Building a Case for Strength

Strategies drawn from structural engineering solidify your furniture

I am not an engineer, but I developed a good sense of loads and structure when I spent several years as a designer of timber-frame structures. Buildings framed with huge timbers may seem like distant cousins to furniture, but they aren't far removed. Understanding the forces acting on a piece of furniture is much like understanding the forces acting on a building.

When I received a commission to build a chest of drawers slightly over 6 ft. in length, my first thought—after roughing out a design with 10 drawers and no supports between the legs at each end—was how to deal with the loads created by all those heavy drawers. My primary concern was deflection, or sagging, which could change the shape of the drawer openings, leading to drawers that don't fit their pockets. Not acceptable! I'll outline here the approaches I used to construct a case that could withstand that load across a long, unsupported span. You can adapt the ideas to casework of any size or style.

Structural strategies

I stiffened the structure in a variety of ways: adding diagonal braces, L-section aprons, and a rigid back that turns solid back panels

Photo, this page: Mike Korsak

and Stiffness

BY MIKE KORSAK

into beams while still permitting them to move with the seasons. The diagonal braces were the biggest game-changer—they greatly stiffened the case but also altered the load path, leading me to strengthen the back to compensate.

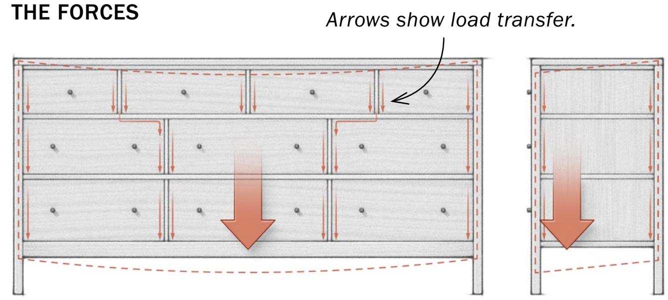
Aprons add stiffness—The front and rear aprons are main load-carrying members, so I designed them to be very stiff. The curving bottom edge of the apron, flowing and asymmetrical, might add a whimsical note to the chest, but engineering influenced its design. I located the tallest part of the apron at mid-span, where the potential for deflection would be greatest; and I let the apron narrow

How to withstand deflection

When I designed the structural components of the chest of drawers, I didn't rely on complex equations. Instead, I simply identified the locations of each load (I considered each drawer side to be a source of load) and traced the paths those loads would take. The small arrows in the drawings below show those paths. And the large arrows indicate what the cumulative force could do to the chest. By tracing the paths for each drawer, I saw where the loads would be concentrated, and where reinforcement would be needed. Because of the chest's wide span, and because the front is an open structure of thin members that is required to carry a lot of weight, I had to think creatively to reduce potential deflection. I made both structural and joinery improvements, grasping every opportunity to strengthen and rigidify the case. I like to think of structure as a team sport. Some parts do multiple jobs, some do only one, but they all work together.

—M.K.

THE FORCES



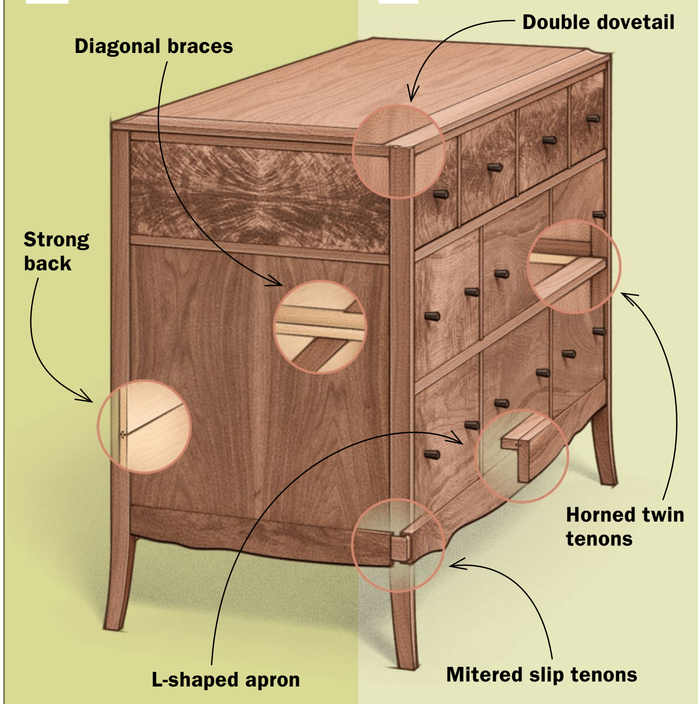
If the bottom rail deflects under the cumulative load, the case will sag.

Without a brace, front rail deflects.

THE FIXES

1 BEEF UP THE STRUCTURE

2 PUNCH UP THE JOINERY



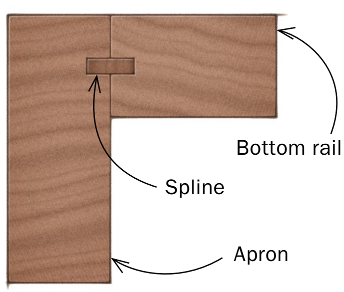
1 Beef up the structure

To keep precisely fitted drawers operating properly in a long case without central support, Korsak had to find ingenious ways to keep the framework rigid.

CREATE A COMPOSITE BEAM

L-SHAPED APRON

The apron is splined and glued to the bottom rail, creating a rigid composite beam that resists both vertical and horizontal stresses.



To stiffen the front apron, Korsak glues it to the bottom rail, making an L-shaped beam. He does this with the back apron as well. He shaped the aprons so they are tallest at mid-span, where the load is greatest.

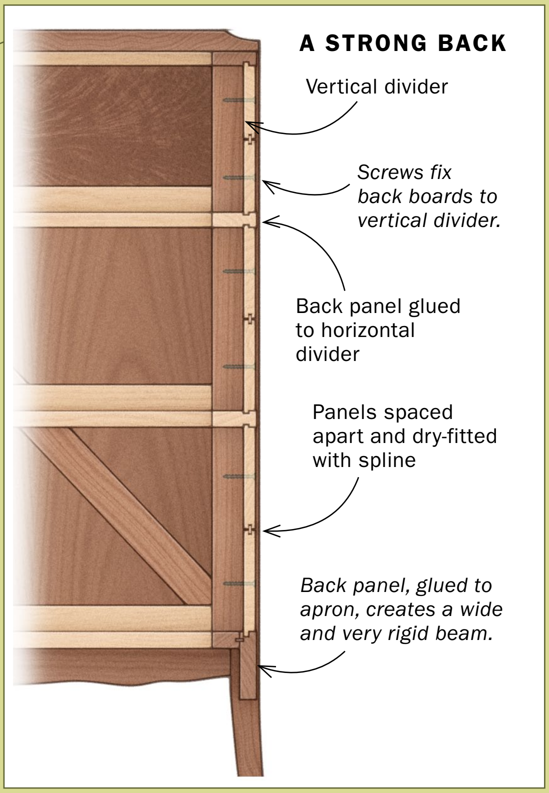
down where it meets the legs. This might seem counterintuitive, but the internal stresses that cause deflection in a beam are generally highest at the center of a span. By contrast, at the ends of a beam the primary stresses are shear—downward forces—which don't require as much material to resist. So it's smart to add height where the bending stresses are greatest, at the center of a span. It is worth noting that for any beam subject to vertical loads, the height of the beam contributes much more to the beam's stiffness than does the thickness.

I further stiffened the front and rear aprons by attaching them to the bottom rails. This created beams with L-shaped cross sections, which are strong in resisting both vertical and horizontal loads.

Braces prevent sagging— When designing timber structures, I used braces wherever possible to improve rigidity. Diagonal braces create rigid

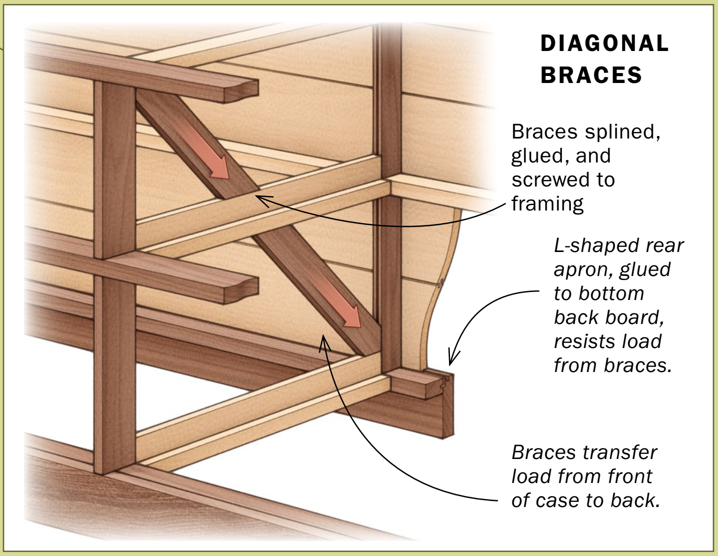
Drawings: Christopher Mills:

THE BACK BOLSTERS THE CASE



To create a wide, rigid beam, Korsak grooves the L-shaped apron (top left) and mills a mating tongue on the back board (left), then glues them together (right). The back board gets grooved along the top edge to accept an unglued spline.

ANGLED BRACING TRANSFERS THE LOAD



Korsak installs diagonal braces to triangulate the structure and to shift load from the weaker front of the case to the back. He grooves the ends of the braces for splines, then glues and screws them in place.

triangles, one of the foundational tools for achieving structural stability. While braces are not typically seen in furniture making, there is absolutely no reason why they shouldn't be. The braces in this piece added tremendous rigidity. They also absorbed vertical load from the open front of the case and transferred it to the back.

A normal rear apron might have bowed outward from the force. But since I had made the rear apron L-shaped in cross-section, it was stiff enough to resist the horizontal load from the braces.

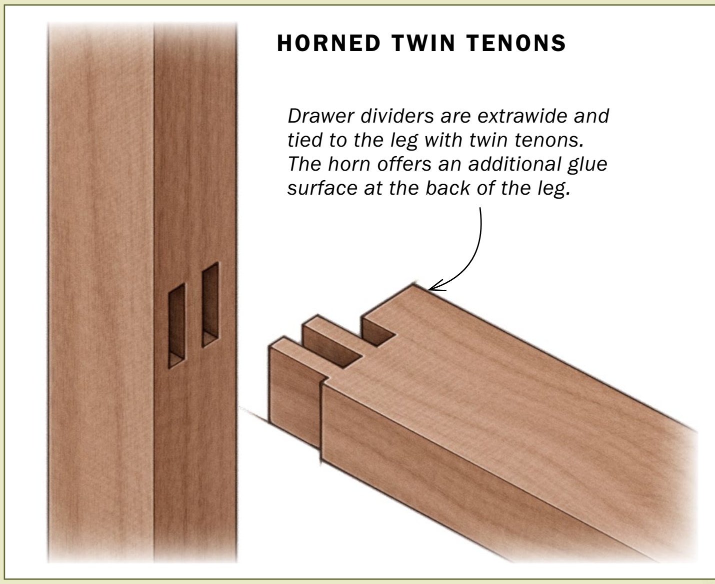
The braces I installed were interrupted by the drawer runners and guides, so each brace was actually two pieces.

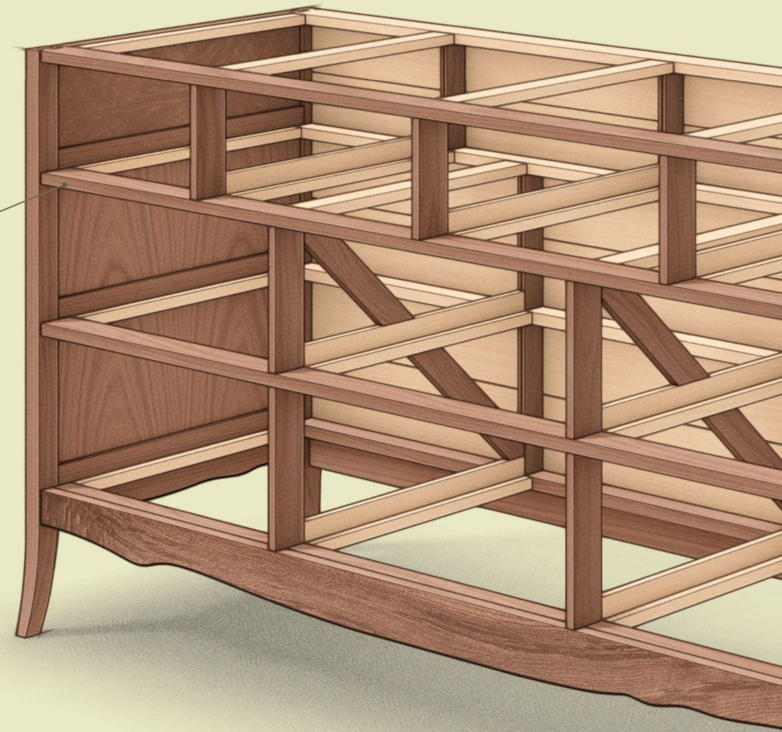
Photos, except where noted: Jonathan Binzen

2 Punch up the joinery

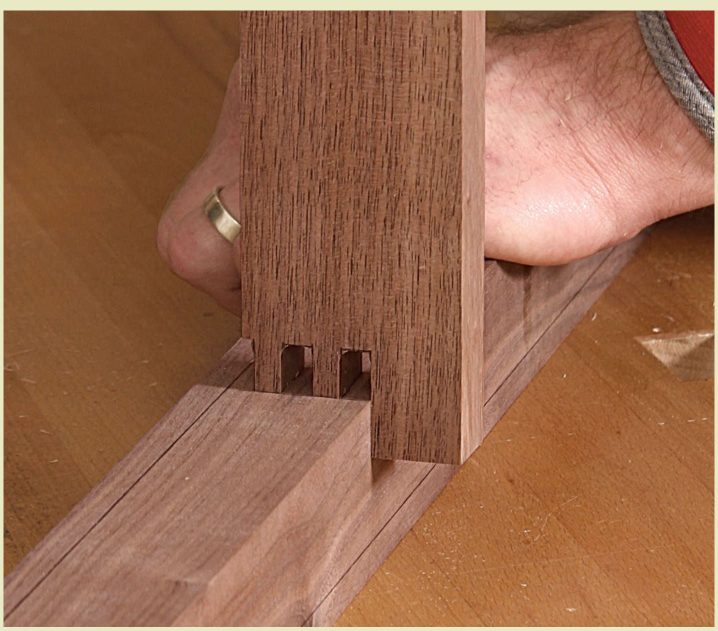
At key spots, Korsak augments the traditional joinery in his chest of drawers with even stronger versions.

SPECIAL JOINERY CINCHES THE STRUCTURE





Korsak's horned twin tenon delivers increased strength where the drawer divider meets the leg. He roughed out the joint at the bandsaw, trimmed it to size with a router and template (right), and cleaned up the corners with a chisel.



I made them a bit thinner than the drawer guides so they wouldn't interfere with the operation of the drawers.

A stiff back—Bearing in mind that the braces would transfer vertical loads from the front of the case to the back, I designed the back itself to provide a huge amount of rigidity. Rather than letting the wide back boards float in a frame-and-panel arrangement, I glued one long edge of each board to a horizontal member, creating a series of very deep composite beams. Along their other long edge, adjacent boards met in an unglued spline that permitted movement. At their ends, the back boards were also glued to the legs, though I left part unglued to allow for movement.

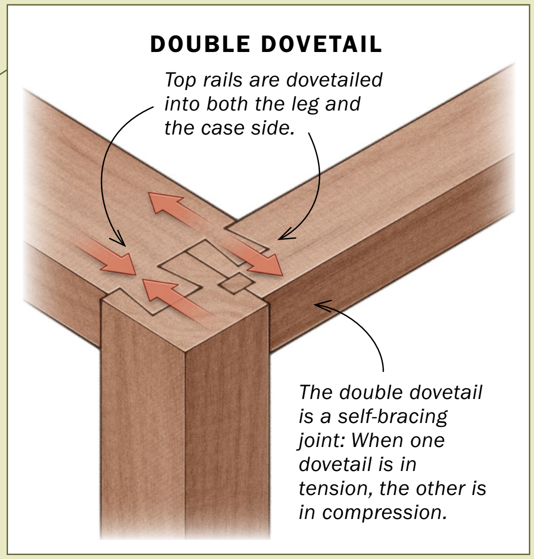
Finally, I screwed the back boards to the rear vertical dividers, helping all parts of the back act as one in resisting loads.

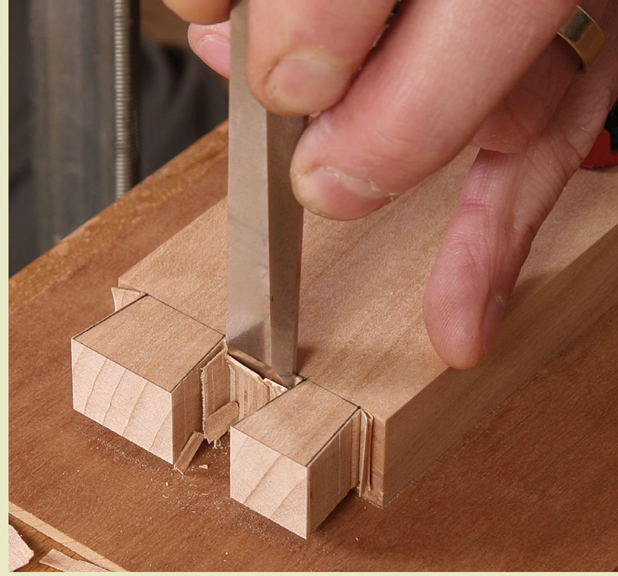
Sides that won't budge—For the sides of the case, rather than using a traditional frame-and-panel structure, I opted for veneered panels. That allowed me to glue the panels on all four sides, creating a completely rigid end structure. I glued the plain and burl walnut veneers to the same plywood substrate, and let in a solid divider between them.

A well-secured top—The top of the chest also contributes to overall stiffness, acting as a horizontal beam. I used it to stiffen the top front rail, heavily fastening the two with screws. Except at the front, I used slotted clearance holes to allow for seasonal movement.

Robust joinery

Strong joinery is a vital step in resisting loads, and I was extremely attentive to it in this piece. To join the horizontal drawer dividers to the legs, I used double tenons, which provide a lot of glue surface and also prevent the dividers





The paired dovetails, cut with a bandsaw and cleaned up with a chisel, lock the top rail to the leg and side for the long haul.

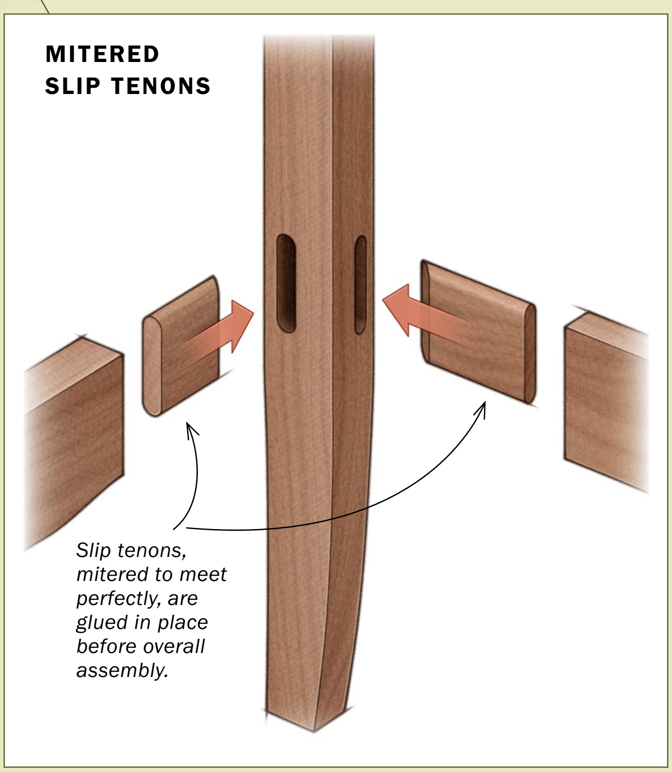
from twisting. To make the joint even stronger, I made the dividers wider than normal and added a horn that wraps the leg on the inside, providing additional glue surface.

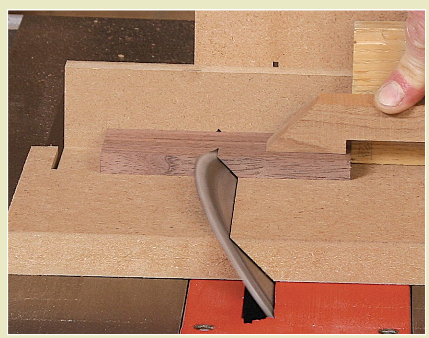
On the ends of the top rails I used double dovetails, one dovetail into the leg and the other into the case side. In engineering terms, the double dovetail is a "moment connection," basically a self-bracing joint: When one dovetail is in tension, the other is in compression, adding welcome resistance to lateral loads.

At the ends of the vertical dividers I used sliding dovetails reinforced with screws. And where the horizontal drawer dividers crossed the vertical ones, I used a lap joint so both members could run through the intersection, maintaining their structural integrity.

Where the aprons joined the legs I used slip tenons. I cut intersecting mortises and precisely mitered the tenons. I glued the tenons in—and to each other at the miters—as the first step of assembly. □

Mike Korsak builds strong, light furniture in Pittsburgh, Pa. Special thanks to Michael Maines for offering up his engineering expertise.





To maximize the length and strength of the slip tenons, Korsak glues them into intersecting mortises, being sure the miters meet. Once the glue cures, he proceeds with the full assembly.