Construction at the Core

Story and photos by Steve C. D'Antonio

Keeping moisture out of the core is all-important

Foam-cored laminate, left, is less susceptible to damage from water intrusion than balsa, but still should be kept dry.

In part II of this two-part series on cored fiberglass construction, we take a closer look at what can go wrong and how to prevent it.

The conventional FRP and cored construction procedures described in the previous installment (*Getting to the core* Issue 146 May/June 2005) use what's called hand lay-up or open molding. That is, the laminates are laid up in an open mold and then allowed to cure.

One different approach is vacuum bagging. This process uses the same techniques described for the hand lay-up, whether it's solid or cored construction. However, after the lay-up is complete but before it cures, a heavy plastic sheet is draped over the laminated surface and sealed around the edges. A vacuum pump is then attached to a tube that pierces the sheet. The vacuum pump, when turned on, draws the air out of the laminate. Because the atmospheric pressure under the sheet is less than the ambient air pressure, force is exerted on the vacuum-bagged laminate. All of the resin is distributed throughout the glass fabric, which ensures a proper resin-to-glass ratio and the resultant strong structure.

Drawing in the resin

A variation on the vacuum-bag process is called Seemann Composites resin infusion molding process (SCRIMP). Like vacuum bagging, the patented SCRIMP technology uses reduced atmospheric pressure to aid in saturating the glass fabric. But, it takes the process one step further. SCRIMP uses a vacuum to draw the resin into the laminate, which means all the fabric and core is laid up dry in the mold. This allows the applicators to take their time in properly fitting and applying these materials.

Cores themselves are available in a variety of materials, shapes and thicknesses. There are basically two types of core material used in recreational-boat building today: wood and synthetic foam, the former being the more common of the two.

Plywood has been used as a core material; however, its use typically is limited to areas that require especially high loads (around deck hardware, spars, ports, etc). The two drawbacks of plywood are its weight and its long grain structure. The long grain means water migrates through it with relative ease and alarming speed.

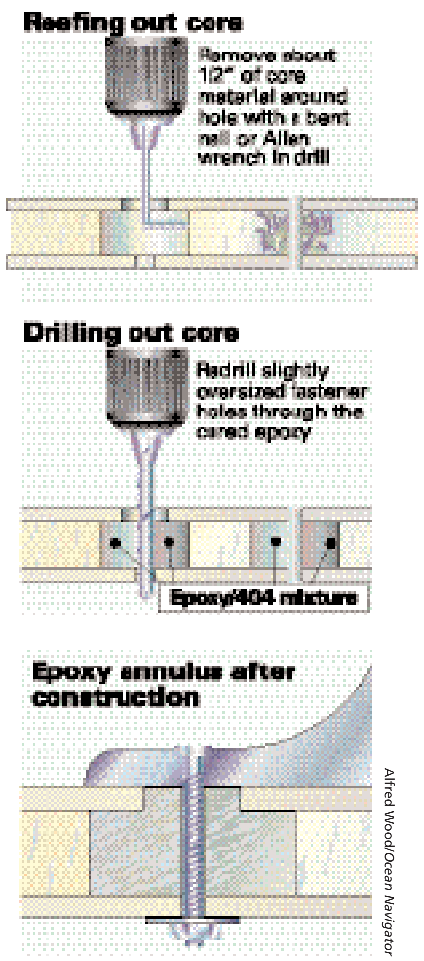
The wood core of choice

The most popular wood used as a coring material is balsa. It is among the stiffest, highest shear- and compression-strength core materials, and it is especially resistant to heat (some synthetic cores soften when heated, even by the sun). Balsa also possesses good acoustic and thermal insulating properties. Perhaps the greatest factor influencing balsa's popularity is its cost. It's less expensive than most quality synthetic core materials.

The primary drawback of balsa, though, is its tendency to absorb water and then delaminate or rot. Even though balsa core is installed as an end grain — that is, it's cut into small blocks across the grain to minimize the transmission of water — this exposed end will suck water up like a sponge.

Synthetic materials

Synthetic core materials may include a series of synthetic expanded foams, including but not limited to linear and cross-linked PVC and styrene acrylonitrile (SAN) foam. One of the



The proper method for adding hardware to cored laminate involves removing core material and injecting epoxy.

primary attributes of nearly all synthetic foams is their resistance to water absorption, some more than others. Although one hopes water will never enter a cored laminate, it certainly will in the event of major damage, collision or grounding, and may through less obvious means. Foams and honeycombs will, in theory, prevent the water from traveling very far. However, if there are kerf channels, then the core's resistance to water absorption is of little use. Unlike balsa, however, if foam (or its kerfs) does get wet, it won't rot.

Foams tend to be more flexible, allowing more movement in a sandwich panel before breaking. This means the structure built with foam will have the ability to absorb impact. Foams, when compressed, also have the ability to recover, to an extent, while balsa does not.

As mentioned, some foams soften and distort when exposed to heat. Even a light-colored deck can reach the heat distortion temperature (HDT) of some foam — particularly older formulas — when exposed to tropical sunshine. Dark hulls are particularly prone to this problem, and as such, foam cores for decks and dark hull applications must be selected carefully. This is also an issue for hulls being painted, going from a light color to a dark color, for instance. Post curing of the FRP laminate, with the potential for print-through, is likely, but will the HDT of the foam core be reached as well? This possibility should be explored for foam-cored hulls, before the paint color is selected.

Another related phenomenon of all core laminates is checkerboarding, a condition where the shape of the core blocks can be seen from the outside of a finished hull or other smooth structure. In some cases, this simply is caused by an outer skin that is too thin to prevent the telegraphing of the core blocks. In other cases, however, it may be a sign that the skin or outer laminate has not cured properly.

Avoiding core failure

Given that cored construction is so strong, so reliable and so much better than solid laminate, it's surprising that coring has such a tarnished reputation. The reason is that core has been misused and improperly installed and continues to be misunderstood both by boatbuilders (to a lesser extent now than in the past) and boat owners (possibly to a greater extent now).

There are several modes of core laminate failure, the primary of which, in terms of frequency of occurrence, is water ingress or contamination. Core strength relies on a solid, permanent bond between the surface of the core and the inner and outer skins. Once water penetrates this hallowed region, the bond can and almost certainly will be compromised. This may be plainly understood in the case of balsa core, with the scenario going something like this: water enters the core; the ambient temperature is above 60° F (the warmer the better for mold spores to propagate); rot sets in, and the result is bond failure after the wood turns to mush. So how does this occur for foam core if it doesn't rot?

This process is a bit more complex. The water enters the core, particularly where there are unfilled kerfs; the weather gets cold, subfreezing; the water freezes and expands, and voilà, the core is no longer attached to the FRP skin. The process continues; a bigger void now holds more water; it freezes again; the void expands more, and so on. The freezing process occurs in both balsa and foam core laminates, while rot only affects balsa.

Sealed from the elements

As long as the cored chamber remains sealed from the elements, it cannot suffer from water-induced core damage. Drill even the smallest hole into a cored laminate, however, and you've compromised the sacred union between a core material and its FRP skins. The telltale sign that water has entered a balsa core is brown, coffee-colored stains emanating from hardware and fastener locations. Interestingly, the area where the brown stains are making their appearance may *not* be where the water is entering. Water's ability to migrate within a cored laminate is nothing short of remarkable. I've seen it travel 20 feet or more, entering at a mast partner and exiting through a light fixture over the galley stove.

The good news is that the most common core failure — that of water penetration — is also the easiest to prevent. Never, never drill or cut into a cored laminate unless you are prepared to reef out and backfill the exposed core with epoxy. Bedding sealants and adhesives are not sufficient for this task, water will eventually leak past them and into the core.

For responsible production-boat builders, hardware installation is dealt with by laminating solid glass or high-density cores into the laminate.

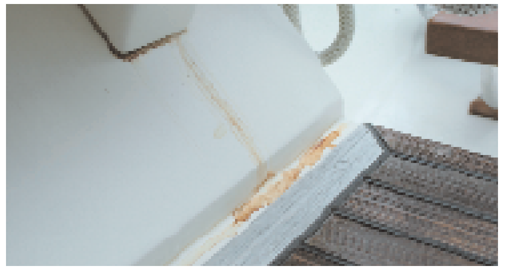
Once water has entered the core, it's difficult and expensive to repair.

Plywood inserts

Some builders use plywood as a high-density core insert for hardware installations. While this certainly is better than ordinary core (provided it's the right grade and sealed in resin), plywood is still susceptible to water saturation and, because of its long-grain orientation, the water will travel quickly throughout the ply, bringing with it all the attendant problems of core saturation. Under heavy loads, plywood also compresses, particularly if wet.

Aftermarket hardware installations require a different tack.

For below-the-waterline cored laminates, high-density inserts usually are insufficient, with a few exceptions, to ensure a strong, water-free laminate. In these cases, ideally the inner and outer FRP skins will be brought together, eliminating the core. More laminate is laid up in this area, to a thickness nearly equaling the cored hull's dimensions.



Tea-like stains are a tell-tale sign of rotting balsa core.

The other common failure mode for cored laminates involves delamination. This scenario, when not induced by water penetration, can nearly always be traced back to poor or improper boatbuilding practices when the vessel was constructed. These causes include poor adhesion of the core to outer skin as a result of FRP skin contamination; failure to prime the core, leading to resin absorption and a "dry" laminate; insufficient resin or bonding material; or poor surface preparation and the voids it causes. If water is not present in a delaminated surface, it can sometimes be repaired by injecting epoxy and then weighting the structure or installing temporary fasteners to hold the skin to the core. After the epoxy has cured, the fasteners are removed, and the holes are filled with epoxy.

Proven reliable

Cored FRP construction is a proven reliable method of fiberglass composite construction that offers many advantages over solid laminates. The blemished reputation core has earned over the years is mainly a result of improper use or installation.

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