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EPOXYWORKS®

BUILDING, RESTORATION & REPAIR with EPOXY

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Pleasant Bay Columns

By Suzanne Leahy

Pleasant Bay Boat and Spar Company is a boat building and spar fabrication shop located in Orleans on beautiful Cape Cod. We have been building, restoring and repairing boats on the Cape since 1999.

Shortly after I set up shop, I began making spars and created a niche for the business. With a lot of help and advice along the way, I developed an efficient system to make hollow "bird's mouth" poles that were turned into masts, booms and gaffs for sailboats, and flagpoles. The machinery didn't know the difference. Working with boat builders and designers pushed us to go further. The crew expanded to include Doug Ingram, our full time spar maker. The masts got longer and more complicated. Flagpoles were shipped as far away as Bermuda or installed on the facade of the Federal Reserve Bank in New York. Our reputation grew exponentially with the level of experience.

In 2006, I was contacted by a wood consultant who found out about our company through the Federal Reserve project. He had a client who was looking for a shop to turn solid Ipe columns.

STA Architectural Group was the principal designer of a private residence under construction in South Florida. Their trademark motif was tropical hardwood columns resembling palm trunks. This design called for unusual dimensions for eight columns.

The smaller four columns were to be 30" in diameter and 18' high. The larger four measured 36" diameter and 24' high. I made a scaled hollow model based on our bird's mouth staved construction, mailed it to the architect but didn't hear back from them. I was certain that Ipe that size would not be found, nor would a lathe capable of turning those dimensions be easy to locate.

In 2008, the client came back. Working with my crew, we set out to build a column to their specifications using real mahogany, cut precisely by CNC to achieve the tapered shape as shown in the drawing. The first column was a prototype. One difficulty with the design was a series of "reveal" or insets that would later receive brass flat stock as a decorative motif. The prototype was accepted and the contract drawn up to stipulate the following criteria:

1. Material: 6/4 pattern grade genuine mahogany.
2. Able to withstand the South Florida's heat, sunshine and extreme weather.
3. Reveals needed to be designed as an integral part of the structure.

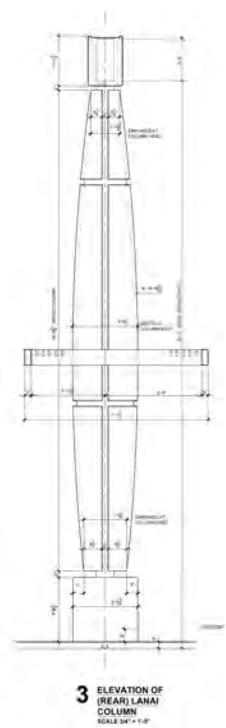
   Picture a column divided into four quarters, then sectioned into three horizontal sections. The challenge was to join all the parts with a backbone. For this we contacted the folks at Gougeon Brothers for glue information and technology.
4. The asymmetrical tapers were as drawn, with no deviation or alteration.
5. Use of bulkheads as a means of securing all the parts.
6. All parts had to be exactly the same. The end result had to be small columns that were identical in all dimensions. Same for the larger ones.
7. Time frame and delivery date was a big factor.

Cover story

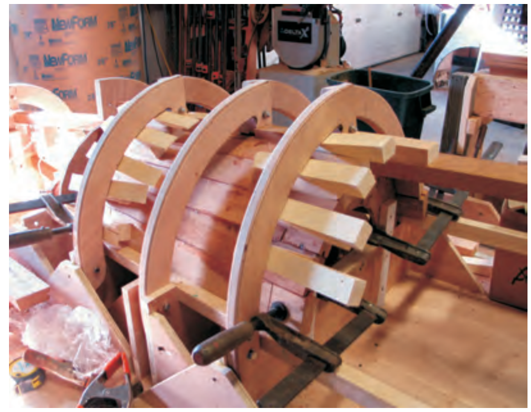
The finished 24' front columns built by Pleasant Bay Boat and Spar Company.

The four smaller, 18'-tall columns during installation at the back of the house in Florida.

Architect's elevation of the 18' rear columns.



Right—The building frame with the permanent Meranti plywood half-bulkheads and vertical reveals for a column half glued in place.



Far right—The staves of a horizontal reveal being glued in place using the plywood brackets to wedge the staves tight until the epoxy cured.

Applying glue to the face and groove of one of the staves. When in place the brackets will be secured over the frame, and wedges forced between the frame and the stave will hold the stave tight against the bulkhead.

We were under pressure to build eight columns, meeting all the criteria within a short time frame, all while we were also building and commissioning boats, spars, flagpoles and a finishing up a major restoration of a 1946 Coast Guard motorized lifeboat.

The first step was to transfer the architect's drawing into Rhino software which enabled Tom Olsen of Olsen Marine, Inc. to program his CNC router appropriately. This was a critical prerequisite to fabricating the columns. Without the exact machining of the CNC, we could not have come close to the budget or time frame of such a complicated project.

Next, we constructed a building frame, similar to what we do in boat building. We built each half of each column separately, then joined them post finishing, making the set up a little bit easier on Tom. He cut faceted Meranti half bulkheads that conformed to the shape of the column in both vertical and horizontal planes and reflected the facet of each stave at each station. They were then keyed into plywood bases located along stations.

We had Tom cut 1"×2" plywood brackets which clamped down the staves. These were bolted to the plywood bases and swung into place as needed. The half bulkheads slid into place without fasteners. That would become an obvious but necessary requirement later when the half column was lifted from the building jig.

Each column was comprised of a total of 126 pieces of mahogany cut, beveled, tongue and grooved to the exact angle and shape needed to make the taper and diameter. But they needed the half bulkheads to hold all of those parts together: the backbone and reveal sections. Needless to say, the first column took many hours of head scratching and worry, not to mention second guessing the architect.

Below—All of the staves are glued in place waiting for the epoxy to cure.

Right—The underside of the half column showing staves on one side of the column glued to the horizontal and vertical reveals, which are glued to the bulkheads.

The backbone became the first part laid in the jig, just like the backbone of the boat. That was glued to Meranti half bulkheads with Gougeon Pro-Set® 175/275 (similar to WEST SYSTEM® Six10® Thickened Epoxy Adhesive.-Ed). This proved to be the best invention since glue itself. The ease of application and the gluing integrity was paramount to the success of this first step. We would have far less cleaning up to do later.

Once the backbone was set, the horizontal reveals had to be set. These were cut to sit under the outer staves, and their facets had to match surface for surface. These reveal sections were critical to the overall structure. They were dry fitted, adjusted then glued and clamped in place with the Pro-Set adhesive and edge glued with WEST SYSTEM 105 Resin/205 Fast Hardener®, then clamped in place.

When the reveals were set and cleaned, the arduous task of dry fitting each section of outer staves began. Again using Pro-Set adhesive and WEST SYSTEM 105/205, our crew got into a rhythm of gluing each half in a day. To clamp, we simply drove wedges between the staves and plywood brackets, hence the need for really strong material. We were literally bending 6/4 mahogany around not-so-subtle curves and needed a lot of clamping pressure until the epoxy cured.

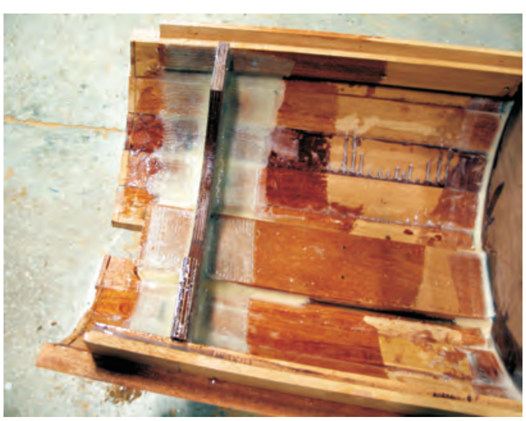
Once the half column had set, it was flipped then the half bulkheads were tabbed in place with 1708 Biaxial cloth and a mixture of WEST SYSTEM 105 Resin and 206 Slow Hardener®.

The half column was ready to be shaped, and we were far from done. This was the most dreaded job. Beginning with a power plane, we shaped, faired, sanded, shaped, faired and sanded again. The columns were getting a natural finish so there was no room for chip, planer cuts or sanding swirls. The reveals

Above—Half of a glued column removed from the building frame.

A half column with the vertical side reveals installed and fillets applied at the bulkheads. Tabbing is applied at the bottom bulkhead.

A half column is placed on a jig for fairing.



Far left—Tabbing at the bottom bulkhead provides extra support for the column base.

Two column halves are fit together. A lap joint that splits the side reveals aligns and joins the two halves.

Two finished column halves are temporarily strapped together for shipping.

Two halves of one of the rear columns being installed over inner steel support columns. The installed columns were stained and finished in place. Brass flat stock was installed in the reveals for added detail.

The finished four columns in place at the rear of the house.

were coated with epoxy then sanded fair, with the idea that a decorative brass sheet metal was going to collect moisture at some point and therefore needed protection. Our rule was to ere on the side of caution at every step.

The entire process was repeated for the second half. Once both parts were finished, completely faired and sealed, they were made ready to fit together. The vertical and horizontal reveals had to line up perfectly. Two of the vertical backbones were ship-lapped in order to fit the halves together. Often they had to be hand shaped to get all the surfaces to align.

The columns were fastened temporarily for transit to Florida, where they would be disassembled and installed on site. This step was all hands on, fitting, shaving off a bit here and there, and refitting. The joints had to be perfect. The big question was how they could install these halves precisely in a vertical position. Judging from the photos, they look fabulous and installation was pretty smooth.

In all respects, we met the design criteria except for the time frame. Putting a boat building shop through that level of exacting and repetitive work, on top of our many other projects was painful. The duration of the project was too long, due in part to the learning curve and management. Once we got down to it we were averaging a column per month, which had been my original goal. The first four averaged one every 2.75 months, too long to sustain the crew's enthusiasm.

The challenge for our shop was to meet the criteria and build better and smarter than the client's expectations. With a top notch crew, beautiful mahogany, and the indispensable help from Tom Olsen, we were able to build some pretty wild columns.

I am extremely grateful to my crew: Doug Ingram and Brian Porter, with help from Molly Avellar, Ryan Benoit, Ned Chamberlain and Alex Holmes of Olsen Marine, Inc., and with the knowledge and assistance we received from Gougeon Brothers, Inc., whose WEST SYSTEM and Pro-Set products we could not survive without. ■

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Building a Custom Stained Glass Mold with G/5

By Tom Pawlak

The finished lamp shade is comprised of eight curved panels, all assembled on a quick and easy-to-build custom mold.

A few years back Mary, my better half, suggested I make a stained glass lamp for our den at home. There are molds commercially available for making glass lampshades. They hold glass pieces in position in the desired curved shape until the soldering process is complete. Unfortunately, the shape I wanted was not available. I wanted something similar in size and shape to the fabric-covered lamp shade in the den. In the end, I decided to make a custom mold.

The original lamp had eight sides so I would do the same on Mary's stained glass lampshade. I started by making thin cardboard templates of the curved shape (side view) of the original lampshade. This template would be used to make mold frames to support the mold surface. Another thin cardboard template was made of the straight-on viewed surfaces. The lampshade had alternating panels that switched from straight edged panels to curved edged panels when viewed from above. So a template of each was needed. All the panels had curvature to them when viewed from the side.

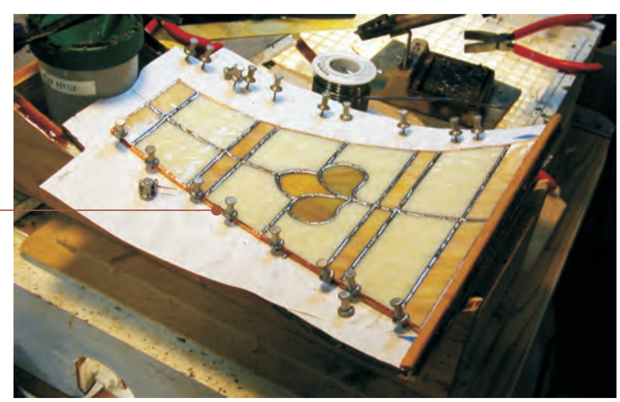
Ideally the mold surface is made of something soft enough to allow a push pin to be easily pressed into it, yet rigid enough to support the glass pieces. I chose $\frac{3}{8}$" thick corrugated cardboard because it would handle heat from the soldering process better than my second choice—Styrofoam™.

The cardboard was too rigid to conform to the curved wood frames, so I scored the back side with $\frac{1}{4}$"-deep cuts every $\frac{3}{4}$" or so across the width of the piece with a utility knife. This depth of cut did not damage the face of the cardboard, and allowed it to easily bend to the shape of the mold frames.

To secure the cardboard to the mold frames I applied G/5® Five-Minute Adhesive thickened with 403 Microfibers along each frame.

I weighed the cardboard down against the mold frames with a few sacks of glass beads while the epoxy cured. Minutes later I was ready to assemble my first glass panel and solder it together.

To make the stained glass panels I used a foil and solder technique where the edges of the individual glass pieces are covered with an adhesive backed copper foil tape. The pieces were assembled like a puzzle onto a pattern held in place with push pins and eventually soldered along the seams to secure them to one another.



After the individual panels were assembled and soldered, they were assembled onto the mounting ring and soldered to one another.

In the end, G/5 Five-Minute Epoxy played a small but critical role in the fabrication of this custom lampshade mold. ■

Ted Moores is a renowned boatbuilder, author and teacher whose name is synonymous with stripper canoes. He and his partner Joan Barrett own Bear Mountain Boats in Peterborough, Ontario. This is the third in a series of articles by Ted Moores on lessons learned from 35 years of wood/epoxy boatbuilding and incorporated in the building of his 30' Electric Hybrid Launch *Sparks,* which was launched in June of 2010.

Lesson 3 Skeg Construction for *Sparks*

Ted 's Cheap Tricks

By Ted Moores

Designing and building a successful skeg for Sparks (our 30' hybrid electric launch featured in *Epoxyworks* 32) took some head scratching. But in the end, it was just another combination of wood and WEST SYSTEM® epoxy. Our skeg needed to be functional and age gracefully, yet be reasonably quick and easy to build and install. This project was an ideal opportunity to explore the limits as well as the advantages of combining wood with epoxy to engineer simple solutions to complex problems.

A traditional wooden skeg is assembled from timbers held together with bolts or drift pins. This large mass of wood is free to expand and contract around the bolts as the moisture content changed. If after a number of wet/dry cycles the joints failed to close, driving in caulking will tighten it up again. Effective, but it required staying on top of the maintenance.

1. Our skeg went together much like a ship's model with the lift shapes taken on the butt lines rather than the waterlines.

We needed to build a skeg that wouldn't move or require the maintenance of a traditional skeg. After two seasons in the water, there is no sign of stress or joints showing through on our skeg. I am happy with it and would build one this way again.

Overcoming movement in a large mass of wood is not all that simple. From experience with Puffin, our 24' strip-plank/epoxy William Garden designed catboat/motor sailor, we knew that covering a stack of ¾" mahogany with epoxy and fiberglass cloth was not all there was to it. Every time we hauled Puffin out, the glass on the skeg would have split in a different place.

This tells me that the power in a large mass of wood cannot be ignored even if the wood has been well sealed with epoxy and reinforced with glass cloth. We can either provide the wood a controlled way to move as the old-timers did, or take the power out of the wood so that any movement is cancelled out.

The shape of our skeg dictated how it would be built. *Sparks'* Designer Steve Killing asked how thin we could build the skeg to get the cleanest flow of water to the prop and rudder. I told him to draw the perfect skeg and we would figure out how to build it. I was worrying about drilling a hole for the shaft tube and coming out the side, thin or not. There would be a lot of work invested before that hole was drilled. We also had to make sure the hole was well sealed from the inside.

Our skeg went together much like a ship's model with the lift shapes taken on the butt lines rather than the waterlines (*Figure 1*). The shape of the Douglas fir layers or 'lifts' are ⅝" butt lines taken out from the centerline. This simple method of building up shaped layers solved all the engineering problems and greatly simplified shaping and keeping both sides symmetrical. The alternating grain direction of the layers balance any movement across the grain. The longitudinal fibers contribute strength and stiffness where it would do the most good. The bonus was that we could build the shaft tube into the structure and I could stop worrying about drilling and sealing that long hole.

Assembly began with cutting to shape and laminating the center three layers. Once glued together on a flat bench, it was stiff enough to hold its shape supported on sawhorses for the convenience of fitting the additional layers (*Figure 2*). A few screws were used to hold the pieces together as the structure was being assembled dry. When we glued the pieces together, the screws guided them into the original position. This kept them from sliding around when the clamps were tightened.

Note: It's important to drill pilot holes if using screws to apply clamping pressure. The screws should pass through the first layer without friction so what you feel through the screwdriver is the two layers being drawn together. This control is handy on thin laminations where the bite of the screw is minimal and stripping is a good possibility. If a screw is simply driven through the two pieces, the odds are 50/50 that it will strip out in the second piece first; they won't have been pulled together and all you'll have is another hole to fill.

An advantage of fitting all the pieces together dry was that we could use the first layer as a guide for trimming additional layers. All the thought and care went into laying out and shaping the first layer, and the remaining layers were cut roughly oversize on the band saw, screwed into position then trimmed en mass. To do this, we used a straight router bit with a pilot bearing following the first layer (*Figure 3*).

This required little skill or effort, made building up the layers go quickly and kept the profile shape under control.

After shaping and fitting all the pieces together dry, we removed the loose pieces down to the core. The combined thickness of these three layers are the diameter of the shaft tube, so two straight cuts through the core were all it took to make space for the tube (*Figure 4*). This simple step eliminated all the suspense, calculations, jigs and tools needed to drill the hole and seal it

To get started, we reassembled the core—now in two pieces—by gluing the first

2. Once glued together on a flat bench, it was stiff enough to hold its shape supported on sawhorses for the convenience of fitting the additional layers.

3. We used the first layer as a guide for trimming additional layers using a straight router bit with a pilot bearing.

4. Two straight cuts through the core were all it took to make space for the tube for the propeller shaft.

5. **We reassembled the core by gluing the first layer on one side using the screw holes as a guide.**

6. **Changes in grain direction and glue lines complicate the use of hand cutting tools, but are indispensable as guides to keeping the curves fluid and the sides symmetrical.**

7. **For a mold, we used a wooden batten cut the same width as the stem-band and covered with plastic packing tape.**

8. **We used a mold for the sides to simplify fitting the ¾" × 1" support for the rudder, which was important that it be installed level.**

layer on one side using the screw holes as a guide (*Figure 5*). To accommodate the stern bearing, a mold of the space it would occupy in the skeg was fitted. The plugged end of the copper shaft tube fit up to the mold so that when it was removed later, the cavity was sealed, finished and ready to go.

Arriving at the final shape began with removing the bulk of the material with planes, chisels and disc sanders then finished with a cabinet scraper. A downside to laminating is that changes in grain direction and glue lines complicate the use of hand cutting tools. On the other hand, they are indispensable as guides to keeping the curves fluid and the sides symmetrical (*Figure 6*).

Squaring up the corners

Sparks was to have a continuous stainless steel stem band ending in a support for the rudder. Before glassing, the edges of the stem and keel had been rounded over to make it possible to wrap the glass around the edge and overlap down the centerline. This would leave us with a round corner under a rectangular stem band. To make up this space gracefully, we filled it in with a mixture of epoxy resin thickened with 403 Microfibers and sanding dust.

For a mold, we used a wooden batten cut the same width as the stem-band and covered with plastic packing tape. Fiber tape held the mold in position. Filling required two steps to work around the tape, but this was better than using temporary screws and filling in holes later (*Figure 7*). To keep the edges crisp, we left the mold in place while sanding the filler. The filler was then buried under the final two coats of epoxy.

To simplify fitting the ¾" × 1" support for the rudder, finishing at the stern took a little more precision. Having a machined bushing in the end, it was important that it be installed level. Here we used a mold for the sides (*Figure 8*). This allowed the mold to be leveled and the filler simply scraped off to the top of the mold.

These are just a few more ways that thinking lazy has worked for us. Look for more Cheap Tricks in a future issue of *Epoxyworks*. ■

The Coupe DeVille of Epoxy Caddies

By Mike Barnard

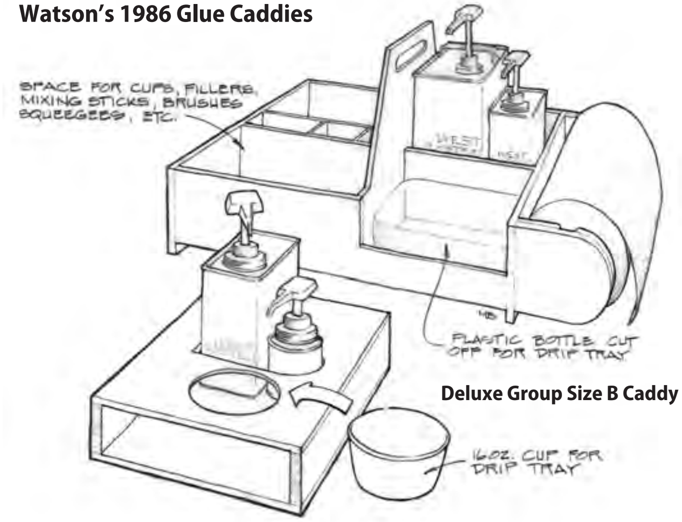
My father has grown very fond of WEST SYSTEM® Epoxy and his box of epoxy-related items has been growing at a steady rate. The overflow of his box in an already "treasure" packed garage emphasized his need for an organization and storage system for these materials. We have had several requests for this same type of solution lately, so I did some digging and found a great *Epoxyworks* article from 1986 written by J.R. Watson. Inspired by this article, my father and I built our own interpretation of the Epoxy Caddy.

Transporting epoxy with the 300 Mini-Pumps in the containers is typically awkward with a risk of overturning. The pumps could become damaged, and the alternative, to remove them, is messy and unnecessary. We always store the epoxy with the pumps in place. Inadvertently, a drip will cause a mess. A pot placed under the mini pumps will catch those rascals, but if the containers or the pot are not positioned correctly all's for naught. The glue caddy solves both transportation and storage problems.

A caddy can be simple or as elaborate as you want. One could design it to become an epoxy work station complete with storage for brushes, stir sticks, hand cleaner, gloves, paper towels and so on. Or it could be designed simply with cutouts for containers and drip pots. One can simplify or expand upon the concept, tailoring to meet your needs.

Set whatever size containers you are going to use together, trace around their bases onto the plywood, and cut it out with a sabre saw. Position the drip pot cutout so it will be under the spouts of the mini pumps. With pots in position, you're ready to go to work. ■

Watson's 1986 Glue Caddies



Deluxe Group Size B Caddy

Basic Group Size A Caddy

1. Lay out the items you want in your caddy on a sheet of plywood. Trace the outline of each item. Be sure to include a drip cup below the resin and hardener mini pump spouts.

2. Cut out the shapes of each item slightly oversized as necessary.

3. Add sides, a bottom and a handle to complete the caddy.

Bubble-free Coating

By Mike Barnard and Don Gutzmer

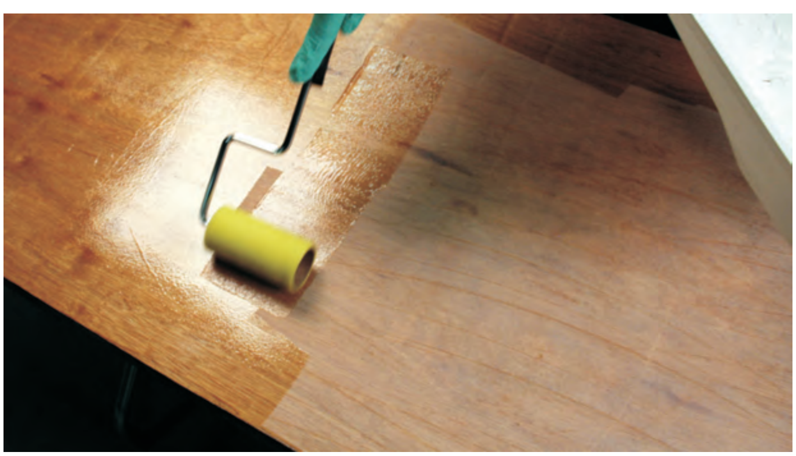
WEST SYSTEM® epoxy has long been a popular choice for clear coating table tops. It works great as a buildup coat and a moisture barrier. It also showcases the beauty of wood grain and fiber weaves.

Formulated with boat building in mind, WEST SYSTEM epoxy is not intended as a final finish coating. You may find it a bit more difficult to achieve a perfect surface with epoxy than with a coating formulated specifically for final finishing, such as varnish. However, WEST SYSTEM offers some distinct advantages. It builds up quickly: a single coat of 105 Epoxy Resin® with 207 Special Clear Hardener™ offers about four times the thickness of a typical coat of polyurethane varnish. WEST SYSTEM epoxy is also an excellent moisture barrier, stabilizing the surface so your final finish coat will look beautiful longer.

When coating a surface that will be used outdoors, it's important to put a UV resistant clear coating over the epoxy. While 207 Special Clear Hardener contains a good UV inhibitor, it will still need an additional UV resistant coats to withstand the degrading effects of sunlight on epoxy.

Since you will need to sand down the epoxied surface and coat the epoxy with varnish, getting a perfect epoxy coating isn't necessary. But the better shape it's in, the more easily you will achieve a beautiful finish. The key is creating the smoothest, flattest epoxy surface possible. This will save you a lot of sanding later.

Applying epoxy over a properly prepared, dust-free surface. Apply epoxy in thin even coats to get the smoothest coating.



Last summer here at the Gougeon shop, we laminated a 35-year-old conference table with carbon fiber and WEST SYSTEM 105/207. We experimented with different methods of achieving a smooth, even coat to reduce the need for sanding prior to the final finish coating.

■ **Prepare the surface**

Proper surface preparation is one of the most important steps in using epoxy. Make sure the surface is clean of contaminants such as wax and paint. Sand the surface smooth. Avoid using solvents immediately before applying the epoxy.

■ **Eliminate dust**

Getting a perfectly smooth surface starts with clearing the air of small particles. These particles may seem harmless, but once they are on a glossy surface it will not look nearly as good as it could. Avoid using tack rags. Vacuum the surface before coating.

■ **Understand outgassing**

Before coating bare wood, heat the wood and apply the epoxy while the wood is cooling. During cooling, the air in the wood contracts, drawing the epoxy in. The opposite happens if you coat wood as it's warming (such as in the morning, in the sunlight, near a heater or anytime ambient temperature is rising). The air in the wood will expand and "outgas" while the wood's temperature is rising, resulting in bubbles in the curing coating.

■ **Applying over stains**

Be careful when using WEST SYSTEM Epoxy over commercial stains. Some stains prevent epoxy from penetrating into the wood. The result can be epoxy that fisheyes or peels off after final cure. Always perform a test before using epoxy over a stain.

■ **Avoiding blush**

It's easy to avoid the inert, waxy residue that is sometimes a byproduct of the curing process and is commonly called "blush." Simply use WEST SYSTEM 207 Special Clear Hardener. It cures blush-free. It's also formulated for excellent wet out and self-leveling. It cures extremely clear and without color.

Far left—Tip off wet epoxy with a roller cover brush using long, even overlapping strokes.

Left—Pass a torch flame quickly over wet epoxy to warm the surface, reduce the surface tension, reduce viscosity slightly and release air bubbles.

If you are using WEST SYSTEM 205 Fast, 206 Slow, or 209 Extra Slow Hardener, blush might develop on the surface, depending on working conditions. It's easily removed after the epoxy cures with plain water and a light scrubbing with a Scotch-Brite™ pad. These hardeners are not normally recommended for clear coating.

■ Rolling and tipping

The only recommended way to coat vertical surfaces with epoxy is the roll and tip method. Roll the epoxy on with a foam roller, then "tip" by dragging another roller across the surface to smooth the epoxy layer.

■ Flow coating

This is the best method for encapsulating items in a clear coat of epoxy. The fewest bubbles result if epoxy is poured from the bottom of a container. A word of caution: Never pour a single layer of epoxy thicker than ¼". Thicker amount can quickly overheat or "exotherm" during cure, resulting in quite a mess on your lovely surface. If you want a final thickness greater than ¼", wait until the first layer is cured to the point where it's firm and about as "tacky" as masking tape then apply the next coat on top of that.

If encapsulating items such as coins, medals, bottle caps and photos on a flat surface, affix them in place with decoupage glue such as Mod Podge® (readily available at craft stores). It's compatible with epoxy and will prevent your items from floating around. Use it to pre-sealed photos and other paper items.

■ Propane torch

This method has been used for years by technical advisors at Gougeon Brothers. Not only is it effective for removing air bubbles from the surface; it also lowers the viscosity of the surface and flattens it out a bit. Be very careful when using this technique because leaving the flame over one spot for too long could cause bubbles to appear. We don't recommend using a propane torch over epoxy coated bare wood. Doing so may cause outgassing into the epoxy layer.

Left—A thick coating of epoxy with bubbles in the coating.

Above—After a quick pass with a torch, the bubbles are released and the coating begins to flow out.

■ Denatured Alcohol

Spraying a fine mist of denatured alcohol over the surface will pop air bubbles as well as lower the viscosity of the surface and flatten it out. There is little risk in this method because denatured alcohol evaporates fairly quickly and does not cause air bubbles to propagate. A fine mist is critical.To get the fine mist we purchased a bottle of hair spray with a push button pump (a Windex™ sprayer is not fine enough) and replaced the hair spray with denatured alcohol. ■

A fine mist of denatured alcohol will reduce surface tension and release air bubbles.

Retired Navy man William Terra of Maine scratch built this 1:20 scale model of the WWII German heavy cruiser Admiral Graf Spee. The model is built like a canoe using ¼ " bass wood strips covered with fiberglass. The 30' long model is powered by a 15 hp outboard engine mounted under the rear gun turret and can cruise up to 15 mph. It weighs about 700 lb, has a 52" beam and can carry two people. The model has a built in music system and while cruising the lakes of Maine, Terra enjoys listen to Wagner. When these photos were taken Terra had spent 4 years building the model and had planned on spending a couple more years to make the model complete.

Readers' Projects

My seven year old niece Mackenzie loves to play with my wife's jewelry box every time she visits. I figured it would be nice gift to make her a jewelry box of her own from the scrap plywood we have in the shop. The plan was to make the design simple, but build it quickly. I decided the G/5® Five-Minute Adhesive and a brad nailer was the ticket. I had a good idea of how it was going to look—two front doors that opened to give her three small drawers on the left side and cupboard on the right side for hanging necklaces. All the wood pieces were cut on the band saw, and the box was coated with Minwax™ stain and clear polyurethane. I found a small mirror at the local dollar store that worked well for a little decorative look on the top lid. Right beside the mirror I burned the wood to engrave her name. Overall it was a fun little project, and she was excited when I gave it to her.
—Don Gutzmer, Gougeon Tech Advisor

Yarmouth, Maine, architect, Victor Trodella built this 11' Lawton tender with strips cut from an Atlantic white cedar tree from his own land. He used West System® 105 Resin and 207 Hardener throughout the construction—first applying a sealer coat to the cedar hull, then laying on a single layer of 10 oz cloth on the outside of the hull followed by a couple of filler coats. The epoxy/10 oz cloth also covers the transom, because this dinghy will be tied to a dock with other dinghies each summer and will get bumped a lot.

The interior also received a layer of 10 oz cloth before finishing with bilge paint. All the trim and the transom are white oak. The interior and exterior stems were laminated from strips of mahogany. The keel and skeg are solid mahogany. The project took 162 hours and cost $1,557 including the plans. The dinghy will be the tender for his Friendship sloop. The designer of the Lawton tender said that he wanted a boat that had to be a dream to row, easy to tow, and look like a piece of furniture. Trodella says, "That sums up this design perfectly. I cannot believe how well she rows!" Trodella also built a Grand Laker canoe that appeared in *Epoxyworks* 33.

In May of 2011 Gougeon Brothers installed a new sign in front of our building. The contractor used West System Six10® Adhesive to bond the top limestone slab into the masonry base. He also used Six10 to bed the limestone cap onto the base.

Joe Bosier and his dad John, of Plainwell, Michigan, had built a cedar strip canoe together some years back using West System® epoxy. Both of them really enjoyed the project and had thought about building another one. Joe also thought about building a teardrop camper along with the cedar strip canoe. A teardrop trailer is a small, lightweight camper that is aerodynamic, compact and easy to tow. You just load it with your clothes and the kitchen and food items and you're ready to go.

After a bit of theorizing and a few sketches, they both agreed that it would be possible to build a teardrop out of wood strips similar to the canoe construction. "We used the trailer frame as the strongback, which was really nice for moving in and out of the barn on the nice days when stripping and sanding," says Joe. They finished the project after about two years of working in their spare time.

Adhesive Bonded Structures

By Jeff Wright

Fiberglass reinforced plastic and other composites influence the design of many products manufactured today. Boat hulls, sports equipment and airplanes can easily take new, complex shapes when composites are used in place of traditional materials. Reinforcing structures also benefit from the versatility of composite materials when prefabricated components are bonded with a high-strength adhesive. This article will discuss some of the engineering aspects to consider when designing or repairing an adhesively bonded composite structure.

Adhesion

We often simplify adhesive bonds into two categories; primary bonds and mechanical bonds. Primary bonds occur when epoxy is applied to a previously applied layer of epoxy that has not fully cured. The layers of adhesive bond as if they were applied at the same time and mixed together. Mechanical bonds rely on the adhesion of the epoxy to a substrate. To visualize this, imagine the epoxy flowing into all of the imperfections and the sanding scratches of the substrate and locking into place. In reality the forces are much more complex and beyond the scope of this article.

The fundamentals of achieving strong secondary bonds are the same whether the interatomic forces are understood or not. They include:

- Wet out the substrate. The epoxy must be able to flow and wet the surface. Surface contaminates can prevent this from happening.
- Let the epoxy cure in place. Clamps must remain in place and the joint can not be stressed until the epoxy cures.
- Use a high-strength epoxy. WEST SYSTEM® epoxy is a structural adhesive after it has cured.

Bondline Stresses

Various stresses can affect the failure of a joint and influence the joint design and the design of the product itself. It is important to understand these stresses when planning the product's design.

Shear Stress

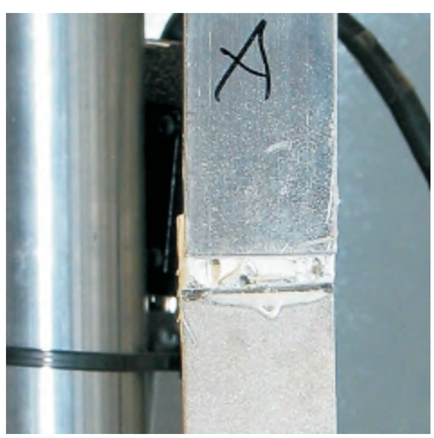
Shear stress occurs when the applied force is parallel to the bondline. Adhesively bonded assemblies generally tolerate shear stress well. If you think of packing tape on a box, it works because it is in shear. It is very difficult to "slide" or shear the tape across the surface of the box.

Shear Stress

The distribution of stress in a bondline that is under a shear load is complex. Just keep in mind that the highest shear stress is at the ends of the bondline. Increasing bondline thickness can reduce the shear stress in the epoxy.

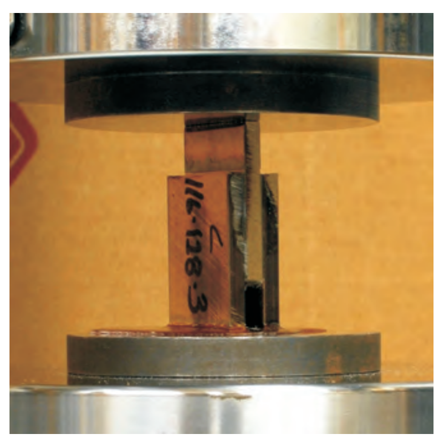
Above—Single lap shear sample in the test machine. The sample is two aluminum plates glued with a ½" overlap.

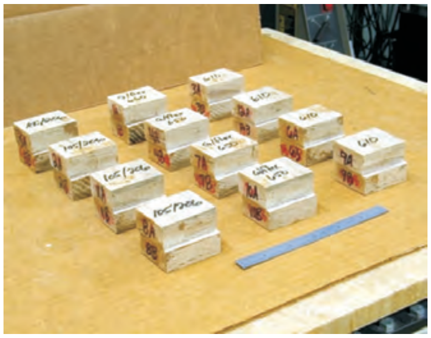
Below—The same sample after a shear failure of the adhesive.



Above—Double lap shear samples before testing.

Below—A double lap shear test in progress. The double lap shear test is more accurate than the single lap shear test.





Above—White oak, single lap sheer test specimens that have been prepared for the ASTM D905 short block shear test.

Below—The ASTM D905 test in progress. The test fixture is designed to minimize peel by presenting the sheer force on the specimen parallel to the glue joint.

Here at Gougeon Brothers we most often use the single lap shear test. This test pulls two tabs that have been overlapped by a ½" until they come apart. Because the samples are overlapped but the test machine grips are in line with one another, a slight peel is generated as the sample deflects. Although this is not pure shear, the introduction of peel makes the test more realistic in ways that will be discussed later.

Double lap shear and ASTM D905 shear testing induce a load closer to pure shear. These specimens require more time to prepare and in the case of the ASTM D905 test, require a special fixture. We use these tests to more accurately determine the shear performance of WEST SYSTEM epoxy but as mentioned earlier, single lap shear often simulates real world applications better.

Tensile Stress

Tensile stress on an adhesive is created when a load is applied perpendicular the surface. The stress generated by the load may cause an adhesion failure that is much lower than the actual tensile strength of the glue. Tensile adhesion value is not the same as tensile strength. WEST SYSTEM epoxy is formulated to have high tensile strength for applications such as creating a strong fiberglass laminate, and high tensile adhesion to common substrates for strong bonds. WEST SYSTEM G/flex® is formulated to achieve the highest adhesion values.

Tensile Stress

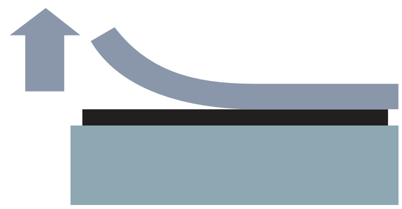
Loads that result in pure tensile adhesion in the real world are rare. When a tensile load is applied to a structure it often causes the substrate to deflect. This deflection then creates a peel stress and can dramatically lower the strength of the assembly. It is also rare to have all the components assembled in such a way that the load path is purely tensile. A slight off-axis load can induce significant peel stress.

The Pneumatic Adhesive Tension Testing Instrument, or PATTI device, uses compressed air to inflate a bladder that lifts a metal stud glued to a substrate. A gauge measures the tensile force required to break the bond.

We use a PATTI device to measure tensile adhesion. This device pulls on bonded studs perpendicular to the surface and measures the load required to pull them off.

Peel Stress

Peel stresses are the most effective way to pull a bonded assembly apart. We do this every day when we pull off masking tape or get a wedge under a corner to pry something apart. A good design will minimize the amount of peel stress to which the bond line is exposed.



Peel Stress

Peel loads concentrate all the stress in a very small area. As the two substrates start to pull apart, a very high tensile load is created at the interface. WEST SYSTEM epoxy is formulated with enough elongation to help distribute this tensile force into the rest of the bond line.

Two common tests measure peel stresses: the climbing drum peel test and the T-peel test. Both tests create a load at the end of the adherand and peel it away from the substrate. The force is measured in piw (pounds per inch width) not in psi (pounds per square inch). As discussed earlier, peel stresses are concentrated on the edge of the bond line, creating an extremely high and concentrated tensile load. The load is not distributed across the bonding area. This is why the width of the bond line is more important when measuring the stress on the overall area.

Avoiding peel loads is important when designing and when bonding parts together. Pay particular attention to loads that may want to lift the edge of the bonded part off of the substrate. Often mechanical fasteners on the perimeter can prevent a peel from starting. Peel loads can also be generated from deflection of the components. An example would be a chainplate bonded to a bulkhead below deck. It appears that all of the loads are in shear, which in many cases is a good assumption, but if the bulkhead is not stiff enough when the hull is under high loads it may “bow” out of shape. This deflection may create a peel force along the edge of the stiff metal chain plate. There are many other scenarios where deflecting components may generate peel loads.

Compression Stress

If a bond line was in pure compression there would be no need for an adhesive. In reality, West System epoxy is used as a chocking material to create a solid foundation and even support of a mechanical mounting system. In this type of application the compression strength is important as well as the resistance to creep stress. Creep failures from compression loads occur when the adhesive is permanently deformed by the constant force applied to the bond line. West System epoxy is tested for resistance to creep stress.

Compression Stress

To reduce creep issues, have enough bonding surface so that the compression stress is well under the compression strength of the epoxy, and increase the bonding surface even more if the area will be exposed to elevated temperatures.

Substrate Considerations

When bonding to wood and some composite materials, the fiber direction on the surface must be considered. With wood substrates, a stronger bond can be achieved when the loads are in the same direction as the wood fibers. If the load is perpendicular to the grain, the applied load may “roll” the wood fibers over each other at a much lower force than if the load were applied in the direction of the grain. This is also a factor with unidirectional reinforcing materials.

With metals, the Coefficient of Thermal Expansion should be considered. As temperature changes, many materials will change size and this will stress the bond line. West System epoxy is tough enough to bond dissimilar materials together. Shear loads create the most stress at the ends, so for best performance take advantage of the strength of West System by not over clamping to allow a thicker bond line.

Joint Design

A good joint design will consider the shear, tensile, compressive and peel loads that will be applied to the assembly. For the ideal assembly, remember:

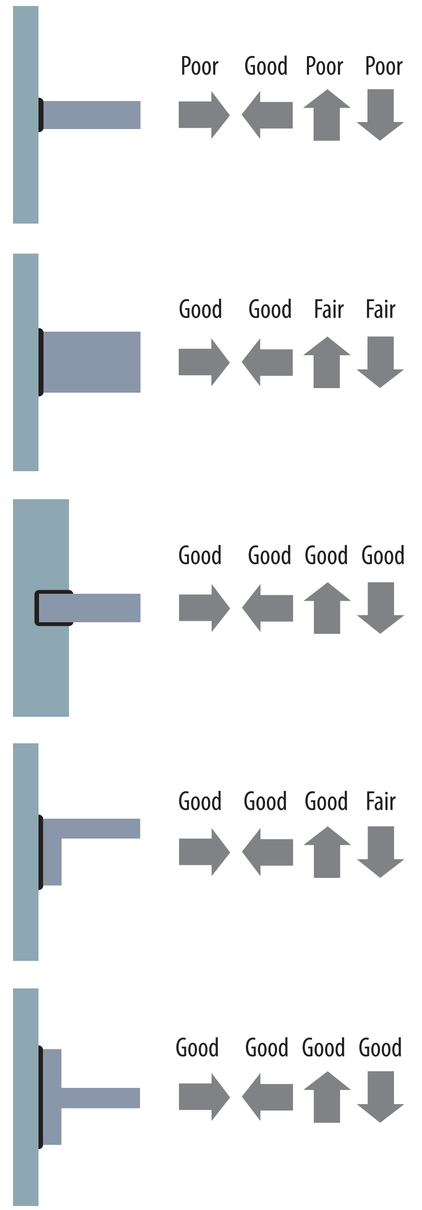
- Try to have loads in shear.
- Avoid peel. adhesives with lower stiffness and higher elongation improve peel resistance.
- Pure Tension is unlikely
- Chocking, fastener bonding and highly concentrated loads require a strong and stiff adhesive.
- Bond line thickness is driven by adhesive properties and handling characteristics.
- Maximize surface area. For peel loads, maximize width.

Adhesive Selection

When selecting a West System epoxy product for use as a bonding adhesive consider the following:

- Working Time
- Assembly Time
- Time required until clamps can be removed
- Cure time

We rarely see failures due to the strength of the epoxy. Problems are more likely to occur when the epoxy is allowed to cure too much before the parts are assembled, or the epoxy isn’t allowed cure sufficiently before a load is applied. Our customers are successful when they select a West System epoxy designated as a structural adhesive with the cure profile that best matches their process and working conditions. In addition, best practices include preparing the surface properly and achieving the appropriate bond line thickness.



Joint Styles **Failure Resistance Qualities**

When designing, building or repairing a structure that relies on bonded components for strength, please call our Technical Advisors at 866-937-8797. We would be glad to discuss your project with you. ■

Foam Strip Plank Boatbuilding

By John Lindahl

A couple of years ago my son Ian asked me about building an A Class catamaran. Having built several of these in the past and knowing what was now on the market, I came up with a build method that would:

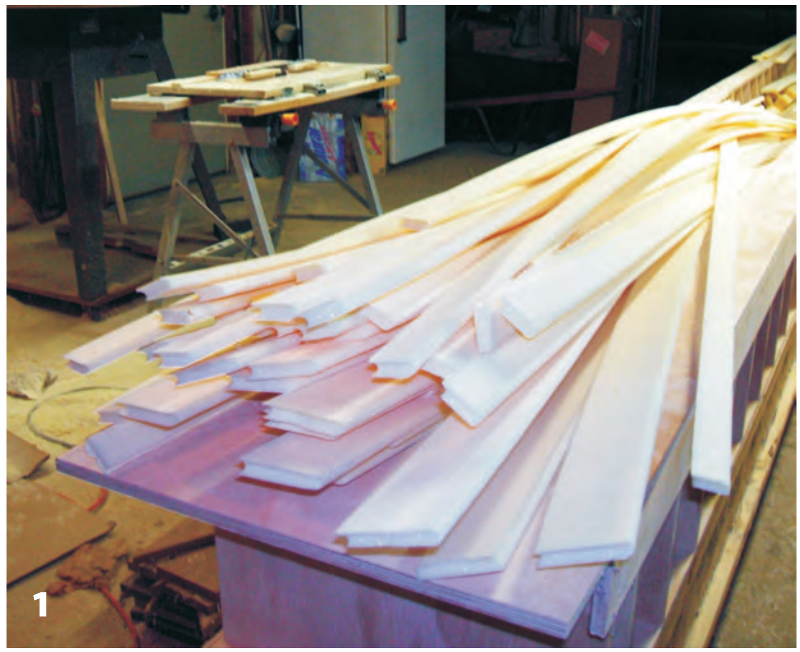
- Allow us to build a competitive design.
- Be at or under the class minimum weight of 165 lb.
- Be as strong and stiff as anything on the market.
- Be competitive in quality and price, but not get trapped in exotic equipment expense. This meant no vacuum bag, no pre-preg, no resin infusion, and no autoclave.

The basic hull build technique is the same as used in strip-plank canoe building.

This method allowed us to use an inexpensive but accurate "mold." We CNC cut a bunch of female building frames that allowed us to build a hull inside these super accurate frames. We cut a frame for every 6" of hull. I felt this many frames were necessary to keep the hull shape as accurate as possible. Only seven sheets of ½" plywood were cut to create the building frames and frame tops. The strongback was simply two 20' floor trusses. In the photos you can see I split the hull horizontally. On the next boat I will split it vertically and make the laminating process easier.

I cut the foam strips into three different widths, so hull shape would not be compromised by a too wide or too narrow strip. These strips were then bead and coved for uniform hull thickness and to ensure fairness. (We don't like to sand). A ¾"-thick foam strip was used as a centerline starter on both the deck top and hull bottom. Putting the strips in the hull frames was fun because we could see the hull take form and it only took a couple hours to "lay it up."

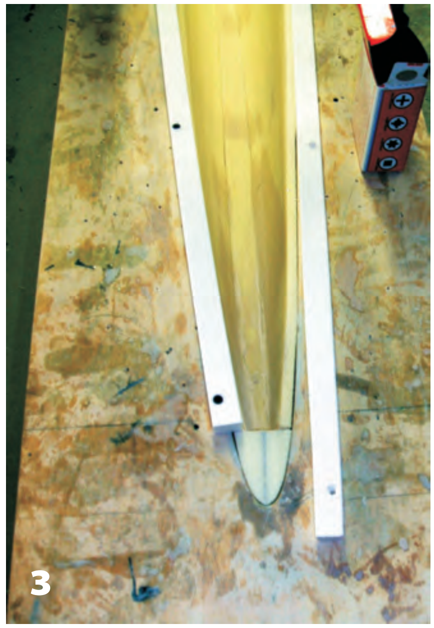
The foam shell needed to be lighted sanded and sheathed in carbon. We sanded the inside first since our frames were female. The excess foam was trimmed flush to our building jig and a shiplap add-on was installed on the deck half building jig. This allowed the inner carbon skin to extend past the join line and form a doubler at the hull joint.



1—Foam strips were cut into three different widths and were then bead and coved for uniform hull thickness and to ensure fairness.

Laminating the inside of the hull was very difficult due to working inside a narrow space, and it was hard to see what I was doing. I complicated this step by laying the carbon on the bias (45-135), which was awkward to work with, but it added hoop strength to the hull. (The outside was done 0-90 for longitudinal strength.) The best method Ian and I came up for laminating the carbon was to lightly wet out the foam, lay in the 50" wide carbon cloth and then squeegee unthickened WEST SYSTEM epoxy into the fabric.

Once we felt it was wet through, we wet it out again to ensure the fabric was laminated to the skin. After cure we could trim the join line, add bulkheads, chain plate reinforcements, and buildup the rudder gudgeon area. The shiplap add-on was now removed to leave us an inside overlap of carbon. This overlap flap made joining the halves rather easy. All it took was some thickened epoxy and a few simple clamps. We were surprised how stiff each half was since we only had the inside skinned with carbon.



2—Lindahl clamped the strips down tightly into the mold.

3—A shiplap add-on was installed on the deck half building jig to allow the inner carbon skin to extend past the join line.

4—After the carbon lay-up cured the join line was trimmed and bulkheads, chain plate reinforcements were added.

5—The hull being hollowed out to prepare for the aft beam to be glued on.

6—Tramp hooks before installation.

7—Hulls sitting in the alignment jig with the beams in their approximate positions.

After the hull halves were joined, we added the dagger board case and the transom. We embedded the tramp hooks into the ¾" thick foam strip on the centerline of the deck. Now the hull could be faired smooth on the outside. Because our foam strips had been cut in widths that corresponded to the hull curvature, the fairing process took only about eight hours per hull. Some fill was needed on a few strip joints and low spots. Carbon was then laminated to the outside of each hull. Again we paid a lot of attention to the amount of epoxy we applied, because excess is weight you don't need.

We filled the cloth weave with WEST SYSTEM epoxy thickened with 410 Microlight® filler, spreading this onto the hull with a squeegee and checking for fairness with a batten. After rolling four coats of an epoxy paint primer onto the hull, we did the final fairing. We didn't prime the areas where beams were to be attached.

All the boats I'd previously built had bolt-on beams, but this hull shape did not have much area for bolts. Instead we glued the beams on. That decision proved correct as it led to a very stiff platform. Torsional stiffness was only limited by the beams themselves, and they were more than adequate.

Rather than reinvent the wheel, we purchased carbon beams from Ben Hall and then added a carbon dolphin striker to the front beam and a traveler track attachment flat to the rear beam. Installing the beams started with a hull alignment jig that was nothing more than a couple sheets of plywood CNC cut to give the seven degree hull cant and to keep the hulls in line and at proper legal width.

With the hulls fixed in the alignment jig the beams could be locked in place. First we had to hollow out the hulls where the beams would sit. We then laid a wet piece of 5.8 oz carbon into the cutout and set the beam into it. Strips of bias cut cloth were then wrapped into the junction of hull and beam. After cure and minor fairing, unidirectional carbon was wrapped over each beam (in and out) and onto the hull. Carbon was laminated from the inside of the beam onto the hull as well.

Low-Density filler and epoxy were used to fair all four joints. A foam cap sealed the end of each beam. A final wrap of 5.8 oz then went over the whole joint.

With the beams attached, tramp hooks, gudgeons, and chain plates installed the platform could be finish-primed and sanded.

The cost of mold frames and the alignment jig was under $500. We had a male pattern CNC'd for boards and rudders, and then made glass tools for building the actual parts. The foils are an excellent shape, and we kept the board weight under three pounds each. Beams and mast came from Ben Hall. We made the spreaders, mast base/rotator, standing rigging, boom. Local suppliers were used for hardware, rudder heads and paint.

Three boats have been built this way. The first two were 3–5 lb under when weighed at the Worlds. On boat Number 3 we sunk the front beam deeper into the hull and trimmed the beam ends flush with the hull. We also did a better job fairing and used less primer. Number 3 was 15 lb under weight at the Worlds. There have been no structural issues on any boat, so we feel we have a winner. Now it will take a little time to learn how to tune it and sail it faster.

One of the neat things about this building method is that it can be used for a lot more than boatbuilding. This method provides the ability to create whatever you want at a fraction of the cost of building fiberglass molds. ■

John Lindahl has been building and racing A Class Catamarans for thirty-five years. For more info on this building method, available boats, kits and components, contact John (269-650-5900) or Ian (858-688-5450) at Lindahl Composite Design, or e-mail: jlindahl_lcd@yahoo.com.
To see more of Lindahl's work visit: www.lindahlcompositedesign.weebly.com

8—Carbon beams were purchased from Ben Hall and then a carbon dolphin striker was added to the front beam.

9, 10—After the hulls were hollowed out where the beams would sit, a wet piece of 5.8 oz carbon was laid into the cutout and the beam was set into it. Strips of bias cut cloth were then wrapped into the junction of hull and beam. After cure and minor fairing, unidirectional carbon was wrapped over each beam and onto the hull.

11—The faired catamaran upside-down on a trailer. Gluing the beams to the hulls rather than bolting them on resulted in a very stiff platform.

White Oak Redux

By Bruce Niederer and Bill Bertelsen

Building stuff, especially boats, with wood is much like a religious calling; once you hear the call, there's no turning back. Those who've heard the call will not suffer fools willingly, so when I decided to conduct some white oak adhesion and shear testing and report the results in Epoxyworks 31, skeptics and believers alike took to the internet wooden boat forums-and had no problem speaking their minds! Having healed from the pummeling I took in some quarters, I'm back again to report the promised follow-up test results.

This round of testing involved cycling the samples in our environmental huts. I moved the samples back and forth from a 100°F/90% relative humidity (RH) environment to a 100°F/15% RH environment. The samples would become essentially saturated in two to four days then dried in a similar time frame. Four sets of samples were conditioned following this pattern for one, two and three weeks and tested at the end of each week. The last sample set was cycled for a total of six weeks where for the last two weeks they spent four or five days getting wet and three or four days getting dry over 14 days. This was done to try to really torture the epoxy bonds before testing took place. The samples were cut from the same exact stock as the first round of testing and prepared such that the grain was all running in the same direction.

In addition to the bonded samples we also built a solid oak sample to test with each round of samples, and a small block to track moisture content along the way. The study again included the same three epoxy systems—G/flex® 650, Six10®, and WEST SYSTEM® 105/205 as the first round of test-

Here are two raw sample pieces showing the sawn surfaces before sanding to 80-grit.

All the surfaces to be bonded were sanded with 60-grit then 80-grit on a marble tile to ensure flatness.

This is the finished sanded surface. Before glue was applied, each surface was also wiped with an isopropyl alcohol pad.

Building four sets of samples with 15 in each set plus a control set with 9 samples required a lot of prep work.

Testimony

I work white oak,
I testify
to simple living,
which is why
my life revolves
around this tree,
the source of my
prosperity.

In any season
I know bark:
rough, shaggy, smooth,
from pale to dark.
Of quality I'm
well aware.
I choose my timber
with great care.

Each tree has its
own tale to tell.
It's my privilege
to listen well
and pass the whispered
legends on
in forms the deaf
can dwell upon.

I weave white oak,
I glorify
the use of hand and
heart and eye.
With simple tools
I sing the praise
of basketry and
mountain ways.

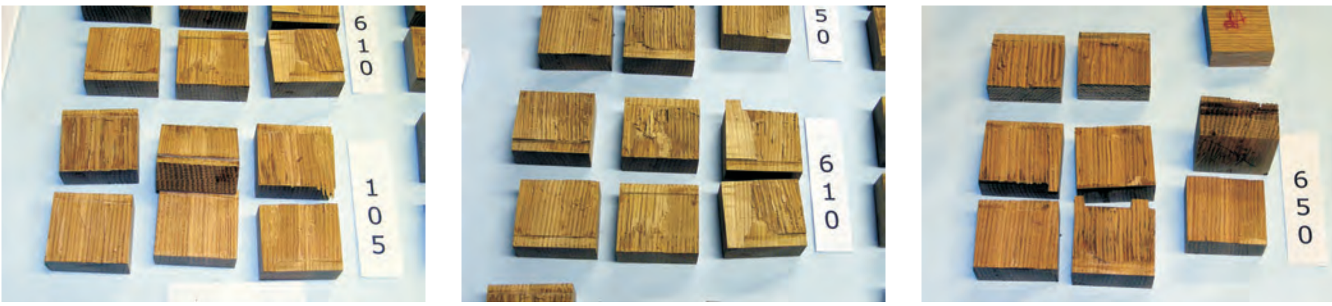
©Ms Rural
from The Basketweavers

Glue	Controls	1 Week	2 Weeks	3 Weeks	6 Weeks
650 G/Flex	1,814 (5)	1,916 (5)	1,919 (5)	1.811 (5)	1,296 (5)
Six10	1,893 (5)	1,901 (5)	1,483 (5)	1,492 (5)	1,093 (5)
105/205	1,576 (5)	1,449 (5)	1,688 (5)	1,397 (4)	729 (4)
Solid Oak	2,416 (1)	2,665 (1)	2,605 (1)	2,539 (1)	1,959 (1)
Moisture block	(-) 4.44%	(+)0.09%	(-) 1.64%	(-) 2.12%	(+)1.59%

All the values shown are in psi and represent the average of the number of samples (in parenthesis) used to calculate the data shown. The moisture values represent the moisture content when tested relative to the initial moisture content as a function of weight.

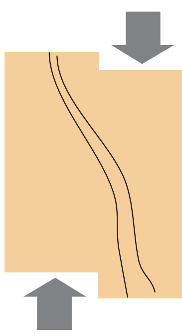
ing. The summary of the test data is shown in the table above.

Let's discuss the data. To begin with, if you refer to the first article, the values for this control set are well below what we got originally—including the solid oak data. Given that the samples for both rounds of testing were cut from the same white oak timber we can only conclude that there must be differences in grain orientation and density along the length of the timber we used. Still, regardless of the lower values, every sample failed the wood—there was no cohesive failure of the glue line.

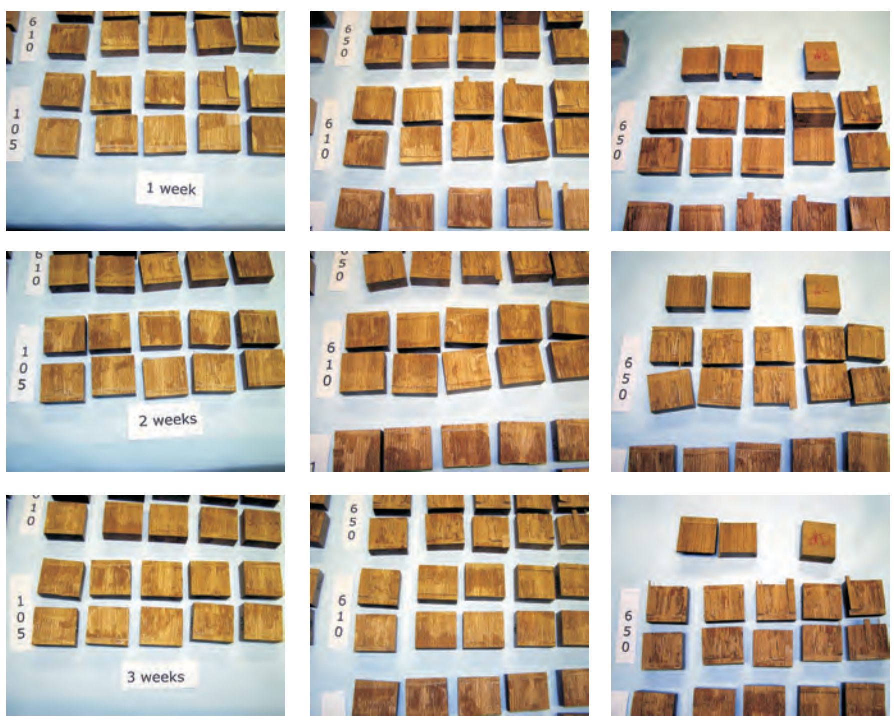


As you can see, all the samples failed 100% wood. The uppermost block in the 650 photo (right) is the solid oak. The little block with red markings is the moisture block. There is very good consistency in the average results from which we conclude that the values represent the shear strength of the oak. If that is indeed true, then why do the solid oak samples have higher values?

As shown in this ▸ diagram, each solid oak sample has grain that passed through the straight line sheer plane. This grain structure, not present in any of the glued samples, effectively increases the area of the sheer plane which results in a higher value. We couldn't reach a definitive answer as to why the first round produced larger average values, other than possible variations in density along the length of the stock the samples were taken from.



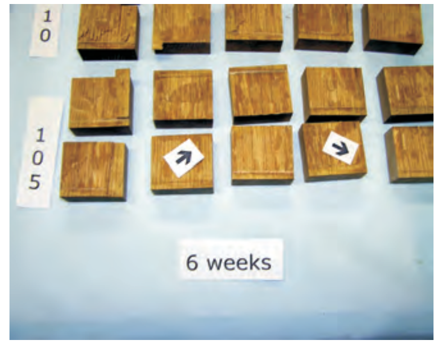
The first, second and third weeks of environmental cycling produced much the same results. Although the sheer strength values all dropped a bit, every sample again resulted in 100% wood failure as shown right.



Every sample resulted in 100% wood failure. The results of the 1st week are shown in the top row, the 2nd week in the middle row and the 3rd week in the bottom row. Samples glued with 105/205 are in the 1st column, Six10 in the 2nd column and G/flex 650 in the 3rd column.

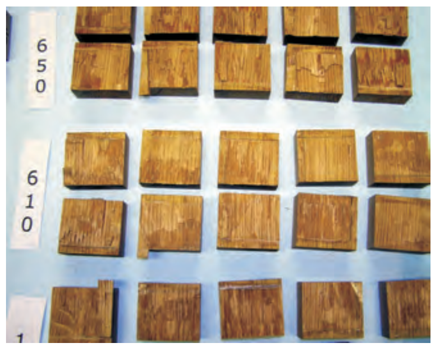
Because we hadn't seen any big changes through the first three weeks of cycling, we decided to let the last set go longer as I've already described. We wanted to really induce some stress and movement in the oak and by extension the glue joint. As the data reveals, we did see some significant changes in the shear strength values. Still, even with the lower values we still saw 100% wood failure/0% cohesive failure of any of the epoxy systems tested, and that is also quite significant. Let's look at some photos.

The arrow is pointing to some shiny epoxy found in a three-week 105/205 sample. Close examination showed that it was not a cohesive failure-both matching areas were shiny, which indicates a void. This sample was not included in the average.



The arrows are again pointing to shiny glue areas indicating a void. The area of the void was large enough on the #4 sample (l-r) that it too was excluded from the average. The effective area of the void on #2 was deemed insignificant and so it was included in the average. Interestingly, even though the average strength of this set of 105/205 samples was 729 psi, there was still no cohesive failure of the glue line.

Here we see some of the damage to the oak blocks after the sixth week. We can also get an idea of the affect grain dive can have in these samples. Do not confuse the saw marks on the ends for the grain.



No surprises here-both the Six10 and G/flex 650 failed the wood extensively after six weeks of accelerated environmental cycling. These samples gained 16% moisture each time they sat in the hot humid environment and dried to a level 2.11% below the original moisture content coming out of the dry hut. The moisture content was 1.59% above the initial room temp/ambient humidity value at testing. The original control MC block which had been dried to -4.44% for testing sat out at room temperature in our shop here in mid-Michigan for the entire six weeks and gained back 0.77% moisture during that period.

We see from the results that the average shear strength of the samples increases as the flexibility of the epoxy system increases. Tensile elongation of the systems tested are: 105/205 3.4%, Six10 7.9% , G/flex 650 32.7% and the respective flex modulus of each are 4.61 E+05, 3.51 E+05, and 1.56 E+05. A high tensile elongation and low flex modulus are good measures of flexibility in an adhesive.

We are convinced that the reason the results show us the strength trends is directly due to the adhesive's flexibility or toughness. As the wood is tortured going through the environmental cycling, the cells of the wood get damaged and a more rigid epoxy will force the failure sooner than a flexible one. Because the fibers are weakened from movement due to wet/dry cycling, the more flexible the glue system the more forgiving the effect on the wood fibers. Keep in mind I'm talking about structural adhesives-3M 5200®, for example, may have elongation of around 300% but it is not a structural adhesive and cannot be used below the water line.

In conclusion, this study has shown that white oak and epoxy construction is plenty strong and should be considered a perfectly acceptable choice in wooden boat construction. We have been recommending WEST SYSTEM epoxy in these applications for years. As with any glued structure made with wood, regardless the species, but in this case specifically white oak, the key to longevity is to keep the wood dry. In any laminated structure, like the stem pictured on the next page, keeping the wood fibers dry is of primary importance. The 105/205 test sample would have continued holding strong if not for the influence of the environmental cycling on the oak. Now that we have developed the G/flex 650 and 655, based on these results, I would recommend these products for any critical wood application that is highly stressed.

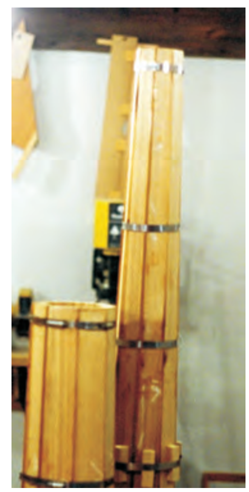
We have come to these conclusions given that we saw a drop in the strength of the solid oak sample and since we've seen only wood failure throughout the sample population.

The folks at BoothBay Harbor Shipyard conducted an in-house test program using G/flex® and white oak and based on the results built the largest stem lamination I have ever seen using any adhesive system. They were confident the G/flex system would meet or exceed their requirements for this project.

Note the number of laminations and the squeeze out on the top of the stem. ■

Construction of a Lantern Post

Having thought about constructing a nice lantern post for many years, I was inspired when I read an article in *Woodenboat Magazine* about building hollow spars with "bird's mouth" joints. Having a pile of red cedar drops from other projects I came up with the design of using two staved sections connected by a turned collar of the same material.



Left—The bird's mouth joints are visible in this end view of the post. Above—Hose clamps held the staves together while the epoxy cured. Below—Turned collars provide a base and separate upper and lower sections of the post.

I used WEST SYSTEM 105 Epoxy Resin® with 206 Slow Hardener® which allowed the time required for careful assembly. All joints were coated with unthickened epoxy allowing for absorption into the soft cedar. Epoxy mixed with 406 Colloidal Silica was used for all joints in the project. Once all work was assembled and cured a generous coat of epoxy was brushed on the entire post. Any area that had a higher absorptive rate was continually coated until full saturation was achieved. Once fully cured the surfaces were scrubbed with water and a Scotch Brite™ pad to remove any blush. Final sanding of all surfaces revealed a perfect surface for paint. A coat of oil based house primer was applied followed by two coats of solid body oil stain.

As of this writing the lantern post has weathered 12 years of southern New England weather with only one re-painting which I did this past October. While preparing the post for a new coat of paint, I found no evidence of degradation of the joints or fillets. I attribute the durability & longevity of the finish to the encapsulation of the red cedar with WEST SYSTEM epoxy. The structural integrity of the project appears that it will last for generations to come.

Donald M. Stevens, Pomfret Center, Connecticut

EPOXY BOAT REPAIR IN 3 NEAT PACKAGES

New Repair Kits

New for 2012, WEST SYSTEM® is offering three specialized boat repair kits designed with the do-it-yourselfer in mind. Each contains the right materials and instructions for making lasting repairs and retails for $29.98 at your local stocking WEST SYSTEM dealer.

105-K Fiberglass Boat Repair Kit

This kit offers the right epoxy, fiberglass and fillers to complete repairs to cracks and holes, gelcoat blisters, delaminated cored panels and more. Detailed instructions show users how to make lasting repairs.

Each Fiberglass Boat Repair Kit contains eight packets of WEST SYSTEM 105 Resin and 205 Hardener, fiberglass fabric, adhesive filler, fairing filler, glue brushes, mixing pots, a mixing stick, an application syringe, three pairs of protective gloves and illustrated instructions for completing a variety of common fiberglass repairs.

All components are contained in a sturdy, re-sealable package that can be easily stowed aboard your boat.

650-K The Aluminum Boat Repair Kit

This kit helps users permanently seal leaky seams and rivets in aluminum boats.

Each Aluminum Boat Repair Kit contains 8 oz of G/flex® epoxy, adhesive filler, application syringes, mixing pots and sticks and protective gloves. Illustrated, detailed instructions explain how to repair leaking seams and rivets in aluminum boats.

All components are contained in a sturdy, re-sealable package.

655-K Plastic Boat Repair Kit

Repair plastic canoes, kayaks and inflatables made from HDPE, LDPE, ABS, PVC or polycarbonate plastic with the contents of this kit. The Plastic Boat Repair Kit features plastic-friendly G/flex 655 epoxy, and is assembled with the do-it-yourselfer in mind.

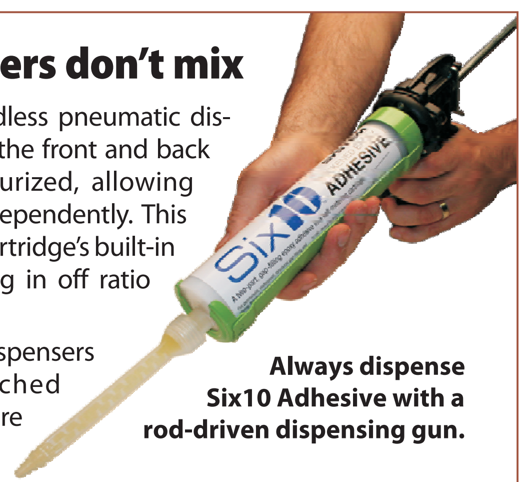
Each Plastic Boat Repair Kit contains 8.4 oz of pre-thickened G/flex epoxy, protective gloves, mixing pallets and mixing sticks. Illustrated, detailed instructions explain how to repair splits and cracks in plastic boats, attach or repair reinforcement points on inflatable boats and repair pinhole leaks in inflatables. ■

Why Six10® and rodless pneumatic dispensers don't mix

Cartridges of Six10 Thickened Epoxy should always be dispensed with "rod-driven" dispensers whether they are manual, pneumatic or electric, and never with a rodless pneumatic dispenser.

The Six10 cartridge has two chambers: one in front and one in back. Each chamber has a drive piston. In a rod-driven dispenser the drive rod pushes the cartridge's back chamber which in turn simultaneously advances the front chamber. This delivers the correct resin-to-hardener ratio. But when a rodless pneumatic dispenser is used, both the front and back chambers are pressurized, allowing them to advance independently. This overrides the Six10 cartridge's built-in ratio control, resulting in off ratio mixtures.

Rodless pneumatic dispensers often result a botched mixed ratio and failure to cure. ■



Always dispense Six10 Adhesive with a rod-driven dispensing gun.

For information about WEST SYSTEM® products or technical information for a building or repair project, Gougeon Brothers offers a range of detailed publications that can help you get started. These publications are available at your local WEST SYSTEM dealer or by contacting Gougeon Brothers. They are also available free at www.westsystem.com.

Free literature (US and Canada only)

Visit www.westsystem.info to order online or call 866-937-8797 for the WEST SYSTEM free literature pack. It includes:

002-950 ***WEST SYSTEM User Manual & Product Guide***—The primary guide to safety, handling and the basic techniques of epoxy use. Includes a complete description of all WEST SYSTEM products.

000-425 ***Other Uses–Suggestions for Household Repair***—Repairs and restoration in an architectural environment. Many useful tips for solving problems around your house and shop with epoxy.

Also included are the current price list and stocking dealer directory.

How-to publications

For sale at WEST SYSTEM dealers, from the WEST SYSTEM Info Store at www.westsystem.info, or by calling our order department, 866-937-8797.

002 ***The Gougeon Brothers on Boat Construction***—A must for anyone building a wooden boat or working with wood and WEST SYSTEM epoxy. Fully illustrated composite construction techniques, materials, lofting, safety and tools. 5th Edition, revised in 2005.*

002-970 ***Wooden Boat Restoration & Repair***—Illustrated guide to restore the structure, improve the appearance, reduce the maintenance and prolong the life of wooden boats with WEST SYSTEM epoxy. Includes dry rot repair, structural framework repair, hull and deck planking repair, and hardware installation with epoxy.*

002-550 ***Fiberglass Boat Repair & Maintenance***—Illustrated guide to repair fiberglass boats with WEST SYSTEM epoxy. Procedures for structural reinforcement, deck and hull repair, hardware installation, keel repair and teak deck installation.*

002-650 ***Gelcoat Blisters-Diagnosis, Repair & Prevention***—A guide for repairing and preventing gelcoat blisters in fiberglass boats with WEST SYSTEM epoxy.*

002-150 ***Vacuum Bagging Techniques***—Step-by-step guide to vacuum bag laminating, a technique for clamping wood, core materials and synthetic composites bonded with WEST SYSTEM epoxy.*

002-740 ***Final Fairing & Finishing***—Techniques for fairing wood, fiberglass and metal surfaces. Includes fairing tools, materials and a general guide to finish coatings.*

002-898 ***WEST SYSTEM Epoxy How-To DVD***—Basic epoxy application techniques, fiberglass boat repair and gelcoat blister repair in one DVD.

*Available as a free downloadable PDF at www.westsystem.com/ss/use-guides.

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Outdoor Sculpture Sculptor

Bill Wood has been making sculpture since high school. He has a degree in Art from Ottawa University, Ottawa, Kansas and attended the Kansas City Art Institute, Kansas City, Missouri. His work has been featured in shows from Connecticut to Key West and as far west as Topeka Kansas.

Wood tells us, "I had been using Polyester Resin and 6 oz cloth for my sculpture and was experiencing problems with cracking. The cracking appeared when I started showing my work in Florida. I believe that the high heat and humidity caused the cracking. In trying to solve these problems I learned about WEST SYSTEM® epoxy, and began using it. *A Little Less Than Meets the Eye* (*below*) was my first project using WEST SYSTEM to repair the cracking that appeared after spending a year in Winter Haven Florida's 9th Annual Florida Outdoor Sculpture Competition. A WEST SYSTEM Tech Advisor suggested I simply grind out the cracks and use the epoxy and filler, sand it, and paint. It was that easy, and after two years in two different shows the piece is crack free and will need nothing more than a coat of paint before moving on to the next show."

***High Road*—160" × 42" × 90", fiberglass and steel. *High Road* was completed last December (*top*) and is featured at The Studios of Key West Sculpture Garden from January through March. See more of Bill Wood's work at: www.billwoodsculptor.com**

***A Little Less Than Meets The Eye* —9' × 7' × 6', Fiberglass and polished aluminum. Installed at Raleigh, North Carolina, Art on City Plaza (above). Under construction (left).**

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