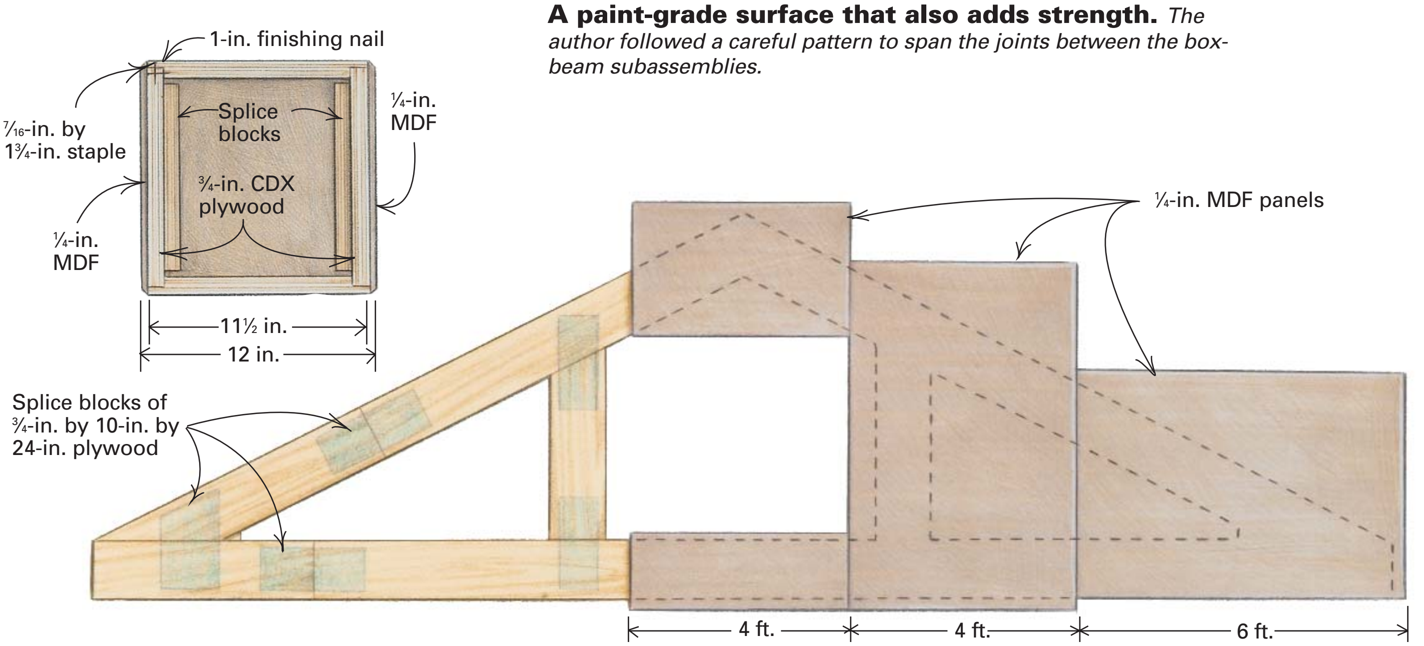
I am a big believer in this kind of template as a tool. In essence it works like a two-dimensional model, and many details were worked out right on the templates. When we did the final assembly of multicomponent structures, we put them together right on top of the templates to ensure that all pieces were precise and identical.

Our templates included cutouts for light fixtures and access holes for bolting the subassemblies into finished components. We tacked the template to its part and followed the cutouts with a bearing-guided router bit to make the holes in the components.

We made our beams out of ¾-in. CDX plywood and ¾-in. paint-grade birch plywood. The birch plywood goes on the bottoms of all the truss chords, and on the tops if they are to be visible. The CDX plywood goes on the sides of the truss-

**Ready to roll.** A completed truss sits atop its trailer, revealing the uplights in the bottom chord and the 2x4 nailer along the top chords. These nailers will provide a base for attaching the purlins that support the roof.

**A paint-grade surface that also adds strength.** *The author followed a careful pattern to span the joints between the box-beam subassemblies.*



**Updating the timber-frame bent.** With the help of a crane, the author's crew lowers a combo truss-column assembly onto its foundation bolts. The assemblies, which were built in a nearby shop, were reinforced with temporary braces during installation.

**Roof loads are carried by purlins.** I-joists arranged as purlins span the length of the roof, bearing on 2x plates affixed to the tops of the box-beam trusses. Solid blocking between the purlins keeps them from twisting.

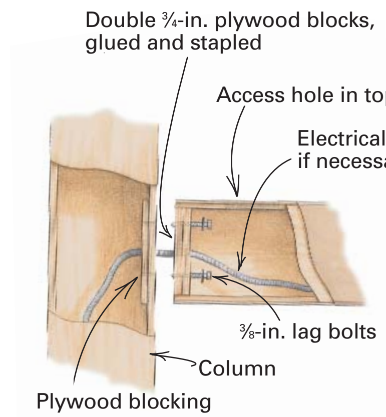
es. We eventually skinned the sides of the trusses with ¼-in. MDF for a paint-grade finish.

**Beams are spliced together—**Most of our hollow box beams are longer than 8 ft., so most of them have joints. For structural integrity, the joints are staggered so that splices are at least 4 ft. apart (drawing p. 107). The butt joints are reinforced on the inside with 24-in. by 10-in. by ¾-in. plywood splice blocks, which we glued and stapled to the abutting pieces.

Our assembly sequence begins by first splicing all the 8-ft. components necessary to make the top chord of one of the box beams. If recessed lights are called for, we install them now in their precut holes and run their wires. Next, the top chord is placed on sawhorses with the rabbeted edges facing up. The CDX-plywood sides are now glued (Franklin Tight Bond),

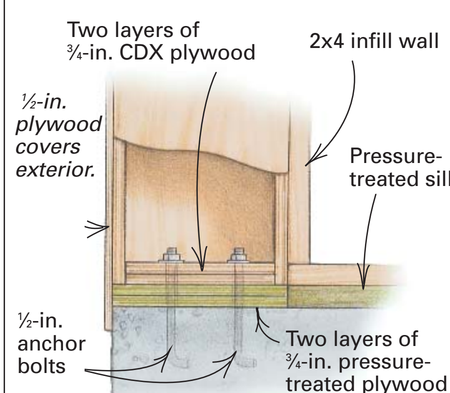
### When beams meet columns

*Horizontal beams engage columns and the bottom chords of trusses throughout the house. They are typically attached with four ⅜-in. lag bolts driven into blocks affixed to the inside of the column or truss.*




### When columns meet mudsill

*Four anchor bolts bear on double blocks at the base of each column. Standard stud walls fill the spaces between the columns, and the entire affair is sheathed with plywood to protect the structure against earthquakes.*



nailed and stapled in both directions. Once we've got a three-sided beam, we install ¾-in. plywood reinforcing blocks where the midspan uprights or beams need attachment, along with ¾-in. plywood bulkheads on 8-ft. centers to square up the assembly. Finally, the birch-plywood bottom chord is glued, nailed and stapled to complete the box.

Box beams that would turn into top chords of trusses get their ends cut off at the appropriate angle, and they receive plywood splice blocks that fit into corresponding holes in the bottom chords (photo top left, p. 108).

**An MDF skin makes a paintable surface—** The faces of each truss are veneered with a ¼-in. thick layer of MDF, which adds an element of shear strength to the trusses and a consistent, paint-grade surface. We applied the MDF sheets in a pattern that overlapped the joints between the box-beam subassemblies, further strengthening the trusses (drawing p. 109).

We went through a lot of glue on this job, and buckets of it went into the veneering (photo top right, p. 108). After drizzling the glue on the plywood, with particular attention to glue coverage at the edges, rough-cut MDF skins were tacked in place with a brad nailer (bottom photo, p. 108). The skins were nailed only at their perimeters, far enough from the edges of the plywood to allow a router with a chamfer bit to do its work without hitting a nail.

Once the glue set up, we trimmed the edges of the MDF with a bearing-guided flush-trimming bit, followed by a pass with the chamfer bit. The resulting ¼-in. bevel created a crisp edge that hides the end grain of the plywood and unifies the look of all the box-beam components. By the way, the horizontal box beams that are bolted to the sides of the trusses are 11½ in. square. This allows them to fit between the chamfers on the sides of the 12-in. sq. trusses or columns.

Our last task prior to installation was to fill the nail holes left by the brad nailer and to spray a coat of primer on the exposed surfaces.

**Enveloped in structure. Plywood box beams, trusses and columns painted white set the style in this contemporary house. They aren't just decoration. The lightweight trusses and columns carry all the structural loads.**

**Engineering calcs lead to code approval—** Hollow box beams are incredibly strong, but they aren't readily recognized as load-bearing elements by our building department. So we had to provide engineering data to reassure the building department that we were building a safe structure. To that end, we set up a test.

As shown in the drawing (p. 106), we placed a 12-ft. long box beam atop a couple of sawhorses, and we marked its vertical and horizontal axes on the side of the beam. Then we stretched a taut line down the horizontal center of the beam and tied it off so that it was arrow straight. Next, 100 lb. at a lift, we stacked 1,200 lb. of sandbags on the center of the beam, causing a deflection of ¹⁄₁₆ in. as measured at the vertical axis. This information gave our engineer a benchmark to work from for further calculations. By the way, our target for a safe margin of error was ¼ in. of deflection.

**Making connections on site—**We worked through one of the rainiest winters in recent memory in the comfort of the shop, building trusses, beams and columns. By spring, we were ready to truck the prefabricated components to the site (photo p. 109) and hoist them into place.

The columns sit on pressure-treated plywood pads, which are the same thickness as the adjacent mudsills (bottom drawing, facing page). Four anchor bolts keep the columns in place. Their nuts and washers bear on doubled plywood blocks at the base of the columns. We cut racetrack-shaped "rat holes" in the bottoms of the columns to allow working room to slip the nuts and washers over the bolt threads. Similar access holes in the top of the horizontal beams provide the necessary space to lag them to the sides of the trusses (top drawing, facing page).

Standard stick-frame stud walls fill spaces between plywood columns. The studs align with the outside faces of the columns. The trusses support I-joists used as purlins (bottom photo, facing page). A layer of ½-in. plywood stitches the whole thing together, tying columns to walls and sill plate for a sturdy connection. □

*Industrial designer Roger Fleck runs Ironwind, a company that designs and fabricates trade-show exhibits. Architect Jonathan Livingston designed Meadow House. Photos by the author, except where noted.*

Photo this page: Vince Valdes