

## **New Lightweight Solid Wood Panels for Green Building**

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### **Abstract**

Wood is an excellent natural renewable material for green building. Wood products have some environmental advantages over other building products. Manufacture of wood products is a rather simple, clean and low-energy process compared to many other products. Wood is a globally available raw material. It is widely in walls, ceilings, floors, roofs, stairs etc.

There is a greater interest now in the use of large solid cross laminated timber panels for prefabricated houses. Due to their large format, these panels are easy and quick to assemble.

A cross laminated panel consists of at least three layers of softwood planks, where the direction of the grain in adjacent layers is perpendicular to each other. Panels of different thicknesses are commonly used in external and internal walls, ceilings and roofs.

A very recent development is the lightweight panel that combines lower weight with high strength and insulation properties. The panel has three layers with a core layer made of low grade sawn timber that has a pattern of hollow cells made into it which reduce its weight. Still, some 50 percent of wood goes into sawdust when the core layer is made.

Production of new lightweight multi-layer timber panels is described in the paper. It features low quality wood sufficiency for the process and low waste levels. For the manufacture of 1 cu m of panels a little bit more than 1 cu m of dry boards is required. Thanks to hollow section construction, the panels have low density (300 – 350 kg/cu m) and good heat insulation factor (better than solid wood). Their mechanical properties are close to known solid wood panels.

Key words: wooden house, prefabricated house, cross laminated timber panel, lightweight solid wood panel.

## **Introduction**

For centuries wood has been a unique renewable raw material for building applications. Wood is processed easily, has rather high strength and low density. It has low heat conductivity and absorbs noise and vibration. In comparison to other building materials, wood products require less power to make, transport and process.

Wood is a user friendly green material effectively used in different structures. Inside a wooden house a favorable environment for human life is created. There is a wide range of designs for wooden houses. Their choice depends on local traditions, climate, availability and cost of wood, construction time and cost etc.

Not so long ago in Europe some technologies of industrial production of prefabricated houses from massive wooden panels were developed. Massive elements of houses (walls, floors, roofs) are made of cross laminated multi-layer panels in which layers from dry boards (moisture content approx. 12 %) are glued or nailed together. These panels consist of at least three layers of softwood 19 - 42 mm thick strips where the direction of the grain in adjacent layers is perpendicular to each other. Outer layers form main direction of elements. The requisite thickness is determined by the end use for wall, floor, roof and smaller units for any number of custom applications. The thickness of elements is from 60 mm to 400 mm in dimensions of up to 4.80 m x 20 m. Each element is prefabricated with given length, width and openings for windows, doors, stairs etc. Surfaces of wall, floor and roof elements may be sanded, which gives the rooms a timber look. All elements are easily assembled at a building site by a small size mobile crane. The building time is typically short.

Multi-layer panels are easily individualized for custom applications. They are a solid, safe, reliable, and environmentally friendly building material. They are dimensionally stable and fire retardant, strong mechanically and low in thermal conductivity. Though high cost of wood limit wide use of these panels in building structures.

Recently complete new solid wood lightweight panels with good mechanical and technological characteristics named Dendrolight® (DendroSolutions GmbH, Euratsfeld, Austria) were developed. This is a three-layered panel. Thin outer layers providing basic stiffness to the panel consist of solid wood or particle board. The middle layer of the panel consists of cross aligned boards with longitudinal kerfs, which are glued to the surface layers at an angle of 45°. The kerfs form multitude of small cells with webs inclined at an angle of 45°.

The panels have low bulk density (300 - 400 kg/m<sup>3</sup>). Panels' weight depends on panel thickness and top layer material. They have high strength and dimensional stability, a very good heat insulation factor (better than solid wood) and fire resistance factor. The panel thickness varies from 24 mm to 240 mm (including top layers), width – up to 2075 mm and length of up to 6000 mm.

Unfortunately, high level of wastes in production of the panels limits their application. When producing the center layer, about 50 percent of the raw material goes into sawdust which adds to the total amount of sawdust in the process. Using the extra sawdust produced for fuel (wood pellets), as some suggest, is not a viable option as it requires additional investment into a new process.

### **New Lightweight Solid Wood Panels**

New lightweight solid wood panels, which do not generate much waste in production, are described below (Skuratov 2010). The panel consists of several layers. Each layer consists of strips, which are trapezoid in section. Strips had been produced by cutting surfaced boards at a fixed angle  $Z$  and the subsequent planing of sharp-angled edges. The simplest panel is glued from two layers with identical grain orientation (Fig. 1).

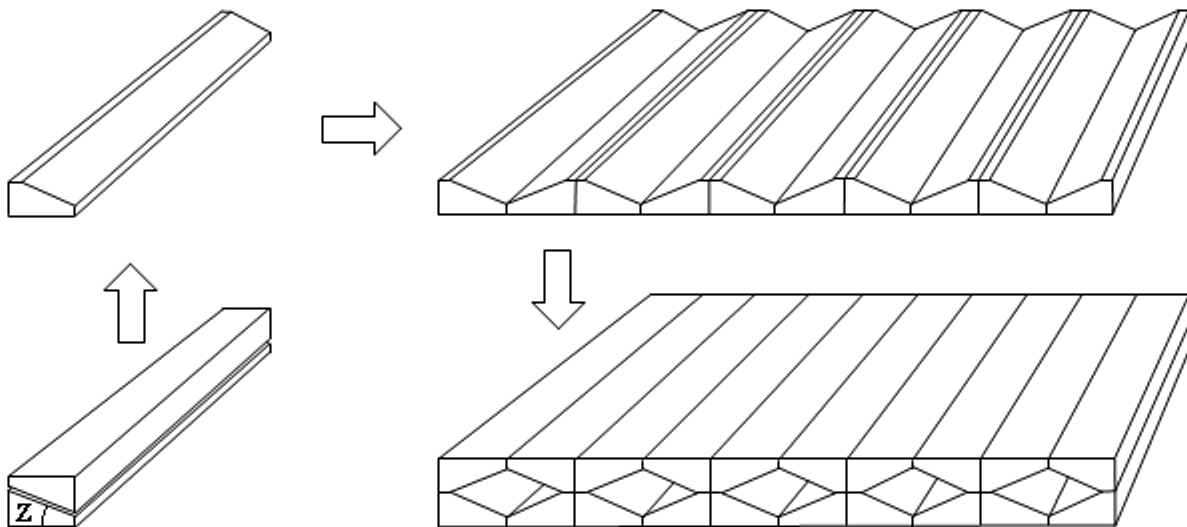


Figure 1. Structure of a simple lightweight wood solid panel.

The angle  $Z$  depends on the cross section of the board and it defines the structure of the panel itself. The larger is the angle  $Z$ , the higher is the thickness of the panel and the lower is the minimal thickness of external wall of the panel. Obviously, that minimal thickness determines to a great extent the stiffness and other mechanical properties of the panel. Outer layers of panels which are exposed to external mechanical impact should have a calculated stiffness property to withstand the impact. To accommodate that property the  $Z$  angle should be smaller. For internal layers the angle  $Z$  can be larger and minimal thickness smaller.

New panels need less wood in production compared to traditional cross laminated multi-layer panels. Simple geometrical calculations show that from 1 cu m of surfaced boards it is possible to produce up to 1.2 - 1.3 cu m of panels. Bulk density of softwood panels is equal to 300 - 350 kg/m<sup>3</sup> (60 – 70% of common density of wood). Thickness of panels, depending on board size and quantity of layers, can be from 40-50 mm up to 300-400 mm. Length and width of panels are

defined by the press dimension. The area of gluing at assembly of layers is equal only to 20 – 25 % of the panel area therefore for gluing of panels the press with rather low capacity is needed. The glue charge will also be low.

The order of stacking of strips and orientation of grain in panel layers can be different than shown above in Fig. 1 (see Fig. 2). In practice, for each specific application it is possible to make a panel with needed mechanical properties and stability. Abundance of hollow sections in the structure of panels reduces heat conductivity of new panels by 25-30 % against standard panels of solid wood. It makes them suitable for use in external walls, floors and roofs, which do not have to be thick even in a cold climate. Additional benefit of hollow channeled structure is the capacity to host wires and pipes. Connecting tongues and grooves for panel fixing can be made by simple movement of layers in pressing (Fig. 2).

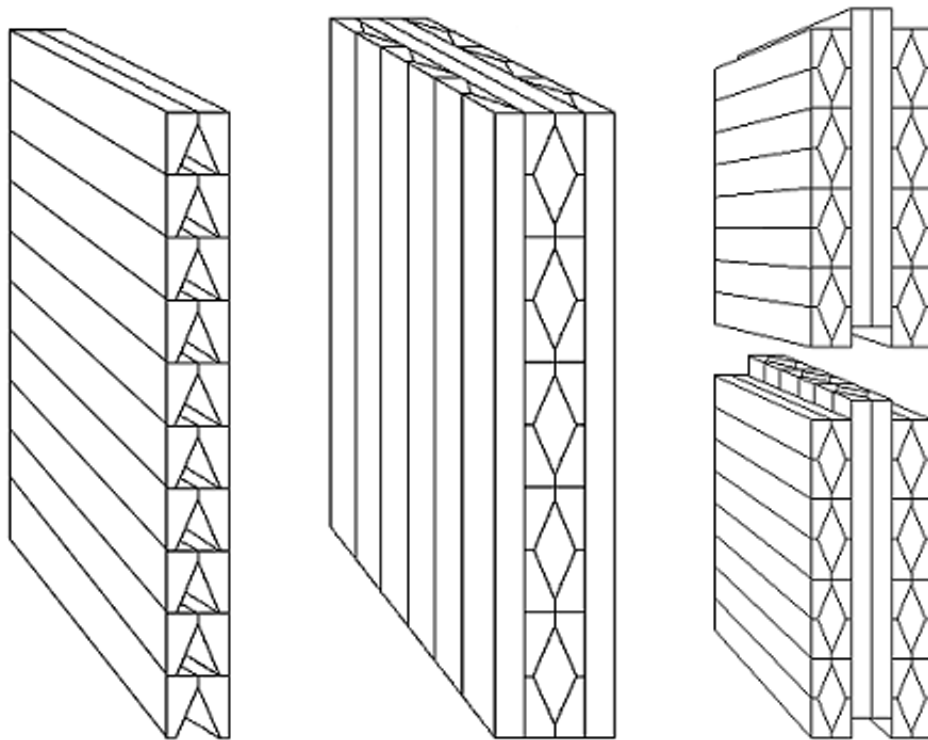


Figure 2. Variants of panel structure and connection in wall constructions.

Panel appearance depends on quality of wood of external layers (Fig. 3). When boards of 1 and 2 grades are used, surfaces can be sanded and painted. For inner layers low quality boards can be used.



Figure 3. Lightweight solid wood panel.

### **New Core Layer for Lightweight Solid Wood Panels**

Use of core layer with cellular structure reduces the weight and wood consumption in production of three-layer panels. New material for inner lightweight layer used in making solid wood panels (patent pending) is described below.

The core layer is also a stratified structure in its own right. The strata are formed by gluing thin strips of wood in an overlapping manner along the edges. The width of gluing zones should be not less than 3 – 4 mm. The arrangement of strips in layers can be vertical or horizontal (Fig. 4). Optimal thickness of strips is equal to 7 – 8 mm and width 20 – 25 mm.

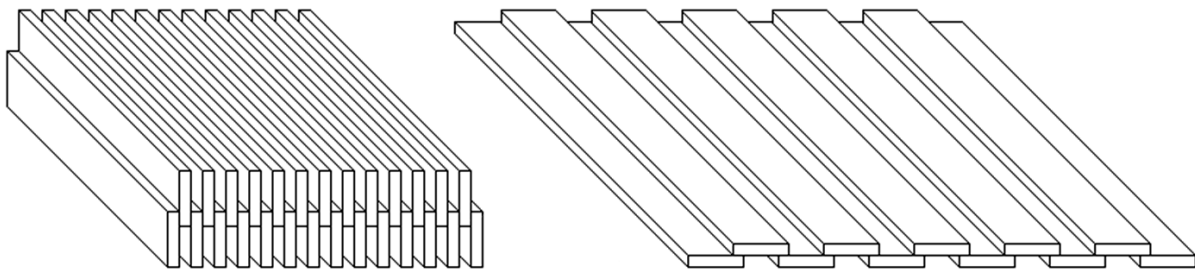


Figure 4. Vertical and horizontal arrangement of strips in layers.

Fibers in the strips of adjacent layers are differently oriented, but the same angle is maintained in relation to one of the axes of the unit (Fig. 5). For symmetry of the structure this should be at 45°. Slight deviation is allowed.

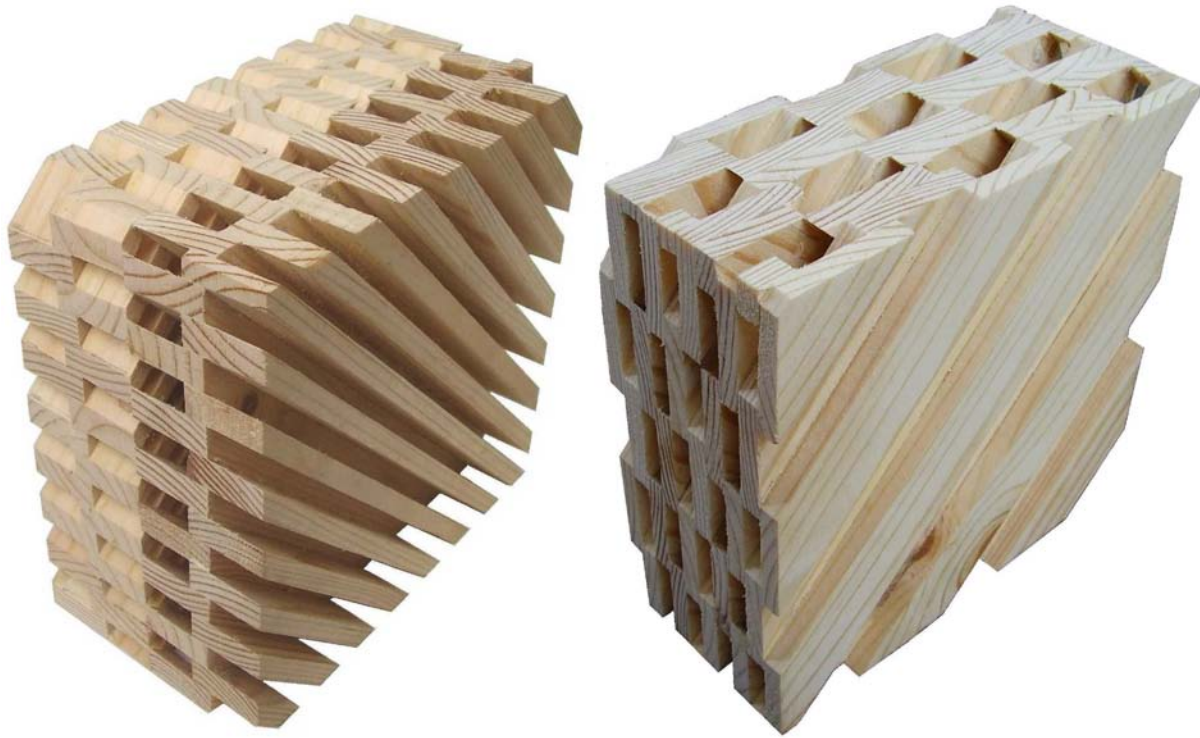


Figure 5. Orientation of layers in the structure of the new unit.

The new unit is low in wood and glue consumption. From 1 cu m of surfaced boards it is possible to produce about 1.05 - 1.15 cu m of the new element. At density of coniferous wood of  $500 \text{ kg/m}^3$  bulk density of the material will be equal only to  $270 - 320 \text{ kg/m}^3$ . Wide area of gluing of strips with each other and cross arrangement of layers provides for high strength and stability to the element. Calculated factor of heat conductivity of the element is about  $0.09 - 0.10 \text{ W/mK}$ , 30 – 40% less than of massive wood. This material as a core layer of three-layer panels can be applied successfully in construction of external walls of wooden houses. As outer layers of wall panels, wood of different species, chipboard, MDF, OSB etc can be used (Fig. 6).

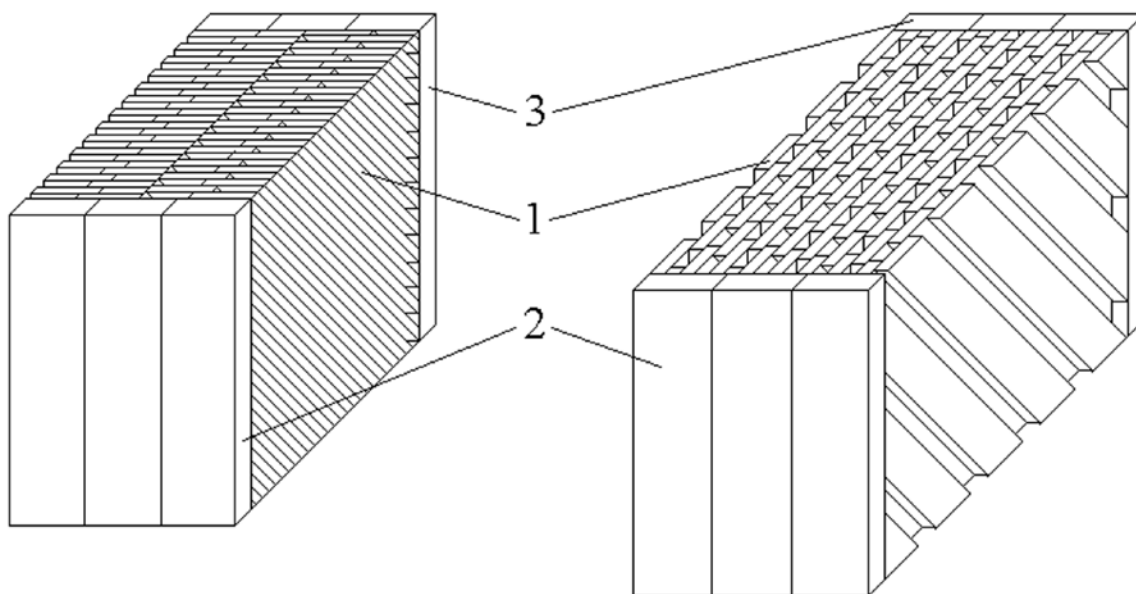


Figure 6. Wall panel with new material.  
1 – core layer, 2 and 3 – outer layers.

### **Conclusion**

Use of new panels and elements of structure saves wood, reduces weight and price of products making housing more accessible. Further it is supposed to define panel and material characteristics and specify field of their effective application.

### **References**

Skuratov N. V. Glued wooden panel. Russian Federation patent RU 93328 U1, 27 Apr. 2010.