TIMBER FRAMING

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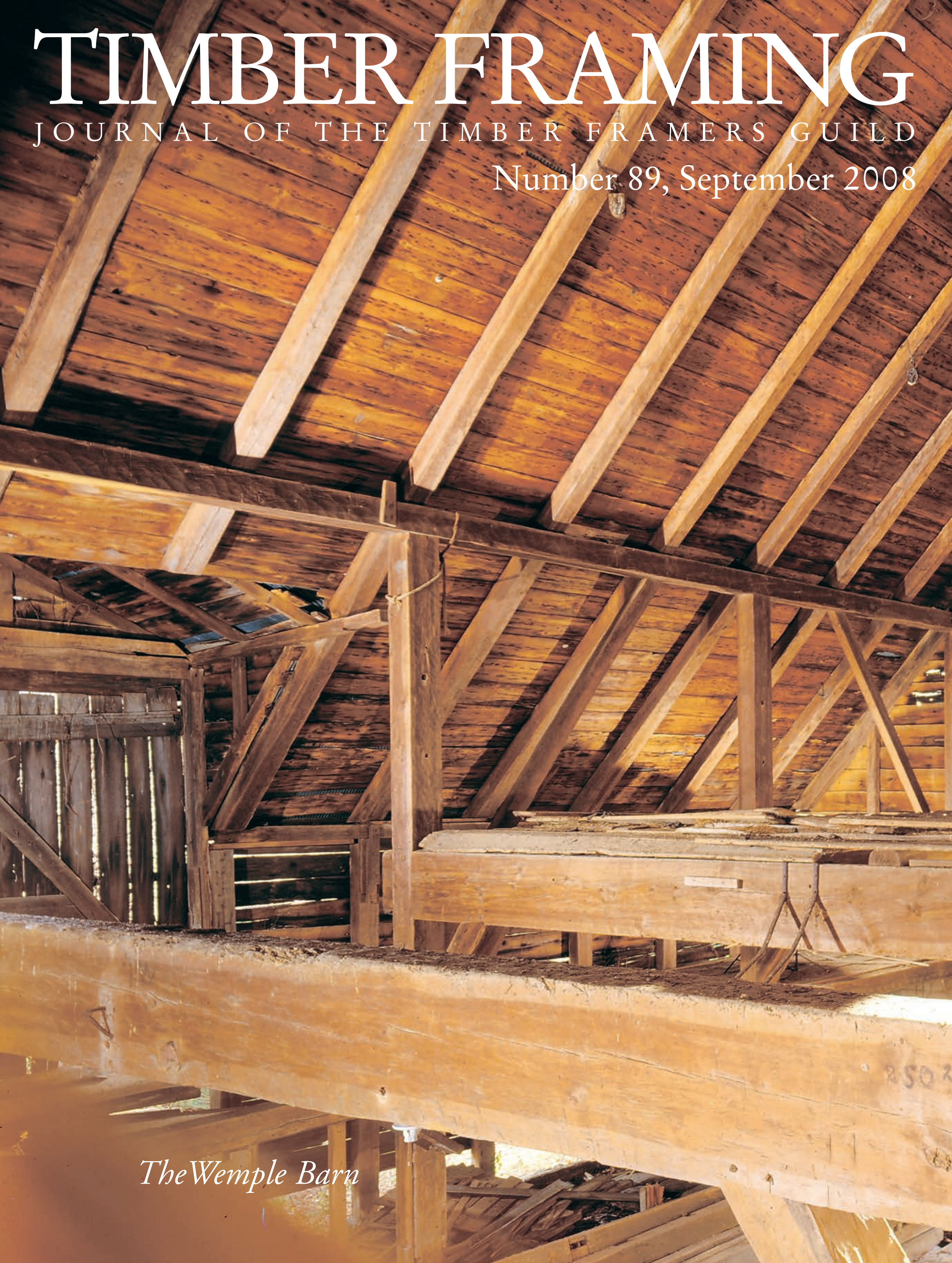

The Wemple Barn

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On the front cover, the Wemple barn, Rotterdam, N.Y., ca. 1760. Photo by Geoffrey Gross. On the back cover, carved ornament on the lantern of St. Michael's Episcopal Church, Charleston, S.C., 1761. Photo by George Fore.

PO Box 60, Becket, MA 01223
888-453-0879 www.tfguild.org

Editorial Correspondence
PO Box 275, Newbury, VT 05051
802-866-5684 journal@tfguild.org

Editor Kenneth Rower

Contributing Editors
Guild Affairs Will Beemer, Joel C. McCarty
History Jack A. Sobon
Frame Design Ed Levin

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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

Community Raisings

I AM just back from a couple of happy weeks of blood (a little, mine), sweat (unlimited, everyone's) and tears (none until the closing prayer), in beautiful Illinois where the Guild was the happy partner and guest of the Collinsville Area Recreation District and Trillium Dell Timber Works, in the thick of moving an antebellum barn (at right) out of the way of progress and onto a charming suburban interpretive center farm and recreation area.

The leadership at CARD had all the right instincts of hospitality and ingenuity, and many of the resources; Trillium Dell filled in the gaps with their relentless energy and capacious tool crib.

It's not precisely fair to say we moved this old barn, since nearly 70 percent of the timber components were replaced with new hewn white oak, though a remarkable amount of the interior finish was salvaged and returned to its original position. Hats off to the folks who made such facile use of CAD and digital photography to make it as simple as it could be made for a mixed collection of volunteers and pros to re-create a fine old barn.

New for us, we posted a daily video blog on youtube and a slightly more extensive report on tfguild.org, including progress reports and short interviews with Guild participants. The statistics indicate that many people were following the tale—certainly some folks called to complain when postings weren't up in a timely manner. Further, we received some justified criticism of the apparent state of our job safety practices; by the time we get to the next project in Montana, we should have that all worked out.

I WAS barely home from Illinois when two years of postdiluvian work in Alstead, N.H., where I live, culminated in the community raising of a replacement (at right below) for the last structure destroyed in our 2005 flooding. (Our flood was smaller than Noah's but it did make a mighty mess, and the national news.) While this was not a Guild event, it sure looked like one, patterned in part after the 1989 Guild Habitat projects in York, Pa. This time, about 40 timber framers, nearly all Guild members, produced a variety of cut timber parts delivered to the site just in time for smooth assembly and raising. Bensonwood Homes, which makes its own home in nearby Walpole, led the effort with much time, energy and material, while Davis Frame from Claremont, N.H., supplied every single one of the 57 common rafters (in a variety of pitches) in good order, good time and perfectly cut. The impact and importance of community service are perhaps better understood in this town than in most. Discounts and outright contributions of everything from sitework to the water well, concrete and wiring flowed freely. No one gets it better than Guild members who continue to demonstrate that working on behalf of an idea bigger than ourselves, even if we can't articulate it all that well, enriches us all.

—Joel C. McCarty

Joel C. McCarty

Above, the Gindler Barn, Collinsville, Illinois, three bays erected. Below, Kmiec's Garage, Alstead, N.H., frame complete.

Bob Wells

Working Out-of-Square Timber

IN the last issue of this journal, Whit Holder gave a good account of laying out twisted or otherwise distorted timber ("Snap-Line Square Rule Layout," TF 88). I've used the layout method he describes, but only on timbers that are to be exposed on four sides, such as the kingposts in his roof frame. In an alternative approach, all other timbers can first be milled or planed true on an outside or upper face to provide a reference surface, which in the long run should be done anyway to make a clean fit with the cladding applied later. Most reclaimed timber dealers will recut stock on one face. If not, then a portable sawmill will do the job nicely (Fig. 1).

Photos Paul Oatman

Fig. 1. Table-mounted portable sawmill, here shown taking 2-in. plank, can true up one face of a twisted timber preparatory to layout and joinery. Longer beams fit through ends of fixed table.

Re-milling timbers calls for a ripping chain, really a series of small chisels that need to be correctly sharpened to work properly. If you plan to do any amount of chainsawing, it's worth investing in a bench model chain grinder (I use an Emak). A chain breaker, which allows you to make your own loops, makes sense too. The price of a reel of chain is a fraction of the cost of a ready-made loop.

With one true face, an out-of-square timber takes little more time to work than an accurately squared timber. A saw that cuts 12 in. deep (which means a chainsaw) will handle most timbers from one side. For a number of years I have used a 75-degree adjustable chainsaw base made by Big Foot Tools that works nicely for end cuts and compound angles (Figs. 2–3).

More recently I have been using Accutech's chainsaw miter mill (again you supply the chainsaw), which also does bevel and compound angle cuts. In addition, the Accutech has a built-in rip guide, allowing you to cut tenon cheeks right away, without the preliminary end cuts necessary for drop-cutting cheeks with a circular saw or with the Big Foot-based chainsaw. This rig also will do shaping and grooving (Figs. 4–5).

Since I have both bases, I use the Big Foot for crosscuts with a standard crosscut chain and I keep a ripping chain on the Accutech. A standard crosscut chain works well for a short rip, however.

Figs. 2–3. Small chainsaw mounted on Big Foot base run against fence will make accurate square cuts from reference face. Fence must be screwed down as clamps will shake loose from saw vibration.

As for joinery operations, the necessary jigs don't have to be complicated or pretty. With these simple appliances, housings and mortises can be worked from the reference face (Figs. 6–7).

Joints to be worked in faces adjacent to the reference face can be approached in analogous ways, with the jig always registered on the reference face and the tool kept square and true to it while off the actual work surface. —Paul Oatman

Paul Oatman (www.pauloatman.com) runs Sherwood Forest Timber Frames in Pioneer, California. He has written in TF on Nevada barns.

Fig. 4. Accutech base adjusted for bevel cut at fixed distance from timber edge. Chain is filed for ripping.

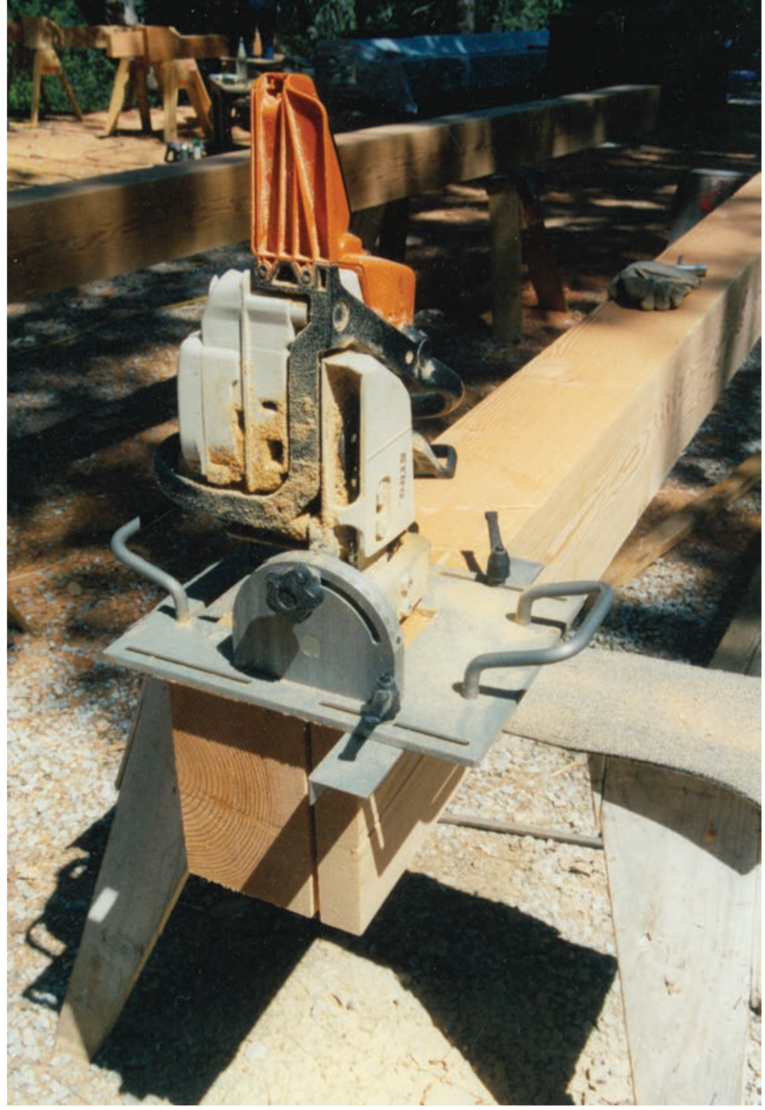


Fig. 5. Accutech base left square, fence adjusted for cutting tenon cheek at desired offset.

Fig. 6. Router mounted on jig ready to produce housing parallel to reference surface (underside of timber in photo).

Fig. 7. Chain mortiser mounted on jig ready to cut mortise perpendicular to reference surface.

Wood Preservatives

THOUGH most American timber framing today is done with untreated wood, timber framers occasionally use and encounter chemically treated materials in new and repair work. Repairers especially may be asked to preserve decayed or partly decayed members. In 2003 the US Environmental Protection Agency (EPA) announced a voluntary ban on the residential use of wood treated with chromate copper arsenate (CCA), the most popular of wood preservatives. But an estimate made by the American Wood Preservers Institute indicates that as much as 75 billion board feet of CCA-treated wood was already in use in or near residences. This total would include the subsills timber framers routinely lay on concrete foundations before erecting their new frames.

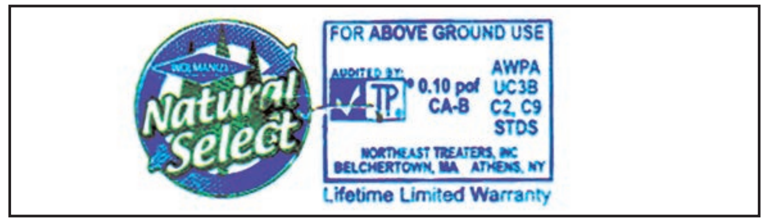
CCA comprises chromium in the form of chromic acid, arsenic salts and copper. These act respectively as fungicide (copper), pesticide (arsenic) and binding agent (chromium) to bind the other two to the wood cells. Introduced to wood through pressure treatment, the combination was first marketed with the introduction of CCA Type A in 1938. Companies that produced and distributed CCA-treated wood evaluated the effectiveness of the compounds through laboratory and field tests, including exposure to termites and decay fungi via ground contact. CCA was available in three forms, Types A, B and C. Type C, introduced in 1968, is a mixture of arsenic peroxide (34 percent), chromic acid (47.5 percent) and cupric acid (18.5 percent). Type C eventually became the most widely used.

Once "cured," CCA-treated wood offered important advantages for use in visible areas. The treated wood was odorless and could be painted, and the treatment was thought to be permanent. As the health risks of using alternatives such as creosote and pentachlorophenol became more widely understood, CCA became the method of choice for preservative treatments and comprised 90–95 percent of the treated wood market by the end of the 1990s.

CCA-treated wood was closely associated with lumber used in buildings or in other applications involving close contact with humans. By contrast, lumber treated with pentachlorophenol and creosote was more likely to be designated for industrial or agricultural uses. Creosote is not registered for residential applications. It was generally not used for building construction, and less likely to come into human contact, although penta products were sold for consumer use.

Creosote, a by-product of the distillation of coal tar, is most notably associated with railroads in the treatment of crossties and bridge timbers. It was first used in the United States in 1875, in Gautier, Mississippi, and generally introduced into wood members by pressure treatment. (John Bethell, in England, secured a patent for a method of pressure-treating wood in 1838.) Demand increased with the expansion of the railroads. Utility companies recognized the preservative value of treating telephone and electricity poles with creosote, which became standard practice. Creosote was also used to treat dock pilings and in other marine applications. The European Union imposed a ban on the use of creosote during the summer of 2003.

Pentachlorophenol (PCP or penta) is registered as a pesticide and was used as a wood preservative from the 1930s, usually through pressure treatment. PCP is applied to wood members likely to be affected by woodborers or to protect wood from attack by decay fungi. Petroleum solvents are required for successful pressure treatment, as the mixture is almost completely water-insoluble. (Sodium penta was also available as a water-based formulation. Its toxicity, however, comes from the mixture of chlorinated compounds used in its creation.)



At top, Alkaline Copper Quaternary (ACQ) lumber tag. UC3B indicates exterior, above-ground use and .25 pcf indicates retention of preservative at .25 pounds per cubic foot. Above, Copper Azole (CA-B) lumber tag also designated for exterior, above-ground use. Retention in this case is .10 pounds per cubic foot.

Penta, mostly as sodium penta, has been used to prevent sapstain (blue stain fungi), which appears often on the sapwood of newly cut white pine. Penta has also been used alone or in conjunction with creosote at or below ground level for treating poles and also for treating millwork. Penta has been limited to the treatment of utility poles, crossties and pilings since 1984.

THE increased use of CCA-treated wood in recent years for decks and playground equipment led to concerns about the accumulation of chromium and arsenic in areas where the treated wood was used. Despite pressure treatment, the CCA was not completely fixed and leaching did occur. In arranging for the voluntary 2003 ban on residential use of CCA-treated wood, the EPA announced that it had "not concluded that CCA-treated wood poses unreasonable risks to the public for existing CCA-treated wood being used around or near their homes or from wood that remains available in stores" and that it did "not believe there is any reason to remove or replace CCA-treated structures, including decks or playground equipment." This somewhat confusing advice amounts to "don't use it any more, but don't remove it either." As a practical matter, ordinary landfills will not accept pressure-treated lumber; it must be taken to a hazardous materials landfill.

No reassurance is available for pentachlorophenol, described by the wood conservation expert Martin Weaver as "a powerful fungicide [that] . . . contains significant amounts of dioxin and is far too toxic to be allowed to get anywhere near the food chain let alone actually come in contact with mammals, including humans."

As for creosote, the EPA lists it as a "possible human carcinogen," but notes that it "has no residential applications." Creosote can be introduced to the body through the lungs, skin or ingestion. It seems to be general opinion that creosote is only an increased danger to those who are in direct contact with it on a regular basis at treatment facilities or by working with treated railroad ties or phone poles.

With the phasing out or complete ban of these three preservatives, and after depending on CCA Type C so heavily for nearly 40 years, the industry sought alternative treatments. Alkaline copper quaternary (ACQ) and copper azole (CA) are compounds introduced into lumber through pressure treatment. ACQ has as its components ammonium (the insecticide) and copper (the fungicide). CA is composed of organic triazoles, including tebuconazole or propiconazole, which act as fungicides. Individual pieces of treated wood are labeled with preservative concentration and use recommendations, as shown in the labels on the facing page. Copper napthenate or Cuprinol was a third alternative, created by the reaction of copper with napthenic acid. Research and public opinion have directed the wood preservatives industry to develop less toxic yet equally effective treatments. This has led to increased interest in the use of borates for wood preservation.

BORATES occur around the world as evaporite mineral deposits in arid regions and in areas of previous volcanic activity. Approximately 230 borate compounds are known; four exist in deposits available for extraction in economic quantities. These are borax, colemanite, kernite and ulexite.

Primary borate deposits in the US are found in Death Valley, on the California-Nevada border, where the climate has played an important role in maintaining the integrity of the deposits. In these locations the borate-rich solutions collected on impermeable beds. Francis Marion Smith discovered a major deposit of borax in the California desert in 1872. The California borax minerals, collected from surface deposits and by open pit mining, were transported by teams of twenty mules (which later came to be identified with several detergent brands, including Borax) to the nearest rail line in Mojave.

Although the US accounts for approximately half of the world's borate production, borate deposits are commercially and economically significant in Turkey, Italy, Kazakhstan, China and Chile. Agricultural purposes include boron's natural aid in plant growth and enhancement of soils, and as an herbicide when introduced in high concentrations. Boron is also used to prevent the spread of a fungus, Heterobasidion annosum, which inhabits stumps of recently harvested trees.

Industrial uses consume the largest percentage of borates as central components in the manufacture of borosilicate glass, including the production of glass fibers for reinforced plastics. Borates are utilized in ceramics as a substitute for lead. They are added to glazes and in glass production to aid in controlling expansion encountered at high temperature changes. Borates are also added to cellulose insulation to discourage insect infestation.

Research using borates to protect wood was carried out in the early 1950s in Australia and New Zealand. Australia's Commonwealth Scientific and Industrial Research Organization was one of the agencies responsible for the first studies. Borate-treated wood is now used in New Zealand and Australia, and elsewhere in areas of high termite activity or high moisture where decay fungi are likely to be encountered.

Borates have properties that make them effective fungicides and insecticides and therefore are ideally suited for use as wood preservatives, for treatment of lumber already in service and for new construction. Application can be by pressure treatment and dip diffusion as well as remedial treatments including brush, spray and solid rods. Borate compounds are conveniently water soluble. They also are highly soluble in ethylene glycol, which allows easier penetration in hard-to-treat wood species.

Research on borate treatment of wood in the US was carried out in the 1970s and continued through the 1980s. The US Department of Agriculture (USDA) in collaboration with several universities conducted testing on diffusible wood preservatives at the Southern Forest Experiment Station in Gulfport, Mississippi. These efforts centered on understanding the performance of borates as a preservative treatment and their effects on wood-destroying insects. Lonnie Williams of the USDA listed eight key characteristics necessary for a good diffusible wood preservative:

1. High toxicity toward most decaying fungi and insects;
2. Favorable effects on fire resistance;
3. Indefinite persistence in the wood when covered by a roof or coating such as paint;
4. Deep penetration into the wood;
5. Ability of treatments to be applied by simple or complex operation;
6. Ease of quality testing of penetration of treatment;
7. Availability of treatment from more than one producer, ensuring low cost;
8. Absence of hazards to the environment or user.

Borate treatments commonly use borax and boric acid (as a combination), or disodium octaborate tetrahydrate and are classed as diffusible preservatives. By definition, diffusion of the preservative occurs as the moisture in wood carries it from an area of greater concentration to an area of lesser concentration. This may be carried out through dip diffusion or pressure treatment. Diffusion of borates is relatively more effective when wood moisture content is 30 percent (fiber saturation point is normally 20–25 percent).

Dip diffusion requires setting up a tank to accommodate a solution of borates and a stack of lumber, a means of hoisting the lumber in and out of the solution and space for the wood to be placed while diffusion of the solution takes place. The water-soluble treatment is introduced into a heated tank of water, which is occasionally stirred to allow for equal distribution of the solution. This process can be carried out as part of a sawmill operation, as it is beneficial to treat the converted materials as soon as possible after the trees are cut. After treatment the lumber is stacked for air-drying under a shelter. Drying time, two to eight weeks, is dependent on species and thickness of wood and environmental conditions.

Another method of introducing borates to wood is by treatment of wood in service. Lumber can be treated by the low-pressure application of borate solutions (garden-type sprayers), by pastes placed on the end grain of timbers or exposed joints, or by inserted solid rods, which theoretically allow for gradual diffusion of the borates as the level of moisture increases inside the wood.

Bora-Care, probably the most recognized commercial product available to treat timbers in situ, is a mixture of boric acid, borax and glycols. Research indicates the product can remain effective from 20 to 50 years in dry conditions. In repeated wet conditions, the solution may need to be reapplied every one to three years.

Solid rod formulations of borates were developed as a response to the observed limitations of pastes, especially poor penetration. Impel Rods, one of these formulations, has been found in tests by its manufacturer to remain effective for three to 10 years.

For borates to be effective in the remedial treatment of wood in service, the water-soluble material obviously must remain in the wood. That borates may leach when subjected to repeated exposure to moisture calls for a formulation, as yet undeveloped, that will "fix" the borate. It will be necessary for the manufacturers and end-users of wood preservatives to ensure that these products are not only effective but relatively less toxic. For the moment, the chromium and arsenic in CCA and phenols associated with creosote are seen as far more damaging to humans and the environment than formulations using borates or boric acid derivatives. It remains true that the boric acid from which they derive is toxic to humans at high-enough concentrations, and the effects of regular long-term exposure are unknown. —Brian Cox

Brian Cox (placidsnow@aol.com) works at Preservation Timber Framing in Berwick, Maine. He has worked for the National Trust for Historic Preservation and holds a master's degree in historic preservation from Columbia University. A complete list of citations for this article, originally part of an academic paper, is available from the author.

The Wemple Barn

AUTHENTIC pre-Revolutionary barns are rare in North America. They have good reason to be. Early barns whose structure and proportions were dictated by fundamentally medieval agricultural practices persisting into the 18th century later became inefficient and were outmoded. One very rare structure that survived the vicissitudes of time and economic conditions is the ca.-1760 Wemple barn in Rotterdam, New York, just west of Schenectady (Fig. 1, shown in the 1930s). This barn retains a striking array of original features both exterior and interior. If one barn in North America were to be saved from the great flood or another all-consuming calamity, to show future generations the skill of certain early timber craftsmen in America, it would be the Wemple barn.

The Wemple barn stands at a point of convergence of very early and considerably later Dutch-American barn building traditions. The earliest structures included the combination house-barn, or *los hoes* (open house), a European form that provided undivided living quarters for the farmer, stabling areas for animals and storage of crops under one long roof (see "Traditional Farm Types of the Netherlands," TF 27). These structures served the needs of a primitive or pioneering settlement farm. Later barns provided no arrangements for human habitation. More "advanced" barns, those built after 1785, had proportions and other traits distinctly at variance with both the earliest remaining barns and those built in the Wemple barn era. Barns from each era accommodated particular agricultural environments. The average production of grain and the acreage under cultivation increased considerably in the later part of the 18th century and the early part of the 19th, and barn heights increased proportionately. Between 1790 and 1820, turnpike companies built over 4000 miles of roads in New York State, giving greater access for farmers to distribute their goods. Subsistence farming became commercial farming. As culture advanced and new markets appeared, so did new barns with appropriate dimensions and certain construction details.

Barns similar to the Wemple appeared in the Dutch-American landscape of New York and New Jersey in post-pioneer building settlements. Their basic dimensions and proportions prevailed for a generation or two, and the Revolutionary War appears to have acted as a sort of boundary. As useful as the Wemple barn type originally was, the end of the Revolutionary War fostered a new environment of barns with different dimensions and shapes. The barns built ten to twenty years after the war retained proportions similar to the Wemple barn's, but after about 1810 or so the barns reflected conditions of the ongoing Industrial Revolution.

How has the Wemple barn maintained its largely unaltered state for the past 250 years? One apparent reason is few owners over time. The greater the number of owners at a farm or plantation, generally the greater level of alteration. From the time the barn was built around 1760 until 1922, the farm was home to only two families, the Dellemonts and the Wemples. The 1847 will of Jacob Dellemont indicates that he left all his real and personal estate to his wife Deborah and his grandson Abraham Dellemont Wemple. (Here the family name Wemple is first seen.) In 1922, George W. Wemple transferred the land and homestead buildings to William Walsh. Four other families have since occupied the property.

Compared to other barn types such as New England three-bay English threshing barns and Pennsylvania forebay bank barns, the distribution of Dutch-American barns of any form is limited. The range is restricted to the river valleys of eastern New York State and the northern half of New Jersey. In total, about 30 counties in both states include these barns in their landscape, with a few outliers as far away as Vermont and Kentucky. In the last 50 years, about 800 Dutch-American barns have been identified in either original or remnant form. It has been estimated that between 50,000 to 100,000 barns existed by the second quarter of the 19th century at Dutch-American homesteads. Surviving 17th-century contracts indicate that both barns and combination house-barns were built beginning in the 1630s. The earliest extant barn (dendrodated) is the 1726 three-bay Bull barn in Orange County, New York. At the other end of the relevant time scale, derivatives of Dutch barns appear to have been erected into the third quarter of the 1800s.

Dutch barns in America appear in several forms. The true-form or classic Dutch barn has three aisles, a tall central aisle for threshing and unloading hay wagons and two lower side aisles where farm animals were stabled and farm crops were stored. Wagon entries appear in both gable walls. Classic barns were built into the 1830s but rarely beyond that time. After about 1800, hybrid types combined Dutch features with traits of other ethnic barn types such as English sidewall wagon entrances. The Wemple barn is strictly a classic-form barn, the most nearly original and the finest built barn of Dutch type in North America.

GENERAL FEATURES. Like most Dutch barns, the Wemple barn, 47 ft. wide and 56 ft. long, is a gable-roofed, one-level structure with no basement. It stands in distinct contrast to bank or two-level barns such as Pennsylvania forebay barns. Sidewall height is 14 ft. 6 in. and height to peak about 40 ft. Wagon doors are centered in both gable walls. Side-aisle farm animal doors appear in both corners in one gable wall; a third door, for humans, possibly original and now gone, at one time stood adjacent to the wagon door visible in Fig. 1. Wagon and animal doors are original. A good deal of the exterior wall surfaces were until recently covered with original horizontal weatherboarding. Likely the barn stands on its original site, some 185 ft. from the ca.-1760 brick farmhouse (Fig. 2). A cemetery that includes Wemple family headstones lies about 100 ft. from the barn. A large post–Civil War farm building stands immediately adjacent to one gable end.

The interior of the Wemple barn is spectacular, with five transverse H-frames, the principal identifying feature of the three-aisle Dutch-American barn and most "hybrid" or Dutch-Anglo barns. Standard H-frames comprise five elements, a substantial tie called an anchorbeam, two tall endposts and two substantial end braces. In contrast to most other vernacular barn bents with principal posts at the walls, the H-frame posts stand 10 to 12 ft. in from the sidewalls, extending from the threshing floor to the purlin plates. There is also a great uninterrupted space from the anchorbeam to the ridge. The interior of the barn in overall visual effect is expansive.

The central aisle is 28 ft. wide, measured outside to outside of the H-frame posts. One side aisle measures 9 ft. 6 in. wide, the other 9 ft. 5 in., taken from the outside of the H-frame post to the outside of the sidewall post. The five H-frames yield four bays, each bay measuring a few inches either side of 14 ft.

Exterior Weatherboarding. The horizontal weatherboards, possibly of pitch pine and the longest about 13 ft. 6 in., were perhaps 70 percent original before recent replacement with new pine boards that closely duplicate the dimensions of the original boards, about an inch thick and 12 to 14 in. wide. All of the original marten or "owl" holes were intact. The original weatherboards, overlapped by 1½–2 in. and secured with prominent rose-headed

Figs. 1–2. The Wemple barn, above, and brick farmhouse, below, ca. 1760, Rotterdam (earlier Dunnsville), Albany County, N.Y. Historic American Buildings Survey photographs by Nelson E. Baldwin, after 1933. Three-ft. scale of researcher is partly subdivided in 2-in. intervals.

wrought nails, had lost about a third of their thickness over 250 years of weather. (A few other classic Dutch barns in New York retain their original siding, including the superb four-bay ca.-1790 Bogart barn in Marbletown, Ulster County. Several have vertical siding and one ca.-1790 barn in Glenn, Montgomery County, originally had both horizontal and vertical siding. Original siding on New Jersey barns is very rare. A few barns in the central part of the state have wooden shakes.)

Tapered rake boards covered the ends of the gable siding and at the roof peak an unusual vertical piece, function unknown, extended above the roof. Only 2-ft. lengths below the peak remain, though more remained when the photo above was made. Perhaps they held weathervanes.

Wagon Doors. The gable walls retain their wagon or threshing-floor double-doors about 12 ft. high and more than 9 ft. wide, with original wooden hinges (Fig. 1). All such doors found so far swing inward, presumably to avoid seasonal snow accumulation. The Wemple barn doors pivot on wood pintles set into grooves (Fig. 3 overleaf). The 11½x9½ door posts stand about 9 ft. 6 in. apart. Originally one leaf of each double door was divided into roughly equal upper and lower parts, perhaps to obtain light and ventilation without having to manage a 12-ft. door. Later at one gable wall the facing leaves were cut in two and, later still, fastened back together. All door sections swing on full-width oak strap hinges, 3 in. wide and tapered in thickness from 4 in. at the hinge edge to about 2 in. at the lock edge. The doors are braced inside by wide diagonal battens (Fig. 4 overleaf). The face boards, about 10 to 13 in. wide for the most part, are tongued and grooved and well fastened to the horizontal battens in a carefully designed pattern (36 intersections) still visible on the inside of the battens. The nails are reversed, with the heads visible on the inside of the batten and the clenched shafts on the outside of the doors. Right and left door leaves can be joined by sliding wood latches.

Photos Greg Huber

Fig. 3. Detail of oak lower door hinge, seen from outside, showing wood pintle let in and nailed to doorpost. Hinge strap measures 3x4 at the pintle. Door has been opened about 120 degrees.

Fig. 4. Complete 12-ft. wagon door leaf in original divided condition. Battens are fastened from the inside.

Originally there was a removable full-height vertical wood pole or *mittelmanse* ("little man in the middle"), about 3x3, where the two door leaves meet. The top end entered a hole in the soffit of the gable wall anchorbeam. The bottom end fitted into a hole in the floor sill. Neither *mittelmanse* survives in the barn, though their upper mortises are visible in the gable wall anchorbeams.

Animal Doors. Horses and cows entered the barn at separate doors in the side aisles at the corners of the gable walls. Only one gable wall has both side-aisle corner animal doors intact (Fig. 1). While of essentially equal width, the doors are not of equal height; horses are taller than cows and need more clearance. Both doors still swing on their original 2-ft. wrought hinges with their distinctive Dutch pancake disks; the iron pintles are driven into the door frame (Fig. 5). Each door has four vertical tongued and grooved boards of about equal width and two interior horizontal battens secured to the boards in the manner of the wagon doors.

Adjacent to the wagon doors at one end at one time (not necessarily original) was a human door, visible in Fig. 1. (A few barns did include such doors in their fabric, including the ca.-1730 Van Bergen Barn near Leeds, Greene County.)

Pentices. In areas of the Hudson, Schoharie and Mohawk river valleys in New York, distinctive short roof projections or pentices were built to protect the wagon doorways from the weather. Original pentices or even pentice remnants are rare. (One survives on the Bogart barn, ca. 1790, and another on the Mahoney barn, ca. 1760, both in Ulster County. Variations on the form occur elsewhere.) Typical pentices appear on both ends of the Wemple barn, although none of their wood elements is now original. Each pentice extends nearly 4 ft. out from the gable wall, supported by three medium-pitched rafters, the outer ends of which join horizontal pentice arms emerging from original mortises in the gable wall anchorbeams (Fig. 1).

THE Wemple barn's framing and its details of style and design, taken together, are found in no other extant classic Dutch-American barn. Likely other barns were constructed using such craftsmanship in the period before the Revolutionary War and to some degree after the war. But no other extant barn has been studied in the last 50 years that comes near the Wemple barn in finely executed elements of construction and architectural expression.

Roof Covering and Sheathing. No original roof covering remains. Most likely it was long wooden shingles. The ca.-1790 Hendricksen Barn (Monmouth County, New Jersey) retained its original wood roof shakes under later roofing, cedar shakes 32 in. long and 7 to 8 in. wide. There is no reason to believe that the Wemple barn was much different, although there is evidence that certain Dutch-American barn roofs were thatched. The Dutch called their boarded sheathing style a *planken* roof. One side of the Wemple roof appears almost 100 percent original as does the other above the level of the purlin plate (Fig. 6). Below the purlin plate on the latter side the original planking was replaced with boards 13 or 14 in. wide, likely sometime in the later half of the 19th century. The original planks average about 18 ft. 9 in. long, laid in three groups with ends all in a line over a rafter. The distinctive feature of the planks is that they are beveled (over a width of about 1¾ in.) and lap one another, gaining stiffness over the relatively long spans from rafter to rafter. (Early buildings in the Mohawk River Valley and perhaps the Schoharie Valley and certain areas of the upper Hudson River Valley often have such plank roofs. They appear at least as early as the 1720s to as late as about 1790. Buildings with such partly beveled and lapped boards are also seen elsewhere, such as in Maryland as exterior wall siding.)

Roof Frame. The Wemple barn's common-rafter roof frame is typical of Dutch barns. There are 13 pairs of remarkably straight hewn rafters on 4 ft. 8 in. centers, altered only for a sidewall wagon entry likely cut in the middle of the 19th century (Fig. 6). Rafters average about 8x8 at the foot and appear to taper slightly over their 30-ft. length. The rafter pairs at the gable walls are joined by collar beams, in an unusual (but not unknown) arrangement. Rafter feet are simply butted and spiked to the sidewall plates, not uncommon in the Mohawk Valley. (Major variations of this connection exist in the Dutch-American barn realm, including cogged and variously birdsmouthed rafter ends.) The rafters are set back about 3½ in.

from the outer edge of the wall plates and deeply notched over the purlin plates. Substantial wrought iron spikes secure some of these joints.

Rafters are spaced precisely in relation to the H-frame posts, the middle (seventh) rafter pair centered over the middle H-frame posts, and other rafter pairs aligning consistently with other H-frames. The front and back halves of the barn are virtual mirror images. The almost perfect symmetry of the rafter placement is very infrequently seen in Dutch-American barns.

H-Frames. It is the five H-frames that elevate the Wemple barn to a level of distinction. Other four-bay barns are much shorter than the 56-ft.-long Wemple barn, and only certain rare six-bay barns are equal or greater in length. It's not just a matter of the Wemple barn's very substantial pitch pine purlin plates that might be said to allow longer bays. The classic four-bay Larger Wemp barn in Mongomery County, N .Y., composed of very large virgin white pine timbers, is only 45 ft. 6 in. long, as was one massively timbered four-bay New Jersey barn of virgin oak that survived until 1998 (see "A Mammoth in Monmouth County," TF 24). The Mammoth very likely had the greatest structural support of any classic Dutch barn surviving into the late 1990s.

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Fig 5. Animal doors on wrought hinges served horses and cows at respective corners of one gable end.

Geoffrey Gross

Fig. 6. Recent general view of Wemple barn interior, showing three central H-frames, long purlin braces and roof framing. Purlins run 56 ft. unscarfed, rafters 30 ft. Anchorbeams, 30 ft. tip to tip, measure about 12x22. At left, sidewall wagon entrance cut in 19th century.

Fig. 7. Diminished shoulder anchorbeam, extended tenon with outside wedges and partial view of H-frame endpost and diminished shoulder kneebrace, all pitch pine except for the oak wedges. Three 1-in. pins secure the connection as well. Hewing and joinery are exemplary. The scale is 3 ft. long, partially subdivided into inches. Historic American Buildings Survey photograph by Nelson E. Baldwin, after 1933.

While the typical bay in Dutch-American barns runs between 9 to 12 ft. wide, the Wemple barn's bays measure nearly 13 ft. 10 in. from layout face to layout face. (The "far-end" bays in certain special-use post-1820 barns can be up to 20 ft. long, but these barns are exceptional.) Because of dissimilar support requirements, the two gable wall H-frames differ somewhat in size and configuration from the three inner H-frames. The gable wall frames have smaller, unbraced anchorbeams, as the frames carry only half the weight of the inner H-frames and gain stiffness from the wagon door posts and the nailed exterior sheathing.

Middle H-Frame. As do almost all Dutch H-frames, the middle H-frame, which bounds the central aisle of the barn, consists of an anchorbeam, two end posts and two end braces. The hewn posts at breast height are 11¾x9½, the wide face parallel to the sidewall. It should be noted that the cross-sectional dimensions are virtually the same along the entire lengths of both posts. These post dimensions are a bit above average for a softwood barn in the upper river valleys of New York. Barns of oak quite often have H-frame posts several inches wider than that seen in pine barns. Many barns do not even have anchorbeams with such dimensions. In the Wemple barn the extension of the post from the top of the anchorbeam to the soffit of the purlin plate is 8 ft. 7 in. (Fig. 6). This dimension is referred to as the *verdiepingh* in certain surviving 17th-century Dutch-American building contracts. Post extensions vary tremendously. A range for most Dutch barns is 7 to 12 ft. The relative length of the *verdiepingh* can suggest the construction age of a barn. (Although the following statement simplifies matters, the shorter this length, the earlier the barn. The few barns in New York State that pre-date the Wemple barn or those that seem to be direct descendants from the earliest barn building traditions consistently have *verdiepingen* 2 to 4 ft. shorter than the Wemple barn's. First- and second-generation Dutch builders in America built barns and houses with relatively high peaks and quite low side walls, as this was the tradition in the Netherlands. As farms became bigger and more storage capacity was needed, sidewalls and *verdiepingen* became taller. By the end of the Revolutionary War, after about 1790 or so, farmers may actually have been in competition and eager to keep up with the Van Joneses.)

Raising Holes. Dutch barn builders frequently fitted through pins to bored holes in the upper post extensions of posts to help raise the H-frame assemblies into position. Ropes connected the pins to hoisting mechanisms such as gin poles. The pins were generally removed after the raising, leaving observers a century or two later to wonder at the significance of the holes. A number of Dutch barns do not show evidence of the technique, especially those with short *verdiepingen*, where the junctures of anchorbeams to posts may have served as suitable points for attaching ropes. Some Dutch barns such as the Wemple have double raising holes, one upper and one lower, per post. (A few barns actually have three holes per post. The function of the added holes is not understood.) Raising holes usually appear in the upper half of post extensions, but they can appear almost anywhere along the posts. The upper holes in the Wemple barn's posts appear consistently 3 ft. 11 in. below the soffits of the purlin plates, the lower 6 ft. 1 in (see foreground post in Fig. 6). All upper holes are 2 in. dia., the lower 1¼ in. In addition to its H-frame raising holes, the corner posts on both sides have 1¼-in. raising holes 24½ in. below the wall plate soffits that presumably assisted in raising the sidewall frames onto their sills.

Anchorbeams. The anchorbeams span 26 ft. 6 in. over the central aisle and are nearly uniform in section at about 12x22 along the full length. (In about a third of known Dutch barns, anchorbeams gradually increase in height toward midspan, rendering an arched appearance and improved bending strength.) The height of the Wemple anchorbeams is near the upper end of the known range. In the Schoharie and the Mohawk river valleys, inner anchorbeams consistently measure 16 to 20 in. and 2 to 4 in. shorter than elsewhere in New York. All the inner anchorbeams of the Wemple barn exceed 22 in. high and thus compare favorably with 95 percent of anchorbeams in other Dutch barns (Fig. 7). At almost a foot, the thickness of the Wemple anchorbeams is also at the top of the class (although a remarkable 16-in.-thick anchorbeam was seen in a ca.-1830 barn in Columbia County).

Centered in the soffit of the middle anchorbeam of the Wemple barn appears a 2½-in.-dia. hole 5½ in. deep, likely provision for a vertical threshing pole that extended down to the threshing floor and may have joined to one or another kind of horse-driven threshing machine.

All the anchorbeams in the Wemple barn are exceedingly well hewn, with sharp well-formed arrises and little or no wane. Sighted across their lower edges, the anchorbeams appear nearly parallel with each other after 250 years of service, extraordinary in relation to other Dutch barns that have been standing for lesser periods.

Rare Carpenter's Mark. Close to one end of the middle anchorbeam, a curious mark is scratched on the nonlayout face, a near-circle about 3½ in. across, intersected by two short arcs (Fig. 8). No similar marks appear elsewhere in the barn, so it cannot indicate H-frame number. It has some resemblance to a medieval mason's mark, extracted from a guild's master pattern of multiple circles and assigned to an individual craftsmen. I know of no other such marks on the Dutch barns I have seen in the last 35 years.

Absence of 2-Ft. Marks. So-called 2-ft. marks are found on the layout faces of anchorbeams in certain scribe-ruled Dutch barns (as well as in other locations on English-style barns). These marks are to be seen 2 ft. in from the outside faces of the H-frame posts and provide reference points for assuring the desired overall width of the H-frame regardless of varying post width. Strangely enough, these scribe marks are infrequently found in pre-1780 barns and again rarely after about 1820, by which time square-rule barns were the norm. The Wemple barn fits the case in that no 2-ft. marks are seen, consistent with a pre–Revolutionary War construction date.

Anchorbeam Joints and Extended Tenons. The housing for the diminished shoulder on the Wemple barn anchorbeam tenon is nearly 1½ in. deep (such housings in other Dutch barns are 1 to 2 in. deep). Three 1-in. pegs transfix the joint in a typical triangular arrangement (post-1800 barns often used two). Peg diameters at the anchorbeam joints are good dating tools. After about 1800, such pegs often were increased to 1½ in. Before 1790 the joints consistently had 1-in. or smaller pegs. The layout or reference faces of the inner H-frames, to which all elements are held flush, relegating irregularities to the opposite or "back" face, are oriented toward the house end of the barn. Typical marriage marks cut by chisels are seen at the anchorbeam joints. (In the majority of cases where three-aisle barns occupy their original locations, the layout faces of inner bents face the house. This orientation may have been done for aesthetic purposes, supposing the farmer usually entered the barn from the house.) In most H-frames, the end braces are only flush at the layout side, unlike the Wemple barn's, where the braces are so broad as to be flush at both sides of the H-frames.

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Fig. 8. Carpenter's mark about 3½ in. across, of uncertain meaning, scratched in one anchorbeam of the Wemple barn.

The extended tenons in the Wemple anchorbeams are almost exactly centered in the H-frame posts. This is quite unusual; in most other Dutch barns the mortises are closer to the layout face. The Wemple tenons are a little over 3 in. thick and extend just over one foot beyond the posts; at 21½ in. high, they are very close to the full height of the anchorbeam (Fig. 7). The square corners have been rounded and the edges are chamfered. (Pitch pine anchorbeams such as the Wemple's and oak anchorbeams in some other Dutch barns generally show such squarish extended tenons, while white pine anchorbeams show distinctly rounded tenons, perhaps reflecting the relative difficulty of working hard and soft woods to a profile.)

Anchorbeam Tenon Wedges. About three-quarters of all anchorbeams with extended tenons that exceed 6 to 8 in. are double outside wedged, as are the Wemple anchorbeams. A number of barns have just one wedge centered in the tenon and a few dozen barns have no wedges at all even in tenons that extend up to a foot, their builders apparently confident in the use of cross-pegging alone. Tenons that extend less than about 6 in. often have no wedges. Certain buildings in the Netherlands have triple wedges in their tenons. (It is not unusual for some of these tenons to have decorative ends.) Two 1-in. oak draw-wedges are fitted to all of the Wemple tenons, each about 16 in. long and 3 in. wide at the wider end (Fig. 7). In a kind of belt-and-suspenders arrangement, these outside wedges additionally secure the anchorbeam and, unlike the pegs, can be taken up after shrinkage of the post. The length of the tenons suggests that the builders expected the wedges to transmit considerable forces, while the neat work testifies to the builders' care and skill.

End Braces. The middle H-frame hewn end braces are close to identical in cross section, 12 in. wide by 9 in. deep, nearly matching the widths of both anchorbeam and posts. Very few Dutch barns have been constructed with larger braces. An average size for anchorbeam braces is about 8x6. (A few pre-1790 extant Dutch barns have braces up to about 13 in. wide.) The Wemple braces are not pitched at 45 degrees. Leg lengths of 46 in.vertical and 34½ in. horizontal form 3-4-5 triangles. Two ¾-in.-dia. pegs fasten the brace tenons.

Gable Wall H-frames. The Wemple barn's gable wall anchorbeams are reduced in section and unbraced to the posts, as is consistent with the few other observable Dutch barns of the era, and traditional earlier practice, but the H-frame posts are the same section as those of the interior H-frames, which is unusual. In almost all Dutch barns, gable wall H-frame anchorbeams are typically shorter in height by 2 to 5 in. (sometimes more) than those of the inner anchorbeams. In the Wemple barn, the average height of the gable wall anchorbeams at mid-span, 14½ in., is about 7½ in. less than the average inner anchorbeam. This reduction is not surprising because, as we have seen, in addition to sustaining substantially reduced loads in their position, the gable wall anchorbeams enjoy the added support of wagon doorposts. The diminished shoulder bearing at the tenons is also reduced a little, from 1½ in. deep to 1¼ in. In breadth these end anchorbeams are reduced only a little, from 12 to 11½ in., and their extended through tenons project similarly to those on the interior anchorbeams. The outside wedges are intact and, like most others in the barn, of quartered oak. Some scribed lines remain outlining the wedge mortises.

Gable Wall Framing. The timber framing of both Wemple gable walls is virtually identical. Above the gable wall anchorbeam and below the gable wall collar beam are five 6x4½ (on average) posts spaced about 4 ft. 2 in. apart. The distance from the top of the anchorbeam to the top of the collar is 13 ft. 1 in., the same measurement as from the top of the anchorbeam to the bottom of the H-frame post. Gable wall collar beams as seen in the Wemple barn are rare in three-aisle Dutch barns after 1790. One structural element conspicuously missing in the Wemple barn but common in classic barns of post-1790 vintage is the H-frame upper tie beam, fitted about a foot below the top of the H-frame posts. Given that early barns often had short *verdiepingen*, the post extensions above the anchorbeam, there was little need for an additional tie beam in their H-frames. Despite its fairly lengthy *verdiepingh*, the Wemple barn's builders remained faithful to the earlier tradition.

From the collar beam, four posts rise to terminate at the gable wall rafters. The middle two posts centered under the peak frame a window opening 2 ft. wide and about 3 ft. 4 in. high. Such high gable windows are unique in the Dutch barn realm.

The gable wall framing at the side aisles comprises two wall posts 6½ in. square, one above the other, separated by a transverse side-aisle tie 6 ft. 6 in. above the floor. The lower wall post frames the corner side-aisle animal door.

Crop Storage Floor over Anchorbeams. Eleven joists 10 in. wide (left round-edged) and 5½ in. thick (hewn top and bottom), all likely original, lie spaced about 18 in. on center over the anchorbeams in the first two bays. Loose boarding, possibly original, lies over the joists to hold farm crops, with signs of at least one opening in the floor. It seems likely that the joists filled all four bays before the addition of the sidewall wagon entry in the later part of the 19th century. (The most common crop storage floor in Dutch barns consists of 3-in. or 4-in. saplings, or *tasliger*, round poles that stretch over the tops of adjacent anchorbeams, but variations are known. In a four-bay classic barn in Germantown, Columbia County, the floor incorporates tight-laid planks from 6 to 12 in. wide and of varying thicknesses. The thicker planks are notched over the anchorbeams.)

Purlin Plates and Braces. The five H-frames in the Wemple barn are longitudinally connected and stabilized by purlin plates, each a single 56-ft. length of timber 10¼x9 (Fig. 6). Most barns of pre-1800 vintage have single-length purlin plates, especially in three-bay barns and those four-bay barns less than 45 ft. long. (With the single outstanding exception of the dated-1766 three-bay Nieuwkirk classic barn near Kingston in Ulster County, almost all three-bay barns of any era have single-length plates. But a number of four-bay barns after about 1810 and definitely after 1820 have plates with scarfed joints. Probably a majority of the 15 to 20 known five-bay barns as well as the six known six-bay barns have scarfed plates.)

The two interior H-frames nearer the ends of the Wemple barn are further stabilized longitudinally by tall braces to the purlin plates. In the majority of Dutch barns, all the posts are braced to the purlin plates, so the Wemple builders' omissions are noteworthy. Purlin brace positioning on H-frame posts varies widely in classic Dutch barns, from points above the anchorbeam to as much as 4 ft. below the anchorbeam in the case of a ca.-1750 three-bay barn near Catskill, Greene County. In the Wemple barn, the braces enter the posts 17½ to 19 in. below the soffits of the anchorbeams (After 1810, braces are rather short and join to the posts only about 4 or 5 ft. below the purlin plate. One Schoharie County four-bay barn has long braces in its end bays and short braces in its two middle bays. A Montgomery County four-bay barn has, uniquely, side-by-side braces in the end bays. Certain three- or five-bay barn middle bays may not have any braces at all. Purlin braces that criss-cross were seen in the Catskill barn.)

Seven original purlin braces survive in the Wemple barn; one brace was removed to make way for the 19th-century sidewall entry and then a new one installed in recent times. Like the H-frame braces, the purlin brace legs and hypotenuse form the builder's ideal 3-4-5 right triangle, set vertically. Early barns show these more steeply pitched braces, reflecting continued European tradition, while post-1800 barns show braces pitched at 45 degrees. The hewn purlin brace sections measure a uniform 4½ x7, by no means heavy for their length.

Threshing Floor. Unlike most Dutch barns in the Netherlands, Dutch-American barns had plank threshing floors. Although much of the central aisle floor in the Wemple barn has deteriorated, enough of it remained in the early 1990s to indicate the prodigious efforts of the builders to include a threshing floor drive that would support far greater weight than it would ever likely be subjected to. Forty-five threshing "floorboards," actually planks or timbers mostly 5 to 6 in. thick and the rest 4 in. thick, were counted in December 1990, though many were ruinous. (Absent was a median longitudinal floor sill to support the midspans of these members, commonly seen in barns in the Mohawk and Schoharie river valleys and to some degree in the Upper Hudson River area.)

Most of the old flooring that spanned the central aisle was tapered in width, reflecting its origin in tapered logs, and laid with wide and narrow ends alternating to help maintain uniform floor width at the ends. Splines (commonly seen in pre-1825 threshing floors) about ¾-in. thick and 1 in. wide and set in grooves nearer the upper surfaces joined the planks to form a grain-tight floor. The original Wemple barn threshing floor contained about 8500 board feet of wood. Of the 45 planks, all but two measuring 10 in. and wider, two were more than 20 in. wide, the wider at 24½ in. The central floor plank had a hole at its midpoint that corresponded to the hole directly above in the soffit of the middle anchorbeam, presumably provision for the lower end of the threshing pole.

Sill and Sleeper System. A great deal of the original sill and sleeper structure below the threshing floor had deteriorated to near oblivion, but most of the extant flooring showed five notches underneath, implying so many longitudinal sleepers. Several transverse sleepers apparently supported the longitudinal sleepers. One end of each of the threshing floor planks was secured by an angled (undersquinted) rabbet worked in a scarfed longitudinal sill under the H-frame posts. The original long sills are nearly intact, about 12¾ in. wide by 11 in. high, supported by stones about 10 in. above ground level. The angled rabbet is 2 in. wide and about 6 in. below the top surface, thus the undersquint is pitched at 1:3. The 39-in. sill scarfs (the only scarfs in the barn), edge-halved with bridled butts, are centered under the middle H-frame posts.

Fig. 9. Manger beam (running left to right in upper part of photo) shows ghosts of manger stakes that held feed above and ahead of the animals. The stakes ran down at an angle a short distance into the central aisle, terminating in a rail above the floor. H-frame post at right.

On the top surface of one sill is a series of 1-in.-dia. holes (seven sets of three and a single hole near a gable), but there is no longitudinal member above with corresponding connection points. The holes, rare in classic barns, may indicate a manger or a containment wall for stabled animals.

The sill on the opposite side of the H-frames also has a series of holes on top in the last three bays, again with no corresponding member above. The rabbet for the flooring ends in this sill is square. The builders probably slid the far end of a floor timber into the angle-rabbeted sill, then dropped the near end into the square rabbet and slid the timber over to make up the splined connection with its mate. Fractional lengths of two transverse sleepers 15 in. wide and two longitudinal sleepers were found intact under the threshing floor, as well as fractional lengths of the gable wall sills.

Few Dutch barn sill systems have been directly examined because intact threshing floors, original or otherwise, naturally obscure what underlies them. When substructure has been exposed, pre-1800 Dutch barns in the upper river valleys of New York have often revealed median floor sills that run the length of the barn, with transverse sleepers tenoned to their edges and reduced to allow planking flush with the top of the sill, and one or two longitudinal sleepers under them on either side of the median sill.

Side Aisles. Side aisles flanking a central aisle define the form of the classic Dutch-American barn. Given the central aisle at 28 ft. (outside measure), the square roof pitch and the fairly high sidewall at about 14 ft. 6 in., the side aisles of the Wemple barn are a bit narrow at 9 ft. 6 in. compared with the 10-ft. to 12-ft. side aisles in most classic barns. (They are the same width as one of the side aisles in another circa-1760 barn, the Van Alstyne in Columbia County. The narrowest side-aisle I have seen in Dutch barns is about 6 ft. wide and the widest 16 ft., both in Ulster County.)

Side aisles were principally used for the stabling of farm stock, mainly horses and cows. Horses in the Wemple barn were stabled in one aisle and cows in the other. Animals entered into the aisles via corner doors and stood with their hindquarters toward the sidewalls. The uninterrupted wall plate of the cow aisle is original, measuring 9¼x6, with waney edges at its extremities. The 13 sidewall posts, averaging 8¾x6¾, are on the same centers as the rafters, and all are through-tenoned to the plate. The tenons are pinned only at posts in line with H-frames and offset to the inside face of the plate, which is unusual; together with the long through-tenons, perhaps they are meant to increase the plate's resistance to being rolled outward by rafter action.

The sidewall of the horse aisle is interrupted by the added 19th-century wagon door entry. There are ten side-aisle ties on this side of the barn, seven in the first two bays, two under the sidewall ramp (in line with the sidewall entry) and one at the far gable wall. The only ties on the cow aisle are in the gable walls.

Remnants of a plank floor are also to be found in the Wemple barn horse aisle, though animals normally stood on dirt in early barns. (One rare floor was found in the ca.-1815 Deertz six-bay barn.) Eight planks from 7½ to 15½ in. wide and 2½ to 5½ in. thick run longitudinally over a transverse sill in one gable wall bay.

Rain Gutters. The Wemple barn was originally equipped with rain gutters at both sidewalls, presumably to collect water for the animals. Few Dutch barns show direct evidence of such gutters, but extant holes in the Wemple barn wall posts almost certainly were for support brackets and indicate two gutter runs per sidewall. On each eaves side, every second wall post including the corner posts has a 1½-in.-dia. gutter support bracket hole. Starting from one gable wall, the holes descend about 2 in. over about half the length of the barn, then a new set of holes begins about 8 in. lower on the wall and continues downward at the same pitch to the opposite gable wall. Perhaps the upper gutter drained into the lower, or perhaps there were two rain barrels. The last three holes actually retain oak peg remnants. (Among the few such, two notable barns have sidewall posts with bracket holes for gutters, the ca.-1815 four-bay classic barn at the very early Bronck homestead in Greene County and a wonderfully crafted ca.-1805 barn not far from Ravena in Albany County.)

Manger Beams. The H-frame posts are connected lengthwise in the Wemple barn by beams about 6 ft. above the threshing floor, offering attachment points for mangers over the heads of the farm animals (Fig. 9). Beams 10x9¾ are placed 5 ft. 5 in. above the threshing floor along the cow aisle and 6 ft. 2 in. high along the horse aisle. (There are no such elements in one end bay.) The beams on the horse aisle show ghosts indicating attachment of angled manger stakes 2¼ in. wide, spaced about 6½ in. on center and 2 in. above the bottom of the beam. There are about 25 ghosts per beam, with small nail holes in the middle of each ghost indicating the method of attachment. (In many three-aisle barns in both New York and New Jersey, the manger stakes were notched into the upper corners of the beams. Intact manger stakes in barns are almost nonexistent, the only clear exception being those in the rare six-bay Deertz barn, ca. 1815, originally in Middleburgh, Schoharie County.) Crops were placed such that the animals could draw the food down between the stakes.

In addition, manger boards were placed a few feet below the stakes, trenched into the H-frame posts, to hold grain (Fig. 10 overleaf). Some of the Wemple barn's H-frame posts are double slotted (upper and lower) for the purpose.

Side-Aisle Ties. In nearly all three-aisle Dutch barns, side-aisle ties link the H-frame posts to the outside walls, in some cases joining to the wall plates but most often to appropriately positioned wall posts. In the Wemple barn, one tier of ties originally appeared along each side aisle. Along the cow aisle, all ties except for those at the gable walls have been removed. (Dutch barns might have one or two tiers of ties from the H-frame posts according to the height of the sidewall and the *verdiepingh* of the H-frame posts. Most post-1790 barns have two tiers. One barn dated 1788 in Monmouth County, New Jersey, uniquely has three tiers.)

In many upper river valley barns of New York, additional ties connect the longitudinal manger beams to sidewall posts. Along

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Fig. 10. Trench in H-frame post for edge of manger board to carry grain for animals. The Wemple barn had such boards at two levels.

with the five ties that normally connect the H-frame posts and each sidewall in a four-bay barn, in the Wemple barn an additional eight ties were fitted on each side at the level of the manger beams and boarded over for crop storage. Ten ties remain in the horse side aisle, as well as a number of likely original boards.

Granary. Granaries, fully closed spaces for grain storage entered through a door, were always positioned in one of the side aisles adjacent to a gable wall. With both original animal doors at one gable wall intact, it would appear that the Wemple barn granary, now disappeared, was likely placed at the other. Intact granaries are extremely rare in three-aisle barns.

What might have been the original granary door in the Wemple barn now stands in the third bay in the horse aisle. A two-board batten door 47x74 in., it swings on two wrought Dutch hinges with typical circular pancake discs. Perhaps in the 19th century the granary was relocated to the third bay under the newly built sidewall entry.

Wood Species. It cannot be said just where the forest was located that supplied the Wemple barn timbers, but likely it was close by. All the barn timbers are pitch pine, indigenous to the greater Schenectady area. (Schenectady, a native American word, means "end of the pine plains.") The builders, having the advantage of large, straight material, maximized timber sections and minimized hewing time by not removing sapwood on interior members, though actual wane is minimal. To produce the anchorbeams, logs would need to have measured at least 3 ft. 6. in. through before conversion. The other wood species in the Wemple barn is oak, strategically used in small items where maximum strength was needed, for instance anchorbeam tenon wedges, trunnels, door hinges and gutter supports, as well as one curious plank nailed to an H-frame post in the horse aisle. Almost 5 ft. long and 2¼ in. thick, the oak plank has four rectangular notches, probably for rails, and may indicate where sheep or young farm stock were stabled.

CONCLUSIONS. Traditions in force when the Wemple barn was constructed were part of a continuum that started about the year 1630. The earliest barn-building modes remained essentially the same until some time in the second quarter of the 18th century. In the era 20 years or so before the Revolutionary War, Dutch barn proportions and dimensions changed, but one gets the sense that the Wemple barn was built almost effortlessly, that the builders knew precisely what they were about, with strong connections to building traditions established long before. Without any ostentation in any of its structural elements, this barn is the closest we have to perfect construction design. Although unique today, it may have had a close cousin in the four-bay Bradt-Mabie barn that stood about four miles away and was taken down in 1990. This barn was remarkably similar in construction features and elements of design and fabric, with only minor variations (such as single raising holes in H-frame posts). Perhaps the same builders constructed both barns.

It is not only the meticulous conversion of forest trees to timbers with razor-sharp arrises, nor the strictly refined joinery, nor the precise spacing of the H-frames that distinguishes the Wemple barn. Intentional proportions seem to underlie the very fabric and constitution of the timber frame. At 56 ft., the length of the barn is twice the width of the central aisle at 28 ft. The width of the central aisle is twice the width of each bay at 14 ft. The purlin braces form 3-4-5 triangles with the purlin plates and the H-frame posts, as do the H-frame braces with the anchorbeams and the H-frame posts. The angle at the roof peak is still exactly 90 degrees, 250 years later. It does seem possible that, after some minor repairs, a Dutch-American farmer could come back to the barn today and resume his farming assignments as if a quarter of a millennium had never passed.

The myriad of specific details incorporated into the Wemple barn could only have occurred during a particular period. All the elements of the structure and the design of various features point to a date around 1760. As substantiating evidence, the accompanying house dates to that time. Nothing in the barn indicates earlier 18th-century work nor post–Revolutionary War work. Among other traits, an earlier barn would likely have had a steeper roof, a shorter *verdiepingh* and a wider central aisle. A postwar barn would have had a shallower pitched roof, a longer *verdiepingh* and a narrower central aisle. Purlin braces entering H-frame posts below the anchorbeams indicate a date in the Revolutionary War era or before. All told, the features of the Wemple barn agree with a date in the decade or two just before the Revolutionary War.

The Wemple barn stands as a celebration of the New World forest, the mind and spirit of early American builders and the needs of an 18th-century Dutch-American farmer of the upper Hudson Valley. Together, they yielded a masterpiece of American pre-Revolutionary barn construction. —Gregory D. Huber

Greg Huber writes frequently on Dutch barns and is a former editor of the Dutch Barn Preservation Society newsletter. He has written more than 100 articles on vernacular houses and barns. Most recently, he edited an augmented edition of John Fitchen's classic work The New World Dutch Barn.

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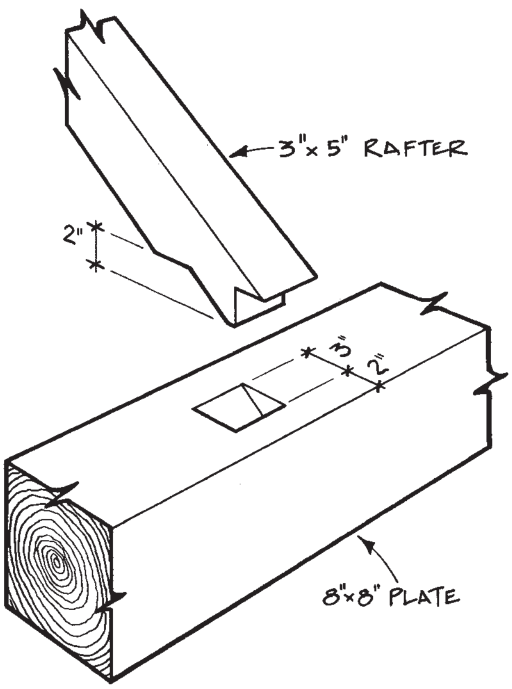
Timber Joinery Addendum I

SINCE the Guild's 2002 publication of *Historic American Timber Joinery, A Graphic Guide*, a dozen or so additional timber joinery examples have come to light. Though all the basic joints have probably been seen, there are likely many local refinements and experiments yet to discover. Here are two rafter seats to ponder.

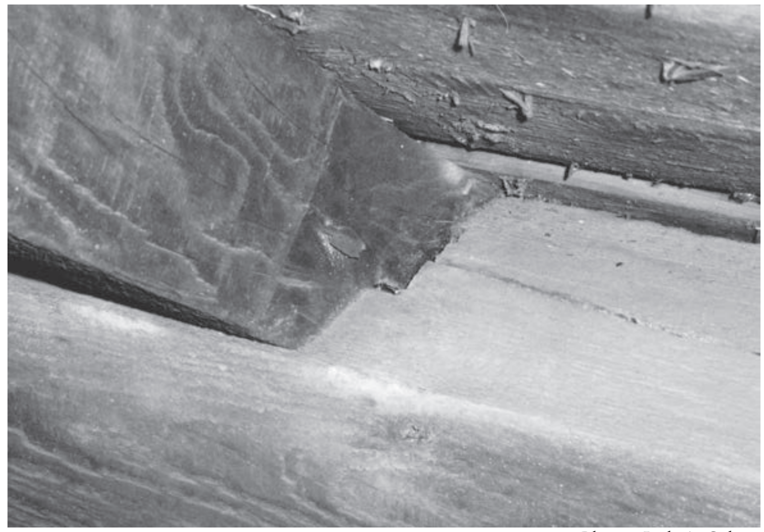
Fig. 1 shows a variation on the housed birdsmouth, found in a 40x70-ft. five-bay, mid-19th-century New England–style barn in Buckland Center, Massachusetts. Typical of this barn type, the 3x5 rafters are supported by a purlin plate on canted posts halfway up the roof slope, where the two separate rafter lengths are butted and nailed (Fig. 2). At the peak, the rafters are nailed to a ridge board. Because of the relative size of rafter and plate, a typical birdsmouth seat at the inner corner of the plate wasn't practical. The builder moved the joint outboard to gain better bearing (Fig. 3).



Jack A. Sobon

Fig. 1. Central birdsmouth, Buckland Ctr., Mass., mid-19th century.

Fig. 2. Purlin on canted posts supports discontinuous rafters. Note ties at plate level.



Photos Jack A. Sobon

Fig. 3. Rafter depth does not allow usual position for birdsmouth on inner corner of plate.

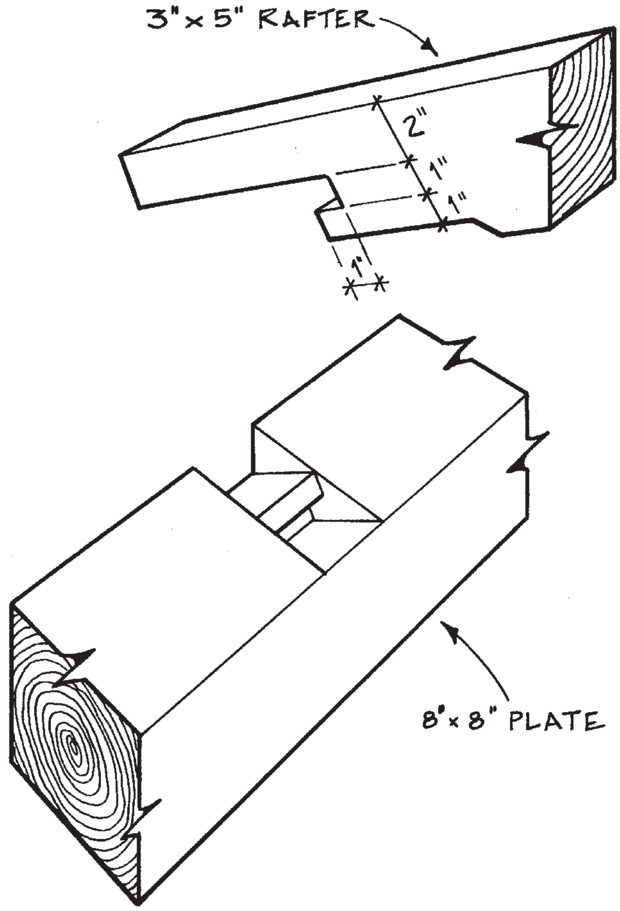


Fig. 4. Stub-tenon steplap rafter seat, Worthington, Mass., ca. 1830.

Fig. 4 illustrates a variation of the common steplap rafter seat as found in an 1830s house ell in Worthington, Massachusetts. The original rafters are gone because the roof was raised, but the telltale rafter seats remain, easily visible on the plate. With the rafters in place, only close inspection could have discerned this variation from the common variety. Probably it was conceived by a carpenter after he had witnessed a roof lift off in a hurricane. It might also have been done to anticipate twisting of plates or rafters during drying. Though it certainly has merits structurally, it's also a good deal more work to execute, on the rafter as well as the plate. The plate showed that a 1-in.-dia. bore was made at each end of the angled mortise preparatory to removing the waste. A nail through the tail portion would have secured the joint. —JACK A. SOBON

HISTORIC AMERICAN TIMBER-FRAMED STEEPLES

V. Engineering a Steeple Restoration

This article is fifth in a series to discuss the form, function and joinery of selected historic American timber-framed steeples. The series was developed from original research under a grant from the National Park Service and the National Center for Preservation Technology and Training. Its contents are solely the responsibility of the authors and do not represent the official position of the NPS or the NCPTT.

THE stability of a steeple in the wind depends on its anchorage to the building's foundations. Steeples may stand free on their own foundations or they may integrate into the endwall or sidewall framing of a larger structure, usually a church. Many roof-mounted timber-framed steeples divide their bearing, with two posts on the endwall of the church and two posts on the first interior roof truss. In many cases, the two interior posts pass through a balcony structure. Endwalls may be timber framed or masonry.

Some steeples comprise square, hexagonal or octagonal stages erected in telescoping fashion and surmounted by a spire, including between their stages transitional structures called crabs. For these steeples a three-dimensional engineering analysis may be most appropriate. A two-dimensional or plane frame analysis may be appropriate for other sorts of steeples.

The engineering analysis of a steeple should consider wind pressure in four directions. No matter what the configuration, wind and seismic forces should be applied in the transverse directions (across the ridge of the main structure) and in the longitudinal directions (parallel to the ridge). Many roof-mounted church steeples lean back toward the nave when support is shared between an endwall and a less-stiff roof truss. Even with the rigid support of timber posts and balcony or narthex wall framing, a steeple will eventually lean if the endwall support is a nonyielding masonry wall. In these cases, a small amount of shrinkage across the grain in each of several large timber plates on the nave side can collectively cause a dramatic lean in a tall church steeple.

For ease of analysis, the timber frame of a steeple may be reduced to primary and secondary framing comprising posts, beams and bracing. Rigidity may depend on X-braces, short knee braces or longer up- or down-braces connecting post to sill or plate, usually at a steeper angle than 45 degrees and running across or through several studs.

A preliminary analysis will reveal whether braces are resisting tension or compression forces. If the computed tension is high, and the ability of the connection to resist tension insufficient, all such tension members should be deleted from the analysis and the program re-run.

The computer model must account for continuity or discontinuity through joints. In the past, traditional truss analysis required that all joints be hinged (able to rotate) to compute axial forces by graphical analysis or the methods of shears or moments. In these cases, bending forces in continuous members were ignored. With the computer and appropriate software, we can provide joints with hinges or we can run members continuously through an intersection. To model half-lapped or intersecting members, a link can be added to the model that allows full or partial continuity through the joint as well as rotation. We can also model springs that allow a support a given amount of movement in response to a given amount of force. Computers thus enable us to more accurately determine the theoretical stiffness of timber trusses and frames.

For steeples with securely fastened sheathing or panels, the additional stiffness thereby afforded to the frame should also be accounted for in the computer model. Despite the relative lightness of their materials, these elements can make a difference.

ST. MICHAEL'S EPISCOPAL CHURCH in Charleston, South Carolina, was built by Samuel Cardy between 1752 and 1761. Its architect unknown (possibly Cardy), it follows English pattern book designs popular in the Colonies and somewhat resembles James Gibbs's design for St. Martin-in-the-Fields in London. St. Michael's survived wars, hurricanes, tornadoes, fires and the 1886 earthquake. During the Revolutionary War it was a center of American resistance and the tower was a target for British naval gunners. The 186-ft. steeple served as an observation post and navigational landmark in this and later military conflicts. As a result of the 1886 earthquake, the steeple settled 8 in. with the spire leaning 18 in. away from the nave toward Meeting Street, requiring reconstruction of the portico below. Repaired cracks in the brick masonry can be observed today from the inside of the tower (Fig. 1).

Hurricane Hugo struck near Charleston at the Isle of Palms in September 1989 and caused damage to St. Michael's resulting in an insurance settlement of $6 million. The winds of this Category 4 storm were sufficient to bend the tapered 2½-in.-square wrought-iron bar carrying the weather vane at the top of the steeple.

The steeple comprises five stages above the roof. The first stage, a square tower pierced by small circular and square windows and partly rusticated in its exterior finish, extends down through the body of the church to form the center portion of the vestibule. Its brick walls vary in thickness from 4 ft. 9½ in. to 5 ft. 3 in. The masonry box, translating from square to octagon, rises through two more stages, the bell stage and the clock stage, to the underside of the open lantern stage. This fourth stage is timber framed, as is the spire, the fifth stage that completes the steeple (Figs. 2–3).

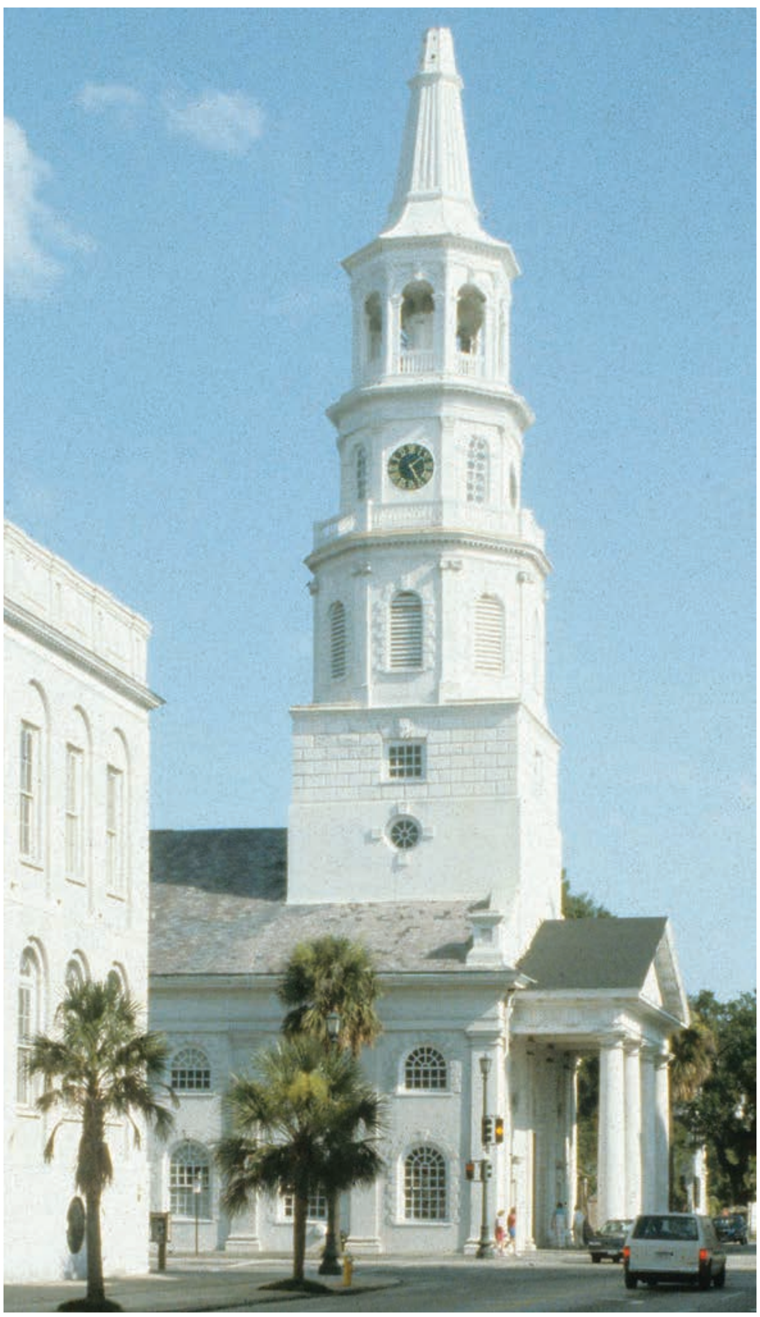
The wood roof trusses in St. Michael's, splendid compound kingpost and queenpost trusses spanning approximately 50 ft., are entirely independent of the steeple.

After Hurricane Hugo, materials conservator George Fore, of Raleigh, North Carolina, produced a condition analysis and conservation study of St. Michael's carpentry, masonry, plaster and finishes. He also provided framing details for the steeple as well as evidence of racking of the upper structure attributable to Hugo, and his report graphically located areas of deteriorated wood within the framework (Figs. 11–12).

To determine the amount of static lean in the steeple, a surveyor set up an instrument in the window of a nearby office building, but measurements were inconclusive. I then made a direct inspection on

C. E. Dutton

Fig. 1. St. Michael's after the 1886 earthquake. Portico leaning toward Meeting Street was rebuilt and large cracks in first bay repaired.



Photos and drawings by David C. Fischetti unless otherwise credited

Fig. 2. St. Michael's in 1996, steeple 186 ft. tall, of which 111 ft. are masonry. Open lantern and spire are wood framed. Ball and weather vane not yet restored to spire.

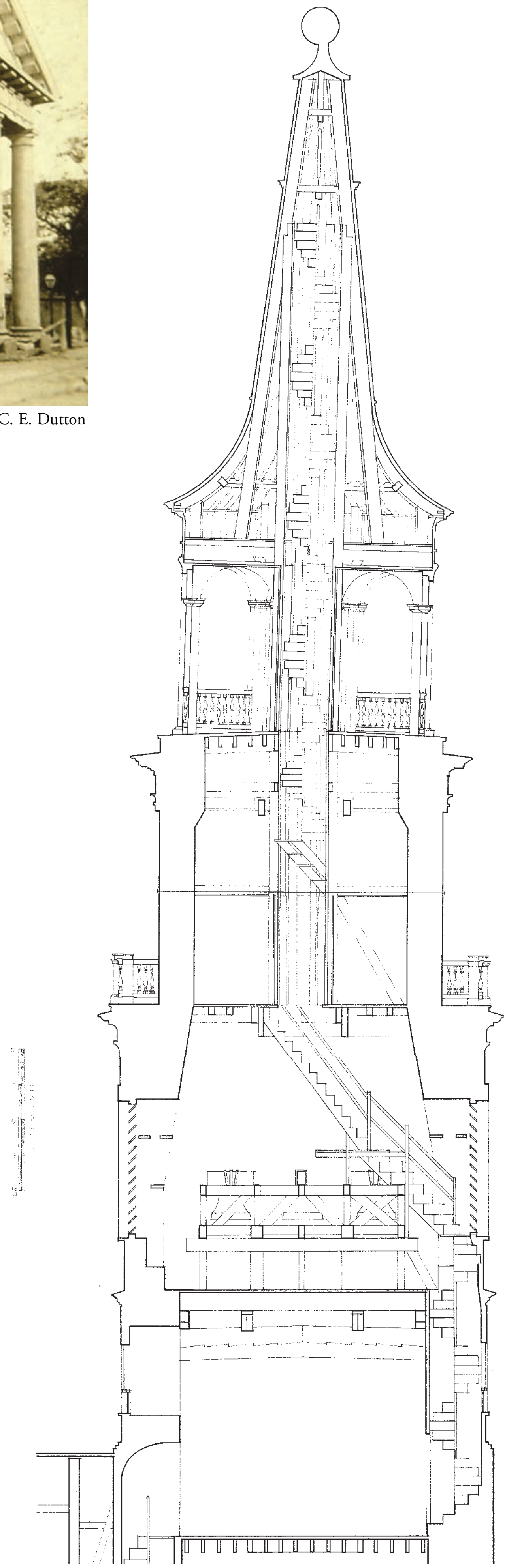


Fig. 3. St. Michael's cutaway steeple elevation looking south. Historic American Buildings Survey, 1963, drawn by Mark W. Steele. Spire and lantern shown listing west, toward Meeting Steeet.

George Fore

Fig. 4. Decorated lantern conceals perimeter posts, portal framing and core of timbers extending down to clock stage.

a day with 5- to 10-mph wind gusts. Craig Bennett P.E. of Cummings and McCrady, architects in Charleston, led me on a climbing tour to the open lantern.

On the day of our visit, we could feel the sway of the lantern and hear the timbers rub against one another. I was impressed by the scale of the structure and the early iron straps and pins added to stiffen the section above the open lantern, a wonderful place with decorative panels, arched openings, curved ceilings and a weatherproof floor covered by lead sheets with tight flat seams. (Exposed, the floor later proved to be caulked with oakum and tar. After repairs to the framing beneath, it was eventually re-covered with sheet copper. See Figs. 15–16.) Access to the lantern was provided by a spiral stair beginning in the clock stage and encircling the primary 8x8 pendant timbers in the central core of the lantern, inside an enclosure cased to match the exterior treatment of the lantern (Fig. 4).

Behind each of the eight arched openings of the lantern was a portal frame comprising two abutting knee braces with a loose wedge between them like a keystone, a perimeter beam and two 11x16 posts. The knee braces, concealed outside by the tightly fitted façade panels, could be observed when we stood on the spiral stair above the lantern ceiling at the base of the spire (Fig. 5).

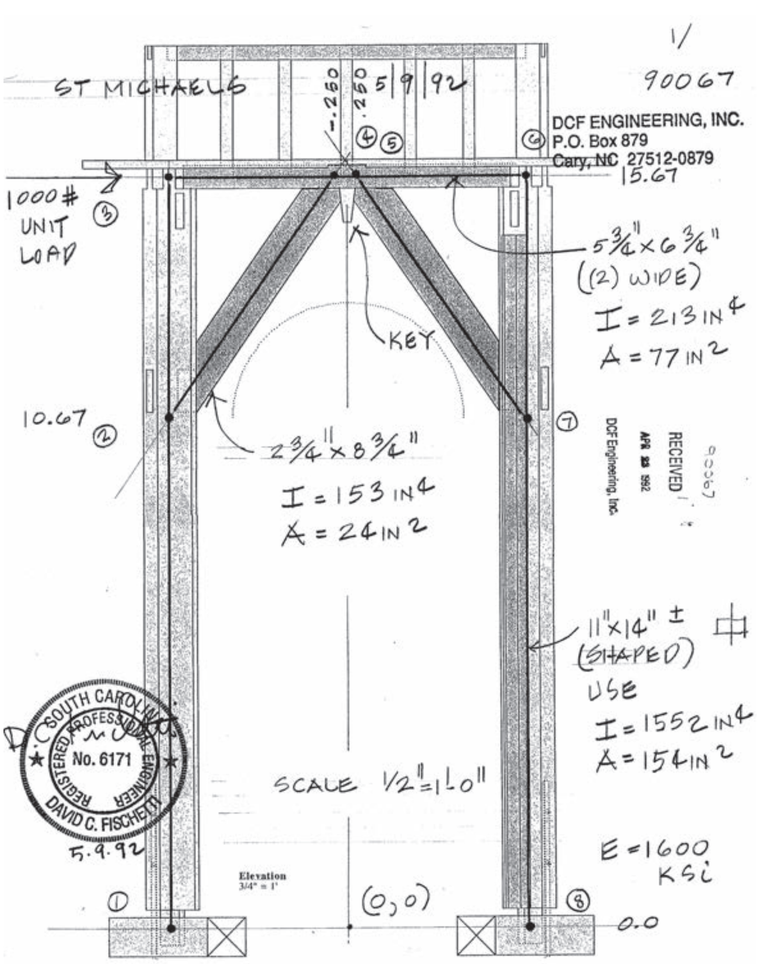


Fig. 5. Portal framing behind finish. Wedge descends through beam.

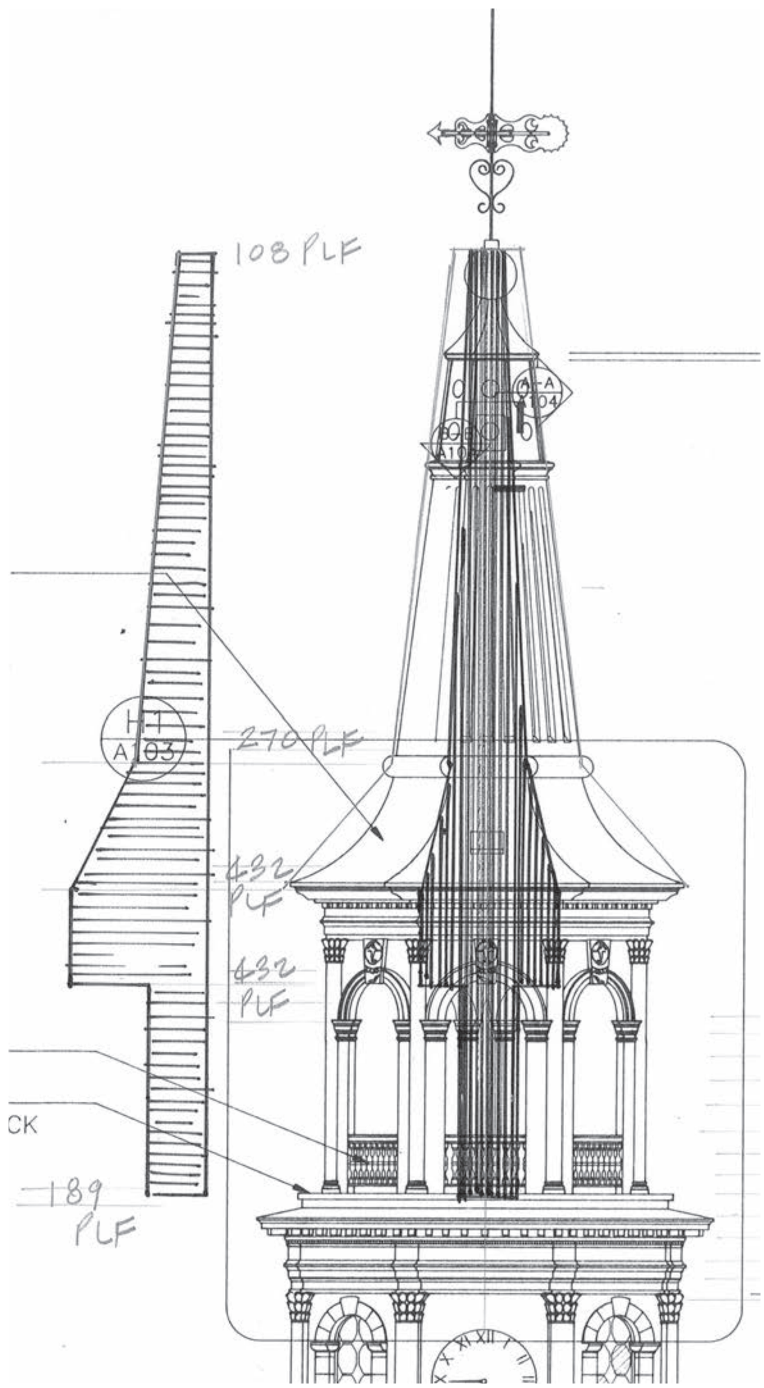
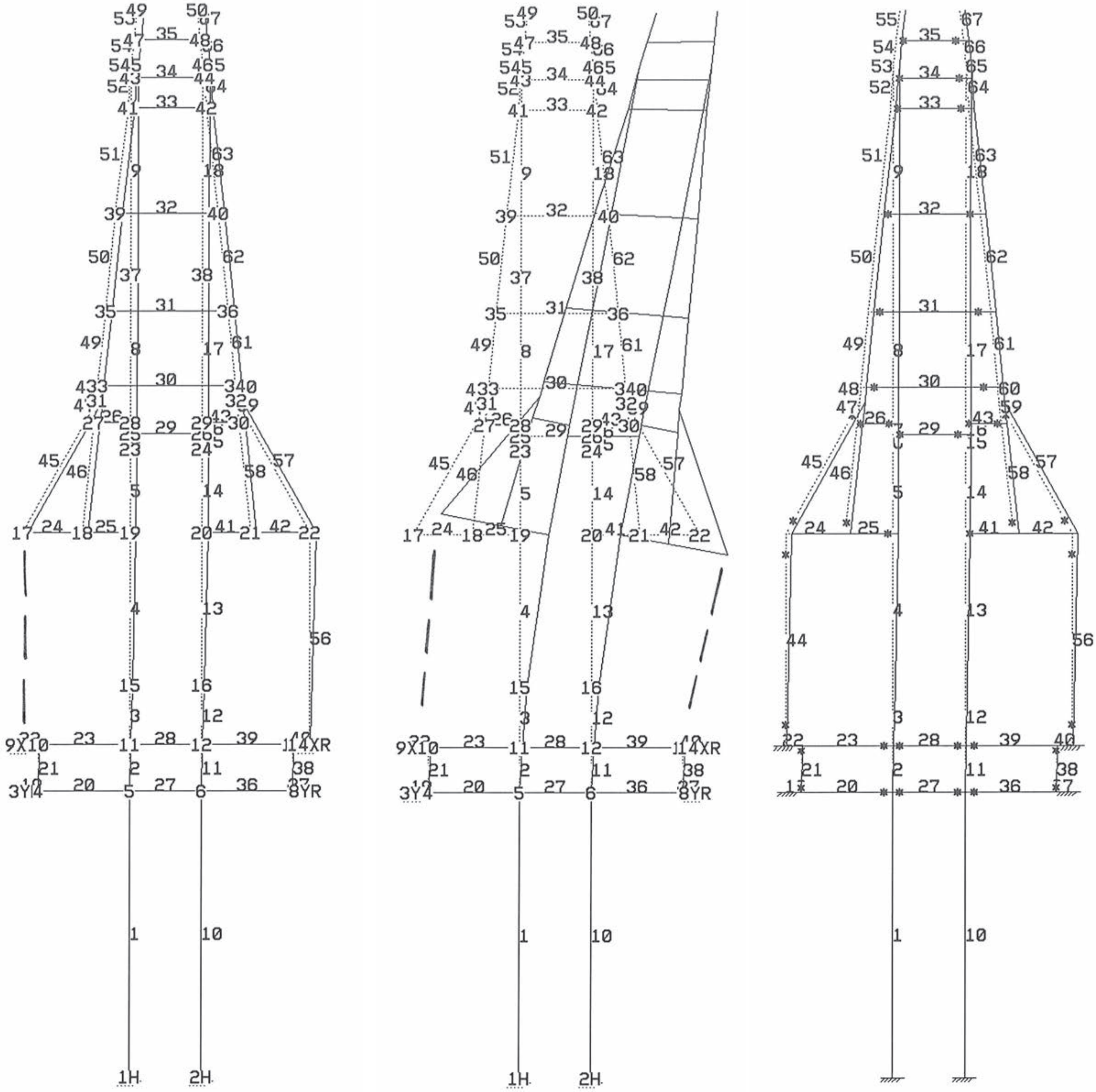


Fig. 6. Application of wind load to vertical projection of one frame.



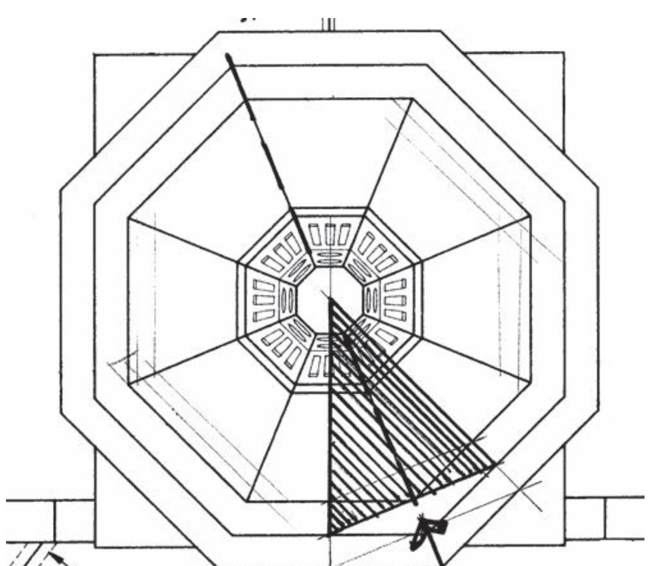


Fig. 7. Pie-shaped part of plan chosen to project upward for loading.

Fig. 8. Wind coming from the left in all cases, drawings represent behavior of a segment of the spire and lantern with the windward post disconnected (model at left, one broken line), windward and leeward posts disconnected (middle model, both broken lines) and both posts connected as built (model at right, solid lines).

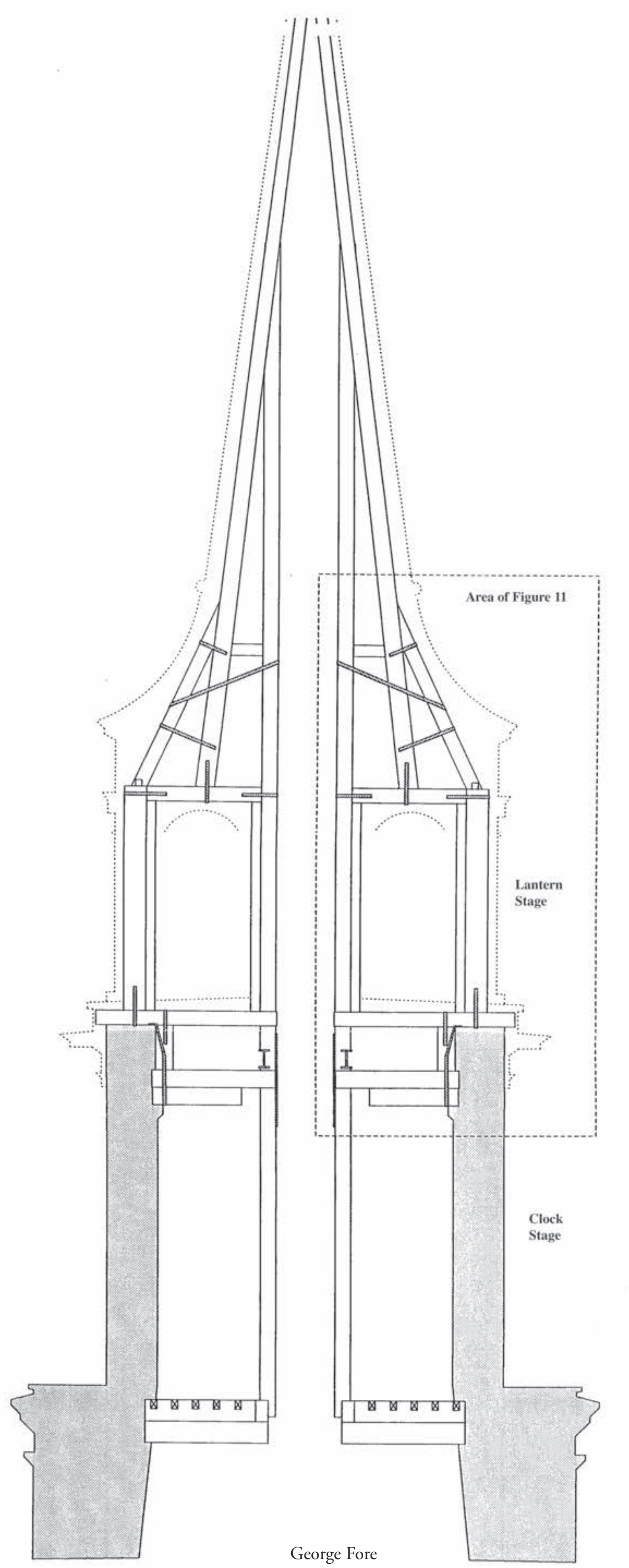
I then performed a plane frame (two-dimensional) analysis of one of the four identical intersecting frames of the spire, applying a 48- to 54-psf wind load to a pie-shaped portion of the plan, modeling the frame as originally built and also as deteriorated or altered by later modifications (Figs. 6–7).

At the same time, preliminary observation had indicated that the eight perimeter posts of the lantern had suffered varying amounts of deterioration where they tenoned into the radial floor beams, which would imply a diminution or actual lack of connection. The engineering analysis indicated that the spire frame responded much less stiffly to forces with these joints at the floor disconnected (Fig. 8).

Fig. 9. Stub post in framing just below the lantern floor, cut by steel beam inserted in 1938. Pendant center posts descending from spire were similarly cut, with significant structural effect.

Of prime concern to all of us were the horizontal steel beams introduced into the steeple in 1938, apparently to provide additional vertical support to the steeple frame (Figs. 9–11). The eight original 8x8 pendant core posts descending from the spire to the masonry clock stage were severed two-thirds through to accommodate these struts. In September 1990 we produced a preliminary structural evaluation report including these observations:

> The introduction of horizontal steel members in the steeple may have caused a discontinuity which is the second major concern. This steel, while providing vertical support, has nearly severed vertical elements which provide a great deal of the overall stability to the steeple. . . . At first glance it would appear that the open condition of the lantern level of the tower is the source of the steeple's inability to resist lateral forces such as wind. But the original designer did provide an excellent method of lateral stabilization with a vertical cantilever which acts much like a flagpole embedded in the ground. The bundle of eight vertical timbers telescopes from the brick masonry box below. The continuity of the eight timbers which extend from the massive masonry ring below the clock level to well into the spire was disrupted by the steel sections which were inserted in 1938. . . . At this time, we agree with George Fore that the deteriorated steel should be removed from the tower, the masonry pockets filled, and the damaged vertical members repaired. Repairs should include epoxy consolidation, epoxy-aided splicing, replacement-in-kind, and appropriate reinforcing which will not change the intended action of the existing structural system or sacrifice original historic fabric.



George Fore

Fig. 10. Framing elevation (no scale) of clock, lantern and spire stages. Eight spire posts form a sort of mast footed at clock stage floor.

We issued a final report in May 1992, offering a simple analysis of the steeple and allowing us to consider a replacement-in-kind option without supplemental steel reinforcing.

George Fore

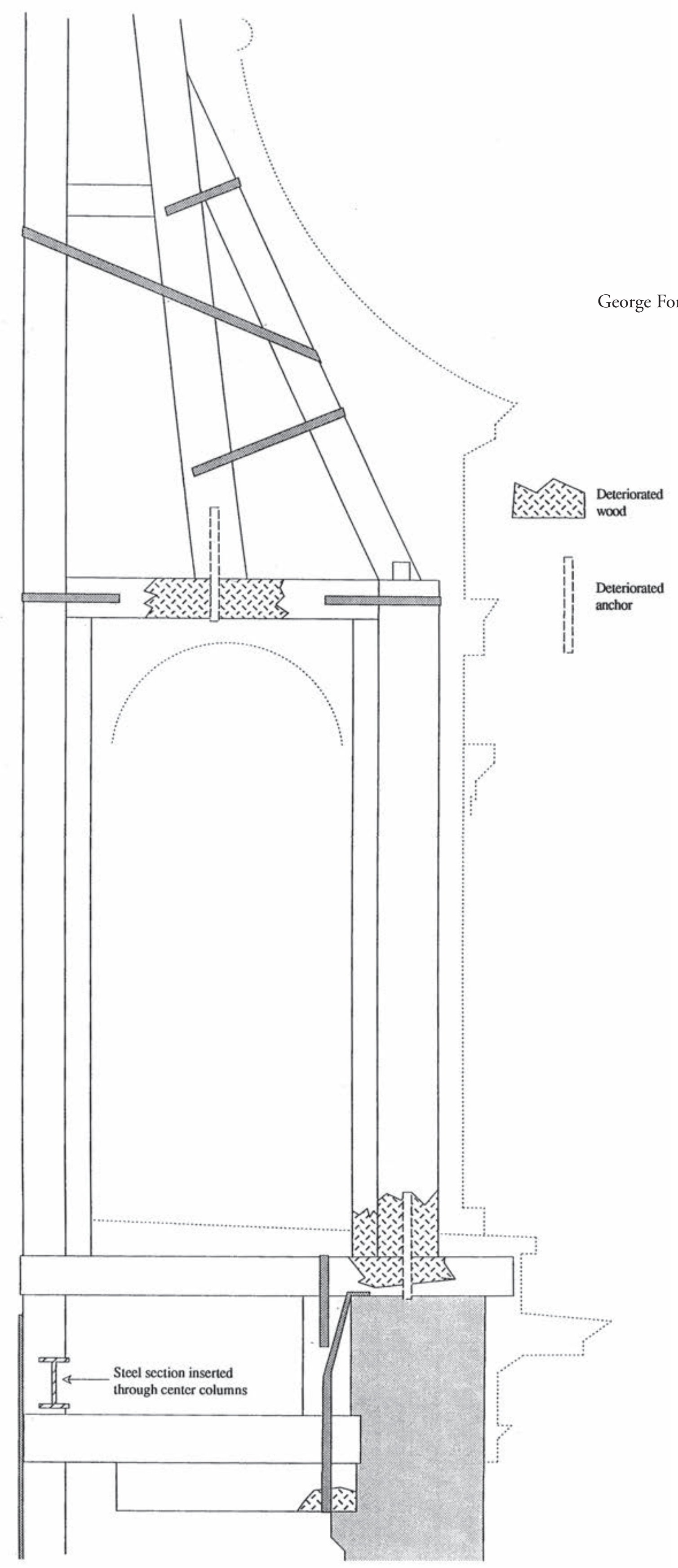


Fig. 11. Detail (no scale) of frame elevation showing deteriorated materials in upper framing. Note inserted I-beam cutting spire post.

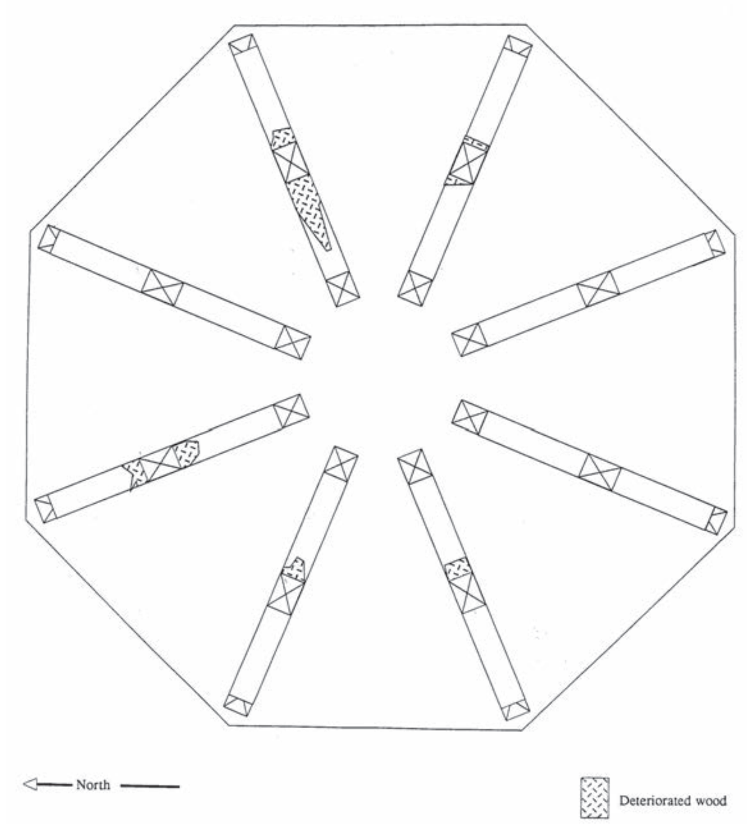


Fig. 12. Plan of framing at base of spire showing deterioration near rafter joints.

For our engineering analysis, we adopted a Use Factor of 1.00 (from the 1988 Standard Building Code) because we thought it highly unlikely that failure of the spire would affect 300 or more occupants in the sanctuary. The limited use of the church sanctuary, normally one day a week, was another reason for selecting the low factor. We applied a support condition to the spire-lantern frame amounting to the approximate stiffness of the two portal frames. The purpose of this exercise was to obtain the most realistic model of the spire by combining the stiffness of one intersecting frame with two portal frames, each of the latter comprising two lantern posts and two 2¾x8¾ knee braces. In determining the stiffness of the portal frame, we deleted the contribution of knee braces when in tension.

We applied a horizontal 1000-lb. unit load to the portal frame to derive the spring constant. To simulate the spire with the base of the lantern perimeter posts not tied down, we placed a roller support with a spring constant in the Y direction at the bottom of the windward post in the portal frame. Using the stiffness of the "deteriorated" (unrestored) portal frame, we re-ran the steeple frame with a new spring constant and the lantern post omitted on the windward side. We used a Modulus of Elasticity of 1600 ksi and limited F_c (compression parallel to grain) to between 1200 psi and 1700 psi and F_t (tension parallel to grain) to 1100 psi (Fig. 8).

The analysis provided the following computed horizontal deflection of the top of the steeple frame under a 100-mph wind load:

As built	2.13 inches
Deteriorated	5.43 inches

This response seemed to be in line with actual conditions. If the spire and lantern were experiencing much larger movements, then their sheathing, cladding and architectural features would be rupturing badly. Each of the eight faces of the lantern stage is sheathed by decorative millwork comprising an arch with exceptional carved applied keystone, engaged columns with carved capitals and smooth entablature (Fig. 4). The lower elements of the lantern architrave were actually molded into the stacked horizontal planks from which the arch was cut, probably by a special-bodied plane shaped like a cooper's croze. George Fore's investigation did point out fractured paint lines at some joints between the planks, indicating that this level of the lantern had indeed racked, causing the

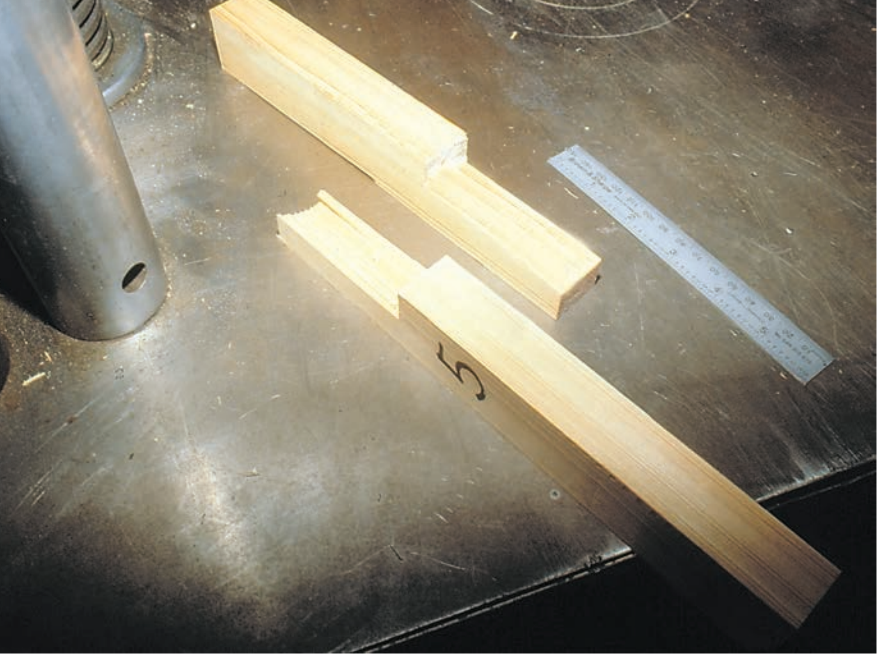


Fig. 13. Gluing-test Specimen 5, establishing joint failure mode.

horizontal planks to slip past one another. Stresses in the various members appeared to be relatively low in their net sections, consistent with a timber-framed structure where the connections govern the design. The highest stress appeared in the interior core posts at the top of the lantern stage, because a large amount of bending was applied to a small net section. (The eight 8x8s, telescoped through the masonry box, resist wind loads in bending through cantilever action. Rotation in the vertical plane of the spire causes maximum bending in the upper portion of the 8x8s.)

As investigation proceeded, the original marriage marks on the scribed timber frame revealed themselves to correspond to compass points. The points shown on our plans keyed to the marriage marks as follows: SSW–I, WSW–II, WNW–III, NNW–IIII, NNE–V, ENE–VI, ESE–VII, SSE–VIII.

Our analysis appeared to set the stage for a replacement-in-kind solution where severely deteriorated members are wholly replaced and the deteriorated ends of other members are repaired.

Tommy Graham, of McClellanville, South Carolina, had been selected by Hill Construction Corporation of Charleston to provide the timberwork in the restoration of St. Michael's steeple. Though my first inclination was to replace in kind the deteriorated timbers and portions of timbers using mechanical splices, Tommy suggested that we make repairs using Dutchmen and a gap-filling epoxy adhesive to maximize the retention of historic fabric. Besides, he said, it would be problematic to acquire large dense cypress timbers dried to a moisture content compatible with the timber inside the tower. To test the epoxy, I directed Tommy to have his crew prepare, under field conditions, six 1-in. by 3-in.-long half-lapped specimen joints that could be transported to a testing laboratory (Fig. 13). With the assistance of the Raleigh office of Froehling & Robertson, Inc., an independent testing laboratory, we tested the specimens at North Carolina State University's Forestry Department using a Tinius-Olsen testing machine. The results tabulated in F&R's report of tensile tests were fairly uniform:

No.	M.C. %	Breaking Load (lbs.)	Stress (p.s.i)
1	10.4	2510	846
2	10.3	2500	842
3	10.2	2855	973
4	10.6	3040	1035
5	10.4	2390	812
6	10.5	1845	634
			(Avg. 857)

Fig. 14. Vertically laminated cypress beam replaced horizontal strut judged beyond usefulness.

We applied a factor of safety of four to the average value obtained by the testing program and used the result to design moment splices between the original wood and rebuilt ends of several of the spider beams. In one case, we discovered a horizontal strut that was totally deteriorated. To replace it, we laminated five cypress boards together on edge (Fig. 14).

New bottom tenons or tenoned ends as necessary for those perimeter posts that had deteriorated at the lantern floor were fabricated from dense cypress with a moisture content of 14 to 16 percent, close to the 11 to 14 percent moisture content of the original frame (Figs. 15–16).

Where the radial 8x10 horizontal timbers (or spider beams as we called them) below the floor of the lantern were severely deteriorated, we replaced them with pressure-treated Southern yellow pine having a 2.5 pcf retention of copper chromated arsenate (CCA) water-borne preservative. These members, embedded 3 ft. deep inside the heavy masonry walls near the top of the clock stage and cantilevered toward the center across brick corbels, provided stabilization and some vertical support to the central spine of the spire. Wrought-iron straps throughout the steeple that had disintegrated too far to be reworked were replaced with stainless steel.

The rehabilitation of St. Michael's steeple required the combined efforts of an architect, an engineer, a materials conservator, a timber framer, a general contractor and a representative of the church. Louis Dawson III, representing the building committee of the church, participated in day-to-day decisions. Besides our reliance on George Fore's materials report and Tommy Graham's timber framing expertise, we enjoyed the frequent advice of consultant John Laurens of Charleston, a near neighbor of the church and an expert in historic fabric. The steady support of Craig Bennett and Dan Beaman A.I.A., also of Cummings & McCrady, Inc., was essential to our own contribution to this project.

—David C. Fischetti

David C. Fischetti P.E. (office@dcfengineering.com) operates DCF Engineering, Inc., in Cary, North Carolina, and has long experience with the repair of historic structures.

Fig. 15. Decayed perimeter post to spider beam connection under lantern floor.

Fig. 16. New post end with tenon completed, bridled beam repair to be fitted and secured.

Fig. 17. Lantern floor peeled of its lead skin reveals splined and caulked floorboards and WSW end of one of the eight radial spider beams.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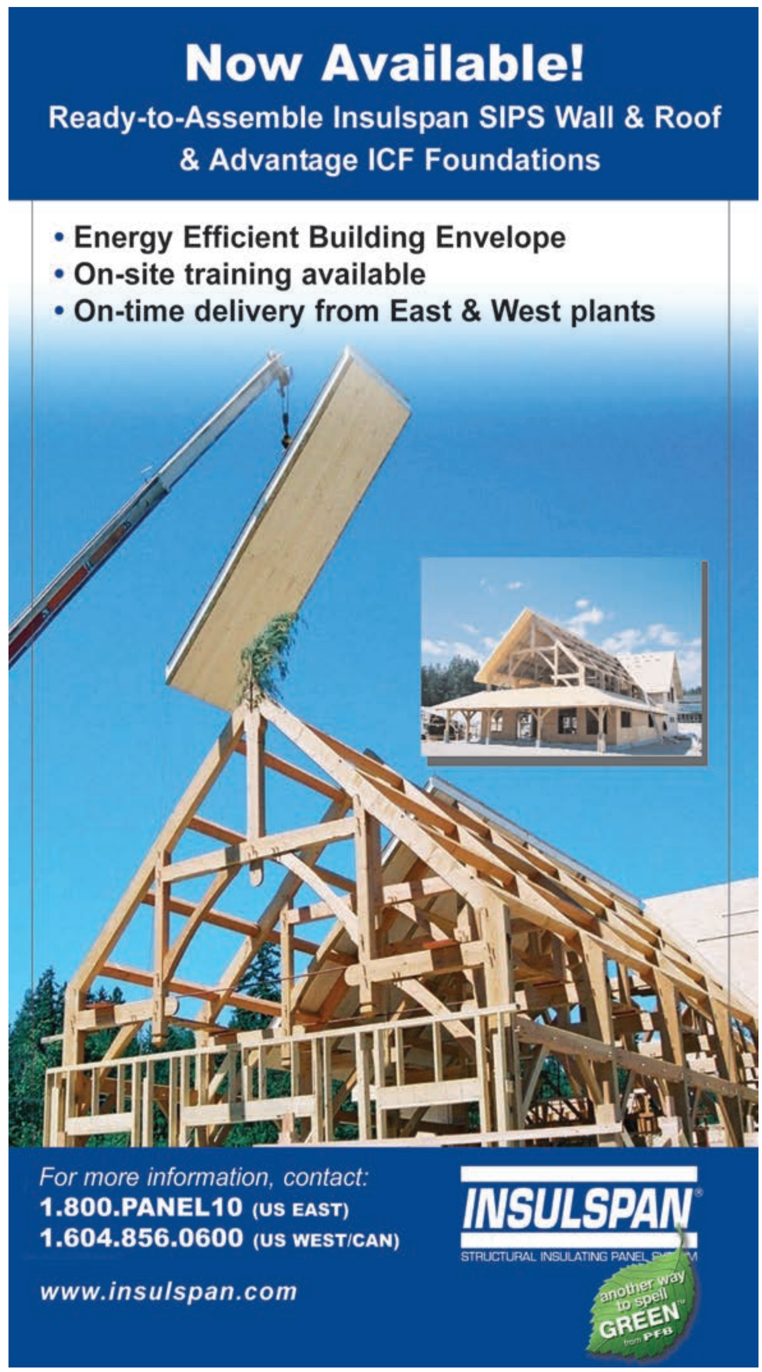
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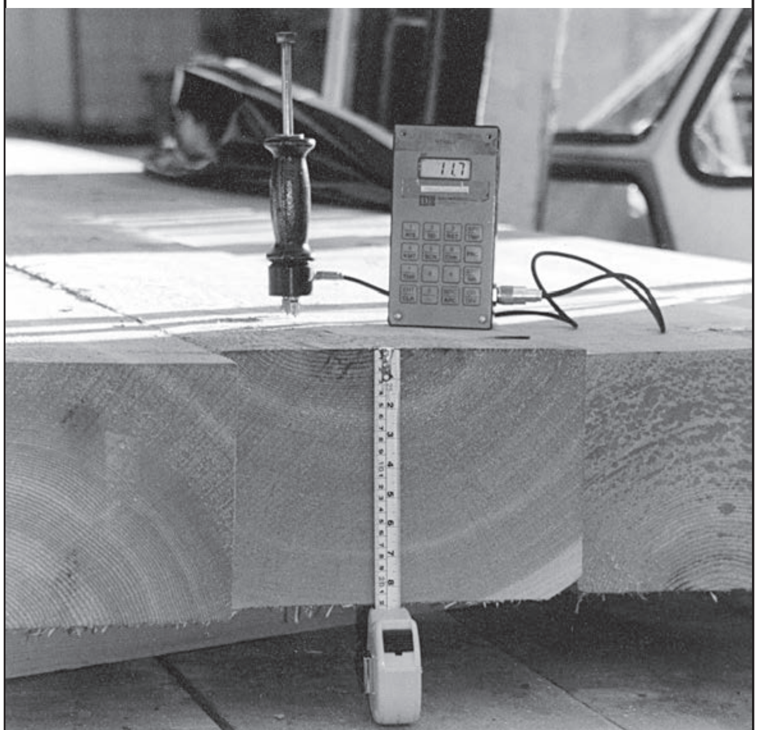


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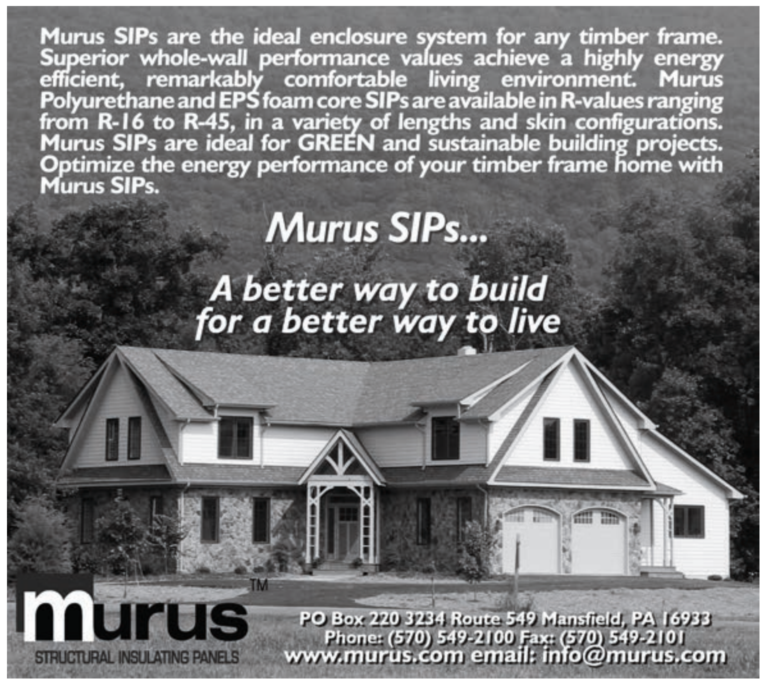
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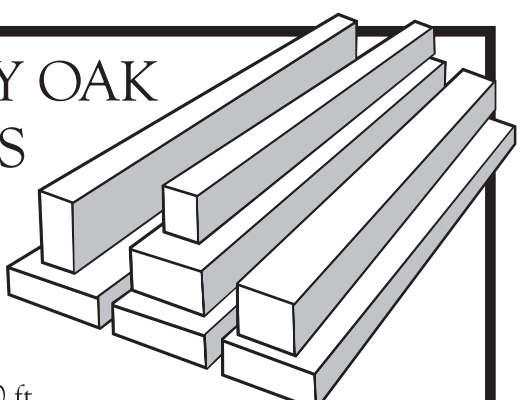
www.murus.com email: info@murus.com



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