TIMBER FRAMING

JOURNAL OF THE TIMBER FRAMERS GUILD

Number 57, September 2000

Salvage logging in British Columbia

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On the cover, diver Steve Jencola begins to grapple with a log submerged for a century in a British Columbia lake. Photo by Environmental Timber Recovery Ltd.

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Published Quarterly. Subscription $25 annually or by membership in the Timber Framers Guild.

ISSN 1061-9860

TIMBER FRAMING, Journal of the Timber Framers Guild, reports on the work of the Guild and its members, and appears quarterly, in March, June, September and December. The journal is written by its readers and pays for interesting articles by experienced and novice writers alike. ♻

1985

Notes & Comment

IT'S an amazing world. I write this report while riding a train through the tidal marshes of Rhode Island on my way to JFK Airport, then in flight overnight to Glasgow, finishing it in the dark on the way back from Iceland. Icelanders are no-nonsense folk but hospitable. The customs lady was so beautiful that a sensible man would have confessed to a crime, any crime, in order to be detained by her.

Gould Farm, UK, Iceland

ALL the talk and planning and meetings and phone calls and e-mails and so forth that went before did little to prepare me for the emotional event that unfolded so effortlessly around us at Gould Farm in Monterey, Massachusetts, in July. Community service building projects as teaching platforms are my Holy Grail; this one met all the challenges, and went over the top.

Some Guild projects, while intrinsically satisfying to our timber frame community, have been isolated by circumstance from the people who would eventually use the results. At Gould Farm most of us lived in the midst of the co-creators of our barn for the entire two weeks, dining together, working side by side, swapping stories and somehow, without quite knowing it, eroding the barrier of unarticulated fear we are likely to carry in the face of mental illness.

Gould Farm's principle is that mental illness is isolating enough without institutionalization, and that meaningful work is therapeutic. What could be more thoroughly tangible and significant than the big positive change in the skyline we are accustomed to make on raising day? Several Guild members had early on approached me privately to pledge their intention to assist because some mental disability or another had dealt their families a glancing blow, or even a head-on collision. All of this was forgotten or at least pushed into the background as we immersed ourselves in our familiar work, coming up for air periodically, initially wondering if that person on the other end of the timber was a Gould Farm guest, staff member or an unknown Guild fellow-traveler, and then cheered by the eventual realization that it didn't matter much (and eventually not at all) and that we couldn't tell who was who. It is a measure of the success of the Gould Farm program.

The teaching and the teachers were relentless, and they were everywhere. We had an all-Massachusetts crew on this one—Todd Bissell, Dave Bowman, Dave Carlon and Alicia Spence Hammarlund—who worked out a low-key but inexorable pace so that not only did we take a day off for timber frame tourism (Hancock Shaker Village, site of the Timber Framers Guild charter conference in 1985), but we also adjourned at a reasonable hour for the swimming hole. No one missed the late nights under the lights or the final hours of chaos often reigning toward the end of a rendezvous. The building itself is not quite 40x60, faithfully patterned after the canted queen post, principal purlin-common rafter system we've all seen at least one of in our travels. We didn't get the reduction details quite right, and the brace angles were unusual (3:4:5, just like the main roof), but all in all it is a pretty frame, common as dirt in parts of the country, and quite beautiful as a venue for the first contradance in the fog and the lamplight.

I think Gould Farm is a wonderful match for us on at least three levels. They have a 90-year track record of accomplishment clearly worthy of anyone's support. There is an articulated need for building projects into the future, not only for the jobs the buildings themselves are to do, but, more important (at least to me), for the transformative power of collective action that these events can provide, both internally to the Farm and to the Guild at large. Finally, the Farm has the infrastructure for support and a resolute hospitality reflex that allow us to come to town, work our magic and ride off into the sunset again, heroes all.

This one worked so well that we're already talking about the next one, as early as 2001. If you didn't make it to the first one in whole or in part, talk to someone who did, and I predict you'll be trying to sign up before we know anything. It is the best of times.

WITHOUT a discernible break in the action I then found myself in Scotland Yard, that is, the Scottish framing yard of Carpenter Oak and Woodland (whose home operation is in Wiltshire), a bit north of Perth on the eastern side of the country, just through the gateway to the Highlands to a village melodically named Lintrathen. The enterprise is housed in a scattered and mossy collection of iron-sided and stone sawmill buildings overlooking one of the reservoir lochs for Perth. The lads (maybe eight at full strength, with a complement of European framers to leaven the bread) are tenants of the Water Board, and for all intents appear to be living and working in a kind of paradise. I was introduced to the Scottish Tea Ceremony (10am and 4pm), wherein all members of this merry band sit around a single table, dispose of substantial amounts of food and tea, and roundly disparage the Square Rule.

Carpenter Oak has invested a huge effort in the creation of a systematic training program, under the direction of Gordon MacDonald, that would appear to occupy several linear feet of shelf space. I just scratched the surface in an afternoon of conversation and reading, but what I saw was thorough, integrated with external certification programs, verifiable, adaptable to different layout systems and various levels of mechanization along the continuum and broad enough in scope to cover worm-drive maintenance and compound roof math. This represents a substantial amount of work, and though far from complete, makes significant progress in an area that Guild shops have been working at for a decade.

From Lintrathen it was nine of us in the van for eight hours south to the site of the building museum at Avoncraft, an impressive collection of old English buildings from various periods. This was to be the site of the Frame 2000 meeting, touted on the back of the t-shirt as "The First Ever Gathering of Timber Framers," which could be a bit of a stretch, but there I was, in the midst of an event that was more than a little reminiscent of the first TFG meeting in Hancock. There were presentations by notables and honorables whose names you would recognize (Lewandoski, McCurdy, Harris and more), there were hands-on events in disciplines you are familiar with and perhaps need to learn more about (rigging, dendrochronology, roof math, hewing). There was an auction, a membership meeting (more on that in a moment) and a great deal of that exuberant camaraderie around the campfire that we've come to expect. The camping was especially nice, in a spot off to one side of the museum, with a cheery fire every night, lots of kids and dogs, and a diverse array of styles and equipment, including several converted box vans and a beautiful canvas-covered Romany caravan.

As to the membership meeting, it was held in a lovely hall with a very old and very elaborate timber roof over new masonry walls. Now, does any of the following sound familiar?

There was a protracted and passionate discussion concerning standards for entry to the association. This eventually resulted in a vote that was not even close. There was a great deal of passion as to whether this association should be performing trade or commercial functions in addition to its educational activities, followed by another vote. There was much heat and light concerning the proposed naming of this new organization, then some more voting and finally a prolonged and lively debate about membership fees and benefits, which were of course put to a vote as well.

I was invited to speak to this assembly, after the voting of course, and was able to congratulate them on your behalf on the formation of what is named for the moment the United Kingdom Carpenters Fellowship. It has some 80 members as of this writing, will do no trade association work, will hold conferences and publish and will be open to all.

While it might have been better for worldwide timber frame hegemony for the UKCF to form itself as a chapter of the TFG, this was clearly not what was wanted in Avoncroft, and we would do well to remember that colonialism is never well received. The men and women of the UKCF have plenty to do in the UK and are poised with the right attitude and plenty of enthusiasm to move ahead. We should also remember that they have most of the really cool old buildings. They even let me join, but I had to pay cash. They were quite clear about that. £30.

THEN I was off to Iceland (it's on the way home, if you think about it) to spend a day and a half with the charming and generous Nikulás Úlfar Másson, head of the Department of Architectural Research at Húsadeild Árbæjarsafns, the national building museum. I looked at an awful lot of old buildings, in the museum setting on the first day and along the old streets of Reykjavík on the second. There are lots of genuine timber framed buildings from the 18th and 19th centuries, mostly of softwood imported from Denmark. Much older buildings survive: stone walls with turf roofs over what can only be described as brush pile roof framing. Foundations are of basalt, original roofs of stone or tile. All the sidewalls and most of the roofs of older wooden buildings are covered with brightly colored corrugated iron sheeting. This material (described by Nikulás as "God's gift to Iceland") is given credit for the continued existence of any old wooden buildings at all in this century, as the dominant feature of Iceland's weather appears to be horizontal rain. I saw lots of decay, especially at sills and post feet, but no leaning structures, in spite of the relentless wind. Frames are of smaller and more frequent timbers than we're accustomed to in North America, mortises and tenons throughout, tie beams with shallow dovetails running over the plates, but no jowled posts. Lots and lots of small common rafters.

Nikulás complained and boasted that it has been the young adults of Iceland who have taken an interest in stabilizing, rehabilitating and using these older buildings rather than replacing them with masonry structures as their parents had been wont to do. Iceland is in economic boom ("the fish have been good to us") and, as a result, Nikulás's budget is healthy enough to take on a 60 million kroner ($800,000), 9-month restoration of a timber building on the waterfront, plus a major facelift to the old apothecary and the complete salvage of a kind of merchant hall (dealing exclusively in falcons for European royalty until not that long ago). He works in a different political and cultural environment from ours: every significant renovation (including exterior color) to any 19th-century and earlier building within Reykjavík (which includes 60 percent of the country's population) must seek counsel and permission from his office. Iceland is a small country (225,000) with a charming demeanor, handsome citizens, breathtaking landscape and an appetite for night life, though the sun never really set while I was there (66 degrees north latitude). I can only imagine what the social scene is like in the winter. The museum hosts two training events each year for restoration carpenters, with the cooperation and support of the carpenter's union. They would like to expand this program. There is a timber frame in the basement of the museum, all in pieces and in need of significant repair. I think we could be happy and useful here.

—Joel McCarty

Environmental Timber Recovery Ltd.

Salvage in British Columbia

LITTLE did the loggers of Howard Logging Company of coastal British Columbia know that the giant Douglas fir logs they were cutting in the late 1800s would not be put to use for more than a hundred years. The massive trees they sweated to fell by hand with double-bitted axe and two-man saw would be preserved in the bottom of the lake for rediscovery by an unknown generation of their grandchildren's grandchildren.

Today, advances in technology are giving new life to these giants from the deep. Desmond Mayne, who operates Environmental Timber Recovery Ltd. on the Sunshine Coast near Vancouver, B.C., represents a new breed of logger who, instead of cutting old-growth timber, is salvaging logs that were cut a century ago and left for waste. "I'm interested in finishing the job the loggers of the late 1880s started," Mayne said. "This wood is much too valuable to be left lying in the bottom of a lake. Some of these trees are up to 1200 years old."

It has been estimated that there are billions of board feet of reusable wood resources submerged across North America. Skeptics doubted that this wood could be located and recovered in the cold deep lakes, or that it would be of a high enough quality to be used if it were. Contrary to expectations, the logs that Mayne is pulling up have been perfectly preserved by the oxygen-depleted water and provide some of the densest fiber ever harvested in Canada. These artifacts of an ancient forest come with a hand-hewn heritage and a story to tell.

In 1880 Howard Logging Company was granted a license to log old-growth Douglas fir on the fertile slopes surrounding several lakes in coastal British Columbia. Mr. Howard had found himself an ideal timber stake that was valued for ship's spars, lumber, veneer and pulp stock. However, he still had to figure out a way to get the timber from the lakes to the coast where it could be hauled to the mill. Steam locomotives were just making an appearance locally and so the far-sighted Mr. Howard got his backers to finance the building of a railway between the coast and the lakes.

In the woods, the backbreaking work of felling the massive trees and getting them to the lake was no small feat in itself. With the advent of chainsaws yet to come, the trees had to be felled with axe and crosscut saw. Because of the size of the trees, on average 6 to 8 ft. in diameter, fallers usually worked in pairs, making the undercut while standing on springboards to get above the flared, pitch-filled butts of the trees.

On the opposite side of the tree, the fallers again cut notches for their springboards and, standing well above the forest floor, used a two-man saw to make the felling cut. Three or four hours of bone-aching work later, there would be the cry *TIMBERRRR* and the huge Douglas fir, up to 50 tons of it, would come crashing down. Then the real work began.

Often standing in precarious positions on hazardous hillsides, the buckers limbed the tree and bucked it to length. The length depended upon the size of the tree, the distance to the lake, and the equipment available to drag the log. Sometimes the trees were so huge that only a little over 20 ft. of length could be managed. If a steam donkey was available, life was easier; many times it was not.

Once bucked, the logs were prepared for hauling. Any remaining limbs were removed and the ends sniped or chamfered by cutting a bevel around the front end so that the logs could be dragged to the lakeshore more easily. Horses were used to pull slowly the many miles to the beach. All told, it could take a few hours, or a few days, to get a big log into the water.

The story of Mr. Howard's company had a very unhappy ending. Just as the building of his railway from the saltchuck to the lake was being completed, Howard Logging Company went bankrupt. A forest of first-growth timber, some having already survived more than 1200 years, was left to float in the lake until it slowly succumbed to a watery grave.

Desmond Mayne says: "This timber was first-class. If the old boys knew they had to drag it a long way down to the lake, they made sure it was a really sweet piece." Many of the logs Mayne's operation has pulled out of the lake have been largely clear, old-growth material, some as fine-grained as 90 rings per inch of diameter.

Mr. Howard never did get his timber to market, but Desmond Mayne is doing the job for him. A normal day for Mayne and one of his employees involves going into the lake in scuba gear to search out the best and most manageable of the huge timbers. Then a specially designed loading platform is maneuvered into place and the log lifted from the lake bed. Licenses for log salvaging forbid any dragging of the log over the lake bottom that might disturb the lake's ecology. Even with the considerable buoyancy effect of the surrounding lake, grappling the log and bringing it to the surface are almost as difficult as the work loggers did a hundred years ago. Mayne says the logs are at 102 percent moisture content with lake water molecularly bound to the cell walls of the timber.

"We finally got a great one today," he recounted recently. "We've been looking at this one that's a good seven and a half feet through for six months off and on, trying to figure out how to get it up. It's so big that the measurement around the circumference is greater than its length. It must have been used as a spar tree to drag other trees to it, because it has a big bolt through it.

"It was touch and go all the way because we can only lift one end of about 6,000 lbs. or it pulls the platform under—we nearly did this today. This will give us 2500 or so bd. ft., much of it clear."

Most of the logs are quartered at the dryland sort area before they are moved. Mayne boasts about his crew member Lance Marko, who can take a chain saw and run it freehand from one end to the other of a log with only a quarter-inch runout.

The log quarters are loaded on a truck and taken to Mayne's sawmill, where each log is custom cut into the sizes required. Until recently, Mayne had only salvaged those logs that contained largely clear fiber, the kind of wood in demand in board and dimension form for use as flooring, panelling, veneer cants and edge-grain window and door stock. In part this was an effect of the existing niche market for high-end products from reclaimed timbers, and in part because production of other materials was limited by the thickness of the fiber that could be dried in conventional kilns.

The opportunity to salvage other logs and convert them to building timbers came when Mayne learned of the advent of a new technology to dry large timbers. The arrival of a radio frequency vacuum drykiln in nearby Garibaldi Highlands, B.C., encouraged Mayne to salvage merchantable-grade Douglas fir logs, small enough in circumference to be handled and transported in one piece and of the appropriate quality to be sawn into tight-grained timbers. Use of the RF vacuum kiln allows these vintage timbers to be dried in just over a week with minimal checking and warping.

—NANCY DICKSON

Nancy Dickson is a former journalist living in Vancouver. For more information about RF vacuum kilns, see info@heatwave.com, www.fraserwoodindustries.com and www.sundriedwood.com. Desmond Mayne can be reached at finewood@uniserve.com.

HISTORIC AMERICAN TIMBER JOINERY

A Graphic Guide

III. Sill and Floor Joints

THIS article is third in a series of six to discuss and illustrate the joints in American traditional timber-framed buildings of the past, showing common examples with variations as well as a few interesting regional deviations. The series was developed under a grant from the National Park Service and the National Center for Preservation Technology and Training. Its contents are solely the responsibility of the author and do not represent the official position of the NPS or the NCPTT. Previous articles, which appeared respectively in TF 55 and 56, covered Tying Joints: Tie below Plate and Tying Joints: Tie at Plate. Future articles in the series will cover Wall Framing, Roof Joinery, and Scarf Joints.

JUST as the plates and tie beams hold together the upper part of the timber frame, the sills tie the posts at the foundation level. Though not subjected to the same stresses as tie beams above, sills keep the bottom of the building from spreading. Many old structures whose sills are decayed are noticeably wider at the bottom.

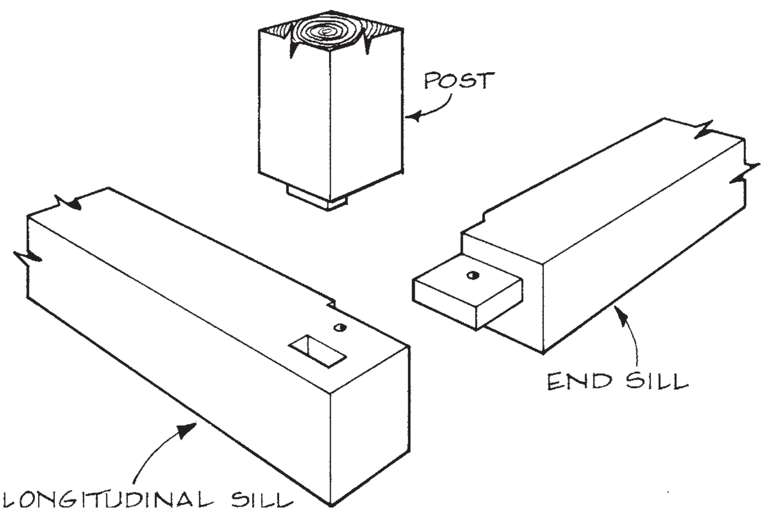
Sills also distribute column loads over the foundation, act as bond beams to hold together the top of the stonework and stiffen and support walls and the first floor. Sill timbers are typically rectangular in cross-section and laid flat.

SILL CORNER JOINTS. The most critical joint, often least documented, is at the corner where the longitudinal (or long wall) sill, the end wall (or gable) sill and the corner post join. In many old structures this joint is badly decayed or the sills have been replaced and a simple half-lap joint substituted.

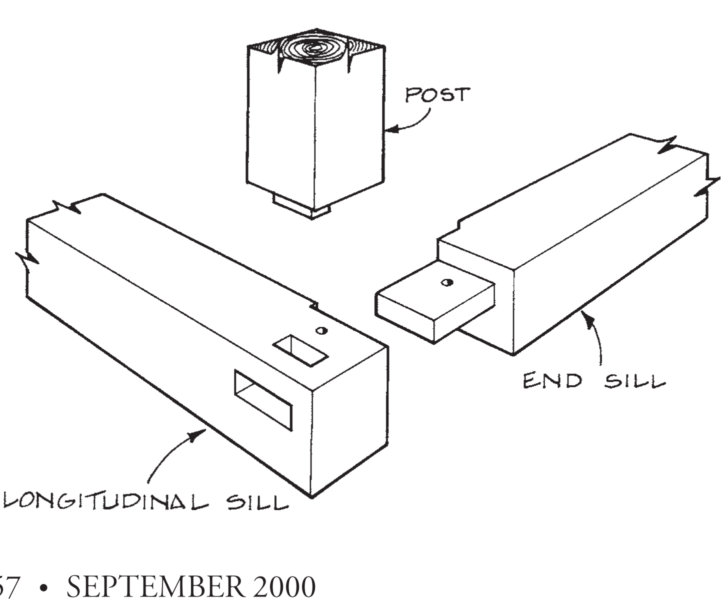
Blind mortise and tenon. Far and away, the most frequent sill corner joint is the blind mortise and tenon (Fig. 1). It combines simplicity with effectiveness. Both the sill and post mortises have relish to prevent horizontal displacement. The relish is usually equal to the tenon thickness, that is, 1 1/2 or 2 in.This design offers a modest amount of weather protection. Even though most American frames are covered by siding, wind-driven rain can penetrate. This joint has its origins in Europe where timber frames are often exposed to the elements. Usually one pin secures the two sills while the post bottom has a stub tenon. If the post has a longer tenon of, say, 3 in. (still without a pin), the sill mortise and tenon will be framed lower to avoid a conflict.

Through Mortise and Tenon. Much less common is this through mortise and tenon variety (Fig. 2). It occurs typically where sills are square in cross-section, or rectangular and set on edge, as the through joint increases tensile capacity for a narrow sill. Unfortunately, weather resistance is diminished compared with the blind joint, and the mortises are more likely to split open and the relish to fail.

Sloped Tabled Corner Lap. Only one example of this joint has so far been found (Fig. 3), in a barn in St. Johnsville, New York. It appears to be of Germanic design. The dovetail-like lap prevents lateral displacement, but, unlike the mortise and tenon type, it must be sandwiched between the post and foundation to be effective. Otherwise, twisting from seasoning or subsiding of the foundation can render it ineffective.



Figs. 1 and 2. Blind (above) and through (below) mortise and tenon joints, both sized according to square rule layout.



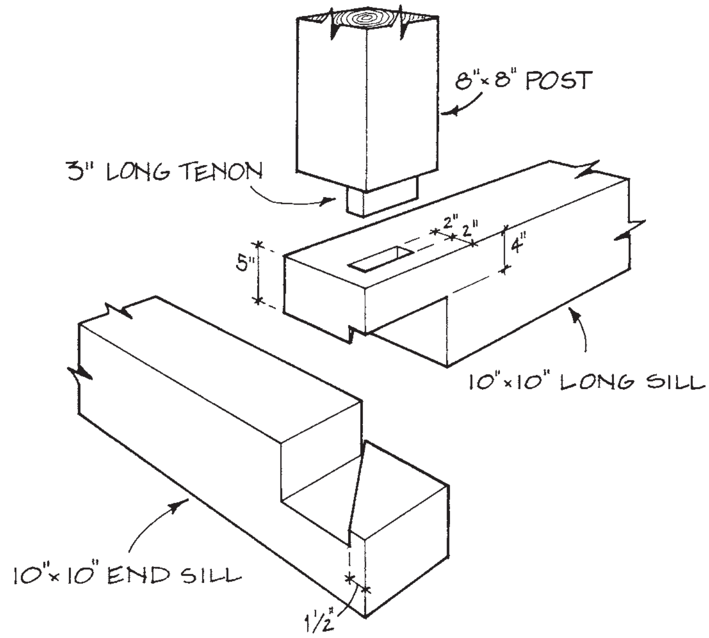


Fig. 3. Unique sloped and tabled corner lap, St. Johnsville, N.Y.

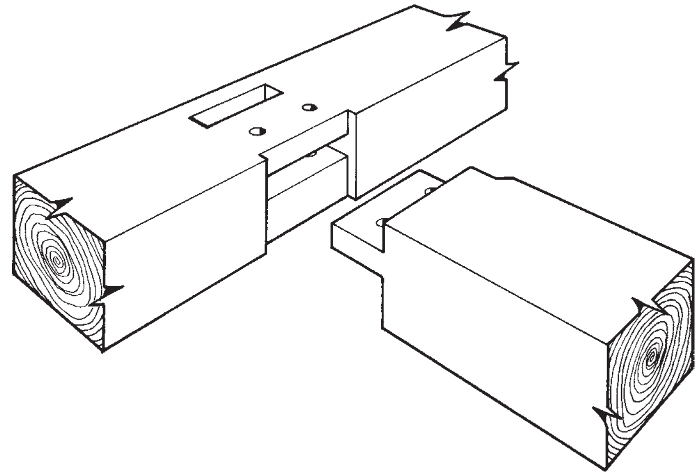


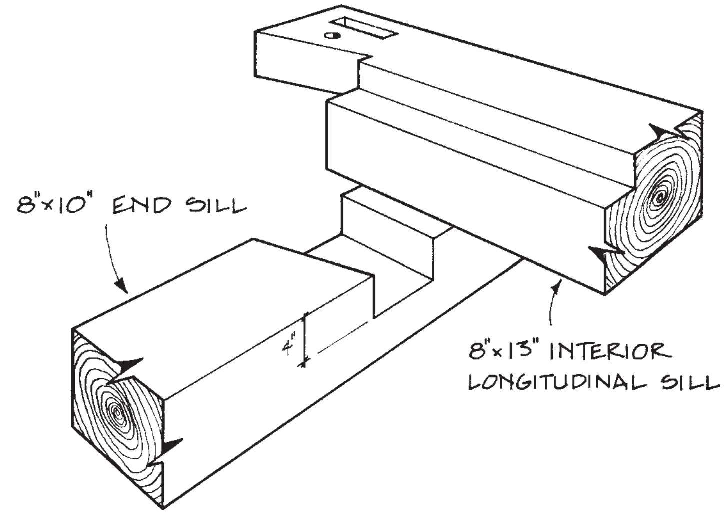
Fig. 4. Blind tenoned girder joint.

INTERMEDIATE SILL GIRDER JOINTS. These are connections where interior sill girders meet either longitudinal or end wall sills. They often have posts bearing on them.

Blind Mortise and Tenon. Again this joint is the most common type (Fig. 4). Because there is no question of relish as at the corner, the tenons can be wider and typically are secured with two pins. This joint is moderately weather-resistant.

Inverted Lapped Full Dovetail. Rarely, the bottom of the end wall sill receives the lap dovetail (Fig.5). It is secured by being sandwiched between the foundation and the sill.

Lapped Half-Dovetail. This simple joint (Fig. 6) is somewhat common in Dutch barns where the interior longitudinal sills for the posts join the end wall sills. The purlin posts are tenoned into the lap dovetail.



Drawings Jack A. Sobon

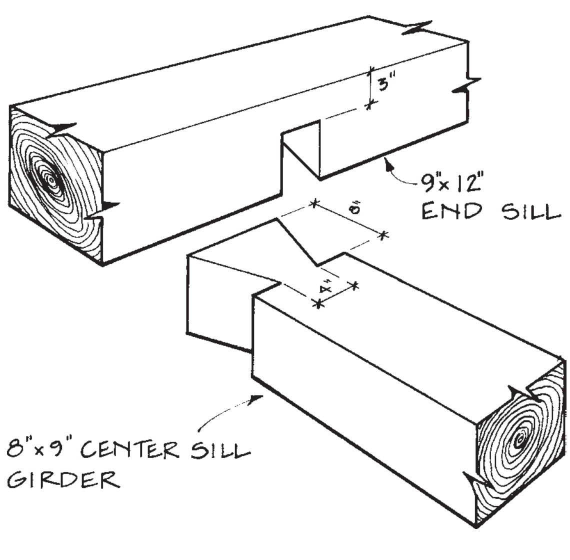


Fig. 5. Inverted lapped dovetail in Dutch barn moved from Guilderland to North Tarrytown, N.Y. The 47-ft. girder supports a 3-in. plank threshing floor and is well protected from weather. Assembled, the undersurface of the girder lies 2 in. below the undersurface of the sill.

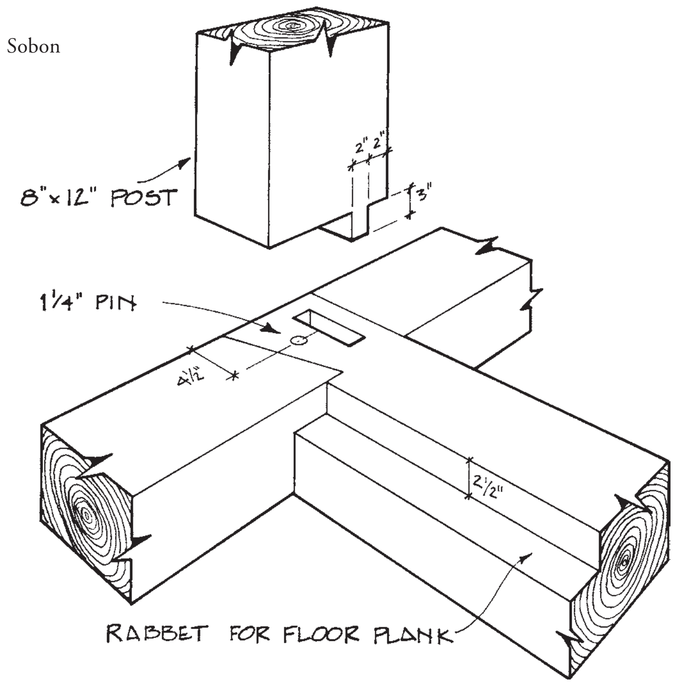


Fig. 6. Views of lapped half-dovetail girder joint in a pre-1820 scribe rule Dutch barn moved from Fort Plain to Altamont, N.Y. The interior sill is rabbetted for the 2½-in. splined plank threshing floor.

Plank Sill. This unusual sill system has been seen on at least two scribe-rule-framed 18th-century New York Dutch houses, one standing in Stuyvesant (Fig. 7) and the other (now dismantled) formerly in Cohoes. Both houses, built with unfired brick infill between the posts, measure about 18 ft. wide, with full-span floor joists. Because of their long span and wide spacing (4-5 ft.), the joists are 12 in. deep. But a corresponding 12-in. sill is both impractical and unnecessary. With the plank sill system, the joists are set into the stone or brick foundation and a 2x6 plank is notched and nailed to secure them. The plank is through-mortised for the posts, and the mortise extends an inch into the joist as well. This design saved on material and joinery, and was probably also a time-saver during the scribe layout process. It has proved itself over time.

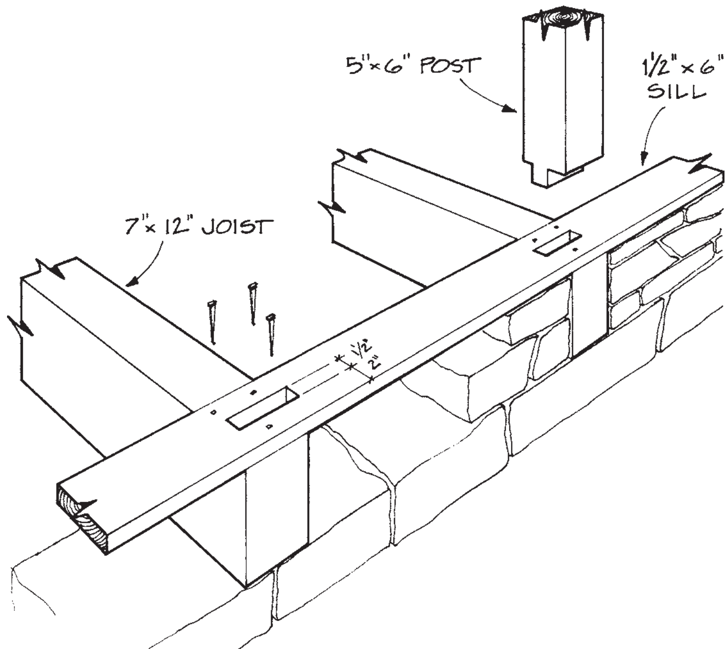


Fig. 7. Plank sill, Stuyvesant, N.Y.

FLOOR JOISTS AND GIRDER JOINTS. In the days when most timber was hewn, considerable time could be saved by hewing some members only on faces that had to be flat to receive sheathing. Thus floor joists, especially ground floor and barn joists, were often hewn only on top. At the joint they were shaped to a rectangular cog (Fig. 8).

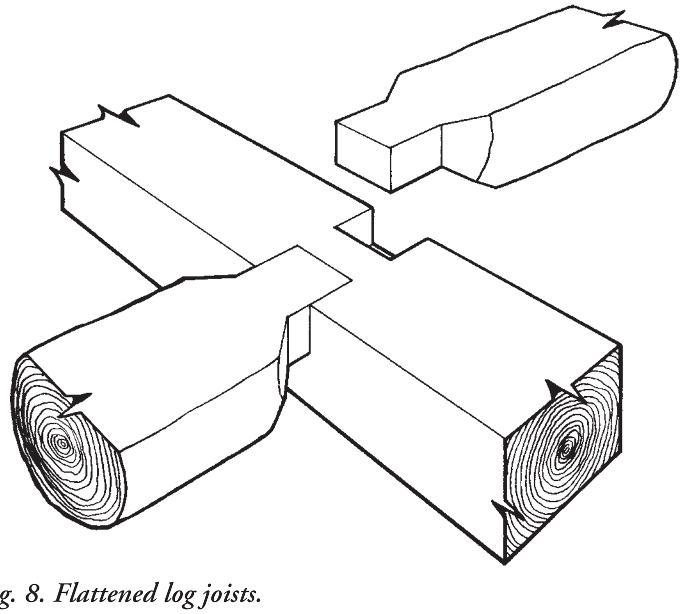


Fig. 8. Flattened log joists.

Butt Cog Joint. The simplest joint to craft and insert, and consequently the most common, is the simple drop-in pocket or butt cog (Fig. 9). The full depth of the joist may be notched into the girder, or, more commonly, the joist is reduced in depth at the joint so as not to cut too much out of the girder. When the joist end is reduced in this way, the stiffness or bending strength of the joist is not affected, but its shear strength is diminished at the joint.

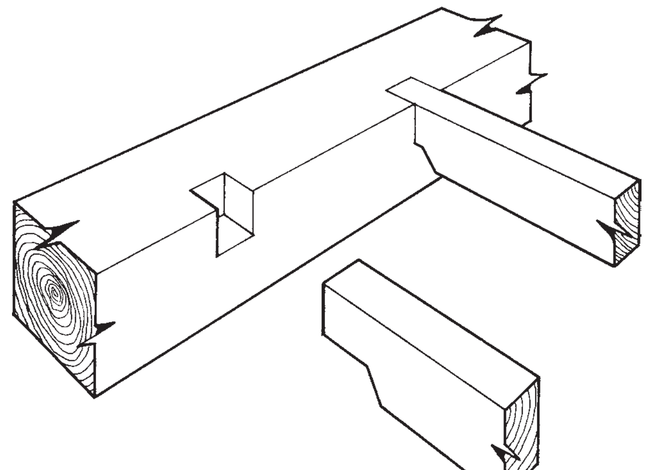


Fig. 9. Butt cog, angle relief.

To avoid concentrating the shear stress at the notch, builders removed additional wood with an axe or adze, on an angle as shown. In a few frames, the joists were reduced in a graceful curve using the adze (Fig. 10).

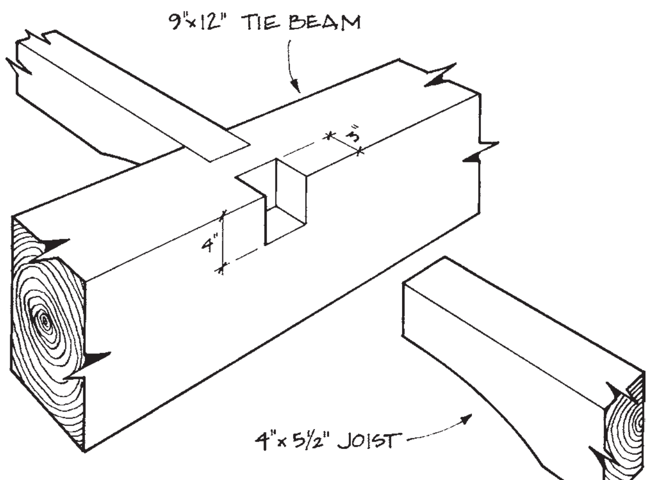


Fig. 10. Butt cog, curved relief.

If the bottoms of joists were to receive lath and plaster, then it was more convenient to use a squared notch at the girder. If the girder was also to be covered with lath and plaster, then the joist was typically notched to half its depth (Fig. 11). The square notch is considerably weaker than the angled or curved type and many old frames exhibit cracks or breaks at the notches.

The popularity of the drop-in joist pocket was in large part due to its convenience during assembly. Drop-in joists are easily inserted from above after the girders or tie beams are in place.

In square rule structures, an additional gain was often cut in the girder below the notch, to size the girder to a consistent width so that all the joists could be cut to one length. The gain was usually a half-inch or less in depth so as not to unduly weaken the girder.

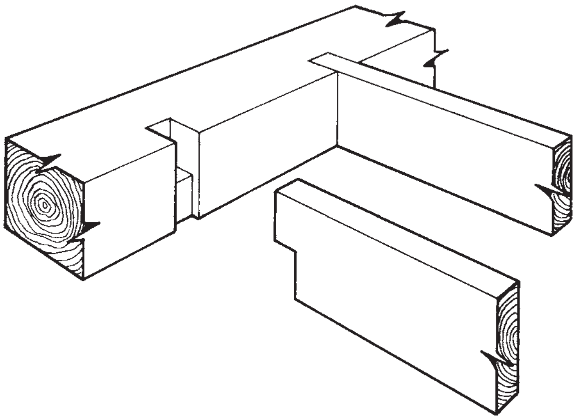
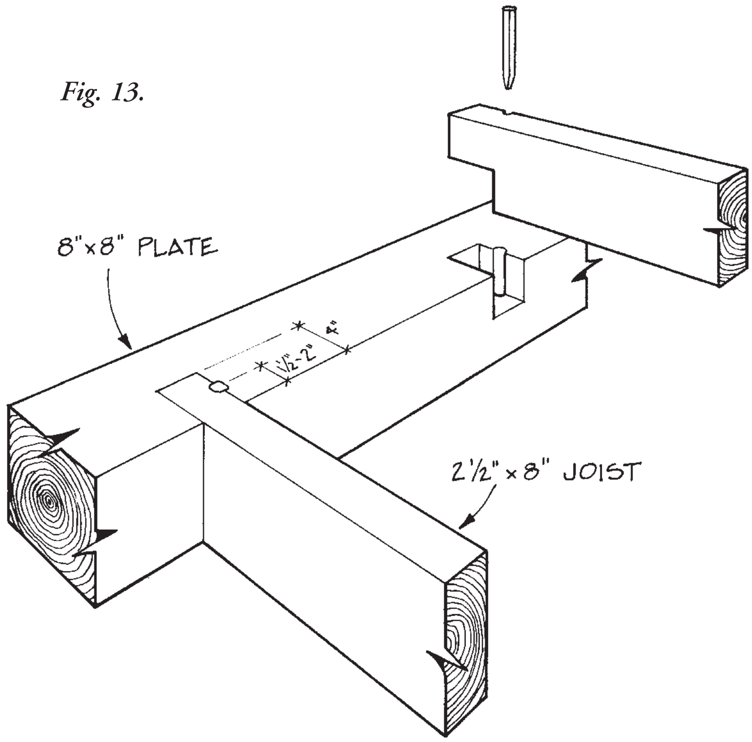


Fig. 11. Narrow full-depth joists with lower sizing housing.

Fig. 13.



TYING JOISTS. Floor frames other than in the smallest buildings required one or two joists in each bay as tying joists to keep the girders or tie beams from spreading. Were they to spread, the cogged joists could withdraw and allow the floor to collapse. The most common tying joint was a half dovetail (Fig. 12).

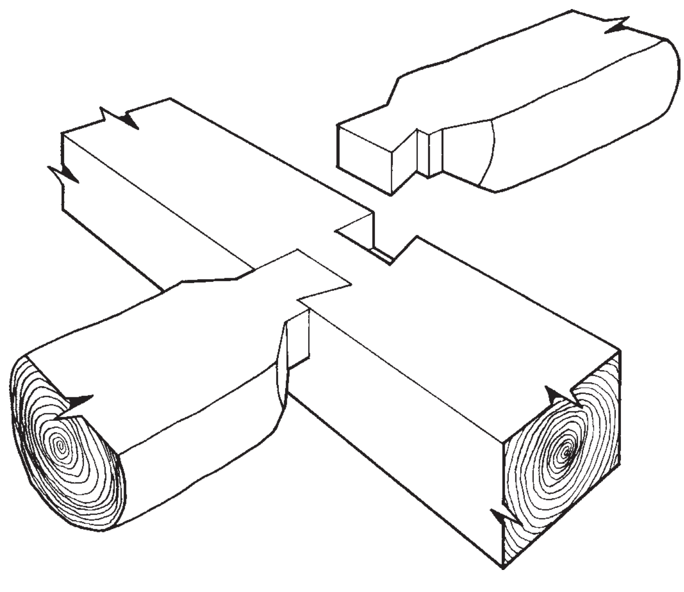


Fig. 12. Half-dovetail butt-cogged flattened log joists.

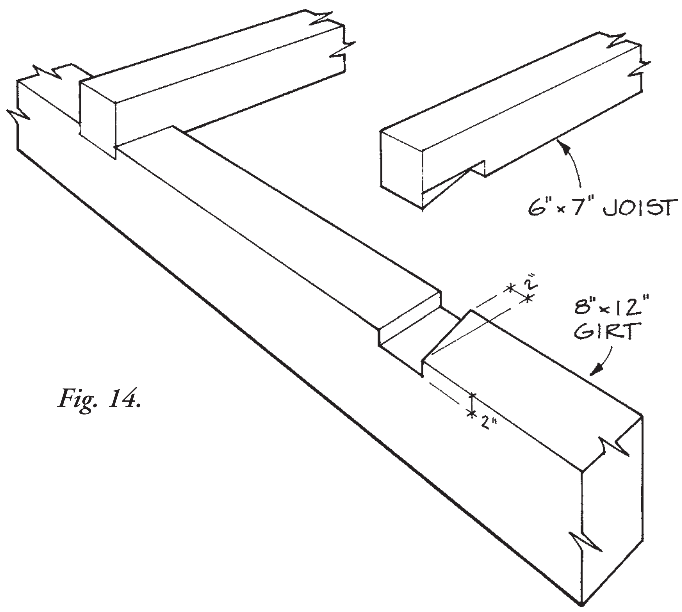


Fig. 14.

A variation was to bore a pin hole at the edge of a joist tenon after the joist was in place and drive a squarish pin that both wedged the joist tight against the opposite side and acted as a cog to prevent withdrawal (Fig. 13). On larger framing, the technique could be used on both sides. In framing where the top surface of the joist was elevated above the girder, a lap dovetail could be used (Fig. 14). If the joists were permitted to extend past the girt, the through lap (Fig. 15) was effective. Both of these joints can be found in the side-aisle lofts of Dutch barns.

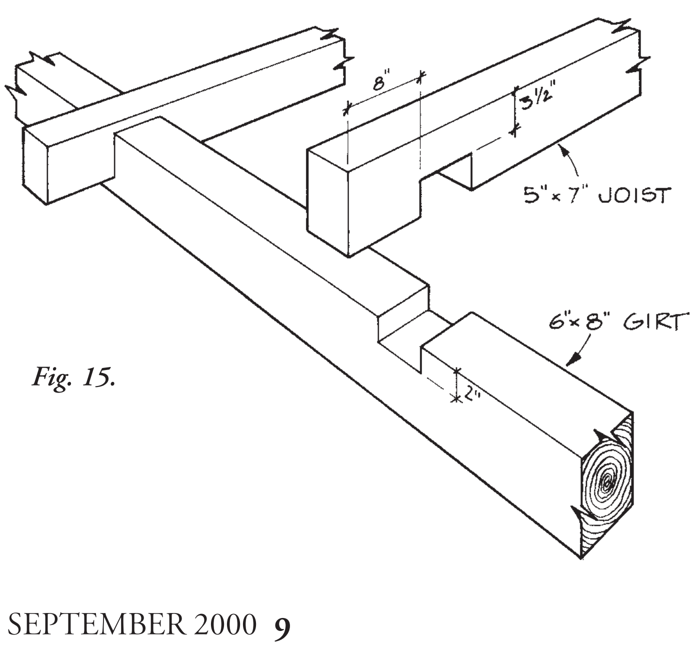


Fig. 15.

Figs. 13-15. At top right (Fig. 13), butt-cogged tying floor joists with cogged pin, Cheshire, Mass., 1791. At middle right (Fig. 14), lapped half-dovetail on side aisle loft joist in a 1680s Dutch barn moved from Saratoga, N.Y., to Hancock, Mass., and since lost to fire. The opposite ends of these joists were vertically tenoned to wall posts. At bottom right (Fig. 15), through laps in side aisle loft joists of a Dutch barn in Westerlo, N.Y. (also lost to fire). The through lap, if simple, is quite effective as a tying joint.

Strengthened Halving. This variation of the half-lap joint (Fig. 16) is configured to increase capacity for both members by adding bearing surfaces. The lower supporting beam has less material removed compared to a half-lap. The side housings provide better support for the upper girder and lessen shear problems. Examples are found in the attic floor of houses where a central spine beam runs the length of the house, lapping over the tie beams and carrying joists from both sides.

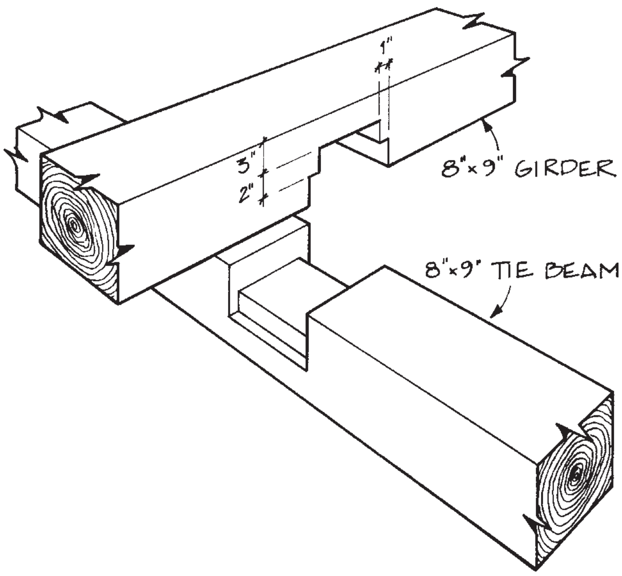


Fig. 16. Strengthened halving found in the attic floor of the 1783 Quaker Meeting House, Adams, Massachusetts. The 8x9 girder ran longitudinally and carried floor joists on both sides.

TENONED JOISTS. The tenoned joint's structural advantage for connecting floor joists to a carrying timber is that in cutting the mortise, little or no wood is removed from the top or bottom surfaces of the carrying beam. Since these surfaces are under the greatest stress (compression in the top and tension in the bottom), a beam mortised in its side retains nearly all of its original strength. By contrast, a beam with a butt cog joint cut into each top edge loses 15 to 40 percent of its original strength. Another advantage is that by adding a pin, a tenoned joist becomes a tying joist. (However, a pin hole bored right through a beam reduces its strength. A tight-fitting pin may effectively replace the missing compression wood on top, but the pin cannot replace the tension wood on the bottom.) There is also a disadvantage to tenoned joists: they must be inserted from the side rather than the top. Thus joists are inserted in sets as each bent reaches vertical, or in the case of tie-at-plate examples, as each tie beam is set. Assembly requires careful work with many hands or temporary support structures. Alternately, joists may be tenoned at one end and merely seated on top of a beam at the other as in several 17th-century Massachusetts Bay houses. The simplest form of tenoned joist has the tenon bearing all the load (Fig. 17). The joint is simple to cut and removes a minimum of wood from the summer beam. It is common where closely spaced joists support a plaster ceiling and the joists and summer beam are the same depth. But the tenon is weak in shear.

Housed mortise and tenon. A vast improvement in structural performance results from housing the entire joist end into the beam (Fig. 18). The shear problem is eliminated. However, the beam must be sufficiently deeper than the joist. This joint is more often seen on large joists spaced far apart and on headers. Fig. 19 shows a variation housed only below the tenon. This retains slightly more compression wood on the top of the beam while not reducing the shear capacity of the joist.

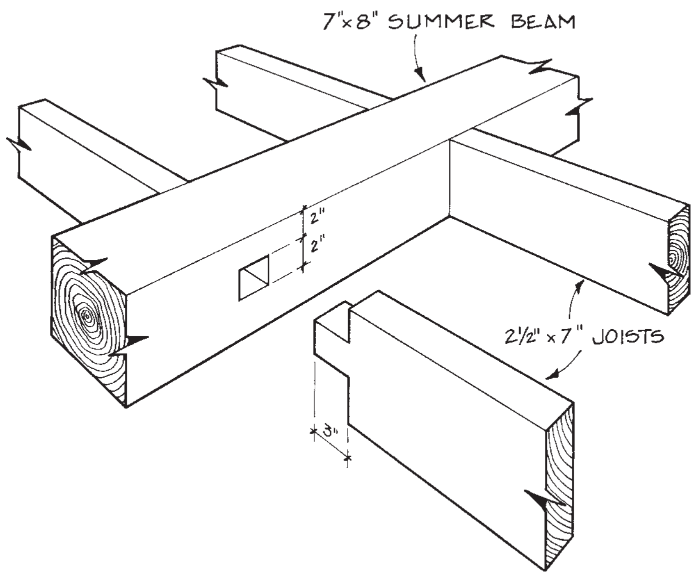


Fig. 17. Simple tenoned joists supported the second floor of a 1791 Cape-style house in Cheshire, Massachusetts.

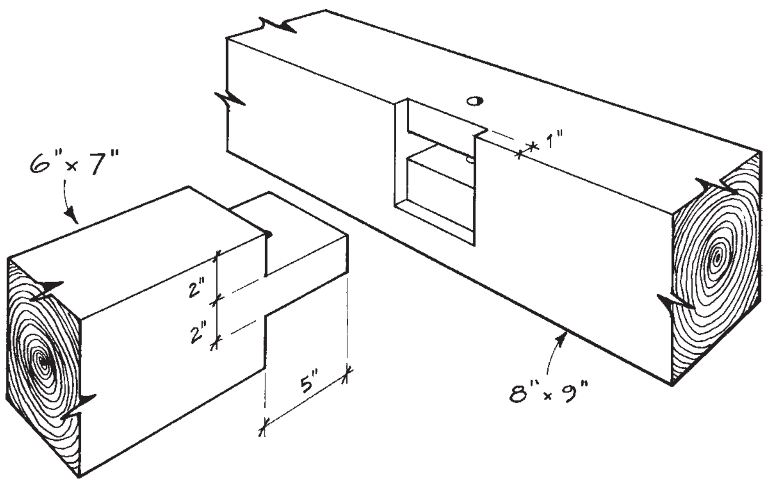


Fig. 18. Heavy aisle loft joist in a pre-1820 Dutch barn in Root, N.Y., part of a set spaced 5 ft. on center with their outboard ends tenoned to posts.

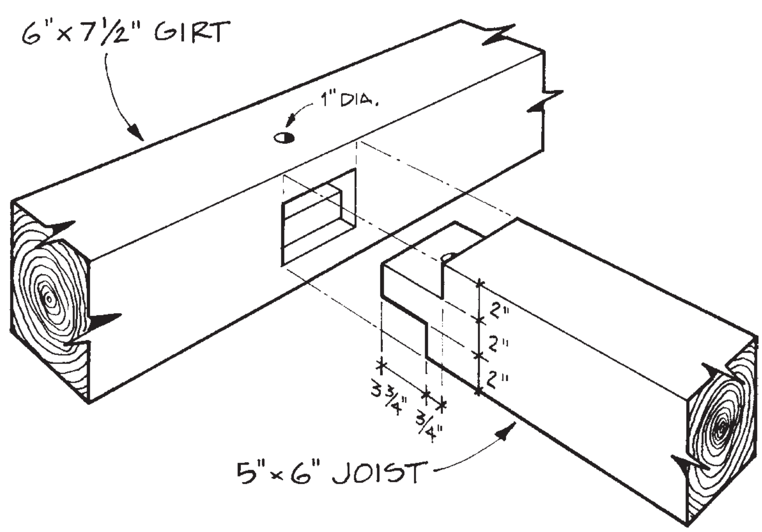


Fig. 19. Aisle loft joist in a Dutch barn, Warnerville, N.Y.

Strengthened Tenons. The ultimate tenoned joist has a sloped shoulder above the tenon (Fig. 20) that brings into bearing the entire depth of the joist while keeping intact the vital compression wood of the carrying beam. In 18th- and 19th-century builder's books it is the floor joint of choice. In ideal form, the underside of the tenon is continuous with the joist (and thus properly termed a soffit tenon, Fig. 20) and the mortise in the carrying timber is centered in the side of the beam.

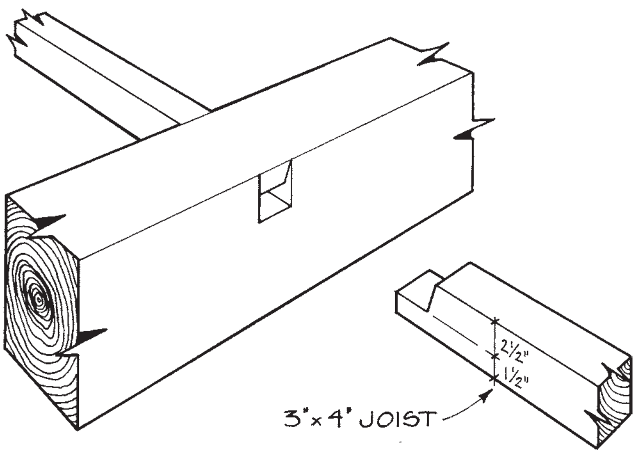
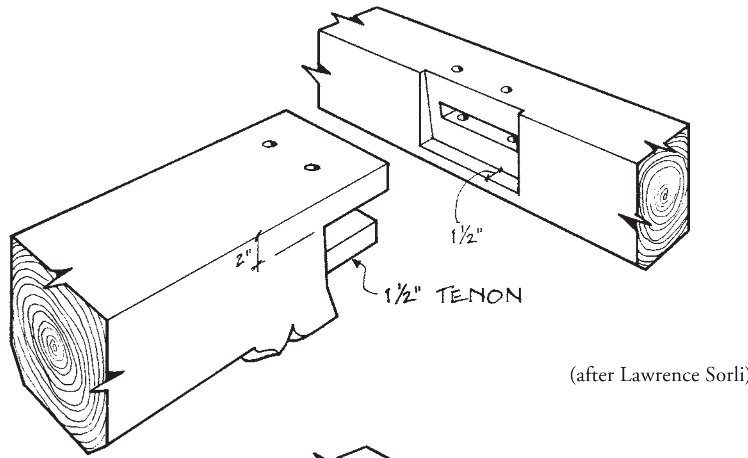


Fig. 20. Typical strengthened tenon, here without pin.



(after Lawrence Sorli)

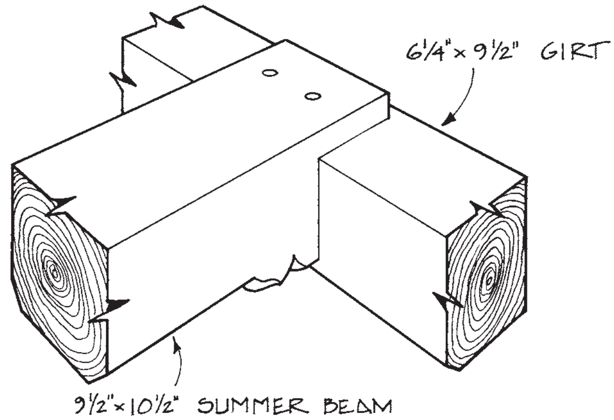


Fig. 22. Equal-depth summer beam and girt in the 1637 Fairbanks House, Dedham, Massachusetts. The summer is raised and lapped 2 in. over the girt to gain needed support at the bottom of the joint. Lack of congruency between housing and tenon shoulders is unexplained.

Historically, some authorities (e.g., Joseph Moxon in *Mechanick Exercises*, 1703) called the upper sloping shoulder a tusk; others (James Newlands, *The Carpenter's Assistant*, ca. 1854) reserved that term for an additional bearing shoulder cut beneath the tenon when the joists are too deep for soffit tenoning. In our day, Cecil Hewett (*English Historic Carpentry*, 1980) referred to the upper sloped shoulder as a diminished haunch and the lower square one as a housed soffit shoulder.

Occasionally the lower shoulder too was angled (Figs. 21 and 22) to form what Hewett called a spurred shoulder.

Other tenon forms. Any joist tenon can become a through mortise and tenon with wedges to increase tensile capacity (Fig. 23). Especially deep members could have paired tenons (Fig. 24, overleaf).

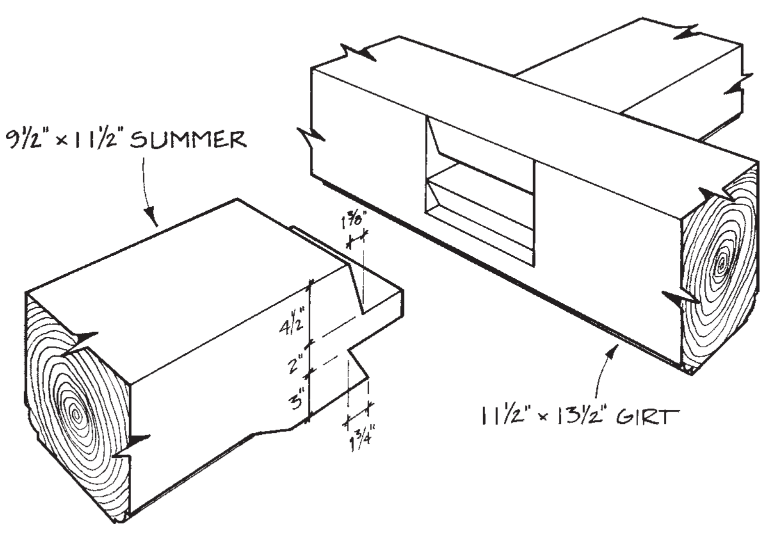


Fig. 21. Summer beam to girt connection in the 1665 Gedney House, Salem, Massachusetts. Both members have molded chamfers.

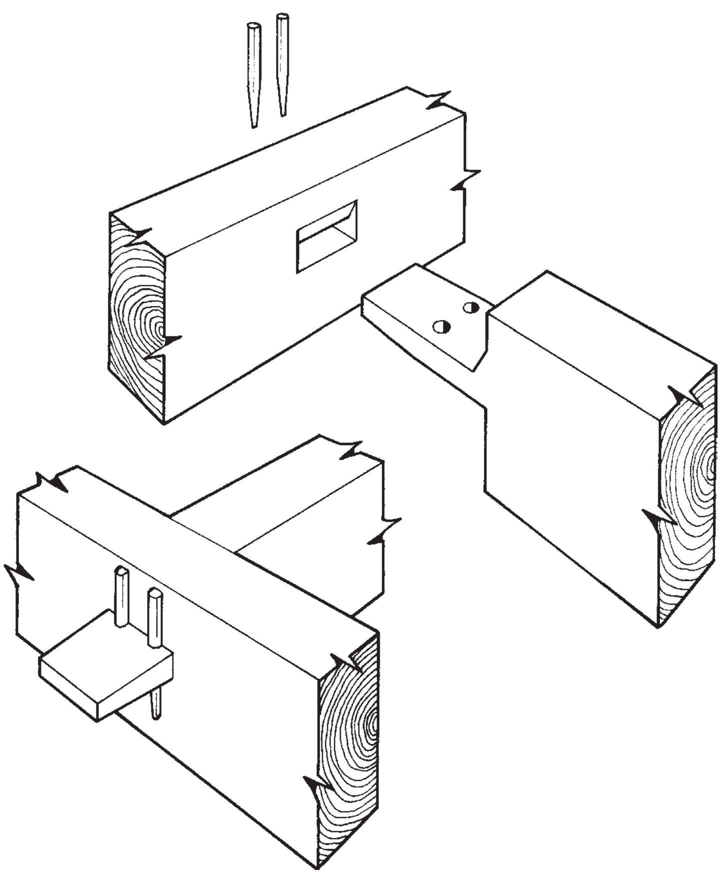


Fig. 23. Through tenon with outside wedges (pins flattened on a taper) in the attic floor of the Presbytere (1847), New Orleans.

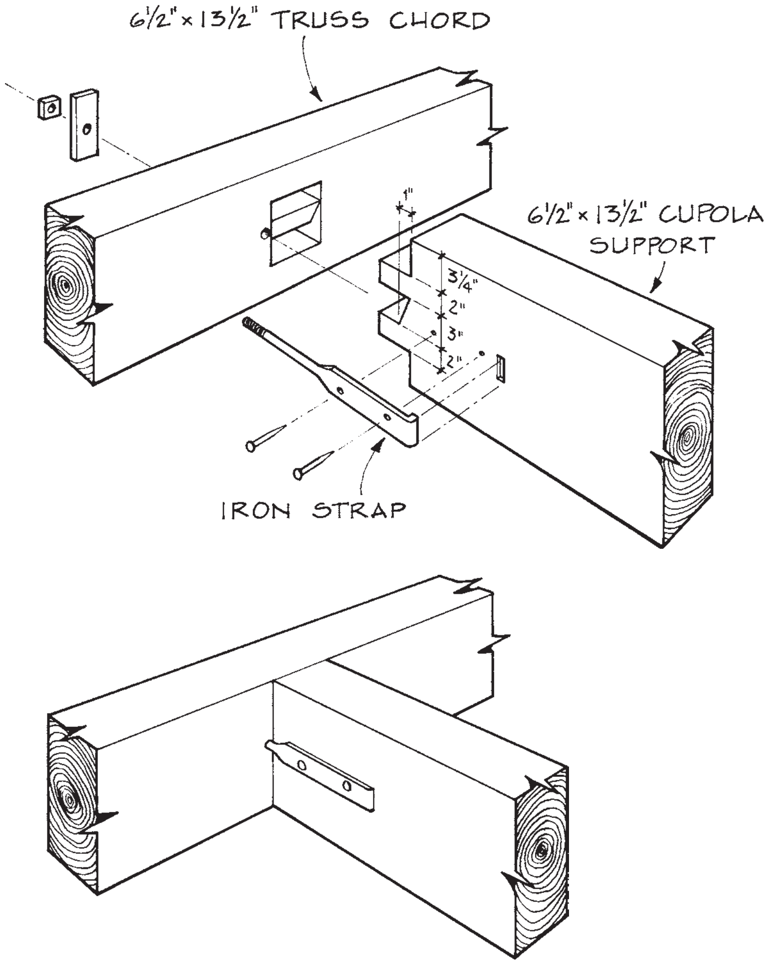


Fig. 24. Paired tenons, one strengthened, carry the ends of beams supporting cupola posts in the roof frame of the Cabildo, the original Spanish city hall in New Orleans (1796, 1849, 1992; see TF 21 and 24). A forged iron strap prevents spreading.

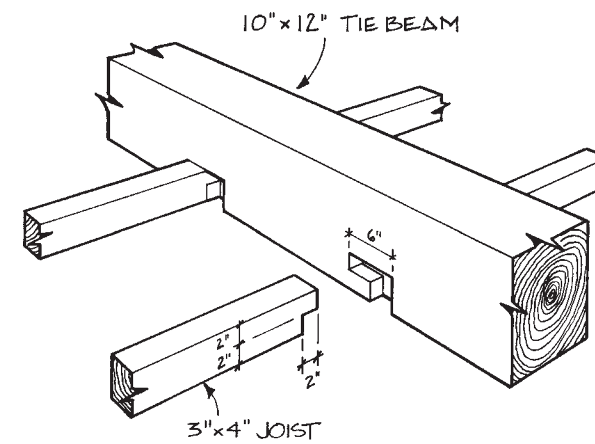


Fig. 25. An L-mortise in the 1829 Newbury, Vermont, Methodist Church. The building measures 45x60 with the ceiling joists spanning about 12 ft. and spaced at 30 in. on center.

SPECIAL MORTISES FOR CEILING JOISTS. In larger structures with trussed roofs, such as meeting houses, it was necessary to provide ceiling joists between the tie beams of the trusses. Builders preferred to keep the ceiling joists flush with the bottom of the tie beams so that an uninterrupted plaster ceiling could result. Tie beams are typically deep in section (10-12 in.), while ceiling joists might only be 4 in. deep. Inserting 20 or more tenoned joists between tie beams as the latter are placed would be daunting. Builders used at least four different methods to insert tenoned joists between the tie beams after the trusses were in place.

The L-Mortise. This mortise allows the tenon to be lifted up and over (Fig. 25). Only one end of the joist has to be accommodated thus since the tenon on the other end of the joist can be inserted first (at a small angle to the horizontal) into a standard mortise. Though the L-mortises are shallow, they still cut into the bottom surface of the beam. Typically, only one side of each tie beam has these mortises.

The Short Joist. A joist with a shorter shoulder to shoulder length than the spacing between the tie beams can be inserted into one mortise an extra 2 or 3 in. deep, then swung into place and slid back until it bears an equal amount at each end (Fig. 26). Of course, the joist needs to be secured from future movement. Its main disadvantage is potential shearing of the tenon.

The Vertical Chase Mortise. One end is again inserted first, and the other swung down from above in a chase mortise (Fig. 27). Inserting joists from above is perhaps more convenient, but these mortises substantially reduce the section of the tie beam. The depth of these mortises must be kept to a minimum.

The Horizontal Chase Mortise. In this variation, also called a pulley mortise, a continuous slot connects two or three joist mortises (Fig. 28). Thus multiple joists are maneuvered into place in the same slot.

With all these post-raising insertion types, the spacing of the tie beams, which are long and somewhat flexible, would be secured by at least one tying member near mid-span to prevent spreading of the beams and collapse of the ceiling. The lath would secure the spacing of the joists. Since the horizontal chase mortise does not remove wood from the bottom surface of the tie beam, it is the best solution structurally. However, it is more time consuming to craft than the first three. —Jack A. Sobon

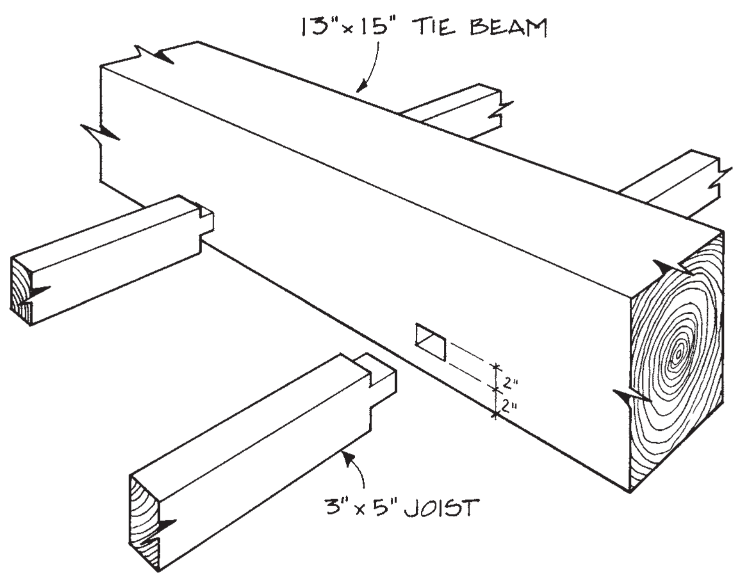
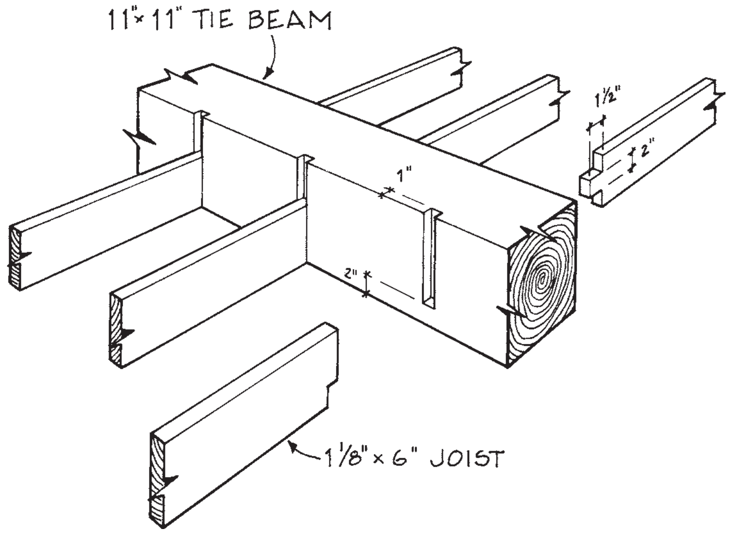


Fig. 26. Beech ceiling joists with shortened shoulders are secured from movement by a single cut nail in the Second Congregational Church, Newport, New Hampshire (1823).

Fig. 27 (right). Board ceiling joists tenoned at one end and notched at the other drop into vertical chase mortises on the tie beams of the 1815 Methodist Church at Chenango Forks, New York (now dismantled). The bearing for the joist in the tie beam is only an inch deep. Close truss spacing of about 8 ft. permits the use of light boards. Similar joinery is found on an 1840 church in Brimfield, Massachusetts.



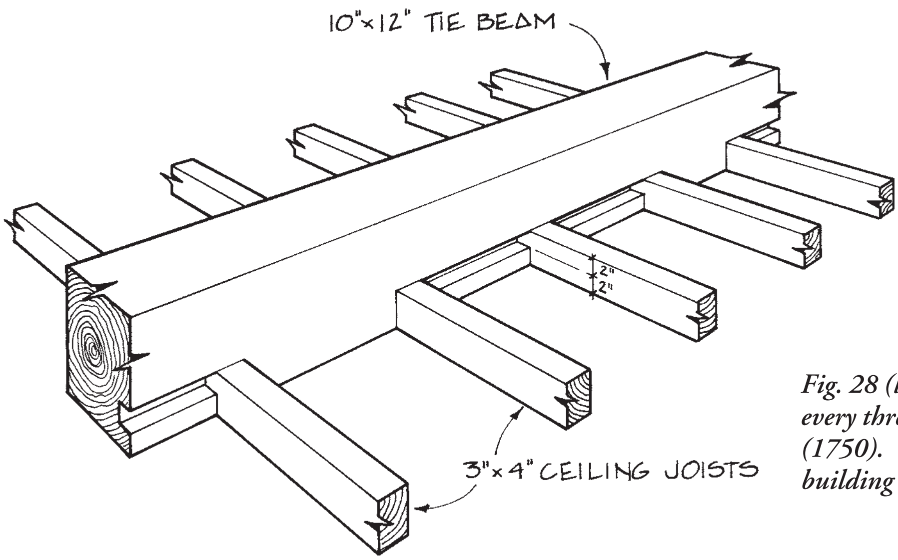


Fig. 28 (left). Long pulley (chase) mortises were cut in the tie beams for every three ceiling joists in the Hatfield, Massachusetts, Meeting House (1750). The opposite side of the ties had simple 2x3 mortises. This building was destroyed while being rolled to a new site in 1979.

Jack A. Sobon

The typical blind sill corner joints on this house frame in Charlemont, Massachusetts, give little clue to their inner mortise and tenon configuration. The first joist to the rear, hewn flat only where necessary, joins the sill in a butt cog. Timber sills and girders, historically a natural part of the timber frame, have virtually disappeared from modern American work.

Design of a Spiral Stair

My grandfather was a farmer, carpenter and barn builder. Although he died three years before I was born, his work was there on our farm for me to see and study. I was always impressed with his workmanship and wise selection of the wood he used. He set a measure by which I judge my own work.

As a carpenter, cabinetmaker and structural engineer who has been involved with heavy timber-framed buildings over the years, I like to retrieve discarded posts and beams from the jobsite. It was a 120-year-old red pine post and several 3x15 white pine joists from a dumpster in the Historic Warehouse District of downtown Toledo, Ohio, that I carried home one day in the back of my pickup. At that time I had no particular use in mind, only to save them until I did.

In due time, my wife wanted me to buy a spiral stairway to lead from our bedroom to a loft directly above. Of course, it had to be wood to match the other exposed wood in our house. After pricing what was available, I could not justify spending $4,000 for a kit of oak parts. So it was that I decided to build it myself, though I had never built one before and did not know how. But with that 8x10 red pine post and all those 3x15 white pine joists piled in my barn, I set about thinking how to design and construct the stair in my shop using those materials.

The stairway details evolved as follows:

The red pine 8x10 became a 6x6 center post with 12 sides, mortised to receive the narrow ends of the tapered treads.

The white pine treads, 2 1/2 in. thick, taper in width and curve at the outside to meet the circular configuration of the stair. Their 3 3/4 in. x 2 1/2 in. tapered tenons are secured with structural epoxy in the post mortises.

The curved handrail, 1 1/2 in. x 6 in., is made of 1/4-in. white pine laminae glued up to the required screw-shape configuration.

The balusters, 1 1/4 in. square white pine, are blind-screwed to both handrail and treads.

The landing, 1 1/2 in. thick and 2 ft. square, is mortised into the post and also supported by the framing surrounding the 4-ft.-square opening in the loft floor.

The loft railing assembly, with 3 1/2 in. square posts, 1 1/4 in. square balusters and a 1 1/2 x 3 3/4 in. top railing, are all made of white pine and surround the opening in the loft floor and adjoin the top post and handrail of the spiral stair itself.

THE big question with which I struggled was this: does the curved handrail assist in supporting the outer ends of the treads? After thinking this through, making detail drawings of the configuration of the curved handrail in relationship to the treads and their connecting balusters and studying other spiral stair designs, I arrived at certain observations and conclusions.

The curved handrail is shaped like a coil spring and resembles threads on a screw or bolt. If this screw were free-standing and propped somehow to keep it from falling over, it would have no strength with which to support gravity loads, such as the ends of the treads. But the proposed curved handrail on my stair would be 1 1/2 in. thick and 6 in. deep. Therefore, if it could be made to support the treads, its contribution would be significant. Thus the handrail is connected to each tread with two square balusters, each with two screws at the top and one at the bottom. The handrail then acts as a curved beam with a 6-in. depth.

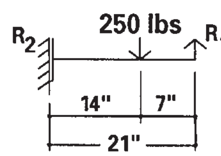
My spiral stair is 4 ft. in diameter, which allows a 21-in. wide person to fit between the post and the handrail. Realistically, a maximum of three persons could occupy the stair at one time, which means that a person's full weight would be upon every third tread. The curved handrail, acting as a 1 1/2 x6 beam, would then need to support the outside ends of three consecutive treads.

For purposes of calculation, the tread is assumed to be rigidly connected to the post mortise and cantilevered from it, and then pin-connected to the two balusters supported by the handrail, itself supported by two adjacent treads. Through these connections, a person's weight is thus supported by three consecutive treads.

The section modulus of the handrail works out to 9 cu. in.

$$S = \frac{bd^2}{6} = \frac{1.5(6)^2}{6} = 9in^3$$

The assumed person-weight is 250 lbs. As the person ascends or descends the stairs, all the weight is placed at the outer third of alternate treads as in the beam diagram below:



To determine the reactions and bending moment in the tread where R_1 is the reaction at the handrail and R_2 is the reaction at the post, P is the assumed person-weight, a is the distance of the contact point from the baluster support, b is the distance from the post and L is the width of the tread:

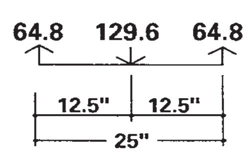
$$R_1 = \frac{Pb^2[a+2L]}{2L^3} = \frac{250(14)^2[7+2(21)]}{2(21)^3} = 129.6lb$$

$$R_2 = \frac{Pa[3L^2 - a^2]}{2L^3} = \frac{250(7)[3(21)^2 - 7^2]}{2(21)^3} = 120.4lb$$

The maximum bending moment at the contact point is determined by R_1 times the distance to the outside (handrail) edge of the tread, for a result of 907.4 inch-pounds.

Since three treads support the 250 lbs., both reactions and the moment may be divided by 3. However, to be conservative, I designed each tread to support the entire weight and did not use the handrail to help out.

The reactions of the three consecutive balusters and the bending moment M in the handrail are found as follows, where P is the load from the person supported by the middle baluster, R_1 the reaction carried by each adjacent baluster, L the distance between the first and third balusters and F_b the design stress value in bending:



$$P = 129.6lb$$

$$R_1 = R_2 = \frac{129.6}{2} = 64.8lb$$

$$M = \frac{PL}{4} = \frac{129.6(25)}{4} = 810in \cdot lb$$

$$S = \frac{M}{F_b} = \frac{810}{1250} = 0.65in^3$$

Therefore, since the allowable S of 9 cu. in. is almost 14 times the actual 0.65 cu. in., the handrail is many times more than adequate, though it is true that in treating it as a beam, I made no adjustment for twist and curvature of the handrail.

By observation, the shear of the two screws at the outer end of the tread will adequately support 129.6 lbs. Also by observation, the shear and bearing of 120.4 lbs at the inner end of the tread will adequately be supported by the mortise in the post.

The section modulus of the end of the tread (by the previous formula) works out to 3.91 cu. in. The required section modulus from the bending moment in the tread is calculated below:

$$S = \frac{M}{F_b} = \frac{907.4}{1250} = 0.73in^3$$

I judge 1,250 psi to be a reasonable bending value for these white pine treads, since they are dry and from 120-year-old virgin, slow-grown Michigan white pine with closely spaced annual rings and straight grain. The 3.91 cu. in. available is thus over fivefold the required section modulus of 0.73.

As to bending in the post itself, the worst situation would be if the live load of one person were at the outer third of one tread at one time. If two or three persons were on the stair at the same time, the weight distribution would produce a nearly balanced loading, thus causing less bending moment. Therefore, in the following calculations I am using the worst condition, i.e. the live load bending moment of one person. The dead loads of the post, treads, handrail, and balusters are nearly balanced and do not cause a significant moment, and so this dead load moment is ignored. The live load bending moment M then is given by

M = 250 lbs x 14 in.= 3,500 lb-in.

Comparing the actual to the required section moduli of the post, the actual section modulus (without showing the complex calculations) works out to nearly 20.2 cu. in., while the required section modulus is calculated below. I used a bending stress (F_b) of 1,050 psi. based on my judgment of the dry 120-year-old Michigan red pine with close annual rings and straight grain.

$$S = \frac{M}{F_b} = \frac{3500}{1050} = 3.33in^3$$

The actual section modulus of 20.2 cu. in. is thus over sixfold what is required.

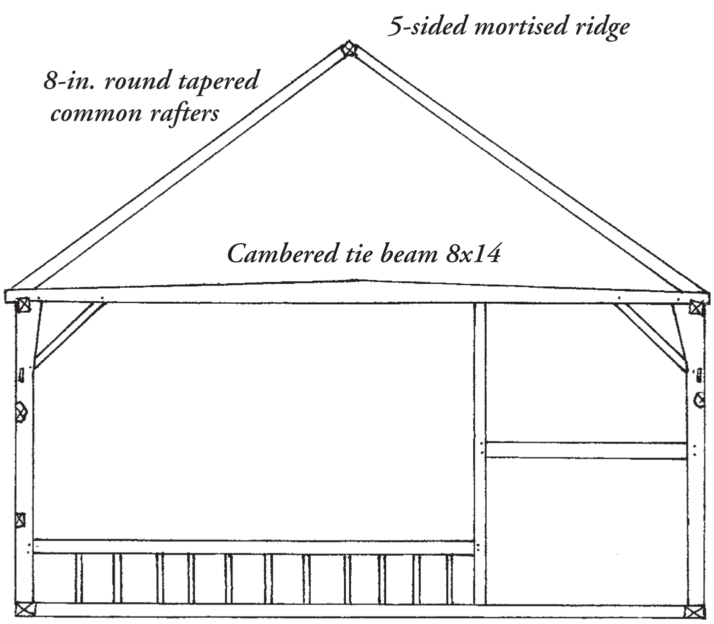
HOISTING and installing the spiral stair unit were also engineering feats in themselves. I built the stairway entirely in my shop as one finished unit with all components fastened in place. Three of my buddies and I man-handled the unit from my shop (located in the mow of my barn), carried it to my house about 100 feet away, hoisted it to a second-floor balcony with the aid of a farm tractor with a boom hoist, then threaded it through the 3-0 x 6-8 door into our bedroom. Then we lifted it by hand into its final position within the loft opening and fastened the bottom of the post base and the landing in place with dowels and long wood screws. Later I made and installed all of the safety railing in the loft using the white pine posts and balusters mortised into a previously installed oak sill plate.

During handling and hoisting operations, the spiral stair with its three coats of varnish suffered some scrapes and bruises, which I later sanded and touched up. The entire project took over 100 hours, and with much satisfaction, pride, and gratitude to my wife and three buddies, I can say the same words I did after my discharge from my two-year army stint (I was drafted during the Vietnam war): "I'm glad for the experience, but I wouldn't want to do it again!" —LARRY FAST

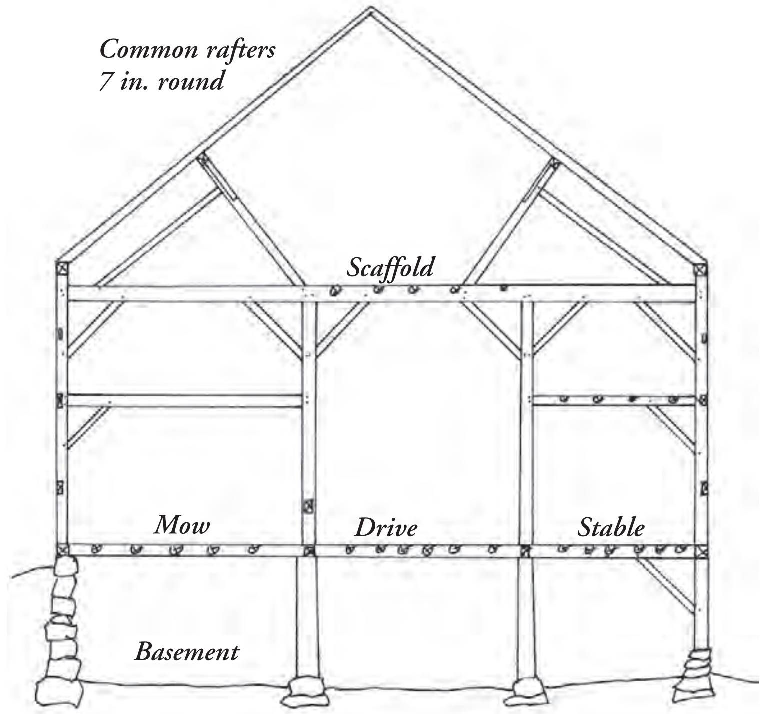
Larry Fast, P.E. (419-885-4258) is a consulting engineer in Sylvania, Ohio. Photo by the author.

TTRAG 2000: Bent Typology

THE Spring 2000 meeting of the Guild's Traditional Timber Framing Research and Advisory Group at Silver Bay, New York, included a symposium on American barn bent typology by region and period, with presentations by Rudy Christian, Jan Lewandoski, John MacFarland, John McNamara, Randy Nash, Jack Sobon and Arron Sturgis. Of the illustrations on view, herewith a small selection, which excludes the radical change in barn frames induced by the arrival of the hay track in New York and Ohio in the third quarter of the 19th century.

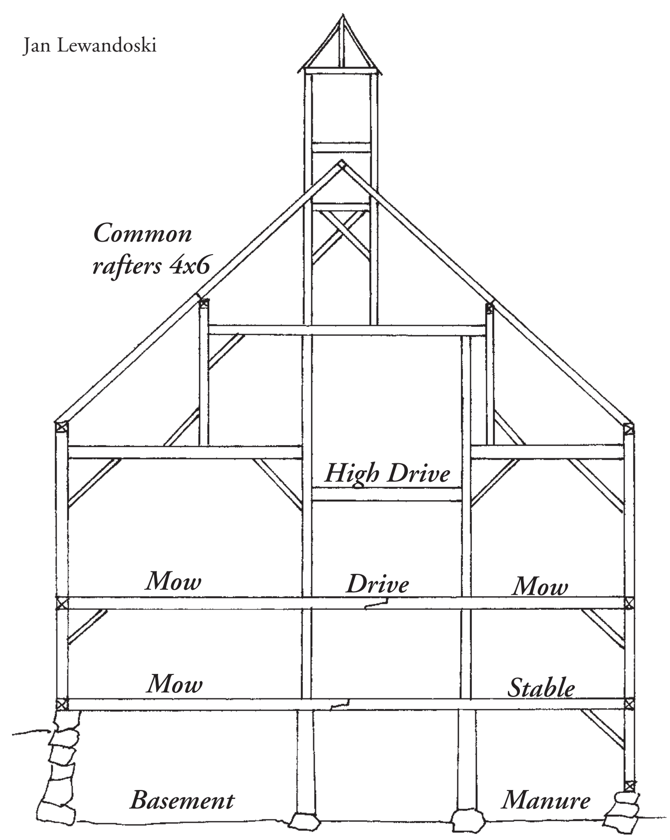


First period (1770-1830) north and central Vermont English style threshing barn, about 30x40. Interior drive bent shown. Four bents, three bays, typical wall height 14 ft., 6 in. Flared posts of beech or spruce, pine or hemlock. English Tying Joints with tie beam of spruce or pine, one piece, often cambered. Braces 3x5 of mixed hardwood, connecting girts (hewn flat one side or four) of mixed hardwood and softwood. Sills, plates and floor girts of softwood. These barns were raised as sidewalls rather than transverse bents.

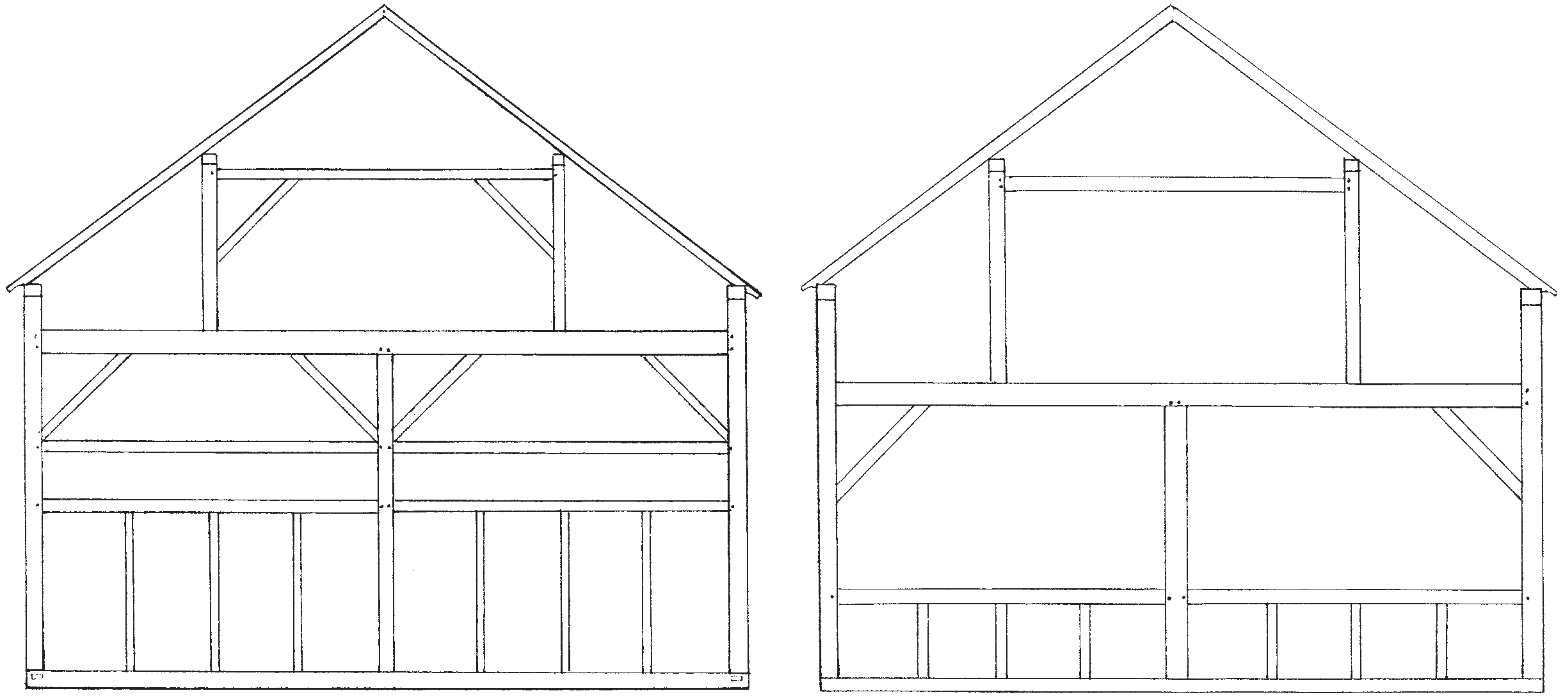


Second period (1810-1870) gable-entry Yankee barn, about 36x60, bank barn with basement, typical wall height 16 ft. All softwood frame, including 4x4 braces, cedar columns in basement.

Jan Lewandoski

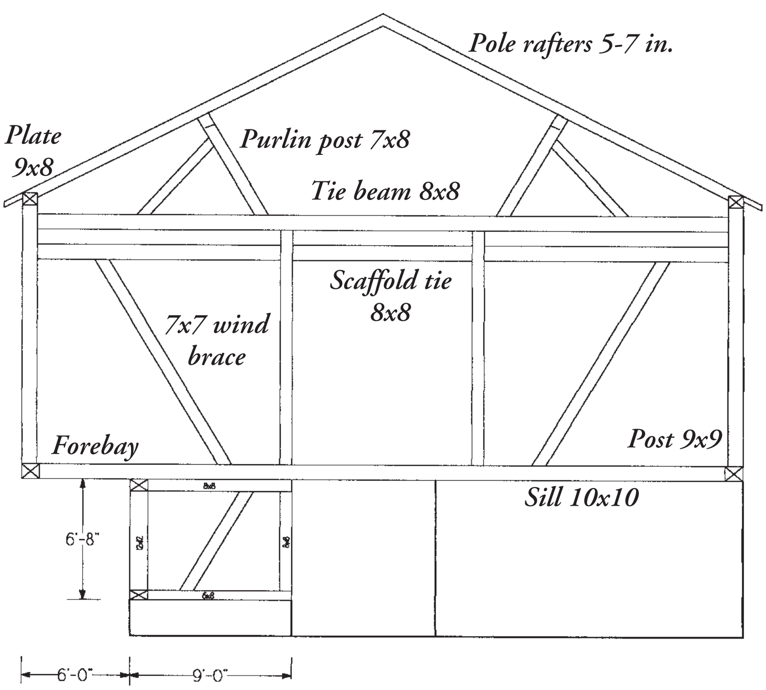


Third period (1870-1920) vertically integrated high drive barn entered by bridge. Range 40 to 50 ft. wide, 80 to 200 ft. long, with 16-to 25- ft. wall height. All softwood, 4x4 braces, rectangular timber 7x7 to 8x10, rarely larger.



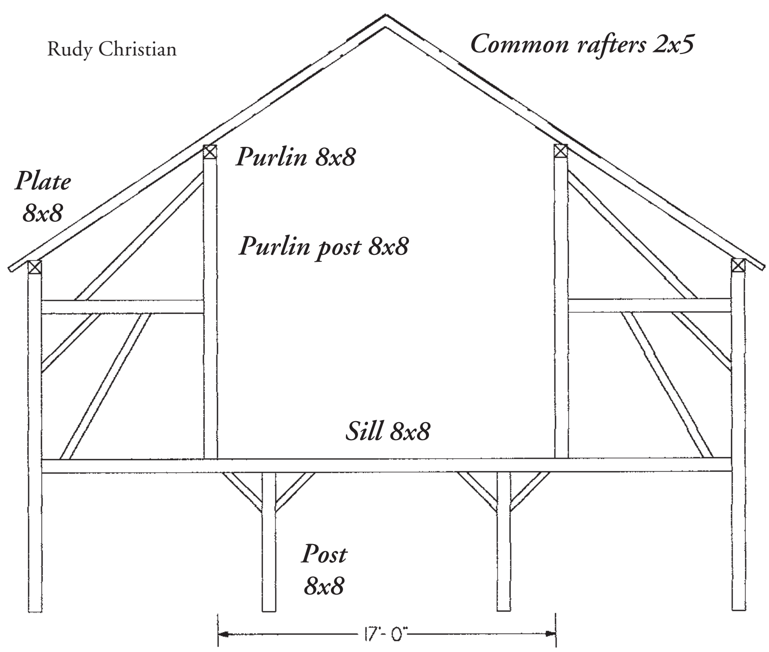
Randy Nash

South wall bent and interior bent of central New York State English threshing barn at the Joseph Smith Historic Site, Palmyra, N.Y. The majority of these barns were built in the first quarter of the 19th century using local trees from land-clearing. Most were laid out according the Square Rule and built with hewn timbers. With relatively low sidewalls 13 to 16 ft. high, the majority have dropped tie beams, with occasional variations such as tie beams tenoned to top plates on end bents only. Dairy barns, while using the same bent forms as the threshing barns, were larger, 36 to 50 ft. and longer, and used more sawtimber (braces, rafters, girts and some posts). Major bent changes in last quarter of 19th century were brought on by the arrival of hay tracks in the 1850s, which led to open interiors and 18- to 22-ft. sidewalls.



Typical forebay wall in a German bank barn with 14-ft. walls, all hewn or riven hardwood (oak and hickory), ca. 1825, Ashland County, Ohio.

Rudy Christian



Center bay bent of Yankee hay barn, also in Ashland County, Ohio, ca. 1900, all sawn beech, 36x42 with 16-ft. walls. Struts and long braces are 6x6, short braces 4x4.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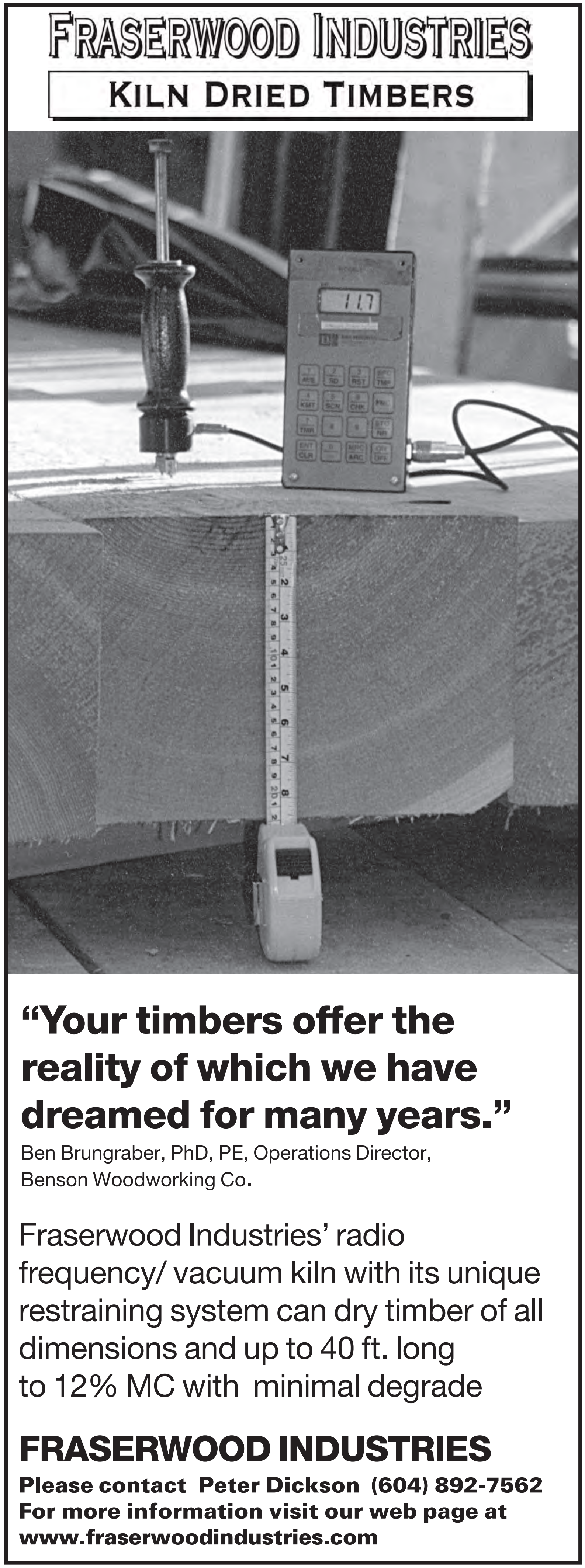
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Randy Nash

Central New York State barn, with typical dropped tie beams and purlin plates supporting the rafters. See TTRAG 2000, page 16.