# Advantages of Corecell versus Other Core Materials in Composite Marine Structures

**Introduction**

Cores, in sandwich construction, are specified by designers and builders to increase stiffness and reduce the weight of a composite structure. While single skin laminates, made from E-glass, S-glass, carbon, aramid, or other fibers are strong, they are not always stiff due to their relatively low thickness. Inserting a core provides additional thickness to the laminate, without adding unnecessary weight. The core acts like a web in an I-beam, separating the flanges and taking the shear stresses to give the whole assembly better stiffness and strength in bending. This results in better performance for both sail and power boats.

To be successful in the marine industry, a core material must have a variety of features and perform well in most of these areas to be considered a good choice. A number of different materials have been introduced over the past 50 or so years, with Corecell being the most recent development, demonstrating particular advantages over other cores, including PVC foams, honeycomb and balsa wood.

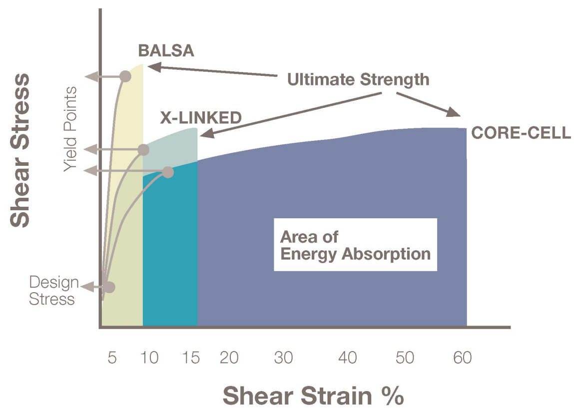
There are a few key considerations for a boat builder when choosing a core material—the conditions under which the core has to work (for example, the hull of a boat can be exposed to extreme conditions, such as repeated slamming against waves, collision with other vessels or sea-found objects, and constant water immersion), the other materials to be used in construction, (for example, the type of fiber reinforcement and the type of resin, which may vary from polyester, vinyl ester to epoxy), and cost.

In this paper we will compare the advantages of Corecell over other core materials in the following areas:

- Toughness and impact resistance
- Stiffness and weight
- Water absorption
- Compatibility with other composite materials
- Cost

**Toughness and Impact Resistance**

A sandwich using a foam core with a high degree of toughness has more impact resistance than a sandwich with a stiff but brittle core, or a single skin laminate of equal or even higher weight. The core acts as a shock absorber that evenly supports the outside skin in severe impacts, and protects the inside skin by dissipating the impact load over a wider area. It absorbs the impact without failing and remains watertight even after high impacts. The core therefore needs to have enough elasticity to absorb the impacts and maintain the bond to the skin under such conditions. But not all foam cores can do this effectively.




This graph shows the relative shear strength and strain to failure of the most commonly used marine cores. While all are stiff at the design stress (well below yield), the graph shows significant difference in the area of energy absorption—the area under the curve—an indication of relative toughness. Corecell, with up to 60% shear elongation, is therefore three times tougher than cross-linked PVC foam and seven times that of balsa.

The more brittle cross-linked PVC foams crumble and shear under severe impact, and are better used in low-impact areas. Brittleness also lowers the resistance to crack propagation. Once there is a crack, such as the 45° crack occurring under impact, it can easily propagate as the sandwich panel continues to flex.

Although aluminum honeycomb produces one of the highest strength/weight ratios of any structural material, it performs poorly when resisting impact. The core will deform irreversibly, whereas the skins will move back to their original position, which results in a locally de-bonded area of skin with much reduced mechanical properties. Corecell foam, however, bounces back to shape after impact, ensuring the bond is not broken.

Balsa performs in a similar fashion to an aluminum honeycomb on impact. However, due to its high

**Single skin fiberglass panel, produced with seven layers of Biax 1808, one layer of mat, and a GP resin. (panel weight 15.6 kg/m²; 3.1 lb./ft.²).**

**Cross-linked PVC foam, 80 kg/m³ (5 lb/ft³), center cross-section. Panel shows typical stress/shear cracks and crack propagation in the core along the skins. (panel weight 14.4 kg/m²; 2.8 lb./ft.²).**

**Balsa-cored panel. Damage to the load side skin is minimal, but core shear cracks and delamination occur throughout the entire panel. (panel weight 16 kg/m²; 3.2 lb./ft.²).**

**Corecell A500 80 kg/m³ (5 lb/ft³), showing local damage to the outer skin, but no foam failures or delamination. (panel weight 14.4 kg/m²; 2.8 lb./ft.²).**

compression strength, an impacted balsa panel often shows no outward sign of damage, lulling the boat owner into thinking there is no serious damage. Yet impacts are readily transmitted from the outside skin to the inside skin, the end grain splitting parallel to the grain and causing local skin delamination. However, unlike the brittle cross-linked PVC foam, delamination usually stays localized.

The hull bottom is not the only section of a boat which should be considered an impact area. Hull sides as well as foredeck and cabin sides can also be faced with slamming-like pressures from boarding seas. These loads are transmitted to the bulkheads inside. For builders wishing to build safe and long-lasting boats, Corecell is the accepted foam core for use throughout the entire structure, hull bottom and sides, main bulkheads, deck and superstructure.

### Stiffness and Weight

Cores were introduced into the marine industry in the 1950s, to increase the stiffness and reduce the weight of laminates. We can see from the graph to the right what a difference a foam core, like Corecell, can make to the stiffness.

Balsa wood was the first type of core to be used in boats. Then boatyards started using composite sandwich laminates and balsa was adopted as the default core material—foam at this point was not available. Balsa has a number of advantages including good stiffness, good thermal insulation and initial positive flotation. However, in an industry where weight is playing an increasingly important role, standard balsa is always a heavier option through its high density and its tendency to absorb large quantities of resin during lamination, adding not only weight but also cost to the overall component. Special lightweight graded balsa can partially alleviate this weight problem, but then the cost rises to the level of the higher performing Corecell.

Cross-linked PVC foams have a similar stiffness to Corecell, both of which are stiffer than linear PVC foams. Cross-linked PVC, however, has much less ductility than Corecell, so does not perform well under impact. Linear PVC has good toughness, but much lower stiffness and heat tolerance. Corecell, however, was designed to have the best balance of properties.

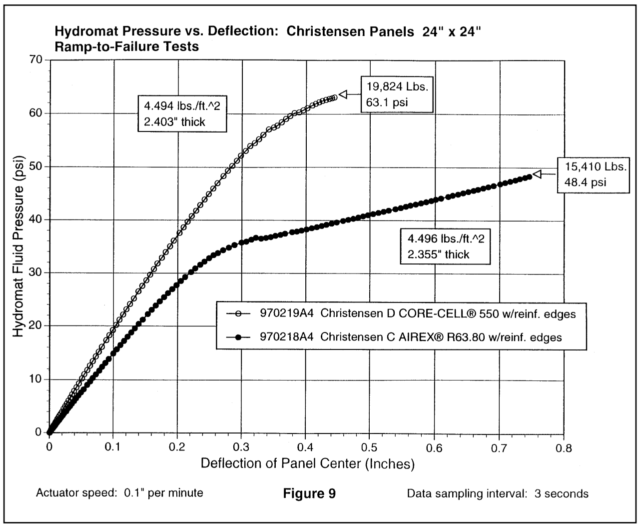
### Water Absorption

As boats are kept in the water for most of their useful lives, it is vital that composite components such as hulls can withstand constant water immersion. This is where Corecell performs particularly well when compared with other core materials.

Despite its good mechanical properties and relatively low price, aluminum honeycombs are rarely used in marine applications due to potential corrosion problems when in a salt-water environment.

Although balsa, as discussed, has a number of strengths, one of its primary weaknesses is its poor performance in water. Balsa soaks up water from small cracks in the skins and has low resistance to water vapour permeability. A number of boatyards have replaced ruined balsa with Corecell.

Corecell has a closed cell structure that is approved by all the major ship classification societies for use in the marine environment. This testing has shown that there is no loss in strength after soaking the material in water. Corecell has been tested and approved for use in the boundaries of integral diesel fuel tanks and has been rigorously tested against IMO criteria for use in the structure of rescue craft.

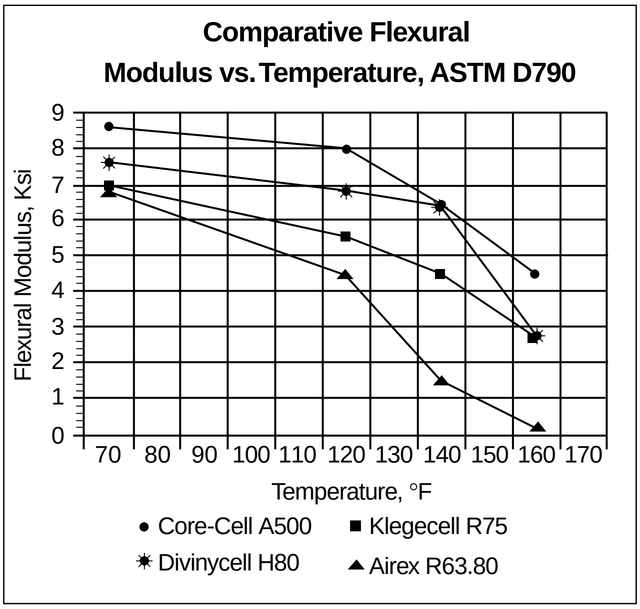



**The Hydromat is used to test two panels with identical layups, but with different linear foam cores: Airex R63.80 and Corecell A550, both cores having similar densities.**

**Compatibility**

Linear PVC foam has a lower resistance to elevated temperatures and styrene, and lower mechanical properties than Corecell, making it less suitable for using with polyester resins and the higher temperature curing epoxy prepregs. It is therefore not recommended that standard PVC foam be used with prepregs.

Balsa wood is also typically not recommended in elevated temperature applications because of the moisture content of the wood.

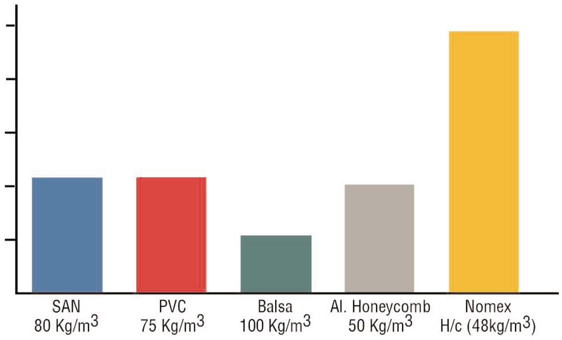



**Flexural Modulus vs. Temperature of different foams. These results represent the foam only, without a sandwich skin.**

Corecell, however, is compatible with all commonly used composite manufacturing techniques and materials. It has been used successfully with polyester, vinyl ester and epoxy resins, and can be processed using wet lamination, infusion and prepreg methods. It has excellent thermal stability and can (in P-Foam and T-Foam form) be cured at the higher temperatures required of most prepregs, as well as being used successfully on dark-coloured hulls, which are exposed to hot climates. Less stable foams can outgas and cause delamination in such conditions.

**Cost**

As seen from the graph below, the cost of Corecell compares favorably with the cost of other core materials. Whilst balsa is the cheapest option, the weight penalty, low impact strength and potential for water absorption makes it a less attractive offer. As previously described, it also absorbs extra resin, the additional cost of which much also be taken into consideration.




**Comparative Prices of Core Materials**

While having high mechanical properties, low density and good long-term stability, honeycomb is typically only used in Aircraft and Aerospace application as well as very high end race boats. because of its high cost and more difficult processing method.

**Summary**

The table overleaf shows a normalized comparison of the commonly used marine core materials. While some cores have a few outstanding properties, designers and builders must determine the overall performance of the core and choose accordingly. For less demanding applications than typical marine use, a separate analysis may show another core material to be a better choice, but for demanding applications this analysis shows Corecell to have a distinct advantage.

## Core Material Evaluation Comparison Table

| | Balsawood | Honeycomb Plastic | Linear PVC (Airex R63.80) | Cross-Linked PVC | SAN (Corecell ) |
|---|---|---|---|---|---|
| Closed Cell Structure | 3 | 1 | 10 | 10 | 10 |
| Resistance to fresh/salt water | 3 | 6 | 10 | 10 | 10 |
| Resistance to Water Vapor Transm. | 2 | – | 9 | 9 | 8 |
| Resistance to Rot/Deterioration | 2 | 9 | 9 | 9 | 9 |
| Resistance to Gasoline/Diesel Oil | 7 | 6 | 9 | 9 | 10 |
| Resistance to Styrene | 10 | 6 | 4 | 8 | 7 |
| Outgassing Tendency | 8 | – | 10 | 1 | 10 |
| Compression Strength | 10 | 3 | 2 | 4 | 3 |
| Flexural Modulus | 6 | 4 | 4 | 6 | 8 |
| Shear Strength | 10 | 3 | 7 | 8 | 7 |
| Impact Strength | 5 | 5 | 10 | 3 | 9 |
| Fatigue Strength | 3 | – | 3 | 7 | 10 |
| Resistance to Crack Propagation | 8 | 5 | 10 | 2 | 9 |
| Heat Distortion Temperature | 10 | 4 | 3 | 6 | 5 |
| Thermal Insulation | 5 | 4 | 7 | 8 | 7 |
| Damping Characteristics | 4 | 3 | 8 | 4 | 7 |
| Burning Characteristics | 8 | 2 | 5 | 5 | 4 |
| Smoke/Toxic Emission | 8 | 6 | 3 | 3 | 4 |
| Versatility in Boatbuilding | 5 | 2 | 3 | 5 | 10 |
| Weight (at common useage) | 5 | 6 | 8 | 7 | 8 |
| Economic Criteria/Price | 9 | 10 | 5 | 7 | 6 |
| Totals | 134 | 85 | 139 | 127 | 161 |

**Core materials are rated on a scale from 1–10, 10 being the most desirable, or best property.**
**The ratings are our estimates, and are based on our general experience as well as data sheet values.**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