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# CARBON CORE

HONEYCOMB ENGINEERING

# FOREWORD

Carbon-Core Corp. was founded in 2013 by Jack Lugus.  After serving as a marketing director and NE sales manager for Carbon-Core Corp. and 3M Structural Composites for 13 years, with a career in core materials business that spans almost 20 years in various executive positions, I  decided create a new company that focuses on innovative new technologies and best and most complete core materials selection in the industry. We have continuously challenged the traditional thought in core materials, and, succeeded, judging by the number of industry awards bestowed upon products incorporating our core materials technology. It is possible to obtain high strength, low weight, cost effective core materials; it is also possible to obtain simultaneously high impact resistance, virtually zero water absorption, high dimensional thermal stability, sound and thermal insulation... not surprisingly the competition never wanted you to know it. It gives us the greatest pleasure to present CarbonCore Portfolio of Core Materials, and other associated products and services offered by Carbon-Core Corporation.

We offer nearly all types of core materials for sale: plastic honeycomb, PU/PIR Foam, PVC Foam, PE Foam, PET Foam, Fiber Reinforced Foam Board, Structural Foam-Filled Honeycomb that offers the best weight to mechanical properties ratio in the industry. We are not partial to recommending you the only core material we manufacture. In a complex composite structure, often multiple different technologies are needed and Carbon-Core Corp. is an unbiased, expert partner.

It has taken plastic honeycomb technology over 25 years to become a reality - from initial and isolated laboratory prototypes to a reality of mass produced parts & structures, serving customers globally. CarbonCore Plastic Honeycomb technology is in more areas everywhere, at the core; from the hulls of mega-yachts in the Mediterranean Sea and passenger ferries in China, to snowboards on the slopes of the French Alps; from commercial housing projects in British Columbia and Telecommunication Shelters in Florida, to Public Transit Buses in California, from mobile generator container made in South Africa for the movie industry worldwide to boats in Brazil. we are proud to say, we have made it all possible.

We are confident that our extensive experience will lend itself to any application under consideration. Unlike other catalogues that list the full range of products available from a company beyond which nothing more can be had, ours is a starting point. Our complete product list is limited only by available materials and current technology. With your imagination, your product requirements, and our experience we can create new products with benefits answering your needs.

Thank you again. We are looking forward to working with you very soon.

Sincerely,

Jack Lugus

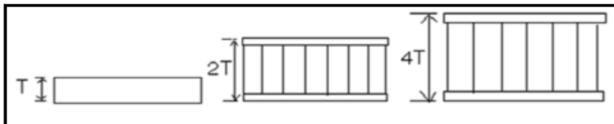
# What is DYNAMIC IMPACT RESISTANCE TECHNOLOGY?

Polypropylene is a thermoplastic polymer with visco-elastic properties. Bee-developed honeycomb in hexagonal form is one of the most efficient structures found in nature. Using complex processing techniques, a proprietary co-polymer compound of polypropylene can be formed into honeycomb panel stock, resulting in a structure with exceptional specific rigidity (stiffness to weight) and energy absorption, while incorporating the material benefits of visco-elasticity. Composite sandwich panel constructions using CarbonCore Plastic Honeycomb are the realization of this **DYNAMIC IMPACT RESISTANCE TECHNOLOGY**.

Honeycombs can be constructed with many different materials. The most common method of fabrication is adhesive bonding flat sheets of material with offset lines of adhesive, and subsequently expanding them to open the cells. This technique is commonly used to used fabricate honeycomb from paper or aluminum products. By contrast, honeycombs may be constructed from thermoplastic materials by extruding profiles through a die and then joining them by thermal fusion to form large blocks, which eliminates the need for adhesives. Regardless of the method used, sheet stock can be cut from the large blocks of honeycomb in the same fashion as foam or end-grain balsa. However, the sheet stock cut from the extruded profiles will possess mechanical properties in the longitudinal and transverse directions of the core that differ from the properties of adhesively bonded and expanded honeycombs. Extruded honeycombs, such as CarbonCore Plastic Honeycomb, have equal properties in either axis.

Although the use of sandwich construction in marine applications often has been the subject of debate, the problems that stimulate the debates are typically traceable to early boat designs that employed inadequate building methods or specified the wrong core material for the engineered load. These isolated incidents, however, are not the norm. The great majority of sandwich constructed boats have performed well over the years.

Why is honeycomb sandwich panel construction used? The primary reason is to maximize the mechanical efficiency of structures to save weight and raw materials. Sandwich panels mimic the characteristics of an I-beam, using flanges to support tensile and compression loads, with a shear web joining the flanges. Composite skins constitute the flange portions of the I-beam. Instead of using narrow webs, as is done on the centerline of an I-beam, low-density core materials are used throughout the space between two skins. The schematic below demonstrates the effectiveness of a honeycomb panel (Al) compared to a solid aluminum sheet in 1/4-inch thickness. By using a core material to double the thickness, the flexural stiffness is increased seven (7) times at almost the same weight! The mechanical efficiency of this cored sandwich can be dramatically increased by increasing core THICKNESS. Core materials have one or more intrinsic properties that are advantageous for specific applications, and these properties must be carefully considered when designing composite structures. Just as composite laminates have specific properties determined by the selected reinforcements and matrix resins, sandwich panels take on many additional characteristics that are uniquely determined by the selected core material. Distinguishing materials by their respective limitations, including strain-to-failure, is as important for core as it is for fibers and resins. Elasticity has been an essential issue in the debate concerning the risks of introducing brittle fibers like carbon, or opting for the damage tolerance provided by aramid fibers, such as Kevlar. When it comes to core material, it is also helpful to compare characteristics in relation to elasticity and damage tolerance. Of the commonly used core materials, balsa and aluminum honeycomb are among the least elastic. Polymeric foams demonstrate a wide range of properties, depending on their specific formulations and densities. In general, thermoset polymers are less elastic than thermoplastics. Urethane-based foams are thermoset, and are the least elastic of the polymeric foams. PVC foams demonstrate a wide range of elasticity, from blended "cross-linked" foams to "linear" foams. Of the foam types commonly used, SAN (Styrene-Acrylo Nitrile) Foams are the most forgiving, but cost is at a premium. It also is common in foams for the temperature resistance to decrease when their elasticity is increased.




| | | | |
|---|---|---|---|
| Relative Stiffness | 1 | 7 | 37 |
| Weight psf | 0.910 | 0.978 | 0.994 |

This is **DYNAMIC IMPACT RESISTANCE TECHNOLOGY**. This is CarbonCore. By comparison, CarbonCore thermoplastic honeycombs (or **DYNAMIC IMPACT RESISTANCE TECHNOLOGY**) have elasticity in the 200 percent range! In real-life terms, the better the elasticity, the greater the IMPACT STRENGTH and derived TOUGHNESS.

Or, in reverse comparison, the stiffer the core material, the better it transfers impact and vibration energy from the side of the impact (or outside skin) to the inside skin, thus subjecting the inside skin to face buckling, delamination or catastrophic failure.

The basic design criterion for **DYNAMIC IMPACT RESISTANCE TECHNOLOGY**is damage tolerance - a measure of the panel's retention of its structural properties after damage compared with its undamaged properties. It is considered desirable for core to deform elastically yet remain intact with the facings. This enables a panel to support a considerable percentage of its designed dynamic loads, despite the damage. In theory, this property can be advantageous when parts are designed to be "underbuilt," that is, they have the damage tolerance calculated into the part itself, thus saving weight and cost. Another important design aspect of **DYNAMIC IMPACT RESISTANCE TECHNOLOGY**is its ability to dampen sound and aid in quieting the structure. One must not confuse the two acoustical phenomena: sound transmission loss and sound absorption. Sound transmission loss relates to the use of sandwich panel as a sound barrier, in which case elastic honeycomb core is not very effective in higher frequencies, although it is extremely effective in lower frequencies. (In the 125 to 150 Hz range of structure -borne vibrations.) Another great plus for all honeycomb sandwiches is great fatigue resistance and toughness. By nature of its design, a honeycomb's cells form thousands of small webs inside the panel, which means that failure of a web (or even a series of webs) does not inevitably lead to catastrophic failure of the whole panel.

The criteria for sound transmission loss is high weight and low flexural stiffness (just the opposite of DYNAMIC IMPACT RESISTANCE TECHNOLOGY), which is why lead is an effective sound barrier. The visco-elastic nature of the plastic honeycomb technology effectively cancels out the sound and vibration energy in a given frequency range. It also is aided by the shape of the honeycomb cell, where sound waves bounce from cell wall to cell wall and get further absorbed by the visco-elastic nature of the plastic.

It should be understood that not all thermoplastics are viscoelastic. Polypropylene, which is used in Carbon-Core Plastic Honeycomb, is visco-elastic and gives its unique properties of impact resistance, resilience and sound damping. The hexagonal cell form provides the compressive strength that separates the two skins to maintain panel stiffness. Impact loads are dissipated by the elastic and damped response of the core under the skin - a controlled deflection with recovery. This equates to the spring-and-shock-absorber system used in automotive suspension. Without the damping component, the structure would respond like a spring and have resonance. Damping indicates an energy conversion, or hysteresis. The "Law of the Conservation of Energy" states that energy cannot be created or destroyed; however, you can convert the energy to another form. In this case the kinetic energy of the impact is converted into small amounts of heat as the viscous nature of the polypropylene provides resistance to deflection, as well as to recovery. The damped resilience permits the use of lower safety factors in designing structures because they are less prone to catastrophic failure. Other core materials, such as balsa and rigid foams, will be initially stiffer, stiff enough to tempt a designer to use thinner laminates. While they may be more rigid, that very rigidity makes them prone to catastrophic failure under impact because there is no damping or shock absorption. Failure modes in balsa-cored panels include contra-coup de-lamination where a plug of end-grain balsa is dislodged under the impact point, which pushes the opposite skin from the core. Rigid foams will demonstrate different failure modes, such as diagonal core ruptures or delaminations starting in the zone under the point of impact, where the core is crushed but the skin recovers. These are all forms of brittle failure. Since balsa- and rigid foam-cored sandwiches are very resonant, they have, in some cases, demonstrated catastrophic failure when subjected to operating conditions at their natural harmonic.

Sandwich core structures made with thin, high-strength skins and polypropylene honeycomb core also demonstrate the desirable acoustic property of "constrained layer damping." All materials have a "natural harmonic" or a frequency at which they will sympathetically vibrate. Polypropylene's "natural harmonic" is at a very low frequency of 125 to 150 Hz. The normal "problem hearing range" is 1,000 to 3,000 Hz. Therefore, the material's natural harmonic is far below the "problem hearing range."

The nature of sound is that the lower the frequency, the greater amount of energy is required for the sound to be heard. To quantify the difference, the amount of energy required for a 50-Hz noise to be noticed is 1 million times that required for a 3000-Hz noise. This constrained layer damping serves to limit the conduction of structure-borne sound in applications such as bulkheads, decks and stringer systems in boats, automobile load floors, sound enclosures and speaker cabinets, etc.

To prevent conduction of sound from one side to the other in most single-wall applications, either the wall has to have a lot of mass or substantial absorbers need to be added on the surface. (Sound transmission straight through a wall is referred to as "airborne" sound, even when a wall separates, for example, two rooms otherwise completely sealed off from one another.) Bulkheads designed with CarbonCore Plastic Honeycomb successfully reduce the sound transmission through damping, where other, heavier construction materials may resonate sympathetically and pass the sound on to the other side. By thermo-fusing polyester based scrim cloth with polypropylene-based barrier film underlayment, CarbonCore Plastic Honeycomb provides a 100 percent bonding surface compatible with most resin systems. The dead air space inside the cells provides insulation (an R factor of 3.3 per inch of thickness) not unlike the double-pane windows in a modern dwelling. While most cores excel in providing one or two desirable properties, **only CarbonCore DYNAMIC IMPACT RESISTANCE TECHNOLOGY is designed to provide all of them - insulation, stiffness, chemical resistance, toughness and light weight -with the added bonus of sound absorption.**

**HONEYCOMB SUMMARY**

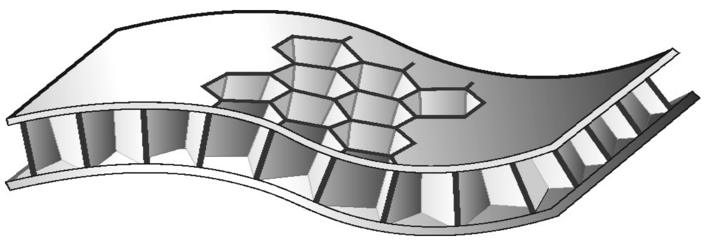
In short, many claims and counter-claims may be made about which product has the best properties for a given application. The structural properties that you actually achieve are very dependent on the manufacturing process. You must design structures with physical properties based on real values that the shop can consistently produce. With elongation exceeding that of any other type of core material, CarbonCore Plastic Honeycomb is the toughest, most resilient core available. Under stresses beyond its design loads it deforms and stretches; however, it remains intact and, unlike with foams, stress cracks do not travel, but remain localized for easy repair. Polypropylene honeycombs remain a viable core of choice for superstructures, floors, bulkheads, stringers and hull sides as well as numerous small composite parts and structures.

It is difficult to compare core materials using only the mechanical data. As noted previously, many other properties must be considered to properly evaluate the overall situation. While some core materials have certain properties that are exemplary, one shouldn't look at these isolated properties without taking into account other aspects, including cost. While most cores provide one or two desirable properties, only CarbonCore **DYNAMIC IMPACT RESISTANCE TECHNOLOGY** is designed to provide them all - insulation, stiffness, chemical resistance, toughness and light weight and sound absorption

Fully considered, nothing available provides the cost/performance benefits of **DYNAMIC IMPACT RESISTANCE TECHNOLOGY** from CarbonCore.

# WHY SANDWICH CONSTRUCTION?

Sandwich construction has been well established in the composites industry for well over 40 years. Naval designers specify sandwich construction for much the same reason architects use I-BEAMS and trusses: to increase stiffness and strength while at the same time decrease weight. The honeycomb core in a sandwich laminate acts much the same as the web in the I-BEAM by connecting the load bearing skins. The increase in stiffness is directly related to the height of the web (or thickness of the core).



CarbonCore doesn't just look good on the lab charts, it stands up to the tests of the real world. The wonderful thing about laboratories is that highly skilled technicians can control the results, but out on the water, bumps and grinds are accidental. Building with CarbonCore Plastic Honeycomb assures you that your boat is built with material ready to handle all kinds of stresses.

**IMPACT STRENGTH**
A sandwich construction using CarbonCore Plastic Honeycomb core, with its high degree of resiliency, is more impact-resistant than a singe-skin laminate of equal or higher weight. The increase in impact strength compared to a single-skin laminate is best understood by considering the core as a shock absorber that permits large, distributed deflections of the impacted skin, absorbing much of the energy and therefore protecting the second skin. The basic principle of energy absorption is to take the kinetic energy of a moving object and convert it into internal work. Honeycombs crush uniformly at a known load, have a long stroke and have the highest strength-to-weight ratio of all energy-absorbing materials. They also are very predictable.

At the same time, the core has elasticity sufficient to maintain the bond line between the core and the skins, and is resilient enough to fully rebound when the skin has not been fractured. If the impacted skin is breached, the second skin is most often unharmed, thereby simplifying repairs considerably. Although sandwich construction is not completely puncture-proof, experience shows that its puncture-resistance is significantly better than solid laminate construction when high-elongation core materials are used.

Conversely, sandwich panels fabricated with stiffer core materials will transfer impact and vibration energy from the side of the impact (or outside skin) to the inside skin, thus subjecting the inside skin to face buckling, delamination or catastrophic failure.

**VIBRATION DAMPING/SOUND ATTENUATION**
With its natural harmonic of 125 to 150 Hz, polypropylene is known for its excellent vibration damping/noise absorption properties. Almost all of our customers who have switched to CarbonCore Plastic Honeycomb from a different core material have reported noticing that boats are quieter. Noise and vibration travel well through a single-skin laminate, but boats with cored hulls are simply quieter. While balsawood and brittle foams in cored hulls tend to transfer noise energy directly through the laminate, polypropylene and some of the more elastic foams further dampen the noise energy due to their elastic nature.

**THERMAL INSULATION**
A vessel's thermal insulation is a key consideration since a boat most often sits in water much colder than the ambient temperature. Condensation forms, staining the vessel and creating an environment which promotes the growth of mildew. Sandwich construction significantly aids in the elimination of condensation and associated bilge water. The cored insulating layer coincidentally eliminates the need for highly flammable spray-in polyurethane.

**DISPLACEMENT BOATS**
Since weight is not the primary concern in displacement and commercial boats, there seems to be a general misconception that these vessels must be constructed with solid laminates. One should not, however, confuse solid with tough and strong. Properly designed sandwich construction has greater impact strength when compared to a single-skin (solid) laminate. Therefore, we believe that sandwich construction is beneficial to the general safety of displacement vessels. The arguments for using composite sandwich construction are overwhelming. No good reason exists for using single-skin fiberglass construction that cannot be countered with a better reason to use a tough, resilient core material like CarbonCore Plastic Honeycombs.

**SHEAR PROPERTIES**

One of the input factors used to determine sandwich laminate thickness is shear strength. Laboratory tests of shear properties, however, do not do justice to some materials, especially honeycomb. Since ASTM and ISO test standards for shear strength specify the sample size - essentially a thin strip of material that is loaded on a relatively short span and measured - honeycomb structures are at a disadvantage because in thin strips, the cell structure is broken along the edges when the sample coupons are cut from a panel. Furthermore, strength values often are cited without indication of the deflection or elongation. High shear strength may be recorded for low elongations, which may necessitate over-designed skin laminates to assure that small deflections will not induce "core shear failure" and consequently catastrophic structural failure. Conversely, low shear strength may be recorded for high elongations, corresponding to deflections that could not be sustained by other design factors or limitations of the laminates, such that this low shear material would never fail in shear. Full-scale structures must be evaluated as a whole, with large panel performance and shear elongation as critical considerations. This is particularly true when considering honeycomb sandwich laminates.

In the 1960s and 1970s, many boats were built using an early version of PVC linear foam that possessed comparatively low shear strength. Several of these boats are still in service and, obviously, have been very successful designs. Any presumption that shear strength is the key design parameter, therefore, is simply not true. As an example, many composite professionals may remember building airplane models with balsa before learning about fiberglass, when it was logical to start with a rigid base and laminate. Conversely, to apply high-performance laminates on either side of a compliant material was counter-intuitive. But the current generation of young airplane model builders is actually using fiberglass strapping tape over the surfaces of expanded polypropylene foam.

Typical shear failure shown with foam cored sandwich panel.

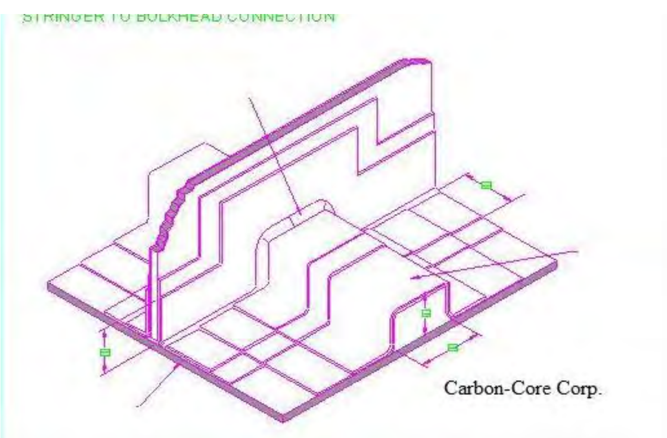
Build time is reduced and, most importantly, the virtually indestructible nature of the resulting structure has provided a far more satisfying product. Likewise, when designing structures using polypropylene honeycombs, one must remember that there is a significant difference in the value of the stress and strain at yield than there is at shear ultimate. Polypropylene honeycomb can stretch and carry loads without failure after the yield point, so the value at ultimate shear is still higher than at yield. It is important to keep in mind that the basis of many design specifications pre-dates the common use of multiaxial stitched reinforcements, which are generally higher in strength, but not as thick, and, therefore, have given up some flexural stiffness. However, when used with sandwich construction to provide the required cross-section for flexural stiffness, multiaxial stitched reinforcements are ideally suited for sandwich construction, achieving further weight reductions compared with previous laminations. Furthermore, since the increased strength of multiaxial stitched reinforcements is achieved at greater strains, Carbon-Core Polypropylene Structural Honeycomb is increasingly selected as the most appropriate core material. A thorough designer must, therefore, consider the most important test for core materials -shear strain (in percent), or shear elongation after the yield point (ISO 1922), which most accurately determines the degree of toughness for a specific core. It is not important whether one uses the shear yield or shear ultimate value in design, what is important is that, based on these figures, appropriate safety factors are built in.

When polypropylene honeycomb is used, one can design much higher on the elastic curve because the factor of safety is in the balance of the elastic range of the curve, and then in shear elongation after yield. We are not saying here that successful designs cannot be made with cross-linked PVC or balsawood, with inherently low shear elongation factors, but simply, the shear stress must be in the lower portion of the curve and not too close to the yield. However, even the balance of the elastic range of the curve is seldom sufficient under severe impacts.

Primary focus should be stiffness, but at the same time there should be an adequate safety margin to fall back on. If the structure is stiff enough, the stresses are usually low, but stiffness without damage tolerance is not a desirable attribute.

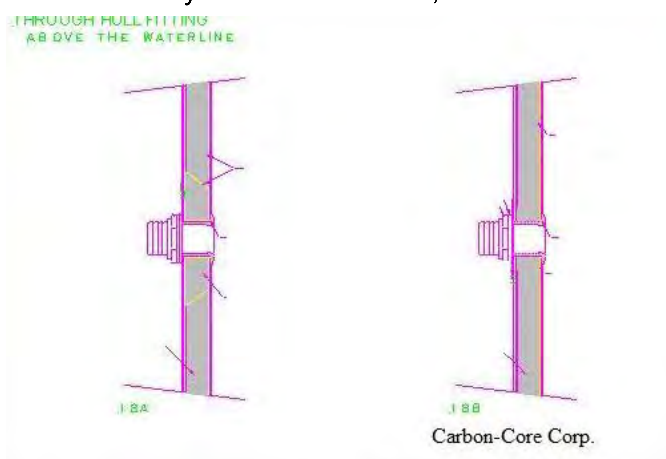
# DESIGN GUIDELINES

Several different sources have been used to obtain criteria for composite boat construction, including adaptations of wood designs with interchangeable single-skin fiberglass equivalent. Several criteria are derived from equivalent designs using metallic materials, primarily aluminum. These criteria seem to work well with some older types of core materials, but are lacking when it comes to NEW core materials such as polypropylene honeycomb, especially when thinner skins are used. The greatest lack is in areas where stresses are applied beyond the normal load range.
Most naval architects have as their primary goal a structure with adequate stiffness, buckling resistance and impact tolerance. All of these criteria are achievable with CarbonCore Plastic Honeycomb.

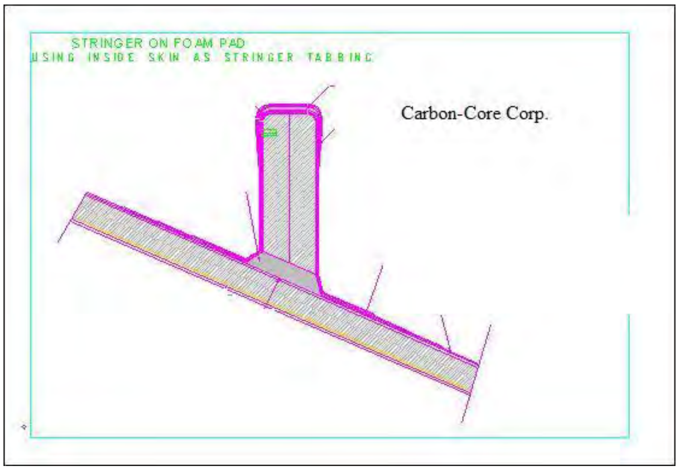



## Shear Properties

Shear strength is used as one of the input factors to determine the sandwich laminate thickness. However, laboratory tests of shear properties do not do justice for some of the materials, primarily honeycomb. ASTM and ISO test standards for testing for shear strength specify the sample size; essentially a thin strip of material that is then loaded on a relatively short span and measured. Honeycomb structures are disadvantaged in thin strips, since the cell structure is broken along the edges when the sample coupons are cut from a panel. Furthermore, strength values may often be sited without indication of deflection or elongation. High shear strength may be recorded for low elongations, which may necessitate over-designed skin laminates to assure that small deflections will not induce "Core Shear Failure" and consequently catastrophic structural failure. Conversely, low shear strength may be recorded for high elongations, corresponding to deflections that could not be sustained by other design factors or limitations of the laminates, such that this low shear material would never fail in shear. Full scale structures must be evaluated as a whole, and increasingly large panel performance and shear elongation are a critical consideration. This is particularly true when considering honeycomb sandwich laminates. In early 1960s and 1970s, a lot of boats

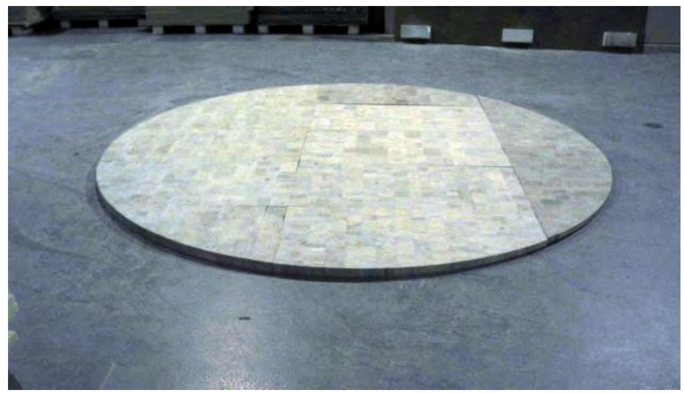



were built with an early version of PVC linear foam, with comparatively low shear strength. Several of these boats are still in service and have been obviously very successful designs. Any presumption that shear strength is the key design parameter is simply not true. While many composite professionals may have built airplane models with balsa before learning about fiberglass, it was logical to start with a rigid base and laminate to it. Conversely, to apply high performance laminates on either side of a compliant material is counter-intuitive. But the current generation of young airplane model builders is actually using fiberglass strapping tape over the surfaces of expanded polypropylene foam. Build time is reduced, but most importantly the virtually indestructible nature of the resulting structure has provided a far more satisfying product. Likewise, when designing structures using polypropylene honeycombs, one must remember that there is a significant difference in the value of the stress and strain at yield than there is at shear ultimate. Polypropylene honeycomb can stretch and carry loads without failure after the yield point, so that the value at ultimate shear is still higher than at yield. It must also be reminded that the basis of many design specifications predate the common of multi-axial stitched reinforcements, which are generally higher in strength but not as thick, and therefore have given up some flexural stiffness. However, when used with sandwich construction to provide the required cross section for flexural stiffness, multi-axial stitched reinforcements are ideally suited for sandwich construction, achieving further weight reductions compared with previous laminations. Furthermore, since the increased strength of multiaxial stitched reinforcements is achieved at greater strains, **CarbonCore Plastic Honeycomb** is increasingly selected as the most appropriate core material. A thorough designer must therefore consider the most important test for core materials - shear strain in %, or shear elongation after the yield point (ISO 1922) which most accurately determines the degree of toughness for a specific core. It is not important whether one uses the shear yield or shear ultimate value in design, what is important that based on these figures, appropriate safety factors are built in. For polypropylene honeycomb one can design much higher up the elastic curve because the factor of safety is in the balance of the elastic range of the curve, and then in shear elongation after yield. We are not saying here that successful designs can not be made with cross-linked PVC or balsawood, with inherently low shear elongation factors, simply the shear stress must be in the lower portion of the curve and not too close to the yield. However, even the balance of the elastic range of the curve is seldom sufficient under severe impacts. Primary focus should be stiffness, while at the same time ensuring there is an adequate safety margin to fall back on. If the structure is stiff enough, the stresses are usually low. However, stiffness without damage tolerance is not a desirable criterion. Several different sources have been used to obtain criteria for composites boat construction. Some are adaptations of wood designs with interchangeable single skin fiberglass equivalent. Several criteria is derived from equivalent designs using metallic materials , primarily aluminum.

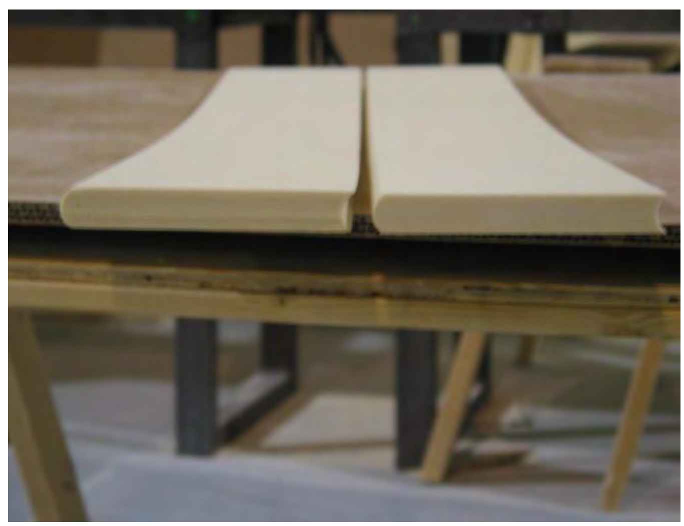



This criteria seems to work well with some older types of core materials but are lacking when it comes to NEW core materials such as polypropylene honeycomb, especially when thinner skins are used. Most design criteria lacks in areas where stresses beyond normal loads are applied.

The primary goal of most Design Engineers is to design a structure with adequate stiffness, resistance to buckling and impact tolerance. **All of these criteria are achievable with CarbonCore Plastic Honeycomb.**



CarbonCore Sloped Bottom Tank kits in CarbonBalsa or CarbonFoam



CarbonCore CNC kits include Bead and Cove cold molding system in PVC foam

# OVERVIEW OF VARIOUS CORE MATERIALS

A general overview of various core materials used within the boatbuilding industry follows. Although no core material is the answer to every possible application, this section highlights the various aspects of various widely available core materials.

**END-GRAIN BALSAWOOD**

End-grain balsa (such as CarbonBalsa) first entered wide use as a core material in the early 1960s when the end-grain configuration was introduced.

Balsawood performs exceptionally well in static laboratory tests. The perpendicular end grains form a structure not unlike a miniature honeycomb, achieving a maximum compressive strength as high as any core material available. The high compression values contribute significantly to the stiffness of balsa-built sandwich panels. In a fire, balsa performs well, since it retains its structural load-carrying ability as it burns for a much longer period than foams do. While balsawood also exhibits exceptional shear values, the values typically presented are based on laboratory tests featuring a 0.25-inch thick panel, where balsa is at its peak in shear values. Shear values, however, are significantly reduced as panel thickness is increased.

Another weakness of balsa is its lack of impact tolerance. Specifically, its high compression stiffness causes impacts to be readily transmitted from the outside to the inside skin. One result is that the end grains are easily split, thus provoking delamination of the inside skin, which can often go undetected. Condensation can collect in the void created between the inner skin and the core and eventually result in severe water damage to the core itself. Even if the damage remains localized, repeated impact in the same area can eventually result in a catastrophic failure of the sandwich structure. Due to the low elongation of balsa, particular care must be given to the shear transfer bonding layers on each side of the core, ensuring that a low-modulus transition layer is used to "bed" the core. Timing is critical, since the core must be positioned and, preferably, vacuum bagged before this layer cures beyond gel point. Since balsa is a lightweight, porous wood with low resistance to water vapor and humidity, it is always sensitive to environmental conditions during manufacture and repair of the cored structure, as well as in the structure's in-service operating environment. Generally, a balsa-cored boat will require more maintenance and care than those with alternative cores.

**POLYMER FOAMS**

Plastics are divided into two groups: thermoplastics and thermosets. Thermoplastics have long molecular chains that can move relative to each other when heated and stay in their new position when cooled. Therefore, thermoplastics can be repeatedly thermoformed. Notable among their many attributes is particularly high impact resistance. Conversely, thermosets, a category that includes typical laminating resins, are catalyzed to initiate exothermic reactions that cross-link the molecules, transforming liquid resins into solid materials that retain their shapes permanently and cannot be reformed. Thermosets have many positive attributes, including high mechanical properties and temperature resistance, but often suffer from poor fracture toughness.

**URETHANE/POLYISOCYANURATE FOAMS**

Urethane foams are often mistakenly compared to polyisocyanurate foams, which were developed for residential insulation applications that demand higher fire resistance and low smoke properties. While they possess similar base chemical components, the difference between them is established by the ratio of the two significant constituents of polyol and isocyanate. The ratio is referred to as the index - urethane foam is low index, while polyiso foam is high index. Low index foams are typically produced in a batch process or bun stock, while high index foams may be run on continuous high-speed lines for roofing board, which can be produced at a lower cost. This cost differential can tempt consideration of the polyiso foam as a core material. However, compared to polyurethane foams (e.g, Carbon-Core's CarbonFoam PUbrand), polyisocyanurate foams are much more friable and can degrade over time, when subjected to dynamic solicitation.

Thermoset polyurethane foams have been widely used in boats and other composite structures since the mid-1960s and, second only to plywood, polyurethane foams have probably been used to build more successful boat transoms than any other core material. To this day, boat transoms remain one of the most suitable applications for high-density polyurethane foam. Polyurethane foams exhibit exceptional chemical (styrene) resistance and heat tolerance (as high as 250°F). They also provide excellent thermal insulation and exhibit mechanical properties that can actually improve with age. Their weaknesses include catastrophic failure under ultimate shear stress at relatively low elongation, which renders the material unsuitable for dynamically loaded structures, such as boat hull sides and decks.

Plastics are divided into two groups: "thermo plasti-cs" and "thermosets". Thermoplastics are linear, whose long, string like molecular chains are arranged in a random amorphous fashion

**CROSS-LINKED PVC FOAMS**

Cross-linked PVC foams are thermosets. Cross-linked foams have anchor points between molecular chains, which result in higher stiffness, but less toughness. Because of their cross-linked structure, thermosets normally have a higher heat distortion temperature than thermoplastics.

Thermoplastics and thermosets can, however, be blended, creating molecular strings that can be anchored to a certain degree yet take on a degree of thermoplastic toughness as well. When thermoset resins (usually di-isocyanate) are blended into PVC resins, a foam with increased mechanical properties - higher heat distortion properties, and better solvent resistance - is created. However, the resulting foam products have their shortcomings: Elongation of these cross-linked foams is typically much lower than for linear foams. The relative brittleness lowers the foam's impact resistance and they can shear easily under impact. Cross-linked PVC foams also may be softened or damaged during the molding process by the combination of styrene vapors and heat from the exotherm associated with curing polyester resins. Several cross-linked PVC manufacturers are adding plasticizers to the resin blend, which may cause future problems since plasticizers tend to migrate out of the foam over time, leaving behind an effectively different foam than the structure was originally engineered around. Out-gassing is another problem with crosslinked PVC foams. Cross-linked PVC foams are manufactured in a water steam chamber, because the di-isocyanate component in the PVC needs a water molecule for the chemical reaction (generally described as water-blown in contrast to CFC-blown). Lower density foams are stored for short periods in a temperature- and humidity controlled environment for aging. Higher density foams require more time for cure/polymerization. While fully cured PVC foam does not normally outgas, the phenomenon can occur when the foam is heated and carbon dioxide ($CO_2$) forms within the foam. When the $CO_2$ tries to force its way out of the foam, it tends to push the outside skin away. Since PVC foams are noted for their low heat tolerance, out-gassing can become a significant problem when dark colored laminates are used.

**LINEAR PVC FOAM**

Linear PVC foams have been successfully used in various forms since the mid-1950s. Even when linear PVC foams exhibit lower mechanical properties than cross-linked PVCs, linear PVC foams in real-life situations still offer one of the highest levels of foam core damage tolerance and toughness, making it ideally suited to boat hull construction, where repeated impacts are a part of normal operation. It is well-suited for dynamically loaded structures, since ultimate failure occurs at very high strain.

The resistance to chemicals (styrene) is limited, so one must be very careful to implement proper shop procedures and use proper resins/adhesives. A major drawback to linear PVC foams is the material's inherent lack of temperature tolerance, making it unsuitable for marine superstructure construction where mechanical properties can suffer from repeated heat cycles endured in marine environments.

**SAN FOAM**

SAN (Styrene-AcryloNitrile) thermoplastic resin-based linear foams have been successfully used in composite sandwich construction. Typically, SAN foams exhibit higher mechanical properties than equivalent densities of PVC and urethane foams, although they do so at a much higher cost. SAN foams exhibit good toughness characteristics; however, as with all foams, the failure mode when reaching ultimate stress is catastrophic, resulting in a 45° degree crack that can propagate easily as the sandwich panel continues to flex.

## HONEYCOMBS

### Paper honeycomb

Paper honeycomb is widely used in the composites industry, mainly due to its low cost, but it is impractical to use material so susceptible to possible damage degradation in marine or outdoor environments. Paper honeycombs, especially in untreated form, are better left to the packaging industry.

### Aluminum honeycomb

Aluminum honeycomb is typically used in aerospace structures, but is unsuitable in most marine-related applications due to poor corrosion resistance as well as high thermal conductivity (no insulation value). Another problem is that the aluminum honeycomb bond line is limited to a very small surface area of the thin cell wall. A small resin ring has to form around each cell to "grab" the core and create the bond to the skin. This is achieved with adhesive films in the aerospace industry. Aluminum honeycombs are used extensively in the aircraft industry, primarily because there are few foams that can withstand the extreme processing temperatures typically required to produce parts for the aerospace sector.

### Polypropylene structural honeycomb

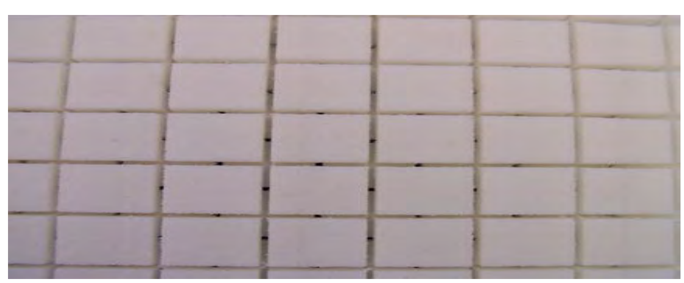
Polypropylene is noted for its inherent toughness, extreme chemical resistance and elongation. Water or chemical agents used in the composites industry do not affect it. CarbonCore polypropylene honeycomb incorporates a thermo-fused (not glued) scrim, thus providing a 100 percent bonding surface (compatible with most resin systems) for stress transfer between the honeycomb and skins. A barrier film also is incorporated to prevent resin from filling the cell structure. Some honeycombs have different mechanical property values for length and width directions, due to the fact that the core is weaker along the glue line. Extruded honeycombs (like CarbonCore Plastic Honeycomb) have equal properties in both directions since they are not glued like traditional honeycombs.

Carbon-Core polypropylene honeycombs can easily be thermoformed or vacuum bagged in place (unlike foams), without the need for scoring in many instances.
Elimination of scoring can prevent excessive resin uptake and the associated cosmetic or structural defects.

The mechanical properties of CarbonCore Plastic Honeycomb are controlled by the following specifications: 1) physical properties of the thermoplastic; 2) cell diameter; 3) wall gauge (thickness of the cell wall); 4) core thickness; and 5) facings applied to the core. Altering one or more of these specifications will produce different performance characteristics. CarbonCore honeycombs can be engineered to be a specific weight, absorb a specific load, rebound at a specified rate and possess the flexibility or stiffness required by the end application. Thanks to its physical and chemical properties, polypropylene is resistant to water and will not absorb it. For this reason CarbonCore honeycomb materials are ideal for numerous areas of industry such as:

### PET Foam (Polyethylene terephthalate)

PET foam (like CarbonFoam PET) has high elongation and superior adhesion resulting in good impact and fatigue strength. The foam can be formed at room temperature to simple shapes and be thermoformed to more complex 3-dimensional parts. A high temperature resistance allows short processing cycles with fast curing resin systems, including thermoplastic fiber reinforced skins making it very suitable for mass-produced lightweight sandwich structures subjected to both static and dynamic loads in service. Good resistance against weak bases, weak acids as well as against most current solvents: alcohol – acetone – perchlorethylene. Limited resistance – check in each case – against strong mineral acids. CarbonFoam does not emit any corrosive gases, even when burned, unlike PVC foams, CarbonFoam does not emit gases that contain halogen such as hydrochloric acid. Excellent closed cell ratio, water and resin absorption comparable to PVC, PU and SAN foams.



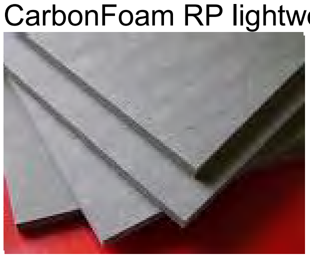
# CNC KITS & MACHINING SERVICES

CNC Kits / Machining Services

CNC Kits for plastic honeycomb panels, balsa wood panels, foam boards, foam sheets and other light-weight core / structural materials.

CarbonCore Plastic Honeycomb, CarbonFoam, CarbonBalsa, can be supplied in CNC precut Kits. Carbon-Core's kit department uses state-of-the-art manufacturing technology to provide the most accurate, best fitting balsa wood panels, plastic honeycomb panels, or foam sheet / board components for your application. Carbon-Core's full line of CNC kits reduce labor costs, reduce inventory space, eliminate waste and speed up production. All CNC kits are manufactured in-house to your specifications, packaged in sequential order and numbered for ease of installation and include an easy to understand schematic for reduced employee training costs. CNC Kits ensure product consistency and quality and save you money.


Carbon-Core Corp. uses state of the art equipment to digitize customer's core kits at customers location or our facility. Our Coordinate Measuring Machine capability assures 0.0017" accuracy in all measurements. CMM can also be utilized to reverse engineer CNC cut kits and compare the measurements to original drawings to ensure highest quality.



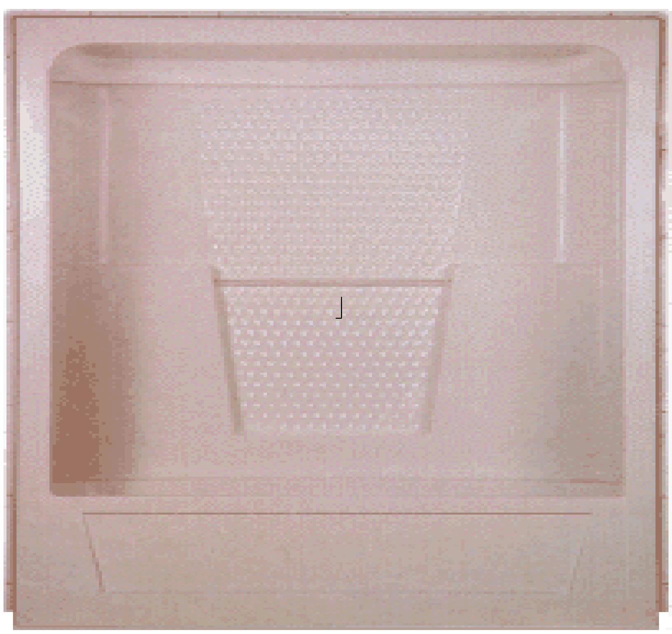
CarbonFoam RP lightweight transoms blend our polyurethane high density technology with our CNC kit cutting department. CarbonFoam RP transoms are made from foam sheets of High density Polyurethane and are made available with predrilled inserts, beveled edges and bleeder holes for optimum laminate bond strength. Our transoms made with CarbonFoam RP offer one of the lowest water absorption rates in the foam board industry with over 98% closed cell foam content. CarbonBond pourable transom material available for repairs and OEM construction.

Carbon-Core's unwavering commitment to quality begins at the design phase. Plastic honeycomb, balsa wood, and foam core products are carefully engineered to ensure the highest quality product. All raw materials are carefully selected from qualified suppliers. Before any structural or composite materials are released to the manufacturing floor, they are thoroughly inspected and tested to ensure product quality and integrity. Ongoing quality checks continue throughout production of all plastic honeycomb panels, balsa wood panels, foam boards, or foam sheets. Each line operator has the authority and possibility to halt machinery should a problem be detected.

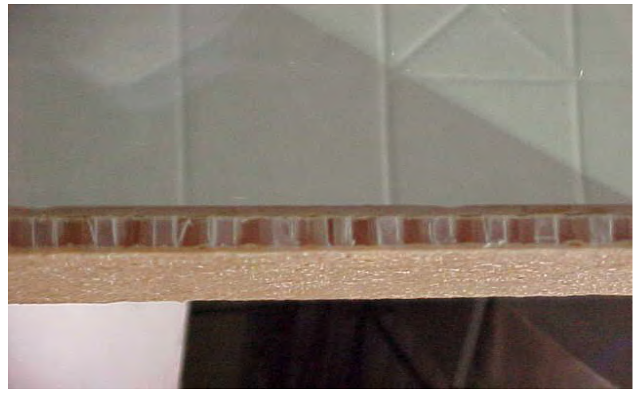
# TUB and SHOWER

Carbon-Core Corporation supplies an extensive range of core materials for the tub and shower industry around the world. We continue to develop specialty structural honeycomb cores that include CNC machined reinforcements for soaker tubs, shower walls, tub bottoms etc. Carbon-Core Plastic Honeycombs, CarbonBalsa, CarbonBalsa PITH, CarbonMat, CarbonBond Products are supplied to Tub and Shower Industry.

CarbonCore is especially suitable for tub bottom coring. CNC cut kits from CarbonBalsa or Honeycomb speed up production and eliminate waste disposal issues associated with lightweight materials.



CarbonBond Radius Filleting Compound are used to get uncured laminate stick to tight radii.



Shower stall walls benefit from the specially scored large sheet(48X96) conforming ability.

# SOLID SURFACE and LIGHT WEIGHT MARBLE APPLICATIONS

**Natural Marble and Granite backed with CarbonCore Plastic Honeycomb or panels.**

CarbonCore plastic honeycombs are often used to back thin natural stone veneers for yacht and RV, elevator construction. In addition to significant weight savings(10 times lighter than solid marble), one will also benefit from added insulation properties as well as substantial noise and vibration canceling properties, due to the visco elastic nature of the plastic honeycomb. Unlimited color and size combinations and adhesive systems are available from Carbon-Core Corp. and from our partner quarries in South America directly.

**Solid Surface**

Solid surface products can be enhanced for transportation and special use applications by adhering a ¼" solid surface to CarbonCore Plastic honeycomb backer, with or without outside composite laminate skin.

Plastic Honeycomb cored natural stone panel in commercial elevator installation.

**The benefits to choosing Solid Surface backed by CarbonCore Plastic Honeycomb's are:**

- **Lower cost due to thinner solid surface material needed**
- **Lighter weight for transportation applications (motor homes, yachts)**
- **Lighter weight for easier installation by smaller crew**
- **Added dimensional stability in dynamically loaded applications**

What is Solid Surface?

Solid surface is an extraordinarily versatile surfacing material which offers a host of benefits in performance and aesthetics with incredible application and design flexibility. It is solid, renewable, and when applicable, may feature inconspicuous seams. Applications for solid surface are extremely far reaching. Traditionally, the largest market for solid surface is kitchen countertops. The design flexibility, color and texture options and performance attributes of solid surface are driving more and more builders, architects, designers and homeowners to choose solid surface.

# CARBONBALSA

End Grain Balsa, a highly processed ultra light wood product, imparts impressive strength and stiffness to the sandwich panel. The end grain configuration of balsa provides high resistance to crushing, and is very difficult to tear apart. End grain balsa cored panels also have the ability to handle excessive dynamic loads with high resistance to fatigue.

Until recently, end grain balsa was excluded from some weight sensitive applications, as there were lower density foam cores available. Now, through controlled growing and careful selection, CarbonBalsa balsa is competitive in weight, as well as offering superior performance in stiffness and strength, particularly where local crushing or bruising is a concern.



CarbonBalsa is select quality, kiln-dried, end-grain balsa wood suitable as a structural core material in composite sandwich construction. CarbonBalsa is a naturally renewable resource.

The balsa plant (Ocroma lagopus) grows from seedling to mature tree in 4-6 years and reaches heights up to 25 m (90 ft) before dying in 8-10 years. Tropical winds spread balsa seeds throughout the equatorial highlands of Ecuador where mature trees are harvested. The trees are then milled, kiln-dried, and converted to CarbonBalsa.

CarbonBalsa's end-grain orientation gives it exceptional compression and shear properties. As an added benefit, CarbonBalsa provides good thermal and acoustic insulation. CarbonBalsa is available in two different densities.(6.5lb/ft3 and 9.5 lb/ft3)

CarbonBalsa is available as a surface primed version of CarbonBalsa, which improves installation quality, shortens application time and reduces resin absorption as well as super lightweight version
CarbonBalsa LT and PITH commercial grade for select applications.

CarbonBalsa is available either scrimmed and scored(1”X1.5” blocks) up to 24”X48” size or rigid sheets up to 48”X96” size as well as solid blocks.




**Open or Contact Molding**

CarbonBalsa may be applied by either bedding into sufficient wet laminate or into a bedding compound such as CarbonBond CBC. Whether bedding into CSM (Chopped Strand Mat) or into CarbonBond CBC certain procedures must be followed for successful application. For many years, end-grain balsa has been used in sandwich core composites. It’s high compressive and shear strength and relative low cost have made it the core of choice for many applications. Recently, much discussion has been made over moisture intrusion after the structure is built and what affect that moisture may have. What had not been addressed is the effect moisture has on the lamination process. There has been a steady increase in incidents of de-lamination and inhibited bond line resin cure over the last several years and always appeared couple to increased relative humidity. What we will examine here is: “What changed and how do we cope with it?” More than forty years ago, the National Forest Products Laboratory and others, determined that end-grain balsa could be successfully used with polyester resin at moisture contents as high as 16% and this standard is still offered by them. Through testing conducted over the last couple of years we have determined that the threshold where moisture content affects the cure and bonding characteristics is much lower than that and problems can be observed as low as 9.5 or 10%. The balsa hasn’t changed. In a natural product, as the humidity increases so does the moisture content of the balsa, just as it always has. During our course of testing we used sample laminating resins from 5 sources and balsa from three manufacturers. Tests were made with all combinations of resin and balsa at specific moisture contents.8 to 9% - With all sample combinations complete cures and excellent core to laminate bond was observed. The resins we use have changed considerably, in most cases, to meet mandated lower styrene monomer levels. Some polyester resins in the past had styrene contents of 45 to 49%. They are now at 32 –35%. We believe the higher styrene content made the resins more tolerant of moisture content, either absorbing or displacing it. 9.5 to 10 % - scrimmed and scored varieties displayed inhibited cures, particularly on the scrim side. Some milky appearance in the scrim grids indicated that the scrim itself had retained moisture.10.5 to 12% - As much as 100% bond line inhibition was observed with outer skins being completely cured and the skin/core interface with a thin layer of sticky, uncured resin. There are sometimes air pockets observed (never bonds) as well as de-laminations. Changes in the resins have affected how resins respond to changes in moisture content of the balsa. The moisture content threshold for successful bonding is far lower than available literature and standards would indicate as these have not been updated in more than 40 years. With the observation that relative humidity directly affects the moisture content and therefore the performance when laminated, correct storage is extremely important. Car--Core Corp. recommends the storage of all Carbon-Balsa products in the original packaging in a climate controlled environment (essentially an air conditioned room). Fluctuations in moisture content will be significantly reduced by observing this practice.

1. CarbonBalsa R and FP are not sealed. Therefore, the "down" side must be "hot coated" with catalyzed laminating resin and allowed to cure at least two hours before the core is installed. This procedure seals the end grain and brings it to the same state as the S2 variety.
2. If CarbonBond CBC is used, the Bond Line Gel Time should be determined by catalyzing a small amount of the Core Bedding Compound and spreading it on a flat surface approximately 1 mm thick. CBC should be catalyzed at he ratio prescribed for the expected ambient shop temperature. Prime six 2" x 2" blocks of sealed balsa with catalyzed laminating resin and lightly press them into the CBC. Close to the projected gel time (say 30 minutes) twist one of the blocks slightly, then a subsequent block every 5 minutes until it one doesn't move and note the gel time.
3. The core material should be precut and pre-fit before bonding in place. This is particularly important when vacuum bedding the core. The sheets should fit together with minimal gaps and all edges that don't butt into another surface should be beveled with a slope length 3 times the core thickness. Bevel strips may be used if the core cannot be beveled so as to eliminate voids and fiber crimp that occur when laminating around sharp corners.
4. Check the cured laminate surface that the core will be bedded to for smoothness. There should be no ridges or protrusions that may hold the core off the surface. It may be necessary to sand the surface with 80 grit paper for good adhesion depending on the resin system and length of time it had cured. Remove any sanding dust prior to core installation. If there is any uncertainty, follow the resin supplier's guidelines and test the bond to a sample of the laminate before installing the core.
5. CarbonBond CBC should be brought to the ambient shop temperature of 65 to 85 deg F (18 - 29 deg C) and mechanically mixed to a uniform consistency in the original pail and working from the bottom up. Storing the pails upside down will result in faster re-mixing.
6. Refer to the CarbonBond CBC Catalyzation Guide in the Carbon-Core Handbook and allow for the empty weight of the 5 gallon pail. Blend the required amount of catalyst and CarbonBond CBC with a mechanical mixer until an even pinkish color is obtained with no streaks. A clean blade or stick should be used to scrape the sides and bottom of the mixing pail.
7. When vacuum bagging or with larger applications, priming of the core and troweling of the CarbonBond CBC should occur concurrently to best use the available working time.
8. A flat trowel, held at 80 degrees to the surface, should be used to apply the CarbonBond to a thickness of .04" (1 mm) on flat surfaces. On highly curved surfaces or where the balsa is

more than one inch thick, more CarbonBond may be required to fill the kerfs. After resin priming, drape the balsa, scrim down, over a drum (covered with plastic film) and trowel the CarbonBond into the kerfs. This will improve the integrity of the core layer and prevent moisture collection should the skins be damaged.

The side of the core to be bedded (down side) must be prime coated with catalyzed laminating resin just prior to putting the core in place. The appropriate amount of resin to coat S2S CarbonBalsa is 0.7 oz/ft^2 (215 gm/m^2). As stated before, the FPS and R must be "hot coated" with catalyzed laminating resin and allowed to cure at least 2 hours prior to installation. Lay the core flat and spray or roll (with a short napped roller) approximately 1.5 oz/ft^2 (430 gm/m^2) Be careful not to apply too much resin so as not to glue the core blocks together. Re-coat with catalyzed resin just before installation as you would for the CarbonBalsa S2. Coating the kerfs of FP and S2 will help the CarbonBond CBC flow into and fill open kerfs. To allow easy clean-up, cover a drum with plastic film and lay down the core to open the kerfs in one direction. Apply the catalyzed resin with a brush and turn the sheet 90 degrees to open the kerfs in the other direction. It is recommended, whenever possible, to install scored balsa scrim side up.

9. If the scrim must be placed down, it is re commended that the scrim side be pre-coated to displace air from the scrim weave within one minute of bedding the core to prevent blocks of balsa from detaching from the scrim. It is not recommended to prime coat ahead of time.
10. Place the primed surface of the CarbonBalsa onto the CarbonBond coated laminate. Use moderate pressure to bed the core sheet evenly into the CarbonBond CBC with metal laminating rollers which forces the Carbon-Bond CBC into any open kerfs filling them as much as possible. Avoid walking on or applying excess pressure to prevent squeezing Carbon-Bond out of the bond-line resulting in possible starved or dry bond locally. Prime and place any fillet strips at this time.
11. The vacuum bag must be sealed and a vacuum drawn before the CarbonBond CBC and resin start to gel. The initial core compaction should be at 10 in-Hg (checked at the bag) and then reduced to 5 in-Hg after a few minutes until the resin/bonding compound has cured.
12. After curing, check the bond. Tapping the scored blocks will reveal any voids in the bond-line. Voids must be repaired before adding subsequent laminates.

Balsawood seed prior to planting

CarbonBalsa Stored for shipping at the Ecuador manufacturing facility

CarbonBalsa block prior to cutting and trim-

CarbonBalsa manufacturing in Ecuador

Balsawood plantation prior to harvesting

# CORE BONDING COMPOUND (CBC)

CarbonBond is a specially formulated, polyester based core bedding compound developed by Carbon-Core Corporation for hand lay-up and vacuum bagging core installation. Use of premium resins results in high tensile and flexural strength. Its high adhesive strength provides an excellent bond between the core and the laminate. Its is suitable for most coring applications and is compatible with our CarbonFoam, CarbonBalsa and CarbonCore Plastic Honeycomb, PVC and SAN foam core materials. Characteristics include: lightweight, non-sagging, and long working time for coverage of large areas. Consult MSDS for additional handling, storing and safety information. CarbonBond is available either Pumpable or Trowelable Normal application of Carbon-Bond CBC on a flat, smooth surface would require about 1/16" per square foot although in certain gap filling applications can be used up to 1/4" thick. Below are coverage rates per gallon and weight per square foot at different thicknesses.

# GENERAL-PURPOSE BONDING COMPOUND (GPC)

Carbon-Bond GPC is a specially formulated, polyester based all purpose bonding compound developed by Carbon-Core Corporation for general purpose filling and bonding. Use of premium resins results in high tensile and flexural strength. Its high adhesive strength provides an excellent bond between the bonded substrates. Consult MSDS for additional handling, storing and safety information. CarbonBond GPC is available either Pumpable or Trowelable. Catalyze with MEKP. Semi-flexible for exceptional crack resistance.

**Formulated with premium resins**
- **Low shrinkage and exotherm**
- **Low styrene content**
- **General purpose bonding**
- **General purpose filler, filleting radii, excellent durability, filling small voids, bonding composites**

# TRANSOM POURABLE CERAMIC COMPOUND (TPC)

Description: CARBON-CORE formulates its *Ceramic Pourable Compound* with premium polyester resins and high strength ceramic spheres resulting in high tensile and flexural strength. This lightweight compound is ideal for filling large volumes where strength and rigidity are major concerns. The CarbonBond *Ceramic Pourable Compound* mixes and pours easily from the 5-gallon pail.Excellent rigidity and strength. Formulated with premium resins Low shrinkage and exotherm Low styrene content Structural applications where high compressive strength is required 7 times better compression strength than plywood!

SPHERE CEL® LAMINATE BULKER

## LAMINATE BULKER

Most laminate bulkers available in the marketplace today are made of polyester fiber and glass microspheres. SphereCel has MULTI-DIRECTIONAL fiber orientation. Unlike the unidirectional fiber orientation used in bulker products manufactured by most of our competitors, our multi-directional fiber orientation provides equal strength characteristics in both length and width directions. It also helps in wetting out the laminate equally in both directions, as opposed to easier wet out in one direction in linear fiber products.SphereCel is easily recognized by its more frequent perforations, which help in the wetout of the material and create more vertical links as well as easing the evacuation of trapped air bubbles throughout the laminate. Print blocking: Thinner-grade SphereCel is a very effective print-through barrier when placed behind a skin coat.Screw retention: SphereCel adds excellent screw retention capability to a laminate, and can be placed, for example, around the perimeter of swim platforms for rub rail installation. Microcracking prevention: SphereCel reduces demolding cracks and stress cracks in gel coated parts. SphereCel performs at a level well above that of competitive products. Its shock resistance is 35 to 50 percent higher, one reason why products made with SphereCel obtain longer useful life cycles. Water absorption is equivalent to that of the competition. Its even, multi-directional fiber distribution offers reinforcement characteristics not available in competitive products. SphereCel exhibits superior impact and shear strength, thanks to stronger links between the different layers within the mat as well as excellent resin distribution throughout the product. SphereCel's excellent impact values underscore the ability of the SphereCel-reinforced laminate to meet toughness requirements and withstand severe-duty fatigue.

SPHERE CEL®

LAMINATE BULKER

## SphereCel GF

A glass fiber material which is volumized by embedding thermoplastic microspheres. Ideal for wet-on-wet laminates. Particularly suitable for thin laminates due to low resin absorption and low weight. Excellent printblock characteristics and laminate homogeneity. Higher bending resistance and tensile strength than material based on polyester tissue. This material comes in 1mm/2mm/3mm/4mm/5mm thickness-

## SphereCel PE

A material made of polyester tissue which is volumized by embedding thermoplastic microspheres. Very elastic and well drapeable when wet. Comparable to Coremat, Upica etc. This material comes in 1mm/2mm/3mm/4mm/5mm thicknesses.

## SphereBlock 1.3 for closed molding process

Is a fiber glass material which is volumized by embedding thermoplastic microspheres. Ideal as surface material in a laminate due to its little resin absorption and low weight. The perfect surface comes with a good laminate homogeneity and good mechanical stability. Overlapping or tearing the material does not affect the performance of the surface laminate. It is applied dry after the gelcoat / barrier coat or a pre-laminated glass mat and impregnated with resin according to the closed mold application. This material comes in 1.3mm thickness.

# SphereCel SBF

A pre-compressed, stitch-bonded glass fiber material which is volumized by embedding thermoplastic microspheres. Particularly suitable for wet-on-wet process for producing both stable and light homogeneous laminates at the same time. The excellent characteristics result from the complete impregnation with ca. 40% by volume of the same resin used to laminate the skin layers. This sandwich material which can be laminated substitutes balsa, PVC foam material and other core materials but has the advantage of being able to adjust to the mold three-dimensionally. This product is available in 6 mm, 8 mm , 10 mm and 12 mm thicknesses. Excellent screw retention.

**Transoms** made with SphereCel SBF is an excellent solution for making transoms up to 70 mm(2.75") thickness. - - - Why? High mechanical properties: Laminates made with SphereCel SBF are more resistant to pressure than laminates made with most other core materials. Furthermore the thermoplastic microspheres inside SphereCel SBF absorb vibrations. Water resistance: The water absorption of SphereCel SBF is comparable with solid glass laminates.

# SphereCel SBF CM

Sphere Core SBF CM is a pre-compressed, stitch-bonded glass fiber material which is volumized through embedded thermoplastic microspheres. SphereCel SBF CM is amended with an additional polypropylene core (flow medium). It is suitable for the production of stable and, at the same time, light homogeneous laminates. An ideal material for sandwich laminates. This product is available in thicknesses of 6 mm, 8 mm and 10 mm

# SphereCel HX Type OM and CM

- The cost effective solution for open and closed mold processes Available in 1,1.5,2,3 mm thicknesses
- Used as core material and resin flow media
- Pressure stable nonwoven and compatible with all regular types of resins, including polyester, vinyl ester, phenolic and epoxy

# CARBONFOAM PU/PIR

CarbonFoam PU/PIR polyurethane foam is available in sheets from 3/16" to 8" (5mm-203 mm) thick blocks in densities from 2 lb/ft3 to 50 lb/ft3.

Standard sheet size is 48" X96" or 1219mmX2438 mm

All CarbonFoam PU/PIR products can be supplied in customer specified CNC cut kit form.

Closed cell content up to 99%

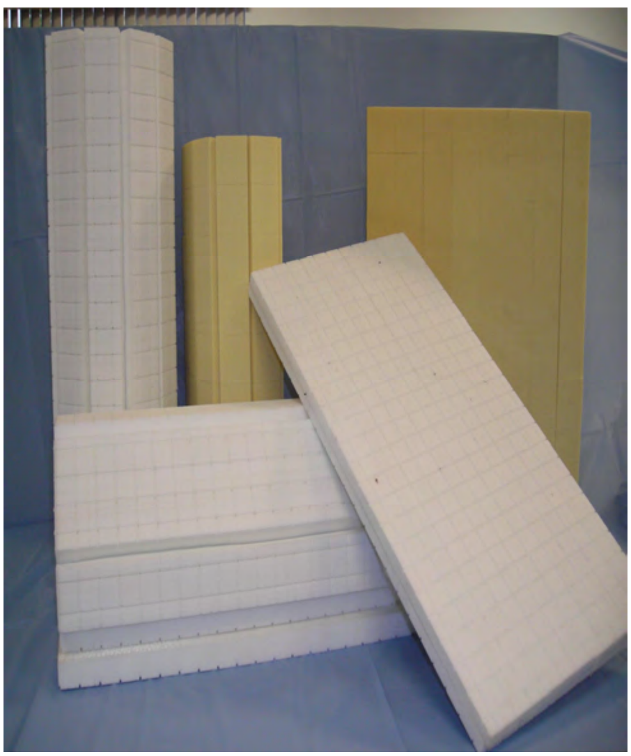
Freeze and thaw cycle tested.

Anti-static additives available for specific applications.

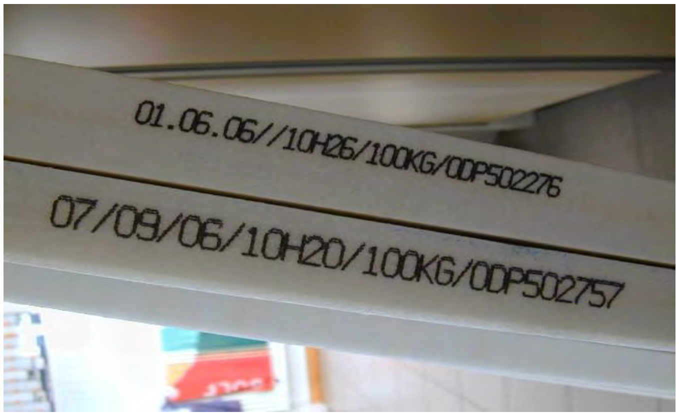
Low-abrasion additives available for machining applications.

Fire - retardant additives available.

Custom pigmentation and customer branding available.



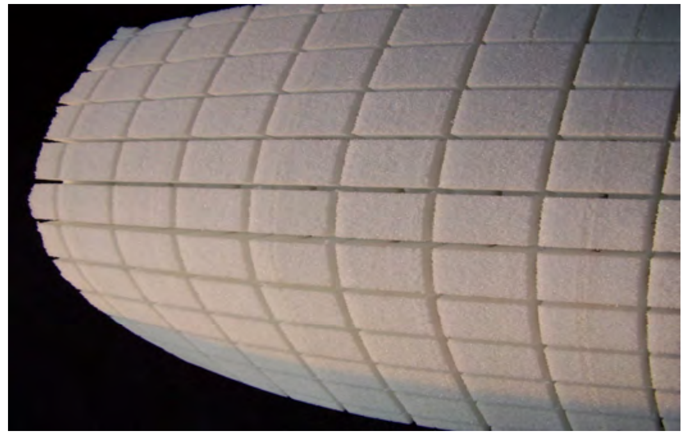
# CARBONFOAM PET



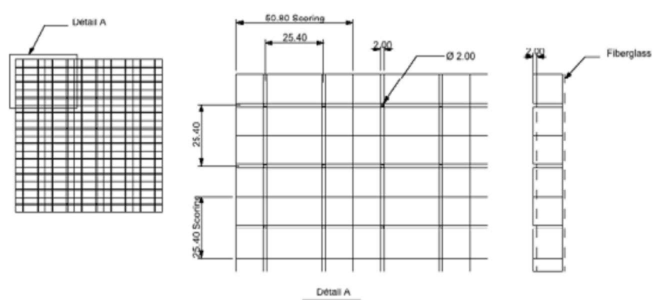

Each CarbonFoam PET board is marked with DOM and specifications particular to batch.

Scrimming and scoring, including grid pattern for infusion laminar resin transfer is available with CarbonFoam PET Please note the consistency of perforations and alignment with grid pattern.

Composite wind blade industry is especially suitable for CarbonFoam PET due to its high process temperature, excellent fatigue resistance and availability.



Thermoformability: CarbonFoam sheets can be thermoformed.
The white color of the CarbonFoam is easy to recognize and distinguish from other available foams. The white color transfers less to the composite part surface, resulting in less gelcoat usage.
Chemical resistance and corrosive gases:
Good resistance against weak bases, weak acids as well as against most current solvents : alcohol – acetone – perchlorethylene. Limited resistance – check in each case – against strong mineral acids. CarbonFoam does not emit any corrosive gases, even when burned, unlike PVC foams. CarbonFoam PET does not emit gases that contain halogen such as hydrochloric acid.
Water and resin absorption:
Excellent closed cell ratio, comparable to PVC, PU and SAN foams.
Certifications:
CarbonFoam has been awarded FST M1 spec burn certificate. Other industry specific certifications are pending and available upon request. Independent laboratory structural testing results available.




Infusion grid score pattern schematic.

# CarbonFoam PE

Carbon-Core Corp. Inc. is proud to introduce it's new, state of the art, Polyester structural foam core product line.

CarbonFoam PE- A new generation technology structural foam core, superior to current technology PVC foam core in both structural performance and cost effectiveness.

CarbonFoam PE is a closed cell rigid cross linked Aromatic polyester foam core, manufactured, using state of the art polymer technology. This new technology allows Carbon-Core Corp. Inc. to offer a new generation structural foam core with outstanding properties of strength, resilience and cost effectiveness as compared to available PVC foam cores.

CarbonFoam PE maintains its dimensional stability and mechanical properties at elevated temperatures that current PVC foam cores can not match. This is particularly applicable to marine deck and floor areas that are exposed to direct sun generated radiant heat.

CarbonFoam PE is a flame retardant, non-friable foam core that provides excellent strength-to-weight ratio in sandwich panel and stringer applications. It will not absorb water and is resistant to most solvents and resins. the use of CarbonFoam PE foam core in the lighter densities will also provide additional positive flotation to applicable marine structures.

CarbonFoam PE is available in a variety of densities ranging from 4 lbs. per sq/ft to 36 lbs. per sq/ft. Standard sheet sizes of 48" x 96" for plain sheets and 48" x 32" for double Contoured and Grid Scored sheets, all cut to the desired standard thickness.

# Fiber Reinforced Panel

Carbon-Core Corp.' CarbonFoam Fiber Reinforced Panel® is a unique closed cell, lightweight composite product manufactured with cross-linked polymer foam and fiberglass, offering high specific strength and toughness. The non-absorbent material is extremely durable and dimensionally stable, provides an excellent bonding surface, has good impact strength, sound and thermal insulation, and is resistant to contamination and high temperatures. Offered in sheets or cut into parts, our material is built for lifetime performance and is ideal for endless coring applications subjected to static and dynamic loads.Our CarbonFoam Fiber Reinforced Panel® is manufactured in a thicknesses from .25" to 2", dimensions up to 60" wide and 170" long, and a density range of 10-40 lbs/ft³, depending upon the product line. Manufactured with polymer foam and a filter fiberglass lay-up, this product is a good coring material in niche applications. Available in a density range of 9 to 30 lbs/ft³ depending upon the thickness required.
This easy to process structural foam core product is 9 lb/ft³ and offered in .50” X 48” X 96” panels. Ideally suited

as core material for a variety of lightweight sandwich structures, and compatible with a wide range of resins and adhesive processes. This exciting new product has an outstanding price-to-performance ratio. Please contact us today for more information on our new 9lb/ft³ product today.

CarbonFoam Fiber Reinforced Panel® LIGHT DUTY
Manufactured with polymer foam and a matt fiberglass lay-up, this product is a great choice for a wide variety of uses from floor to ceiling. Available in a density range of 9 to 40 lbs/ft³ depending upon the thickness required.

CarbonFoam Fiber Reinforced Panel® HEAVY DUTY
Manufactured with polymer foam and a medium-weight woven fiberglass lay-up, this product is acceptable for standard structural loading applications. Available in a density range of 20 to 40 lbs/ft³ depending upon the thickness required.

CarbonFoam Fiber Reinforced Panel® ULTRA DUTY
Manufactured with polymer foam and an ultra-heavy weight woven fiberglass lay-up that offers superior mechanical properties, making it the ultimate product where the utmost specific structural strength is required. Available in a density range of 26 to 40 lbs/ft³ depending upon the thickness required.

# HOW TO USE CARBONBOND POURABLE TRANSOM COMPOUND

**CARBONBOND POURABLE TRANSOM COMPOUND** is ceramic filled polyester exhibiting exceptional physical properties. In particular, the compressive strength has been documented by an independent testing laboratory to be 3,895 psi (ASTM 695). This is several times that of plywood and 8 to 10 times that of PVC foam. In addition, the failure mode shows elastic yielding before failure. This makes the **CARBONBOND POURABLE TRANSOM COMPOUND** material an excellent choice for critical applications such as coring transoms on power boat hulls. There are three methods of employing the **CARBONBOND POURABLE TRANSOM COMPOUND** material as a transom core

**A. Specially Designed Hull Liner**

By appropriately designing the hull liner at the transom, a gap can be created into which the **CarbonBond Pourable Transom Compound** can be poured or pumped. Special consideration needs to be given to the details of bonding the liner to the hull so that a minimum of added time and material is required to seal the cavity.

The advantages are:

- The laminate to core bonds are exceptional
- The cycle time and labor are greatly reduced
- The absence of wood is a marketing advantage

**B. Use of transom jigs**

An alternative method that does not require retooling before being able to utilize the **CarbonBond Pourable Transom Compound** material involves the use of reuseable transom jigs, although other material will work also. After the hull is laminated, the jig is set in place and taped all around. The **CarbonBond Pourable Transom Compound** material is poured into the gap. After it has gelled, the jigs can be removed. Depending on the choice of material and release system employed, some surface preparation may be required in order to ensure adequate bonding of the subsequent laminate. An alternative to the above method involves skinning out the backside of the hull jig with 1 1/2 ounce mat prior to setting it in the boat. This provides a superior core to laminate bond. Next, a suitable laminate is added to the backside of the core or the 1 1/2 once mat. Because of the physical properties of the **CarbonBond Pourable Transom Compound**, it may be possible to reduce the laminate compared to that which is required for other cores. This should only be done after appropriate testing is conducted.

**C. Filling the Cavity**

Introducing the material into the cavity can be done either manually or by using dispensing equipment. It is critically important to insure that sufficient catalyst levels are employed and that thorough mixing takes place. Hand mixing can be an effective way to guarantee consistently takes place.

The CARBONBOND POURABLE TRANSOM COMPOUND material is truly an exciting new product, being successfully employed by quality conscious, efficiency minded boat manufacturers.

**Alternative method to filling the cavity and installation tips :**

**Installing CarbonBond Pourable Transom Compound** with transom jig-dam involves the use of reusable transom jigs made of fiberglass, plywood, plastic or metallic materials.

1. Template the inside of the boat transom to be filled with CarbonBond PTC to accuracy of 1/ 8"
2. Transfer the template to jig material and fabricate the jig-dam by cutting to 1/8" tolerances or better.
3. Apply seal or sealant (prior to pour) around the outside lower edge of the jig-dam to avoid compound seepage.
4. Inside the boat hull mark the final location of the jig-dam with visible marker.
5. Prepare the fabricated jig-dam for lamination, by cleaning and applying wax to the surface.
6. Gel-coat the jig-dam in horizontal position outside of the boat hull.
7. Apply laminate to the gel-coated jig-dam to the desired laminate schedule, that will form the inside laminate of the finished transom.
8. Green trim edges of the jig-dam and transfer the gel-coated, laminated jig-dam inside the boat hull, line up with marker lines.
9. Use mechanical fasteners or clams to secure the jig-dam in place for pour.
10. Pour or pump CarbonBond PTC into cavity
11. Remove jig-dam and tape transom to hull seam with fiberglass tape.

Product Data
Wt/Gal.: 7.25 lbs/Gal
MEKP: 8 lbs/Gal
Avg. lbs/pail: 36 lbs/pail

The chart shows the recommended catalyst addition for a working time of approximately **18 to 20 minutes**
Formulated for average material temperatures greater than 75° F

| Material Tempera-ture | % by weight | gm/gal | gm/5 gal | cc/gal | cc/5 gal |
|---|---|---|---|---|---|
| 60-65° F | 2.00 | 66 | 323 | 63 | 310 |
| 65-70° F | 1.80 | 59 | 290 | 57 | 279 |
| 70-75° F | 1.60 | 53 | 258 | 51 | 248 |
| 75-80° F | 1.50 | 49 | 242 | 47 | 232 |
| 80-85° F | 1.20 | 39 | 194 | 38 | 186 |
| 85-90° F | 1.00 | 33 | 161 | 32 | 155 |
| 90-95° F | 0.80 | 26 | 129 | 25 | 124 |

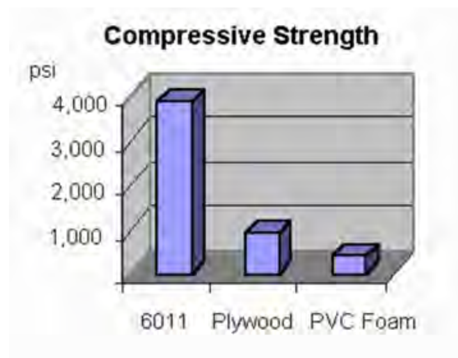
**Description: CARBONCORE** formulates its *Ceramic Pourable Compound* with premium polyester resins and high strength ceramic spheres resulting in high tensile and flexural strength. This lightweight compound is ideal for filling large volumes where strength and rigidity are major concerns. The *Ceramic Pourable Compound* mixes and pours easily from the 5-gallon pail.

**Features:**

- Excellent rigidity and strength , Formulated with premium resins
- Low exotherm
- Mixes easily, pumpable or pourable
- Excellent stability

**Uses:**

- Filling large volumes
- General purpose filler
- Radius compound
- Structural applications where high compressive strength is required




**Viscosity Ranges:** Viscosity (m) tests performed on Brookfield RVT (#7 spindle) at 77 deg F.

A winter version is also available.

**Gel Properties:**
Sample mass is 150 g initiated with 1.5% with DDM-9 MEKP @ 77 deg F
Gel Time: 18 - 24 min
Interval: 20 - 28 min
Total: 38 - 52 min

Peak Exotherm: 150 - 180 º F

**Product Specifications:**
Color and odor: Gray with styrene odor
Physical appearance: thick liquid
Weight per gallon: 7.1 - 7.3 lbs/gal
Uncured stability: up to 6 months (depending on storage)

Disclaimer: The information contained herein is solely for informational purposes. Suitability to task should be determined by user prior to specific application. Nothing herein constitutes a warranty, express or implied, including any warranty of merchantability or fitness. Before use and handling of this product, consult its MSDS for important safety information.

# WORKING WITH CARBONBOND CBC (core bonding compound)

Clockwise from the top:

1. Wet out or prime core prior to placing it into the CarbonBond CBC to eliminate wicking of resin from the compound.
2. CarbonBond CBC must be spread with notched trowel Gauge the evenness of the surface and remove obvious high spots from laminate.
   Smooth out surface by spreading evenly over area that you can finish within the gel time window.

| Material Temperature | % by weight | gm/gal | gm/5gal | cc/gal | cc/5gal | 30ml/shots |
|---|---|---|---|---|---|---|
| 50-60° F | 2.50 | 73 | 349 | 70 | 335 | 11 |
| 60-65º | 2.25 | 65 | 314 | 63 | 301 | 10 |
| 65-70° | 2.00 | 58 | 279 | 56 | 268 | 9 |
| 70-75º | 1.75 | 51 | 244 | 49 | 234 | 8 |
| 75-80º | 1.50 | 44 | 209 | 42 | 201 | 7 |
| 80-85° | 1.25 | 36 | 174 | 35 | 167 | 6 |
| 85-90° | 1.00 | 29 | 139 | 28 | 134 | 4 |
| 90-95° | 0.75 | 22 | 105 | 21 | 100 | 3 |

Normal application of CarbonBond CBC on a flat, smooth surface would require about 1/16" per square foot although in certain gap filling applications can be used up to 1/4" thick. Below are coverage rates per gallon and weight per square foot at different thicknesses.

| Thickness | Square feet per gallon | Weight per square foot |
|---|---|---|
| 1/16" | 25 | 2 oz |
| 1/8" | 12.5 | 4 oz |
| 3/16" | 9.38 | 6 oz |
| 1/4" | 6.25 | 8 oz |

# WORKING WITH CARBONCORE Plastic Honeycomb

CARBON-CORE is a polypropylene honeycomb covered on both faces with a soft polyester non-woven fabric. It is available in 2440 x1219 mm (4' x 8') ready for direct use: lamination or gluing. Other sizes are available. Please inquire.

The flexible and light sheets enable an easy use in sandwich panels where most usual techniques of cutting, laminating and gluing can be applied. Since it is a thermoplastic product, other additional specific properties make its use even easier.

**1 – CUTTING and MACHINING**

**1.1.- CUTTING**

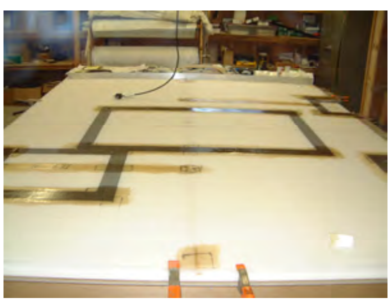
CARBON-CORE is conventionally cut by usual means: saws, knives or a hot wire as it is thermoplastic.

● **Saws –**
In order not to burst or melt CARBON-CORE when cutting, the best tooth spacing is close to:

**10 teeth per inch**

Circular saws are particularly suitable for straight parts.
½ to 1" wide band saws are suitable for straight cuts, 3/8" for curved cuts.

● **Knives –**
Cutting with a knife is possible. A "hawk bill" or "Linoleum" knife is quite suitable.
●**Hot wire –**
Cutting can be carried out with an approx. 2mm tensioned wire heated at about 350˚Cs (662°F).



Deck hatch being manufactured using vacuum bag. Note the PVC foam perimeter to ease post machining of the hatch. Photo courtesy of Dixon Marine, NY

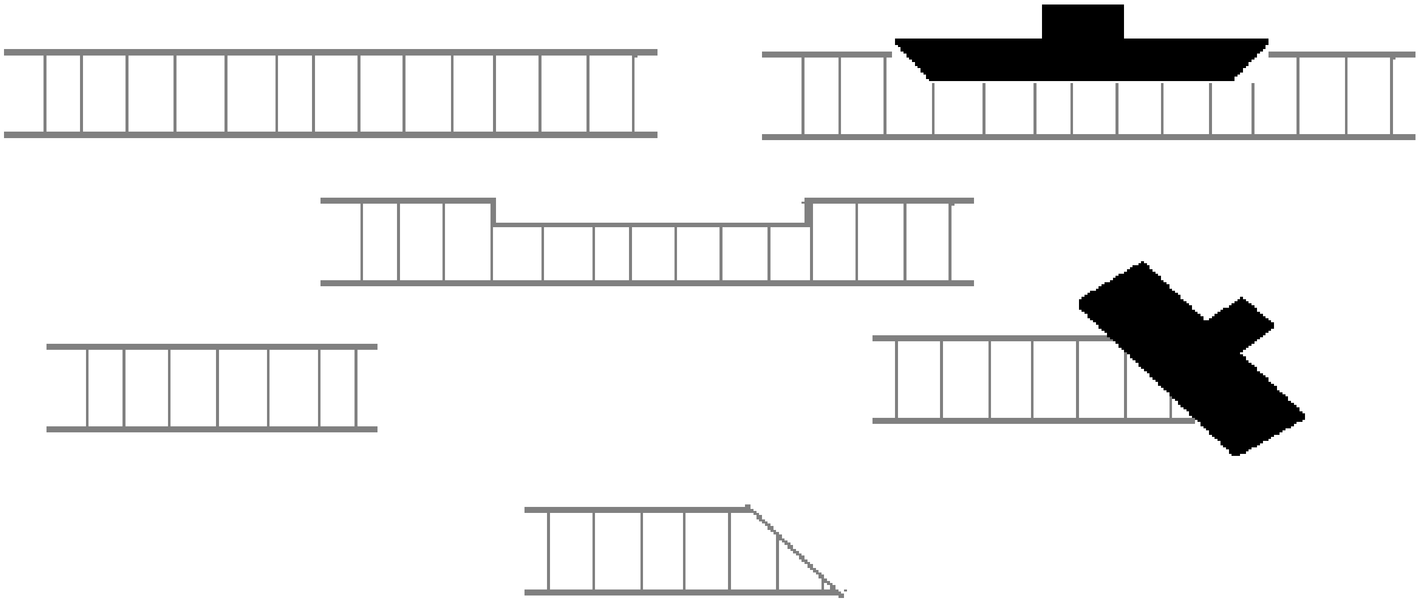
**1.2– Machining**

● **At cold temperature –**

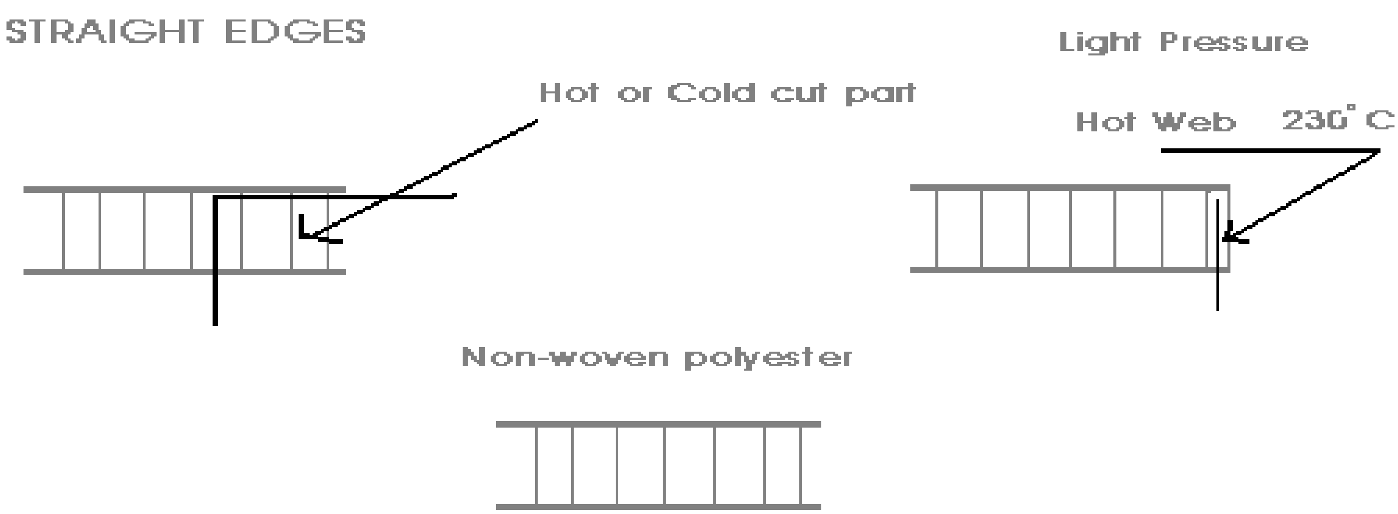
Classical tools for wood (ripper, grinder…) can be used by adapting the number of cutting blades and possibly the speed (too few blades can burst CARBONCORE; too many can melt it).

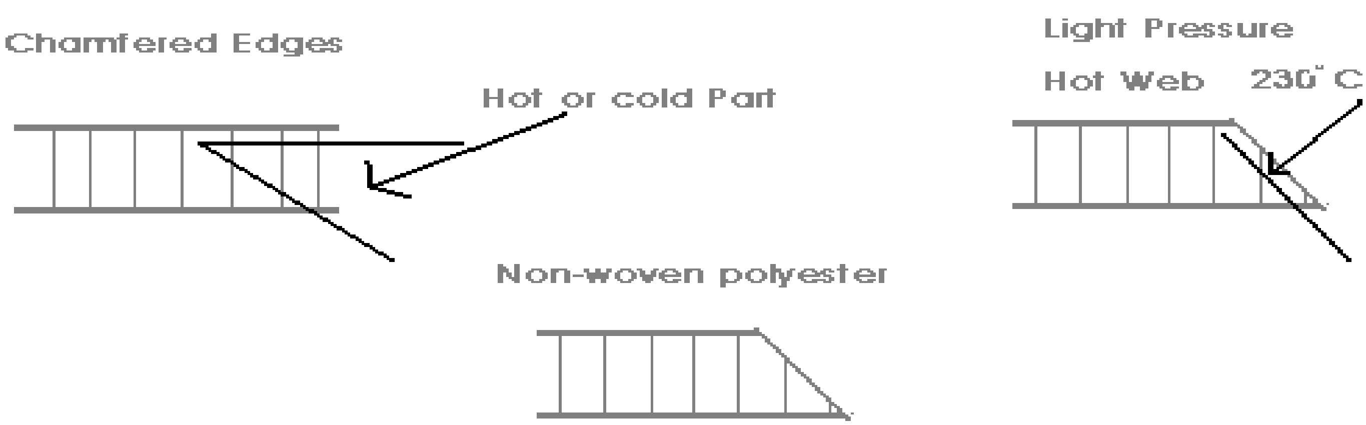
● **At hot temperature –**
Another way is to use the thermoplastic property: softening under heat. CARBONCORE polypropylene cells melt at 160˚C (320.0°F) whereas the non-woven polyester, which covers the facings, melts at 240˚C (464°F).

Hence if CARBON-CORE is heated at about 200˚C (392°F), (it melts locally to the shape required (hot stamping) without damaging the non-woven facing.



Second way is to cut the required shape and then to re-weld the non-woven polyester. For example, the following edges can be achieved:



## 2 - FORMING

### 2.1 – COLD FORMING

The soft polyester non-woven scrim, which covers the large faces of CARBONCORE, makes it formable by:

In the *case* of *standard panels (*3 psi to 12 psi) should be applied during curing time of polyester or glue. This can be done on a mold with vacuum or a matched die mold and a press.
In the case of *marine panels* (scored 2” x 2” = 50mm x 50mm one side), a simple mold is sufficient

### 2.2 - HOT FORMING and PREFORMING

Again a thermoplastic product is easily thermoformed:

In an oven, in a mold, at less than 100°C (212°F), CARBONCORE softens and under a very light pressure it very easily takes the required shape.

CARBONCORE can also be hot preformed. Two possible processes:

- Pre-heating in an oven between 140°C (284°F) and 150°C (302°F), then forming in a cold mold.
- Forming in a mold heated at 130°C (266°F) -140°C (284°F).

In both cases CARBONCORE will keep its shape at cold temperature.

In all cases, temperatures, pressures and timings should be set up according to the shape of the part and to the thickness of CARBONCORE.

## 3 - WORKING UP

Sandwich panels with a CARBONCORE core can be achieved either by direct laminations or by gluing a rigid skin.

### 3.1 - LAMINATION

The non-woven polyester applied on CARBONCORE is an ideal surface for direct lamination of thermo hardening resins of polyester type (or other). However, considering their huge variety, resin formulations and lay up techniques should be checked against their compatibility with CARBONCORE.

Most traditional techniques (hand lay up, spraying, vacuum, pressing, low pressure injection), which are function of existing tooling and depend upon the parts to be achieved, can be applied and need only slight adjustments to CARBONCORE specificities.

CARBONCORE is especially suitable for lamination. Indeed, CARBONCORE Plastic Honeycomb has, as an under face of the non-woven polyester, a plastic film which restricts resin passing trough into cells.

The operating principle of sandwich panels is to have a perfect adherence between the core and the rigid skins. Therefore when working up a panel, it is necessary to check:
- The good impregnation by resin to the core and skins.
- The good contact, e.g. through pressure, between the core and the skins.

**• Manufacturing process of a laminated sandwich panel with a CARBONCORE core:**

a) Traditionally make the first skin of sandwich panel (gel coat on the mold, then required layers of glass-resin).

b) Before the first skin has hardened, apply CARBONCORE, interposing an extra ca 400-g/m² quantity of resin, either applied on the skin or on CARBONCORE when hand lay up laminating.

If necessary, in the manufacturing process or in case of a thin laminate and if a very high quality surface finishing is required, it is possible to let the gel coat and one of several layers of glass-resin polymerize. As soon as polymerization is over, a last of glass-resin is spread in order to glue CARBONCORE as explained earlier. It is also possible to glue with low shrink polyester glue.

c) On CARBONCORE, traditionally apply the required layers of glass-resin of the second skin, providing for and extra ca 400- g/m2(11/2 fl. oz. /ft²) quantity of resin to impregnate CARBONCORE and to ensure gluing with the laminate.

If necessary or if a gel coat finishing is planned on both faces of the sandwich, either a mould or counter mold are used, or the first layers of the laminate are made first and they are glued to CARBONCORE as explained before.

Pouring resin in heaps on CARBONCORE without spreading it immediately should be avoided in order to prevent it from going through into the cells by gravity.

As CARBONCORE is a heater insulator, using a resin with too much exothermic should be avoided since it could damage the laminate or cause air bubbles.

A glass mat should be preferred to a fabric for direct contact with CARBONCORE.

d) Once the part is achieved, it is advised to apply the most evenly distributed pressure on the whole (vacuum, press, and weight…).
Hand lay up working is possible but a good CARBONCORE laminate bonding (on the mould side) should be ensure by a former impregnation of CARBONCORE then by a hand pressure on CARBONCORE when fitting it. It is the same on lamination by simultaneous glass-resin spraying. Bonding of the other side is easier to check, as it is visible: additionally it is naturally made on the pressure un bubbling of the glass-resin layers.

**• RTM**
RTM techniques are possible with some products of the CARBONCORE range. It depends on the technique used, injection pressure, temperature, and fluidity; therefore it is preferable to consult us in order to decide together upon a suitable product.

### 3.2- <u>GLUING</u>

There again, non-woven polyester is used as a gluing surface to a lot of rigid skins such as wood, melamine laminates, marble, fibrocement or metal.

The glue to be used essentially depends upon the skin to be glued and on the physical and mechanical strains applied to the finished sandwich panel. Numerous glues were already satisfactory tested on CARBONCORE: polyurethane, epoxy, neoprene, vinyl, polyester, and urea formaldehyde.

However, in all cases using glue, tests should ensure compatibility of the different materials and the mechanical properties of the sandwich panel made. Polyurethane or epoxy bi-component glues are the most often used thanks to their good mechanical characteristics and their adherence on most materials.

- **Gluing process of sandwich panel with a CARBONCORE core:**

According to the manufacture's directions, evenly apply the required quantity of glue on the rigid skin or on CARBONCORE or both at the same time, if so required by the glue. For polyurethane glue the quantity should be around 400 g/m2(11/2 fl. oz/ft.2)

In the same way apply glue on the second skin or on the face of CARBONCORE.

On the panel made apply the pressure specified for the glue, minimum of 0.2 bars and maximum of 1 (15 psi 29 in Hg.) bar is enough with regard to CARBON-CORE. Let the glue set under the indicated conditions before handling or applying efforts on the panel.

Characteristics of the sandwich panels are mainly due to the good adherence between the core and the skins, therefore a special care should be brought to gluing and the results obtained should be well checked.

***Note:*** *Cells may show through the glued skin if the latter is too thin or not rigid enough. Print through is made worse by an excessive gluing pressure and/or the glue shrinkage when drying.*

### 3.3- <u>WORKING UP PREPREGS</u>

The high melting temperature of polypropylene makes it possible to use pre-pregs, which polymerize at temperatures up to 125ºC (at 100ºC [212°F] CARBONCORE still resist to 1 daN/cm compression).

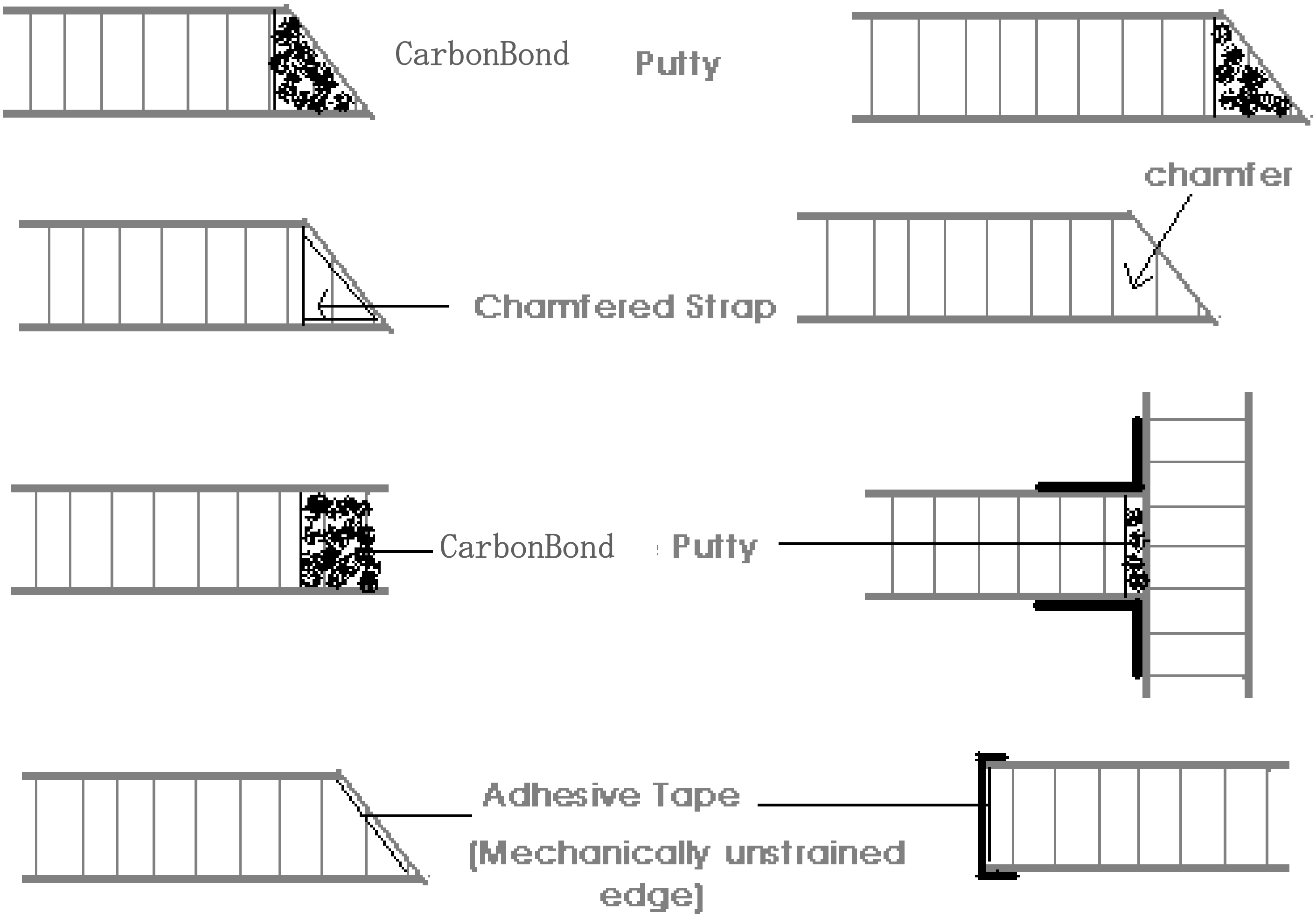
Position the pre-preg on CARBON-CORE, apply pressure at the required temperature and let the whole polymerize. According to the temperature and to the polymerization time, check that there is no risk of collapse of CARBONCORE due to the flow. Under a press, a possible solution consists in positioning shims very slightly less thick than CARBONCORE in order to avoid this flow.

De-molding should not be carried out too hot to avoid any risk of distorting the panel or of delaminating CARBONCORE.

# 4 - FINISHING of the SANDWICH PANEL

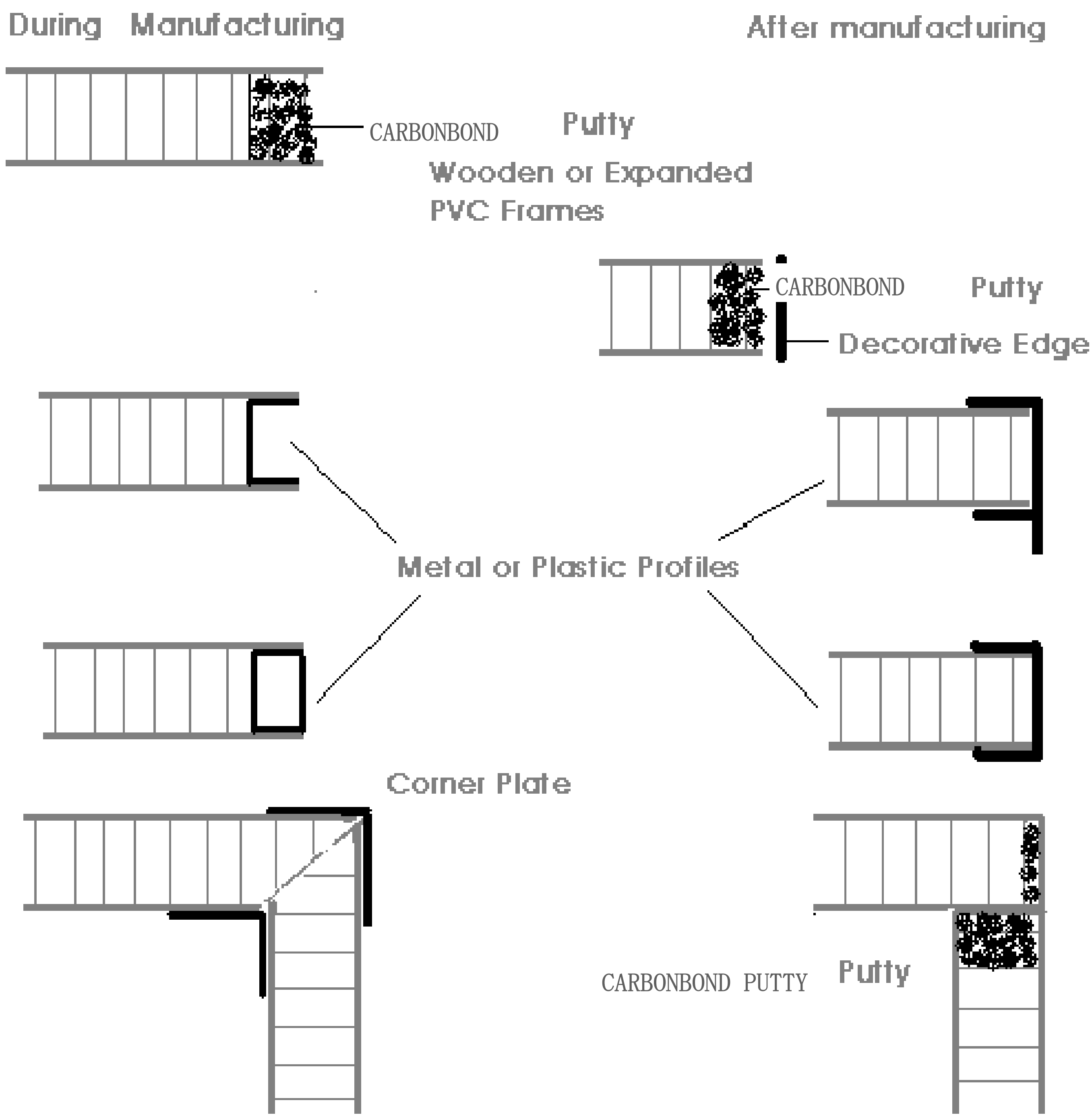
### 4.1.1 – Laminated panels –

Several types of finishes are possible in case of laminated panels. Molding of polyester skins makes it easier to work out edges as shown in the following examples:




Most frequently, edge finishing is carried out through a frame or a finishing profile. Its material will be chosen according to the physical-chemical strains of manufacture and use. Wood is interesting by its very wide flexibility of use but it may require trimming and is sensitive to moisture. Plastic or metal enable a direct finishing but need a very exact size.

Setting the frames or profiles can be carried out, as shown by the following examples, either before or after the panel is made:

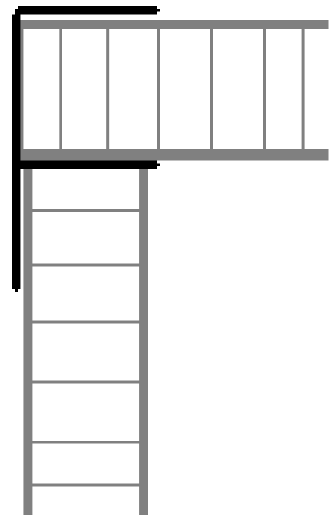



### 4.1.3 – Glued panels

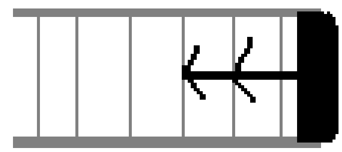
Several types of finishes are possible according to the skins, the panel use and the mechanical strains applied.

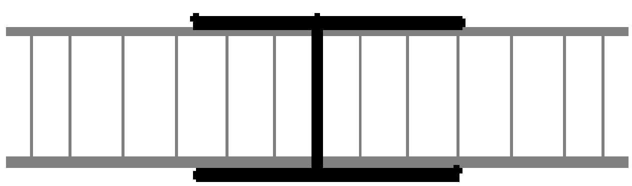
Unstrained decorative edges can be merely glued on both rigid skins. In case of a metal sheet, a mere fold can hide the edge.

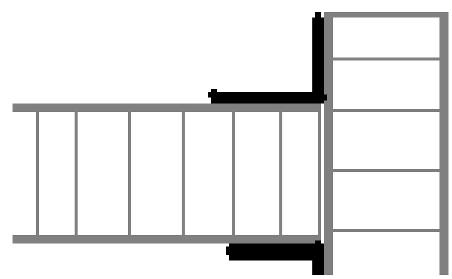
Glued Edge Strap

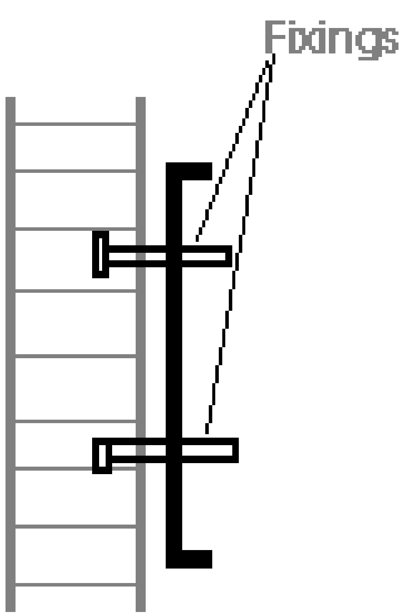


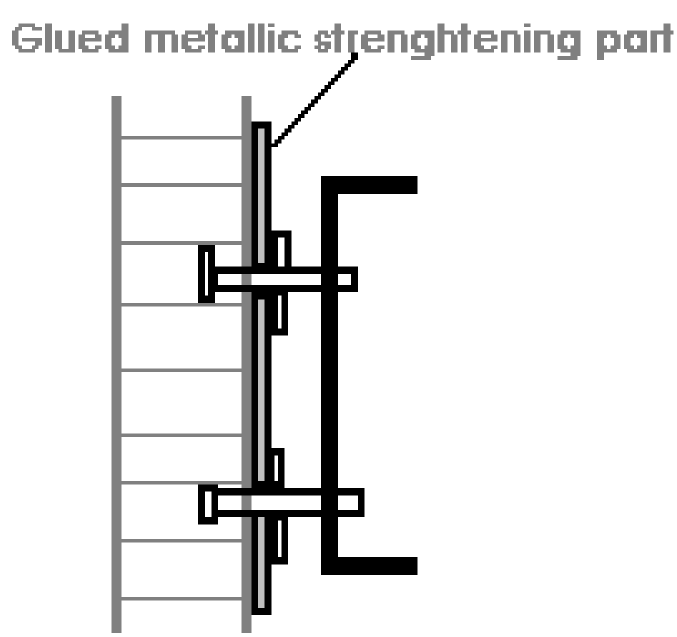
Fish Tail Profile









### 4.2 – LOCAL STRENGTHENING PARTS, FIXING INSERTS for ELEMENTS OR OBJECTS

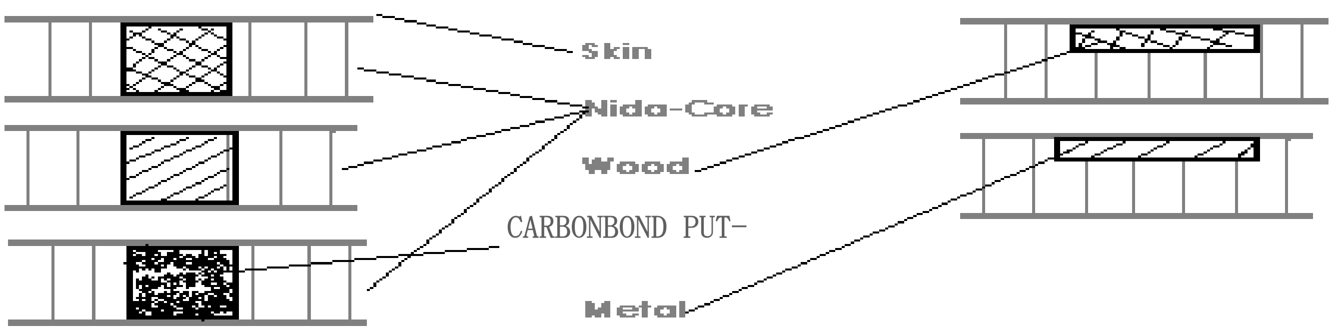
Fastening elements on a sandwich panel may require local strengthening parts or inserts. Choosing the adequate solution essentially depends on the strains transmitted by fixing to the skins or to the core. Fixings can be traversing or not.

#### 4.2.1 – NON-TRANVERSING FASTENING

##### 4.2.1.1 – *Light loads* –

Considering the good cohesion of CARBON-CORE and the good adherence of skins if they were bonded up properly, fastening can be carried out in a normal way: rivets, bolts and, self tapping screws, on only one skin (Fig. 1).

If the load makes it necessary or if the skin is insufficiently strong, a glued metallic strengthening part can be added and will distribute the stress (Fig. 2).




##### 4.2.1.2 – *Heavy concentrated loads-*

● In case of non-though fastenings, the most frequent solution consists of, before gluing the skins of the sandwich panel, in placing inserts which locally build up a solid panel into which fastening is carried out in a classical way.

The most frequently used insert is wood, but metal or resin inserts are also suitable.

The insert can occupy the full or only part of the thickness of the panel.

● For a greater flexibility of use, it is also possible to make resin inserts on finished panels.

Considering the fixings to be made, inserts can be large or small:

A) *Large inserts*

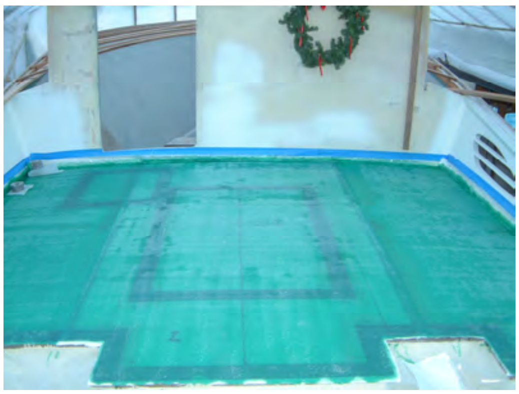
The upper skin is removed from the surface concerned by the insert. A mastic resin is applied with a spatula into the cells of CARBON-CORE. Once the resin is dry, its sandpaper leaves a clean and surface on which solid fixing is possible.

b) *Small inserts*

The upper skin is perforated at the spot planned for the insert. Using a cutting tool, a few cells are sheared around the hole then filled up with resin. Fasteners can be inserted into the resin.

**4.2.2. <u>THROUGH FASTENINGS</u>**

Through fastening can be carried out: with inserts as described above, with a metal or pultruded plastic compression sleeve, with to specially adapted fasteners.



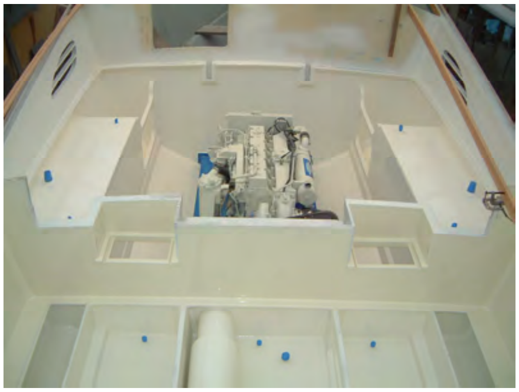
Cabin sole laminated withplastic honeycomb with PVC foam inserts. Photo courtesy of Dixon Marine, NY.

Engine room constructed using plastic honecyomb +18 oz WR panel system for sound and vibration absorption.

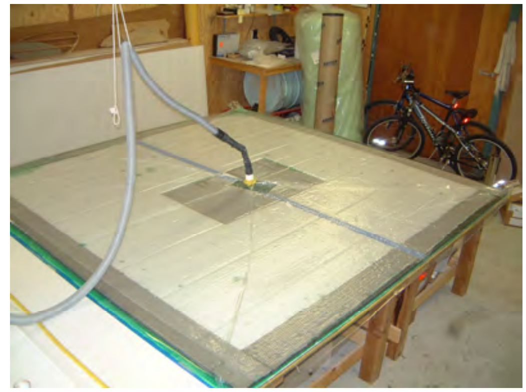
**4.3 – <u>THERMOWELDED INSERTS</u>**

Because of its polypropylene composition, CARBONCORE can very easily receive polypropylene inserts by friction welding. The 15mm thick insert, whose diameter can vary according to the resistance wished, is positioned on CARBONCORE at required spot.
Using to a rotating tool at 1500 revolutions a minute, a light pressure is applied on the insert.
Rotation and pressure create the heating, which enables a perfect welding between the insert and CARBONCORE.

The panel thus prepared can received the final skins. On the insert, solid fixing is carried out with specially adapted screws.



Professional, clean installation utilizing plastic honeycomb panel system for low weight, chemical resistance, sound absorption and gel coat finish.



Large hatch being constructed with plastic honeycomb and PVC foam inserts. Core installed by vacuum bag method. Photo courtesy of Dixon Marine, NY.

*The indicated direction can serve as a guide to use the product but cannot be considered as a guarantee of a good working up. Additionally application, utilization and/or transformation of the products escape our control possibilities. As a consequence, they exclusively remain the responsibility of the applicator and/or the user and/or the transformer.*

## VACUUM CORE BEDDING

## CARBONCORE PLASTIC HONEYCOMB

Vacuum core bedding is probably the best single means of controlling quality in sandwich core construction. The process is simple and easily mastered. Expendable materials are minimal, consisting of bagging film, sealant tape and perhaps some distribution media such as bubble pack, spiral wrap. The objective is to apply a bonding medium such as saturated ¾ to 1 ½ oz CSM  or more preferably CarbonBond CBC core bedding compound and use the vacuum bag to apply an even pressure over the entire bedding area to effect the best possible bond with no voids.

1. The first step is to insure that the laminate where the core will be bedded is relatively smooth without lumps and free of dust.
2. Next, the core is pre-cut to fit the area to be bedded.
3. Place the sealing or “tacky” tape around the perimeter of the area to be bedded leaving release paper on top. The release paper will help keep resin, chopped strand glass or CBC bonding media from contaminating the sealant tape.
4. Pre- cut the bagging film slightly larger than the area surrounded by the sealant tape. This is to prevent the vacuum bag from fitting so tight that it “bridges” from the top edge of the core rather that may cause excessive pressure which may squeeze resin or CBC from the under the core edge and creating a poor bond.
5. The core bedding media (catalyzed CarbonBond CBC or CSM wet out with catalyzed resin) is applied to the laminate. If the CBC is used it should be troweled on to a thickness of ¾ to 1 millimeter. Chopped strand mat should be evenly wet out and the air bubbles rolled out.

1. The bedding face of the core should have a light wetting with catalyzed resin immediately prior to bedding regardless of whether CarbonBond CBC or CSM is used. This is to prevent leaching from the media which might cause a dry area and result in a poor bond or worse, no bond. The core is then placed into the bedding material.
2. If an air “frog” is used for evacuating the bag, it should have been already installed where it will be in close proximity to the “distribution media”.
3. Place the “distribution media” on top of the core.
4. Lay the pre-cut bag on top of the “distribution media” and seal the edge down as the release paper is pulled off the sealant tape. As the film is somewhat oversized there will be some folds or puckers at the edge of the bag that will require some sealant tape to fill and seal the fold.
5. When the bag is completely sealed, the vacuum hose is attached to the “frog”. If a “frog” is not used, a small hole must be cut in the bag and the hose inserted and sealed to the bag. Provision must be made to insure the vacuum bag cannot be drawn to and close off the end of the hose. If spiral wrap is used for the distribution media, the end of the hose may be actually be inserted into the end of the wrap. PVC pipe, cross-drilled with 3/16” holes every six inches can also be configured to draw from a very large area.
6. Start the vacuum and check for leaks. Maintain a vacuum of no more than 14 in/Hg (approximately 7 psi) with the CSM bedding. The CarbonBond CBC may be used up to 25 in/Hg (about 12.5 psi).

Do not release the vacuum until the bonding media has cured hard and dropped back to ambient temperature. General Observations

1. Start small and work your way to larger areas as you become familiar with the process.
2. Have your materials pre-cut and ready to use.

Do a dry run or two to get the feel of the process before actually applying the bedding media.

Figure 1:

**HOW TO WORK WITH CARBONCORE VENEER SKINNED PANELS**

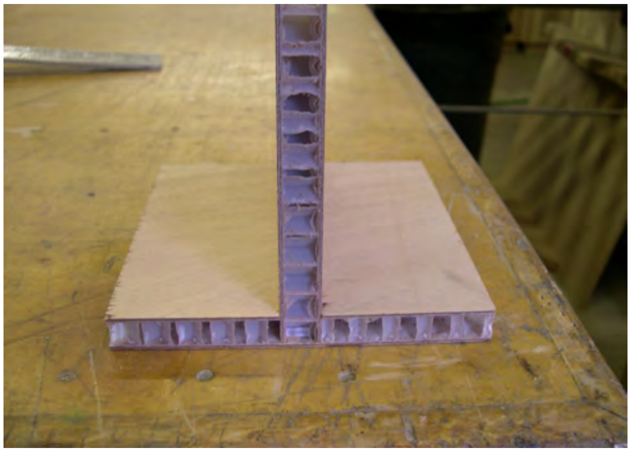
Carbon-Core Okoume and Lauan/Mderanti panels are an ideal way to save weight for your yacht cabinets. The heart of the panel is the same Carbon-Core polypropylene honey comb, that yacht builders have trusted for years to give them years of tough, rot proof service, that they have learned to expect, from the industries premier core manufacturer.

The panels come in thicknesses that mock the plywood that you are used to using, so the geometry of the cabinets, need not change.

Cabinet joints can be accomplished by several methods.

Cut a dado through the core, but not through the back veneer, the full thickness of the finished CarbonCore panel. Brush in thickened epoxy, and insert panel into groove. See figure 2.

Figure 2



Another method of fixing shelves or bulk-heads is by attaching a spline with epoxy then dado the core from the adjoining panel the depth of the spline, brush in thickened epoxy and slip the panel over the spline. (See figure 3 & 4)

Figure 3:

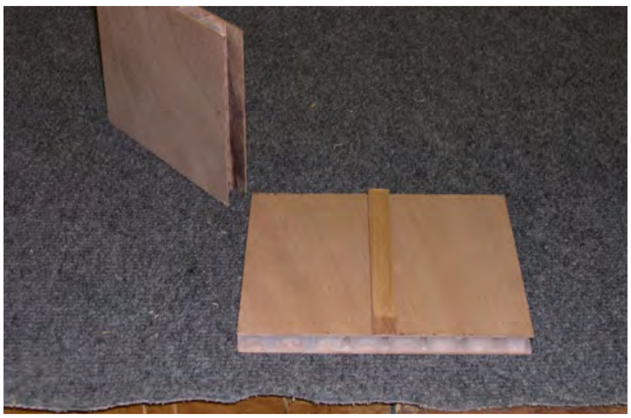


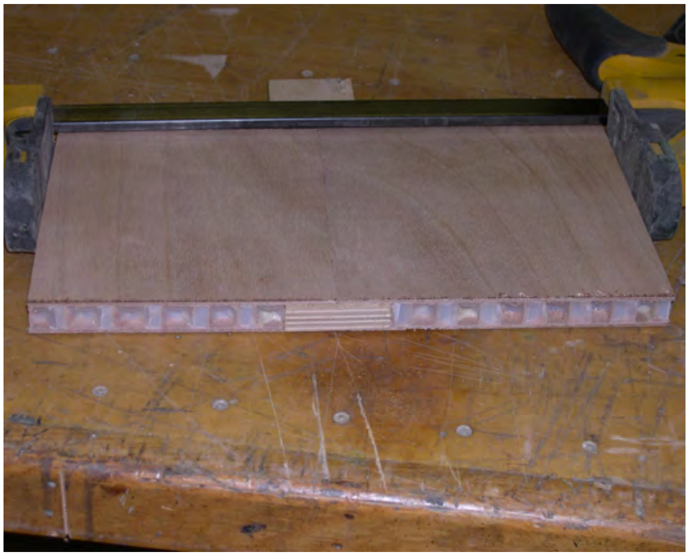
Figure 4:

An out side corner, can be accomplished much the same way, only you will rabbit the edge of one panel (Figure 5) and apply thickened epoxy into the rabbit, and clamp in adjoining piece, (Figure 6)

Figure 5:

Figure 6:

Figure 7:



To join two panels edge to edge, dado both panels the thickness of the core, brush in thickened epoxy and inserts a spline. (See figure 7)

If a radius is required, kerf the panel at the starting point of the radius. Clamp the panel to a flat surface and raise the loose end until the kerf is closed. Measure the distance between the raised portion and the surface of the bench, at the desired radius. If the radius is to be 3 inches then measure 3 inches from the kerf then measure the distance the raised portion is off the bench. This is the distance between saw kerfs. Spread thickened epoxy into the kerfs and bend to the radius desired. Squeegee off the excess epoxy from the back of the panel.
See figures 8, 9 & 10.

Figure 8:

Figure 9:

Figure 10:

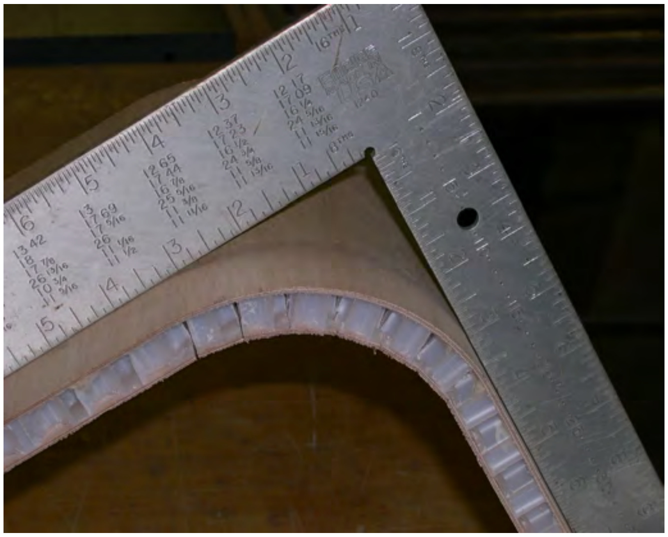


Figure 11:

Cutting a dado into a solid frame, and gluing the CarbonCore panel into the dado can accomplish door frames. There is no special treatment to the panel. (See figure 11)

A door can be hung in the frame by one of two methods. Dado the core out of the edge of the panel, brush in thickened epoxy and insert the spline.
(See figure 12 & 13) Then attach the hinge as normal and hang the door. (See figure 14)

Figure 12:

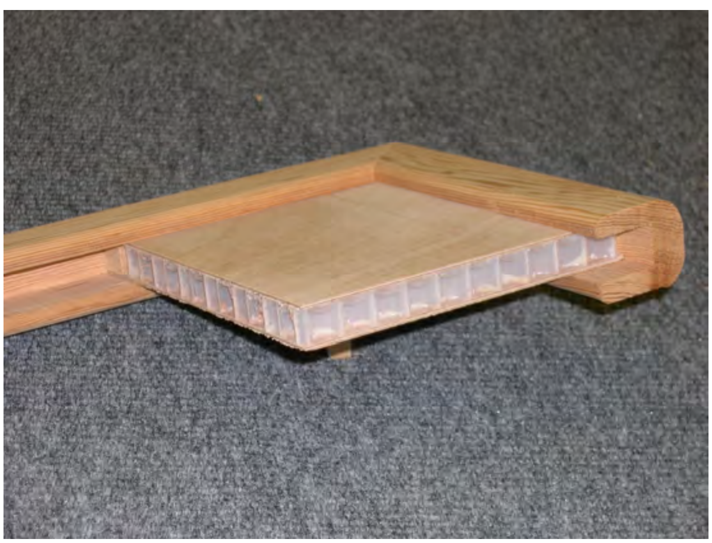
Figure 13:

Figure 14:

You can also make a frame for the door as in figure 14 and hang as normal.

Counter tops and table tops, or shelf edges can be accomplished by cutting your edge molding to the desired shape and brushing in epoxy then bonding it to the panel. (See figure 16)

Figure 15:



When using a cored panel, careful planning will eliminate problems encountered once the cabinet is assembled. There is very little extra time involved but the end result will be a very strong and lightweight cabinet.

If you have specific questions or concerns about changing your process to CarbonCore panels, call 1-434-990 9909 and consult our technical staff.

**Payment:**

COD or Pre-approved account: subject to credit approval. All late invoices will incur a 1-1/2 % late charge per month. Refer to credit application for other terms and conditions on open accounts Additional 1% prepayment discount available on all orders. VISA, MasterCard, AMEX ,Discover, Paypal Accepted

**FOB:**

TROY,VA

**Freight:**

All orders are shipped freight collect; Carrier shall be determined by customer. Shipments will be shipped best way unless otherwise specified.

**Lead Times:**

Delivery on standard CarbonCore in stock products is normally within 1 -2 weeks ARO All ship dates will be confirmed at time of order placement. Carbon-Core Corp. will not absorb any losses for missed schedule dates beyond our control.

All orders placed will be reviewed individually.

**Sample Policy:**

A free of charge sample can be arranged for delivery at customer's request. Courier charges will be the responsibility of the customer. Please consult with your sales representative for details.

**Return Policy:**

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The product information presented herein is believed to be reliable yet is not to be construed as any type of warranty or representation for which Carbon-Core Corporation assumes any legal responsibility. All risk and liability arising from the fabrication of any of the core related systems shall rest with the buyer or user. No warranty of fitness for a particular purpose or process is made. Any and all disputes including but not limited to product liability must be adjudicated in the Courts of the State of Virginia subject to the laws of Virginia. Since some information may have been updated since the time of printing, please check our website for most up to date information. Carbon-Core Corp. reserves the right to make changes at any time, without notice, in materials, equipment, specifications and availability. Any and all disputes including but not limited to product liability must be adjudicated in the Courts of the State of Virginia subject to the laws of Virginia.

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