Planking Begins

At the beginning of this project I removed the first five planks (from the keel rabbet upwards) from each side of the boat. The first three (on each side) definitely need to be replaced while the remaining two might be serviceable after some repairs. It's now time to replace these first three planks and since this is my first attempt at planking a large hull I expected it to be a learning experience.

Although the boat is mostly double planked, the original planking in this area of the boat is single planked tight seam construction. I've decided, however, to replace these planks using traditional Carvel plank construction; i.e., with caulking between planks. I've chosen this route for two reasons: (1) It's easier to get water-tight seams, and (2) I'm hoping there will be less compression stress on the planks (it appears that the original planking suffered from compressive failure).

Here is a pic showing the first 5 planks that were removed. Note that plank #5 is 25' long!

The next three shots show some of the damage.

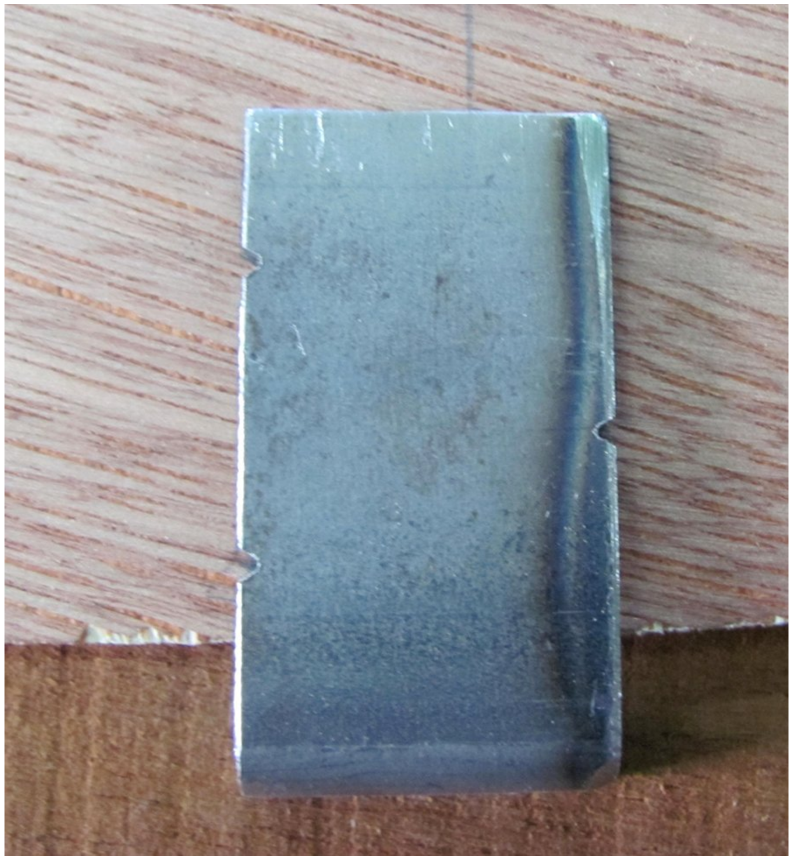
Although this is my first attempt at Carvel planking, I've read numerous references on the subject. I'm also lucky in that I have the old planks for templates so I don't have to worry about lining off the boat. Also the first plank is relatively short and located in a flat section of the hull so neither steaming (to facilitate plank twist or bow) nor scrubbing (shaping the face of the plank to fit the curvature of the hull) is required. So I got an easy start. The second plank was a bit more complicated as it has some twist at the nib end, so I had to boil the end. It's not until I reached the third plank that things really got complicated. This third plank is over eight feet long and requires considerable twisting, bowing, and scrubbing to fit. I can force the plank into position, but I think it would be best if I steam it first. So I'll need to build a steam box. But I'm getting ahead of myself. Let's examine the planking process, starting with plank #1.

To see what we're dealing with, here is a pic of the new plank #1 on the starboard side.

To make this plank, the first thing to do is to mark the shape of the top edge of the plank on the hull. Since I have the old plank, I could just put it in position on the hull and trace out the top edge of the plank; but, the plank edges are damaged so I just make a few strategic marks on the hull and use a fairing batten to construct a fair curve through the marks. This is particularly easy for the first plank because the top edge is straight. I also mark the location of the plank's nib end. Traditionally, and for no particular reason, the nib is cut at right angles to the top edge of the plank.

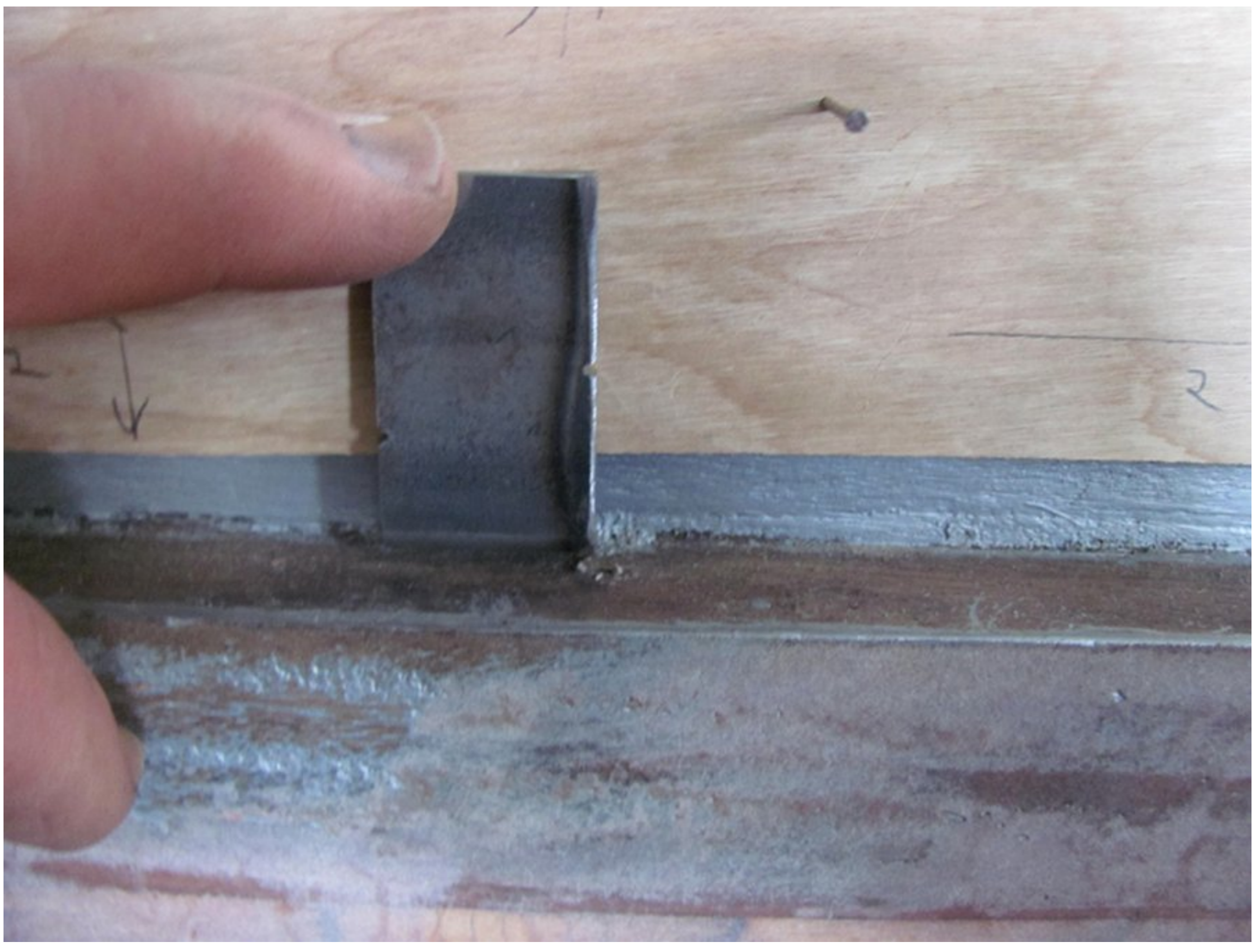
The next thing we need is a spiling batten that is just a bit smaller than the plank. Since I have the old plank it's a simple matter of tracing the plank onto my spiling stock and cutting about ¼" inside the lines. I'm using 3/16" Luan underlayment as spiling stock. It's inexpensive, comes in 4' x 8' sheets, is light colored to clearly show pencil marks, and it has just the right amount of flexibility: supple enough to conform to the shape of the hull but stiff edge-wise to reduce the chance of introducing edge-set in the plank. The pic below shows the spiling batten tacked (a few small finishing nails) in place on the hull.

Next we transfer the outline of the plank to the spiling batten. This can be done using any number of tools and published methods. I've experimented with a compass and custom made spiling blocks, but my favorite is a little tool that I learned about reading the Cherokee Blog. Below is a pic of the tool and the marks that you make with it (ignore the vertical line down the center).

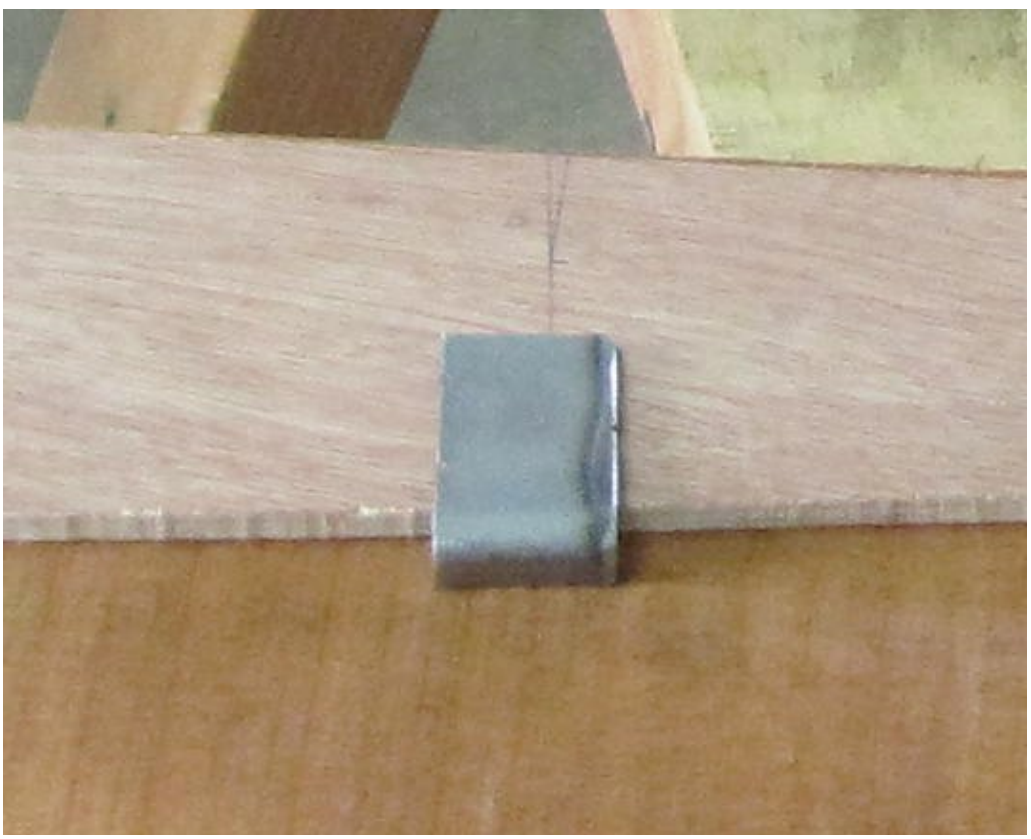


Although not visible in the picture of the tool above, the lower edge of the tool is bent downward forming a lip of about 3/16”. Since the spiling stock is 3/16” thick, the bottom edge of the tool is flush with the back of the template, facilitating accurate measurements.

Using the spiling tool, we make marks at regular intervals along the length of the plank, usually at every frame location. The frequency of marks is proportional to the complexity of the shape. Here I am capturing the distance to the keel rabbet at one point along the bottom of plank #1.



Now remove the spiling batten and tack it to a piece of planking stock. I tried to select all quarter-sawn, or at least riff-sawn, H. Mahogany stock but the price was prohibitive so I’m stuck with some plane-sawn stock too. Fortunately, the ratio of tangential to radial shrinkage for H. Mahogany is not too large. This and the fact that I’m keeping the RH of the garage above 70% should reduce the differential shrinkage problem. With spiling batten in place on the planking stock, we transfer the marks from the spiling batten to the planking stock …

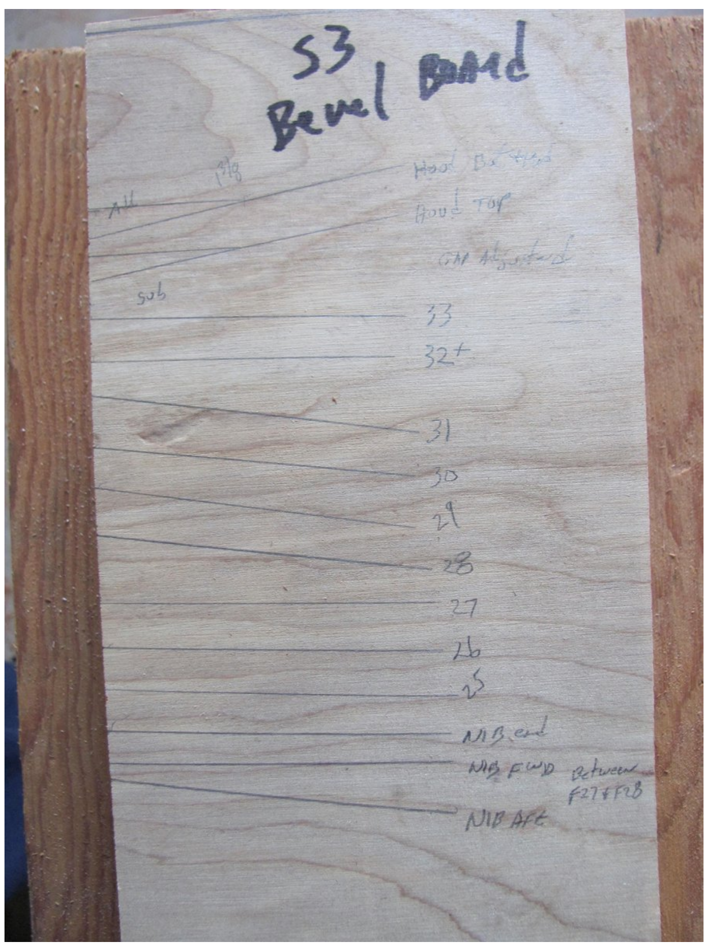


and connect the marks using a fairing batten.

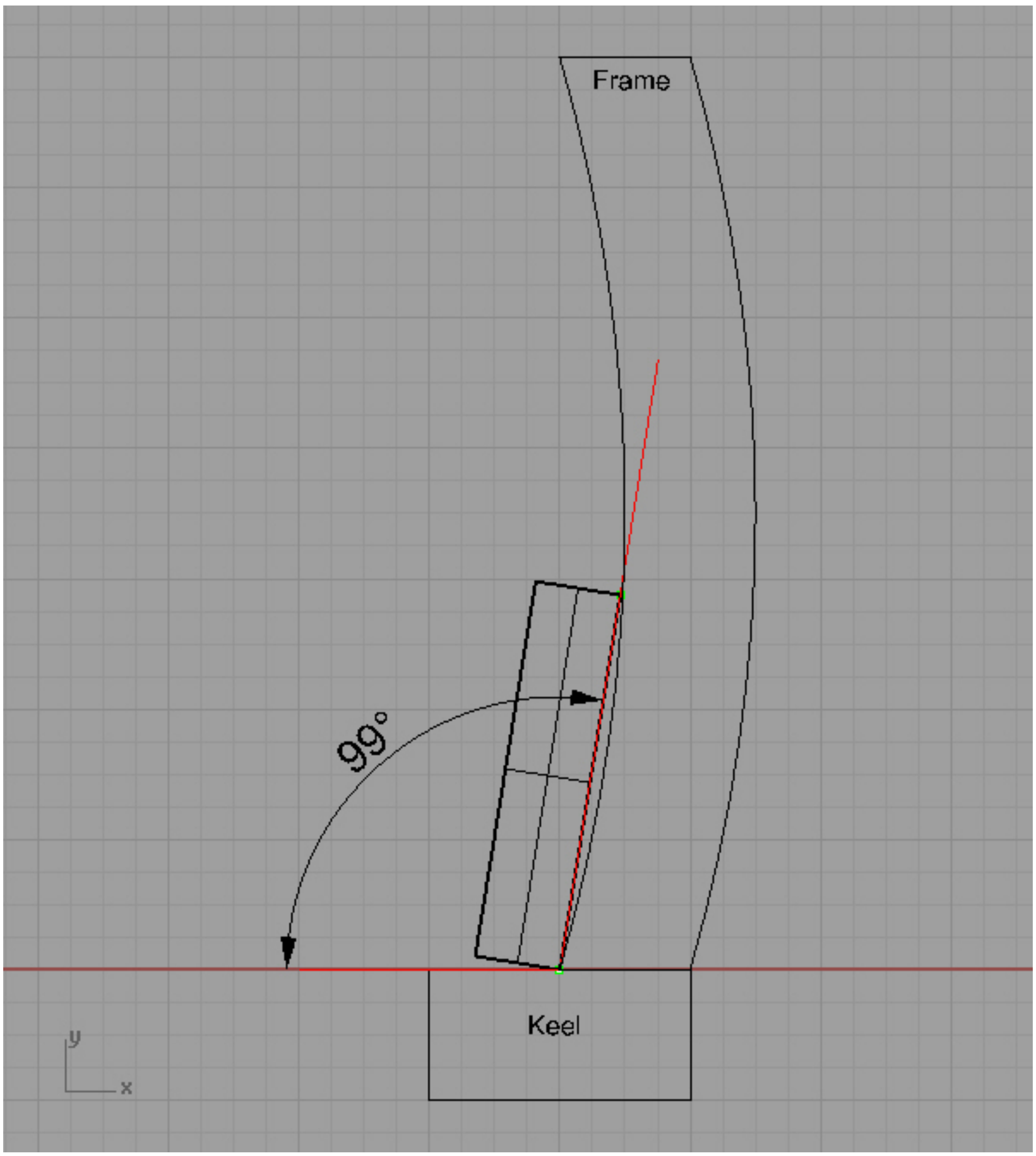
Although we might be tempted to cut out the plank, we better check the bevels first to be sure that we don't need to make any adjustments to the shape before cutting. To understand why adjustments might be needed, let's talk about bevels.

When a plank is first cut from planking stock, the edges are typically square to the face; however, when the plank is fastened to the hull one or more edges might need to be beveled so that it mates flush with the edge of the adjacent plank or backbone rabbet.

By convention, the top edge of a plank is planed square to the face, so beveling is not needed for that edge. Likewise, the nib end is cut square to the face. Now if you were building a boat from scratch, you would probably cut the keel rabbet and stern post rabbets square to the backbone timbers. In that case, no beveling would be required for plank #1 (ahh, except for the caulking bevels, which I'll mention in a bit). But alas this is a restoration and after 50 years in service things change! So it's important to measure the bevels at regular intervals (say 10" or less, depending on how much they vary). These bevel angles are recorded on a bevel board. (The bevel board in the pic below is actually for plank #3.)

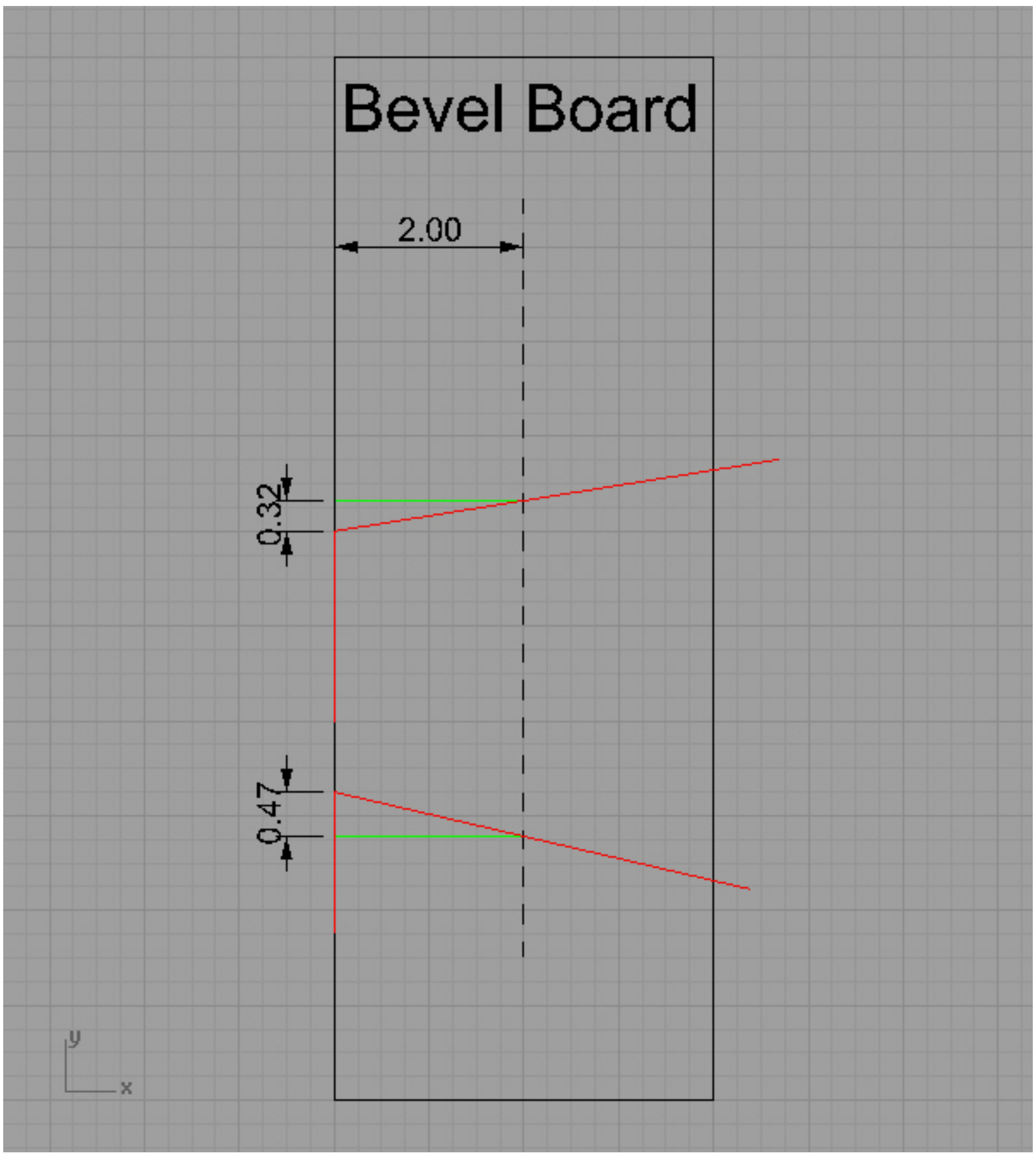


The use of a bevel board is described in a number of references, but inevitably the descriptions are oversimplified. Sure, everything works fine in the simple case but in restoration things are seldom simple! Let me say up front that I'm as guilty as other writers in not providing explanations that are crystal clear to everyone. Having been a teacher for many years, I'm quite certain that it can't be done – one-way communication is just inadequate. But I'll do what I can and you can send me email if you have any questions. So let's take a closer look …



The diagram above depicts a garboard plank being fitted to a frame and keel rabbet. Note that at this stage the plank does not fit very well – it is neither flush with the frame nor is its lower edge flush with the top of the keel. We'll talk about fitting the plank to the frame a bit later. For now, we will see how to bevel the lower edge of the plank so that it is flush with the top of the keel. To determine the proper bevel, we need to capture the angle shown by the red lines (99 degrees in this case).

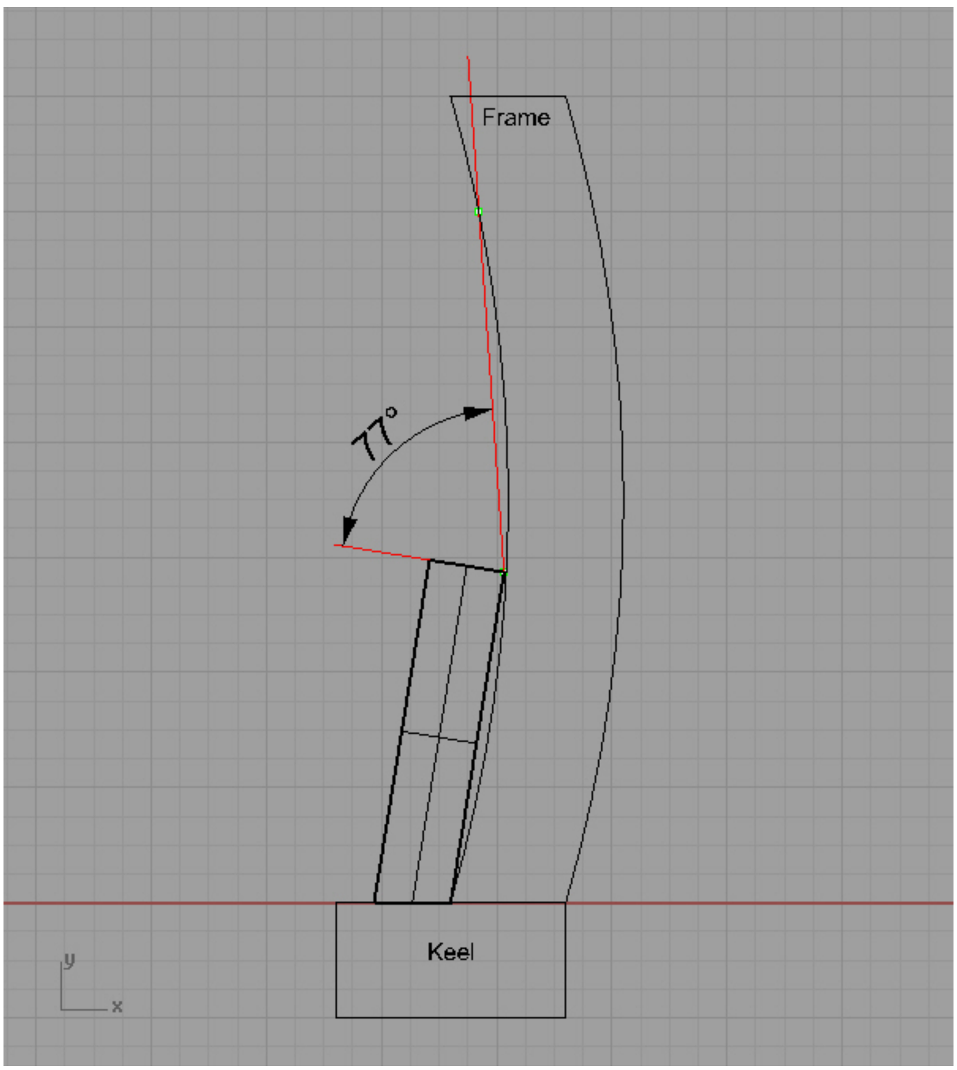
Unfortunately, the angle itself is not particularly useful for cutting the bevel. What we what to know is how much wood to remove from the plank to achieve the correct bevel. This is where the bevel board comes in. We capture the angle using a bevel gage, and then transfer the angle to our bevel board (the red lines in the middle of the pic below).



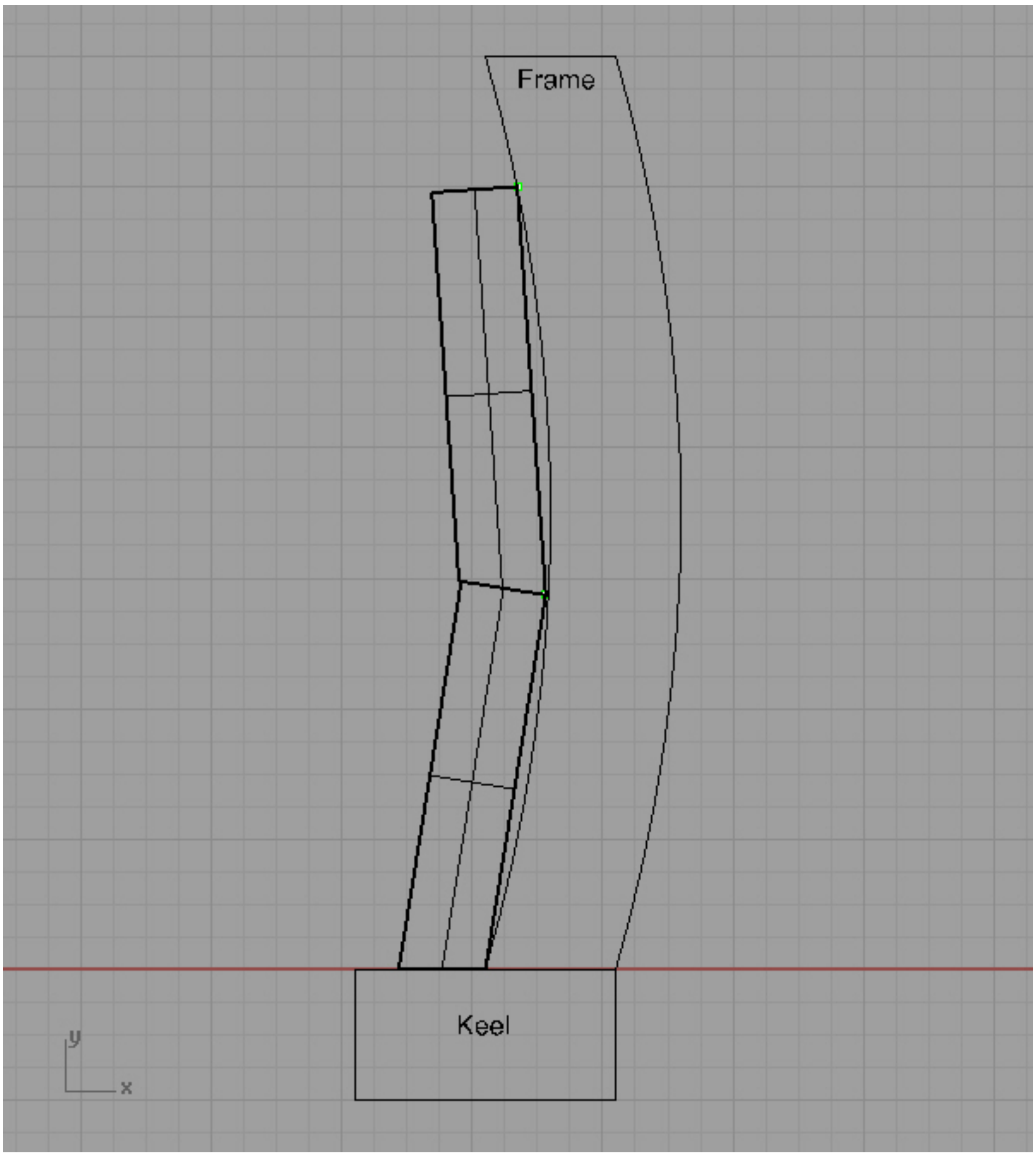
We then draw a vertical line (dashed line in the pic above) parallel to the left edge of our bevel board, which represents the thickness of our planking (2” in this example). Next we draw a horizontal line (green in the pic above) from the left edge of our bevel board to the intersection of red and dashed lines. The gap between the red and green lines at the left edge represents the amount of wood the must be removed (0.32” in the example above).

But removed from where? I think you can see from the illustration of the plank above that the wood must be removed from the lower INSIDE edge of the plank. Note that trimming the inside edge of the plank creates a problem – the plank width is effectively reduced. So the top edge of the plank no longer contacts the frame at the desired location. The solution is to INITIALLY cut the plank 0.32” wider at this point. The bevel angle typically changes from frame to frame, so the amount to be added varies accordingly. So, you see, it’s very important to measure your bevels before you cut the plank.

Not all bevels require adding additional wood to the plank width. To see this, let’s add a second plank to our example above.



Here we measure the bevel angle of our second plank (77 degrees) and transfer it to our bevel board (the lines at the bottom of our bevel board illustration). In this case the amount of wood to remove is 0.47”, but now this wood must be removed from the OUTSIDE lower edge of the second plank. Note that since we are not removing wood from the inside edge, the effective plank width is not changed. So we don’t have to make the plank wider to compensate.



In summary, if our bevel angle is obtuse (>90 degrees) we need to trim the inside edge, so the plank needs to be made wider to compensate. If the angle is acute (<=90 degrees), only the outside edge is affected and no additional width is required. Planks above the turn of the bilge tend to exhibit obtuse angles, whereas planks lower tend to have acute angles. This generality does not always hold, however. I have encountered situations where the angle changed from acute to obtuse in the same plank!

Back to plank #1 …

After making any shape adjustments required by the bevels, we can cut out the plank. I've found that a quality circular saw is the tool of choice for this job. I've considered other recommended alternatives such as a bandsaw or table saw but it's much easier to move a light weight circular saw along a stationary plank than to feed a 10' to 25' plank through a saw – especially single handed with limited space!

I've read that you should cut right to the line, but I've found that prudence is the better part of valor, especially when I'm paying for Mahogany! So I stay away from the line about 1/16" which means that occasionally I cut right to the line but not further. Then a few minutes with hand planes finishes the job.

After sawing out the plank and planing to the lines, we cut the bevels. The bevel board shows how much wood needs to be removed at each location along the plank edge. We use the bevel board to transfer this information to the face of the plank, and then, using a fairing batten, we draw a line connecting all the marks. We then plane the edge down to the line, being sure not to remove any material from the opposite side. It helps to draw a series of pencil lines across the edge so that you can monitor your progress.

We then clamp the plank in place on the hull to check the fit, making adjustments as needed.

After all the fitting is done, it's time to cut the caulking bevels. The general rule of thumb is to cut the caulking bevel so that the opening to the outside of the plank is 1/16" per inch of plank thickness. The proper depth of the bevel seems to be a matter of opinion. Depths from ½ the plank thickness to the full depth of the plank has been recommended. The advantage of a full-depth bevel is that it produces the shallowest angle, which is good for keeping the caulking in place. The down side is that the inside edge is quite fragile (a feather edge). Providing more contact surface between planks is better in this regard but generates a steeper angle. Also, the larger contact surface may put more stress on the plank edge, especially for hardwood planking such as teak or mahogany. As a compromise, I'm cutting bevels that are about ¾" deep for 1" planking (1/4" of inside edge contact).

These bevels are fairly easy to cut since the dimensions are not critical. Just draw a line on the face of the plank 1/16" up from the lower edge (only the lower edge receives the bevel). Draw another line on the edge to be beveled ¾" from the front face of the plank. Now simply plane a bevel that touches both lines.

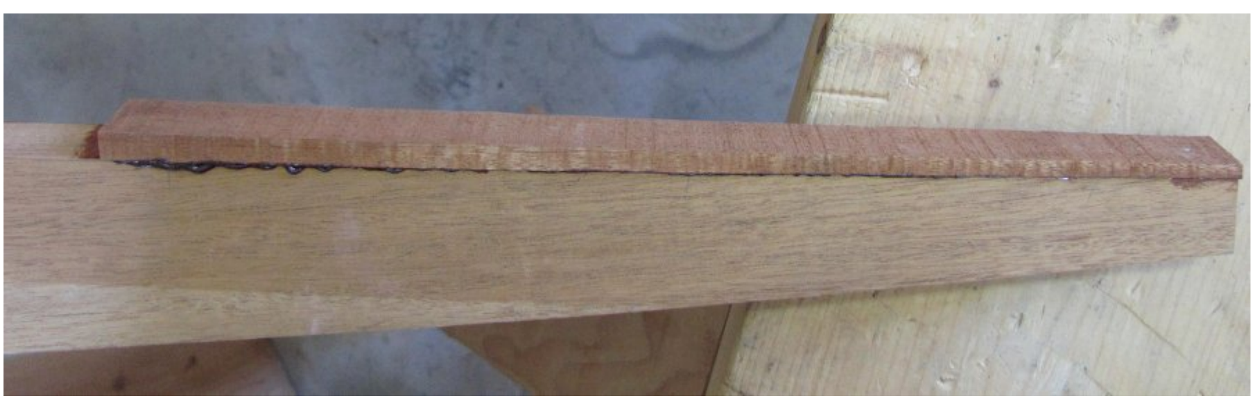
After final fitting, I painted the back face of the plank with 2 coats of Primocon (first coated thinned 10-15% with Xylene). More coats would be better, perhaps, but …

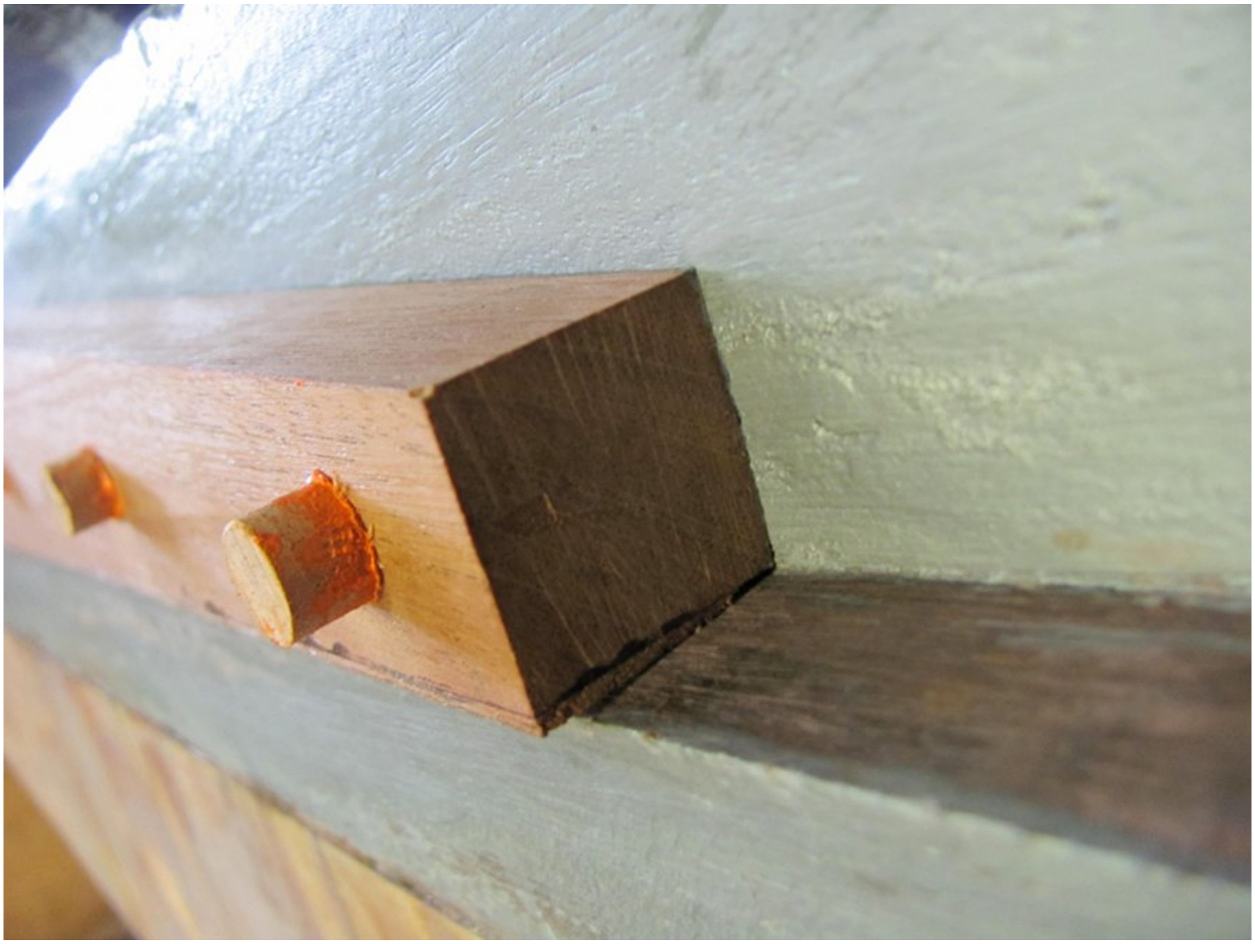
Next the plank is clamped and fastened.

Clamping planks often requires some innovation. Note the improvised bar clamp aft.

I used #12 2-1/2” bronze slotted-head wood screws when fastening to a backbone member. I dropped down to 2” when fastening to frames. The screws were first coated with red lead primer to act as a lubricant and sealant. H. Mahogany bungs were then driven in, bedded in red lead. I made my own bungs out of scrap. Note the two bungs close together near the center of the picture. One of these is a blind hole where I inadvertently drilled into a backbone bolt!

I should confess at this point that I neglected to check the bevels before cutting out plank #1 on the starboard side. As it so happens, the bevels near the nib end were greater than 90 degree, which resulted in too much bevel between the plank and the keel rabbet. Consequently, I had to “scab” on a piece (using Aerodux 185 resorcinol) and re-cut the bevels.





As I mentioned before, this is a learning experience.

After making a duplicate plank for the port side, it's on to plank #2. This plank was longer than plank #1 but except for some twist at the nib end, it laid fairly flat. No scrubbing was required. The one complication was fitting the notch in the new plank to the nib end of plank #1. Not a big deal, but it requires creating a close fit both at the notch and the hood ends. Here is a pic of the spiling batten in place.

When I first removed these first five planks, I noticed that some of the frame ends contained wedges between frame and plank. My guess is that this was necessary to achieve the required curvature without over-bending the frames. These wedges may have been glued to the frames initially but simply fell out when the planks were removed.

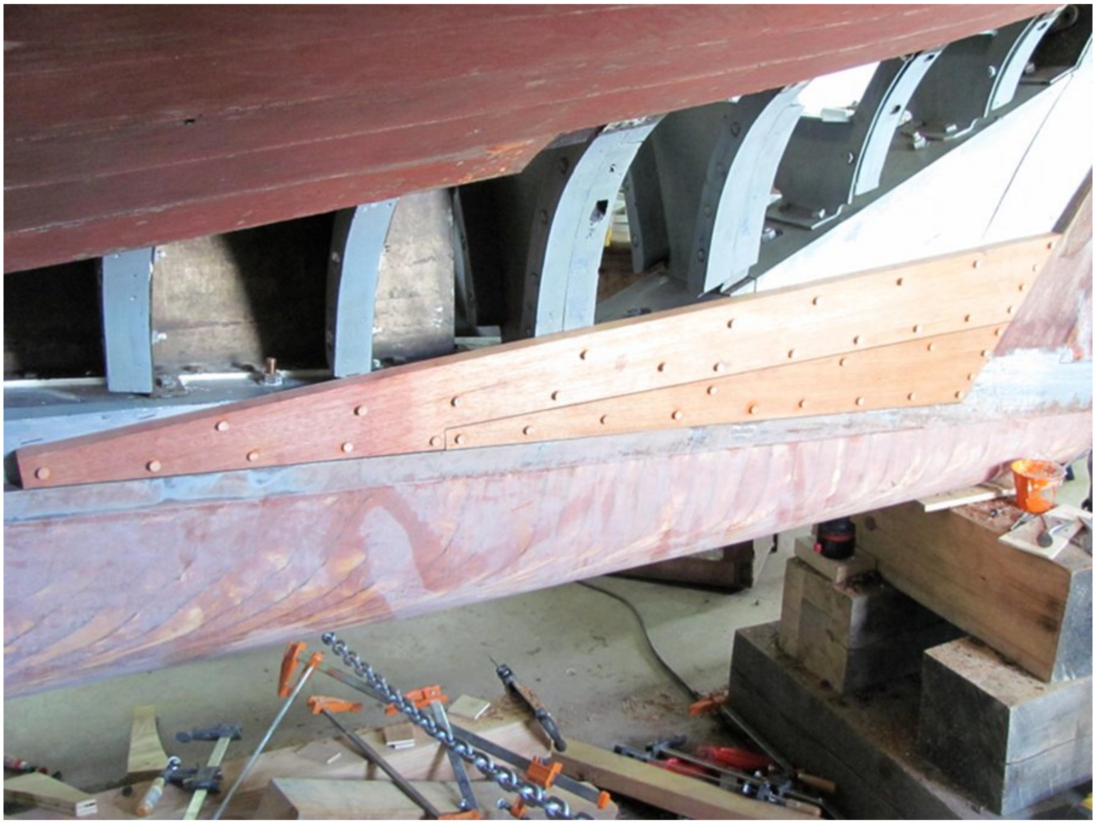
I decided to re-glue the wedges (adding replacements as needed) in place and fair them to the keel rabbet. This was done after I had removed the centerboard trunk and the integral bronze floors. It didn’t occur to me at the time that the frames might move when the floors were removed. So now these frame ends are not as fair as they were before reinstalling the trunk. Well another lesson learned. In addition, even some areas not connected to the CB trunk are not fair. An example is shown in the pic below.

Here both the frame and the floor were not fair with the keel rabbet (although I’m quite certain they were when built), so I had to add a shim. Although the bolts holding this floor in place were replaced as part of the deadwood replacement, a shifting of the floor to port seems unlikely, since the port side seems to be fair. Shrinkage also seems unlikely since the grain in the floor runs transverse to the centerline. Note that the grain of the shim runs counter to the grain of the floor, so the bond might not endure; however, it's just a shim that will be held in place by the planking screws. So I'm not concerned about it.

To deal with the required twist at the nib end, I decided to boil the end for one hour (rule of thumb: 1 hr per inch of plank thickness). First the back face of the plank was painted with two coats of Primocon. It's interesting that neither steaming or boiling seems to affect the paint.

More improvised clamping …

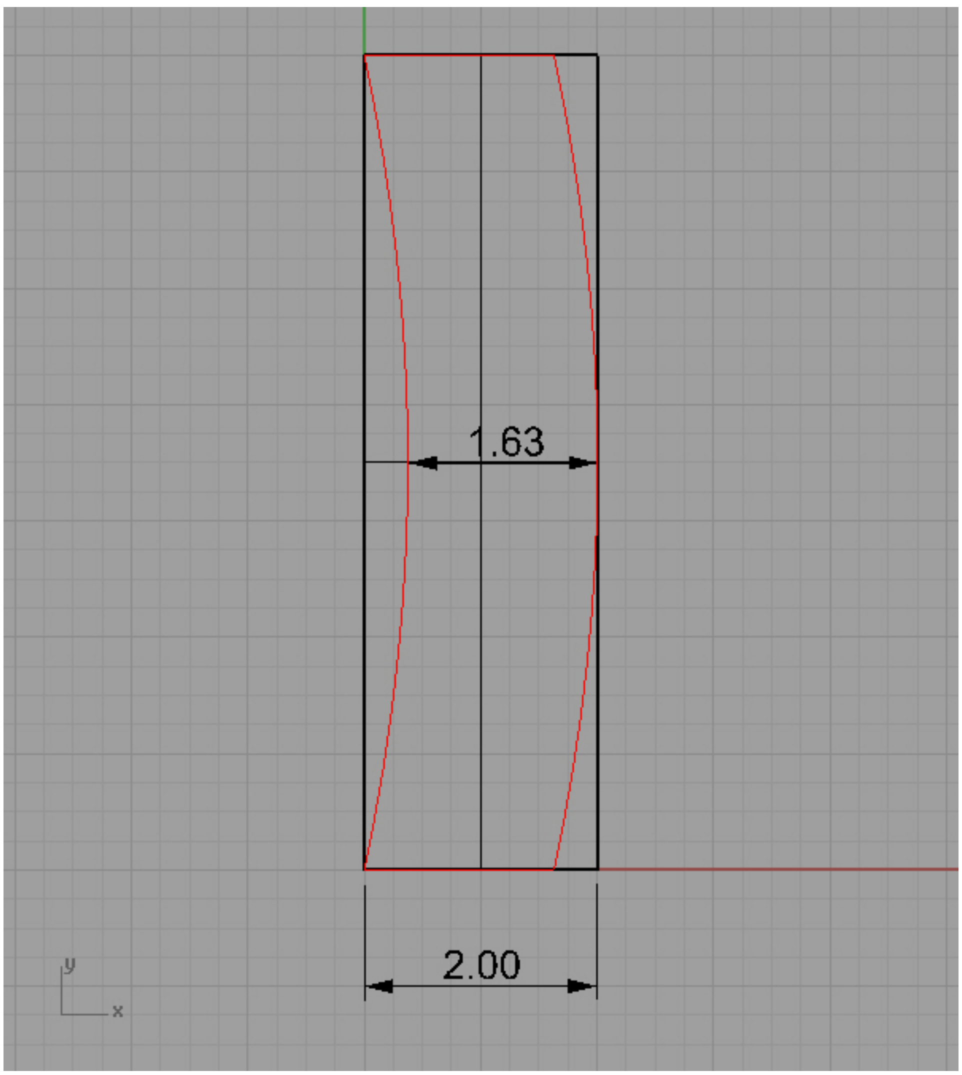
Plank #2 in place.



On to plank #3 …

Well the easy stuff is done. We now have to consider what's involved in fitting a plank to a series of curved frames.

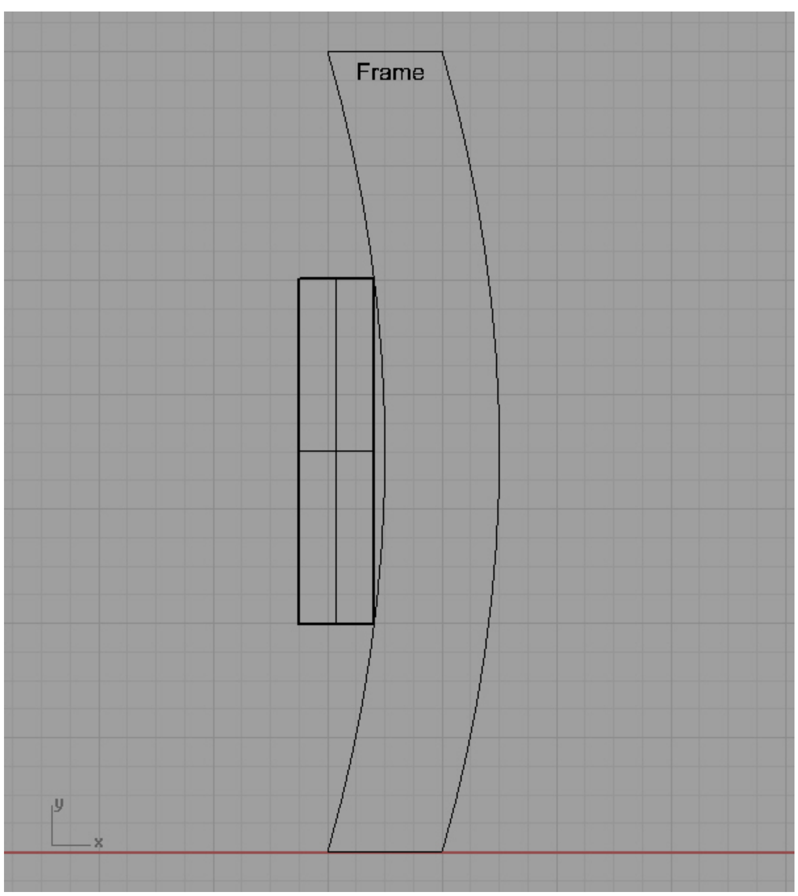
In general, wood must be removed from both faces of a plank to have it conform to the shape of the hull. This process is called scrubbing. If the frame curves inward, the inside face of the plank will have to be scrubbed convex to fit the frame and the outside of the plank will have to be scrubbed concave to match. Similarly, if the frame curves outward, the inside face of the plank will be concave and the outside convex. In either case, the planking stock will have to be somewhat thicker than nominal to account for the scrubbing. As illustrated in the pic below, if we want the finished plank thickness to be 1-5/8" (1.625") then the initial plank thickness must be 2".



Of course this depends on the curvature of the frame as well as the width of the plank, both of which vary from frame to frame. So one must estimate the amount to be scrubbed at each frame location and use the maximum to determine initial plank thickness. Unfortunately, this additional starting plank thickness impacts the cutting of the bevels. Recall that plank thickness is recorded on the bevel board to determine how much wood must be removed to achieve the correct bevel. Consequently, if you cut the bevels after scrubbing, you use the final plank thickness when transferring the bevels to the plank. If the bevels are cut before scrubbing, you must use the initial plank thickness for the angles to be correct.

In my limited experience, the most difficult plank to fit is one that is cut to receive the nib end of a previous plank, sometimes called a stealer plank. We've already encountered this with plank #2 as it had to fit the nib end of plank #1 (the stealer); however, because both planks were flat this caused no particular problem. It's a different story for planks that must be scrubbed. To understand why this is problematic, consider a plank that varies smoothly in width but that must be scrubbed to fit the curvature of the frames.

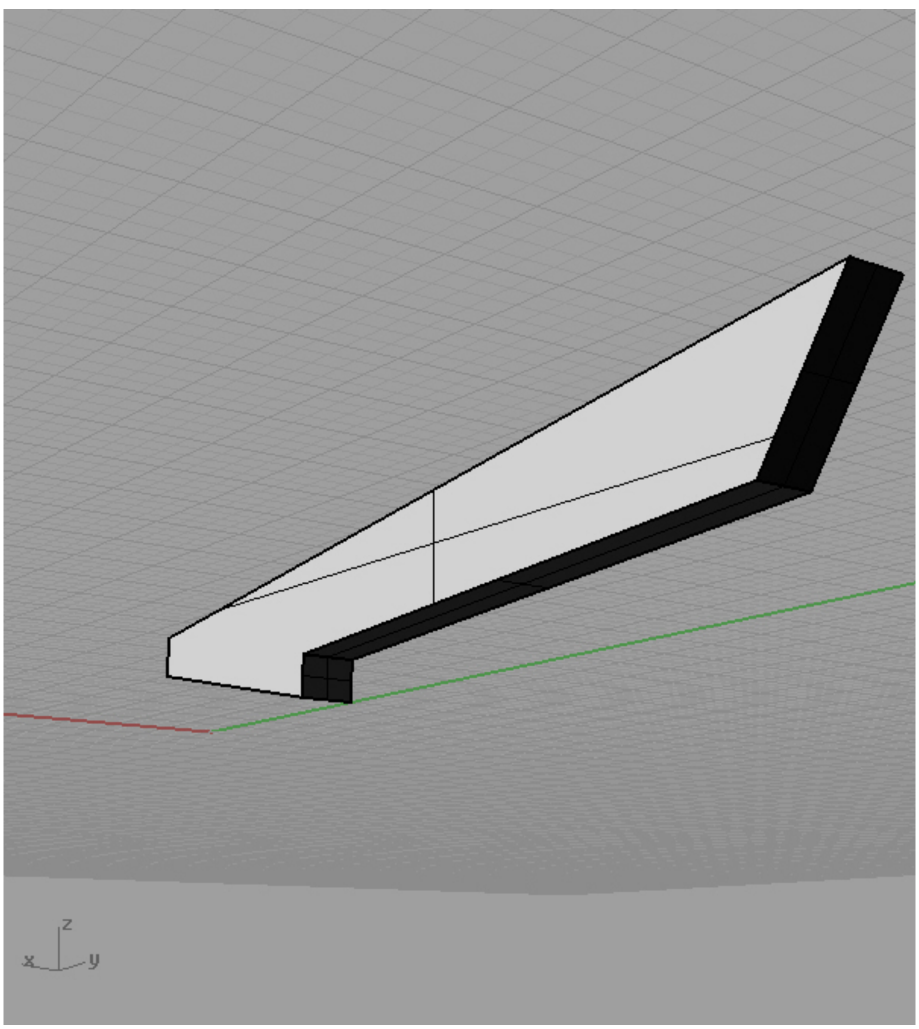
By way of example, assume that the inside face of the plank must be cut convex to fit the frames. For simplicity, assume that the convexities are just segments of circles that vary in height from frame to frame (due to differences in plank width or frame curvature). Now if we clamp our plank in position before it is scrubbed, only the edges of the plank will touch the frames. Thus at each frame, the inside face of the plank will represent the cord of the circular segment defined by that frame. The outside face of the plank will of course be parallel to the inside face. This example is illustrated in the pic below.



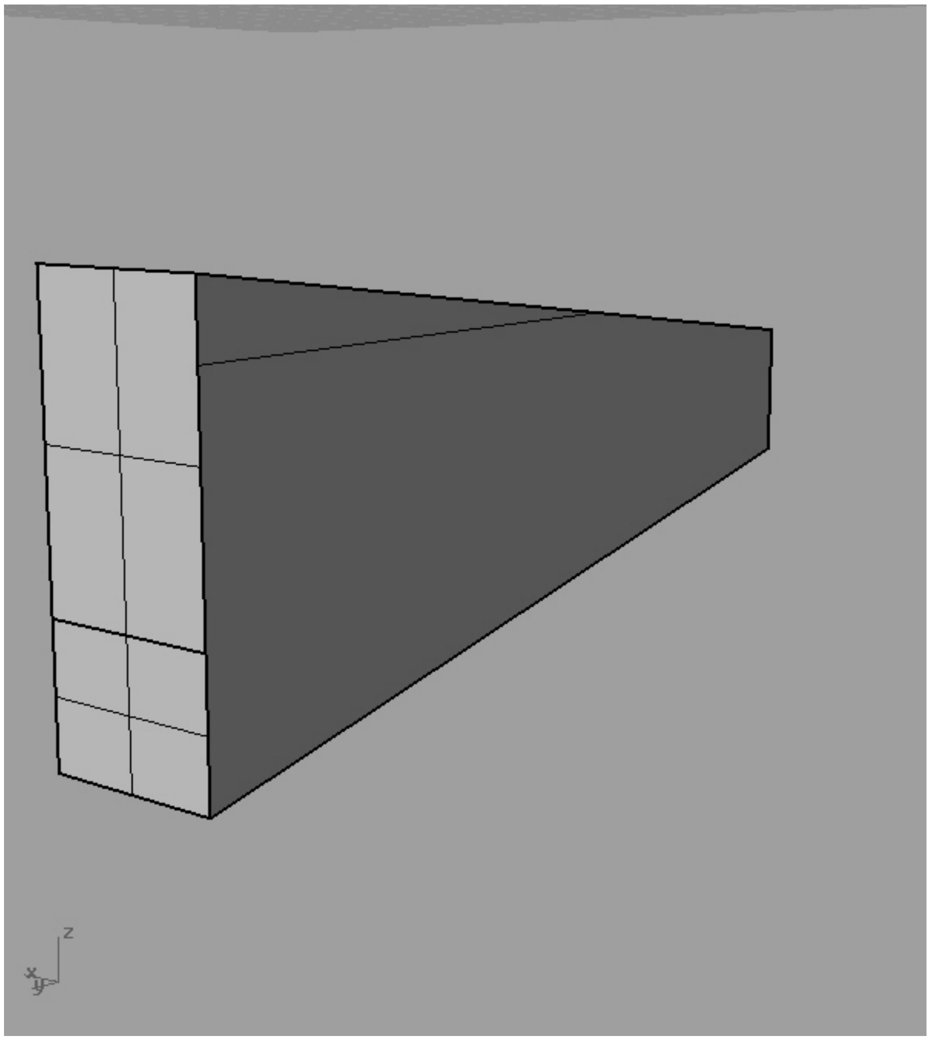
The most straight forward method of fitting the plank is to remove material symmetrically from the top and bottom of the plank so that the outside face of the plank remains parallel to the cord. It is important to realize that this decision to keep the outside face of the plank parallel to the cords is somewhat arbitrary. We could remove more material from the top of the plank and less from the bottom (or vise versa), maintaining the same circular segment but with the cord no longer parallel to the outside face of the plank. The result would be a decrease or increase in the amount of twist required by the plank to fit the frames.

Now consider what happens if the width of the plank changes abruptly, like at the notch to receive the nib of the previous plank. What happens if we have frames on either side of the notch. Only the wider part of the plank will contact the frame at two points (defining the cord of the segment), the narrower part of the plank will only touch the frame at one point (the top edge if the notch is cut in the bottom edge). The problem is that although the curvature is the same on both sides of the notch, the cord lengths are substantially different. In effect, it requires that the plank twist a finite amount in zero distance! The problem is created because we assume that the inside face of the plank is always parallel to the cord.

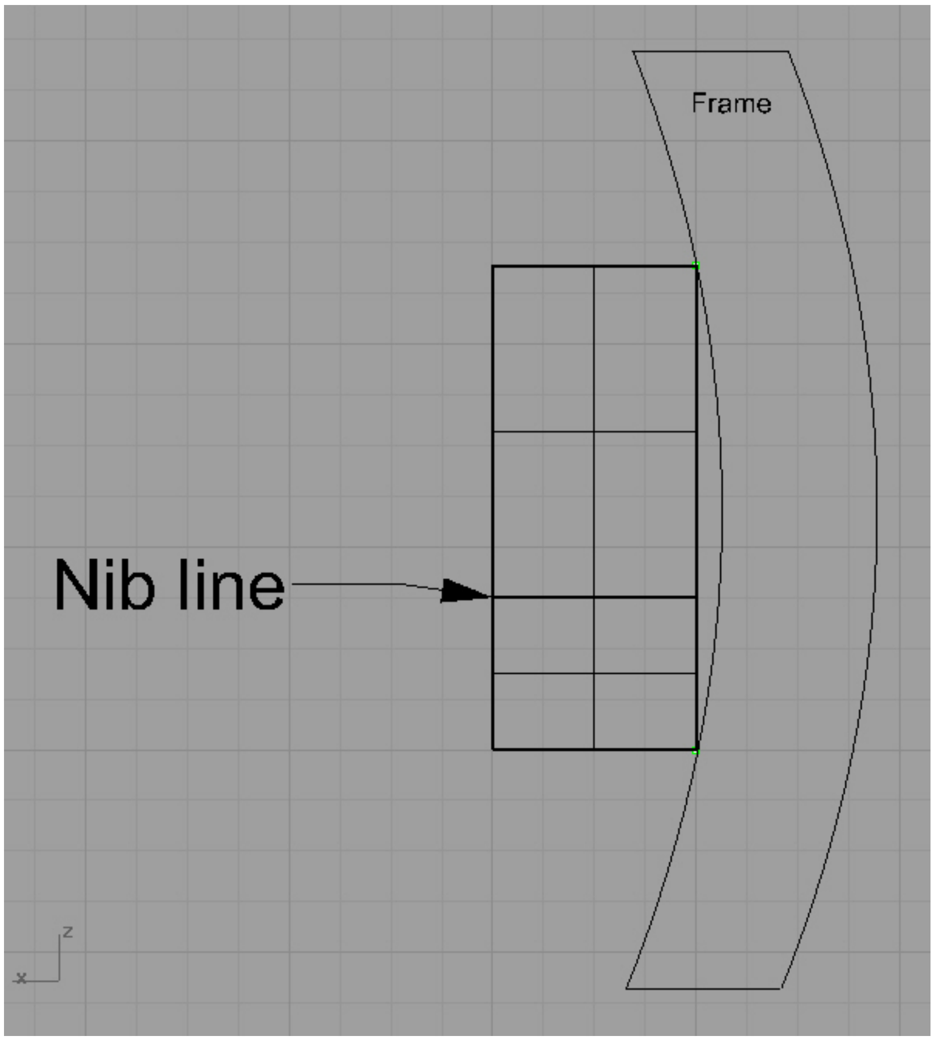
Here as some pics to illustrate this problem. First we have a 3D pic of a typical plank that is notched to receive a nib.



Now take a cross-section of the plank just forward of the notch.

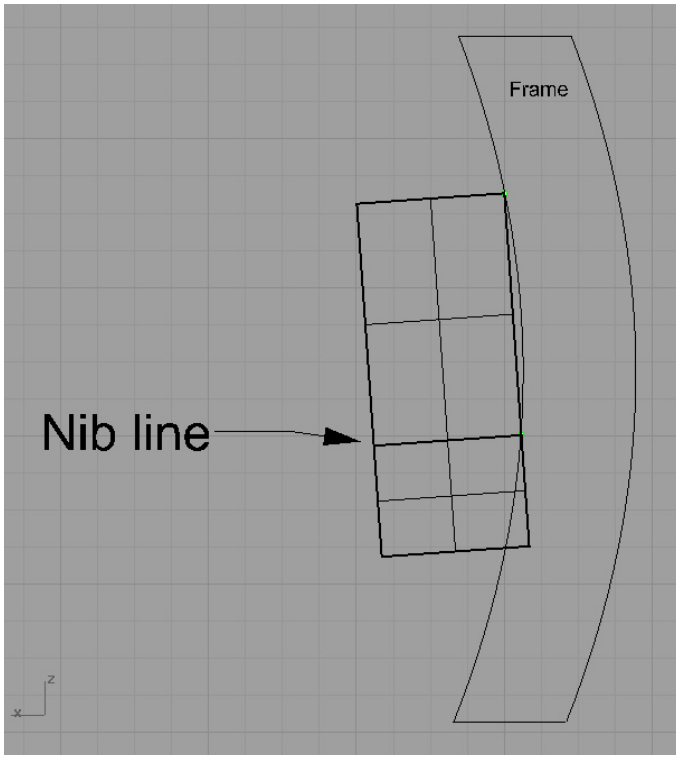


And now a planar view of this cross-section as it lies against the frame.



Note that the top edge of the plank and the bottom edge just forward of the notch are both in contact with the frame. The segment of the circle between the plank and the frame would be filled by scrubbing.

Now consider what happens just aft for the notch. The plank changes width dramatically.



Note that the segment now to be filled by scrubbing is much small and the plank has rotated. Of course this cannot happen, so in reality you just end up with a poor fit.

Although I've only considered what happens right at the notch, the effect can be felt over several frames. The problem is caused by measuring the curvature of each frame in isolation, without considering the rotation of the cords and the associated twist that occurs from frame to frame.

I'm not sure how the pros deal with this. I've not heard or read anything about this problem. The most accurate approach would be to record how much the cords rotate from frame to frame and then make sure this rotation varies smoothly from frame to frame. If a large change in twist is required, this can be reduced using asymmetrical scrubbing as described above.

As yet I have not figured out how to measure these cord rotations. I could probably get them from the plans but the difference between the design and actual boat can be substantial, especially with restorations. So I've devised a method that seems to be satisfactory. At each frame location, I make a template defining the shape of the curve between the top and bottom edges of the plank. I make my templates out of 3/16" Luan underlayment. At a frame, making a template is easy. You just lay a piece of template stock on the top edge of the plank below and trace the shape of the frame onto the template. I then cut out the shape on a bandsaw. On the template, I mark the location of the top edge of the new plank and draw the cord between the top and bottom edges of the plank. I also make a mating template for scrubbing the outer face of the plank. Making a template away from a frame (say at the keel rabbet or around other backbone members) is a bit more trial and error. I cut a piece of template stock to the width of the plank, put it in position on the top edge of the previous plank and measure the maximum gap between template and backbone. I use this gap measurement to draw a smooth arc on the template with the same curvature. Usually, this produces a pretty good fit, but if not a little work with a pocket plane finishes the job. Lastly, I adjust the bevel angle to the template so that when the template lies squarely on the top edge of the plank below, the template fits tightly to the backbone.

I also make a spiling batten that is approximately the size of the finished plank (about ¼" gap all around). I then tack the batten into place along its top edge but only occasionally along the bottom edge so as not to distort the batten. So for example at the notch for a nib, I'll tack the batten at the top and bottom where the plank is widest but the narrow part will be left unattached at the bottom for several frames. I then measure the gap between the batten and the frame behind it. I use this gap measurement to adjust the bottom edge of the cord on the template.

It's important to note that changing the cord changes the bevel. So I no longer use a bevel gage to pick off the bevels directly from the frames. Instead, I take the bevel measurement from the template.

The last step before hanging the plank is to scrub the outside face of the plank to match the curvature of the frames. Final fairing must be done after the planks are on the boat but a rough approximation to the final shape can be done more easily off the boat. The templates that I made at each frame location helps. The key is to scrub the plank until the templates fit without touching either edge - well except for those places where we had to rotate the cords. In those spots we have to make the same adjustments that we made on the inside face so that the plank is 1" thick at both edges.

An additional word or two about scrubbing …

Initial plank thickness is determined by the section that requires the greatest convexity or concavity. Often other sections are much flatter and so this extra thickness must be planed off. You can chose to remove the bulk of this material from either face, but since it's easier to work with a smooth plane than a convex soled scrubbing plane, it's best to remove the bulk from the convex face.

I wasn't aware of these problems when I started plank #3, so ultimately my first attempt ended in the scrap pile. Here are some pics of a successful plank #3 (I'll bet I worked on this plank for 2 weeks!).

Finished plank prior to painting.

Note the detail work at the end. This was required to clear a section of bronze hull strapping and fasteners.

More improvised clamping …

I was actually able to clamp this plank in place without steaming, but it took more pressure than I liked. So I decided to steam it before fastening it. Here is the steam box.

So after an hour of steaming, I pulled the plank and clamped it into place, but much to my dismay the plank did not fit as well as it had before steaming! Evidently, the process of steaming relieved some internal stresses and now the plank needed about ¼” of edge set! I left the plank in clamps overnight and then spent the next day adjusting the fit. I believe that steaming helped the plank conform to the required twist and bow, although the effect was not dramatic.

Finally …

With the port side done, it’s time to work on plank #3 on the starboard side. I hope that what I’ve learned will make this task easier. Here we go …

Although books tell you to start by making a copy of the plank just hung, I feel better spiling both sides. Variations from one side to the other inevitably creep in (especially with restorations) and spiling will help to correct for these. I do try to create identical curves for the top edge of the plank. So I use the templates from the port side to establish the width of the starboard plank at a number of landmarks and then create a fair curve using a fairing batten.

I used the port side plank to create the spiling batten for the starboard side. I simply traced the outline on my spiling stock and cut about ¼” inside the lines. Here are some pics of the spiling batten in place.

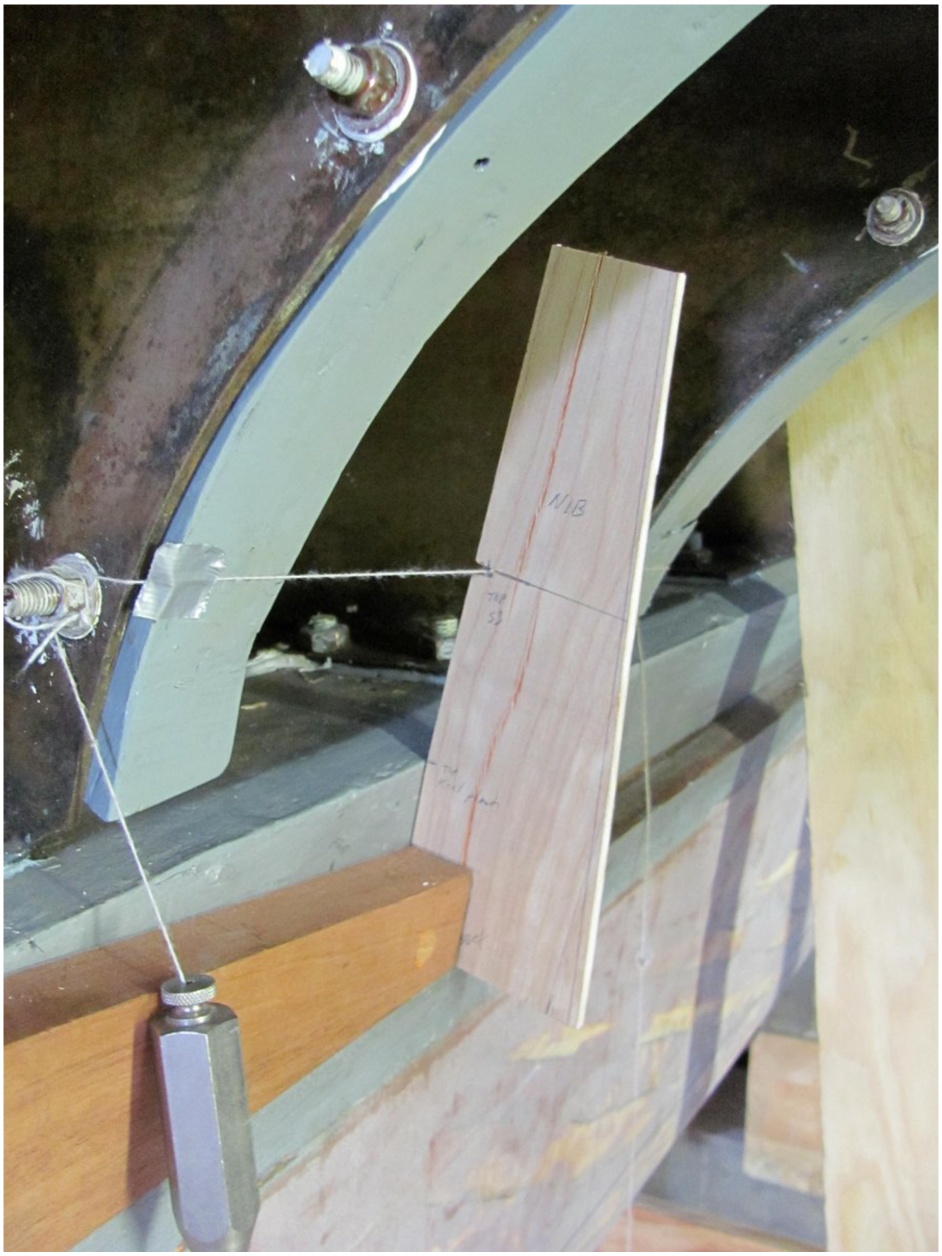
Note that in the pic above, I’ve been very careful to attach the batten so that it forms a fair curve. So on two of the frames you can see that I’ve added shims between the batten and the frame. A detail is shown below.

In this pic, you can see that I've recorded that gap between the batten and the frame (both top and bottom of the batten). I will use this information to create the appropriate templates.

In this pic, you can see that an appendage has been attached (hot melt glue) to the end of the spiling batten. This appendage represents the exact shape of the nib end of this plank. It is often better to create such an appendage rather than to record a multitude of measurements over a small area.

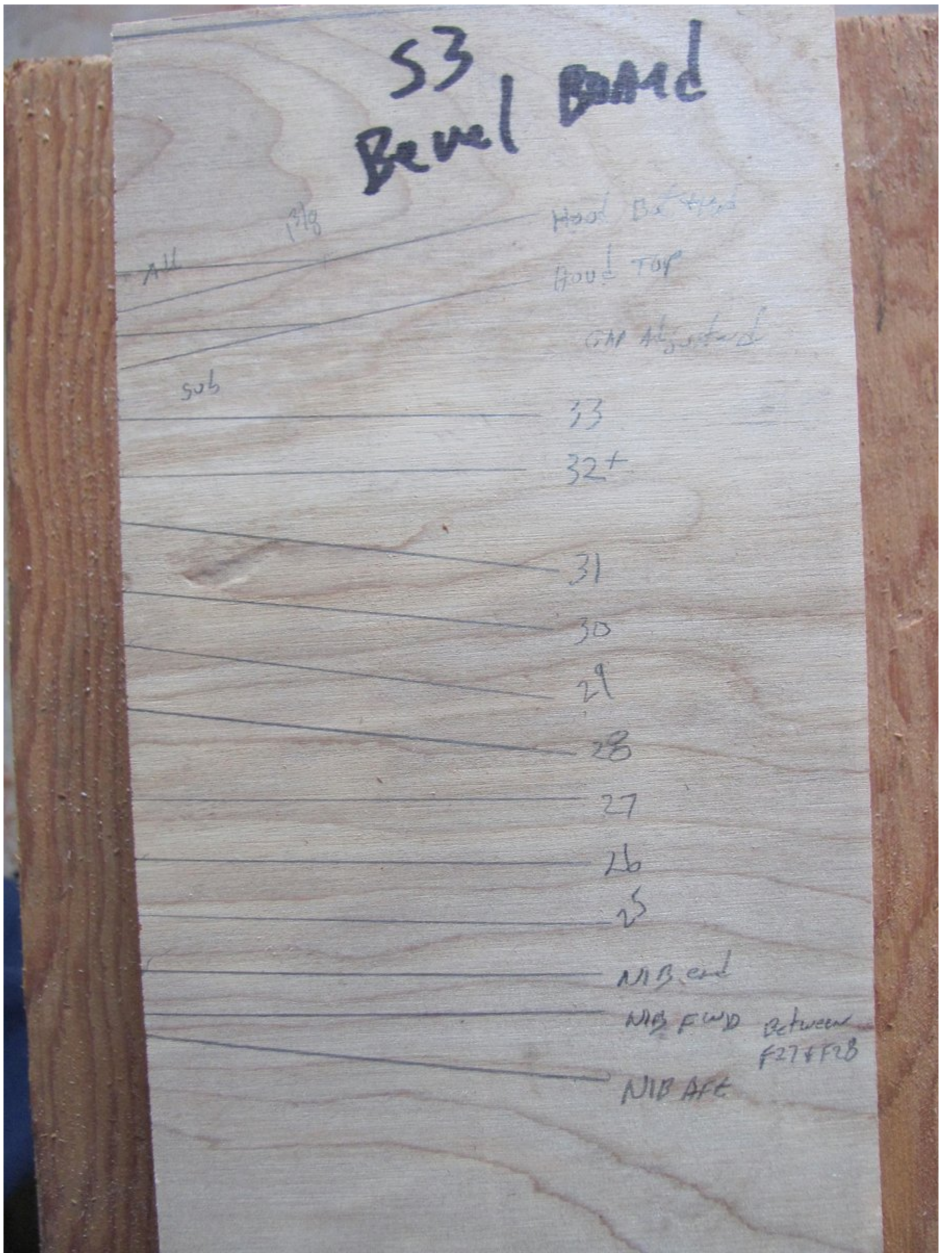
Here we see the detail of the notch for the nib of plank #2. I could have used an appendage here as well, but I could capture the shape well enough with a few measurements. In particular, notice the gap measurements. We have 0 gap at the bottom edge in front of the nib but about 1/8" (10/32 - thickness of spiling batten) at the top of the nib. Per our previous discussion, this is to be expected.

With all pertinent measurements recorded, I removed the spiling batten and created templates at all the frame locations and at a couple of other key spots. The one at the nib was particularly tricky.



Since this template is not at a frame, it's difficult to capture the location of the top edge of the plank. Here I'm running a string from frame to frame to define that edge. This is an important template because it occurs where we have that step transition in plank width.

After making the templates, we adjust the cords based on the gaps that we measured using or spiling batten. We then take the bevel angles from the templates and transfer them to the bevel board.

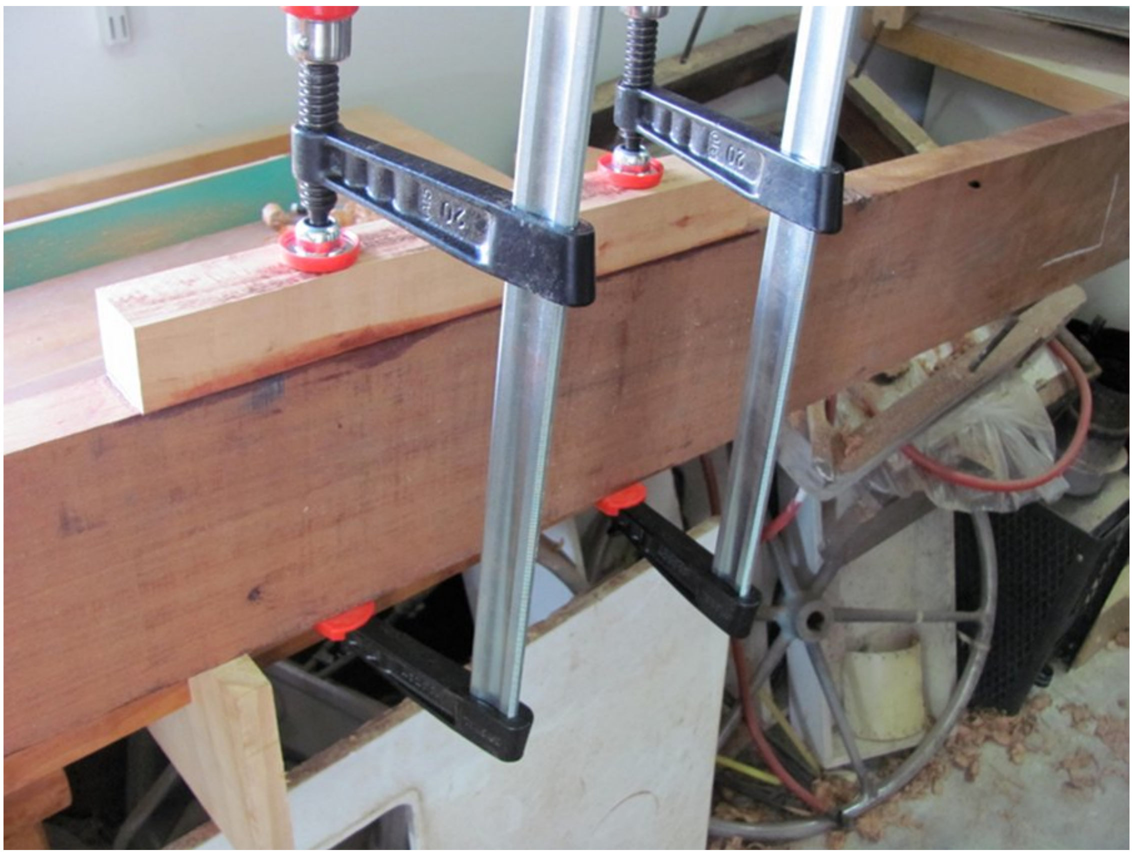


The bevel board indicates that the only obtuse angles are those at the hood end of the plank, so I'll have to add a little extra length to my plank to account for this, but none otherwise.

Based on my templates, it looks like I'll need to add 3/8" to my plank thickness to account for scrubbing.

With this I can rough cut the plank and plane it to the lines.

Of course sometimes the available planking stock isn't quite as wide as you need it, so I'm forced to scab on a little extra.



The piece in the picture is much larger than I need, but better safe than sorry. The extra width was needed just for the very tip of the notch for the nib end of plank #2. This is a low stress area and I bonded the scab with Aerodux 185 resorcinol.

… and that's were I am to date.