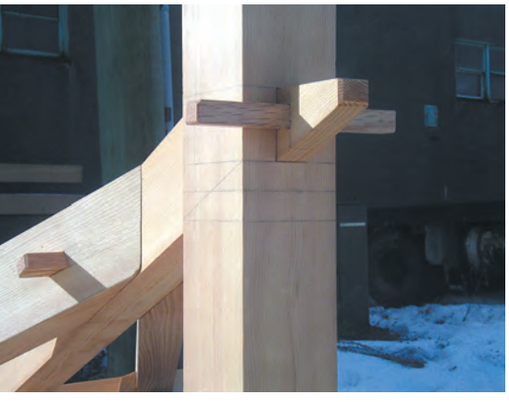
TIMBER FRAMING

JOURNAL OF THE TIMBER FRAMERS GUILD

Number 80, June 2006

Shop Safety



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On the cover, large photo shows marked-out traffic lane at Benson Woodworking's spacious Keene, New Hampshire, workshop. Sawhorses, unattended tool carts and moving loads are excluded from the lane between the black-and-white stripes. On the left, Duane Beiler prepares a laminated curved beam. Story, page 14. Photo by Will Beemer. Smaller photos, left to right, by Chris Hall, G.R. Plume and Jack A. Sobon.

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TIMBER FRAMING, Journal of the Timber Framers Guild, appears 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

BOOKS

Dutch-American Vernacular

Dutch Vernacular Architecture in North America, 1640–1830, by John R. Stevens. West Hurley, New York, HVVA Society for the Preservation of Hudson Valley Vernacular Architecture, 2005. 12x9 in., 450 pages, copiously illustrated. Cloth $65, paper $50.

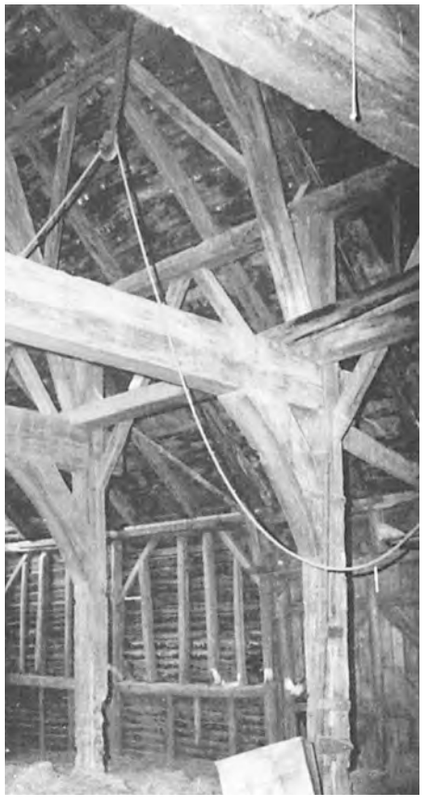
THIS is the book that many of us have been waiting for, for years. Like Abbott Lowell Cummings' tome, *The Framed Houses of Massachusetts Bay, 1625–1725,* John Stevens' survey of another major first-period region is destined to be a classic. Though the work is billed as a North American study, the Dutch cultural hearth is primarily Eastern New York and New Jersey, with its best examples in early settlements along the major rivers.

Stevens' book is not the first to address Dutch-American architecture. The 1960s saw two important books published: Helen Wilkinson Reynolds' *Dutch Houses in the Hudson Valley Before 1776,* and John Fitchen's *The New World Dutch Barn.* While Reynolds' book presents the histories of numerous houses, there are only photographs of house exteriors, with no plans, sections or details. Fitchen's book is much better illustrated. (It was reprinted in 2001 in an expanded edition edited by Greg Huber.) For 30 years, Reynolds and Fitchen were the authors to consult.

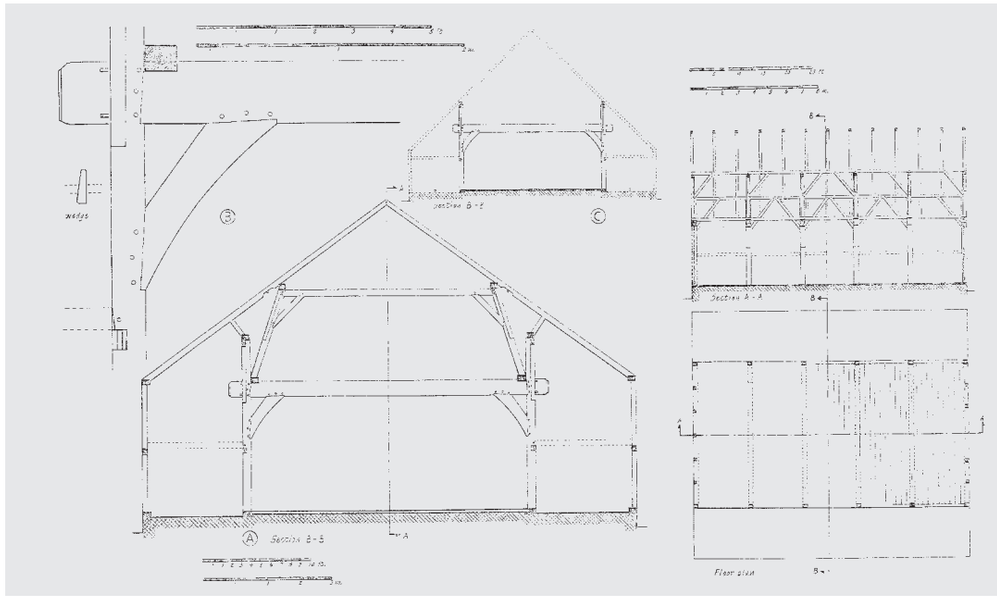
In the 1990s, we saw the publication of three additional books: David Steven Cohen's *The Dutch American Farm,* Shirley W. Dunn and Allison P. Bennett's *Dutch Architecture Near Albany, the Polgreen Photographs,* and Harrison Meeske's *The Hudson Valley Dutch and Their Houses.* All filled a need in expanding the information available. In 2002, Roderick H. Blackburn's book, *Dutch Colonial Homes in America*, with its beautiful and inspiring big color photographs, brought Dutch-American architecture to life.

Photos and drawings John R. Stevens

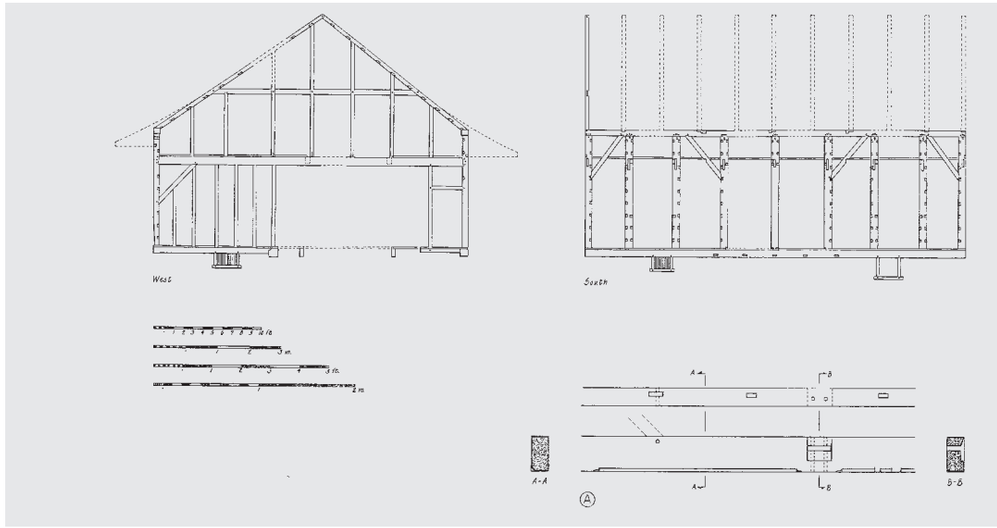
Framing of the Minne Schenck House, ca. 1730. Shingle lath passes over studs and brace but is let in to corner post.



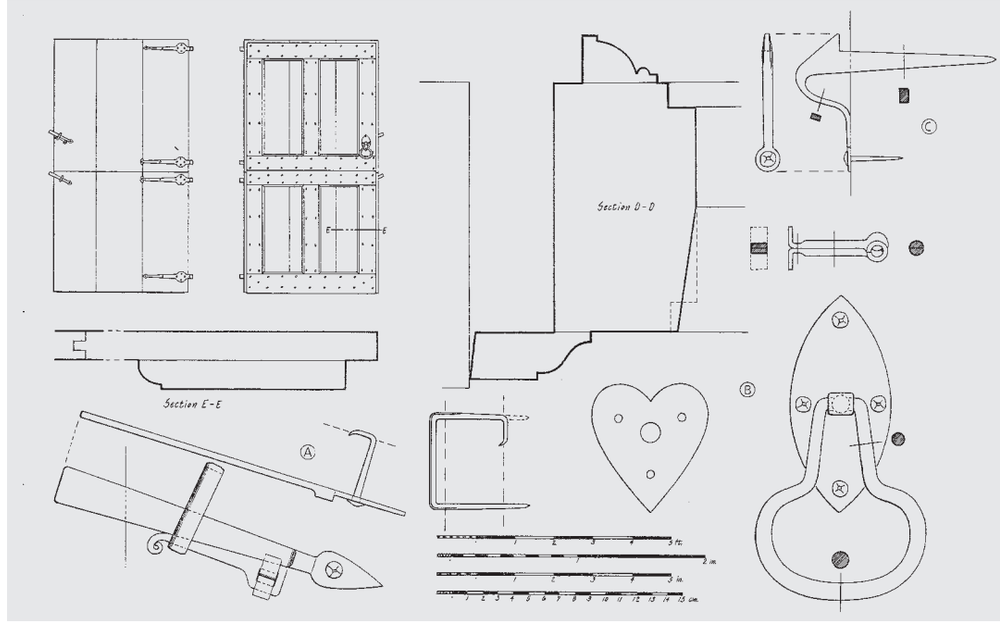
Van Bergen-Vedder barn, traditionally dated to 1680s, possibly post-1700, formerly at Leeds, Greene County, N.Y. Canted roof strutting is 19th century.



Van Bergen-Vedder barn, showing original cross-section and later raised roof with strutting.



Framing of the Minne Schenck house, formerly at Manhasset, Nassau County, N.Y.



Dutch exterior door at the Minne Schenck house, with details of jambs, casings and hardware.

John Stevens' book represents a lifetime of study and, though slow in coming, benefits from a multitude of more recent fieldwork. Many individuals as well as such groups as the Dutch Barn Preservation Society, HVVA Society for the Preservation of Hudson Valley Vernacular Architecture, Stichting Historisch Boerderij-Onderzoek (the Institute for Historic Farm Research in The Netherlands) and, of course, our own Traditional Timberframe Research and Advisory Group, have greatly expanded the database. Also, with dendrochronology, we now have firm dating of wood structures.

The book covers multiple building types: houses, barns, hay barracks, wind and water mills. The details, timber framing, doors, windows, woodwork, and ironwork are all illustrated. In addition to photos, there are probably more plans, sections, elevations and detail drawings than in all the other books combined. With its scaled drawings, *Dutch Vernacular Architecture* will be invaluable to professionals involved in preservation and restoration work. For those interested in any way by the unique architecture of Dutch barns and houses, this book is a must-have.

—Jack A. Sobon

Japanese Compound Layout

III. The Sawhorse in the Roof

AT first glance, the sawhorse may appear to have little relevance to roof work except, as we saw in the last article (TF 79), for steeples and the like. But the layout geometry of the sawhorse has a wide range of applications. One such forms the second level of the Japanese carpentry exam; indeed the earlier iteration of this exam featured four-way splayed post work, our last topic, as its subject.

In the current exam, the object is to construct a roof model as shown in Fig. 1. A pair of common rafters is attached at an askew angle to a central common rafter. The askew rafters are parallelogram-shaped in section to have plumb sides and top and bottom surfaces in plane with the roof surface (Figs. 2, 3). These rafters are in fact very similar to the legs of the sawhorse.

The rafter tips are cut to accept a fascia (*kakushi-ita* or "concealing board"). The common rafter supports the askew rafters with a half-lapped version of a *kashigigi-ō-ire* (inclined housing) joint and is fixed to the rear support post by a tapered and outside-pinned through tenon (cover photo). To pass the carpentry exam, one has six hours' time to draw the model with developed views of an askew rafter, take material supplied 1mm oversize and plane everything to dimension, then cut all the joinery and fit the model together, leaving the layout lines so alignment can be seen. In the model here, I have added a wedging pin (*hiyo-dori sen,* "brown-eared bulbul pin") to fix the askew rafters to the central common, but in the actual exam nails are employed (don't tell anyone!). The pin's name is probably a reference to the flight pattern of the bulbul bird.

The askew rafter serves as a vehicle of understanding a layout method generally applied to cantilever beams, *ha-ne-gi,* employed in a Japanese double-roof system. Typically *hanegi* are left in the round, since logs are stronger for a given diameter than rectilinear beams, but rectilinear beams are also sometimes used, and it also happens that sometimes flat surfaces and joinery need to be developed on logs. In a gable roof, the *hanegi* need to be supported from the wall plate, and travel at angles between the common angle and the hip angle toward the lower corners of the gable. It is these cases to which our askew rafter example applies most directly.

Fig. 4 begins the descriptive geometrical drawing for the askew rafter in the model. I have broken the layout of this rafter into stages since the procedure is a bit different from that given in the last article for four-way splayed posts. Also, the section of the askew rafter is a rectangle adjusted to form a parallelogram, rather than a square adjusted into a rhombus as before.

In our model, the common rafter slopes 5 in 10 and the askew rafter slopes away from the common also at 5 in 10. Fig. 4 depicts the common rafter rotated onto its side to show the dimension and the relationship where it meets the *kakushi-ita* (fascia). In this side view, where the bottom of the rafter meets the *kakushi-ita,* a red dotted line extends along the fascia. Where this line crosses the askew rafter-to-*kakushi-ita* intersection, it also defines where the bottom of the askew rafter touches; the four points A, B, C and D bound the contact between the askew rafter and the *kakushi-ita*. The askew rafter also crosses the plate, and I have labeled E and F the points on the rafter plumb over the centerline of the plate. The dimensions of the common rafter we will fix at a unitary 1x1.2, the typical proportions used for Japanese decorative rafters.

Fig. 1. The model demonstrates various joints as well as geometry.

Fig. 2. Askew rafters are reshaped top and bottom; sides are held plumb.

Fig. 3. Top surfaces of common and askew rafters form roof plane.

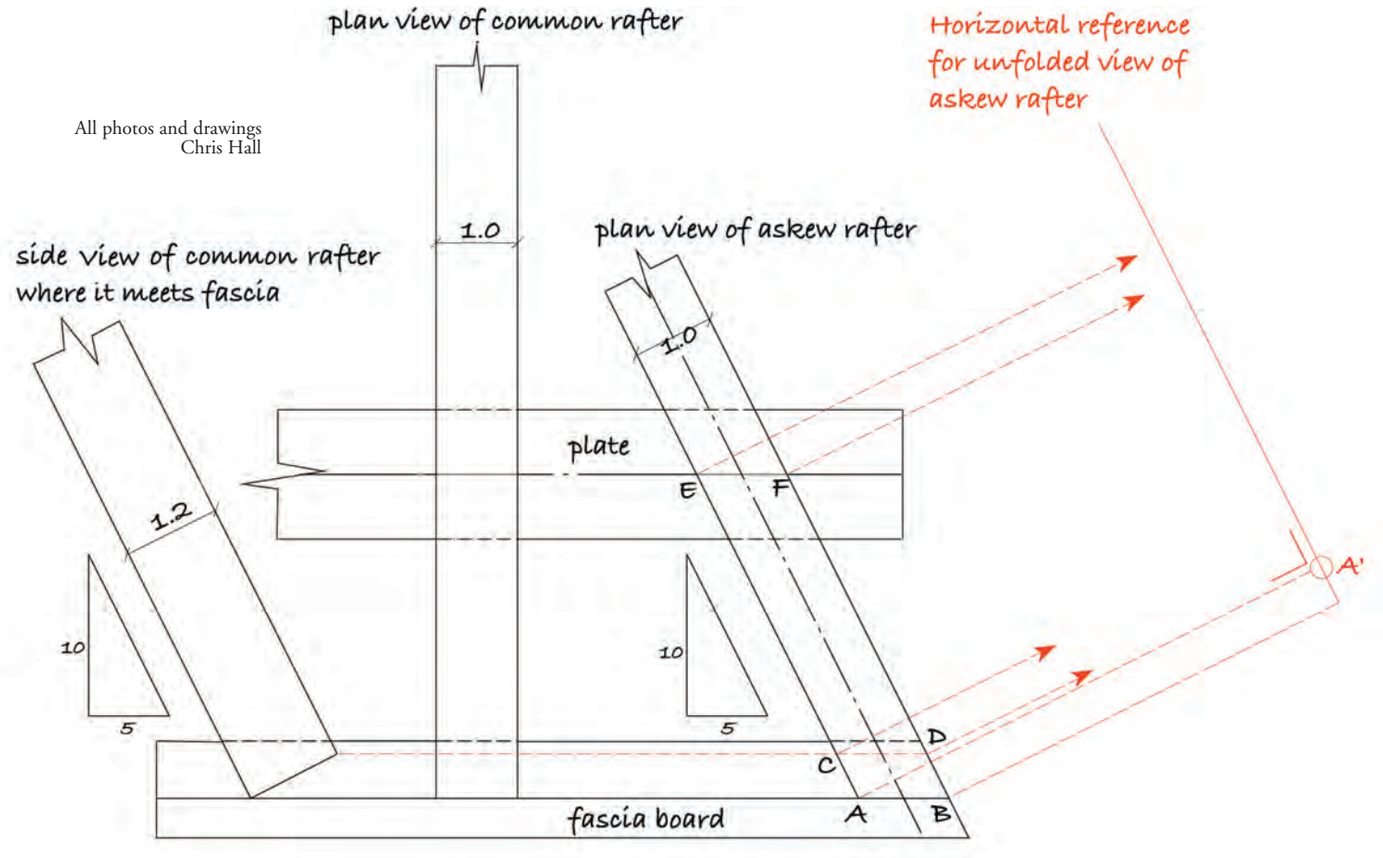


Fig. 4. Beginning layout showing elements of the model and first development of the askew rafter.

From points A, B, C, D, E and F, project lines at 90 degrees to the askew rafter and mark another line parallel to the rafter. This last will serve as a horizontal reference for laying out the slope of the askew rafter. The line from A crosses the horizontal reference at A′.

In Japanese, "rafter" is *taruki* and "askew rafter" is *fu-re-daruki,* the terms I will employ for the most part. In the interest of simplicity, I will omit joinery considerations and consider only the layout of the nose of the *fure-daruki* and the layout of the line drawn around all four faces of the rafter where it meets the plane of the centerline on the plate. To begin with, let's establish certain necessary dimensions.

The plumb measure along the side of the common rafter is 1.3416, calculated using the common triangle illustrated in Fig. 5. In this drawing, the sides of the two rafters are back to back and drawn to share the same plumb measure. The common *taruki* and the *fure-daruki* share two planes—the top of the plate and the roof plane formed by their top surfaces. Since the slopes of the common *taruki* and the *fure-daruki* are different, it follows that to give the same plumb measure as the common *taruki*, the side dimension (or perpendicular depth) of the *fure-daruki* must be adjusted.

Fig. 5 (bottom) depicts this calculation. Once the plumb distance is established, it is a straightforward matter to determine the side dimension of the *fure-daruki*. We find it measures 1.2247.

WE know that a given piece of wood that slopes an equal amount in two directions has a different resultant slope. This slope can be determined using the *futaba-korobi* method that we described in the last article (TF 79) or by taking the *chū-kō* measure. (If you are unsure why *chū-kō* gives the necessary angle, please review the first article in the series, on hopper layout, in TF 78.)

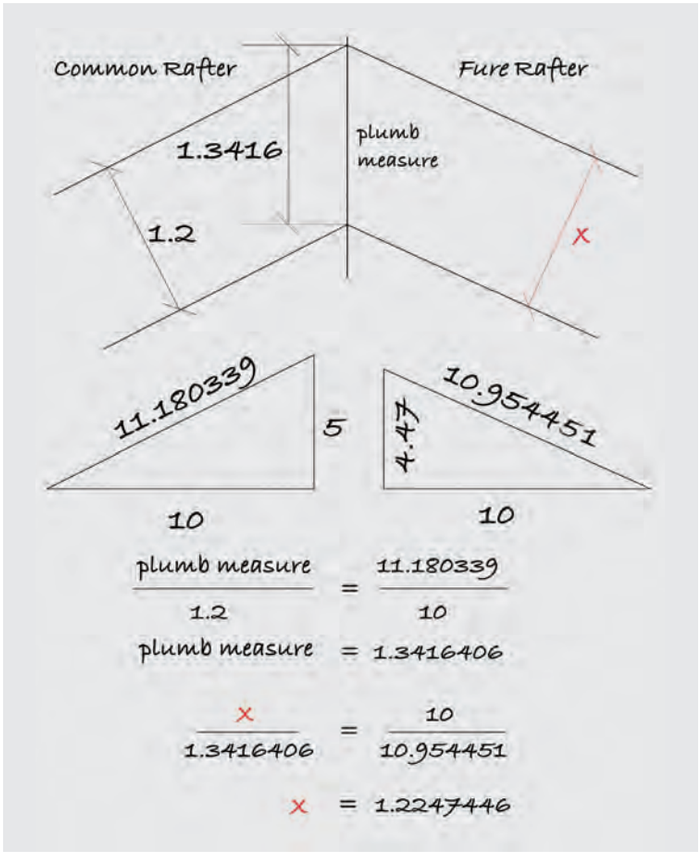


Fig. 5. Establishing plumb depth of common rafter and perpendicular depth X of askew rafter (fure-daruki).

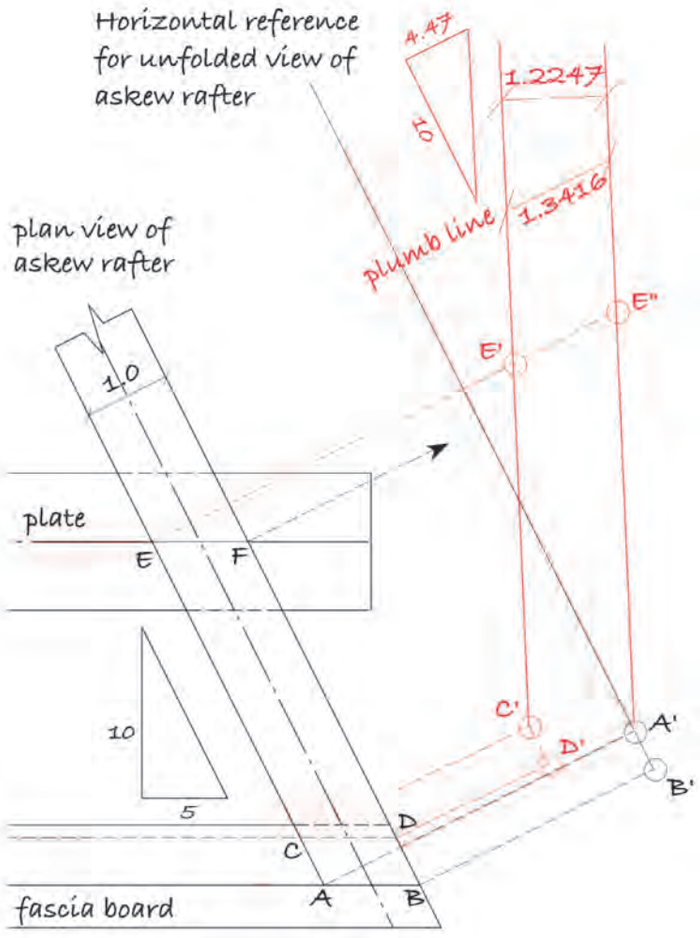


Fig. 6. Development of lower and upper inside arrises of askew rafter.

In Fig. 6, extend the projected perpendicular line from B to the horizontal reference line, giving B′. At the intersection point A′, we establish the *chū-kō* slope line, 4.47 in 10, in relation to the horizontal reference line. This line also denotes the upper inside arris of the *fure-daruki*.

To obtain the lower inside arris, measure from the *fure-daruki* slope line the side dimension of 1.2247 established in Fig. 5. Mark a parallel line, thus defining both the lower inside arris and the side of the *fure-daruki*. Extend the line from point E to cross these two lines, giving points E′ and E″. Project the points C and D, which define the lower corners of the *fure-daruki* at the fascia, to the inside lower arris line of the *fure-daruki*. Point C′ forms directly by projection; point D′, like B′, is connected by the line C′–D′, in parallel to the horizontal reference line. Line C′–D′ is parallel to line A′–B′ since the bottom surface C–D of the *fure-daruki* is parallel to the top surface A–B.

Before the line for the other arris of the top of the rafter can be drawn, that is, before we can unfold the *fure-daruki* top surface in Fig. 8, the top surface width needs to be established. Note that the top of the *fure-daruki* is not square to its sides. From points B′ and D′, project lines up parallel to the arrises already marked. The distance A–C, given the common slope of 5:10 and *taruki* thickness of 1, is 0.5. This distance, also denoted by the line C′–D′, forms the long leg of a triangle similar to the one giving the *fure-daruki* resultant slope—4.47 in 10.

Fig. 7 examines the askew rafter top surface in detail. The distance *X* is the amount that the rafter surface must rise from one arris to bring the top (or bottom) surface of the rafter into plane with the common. By calculation, knowing the unitary triangle for the *fure-daruki* slope, we can determine *X* to be approximately 0.2041.

With this information, the rafter top surface width can be calculated as in Fig. 7 and turns out to be approximately 1.02. As one would expect, the top surface on the askew rafter is slightly wider than the top surface on the regular rafter.

In Fig. 8, then, measure 1.02 from the top inside arris of the askew rafter (the line rising from A′) to establish the top outside arris (and therefore the top face as well). From B′ project a line 90 degrees toward this new arris, giving point B″. Also, extend the line from point F to cross the projection lines rising from point D′ and B′, giving points F′ and F″.

Construct additional lines from E′ to F′ and E″ to F″, each parallel to the horizontal reference line.

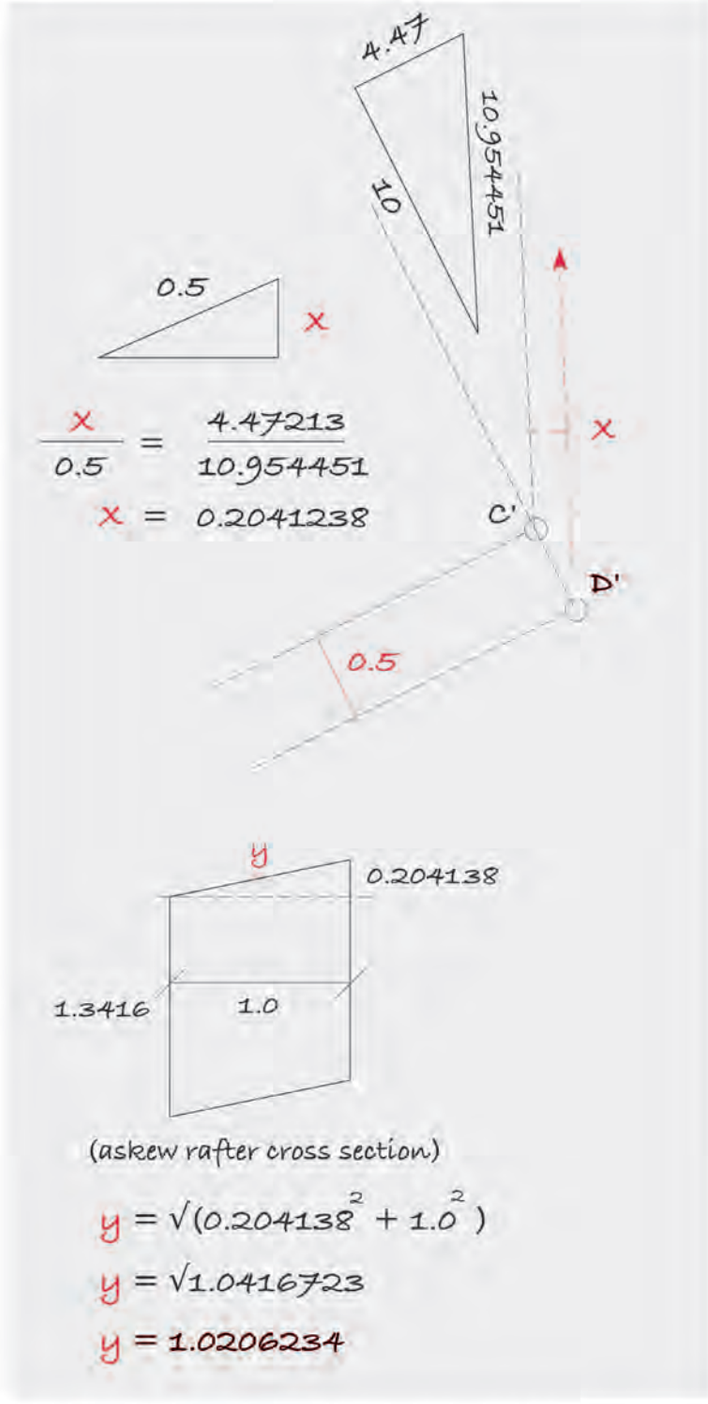


Fig. 7. Calculating the width of the askew rafter top surface.

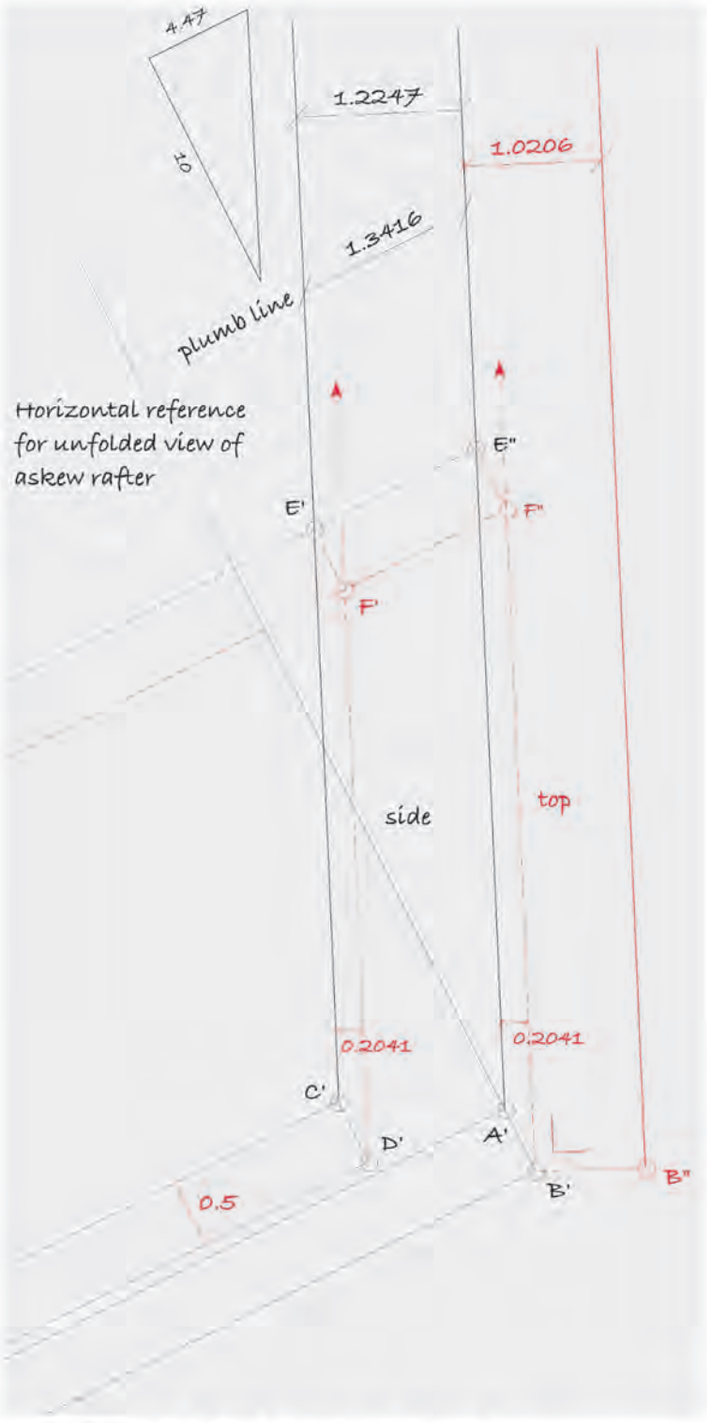


Fig. 8. Beginning the unfolding of the askew rafter.

Fig. 9 shows the remaining two faces of the *fure-daruki* unfolded to the right. Project lines 90 degrees from points C′, D′, E′ and F′ to the newly drawn rafter arrises. Draw in the askew rafter cross-section as shown, using the given rafter width of 1 (as understood from Fig. 7). Project a line from F″ to the arris to its right, similar to line B′–B″ below. At this stage, all the points necessary to determine the nose cut for the rafter have been established.

In Fig. 10, the *kō-ko-gen* triangle that we have explored previously, gives the cuts for the nose of the askew rafter. A fascia, when used, is oriented analogously to the *nuki* (stretcher) in the sawhorse, but the proportion of height to thickness is reversed. Since, as we saw previously, the top and bottom cuts for the sawhorse leg mortises were given by the *shō-chū-kō* angle, it follows then that the side cut angles on the *fure-daruki* are given by the *shō-chū-kō* slope.

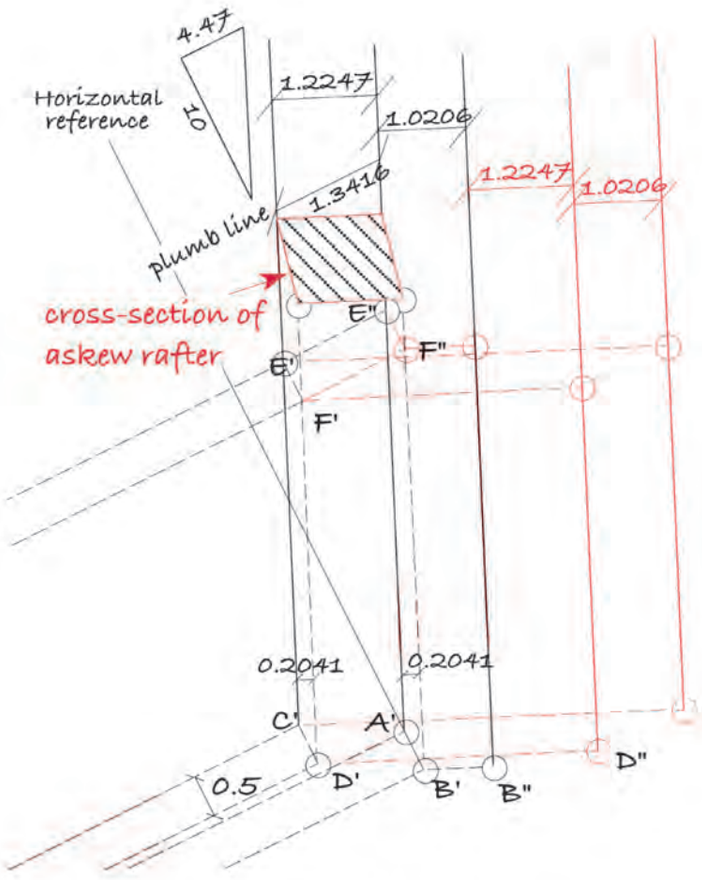


Fig. 9. Completing the unfolding of the askew rafter.

Fig. 11 overleaf shows the lines for the nose cut and the reference line drawn in. When the rafter is placed in position on the plate, the centerline on the plate will coincide with the labeled reference line on the bottom surface of the rafter. The labeled reference lines for the sides and top of the rafter denote a vertical plane of reference to the plate centerline. All of these reference lines can also be established on their respective faces using the *chū-kō* angle. This procedure is similar to establishing the horizon lines on the leg of the sawhorse, described in the previous article.

Fig. 12 overleaf shows the completed marking for the nose cut of the *fure* rafter, along with the reference line over the plate centerline, with marks denoting the appropriate angles when using measures derived from the *kō-ko-gen* triangle.

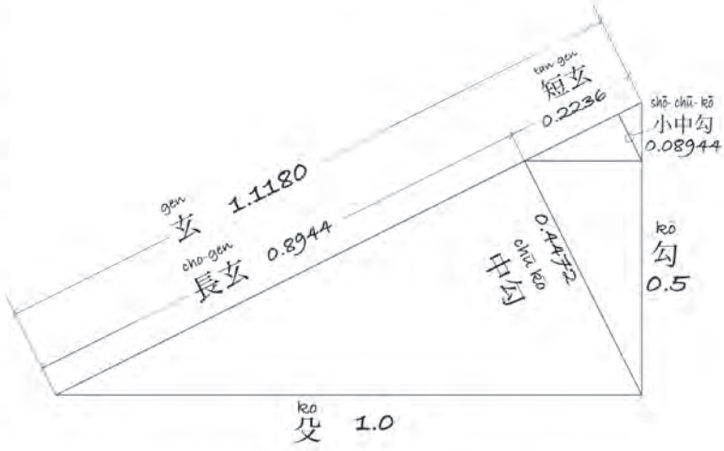
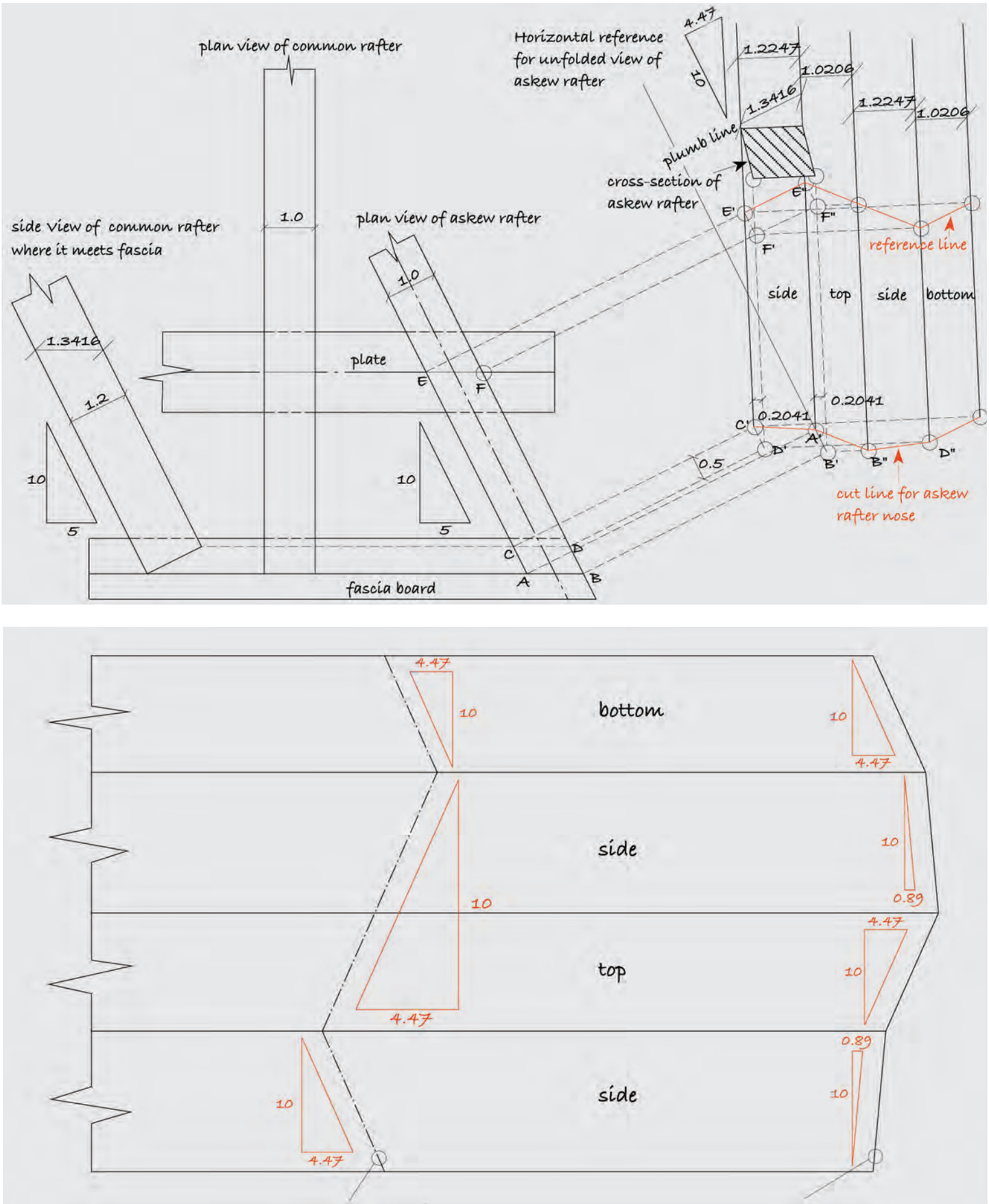


Fig. 10. The kō-ko-gen triangle for a 0.5 in 1 slope.



Figs. 11, 12. Unfolded views of the askew rafter with completed markings for the nose cut, plate centerline references and cut angles.

In the next installment of this series, we will apply what we have discussed as we begin our look at regular hip rafter layout.

—Chris Hall

Chris Hall specializes in Japanese timber framing and resides in Leverett, Massachusetts. Previous articles in this series have appeared in TF 78 and 79.

Western Conference Slide Show

THE Guild's 2006 Western Conference, held on the east coast of Vancouver Island at Parksville, British Columbia, April 21-23, drew 380 people (a record for the Western) and ran on four tracks—natural building, design (including engineering), shop practice and business. Thirty-one presenters produced a long and varied slide show, from which a few buildings are shown here.

Laurie Dickson, above; below, Lisl Dennis

Peregrine House, Tesuque, New Mexico

At left, view of dining-living room. At bottom left, view of sheltered entrance. The straw-clay walls are plastered inside and out. Tightly organized timber-framed house has six rooms and two baths on 1470 sq. ft. Timber framer and straw-clay specialist Robert Laporte and architect Paula Baker-Laporte, who collaborate as Econest Building Co. in Tesuque, built it as their first house.

Witter Memorial, Bellingham, Washington

Below, bandstand designed by Greg Robinson, a memorial to the late timber framer and skilled blues musician Mark Witter, to be built by his former colleagues at The Cascade Joinery in a Bellingham city park. The structure, about 28x28 ft. at the roof, would be framed in native timber, recycled if possible, roofed with translucent material and might incorporate a paneled backdrop bearing historical themes, as rendered below.

David Kaplan

Photos Dos Osos Timber Works

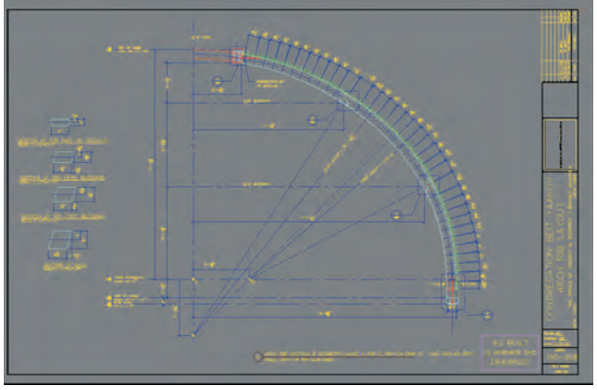
Los Osos and Nipomo Houses, California

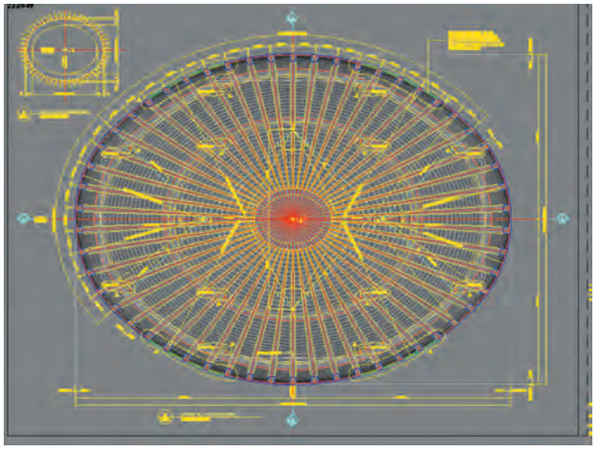
Built by Dos Osos Timber Works, Los Osos, California, to designs of Dos Osos' Bill Hurley (who calls the firm "a surfing company with a timber framing problem"), these related houses have light-framed walls and weather roofs over timber-framed cores in Douglas fir, and show composite architectural design, with apparent Japanese and International Style influences. The Los Osos house, above and at left, meets seismic requirements by linking interior steel shear structures to external concrete tower buttresses via 5x5 square tube Cor-Ten steel.

Below and on facing page, views of the Nipomo house, another ocean-view commission that developed from the Los Osos house. Below, the Japanese courtyard, internal verandah and exposed rafter system seen through glass corner from interior. (Note Japanese rainchains.) Facing page, at top, view of starkly modern walls (shear system begins externally on left), Japanese-style roof and rafters. At middle, from left to right, views of a trussed hip, the kitchen area and the entryway. At bottom, view of Nipomo dining area. Deep beam is part of shear structure.

The Morway house, owner designed and built by Benson Woodworking, Keene, N.H., on a ski mountain in Vermont. At left, the house sheathed, roofed and fenestrated. Below left, raising well advanced. Below, cluster-column assembled to wall girt and half-scarfed plate rises carefully. Most work took place over a really long drop; in photo below, abundant personal safety equipment is visible on Philip Henry (yellow hat) and Neal Noble. The 2800-sq.-ft. house has concrete cantilevers in the two towers topped by crossing Douglas fir glulams, on which the frame is erected. Red and white pine quartered logs make up the bolted cluster-columns (which fit over hardwood splines emerging from the deck, as in photo below, far left). Sitka spruce and recycled Douglas fir provide the rest of the framing. Windows and panels had to be installed sequentially to balance dead loads side to side on the building.

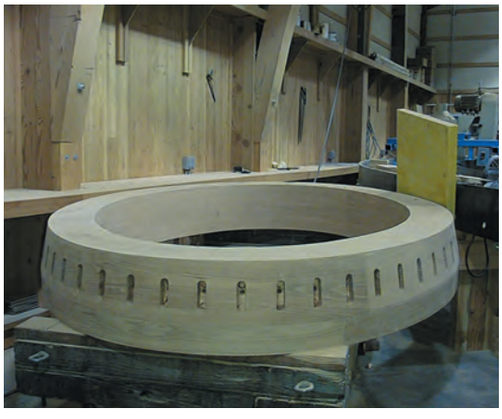
Morway House, Warren, Vermont





Photos G. R. Plume Co.

Edmund J. Safra Synagogue, New York City



The Edmund J. Safra Synagogue, on East 63rd Street in New York City, designed by the Office of Thierry Despont, New York, and built by general contractor Skanska, USA, with engineering by KPFF, Seattle, and architectural millwork by the G. R. Plume Co., Ferndale, Washington. The elliptical timber dome built by Plume rises from a 32x48-ft. tension ring, with 54 ribs (14 patterns) tapering from 8x8 in. at the base to 2x8 in. at the oculus (seen alone at left). Two courses of 8x8 blocking at third-points are free-tenoned and invisibly bolted right through the ribs; 35 courses of level planking, curved across the grain to follow the backs of the ribs and spaced 2 in. apart to allow for sound insulation, complete the dome, as seen in the construction photos above and the finished portrait at top right.

All material has a core of glued Douglas fir (visible in the rib-blocking above right) under plainsawn American white oak veneer. Plume's work began with an AutoCAD 3-D model developed from Despont's supplied geometry (drawings at top left). The model then generated patterns for each piece. Dome pieces were craned into the building through a skylight.

THE GUILD CURRICULUM

II. Shop Safety

ALL of us are responsible for our own safety, but, as our businesses grow, inevitably we become responsible for others' safety as well. This is not only the right thing to do if we own a workshop and the business that controls it; it's also the law. At the same time, all of us who work for others in shops, no matter how large or small, have to work in partnership with the owners to maintain a safe workplace. After all, we're the ones who see the hazards every day.

This article, second in a series drawn from the developing Guild training curriculum (see "Site Safety," TF 77), will identify and describe five subjects:

Safety legislation, rules and regulations.
Common shop hazards.
Purposes and makeup of the safety committee.
First aid facilities required at the shop.
How to record and report accidents and injuries.

SAFETY LEGISLATION. Those who have worked solo "without a net," or "under the radar," may have been able to get by through blissful ignorance, or otherwise avoided facing the legal requirements. But it is every timber framer's responsibility to understand good safety practice and the law. If you go to work for a shop or if you hire someone to help you, you must do all you can to avoid financial, physical and mental loss or hardship.

OSHA, the Occupational Safety and Health Administration, part of the US Department of Labor, rules the world of workplace safety in the United States. OSHA's mission is "to assure the safety and health of America's workers by setting and enforcing standards; providing training, outreach, and education; establishing partnerships; and encouraging continual improvement in workplace safety and health." Canada's equivalent is CCOHS, the Canadian Centre for Occupational Health and Safety. Since labor legislation is primarily a provincial responsibility in Canada, and many of the guidelines are similar, we will use OSHA's broader scope as background.

OSHA is not just the safety police. It's also a valuable resource for training tools and publications, most of them free. OSHA began to set standards and legislation under the Occupational Safety and Health Act of 1970, using research and workplace monitoring to develop legislation. Part 1910 of the Workplace Standards (29CFR) particularly relates to safety in a shop environment. In contrast, Part 1926 regulates construction worksite safety. All of these regulations are available in the finest detail on the OSHA website (see Additional Resources), and not only make delightful bedtime reading, but also include some very helpful information for running your shop.

OSHA may perform inspections of your workplace to make sure that their standards are being followed. (The self-employed and a few specialized occupations fall outside OSHA jurisdiction.) These inspections are done by a regional inspector and can be unannounced. Investigations can also be done via fax or phone.

What triggers an investigation? It could be a result of complaints from workers or neighbors, referrals from another investigation, a follow-up from a previous violation or an indication of imminent danger. Reports of serious injuries or fatalities will also result in a visit, of course, and high-hazard industries are more susceptible. Penalties can be severe, especially for a small shop: $7000 for each serious violation, and from a minimum of $5000 up to $70,000 for willful or repeated violations. Maintaining a safe workplace is your best defense against attracting OSHA's attention.

One of OSHA's main jobs is to track workplace injuries. Under "woodworking shops," the subcategory of "Manufacturing" that a timber framing shop would fall into, we find the following observations, as reported by the Bureau of Labor Statistics. Nearly a third of all occupational injuries and illnesses stem from overexertion or repetitive motion. The nonfatal injury and illness rate is 6.6 workers per 100 full-time workers. A third of all injuries in a shop come from working with machinery. Half of all shop injuries come from being struck or being caught, compressed or crushed by an object. Cuts and punctures account for a third of all shop injuries, with strains and sprains a close second.

COMMON SHOP HAZARDS. Except to offer general advice on good practice, we will not describe here how to mitigate a particular hazard unless that subject is not covered in later curriculum chapters.

ELECTRICITY. The hazards from this source include electrocution, fire and explosions. Even slight shocks can lead to injury or death. Damaged or overloaded cords and circuits, as well as working around flammable materials, can contribute to the hazards.

DUST. Exposure to wood dust has long been associated with adverse health, including dermatitis and allergic, nonallergic and mucosal respiratory effects—and cancer. Contact with the irritant compounds in wood sap can cause dermatitis and other allergic reactions. The respiratory effects of wood-dust exposure include asthma, hypersensitivity pneumonitis and chronic bronchitis. Certain species of hardwood—such as oak, mahogany, beech, walnut, birch, elm, and ash—have been reported to cause nasal cancer in woodworkers.

FIRE. Woodworking facilities are especially at risk for fire because of their abundant production of sawdust, which will ignite and burn far more easily than whole pieces of timber. It can accumulate on rafters and other structural components and in unexpected spots all around your facility, far from the point of generation. Ignition sources in shops include potentially faulty electrical wiring, cutting and welding operations, sparking tools, heating equipment (especially wood-fired) and propellant-actuated tools, not to mention cigarette smoking legal or illegal. There is also the potential for static electrical discharges and lightning.

In the absence of a sprinkler system, fire extinguishers should be provided in sufficient number according to the size of the shop.

Fire extinguishers are divided into four categories, according to the types of fires they are intended to fight. Each extinguisher also has a numerical rating that serves as a guide for the amount of fire the extinguisher can handle. The higher the number, the more fire-fighting power. A fire extinguisher in a woodworking shop should have minimum 2-A:10-B:C and preferably 3-A:40-B:C rating.

An extinguisher with this last rating can fight a Type A fire (ordinary combustible materials) that would require three gallons of water to extinguish or a Type B fire (flammable liquids) of 40 sq. ft. in extent. It can also fight Type C (electrical) fires, which are not rated in extent and cannot safely be fought with water (Fig. 1).

The higher the rating, the bigger and heavier the extinguisher. The 3-A:40-B:C device is a good combination of effectiveness and portability. The following is a guide to help you choose the right type of extinguisher.

Class A extinguishers are for ordinary combustible materials such as paper, wood and cardboard, and most plastics. The numerical rating on these extinguishers indicates the amount of water they hold and the amount of fire they can extinguish. Class A ratings go from 1 to 40.

Class B extinguishers handle flammable or combustible liquids such as gasoline, kerosene, grease and oil. The numerical rating for class B extinguishers indicates the approximate number of square feet of fire they can extinguish. The range for class B goes from 1 to 640.

Class C extinguishers are used on electrical equipment such as appliances, wiring, circuit breakers and outlets. Never use water to extinguish class C fires; the risk of electrical shock is far too great. Class C extinguishers do not have a numerical rating. The C classification means the extinguishing agent is nonconductive.

Class D extinguishers, commonly found in chemical laboratories, are used on combustible metals such as magnesium, titanium, potassium and sodium. This class of extinguisher also has no numerical rating, nor is it given a multipurpose rating; the extinguisher is designed for class D fires only.

Some fires may involve a combination of these classifications. Fire extinguishers for woodshops should carry ABC ratings (Fig. 1).

Note that class A extinguishers containing water or air-pressurized water (APW) extinguishers are suitable for class A fires only. Never use a water extinguisher on grease fires, electrical fires or class D fires; the flames will spread and make the fire bigger. Water extinguishers are filled with water and pressurized with oxygen. Again: water extinguishers can be very dangerous in the wrong situation. Fight the fire with water only if you're certain it contains nothing but ordinary combustible materials.

Carbon Dioxide (CO_2) extinguishers are used for Class B and C fires, that is, on flammable liquids and electrical equipment. These extinguishers contain highly pressurized carbon dioxide, a non-flammable gas. The pressure is so great that it's not uncommon for bits of frozen CO_2 (dry ice) to shoot out the nozzle. CO_2 extinguishers don't work very well on Class A fires (paper, wood, cardboard) because they may not be able to displace enough oxygen to put the fire out, therefore allowing it to reignite.

Dry Chemical extinguishers come in a variety of types and are suitable for class A, B and C fires singly or in combination—that is, paper and wood or the like combined with flammable liquids and electrical equipment. These extinguishers are filled with foam or powder and pressurized with nitrogen.

BC, the regular type of dry chemical extinguisher, is filled with sodium bicarbonate or potassium bicarbonate. (BC does not stand for bicarbonate; it refers only to the type of fire for which the extinguisher is appropriate.) The bicarbonate leaves a mildly corrosive residue that must be cleaned immediately to prevent any damage to materials. ABC is the multipurpose dry chemical extinguisher, and the most suitable for a woodshop. The ABC type is filled with

Photos Will Beemer unless otherwise credited

Fig. 1. Versatile dry chemical fire extinguisher for woodworking shops. This one will extinguish a wood fire needing three gallons of water or a flammable liquid fire of 40 sq. ft. Electrical fires are not quantifed.

Fig. 2. Fire extinguisher locations should be well advertised and escape routes mapped and posted prominently.

Figs. 3, 3a. Moving loads, whether carried on a forklift (at top) or on a bridge crane (above), call for vigilance all around.

monoammonium phosphate, a yellow powder that leaves a sticky residue that's helpful to extinguish the fire but also may be damaging to electrical appliances such as a computer.

Dry chemical extinguishers have an advantage over CO_2 extinguishers since they deposit a nonflammable substance on the combustible material, reducing the likelihood of reignition.

On the other hand, CO_2 extinguishers have an advantage over dry chemical extinguishers since they don't leave any harmful residue, and so are a good choice for an electrical fire in a computer or other electronic device.

Again, it's vital to know what type of extinguisher you are using. Using the wrong type of extinguisher can be life threatening.

Fire extinguishers should be clearly visible and easy of access. Readily understood location maps of fire extinguishers as well as first-aid kits and emergency exits should be posted at various places in the shop and included with every new employee's orientation kit (Fig. 2 previous page).

MOVING OBJECTS. Workers in a timber framing shop must always be aware of timbers and machinery moving around them, and stay clear. Most woodworking machines have belts and pulleys, usually guarded, but sometimes they have unguarded conveyers that can pull a worker into the machine if loose clothing or long hair is caught. Timbers moving along a conveyer or being transported by a forklift or overhead bridge crane can strike a worker. Avoid walking under a moving or suspended load (Figs. 3, 3a).

Although falls are the first cause of construction-related deaths (including on-site work), the second most frequent is being struck by an object. Workers can be struck or crushed by timber as it moves through the shop. Approximately three-quarters of struck-by fatalities involve heavy equipment such as trucks or cranes.

MACHINERY MAINTENANCE. Each year, more than a hundred industrial workers are killed and many more are injured while repairing or maintaining machines. A co-worker may start a machine that another person is repairing. Sometimes it is the worker alone who accidentally knocks a switch and energizes the machine while clearing a jam or cleaning the equipment. Workers may be crushed at the point of operation, drawn into rotating parts, instantly electrocuted or mangled by other moving parts.

A lockout-tagout system safeguards workers from hazardous energy (including electrical, mechanical, hydraulic and pneumatic) while they work with machines and equipment. The system includes signs and tags warning that a machine is not usable, as well as physical locks on the power switches.

Unplugging a tool or machine is not enough. What would happen if someone came along to use an unplugged machine on which someone else had invisibly removed or loosened a part for maintenance? The person locking the machine should be the one to keep the key, and the tags should indicate who, when and why

Figs. 4, 5. Machines under maintenance should be disconnected at the power source and the switch locked, then tagged to indicate status.

the machine was locked. Someone else who needs to use the machine can then find out why it's not available. Such a lockout system is particularly important in a large shop with many workers using the same machine (Figs. 4, 5).

UNSAFE MATERIALS STORAGE. Workers may be struck or crushed by timber or other materials improperly stacked or stored. (Fig. 6). Placement of timbers for layout and cutting is also important. Timbers should sit at a comfortable height for working and near tools that will be needed. Tool carts are especially useful; it's usually easier to bring the tool to the timber rather than vice versa. Make sure sawhorses or trestles are well constructed, and be aware at all times of the stability of both ends of a timber (Fig. 7). It's common enough when rolling or sliding timber for one end to get close to tipping off its support. This can be especially dangerous if two people are working on the same timber.

LIFTING TIMBERS. Strains and sprains can result from trying to lift too heavy a load without assistance, or lifting in an awkward position. Overreaching to catch a falling tool or timber is a common source of injury. Crushed fingers or other body parts can result when timbers or timber piles move unexpectedly, or when a forklift operator can't see co-workers.

UNSAFE CLOTHING. Loose clothing, jewelry or long hair can be easily caught up in rotating parts of machinery. Untied shoelaces, baggy pants and other loose clothing can also be a tripping and falling hazard. Gloves should be worn when handling rough or hazardous materials, but not worn if they would interfere with the safe operation of machinery.

HAZARDOUS CHEMICALS AND MATERIALS. Finishing and gluing operations pose a wide range of health and safety hazards. Adhesives, solvents and coating agents may all contain toxic chemicals; especially hazardous is epoxy resin. These materials can also pose significant fire and explosion hazards. Timber preservatives also pose a health risk. Woodworkers are generally exposed to chemicals through inhalation and contact with the skin. OSHA requires that an employer educate employees about any hazardous chemicals they may be exposed to on the job.

PORTABLE AND STATIONARY TOOL HAZARDS. Employees can be injured if their hands get too close to a blade, particularly when working on small pieces of stock. Stock can be captured by a machine and actually pull the operator's hands into the blade, bit or cutterhead.

Employees can be injured if a machine or its guard is not properly adjusted or maintained. Maintenance includes making sure that blades and bits are sharp, the machine and surfaces are properly cleaned and lubricated and that guards are not disabled. Of course, workers should also have the proper training and authority to use the machine.

If the machine has controls that are not recessed or remote, and the equipment is accidentally started, a worker's hands may be caught at the point of operation. Contact can occur also during machine repair or cleaning if care is not taken to disconnect the machine from its power source.

An employee may be injured by reaching in to clean a tool or remove a piece of stock after the tool has been turned off but while it is still moving.

Other machinery hazards are legion: kickbacks, flying chips and other material (be especially vigilant for embedded metal in reclaimed timber), projection of moving parts (pulleys, gears), electrical hazards, excessive noise and vibration.

Hand tools are not exempt from hazard. Chisels and other edge tools can cause severe cuts, especially as they get dull and are forced through the work. Tools resting on timbers can roll off unexpectedly and cause injury. A common shop injury occurs when one hand is cleaning away chips from a joint being cut and the other hand is holding the chisel too close.

Figs. 6, 7. At top, pile of offcuts threatens to tumble. Above, safely supporting a curved timber requires a little thought.

Fig. 8. Damaging effects of excessive noise are well recognized, and efficient hearing protection should be routine. Here, from left, Doug Ward, Duane Beiler (who wears eye protection as well) and Brendan Jones guide a curved glulam through a thickness planer.

REPETITIVE STRAIN INJURIES. Repetitive strain injury is an occupational overuse syndrome affecting muscles, tendons and nerves in the arms and upper back. It occurs when muscles in these areas are kept tense for very long periods of time because of poor posture or repetitive motions. Learn to lift properly, and avoid body strain from repeating the same movements for long periods without rest.

WORKING ALONE. In most cases, a lone worker should not undertake high-risk activities such as working at heights or in confined spaces like tanks or elevators (unlikely as these spaces might be in a woodworking shop); working with electricity and hazardous substances or materials; working with hazardous equipment such as chainsaws or firearms; and working with materials under great pressure. Good sense alone dictates the company of other workers in case of injury, accident or the unexpected.

NOISE AND VIBRATION. Excessive noise can damage a person's ability to hear—an effect that can be temporary or permanent. There also is mounting evidence that noise may adversely affect other parts of the body—particularly the cardiovascular, endocrine and muscular systems—and it may also lead to stress-related disorders, such as nervousness, chronic fatigue, increased blood pressure and impaired concentration or mental function (Fig. 8).

Both hand-held and stationary tools that transmit vibration through a workpiece can cause "white fingers" or hand-arm vibration syndrome. White fingers, or Raynaud's Syndrome, is a disease of the hands in which the blood vessels in the fingers collapse due to repeated exposure to vibration.

BAD SHOP LAYOUT. Congested workplaces are unsafe. Crowding, inefficient waste disposal and inability to move timber safely may be a function of poor shop design and layout, which can also result in other safety hazards such as poor illumination, poor ventilation and excessive noise. Moving operations outdoors may solve some of these problems, but inclement weather can cause others. Workers who are uncomfortable may take shortcuts and become inattentive.

Analyze traffic flow through the shop and leave pathways open for efficient movement. In large shops, mark these pathways with high-visibility tape so that timbers, tools and other obstructions can be kept clear. Workers should be able to move themselves and their tool carts from one end of the shop to the other without having to step or climb over timbers (Fig. 9).

SPONTANEOUS COMBUSTION. Spontaneous combustion can occur when towels, rags, booth filters, paint scrapings, steel wool, masking and other materials wetted or saturated with common materials such as linseed oil, alkyd enamel resins and drying oils are not handled or disposed of properly.

Material Safety Data Sheets and product labels or container information warn of the dangers of spontaneous combustion and recommend safe disposal practice.

Spontaneous combustion of oil-soaked rags is caused by auto-oxidation, which generates heat in dangerous amounts if not allowed to dissipate or not contained properly. Such rags should be wetted with water and stored loosely in a sealed, airtight container (Fig. 10).

BAD HOUSEKEEPING. The workplace should be kept clear of clutter and scrap materials. Tripping hazards in particular should be eliminated before they cause an accident. Tools and equipment should be kept clean and in good working order and returned to their proper storage compartment if not to be used in the near future.

GIVEN that we recognize the hazards, what rules, procedures and habits can we observe in the shop to help workers avoid them? OSHA Part 1910 dictates most of the standards that govern. The following subjects are specifically addressed:

1. Walking and working surfaces, including stairs, ladders and scaffolds.
2. Exit routes, fire prevention and emergency plans.
3. Powered and vehicle-mounted work platforms.
4. Ventilation.
5. Hazardous materials.
6. Personal protective equipment (PPE).
7. First aid.
8. Materials handling and storage.
9. Machinery and machine guarding.
10. Hand and portable power tools.

Part 1910 also includes standards for specialized industries such as sawmills and logging operations.

Persons responsible for developing the safety program in your shop should read all of the relevant parts of 1910 to make sure the shop is meeting the formal requirements in the listed areas. Here's another list, informal but imperative, that would be appropriate for posting in your shop:

TEN RULES OF GOOD SHOP PRACTICE

1. Be alert. Think.
2. Keep a clean shop.
3. Avoid distractions.
4. Don't rush.
5. Don't force it.
6. Protect yourself.
7. Let the tool stop.
8. Ventilate the shop.
9. Maintain the tools.
10. Exclude alcohol and drugs.

THE SAFETY COMMITTEE. OSHA mandates that the employer provide safe employment and a safe work environment. A safety committee should be formed to assist management in a cooperative effort, acting as liaison between workers and employer. The safety committee should assist in developing and adopting a safety program by identifying unsafe work practices and conditions. It should also assist open communication between workers and management, make appropriate inspections and point out violations (or violators) of safety rules. The committee should meet regularly (monthly is best) and designate a leader to run the meetings and a clerk to keep minutes.

The safety committee is not a police force but an advocate. Training, raising awareness, and discussing new solutions are its key activities. There's more to the program than just identifying unsafe conditions; it should also make safe conditions better. The safety committee should review incident reports for trends or problems, participate in accident and near-hit investigations and evaluate personal protective equipment (PPE). As you might infer from this list of responsibilities, safety committee members themselves need training to do their job well.

Members of the safety committee should include managers and supervisors appropriate to company size, but workers should make up the majority.

BUILD A CULTURE OF SHOP SAFETY. Meeting OSHA-mandated regulations and providing the minimum safety equipment is often not enough to eliminate all hazard. Shops are still dangerous places. Owners and management may recognize that improved safety results in increased productivity and earnings, and employees may accept that working safely is in their best interest, yet withal only a fraction of workers may actually comply with safety procedures.

Creating a culture of shop safety is key to making a truly productive and accident-free workplace. This requires the cooperation of everyone concerned and perhaps outside advice from safety

Figs. 9, 10. At top, a clear traffic lane for personnel, with access to tool carts. Above, oil-soaked rags are segregated and submerged in water.

equipment suppliers. When employees see that the company is doing *all* it can to keep them safe, they generally want to become part of that safety culture, and comply more enthusiastically. No amount of training or equipment can compensate for the workers' adopting safety as part of their everyday practice.

For example, if the company supplies PPE as it's obliged to do, but that equipment is the minimum required (read cheapest), employees may find it uncomfortable and a nuisance. Higher quality equipment will last longer and get used more, be more economical in the long run and demonstrate that the company cares about safety. Full-service safety equipment suppliers may offer audits of your workplace at no charge, and they may be able to identify problems you haven't seen or thought of. By talking to employees on the shop floor, they can listen to the concerns of those who are expert at their tasks, and offer remedies.

Consider the problem of factory table saw blade guards. They protect your hands if you slip but, by concealing or distorting your view of the workpiece as it meets the blade, they may make you feel uneasy and prone to mishap. The remedy is a guard that allows you to work safely without compromising, to see *and* to be safe. Such guards exist. I have one and wouldn't run my own saw without it.

If workers have a say in safety decisions, they are more likely to comply. There are dozens, if not hundreds, of safety training programs available from equipment distributors and workplace safety companies. Through regularly scheduled presentations of such programs for them, workers eventually accept the idea that preventing injuries is part of their regular duties. Your company may even consider recognizing safe behavior through incentives or rewards.

Accidents occur because of poor work conditions or poor behavior. To change attitudes and behavior patterns from taking risks to taking care, especially in younger workers, should be a primary goal. By the same token, if management's emphasis is on productivity, that can result in less attention to safety issues. Slowing down allows workers to think carefully about what they are doing and the hazards involved. The closest I've ever come to having a serious accident was while trying to be more productive, thinking about the next piece I was going to cut rather than the one I was actually cutting.

IT'S critical that older and more experienced employees set the pace and be good examples. Younger workers are more likely to listen to advice from their peers than from management. This is especially effective to combat fooling around.

Here are some examples of doubtful opening lines.

Watch this. Famous last words. Horseplay may be a good way of relieving stress, having fun or showing off, but it has no place in the shop when it violates common sense and obvious safety lines. Don't eliminate all fun, but tolerate and encourage safer forms.

Let's try this. Timber framers are a creative lot, but innovation may create new safety issues. Workers may be willing to take increased risks to see if a new idea will work. On the other hand, innovation should not be stifled, as it may just as well lead to solutions to safety problems.

It can't happen to me. The young and inexperienced often feel invulnerable and will tend to minimize the perceived risk in an activity unless sobered by someone who's been in the shop longer.

Rules are meant to be broken. Workers may become frustrated by the extra effort needed to comply with shop rules, especially if they come from a previous workplace that ignored them. Generally it's up to the workers who have seniority to set a good example. Unfortunately, some older, more experienced workers may actually be *more* prone to accident because they have become complacent and inattentive.

We can do it later. Safety issues, including cleaning up, maintaining tools, storing materials and organizing the workspace, shouldn't be put off until workers are tired or simply forget to do it.

Formal methods for cultivating shop safety include training programs, awareness campaigns (warning signs, employee manuals, and the like), good equipment and frequent inspections. Encouraging your employees and co-workers to talk about safety regularly must complement these efforts. Those on the shop floor will intuitively know what the issues are and have probably figured out effective solutions already. Listening to their experience increases the chances that more-formal procedures will be implemented in practice.

Safety is a team effort, and the team should be aware of attempts to ostracize or alienate co-workers. Intentional malicious acts by disgruntled employees can create dangers that are outside the norm. Be especially sensitive to issues involving female employees in what has traditionally been a male workplace. Everyone must be involved, encouraged and willing to participate for any safety program to be effective.

While management should provide a safe environment and well-maintained tools, employees for their part should never feel intimidated to speak up if they see an unsafe situation. In sum, employees have the duty to act responsibly, follow shop rules, attend all training sessions and adapt to their roles on the team.

FIRST-AID FACILITIES. OSHA Part 1910 dictates three first-aid requirements in the workplace:

1. The employer shall ensure the ready availability of medical personnel for advice and consultation on matters of plant health (151a).

2. In the absence of an infirmary, clinic, or hospital in near proximity to the workplace, which is used for the treatment of all injured employees, a person or persons shall be adequately trained to render first aid. Adequate first-aid supplies shall be readily available (151b).

3. Where the eyes or body of any person may be exposed to injurious corrosive materials, suitable facilities for quick drenching or flushing of the eyes and body shall be provided within the work area for immediate emergency use (151c).

OSHA does not require specific contents in a first-aid kit, but allows the employer to determine what is appropriate.

American National Standards Institute (ANSI) Standards. The minimal contents of a generic first-aid kit for small workshops (fewer than 10 people) are described in ANSI Z308.1-2003 "Minimum Requirements for Industrial Unit-Type First-Aid Kits."

1 absorbent compress 32 sq. in.
16 adhesive bandages 1 in. x 3 in.
1 adhesive tape 3/8 in. x 5 yds.
10 antiseptic 0.14 fl. oz. (application).
6 burn treatment 1/32 oz. (application).
2 pair medical exam gloves as needed.
4 sterile pads 3 in. x 3 in.
1 triangular bandage 40 in. x 40 in. x 56 in.

The contents of the ANSI kit should be adequate for small worksites. When larger operations or multiple operations are being conducted at the same location, employers should determine the need for additional first-aid kits at the worksite, additional types of first-aid equipment and supplies, and additional quantities of supplies and equipment in the first-aid kits. Quantities and types of items change as the shop size increases.

First-aid kits should be Type II (portable indoor use) in a shop, but it's advised to also have a stationary Type I kit and an eyewash station (Fig. 12).

Phone numbers for ambulance services should be prominently displayed near the first aid kit and shop phone. Directions to the nearest hospital emergency room should also be included with the first aid kit.

PROCEDURES TO REPORT ACCIDENTS OR INJURY. Recording and reporting accidents are a joint responsibility of workers, employers and physicians.

If your company had ten or fewer employees at all times during the last calendar year, you do not need to keep OSHA injury and illness records unless OSHA informs you otherwise in writing. However, all employers—regardless of company size—must report within eight hours by telephone or in person to the nearest OSHA office (or by calling 1-800-321-OSHA) any workplace incident that results in a fatality or the hospitalization of three or more employees.

If your company had more than ten employees at any time during the last calendar year, you must keep OSHA injury and illness records unless your establishment is classified as a partially exempt industry under §1904.2.

OSHA logs must be kept for a minimum of five years and made accessible to all employees.

In addition, each US state and Canadian province has a Workers Compensation Board (WCB) that regulates reporting of accidents, payment of medical bills and lost wages due to injury, and rehabilitation and alternative work options for the worker. Workers must report all accidents to their employers, and employers must keep a record of the accidents. In most states and provinces, workers, employers and physicians must report any accident to the WCB if it disables or is likely to disable the worker beyond the day of the accident. Employers must also notify the WCB if the worker is entitled to medical aid beyond first aid. Records must usually be kept a minimum of three years.

Links to WCB rules and regulations for various US states can be found online at www.dol.gov/esa/regs/compliance/owcp/wc. For Canadian provinces, see www.ccohs.ca and link to oshanswers. Each state or provincial WCB will have forms for the worker and employer to fill out to report an accident or injury. These are obtainable from the WCB website. OSHA will have separate recordkeeping requirements and forms that the employer is required to keep. Safety statistics and accident records must be available for review by all employees.

WCB documents are used to determine compensation and benefits due the injured worker. OSHA documents are used to collect nationwide data on job-related injuries and illness.

—Will Beemer

All photos for this article were taken at Benson Woodworking, Keene, New Hampshire. This article is second in a series derived from the nascent Guild Training Curriculum. The first article was Gordon Macdonald's "Site Safety" (TF 77, September 2005). Readers who retain the information given here should be able to achieve the goals of Section 1A of the module Safe Work Practices. For a complete list of Guild curriculum topics, see tfguild.org/members/curriculum.

Dennis Marcom

Fig. 12. First-aid station for a company of up to 30. Phone numbers for ambulance and hospital are now simplified to 911 in most areas.

Additional Resources

Books and printed material

Basic Safety, ISBN 0-13-160004-4 (Student), ISBN 0-13-160013-3 (Instructor), Core Curriculum Module 00101, from the National Center for Construction Education and Research, *www.nccer.org.*

Websites

www.osha.gov is the mother lode of safety information. Free training available at the e-tools section.

www.osha.gov/dts/osta/oshasoft/index.html. Good free training in lockout-tagout systems, machine guarding and more.

www.labsafety.com. EZFacts® safety information documents online, plus leading safety equipment supplier.

www.labsafety.com/refinfo/safetylinks.htm#government. Links to many other safety organizations.

www.cbs.state.or.us/external/osha/standards/publications.html. Free publications, including one on forming a safety committee.

www.afscme.org/health/. Good, free guide to safety in the workplace.

www.nccer.org/resources/downloads.asp#safetyresources. Safety information downloads from the National Center for Construction Education and Research.

www.canoshweb.org/en. Canadian Center for Occupational Health and Safety.

www.pp.okstate.edu/ehs/LINKS/index. Oklahoma State University online safety library and links to many other sites.

www.safetyinfo.com. Safety training videos, software, online courses.

www.nsc.org. National Safety Council and Safety Library (membership fee required).

www.4-safety.com. Safety training and equipment.

www.free-training.com. Free online training programs and links to other free training sites.

Check out state OSHA websites, such as Oregon's at *www.orosha.org*, for much valuable information that might be tailored to your region.

The English Barn in America

Fig. 1. The author's English barn, raised in 2005, 25 ft. 6 in. x 34 ft.

Photos Jack A. Sobon

Fig. 2. Broad doors open to threshing bay, small doors to stalls.

TO the student of vernacular architecture, the English barn is perhaps the most pervasive and recognizable building type in New England. Its chief competitor for that status would be the Cape (Cod) house with which it is typically associated. The English barn in America has always fascinated me because it is so unvarying in its plan across its range, and I chose to build a barn to this pattern for our homestead in the Berkshires (Figs. 1, 2). Though replaced in popularity about 1850 by the more efficient New England barn, built with main entrance at a gable end, variations of the English barn were built from the first settlements up into the early 20th century.

Despite its predominance, there is surprisingly little detailed published information about the construction and use of the English barn. Changes in farming practices and the ravages of time and neglect have taken their toll on these barns. Some are indeed no longer recognizable except after a thorough investigation. But from observations taken over 30 years, examining hundreds of barns throughout New England and New York, it's possible to see a common pattern.

The identifying features of the English barn include a rectangular plan very often measuring 30x40 ft., divided into three bays of unequal size, with the ridge running roughly east-west, and the whole built on flat or gently sloping ground without a basement level. Typically, large hinged doors on one or both eaves sides open into a central threshing bay running north-south across the width of the barn, with a narrow cow bay to the east and a wider mow bay to the west, often with horse or oxen stalls along the south wall of this bay (Figs. 3, 5).

The English barn's absence of exterior detailing or architectural styling is notable, although one is occasionally found with a long narrow window, a "row of lights," over the wagon doors. Though varying in size from as small as 23x32 ft. to as large as 34x44 ft., without question the English barn most often appears at 30x40 ft. (Fig. 4). For example, in Colrain, Massachusetts, the 1798 Federal Direct Tax Census revealed that 54 percent (39 barns) measured 30x40 (Garrison, 122). We can thank Pythagoras for the abundance of 30x40 barns and, for that matter, the very common 9 in 12 roof pitch. The 3-4-5 right triangle (measuring five on the hypotenuse)

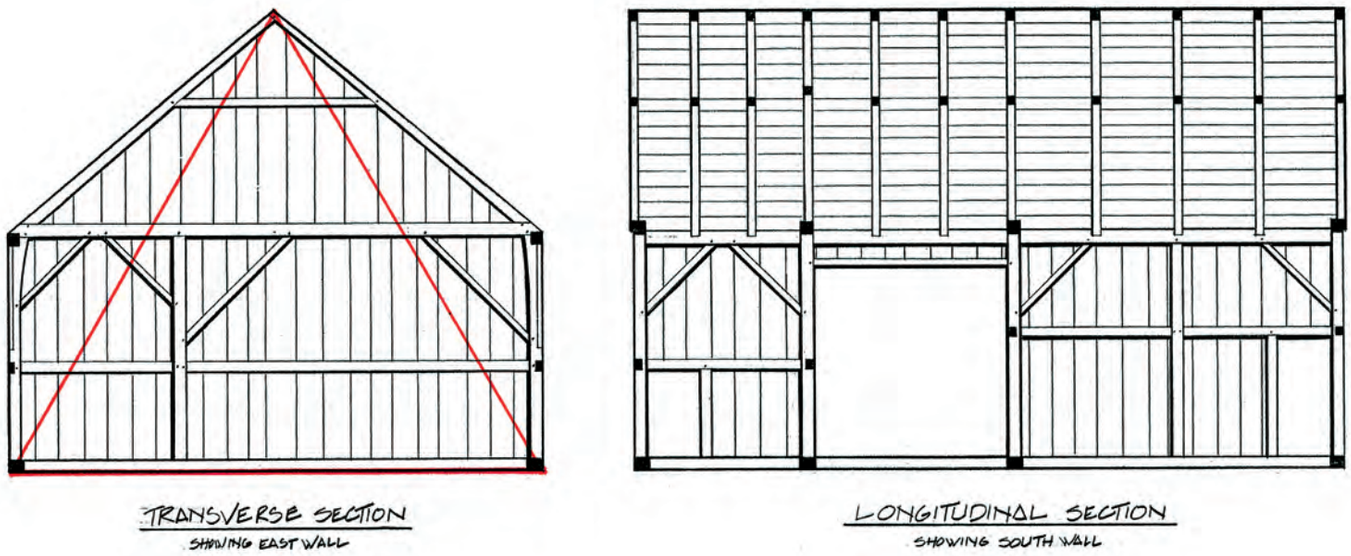


Fig. 3. Transverse and longitudinal sections, late-18th-century English barn, Adams, Massachusetts. Transverse section reflects equilateral triangle.

has always been a favorite of builders and, in fact, almost a necessity for squaring work. Builders sometimes use this ratio playfully. I've seen barns where the wall girts are spaced 3 ft., 4 ft. and 5 ft. apart from floor to plate and one in Adams, Massachusetts, has rafters spaced 3 ft., 4 ft. and 5 ft. respectively in the three roof bays. The builder was undoubtedly flaunting the numbers.

Though varying in footprint, the sectional proportions of our English barns remain remarkably the same. Their cross-sections are typically designed on the equilateral triangle (three equal sides, three equal angles), with the triangle inscribed between the top outside corners of the sill and the peak of the rafters or ridge (Fig. 3). Historically, vernacular buildings as well as high-style buildings were governed by geometry, as the compass will show. The equilateral triangle in particular governs Gothic as well as many Greek Revival façades.

When unencumbered by site restrictions, the English barn in America is usually oriented with the ridge running roughly east-west and the smaller bay to the east. The east bay was typically for cattle and required morning light for the farmer to work in. However, many surviving barns have been moved, either intact or disassembled, to make way for road widening and farm reorganization, and they may have been reoriented.

Bay sizes are almost always unequal because each bay serves a different function. Often the west bay is too wide for the wall plate to span without an intermediate post. (A 20-ft. span is not uncommon.) The post in turn occasionally may have an accompanying tie beam or principal rafter above, leading to some confusion as to the barn's number of bays. If there is no transverse sill beam below these posts, then the barn remains properly three bays.

The cow bay, ranging in width from 9 ft. to 12 ft. 4 in. (and typically 10 ft.) accommodated cows in stanchions facing the threshing floor. Reasoning from surviving stanchions spaced at between

Fig. 4. Extant English barn, 30x40 ft., Savoy, Massachusetts, built before 1840. Use of square-rule layout dates it after 1812 in this area.

2 ft. 6 in. and 2 ft. 9 in. (Fig. 6 overleaf), a barn 30 ft. wide could have as many as 11 cows. There was rarely a framed floor in the cow bay; the animals stood on the ground and stepped over the sill to enter. There was no walk-through access between the cow bay and the threshing bay, but hay could be tossed into the feed alley from the threshing side. Cows and humans entered through a door in the south wall at the corner (Fig. 5).

Above the cow bay was a low loft. From top of sill to top of loft beam was typically 6 ft. The loft might have framed-in joists or be simply ceiled with slab off-cuts spanning the bay. Hay or straw could be piled to the roof.

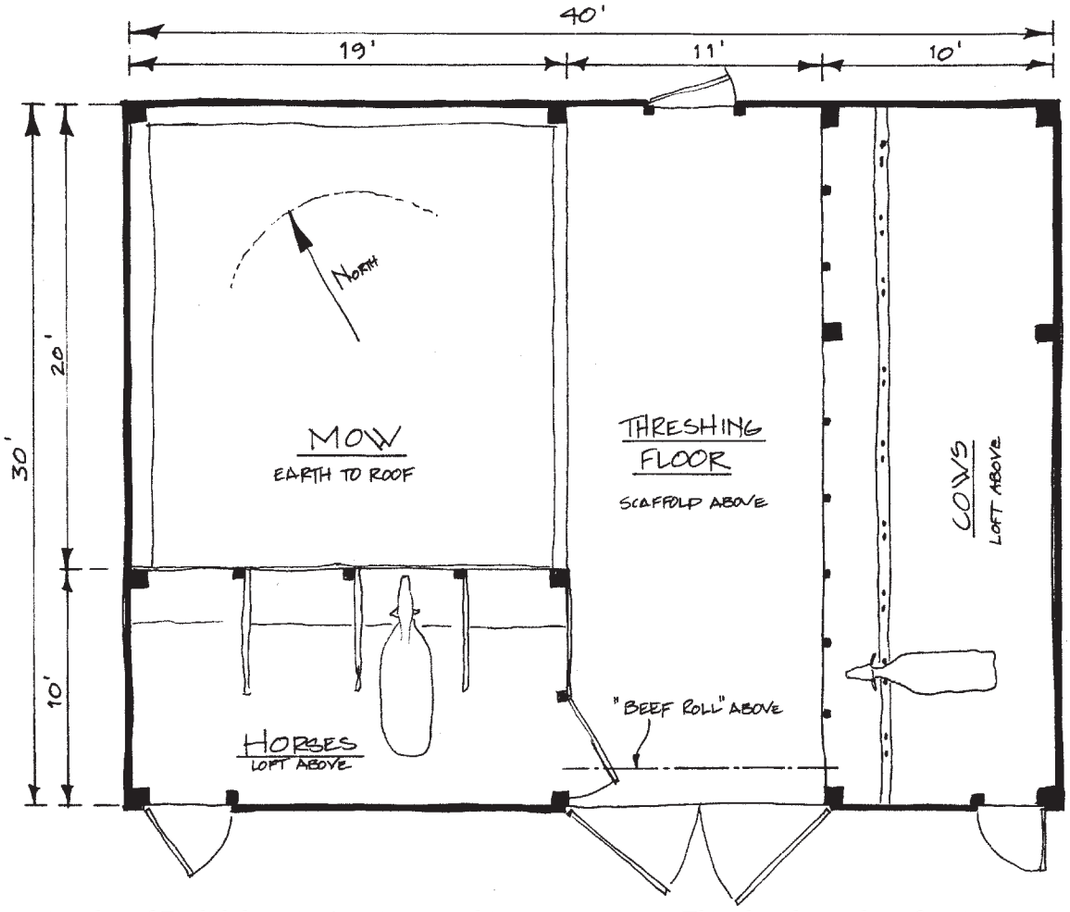


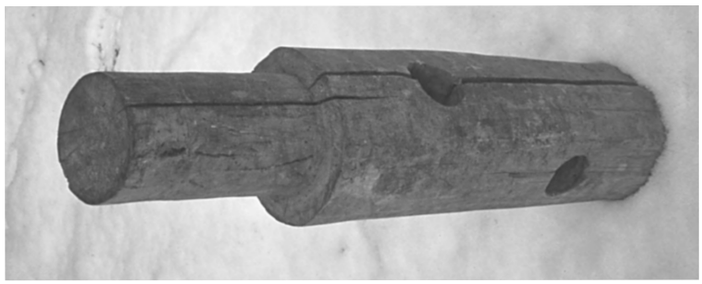
Fig. 5. Representative plan of English barn in America, a multipurpose structure. This plan shows places for nine cows and four horses.

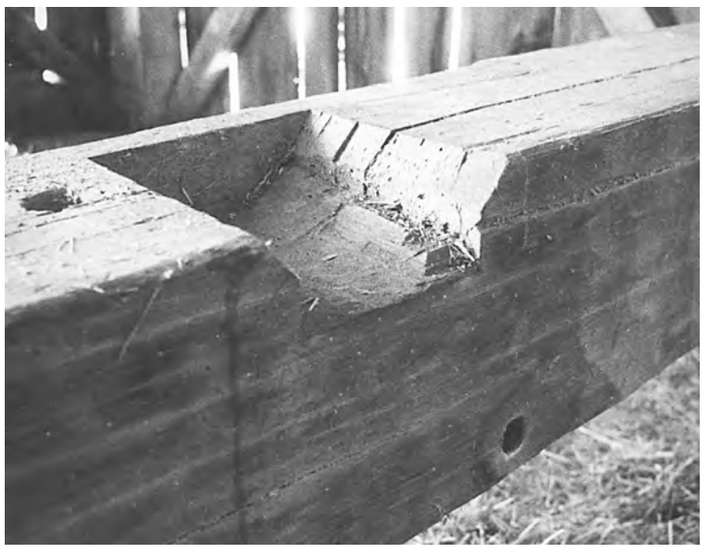
Fig. 6. Rare original cow stanchions in 32x42 Savoy, Massachusetts, barn, destroyed 1997 in a local fire department exercise. Two upright poles, one sliding, one fixed, are mortised into a 32-ft. hewn 4x5 at the top and a hewn 7x14 (on edge) at the bottom.

Fig. 7. Ladders on both sides of threshing floor in the extant 30x40 Savoy barn looking toward loft over the cows. Ladders could also be made by cantilevering the shaved rungs out from each side of a post.

The center threshing (or thrashing) bay is usually found from 10 ft. to 14 ft. 4 in. (typically 11 ft.) wide between posts and has bay-width out-swinging wagon doors at one end (south preferred) or both ends of the bay. If at only one end, there is a smaller 6-ft. high door at the other. On hillside sites, this door might be a few feet off the ground without access.

The threshing floor of the barn was an important part of the farmstead. The grain crop was threshed with hand flails on this carefully fitted, splined, tongue-and-grooved or double-boarded floor. The grain, after being separated from the straw, was scooped up in shallow wooden scoops. With doors opened at each end of the threshing bay for a cross breeze, the grain was lightly tossed in the scoops until the chaff was blown away, in the process called winnowing. Any gaps in the flooring would allow the precious grain to slip through, thus the exceptional care taken in making the floor. At the doorways, a plank on edge, called a thresh hold, was temporarily fitted to keep the wind from blowing at the floor surface and to keep out poultry (Endersby, 90-91; for more on threshing and winnowing, see Fink 98-103 and Brunskill 36-43). Threshing floors were constructed such that they could ride up and down with the frosts like a raft and remain tight. Many barns had





Figs. 8, 9. At top, the end of a "beef roll" salvaged from a collapsed barn. The roughly shaped 6-in.-dia. sugar maple log is reduced to 4 in. at the end and has two 2-in.-dia. holes bored through at right angles to each other, one at 5½ in. from the end, the other at 13 in. Fig. 9 above shows curved bearing notch in a tie beam from an 18th-century English barn in Adams, Massachusetts, that held one end of a beef roll just inside the south doorway.

joists spanning the 30-ft. width and supported at their midspan by a sleeper that additionally held the two center sills from spreading. Wooden pins were favored over nails to secure the planks.

This center bay also served as the wagon bay. Hay and grain crops were unloaded here, the height of the wagon making the lofts easily accessible for forking the hay. Of course, the wagon could be stored here when not in use. This bay was also a prime location for miscellaneous farm crafts and activities.

Above the threshing floor was a high loft, either framed into the tie beams and covered with loosely spaced boards, or made up of closely spaced loose poles laid across the ties, the latter sometimes called a scaffold because of its precarious and temporary nature. The grain crop (wheat, oats, rye, etc.) was stacked here to dry before being threshed. Many barns had a built-in ladder on one or both sides of the threshing floor to reach the lofts (Fig. 7).

Evidence of a butchering windlass is typically found above and just inside the main doorway. This device enabled two men to hoist a cow up by its hind legs for butchering. In its simplest form, a peeled hardwood log 6 to 7 in. in diameter was shaped to a 3 to 4-in.-dia. shaft at each end. Called a beef roll by the older farmers in my area, the shaft turned in rounded notches in the ties (Figs. 8, 9).

At one end of the shaft, offset holes 1½ to 2 in. dia. were bored through at right angles to each other to insert levering poles. A pair of smaller holes 5 to 6 ft. apart held square pins that secured the hoisting ropes or chains. More elaborate hoists had a large diameter wheel on the shaft on which a loop of rope was passed. It allowed one-man operation much like a chain fall.

Figs. 10, 11. Original weathered eaves trough support, apparently yellow birch, at the 32x42 Savoy barn, in place at top and salvaged from destroyed barn, above. Shank is 2 in. dia., 9 in. long.

The wider bay to the west of the threshing floor is found 12 ft. to 20 ft. 6 in. wide (and typically 19 ft.), measured outside to outside of posts. This bay housed the mow and stable. A 10-ft.-wide section along the south wall was partitioned off for draft animals. If the framed height of the loft above was the same as the cow bay, the west bay was probably for oxen. If it was a foot higher at 7 ft., it was likely for horses. Some barns show evidence of a manger that could be filled with hay from the loft above. This stable area was accessed by one door on the south wall, usually at the west end, and another off the threshing floor. The remainder of the large bay was a haymow. It never had a floor; the hay was stored from ground to roof. A low sheathed wall separated the threshing bay from the mow.

It should be noted that the framed wooden threshing floor typical here is virtually nonexistent in England. There, the threshing floor surfaces included hard-packed clay, brick, tile, flagstones and oak planks, all supported by the ground (Williams, 139-141).

Two minor features commonly found associated with the English barn have not been broached before. One is the dovecote, which offered an additional food supply for the farm. High up in the gables of English barns in America, I have several times found evidence of a framed platform and holes suitable for pigeons cut in the siding. Dovecotes were common in England; why wouldn't English settlers build them here?

The other feature, eaves troughs, provided water for the animals. The south side of the roof typically would drain into a single-piece hewn gutter pitched toward one or both ends. A trough by the animal doors would be full after each storm, requiring no tedious hand pumping by the farmer. I have found no original English barn eaves troughs in situ, but plenty of evidence. Many barns have 2-in.-dia. holes bored into the posts just below the plate on one or both longitudinal walls. These holes held wooden gutter supports. The supports survived on one post-1812 barn in Savoy, Massachusetts, until 1997 (Figs. 10, 11). At least two additional barns survive with wrought-iron gutter supports.

The English barn was thus a multipurpose structure: threshing barn, cow house, stable, hay barn, butcher house, water supply, wagon shed and dovecote. Despite its name, the barn type so common and standard in New England has scant representation in England, where the many purposes were often housed under several roofs. The closest prototype of our American English barn might be the stone barn identified as Type 5 by Peters (page 23), with concentrations found in "north Cheshire, Lancashire south of the Lune, the Yorkshire Dales, Radnorshire [now Powys] and part of northwest Wales." Such a type Peters considers most appropriate for the smaller farms in the north of England (Fig. 12).

Foundations for English barns in America varied with the wherewithal of the owner and the available stone. Some barns have a carefully laid continuous dry stone foundation of flat stones keeping the sills at least a foot off the ground. Others have a few stone piles under the post locations only. Perhaps the farmers intended to fill in between with stone later. A few barns appear to have the sills laid nearly on the ground, though the arrangement is unlikely to be original. Over time, the combination of frost action and the weight of the building tend to sink stones into the earth. No English barns have been found with an original basement level although many barns were later moved and raised to provide a walk-out basement

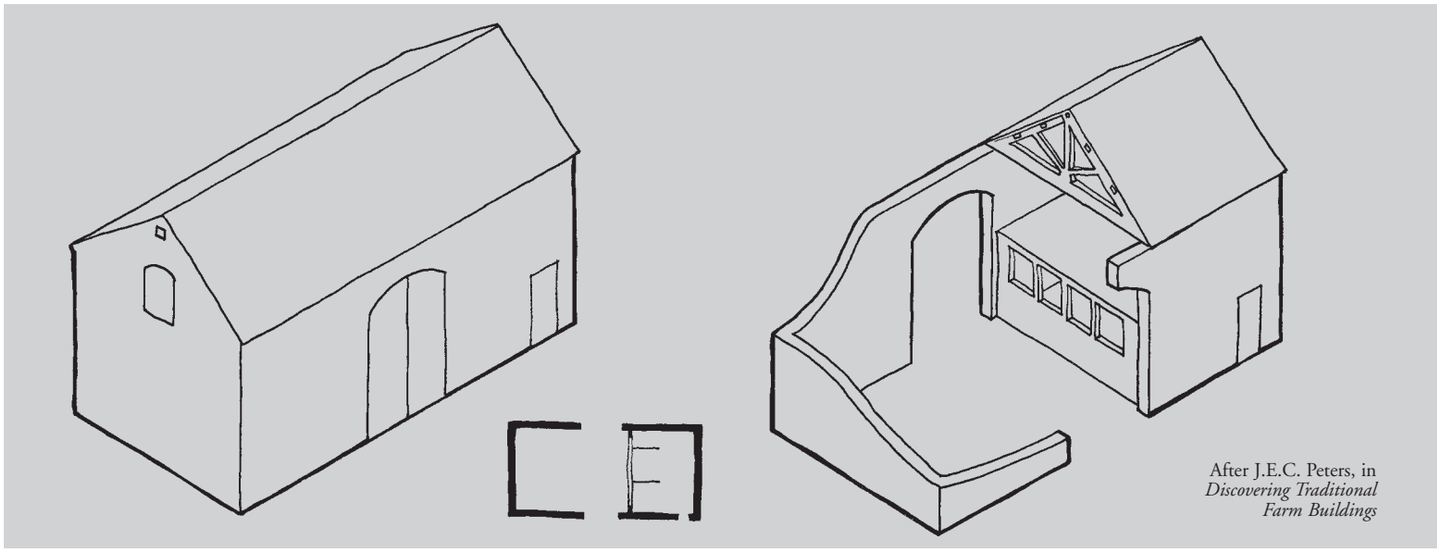


Fig. 12. Early 17th-century English stone barn form on native soil, combining previously separated functions under one roof.

Picturesque Berkshire, 1893

Fig. 13. In this pre-1893 photo of a New Ashford, Massachusetts, farm, the English barn at right clearly presents a board-on-board roof.

level, according to Thomas Hubka. On hilly upland farms, however, some English barns were set with one end a few feet off the ground to gain level. It's likely that sheep sheltered in the space below.

Vertical board sheathing was the most common covering on English barns, and thus the framing required horizontal wall girts as nailers. A few early surviving English barns were framed with wall studs for horizontal weather boarding. Some barns combine the two types, having vertical sheathing up to the plates and ties, then horizontal in the upper gables—or the reverse—creating an interesting and quaint aesthetic.

On roofs, horizontal boarding was applied across a common rafter roof, vertical boarding over a common purlin roof. On very early, steeply pitched roofs with closely spaced and light-scantling purlins, shingles or thatch may have been applied directly on the purlins. On common rafter roofs, wood shingles were typically applied over a layer of boards. For vertically boarded, purlin roofs, it cannot be assumed that the roof was originally shingled. Many original barn board-on-board roofs survived long enough to be photographed in the latter half of the 19th century (Fig. 13).

From a labor perspective, the board-on-board roof was much less expensive than the shingled roof. Both, however, made use of clear, old-growth heartwood pine or spruce. At least one English barn has been found (in Milford, Connecticut) where the front roof was framed with common rafters and horizontal boards, suggesting a shingled roof, while the back side, a slightly steeper pitch, had common trenched purlins and probably a board-on-board roof. Best face forward?

From layout to finish, the English barn was practical, efficient and enduring. We shall see in subsequent articles on its timber framing, erection and enclosure that the barn's carpentry was likewise.

—Jack A. Sobon

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D-I-Y Cathedral in Québec

PERHAPS my story starts when I was 10 years old and with my older brother's help built a small log structure at our family's summer camp. After that, I was always interested in timber frame building and architecture in general. Some ask, "Why a cathedral?" I find the medieval cathedral a superb accomplishment of beauty and grace. My idea is to use a cathedral plan because it's the most beautiful form for me, and use timber framing because of its strength and durability and the richness of the wood. The first challenges were to design a very functional building and to find the perfect land to build it on. It took 10 years. Then, late in 2003, on the shore of Lake Bowker in Orford, Québec, I found land, sold my house, entrusted my software business to the hands of my best employee and started the project, all in the same week!

Two years later, the frame was complete. I did the entire job by myself and with some very good friends—plans, technical drawing, foundations, floor warming system, wood planing, timber framing, the lot. The foundation alone took a year because I wanted it on bedrock, insulated and made of steel-reinforced concrete. Doing that on the edge of a 50-ft. cliff required much more time than placing concrete on horizontal ground but, in the end, it will prolong the life of the building—and the view is great.

The second step was the frame itself, the most interesting part. It also took me a year, working alone, to produce the 400 pieces of timber, framed into two and a half stories and a dome 32 ft. high in five sections with an attached solarium. The frame raising was intense because I did it with friends, scaffolding and chainfalls only. The method was effective for a personal project because I could prepare 10 or 20 pieces during the week and then raise them in a day with my friends. I plan to slate the roof and then build the stairways and the kitchen cabinetry. The house should be ready to move into before the end of 2008, but I try to avoid deadlines so I can take the time I need to reflect and address problems correctly. On the other hand, I dream of a Carolina climate, because taking your time in Québec means very cold weather in winter (-10 degrees F is not rare) and lots of snow, too, which complicate matters.

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