Cross-Laminated Timber in the United States: Opportunities and Challenges

Brettsperrholz – neue Möglichkeiten mit Anlaufschwierigkeiten

Le CLT – de nouvelles opportunités, mais des ratés au démarrage
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1. Introduction

Cross-Laminated Timber, or CLT, is a relatively new construction technology developed in the early 1990s in Europe, where it has become a major building material. Today CLT successfully competes with steel, brick, and concrete in some markets. CLT is “a prefabricated engineered wood product made of at least three orthogonally bonded layers of solid-sawn lumber that are laminated by gluing of longitudinal and transverse layers with structural adhesives to form a solid rectangular-shaped element intended for roof, floor, or wall applications (ANSI, 2012).” CLT panels (Figure 1) are pre-fabricated, with openings for doors, windows, and ducts precision-cut with CNC routers. The prefinished panels are transported to the construction site and put into place with cranes. Walls and floor systems are joined using metal connectors. Additional insulation layers can be applied to CLT walls and ceilings, or left bare to take advantage of the warmth and aesthetics of wood.

![Figure 1: Cross-Laminated Timber sections.](image)

CLT attractiveness as a building system originates in part from the speed at which CLT buildings can be raised, with considerable savings in labor and minimal disturbance to the site’s surroundings (Crespell & Gagnon, 2011). CLT has been used in tall buildings, such as the Stadhaus in London (9 stories, (Hopkins, 2012; Lattke, 2007)), the Forte in Melbourne (10 stories, (Lend Lease Corporation, 2013; Wells, 2011) ) and the Wood Innovation Design Center in British Columbia (9 stories, (Partnership BC, 2013)). In the U.S., the architectural firm Skidmore, Owings & Merrill has proposed a 42-storied CLT building (SOM, 2013) (Figure 2).
CLT is comparable and, in some aspects superior, to concrete or steel. As a building system, CLT allows covering long spans without support. A CLT panel with 7 layers and a total thickness of 9 inches can be used to cover spans of about 25 feet (Karacabeyli & Douglas, 2013). Variations of CLT, such as “cassette” or “folded” floors, allow for even greater spans (Crespell & Gagnon, 2011). Regarding structural performance, CLT panels can be used as load-bearing plates and shear panels, in contrast to other wood-based engineered composite panel products (Steiger, Gülzow, & Gsell, 2008). CLT also has advantages regarding its fire performance due to the predictable burning properties of large-section wood structural elements (when exposed to fire, wood decomposes and forms a layer of char that acts as a retardant against further thermal degradation of the unburned core, thus preventing mass loss and reduction of load-carrying capacity (Forest Products Laboratory, 2010)). CLT construction reduces concealed spaces, which reduces fire spread (Craft, 2011). The seismic performance of CLT has been the subject of several studies. In one experiment, a seven-story building specimen was subjected to severe earthquake-like motions, equivalent to 7.2 on the Ritcher scale. CLT showed excellent seismic behavior, with maximum inter-story drifts of 1.5 in. and lateral deformation of less than 12 in. (Quenneville & Morris, 2007). In respect to environmental performance, CLT has shown superior qualities compared to steel, brick, glass, plastics, or concrete. The environmental performance attributes of CLT originate mainly from the characteristics of wood, which have been demonstrated in numerous Life-Cycle Analysis studies as being extremely favorable (CORRIM, 2010; Hubbard & Bowe, 2010; Lippke, Wilson, Perez-Garcia, Bowyer, & Meil, 2004; Wilson et al., 2005). Given sustainably managed forests, replacing metals, concrete, or plastics with wood as raw material reduces carbon emissions. Wood has the additional benefit of acting as carbon sink (Bowyer et al., 2011). A 2011 study by the Forest Service concluded that wood has superior environmental performance over other materials such as concrete or steel, even when the wood stems from diseased trees (Ritter, Skog, & Bergman, 2011). A number of independent studies compared the environmental performance of multi-story buildings built with CLT and concrete (Chen, 2012; Durlinger, Crossin, & Wong, 2013; John, Nebel, Perez, & Buchanan, 2008; Adam Blake Robertson, 2011). These studies consistently concluded that CLT buildings had lower embodied energy than concrete-based buildings and superior performance than concrete and steel in respect to ozone depletion, global warming potential, and eutrophication (Chen, 2012; Durlinger et al., 2013; John et al., 2008; Adam Blake Robertson, 2011). Lastly, tests in Canada showed that CLT’s volatile organic compounds and formaldehyde emissions are below established standards (Adam B. Robertson, Lam, & Cole, 2012).
While being a proven and widely used material in Europe, the U.S. market for CLT is in its embryonic stage. Only a handful of small projects have been built with CLT and there is only one commercial CLT producer (Smart Lam LLC, Columbia Falls, MT) in the country. However, efforts are being made to incorporate CLT into building codes and to test the material's structural performance. However, market acceptance is a slow process and widespread adoption of CLT will depend on successful projects being executed in the U.S.

2. U.S. Forest Resources

The U.S. contains some of the most productive forests in the world. Americans use on average 5 times more round wood per capita than does the rest of the world (FAO, 2011), and yet the U.S. forested area has not changed in 100 years (Alvarez, 2007). However, despite this resilience, U.S. forest resources face significant challenges:  

**Increasing Prevalence of Small-Diameter Timber.** Due in part to insufficient demand and lack of resources to manage U.S. forests, decades of fire suppression, and high-grading, the prevalence of small-diameter timber of low quality and low value is growing (Perkins, 2006). Also, the recent drop in pulping capacity, which depressed pulpwod stumpage prices (Perkins, 2006), invasive species, urban growth, and climate change are other factors challenging U.S. forests’ health (Alvarez, 2007). Yet, studies have suggested that small-diameter logs can yield high quality material, when processed using appropriate methods (LeVan-Green & Livingston, 2003; Lowell & Green, 2001; Wagner, Fiedler, & Keegan, 2000). However, removal of these low-value and underutilized trees will only happen if an economic incentive exists for landowners or revenue from the removal for National forests. Use of the small-diameter stock for pulping (Ahmed, Myers, & AbuBakr, 2000), highway applications (Hascall, Reid, Faller, Sicking, & Kretschmann, 2007; Paun & Jackson, 2000), engineered wood composites, or energy applications (LeVan-Green & Livingston, 2003) are low value-added and do not generate enough income to pay for the removal of underutilized timber in our national forests. However, this economic calculation changes when a high value product like CLT can be produced from the nation’s low value, small diameter trees.  

**Insect Infestation.** The U.S. forest resource is also subject to stress due to insect infestation, such as the mountain pine beetle (MPB), the gypsy moth, the southern pine beetle, and others (Alvarez, 2007). In total, by 2006, about 58 million acres were at significant risk of insect attack and disease(Alvarez, 2007), with 24 million acres in National Forests (Jr. et al., 2014). The MPB has been immensely detrimental to western forests from New Mexico to Montana, where entire regions are succumbing to this infestation (Robbins, 2008). However, tests on properties of timber from MPB-killed trees show that there is no significant reduction in stiffness and breaking strength, and the materials’ glue joint integrity is undistinguishable from non-affected wood (Forintek, 2003; Uyema, 2012).

Consensus exists that traditional markets cannot absorb all the low quality timber in existence (Bumgardner, Hansen, Schuler, & Araman, 2001), thus there is a need to find profitable uses for this resource. Since CLT is made of small wood pieces glued together, the quality of individual pieces is not as critical as with other timber-based building applications. The authors interviewed an European manufacturer who stated that CLT panels can be made from wood pieces as small as 40x50x9mm when finger jointing is employed (Leibundgut, 2014), thus allowing the efficient utilization of low value, small diameter trees. Such new, high value-added uses of low value, small diameter trees are of critical importance to support proper forest management and enhance the economic wellbeing of timber-reliant rural communities.

3. Potential Implications of CLT for U.S. Timber Resources and Economy

Several authors have emphasized the benefits of using forest management solutions to ameliorate the challenges stemming from climate change. The proposed solutions include increasing the use of wood products since they store carbon for the duration of service and require less energy for its transformation than do other materials(Bowyer et
al., 2011; R.W. Malmshimer et al., 2011; Robert William Malmshimer et al., 2009). Due to its solid nature, CLT may generate concerns that its adoption may have negative effects on U.S. forest resources due to over utilization. Indeed, findings from recent research by the authors suggest that architects view the amount of wood needed for CLT as potential barrier to its adoption (see Section G) (Lagarda-Mallo, 2014; Lagarda-Mallo & Espinoza, 2014, 2015). However, no scientific study has been carried out to estimate the potential impact of a thriving CLT market on U.S. timber resources. This study intends to fill this gap, with focus on the National Forests. The authors conducted preliminary calculations to estimate the potential utilization of forest resources from a growing CLT industry in the U.S. We obtained timber usage data for 23 CLT buildings from a Swiss manufacturer (Leibundgut, 2014) and assumed that 20% of the square footage of multifamily housing built in 2013 (U.S. Census Bureau, 2015) used CLT. Calculations show that this scenario would require 0.5 billion board feet of lumber, capturing about 1.2 million metric tons of CO2 (Lugt, 2012), creating jobs in mainly rural areas, and greatly enhancing utilization of our National Forests (detailed calculation in the Appendix). We consider this represents just a fraction of the actual potential of CLT, as it only considered multifamily buildings.

Given these opportunities, the manufacturing and marketing of CLT made from underutilized, small-diameter, low-value timber needs to be studied and promoted aggressively to unlock the potential to create new, high-value added markets for this resource. Only through the creation of economic incentives can the health and productivity of the U.S. forest resource be improved. The author believes that CLT presents a unique opportunity to increase the value of our timber resource, create employment and improve the economic prosperity in mainly rural parts of the country, thus contributing to the welfare of all Americans.

4. **Market Research**

Due to its design and structural capabilities, there has been growing interest in CLT in the U.S. Also, CLT’s potential for job creation and its ability to use low-value, small-diameter timber to make a high value-added product has fostered interest in this new approach to constructing with wood. Research is being carried out in several institutions on various aspects of CLT (Hindman et al., 2012; Peralta, 2012). However, most of the ongoing research is focused on technical aspects of CLT, and, to no study focuses on market acceptance and the perceptions of potential adopters of the product. The author and his collaborators fill this gap by addressing marketing aspects of CLT adoption in the U.S. Our long-term goal is to support and improve the health of U.S. forests by supporting the U.S. forest products industry. Specifically, we want to investigate, identify, and disseminate market opportunities and barriers to the adoption of CLT in the commercial, multi-family, and institutional construction industry and its supply chain.

5. **References**


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