Bridge Construction

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Wood Species

The most typical wood species used in bridges are:

- Eastern Hard Rock or Sugar Maple (Cerscharum)
- Hornbeam (Cupinieus betelus)
- Old Steinways used thin American Chestnut laminatoion, alternated with maple
- Asian maple.

Cuts and Joinery Details

Lamination combinations:

- Vertical laminations
- solid wood with scarf joints
- plywood laminations
- solid wood cap over vertical laminations
- flat-sawn vertical quarter-sawn caps.

Sawing Cuts:

Flat sawn: rings curve across the board because it is cut across the rings

Quarter Sawn: the grain goes up and down

Radial sawn: they spin the log like the rings, so it is like super-flat-sawn.

Wood Principles:

- The major movement in wood is perpendicular to the growth rings.
- If you make the best woodworking decision, you will usually end up with the best acoustical decision as well.
- If the expansion and contraction of the wood is not constrained, it will sound good.
- Quarter-sawn bridges last much longer.
- One example bridge was vertically laminated that were flat-sawn but are laid up like a quarter-sawn piece. This works best when the grain line is lined up with the strings.
- Flat-sawn caps glued to quarter-sawn bridges will chequer up because the glue can't move with the wood.
- Solid wood cap over vertical lamination is common.
- Laminated pieces are flat-sawn, but when glued on edge they act like quarter-sawn.

Glues

Most common glues used for making bridges:

- Animal hide glue
- resorcinal glue
- epoxy
- aliphatic resin,

Comments on glues

- The old bridges were made with hot hide glue. If the edges of the laminations were exposed they would deteriorate, so the cap glued on top would protect this from happening.
- Newer glues use urea catalized with water so it is very strong and water-resistant.

- Western wood epoxies are very good for wood, are as natural as wood, and are as dense as the wood itself. These glues are hard and damage cutting edges on tools.
- Aliphatic resins, like Titebond, are layered polymers, which are stronger than cross-linked polymers.

Laminating
When you glue, you actually flip each layer so the rising grains will fight each other. That way with down-bearing all the grains won't die at once.
Maple is very hard to plane without chipping. It is important to plane in the direction down the end grain instead of into the end grain.

Cauls
Put clamps on and do dry fitting first.
You want a nice thin glue line.
Factories make a big cast structure, but they will still use wood on the other part.
Clamps weigh a lot, so you need a strong table.
With wood-working you never have enough clamps and can always need more.
It takes a couple hours to spread glue and clamp everything.
Aliphatic resins set up too fast (about 20 minutes); slow epoxy has a huge working time (about an hour).
Wet the boards down with wet rags before putting the glue on.
Get paint rollers with low nap to spread up the spreading of the glue.

Example of cauls and bridges:
85-note Steinway A
Steinway M, O
Chickering 116 & 119
Kawai 7'6"
B bass bridges
Sawn-off caps

Bridge Caps
When re-capping a bridge, the grain line should go with the grain of the bridge. The grain line in the capping material should be as close as possible to the line of the bridge. Since the bridge curves around, there are grain tangents. Sometimes a piece or two may need to be added at the dog-legs.
Ed might take a bridge that had three pieces of caps and will make four.

Bridge shape
- Crowned bridges have a warmer tone.
- Ideally bridges should be tapered in height -- thickest in the bass and progressively thinner to the treble.
- Shape the bottom of the bridge to conform to the curve of the soundboard.
- There is a slight curve sideways, but there is a large curve on the length of a soundboard.
- Ed will cut the bottom of a bridge to match this curve.
- The human ear can identify such small differences in voice quality that it makes a difference in how the bridge contacts the soundboard. The goal is to bring out desirable vowel sounds.
- Fitting the bridge requires grinding it to conform.

Making a Bridge

They don't just depend on the glue joint. There always is extra reinforcement.
Spruce is kind of weak. Reinforcing with dowels and ribs into the board strengthens the joint.
It is easier to pull a bridge in to the caul than to pull it over to the caul: it's easier to stretch into the curve, with the clamps on the other side.

Establishing Down-Bearing

- The initial caps should be a few millimeters higher than the finished result to allow for differences in bridge height and adjustments.
- Raising the plate will make your hammer travel longer. The shape of the plate decides positioning.
- If the original configuration is not optional, bridge alterations provide the ability to adjust the bearing. We need more down-bearing in the middle, and it should drop off towards the ends.
- If you load the board too much it will start twisting and not be able to vibrate with the low frequencies, so the bass won't be as good.

Soundboard Crown

- The amount of crown a new board has must stabilize before setting the bearing.
- The down-bearing must not exceed the crown.
- The advantage of crown is that the relationship between stiffness and weight can be changed. Crown is the expansion joint to handle humidity changes. New soundboards must start out very dry.
- There are several ways to create crown.
- The first belly, do the ribs. The second belly, glue the bridge on.

Procedure

1. Plane down the pattern on the caps.
2. Make a drawing. The original drawings already had errors, so don't assume that they are perfect.
3. Treat the caul as the drafting table. Use cord to mimic the line of the string.
4. Remove the bridge pins.
5. Clean off the surface.
6. Use masking tape to make the pattern. Use heavy wide tape. Put it on the bridge, leaving some hanging out and it is lapped over the other tape. Take a razor blade and cut off the overhand perfectly evenly with the bridge. Mark the holes. Mark the ends of each section. Carefully peel off the tape and label which piano it belongs to and hang it somewhere to save it. When the plate is in you can use natural straight lines to mark the cap. Pull the plate out, transfer your marks from the tape, and then start looking at the side-to-side spacing. Mark the center line of each note. Look at the spacings and measure to see if they are running off funny. Make sure they are nice and even.

A lot of pianos at the speaking lengths in the centers are not logarithmic. The old pianos took sample notes at the tops and bottoms of each section and would use sample sticks that looked like the right bend. A millimeter on the short strings makes a big difference in tone.

Henry Ziggler, who designed the console piano, the M, the O and the big A, was experimenting with note 88 to make it longer, which gets a better treble and helps with the break point.

Bridge Pins
Put the back rows of pins at 10mm, which is closer than normal, gradually increasing while paying attention that the back row pins are not interfering with the front row of pins. In the second treble section Ed bevels those sections so each string line has a slightly different length. The width of the unisons is often wider than necessary in the treble. Bringing the neighboring bridge pins together weakens the structure. The new Steinways are all 7. Ed uses size 6 bridge pins. Even though they are harder to drive, they are lighter and they produce a better tone. There is too much strain on the wood with shorter pins because the side-bearing is dependent on less wood, causing the bridges to fail.

Bridge Pin Types
Nickel-plate mild steel
Copper-plated mild steel
Blued mild steel
Plain nails, not blued, in old pianos
Titanium alloy in Zauders
High carbon drill rod
Some pianos use brass bridge agraffes
Stamped steel
Plated mild steel
Soft brass alloy

Softer bridge pins would have a slightly dampening effect. What acts to dampen the movement? Piano hammers actually dampen the sound slightly before it leaves the strings. A honeycomb soundboard would have great ring. Take out a copperized bridge pin and you can see where the string has cut into it. If that pin were triple-plated it would hold up better and wouldn't score where the string contacts it.

Filing Bridge Pins
Ed starts with a coarse manual bastard file, and then uses a finer bastard file. Wear gloves.
When finished, put a drop a lacquer on each one so it won't rust.