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Mr. Peter Sing
1128 Madison Ave N.
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Dear Mr. Sing:

With reference to our conversation yesterday, I am herewith confirming what I think is unique about your invention. I believe I am qualified to evaluate your panel product for the following reasons:

While preparing for my BS, MS and doctoral degrees I aquired a background in wood science and technology which, in effect, contained strong components of biology and chemistry as well as engineering. For 38 years I taught, performed research and consulted in the field of wood utilization technology at the University of Washington College of Forest Resources. Subjects taught included:

- the mechanical properties of wood,
- design of timber structures,
- composition board technology,
- adhesives and wood/resin systems.

Further, I carried out many research projects in these areas and consulted with forest products companies, adhesives and resin manufacturers as well as machinery companies that served the forest products industries. In addition I hold three patents on wood-based structural panel products each of which took advantage of my understanding of the unique characteristics of wood and of cellulosic fibers. These are:

- 1954, U.S. Patent: A corrugated, structural, veneer laminate.
- 1958, U.S. Patent: A fiber-overlaid plywood process & product.
- 1959, U.S. Patent: A structural, lumber-core building panel.

While none of these inventions were hollow-core sandwich panels, all of them included the concepts of stressed-skin and took into account the inherent stiffness and bending strength of wood elements in the grain direction, the weakness of wood in shear resistance in the grain direction, and the weakness of wood in compression and tension properties at right angles to the grain.

I am familiar with the early work of the U.S. Forest Products Laboratory during and after World War II on the properties and design of sandwich panels with paper-honeycomb, resin-impregnated paper honeycomb, and other hollow-core and foam-plastic core designs. And I am familiar with molded-pulp-cores for sandwich panels. Also, with a German process for making watch-spring-like coils of wood to separate the faces of sandwich panels, where the grain of the wood lies parallel to the faces. In this panel localized pressure on the skin at right angles to the face places

the spirals in the core in compression perpendicular to the grain of the wood. This is one of the weakest properties of wood.

Stress skin-- or sandwich-- panels are usually used to provide light-weight panels capable of carrying loads on long spans, where bending strength (in compression strength on the top surface and tension strength on the bottom surface) and stiffness (measured by modulus of elasticity) are the primary considerations. The core material functions to hold the surfaces apart and to have adequate shear strength to resist the forces generated by loads applied to long spans (i.e. a length to panel thickness ratio of 25-to-one or more.).

When wood elements are used in the hollow core of stress skin panels the differences in the strength properties of wood along vs across its grain-- or fiber-- direction must be considered. The compression strength of wood parallel to the grain is about 10 times the compression strength at right angles (i.e. normal) to the grain, at the same moisture content. Conversely, the ratio of shear strength parallel to the grain is only a fraction of that across the grain. (The shear resistance of wood at right angles to the grain cannot be measured with a a simple test. There is no need to consider it in engineered wood structures since it is not a limiting factor in the design of wood structures.

Your invention is unique in that the grain of the wood, which is made from cross sections of bamboo or of veneer formed into circles, lies at right angles to the plane of the face materials. This means that any concentration of loads applied perpendicular to the face of the panel that would tend to crush the panel (i.e. causing the hollow core to collapse) would be resisted by the veneer tubes which are favorably oriented to act in compression parallel to their grain, each of them acting as a short, stiff column. At the same time, if the panel is acting in bending, the horizontal shearing forces generated in the core material would be acting at right angles to the grain orientation of these short circular columns, thus giving the core very high shear resistance in comparison to other panels where the wood elements of the core are oriented such that the grain of the wood is parallel to the plane of the skin material on the faces of the panel.

For the above reasons your panel could function uniquely well where light weight and crushing strength as well as high shear strength are required. Structural engineers recognize that short, deep-- or thick-- beams and panels (with span/depth ratios of less than about 15-to-one are capable of carrying high bending loads with very little deflection, but the core must be capable of resisting the high horizontal shearing stresses that are developed. (For example, a sandwich panel that is 48 inches long, supported on both ends, and 4 inches thick, would have a span/depth ratio of 12/1. The load carrying capacity of such a panel might well be determined by the shear strength of the panel. The strength property that determines the load carrying capacity of such a panel is the shear strength of the material used in the core. If tested to failure, it would fail in shear rather than in the

in compression or tension in the skins.

If a short-span, thick sandwich panel were designed for with your core material, a thin, high-stiffness skin material, such as aluminum, could be used for the skins to achieve high stiffness and high bending stresses, and the core material would provide the resistance to localized crushing stresses as well as very high resistance to horizontal shear (i.e. shearing stresses in the plane of the core and at right angles to the circular veneer or bamboo columns).

One particular application comes to mind where all of the above-mentioned properties are required, i.e., high stiffness (or deflection resistance), high bending strength, and high localized crushing strength (i.e. concentrated wheel loads) and high shear strength. This is the floor panels for shipping containers. Another application would be for "slave pallets" that are used in automated warehouses which store heavy machinery components.

In summary, Mr. Sing, I believe that your patent application describes a unique sandwich panel construction which provides a core material that, when faced with a variety of skin materials secured to the core with a suitable adhesive, can offer structural properties superior to those of other panels with which I am familiar, that have cores made of spaced wood elements.

Respectfully,

Ben S. Bryant

Dr. Ben S. Bryant, Professor (emeritus)
Wood Utilization Technology