TIMBER FRAMING

JOURNAL OF THE TIMBER FRAMERS GUILD

Number 88, June 2008

Height Safety for Timber Framers

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On the front cover, at top, framers have tied off their pipe staging to the building frame, a re-erected barn, and themselves to the staging (photo by Joel McCarty); below, retractable lanyard in use as roof panels are flown in to newly built timber frame (photo by Bensonwood Homes).
On the back cover, views of social and cultural center underway for Rignano sull'Arno, Italy, about 12 miles southeast of Florence, with design by Legno Più Engineering of Prato and construction by Pevedil Timber Builders of Fondi. The timber, Douglas fir and white fir from Tuscan forests, was donated to the municipality by local mountain communities. The ribbed gridshell roof uses a nailed plank system popularized by the German structural engineer Julius Natterer. Photos by Thomas Allocca.

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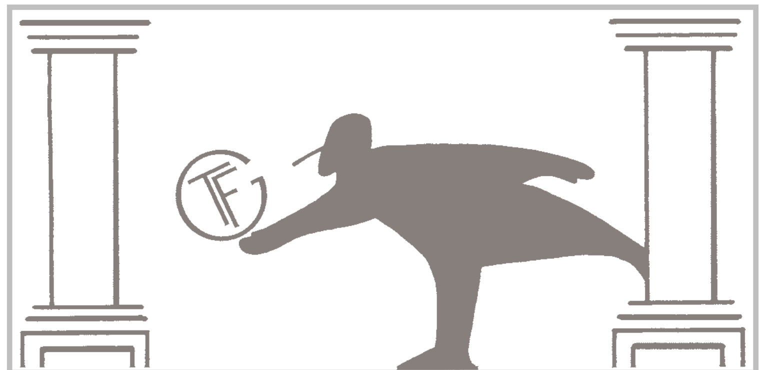
TIMBER FRAMING, Journal of the Timber Framers Guild, appears in March, June, September and December. The journal is written by its readers and pays for interesting articles by experienced and novice writers alike.

1985



Notes & Comment

Apprenticeship Report

BACK at the Guild's first membership conference at Hancock Shaker Village in 1985, one of our stated goals was to establish an apprenticeship program. For many years this goal seemed unattainable given the wide variety and unstandardized methods in our small niche trade. Our membership was (and remains) far flung, with few concentrations of shops in any one area to support a centralized training facility. Nevertheless, after about ten years we felt we had matured enough to investigate what it would take to register a timber framing apprenticeship with the US Department of Labor. If we succeeded, we would have a systematic way to bring up new timber framers. There were financial benefits, too: companies could qualify for job training funding and vets could get benefits under the GI bill.

One of the first requirements of the government application was the submission of a detailed curriculum for training. This stopped us in our tracks, and it took us until 2004 to get the research done and the curriculum outlines completed. The research included surveys of companies and individuals as to what skills they felt a competent timber framer should have, a look at what firms were doing to train their new hires and what schools and organizations currently offered for workshops and courses, and then combining all this into a sensible and attainable training curriculum that outlined content (knowledge learned) and goals (skills attained). These outlines can be found and downloaded at the Guild Website.

We've now submitted the application to the Department of Labor to register a timber framing apprenticeship. It's not enough just to submit the curriculum; we also had to propose how the content is to be delivered through on-the-job and related classroom time. The program (which we can modify as it evolves) is set up to take an apprentice three years, with approximately 2000 hours in the shop and 144 hours in the classroom per year. Basic skills such as safety and layout are taught early, advanced subjects such as computers and engineering toward the end. The expertise required to complete the training is designed to produce "journeymen," not masters. We are seeking a level of competency that will make a timber framer efficient on the job, comfortable and familiar with the skills and techniques we commonly employ.

As the curriculum evolved, we anticipated that the Guild would be the content providers publishing materials for use in the shops to train employees. We would also endeavor to train the trainers, developing a cadre of instructors to use the materials to teach workshops and courses at Guild events and at shops that requested the training. Recent developments have encouraged us additionally to establish and register a program that includes monitoring the apprentices and their on-the-job training on a national (and perhaps international) level. One impetus is a requirement that seems to be cropping up in bid documents for public projects. Some states mandate that to be considered a qualified bidder, a company must have employees registered in an approved apprenticeship program. This requirement may originate with self-serving interests but can't be ignored as timber framing companies increase their capabilities for public projects.

A second reason for the Guild to administer the program is that many companies are too small to be capable of registering their own employees through state apprenticeship offices. The paperwork along with the lack of collective resources from companies in any one state would require each company to start from scratch. We have been advised by both the US Labor Department and the Office of Apprenticeship in Massachusetts (the state we're incorporated in) that we are better off applying on the national level.

The process will no doubt include some controversial steps ahead. Part of the initial application includes determining our occupational code: we need a number that identifies us as a trade. Currently, timber framing is listed under Rough Carpenters, a category that also includes concrete formworkers. Forty years ago timber framers were categorized under Mining; evidently all we did then was to shore up mine shafts.

It's not yet clear all the ramifications the code number might have, but if it's used to set Worker's Compensation rates, for example, it could be significant. We made sure that, regardless of our nominal category, we would have the freedom to set and use our own curriculum and not (for instance) require our apprentices to learn to shore up excavations. We may even get our own code number, based on the following description in the application of what a timber framer does:

> Build finished wooden frame structures of heavy timber, such as residential and commercial buildings, according to blueprints and specifications. Study drawings to determine lengths of timbers and location of wooden or metal joinery. Procure timbers from sawmills and visually grade materials to meet engineering specifications. Understand the behavior of green (unseasoned) timber in a structure and know how to minimize undesirable effects. Efficiently move and manipulate heavy timber in a production shop environment using specialized equipment. Measure and mark materials. . . . Use layout techniques that account for variability in nominal size and shape of timber; incorporate round and crooked timber in finished frames. Cut timbers and joinery using specialized equipment such as portable chain mortisers and large portable circular saws. Finish timbers using portable electric planers and suitable coatings. Assemble timber frames using wooden, pegged joinery and specialized equipment such as comealongs and clamps. Bore peg holes using electric or hand drill and offset to draw joinery tight during assembly. Erect timber frames on-site using cranes, hoists, ladders, temporary bracing and appropriate fall prevention and protection equipment. Build rough and finished stairs. Install enclosure systems, particularly structural insulated panels (SIPs). Examine and repair defective timbers in existing timber-framed buildings. Survey and apply sound structural and conservation standards to historic timber structures in need of repair, such as barns, steeples and covered bridges. Employ sound small business practices and project management skills.

(You can use all that to tell your mom what you do, next time she asks.)

Once we get approval from the government to continue, we'll post on the Guild Website in detail how the three-year program works. Thorny issues, particularly wages and the supervision of apprentices, will need to be dealt with, and I'm speculating a bit in what follows below. It's encouraging that our contacts in the Labor Department have been very supportive and indicate we'll have flexibility to tweak the program as it evolves.

When apprentices enroll in the program, they will usually need to enter into an agreement with a company that employs experienced workers or journeymen (apologies for the sexist term, which seems to have no credible alternative) who will be their mentors, signing off in their work log and verifying that they get the required training. The journeymen don't have to be qualified to instruct the apprentice in all aspects of the curriculum, but will be responsible for making sure someone qualified in a particular skill trains the apprentice. Old Bob may have spent 40 years as the tool sharpener in the shop, for example, but he isn't a journeyman timber framer. The journeyman of record can send the apprentice in to Bob for his sharpening training. Apprentices may come to a Guild event to get compound joinery instruction, or go to another shop to get scribing instruction, since not all shops do all kinds of work, but their supervising journeymen will verify that they received the training.

Our application specifies the ratio of apprentices to journeymen at one to one. In other words, each participating shop must have at least one journeyman for each apprentice; a single journeyman can't take on two or more apprentices. It's unclear how much an apprentice can move around between shops and work under different journeymen (an important consideration for itinerants and the fluid nature of our workforce). Again, it appears we'll have the flexibility to do what works best. In our case, it might provide better continuity to have an apprentice be supervised by a single journeyman even if not working directly under that person all the time.

But which comes first, the chicken or the egg? Who shall be the journeymen to supervise the first batch of apprentices? The Labor Department tells us that we can appoint journeymen using any criteria we want, and this is how to get the program started. These appointments will be tricky, but they could be based on a combination of the subject's work experience and résumé, peer review and curriculum exam results. If one isn't qualified to be a journeyman by these criteria, enrollment in the apprenticeship program will most quickly achieve the necessary credentials.

We'll probably do a trial run of the program with a dozen or so shops of various sizes, and trust that the criteria used to select the initial crop of journeymen and apprentices will be objective enough to be fruitful. The proof of the pudding is in the eating: if the apprentices cannot pass the goals of the curriculum, then the journeymen supervising them will be scrutinized as well. It's possible that testing will not be done by the journeymen but by independent means, such as at a Guild event. The journeymen may be responsible for logging the apprentices' work hours and making sure they get the training but not testing them for competency. Once the process gets rolling it should be self-perpetuating: the apprentices should be the next generation of journeymen.

No one will be required to participate in the program except to take on an apprentice, and for some this may be the only reason to want or need a journeyman certification. While the cert may serve an inner need, we expect and hope a journeyman would take on an apprentice at some point in a timber framing career. Journeymen and apprentices will have to be Guild members, of course.

All apprenticeships registered with the Labor Department require an agreement with the employer that specifies wages. Usually the apprentice's wage is set at some percentage of the journeyman's rate (50 percent, for example) and is guaranteed. Establishing these rates and their likely regional adjustments may require onerous work and discussions.

This program is a big step for the Guild and for American timber framing. Supervising the workplace and the apprentices within it will be a new endeavor for us and probably will require more staff and resources. The major benefit for all of us will be to attract and encourage new young timber framers and welcome them into a framework where they can develop a career with pride and enthusiasm.

—Will Beemer

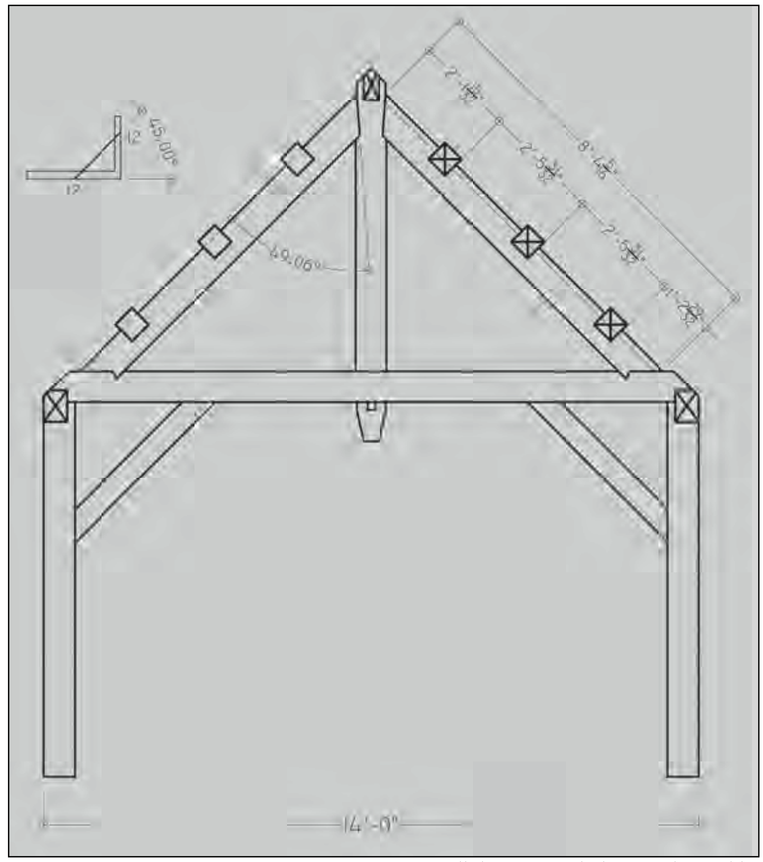
Snap-Line Square Rule Layout

MOST carpenters, if they frame long enough, will eventually find it necessary to use irregular timber that does not yield joinery of acceptable quality when laid out by simple face-and-edge reference alone. With knowledge, foresight and a good chalk box, these irregularities can be accounted for during layout, thereby eliminating the need to scribe or preassemble frames to obtain accurate joinery.

Snap-line square rule is a system of layout in which the carpenter lays out from snapped chalk lines on the timber instead of from its edge or face, which might be distorted by crown, bow, wind (twist), out-of-squareness or other surface irregularity that will skew the layout. The carpenter makes no assumptions regarding the surfaces of the timber, not even the reference face and edge.

In our shop, we don't snap lines unless the circumstances require it. As a rule, we edge-reference whenever possible simply because snapping lines takes more time. We find it adds roughly 20 percent to our layout and cutting time. But around half of the timbers that we square-rule get lined. So why do it?

We might choose snap-line square rule when the timber on hand is crowned, bowed or wound (twisted); poorly milled but otherwise acceptable; round, semi-round or very waney; or when the construction documents specify hewn timber or reclaimed timber not to be resawn. The point is that snap-line square rule allows us to work with a wider variety of material. The carpenter who always works with near-perfect rectangular timber and plans to continue doing so will not need this layout system. This article is written for the carpenter who desires the ability to square-rule any type of timber with absolute confidence in the fit of the joinery.



All drawings and photos Whit Holder

Fig. 1. Representative crossframe with kingpost-trussed rafters.

A Practical Example. Suppose I need to lay out five pairs of principal rafters for the kingpost truss-common purlin roof shown in Fig. 1. I have examined my stock of designated 8x8x10 timber and found that crown, bow and wind each averages about an inch. I begin by studying the shop drawing, which shows the purlins seated to rise above the rafters. If I lay out the rafters simply from the top and one side, rafter crown will result in humps in the roof surface, rafter bow will result in variations in purlin lengths, and rafter wind will result in poorly fitting joinery at both the tie beam and kingpost connections. These issues will present themselves when the timbers are introduced to each other. The tenons will not be in plane with the mortises and the tenon shoulders will show pronounced gaps.

Two layout systems can account for crown, bow and wind—snap-line square rule and scribing. (I'll discuss pros and cons of these a bit later.) I decide to use the first, and to snap lines on the rafters in order to keep the roof flat, cut all the purlins the same length and obtain tight shoulders at the tie beam and kingpost connections. I will set each rafter crown up, pick a reference face and snap lengthwise reference lines on all four sides of the timber. But first I must determine where to snap the lines. Joinery is the biggest factor in this decision. Line placement affects layout efficiency.

Reference lines are designated by their offset distance from the reference arris of the timber. A 1½-in. line is my default choice, because it's particularly handy for squaring reference points around an edge. A second line for repeated joints can often increase layout speed, so, in addition to the 1½-in. line on the sides of the rafter, I will snap a 4½-in. line to establish the bottom of the purlin housings. I would typically snap a line at the tenon offset (in this case 2 in.), but here I'd rather define the backs of the three purlin housings than the sides of the two tenons. So on the top of the rafter I will snap lines at 1½ in. and 6½ in. indicating the backs of all the purlin housings. On the bottom of the rafter I will snap a line at 1½ in.

The shop drawing gives a length of 8 ft. $4\frac{5}{16}$ in. along the top of the rafter. Since I won't be referring to the top surface of the rafter, I need to determine the rafter length along my 1½-in. reference line, the distance between the two points on my line where the kingpost shoulder and the tie beam shoulder intersect the line.

Given the roof pitch of 12 in 12, in Fig. 2 we see that because the rafter foot is cut level, the length along the top of the rafter is 1½ in. longer than the length along the 1½-in. reference line at the foot. Fig. 3 shows the kingpost shoulder at the peak of the rafter is not a plumb cut because it enters a diminished housing. The angle is given as 49.06 degrees and therefore we can determine by trig that the length along the 1½-in. line is $1\frac{5}{16}$ in. less than the length along the top of the rafter at the peak. Subtracting 1½ in. at the foot and $1\frac{5}{16}$ in. at the peak from 8 ft. $4\frac{5}{16}$ in. gives me a rafter length of 8 ft. 1½ in. from shoulder to shoulder along the 1½-in. reference line. Allowing 3 in. for each tenon to extend beyond the shoulders, I have an overall rafter length, from tip of tenon to tip of tenon, of 8 ft. 7½ in.

Unwinding (Truing) the Timber. Using a chainsaw, I cut the timber to 8 ft. 7½ in., being careful to make a reasonably clean, square cut and using this opportunity to remove end defects. With the crown up, I make a mark with carpenter's chalk about 3 in. from each end, the proximate locations where the reference lines

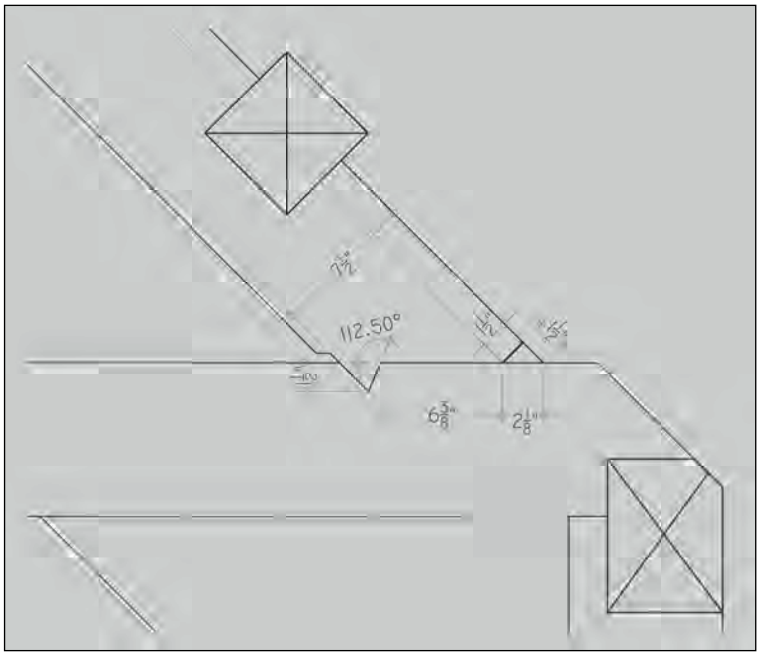


Fig. 2. Detail at principal rafter foot. Tenons omitted for clarity. Note birdsmouth at heel of rafter foot.

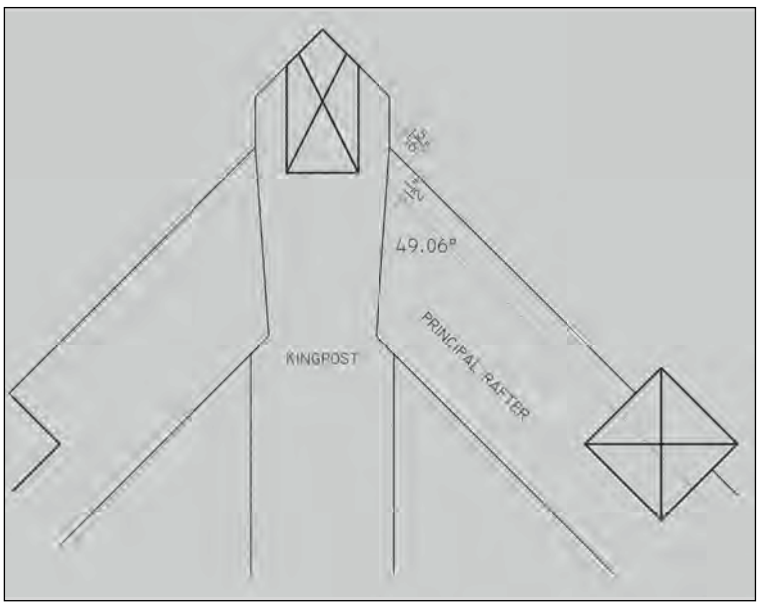


Fig. 3. Detail at kingpost head. Tenons omitted for clarity.

will cross the shoulders. I can quantify the wind in the timber by placing levels across the grain at each location, noting the amount of difference between the bubbles (Fig. 4).

At this stage I am only using the levels to compare the bubbles with one another—not to judge against true level. The difference between the two is the amount of wind in the timber.

I must now locate a zero point for the wind. If I wish to put the wind at one end of the timber, then I level the opposite end. On these rafters, however, I wish to put half the wind at each end (to minimize it at the connections to tie and kingpost), so I move the level along the timber to a point where the bubble splits the difference between the two ends—the zero point—and wedge the timber on its supports until it reads level at this location (Fig. 5).

I make a mark here that I can use to check joinery during and after cutting. On a twisted tie beam, for example, this level mark would be at the location on the top of the beam that will be level after the frame is raised. On this twisted rafter, it will ultimately be the area that's parallel to the roof plane.

Fig. 4. Determining the amount of wind by comparing levels.

Fig. 5. Wedging the timber to level at "zero" point along surface.

Taking a square to one end of the timber, I hold it on the reference edge and parallel with the level, and mark the top of the rafter at 1½ in. and 6½ in. and the reference side of the rafter at 1½ in. and 4½ in. (Fig. 6).

Fig. 6. Marking line locations on endgrain. A knifed notch at the arrows will later keep the stretched line in place.

Using the level on the endgrain, I extend these marks to the opposite (non-reference) faces of the timber and repeat the process at the other end before removing the wedges (Fig. 7).

Fig. 7. Transferring line locations to nonreference faces.

These pencil lines on the endgrain define *X* and *Y* planes running through the timber, to which the joinery will be parallel and perpendicular. At this stage, it's important to have a good mental image of adjoining timbers. When marking line locations on the rafter, for example, it's an option to adjust a bit to avoid an overly deep purlin housing on one side and a shallow one on the opposite side. This adjustment, however, will move the edge out of flush with the edge of the adjoining kingpost or tie beam.

Lining the Timber. The lines on the top of the rafter can now be snapped. Any chalk line will do, of course, but we work to the center of the line at all times, so a thin, crisp line is easier to work with during both layout and cutting. Some carpenters use ink lines, but I prefer red or black chalk when the lines can stay on the timber and white chalk when they must be removed without sanding or planing. A thin braided and uncoated fly-fishing line works well, and Tajima also sells an ultra-fine replacement line.

To keep the line in place, I cut small notches on the ends of the timber at each of my marks, hook the end of the line on the end of the timber at the bottom edge, place the line in the 1½-in. notch and pay it out. I then snap the line lightly, taking care to snap in plane with the lines I've just drawn on the endgrain, and repeat the process for the 6½-in. line. It can be helpful to place a thin straightedge across the grain flatwise, stretch the line taut over it, and carefully stand it up on edge to allow the fingers to grasp a fine line, especially when snapping on crowned surfaces (Fig. 8).

Fig. 8. A straightedge set under a taut chalkline can be rolled on edge, allowing fingers to grasp the fine line easily.

Stretching a tape measure along the 1½-in. line, I now mark all eight of my reference points: the tie beam shoulder at the foot of the rafter, each side of three purlin housings and the kingpost shoulder at the peak. At this point I am still working on the top, or crown, of the rafter. I have not rolled the timber yet. It's important to note that the two end reference marks I made on the top of the rafter indicate where the shoulders pass through the 1½-in. lines that I'm about to snap on the sides of the rafter. My two end reference marks measure 8 ft. 1½ in. apart and are located where I placed the levels earlier.

Setting the blade of the square on the 1½-in. line, I align the tongue with the reference point for the tie beam shoulder and make a tick mark on both edges of the timber. A line is unnecessary; I only need tick marks at the edges to enable me later to square this point onto each adjacent side. I then square the sides of the purlin housings across the top of the rafter, penciling in each side of the housings from the chalk lines to the edge of the timber. Finally, at the reference point at the kingpost shoulder, I square a tick mark to both edges as I did at the tie beam shoulder.

I can now roll the timber so that the reference side is up and snap the 1½-in. and 4½-in. lines. To complete the purlin housing layout, I need only square the sides of the housings from the top edge of the rafter down to the 4½-in. line, using the 1½-in. line to register the square (Fig. 9).

Fig. 9. Marking sides of a purlin housing by squaring down to the 4½-in. line. Square is registered on the 1½-in. line.

At the foot of the rafter, I need to lay out the level cut for the tie beam shoulder. I find the tick mark that I squared to the top edge earlier and square it down the side of the rafter, marking the point where it intersects the 1½-in. line. The shoulder will pass through this point, indicated by the awl in Fig. 10.

I can now use the square to lay out the level cut, being sure to establish the pitch using the 1½-in. line, not the edge of the timber. Working from the intersection of reference and shoulder lines, I mark 6⅜ in. to locate the point on the shoulder cut where the birdsmouth begins (see Fig. 2). I now set the square on the reference line to produce a 22.5-degree angle through this point, and lay out the bearing face of the birdsmouth (Fig. 11).

The rafter must also be reduced in depth (measured perpendicular to the roof surface) to 7½ in. to fit into the birdsmouth. This reduction must be drawn parallel to the reference line. It's helpful to have a small v-notch filed in the end of the blade of the square 1½ in. from the outside edge. When referencing the line, it's easy to align this notch on one end and the 1½-in. graduation on the tongue of the square on the other end. This allows the use of the tongue to measure across the grain of the timber without mentally compensating for the ½-in. difference between the reference line at 1½ in. and the width of the square blade at 2 in. If you use a Borneman layout template, remove the fence to allow you to set it against the line, and draw parallel lines. Using either technique, I can now mark the 7½-in. depth at the rafter foot (Fig. 12).

Fig. 10. Awl points out intersection of shoulder and reference lines.

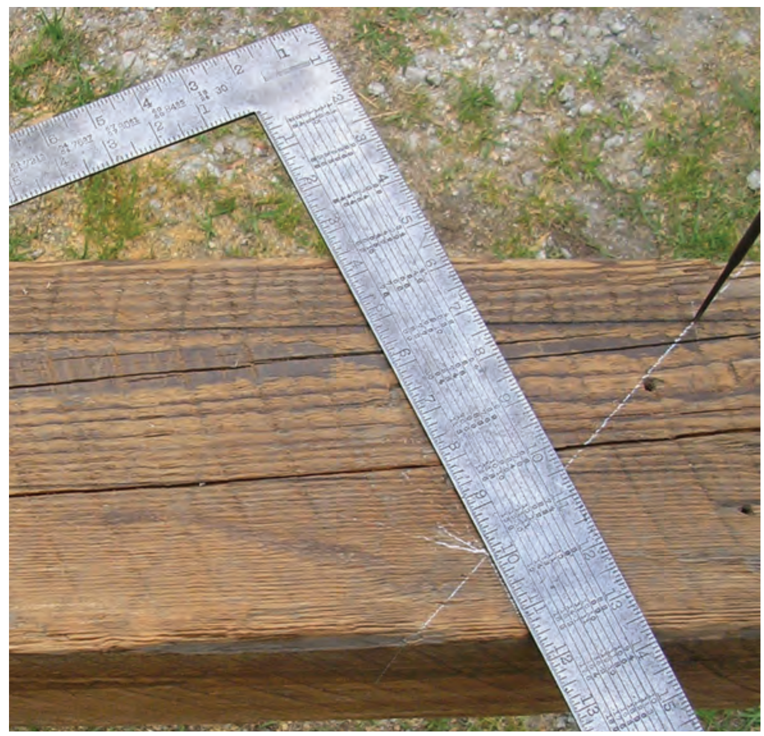


Fig. 11. Laying out birdsmouth, reference point marked by awl.

Fig. 12. Marking reduction at rafter foot using a Borneman template.

At the peak of the rafter, the process is the same: locate the tick mark on the top edge, square it down to the 1½-in. line and draw the shoulder line through this point using the reference line to draw the pitch. Then measure along the shoulder from the reference line to locate the tenon clip and draw the 7½-in. depth reduction. The rafter can now be rolled twice, so that the nonreference side is up. The layout process is the same for this side.

I can now roll the belly of the rafter up and snap only a 1½-in. line (no joinery on this face). To lay out the tenon cheeks at each end, I first connect the shoulder lines on the sides of the rafter with a straightedge. *These lines must be connected with a straightedge, not squared around.* The more wind in the timber, the more obviously out of square this line will appear (Fig. 13).

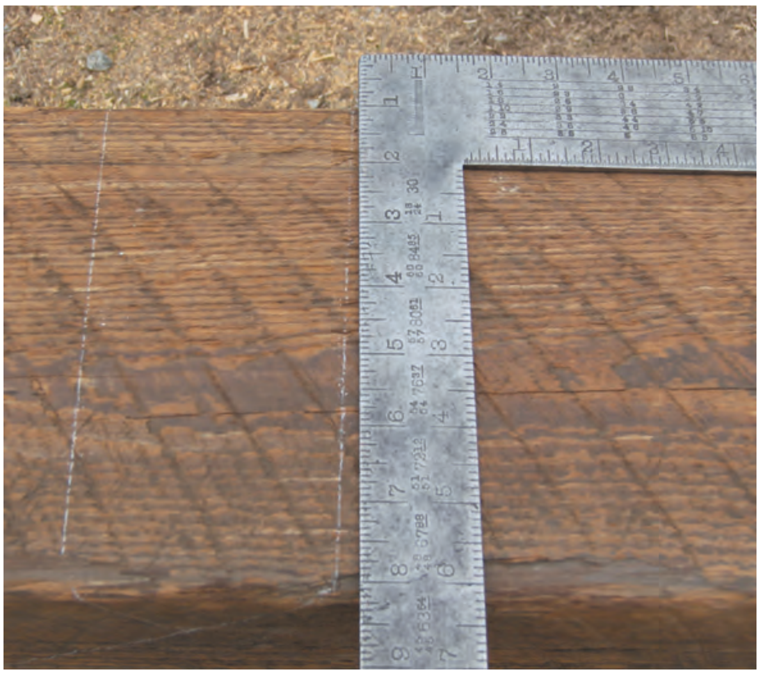


Fig. 13. Shoulder lines must be connected with a straightedge, not squared around. Framing square registered on reference line shows divergence of actual shoulder lines.

Now I can draw the tenon cheeks parallel to the reference line. Were the tenon layout 1½, 1½, I would simply register the tongue of the square against the reference line and draw a parallel line. My layout is 2, 2, so I use the Borneman template to draw the lines or measure over with the square twice and connect ticks.

To complete the layout, I roll the timber twice so that the crown is up once more, connect the shoulder lines across the grain with a straightedge (remember, don't try to square across) and draw remaining tenon cheek lines.

Cutting. When cutting a timber such as our rafter, the surfaces cannot be assumed to be parallel to joint surfaces. Shoulder cuts, for example, will likely change depth from one side to the other, making it necessary to check both and then set the circular saw depth to the shallow side. Shoulder lines will also frequently be out of square to the surface of the timber, requiring the operator to tilt or adjust the saw slightly to achieve the correct line. On notably out-of-square timber, it may help to think of the saw base as a depth stop. Although a bit daunting at first, this technique is quickly learned. Handsaws are better suited to cutting snap-line joinery since they do not depend on the surface of the timber. An out-of-square line is no more trouble for the carpenter to handsaw than a square line. We often choose the handsaw when cutting small hewn pieces that vary quite a bit in depth from one side of the shoulder to the other.

Before cutting a piece of wood away, it's important to connect the reference lines around the endgrain to help draw the joinery and to use for future reference. When cutting our rafter, the tenon cheeks and the location of the clip should be connected along the endgrain because, if cut away, the lines cannot be relocated by measuring from the surface.

Since the surfaces of the timber cannot be used to check joinery, a different strategy is necessary. I clamp or strap a level to the level mark and wedge the timber plumb or level to check the accuracy of cut joinery. With the level placed on the level mark and reading level, for example, the backs of the purlin housings and the tenon cheeks should all be plumb and the 7½-in. depth reductions should read level. All joinery should be checked using this method to ensure a proper fit on raising day.

During assembly, I take all measurements from line to line. When the frame stands complete, the lines will run plumb and level regardless of the irregularity of the timber, and I can use the lines to plumb the posts.

SUMMARY. I will admit that snap-line square rule is a lot of work. So why do it? I have found it an appropriate method for hewn timber and bowed and twisted material, such as reclaimed timber with original surfaces, and for projects requiring historically accurate methods. Although bowed and twisted timber can be laid out and cut to fit properly, it's still important to cull beforehand (supposing you have the choice). If, after culling, you still have irregular timber to work with, the timbers should be planed, sawn or hewn flat on surfaces that will form floor, wall or roof planes.

Twisted stock joins up neatly using snap line square rule, but the faces of timbers will usually be out of flush at the joints. This can cause an otherwise tight-fitting joint to look untidy. Twisted stock should be squared locally at the joints prior to layout, or the "overwood" removed after assembly.

I only snap lines on the timbers that need them. Some frames may only have a few timbers that need reference lines, and timbers that are bowed in one direction and straight in the other will only require a line on two sides rather than four. There is no hard and fast rule that requires a line on every face.

When choosing a layout system, snap-line square rule often comes up against scribing as the other method to deal with imperfect stock. Choose scribing if it is undesirable to see repetitive gains at mortises and reductions at tenons in the timber frame, or to greatly simplify the necessary math. But choose snap line square rule to minimize material handling or if you don't have all of the necessary timber on hand when framing begins.

Not least, snap line square rule serves as a good common language layout system when framers from different backgrounds come together, such as at Guild projects, where it has been used many times with great success. —Whit Holder

Whit Holder (whit@holderbros.com) is a principal at Holder Bros. Timber Frames, Monroe, Georgia, and a Guild director.

SAFE WORK PRACTICES

IV. Height Safety for Timber Framers

Ray Gibbs

Fig. 1. Framers setting common purlins and using work-positioning restraints (fall limited to 2 ft.). Shock-absorbing fall-arrest devices worn on the back will be secured when detaching positioning devices to get around obstacles such as post on left. Commanders sitting unsecured on beams may have been deemed impractical to attach via lanyard to framer or frame, as are smaller tools routinely. Controlled-access zone beneath.

FALLS are the leading cause of worker fatalities in the construction industry. There were 827 fatal falls in the US during 2006; a fifth of these were falls from roofs or ladders. More than 100,000 are injured as a result of falls at construction sites. OSHA, the Occupational Safety and Health Administration, recognizes that falls are generally complex events frequently involving a variety of factors. Consequently, the standard for fall protection deals with both the human and equipment-related issues in protecting workers from fall hazards. These regulations can be confusing and apparently contradictory to common sense, especially for a specialized trade such as timber framing that doesn't fit neatly into the parameters the regulations were designed for. In this article we will summarize the OSHA standards for fall protection, suggest not-so-difficult ways timber framers can meet these requirements and conclude with a glossary of terms.

It's totally possible to put up timber frames safely and within the OSHA rules of play (Fig. 1). This requires a basic understanding of the standards and an appreciation for the philosophy that underpins those standards. (The authors recognize that OSHA only covers US jobsites, but Occupational Health and Safety or OHS boards in other countries are very similar.) All jobs are different, requiring us to be flexible about the methods we use: no single solution will work for every job, but there are some strategies that we tend to return to time after time.

Despite the great range of height safety tools, training, techniques and specialized equipment currently available, our most effective tool is good old-fashioned work planning. OSHA inspectors certainly know this, and if they show up on our jobsite they will expect us to prove that our work methods were planned in advance. In most circumstances, they will expect us to produce a written plan as evidence. The breadth and detail of that written plan reflect the complexity of our particular frame raising, but we shouldn't feel intimidated by the task of putting this information together, because we typically plan our raisings anyway to ensure that they go as smoothly as possible. In many cases, the only difference between what we're already doing and what OSHA requires is writing the stuff down.

It helps to understand where OSHA is coming from: they know that people often get hurt by falling off ladders, mobile scaffolds and unprotected or leading edges (see glossary), as well as into holes, so they periodically revise certain regulations to get contractors thinking about alternative, safer work methods. For example, OSHA is now trying to make the use of fall-arrest systems less attractive than work positioning with boom lifts, making the former the last option rather than the first choice of contractors. Why? Understanding this basic question is really important and the answer is actually quite obvious: falling is the ugly part of the height-safety business. Successful height-safety strategies always seek to avoid people falling because that's when they are most likely to be injured, even if they're wearing a good fall-arrest system. From OSHA's perspective, any strategy that prevents or avoids a fall in the first place is better than arresting a fall afterward. Fall prevention is the goal, and fall arrest should be viewed as a last resort. The distinction between fall prevention and fall arrest is critical to understanding the OSHA (USA) and OHS (Canada) regulations, and to making a good height-safety plan.

We often need to make high connections before there's much building to stand on, and our industry suffers a lack of standard guidance for working at height. There are regulations and exceptions specifically designed for light-frame residential builders, as well as for the steel-erection industry, but not for timber framing—which means that we fall under the general construction regulations. It's harder for us to deal with these blanket regulations. The authors' own experience has been that health and safety inspectors recognize that we're doing something unusual, and they are receptive to any active approach as long as it keeps people safe and demonstrates an awareness of the regulations that the inspectors are expected to enforce. OSHA is particularly interested in knowing whether we have considered all of the safer methods of access before resorting to fall arrest. They just don't like cowboys who reach for a harness instead of considering some of the safer alternatives.

In general, OSHA says that employers and workers need to:

Construct and install proper safety systems.
Supervise workers properly.
Use safe work procedures.
Where protection is required, select fall-protection systems appropriate for given situations.
Train workers in the proper selection, use and maintenance of fall-protection systems.
Use certified equipment appropriate for the job and in good condition.

The key matters OSHA will look for are planning, supervision, training and proper equipment. These considerations apply to every job and can be reinforced often at the shop and in company meetings. Once you get your first look at the jobsite, then it's time to consider specifics.

The Risk Assessment. The first steps in any fall-prevention and fall-protection plan are to evaluate the site and analyze the fall hazards. A fall hazard is anything in the workplace that could cause a loss of balance or bodily support and result in a fall to a lower level. Fall hazards are foreseeable! You can identify them, eliminate exposure to them, eliminate them or control them before they result in injuries or death.

Review the blueprints before the work ever begins on the site to determine where workers will be exposed to hazards. The procedure might include these questions:

Will working surfaces on the incomplete structure have the strength and structural integrity to safely support workers?
Will the frame be well braced and its joinery secure?
Will the workers be exposed to slippery surfaces?
Are the timbers strong enough to support someone walking on them? Are they adequate to meet the requirements for anchor points with personal fall-arrest systems?
Can you change the erection sequence to eliminate hazards?
Can guardrails or safety nets be used? If not, will personal fall-arrest or restraining systems, controlled-access zones, monitoring systems, warning-line systems and work-positioning systems be employed?
Can you restrict access to the area by untrained people?
What openings and unprotected edges will the workers be exposed to?
Is there the possibility of workers being struck by falling objects?
Will aerial lifts, cranes, ladders or scaffolding be used?
How often and for how long will the workers be exposed to the hazard, and how many will be exposed?
Will horizontal or vertical movement be required?
What is the distance to lower levels?

If done properly, notes on the drawings regarding hazards and fall-protection systems can satisfy the requirement for a written plan. Anticipate hazards that may appear in the future by not only reviewing the plans but also interviewing the workers and supervisors as the job progresses. If proper planning isn't done at the outset, injuries or death can occur simply by not having made the time or effort to identify and control the hazards.

The OSHA standards say a competent person must make this risk assessment, and the employer is responsible for making sure that this happens. A *competent* person is someone capable of identifying existing and predictable hazards in the surroundings or working conditions that are dangerous to workers, and who has authorization to take prompt corrective measures to eliminate them. This person is also required to understand the relevant OSHA standard (1926, Subpart M).

If a job-built fall-protection system is needed, such as a horizontal lifeline system with anchorage points, it must be designed by a *qualified* person, one who has the certification or demonstrable experience to meet the engineering requirements of the system. This person does not need to be on site during the job, but a competent person, as described above, does.

Another useful term to understand is *authorized*. An authorized person is a worker who has been properly trained in the use of fall-protection equipment and understands the rules and hazards on the site. Only authorized persons are allowed in a controlled-access zone.

Courses and certification in each of the above three classifications are available through many safety equipment suppliers. In-shop training is usually adequate to authorize people. Certification helps legitimize the competent person on your crew, but is not absolutely necessary to meet the OSHA standard as long as the person can demonstrate competency. It's generally accepted that the qualified person has to have some sort of degree, equivalent certification or extensive work experience.

Once the hazards have been identified, then start using this mantra: *elimination, prevention, protection.* First, eliminate fall hazards. Second, prevent falls. Third, protect through control of falls (fall-arrest).

Elimination of fall hazards is the first and best line of defense against falls from heights. It requires a careful assessment of the workplace and the work process itself. Elimination means any strategy, including engineering controls or alternative work methods, that removes the risk altogether. Examples include building timber frame assemblies on the ground and then lifting them into place with a crane rather than building piece by piece; altering joinery or frame design to make the frame-raising easier and reducing the amount of time spent working aloft; and installing temporary access systems, platforms, ropes, anchors, etc., as part of the frame so that people won't need to climb into unprotected places.

When fall hazards cannot be entirely eliminated, *prevention* of falls is the second line of defense. Make changes to the workplace to avoid relying on worker behavior and personal protective equipment to prevent falls. Examples include addition of scaffolding, stairs, temporary floors, hole covers, guardrails and barriers to pre-

Will Beemer

Fig. 2. Solid temporary stair is far safer than ladders.

Will Beemer

Fig. 3. Catwalk gives continuous access for serial assemblies.

vent the worker from direct and unprotected exposure to the fall hazard. Alternatively, workers might use elevated work platforms such as boom-lifts, scissor lifts or man-baskets to access tricky parts of a frame (Figs. 2–6).

Work restraint is another good option: using harnesses and lanyards to prevent workers from walking up to an unprotected edge. These techniques all prevent a fall before the fact.

Protection through the control of falls is the last line of defense. It should be considered only after determining that the fall hazard cannot be eliminated or prevented. Fall controls include safety nets or the use of fall-arrest equipment such as harnesses, shock-absorbing lanyards and climbing helmets. These controls reduce the risk of injury resulting from a fall. Fall protection is required whenever a person could potentially fall 6 ft. (1.8m) or more to a lower level. Protection also must be provided for construction workers who are exposed to the hazard of falling objects or to prevent them from falling into dangerous equipment.

If a worker is exposed to falling 6 ft. or more from an unprotected side or edge, the employer must select a guardrail system, safety-net system, or personal fall-arrest system to protect the worker. If the use of these conventional fall-protection systems is infeasible or their use would create a greater hazard, an alternative plan is acceptable provided certain conditions are met; see OSHA 29 CFR 1926.502(k). (A definition of "infeasible" can be found in the glossary at the end of this article.) Again, one of the most

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Fig. 4. Assemble as much as possible on the ground.

Joel McCarty

Fig. 5. Guardrail protects at edge of busy elevated deck.

Joel McCarty

Fig. 6. Mobile elevated work platforms offer ideal positioning and leave no structure behind.

important of these conditions is that you demonstrate you have assessed the hazards and evaluated the options competently. In summary, the OSHA standards are heavily weighted toward preventing falls in the first instance rather than ensuring that a worker will be safe in the event of a fall. This distinction provides a key insight into the OSHA approach.

Site Visits. In the case of an OSHA site visit, it's up to you to demonstrate that you have considered the hazards and options for their elimination, and selected safety systems compatible with the type of work being performed. If you can show due diligence it will go a long way toward keeping the visit pleasant. To make OSHA happy, the height-safety plan you develop for the job should include evidence that you have done the following:

Determined that the structure and its walking and working surfaces are structurally safe.
Conducted a fall-hazard assessment.
Eliminated the need for fall protection if possible.
Selected the appropriate type of fall-prevention or fall-protection system.
Developed rescue and retrieval procedures.
Developed an equipment inspection, maintenance and storage program.
Provided fall-protection training.
Monitored the fall-protection program.
Identified who is specifically responsible for monitoring the fall-protection system, and who can authorize a change or amendment to the plan.

CHOOSING a system. Let's look at the various prevention and protection systems and alternatives in more detail. In deciding which to use, you'll need to consider a number of factors. Look at the activities that will require fall protection (installing rafters, joists, purlins, for example) and identify which tools will be needed aloft. How will the workers carry them? Will the workers be moving horizontally or vertically often and over large distances? Will they need both hands free? Will they need to straddle or step over framing members, and will the fall-protection system interfere with movement? Are there anchorage points of suitable strength and design for attaching the protection system, and where are they? How often will leading edges, anchorages and working surfaces change during erection? What will the environmental conditions be (snow, wind, rain, cold) and will they interfere with using the system? Are there sharp or rough surfaces or edges that could compromise the system? How will workers be rescued or recovered if they fall?

Typically you will use one or more of the following:

Personal fall-arrest system
Guardrail system
Safety-net system
Fall-restraint system
Work-positioning system
Warning-line system
Safety-monitoring system
Controlled-access zone

Personal fall-arrest systems consist of an anchorage, connectors and a body harness, and may include a lanyard, deceleration device, lifeline or suitable combinations. Arrest brings a person to a safe stop once having fallen. The personal fall-arrest system is effective only if all of the components work together to arrest the fall. It's also very important to make sure all of the components are compatible with each other. Components from different manufacturers, especially snaphooks and D-rings, may be incompatible.

You can view the OSHA standard to see specifically the loads all the components of the fall-arrest system must be able to withstand. In general they should be labeled to comply with ANSI Z359.1, CSA Z259 or OSHA 1926.502.

Personal fall-arrest systems must be inspected by a competent person (as defined earlier) before each use for wear damage and other deterioration; defective components must be removed from service. D-rings and snaphooks must have a minimum tensile strength of 5000 pounds (they should be stamped as such); anchorages and lifelines have the same requirement. Snaphooks should be of the locking type; nonlocking or improperly sized snaphooks can roll out of connections and release unintentionally (Figs. 7–8).


Steve Lawrence

Figs. 7–8. At left, nonlocking snaphooks not acceptable to OSHA. Right, acceptable snaphooks, which must also be compatible with equipment they are attached to. OSHA considers a hook compatible when the diameter of the D-ring it's attached to is greater than the longest inside length of the snaphook.

Lanyards connect the belt or harness to the final tie-off point, sometimes in combination with lifelines. When used to restrain a worker in a work positioning system, the lanyard should be kept as short as possible and limit a fall to 2 ft. or less. A double-leg lanyard allows one to move horizontally and change one attachment while remaining attached at the other. When used as fall protection (as distinct from fall restraint), the lanyard must have a shock-absorbing feature built in. Restraint prevents a fall from taking place by restricting the area that a person is free to roam.

Horizontal or vertical lifelines add versatility to the system and, when used in combination with rope grabs, allow the worker to move easily along the length of the line, handy for setting upper floor joists, rafters or purlins. Lifelines and anchorages must be designed and installed under the supervision of a qualified person (as defined earlier) and should be capable of supporting at least twice the weight expected to be imposed upon them (Figs. 9–10).

Note that the use of a body belt for fall arrest is prohibited; the use of a body belt for restraint in a work-positioning system is acceptable.

Guardrail systems are vertical barriers on scaffolding and decks consisting of toprails, midrails, and intermediate vertical members (Fig. 5).

Toprails and midrails of guardrail systems can be wood (2x4s) or wire rope (at least ¼-in. nominal dia. to prevent cuts and lacerations). Upper surface of toprails must be 42 in. plus or minus 3 in. above the walking level. When midrails are used, they must be installed at a height midway between the top of the guardrail system and the walking level. Posts must be no farther apart than 8 ft. Diagonal bracing on scaffolding can meet the guardrail requirements if their crossing point occurs at the required height.

The guardrail system must be capable of withstanding a force of at least 200 lbs. along the top edge and 150 lbs. on other structural members. Materials should be surfaced to protect workers from punctures or lacerations and to prevent clothing from snagging (no nail heads or tips sticking out).

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Figs. 9–10. At left, Grillon, a temporary horizontal lifeline and work-positioning device by Petzl that allows rope through inone direction but jams the other way. Right, double lanyards allow one to stay secured to lifeline while changing position and securing a new connection the other side of an obstacle. Note that fall-arrest lanyard (on framer's back) must be shock-absorbing type and secured to dorsalring on harness.

When guardrail systems are used at hoisting or access areas, a chain, gate or removable guardrail section must be placed across the access opening between guardrail sections when hoisting operations are not taking place.

At holes, ramps or walkways, guardrail systems must be set up on all unprotected sides or edges. When holes are used for the passage of materials, the hole must not have more than two sides with removable guardrail sections. When the hole is not in use, it must be covered or provided with guardrails along all unprotected sides or edges. Make sure subcontractors working on site with you understand these rules and follow them.

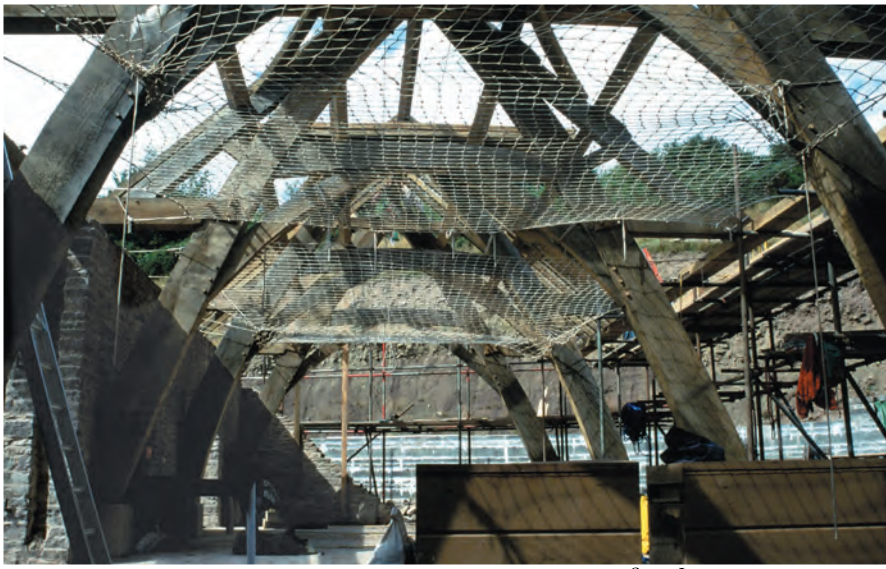
Safety-net systems consist of mesh nets, panels and connecting components. They are typically used as protection for those who work 25 ft. or more above lower levels. We don't seem to use them much in residential construction in America, but they could be practical for restoration work or large clear-span environments such as bridges or churches (Fig. 11).

Safety nets are installed as close as practicable under walking and working surfaces, with sufficient clearance underneath to prevent contact with the surface or structure below.

Items that have fallen into safety nets (materials, scrap, equipment, people and tools) must be removed as soon as possible, especially people, who can spoil if left too long in the net.

A *fall-restraint system* consists of an anchor, connectors and a body harness or a body belt. Unlike the personal fall-arrest system (designed to stop a fall), the fall-restraint systems prevent a fall by supporting workers or keeping them from approaching a fall hazard, and are thus preferable. A fall-restraint system can utilize the front or side hooks on a harness or a body belt and doesn't require a shock-absorbing lanyard. It might be used for roof workers on a low-sloped roof, for example, with a lanyard short enough to keep them from the edge. The fall-restraint system's anchor must be able to support at least 3000 pounds and must be designed, installed, and used under the supervision of a qualified person as defined earlier. Fig. 12 shows an extensible connector.

Work-positioning systems enable the worker to work with both hands free while using fall restraint. The difference between a work-positioning system and a personal fall-arrest system is that the positioning system supports the worker on an elevated surface (like a bent) and limits a fall to 2 ft. The fall-restraint lanyard may attach to the front or side D-rings on the harness, while a backup (if feasible) fall-arrest lanyard with shock-absorbing lanyard attaches to the D-ring on the back (Fig. 10).



Steve Lawrence

Fig. 11. Safety nets provide protection through fall control when fall-arrest harnesses are impractical. They also catch tools and debris.

Will Beemer

Fig. 12. Retracting fall-restraint/arrest device. One end anchored to building, the other to worker's body harness. Cable can be played out slowly but drum locks upon sudden acceleration of cable.

Warning-line systems consist of ropes, wires or chains and supporting stanchions that form a barrier to warn those who approach an unprotected roof side or edge. The lines mark off an area where one can do work without using guardrails or safety nets. These may not be very useful during a normal timber frame raising but are practical for working on low-pitched roof decks, for example. When warning lines are used, they shall be erected not less than 6 ft. nor more than 25 ft. from the unprotected or leading edge.

A *safety-monitoring system* is a set of procedures assigned to a competent person for monitoring or warning workers who may be unaware of fall hazards. A safety-monitoring system used in conjunction with a controlled-access zone (see below) and a fall-protection plan is appropriate in situations where conventional fall protection is not feasible and all other options have been considered.

The safety monitor should be competent in the recognition of fall hazards and capable of warning workers of fall hazards and detecting unsafe work practices. The monitor should be operating on the same walking or working surfaces of the workers, able to see them and close enough to work operations to communicate orally with workers.

Safety monitors ideally should have no other duties to distract from the monitoring function, but on a small raising crew it's impractical for one person to have only that job. As an alternative, use a buddy system where properly trained workers look out for and communicate with each other. Whatever the arrangement, there should be one person who is designated as the competent person on site and the "official" safety monitor, and everyone on the crew should know who that is. We've heard anecdotally of OSHA inspectors coming on site and, first thing, asking the greenest kid on the crew: "Who's the Safety Monitor?" Make sure he or she has the right answer.

Controlled-Access Zones. A controlled-access zone (CAZ) is a work area designated and clearly marked in which certain types of work may take place without the use of conventional fall protection systems (guardrail, personal fall-arrest or safety net). CAZs are used to keep out workers other than those properly trained and authorized to enter work areas from which fall protection has been removed. All workers in a CAZ should be instructed to promptly comply with fall hazard warnings issued by safety monitors.

Controlled-access zones must be defined by a control line or by any other means that restrict access. These could consist of ropes, wires, tapes or equivalent materials, and supporting stanchions, and each must be:

Flagged or otherwise clearly marked at not more than 6-ft. intervals with high visibility material.
Rigged and supported in such a way that the lowest point (including sag) is 39 to 45 in. from the walking or working surface.
Rated with a breaking strength of at least 200 lbs.
Extended along the entire length of the raising area approximately parallel to the unprotected or leading edge.

CAZs should include the crane's lifting zones and other staging areas where there is danger from falling objects. The control lines not only prevent unauthorized persons from entering but also warn workers outside the CAZ who may back into the area inadvertently.

Equipment Inspection, Maintenance and Storage. First and foremost, when it comes to equipment inspection and maintenance—follow the manufacturer's recommendations! All fall protection equipment, including harnesses, lanyards and other connectors must be visually inspected before each use.

Periodic inspections by a competent person for wear, damage or corrosion should be a part of your safety inspection program. Defective equipment must be immediately taken out of service and tagged or marked as unusable, or destroyed. Do not return strained equipment to use unless a competent person determines that no damage was done. Best practice is to destroy equipment when it has been subjected to any significant damage or loading.

Basic care of equipment will prolong its life and contribute toward the performance of its vital safety function. Proper storage and maintenance after use are as important as pre-use inspections. Clean the equipment of dirt, corrosives or other contaminants. Storage areas should be clean, dry, and free from exposure to fumes or corrosive elements. Synthetic materials should always be kept away from strong sunlight and extreme temperatures that could degrade the materials (color fading may indicate UV exposure).

Inspect for cuts, tears, rips, snags, punctures, abrasions, mold, or stretching; alterations or additions that might effect the system's efficiency; damage caused by acids and other corrosives; distorted hooks or faulty hook springs; cracked, broken, or deformed D-rings, carabiners, grommets and snaphooks; loose, damaged or non-functioning mountings and parts; and wear or any internal deterioration in ropes, and color fading possibly indicating UV exposure.

RESCUE AND RETRIEVAL. Analyzing the hazards and understanding how to install and use height-safety systems are only parts of the plan. A worker who has suffered a fall and is suspended in his harness is hardly safe yet, and may be suffering from suspension trauma or "orthostatic intolerance," where prolonged suspension and lack of blood and oxygen flow lead to unconsciousness or even death—a true medical emergency. Rescue has to be planned, practiced and performed quickly and effectively or the victim may very well die.

Workers in fall training should be told to keep body parts moving frequently in a post-fall wait for rescue; rescuers need special training for understanding suspended-worker physiology. We recommend the following practices and considerations:

Train your designated rescuers in rescue techniques and practice rescuing suspended workers as quickly as possible.
Be aware that suspended workers are at risk of orthostatic intolerance and suspension trauma.
Learn the signs and symptoms of orthostatic intolerance, potentially life threatening. Suspended workers with head injuries or who are unconscious are particularly at risk.
Learn the factors that increase the risk of suspension trauma.
Be aware that some authorities advise against moving rescued workers to a horizontal position too quickly.
Ensure necessary equipment is readily available.
Communicate with other contractors on site.
Arrange in advance for outside services such as an ambulance and designate someone to direct it upon arrival.
Plan a route to a hospital and establish lines of communication.

As part of your official training program, workers who wear fall-arrest devices while working should be trained in how to ascertain whether their personal protective equipment is properly fitted and worn, so that it performs as intended. They should also learn how orthostatic intolerance and suspension trauma occur, the factors that increase a worker's risk, how to recognize the signs and symptoms and methods to diminish risk while suspended.

Worker Training. Each worker who may be exposed to fall hazards must be trained in how to recognize fall hazards and the procedures to follow to minimize them. The OSHA standard requires the trainers to be competent persons who can recognize the nature of fall hazards in the work area and who know proper procedures for erecting, maintaining, disassembling and inspecting fall-protection systems. They must understand the use and operation of controlled-access zones and guardrails and personal fall-arrest, safety-net, warning-line and safety-monitoring systems. They must know correct procedures for the handling and storage of equipment and materials and the erection of overhead protection, the worker's role in fall-protection plans and the OSHA Part 1926 Subpart M standards.

In other words, the trainer must be familiar with fall-protection systems and able to train employees how to recognize fall hazards and how to properly use, inspect and maintain fall-protection equipment.

Training must be provided whenever new workers are assigned to work where fall hazards exist, responsibilities change or new methods are used, there is a new fall hazard, the fall-protection program is deemed inadequate or workers have not acquired or retained adequate understanding. The standard does not specify the required length or format of the training program. Consider both classroom instruction and hands-on training in the proper use of the fall-protection equipment. Training can be done at your own shop by your own competent trainers, but can also be obtained through safety professionals and equipment suppliers. Height-safety training will become a regular feature at Guild events as our curriculum matures. To document the training, trainers must prepare a written certification that identifies the person trained and the date of the training. The employer or trainer must sign the certification record.

MONITORING. Continuously monitor the effectiveness of your fall-protection program to ensure that the required procedures are being followed at the jobsite.

Build a culture of site safety by having workers actively promote the proper use of fall-protection equipment. Encourage worker involvement and support of the program, and provide positive feedback to workers who use fall protection properly. It's especially important for your older, more experienced workers to set a good example.

Display posters and distribute information sheets to workers to reinforce the importance of fall protection. Conduct safety meetings with workers about fall protection, respond positively and in a timely manner to suggestions for improving the program or equipment and establish a safety committee to actively monitor the program.

It can be helpful to collect and distribute success stories about injuries prevented by the use of fall protection. Finally, recognize all involved!

To monitor the program, conduct periodic inspections to ensure that workers are properly using fall protection. If they are not doing so, take immediate corrective action including the use of disciplinary action. Conduct a formal audit of the entire fall-protection program at least annually; document and communicate the results of the audit to everyone; compare the results with previous audits.

Conduct periodic inspections of equipment storage areas. Require workers to notify their supervisor if they have any problems with the use or maintenance of their equipment or if they are involved in any fall incident; promptly and thoroughly investigate and document. Hold managers and supervisors accountable for their crew.

Residential construction, timber framing and STD 3.1. Residential construction fall-protection requirements mirror those for the general construction industry. However, OSHA Instruction STD 3.1, "Interim Fall Protection Compliance Guidelines for Residential Construction," issued December 8, 1995, identifies certain tasks that may be performed without the use of conventional fall protection provided the employer follows all guidelines in Appendix E of Subpart M. It relieves the residential home-builder from the obligation to show "infeasibility or greater hazard" when electing to use alternative fall-protection plans in lieu of conventional fall protection and, while a fall-protection plan is required, it does not have to be written as specified in 1926.502(k). These exemptions may be helpful to timber framers involved in light-framing a deck or an addition, for example.

However, in a ruling issued December 8, 2003, OSHA determined that timber framing does not qualify as a "traditional wooden residential construction" method (light-framing), and thus STD 3.1 does not apply.[1] Subpart M of OSHA 1926 thus allows a residential timber framing company to use alternative fall-protection methods if it can demonstrate the infeasibility of conventional fall protection, but the alternative procedures must be in a written and site-specific plan that complies with the criteria in 1926.502(k). This fall-protection plan should be part of the project Method Statement and available on site. To see sample fall-protection plans, go to tfguild.org/members/reports.html or Appendix E of OSHA 1926 Subpart M on OSHA's Website.

To meet OSHA requirements outlined in 1926.502(k),an alternative plan for any timber framing site should:

Be prepared by a qualified person.

Be specifically developed for the site where the work will be performed.

Be kept up to date with any changes.

Document the reasons why the use of conventional fall-protection systems (guardrail systems, personal fall-arrest systems or safety-net systems) are infeasible or why their use would create a greater hazard.

Include a written description of other measures to be taken to reduce or eliminate the fall hazard.

Include a statement that provides the name or other method of identification (such as color-coded hard-hats) for each worker designated to work in controlled-access zones.

Describe the safety-monitoring system.

Follow the guidelines mentioned throughout this article and, for 90 percent of your timber framing work, it will not be onerous. For example, you could mark the site drawings with red pen showing the controlled-access zones as part of the pre work briefing, show appropriate anchors for any horizontal lines (because they carry the largest loads) and identify any bracing that needs to be in place before the system is used. Date and initial the drawing and note in the job foreman's field journal who was there for the briefing and points discussed, such as who is in charge, whom you can ask for help or advice and who can authorize alternative solutions and changes to this plan. In general:

Don't forget to check your fall-pro gear every day before use.

Use the buddy system: check your partner's rig every time it goes on.

Use appropriate anchors.

Keep anchor points high and use double lanyards.

. . . and get to work. That's going to be enough in most instances because it achieves the minimum objectives of the OSHA standards and, more important, it respects OSHA's intentions in writing them. Most companies will benefit from putting together a simple health and safety (H&S) plan with a one-page policy statement at the beginning (a sort of executive summary). It only has to be written once, reviewed once a year, and it will tackle most of the other items that OSHA wants to see in a more generic way. That's not a big investment for any business. Add a copy to the site drawing and field notes and, hey-presto, you're fully compliant for most of your work.

[1]Osha.gov/pls/oshaweb/owadisp.show_document?p_table=INTERPRETATIONS&p_id=24680.

Big jobs are different. One only has to cruise a selection of our members' Websites to see that there are some pretty big jobs out there, and public and commercial work require a more formal approach. The same is true of Guild events; that's why we've got a bunch of large, cumbersome documents on record. For those jobs, it's wise to build an amount for health and safety planning right into the fee. Nobody is going to complain when they see that as a line item on the quote: complaining about health and safety is like picking on gay whales in British Columbia—it's just not done.

—Gordon Macdonald and Will Beemer

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Glossary

Anchorage. A secure point of attachment for lifelines, lanyards or deceleration devices.

Body belt. A strap with means both for securing it about the waist and for attaching it to a lanyard, lifeline, or deceleration device.

Body harness. Straps that may be secured about the person in a manner that distributes the fall-arrest forces over at least the thighs, pelvis, waist, chest and shoulders with a means for attaching the harness to other components of a personal fall-arrest system.

Competent person. A person capable of identifying existing and predictable hazards in the surrounding working conditions which are hazardous to employees, and who has authorization to take prompt corrective measures to eliminate them.

Connector. A device used to couple (connect) together parts of a personal fall-arrest system or work-positioning system. It may be an independent component of the system, such as a carabiner, or it may be an integral component of part of the system, such as a buckle or D-ring sewn into a body belt or body harness, or a snaphook spliced or sewn to a lanyard or self-retracting lanyard.

Controlled-access zone (CAZ). A work area designated and clearly marked in which certain types of work may take place without the use of conventional fall-protection systems—guardrail, personal arrest or safety net—to protect the employees working in the zone. Access to the CAZ must also be controlled.

Deceleration device. Any mechanism such as rope, grab, rip-stitch lanyard, specially-woven lanyard, tearing or deforming lanyards, automatic self-retracting lifelines or lanyards, that serves to dissipate a substantial amount of energy during a fall arrest, or otherwise limits the energy imposed on a worker during fall arrest.

Deceleration distance. The additional vertical distance a falling person travels, excluding lifeline elongation and free-fall distance, before stopping, from the point at which a deceleration device begins to operate.

Equivalent. Alternative designs, materials or methods to protect against a hazard which the employer can demonstrate will provide an equal or greater degree of safety for employees than the methods, materials or designs specified in the OSHA standard.

Free fall. The act of falling before the personal fall-arrest system begins to apply force to arrest the fall.

Free-fall distance. The vertical displacement between onset of the fall and just before the fall-arrest system begins to apply force to arrest the fall. This distance excludes deceleration distance and lifeline or lanyard elongation, but includes any deceleration device slide distance or self-retracting line extension before they operate to arrest a fall.

Guardrail system. A barrier erected to prevent workers from falling to lower levels.

Hole. A void or gap 2 in. (5.1cm) or more in its least dimension in a floor, roof or other walking or working surface.

Infeasible. Impossible to perform the construction work using a conventional fall-protection system (i.e., guardrail system, safety-net system or personal fall-arrest system) or technologically impossible to use any one of these systems to provide fall protection.

Lanyard. A flexible line of rope, wire rope or strap that generally has a connector at each end for connecting the body belt or body harness to a deceleration device, lifeline or anchorage.

Leading edge. The edge of a floor, roof, or formwork for a floor or other walking or working surface (such as the deck) that changes location as additional floor, roof, decking or formwork sections are placed, formed or constructed. A leading edge is considered to be an "unprotected side and edge" during periods when it is not actively and continuously under construction.

Lifeline. A component consisting of a flexible line for connection to an anchorage at one end to hang vertically (vertical lifeline), or for connection to anchorages at both ends to stretch horizontally (horizontal lifeline), and that serves as a means for connecting other components of a personal fall-arrest system to the anchorage.

Lower levels. Those areas or surfaces to which an employee can fall. Such areas or surfaces include but are not limited to ground levels, floors, platforms, ramps, runways, excavations, pits, tanks, material, water, equipment, structures or portions thereof.

Opening. A gap or void 30 in. (76cm) or more high and 18 in. (46cm) or more wide in a wall or partition through which workers can fall to a lower level.

Personal fall-arrest system. A system including but not limited to an anchorage, connectors and a body belt or body harness used to arrest a worker in a fall from a working level. As of January 1, 1998, the use of a body belt for fall arrest is prohibited.

Positioning-device system. A body belt or body harness system rigged to allow a worker to be supported on an elevated vertical surface, such as a wall, and work with both hands free while leaning backward.

Qualified person. A person with a recognized degree, professional certificate or extensive knowledge and experience in the subject field who is capable of design, analysis, evaluation and specification in the subject work, project or product.

Rope grab. A deceleration device that travels on a lifeline and automatically engages the lifeline by friction and locks to arrest a fall.

Safety monitoring system. A safety system in which a competent person is responsible for recognizing and warning workers of fall hazards.

Self-retracting lifeline or lanyard. A deceleration device containing a drum-wound line that can be slowly extracted from, or retracted onto, the drum under minimal tension during normal worker movement and that, after onset of a fall, automatically locks the drum and arrests the fall.

Snaphook. A connector consisting of a hook-shaped member with a normally closed keeper, or similar arrangement, that may be opened to permit the hook to receive an object and when released automatically closes to retain the object. As of January 1, 1998, the use of a non-locking snaphook as part of personal fall-arrest systems and work-positioning systems is prohibited.

Tie-off. The act of a worker, wearing personal fall-protection equipment, connecting directly or indirectly to an anchorage, or the condition of a worker being connected to an anchorage.

Toeboard. A low protective barrier that prevents material and equipment from falling to lower levels and that protects personnel from falling.

Unprotected sides and edges. Any side or edge (except at entrances to points of access) of a walking or working surface (e.g., floor, roof, ramp or runway) where there is no wall or guardrail system at least 39 in. (1m) high.

Walking or working surface. Any surface, horizontal or vertical, on which a worker walks or works, including but not limited to floors, roofs, ramps, bridges, runways, formwork and concrete reinforcing steel. This definition does not include ladders, vehicles or trailers on which workers must be located to perform their work duties.

Warning-line system. A barrier erected on a roof to warn employees that they are approaching an unprotected roof side or edge, and which designates an area in which roofing work may take place without the use of guardrails, body belts, or safety nets to protect workers in the area.

Work area. That portion of a walking or working surface where job duties are performed.

Fratticci: Cabins of Italy's Medieval Ciociaria

All photos Thomas Allocca

The Comino valley, between Cassino and Sora in the province of Frosinone, where the author found a derelict *fratticco*.

RURAL architecture gives structure to territory. With its capacity to stimulate communication routes between urban centers and the emerging extramural architecture of castles and monasteries, rural architecture was the walled city's structural and linking element with the rest of the world, the inside with the outside, concentrated and vertical architecture with dilated and horizontal architecture, the delimited city with the unlimited one, townspeople with country peasants, nobles with serfs, those who prided themselves on being idle and white and those who instead were ashamed of being browned by the sun and always tired.

In Ciociaria, central Italy, the historical area of the Lazio region extending today for about 3500 sq. km and corresponding roughly to the province of Frosinone, this function of rural architecture was performed by *fratticci*, the most widely diffused medieval rural habitation.

Every single element of a building, and by extension every building of the city, determines the materials of its forms and dimensions not by chance or by simple availability, but over a long period of experimentation to establish the relations among need, availability and performance, including the necessity to preserve acquired experience by means of shapes and dimensions easy to reproduce and codify. It is the instinct of survival applied to architecture, to building techniques and sciences. The emblematic historical period of rural architecture is the age of Charlemagne, followed by the emergence of towns, because in this period we conquer nature once again: after the abandonment of the countryside with the fall of the Roman Empire and the barbarian invasions, the landscape changes again from wilderness to agricultural woodlands.

The medieval countryman wakes up at sunrise and returns home at sunset. He has only enough time to bolt down his dinner and go to bed, because even candles are a luxury. No winter sunrise is too cold not to get up, the land and the animals don't produce by themselves and the owner requires quality and quantity. No day is ever long enough to finish early because, if there is free time, it must be spent helping the owner in his house with maintenance, in repairing livestock pens and boundary fences, transporting cattle and foodstuffs, or in extra cleaning and procuring special foods if the owner plans to receive a special guest. As for the woman, who has stayed at home to patch the roof, tend the fire and keep a tranquil house, her work is no less hard, since she must also take care of the husband without whom, since she is neither nun nor prostitute, she would be unable to survive. Hence the recommendation to medieval women destined to be wives that "three are the things that keep a man away from his home: a roof that leaks, a fireplace that smokes, and a wife who grumbles" (Power, Chap. IV).

The life of the medieval countryman is extremely busy and tiring. There is neither time nor strength to dedicate to home and other annexed rural buildings, which perform first of all the function of shelter, with minimum waste of resource both in construction and in maintenance. The rural architecture that takes any notice of the aesthetic is only the master's architecture, the architecture of the one who manages the land but doesn't plow, doesn't pasture the cattle, doesn't sweat, and who has time and resources enough to afford the luxury of stone houses.

The *fratticci* of Ciociaria were the houses of the countrymen who were not owners, who were lowest in the hierarchy of the countryside and at the same time "most of the medieval people on whose humble hard work the world's prosperity depended, the hidden foundations of the building of medieval civilization" (Power, Chap. I). *Fratticci* are made of timber and straw, mud and leaves, but by considered criteria of shelter and heat. In the timbers of these cabins more than in the stones of castle towers and cathedrals we can recognize one of the most representative archetypes of medieval Italy, a rural world where a substantial difference in typology and indoor comfort didn't exist between the residential hut next to the landowner and the seasonal cabin next to the fields where the countryman slept together with cattle, timber, tools, foodstuffs—all "objects" belonging to the owner.

In medieval times, the landowner considered that "the land had to be exploited as much as possible together with men, ploughs and animals" (Orlando, 121). The miserable conditions of peasant houses in Ciociaria were not only central Italy's worst in medieval times but persisted up until the beginning of the 20th century—"wretched countrymen of Ciociaria, the only ones resigned to living in the terrible marshy conditions" (Orlando, 127). The countrymen were resigned not out of cowardice but from humility and a strong maternal sense. It is widely known that the greatest sons of not only Imperial Rome but also that city's recent history

Remains of the cabin near an abandoned rural stone house built around the beginning of the 19th century. Typical *fratticco* post joint clasps plate in natural crook. Lapped rafter peak clasps ridge.

thrived on milk from the generous breasts of the wet-nurses of Ciociaria, who were sought by city families until a few decades ago.

Still, in the '20s through the '40s of the last century, the typical rural architecture in Ciociaria was

> a cabin of boughs and dung, with thatched rye roof, only one room comprising the kitchen, dining-room, bed and stable; the animals helped to heat the room and they were directly controlled within sight to avoid accidents and theft . . . . Drinking water came from small local springs, but in summer they went to the rivers . . . . Natural bodily functions were done in the fields and they wiped with grass (the most demanding ones looked for wild mint); in wintertime they had to squat in the stable and to be content with straw . . . . For a bath in summer they went to the river and in winter they washed little more then their faces. . . . For clothes they wore fustian . . . shoes were unknown; everyone wore *ciocie* that didn't protect from water but were suitable for walking in mud. . . . The bed was of straw and corn husks on a timber frame with planks all covered with sheets of *mistich* (hempen cloth). . . . In the town the situation was different, it was inhabited by the rich, the landowners whose only task was to check the harvest produced by the sharecropper . . . the others were the artists, the craftsmen, the blacksmiths, the carpenters, the masons. . . . In the city the houses were built much more solidly, of stone masonry, and the streets were paved. . . . The relationship between the two populations was extremely strained, abuse of countrymen was considered normal behavior and the most offensive and humiliating insult was the word *cafone* [boor]. (Mancini, 776–78)

Over 60 percent of this architecture was destroyed during the world wars and the remaining 40 percent was destroyed by the criminally insane rebuilding process that enriched the owners of cement factories, first under the fascists, then by the modernist movement, and in the end by the industrialization of the province of Frosinone. Without wars and speculation these dwellings would not be a fragile memory but an objective reality. Instead, what remains of them is only some archetypical elements among abandoned rural ruins not yet razed and in a few readapted cabins. During the Second World War, both the air bombardments and land raids represented for all of Ciociaria a frightening destructive avalanche that covered all the countryside with deep chasms, ruins, abandoned trucks and tanks, ammunition depots, camps. Not one span of land was left free from disaster. All the crops were crushed, carelessly, indifferently; everything was destroyed, forced to wait, left behind from the need to smoke out the enemy and to gain position, to conquer the territory.

And when the war ended and the time to rebuild came, the typical rural house was lost forever. The few that remained, having survived the human stupidity of the war, did not survive people's desire to forget that painful past and detach themselves from it. The boom of the 1960s contributed to the definitive abandonment of the *fratticci* and the earlier way of life with its miserable housing conditions. The new rural houses, while still poor in comparison to those in the city, were not built of straw, wood and stone but rather of hollow clay bricks, steel and concrete blocks. Where stone and wood survived as building materials, they were used for aesthetic rather than structural value.

In the old constructions, the first criterion of choice was the material; the second was the supporting framework and the shape of the roof; the third was insulation from the cold; the fourth was insulation from humidity. Since the land was near rivers and woods, the most available materials were reeds, pebbles, straw, earth and water, and of these materials *fratticci* were made. Regarding the main frame and the shape of the roof, the cabin on poles with a roof of one or two strongly sloping pitches was certainly the easiest type to build and the solution most practiced over time for protection against wind and rain. As for the walls, once again considering the available resources, the wisest solution was the wattling technique resembling rush matting.

Small modern barn nearby replaces wood posts with concrete block posts but retains *fratticco* rush infill. Plaster omitted in favor of ventilation for hay inside.

Finally, the weight-bearing poles kept the main frame from contact with the ground, nor did the walls touch the earth. Under the first floor made of timber and straw, pebbles and rushes were placed at least 10cm thick to guarantee dry soil and thus more warm and dry air. If not actually raised above the ground, the first floor was made by setting timber planks directly on a great layer of branches and pebbles (not shallower than 20-30cm), but this solution was less efficient.

The main frame of the *fratticco* was therefore made with poles without foundations, a simple but essential type, among the most ancient that primitives experimented with before building with stone and clay brick. Vertical poles in the corners, and in intermediate positions called *passoni* (Bertagnin, 223), were made of oak or chestnut, or both, depending on the nearest available wood, which might be reused material from older demolished or abandoned cabins.

If usually an open one-room solution developed on a single level above the ground, more complex *fratticci* weren't unusual in the larger properties where the master needed larger countrymen's families. In these cases the *fratticco* consisted of two or three rooms separated by wattled walls, dividing animals from humans. The roof frame was light if made of rush and straw or willow, oak or chestnut branches, heavier if also covered with a layer of stone tiles to secure the light materials from the wind.

The woven walls were plastered both outside and inside using mud or a mixture of clay and straw, or, getting a mixture directly from nature, cow dung. The straw in the clay or dung was to stiffen the covering, just as modern architecture uses fibers in plaster. The straw was arranged in the mud, both in threads to link the mud during the application and chopped up for better consistency of the mixture during drying. The use of dung was however preferred because it was both a readymade mixture and more efficient in protecting frames from insects and timber parasites. *Smerdata* ("made of dung") indicates the wall technique as well as the whole cabin.

Every historical event is unique, unrepeatable. Nothing stays the same, but it's necessary to preserve our experiences so as not to have to start from zero at each new beginning. If absolute preservation is impossible, not to say unwise, any architectural work of restoration or new construction should not be an element of discontinuity between past and present but rather their link, a guarantee of dialogue between the former and the latter, between the generator and the generated. Even if it takes place in a different language, the dialogue should be not interrupted but continued. If memory can still protect the archetypes, even a total material destruction may no longer be an act of violation. Just as the most careful conservation, if it does not protect present-day needs, certainly becomes an act of violence or in any case an architecture of nonsense.

In a few decades, probably no material remains of the *fratticci* of Ciociaria will survive; but as long as their memory is kept alive through the analysis of archetypes, the experience will be preserved and invested, an experience of reconstructing people of whom we have no official historical memory but whose existence has been essential for every one of us, and whose architecture was fundamental for the evolution of the techniques and the typology that we now use to bring the countryside to new life after thousands of years, from generation to generation. —Thomas Allocca

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TTRAG Proceedings 2008

Ken Rower

Slaking lime at TTRAG '08, heat of reaction dramatically vaporizing excess water. Left to right: Michael Burrey, Penelope Austin, Sean Mears.

TTRAG, the Guild's Traditional Timber Frame Advisory Group, revisited Shepherdstown, West Virginia, to hold its 17th annual symposium at the National Conservation Training Center, a pleasing campus of large traditionally proportioned buildings on the south bank of the Potomac River maintained mostly for use of the US Fish and Wildlife Service. A daylong barn tour led by local hero Doug Reed preceded two days of presentations March 15 and 16 for the nearly 170 framers and scholars—plus a crew of lime masons. Presenting in addition to those whose proceedings appear here were Doug Reed (perils of dating old structures), John Allen (architectural history of Jefferson County), Chris Robinson and Moss Rudley (masonry foundations), Brian Phoebus (insuring historic buildings), Dean Fitzgerald (methods of lifting old buildings), Keven Walker (restoration at Antietam Battlefield), Brian Cox (wood preservatives) and Arron Sturgis (craftsman-owner relations). A full list of presenters and their affiliations appears on page 22.

Building with Lime

Brian Pfeiffer

LIME and all the things made from it—plaster, mortar and lime washes—have a long and compatible history with timber construction. Since prehistory humans have possessed an empirical understanding of the uses of lime and passed that understanding through apprenticeship from generation to generation, until the recent past. English and European immigrants brought this building tradition to the United States and it can be seen up and down the East Coast where different geological conditions and cultural backgrounds led to the development of local traditions. In New England where calcareous stones are scarce, settlers depended upon burning seashells from the giant middens left from Native American settlements. Eventually, sources of limestone were found, but preindustrial building traditions in New England continued to make economical use of lime, drawing upon equally ancient building practice by using clay as mortar in places that were protected from weather. In the Mid-Atlantic where limestone is plentiful and settlers came from Central and Northern Europe as well as the British Isles, masonry construction was widespread. In the coastal South, where contact with Spain and Africa brought different influences and large middens of oyster shells existed, tabby construction became a popular local variant in the use of lime.

In all of these traditions, lime mortar provided a bedding material that was softer than surrounding brick or stone, and it served as a sacrificial material during thermal expansion and contraction. In addition, it tended to be more vapor permeable than surrounding masonry units, allowing vapor from the wall to evaporate out, depositing any soluble salts in the mortar where their damaging effects could be limited to a material more easily renewed than surrounding bricks and stone. In addition, a high proportion of preindustrial masonry buildings were coated with lime wash or oil paint to protect their soft-fired bricks from harsh weather. And, a significant number of masonry and even wooden buildings were covered with lime plaster—essentially mortar applied to lath or directly to a masonry surface to shelter them from the effects of weather. Making a virtue of necessity, builders of the past often decorated these exterior plasters with scored lines to resemble masonry.

Since the end of the 19th century, the majority of these original finishes have been lost to neglect and the quest for maintenance-free exterior materials, or to restorers who saw the underlying brick and stonework as picturesque and failed to consider the function as well as the antiquity of the coatings. Major public buildings such as Boston's Old State House (1712) and Faneuil Hall (1742, 1806) were actively stripped of coatings that had been in place since at least the late 18th and early 19th centuries. These materials were used for the full range of buildings—high-style to vernacular — during the preindustrial era, but they are more easily documented in high-style buildings because of surviving construction and maintenance accounts. The effects of modern repair materials become more apparent over time and in many cases have hastened decay by interfering with the movement of vapor and the introduction of excessive stiffness to structures otherwise relatively soft.

In the UK and Europe, lime has undergone a revival over the past 20 years, not just for the repair of historic buildings but also for new construction as a potentially "greener" material than modern cements, which require higher energy inputs to produce, do not reabsorb carbon dioxide and do not decay into beneficial materials. As the evidence accumulates, it pushes steadily in the direction of resuscitating our use of this traditional material for the full spectrum of building types that survive from our preindustrial past.

LIME is calcium carbonate ($CaCO_3$), the material of limestone, marble, chalk, a variety of seashells and even eggshells. One of the most widely occurring substances on the planet, it has been used by nearly all cultures since prehistory as a basic building material because of the relative ease with which it can be configured as mortars, plasters and coatings.

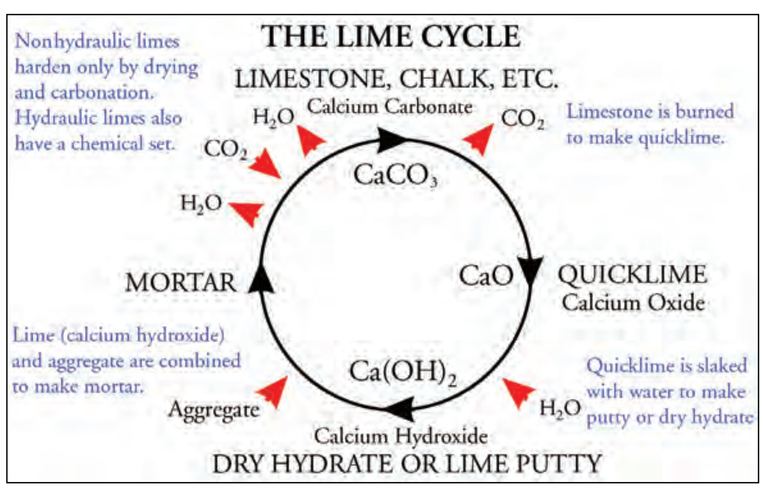
The Lime Cycle consists of calcining (burning) chunks of limestone, marble, shells or other calcareous materials to a temperature at which the carbon dioxide (CO_2) is driven off and only calcium oxide (CaO), known as quicklime, remains. By general practice, calcium carbonate must be heated until it has reached and sustained a temperature of 900°C for between two and three hours. Historically, this heat was achieved by stacking lime-rock, shells or other calcareous materials in a kiln and firing it with wood for three or more days (see Michael Wingate, *Small-Scale Lime Burning: A Practical Introduction*).

Although quicklime continues to retain the shape of the stone from which it was burned and looks harmless, it is a volatile and caustic substance that must be handled with care. To convert quicklime into putty from which mortar, plaster and coatings can be made, it must first be slaked with water. This process produces a violent reaction during which heat is released and the calcium oxide (CO) combines with water (H_2O) to yield calcium hydroxide $Ca(OH)_2$ or lime putty. After the slaking is complete, the putty is customarily allowed to mature for a period of at least three to four weeks to allow all particles of the quicklime to be converted to calcium hydroxide; the putty is then mixed with aggregate (usually sand) to increase its bulk and fiber (usually animal hair) to reduce shrinkage and cracking. Mixed in this way and known as "coarse stuff," lime is then ready to be applied as mortar, plaster or exterior render. (For further technical information, go to scotlime.org.)

Brian Pfeiffer

Above, broken oyster shells for burning. At top, first firing of wood-fired limekiln built by Michael Burrey in Plymouth, Massachusetts.

The final step in the process occurs after the coarse stuff has been set in its desired position. Thereafter, it must be kept damp for a period of 10–28 days so the process of carbonation can be well established. During this time, lime takes carbon dioxide (CO_2) from the air, releases water (H_2O) and returns to its original state as calcium carbonate ($CaCO_3$), but with an important exception—it has now been reconfigured into an architectural form that serves human purposes.



Scottish Lime Centre

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Mid-Maryland Barns

Lisa Mroszczyk

Lisa Mroszczyk

Meyerhoffer Barn, Frederick County, Maryland, ca. 1845, a brick barn with open wooden forebay.

IN Frederick, Washington and Carroll counties in mid-Maryland, where ground barns and dairy barns are also common, the bank barn has the greatest number of examples, characterized by having one foundation wall cut into the slope or bank of the earth, providing protection from the weather and access to two levels from grade. The overhanging forebay most often faces south or southeast, providing the greatest protection from harsh northern weather and the most benefit from southern warmth. The upper level of the bank barn provided a space for threshing, the process of breaking the seeds from the husks, and storing grain. The lower level of the bank barn was used for sheltering and feeding livestock.

For the approximately 350 barns seen in the field or reviewed by documentation, about 60 percent were framed of heavy timber with mortise and tenon joints, most often variants of purlin post and queenpost systems, and their foundations were constructed of rubble or fieldstone, with only a few exceptions in brick. Approximately 25 percent of the barns used stone in exterior walls either exclusively (not including the forebay wall, always of timber) or in combination with timber framing in the gable sections. Only about 11 percent had exterior walls of brick or brick in combination with timber framing. The fewest, approximately 2 percent, were of log construction. (This is not necessarily an indication of the number of log barns that once stood.)

Within this type were several subtypes according to combinations of symmetrical and asymmetrical gables and whether the forebay is closed or open. Bank barns with asymmetrical gables have forebays that are not constructed within the main framing structure of the barn, resulting in an extended roof plane on the forebay side. The roofs of these barns have steeper slopes than barns with symmetrical gables and the forebay wall is generally much shorter. Such barns are likely to be earlier than those with symmetrical gables. Closed forebay barns are those where one or both gable end foundation walls extend to the edge of the forebay, supporting it and providing more protection for the area immediately outside the entrance to the barn on the lower level.

Log barns were some of the earliest. Stone barns with asymmetrical gables tended to be constructed in the period from the last quarter of the 18th century until about 1840. Brick barns with asymmetrical gables were generally constructed during the period between 1810 and 1860. All heavy timber construction of this type was mainly built in the period from 1840 to 1900 with exceptions such as the Newcomer Barn at Antietam National Battlefield built as early as 1790.

Few symmetrical gabled stone barns, common in the first quarter of the 19th century, survive. Brick barns of this subtype were constructed from as early as 1800 to as late as 1860. Timber barns with closed forebays were largely constructed in the second half of the 19th century but can be seen as early as 1810 and as late as 1910. All-timber barns with symmetrical gable ends and fully cantilevered forebays were also generally constructed in the second half of the 19th century, with examples as early as 1810 and as late as 1930.

The agricultural productivity of the region is reflected in the number of farms established and the barns built to facilitate production. Barns that have for centuries dotted the mid-Maryland landscape are disappearing due to long-term neglect or by the encroachment of large-scale commercial and residential developments. If these developments do not lead to the barns being destroyed, the new subdivisions disrupt the relationship of the barn to the land. The formal development of farms into subdivisions began in the 1950s and continues today and will continue tomorrow unless their preservation becomes a priority.

Historic American Buildings Survey

Mark Schara, AIA

THE Historic American Buildings Survey was founded in 1933 as a New Deal program to employ out-of-work architects during the Depression. Building on earlier efforts, the idea for HABS was suggested by a young National Park Service architect, Charles E. Peterson, then working at the Yorktown National Battlefield in Virginia, who was concerned about the ongoing loss of historic buildings and structures across the country. Within two months of

Joseph Poffenberger Farm barn, HABS-MD-966-A, view from the southwest, Photograph by Thomas T. Waterman, 1940. At right, HABS-MD-966-A, interior view, photograph by James W. Rosenthal, 2005. The Poffenberger barn is now part of Antietam National Battlefield in Maryland.

Peterson's memo proposing the program, teams of architects were established across the United States, tasked with producing documentation of important historic and threatened buildings, consisting of detailed architectural measured drawings, large-format photographs and written historical reports. In 1934 a tripartite agreement was signed between the National Park Service, the American Institute of Architects and the Library of Congress, with the National Park Service agreeing to operate the program, the American Institute of Architects agreeing to provide professional oversight and the Library of Congress agreeing to house the collection and provide archival standards for the documentation. The agreement continues to guide the HABS program today.

Made part of a group of programs called the Works Progress Administration, HABS continued in operation throughout the 1930s. After dormancy during World War II, the program was revitalized during the 1950s, when HABS transitioned to primarily employing student documentation teams during the summer months. The scope of documentation was expanded with the establishment of two sister programs, the Historic American Engineering Record in 1969 and the Historic American Landscapes Survey in 2000. Today celebrating its 75th anniversary, HABS is notable as the oldest federal government historic preservation program, and as the only WPA program still active. The HABS/HAER/HALS collection at the Library of Congress, the world's largest architectural archive, records more than 38,000 sites across the United States and includes more than 61,000 sheets of measured drawings and more than 250,000 photographs.

The majority of the work undertaken by HABS remains integral to the National Park Service, an important example of which has been the ongoing partnership between HABS and Antietam National Battlefield in Maryland, site of one of the nation's most significant Civil War battles. HABS first visited Antietam in 1940, when Thomas T. Waterman photographed a number of buildings at several of the farmsteads associated with the battle. Among these was the barn at the Joseph Poffenberger Farm, which had served as a field hospital for wounded Union troops. The Poffenberger barn (built ca. 1820) is a classic example of a Pennsylvania bank barn of the "standard" type, with cantilevered forebay. In 1989, a much more extensive photographic survey of properties on and associated with the battlefield was undertaken by HABS, during which the Poffenberger barn was photographed a second time.

In 2000 the Poffenberger property was acquired by the National Park Service and incorporated into the National Battlefield. In 2005 HABS began a multiyear project to document several of the recently acquired farms and their associated historic buildings at Antietam, as a basis for their preservation and restoration. At the Poffenberger Farm, a site plan was surveyed, and each of the six antebellum buildings was recorded with a complete set of HABS photographs and drawings. Fifteen large-format (5x7 negative), perspective-corrected, black-and-white photographs were taken of the Poffenberger Barn (making it one of the very few structures in the HABS Collection to have been photographed on three separate occasions). Ten exterior views included perspective corner views, to capture the building's massing, and straight-on elevation views, which were also used (as scanned images) to capture details of the stonework and irregularities in the siding for the drawings. Five interior views were taken to give a sense of the interior spaces, as well as to show the timber framing. The barn was also documented with eight sheets of measured drawings. Extensive onsite measurements were taken, primarily by hand, and recorded onto pencil-sketched filed notes on graph paper. Final drawings were executed using CAD in the HABS Washington office. The set of drawings includes a plan at each of the two levels, four elevations, and two sections. Because of the significance of the building's heavy timber frame, Gregoire Holeyman's axonometric drawing of the frame with typical members labeled was also included in the set.

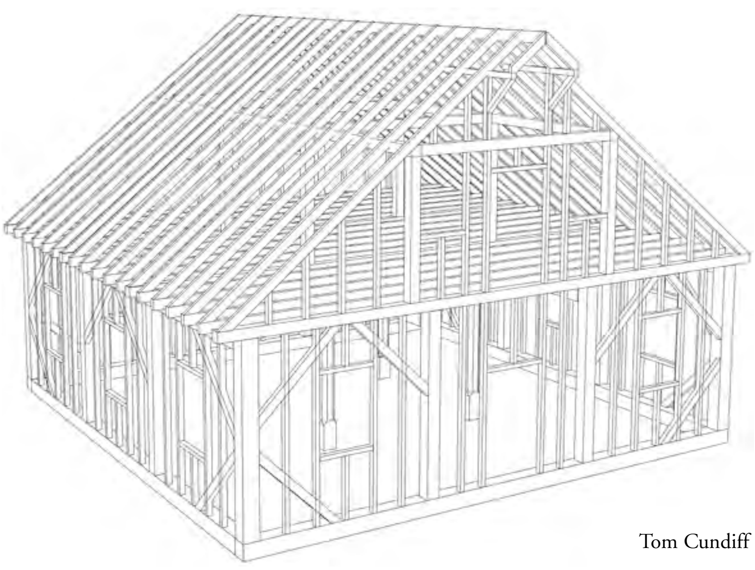
CAD for Documentation

Tom Cundiff

PRELIMINARY drawings of old timber frame structures considered for restoration or relocation, essential to planning and coordination of the project, require visiting the building, taking measurements and field notes and then converting that information to a set of drawings. One of the first things I try to determine is the original layout method (square rule, mill rule, scribed or a combination) used to construct the frame. I find often that the reference planes of old frames tend to fall on whole numbered measurements, keeping the dimensioning of the bent and wall sketches fairly simple. Field notes include the timber sizes and the amount of reduction if any at the joinery locations, as well as shoulder-to-shoulder lengths of connecting girts and typical brace-leg dimensions. A calculator such as a Construction Master with a rise-over-run function is very useful for determining the geometry of the roof framing. I also find that methodically taking digital views of of the framing is very useful and can save having to make additional trips to the site.

With field notes and photos in hand, I can begin to create the CAD drawings in VectorWorks, which I found easy to learn. I first create 2D drawings of each bent and wall section. Using the rectangle tool I click and drag the object that I want to draw. I can then modify the width and height of the rectangle using the object information window. Once I have created an object I can duplicate it as needed to draw similar elements. I can also modify the duplicate objects using the object information window. The polygon tool is used to draw nonrectangular objects such as braces or rafters. The object information window displays the rectangular dimensions of polygons, which in the case of a brace is the same as the brace leg dimensions. To make the drawing of angled objects with the polygon tool easier, I first draw a rectangle of the correct size for the material and then rotate it to the desired angle using the rotate command. I then use the polygon tool to trace the rotated rectangle to where it intersects with other objects in the drawing. The rotated rectangle can then be deleted, leaving the polygon of the correct size in place. I use the mirror tool to create the opposing brace or rafter. Once a bent or wall section has been drawn, it can be duplicated to create similar bents or wall sections and then modified to reflect the differences between the sections. Duplicate objects or whole sections can also be flipped horizontally to create the mirror image, for instance identical bents that have reference planes facing each other such as typically found on either side of a drive bay. Using these simple tools and commands I can quickly create all of the 2D cross sections of a frame. All that remains is to label and dimension the 2D drawings.

To create a 3D model of the structure I simply copy and paste the 2D sections onto their respective working planes and extrude the individual elements to the correct thickness. A working plane is a grid set up in the 3D drawing to correspond with the reference planes of the timber frame. Starting with the ground plane, the working planes are rotated and moved to the appropriate location and saved to the working plane palette. When saving working planes, I give them names that correspond to the bent or wall plane locations. When viewing working planes, remember that you are looking at the nonreference side, or from the inside. When pasting the 2D drawing to the working plane, it needs to be flipped horizontally before extruding to thickness, assuming you have drawn it viewed from reference. I group all the elements of a bent or wall section so that I can edit the group and not select the wrong object that is in another section in front of the one I am working on. Framing that does not fall directly on a working plane, such as centered braces, can be shifted after being extruded by using the move or move 3D command. Objects such as common rafters can be extruded once, where they fall on a working plane, and multiples can be created at the desired spacing using the duplicate array command. To draw complex 3D objects that can't be created by simply extruding 2D shapes, I use the 3D polygon tool, drawing each face individually and joining the faces together to form the desired 3D object. The mirror tool is also useful when creating opposite faces of symmetrical objects.



Tom Cundiff

3D model of Lyles Mill, Frontier Culture Museum, Staunton, Virginia, documented at a three-day analysis and design workshop.

Conservation and the Specialty Contractor

David C. Fischetti, P.E.

A PROPER preservation philosophy requires that repairs to timber frame structures respect the work of the original framer. Through observation, measurement, testing and analysis the structural engineer must select and design a repair appropriate to the task. It is often the structural engineer who makes the decision to repair or replace. Sometimes that decision is a response to the desires of the architect working in concert with the owner or a requirement of the contract, based on state or federal funds, or based on a particular grant, or the necessity to obtain tax credits for historic preservation. How the design is communicated to owner, architect and general contractor often determines whether a project is successful. It is important to persuade stakeholders that craftspersons with specific skills are required as well as materials that may not be readily available.

My preservation philosophy starts with structural safety and stability, with the realization that providing a structurally safe building may be independent of satisfying building code requirements. Second, repairs should be in the same fashion as the original construction as much as possible. If traditional methods will not provide adequate strength, then reinforcing may require other technologies in order to preserve the maximum amount of historic fabric. Timber structures should be rehabilitated as timber structures. Reinforcing and repairs should deal directly with the inadequacies in a way that would be easily understood by the original builder.

We have caused various owners and general contractors to engage specialty contractors and conservation professionals to accomplish tasks that are not common in today's construction market. We have recommended manufacturers of handmade brick, restoration masons, timber framers, structural movers, stone masons, specialty lumber suppliers, glued laminated timber manufacturers, foundries, preservation architects, testing laboratories, surveyors, historians, wood scientists, grant writers, marine contractors, and specialists in ground modification and the installation of pipe-pile foundations.

These days, many general contractors are uncomfortable with aspects of projects that involve jacking, shoring or underpinning. Often, the only answer is to engage a specialty contractor to undertake this work. For many projects, we have provided qualification-based specifications causing the general contractor to obtain the services of such contractors. Certainly, the standard specifications for shoring and bracing are applicable for projects involving patent scaffolding used in the typical applications. In these cases, engineers working for the scaffolding firms expect to receive from the engineer of record a tabulation of the loads to be supported by the patent scaffolding system. Engineers are uneasy when approached for a project that involves jacking as well as shoring or the use of patent scaffolding in unusual ways, such as in a condition that will require the system to be braced to resist lateral loads.

Although the engineer of record should not become responsible for means and methods at the construction site, enough information must be provided in the contract documents to describe the work in sufficient detail for it to be accomplished.

The restoration of the 1841 Market Hall in Charleston, South Carolina, required that craftsmen with timber framing skills be engaged by the general contractor. The contractor insisted that his carpenters were fully capable of executing the work described in the plans, in spite of his reluctance to submit qualifications as required by the specifications. Eventually, we prevailed. I played matchmaker between the contractor and the timber framers. Within a few days, I received a phone call from the construction superintendent. He said, more or less, "You were right! These guys are fast. Our carpenters would not have been able to do this."

David C. Fischetti

Charleston Market Hall, 1841, and detail of roof frame repairs.

There is a tendency for general contractors to think that there is nothing special or difficult about timber frame work. It is precisely what cannot be easily seen that is critical to the structural engineer. Square and tight joints with critical surfaces fully bearing are what the typical timber frame demands. Trunnels and pins must be properly installed without damage to them or the members joined. Connections that rely on multiple surfaces engaged at the same time, such as sawtooth or bolt-o'-lightning splices, require great precision. Before scribing and cutting the first joint, the proper grade of timber must be obtained and properly seasoned. Often it requires a framer's eye to determine the actual quality of the timber in spite of the specified lumber grades.

Some Mechanical Aspects of Steeple Framing

Jan Lewandoski

WOODEN church steeples are among the most ambitious and challenging projects in the history of timber framing. Tall and slender, these multistaged and highly decorated objects, along with their churches below, were frequently the most important public buildings in European and American towns. Exposed to high winds and the dynamic action of bells, and difficult to access for inspection and maintenance, it was important to make them strong and enduring within the confines of their shape and style. Framing techniques evolved from the anonymity of the vernacular craft tradition and in one case apparently from the work of the architect Christopher Wren, but all are actually of unknown origin, their prototypes perhaps hidden in some unexamined or long destroyed tower in an unexpected corner of the world.

Five mechanical systems of timber kept steeples in place in English and American framing of the 17th, 18th and 19th centuries.

Old Complex Framing. Ascending stages are stacked upon each other and attached to those immediately below by braces, joinery and tie-downs of wood, metal or both. A great number of diagonal braces and buttressing timbers concealed within the base of any stage provide triangulation and stiffness. Wren's 17th-century timber spires in London, now destroyed, apparently depended upon this system, as does Smith's Christ Church (1753) in Philadelphia. Framers and engineers by the later 18th century saw some of the framing members in these steeples as unnecessary or redundant.

Deep Telescoping. Characteristic of a great many New England steeples, the framing of one stage of a steeple stands deep within one or more previous stages, tenoned into sleepers that merely lodge there. In effect a vertical cantilever is created with half or less of any stage exposed to the wind and the remainder concealed, perhaps heavily braced within itself, inside lower stages. There is usually no weakening joinery cut into the columns where they emerge from a tower, but a nailed-together skirting roof and finish materials with minor stabilizing effect. Deep telescoping depends upon the availability of large and long timber. Ithiel Town's great Center Church (1811) on New Haven Green in Connecticut features 72-ft. octagon posts that conceal 38 ft. within lower stages.

Pendant Mast. A long (40–80 ft.) timber depends from the apex of a spire as a sort of pendulum that can help the spire return to plumb when blown sideways, and which generally moves the center of gravity of the entire tall and lightweight ensemble inward and downward. Gwilt's *Encyclopedia* (1867) attributes the invention of this device to Wren and Gibbs in the 17th century. It can be seen in the 1832 Castleton Federated Church in Castleton, Vermont, where a 49-ft. 7x7 timber hangs from the apex of slender spruce pole rafters to reside in two lower stages.

Rigid Mast. A central mast is common in many steeples, acting as an armature to keep the ascending framing in line and rigidly linked together. These masts are usually clasped by partner timbers or have partners, bracing and crabs around them. A prototype can be seen in the 13th-century Church of St. Mary the Virgin at Cleobury-Mortimer, UK, where a mast footed on a starlike crab rises with much horizontal and diagonal joinery to the apex of the spire. The origin is probably ancient, based upon our admiration of tree trunks and early earthfast pole and palisade construction.

Queenposts as Tower Posts. The lowest, usually square, stage of a steeple is called a tower. Sometimes the tower posts, typically very large and tall timbers, rest upon sleepers that span from the front wall of a church to the bottom chord of the first interior roof truss. Frequently the tower posts are augmented and built into a transverse queenpost truss with a wide and heavy base. This truss-tower combination can be found in hundreds of New England churches.

A more elaborate form related to towers or octagons centered in a roof uses two pairs of queenpost trusses crossing perpendicular to each other, with their eight posts becoming the octagon columns. Nicholas Hawksmoor crossed four queenpost trusses within the dome of England's Greenwich Naval Hospital in 1698 (although the octagon posts rose from sleepers across the trusses, not as the queens themselves). The Moravian Home Church (1800) in Old Salem, North Carolina, uses four queenpost trusses with the queens as posts to frame its octagon, although the truss form, while successful, is far from usual as the queen braces and their straining beams are positioned 7 to 10 ft. apart on the posts. The nearby Bethabara Gemeinhaus (1788), also Moravian, uses the same technique.

Ken Rower

Bethabara, North Carolina, Gemeinhaus (1788), combined dwelling and meetinghouse, with ocagonal single-stage steeple.

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