TIMBER FRAMING

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Framing in Nepal

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CONTENTS

On the front cover, scarf joints for new temple to Shiva await assembly in Pokhara, Nepal. On the back cover, window frame in house under construction in the Nepali countryside. Photos by Jeffrey Empfield.

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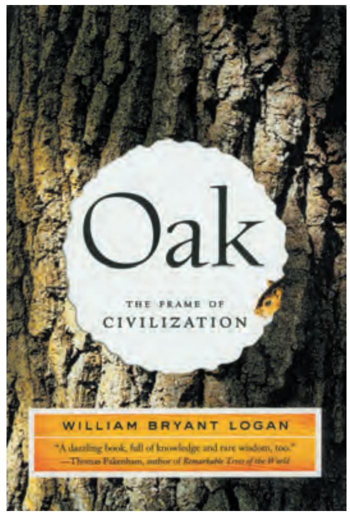
TIMBER FRAMING, Journal of the Timber Framers Guild, appears in March, June, September and December. The journal is written by its readers and pays for interesting articles by experienced and novice writers alike.

BOOKS

Oak's Importance; Preservation Technology

Oak: The Frame of Civilization, by William Bryant Logan. New York, W. W. Norton, 2005. 5½ x 8¼, 336 pp., illustrated. Library binding, $24.95; paper, $15.95.



SPRING has finally made it to most of North America, and with it I have the perfect suggestion to accompany your warmer evenings. With a degree in forestry and 13 years experience working oak from forest to finished product, I could only imagine that *Oak: The Frame of Civilization,* sent to me by a friend, was another in a series of books that just scratches the surface of the tree that I have come to depend on for a living. How nice it was to be surprised and wrong! What I found was a richly crafted, engaging book, written by a peer. Logan, who has also produced *Dirt: The Ecstatic Skin of the Earth,* is an award-winning nature writer and a professional arborist in New York City.

For the woodsman or carpenter, *Oak* brings a greater depth to our work, and places us as successors to a very long line of users. The book also shows how important is the stewardship of our inheritance. For millennia mankind has depended on the oak, not only for building, and the author makes a clear case for a persisting human relationship to the tree. "The distribution of oak trees," he observes, "is coterminous with the locations of the settled civilizations of Asia, Europe and North America."

Logan surveys the global distribution of oak, a northern hemisphere tree that dips below the equator in Indonesia, discussing how the trees have evolved over time and influenced the naming of people and places, and then takes up a little-known benefit of oak, specifically the acorn as an important foodstuff. For those of us who grew up around dense oak forests, it's not surprising that acorns are a ready food source, though we may never have made acorn meal nor understood what a critical staple acorns were in early human diets. Logan uses the term *balanoculture* to describe the human consumption of acorns, citing numerous mentions in classical literature and specific historic examples from Mesopotamia and North Africa—and California. For instance, Indian Grinding Rock State Park in the Sierra foothills has almost 1200 mortar holes in bedrock representing 5000 years of balanoculture. As for our own time, Logan reports finding acorn starch flower and acorn jelly for sale in a Korean grocery store in Manhattan.

It's fascinating to learn how far back the roots of our trade really go. "A craftsman's intellect is valuable because it's tested," Logan

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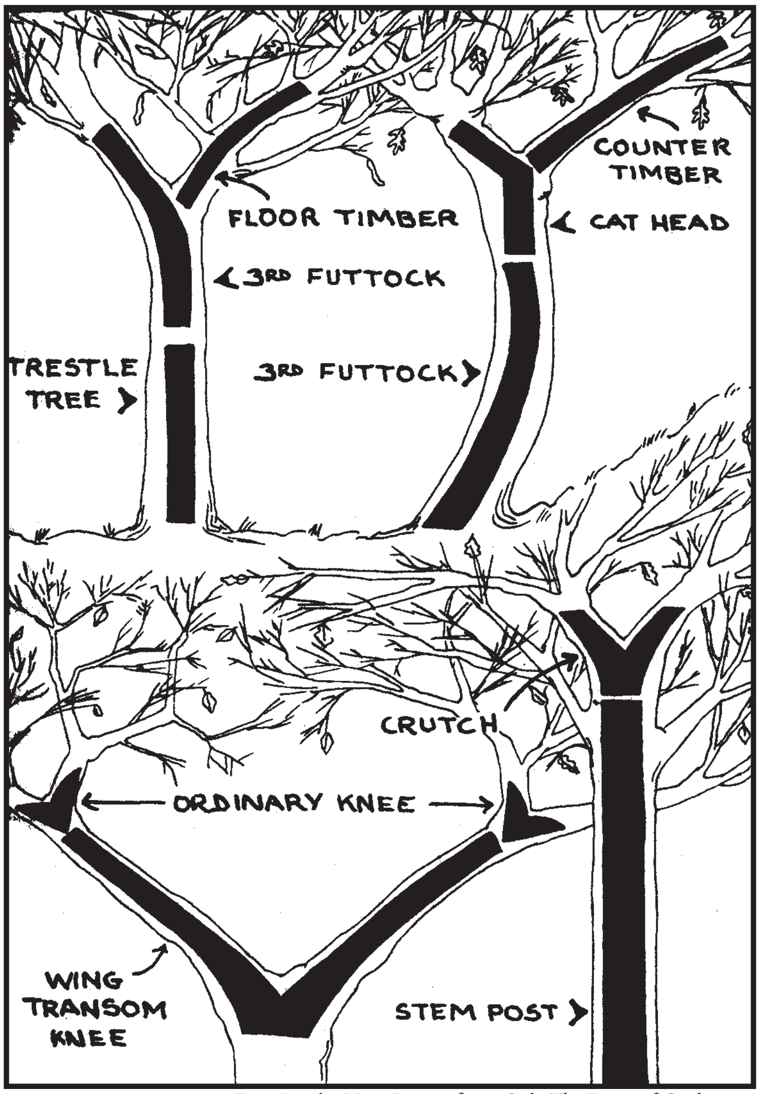
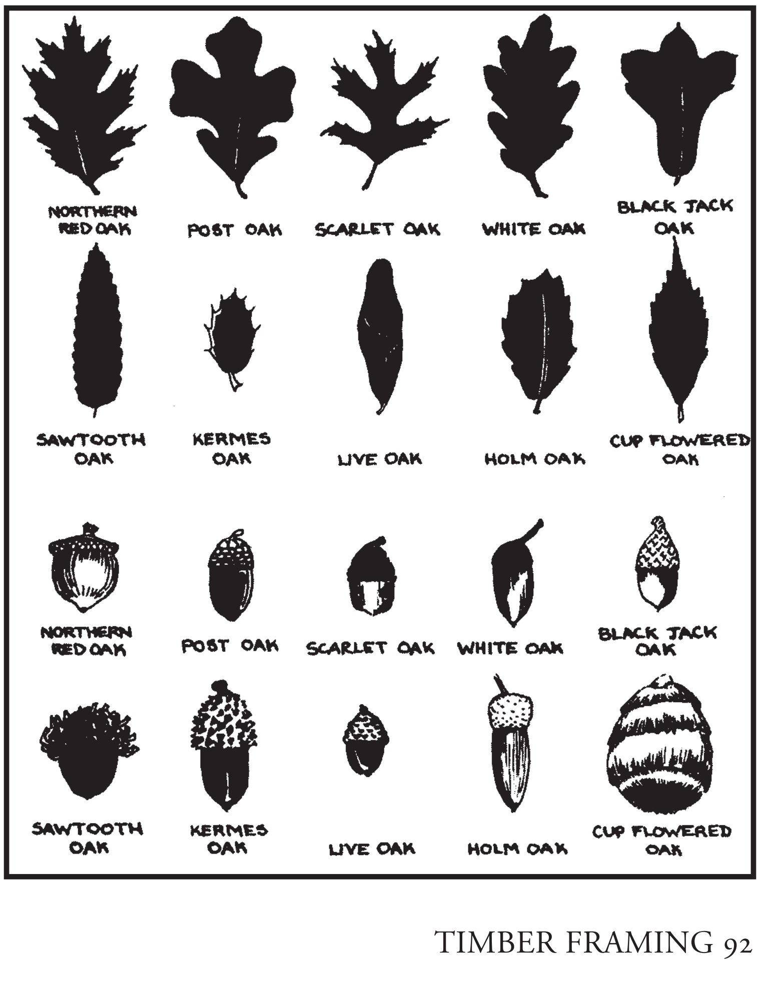
Erratum

The photographer of the Weston House interior shown in TF 91, page 9, was misidentified. Anthony Tieuli took the picture. The editor regrets the error.



Drawings by Nora Logan, from *Oak: The Frame of Civilization*

European sailing ship oak parts. Futtock, of course, is foot oak. Below, leaves and acorns of a few of the 250 species of standing oak.



remarks: techniques and workmanship actually matter. In sailing vessels, they can be matters of life or death. He discusses the massive network of plank roads in megalithic Europe, cunningly evolved, and highlights other structures from the period such as early stave buildings and a large livestock containment facility in England. Mankind has been using woodwork joinery and relying heavily on structural oak for over 3000 years. Among numerous early oak constructions cited in the book, most interesting to me as a builder was an archaeological find in the Netherlands dating from ca. 1475 BCE. Although I'm not going to tell you what was found, I will say that it's what we all build today.

Logan offers a broad discussion of European sailing ships, from the Vikings to the golden age of shipbuilding in the 18th century, and ending with the building of the ironclad ships of the US Civil War. Not a shipwright myself but an admirer of the trade, I found engrossing his story of Viking ships, whose flexibility made them fast and simultaneously seaworthy enough for journeys to North America. Viking craft were not built plank on frame but rather as shells of lapped and riveted cleft-oak strakes erected on keels and stems, with their stiffening ribs fitted last to the inside of the hull. Logan discusses in some detail the British and American fleets of the War of 1812, as well as the massive shipyards in both countries throughout the 19th century, citing the superior construction of the USS *Constitution*, "Old Ironsides," framed with live oak and planked with white oak, and the standoff battle between the CSS *Virginia* and the USS *Monitor* during the Civil War.

In redrawn sketches and drawings reproduced from familiar sources such as Hewett and Harris, as well as original drawings by Nora Logan, we see how people have used oak, often exploring in detail trades that sprang specifically from oak—shipbuilding and house carpentry in particular, but also tanning, charcoal-making and cooperage. Sometimes Logan touches on the question why we have revered oak as a building material for so long: "Permanence, dignity, grace, strength. These are the qualities that men and women sought in oak."

Resource management of original oak forests in the United States has been neglected. In Illinois, the last remaining megalithic-era forests of our region, bur oak savannas such as once existed in ancient Europe, are slowly and systematically being destroyed. While we continue to harvest the result of seedling growth of 70–165 years ago, the inner circles of forestry spell doom for oak forests in North America. Chemical use, lack of fire, nuclear energy, pasturing forest land, soil pH changes from acid rain, invasive species deranging soil temperatures for germination of acorns—the list of problems is long and does not look good for the oak tree.

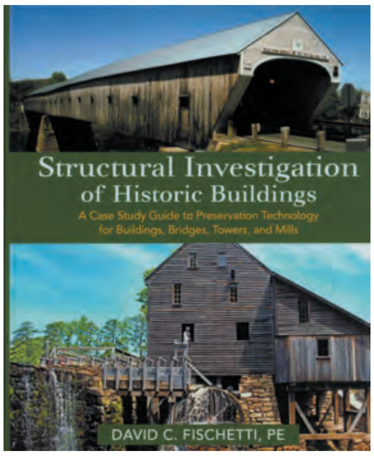
Throughout the book, Logan emphasizes the long importance of oak in the temperate, deciduous and chapparal forest biomes, and the very short time frame underlying modern thinking. We live in a version of the world made with fossil fuels. Comparing "the world made with wood and the world made with coal and oil," he observes, "one lasted 12 to 15 millennia; the other has lasted about 250 years so far," and quotes C. S. Lewis: "When you are on the wrong road, the shortest way to go forward is to go back to where you made the wrong turn and make the right one." Good advice for an age of increasing information and technology. Logan's advice to us regarding oak trees, the environment and living sustainably is that to live in the present we need to put one foot in the past and one in the future.

Upon finishing this book, I felt the need to go right out and plant an oak tree. I would have done so except that the ground was still frozen. I will wait a few weeks, but you can bet this year I'll be scrounging the woods for acorns to germinate from some of the best-looking trees I can find. —Rick Collins

Rick Collins (r.collins@trilliumdell.com) leads Trillium Dell Timberworks in Knoxville, Illinois. He is president of the Guild for 2009.

Preservation Technology

Structural Investigation of Historic Buildings: A Case Study Guide to Preservation Technology for Buildings, Bridges, Towers, and Mills, by David C. Fischetti, PE. Hoboken, N.J., John Wiley & Sons, 2009. 7⅝ x 9¼, 288 pp., illustrated. Hardcover, $95.



IT was on my first visit to the UK that I began to understand the interwoven worlds the British euphoniously describe as "conservation" and "new build," learning that timber framers in Old Europe were by and large switch-hitters, equally at home in preservation and new construction. Not so back in the day in the US, where the great majority worked exclusively building new *or* restoring old frames and there was scant cross-fertilization. Fortunately, this gulf has diminished over the four decades since timber framing re-entered the construction mainstream in North America. And one positive sign of reunion is the publication of *Structural Investigation of Historic Buildings,* by David C. Fischetti, a civil engineer with offices in Cary, North Carolina.

Over a career spanning 40 years (to date) as DCF Engineering, both timber engineer and preservation specialist, the author has done much to bring together the best of both worlds. And it's clear that both sides of the equation stand to benefit. For new builders, historical timber framing offers a vast textbook of technique, style and experimentation in which to delve. Likewise innovation, new tooling, imaging technology, materials testing and computer analysis all find applications in historic preservation—to say nothing of the mutually beneficial exchange between professionals from both areas. The book at hand is particularly valuable as a distillation of the author's broad experience across multiple disciplines, most especially in his preservation philosophy and sometimes iconoclastic opinions on code and the complexities of engineering and preservation practice. You may not always agree with Dave Fischetti's conclusions, but you can't fail to find them thought provoking.

Preservation engineering has its own requirements. Fischetti cites relevant code provisions and rehabilitation guidelines and explains the difficulties of assessing traditional structure behavior against modern performance standards. He recommends recourse to *The Secretary of the Interior's Standards for Rehabilitation* (first developed and published in 1977) and to selected code provisions specifically addressing historic buildings. For instance, the 2003 International Building Code (IBC), Section 3407, states: "The provisions of this code relating to the construction, repair, alteration, addition, restoration, and movement of structures, and change of occupancy shall not be mandatory for historic buildings where such buildings are judged by the building official not to constitute a distinct life safety hazard." In this light, Fischetti opines that "for timber structures it may be unrealistic [when load testing] to apply full live load plus an increase for a period such as 24 or 48 hours, when the structure actually will never reach that service loading for that length of time."

Cleaving to the principle of "First, do no harm," the author looks for rigorous analysis to support "doing nothing to a historic timber structure that has been performing satisfactorily for many years." When analysis and observation do indicate unsafe conditions, structures should "be reinforced in the most sensitive manner in an attempt to retain as much historic fabric as possible." In a short chapter, he can hardly offer a complete course of study, but manages to touch on important points, opening doorways to further investigation. Beyond technicalities, we are reminded that, in the age of global warming, rehab and reuse of our considerable pool of existing buildings are the first options for sustainable construction.

If under the tenets of preservation philosophy the first option along the critical path of restoration choices is to do nothing if possible, then to repair in place, then replace in kind, and always to maximize the retention of historic fabric, what to do when these less intrusive options won't suffice? Sometimes the right choice is neither intuitive nor obvious. In several major building repairs, Fischetti specified cast-in-place flat-plate concrete floors to bring inadequate timber frame buildings up to code. In these cases, the iconoclastic system was both more affordable and did less to disturb historic structures than proposed alternatives.

You learn quickly in this book that the author is not shy of opinion and advocacy. While *Structural Investigation of Historic Buildings* covers concrete, brick, steel and tabby (originally lime, water, sand, oyster shells and ash), its prime focus is historic timber framing. Fischetti observes that, unfortunately, "many structural engineers earn degrees in structural engineering without ever taking a course in timber design," and dedicated timber engineering programs are few and far between. For them (and for the rest of us), Fischetti devotes chapters to simplified engineering and to engineering principles applied to historic structures, covering preservation philosophy, structural review, engineering judgment and load duration and creep, with several illustrative brief case studies. Lamenting the ongoing trend toward increasing complexity and convolution in modern structural engineering, Fischetti offers a primer in simplified engineering, pointing out top-heavy areas of code and practice and offering alternatives where possible. He points out that "as the computer reduces calculation time, it also reduces the time spent on a project with all of its intricacies and details. We thus lose time spent 'sleeping on it' that can give us a clearer picture." In addition, the author singles out seismic design:

> Based on the limited risk of a seismic event in most of the United States, it is in the best interest of the public, the construction industry, and architectural and engineering professions, to limit the complexity of the seismic code and its application to existing buildings.
>
> When California and Hawaii are excluded, we have suffered a total of 261 deaths from earthquakes in 245 years. More structural engineers in the United States will die from heart attacks due to stress—caused, in part, by an effort to implement a complicated seismic code—than all of the earthquake victims combined.

One chapter focuses on the role of specialty contractors in historic preservation. Often the low bidders on preservation projects are mainstream general contractors whose capabilities stop short of the specialized techniques required. The politics can be intricate to find and engage specialists, including masons, building movers, historians, wood scientists, surveyors and preservation architects. Given the primacy of timber framing as the fundamental structural system in many old buildings, however, timber framers take a leading role in most of the case studies cited. In the unfolding of these stories, readers may recognize old friends and colleagues. Indeed, the core of the book (ten chapters) comprises project case studies from the DCF Engineering workbook. Interspersed is additional material on timber structures in general and covered bridges in particular, along with individual chapters dealing with of uses of glulam and engineering with tabby. The first set of case studies features historic buildings, the second covered bridges.

Among my favorites were the relocation of the Cape Hatteras Light, house-moving on a remarkable scale, and the rehabilitation of the Market Hall in Charleston, South Carolina. The 1841 Market Hall faced many of the usual ravages of time, but also suffered the effects of a major earthquake in 1886. And, during Civil War bombardment by federal artillery, a shell came down through the roof grazing the bottom chord of one of the kingpost trusses, a repair challenge that you don't face every day. An even greater challenge to the building turned out to be 20th-century preservation politics, which called forth all the author's persuasive powers to reach agreement on a repair solution among contending factions.

One of the roads not taken in Charleston employed plywood diaphragms. Fischetti remarks:

> Although the American Plywood Association credits the ancient Egyptians with the invention of plywood by altering the direction of grain of wood veneers in the construction of mummy cases, I did not want to use a twentieth-century construction material in the restoration of the Market Hall. One concern of using plywood for such an application is that the layers of adhesive, although thin, might act as an improved vapor barrier, retarding the movement of moisture through a building.

In the Cape Hatteras Light project, politics again proved the principal obstacle, requiring a major public campaign to persuade the National Park Service that the only feasible strategy for saving the building from the erosion of its barrier island home was to shift it 1000 yards inland. Future relocations of the 208-ft., 2600-ton brick-and-granite lighthouse won't be Dave Fischetti's problem. But he wonders:

> In the movie *Brazil* . . . Harry Tuttle is a heating engineer illegally providing mechanical repairs outside the government's inept Central Services branch. . . . "Get in, get out, travel light . . . a man alone" is his philosophy as he provides much-needed emergency repair services, which are considered by the government to be sabotage.
>
> As we dictate methodologies in our building codes in an effort to ensure uniformity in approach, do we stifle creativity? Do we remove humanity from the design process as mandated design is implemented? Are mandated design methods an attempt by some in the design community to ensure that designers conform to a certain analysis-based ideal? In the future, will we have to depend on the Harry Tuttles, working outside of the system, to keep the system running?

Covered bridge enthusiasts will be delighted to find bridges old and new, with two chapters on history and morphology. We recall that an estimated 10,000 covered spans were built in the US between 1805 and 1885. A woeful saga of neglect and well-meaning but misguided repair has left us with only about 800 survivors. The lives and work of noted truss designers and bridge builders Theodore Burr, Ithiel Town and Herman Haupt are recognized, along with modern restoration work by Milton, Arnold and JR Graton and Jan Lewandoski. Fischetti singles out three bridges for special attention, including the 406-ft. two-span Cornish-Windsor bridge spanning the Connecticut from Vermont to New Hampshire, built in 1886 by James Tasker and Bela Fletcher. It's the longest surviving covered bridge in the country and the longest two-span covered bridge in the world. Following a debate on restoration methods (addition of laminated timber arches vs. substitution of glulam for heavy timber), in 1989 the bridge was repaired and its carrying capacity upgraded for truck traffic by replacing chords, floor beams and bolsters with glulam timber.

—Ed Levin

CITATIONS

With this issue we begin a new column of short personal reviews to cite books, articles and websites of interest to timber framers. —Ed.

"Bending Wood," text and illustrations by Harry Bryan, *WoodenBoat*, Jan/Feb 2009, No. 206, pp. 33–38. This sweet article describes reasonable ways to fashion curved structural timbers—and, just as important, some ways not to do it. Laminating and steam-bending are nicely summarized. This issue's regular wood technology feature, by Richard Jagels, is titled "Customizing Our Woodlots to Adapt to Climate Change." I love this magazine for several reasons. It is, for instance, a crucial and long-time component of my treatment program to resist actually owning a wooden boat.

¶"Cathedral of Christ the Light, Oakland, California," by Mark Sarkisian, P.E., S.E., Peter Lee, P.E., S.E., and Eric Long, P.E., *Structural Engineer,* February 2009, pp. 30–33. A great story on the new and magnificent 1350-seat cathedral, inspired by the *vesica piscis* ("bladder of the fish") and shaped with Fibonacci Sequence geometry. Its vertical glulam ribs are wrapped in glass, making the building spectacular from within and viewed from without. It sits close to a major fault line but is designed and expected to resist the 1000-year quake. This cathedral is a testament to the state of our building art—as cathedrals always have been.

¶"Steel moment frames in light-framed wood structures," by Paul McEntee, S.E., ibid, pp. 24–28. A splendid summary of the history and design concerns in building lateral-load-resisting steel components into wooden structures. If you have not, yet, run into a steel-moment frame in your buildings, brace yourself.

¶http://books.google.com/books?id=WEwLAAAAYAAA&printsec=titlepage&source=gbs_summary_r&cad=0#PPA732,M1.I have found some pretty great websites, in the course of my surfing. This one is a scanned version of the classic work on key-laminated beams, by Kidwell, and seems part of the Google effort to scan all printed words into its databanks.

¶http://www.treehugger.com/files/2009/02/swedish-mirrored-treehouse.php. I recently attended the World Treehouse Conference, addressing a few remarks on timber structural engineering as applied to structures in trees, all while learning a ton. This site describes a Stealth Treehouse that can sneak past authorities. I imagine that timber framers could find applications, as well.

—Ben Brungraber

LETTERS

In Ben Weiss's excellent article "Four Portable Chain Mortisers" (TF 91), he mentions that both "Hema and Mafell mortisers are sold as slotting machines that can be upgraded to mortisers." I cannot speak for Hema, but the first Mafell mortiser, developed in 1926, was strictly for making mortises. It wasn't until the 1980s that slot-mortising attachments were offered as options. This has remained the case to this day.

With regard to Ben's comments on electric plugs, unfortunately it is not a matter of the retailer supplying machines with the "more popular plugs." Manufacturers are required to adhere to industrial and governmental standards to get appropriate safety certifications. The motor on our mortiser is rated at 20 amps. We are therefore required to supply a plug rated for this amperage, the plug Ben referred to regretfully in his article.

Dennis Hambruch — Manager, Mafell North America Inc.
Williamsville, New York 14221

WHEN ROOFS COLLIDE

V. More Powers of the Tangent

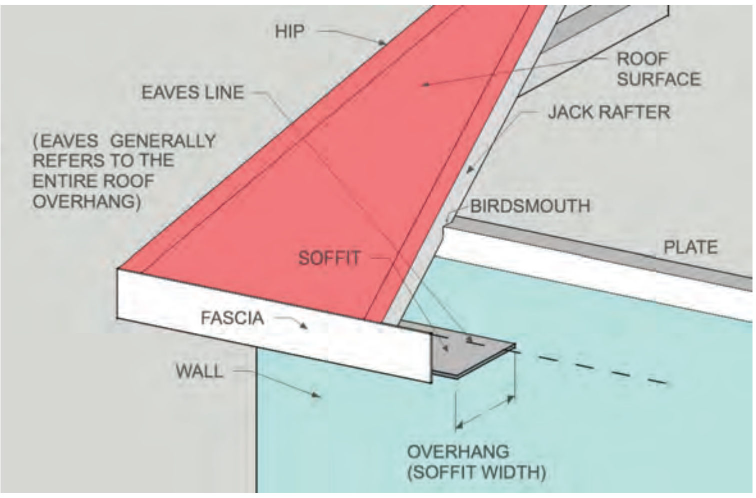
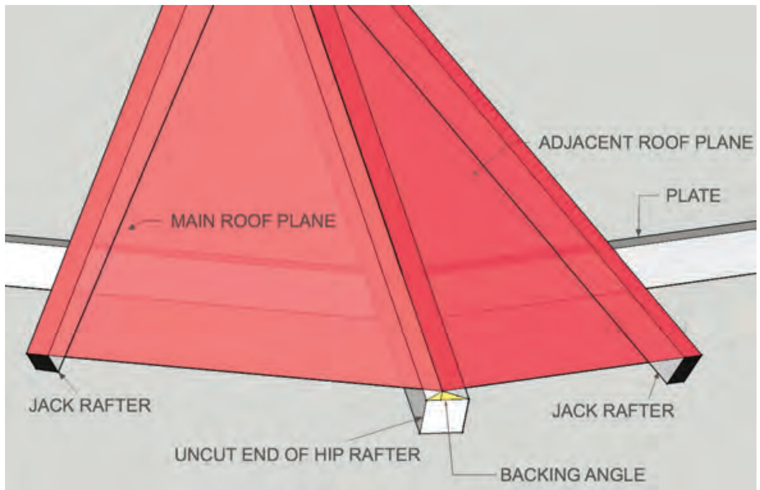


Fig. 1. Anatomy of trim applied to compound roof.



Drawings Will Beemer

Fig. 2. The backing angle in context. Plates uncorrected for height.

This article is fifth in a series. The first three articles of the series appeared in TF 70, 71 and 73 respectively under the general heading "Timber Framing for Beginners." The fourth appeared in TF 90 under the current heading "When Roofs Collide."

IN the preceding article in this series, we saw the power of the tangent, a line drawn in plan view square to the run of any rafter. We used this line to develop triangles and planes that define various cuts on rafters in compound roofs.

Here we will continue to use the tangent to help us find solutions to more problems that occur when we have *irregular pitch* roofs, compound roofs with different pitches (Fig. 1).

Consider first the backing angle (Fig. 2). This is the compound bevel (shown in yellow) formed on the top surface of the hip or valley rafter to carry the two different roof sheathing planes (in red). Because we have two different roof pitches intersecting in an irregular roof, the corresponding backing angles will also differ. There are various ways to find these two angles graphically or mathematically; the easiest way I've found is to draw it the way we did in the first article of this series (TF 70, December 2003). Graphic methods allow you to learn and see the development, compared with math.

Here's how the backing angle can be found graphically on any hip or valley rafter of irregular plan or pitch:

In Fig. 3, we have a 9:12 pitch main roof with a 12:12 adjacent roof, with the plan view of one representative corner projected down to the deck. In the plan view (Fig. 4), draw the run of one of the hips, the eaves and an elevation view of the hip rafter (in red) as we did in the previous articles (I'll use "hip" only from here on out since the procedure for the valley is the same). Next draw a line (the tangent) square to the hip run out to the eaves line; it can be drawn anywhere along the run as long as it intersects the eaves. This is the backing run. From where the backing run strikes the hip run, draw a second line square to the hip length; this is the backing rise. Then, with the compass, arc this point down along the length until it intersects the hip run. Connect this new point along the hip run out to the point along the eaves where your tangent intersects and you have defined the backing angle. Repeat on the other side for the adjacent roof.

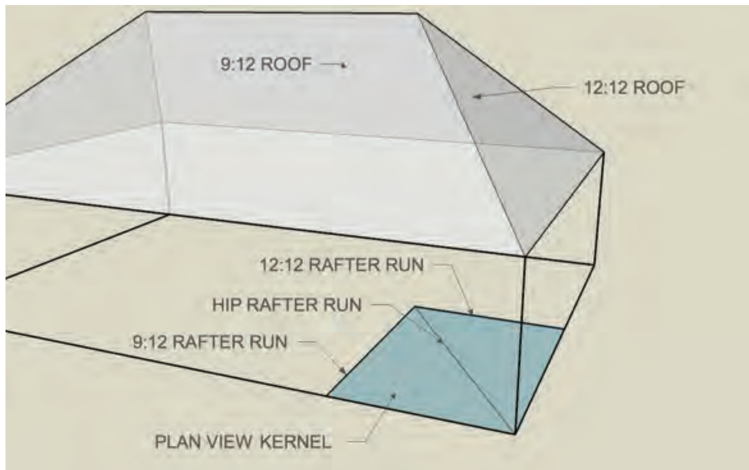


Fig. 3. Representative hip roof, plan view projected onto deck.

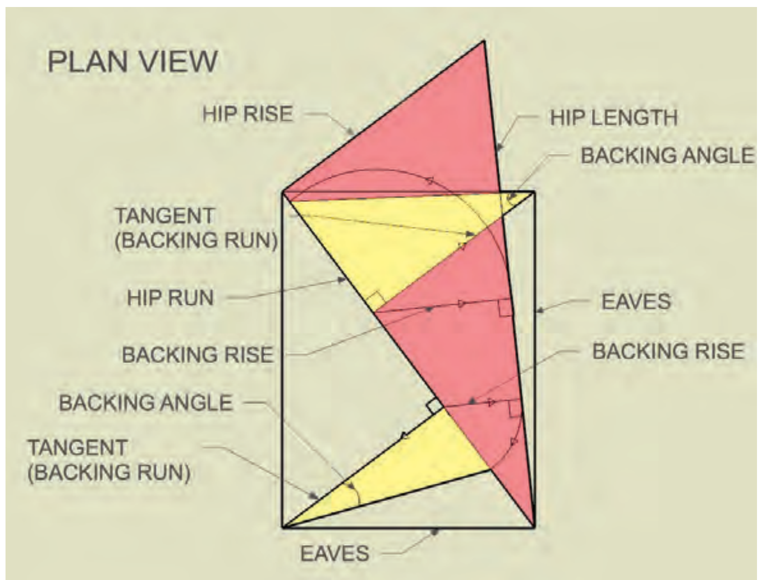


Fig. 4. Plan view showing development of backing angles.

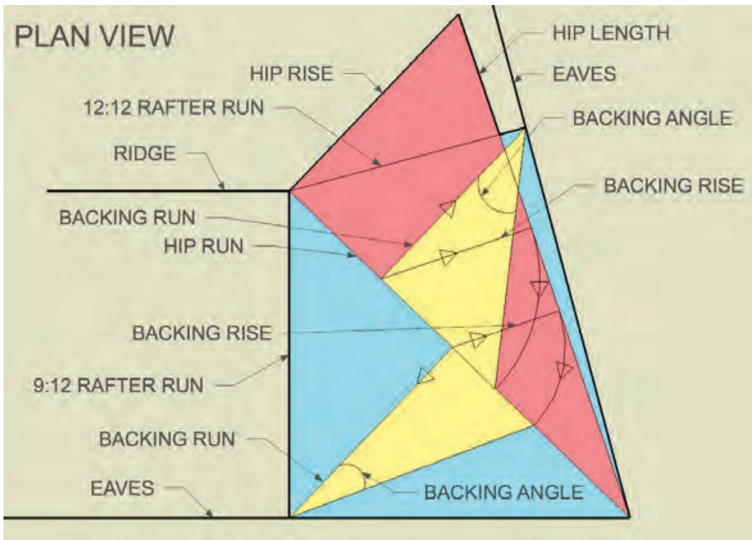


Fig. 5. Development of backing angle for irregular-pitch, irregular-plan roof. Procedure same as in Fig. 4.

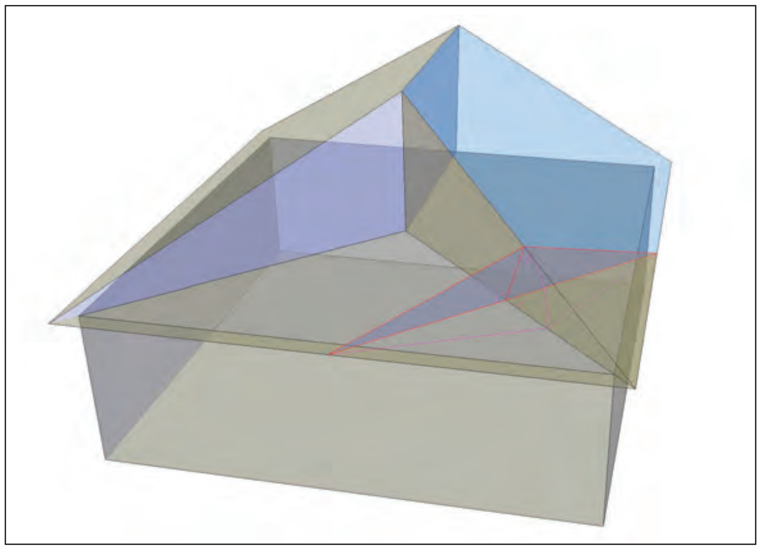


Fig. 6. View of the backing angle looking up hip and then folding it down onto plan view for transfer to bevel gauge.

In Fig. 5, we see an example from our last article in TF 90 with irregular pitch and irregular plan (the 9:12 and 12:12 roofs meet at other than a 45-degree deck angle). The procedure is the same and no harder than for a regular-plan roof.

In Fig. 6, we see a view of a hip roof showing why this graphical layout works. Looking up the axis of the hip, the backing angle is defined by the rise and run of the backing forming a right triangle with the roof surface as hypotenuse. To be able to transfer this angle to a bevel gauge, we fold this triangle down onto the plan view, using the run as a hinge.

In Fig. 7, we see the same technique used to find the backing for the irregular-pitch valley we also discussed in the preceding article. Note how we define the kernel in these views, only considering the plan underneath one of the valleys. The other valley is a mirror-image, so the angles will be the same. If the roof were highly irregular and each hip or valley different from any other, you would need to do this exercise for each intersection. Note that in our valley case of a 9:12 roof colliding with a 12:12 roof, the developed backing triangles appear on opposite sides of the valley plan from where they will be used because we are actually drawing the neighboring roof plane as it might continue down into the building after passing through the valley.

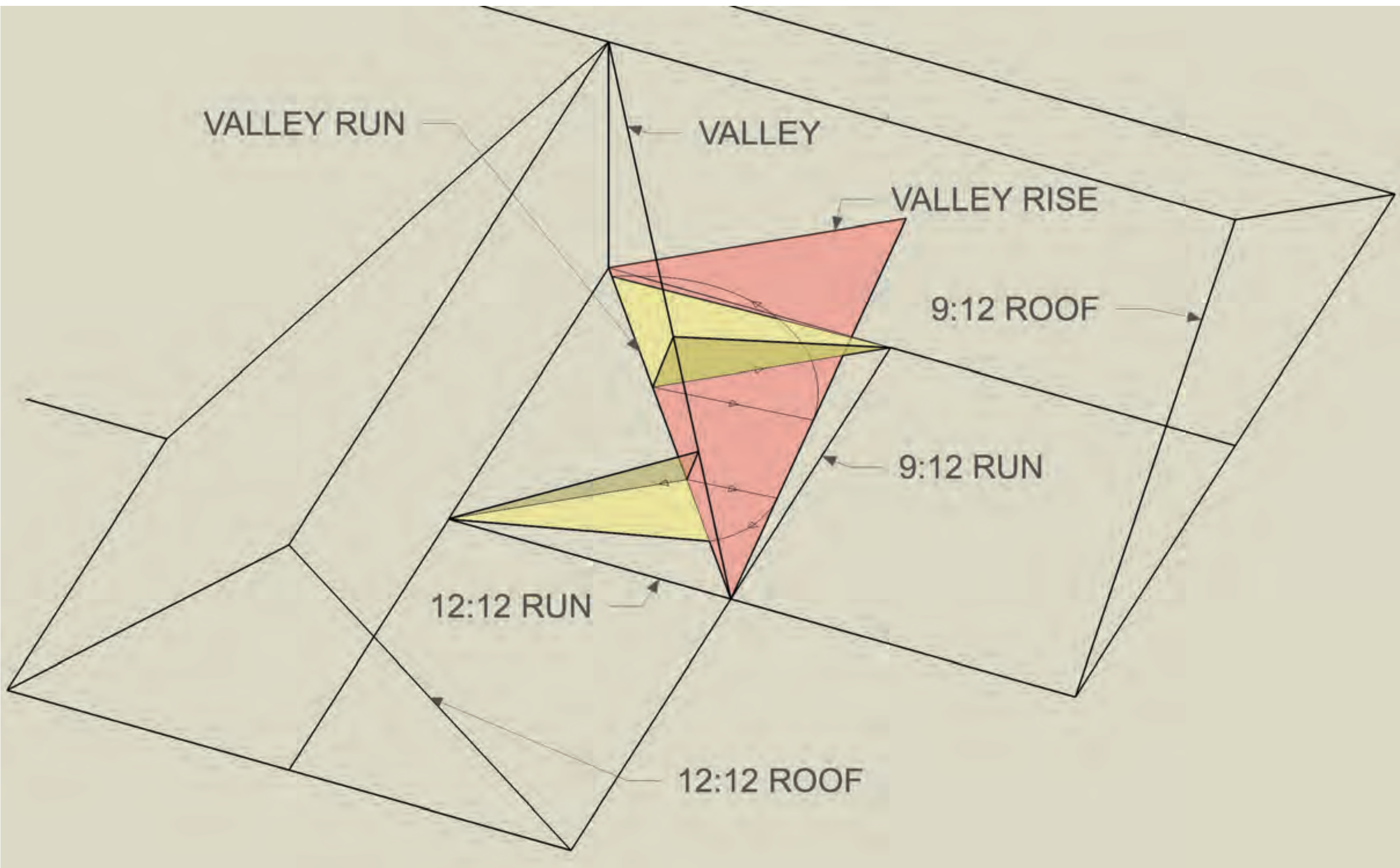


Fig. 7. Backing angle development in valley context.

Now that we have determined the two backing angles, we can lay them out on the hip (or valley) rafter. For the rest of this article we'll use an example of a hip-roofed structure with a 14:12 main roof meeting a 10:12 pitch adjacent roof (Fig. 8).

In the plan view (Fig. 9), you can see that the run is different for each of the two pitches while the rise is the same (all hips meet at the peak). Thus the hip run does not cross the corner of the building at 45 degrees.

Draw the hip kernel to derive our backing angles using the procedure described. Lay out the backing from centerline on the end of the hip (we've chosen an 8x8) for the result seen in Fig. 10. Because the main and adjacent angles are different, the backing (roof) surfaces will exit the sides of the hip at different heights. In some cases this difference will be quite extreme, and since rafters are usually visible in timber framing we may want to keep the plumb sides of the hip equal in height. Doing so will also make the jack rafter intersections more consistent and visually pleasing on both sides of the hip, and it will make trimming out the eaves easier if there is an overhang with fascia. But it means offsetting the hip from the corner. Again, we turn to the tangent to find out how much.

In the plan view (Fig. 11), draw a tangent line from the foot of the hip square to the hip run and out each side to a length equal to the hip width, say in this example 8 in. Draw lines from these end points *parallel to the opposite eaves* until they intersect the eaves. These two points indicate where the upper corners of the hip lie in a level plane with the peak of the backing and thus where the sides of the hip should be offset relative to the peak line. This procedure works on irregular plan roofs as well as regular roofs. Given this offset, you can now lay out the peak line on the unbacked top surface of the hip, draw the backing angles on the end (Fig. 12) and, *voilà,* the sides are the same height.

In our example, we went out along the tangent line a distance equal to the hip width and then, to find our offset, struck a line parallel to the opposite eaves. Because the roof is regular plan, the corner is 90 degrees and so this line happened also to be perpendicular to the adjacent eaves. But this will not always be the case. Looking at an irregular plan example will illustrate why.

In Fig. 13, we have an eaves corner meeting with the hip run at some indeterminate angle (it doesn't matter in this procedure). By striking out along the tangent to a distance equal to the hip width, and then back to the adjacent eaves with a line parallel to the opposite eaves (indicated by equivalent hash marks), we form two blue triangles equal to the yellow one. The line marked *W*, then, must equal the hip width, and by definition all three points along the eaves that form the corners of the yellow triangle are in a level plane, as are all points along the eaves. Another representation of the same information is shown in Fig. 14 where we have rotated the view to look almost directly down the axis of the hip; the hip section is shown in green.

In Fig. 15, we see what would happen in the same view if we simply centered the hip on its length line. Because the three points that form the eaves corner must be a level plane, the two level points on the side of the hip that define the backing bevels would not be across from each other (square to the hip run) at a distance equal to the hip width.

Up to this point we have treated the rafters as if they ended at the plate line, but if they (or the roof panels) extend beyond to form an overhang, we have some new concerns. Since the hip run does not bisect the corner with equal angles as it would in a regular pitch roof, the overhanging eaves of the intersecting roofs must be of different widths if we want to hold equal-height soffits, and the corner of the overhang does not lie on the miter line of the plates (Fig. 16).

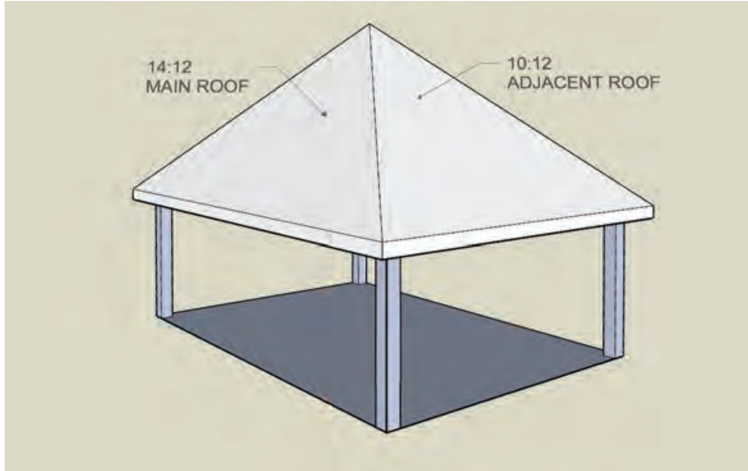


Fig. 8. Representative irregular-pitch hip-roofed structure.

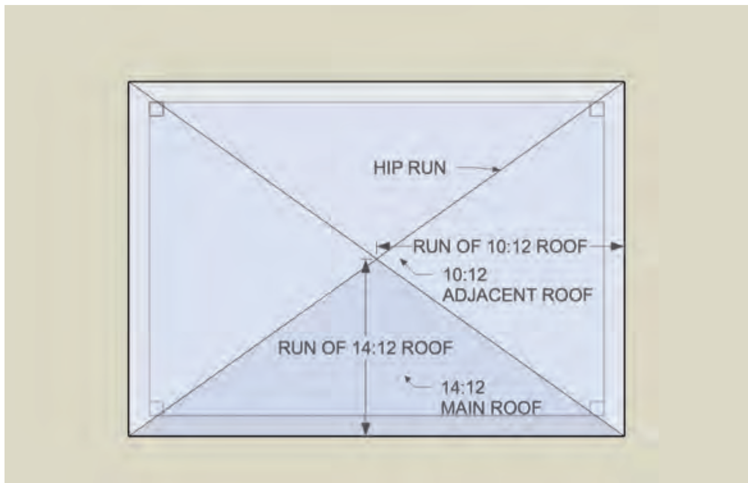


Fig. 9. Plan view reveals offset of hip peak lines given equal overhangs.

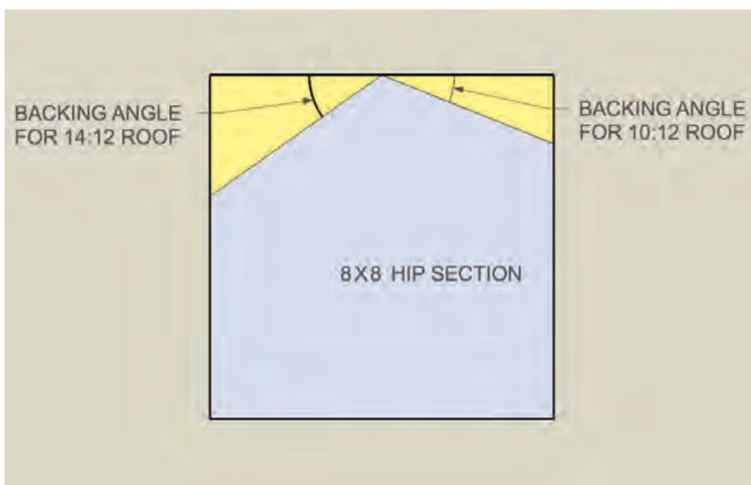


Fig. 10. Backing layout from centerline yields unequal hip sides.

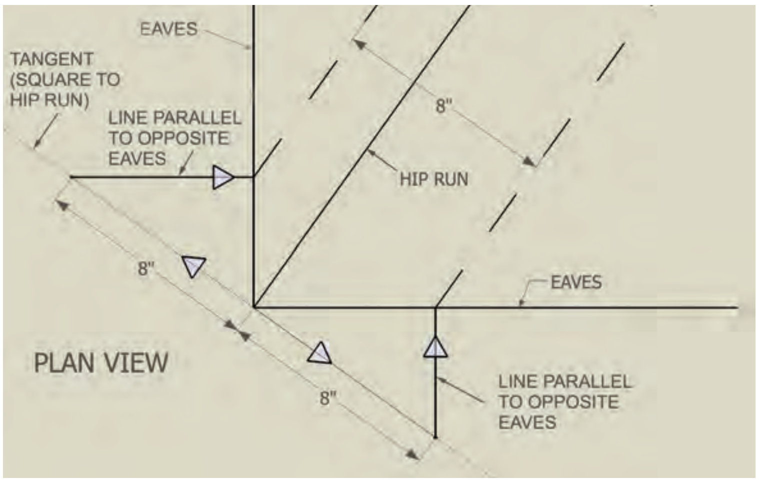


Fig. 11. Procedure to determine relation of hip sides to peak line.

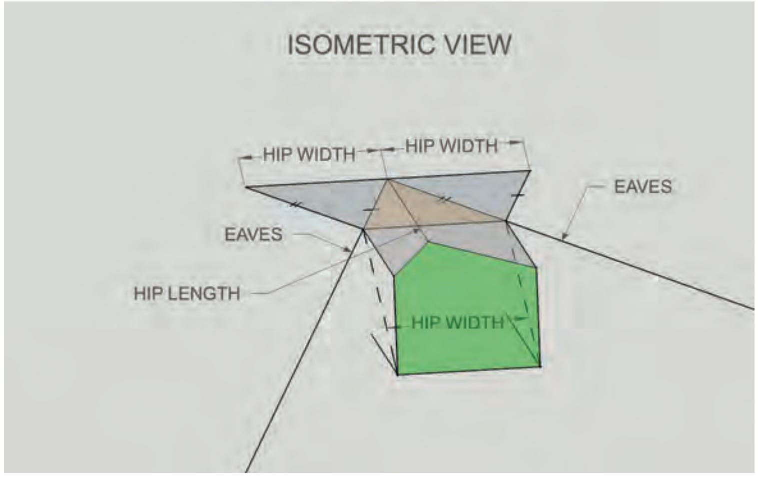


Fig. 14. Looking down hip axis at offset peak line.

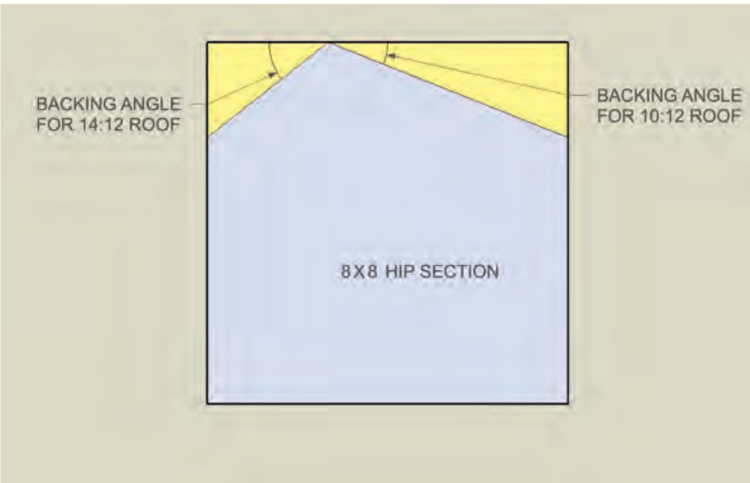


Fig. 12. Backing angle laid out for equal hip sides.

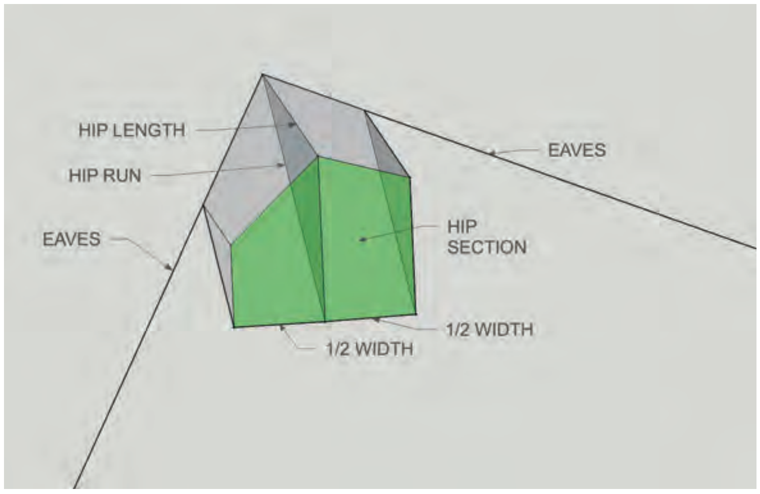


Fig. 15. Result of centering hip peak line, here labeled "hip length."

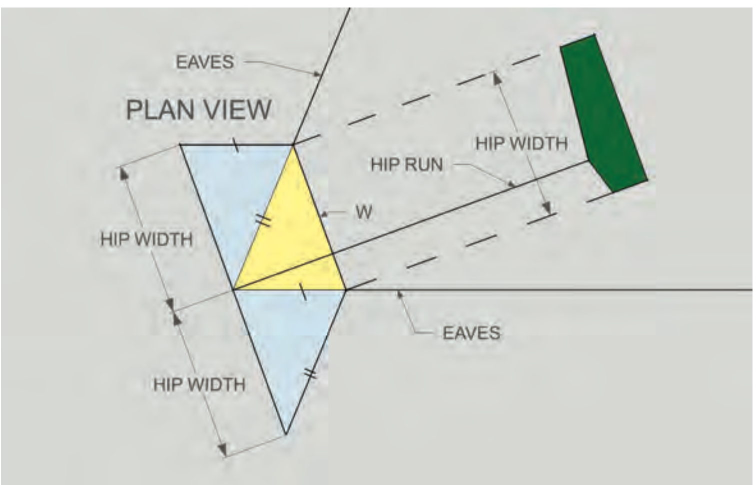


Fig. 13. Finding hip offset and relation of hip sides to peak line.

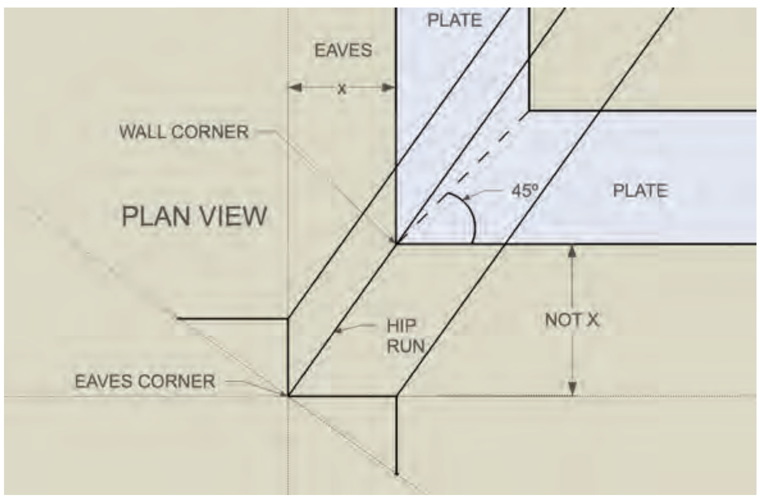


Fig. 16. Unequal overhangs if eaves meet at same height.

Furthermore, since the roofs are of different pitches, the common rafters (including the jacks) cannot end at the same height if they cross the plates at the same height and if we want to hold equal overhangs (Fig. 17).

If we want to have equal overhangs and equal fascia heights (a uniformly wide, level soffit all around the building), the neatest and easiest configuration to trim, then we need both to offset the hip additionally at the corner of the plates and to raise the height of one plate. Let's see how that's figured graphically.

In the plan view (Fig. 18) draw the eaves lines equidistant *X* from the walls of the building. Rafter runs will be measured from the eaves line, also called the *gutter track* (the boundary of a level plane at the eaves through the building), rather than the building line, and the intersection at the eaves corner will determine where the hip ends. (The other end of the hip and the rest of the roof plan will be located by the regular geometry of the two roof pitches.) Notice that now, with equal overhang, the corner of the eaves lies on the miter line of the corner of the building but the run of the hip does not cross that corner. The hip must be offset from the corner by the distance *Z;* the offset will always occur toward the steeper roof in a hip and toward the shallower roof in a valley.

This distance can be measured in a scaled plan view and is proportional to the runs of the two roofs and the deck plan angles. It can be determined mathematically using similar triangles and ratios. Say we want *X* (the 14:12 overhang) and *X′* (the 10:12 overhang) to be equal at 12 in. Looking at the deck angle in our plan view, we see that the two red triangles are similar. The difference in rises between the two roofs over an equal run is in the same proportion as the difference in run between the two roofs over equal rises. The rise at the top of the hip where it crosses the plate line must be the same on both roofs. For the 14:12 roof, the rise is 14 in. over a run of 12 in. For the 10:12 roof, the rise will be 14 in. over a run of *X′* + *Z*.

So: 10 ÷ 12 = 14 ÷ (12 + Z). Solving for *Z* gives us a 4¹³⁄16 in. offset at the corner.

Now that we have equal overhangs, and we posit a level soffit, we need to raise the plate (or reduce the depth of the rafter-to-plate joint) under the steeper roof to meet the more-rapidly rising rafters. This amount can again be figured mathematically or graphically with a full-size or scale drawing. If the difference is slight, all that may be needed is to cut a slightly shallower birdsmouth on the steeper set of rafters (if that joinery is used), or to use a raised (or taller) plate. In most cases, the latter will result in a cleaner solution.

Fig. 19 represents the building line and equal soffit projection and height for the two roof pitches. Draw two pitch lines from the end of the roof up toward the ridge. The two lines will diverge as they rise, and the plumb distance where they cross the building line is the amount to raise the plate (or make the birdsmouth shallower) for the steeper rafters. Alternately, you can use the proportional relationship of the two pitches to calculate the difference in rise for the two pitches over the equal runs of the soffit. Raise the steeper roof's plate by the amount of the difference. In our case, since a 14:12 pitch rises 4 in. more than a 10:12 pitch over 12 in. of run, for equal width soffits the steeper roof's plate must be 4 in. higher than the shallower roof's, given equal height above the plate (HAP) and birdsmouth in the respective rafters.

Figs. 20–21 show an application of these concepts, which prove useful even if rafters don't extend beyond the building, since insulated panels of equal thickness often extend to form the overhang of a timber-framed building. All the geometric information in this series applies to light (or "stick") framing as well as to timber framing, although certain techniques, such as backing hips and valley rafters, are more nearly typical of timber framing because of the larger timber sections. Those, along with the visibility of exposed timbers, make accuracy more critical as well. —Will Beemer

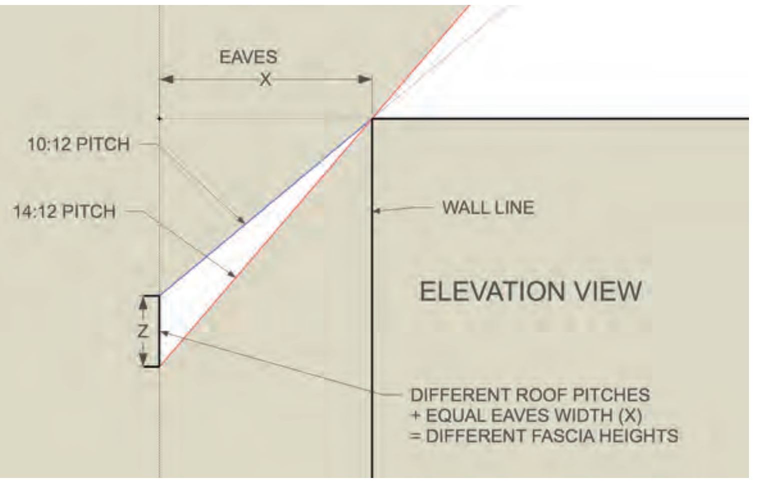


Fig. 17. Difference in rafter tail height at equal overhang.

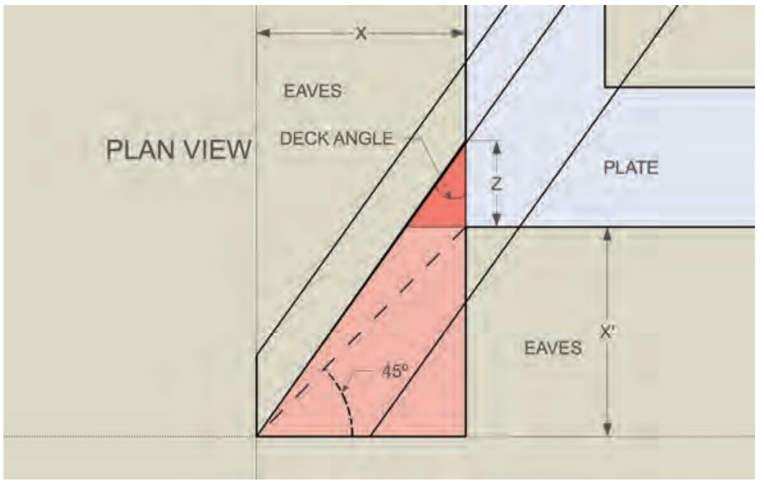


Fig. 18. Eaves corner now lies on building corner miter.

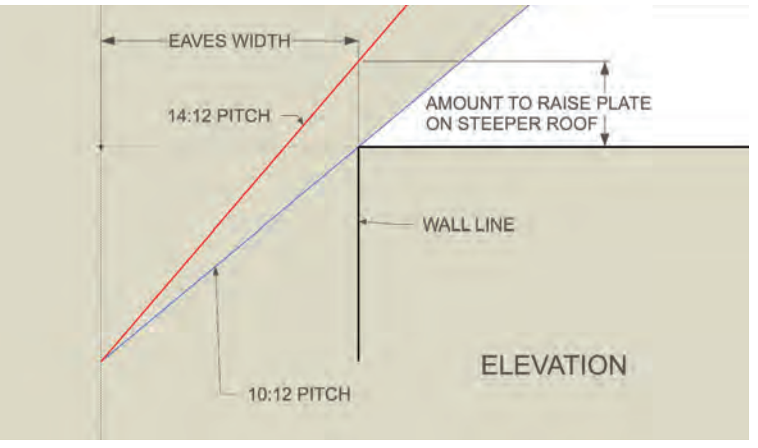


Fig. 19. Plate height adjustment for equal-width and -height soffit.

Bibliography:

A Roof Cutter's Secrets, by Will L. Holladay. A *Journal of Light Construction* book, 2002.

Construction Geometry, by Brian Walmsley. Centennial College Press, 1981. Available through Lee Valley Tools.

Roof Framing, by H. H. Siegele. Drake Publishing, 1971.

Manuel des Traits de Charpente, by Manfred Euchner. Eyrolles, France, 1997.

"Hip and Valley Framing," by Ed Levin. *Timber Frame Joinery & Design Workbook,* Vol. 1, pp. 84–86. Timber Framers Guild, 1998.

Jack Witherington

Figs. 20–21. Views of irregular-pitch, regular-plan hip roof framed in Douglas fir. Note unequal height plates and substantial offset of hip from intersection of plates.

Timber Framing in Nepal

What was the wood? What was the tree from which heaven and earth were fashioned forth? —Rig Veda

HERE are observations of a New World carpenter who traveled to the Himalaya to run rivers and look for timber joinery. Before I developed an interest in joinery, I pursued several other vocations including interpretive river guiding. In recent years I had the idea of using my guide skills as a means to travel. In the summer of 2007, I went to Alaska and worked on the Nenana river in Denali National Park. This past autumn and winter I fulfilled a lifelong dream of visiting the Himalayas. I went to Nepal and guided on the Bhote Kosi, the Belephi Khola, and the Sunkosi. *Kosi* and *khola* are words for "river" in Nepali; *khola* may more accurately translate as "torrent." I spent the first month near a village called Sukute at a river base camp about three hours northeast of Kathmandu. There and downstream on the Sunkosi I used my time river guiding to learn basic Nepali and to seek out examples of timber framing. My greatest hope was to find carpenters actually cutting joinery. Later, I would travel west and north to higher elevations to continue my survey.

The Terai, a narrow band of Nepal's territory culturally part of the North Indian Plain, has a distinct building tradition. I traveled through the Terai several times on 24-hour bus rides returning from the Sunkosi. As seen from the bus, the most common building system on the Terai is an elevated wood and earthen house on round posts, with through mortise and tenon beams supporting the main living space. Earthen walls under the platform enclose storage rooms and work space. The ground level is elevated a foot or two on platforms made of stone and earth. Many of the timbers are reused with old mortises showing in random locations.

In the more mountainous areas of central and eastern Nepal, the near-universal building system comprises masonry walls integrated with joined timber elements for window, door, balcony, floor and roof systems. A new house construction near Balphi serves as a good example (Fig. 1).

All photos Jeffrey Empfield

Fig. 1. New house near Balphi. Framing below for shop-front doors.

Note the double-post (*tha*) system supporting the full-length lintel or beam (*nina*) and stone wall on the front of the house. Various timber species are used for posts, beams and floor joists (*dhali*). The double-post design is very old and widespread, seen from the oldest shop-front homes of Kathmandu to recently built multiple-story trekking guesthouses in the high valleys of the Himalaya. This building marker appears to reflect the history of the Newar culture of the Kathmandu Valley growing in power and coming to influence much of modern Nepal. Similarly, the Newar language is a precursor to Nepali and remains closely related, even interchangeable at times, with the modern national language. They're both similar to Hindi.

Nepal has a Hindu majority associated with Indo-Aryan migrations from North India, at latest by the 2nd century. At that time the Indo-Aryan Licchavi dynasty came to power and ruled for the next 600 years. More recent migrations from the south occurred in significant numbers in the 13th, 14th and 15th centuries. Those refugees of Muslim invasions mixed with existing populations to form the Newar culture centered in the Kathmandu Valley. After repeated expansion and retraction, Newar culture expanded once again after 1769 when Nepal became unified under the control of Kathmandu.

The superior arts and crafts of Newar people subsequently came to influence much of modern-day Nepal. Similar building characteristics are seen from low-elevation river valleys in the east to areas west of Kathmandu and even at higher elevations to the north, overlying the older mosaic of regional ethnic building traditions. More than 40 languages are spoken in Nepal, reflecting a mix of peoples who have immigrated from all directions over the centuries. Both ancient styles and more recent Newar-influenced structures exist side by side in areas outside the Kathmandu Valley.

Another cultural marker is the Nepali axe, used for all forestry, logging, and firewood cutting. During my months in Nepal I never saw or heard a single chainsaw. Even in Kathmandu, all rough woodcutting is done with the axe. It varies slightly in size but has a consistent curved edge and roughly shaped handles (Fig. 2).

Traditional forestry practices align remarkably well with ecological ideals of sustainable forestry. Indeed, old-growth and mixed-age forests are common even on the edges of many villages and larger communities. For anyone with a fondness for the eastern hardwood forests of North America, the middle elevations of the Himalaya will seem sweetly familiar. These sometimes open broadleaf woodlands support the theory that humans crave shelter and prospect—the hominid ideal of savanna. To be sure, many parts of Nepal face challenges of despoiled forests and rivers. This is the case especially at lower elevations with recent sharp increases in population. But it's also evident that many long-settled parts of Nepal blend relatively well with their natural surroundings.

Fig. 2. Nepali axe with forged round eye and sharply curved bit, apparently hafted for hewing.

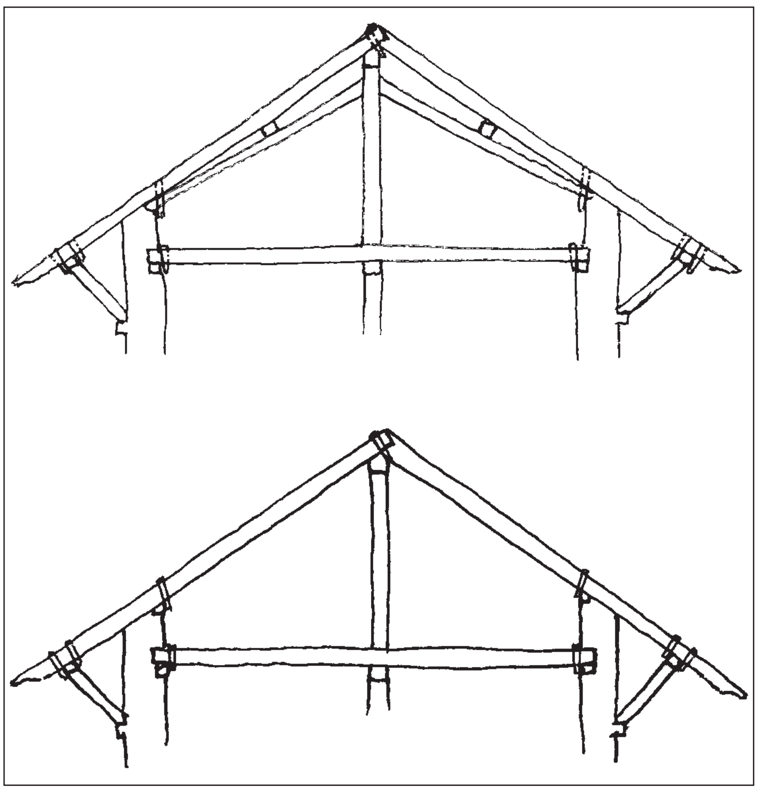
Traveling on the Sunkosi, patterns of building culture emerge. As one drops in elevation and approaches the North Indian Plain, masonry gradually gives way to lighter wood, grass and earthen

Fig. 3. Sunkosi River village with lime and red-clay exteriors. Several double-posted shop fronts as well as thatch and tile roofs are visible.

structures. Conversely, the lime-washed and red-clay exteriors seen in Fig. 3 are so universal that recent concrete construction in Kathmandu is painted to mimic the style.

Almost all houses are rectangular (in some parts of central Nepal, very old Garung houses are elliptical). In the countryside I saw numerous connected buildings that extend linearly but only one example of the ell layout so common with older American farmhouses. In old urban development, family compounds were built into a square layout around a courtyard known as a *chowk*. Pent roofs provide protection for gable-end walls. Traditionally throughout Nepal, houses are thatched or roofed with flat stones or tile. But now buildings of all kinds also receive metal roofs. The introduction of sheet metal is having an effect on roof styles: shed roofs, though traditional in some places, seem to be more common now than previously. Traditional peaked-roof framing uses center posts and ridge beam to carry rafters and is still used in some contemporary construction (Fig. 4).

Both on my own and when I had an interpreter, I was surprised by the infrequency of informative answers concerning carpentry methods and traditions. Carpentry and other crafts are so much a part of everyday life, perhaps, that Nepalis may not be reflective about them. The knowledge is traditionally conveyed through long-term relationships—between fathers and sons working together, for example—rather than through narrative. A few carpenters I approached seemed amused that I was interested in their tools and techniques. In North America, joiners are a self-aware specialist minority while in Nepal carpenters unselfconsciously use joinery that has remained the dominant technology for hundreds of years. Where Western timber framers study, analyze and mix joinery in all its regional and international variety, old and new, Nepali carpenters are integrated with a functional, if less-varied, selection of joinery.



Drawn by Jeffrey Empfield after Katherine D. Blair and Wolfgang Korn

Fig. 4. Traditional Newari roof framing with fully supported ridge, broad overhang and external brackets. At top, double-rafter system for heavier roof loads. Stout pegs at ridge and wall keep rafters from sliding down. Doubled pegs locate jetty plate, supported by struts from wall. Pegs through joists inside wall ledgers suggest that carpenters worry about roof load pushing walls in rather than out.

Fig. 5. *Pati* in Swayambhu shows typical carved posts and brackets and lapped corners.

Fig. 6. *Cholu* scarf joint in *pati* beam, Patan.

The majority of material culture is still made by hand in Nepal. Outside of cities, there are no factory-made windows or doors. Local carpenters working in small groups build structural frames, doors, intricate window screens, furniture and everything else needed in their community. In this way communities are self-contained. Carpenters often have stacks of raw logs outside their shops from which they convert their own stock. Logs are commonly converted by hand with two-man saws or are first hewn square and then, if small enough, cut on table saws where electricity is available. In Kathmandu and other larger communities, specialized shops provide frames, doors and furniture, but in villages usually one or two shops perform all types of carpentry.

The most accessible timber structure is the *pati*, a raised, covered platform with framed open sides and a masonry back wall. These common buildings are variable in size and shape and characterized by carved posts (*tha*) and brackets (*metha*), and beams (*nina*) lapped at the corners. A long square post tenon (*sa*) extends through the bracket into the beam. The *pati* serves as a free rest-shelter for travelers and is also often used for socializing, temporary storage or work space both in cities and in the countryside (Fig. 5).

Though joinery is the dominant technology and you see it everywhere, there isn't a large variety. In addition to through mortise and tenon, lap and dovetail joints, I came across quite a few examples of a short tabled and bladed scarf joint with locking key, the whole called *cholu* (Fig. 6).

Pegs are used both in the Terai and in mountainous areas. In the Terai, pegs are rounded and used to lock joinery, but not universally. I am confident that carpenters have some form of auger for forming holes, but I never saw one in use. Elsewhere, pegs are typically square and used in tandem to fasten or locate rafters on top of plates. These square pegs (*chuku*) are similarly used to hold cantilevered beams in place within masonry walls and to hang rafters on center ridge beams. Traditionally, overhanging roofs (*chhana*) for both temples and houses use carved timber struts (*tunasi*) to support roof plates (*nas*) and rafters (*musi*) which are held in place on top of the plate with these two square pegs. Instead of going through the roof plate, however, the pegs extend through the rafters fitting snugly on either side of the plate both inside and out. The snug fit, angle of the roof and the weight of the roof, usually covered in stone or tile, are sufficient to hold everything in place (Fig. 7). I didn't see any of the diagonal braces common in Western wall and roof framing. Nepalis do use diagonal struts to support large overhanging roofs and balconies (Fig. 8).

Fig. 7. Stout square pegs (*chuku*) often locate one beam on another.

AFTER weeks in the river valleys investigating buildings, I traveled to higher elevations on the classic trekking route, the Annapurna Circuit. The Annapurna Mountains (or *Massif* or *Himal*) are an anomaly of the greater Himalayan Mountains and, along with the Dhaulagiri *Himal*, sit slightly south of other ranges such as the Damodar *Himal*. There is a slight bend in the Himalayan Range at this point. The Dhaulagiri and Annapurna stick out slightly on the elbow of that bend. The Annapurna is connected to other Himalayan ranges to the north by the Tibeto-Buddhist Marsiyandi River Valley and Thorung La Pass. With two of the highest mountains on earth, rain shadow effects north of the Annapurna are strong. The arid environment along with ancient trade routes combined to extend the culture of the dry Tibetan Plateau in north-central Nepal—the Tibetan culture fit the high, dry climate. Despite distinct differences in culture and architecture compared to Hindu-dominated lower elevations, masonry integrated with joined timber elements also characterize traditional buildings here.

I had a good visit with three carpenters in Danakyu, a small village near Chame. The leader, Orgun Grung, 50 years old, shown in Fig. 9 using the adze, and his quiet friend Lok Baha Dur, 51, are full-time carpenters. Mr. Grung's son Dale, 25, helps out.

Fig. 8. Diagonal struts support both balconies and large roof eaves. Note double scarf joint at middle of jetty sill.

Fig 9. Orgun Grung hand-adzes a roughsawn timber to size, hewing to struck line. Timber will later be bench planed.

The men are filling an order for a new guesthouse. They don't have another form of income and they get all the work they need in Danakyu and neighboring villages. Young Dale hasn't fully committed to carpentry yet but works with Orgun and Lok when there's a big order to fill. He has some other irons in the fire in the neighboring village of Bagarchhap, he told me. Tourism, particularly trekking, is the main cash source in the area, income not only for hospitality providers but also for carpenters and stonemasons. The popular trekking routes and the thousands of foreign backpackers they attract every spring and autumn provide some incentive for young people to stay in villages such as Danakyu. Elsewhere in Nepal, communities are losing their youths to Kathmandu and to emigration.

According to Dale, Nepali joinery layout is always done from one best face of the timber. Carpenters never use centerline layout. To establish straight lines, they stretch their all-purpose black string with spools (*hākhi*) and trace it onto the work surface. In Danakyu and most remote parts of the country, timbers are completely hand shaped, sawn, adzed and planed. It was hard for me not to marvel out loud at the details. Orgun didn't say much, but he understood my compliments and smiled knowingly when I commented on their work.

In Danakyu and elsewhere, carpenters don't drill for mortises. After layout lines are applied by pencil, they remove material directly with chisel (*hā*) and mallet (*hākhimugah*). They make their own chisel and adze handles as well as plane bodies, mallets, and other tools. Dale spoke as if carpenters made their own adze heads as well, but I think I misunderstood. I saw many locally made adze heads for sale everywhere (cities, villages). Probably Dale meant merely that the adzes are locally made. When I asked if the carpenters' chisels came from China, it seemed important to him that

Fig. 10. Through mortise and tenon door and window frames.

Fig. 11. Carpenters' yard at Danakyu, elevation 2300m. Lining one roughsawn timber on bench while another is sized with adze. It will be finished with a long plane.

I understand the chisels were Indian. I don't know if it was a matter of quality or of geopolitics—or just a matter of fact.

The carpenters' yard shown in Fig. 11 typifies work space in Nepal with its seemingly random location just off the main path of the village. In the background is a temple with prayer flags strung in several directions. Workshops and outdoor yards for any variety of craft are integrated throughout towns and villages with no separation between residential, commercial, industrial or spiritual areas. Craftsmen often set up and work in surprisingly small shacks or in spaces between buildings or on sidewalks, if that's where they find the warmth of the winter sun.

At the elevation of Danakyu (2300m, 7546 ft.) and higher, the species of choice for construction purposes is blue pine or *gobre salla (Pinus wallichiana)*, a tall, straight, blue-green five-needle pine (Fig. 12) that strongly resembles the Eastern white pine (*P. strobus*) of North America. (Thoughts turn to the mesozoic era supercontinent Pangaea and the likelihood that *P. strobus* and *P. wallichiana,* ancient species from an evolutionary line much older than all the flowering plants, are possibly close relatives. It would take a DNA test to know.)

Higher up the valley, the Tibetan-Buddhist influence on settlement pattern is stronger still. Here, settlements are built in high-density clusters, often on hillsides, with flat roofs used as living space for houses located upslope. Also characteristic of these higher elevations is a striking cantilevered timber bridge, still common but gradually being replaced by steel cable bridges, which extends a cambered deck across transverse cribbing supported by cantilevered

Fig. 12. Sawpit with young blue pine in the background.

timbers buried in masonry abutments. Vertical needles at the ends of the cribbing restrain the framing (Figs. 13 and 14).

At lower elevations, the hardwood *sal* (*Shorea robusta*) is favored for carved timbers, door and window frames, temple roof struts and cantilevered balconies. *Sal* is the most important timber species in Nepal and India. It's believed the tree is home to various gods and it is thus worshiped for bountiful harvests, victory in battle and general success and happiness. Carved *sal* timbers feature in all temples and other prominent buildings. Though ornate and variable in detail, temples are nonetheless similar in structure to common buildings.The plinth base of many temples is akin to a *pati*, both in structure and use, while the timbered roofs are similar to those of houses (Fig. 15).

Despite the social preference for *sal,* Nepal has dozens of tree species used for building and woodworking. Other hardwoods important for timber construction include chestnut, *dhalay katus* (*Castanopsis indica*), *seti kath* (*Myrsine capitellata*) and several species of oak, especially the brown oak or *khasru* (*Quercus semecarpifolia*). A species of walnut, *dhant okhar* (*Juglans regia*), extends from the Balkans of Europe across mountainous Eurasia as far east as China and Japan and is commonly used for woodcarving and furniture. The Himalayan mulberry or *kimu* (*Morus serrata*) is also used for furniture and carving as are many other species. Besides blue pine, other softwoods used for construction include deodar cedar or *devdaru* (*Cedrus deodara*), Himalayan cypress or *raisalla* (*Cupressus torulosa*), and chir pine or *khote salla* (*Pinus roxburghii*).

JUST south of the Annapurna is Pokhara, a popular lakeside town about 200km west of Kathmandu. Walking through a park there, I happened upon a new temple to Shiva under construction. It was a Saturday, the holy day in Nepal, so there was little going on. Fortunately for me, Mr. Deepak Raj Tuladhar was on site resting, perhaps in the interest of site security. After he noticed me looking around, he came over and I was able to ask about the project. Deepak is co-owner, along with his brother Daman, of Traditional Handicrafts of Bungamati in Lalitpur (labeled Patan on most maps, just south of Kathmandu). For the past two years, the Tuladhar brothers and their crew of carpenter woodcarvers have been preparing timber elements for a temple whose structure will be primarily concrete and brick.

Their work includes both joinery for the eaves structures and woodcarvings of 24 deities represented on roof struts. It also includs intricately carved door jams and lintels, some of which

Fig. 13. Cantilever bridge near Braga (3450m). Milky-blue color of Marsiyandi River comes from suspended glacial till, a fine rock powder.

Fig. 14. Vertical needles thread through successive crib ends. Independent railing appears not to contribute to bridge stiffness.

Fig. 15. Krishna Dega Ga Temple, Patan, exemplifies basic Newar-style framing embellished with high art woodcarving.

Fig. 16. Carved timber elements, entryway of new temple in Pokhara. Body of temple is concrete and brick. Note bamboo scaffolding.

Fig. 17. Ganesh, elephant-headed god of wisdom and good fortune, is important throughout South Asia.

have already been installed to form entranceways within the ground-level masonry walls (Figs. 16 and 17).

The joinery design uses many dovetail (*dobusa*) and scarf joints (*cholu*) to carry large eaves beyond the brick-veneered concrete core. I tried to explain the avian origins of dovetail in English and European languages in hopes that *dobusa* meant something similar. Apparently it doesn't.

During cutting, timbers are numbered first in chalk and later by carving numerals into the wood, much like marriage marks in Western timber framing. The number in Figs. 18 and 19 that looks like a 9 is actually a 1. Numerals 2 and 3 are easily recognizable but the others are confusing to anyone used to Arabic numerals. Nepal and India (their respective national languages Nepali and Hindi) use a unique alphanumerical system called Devanāgarī, derived from ancient Sanskrit. With common roots in this prehistoric Indo-European language family, there are some surprising cognates between Nepali and English. For example, the Nepali word for name is *naam. Mero naam Jeff ho* means, "my name is Jeff."

Temple carving is laborious (Fig. 20). When I asked Deepak about the *tika* powder on the forehead of one of the recently carved figures, he just laughed, almost embarrassed, and brushed off the powder. *Tika* is generally a blessing placed on one's forehead during festival or at the time of departure for a journey. Too complex to explain, the *tika* on the figure probably has vague spiritual significance as well as festive, comic, aesthetic and family associations. Hindu cultural practices are rarely simple or compartmentalized (Fig 21.)

Figs. 18–19. New Shiva temple, Pokhara. Dovetailed timbers are horizontal exterior beams to be located above brick façade and at feet of the struts, oriented with marriage marks on top and dentil carvings facing out, forming a horizontal band (cf. Fig. 15). The temple will have a two-stage roof with corresponding proportions of perimeter beams and struts.

Fig. 20. Woodcarving, a defining art form of Nepal, contributes to national consciousness. Massive strut shown for new Pokhara temple will support one corner of large lower *chhana* (overhanging roof). Struts will carry jetty plates and rafters secured with square pegs. Note sharpening stone, worn in for gouges, in left foreground.

I spent some time exploring the forests around Pokhara and Kathmandu. Evergreen oaks, ash, chestnut and holly, as well as other less-recognizable hardwoods, mix with native rhododendron, bamboo, and palm trees in a diverse and beautiful midlands forest. You can see wild monkeys monkeying around and water buffalo browsing. I discovered ruins of a village on top of one ridge, abandoned at least a hundred years ago, with stone walkways and walls and even oval house remains, evidence of the Garung. Old rice terraces were all regrown in forest now. Far afield, I discovered a little forest shrine and then standing stones, examples of the seemingly worldwide phenomenon.

On another ridge I met a farmer-yogi-Brahman-philosopher who wanted to talk, especially when he learned I was interested in trees. He was concerned with the importance of simplicity and the lost way of so many of his money-obsessed countrymen. He blamed tourism. I think he overlooked the larger global trends that cause people to leave traditional lifestyles in hope of finding opportunity elsewhere. I couldn't help thinking about the contrast between his culture and ours, the degree to which craft and handwork remain dominant in Nepal, a vital, breathing part of society, and in spite of that, how wise men and farmers everywhere see problems in the loss of tradition. —Jeffrey Empfield

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Bibliography

Blair, Katherine D. *Four Villages: Architecture in Nepal, Studies of Village Life,* Craft and Folk Museum, Los Angeles, 1983.

Gutschow, Niels, Bernhard Kolver and Ishwaranand. *Newar, Towns and Buildings: An Illustrated Dictionary, Newari–English,* VGH Wissenschaftsverlag, Sankt Augustin, Germany, 1987. Detailed descriptions, photos and drawings of the complex, multi-layered, carved and joined window screens as well as many other craft forms.

Korn, Wolfgang. *The Traditional Architecture of the Kathmandu Valley* in *Bibliotheca Himalayica,* Series III, Vol. 11. Ratna Pustak Bhandar, Kathmandu, 1976. Summarizes building types and basic structure with excellent drawings.

Storrs, Adrian and Jimmie. *Trees and Shrubs of Nepal and the Himalayas,* Book Faith India, Delhi, 1998.

Fig. 21. Roof strut for Pokhara temple with carved deity. Tika powder is applied as a blessing to people and representative figures.

Milling Your Own Timbers

Photos and drawings Ben Weiss

Fig. 1. A simple jig holds strings above the bed rails to aid in truing the mill. Clamps attached to crossrails at far end of mill are log dogs.

THE efficiency of timber framing is highly dependent on the quality of timbers used. Out-of-square or excessively waney timbers can have a significant impact on procedure when cutting and raising a frame. Poorly sawn timbers are hard to lay out accurately and joints don't fit well unless considerable time is spent scribing or applying other special layout methods (see, for instance, "Snap Line Square Rule," TF 88), or correcting surfaces locally before layout. Milling your own timbers puts you in control of timber quality. Although it can be labor-intensive, milling is not difficult, and producing square timbers is thoroughly satisfying. As well as saving time during fabrication, the nearer the timbers are to square the better they and their joinery look if left roughsawn in the completed frame.

Choosing a Portable Saw Mill. Small mills come in two basic varieties—bandsaw mills and circular saw mills. Band mills are the most popular, because they cut a thin kerf, and so waste much less wood in sawdust, and because they can cut through large-diameter logs in a single pass. Circular mills such as the Lucas and the Peterson can cut in both directions for faster production, and the sawhead can be swung 90 degrees for edging. But for wider pieces circular mills require two-pass cutting, which doesn't always align perfectly, and they put the operator behind a spinning horizontal circular blade rather than beside a bandsaw drive wheel.

There are several US manufacturers of band mills. I chose Wood-Mizer because they make the most popular line and provide the most presale information on their machines. I found their sales and service reps to be knowledgeable, and parts are readily available.

Wood-Mizer offers a line of mills ranging from a compact 7HP machine ($3700) to an automatic, fully hydraulic 55HP model ($47,000). I chose the LT15 (15HP, $5900) since I didn't need to move the mill around (larger models have integrated trailers) and I wanted the mill bed close to the ground, making log loading easier. The LT15 also features an unlimited bed length (with optional extenders), which would allow me to cut the 24-ft. timbers required for the frame I intended to build. With a 23-in. throat capacity and a maximum blade height of 27 in., the LT15 can cut logs up to 28 in. diameter, more than adequate for milling common timber sizes. After having milled for one season with the LT15, I'm still happy with my choice, though I recommend considering the optional 25HP engine. The standard 15HP engine does a good job cutting white pine timbers, but can bog down when edging many flitches at once.

Setting Up the Mill. The Wood-Mizer comes with good instructions for assembling and configuring the machine. Three adjustments are critical for achieving square timbers: a true bed, vertical

Fig. 2. Adjustable side supports should be squared to trued-up mill bed.

side supports and a properly adjusted blade scale. A true bed, free from twist, hog or sag, requires a stable base under the mill. I was lucky to have a paved area (a basketball court I built for my kids 15 years ago) to use as a milling site. After the machine is assembled, the bed is trued by raising or lowering threaded feet (four per bed section). To speed the process, I used a couple of 1-in. sticks with holes in each end (Fig. 1). The sticks clamp to crossrails on each end of the bed and the strings pass through the holes and wrap over the top of the sticks. The feet are then adjusted so that each crossrail is exactly 1 in. below the strings. Once I had trued the mill bed, I spray-painted the pavement around each leg so that when the mill gets bumped (unavoidable when loading logs with a tractor) it can be returned easily to the position where it was trued.

Two side supports on each bed section hold the log in place and help in squaring the timber. These supports can be squared to the mill bed by putting a flat board on the mill and holding a square between the board and each support (Fig. 2). An adjustment bolt on the base of each support can be tightened or loosened to tilt the support in or out.

The last setting is to the blade height mechanism, controlled by crank wheel and indicated on a vertical scale. Wheel and scale are independently adjustable (strangely, the Wood-Mizer manual describes only a procedure to set the scale). Start by tensioning the blade and moving the mill head over a bed crossrail. Raise or lower the blade by pressing the lock-release handle and turning the crank; each notch in the wheel represents 1⁄16 in. of blade height. Turn the crank so when released the crank arm is positioned in one of the inch marks on the wheel (Fig. 3).

Next, measure from the top of a bed rail to the blade. If this measurement is not exactly on an inch mark, loosen the two bolts (one bolt is obscured by the handle in Fig. 3) on the crank wheel and rotate the wheel until the blade is exactly on an inch increment of your measure, then retighten the bolts. Once the crank wheel is properly set, calibrate the inch scale indicator by loosening the nut holding its bracket and moving the scale up or down. I only use the inch scale to know which inch I am working in, so I don't worry about exact alignment.

Fig. 3. Each notch of the crank wheel raises or lowers the blade by 1⁄16 in. Lock release shown below end of crank handle.

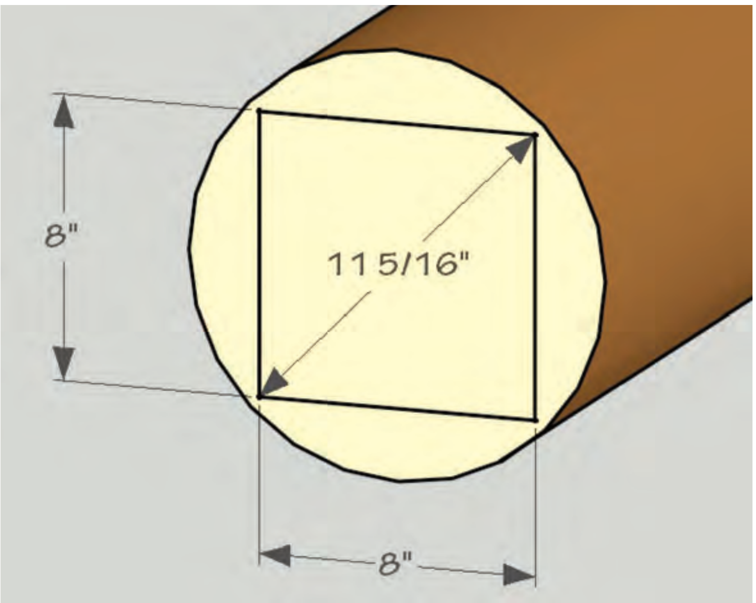


Fig. 4. In a perfect world an 11⁵⁄₁₆-in. diameter log would always yield an 8x8.

Choosing and preparing logs. In a perfect world, calculating whether or not a log were large enough to make the desired timber would be easy. Logs would be perfect cylinders with no taper, bumps or crook, and the minimum log diameter would simply be the diagonal measurement of the square timber. Neglecting bark and sapwood, for 8x8 timbers an 11⁵⁄₁₆-in.-dia. log would work 100 percent of the time (Fig. 4).

But real-world trees are much trickier. For 8x8s, I use 12½ in. as the minimum diameter of the small end of the log. This generally works if the log is fairly straight or if some wane is acceptable. Obviously, the more crooked the log, the larger its diameter needs to be, but trial and error is the only way to gain the experience to be sure.

If you decide to mill your own timbers, you'll probably be doing the logging yourself too. Skidding logs to the mill usually means dirty logs. To prolong blade life, I like to pressure-spray logs while they are raised on the palette forks of my tractor just before loading them onto the mill.

With the log off the ground, it's also a good time to examine it for crooks and other milling issues. I like to buck logs at least 2 ft. longer than the timbers I need so I'll have some wiggle room to deal with crook. Sometimes this means cutting a crooked section off one or both ends of a log with a chainsaw. But beware that cutting too much off one end can cause a log to become unbalanced and pivot off the forks. If the log is really long and heavy, cutting one end can even unbalance the tractor. If you're not sure about a log's stability, block up under each end just inside the proposed cuts.

The final step in prep is to mark the log centers. The marks will be used to make the log's axis as nearly as possible parallel to the mill. I find a center by simply taking two diameter measurements at 90 degrees to each other and marking their intersection (Fig. 5).

Loading Logs onto the Mill. Before loading the log on the mill bed, make sure to move the cutting head back to its starting position, pivot the side supports to their upright position and lower the log clamps. With a clean and trimmed log on the tractor forks, it's simply a matter of carefully driving the log to the mill and lowering it onto the bed. This is usually a two-person operation, one operating the tractor and the other alongside the bed with a cant hook, slowly rolling the log off the forks and onto the bed. When loading heavy logs or working solo, I use lifting straps suspended from the forks for more control.

If there's any crook in the log, you'll want to rotate it to face up at 90 degrees to the blade. This orientation will maximize the usable wood in the log. If the crook is otherwise oriented, the void area of the log opposite the crook will be positioned more or less on a timber corner, making it tougher to achieve the desired section.

Once the log is properly rotated and pushed against the side supports, its axis should be made as nearly parallel to the bed as practical. For this purpose, Wood-Mizer offers a wedge to fit on the bed rails (this is an essential option) with stepped notches conveniently sized at ¼ in. each. With the log overhanging the crossrails, a direct measurement isn't usually possible from bedrail or siderail to log center. Though it might be possible to build a jig to do so, given the divergence of most logs from true cylinders I merely measure from the ground to the center mark on each end of the log. Position the wedge on a rail near the end of the log that needs to be raised and push it flush against the log. With one person lifting the log using a pulp hook or hookeroon, the other can slide the wedge under the log, counting the notches to figure the desired amount of lift. Sometimes the opposite end of the log will lower itself while you raise one end, so remeasuring centers is a good idea.

With heavy logs, it may not be possible to lift one end—another reason to use straps to load large logs. (But make sure your strap positions do not align with any bed rails, or you'll have trouble removing the straps.) After lowering the log on the bed, one strap can be left on and the forks used to lift the lower end of the log (allowing the wedge to be inserted by one person).

The final step before cutting is to use the log clamps to pin the log firmly against the side supports. A great deal of clamping force is not needed, and with small diameter logs excessive force can actually bend the log. The clamps need only prevent the log from moving while being cut.

Cutting the First and Adjacent Timber Faces. Cutting the timber out of the center of the log usually yields the best quality timber. With the log centerline nearly parallel to the bed, it's a simple matter of removing the outer wood. Depending on the size of the log, quite a few 1x or 2x boards can be milled at the same time as the timber is produced.

Before starting the engine, set up the first cut by moving the cutting head close to the log and raising or lowering the blade to align with the center mark. Once aligned, look at the blade scale and crank wheel to get the height of the center. The vertical scale will give you a rough idea of the height, but use the crank wheel notches for the exact height. Each notch on the crank wheel is ¹⁄₁₆ in., with the longest lines representing inches (it's useful to add your own labels to the crank wheel as in Fig. 3).

With the blade height at the center mark, raise it by half the height of your timber (4 in. for an 8x8). Then, sight above the blade to estimate how many 1x boards or 2x boards can be milled above the timber. For each 1x, add 1¹⁄₁₆ in. and for each 2x add 2¹⁄₁₆ in. The extra ¹⁄₁₆ in. accounts for the kerf of the blade. For example, let's say you're cutting an 8x8 timber and your center height is 10⅜ in. Raise the blade to 14⅜ in. and calculate your outside boards. If a bit more than 3 inches of millable log remains above the blade, then add 3⅛ in. to the blade height (2 in. for one 2x, 1 in. for one 1x and two sixteenths for the two cuts).

Now you're ready to cut the bark slab, the outer boards and the first face of the timber. Following the previous example, the blade height would be set to 17½ in. and the first cut would result in a slab (outside waste piece). After making this cut, disengage the clutch, stopping the blade, and pull off the slab. Then lift the blade up about an inch, so it won't catch on bark, and return the cutting head to its starting position. Next lower the blade to 16⁷⁄₁₆ in. (down 1¹⁄₁₆) using the crank wheel notches and cut a 1x flitch (a free-edge piece). After removing the flitch, raise and return the head before lowering the blade to 14⅜ in. This cut will free up the 2x flitch and cut the first face of the timber (Fig. 6 facing and Fig. 7 overleaf).

Fig. 5. White pine log on forks, a good time to clean the log, mark centers and check for crook.

Fig. 6. The cant after first cut. Flitch on left.

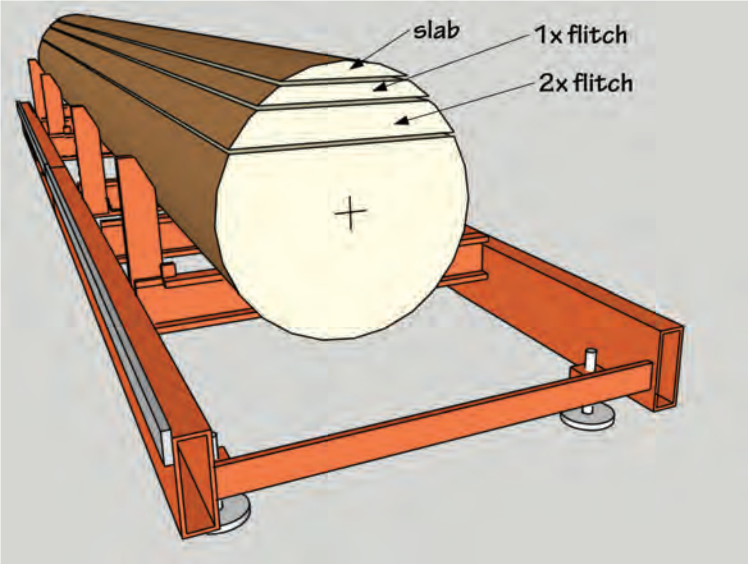


Fig. 7. Successive cuts for first face of timber.

The second cut, for the adjacent face of the timber, is the most critical (Fig. 8). If the second face is square to the first, squaring the remaining two sides is easy, and joinery layout later will be straightforward. Start by unclamping the cant (a log with one or more sawn faces) and rotate it 90 degrees toward the side supports. Large logs often require two people with cant hooks. If working solo or with especially heavy logs, I pick up the cant with lifting straps on the tractor forks. Rotating a log while it's hanging in straps is easily done with a cant hook. After rotating it, slide the cant against the side supports, level the log centers using the wedge and clamp the log.

You can generally get the log close to square by pinning the first face squarely against the side supports, but I always do a test cut to be sure. The difference in the adjacent-face cutting procedure is to allow for this test cut. Even though the blade kerf is only 1/16 in., I allow an extra ¼ in. so that the squaring procedure can be repeated if necessary. After the first cut, remove the slab and test for square with a framing square. I test several spots along the log, avoiding areas near knots, which can cause the saw blade to rise a bit. If the test cut is not square to the first face, unclamp the log, rotate it appropriately and reclamp it. (The cant won't return to its first position when you reclamp because of weight and friction.) Then lower the blade by ⅛ in. and make another test cut. Once the log is properly squared, you can proceed with cutting the outside boards and the adjacent timber face, following the same procedure as before.

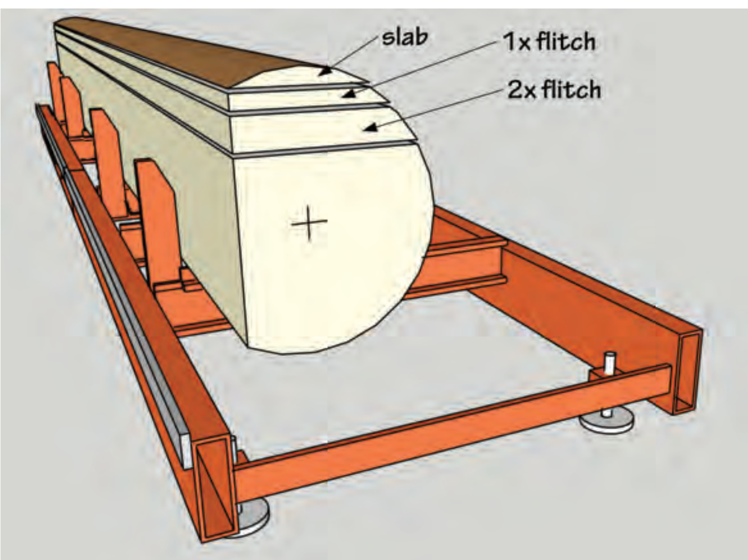
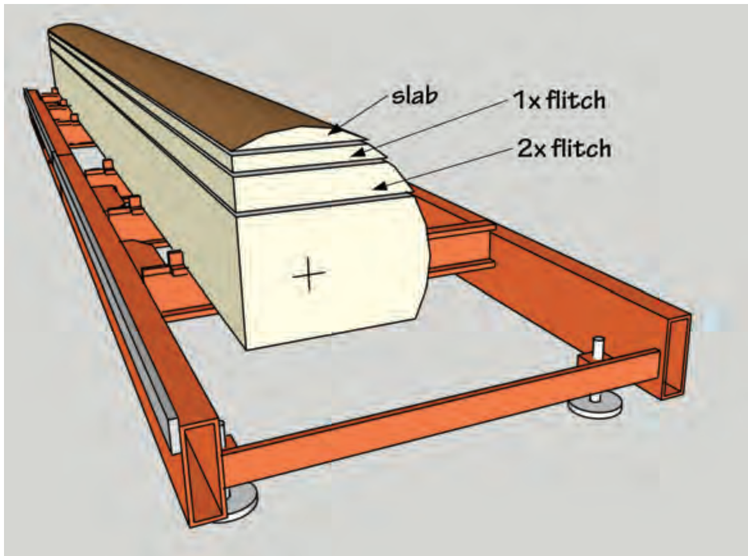


Fig. 8. Successive cuts for second face.

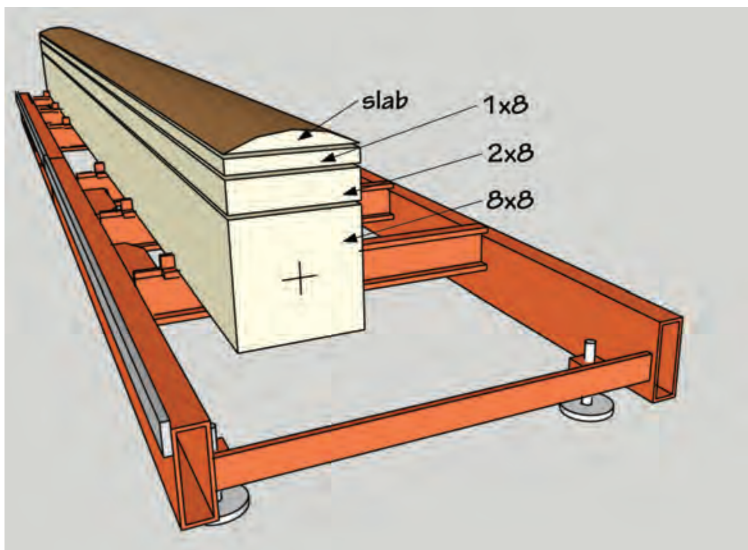
Cutting the Remaining Timber Faces. The two faces remaining are the easiest cuts. Unclamp the log and lower the side supports, which are not used for the remaining cuts. After rotating the cant 90 degrees toward the side supports, the first face of the timber rests evenly on the mill bed, so wedging is no longer necessary. Push the log firmly against the short tabs on the mill bed and clamp, again avoiding excessive force.

With a finished timber face on the bed, you no longer need to measure from the center. Simply calculate the boards or planks available above your timber and add 1/16 in. for each cut. Following our 8x8 example, if more than 12 in. of usable log remains, set your blade height to 12⅛ in. (8 in. for the timber, say 4 in. for two 2-in. planks and two sixteenths for two cuts). The first cut generates a slab. Lower the blade to 10 1/16 in. to cut the first plank. Then lower the blade to 8 in. to cut the second plank and the third face of the timber (Fig. 9).

Cutting the fourth face of the timber is identical to cutting the third, except that the outer boards will not require edging (Fig. 10). With the timber milled, all that's left to do is stack and sticker the timber and trim the free-edge flitches from earlier cuts.

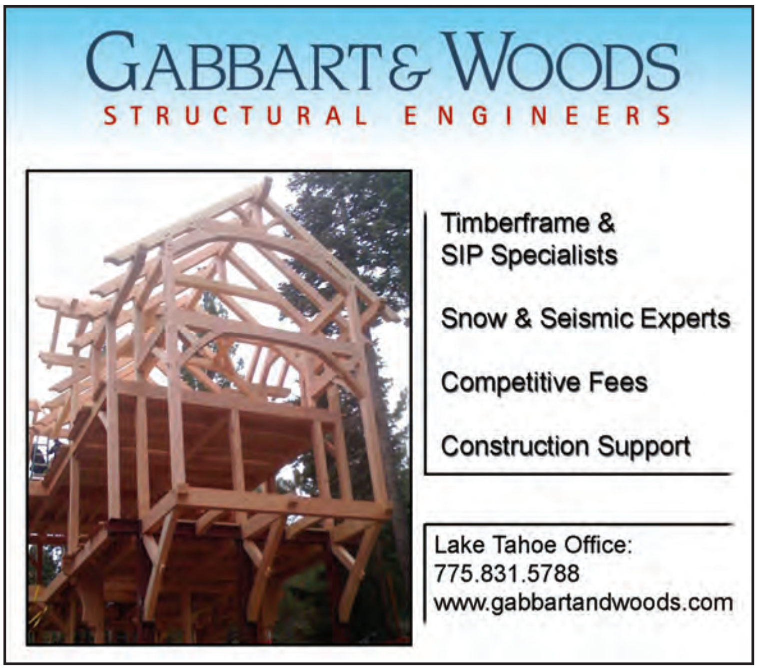


Figs. 9–10. Third face of timber is parallel to first, fourth to second.



Milling timbers has parallels to timber framing. A similar level of precision is required and experience with moving heavy materials is useful. Most of all, the pride of workmanship in milling a truly square timber is comparable to that taken in a well-fitted timber frame joint. —Ben Weiss

Ben Weiss posts his timber framing experiences at www.frame1.org.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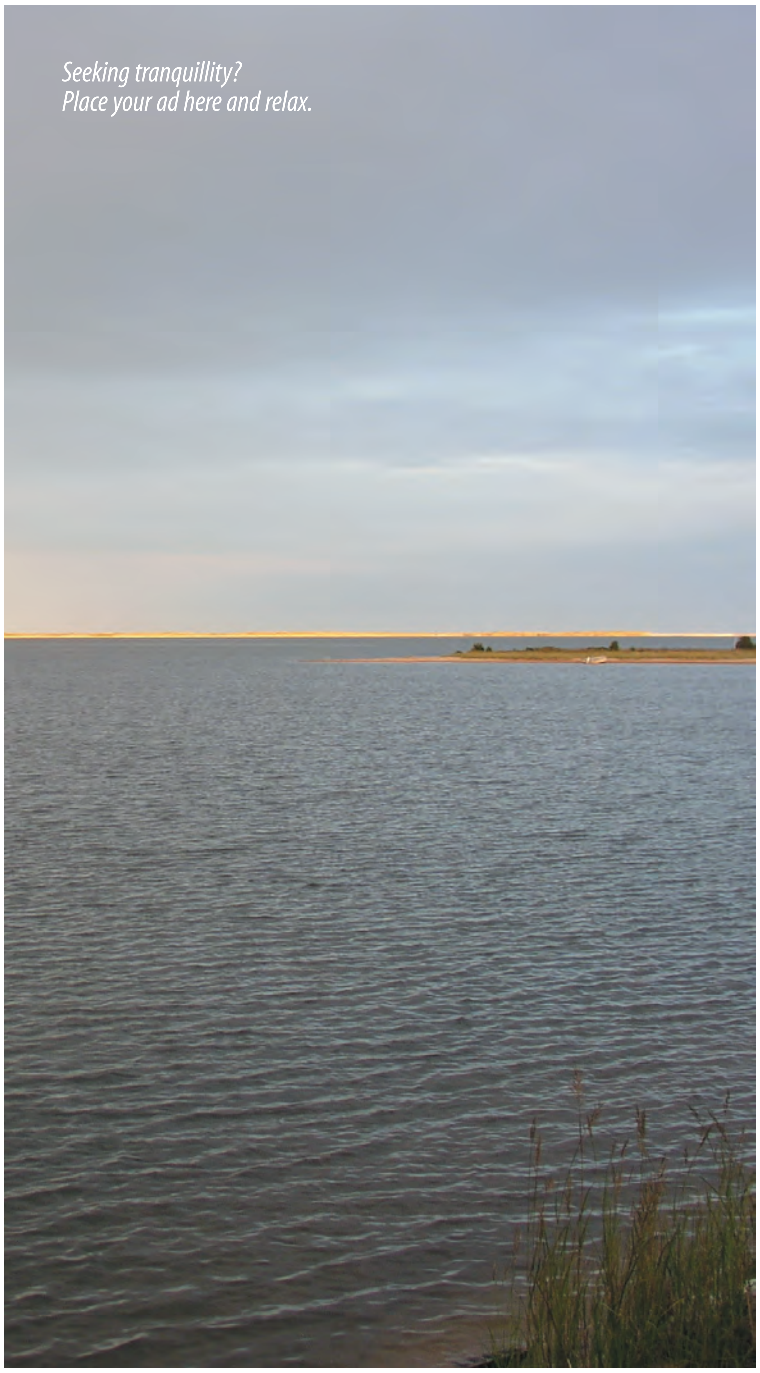
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