Master Carpenter

The Essential Timber-Frame JOINT

Learn a veteran framer's technique for making large pegged mortises and tenons

BY WILL BEEMER

At first glance, a timber frame is all about the exposed wood and the strength implied by its large scale. Look a little closer, and you'll see that the real magic lies in the joinery that unifies the wood into a structure. The joint I'll concentrate on here is the mortise and tenon, which is ubiquitous throughout furniture-making and cabinet making and is used to join one piece coming in at an angle (often 90°) to another piece. As an extension of the long grain, a tenon inserted into a mortise increases the captured surface area within a joint. In a timber frame, pegs (also known as trunnels or tree nails) secure the joint and prevent rotation and withdrawal. Modern mechanical fasteners can be used instead of pegs, but in centuries past, they weren't an option.

Here, I'll demonstrate the basic techniques used to cut mortise-and-tenon joints. I start by setting a timber level on sawhorses. I cut the tenon,

THE CRAFTSMAN

Timber-framing is one of the oldest forms of home building still being practiced. It's part of a tradition that can be seen today in buildings constructed 800 years ago. While it's no longer the conventional form of building, many still view timber-framing as the embodiment of carpentry and the craft of home building. One of the people responsible for preserving the tradition is Will Beemer. For the past 30 years, Will and his wife, Michele, have run the Heartwood School in Washington, Mass., where they teach courses on carpentry and timber-framing. Will also has been active for many years in the Timber Framers Guild, an educational nonprofit organization dedicated to keeping the craft alive.

Last spring, senior editor Charles Bickford took a drive up to the Berkshires to hang out with Will and to watch as he had his way with a mortise and tenon.

LEVEL YOUR WORKSURFACE

Aim low. *The larger dimensions of the timbers create the potential for a higher-than-normal worksurface. Bring down the surface to a normal height by using shorter sawhorses. A 24-in. to 30-in. height is common.*

Find level. *Because most timber-frame joints are made by drilling and cutting plumb, a level timber improves accuracy. While shimming the legs of the sawhorses is a possibility, the best option is to start with a level piece of ground or, even better, a shop floor.*

Find the arris. *With the timber level, use a framing square to find the two sides that are square to each other. These sides become the reference used for layout, and their intersection is known as the arris. It's a good idea to indicate the arris with a chalk mark.*

A few rules of thumb

One thing to keep in mind is that mortises reduce the strength of any timber, so smaller mortises are better than bigger tenons. Of course, properly sized joinery ultimately is an engineering question, so if in doubt, consult a qualified timber engineer. Here are some general rules.

- **Mortises and tenons should typically be one-quarter the width of the timber but never more than one-third.**
- **The wood remaining on each side of the mortise should be at least the thickness of the tenon, and the peg should penetrate at least that amount on both sides of the tenon.**
- **The peg diameter should be one-half the thickness of the tenon.**

Top and bottom photos this page: John Ross

TENONS START WITH THE SHOULDER

When cutting a tenon, always cut the shoulders of the tenon first with a defining kerf, then come in from the end with a chisel. The waste should pop out.

The tenon should be full dimension for at least half the length nearest to the shoulder, but it can be slightly smaller at the outer end where it first engages the mortise so that it enters easily. Taper it about ⅛ in. on the sides and on any nonbearing surfaces. The bottom face of a joist tenon should not be tapered because it's bearing the load. A 45° chamfer all around, about ¼ in. wide, on the end of the tenon will keep chips from splitting off as the tenon is inserted.

Keep the cut shallow. *To compensate for out-of-square timbers, adjust the blade depth to the shallowest cut. Once the shoulder is cut, kerf out the remaining tenon waste.*

then the mortise. I wrap up with drawboring, the technique to secure the joint. Before getting started, there are some things to know about timbers.

Choose timber wisely

In timber-framing, the mortise-and-tenon joint is meant to align the timbers in the frame, to pull the timbers tight during assembly, and to keep them tight as the frame shrinks. Some mortise-and-tenon joints are not even pegged if their role is just to register timbers. Some joinery also can bear a considerable weight in compression or shear after the frame is up, but I usually rely on the shoulders or housings around the joints, rather than the tenon itself, to take on this work, especially because the tenons are often tapered a bit to make assembly easier.

The large dimensions of the timbers themselves create some unique issues. For example, you usually bring the tool to the timber rather than vice versa. Also, as wood dries, it becomes more difficult to work with hand tools, so if you're planning to use seasoned timbers, hardwoods, or a species like Douglas fir that has hard annular rings, you might want to

TRICK OF THE TRADE

Try the French snap

The French snap is a neat trick to use when cutting a tenon. (American timber framers learned the trick from French framers, hence the name.) Make two crosscuts, one at the shoulder and one from the other side at the end of the tenon. When you hit the end of the waste block, the timber splits along one of the cheeks of the tenon, saving you a cut. It's a cool trick that dramatically shows how grain can be your friend. However, it's a good idea to make sure the grain is relatively straight before trying it.

Drawing facing page: Dan Thornton

In a perfect world,
timbers are perfectly milled and uniform

In reality, timbers usually arrive on site only roughly square and nominally dimensioned. To make layout easier, you can use several methods to correct the material's inconsistencies. The method used here is called the square rule. It's based on the idea that within every irregular, rough-sawn (or hewn) timber, there lies a slightly smaller perfect timber. For example, a 7x7 post may actually measure 7¼ in. by 6¾ in.; it would be laid out as if it were a perfect 6½ in. by 6½ in. On each timber, the straightest two sides that are most square to each other are marked as reference faces. All joinery measurements are made from these faces. Any discrepancies in a timber's dimensions are canceled by cutting a housing or shoulder on the joint's mating surface that reduces the parts to the perfect timber size.

Nibble your way to the line. *Because the grain direction may not run parallel to the tenon, it's a good idea to remove waste gradually with a mallet and chisel, starting well above the line. With most of the kerfed waste removed, turn the chisel, and pare across the grain down to the line.*

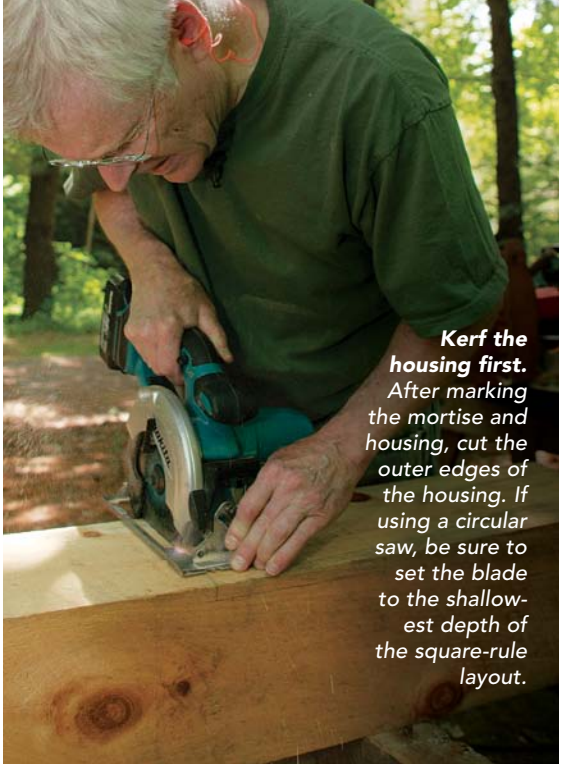
Clean up the tenon. *A block plane works well to chamfer the edges.*

CUT THE HOUSING AND THE MORTISE

Many mortises have housings to accept the end of the tenoned piece. A housing is one way to hide the effects of shrinkage, and it also provides additional support to the joint. Typically, the author defines the housing with a sawkerf at each side before drilling the mortise.

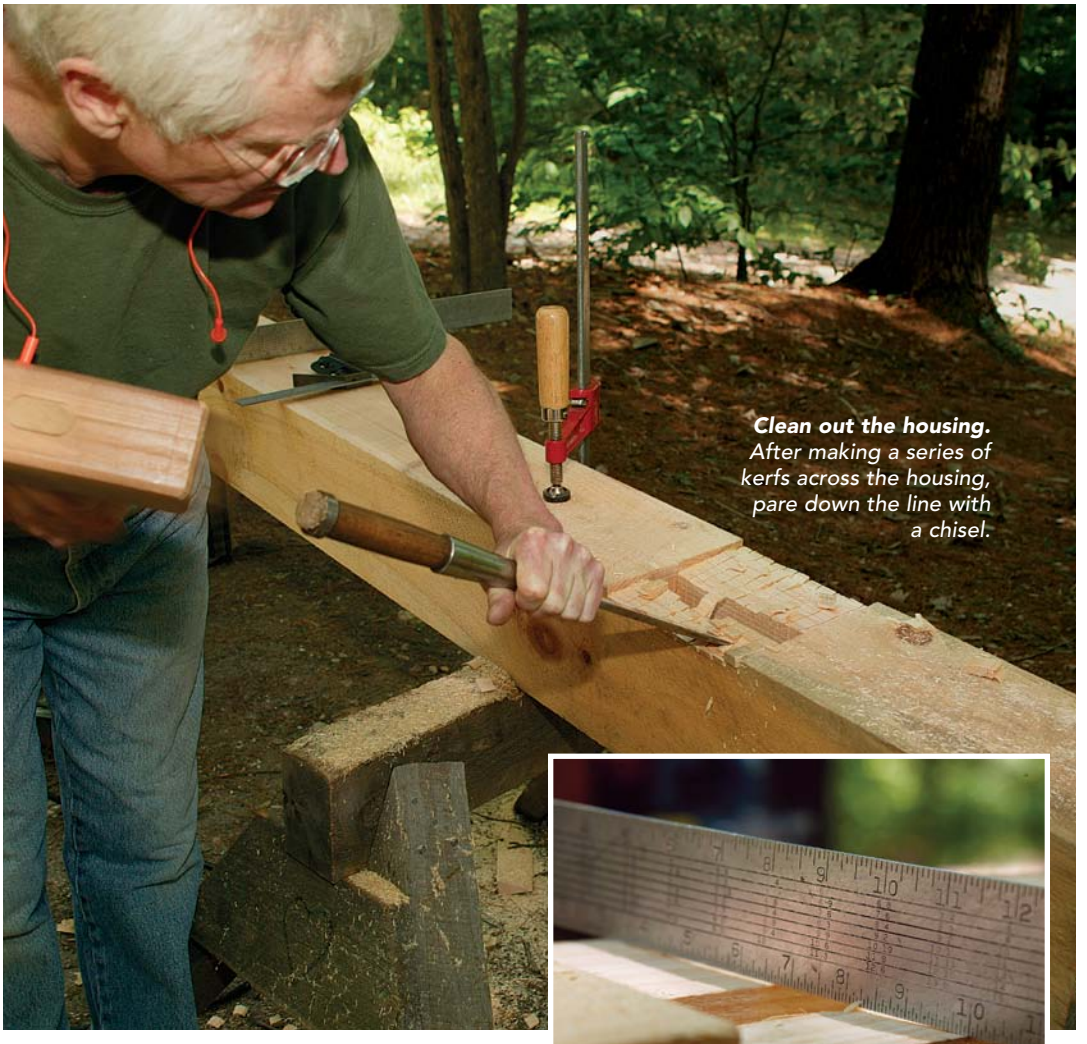
Whether you use a chain mortiser (as in the photos) or hand tools, drill the two holes at the ends of the mortise first, then excavate with holes between. Use a drill bit as wide as the mortise will be. Next, chop down across the end grain with a chisel, and then turn the chisel 90° to pare out the parts that have been severed. Repeat as you work your way down into the mortise. Always make the mortise ⅛ in. to ¼ in. deeper than the tenon is long so that the tenon doesn't bottom out in the joint as the timbers dry.

If you're using the surface of the timber as a reference to measure both squareness and depth, the housing tables can be cut slightly concave so that as the timber dries, the tangential shrinkage will make the table flatter, rather than bellying up to push the joint apart.



Kerf the housing first. *After marking the mortise and housing, cut the outer edges of the housing. If using a circular saw, be sure to set the blade to the shallowest depth of the square-rule layout.*

Define the mortise. *A chain mortiser is like a mini-chainsaw set up for plunge cuts. Begin at the ends, then cut out the middle of the mortise.*



Clean out the housing. *After making a series of kerfs across the housing, pare down the line with a chisel.*

Plan for wood shrinkage. *It's best to make the housing surface or table slightly concave so that the joint stays tight as the wood shrinks.*

DRAW THE JOINT TIGHT WITH AN OFFSET PEG

Prevent blow-out. *Because the auger bit is pulled through the timber by its screwhead, it will stop cutting when the tip emerges. If you pull up while drilling, you won't bore through the other side.*

Peg holes should be drilled perpendicular or slightly off angle to the face, and all the way through the mortised member. It's best to start from the face closest to the tenon. Some timber framers drill the joints for pegs all at once after the frame is assembled and pulled together on site, but those joints will never get any tighter and may open over time. When pegs are driven through a joint, the drilled hole shouldn't really be straight. Instead, the peg holes should be slightly offset, or drawbored, to pull the joint tight during assembly and to keep the joint tight as the timbers settle. By offsetting the peg hole in the tenon a bit, the peg bends slightly to pull the tenon into the mortise and to act like a spring for maintaining tension as the timbers season.

Mark the offset. *Fully insert the tenon into the mortise, and lightly mark the tenon with the drill bit. Pull out the tenon, and mark an offset of a light ⅛ in. toward the tenon's shoulder. Drill the tenon's peg hole in the offset location.*

Lock the joint. *After fully reseating the tenon, drive a tapered drawbore peg into the hole, which draws together the joint.*

Drill a plumb hole by looking in the mirror

I was taught this trick by a Japanese carpenter and passed it on to the Timber Framers Guild. Place the mirror's aperture on the peg-hole location, and center the drill bit. While drilling, line up the bit and its reflection in the mirror. The hole will always be perpendicular to the timber. Order this $15 tool at the Timber Framers Guild website: tfguild.stores.yahoo.net/midrgu.html.

opt for power tools. If you prefer hand tools, you should use an easy-to-work species, such as green eastern white pine.

I recommend that you cut joints as soon as possible after timbers are milled, get the frame raised, and let the timbers shrink after being locked in place. You can accommodate shrinkage in the design and joinery decisions. If you are going to season the timbers, begin by peeling the logs and letting them dry. Wait to mill them square until just before cutting the joints. If you mill timbers square or do the joinery and then store them unassembled for more than a year or so, they may twist so badly that they'll be unusable. Again, use a species that shrinks less, like eastern white pine, rather than hardwoods.

The effects of shrinkage can be particularly pronounced when using large, green timbers that have just come from a sawmill and have not been planed. If you're not using seasoned or planed-to-dimension timbers, you need to be aware of the reference planes of the frame you're building to and to adjust the base of the tools to cut parallel and perpendicular to these planes. This might mean shimming the base of mortises or, if cutting the shoulders or waste from a tenon, being sure to set the depth of the circular saw at the shallowest setting. □

Photos by Charles Bickford, except where noted.

Online members can watch the *Master Carpenter* video at **FineHomebuilding.com/extras.**