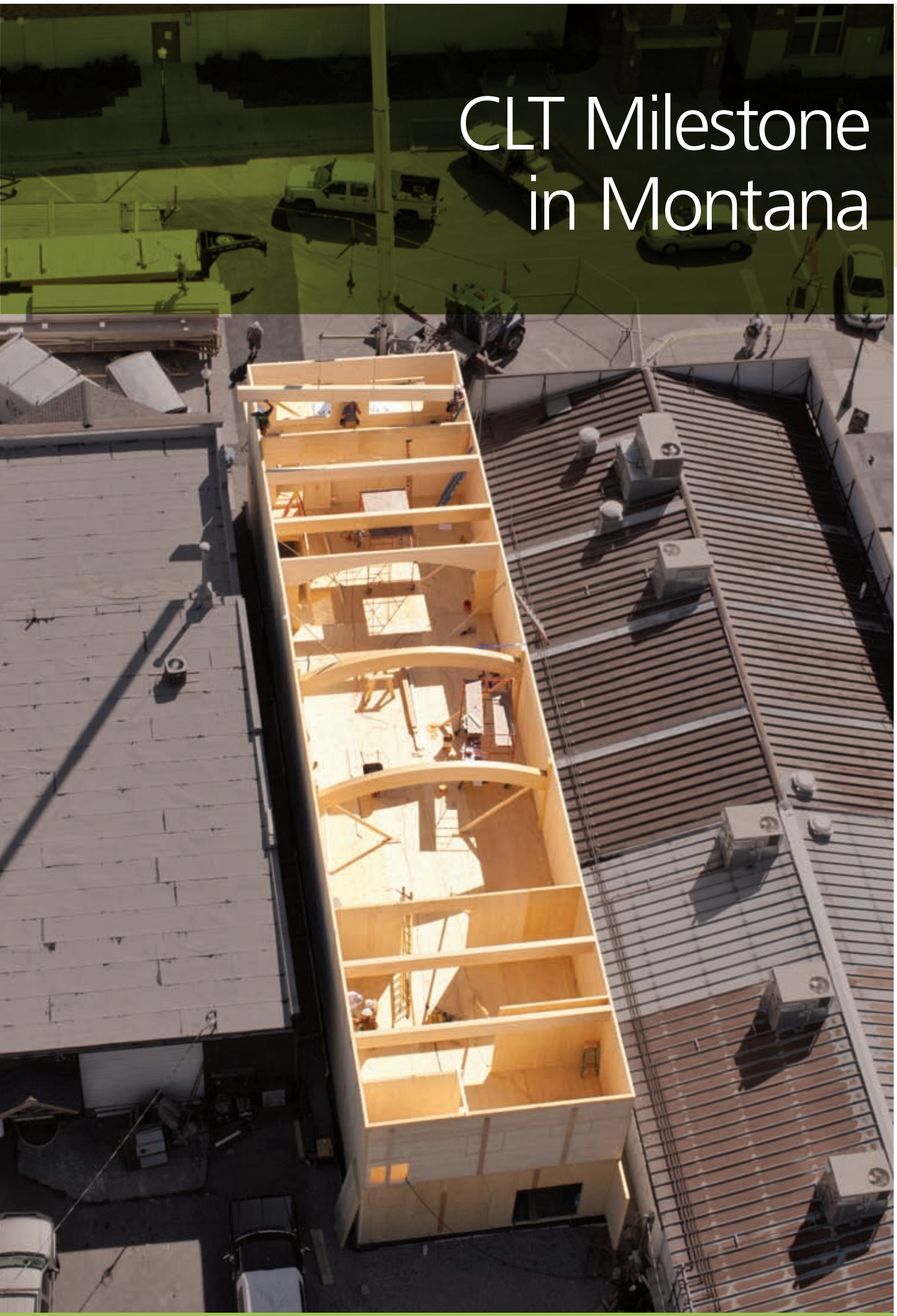
WoodWorks

CaseStudy



CLT Milestone in Montana

Cross Laminated Timber Makes its Mark with The Long Hall

It happened so quickly that most design and construction professionals probably missed it. But when the first commercial building project in the U.S. constructed with cross laminated timber (CLT) was completed in 2011, it opened the door to new opportunities for the entire building industry.

The Long Hall in Whitefish, Montana epitomizes many of the benefits of CLT construction—speed of installation, environmental and aesthetic benefits of wood, and energy efficiency. The two-story wood structure took just five days to erect, and gave the owner a sustainable, energy-efficient building.

Converting from CMU

The Long Hall is a mixed-use, urban infill project designed to replace an unsightly 60-year-old Quonset hut in downtown Whitefish, Montana. The new 4,863-square-foot structure provides business and retail space on the first floor, and the second floor is occupied by a martial arts studio.

Originally designed with concrete masonry units (CMU), the building designer, Datum Design Drafting, worked with Innovative Timber Systems (ITS) and Darryl Byle, PE, of DSB Engineering & Consulting to convert the structure to CLT. "Together, we convinced the client that CLT would be a cost-effective alternative to CMU while delivering a high-performance building, more sustainably and with a better design aesthetic," said Byle. "The client had no particular affinity for concrete and also had time constraints. We were confident that CLT would provide the perfect solution."

Byle said the top three benefits of using CLT for The Long Hall were speed, aesthetics and thermal performance. "With CLT, the entire two-story structure took just five days to install. We went from slab to occupancy in three months. And the owner loves the interior feel and renewability of the resource. He also wanted a high-performing structure; the energy efficiency of the CLT system made this a good choice."

The resulting Type VB structure was built to 2009 *International Building Code (IBC)* requirements. The building consists of 38 glulam beams along with 13,000 square feet of CLT for the walls, second floor, roof, clerestory, partitions and arches.

Cost Competitive

Overall cost of the entire project was approximately $145 per square foot, $60 of which was attributable to the installed cost of the CLT and glulam.

Because CLT had not been used for a commercial building in the U.S., one of the first things Byle and his team verified was its cost competitiveness. Pete McCrone, a Quantity Surveyor with ITS, compared CMU and CLT across approximately 30 project elements. The analysis favored CLT, in part because the exposed wood structural shell could serve both as interior wall and ceiling finish. The CLT system also required less time on site for erection, which reduced construction costs.

Initial estimates put the cost difference between CLT and CMU close to even, but Byle said time value of the finished building tipped the scales in favor of CLT. "Originally, the owner was going to have to close his martial arts studio through the fall," he explained. "By raising the building structure in just five days, he was able to open the studio for the fall season."

Planning Ahead

Because local code officials and subcontractors were not familiar with CLT, Byle said it was critical to plan ahead.

"I worked as a building official myself, so I understood their concerns about being first to use a new product," he said. "That's why I began talking with our local building department more than six months in advance; to make sure they were comfortable with it. The project became a real team effort; we all wanted to do this right so the building officials were there asking questions and educating themselves but also keeping an eye out for us."

Preplanning was also critical because CLT for The Long Hall was sourced from Europe (although there are now several North American suppliers). CLT panels are manufactured for specific applications, so are prefabricated and shipped directly from the manufacturer to the job site, where they can be quickly and efficiently lifted into place. "By modeling the entire structure in 3-D and meeting with vendors and subcontractors well in advance, we defined the design challenges and resolved issues dynamically," said Byle.

Pre-assembled Walls

Because of shipping constraints from Europe, CLT panel size was limited to 7 feet 4 inches in width and 39 feet in length, said Byle. "This meant the wall panels could not stack full-story height as is often the case with other pre-manufactured CLT wall assemblies. After reviewing the pros and cons of vertical versus horizontal stacking, we determined that it would be more effective to assemble the walls as vertical elements in a standard platform framing configuration."

The Long Hall had less than 30 inches of spacing between it and adjacent buildings. Because this left virtually no room for on-site construction, contractors pre-assembled the main vertical CLT walls in four- and five-panel elements at a nearby site. They glued and screwed the splines and then transported the pre-assembled wall panels to the job site (the largest were 30 x 11 feet) using an A-frame on a low-boy trailer.

By pre-assembling the vertical panels and lifting them into place via crane, the contractor minimized on-site installation time. Panels arrived from the manufacturer with pre-slung lift webbing, which also helped construction move quickly and efficiently. The CLT manufacturer used CNC equipment to precisely pre-cut beam pockets and openings for windows and doors at the factory.

Approved as a One-hour Rated Assembly

While The Long Hall was designed as a Type VB structure, fire protection was still a consideration in terms of getting CLT accepted for use. Since the structure was sited within five feet of the property line, the north and south exterior walls were required to be one-hour fire-rated, and the entire building was sprinklered.

Byle met with building officials to resolve concerns about fire safety. In order to meet the design objective to feature exposed CLT on the interior, they needed approval of the CLT system as a stand-alone, one-hour rated assembly. Byle used data on fire design from sources such as the *National Design Specification® (NDS®) for Wood Construction* and experimental CLT fire test data from manufacturers and independent sources[1] to show CLT panels could be expected to perform well in a fire event.

Additionally, Byle negotiated to reduce the required overall thickness of the wall assembly by taking advantage of CLT's unique structural characteristics. Because CLT is only exposed on one side, it can easily withstand the code-prescribed one-hour burn. Further, the undamaged portion will still transfer loads bi-directionally around the compromised area. Working with the local code official, Byle established a reasonable fire event dimension and designed the structure to deal with that localized structural compromise (an approach that is conceptually similar to disproportionate collapse regulations used in the United Kingdom).

CLT Met Other Design Challenges

The design and construction team used CLT to overcome a number of other challenges. For example, the site's soils got softer as they went deeper, so the foundation had to stay shallow. Since CLT weighs less than CMU, they were able to use a smaller foundation. Heavier CMU would have also increased footing size and slab connection requirements, so additional cost savings were realized by using CLT.

In order to optimize available floor space and internal space configuration, the structure was designed to free-span the 25-foot-wide lot. They incorporated CLT wall panels as out-of-plane bending elements to provide sufficient stiffness for the transverse lateral loads on the structure. Each panel/column/beam assembly acts as a modified moment frame to absorb lateral forces and distribute them to the foundation.

Because CLT has high stiffness, the design had to accommodate vertical motion along the longitudinal walls. In order to do that, the engineer designed a flexible glulam beam base plate using a tongue and groove connection at the base of the CLT wall. Anchor bolts connect the plate to the foundation at locations offset from panel attachment points, providing a flexible connection able to take the prescribed seismic loads.

Thermal Performance

CLT's thermal performance was an attractive benefit for The Long Hall's owner. Because CLT is a solid wood panel, it provides thermal mass. Wood is also a good natural insulator. And, since CLT panels can be manufactured using CNC equipment to precise tolerances, panel joints fit tight, which further improves energy efficiency.

To help illustrate this benefit, Byle contacted a Montana Department of Environmental Quality (DEQ) official, who conducted a blower door test on the structure for educational purposes with an Energy Systems class. "They don't normally do these tests for commercial buildings," he said, "but the results reflected a very airtight system. Energy code maximum is four air changes per hour, and two is considered tight for an energy-efficient home. This CLT system measured just 1.5 air changes per hour, which is excellent."

Byle said they taped panel joints and beam ends before installing mineral wool insulation boards on the exterior of the structure. "This fast, simple installation helps us maintain a vapor-open, breathable structure."

Pre-planning Paid Off

The significance of being involved with the first commercial CLT installation in the U.S. was not lost on Byle. "I learned that I am going to love using CLT," he said. "The owner had never heard of CLT before this project, but he loves wood; CLT allows him to have a high-performance structure that looks good. He had considered using CMU and metal, and was hesitant about being first to use something new, but he is thrilled with the end result."

Byle knew that breaking ground with CLT would be a challenge, but cites careful planning as key to their success. "Getting early buy-in from the code officials was a definite advantage," he said.

He added that early design completion was probably the most important thing he learned. "Having the design finalized well in advance of construction helped us pre-emptively identify and solve problems," said Byle. "Pre-planning with our CLT supplier and subcontractors also paid off. As a result, we finished the project on time and on budget. I look forward to more success with CLT."

What is CLT?

Developed and used in Europe since 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 strength, stability and rigidity.

CLT offers a lighter environmental footprint than concrete or steel as well as numerous other benefits, including quicker installation, less on-site waste, lighter weight, improved thermal performance and energy efficiency, and design versatility.

Carbon Benefits

Wood lowers a building's carbon footprint in two ways. It continues to store carbon absorbed during the tree's growing cycle, keeping it out of the atmosphere for the lifetime of the building—longer if the wood is reclaimed and used elsewhere. (Like other wood products, CLT lends itself to recycling and re-use.) When used in place of fossil fuel-intensive materials such as steel and concrete, it also results in 'avoided' greenhouse gas emissions.

Volume of wood products used:
148 cubic meters/5,227 cubic feet of CLT and glulam

U.S. and Canadian forests grow this much wood in:
26 seconds

Carbon stored in the wood:
104 metric tons of CO_2

Avoided greenhouse gas emissions:
59 metric tons of CO_2

TOTAL POTENTIAL CARBON BENEFIT:
163 metric tons of CO_2

EQUIVALENT TO:

31 cars off the road for a year

Energy to operate a home for 14 years

Source: US EPA

Estimated by the Wood Carbon Calculator for Buildings*, based on research by Sarthre, R. and J. O'Connor, 2010, A Synthesis of Research on Wood Products and Greenhouse Gas Impacts, FPInnovations. Note: CO_2 on this chart refers to CO_2 equivalent. Results from this tool are estimates only. Detailed life cycle assessments (LCA) are required to accurately determine a building's carbon footprint.*

Project Overview

NAME:
The Long Hall

LOCATION:
Whitefish, MT

OWNER/GENERAL CONTRACTOR:
The Long Hall LLC

DESIGNER:
Datum Design Drafting

STRUCTURAL ENGINEER/ PROJECT MANAGER:
DSB Engineering & Consulting, P.C.

CLT SUPPLIER/INSTALLATION:
Innovative Timber Systems, LLC

COMPLETED:
2011

1 *Experimental Analysis of Cross-laminated Timber Panels in Fire,* Andrea Frangi, Mario Fontana, Erich Hugi, Robert Jübstlin, *Fire Safety Journal* (2009)

Photos: (cover) Gravityshots.com, DSB Engineering & Consulting; (p.2) Gravityshots.com, Innovative Timber Systems; (p.3) Innovative Timber Systems, DSB Engineering & Consulting; (p.4) FPInnovations, DSB Engineering & Consulting

WoodWorks is an initiative of the Wood Products Council, a cooperative venture of major North American wood associations.