Making a Plank for a Carvel-Planked Boat

This article describes how to layout and cut a plank for a Carvel planked boat. Because the shape of a boat is typically complex, fitting a plank requires making a number of precise measurements – the plank must have the correct shape in profile, it must be beveled on its edges to mate with the plank below it and above it, its inside face must be contoured to fit the curvature of the frame that it fastens to, and the outside face must be shaped to match the desired shape of the hull. In addition, the planking material itself imposes certain limitations on the shape of the plank – it can only twist and bend so much.

Although the process of "getting out a plank" is described in numerous references, these descriptions typically lack sufficient detail for the novice. The goal here is provide some of that missing detail.

We initially consider a plank that has a convex inside face, one that you would typically encounter below the turn of the bilge. Later we will examine the case of a plank above the turn in the bilge where the inside face is concave. We also consider the problems associated with nibbed planks.

Plank below the Turn of the Bilge

Fig. 1 illustrates the cross-section of a typical frame with the garboard plank already in place. The goal is to fit a plank between the two green points in the figure. The bottom point represents the top edge of the garboard plank below. The upper point represents the top edge of the plank to be fitted. We assume that the location of this top edge has been drawn on the frames, either from the lining-off process for a new boat or from the bottom edge of the plank above if we are replacing a plank. The bottom edge of the new plank must be beveled to match the top edge of the garboard plank below. The top edge will be left square to the face of the plank (unless you're fitting a replacement or a shutter plank). In addition, the inside face of the plank must be shaped (convex) to fit against the frame – a process called backing out or scrubbing. The outside face must also be scrubbed (concave) to conform to the desired shape of the hull.

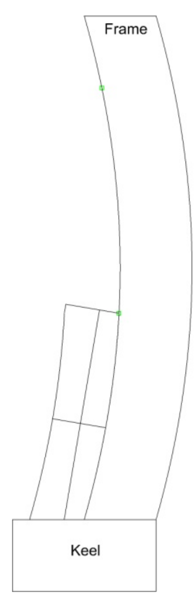


Fig. 1

Fig. 2 shows the finished plank in place.

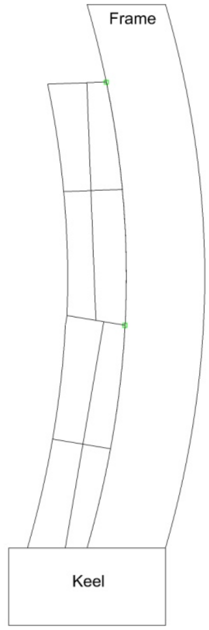


Fig. 2

Spiling

The first step is to capture the shape of the plank in profile. This is done using a technique called spiling. The idea is to make a template, called a spiling batten, that roughly approximates the shape of the plank. The spiling batten is temporarily fastened to the boat where the plank will go. The spiling batten is made from flexible stock so that it easily conforms to the twists and bows required by the shape of the hull. With the spiling batten in place, we record on the batten the width of the plank at regular intervals. We also capture the details of the plank ends. The template is then removed, fastened to the planking stock, and the perimeter dimensions are transferred from the spiling batten to the stock; i.e., reverse spiling.

In Fig. 3 below, we see an example of a plank that is to be replaced. Fig. 4 shows the spiling batten used to capture the shape of the plank.

Fig. 3

Fig. 4

Although in principle one could trace the profile of the old plank onto the new stock, the old plank has too much twist and bow and numerous checks, which would lead to inaccurate results. We can use the old plank to construct the spiling batten, however.

The batten is made from ¼" plywood. We trace the shape of the old plank onto the batten and then cut inside the lines by about ¼". You want the batten close to the finished plank dimensions for accuracy, but you need some clearance to do accurate spiling.

Fig. 5 below shows the front end of the batten, illustrating an important detail.

Fig. 5

We see that the batten was constructed in sections – the front piece is spliced to the main part by using a small overlapping piece that is hot-melt glued in place. Unlike the rest of the batten, the front piece is an accurate template cut exactly to the shape of the finished plank. Using a template is often done in areas having intricate detail or being too small for accurate spiling. It's quite easy to construct small templates like this by simple trial and error. Once the template is cut to shape, it is tacked in place on the boat (see the small finishing nails in Fig. 5). Other templates could be constructed in a similar fashion. The rest of the spiling batten is then tacked into position and the splices hot-melt glued into place. This locks all the templates into proper registration.

When positioning the batten on the hull, it's important that the batten defines a fair surface – no edge set. Any edge set in the batten will lead to edge set in the plank, which is undesirable. Also, it's very important not to introduce excessive twist in the batten. Keep in mind that whatever you're asking the batten to do will also be required of the plank, which is much thicker and therefore considerably less flexible. I use ¼" plywood for my spiling battens. Thinner material is generally unsuitable for the reasons just mentioned.

With the spiling batten in place, determine the locations for measuring plank dimensions. We call these locations stations. Typically, we define a station at every frame and at regular intervals where the plank fastens to the backbone. Mark the location of the stations (top and bottom) onto the face of the spiling batten.

Next, transfer the plank dimensions to the spiling batten. A variety of tools exist for doing this, but after experimenting with these methods, I'm now convinced that the spiling compass is best. Fig. 6 illustrates the use of the spiling compass when capturing the bottom edge of the plank.

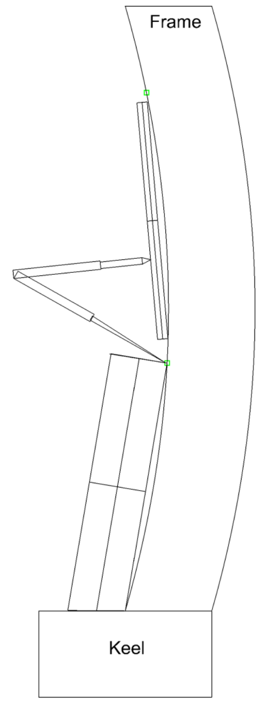


Fig. 6

As you can see in the figure, you need a compass with a point that can get right at the frame/plank intersection. In some cases you need to capture a point between frames, in which case the plank edge has no backing. In that case, use a temporarily backing block behind the plank to create a corner for the compass point.

Using the compass, scribe an arc on the spiling batten. The arc should swing through 90 degrees if possible. Scribe an arc at every station location both for the bottom edge and top edge of the plank (Fig. 7).

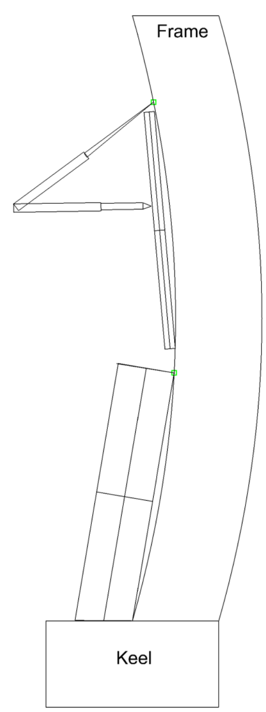


Fig. 7

Also, scribe arcs at the plank ends and other detail locations (such as nibs), unless templates are used. In the end, the spiling batten will be littered with arcs such as the ones in red in the figure below. When spiling, it's important to keep a constant arc radius. So, it's a good idea to record this information on the spiling batten. That's the purpose of the arc and point in magenta. If the compass setting is disturbed, you can easily reset it using the point and arc.

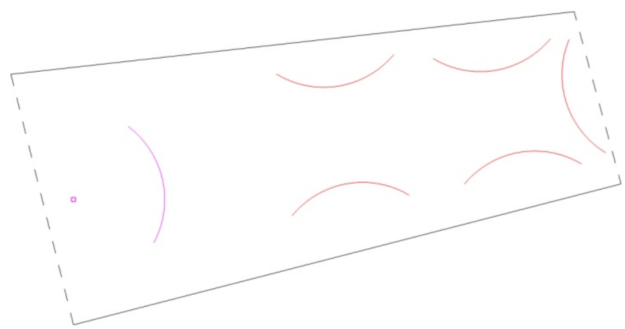


Fig. 8

When all the pertinent data is recorded on the spiling batten, remove the batten from the boat. It's tempting to promptly transfer this information to the planking stock and cutout the plank, but this would be a mistake. Depending on the plank we may need to provide additional length or width to account for beveling. We also have yet to determine how much to increase the plank thickness to account for scrubbing.

To improve readability, however, I will describe the reverse spiling procedure now with the understanding that we will postpone the operation until later.

To begin, we select a piece of quality planking stock (quarter sawn or at least riff sawn) and plane it to proper thickness. We then tack the spiling batten to the planking stock and transfer the plank dimensions to the planking stock. Fig. 9 illustrates this process.

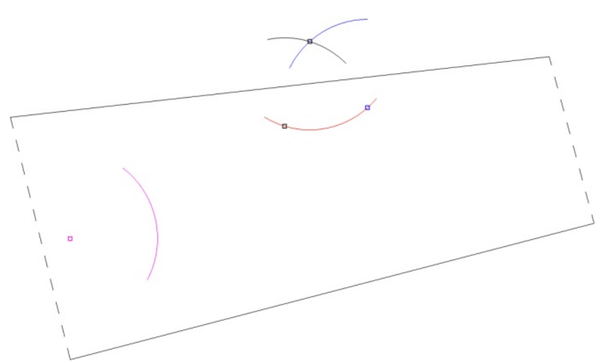


Fig. 9

The red arc represents one of the many arcs that were scribed onto the spiling batten. The data in magenta records the arc radius as mentioned previously. Now with the compass set to this radius, put the point of the compass on the red arc (at the blue point) and scribe an arc (blue) onto the planking stock. Do the same at another point (black point) producing the black arc. The intersection of these two arcs defines one of the points that defines the plank edge. A third arc can be scribed to check for accuracy (the three arcs should interest at one point).

Repeat this process at every station. Before removing the spiling batten from the plank, transfer the station locations to the plank. Now make any adjustments to the points to account for beveling and connect all the points using fairing battens. You now have an accurate drawing of the perimeter of the plank.

Now using a circular saw cut out the plank leaving about a ½” all around in case the planking stock has some residual stress that might cause it to move. At this point you can repeat the reverse spiling process and cut/plane to the line.

Scrub Templates

Our plank must be shaped to fit the curvature of the frames (or backbone members), so we need a method for measuring this curvature. We do this with a series of scrubbing templates. At each station we construct a pair of templates that define the curvature at that station – one template for the convex inside face of the plank and another for the concave inside face. Fig. 10 shows a typical pair made out of thin plywood (3/16” Luan underlayment).

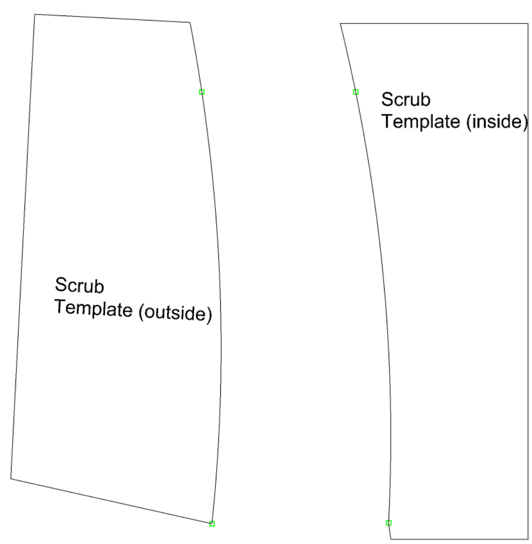


Fig. 10

The outside template is made first. If the station corresponds to a frame location, you can just trace the shape of the frame onto a piece of spiling stock and cut/plane to the line. If the station corresponds to a backbone member, some trial-and-error fitting will be required. I usually start by laying a straight edge “between the dots” and measuring the space between the straight edge and the backbone. I then use a fairing batten to draw an arc on the template. The arc has a cord length equal to the distance between the dots and a cord depth equal to the space. This usually gets me pretty close. Then, since the template is quite thin, it’s easy to trim to final shape with a small block plane.

When the template is shaped correctly, place the template against the frame (or backbone) and mark the location of the top edge of the plank. The bottom edge will naturally be at the apex of the template where it contacts the plank below. It is not necessary for the bottom edge of the template to lie flush with the top of the plank below, although it's easier to measure bevels if it is.

Also record on the template

- A plank identifier
- The station id

Fig. 11 shows the template in position on the boat.

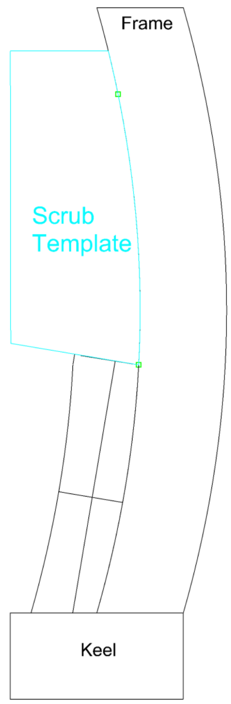


Fig. 11

Note that the figure shows that the top and bottom edges of the plank are recorded on the template (green dots).

As shown in Fig. 12 below, we can extract two useful pieces of information from this template: the bevel angle (more on this later) and the cord depth - the maximum distance between a line connecting the two green dots and the edge of the template. The cord depth is used to determine the initial plank thickness (before scrubbing).

Remember that our plank must be shaped to fit the curvature of the frames. Thus the plank must be initially thicker to allow for this shaping. The more curvature we have the thicker the plank must be. The cord depth tells us how much extra thickness we need. In general, the cord depth varies from station to station. So to determine the initial plank thickness we must find the maximum cord depth over all the stations and add this to the desired final plank thickness.

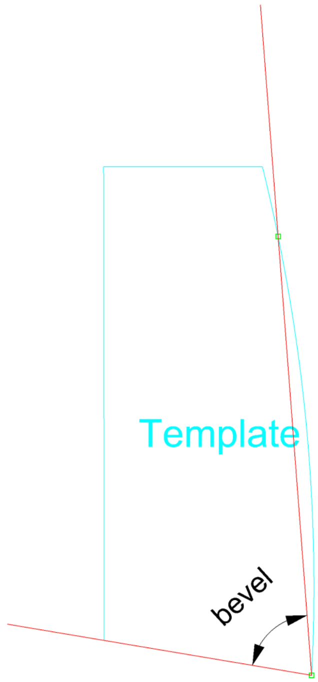


Fig. 12a

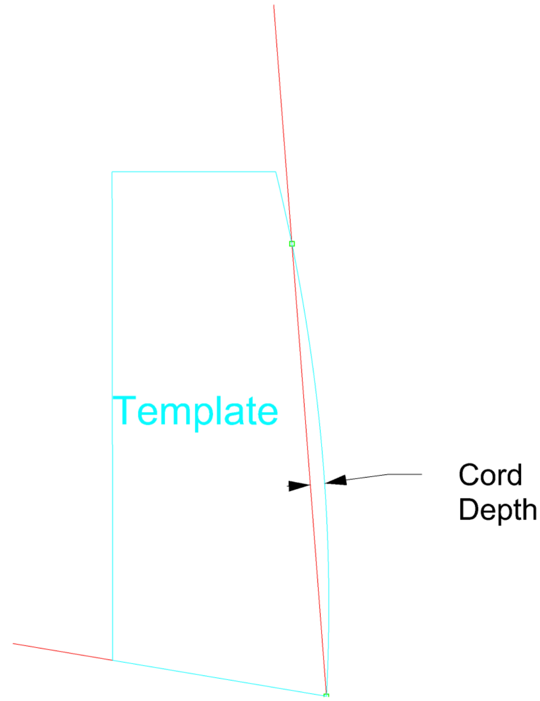


Fig. 12b

The inside scrubbing template is constructed from the outside template and the plank edge locations are transcribed as well.

Measuring the Bevels

At this point, we can determine the bevels. We will assume that the top edge of the plank will be left square to the face (the usual case unless your replacing a plank or fitting a shutter), so the task is to determine the bevels on the bottom edge. Note that these bevels change as we move from one end of the plank to the other – called a rolling bevel. So we must measure the bevels at each station location and somehow interpolate between our measurements to form the rolling bevel. The angle of interest, is between the top edge of the plank below and the inside face of the new plank, defined by a line between the two green dots.

Several methods are available for determining the bevels. The simplest (Method #1) is to use a bevel gage. Place one leg of the gage on the top edge of the plank below and the other along the frame. Unfortunately, the accuracy of the result depends on the length of the second leg of the bevel gage (because of the curvature in the frame).

An improvement (Method 2) is to use the scrubbing template (outside). Fig. 12a illustrates the measurement. Note that accuracy depends on the bottom edge of the template being parallel to the top edge of the plank below. This is the case in Fig. 11. Unfortunately, it's sometimes difficult to achieve this in practice.

In that case, a simple modification to the method corrects the problem, as shown in the sideboard on the next page.

Bevel Angles from Imperfect Templates

When the bottom edge of your template is not parallel to the top edge of the plank below (Fig. A), a simple remedy is at hand.

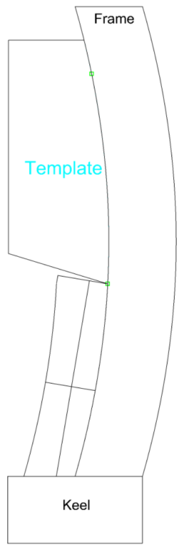


Fig. A

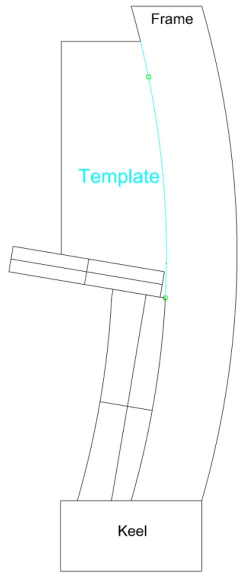


Fig. B

Using a small straight edge, we can construct a line parallel to the top edge, as shown in Fig. B. Then we measure the bevel angle as shown in Fig. C.

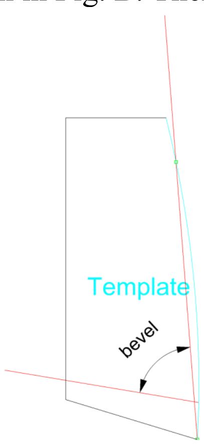


Fig. C

The down side to this approach is that it's more difficult to transfer the angle to the bevel board – a bevel gage just doesn't work well without a solid edge as a reference; however, a protractor works or you can use constructive geometry to transfer the angle from template to bevel board.

The next step is to record these bevel measurements on a bevel board (Fig. 13).

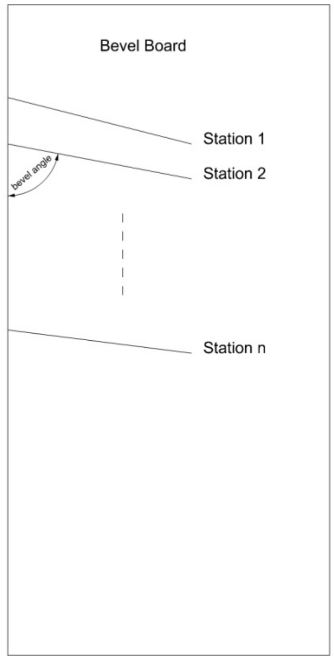


Fig. 13

The bevel board is typically a piece of plywood with one straight edge (to the left). The bevels angles are recorded for each station, using a bevel gage, protractor, etc.

At this point it's important to point out that the bevel angles in Fig. 13 are all less than 90 degrees (i.e., acute angles). As you can see in Fig. 2 this means that cutting the bevels results in outside face of the plank being narrower than the inside face. So the inside face is not affected by beveling. This is important since the width of the plank is defined by the inside face.

Angles greater than 90 degrees (obtuse angles) are not uncommon and result in a narrower inside face. Thus, extra width must be added to the plank to account for this. For now we will assume that all bevel angles are acute and defer discussion of obtuse angles until later.

Scrubbing the Inside Face

With acute bevel angles, it's simpler to cut the bevels after the inside face has been scrubbed. So let's see how this is done. We will assume that at this point the planking stock has been planed to the initial plank thickness as determined by the maximum cord depth, and that all the (inside) scrubbing templates are in hand (Fig. 14).

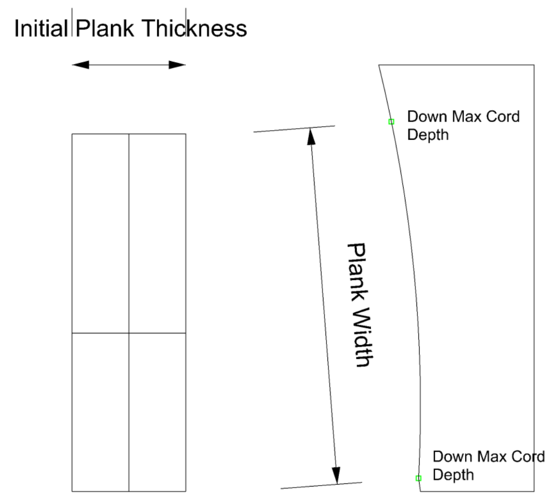


Fig. 14

After making any adjustments to plank width due to obtuse bevels (we assume none), we cut out the plank. If we've done things correctly the width of the plank at this station should match the distance between the green dots on the template.

Next we draw lines on the top and bottom edges of the plank at a distance from the inside face equivalent to the Maximum Cord Depth (Fig. 15). These lines define the scrubbing limit. We then plane the inside face so that it matches the curvature of the template at every station with the green dots at the scrubbing limit.

Note that the shape of the curve typically varies quite a bit from station to station. For stations with maximum curvature, the center of the plank remains untouched. Whereas for stations with little curvature, the full width of the plank is planed down to the scrubbing limit.

My approach is to plane a little over the full length of the plank and check each station with the corresponding template. I mark in pencil where the template does not make contact with the plank and avoid planing those areas until the next cycle – plane, check template, mark. Once the basic shape is achieved, you can plane more agressively until you get close to the scrubbing limits.

For this simple example, the scrubbing limit is the same for both the top and bottom of the plank and equal to the maximum cord depth. It's also the same for every station. As we will see later, the scrubbing limit can be different between top and bottom and it can vary from station to station. Consequently, it's good practice to write the scrubbing limits on the template as shown in Figs. 14 & 15. Here "down" means that the inside face is planed down to the limit.

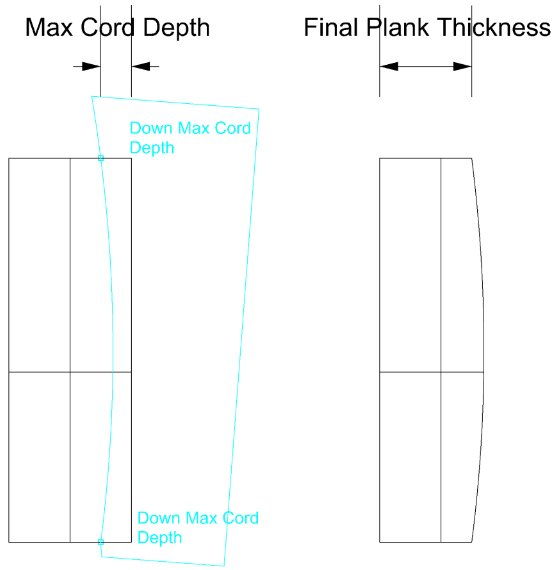


Fig. 15

Cutting the Bevels

With the inside face scrubbed, the edges of the plank are at the final plank thickness. At this point it's fairly eash to mark and cut the bevels.

Using bevel angles directly is inconvenient. One would have to plane a little and check the angle, plane a bit more and recheck the angle – a very tedious process. Instead, we use the bevel board to establish a bevel depth limit for the bevel. The bevel limit is a mark on the outside face of the plank that indicates how much wood to remove to achieve the correct bevel. Fig. 16 illustrates how we determine the bevel limit.

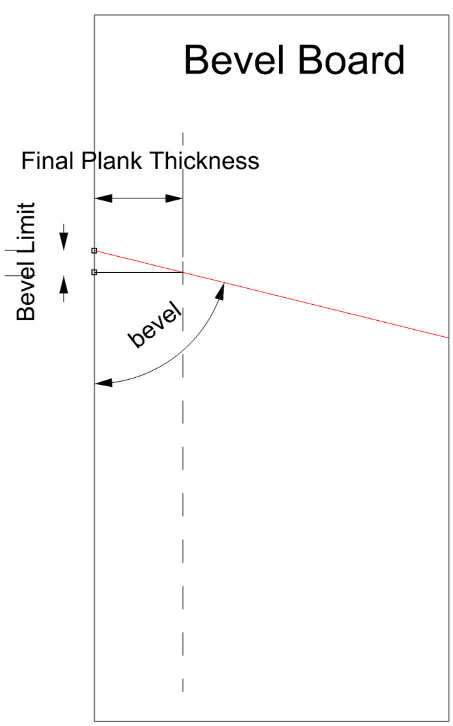


Fig. 16

The bevel angle is defined by the red line and the left edge of the bevel board. We draw a vertical line parallel to the left edge at a distance equal to the Final Plank Thickness. At the intersection of this line and the red line we draw a line perpendicular to the left edge of the bevel board. The bevel limit is the distance between the two points as show in Fig. 16.

At each station, we transfer the bevel limit to the outside face of the plank (Fig. 17). (We can use the left edge of the bevel board directly to transfer this dimension to the plank.) Then we draw a fair curve though all the points. To achieve the correct bevel angle, we plane down until we simultaneously reach the bevel limit line and the inside face of the plank.

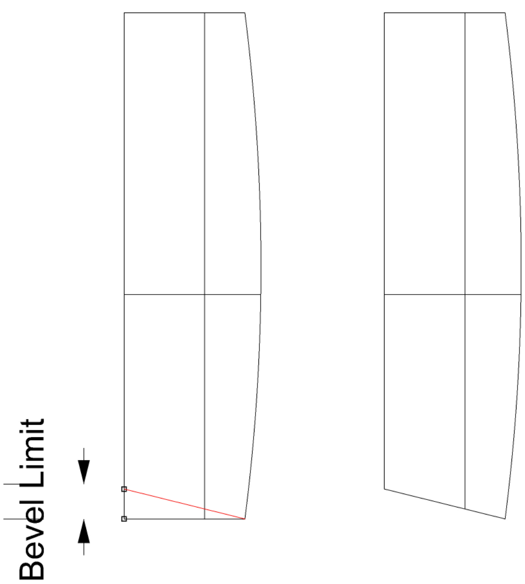


Fig. 17

It's a good idea to verify the bevel angles occasionally using a bevel gage and the bevel board.

Note that bevels may need to be cut on the ends of the plank as well. We will, however, ignore that detail until we discuss obtuse bevel angles.

Finishing Up

The next step is to scrub the outside face of the plank (Fig. 18). A specialize scrubbing plane is best for this (Fig. 19). Note that the width of the plank on the outside face has been reduced due to the bevel. Thus, the lower end of the outside scrubbing template doesn't quite fit the plank. This is of little concern since final shaping will be done on the boat when all the planking is hung. For now, we're satisfied with an approximate shape.

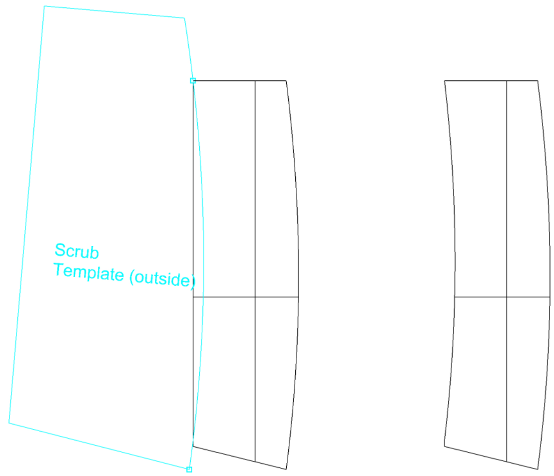


Fig. 18

Fig. 19

It's now time for final fitting. If we've been careful, the largest seam between the plank edges should be less than 1/16". A better fit can be achieved though a series of adjustments to the plank edge. This process is described in the sideboard below. Once a satisfactory fit is achieved (say seams less than .030”) you can cut the caulking bevel. Then paint the inside face of the plank, steam (if necessary), clamp, fasten, and bung.

Fitting the Plank

At this point the plank has been cut to size in profile, bottom edge beveled, and both inside and outside faces scrubbed. The plank ends have undergone whatever treatment that’s required and so the plank is ready for a trial fit.

So we clamp the plank into position on the boat, using wedges, etc. to remove any edge set that has developed. In a perfect world, the bottom edge of our new plank will seat snugly against the plank below along its entire length. This “holy grail” of fit is seldom if ever achieved in practice. Instead, we hope that any open seams between the two planks are limited to 1/16” or less, which we will attempt to eliminate or at least reduce to less than 1/32”.

Before we describe the procedure, let’s take a good look at the problem. Fig. a illustrates the cross-section of the two planks with a perfect seam.

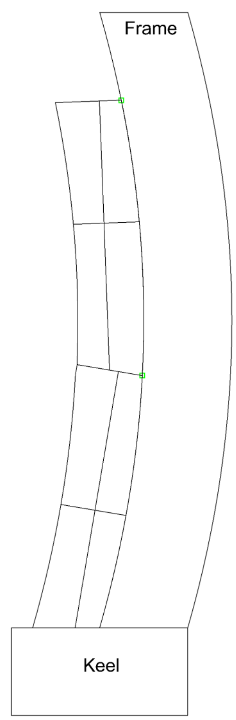


Fig. a

Fig. b illustrates a typical open seam.

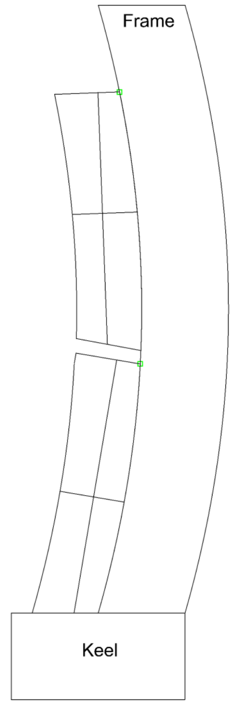


Fig. b

Of course the width of the seam will vary along the length of the plank. This is illustrated in Fig. c below.

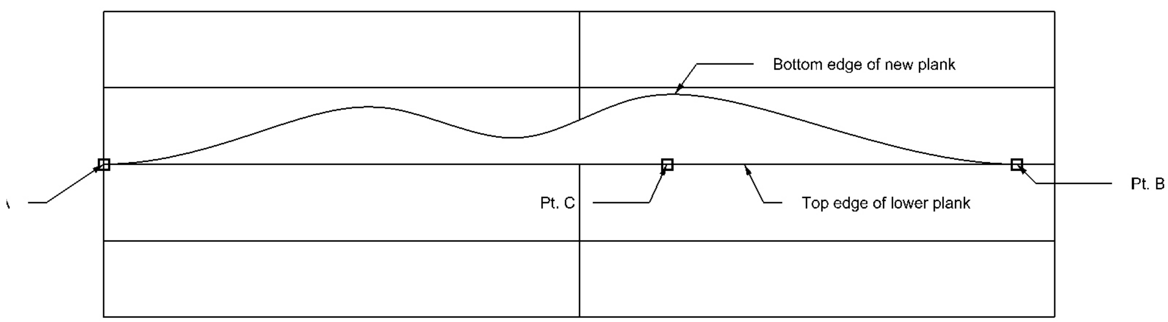


Fig. c

Fig. c represents a section of the plank bounded by tight seams at points A and B. A typical plank will have several such sections. Between points A and B the width of the seam is non-zero (Fig. b), with a maximum opening for this section near Pt. c.

The goal is to remove wood in the neighborhood of Pts. A and B, thus reducing the width of the seams. Fig. d illustrates this concept.

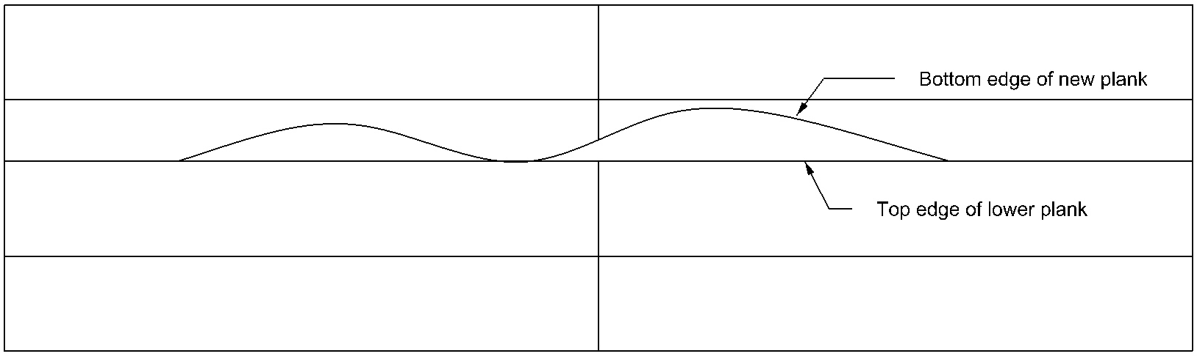


Fig. d

Note that one section now becomes two. So we repeat the process of removing wood where the seams are tight until we achieve the desired fit.

The key to this approach is to identify those areas where wood needs to be removed. I do this using a set of feeler gages ranging from 0.010" to 0.063" in steps of about 0.010". Fig. e shows these gages in operation.

Fig. e

Referring to Fig. c, the process proceeds as follows:

1. Locate a section of the plank having an open seam and select the thinnest gage (0.010”).
2. Insert the gage into the seam.
3. Slide the gage left until it stops when it encounters Pt. A. Mark this location on the plank with the number 10, reflecting the size of the opening.
4. Repeat step 3 moving to the right. You now have established the limits of this section.
5. Now insert the next thinnest gage (0.020”) into the seam just to the right of the mark you made near Pt. A. Slide it left until it stops and mark this location with the number 20.
6. Repeat step 5 just left of the mark at Pt. B (moving right).
7. To check for any low spots between Pts .A and B, slide the gage left from Pt. B and then right from Pt. A marking any places where the gage stops. At this point the plank might be labeled as show in Fig. f.
8. We repeat this process for all gages that will fit into the seam.
9. After completing this section, we move to another seam defining a new section, until the entire plank has been marked.

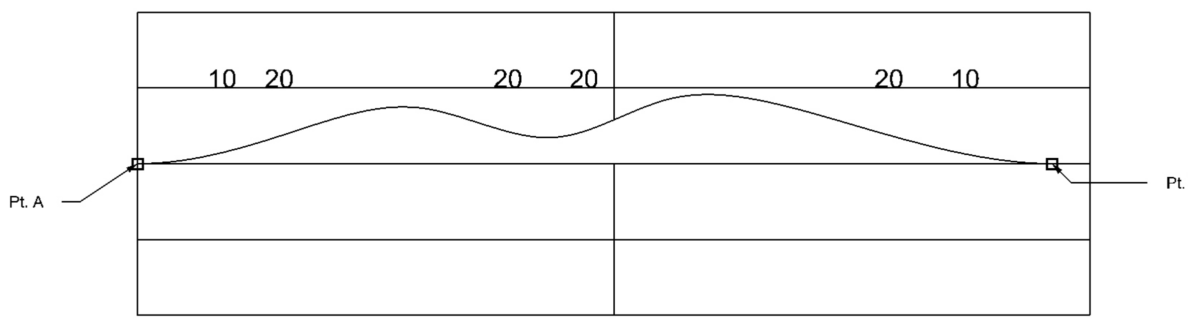


Fig. f

We then remove the plank from the boat and plane down those areas where the seam is 0.010” or less. We set the plane to produce a very fine shaving (<0.010”). We draw pencil lines across the edge (where the seam is 0.010” or less) so we can monitor our progress, planning until all the lines have been removed. It’s a good idea to check your bevels to be sure that you aren’t removing more from one side or the other.

After removing all the lines repeat the process but now for those areas where the seam is 0.020” or less, including those areas that you just finished planing.

Repeat again for 0.030”. At this point it’s best to check the fit again. You should see a big improvement. After about three cycles of this, the fit should be acceptable.

At this point it’s important to mention a few details that I’ve omitted for simplicity in conveying the basic concept. The open seam as shown in Fig. b is an idealization. This only happens if your bevels are precise. Instead the seams tend to look more like the illustrations in Figs. g & h below.

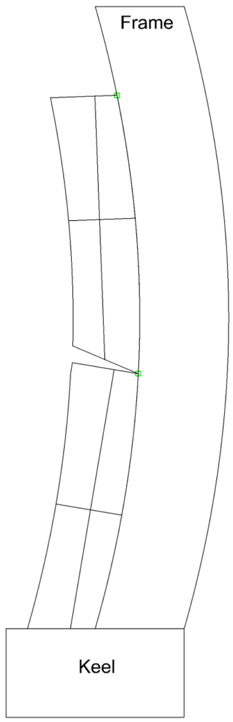


Fig. g

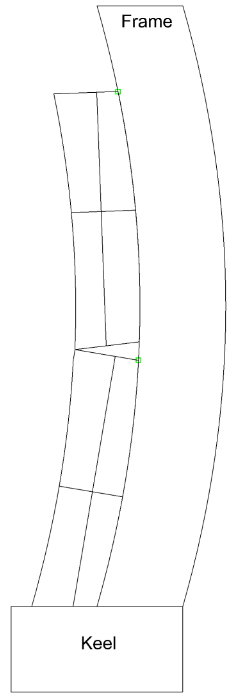


Fig. h

When encountering seams such as shown in Fig. g, it’s important to note on the plank that wood should be preferentially taken from the inside edge.

For cases like Fig. h, it’s not easy to distinguish this case from the ideal one in Fig. b (unless you can check seams on the inside of the boat), but it’s not necessary. When in doubt simply preferentially remove wood from the outside edge. This policy will eventually transform the seam from Fig. h to the seam in Fig. g.

In fact it’s a good idea to strive for a small opening at the outside edge, just to insure that Fig. h doesn’t occur. Also, we will eventually be cutting a caulking bevel on these edges which will intentionally create an open seam at the outside edge. The contact area between plank edges will then be just about ¼ to 1/3 of the plank width at the inside edge.

Obtuse Bevel Angles

In our previous discussion, we assumed that all bevel angles were acute. When cutting acute bevel angles, the outside face of the plank is affected but not the inside face. This is convenient since the inside face is what establishes the width of the plank. For obtuse bevel angles, which are quite common, the inside face is affected and this results in additional complexity, which I will now address.

Fig. 20 illustrates an obtuse bevel and Fig. 21 shows the finished plank in place.

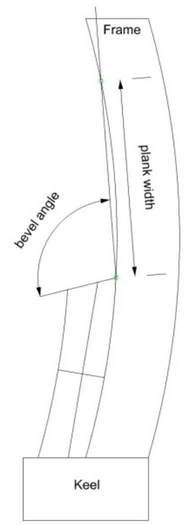


Fig. 20

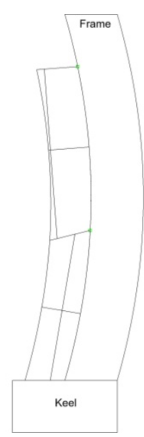


Fig. 21

Fig. 22 shows a cross-section of the finished plank (in red) overlaid on the plank before it is scrubbed and before the bevel is cut (in black). Note that the initial thickness of the plank must be greater than the desired final thickness to account for scrubbing. This additional thickness complicates the process of cutting the bevel.

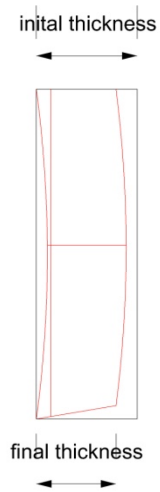


Fig. 22

Fig. 23 illustrates what must happen to cut the correct bevel, assuming that the bevel is cut before scrubbing. You can of course scrub before cutting the bevel, but then it becomes difficult to locate the correct depth limit because the face of the plank is curved. So, we'll assume that the bevel is cut before scrubbing.

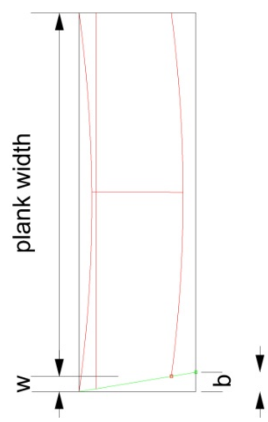


Fig. 23

Again referring to Fig. 23, note that the obtuse bevel angle means that to create the bevel we must remove wood from the inside face of the plank. The plank width is defined at the inside face (where it contacts the frame), so we must increase the initial plank width by an amount w, to make up for the amount removed due to the bevel. Fig. 24 illustrates how we compute w from the bevel board. Note that we must compute this w at every station and adjust our spiling accordingly BEFORE we cut the plank!

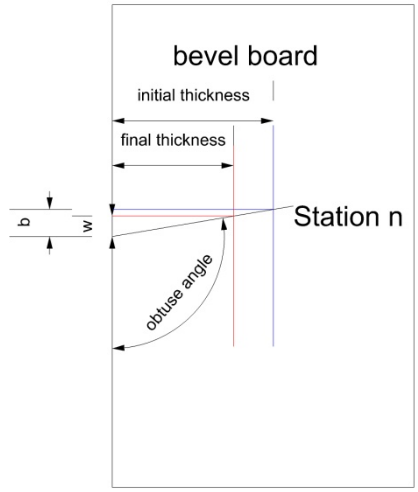


Fig. 24

As we did in our first example, we measure our bevel angle from the scrubbing template. Note that in this case the bevel line slopes upward creating an obtuse angle with the edge of the bevel board. To get the amount of width w to add we draw a vertical line (in red) at a distance from the left edge of the bevel board equal to the final plank width. We then project a line (also red) from the intersection of this line with the bevel line. The distance w is then taken from the edge of the bevel board.

After the plank has been cut to size (but not scrubbed), we can cut the bevel. To do this we need to scribe a depth limit b on the inside face of the plank. To compute the value of b, we again use our bevel board. In this case, we use the initial thickness of the plank to draw our vertical line (blue line in Fig. 24). Proceeding as before, the value of b is taken from the edge of the bevel board.

Once the bevel has been cut, we can scrub the inside face of the plank as before. We can also scrub the outside face using the outside scrubbing template, but because the outside face is wider than the inside, the scubbing should be viewed as an approximation that will be finalized once the plank is on the boat.

Problems Caused by Nibbed Planks

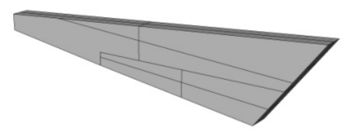


Fig. 25

Fig. 25 shows an example of two mating planks the lower of which has a nib end. Fig. 26 shows an exploded view of these two planks.

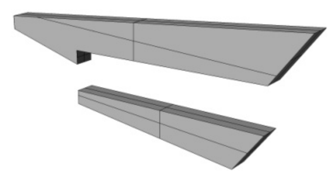


Fig. 26

The nib is used to avoid a feather end, which would be difficult to fasten.

Let's assume that the lower plank is already in place and that we wish to create the plank above it. Fig. 27 shows the associated spiling batten.

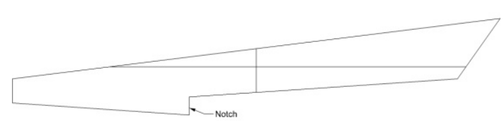


Fig. 27

To appreciate the problem, let's consider what happens in the vicinity of the notch, which accepts the nib of the plank below.

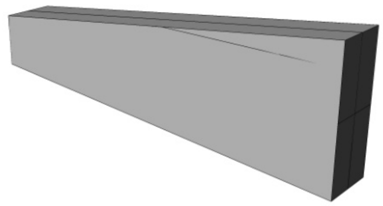


Fig. 28

Fig. 28 shows the new plank just forward of the notch, and Fig. 29 shows the corresponding cross-section, with the location of the nib of the previous plank indicated.

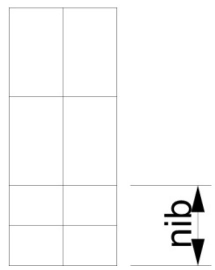


Fig. 29

Fig. 30 shows the spiling batten and a frame that is assumed to be located just to the left of the notch. Note that the spiling batten contacts the frame at both its top and bottom edges (at the red points). This means that the cord between the two points is parallel to the plane of the spiling batten and thus parallel to the face of the plank. Thus the methods describe previously for computing bevel angles and for scrubbing apply.

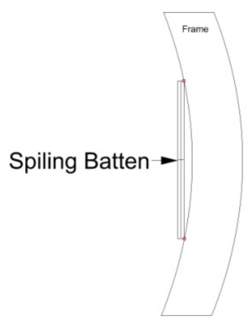


Fig. 30

Fig. 31 shows the plank as it lies against the frame. All is well at this point.

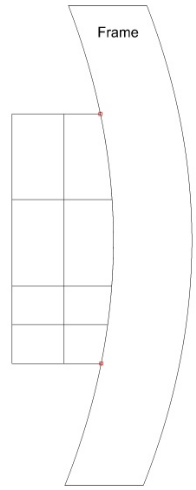


Fig. 31

Now consider what occurs just to the right of the notch (Fig. 32).

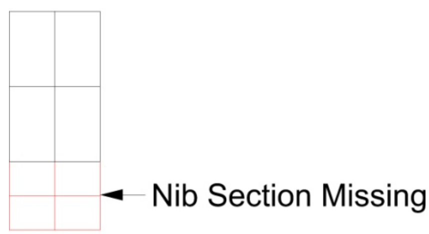


Fig. 32

Note that there is now a step change in the width of the plank – the section adjacent to the nib is missing. Consequently, the spiling batten also exhibits a step change in width at this point. The result is shown in Fig. 33.

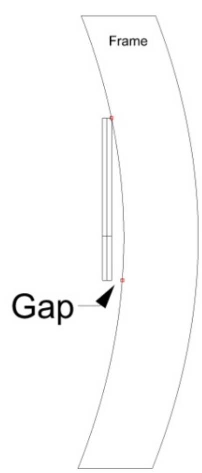


Fig. 33

Observe that the spiling batten no longer makes contact with the frame at the bottom, thus creating a gap. If we attempted to eliminate the gap, the batten would have to rotate as shown in Fig. 34. This rotation would cause the batten (and ultimately the plank as well; Fig. 35) to twist instantaneously, which is impossible.

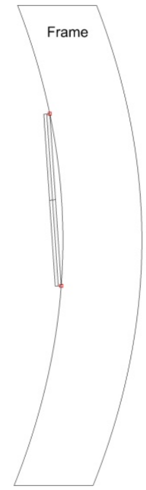


Fig. 34

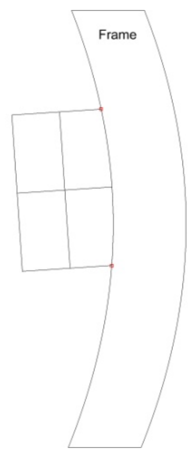


Fig. 35

Compare Fig. 35 with Fig. 36, which is the correct shape of the plank. Here the twist is eliminated by providing extra plank thickness.

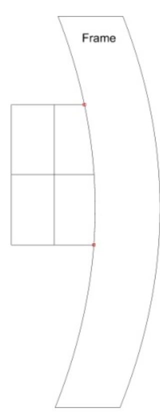


Fig. 36

To achieve the result in Fig. 36, one must be very careful how the bevels are measured and how the plank is scrubbed. In particular, one cannot measure the bevel angle relative to the cord, you must instead measure relative to the face of the spiling batten. Also, depth limits for scrubbing will be different for the top and bottom of the plank.

This problem always occurs in the vicinity of a nib but can occur elsewhere, wherever you have unfair spots in the framing. To deal with this problem, we need to make some changes to how we measure bevel angles and how we perform scrubbing. The following section describes these changes in detail.

Improved Method

We begin as we've described previously:
- Make a spiling batten.
- Record on the spiling batten the width of the plank at each station.
- Make the set of scrubbing templates.
- Use the scrubbing templates to determine the bevel angles (these may need to be modified later), including any bevels at the ends of the plank.
- Record the bevels on a bevel board.

Now instead of reverse spiling to our planking stock, we reverse spile to a piece of ¼" plywood creating a plank pattern – an exact replica (except for thickness) of the new plank. Although this step is time consuming (professionals could not justify the time), the plank pattern offers several advantages:
- It's easier to fit the pattern to the boat than a full size plank. In some cases the plank must be steamed to conform to it's final shape. The pattern needs no such treatment.
- The plank pattern provides some insurance against spiling mistakes.
- The pattern can be useful for determining bevel angles.
- The pattern provides an accurate means of measuring gaps.

After cutting the pattern to shape, cut the rolling bevel on the bottom edge of the pattern. These bevels need only be approximate, they are needed to provide sufficient clearance so that the plank below does not interfere with the proper positioning of the pattern. Note that it is not necessary to make any adjustments in pattern width for obtuse bevel angles, nor is it necessary to cut any obtuse bevels. Obtuse bevels naturally provide the required clearance.

Now, tack the plank pattern in position on the boat such that the top edge of the pattern lines up with the points defining the top edge of the plank. Fig. 37 shows the plank pattern in place.

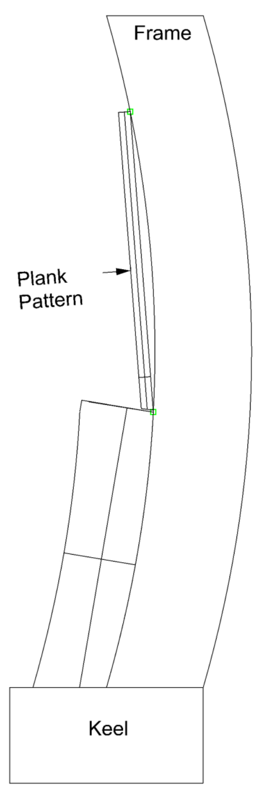


Fig. 37

Inevitably, the bottom edge of the pattern will not lie perfectly against the edge of the plank below. At this point you should go through a few fitting cycles to improve the fit. Ultimately, you are striving for about 0.010” clearance between the pattern and the plank below; however, this is not critical. What is important is that there is some clearance and that you record the amount of clearance on the pattern. Later you will be able to trace the shape of the lower edge onto planking stock, making adjustments for excessive clearance. Note that it is considerably easier to fit the pattern than it is to fit the plank.

At some frames, the pattern might not lie against the frame (or the backbone) at either the top or bottom edges or both, forming a gap(s). This is illustrated in Fig. 38 below. It’s important that the bottom edge of the template is free to move; i.e., does not bind on the plank below. If it does you will need to trim the bottom edge of your pattern to rectify this.

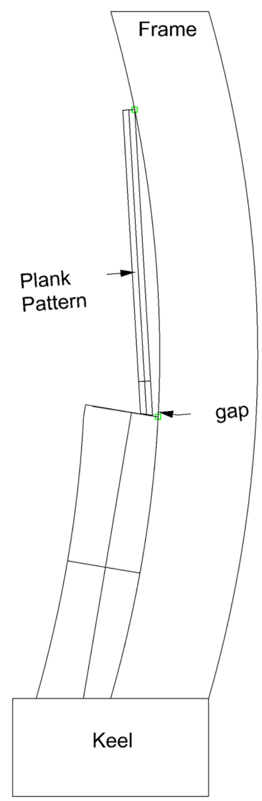


Fig. 38

With the pattern in place, we can now measure the bevel angle and the size of the gap (Fig. 39) at each station. Note that computing the bevels in this fashion can be more accurate than taking them directly from the scrubbing templates (when gaps occur). See the following sidepanel for an explanation.

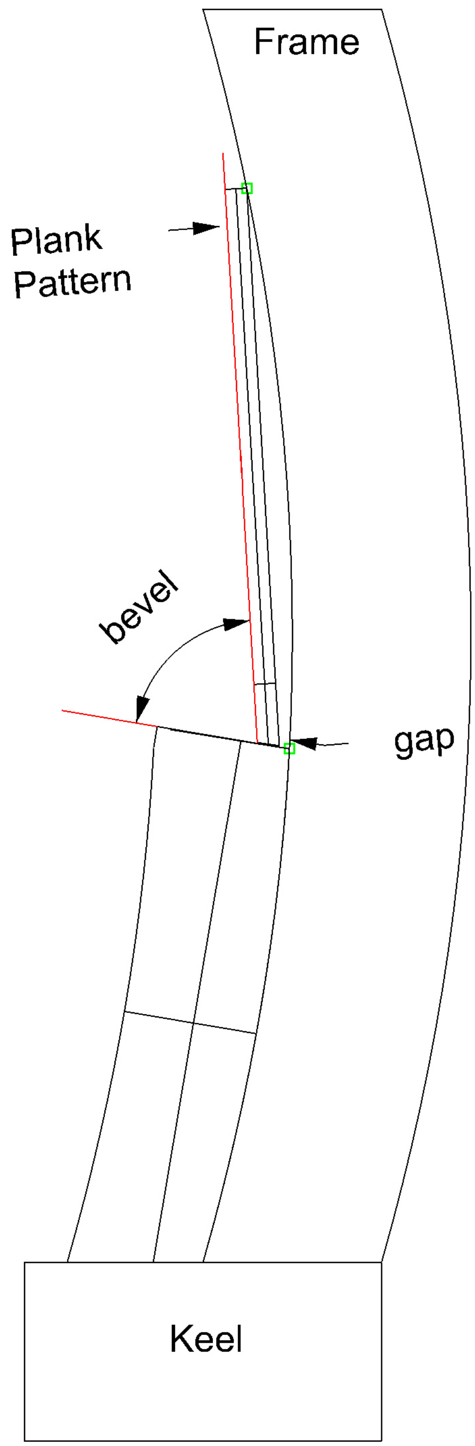
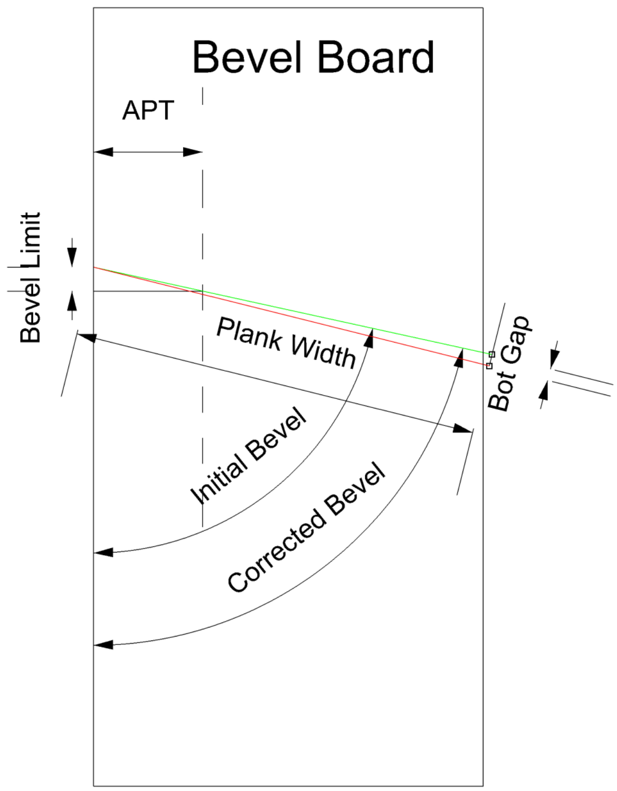


Fig. 39

Adjusting Bevels for Gaps

As we have seen, if we measure the bevels directly from the plank pattern, gaps are accounted for automatically. If instead you measure the bevels from the scrubbing template, some adjustment is required. Consider the bevel board shown below, which illustrates the situation with a gap at the bottom.



The angle between the left edge of the bevel board and the red line represents the initial bevel as determined from the scrubbing template. Note that the effect of a gap at the bottom of the plank is to rotate the bottom edge of the plank away from the frame. The effect of this rotation is shown as the green line in the illustration, where we have rotated away from the red line a distance of Bot Gap at a length equal to Plank Width. To determine the bevel limit you use an Adjusted Plank Thickness (APT), which is equal to the Final Plank Thickness + Bot Gap.

Note that the situation is similar for a gap at the top, only now the top edge of the plank rotates away from the frame. Thus the green line would rotate downward away from the red line by Top Gap. The Adjusted Plank Thickness is just the Final Plank Thickness since a gap at the top doesn't change the plank width at the bottom.

If gaps occur at both top and bottom, it's the difference between the two gaps that is used to make the adjustment. If the Bot Gap is greater that Top Gap, adjustment is treated as Bot Gap that has been reduced by Top Gap. If Top Gap is greater, then it's treated like a Top Gap adjustment.

There are a variety of methods for measuring the gap. In practice indirect methods seem to work best. In one approach, you cut a small notch in the bottom edge of the pattern at each station and then use a small diameter dowel inserted into the notch. Mark the dowel where it exits the notch and subtract the thickness of the pattern. An alternative is to measure the distance from the outside edge of the plank below to the outside face of the pattern. Call this dimension d. If the thickness of the plank is T and the thickness of the pattern is t, then the gap $g = T - t - d$.

Gaps can also occur (but less often) at the top edge of the pattern. These we can measure directly.

The following data is recorded on the plank pattern:

- Station locations. The positions along the pattern where the bevels and gaps were measured. The location of a station should be in the form of line extending across the face of the pattern, so that both lateral position and orientation are recorded. The stations should be numbered for reference.
- Gap sizes. At each station, indicate the size of the gap (even if 0) at the top and bottom edges of the pattern.
- Clearance between pattern and the plank below.

The gap information should also be recorded on the scrubbing templates.

The presence of gaps can affect the initial plank thickness. We measure the cord depth as usual but to this we add the maximum gap at this station. After completing all the templates, find the one with the maximum cord depth + gap. The result is a conservative estimate of the extra planking thickness that is required for scrubbing.

Fig. 40 illustrates a properly labeled template for plank P4 at station 1.

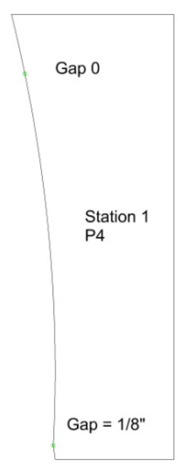


Fig. 40

Now that we have all the data that we need, we're ready to layout and cut the plank.

Attach the spiling batten to the planking stock and transfer the points on the batten to the stock, including the station locations. At every station that contains an obtuse bevel, increase the width of the plank (bottom edge) by the amount indicated on the bevel board. Do the same for the ends if necessary. Now use a fairing batten to draw a fair curve through all the points. Rough cut the plank to size. I recommend that you cut the plank 1/2" oversize to allow the plank stock to relieve any internal stresses.

Now reverse spile again but now fair only those points that define the top edge of the plank. We must be careful when drawing the bottom edge of the plank. This edge has to mate with the previous plank, so if the top edge of the previous plank is not fair, then you'll have to live with that unfairness on the bottom edge of the new plank. This is where the effort that we invested in a plank pattern pays dividends.

Attach the plank pattern to the planking stock so that the bottom edge of the pattern lines up with the spiling points on the stock at each station. If we've done the spiling correctly, these should match except at stations with bottom gaps. Don't be concerned with the top edge of the pattern. Through the process of fitting the top edge of the pattern might not match the plank exactly. Now trace the bottom edge of the pattern (and ends) onto the stock, making adjustments for

1. Extra plank width due to obtuse bevels
2. Stations that exhibit bottom gaps (favor the spiling marks at these stations over the pattern edge).
3. Clearance data written on the pattern. For example, if the pattern shows a clearance of 1/32" at some location, we should adjust the tracing downward by 1/32".

Don't get carried away with these adjustments. Keep in mind that we've dealing with pencil lines. So trying to make adjustments finer than 1/32" is probably folly. You will still need to do some fitting of the plank itself, but hopefully there will be less of it.

Next we cut the bevels. When we were discussing acute bevel angles, we recognized that it was somewhat easier to scrub the inside face before cutting the bevels. Then when we discussed obtuse bevels, we found that it's better to bevel first and then scrub. So for consistency, we will cut all the bevels before scrubbing. Let's see how the presence of gaps affects the bevels – acute bevels first.

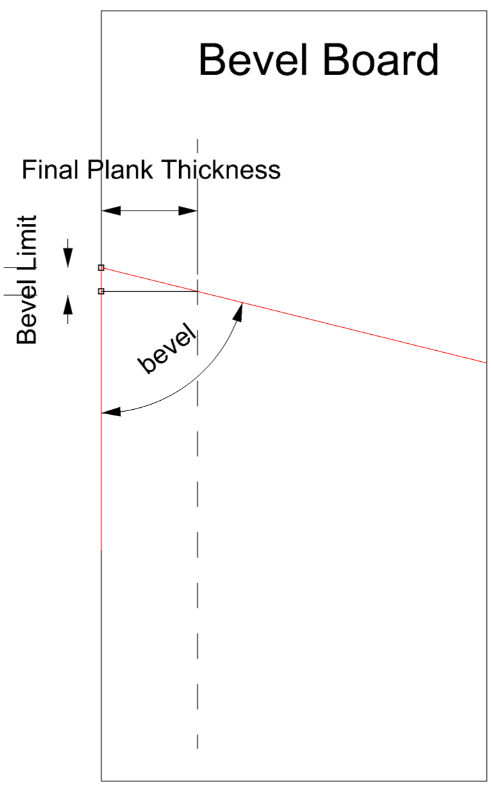


Fig. 41a

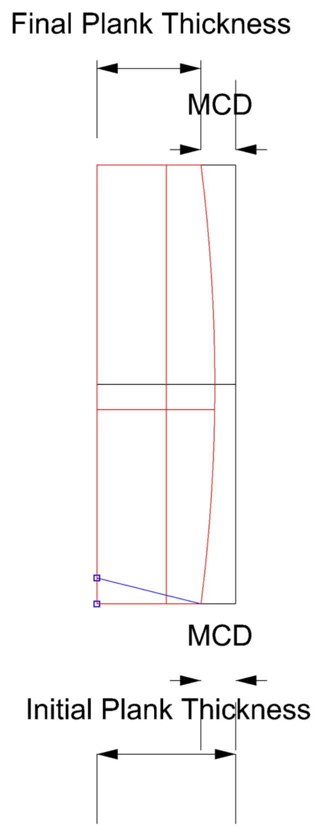


Fig. 41b

By way of review, Fig. 41 shows the bevel board for an acute bevel angle and how the bevel is laid out. MCD is the Maximum Cord Depth over all stations. Fig. 42 shows the same angle when there is a gap at the bottom.

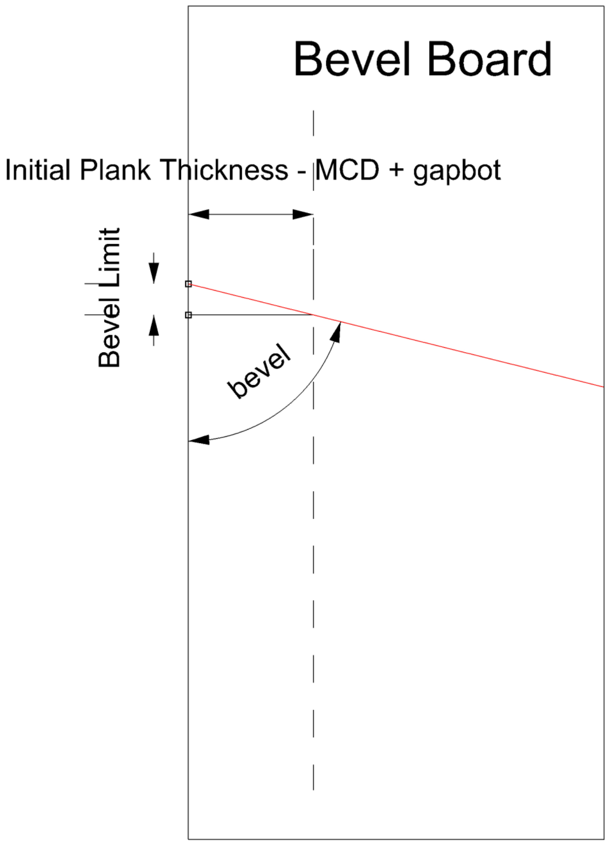


Fig. 42a

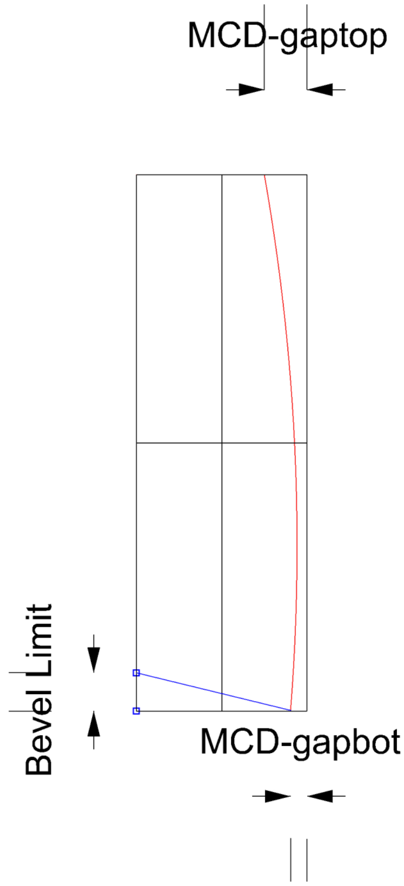


Fig. 42b

The difference is in the plank thickness used. Without a bottom gap it's the Final Plank Thickness that's used. This is just the Initial Plank Thickness less the Maximum Cord Depth (MCD). The presence of a bottom gap causes the plank to be a bit thicker at the bottom, hence the addition of gapbot in Fig. 42. Note that a top gap has no effect on the bevel angle.

For obtuse bevels, the bevel board is the same as without gaps (Fig. 24). The bevel layout is shown in Fig. 43.

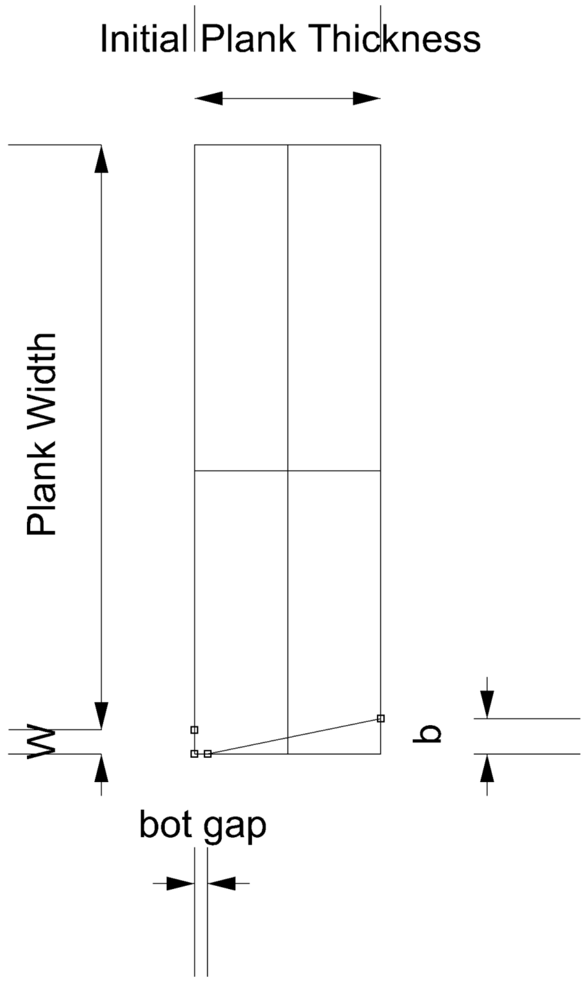


Fig. 43

After cutting the bevels, we scrub the plank on both the inside and outside faces and complete the final fitting cycles. To finish up, we cut the caulking bevel, paint the inside face with two or more coats of paint, mark for fasteners, steam the plank if necessary, clamp, fasten, and bung.

*** section under revision ***

Planks above the Turn of the Bilge

Planks above the turn in the bilge require a somewhat different treatment than those below. The following text describes this process as I envision it – since I have not yet dealt with a plank in this area.

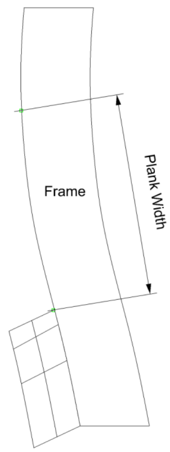


Fig. 44

Fig. 44 shows an example frame with the new plank to be positioned between the two green points, which define the width of the plank.

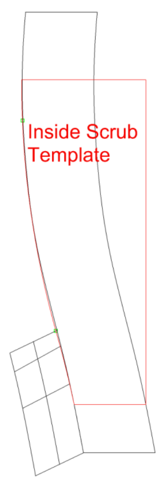


Fig. 45

First we construct an inside scrubbing template describing the shape of the frame/ backbone at this station (Fig. 45). Note that in this case the inside template is convex. Using the template, we can determine the cord depth at this station, as show in Fig. 46.

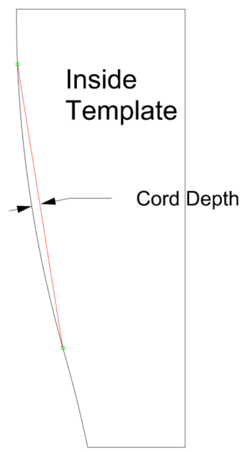


Fig. 46

After developing the inside templates for every station, we can determine the maximum cord depth MCD over all the stations. MCD determines how much extra thickness we will need to account for scrubbing. So the Initial Plank Thickness equals Final Plank Thickness + MCD.

We also use the inside templates to creating the outside scrubbing templates, as shown in Fig. 47 below.

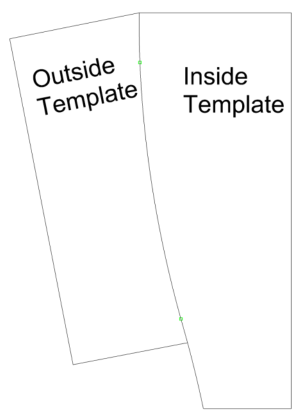


Fig. 47

Next we tack our spiling batten in place on the hull (Fig. 48), making sure that the batten defines a fair surface. As mentioned previously, we don't want to introduce any undue twist that cannot be accommodated by the plank. Unlike for planks below the turn of the bilge, there will always be gaps between the batten and the frame because the outside face of the frame is convex whereas the batten is flat. It's the difference between these gaps that determines how the plank will be scrubbed.

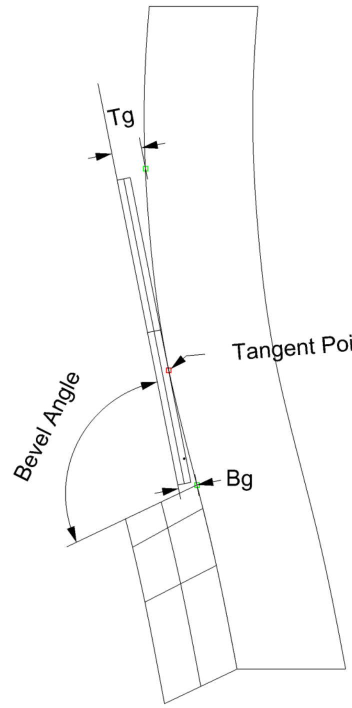


Fig. 48

Fig. 48 illustrates the case where the top gap is larger than the bottom gap. To measure the gaps, use a scale to measure the distance from the outside face of the batten to the face of the frame. These distances are labeled Tg and Bg in Fig. 48. Since we are primarily interested in the difference between the gaps, D = Tg – Bg gives us the desired result.

Fig. 48 also illustrates the proper bevel angle (between the top edge of the plank below and the outside face of the spiling batten), which we measure with a bevel gage and transfer to a bevel board.

The next step is to layout and cut the bevels. Fig. 49a shows the layout, where x is the added width of the plank to account for the obtuse bevel and W is the bevel limit. Fig. 49b shows the plank after the bevel has been cut.

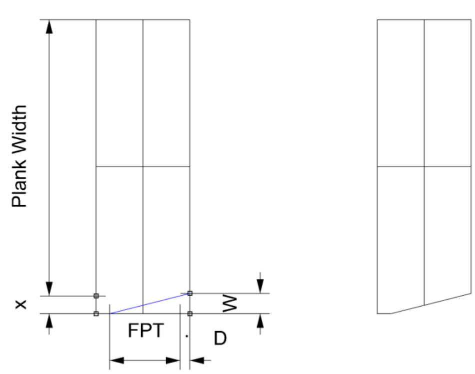


Fig. 49a Fig. 49b

Fig. 50 shows how x and W are determined. The same bevel angle is used in both cases. In fact the same bevel board is used, I've just drawn them separately for clarity. The extra plank width x is derived from the Final Plank Thickness, whereas the bevel limit W is derived from FPT + the gap difference D. In this example, the top gap is greater than the bottom gap, so the plank rotates in toward the frame at the bottom by a distance D. If on the other hand, the bottom gap would be larger, then the plank would rotate towards the frame at the top, and this would not impact the bevel. In that case W and x are the same.

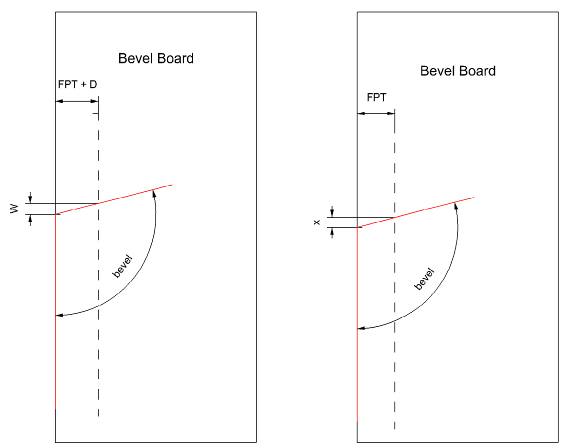


Fig. 50a Fig. 50b

Fig. 51 illustrates how the inside scrubbing template is used to scrub the inside face of the plank. Note that the top mark of the template coincides with the inside top corner of the plank, whereas the bottom mark moves toward the outside face a distance D. If the bottom gap had been greater, the bottom mark would coincide with the inside edge of the plank and the top mark would move toward the outside by a distance D.

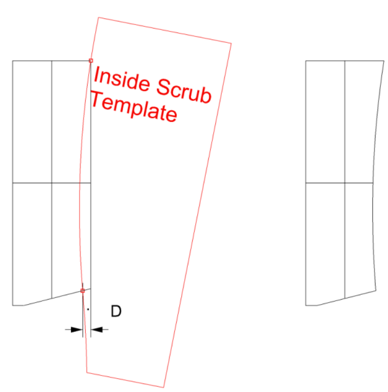


Fig. 51

Fig. 52 shows how the outside template guides the shaping of the outside face of the plank.

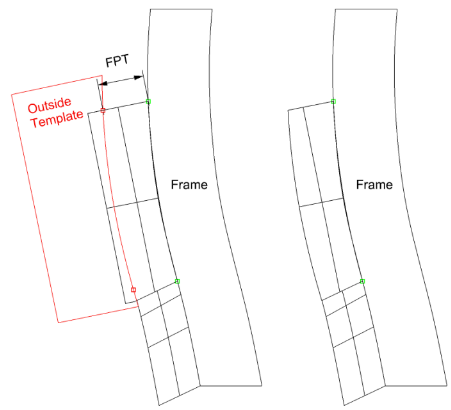


Fig. 52

Note that more wood is removed from the outside face of the plank than the inside. This is by design. Ultimately, the plank must to planed down to the Final Plank Thickness. Whether we remove more wood from one face or the other is somewhat arbitrary; however, it’s easier to plane a convex surface.

Notice that I am not advocating the use of a plank pattern for these planks, because I see no advantage – the spiling batten is sufficient for determining the bevel angles and the gaps, and a plank pattern would not help with fitting since the presence of convex frames renders a flat pattern useless.