Versatile Option for Leg Joinery

Threaded rod and epoxy offer a rock-solid alternative to the traditional mortise and tenon

BY TIMOTHY COLEMAN

I love wood-to-wood joinery, and the mortise-and-tenon joint, or some variation of it, is at the foundation of many of my tables, chairs, and cabinets. But in building a recent bench I found myself seeking an alternative to the traditional mortise-and-tenon. The bench would feature some extra-curly maple, and I decided to limit structural components for a clean, minimalist look. This meant no aprons to join the legs, and no intermediate stretchers to brace them. A long seat, and four legs. That's all.

At first thought, the joinery seemed straightforward. The legs were beefy and the seat was 1⅝ in. thick where the legs join. Plenty of room for two side-by-side floating tenons. Using my slot mortiser (or Domino, or router) I could cut mortises in the legs and seat in a jiffy. But there was a complication. The bottom of the seat is curved, and the legs are rotated so their outside faces aren't parallel with the edge of the seat. Cutting the seat mortises on an angle would be unwieldy and inaccurate using my slot mortiser, and if I used a router or Domino instead, I would need a custom jig setup.

Hoping for joinery that would be simpler but no less durable, my thoughts turned to dowels. I could make a simple drilling jig to guide the bit when cutting holes in the legs and seat. This would be an efficient and economical solution. But I was concerned about the strength of wooden dowels, even with four in each leg. I have seen wooden dowels loosen or break when a joint such as this is subject to a severe lateral blow.

Threaded rods simplify complex joinery. *Adapting a technique used with wooden dowels, Coleman uses a dirt-simple shopmade drilling jig and a hand drill to cut perfectly mating holes in parts that meet at odd angles. The combination of steel threaded rod and epoxy can create very strong joints in unlikely places.*

Photos: Jonathan Binzen

MAKE THE DRILLING JIG

Start with the leg. *Before making the drilling jig, cut the leg blanks' end angles. To help with layout Coleman worked from his full-size drawing to make thin plywood templates of the leg and the edge of the seat. He used a straightedge and bevel gauge to measure the angles at the top and bottom of the leg, then used those bevel gauge settings to set the miter angle on his chopsaw.*

Centerlines orient the jig. *Draw crossing centerlines on the top of the leg and extend them a little way down the sides. Then, having made a hardwood block sized exactly to the leg's width and thickness, set it on the top of the leg and transfer the centerlines to the block.*

Drill two types of holes. *At the drill press Coleman first drills the four guide holes. Then he drills four clearance holes down the middle for screws to attach the jig to the workpiece. He countersinks the clearance holes on both faces of the jig.*

The solution came in the form of ⅜-in. threaded steel rod instead of wood dowels, and slow-set epoxy for the adhesive. The epoxy gets in and around the threads and creates an incredibly strong and durable bond. And unlike wood dowels, the steel rods can withstand the most severe forces. This was a joint that I felt confident would hold up over time.

A dirt-simple drilling jig

The drilling jig is sized to match the top end of the leg, so I started by making the leg blanks. After sketching the concept for the bench, I created a full-size elevation drawing to determine the size of the blanks and the angles on the top and bottom of the legs. Working from the drawing, I made one thin plywood template for the legs and another for the edge of the seat. I traced the leg template to lay out all the leg blanks, and then cut the legs' top and bottom angles on a miter saw. Next I marked crossing centerlines on the top of each leg; these would help locate the drilling jig accurately. Then I drew a reference triangle on the top of the leg, pointing toward the leg's inside face.

Next I made the hardwood drilling jig. It should be at least 1 in. thick and exactly the same width and length as the top of the leg—in my case, 3½ in. by 2 in. Place the jig on top of the leg and transfer the centerlines from the leg to the jig. Make a reference triangle on the top of the jig just as you did on the leg, also pointing toward the inside face of the leg. This triangle must face up when you drill into the legs.

The four ⅜-in.-dia. guide holes in my jig are located 1 in. from the ends of the jig and ⅝ in. from the edges. Before drilling them, I cut a test hole in a scrap the same species as the jig and tested the fit of the threaded rod. It should slip into the hole easily. Given epoxy's gap-filling ability, having the fit a little loose is fine; you definitely don't want to have to force the rod in. Use a drill press to cut the four guide holes in the jig. Then drill clearance holes for the screws you'll use to attach the jig to the workpieces. Although I planned to use two screws, I drilled four clearance holes in case I needed to redrive a screw.

Drill the legs first

Clamp the leg blank upright in a vise and align the drilling jig with the reference marks on the leg. Clamp the jig in place on

the leg and drive two self-drilling pocket screws to hold it there. If a screw pulls the jig out of alignment, remove it and try again in one of the extra holes.

With my hand drill, I drilled 2-in.-deep holes into the leg using a brad-point bit with a wooden stop to regulate the depth. My hand drill has a bubble in the handle to help me keep the bit vertical as I drill; and I used a spirit level as I tightened the vise to be sure the top of the leg blank was horizontal. An alternate way to improve drilling accuracy is to make the jig thicker.

For best results, don't try to drill the entire depth of the holes at once. Back the bit partway out periodically to eject chips from the cut and keep the bit from overheating. Countersink the holes slightly. After all the holes are drilled, the legs' curves and tapers can be cut on the bandsaw, and then shaped with a router and hand tools.

Position the legs and drill the seat

I had to be accurate when smoothing the underside of the seat, especially at the joinery points. The curve and thickness

DRILL THE LEGS

Level up the leg. *To make it easier to drill accurate vertical holes with a hand drill, first level up the leg.*

The jig is fixed. *With the drilling jig clamped in place, Coleman drives a pair of self-drilling pocket screws to lock it to the leg.*

Holes for the rod. *Using a handheld drill with a bubble in the handle and a shopmade depth stop, Coleman cuts the four holes for the threaded rod. He uses a brad-point bit sized to make a hole the rod will slide into easily.*

Quick chamfer. *Countersink the rod holes to clean the rim and provide space for some epoxy squeeze-out.*

LOCATE THE LEGS

Design by phone. *Coleman uses a phone photo to help determine what placement of the legs looks best. After taking the photo, he imports it to his computer, then flips the image upside down and enlarges it to assess the arrangement.*

Locate the drilling jig. *Use the centerlines to orient the drilling jig on the underside of the seat.*

Create a mating flat. *The underside of the seat is slightly curved, so Coleman uses a plane to create flats where the legs will be. He's careful not to erase his reference marks.*

Screw down the jig, and drill. *Aligning the drilling jig with the reference marks, screw it in place and then drill the holes for the threaded rod. Before drilling, triple check that the depth stop is properly set.*

needed to be consistent for the legs to project at the correct angle. Once the underside was smoothed, I could determine the final placement of the legs. To do this, I put the seat upside down in front of a seamless backdrop and used double-sided tape to hold two legs in place. I took a photo of the upside-down bench, and turned it right-side up in my laptop. I could then easily reposition the legs and take another photo to get it right. It was surprising how much difference moving the legs just an inch could make.

Once the leg position is set, place the drilling jig at the location of each leg, trace around it, and mark the centerlines from the jig onto the seat. The centerlines help with placement now that the legs have been shaped. Make sure that the jig's triangle reference face is in contact with the seat and pointing toward the middle.

The jig should have full contact with the joinery area. If it does not make full contact, use a sharp block plane to create a flat for each leg by planing across the grain. This should only be a small correction. Any more and you risk changing the angle of the leg. Label each leg location on the seat and put a corresponding label on each leg. Then screw the jig in place.

Be very careful to avoid drilling these holes too deep. My seat's thickness was 1⅝ in. at the joints, so I set the tip of the brad point to project 1½ in. when inserted through the jig. The holes are slightly off perpendicular to the seat, so let the jig guide the bit for the correct angle. After drilling, countersink the holes slightly.

Prepare the rod

To find the correct length for the threaded rod, clean all chips out of the holes in the seat and the legs and use a caliper with a depth gauge to measure their depth. Measure at the side of the hole, rather than the center where the brad point cut. I subtract

GET THE ROD READY

Cut and file the rod. *Hacksaw the threaded rod to length, then chamfer both ends with a file to remove burrs and make insertion easier.*

The joints need masking. *After drilling holes for the rod, mask off the joint and a generous margin around it. Then insert the rods, dry-fit the leg, and carefully knife around the leg. Then remove the leg, the posts, and the tape inside the scribe lines.*

⅛ in. from the combined total depth to ensure that the rods don't bottom out and allow room for a little epoxy at the bottom.

I use a hacksaw to cut the rod to length, and a file or grinder to soften the ends. This keeps them from digging into the sides of the hole and hanging things up during assembly. Insert the rods in the holes and check each one with the depth gauge. Keep the rods in their respective holes and test the fit of each leg in the seat.

Epoxy glue-up

I use a slow-set epoxy and have been happy with System Three T-88. It's more viscous than others, which makes it good for joinery. I'll mix about 1 oz. of epoxy to glue all four legs. Use a bamboo skewer to put glue in the holes, doing one leg at a time. Insert the rods and move them up and down to help distribute the epoxy. Spread glue in the seat holes and make a thin bed of it at the contact point. Apply a little glue to the ends of the rods in the leg and assemble. Rock the leg slightly to help disperse the glue and press it in as far as possible until glue squeezes out all around. Repeat with the other legs and clean up excess glue with lacquer thinner.

To hold the leg tight while the epoxy cures, I clamp two blocks faced with sandpaper to the sides of the leg, and then cross clamp them to pull the leg home. Let the assembly sit overnight before removing the clamps. Any leftover epoxy can be cleaned up with a scraper and sandpaper. □

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ASSEMBLE WITH EPOXY

Apply the epoxy. *Coleman uses a bamboo skewer to spread epoxy in the holes, then pushes the posts in and out to spread the glue. He also butters the top end of the leg.*

The clincher. *Use hand pressure to push the joint together. If necessary, use clamps to bring the leg all the way home, then remove the mask of tape. While the epoxy cures, Coleman holds the leg tight with F-clamps pulling down on a pair of battens clamped to the leg. Sandpaper adhered to the inside face of the battens keeps them from shifting.*