Cross laminated timber (CLT) offers a new building system option for non-residential and multi-family construction.

WoodWorks
While eight-story cross laminated timber buildings exist in Europe, a recent study conducted on behalf of the Canadian Wood Council concluded that CLt is feasible for 12 stories or more. As a result, CLt has the potential to change how wood is used in non-residential and multi-family construction.

CLt offers high strength and the structural simplicity needed for cost-effective buildings, as well as a lighter environmental footprint than concrete or steel. It also provides numerous other benefits, including quicker installation, reduced waste, improved thermal performance and design versatility.

While CLt has been extensively tested and widely used in Europe, it is still relatively new to the U.S. This cost-competitive wood building system can be used in a wide range of applications, including mid-rise urban infill, industrial, educational and civic structures.
Pioneer Product
Developed in Europe in the 1990s, CLT is an engineered wood panel typically consisting of three, five or seven layers of dimensional lumber. Kiln-dried boards are layered perpendicular to one another and then glued. This cross lamination provides dimensional stability, strength and rigidity.

Most manufacturers use formaldehyde-free interior/exterior polyurethane (PUR) adhesives. Boards are face-glued and then pressed, planed and sanded into panels. Using Computerized Numerical Control (CNC) machinery, the panels can be custom fabricated to create openings, compound angles and unique features requiring complex geometry to meet specific end-use applications.

Panel sizes vary by manufacturer. CLT is currently available in North America with dimensions up to 19-1/2 inches thick, 18 feet wide and 98 feet long.

Versatility at Work
Since CLT panels resist high racking and compressive forces, they are particularly cost effective for multi-story and long-span diaphragm applications. They weigh less than concrete or steel, so can also reduce foundation costs. In addition, CLT elements can be combined with other building materials such as glulam beams, enabling flexibility in design, style and finish architecture.

While CLT panels act as two-way slabs, the stronger direction follows the grain of the outer layers. For example, when used for walls, CLT is installed so the boards on the outer layer of the panel have their grain running vertically. When CLT is used in floor and roof applications, panels are installed so the boards on the outer layer run parallel to the span direction.

Because they are manufactured for specific applications, CLT panels are prefabricated and shipped directly from the manufacturer to the job site, where they can be quickly and efficiently lifted into place.
CLT's Key Benefits

As use grows in North America, building professionals will become increasingly familiar with CLT's advantages.

• **Design flexibility:** It is relatively easy to increase the thickness of a CLT panel to allow for longer spans requiring fewer interior support elements. Manufacturers use CNC equipment to cut panels and openings to exact specifications, often to meet very tight tolerances (within millimeters). Plus, when field modifications are needed, they can be made with simple tools.

• **Thermal performance and energy efficiency:** CLT’s thermal performance is determined by its U-value, or coefficient of heat transfer, which relates to panel thickness. Thicker panels have lower U-values; they are better insulators and therefore require less insulation. Since CLT panels can be manufactured using CNC equipment to precise tolerances, panel joints also fit tighter, which results in better energy efficiency for the structure. Because the panels are solid, there is little potential for airflow through the system. As a result, interior temperatures of a finished CLT structure can be maintained with just one-third the normally required heating or cooling energy.2

• **Cost effectiveness:** In a 2010 study by FPInnovations, researchers compared the cost of CLT versus certain concrete, masonry and steel building types. While the advantages of faster construction time and lower foundation costs were not accounted for, the estimated cost of a U.S.-built CLT structure was found to be particularly competitive for mid-rise residential (15 percent less), mid-rise non-residential (15 to 50 percent less), low-rise educational (15 to 50 percent less), low-rise commercial (25 percent less), and one-story industrial buildings (10 percent less).3

• **Environmental advantages:** Manufactured using wood from sustainably managed forests, CLT provides a number of environmental benefits in addition to its excellent thermal performance. Wood is the only major building material that grows naturally and is renewable, and life cycle assessment studies consistently show that wood outperforms steel and concrete in terms of embodied energy, air pollution and water pollution. It also has a lighter carbon footprint—because wood products continue to store carbon absorbed by the trees while growing, and wood manufacturing requires less energy and results in less greenhouse gas emissions.4

• **Less waste:** CLT panels are manufactured for specific end-use applications, which results in little to no job site waste. Plus, manufacturers can reuse fabrication scraps for stairs and other architectural elements, or as biofuel.

• **Fast installation:** Because panels are prefabricated, erection time is greatly reduced, which improves efficiency and results in lower capital costs and faster occupancy. Wall, floor and roof elements can be pre-cut, including openings for doors, windows, stairs, service channels and ducts. Insulation and finishes can also be applied prior to installation, reducing demand for skilled workers on site.

• **Fire protection:** CLT’s thick cross-section provides valuable fire resistance because panels char slowly. Once formed, char protects the wood from further degradation. When used in Type IV construction, CLT assemblies also have fewer concealed spaces, which reduces a fire’s ability to spread undetected. In addition, CLT offers increased compartmentalization if used for interior walls.

• **Seismic performance:** Because of their dimensional stability and rigidity, CLT panels create an effective lateral load resisting system. Researchers have conducted extensive seismic testing on CLT and found panels to perform exceptionally well with no residual deformation, particularly in multi-story applications. In Japan, for example, a seven-story CLT building was tested on the world’s largest shake table. It survived 14 consecutive seismic events with almost no damage. CLT also offers good ductile behavior and energy dissipation.

• **Acoustic performance:** Test results show that because the mass of the wall contributes to acoustic performance, CLT building systems provide adequate noise control for both airborne and impact sound transmission. CLT building systems offer additional acoustic benefits because builders use sealant and other types of membranes to provide air tightness and improve sound insulation at the interfaces between the floor and wall plates.5
CLT Properties and Performance

• High axial load capacity for walls
• Less susceptible to buckling
• High stiffness/strength-to-mass ratio
• High shear strength to resist horizontal loads
• Less susceptible to effects of soft story failure than other platform-type structural systems
• Floor span-to-depth ratios 20:30; roof span-to-depth ratios 30:40
Quick and Efficient Installation

One of the biggest benefits of using CLT is that the structure can be built quickly and efficiently. Many manufacturers ship panels with pre-installed lifting straps; contractors then use cranes to lift panels directly into place. Because panels are designed for specific end-use applications, they are often delivered and erected using a ‘just-in-time’ construction method, making CLT ideal for projects with limited on-site storage capacity.

There are a number of simple details that can be used to establish roof/wall, wall/floor, and inter-story connections in CLT assemblies, to connect CLT panels to other wood-based elements, or to connect CLT panels to concrete or steel for a hybrid assembly. The type of hardware depends on the assemblies to be connected (i.e., panel-to-panel, floor-to-wall, etc.), on the panel configuration, and on the type of structural system used in the building. Some of the more common connections include metal ‘L’ brackets or traditional strap holdowns used to transfer forces from one level to another.

Self-tapping screws are commonly used at panel-to-panel connections. Ease of installation along with high lateral and withdrawal capacity make these fasteners popular because they can take combined axial and lateral loads.

New and innovative fastening systems are also being developed, facilitated and enabled by CNC technology. For example, glued-in rods can be used for connections under high longitudinal and transverse loads. HBV-Shear Connectors, a proprietary product from Germany, can also be used to create composite floors with structural concrete over CLT.

Big Things on the Horizon for CLT

Market potential for CLT in North America is promising, as industry, association, research, and engineering experts in the U.S. and Canada work for its continued use and acceptance.


CLT’s structural performance and cost competitiveness allow it to compete directly with concrete and steel. As demand continues to grow for efficient, cost-effective and sustainable building materials with proven performance, innovative construction professionals will increasingly turn to CLT for non-residential and multi-family building solutions.
Bridport House
Location: Borough of Hackney, London (United Kingdom)
Architect: Karakusevic Carson Architects

When it was constructed in 2011, this five- and eight-story structure formed the largest timber-built apartment block in the world. The site required a lightweight structure because of the building’s location over a large storm sewer, making CLT an ideal solution.

Photo: Karakusevic Carson Architects

St. Agnes Primary School
Location: Longsight, Manchester (United Kingdom)
Architect: Robinson Architects

Architects for this three-story school used CLT for a number of reasons. They left the structure exposed to the interior to take advantage of wood’s aesthetic benefits. In addition, the new school was located on one of the smallest school sites in the country. Installation of prefabricated CLT panels simplified material delivery and increased speed of construction; overall erection took just 12 weeks.

Photo: Willmott Dixon Construction

The Long Hall
Location: Whitefish, Montana (U.S.)
Designer: Datum Drafting & Design

This two-story, 4,863-square-foot commercial mixed-use building was constructed in just four days. CLT was left exposed on the building’s interior to take advantage of wood’s natural aesthetic.

Photo: Pete Kobelt

Collège Durocher Atrium
Location: St-Lambert, Quebec (Canada)
Architect: Leclerc – Architecte

Architects used 36-foot-long CLT panels for the expansion of this existing educational structure in Quebec. About 1,300 students can assemble for a meal or gathering in the new space.

Photo: Nordic Engineered Wood

Earth Systems Science Building, University of British Columbia
Location: Vancouver, British Columbia (Canada)
Architect: Perkins+Will Canada

This five-story building was designed as an assembly occupancy. It was built using a combination of massive timber systems including CLT, composite laminated strand lumber/concrete floors, and glulam heavy timber braced frames. CLT was used for the roof and exterior canopies.

Photo: KK Law, courtesy naturallywood.com

Centre des Loisirs
Location: St. Prime, Quebec (Canada)
Architect: Christian Côté

Built in 2011, this modern post and beam multi-story design used CLT panels, which were 55 feet long and 4 inches thick.

Photo: Nordic Engineered Wood