Precision Band Sawed Prop Pitch Blocks

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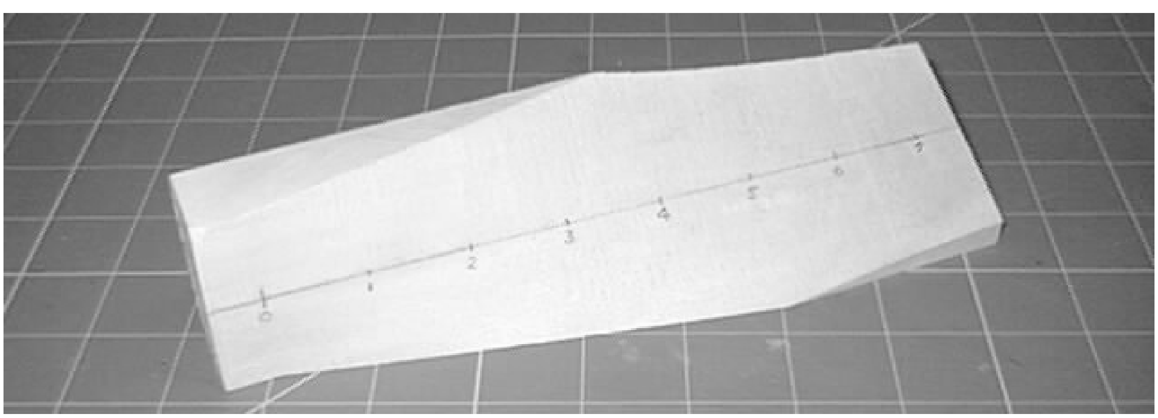
Making Prop Blocks on a Band Saw is Quick and Accurate

Carving prop pitch blocks by hand can be time consuming and tedious and the results are often less than satisfactory. The procedure is so laborious that even many top fliers report making all their blades on only one or two different blocks. Wouldn't it be great if you could make a precise block for exactly the pitch you need in only a few minutes? And even better if you could do it without any expensive numerical control machines? This article describes a fixture for machining precision prop blocks on an ordinary bandsaw. The fixture is easy to construct and is adjustable for a wide range of pitches. The resulting blocks are accurate to a fraction of a degree. And as an added bonus you get two identical blocks from each piece of wood.

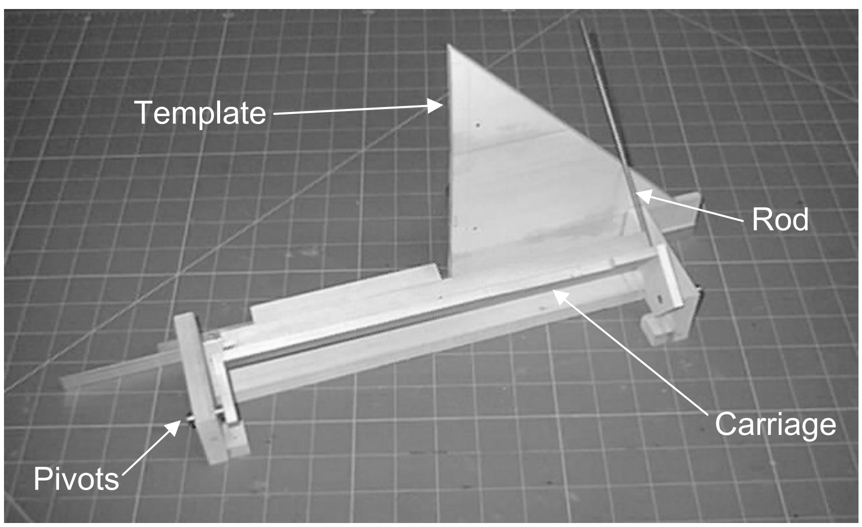


Beautiful Band Saw Machined Prop Block

In his wonderful book "Secrets of Aids for Advanced Aeromodeling" Joe Maxwell describes a fixture for making prop blocks on a radial arm saw. We initially thought this would be just the thing, but there were a few difficulties. The fixture itself looks easy to construct, however the accuracy appears to hinge on a template having a transcendental looking curved shape. Generating the curve precisely appeared daunting. A unique template is also required for each pitch, so you have to spend some time laying out and cutting formica. Besides, neither of us owns a radial arm saw! We do however own two bandsaws between us so we put our heads together and came up with the concept presented here.

Fixture Design Concept

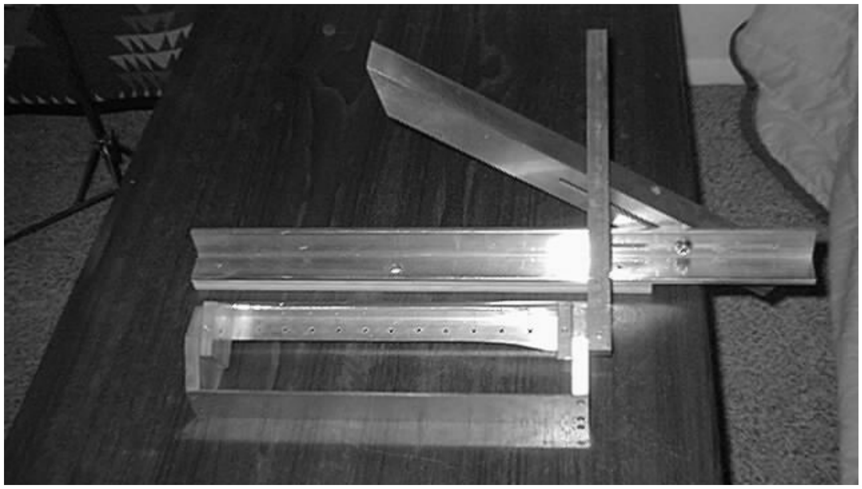
Our fixture guides a hardwood block through a band saw blade using a sliding carriage. As it is sliced in two by the blade, the block is rotated at the required arctangent rate to give a helical angle distribution. A lever arm similar to Maxwell's follows a template. However, since we have rotated our cut by 90 degrees, our templates are straight lines rather than curves which makes them easy to make. Furthermore, you don't even need to make different templates, we just use a hinged straightedge. In a few seconds, the hinge angle can be adjusted to any one of an infinity of pitches. And because our blocks are sliced cleanly in two, there's no finish sanding required, no waste, a lot less sawdust, and you end up with two identical blocks from each cut.



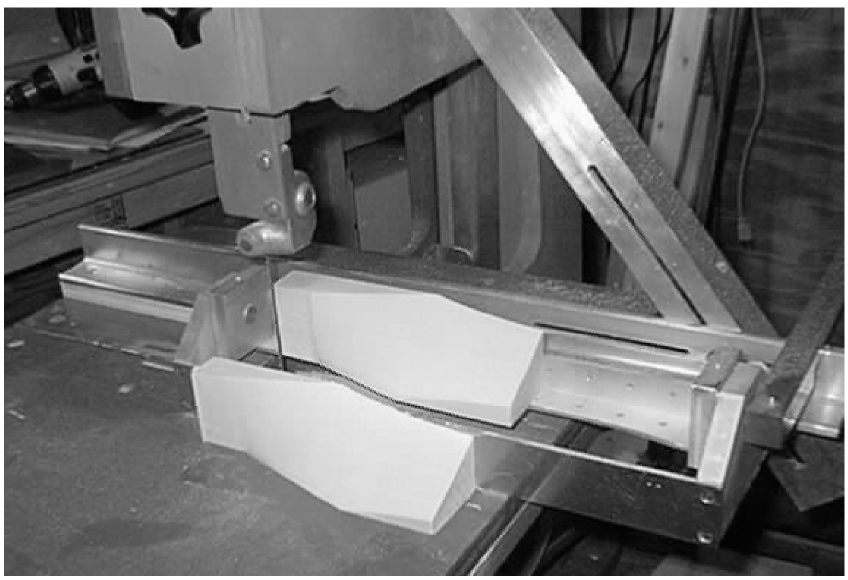
Prototype Hardwood Fixture with Fixed Template

We made an initial prototype out of hardwood in only a couple of hours. It was made by gluing parts made out of 1/4" Aspen from Home Depot together with CA. It used brass tubing for the bearings and had a fixed angle template which was followed with a 1/8" piano wire rod. With the aid of a machinist's caliper, the component tolerances can be easily held to 0.005". We made a few test blocks out of balsa and were delighted when their accuracy exceeded the ability of a protractor to measure any error.

Encouraged by our initial successes, we made a heavy duty model out of aluminum. This improved version allows us to cut blocks up to about 10" in length and has an adjustable arm instead of a fixed template.



Improved Adjustable Aluminum Fixture



Two Identical Blocks from Each Piece of Stock!

Making A Fixture

There are a few things to consider when making a one of these fixtures; first and foremost is stiffness. For the finished prop block to be accurate, both ends of the rotating carriage must turn at the exact same rate and follow the exact angle set by the lever arm. As the bandsaw blade cuts, it resists the rotation of the wood block so any flexibility in the system will result in a variable error in the pitch angle.

- Carriage frame – We decided to build the outer carriage frame of our aluminum fixture in the form of a closed box, as viewed from above, to increase the stiffness of the system. The down-side of this approach is that in order to put the blade next to the wood, we have to take apart the box each time we put the fixture on the bandsaw. Fortunately we only need to remove two screws at one corner to sneak the blade in. Our prototype fixture had an open 'U' shape as viewed from the top. With this arrangement there was no need to take anything apart but the frame deflected and twisted when loaded by the blade forces.

- Lever Arm – Our prototype used a heavy piano wire rod to ride along the template and rotate the carriage. Surprisingly, there was a noticeable deflection in the rod under certain conditions. The newer design uses a more solid ½" square aluminum bar. The bottom edge of the bar is aligned with the center of the carriage rotation axis and only one corner of the bar rides along the template. This feature eliminates any small error associated with the changing cross section of the rod as it rides along the template.

- Pivots – The larger the diameter, the stiffer the system. We used ½" diameter rods as pivot axles for the rotating frame but any gain in stiffness from using large diameter rods may be offset by the difficulty in drilling a larger hole with precision, depending on what tools you're using.

- Wood Attachment – We started out using double-stick tape to hold the wood block on the fixture but it gave way when cutting one time so now we always screw the blocks on.

- Rotating Carriage – You have to plan ahead a bit to make sure that you don't end up cutting through your carriage. We used a 90 degree aluminum angle for the carriage frame as shown in the photos. Our fixture is set up for 2" x 2" wood blanks so part of the angle had to be cut back to about 7/8" to clear the bandsaw blade and its widely set teeth.

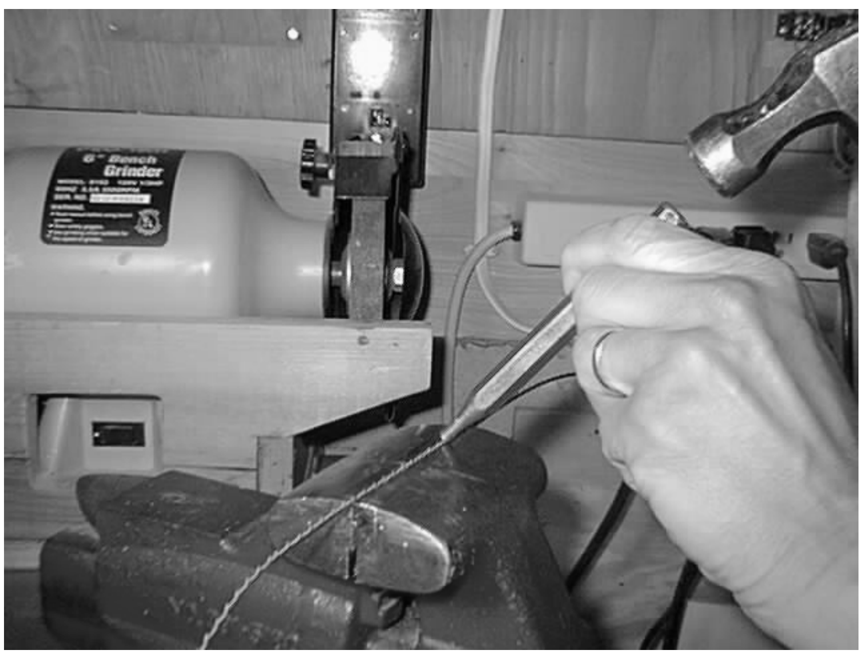
- Template – One of the beauties of this system is the lack of complex templates. In fact, we don't use any templates at all! Instead, we use a sliding bar that can be adjusted to the proper angle and locked in place. We have a simple equation that tells you the angle needed. All you need to know is the pitch of the block and distance from the bandsaw blade to the template edge. The only real trick is that you have to set up the bar to work within the clearance limits of your bandsaw and the range of block pitches that you intend to use. A block with smaller pitch requires a taller template. This description would be easier to follow if you build a simple wood mockup first. We ended up using fairly substantial slotted aluminum angle sections for our template bar system because a side force is applied when the lever arm is tilted up.

- Fence – The bandsaw that we use doesn't have any fence guides or grooves in the table so we use the base of our template bar as a fence. With this arrangement you push the fixture sideways, into the base as you push the block of wood into the blade. It is important to keep the carriage axis of rotation in line with the center of the blade so we set up carefully one time and then drilled and screwed our template base right into the table of the bandsaw. Now the base always goes back in the same spot and we don't have to fuss with aligning it.

Importance of Kerf

They say that the devil is in the details and this critical detail almost brought an end to our project. The first time we cut a block using our prototype fixture, we found that the blade wandered as the carriage rotated. After examining the blade as it began to jam we found that the width of the cut, or kerf, wasn't wide enough to allow the wood to rotate while the blade stayed vertical. Looking down at the blade from above, you could see that angled blade teeth were cutting away fresh wood on both sides of the kerf but the back edge of the blade was rubbing on one side. As the carriage rotated the block of wood, the back edge of the blade that was rubbing would steer the blade away from its intended path and the entire side of the blade would rub that much harder. This spiral of destruction would continue until the basement was filled with the rustic smell of burnt wood. A similar situation was going on at the bottom of the block, but in the other direction. It became obvious that we needed a narrow blade (measured front to back) with widely set teeth to cut a wide kerf.

We tried all of the blades in the basement with no better luck and then went on to order specialty blades. One blade was designed to cut an extra wide kerf for just this sort of thing but had a relatively large blade width of ¼". Another blade had a very small width of 1/16" but had tiny teeth and produced a narrow kerf. We ended up trying a number of blades: 1/4" - 6tpi, 1/8" - 14tpi, 1/16" - 20tpi, 1/4" - 4tpi, but we finally settled on hand setting one of 1/8" - 7.5tpi. Hand setting involves carefully bending the teeth to a greater angle as in the photo below. The final solution was inelegant but did the job surprisingly well. Unless someone comes up with a source for a better blade or a clever gizmo for setting small teeth, this may be your only option.



Setting Kerf By Hand

At first look, resetting the teeth of an 80" blade with 14 teeth per inch looks a little daunting (1,120 teeth!) In reality, it isn't that bad if you're not too picky and can spare half an hour. We held a section of the blade at a time in a vice with 3" wide jaws and gave each tooth in that 3" span one solid tap with a hammer and punch. We set the teeth so that every other tooth was in the opposite direction. There may be better ways to do this but we found that the blade produced a very smooth cut if you just pushed the block slowly through the bandsaw. This is similar to the concept that Joe Maxwell described in his book: one tooth of any circular saw blade will have a larger radius than all the others and will set the depth of the cut.

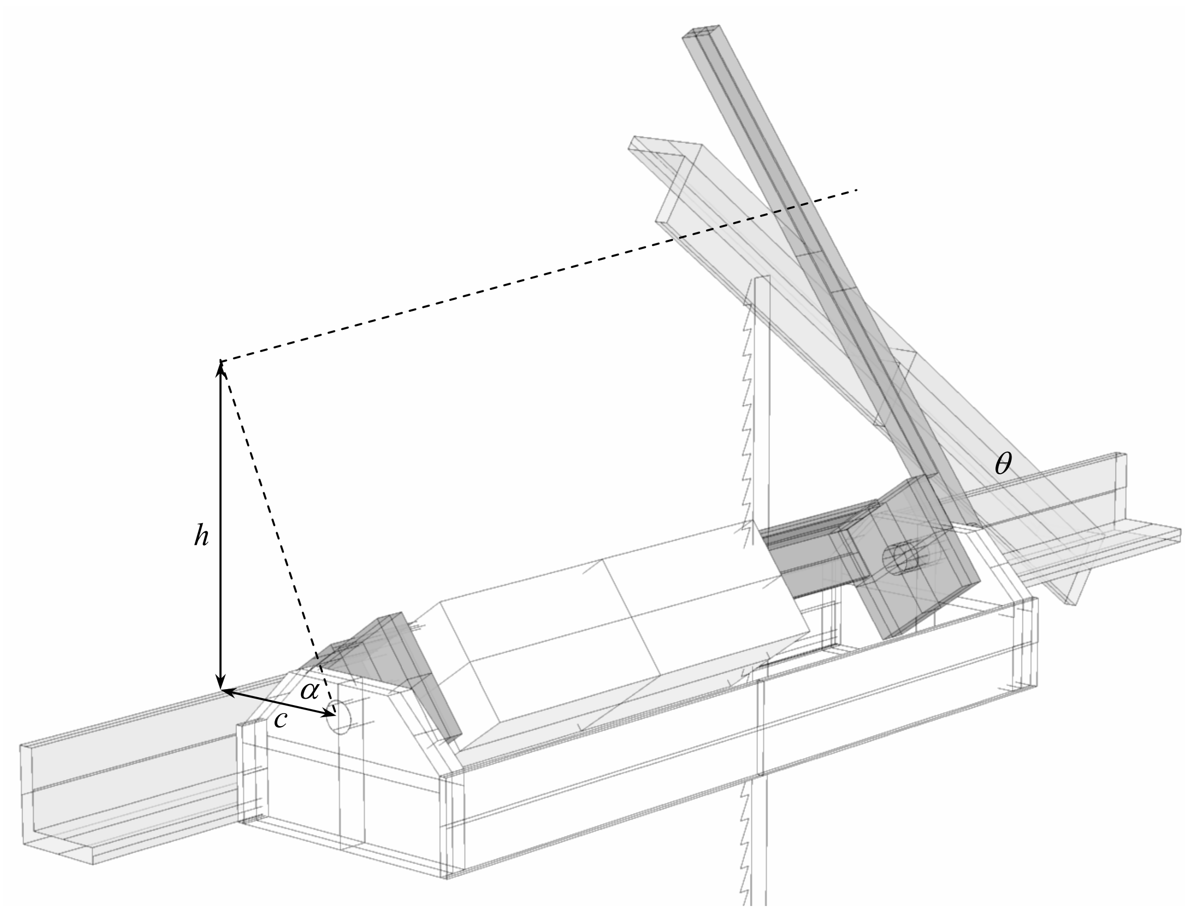
Fixture Geometry

To set your fixture up for accurate cuts is not difficult but requires a little elementary computation. As every fixture will differ slightly in dimensions, we first derive a general formula to set the angle of the template.

The helical pitch equation is:

$$\alpha = \tan^{-1}(P / 2\pi\ r)$$

where α is the helix angle, P is the pitch and r is the distance from the hub. When r is zero, α is 90° and when r is large, α is zero.



Fixture Geometry

In the figure above, h is the height above the carriage pivot that the rod contacts the hinged template arm, c is the lateral offset of the pivot from the template (3" in our case), and α is the resulting helix angle. So we have:

$$\alpha = \tan^{-1}(c / h)$$

And equating the two equations gives an expression for template height as a function of distance from the hub:

$$h = 2\pi \ rc / P$$

Note that *h* is a constant times *r*, in other words a linear function of *r*, and that's why the template is a straight line!

The hinge arm angle θ with the horizontal is then:

$$\theta = \tan^{-1}(2\pi c / P)$$

If your pivot offset *c* were 3", you would use the following angles for your template bar:

Pitch	15"	16"	17"	18"	19"	20"	21"	22"	23"	24"	25"
θ	51.49°	49.67°	47.95°	46.32°	44.77°	43.30°	41.91°	40.59°	39.34°	38.15°	37.02°

Template Bar Angles for a 3" Offset

Cutting Blocks

Cutting blocks is easy with a little practice but requires careful setup for best results. First, choose a suitable clear grained wood stock. We like a special carving wood called Jelutong from Malaysia which is exceptionally fine and even textured and machines freely. But we've also used select pine from Home Depot with good results.

Our fixture cuts blocks up to 2" x 2" x 10" long. The 2" width is good for blades up to about 2.75" chord. We've also cut them with pitches as low as about 15". The wider the chord and the smaller the pitch, the more kerf you need as the turning rate of the blade through the stock increases. The greater the pitch, the easier is the cut. Be careful in squaring the blocks to provide accurate reference surfaces.

When cutting, feed the stock slowly and make sure that the bar remains in contact with the template. If the bar won't remain in contact, then the turning rate is too great and you need more kerf! The two cut blocks should be virtually identical and not require any additional finishing work.

You can check the finished blocks using a machinist's protractor such as General Tool No. 18 from Home Depot. (It's also handy for setting the template angle.) It's remarkable how accurate the blocks can be. The protractor measures to about 0.5° and the blocks are easily better than that.

Summary

This fixture has saved us a ton of work in making pitch blocks. We used to avoid carving new blocks by making do with existing ones which weren't the right pitch and may have been inaccurately made. Now we just head to the bandsaw and zip out the exact one we need in about 10 minutes! This is just the ticket if you want to do a lot of optimizing of prop pitches. We hope you will make your own bandsaw prop block fixture. If you have any questions, please don't hesitate to contact us.