A New Generation of Solid Wood Panels

Cross-laminated timber is about to transform the way we build

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There is a new product entering the U.S. and Canadian markets that has the potential to significantly change the way we design and build with wood. It will allow the wood industry to modernize conventional wood-frame construction and enter new sectors of the construction market. This product is cross-laminated timber panels (CLT). CLT panels have been available and used in a variety of countries in Europe and Scandinavia for roughly 15 years. In the next few months, we will see a number of companies starting to manufacture and supply this product in Canada and the U.S.

CLT panels are large prefabricated wall and floor assemblies that are used in a variety of building types for the residential and non-residential markets. They can be assembled in a platform-frame fashion to create buildings with structures that are analogous to concrete suspended slabs, spanning between load-bearing concrete walls to resist gravity and lateral loads. The panels can also be used in combination with post-and-beam wood frame or steel frame components. The vertically-oriented panels enclose the building, similar to tilt-up construction, while the horizontally-oriented panels span across beams to create the floor plates. Another option that takes advantage of the large panel dimensions, and is sometimes used for industrial buildings, is balloon-frame construction, where the floor assemblies are hung from multi-story wall panels.

CLT panels were developed in Europe and Scandinavia over a long period and as a result, there are many manufacturers who make a wide variety of panel types. The focus on CLT in the U.S. and Canada is a result of the many proven advantages of using CLT in the European market.

CLT panels can be manufactured up to approximately 10 ft. by 60 ft. and then cut to size for each project. They are normally produced in thicknesses from 2-in. to 16-in. although thicker panels are available. The laminates that make up the panels are pieces of dimension lumber (such as 1 x 4, 1 x 6, or 2 x 4, 2 x 6 or similar) that are either glued using radio-frequency presses or fastened to each other. The lumber is stacked in its flat orientation into 3-, 5-, 7-layers or more on a forming bed and then subjected to uniform pressure using hydraulic or vacuum presses. The outer layers tend to use higher grade lumber for strength and appearance, while lower grade material can be used for the inner layers. Each layer is perpendicular to the adjacent layers (cross-laminated) and this leads to the first of many great ideas surrounding this product: when the lumber in each layer tries to expand or contract due to shrinkage or swelling, the adjacent layers restrain any movement. This contributes to the superior dimensional stability of the CLT panel.

After pressing, completed CLT panels are moved onto a CNC cutting machine to trim the panel edges and plane, sand, or wire-brush the panel faces. The CNC machines drill out the panel for connection hardware and cut openings for windows, doors, stairs and mechanical chases. The use of automated CNC machines is a natural next step for a technology that was developed in Europe and Scandinavia with a now-proven track

Opposite and **below:** Austria House features the first Canadian application of Cross Laminated Timber (CLT) panels for roof and floor structure and diagonally dowelled solid wood panels for wall structure. The 2,700-sq.ft. house is also the first Passive House (Passivhaus) to be built in Canada.

PHOTO CREDIT: APG Austrian Passive House Group, www.oesterreichhaus.at

Above: The laminates that make up the panels are pieces of dimension lumber, such as 1 x 4, 1 x 6, or 2 x 4, 2 x 6 or similar, and are either glued using radio-frequency presses or fastened to each other. The lumber is stacked in its flat orientation into 3-, 5-, 7-layers or more on a forming bed and then subjected to uniform pressure using hydraulic or vacuum presses.

record to accurately and efficiently cut and profile conventional solid and glue-laminated wood products. Great idea number two: prefabricate a high-performance product under controlled conditions.

Prefabrication can sometimes have negative associations. Henry Ford said of his cars that you can buy a Model T in any colour, as long as it's black. This notion of standardization can overshadow the benefits of prefabrication in many people's minds, whether for cars or construction. This is certainly not the case for CLT panels. Fully-detailed models of the panels allow designers to customize layouts and window and door openings. The product may be prefabricated, but it is the designers who maintain control – the automation is in the process of manufacturing the product.

After the design is complete, and once the CLT components have been determined for each project, the cutting patterns can be optimized to reduce waste. Any material that is cut away from the panel can be collected as wood waste and re-used in other ways by the manufacturer (as opposed to conventional field-built assemblies where site waste must be carefully separated and sent away for re-use or recycling at added cost). Quality control in the plant is much better than field construction, and the controlled environment means no temperature and humidity cycles, and protection from the elements such as water, snow and UV. Once assembled on site, the joints are tight and this makes for a tighter building by creating cleaner surfaces for the attachment of building envelope components. Construction time on site is significantly reduced as work on site becomes assembly rather than carpentry. Panels up to 60-ft. long and 10-ft. wide can be used in single elements to simplify installation. The short construction cycle has immediate effects on project costs and results in less time on site where the CLT panels are exposed to the elements since the roofing and cladding can be installed much faster, thereby keeping the components protected. Unlike concrete, CLT panels do not require additional protection and heating to cure in cold weather. In addition, the relatively light weight of the panels reduces the need for heavy lifting equipment on site.

CLT panels have unique environmental, architectural, structural, thermal and fire resistance properties and benefits. In Europe and Scandinavia, architects have long recognized that wood has a lower carbon footprint than other conventional building materials (wood harvesting and processing takes very little energy and the material itself is a carbon sink). The architects who use CLT panels are able to offset the total carbon usage in the manufacturing of the material, construction and operation of their buildings to make them effectively carbon neutral. On

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interiors, the panels can be left exposed as a finished material with no need for additional materials (at the discretion of the designer and depending on fire code requirements). In North America, low- and medium-quality lumber and standing dead timber killed by mountain pine beetles can provide a good resource for CLT manufacture.

Programmatically, the panels lend themselves well to repetitive, shallow floor plates for mid-rise and high-rise buildings although they can just as easily be adopted for single-story or low-rise construction. There are now precedents in Europe of eight- and ten-story CLT buildings. In North America, CLT lends itself well to making more liveable cities through neighborhood densification and mid-rise construction.

Acoustic performance for sound transmission between walls and floors is very good with CLT panels due to their solid mass. Additional sound insulation through a variety of tested techniques in Europe has led to floor systems with STC ratings over 65 dB with careful detailing between walls and floors, and at stairwells.

The thermal mass of CLT panels gives them some ability to moderate temperature. Working as a component of a building envelope system, panelized construction leads to tighter building envelopes with blower door tests resulting in very low air exchanges per hour. In a traditional wood frame wall assembly, air flow is controlled using an air-barrier approach using sealed polyethylene, air-tight drywall, sealed sheathing, or a sealed sheathing membrane. In a CLT panel wall assembly, the most practical strategies for creating a continuous air barrier are either a sealed exterior sheathing (CLT) membrane or interior air-tight dry wall.

Fire performance of massive wood members is recognized in our building codes for heavy timber construction but does not specifically address CLT at present. In Europe, it has been shown that CLT panels exposed to fire will form a char layer that protects the rest of the panel and allows the panel to retain its strength and dimensional stability. Unlike conventional construction, in a solid wood product there is less risk of fire spread through gaps or voids in the building components.

Structurally, CLT panels have strength and stiffness in-plane and out-of-plane that make them suitable for gravity and lateral load resistance. The excellent axial resistance and in-plane shear resistance of CLT panels for walls make them suitable for load-bearing and shear wall construction. The outer layers of lumber are oriented to take advantage of the longitudinal tension and compression properties of lumber and to act as bending members for floors and tall walls. The in-plane panel stiffness also makes CLT panels excellent performers as floor and roof diaphragms. In seismically active regions, this can be a significant improvement over conventional framing and systems made with other materials. Ductility (energy absorption) is provided

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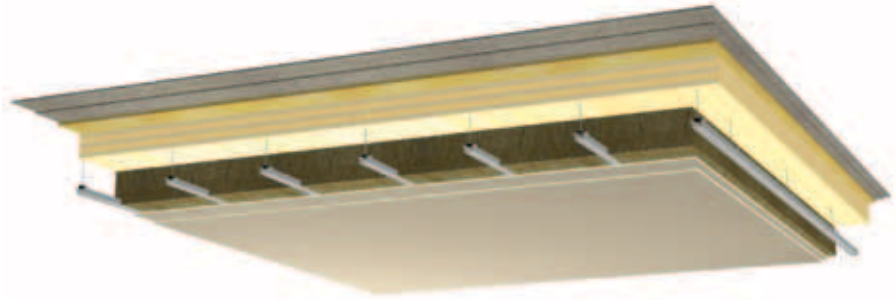
Bottom photo PHOTO CREDIT: KLH



through metal connections. For multi-story construction, the lighter weight of wood walls compared to other materials (such as concrete and masonry) can result in smaller footing sizes, thereby saving cost and materials. Connections between wall and floor panels and to other building components are available as a number of proprietary fasteners or they can be custom designed and fabricated.

There are a few side benefits to CLT construction that have been observed by practitioners in Europe and Scandinavia. Andrew Waugh (Waugh Thistleton Architect) in London is experienced in solid wood panel design and has found that through prefabrication, not only is construction time reduced and the quality improved, but waste on site during construction is significantly reduced to almost nothing. Another side benefit is the ease of attachment of services such as electrical conduit, sprinkler lines, plumbing, etc. In Europe, CLT panels compete against concrete and masonry construction where impact drills must be used to attach pipe hangers – this is labour intensive and can result in joint damage and other injuries for workers. Attaching to wood is much simpler and does not require impact drills.

In North America, standards are being developed for the manufacture and design of CLT panels through NLGA, CSA and ANSI. These standards will deal with the grade of softwood to be used, certain layup requirements, quality control during fabrication and structural design standards, in addition to a CLT plant qualification standard to ensure quality. Each manufacturer will be required to meet minimum standards, but manufacturers will be allowed to develop their own systems, much like in Europe. Some manufacturers may choose to use other wood products such as LVL or OSL in their panels; others may follow some of the European systems and use internal wood dowels, keyways, grooves, spaces between laminates, or varying laminate orientation. Regardless of the manufacturer, the end products share certain characteristics: they are all prefabricated; they are manufactured in a controlled environment and processed using automation and CNC equipment; they can be used as monolithic walls, floors, ceilings, elevator shafts and stairwells; and they can be easily assembled on construction sites.

Guidelines will be released for architectural detailing, engineering and construction. Research is ongoing related to all the issues normally associated with any new product in the building code: strength and seismic performance, connections, fire resistance, thermal behavior, acoustic and vibration performance and durability. Much of this research has already been carried out in Europe, Canada and the U.S. In North America, researchers are establishing new criteria for the North American context and developing research into new areas as well.

Solid wood panels evolved in Europe through a combination of private interests and university research that looked at new ways of building with wood in order to improve efficiency in construction and, ultimately, to provide designers with new and alternative wood-based systems and solutions.

With a new sensitivity to sustainability, a desire to use low-embodied energy materials, and an eye to superior quality finished products, Europeans have developed a market for prefabricated CLT panels. In Canada and the United States, the wood industry is actively conducting research and developing the products, standards and guidelines to bring these products to market in a very short timeframe. Great idea number three: the industry is working together, aligning their efforts to make this possible.

Big changes to the product line of the forest products industry do not happen very often, and experience over the last 100 years has shown that new products, such as plywood, I-joists and composite lumber, take time to develop and to gain market acceptance. Manufacturers, trade associations and researchers in Canada and the United States are working hard to provide support to designers and builders who want to use CLT products in their projects in the near future. Hopefully you will be one of them.

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