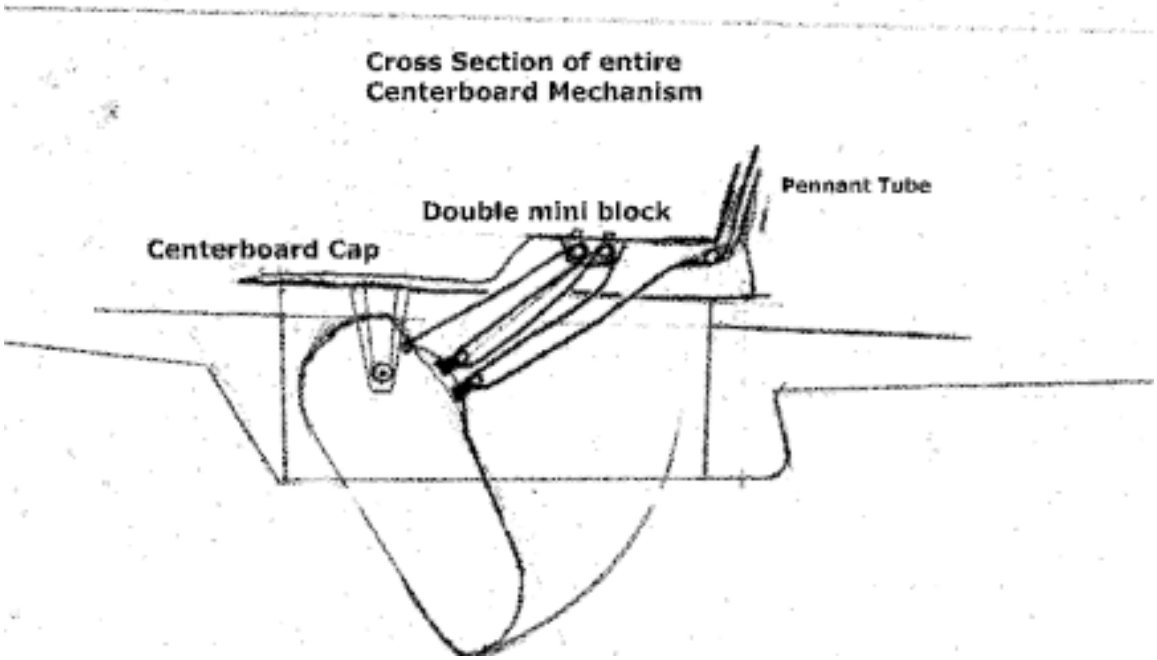
Rhodes 22 Centerboard & Trunk Restoration

This article makes the assumption that there is possibly something wrong below your boat regarding the centerboard, the trunk in which it's housed, or the mechanical advantage system which deploys and retracts the board. I bought my 1981 Rhodes knowing that there would be water damage somewhere inside the boat. Its my first boat and I didn't realize the magnitude of the situation until I transported the boat to a yard and began repairs. Thankfully, the Rhodes22 listserve functioned well to put me in contact with some experts who assisted me in completely renovating the centerboard trunk, board and mechanical advantage. While I have the older style board which has the exact shape of its rudder, the newer diamond boards are housed in similar trunks, I believe they could be repaired in the same manner.



An Explanation of how concrete cures and affects the ballast on my Rhodes.

by Roger Pihlaja

The curing of concrete is not drying. It is actually a series of chemical reactions between certain ingredients in the Portland cement and the water that is mixed with it. Once the Portland cement is mixed with water, nothing can stop the chemical reactions. Portland cement will even cure underwater!

Portland cement is composed largely of 4 types of minerals: alite, belite, aluminate, and a ferrite phase. The curing process is actually quite complex; but, the most important chemical reactions involve the alite and belite minerals reacting with water to form calcium silicate hydrate

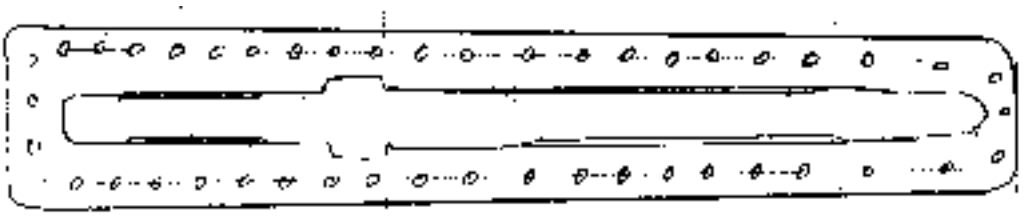
(C-S-H) and calcium hydroxide. C-S-H is the main hydration product and is the main source of concrete strength. C-S-H is a weird material! It has no fixed molecular formula. The [Silicon]/[Calcium] ratio can vary between about 0.45-0.50 and the amount of water taken up during hydration can range from 1 water molecule/C-S-H molecule - 8 water molecules/C-S-H molecule. The exact composition of the C-S-H after curing depends upon the source of the limestone used to make the Portland cement, the amount of water in the concrete blend, and the curing conditions. Both alite and belite are crystalline solids. C-S-H is a hard, sticky, amorphous (glassy), gel with no crystal structure. Fully hydrated C-S-H can be up to 20% less dense than alite or belite. Or, to put it another way, alite and belite can expand up to 20% as they are converted to C-S-H. The waters of hydration are more or less tightly bound to the C-S-H molecule. The first few water molecules are very tightly bound. The last few water molecules are rather loosely bound and are available to move between C-S-H molecules by diffusion. They can also be driven off as water vapor if they are near the surface and the surface is allowed to dry out too quickly.

So, concrete curing proceeds something like this: As soon as the fresh concrete is poured into the form, the solid particles tend to sink to the bottom. This leaves a water-rich layer near the top surface. The particles of alite and belite in this water-rich layer have the best supply of water. Thus, they tend to react the fastest and pick up the most waters of hydration. As the free water is taken up into the C-S-H gel, the gel expands to fill up the void space originally occupied by the free water and any entrained air. The sticky C-S-H gel expands around all the little particles of aggregate rock, sand, and un-hydrated Portland cement, fusing them into a solid mass. Curing proceeds from the surface inwards. After all the free water is taken up into the C-S-H gel in about 2 days, the concrete mass appears to be fully cured. However, water molecules are still diffusing inward from relatively water-rich C-S-H gel near the surface to relatively water-poor C-S-H gel in the interior. This solid-state diffusion/chemical reaction process can take up to a month before all the C-S-H gel has about the same composition and the concrete develops full strength.

The relative amounts of free water, Portland cement, sand or aggregate, and entrained air in the fresh concrete mixture are usually adjusted such that the final cured concrete mass has close to a zero volume change. However, if this cured concrete mixture is exposed to additional water, it will typically expand by 2-4% more as the C-S-H gel takes up more waters of hydration. Used as ballast in the shoal draft keels of our R-22's, this property of concrete is a "good thing". If a tiny crack were to form in the concrete, say to due to a hard impact that penetrated the FRP skin of the shoal draft keel and let water into the ballast cavity, the partially hydrated C-S-H gel will actually expand into the crack in the concrete and "heal" it!

However, there is also a down side to this C-S-H gel expansion. The expansion can generate a tremendous amount of internal pressure inside the ballast cavity.

If the FRP structure of the ballast cavity is not strong enough; then, this internal pressure will cause the FRP structure to start to bend. This is what happened on Lou's boat. When the sides of the centerboard well distorted sufficiently, the centerboard became jammed.



The dark lines inside this drawing illustrate the bulges that were encumbering the movement of the board.

REPAIRING THE CENTERBOARD TRUNK, FLANGE AND MECHANICAL ADVANTAGE

The following method of repair was worked out by Roger Pihlaja and myself from Nov 2004 through Sept 2005. I owe a great amount of thanks to Roger for his knowledge, patience and professional advice on engineering and chemical properties.

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Part One / Diagnosis & Surgery

I. Evaluating the problem.
- a. remove wood floor around trunk cap
- b. look for any damage around trunk flange
- c. mark areas of holes, cracks etc on bilge floor or later on flange top

II. Board removal
- a. removing the trunk cap with pennant pipe
- b. remove 40+ 1/4x20 UNC through bolts with old silicone residue
- c. carefully peeling off the cap and neoprene gasket
- d. noting pennant threading

e. evaluation of cap, board blocks

III. Getting your stuck board into the cabin
a. jack up from bottom, pull from top
b. support jack and mechanical advantage securely
c. You will need the help of at least one more strong person for this part of the job.

IV Evaluating the damage to your trunk interior.
a. measure width of trunk opening from fore to aft in one foot increments.
b. measure width of board at same increments

V. Prep for cutting the bad laminate out
a. purchase a Dremel Multitool, and a Flex Drive attachment. Craftsmen makes a similar unit, called a rotary utility tool, which is what I actually own. You can use Dremel brand accessories on the Craftsman. I recommend the diamond tipped circular blade along with all the small trimming tools. Most importantly, you will need the 1/2" diameter sanding drum attachments. You will need a minimum of 3 drum attachments with at least 20-30, 60 grit, 1/2" diameter sanding drums. These 1/2" diameter sanding drums are sold in packages of 10, so purchase 2 or 3 packages.

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b. A good full-face style respirator with an organic vapor + particle cartridge is recommended. You will be using acetone in gallon quantities as well as epoxy.
Although a full-face style of respirator is recommended, you can get away with a half face style as long as you also wear chemical worker's goggles. The respirator & goggles will protect your face and eyes from the fine dust generated while you are cutting away the laminate.

c. A word about a good set of goggles. I wear glasses and it's really annoying, but I have not had anything go in my eye while working. While under the boat applying epoxy, upside down, they have saved my eyes more than once. I also recommend purchasing a disposable Tyvek jumpsuit. All of these items are available at most marine & hardware stores.

d. You will need to make a custom extension for the Flex Drive so that you can hold it securely while its spinning a good 2 feet away from you. I used an electrical U-shaped conduit fastener bolted to an 18" slim piece of steel which could be bent easily as needed. This extension rig was cable tied to the Flex drive.

VI. Cutting away the bulging laminate and exposing the bad ballast.

a. I used a long wood chisel, but any long, strong tool will help you pry the laminate away and chip away at the cement will work.

b. If the cement is still wet, DO NOT let it dry out first, cut it out right away. It will reset when dry and then will be much more difficult to get out.

The pivot slots shown after they were taken out and restored

Part Two / Reconstruction

I. Measure the holes you have cut and buy enough G 10 Garolite to cover the area.

a. Use a stiff cardboard to make templates of all holes cut out.

b. Use masking tape to hold the template in place.

The aft port side hole in my trunk.. seeing the cement was always a frightening site when coming back to work on the project.

The extended caliper was used to measure the trunk and the middle of the centerboard. Mirrors were essential to seeing into crevices.

c. Placing the templates into place, practice for the finished job.

d. Measure and measure again.

II. Cut the Garolite using your templates.

a. Use a jig saw, use short, tight tooth, plastic cutting blades.

b. Sand down garolite patches for epoxy key to both sides of

patch (later on)

c. You will bevel the lower edge of the garolite patch, or the edge that comes into direct contact with the original wall.

III. Epoxy

a. I recommend the WEST SYSTEM. Their "Fiber Glass Boat Repair & Maintenance" pamplet (002-550) provides a wealth of info on their products and applications regarding boats. I also used Don Casey's Sailboat Hull and Deck Repair book, both of which you can get at any West Marine.

b. Depending upon the location of your boat in the world, you may need a FAST hardener or a SLOW hardener for your epoxy job(s). As my work progressed from late spring to summer I used the slow hardener and now in late fall I am using the Fast again. Buy both if in doubt, its not like mayonnaise it doesn't spoil. Actually, they do have a limited shelf life, especially if stored in sub freezing temperatures &/or very warm temperatures. Check the label!

Follow the advice in the manual & book listed above for acquiring all the tools and things needed to apply epoxy.

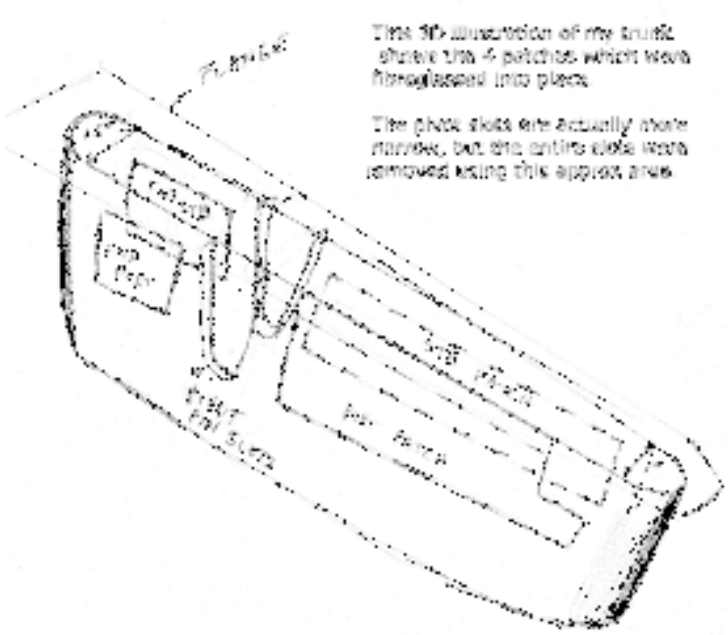
c. If you have to go out to dinner or work in FORMAL WEAR, allow an extra hour for clean up after applying epoxy, especially if its under the boat working upside down.

My board had gel coat patches, three layers of paint which needed to be taken off. The fittings had to be restored as well.

IV. Your Centerboard.

a. Strip all paint off with a sharpened putty knife. remove all hardware, pennant.
b. Sand off all bottom paint, use mask, goggles and keep animals away!
c. Add thickened epoxy (see manual) to any cracks, dents or serious wounds to the board / sand when dry
d. Add 2 layers of un-thickened epoxy.
e. Follow with one layer of barrier coat additive with epoxy. Just let the un-thickened layer get tacky, it doesn't need to cure.
f. Sand down for paint prep
g. Paint with good bottom paint
h. Add/ replace hardware.
i. Assess condition of pivot pin and sheath, replace if either look worn out. I used SS 316 to replace my pivot sheath tube. Do Not use aluminum or brass.
j. Replace pennant

k. A few words on moving the board in and out of the boat alone: the original centerboard weighs in around 70lbs and you must be very careful on your abdominals, leg muscles and limbs when moving this hefty fin around the tight cabin and cockpit. I found it useful to pad as much of my cockpit and cabin with plywood and foam when moving it around.



V. Inserting the patches & Dry fits

a. After cutting the patches from the templates it is time to drop them into place using masking tape to dry fit them and test the clearance for the first time with all patches in place.

b. I devised a way to drop the panels into place one by one using bailing wire and duct tape. If you are doing the same type of repair, you will find whatever method works for you here.

c. After you have placed each panel into its place, you must find a way to hold it in place without disturbing its delicate alignment. I used wood which eventually would be covered in wax paper to prevent it from attaching itself to the side of the panel or the good sides of the walls. These wedges, as I will refer to them, are very useful. I would wedge a thick piece of wood down into the trunk to hold the fore end of a 33" long patch which would have 2 other pieces in the middle and aft end for support. I would then make sure , using other shims which would shim the bottom edge of the main wood so that there was equal pressure from top to bottom exerted on the patch from the wood. Remember, when you are finally ready to insert the patch for good, you will need to cover any wood contacting the walls or panel with wax paper.

d. I actually tested my dryfits with the finished board by dropping it into place and noting the clearances on all sides. The first dryfits didn't use the pivot pin, I just hung the board into

place and made sure there was enough room for it to move. This process sounds easy but it took months of prep and re sanding and finishing before I was confident to move to the final stage of the process.

VI. Tie layers, fiberglass tape & prep of the trunk wall

By now, if your wife was pregnant when you began this process, she has given birth and gone home from the hospital. It's a... Boat!!

a. Sand down the trunk wall using fairing sticks, your dremel tool and your hands with blocks of wood and sand paper.

b. Purchase Biaxial glass tape. Once again I used the Epiglass Biaxial Tape from West System. Depending upon how many panels you are putting in, you will most likely only need 2 packages. Bi Axial Glass tape is relatively inexpensive.

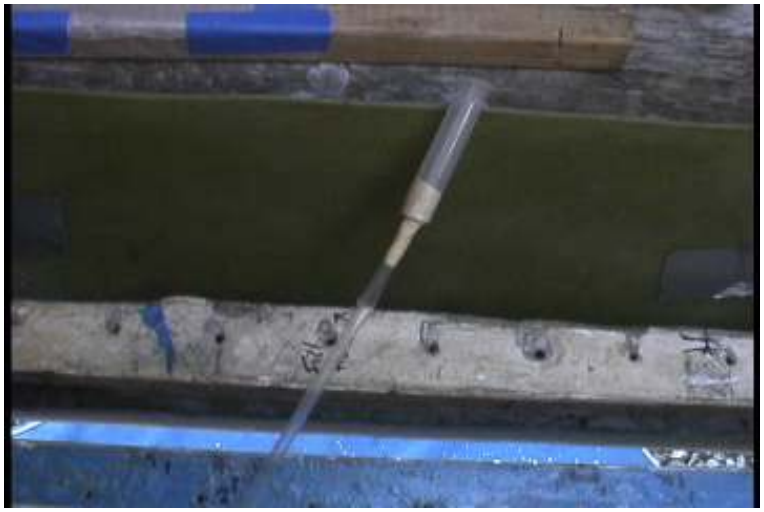
c. Here is how my process worked out:

The basic prep for epoxy is ; SAND, CLEAN and DRY the surface before applying. I would add a wipe down of acetone then dry.

I would apply an un-thickened layer of epoxy to the bare cement wall of the trunk with a throw away brush. Its not going to be possible to get the epoxy into every nook and cranny of that cement.

d. I only waited about 30 minutes after the tie layer was applied Now you lower your patch into place, its been sanded and beveled already. I would have my wood wedges prepped and ready to hold the patch into its place. The horizontal patch zone if you will, is blocked by the wood, but you can leave the vertical patch area clear so you can lay in your biaxial tape on the vertical ends first.

e. After placing the patch into its position, I had enough gaps around the patch to inject thickened epoxy with syringes attached to straws for remote placement of the thick epoxy. Wide drinking straws from Duncan Donuts worked great, but any fast food joint will have some of these laying around. The end of the straw was attached with masking tape to the syringe. I tried using the re useable caulking tubes, but it was a failed experiment.



One of the more difficult tasks: injecting the thickened epoxy into voids between the new panels and the trunk wall.

Here is where it got extremely messy. You need to mix small amounts of thick epoxy and have a small vessel. I used pudding containers or yogurt containers to pour the thick mix into the top of the syringe. Then you put the plunger in and find a good hole to inject the mix into. You need to get as much epoxy into that space as possible. It will drip down and leave the trunk all together if so watch out what is below the keel at this point. This extra epoxy is adding volume and some strength to the panel as its now being bonded to the existing cement. In my case, I had so many voids; that, I could add sand and extra glass attached to the inside of the panels to help bond the panel to the wall as well. I am actually still in the process of adding the final layer of sand and thickened epoxy to fill up those last few voids even after the board is in place. I had drilled holes into the bilge floor next to the flange and poured a half gallon of sand into my largest starboard side void before final finishing and painting.

f. To be clear, we are placing 4 separate sections of glass tape around the patch. The tape is 4 inches wide so I used 2 inches on the patch and the rest covering the gap and contacting the wall. You only have to place the vertical sections of glass tape on the first day. The wood wedges stay in over night and then you pull the wedges carefully and place the last 2 horizontal sections of glass in.

g. The method I used to place the glass onto the patch was simple: After each patch was in place I would first roll in a tie layer of unthickened epoxy around the edge or the patch. By now if the thickened layer has kicked and you can just lay some extra over that layer. Now I carefully dropped the piece of glass tape into position and rolled it with a glass roller into its final position. I then wetted it out with epoxy, making sure it got wet throughout and smoothed to bridge the gap from the panel to the existing wall. clean up and go home. If you have just done the verticals you come back as soon as the last layer hardens, and that depends upon air temp, humidity and the type of hardener you used.

VII Your patches are in and it looks good to your eye. Only your board knows for sure.

a. Using the same mechanical advantage, this time using the pivot pin, drop the board into its position and check the clearances. If they all look good, you are ready to start finishing.

b. Sand entire trunk as smooth as possible.

c. Add 2 layers of unthickened epoxy.

d. Add 1 barrier coat layer.

e. Sand again for paint prep.

f. Paint with a hard bottom paint. (Pettit Trinidad SR or equivalent)

VIII Reassemble and test final time

a. Your pivot slots were probably ok but mine were not. I had to remove those slots which hold the pivot pin and restore the glass and reinforce the backs on one side with wood before re installing. The alignment alone of these parts took days to accomplish.
Make sure your pivot pin is aligned correctly and not making the board move on an angle in the trunk. This will cause the same problem we are trying to remedy.

The two pivot slots removed from the trunk allowed me to completely renovate these important elements and re insert them with confidence that they would function better than leaving them alone.

b. Place wood under the keel to support the bottom of the board so its just sticking out of the bottom of the keel just a few inches and level with the keel edge. Support the main part of the board inside with the mechanical advantage used to remove it.

c. In threading the pennant: note that it has to go through the gasket first. I placed the gasket on the flange and made it work this way, but you could easily put the gasket on the cap with a few bolts holding it on and then thread the pennant through its blocks and up through the tube before installing the cap. Place silicone sealant between flange and gasket and gasket to cap for leakage protection. Replace 40+ 1/4x20 through bolts and tighten.

d. Test board and calibrate pennant for different draft positions.

Your new born child should be talking by now.
enjoy!

disclaimer: I am recommending brand name tools which I found at common hardware outlet store found all over America. Any tool that you feel is capable of doing the job usually works, just keep your safety first as a motto.

Materials: G-10 FR bought from McMaster-Carr, (online)
West System epoxies and glass supplies

References: Sailboat Hull and Deck Repair, Don Casey
International Marine Sailboat Library

West System Manuals
#002-550 Fiberglass Boat Repair & Maintenance
#002-650 Gel coat Blisters Diagnosis, Repair & Prevention