Proper core installation






ALCAN COMPOSITES CORE MATERIALS
2009






1. Useful hints for proper core installation

Balsa and foam cores have been used in the composites industry for over 50 years. The marine industry, specifically, was the first to pioneer the use of cored sandwich construction to achieve lighter weights, greater stiffness, and improved performance. However, over that 50 year period a lot of painful lessons were learned about the proper lamination of core. Poorly installed core can allow water to enter the laminate which can result in a saturated core as well as reduced laminate strength and durability. Indeed, the vast majority of cases of reported problems with sandwich laminates in the field can be traced to what can now be defined as poor core installation. It is difficult to fault anyone for that situation in the past, since in a lot of respects, back then we were all learning on the job, and inventing a whole new industry. However, we as an industry have learned from those early mistakes. But we need to implement those lessons in practice.

In order to avoid future problems, and benefit from the lessons so painfully learned and relearned over the past several decades it is important to list the characteristics that define “Proper Core Installation”. These characteristics are universal and apply equally to foam cores and balsa cores. The four primary requirements are:

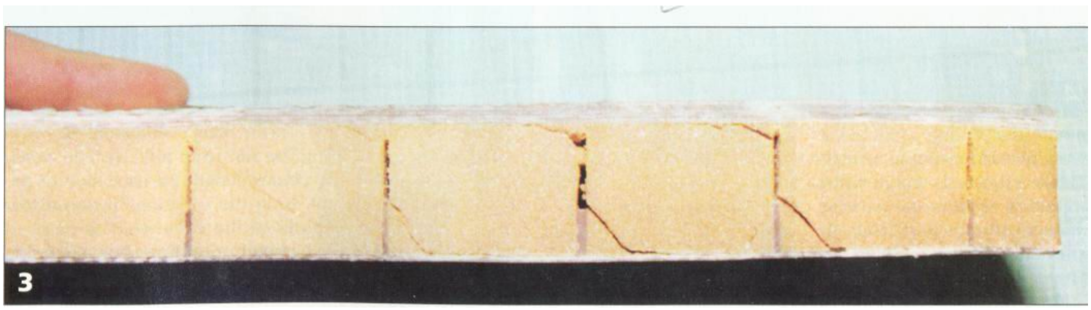
1.1. Avoid “Never Bonds”

Never Bond is a term originally defined by Bruce Pfund. Never Bonds, which generally occur in hand lay-up laminates, are areas under the core that were never bonded in the first place. These areas are often diagnosed by the surveyor after the fact as a delamination, or a failure in service. However, further investigation almost always determines that the core never made contact with its bedding layer during construction. As described above, Never Bonds can be detected by proper “sounding” of the core after installation, and corrected before the closing layer of glass is applied. However, if left in the laminate they can blister badly when exposed to the heat of the sun and will collect water, especially if combined with an unfilled kerf system.

Never bonds can almost always be avoided by vacuum bagging the core into either a resin rich bedding layer, or preferably into a core bond adhesive, along with proper quality control. The use of Vacuum infusion will also eliminate Never Bonds.

1.2. Fill the Kerfs

Kerfs, both saw cut and knife cut, are required in order to convert what is originally a rigid inflexible sheet of core to a contourable material that will adapt itself to the compound curvatures found in boat decks and hulls. However, an unfilled kerf system can reduce the strength of a laminate, as well as act as a conduit to transmit water throughout the laminate. No other factor will cause a yacht to fail its survey as much as an elevated moisture reading in a cored laminate. This elevated moisture reading is inevitably caused by water in the kerf system of the core. Often the point of ingress for the water can be determined by “mapping” the area of high moisture readings, which will inevitably lead to a cut out which has exposed the core. Water migration through a cored laminate requires an open kerf system.



Filling the kerf system means that any water that enters through a puncture of the skin will be isolated to the point of puncture. An open kerf system, on the other hand, will allow any water from that puncture to migrate through the laminate. Therefore to improve the strength of the laminate and to prevent migration of water – Fill The Kerf System.

To fill the kerf system the absolute minimum requirement is to “prime” or back wet the core with catalyzed resin before the core is installed into the bedding layer of mat or the core bond adhesive. When priming, it is desirable to place the core on a curved surface to open the kerfs and roll the resin on with a short nap roller to force the free resin into the open kerf system. This is easier to achieve with knife cut kerfs. If the core contains saw cut kerfs, the best way to assure the filling of the kerf system is to bed the core into a special adhesive putty. The use of a vacuum bag for core installation in conjunction with priming and, if necessary, core adhesive putty, is also highly recommended. Closed mold processes such as Vacuum Infusion is a sure way to guarantee the filling of all kerfs and the elimination of all voids. The use of rigid sheets with perfs, or thermoforming the core to shape, also solves the problem of unfilled kerfs by eliminating the kerfs themselves.

1.3. Fillet all Core Edges

Any transition from a sandwich to a single skin laminate must have a fillet on the edge of the core to ease the transition of the laminate skins. Fabrics cannot be forced into sharp corners. The skins will not be able to take the two 90 degree turns involved along the edge of the core as the inside skin laminate leaves the core to join the outside skin, and a continuous air bubble will be created. Not only does this introduce a structural weakness, but this continuous line bubble will allow water to travel along the full length of the core. When combined with unfilled kerf systems, it does not take much imagination to see this leading to the complete saturation of the cored laminate with water.

Proper fillets can be created by using and installing fillet strips, by grinding (beveling) the edge of the core after installation, by using core kits which already have the fillet cut into the edge of the core, or by using core adhesive putty to create the fillet.

1.4. Segregate the Core from all Openings

It stands to reason that any opening cut into or through the core can and will be a potential source of exposure to water. If the kerf system is unfilled and open, this water is virtually guaranteed to migrate through the laminate. It is imperative that no openings be cut through the core to expose the core edge to potential contact with water. This applies to all core materials, foam and balsa. This is especially critical with fittings mounted on the hull bottom. However, it is also important for all openings cut through the laminate including vents and ports in hull sides, hatches and ports on the deck, deck fills, rod holders, etc, etc. Nowhere should a cut out or a hole in the laminate expose the core.

Segregating the core can be achieved in a number of different ways. The core can be phased out by the use of fillets and the opening cut or drilled through built up single skin laminate. A solid high density insert can be introduced into the laminate, replacing the core in the area where the hole or opening is to be cut. Alternatively, the exposed edges of core can be routed back away from the opening and the resulting void between the two skins “potted” with thickened resin (usually epoxy). Merely using caulk or sealing compound to close out exposed core is not recommended, and will ultimately lead to water contacting the core over time.

Plywood is sometimes used as the “high density” insert in way of a cut-out, but plywood will allow migration of water along the grain structure, and will swell in thickness if it gets wet, potentially cracking the laminate. Use of plywood in a laminate should be avoided.

2. When Things Go Wrong – Wet Core

2.1. How Cores Get Wet

Cores get wet when the core itself is exposed to a source of water. Cores do not get wet by water migrating through the laminate into the core. During the blistering “crisis of the ‘80s there was a line of thought that if water vapor can migrate through the gelcoat to form blisters, then that vapor would eventually find it’s way to the core, especially balsa core. A 14 year water immersion study conducted by Alcan Baltek Corp put that theory to rest when typical cored laminates were immersed in water, some samples exposed on both sides, and the moisture level monitored each year. At the end of 14 years the laminates were stripped of their skins and the cores weighed and then dried, and weighed again to determine the level of moisture. In every case, no significant increase in the moisture level of the cores was detected. Cores only get wet if the edge of the core is exposed to water, and there is a means for that water to migrate through the core. That is why it is so important to isolate all core from openings through the laminate, and to fill all kerf systems to prevent the transmission of moisture.

2.2. Water Migration within the Laminate

If water does contact the core through a fracture of the outside skin or a puncture of the inside skin, it is important that that water not progress beyond that point. The best way to achieve that is to fill the kerf system with resin or putty. A significant study on water propagation through the kerf system was conducted by Alcan Baltek where curved hand laid foam and balsa cored laminates with open kerfs were punctured with a 2" diameter hole and immersed in water for almost a year. Identical panels were vacuum infused with filled kerfs and exposed in exactly the same manner for the same length of time as the hand laid panels. Both the foam core and the

balsa core hand laid samples with the open kerf systems absorbed considerable amount of water within the laminate, with the balsa continuing to absorb more water over time. However, the infused balsa and foam cores with filled kerfs both absorbed substantially less water (5% by weight) with the infused balsa and foam behaving almost identically. Filling the kerf systems is essential to prevent water migration and absorption by the core. Vacuum Infusion is the best way to achieve this.

2.3. Properties of Wet Balsa

We saw above, if water is allowed to permeate a balsa cored laminate with open kerfs, the balsa will absorb moisture. Various studies, conducted by Lloyds Register, TPI Composites, Sea Ray and Alcan Baltek, have all shown that balsa will readily transmit moisture in the direction of the grain, but substantially more slowly across the grain. Indeed, once the moisture enters the balsa across the grain it pretty well bogs down at about ½" into the core and doesn't go much further. The rapid water migration in the direction of the grain in end-grain balsa means that it will migrate only from one skin to the other, and no further. However, when you are dealing with a 1" x 2" module in a CK configuration, a ½" migration across the grain from water surrounding a module has the potential to saturate that module. Therefore, the question then becomes, what happens to the properties of balsa core as the moisture level increases to up to 100% by weight?

The results of that study indicate that the properties of wet balsa core are directly related to the Fiber Saturation Point. All woods have a certain amount of moisture present. Indeed, the published properties of balsa are determined at a standard moisture content of about 10 to 12%. If exposed to excess moisture, the moisture level of the balsa can increase to the Fiber Saturation Point, where the structure of the wood cannot retain any more water vapor. This is about 28% by weight. Any additional moisture is no longer absorbed by the structure of the wood and is precipitated out as liquid water in the open cells. Incidentally, that's why all moisture meters will "pin" at about 30% moisture level when reading the moisture level of balsa. Therefore, it's intuitively obvious that if the physical properties of balsa are influenced by the moisture content in the structure of the wood, that those properties would "plateau" at the fiber saturation point, because at this point the wood is stable (saturated) and will not absorb more moisture. And that is what is confirmed in the testing. All properties reduce as moisture levels increase from 12% to about 30%, but then stay relatively constant as moisture levels increase beyond this. The good news here is that this reduction in properties is predictable, and the all important Shear Strength and Compression Strength reduce by a predictable 20%. Considering that balsa has shear and compression strengths that are substantially higher than the "equivalent" foam core, this 20% reduction in properties is not enough to immediately condemn the boat, or even justifying stripping and replacing the skins and core. Wet balsa core is not a good situation, and should by all means be avoided by the core installation techniques described in detail above. However, if wet balsa is detected, we now know that it has defined physical properties, and the laminate safety factors should be recalculated based on those reduced and defined properties. Stripping the outside skin and replacing the core, if the moisture is extensive, may cause more harm than good. This is especially true for foam cores, where the moisture can often be sucked out of the kerfs, and the presence of moisture has no adverse effects on the physical properties of the core. High moisture levels are a concern, but careful consideration should be given to the best method of addressing it.

2.4. Conditions required for Decay

Wet balsa will decay if it is exposed to oxygen. That's why if there is decay, it is always located at the point of water ingress to the core, because that's also where it's exposed to air. The three requirements for decay are:

- Moisture level at 20% or higher
- Presence of Oxygen
- Temperature range between 50 and 95 degrees F

This explains why you can often have exposed balsa in a deck cut out in a 39 year old boat, as I have, and not have any decay, because the balsa has a chance to dry out if it gets wet. However, I also had decayed balsa in the same deck at a cutout that was improperly sealed that allowed water to stay in contact with the core and not dry out, resulting in decayed core. If you find wet balsa, it's very important to trace the moisture to its point of ingress, and seal the access point, sealing off both the source of water and the source of air. Then you can address what you want to do with the wet, but un-decayed core, Decayed core should always be removed and replaced. Wet, but un-decayed core is a more difficult call.

2.5. Freeze Thaw Cycles

There is a persistent opinion in the marine industry that wet core can freeze, and a number of freeze/thaw cycles will lead to delaminations. Indeed, surveyors will often attribute water filled delaminations to the effects of freeze/thaw cycles.

However, independent researchers have found that if you deliberately create a water filled void in a laminate and subject it to numerous freeze/thaw cycles, it will not increase the size of the existing void. Studies conducted by Rick Strand of Impact Matrix Systems and presented in Professional Boatbuilder

magazine, where deliberate Never Bonds where filled with water and repeatably froze and thawed, showed no measurable increase in the size or extent of the void. In a similar manner, tests conducted by Alcan Baltek Technical Service showed that when open kerf systems in both foam and balsa cores are filled with water and then repeatable froze and thawed, no delaminations of the skin from the core was evident. Again, water in the core is not desirable, and should be avoided at all cost, but there is no evidence that the freezing and thawing of this water leads to any skin to core delaminations.

3. Repair Methods

As discussed above, when high moisture levels are discovered in cored laminates, a lot more consideration must be given before a plan of action is determined. The first step in a balsa cored boat is to determine the true moisture level in the core with a pin type moisture meter, which, as we discussed above, will "top out" at 30%. If the reading is in this range, then a plug should be taken, sealed in plastic, and sent to a knowledgeable lab to determine the true moisture level. The extent and source of the moisture is then determined by "mapping" the area of elevated moisture in the hull and deck, and looking for signs of decay, then sealing the source of water and oxygen. Once the extent and amount of the moisture is defined, then the best solution can be determined in consultation with the owner, the yard, the boat manufacturer, the core supplier, and if necessary an independent Naval Architect who can determine the safety factor of the compromised laminate. As discussed above, doing nothing at all may in fact be the least disruptive, and best option.