

THE RELATIONSHIP BETWEEN DOVETAIL ANGLE AND JOINT STRENGTH

Notes from The Forest Products Research Laboratory tests (KS Walker) reported in Woodworker Magazine, January 1958. Additional comments by Jeff Gorman and Kevan Lear.

Machine-cut dovetails were formed on a single-spindle moulder with the aid of a dovetailing attachment. For most of the tests, cutters without wings were used. Some tests were made with winged cutters but no difference was reported.

Caveat

Machine-cut dovetails means that the bottoms of the half blind tail sockets and mating tails were rounded. Hence the test was not strictly comparable to hand-made joints, but it seems reasonable to assume that the results would be the same.

All dimensions other than the included angle were kept constant. The pin and tail profiles were identical, as would be formed on a half blind template jig. Board width was 6", the tail piece thickness was 1/2", the pin piece thickness was 3/4", and the pitch was 1".

The included angles were 7.5° (1 in 7-1/2), 10.5° (1 in 5-1/4), 13.5° (1 in 4), and 17.75° (1 in 3-1/4). It appears the angles depended on the cutters that were available.

The joints were tested by a direct pull on a hydraulic press.

Species

African Mahogany (hardwood) and Whitewood (softwood) were used for the tests. The samples were cut from the same board to minimize the differences inherent in natural materials

Dry Un-glued joints

Sixteen tests were made on mahogany, and forty on whitewood. As the strain was imposed, the load first rose steadily and visual examination showed a "stretching" with elastic deformation of the tails and to a lesser extent, the pins.

As the strain increased, a point was reached at which the load dropped momentarily before continuing to rise. This discontinuity in load was due to the two parts of the joint slipping relative to one another.

The applied load on a 6" wide joint in mahogany was between 1,000 and 1,700 lbs. This was regarded as the point at which the joint would have failed in service. By continuing to pull to complete destruction, it was found that joints could bear between one half and one ton.

At the first moment of slip, all failures were the same. The fibers in the tails closed up like a fan. There were several modes of failure:

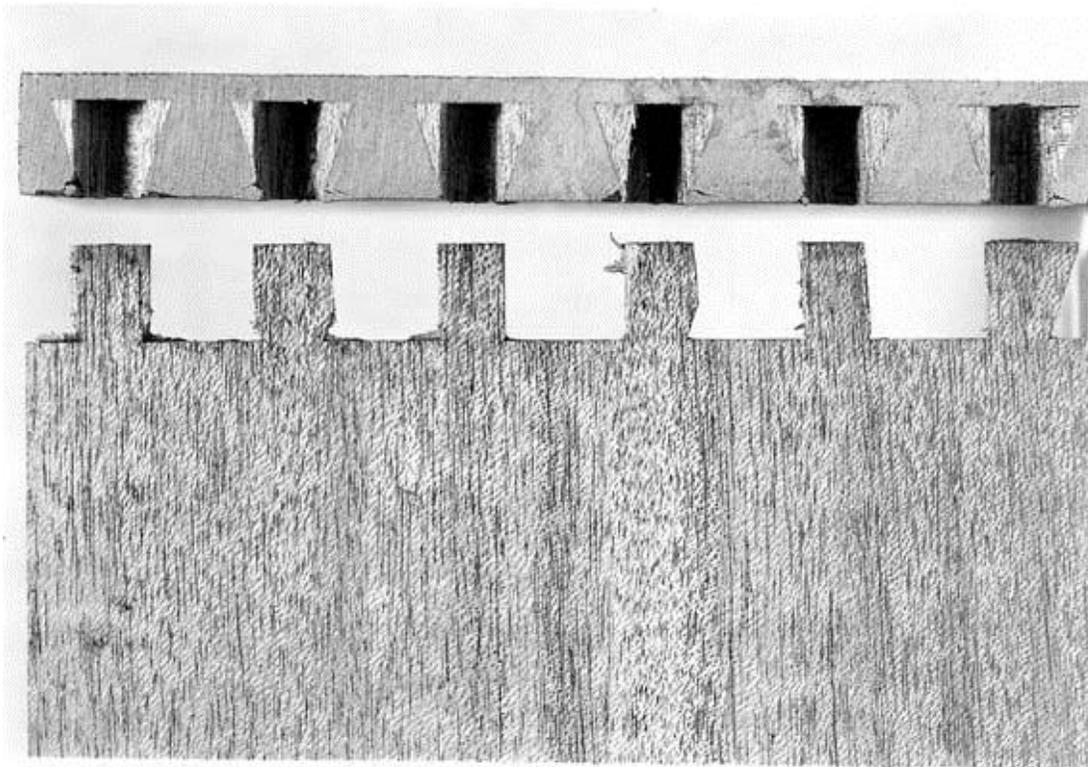
In the hardwood, the 7.5° tails closed up like a fan so they could slide out, with only a slight tendency for the top corners around the recesses to break along the short grain and pull up. This latter mode of failure became more marked with increasing angle until at 17.75° large pieces of the pin piece were pulled out.

In the softwood all the joints failed earlier by the tails closing up (due to the greater compressibility of softwood fibers), even at 17.75°. Interestingly, after the tails had pulled out, they opened out again, almost to their original size.

Glued joints

Only hardwood was tested. A urea-formaldehyde resin and separate hardener was applied and left to cure for four days.

All joints failed by shear along the short grain, regardless of angle, leaving wedge-shaped sections behind in the sockets, as shown below:



The Surprise

An unexpected result was that the failure point was lower when the joints were glued than when they were assembled dry. This appears to be due to the wedging action of the dry joints, where the joint is allowed to slide partially apart, putting the tails into compression across the grain, and thus increasing the shear strength of the wood fibers.

Conclusions

Bear in mind, these joints were all tested with a straight controlled pull under laboratory conditions. In real life, dovetail joints may be subjected to twisting loads (such as when you're moving furniture), linear shock loads (such as when you slam a drawer shut), racking, wrenching, and so on.

It's pretty easy to deduce from the images, these test joints failed, either when the wood fibers were compressed, allowing the joint to slide apart without shearing the fibers, or when the wood fibers reached the limit of their shear strength.

In the case of glued joints, since adhesives are stronger than wood grain, and the joint was unable to slide apart, the wood fibers sheared, and so the dovetail angle made absolutely no difference to the strength of the joint.

In the case of unglued joints, the wider the angle, the stronger the joint, up to the 17.75° angled joint tested.

Traditionally, some cultures used 7° dovetails for hardwood and 9° for softwood, and others used 8° for any species. This research clearly negates any argument the traditionalists might present for dovetail angle strength.

AKEDA Cutter Geometry

The AKEDA cutter geometry is based on each dovetail bit having the same diameter at the upper end, and the same diameter at the lower end. As the length of the dovetail bit varies from 1/4" up to 1", so the angle changes. This has a number of advantages, not the least of which is that it translates into dovetail jig ease-of-use by an operator.

Our theory was, as the material gets thinner, we would need a steeper dovetail angle to maintain the holding power. But the above research seems to negate that theory. Nevertheless, aesthetically, to our eyes anyway, the smaller dovetails seem to look better with a steeper angle, and the larger dovetails look far more elegant with a shallower angle.

The Last Word on Dovetail Angle

We can safely say, dovetail angle is simply a matter of aesthetics and personal taste. And in matters of personal taste, non gustibus disputandum.