Construction Advantages Sell Hotel Developer on CLT

CLT builds faster and more safely with fewer workers

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From the outside, it looks similar to the thousands of other hotels built across the country in 2015. But when you learn that this project was completed 37 percent faster and the structure built with 44 percent fewer person hours than similar hotels, it warrants a closer look.

Developer Lendlease used cross-laminated timber (CLT) to build the four-story, 62,688-square-foot Candlewood Suites® hotel at Redstone Arsenal, a U.S. Army post near Huntsville, Alabama. Completed in December 2015, the project exemplifies one of the biggest benefits of CLT—construction efficiency.

The 92-room structure, the first hotel built in the U.S. using CLT, is part of the Privatization of Army Lodging (PAL) program, a 50-year public-private partnership between the U.S. Army and Lendlease, a well-known international development company. PAL is designed to provide quality private-sector hotel lodging for soldiers and guests on U.S. Army installations and joint bases. Along with this property, Lendlease owns PAL hotels on more than 40 military installations. The hotels are operated by IHG®, the InterContinental Hotels Group.

Lendlease is no stranger to CLT construction. In 2012, the company's Australian office built Forté, a 10-story CLT residential building in Melbourne. Even so, the decision to use CLT on this U.S. project was not automatic. As owner, developer, design-builder and asset manager for all lodging in the PAL program, Lendlease has built the majority of its new hotels with conventional steel stud framing. So before Jeff Morrow, Program Manager for Lendlease, could convince the team to use CLT for the Redstone Arsenal property, he thoroughly researched the idea and presented the potential opportunities of using CLT for this commercial application.

"As an architect, I was initially skeptical of the concept," said Charles Starck, Senior Architect/Design Manager of Project Management and Construction at Lendlease, "but the more I learned, the more I realized this could be a game changer. It's not often that an architect gets a chance to get in on the ground floor of something that's going to have such a profound impact on the industry. Once I realized what fundamental change we could affect with CLT and heavy timber, I was on board."

Constructability

Ease and speed of construction are two of the greatest advantages afforded by the CLT building system. The Lendlease team not only erected the structure 37 percent faster with 44 percent fewer person hours than their typical hotels, they did so using just an 11-person crew—three experienced carpenters and eight laborers. The laborers were formerly unemployed veterans who were trained at the Redstone Arsenal jobsite.

Construction speed was increased mainly because CLT panels arrive prefabricated, which greatly improves efficiency. "Coordination with the CLT supplier allowed us to control the sequence; the trucks arrived loaded with panels in the order we needed them," said Bill Tobin, Vice President and Master Superintendent at Lendlease.

Crews were also able to work through everything an Alabama winter could dish out. "We worked in the rain almost half the time," added Tobin. "That's the beauty of CLT construction: we could work safely in almost any condition and in all types of weather. We just made sure to measure moisture content of the wood before applying finishes to the structure." Most CLT manufacturers will provide a sealant on panel edges and often on the faces. Because the end grain of the lumber is not taking the brunt of the weather exposure, CLT panels do not readily absorb water that can accumulate during construction.

Jobsite safety was another benefit, said Tobin. "Lendlease is extremely safety conscious. CLT panels allowed us to erect walls quickly and safely, with very few crew members working in the radius and swing fall of the crane." Erection crews assembled safety devices and handrails to panels while they were still on the ground so, as each connecting floor panel was lifted into place, the area was immediately safe for workers. Once the floor deck was installed, crews enclosed the exterior of the building before coming back to install the interior walls. This allowed them to eliminate the potential for falls from elevated heights to the exterior as quickly as possible. The approach enabled the team to safely install almost 400 square feet of floor every 20 minutes with just three workers.

The fact that eight members of the crew could be trained on site opens far-reaching possibilities for Lendlease. In fact, the industry's shrinking skilled labor force favors CLT construction. A 2015 survey of construction personnel executives[1] warned that labor shortages could slow future construction; 24 percent of respondents said they would be unable to bid more work and 32 percent said they would experience slow growth if their companies could not reasonably meet the need for skilled labor and tradespeople. "It is definitely becoming harder to find people to build," said Morrow. "CLT gave us the opportunity to build this quality building with fewer people."

The Case for CLT Construction

PAL Portfolio	Typical New PAL Hotel (Actual*)	Redstone Arsenal (Actual)	Difference
Gross square feet (sf)	54,891	62,688	+14%
Average # of employees	18 (peak 26)	10 (peak 11)	-43%
Structural duration (days)	123	78	-37%
Structural person hours	14,735	8,203	-44%
Structural production rate/day	460 sf	803 sf	+75%
Overall schedule	15 months	12 months	-20%

* PAL New Build Hotel Historical Average
Source: Lendlease

Project Overview

Candlewood Suites at Redstone Arsenal

LOCATION: Redstone Arsenal, AL

OWNER: Lendlease • New York, NY

ARCHITECT: Lendlease • Nashville, TN / Leidos • St. Paul, MN

PROJECT ENGINEER: Schaefer Structural Engineers • Cincinnati, OH

CLT ENGINEER AND FABRICATOR: Nordic Structures • Montréal, Quebec

GENERAL CONTRACTOR: Lendlease • Nashville, TN

COMPLETED: December 2015

Cost Considerations

Since Lendlease owns and is responsible for maintaining the Candlewood Suites at Redstone Arsenal, ongoing cost was a key consideration. "In the past, we've used light-gauge metal stud framing for the hotels on military installations," said Morrow. "We cost-modeled the CLT system against data collected on our buildings constructed with metal studs and found we could save with the CLT, mostly because we were able to frame the building so much faster."

The cost analysis was not an apples-to-apples comparison. Labor costs were higher at Redstone Arsenal than at some other military installations, which further added to the advantage of CLT for this project. "CLT was a more expensive material but installation was faster, so we thought this project would be our best opportunity to take advantage of CLT's overall cost effectiveness compared to traditional framing materials," Morrow said. "In addition, Lendlease will realize additional hotel revenues from the earlier completion, which is another benefit of using CLT." Faster construction results in lower capital costs and quicker hotel occupancy.

While some designers choose CLT out of a desire to expose the wood structure to the building's interior, that was not the case for this hotel as it has no exposed wood. The design team made this decision in part so Lendlease could simplify the approval process, but also to meet IHG's aesthetic brand. With a Type IIIB structure, wood exposure is possible but would have changed the methods for proving fire resistance. "Some in the industry think that CLT is best used for pretty, wood-focused applications. However, it can be just as effective for core and shell structural systems, even when it is buried in finishes and clad, because it is easy, simple and speedy to install," said Tobin. "Redstone taught us that CLT has a place in the market for non-exposed, utilitarian applications."

Starck agreed, saying, "We've proven at Redstone that CLT can be made to work economically in the high end of the low- and mid-rise sectors. Because this represents a large percentage of construction, this is where we can make some serious changes in how we build buildings."

Mass Timber Structure

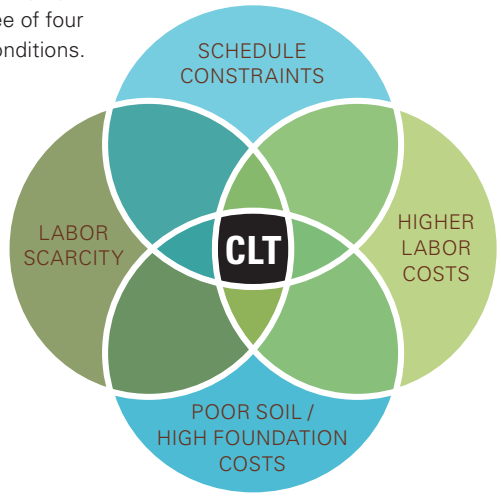
As is typical of a mass timber structure, the four-story, rectangular slab-on-grade hotel used CLT for all exterior walls, parapet walls, interior walls, elevated floor slabs and roof deck. The structure also utilized glulam columns and beams.

While thicker CLT can span up to 25 feet without beams or columns, the 3-1/8-inch-thick roof panels of this Candlewood Suites spanned 16-1/2 feet. In a CLT structure, floors can rest directly on columns without intermediate beams at panel edges because of the bi-directional capacity afforded by CLT's cross-lamination. Redstone's floor panels were 7 inches thick and walls came in a variety of thicknesses, with 3- and 4-inch-thick interior and demising walls and 4-inch-thick exterior walls. Wall height at each level was 10-1/2 feet. The entire stairwell assembly—including shaft walls (which were protected with gypsum to meet the 2-hour fire-resistance requirement), stringers, treads, risers, support beams and landings—was composed of CLT and glulam.

Altogether, the project used 1,557 CLT panels, 11 glulam columns, 44 glulam beams and more than 200,000 CLT fasteners. The sizable number of fasteners was due in large part to the military's blast resistance requirements and is not typical for most CLT construction.

CLT's Sweet Spot

Use of CLT makes the most sense when a project faces at least three of four common conditions.



Building Design

Energy efficiency, moisture and sound protection are always considerations for quality builders. But they were especially important on this project since the builder, Lendlease, is also the owner of the hotel.

"Like most architects, moisture concerns keep me up at night," joked Starck. "I would rather be able to sleep well, so we took a few simple steps to keep things dry inside."

As with all multi-story wood construction, the team had to consider shrinkage and swelling due to fluctuations in environmental conditions. "But shrinkage was a not a major concern for this project," said Doug Steimle, PE, Principal at Schaefer Structural Engineers. "CLT shrinks very little in any direction since most of the shrinkage in the wood has taken place during the drying process, prior to panel lay-up. This reduces the potential for any further dimensional changes once the panels are in place."

They also had to consider the differential movement between CLT and other materials. This Candlewood Suites featured a full-height, four-story concrete brick veneer with a continuous drainage plane behind the cladding. "To overcome the prescriptive limits for the height of the brick veneer, we used an engineered concrete brick product that is self-supporting up to 85 feet," said Steimle. "This means we didn't have to support the brick at each floor, which would have complicated the building envelope design."

Typical detailing includes supporting the brick at each floor level, increasing the number of possible locations for bulk water intrusion. The advantage of supporting the brick at each floor is that shrinkage can be isolated at each level and doesn't accumulate at the top of the structure. "But not supporting brick at each floor typically forces us to address the cumulative change between the wood structure and the brick veneer at either the top or bottom of the full-height wall, which is not always easy," continued Steimle. "Because there was so little wood shrinkage, this was not a difficult task with CLT. The anticipated differential movement for the four-story wall was less than 1/4 inch."

They also installed a weep and vent system to ensure air circulation behind the cladding. The continuous brick veneer allowed them to maintain the drainage plane from top to bottom without being interrupted by shelf angles attached to the structure at every floor. "That was unusual," said Starck. "You don't see a lot of buildings with a continuous drainage plane like that. Our goal was to make sure that any condensation which does get into the envelope has free passage down to sthe weep holes, where it can exit the system."

Force Protection

Candlewood Suites at Redstone Arsenal required extensive design collaboration between Lendlease and the U.S. Army Corps of Engineers Protective Design Center (USACE PDC). Because it is located on a U.S. military base, the structure needed to meet Anti-Terrorism and Force Protection (ATFP) standards. Since CLT is not listed as a conventional building type for meeting ATFP standoff, blast resistance and progressive collapse, the design team needed to seek approval from the USACE PDC. Lendlease, their design consultants and the CLT manufacturer supplied extensive engineering analyses to prove compliance with the standards.

Tobin added, "We didn't use intermediate weeps or drains except around the flashing details of windows and penetrations. We used the mechanical flashing plus a peel-and-stick counter flashing as well as a fluid-applied membrane."

Energy efficiency was also important to Lendlease. By design, CLT systems are intended to provide a tighter building envelope with less air infiltration than conventional light-gauge steel framing. CLT panels for the hotel were manufactured to a tolerance of less than 1/16 inch, which is far tighter than anything that can be achieved in the field using conventional construction and materials. "I think quality control was much easier to manage in this building," said Tobin. "It was simple to train the crew on correct installation and, since the panels were true, it gave us a tighter core and shell."

To further improve energy performance, Lendlease installed 1-1/2 inches of mineral wool as continuous insulation. The high R-value and airtightness of this system reduced the size of the HVAC equipment required to heat and cool the building. Lendlease projects that the Redstone Arsenal Candlewood Suites will be 31 percent more energy efficient than previously-built PAL hotels of similar size. In addition, the hotel achieved LEED Silver certification.

Sound control is also critically important in hotels. On its own, CLT could not meet IHG's acoustical requirement between units. However, field testing showed that the CLT floor and wall assemblies used at Redstone Arsenal produced a Sound Transmission Class (STC) rating substantially greater than that required by code. "The building code requires a minimum 50 STC between units, but our hotel operator requires an STC of 55 so that is what we designed for, using an assembly engineered by an acoustical consultant," Starck said. "After we completed construction and had our assemblies in place, we did some field testing. Our lowest Field Sound Transmission Class (FSTC) for the wall came in at 63. The CLT floor assembly achieved a Field Impact Insulation Class (FIIC) rating of 74, which was also substantially more than the Impact Insulation Class rating of 50 required by code." Field tests typically yield results which are 1 to 3 points lower than laboratory tests. The high FSTC rating demonstrates that this CLT assembly has better sound absorption qualities than originally determined by theoretical analysis.

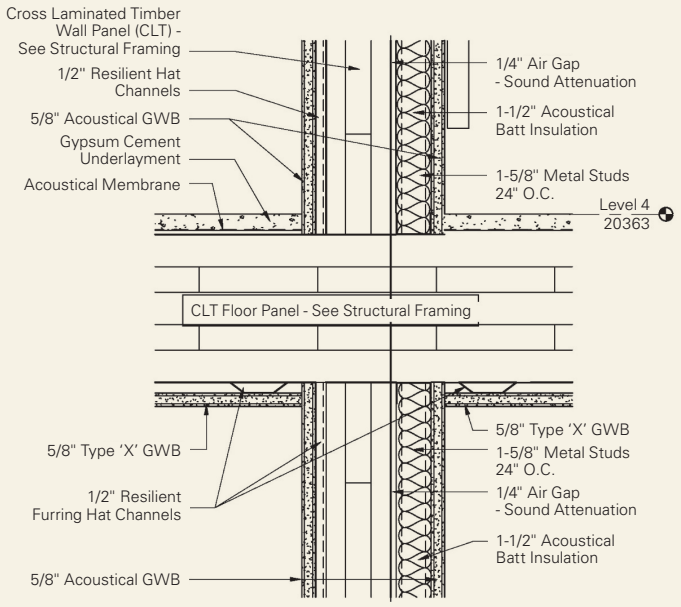
One of the issues of CLT design is choosing where to run conduit for electrical, HVAC and other utilities. Rather than routing out the CLT panels, the design team decided to run 1-1/2-inch furring strips on the inside of the assembly, adding additional insulation in the cavity and supporting a gypsum board finish. A 1/4-inch air gap between the CLT and furring wall allowed conduit to fit between the gypsum board and the face of the CLT panel.

CLT Overview

CLT is an innovative engineered wood product originally developed in Europe, but gaining popularity among North American building designers. It can be used for walls, floors and roofs of both residential and commercial structures. CLT panels consist of layers of dimension lumber or structural composite lumber (SCL) glued together under pressure with the grain of the boards in one layer running perpendicular to the grain in adjacent layers. CLT is typically manufactured in three-, five-, seven- and nine-ply panels up to 10 feet wide and 64 feet long, and then cut to exact specifications. Panels are engineered for specific use in a building and can be pre-cut with window and door openings.

CLT is dimensionally stable and strong, creating an effective lateral load-resisting system. Panels perform exceptionally well in multi-story applications.

Interior Wall and Floor Assembly



Source: Lendlease

Understanding the Fire Performance of CLT

Candlewood Suites at Redstone Arsenal was designed and built to IBC 2012, Type IIIB construction, R-1 occupancy (hospitality), and was also required to comply with the Unified Facilities Criteria (UFC), which incorporates the requirements of the IBC plus Department of Defense-specific and anti-terrorism provisions. While it is standard that all Candlewood Suites be sprinklered regardless of height and area, fire resistance was still a consideration because of both the occupancy and requirements of the construction type.

While it has been used in Europe for more than 20 years, CLT is still relatively new to North America and was not an approved structural material under the 2012 IBC. To use CLT at the Candlewood Suites hotel, Lendlease took advantage of Section 104.11, Alternative Materials, Design and Methods of Construction and Equipment, of the 2012 IBC. Using this code-approved procedure, Lendlease had to prove that the building had structural, fire protection and seismic resistance equivalent to the prescriptive requirements of the building code; this required extensive engineering analysis and rigorous design methodologies. Since fire-rated assemblies for CLT did not exist in the IBC, Lendlease used the Calculated Fire Resistance provisions of IBC Section 722, to determine assembly fire-resistance ratings.

A great deal of research is available on the fire performance of CLT and other mass timber products. For example, the American Wood Council (AWC) conducted a fire-resistance test on a load-bearing CLT wall in 2012, which contributed to the inclusion of CLT in the 2015 IBC. Conducted in accordance with ASTM E-119-11a (Standard Test Methods for Fire Tests of Building Construction and Materials), the test evaluated CLT's fire-resistance properties. A five-ply CLT wall (approximately 6-7/8 inches thick) was covered on each side with a single layer of 5/8-inch Type X gypsum wallboard and then loaded to 87,000 pounds, the maximum load attainable by the testing equipment. The 10x10-foot test specimen lasted three hours, five minutes and 57 seconds—well beyond the two-hour goal.

More recently, AWC sponsored two demonstration fire tests[2] of typical residential occupancies. The test compartments were 8 feet 7 inches high, with a footprint of approximately 6x12 feet. One compartment was made with CLT walls and ceiling, and the other with CLT walls and a nail-laminated timber ceiling; both were fully protected with gypsum wallboard. After approximately 180 minutes of burning and temperatures reaching 2,000°F, the gypsum was removed. The structural wood had remained below char temperature throughout the test, demonstrating that protected mass timber can provide adequate fire performance in residential construction, even under the extreme scenario in which automatic fire sprinklers fail and fire service is unable to respond quickly.

For more information on CLT research, visit the mass timber section of the reThink Wood website (www.rethinkwood.com), or download the paper, *CLT Research: Available and Accessible to North American Building Designers.*[3]

Advantages Add Up

Quicker to build. Cost effective to construct. Quieter. More energy efficient. Easier and safer to erect. Environmentally friendly.

CLT's advantages added up.

Even with the additional requirements of blast protection, the Candlewood Suites at Redstone Arsenal demonstrates that CLT is an effective option for non-military hotels and other mid-rise projects.

"Utilization of CLT is an extremely collaborative process," said Morrow. "A lot of the success with this project was due, not only to what Lendlease did, but also to the fact that we had some very competent, able and willing partners, including Nordic Engineered Wood and Schaefer, who were both willing to help us succeed. You can't build with new materials in a vacuum; you must have good partners along the way."

Morrow added, "CLT gave us the opportunity to build a more robust, higher quality and higher performing hotel than we've built in the past. It's just better building."

Carbon Benefits

Wood lowers a building's carbon footprint in two ways. It continues to store carbon absorbed by the tree while growing, keeping it out of the atmosphere for the lifetime of the building—longer if the wood is reclaimed and reused or manufactured into other products. 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:
935,696 board feet (equivalent)

U.S. and Canadian forests grow this much wood in:
5 minutes

Carbon stored in the wood:
1,276 metric tons of CO_2

Avoided greenhouse gas emissions:
494 metric tons of CO_2

TOTAL POTENTIAL CARBON BENEFIT:
1,770 metric tons of CO_2

EQUIVALENT TO:

Source: US EPA

374 cars off the road for a year

Energy to operate 187 homes for a year

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.

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Use the carbon calculator to estimate the carbon benefits of wood buildings. Visit **woodworks.org**.

[1] Wilson, K. and P. Warner, FMI, *Craft Labor Recruiting and Retention 2015 Survey Report*

[2] American Wood Council, *Technical Data in Support of G165-PC2: NLT-CLT Compartment Fire Tests Summary,* September 2015

[3] Podesto, L. and S. Breneman, *CLT Research: Available and Accessible to North American Building Designers* – Wood Design Focus, Volume 26, No. 1, 2016, www.woodworks.org/wp-content/uploads/CLT-Research_Podesto_Breneman.pdf