Modern Tall Wood Buildings: Opportunities for Innovation

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15 January 2016

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EXECUTIVE SUMMARY

Tall wood buildings are an early 21st century phenomenon, made possible by development of a number of new engineered wood products. Building codes in many jurisdictions currently limit wood structures to no more than 4 or 6-stories; however, the technical limits of wood construction have increased to 40-stories and more through recent innovations. In response, tall wood buildings are rising all over the world.

Modern tall wood construction is enabled by European development of large wood panels known as cross laminated timber. Canada was first in North America to experiment with the new construction material. In British Columbia an 18-story wood building is currently in early stages of construction. In Québec, wood construction of up to 12-stories has recently been approved.

In the U.S., building codes allow wood construction up to 6-stories in some regions, but no more than four in others. However, specific tall wood building projects have recently been granted exemptions to code in several municipalities. Structures of up to 12-stories are planned for Portland, Oregon and New York City.

Current concerns about climate issues coupled with increasing recognition of the positive environmental attributes of wood – which include low carbon emissions in processing and massive carbon storage in use – have attracted interest in greater wood use in construction. The extent to which tall wood buildings will be developed in the U.S. remains to be seen, but there is little doubt that wood use will increase in high-rise structures.

Tall wood buildings offer an opportunity to connect rural resources with urban communities in a manner that has the potential to support forest restoration, drive green building, and address carbon emission reduction objectives. However, the use of engineered wood products and new building technologies requires thoughtful consideration of questions about durability, performance, and long-term impact. The continued evaluation, testing, and reporting on tall-wood building research is a key component to ensure the safe and responsible realization of this innovation and its full suite of potential benefits.

INTRODUCTION

Tall wood buildings[1] are not a new concept. For instance, the Yingxian Pagoda in Shanxi Province, China is a 9-story wooden structure completed in 1056. Now 959 years old, it is the oldest wooden multi-story building in the world.[2] Far newer, but old by U.S. standards, the 8-story Butler Building in Minneapolis, built of heavy timbers with a brick facade in 1906, provides a living example of heavy timber construction of that era (Figure 1). Used today as an office building, the 500,000 ft^2 structure originally served as a warehouse. Similar structures are the 8-story 120,000 square foot 320 Summer Street building in Boston's Fort Point Channel neighborhood, also constructed in 1906, and the 7-story Perry House in Brisbane, Australia (1913) among others.[3]

Figure 1
Butler Building, Minneapolis, Minnesota (Built in 1906)

[1] Defined as a building over 5-stories in height built with wood as the primary structural material.
[2] UNESCO (2013)
[3] Gerard (2014)

Figure 2
Limnologen
Växjö, Sweden

Most tall buildings built throughout the 20th century were constructed of steel and concrete, a practice that continues today. While steel and concrete dominated the tall buildings scene, wood framing dominated single-family and low-rise residential construction. And, during this same period, large wooden columns and beams, made by gluing smaller pieces of wood together with the grain of all pieces parallel to one another – today commonly known as "glulam" – became increasingly common in construction of church buildings and other types of structures.[4] However, development of new types of engineered wood products in North America in the 1980s and '90s – including various forms of structural composite lumber, wood I-joists, and thick composite panels – significantly increased design options for wood structures. These developments, coupled with interest in more economical construction, led to an increase in the number of 4 to 5-story wood-framed buildings around the turn of the 21st century.[5] This trend continues today.[6] Acceptance of taller wood-framed buildings is now overshadowed by a new development – one that has its roots in Europe. Almost overnight, the height potential for modern wood buildings has increased dramatically.

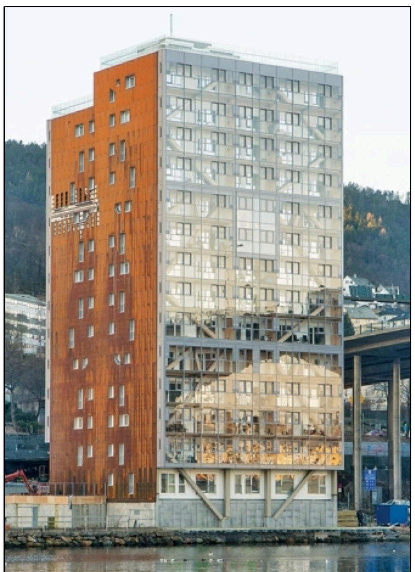


Figure 3
Treet
Bergen, Norway

The game-changer for tall wood was the introduction of a new product – Cross Laminated Timber (CLT). CLT is made of a number of layers of lumber, glued together with the grain of alternate layers laid at right angles to one another, much like the veneers of plywood. CLT panels can be as large as 20 inches thick x 10 feet x 60 feet (0.5 x 6 x 18 meters). CLT combines the advantages of large size load-bearing panels, stability, fire resistance, long-term carbon storage, and renewability. CLT panels also can be made using relatively low quality, small diameter timber. A related product, made by nailing wood components together, is marketed as Nail Laminated Timber or NLT.

Engineers and architects soon discovered that through the use of large CLT panels, wood buildings could be constructed to previously unimagined heights. Within a period of only six years a number of wood buildings were constructed around the world ranging in height from 6 to 14-stories, including several 9-story apartment buildings constructed in Växjö, Sweden in 2009 (Figure 2), and the 14-story Treet building completed in 2015 (Figure 3)[7]. It was been demonstrated that wood structures as tall as 40-stories are technically feasible. This report explores tall-wood buildings, including developments globally, opportunities in the U.S., potential economic and environmental benefits, concerns that need to be addressed, and the future outlook for use of wood in tall structures.

4 Large timbers made by gluing smaller pieces of wood together were first used in the mid-1800s in Europe and patented in the late 19th century in Germany.

5 Wallace et al. (1998)

6 Kam-Biron (2012); Stumpfoll (2015)

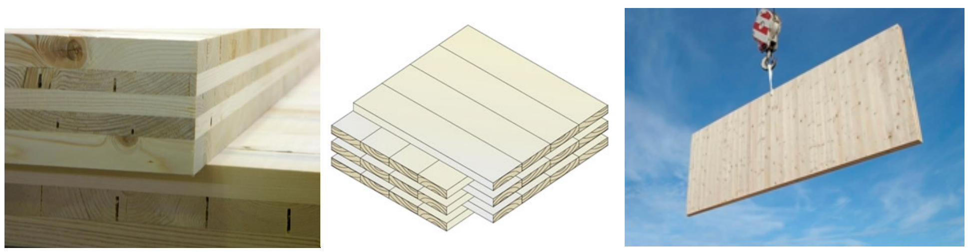
7 Photo source: http://www.bygg.no/article/1261829?image=dp-image73462-1261843

CLT – A BRIEF HISTORY

Like many new technologies, development of CLT (Figure 4) occurred over a period of several decades. The concept was first employed in German roof systems during the mid-1970s, patented as general use construction panels in France during the mid-1980s, and first commercially produced in the mid-1990s.[8] The first buildings constructed of CLT appeared in Switzerland (1993), Germany (1995), and Austria (1998); the latter structure was the first multi-story CLT project.[9] Thereafter, CLT production began to increase, rising from an estimated 0.095 million m^3 in 2000 to 0.61 million m^3 in 2010; growth since that time has been substantial.

Canada was first in introducing CLT to North America. The Canadian wood research enterprise FPInnovations launched a multi-disciplinary research program on cross-laminated timber in 2005 as part of the Transformative Technologies Program of Natural Resources Canada.[10] Soon thereafter, Simpson Strong-Tie partnered with Colorado State University to evaluate earthquake performance of a multistory CLT structure. Research, conducted at a laboratory near Kobe, Japan, involved a severe shake-table test of a 7-story CLT structure.[11] Remarkably little damage occurred, prompting immediate interest on the part of governments around the world.

Figure 4
Cross Laminated Timber



In 2009 the government of British Columbia increased the allowable height of wood structures from 4 to 6-stories, and a year later the first 6-story wood structure was built in Vancouver. Three years later the first multi-story CLT structure was built in Canada on the campus of the University of British Columbia (UBC). CLT had arrived in North America. Subsequently, a number of CLT projects have been undertaken in western Canada, the latest an announced 18-story dormitory building, again on the UBC campus. Meanwhile, the concept has gained popularity elsewhere in Canada. Subsequent to actions in BC, wood construction of up to 6-stories was approved in the provinces of Québec and Ontario, and in Calgary, Alberta.[12] Massive wood construction of up to 12-stories was recently approved in Québec as an 'alternative solution' to the existing building code, spurred by the planned development of a 13-story project (12-stories of wood over a first-story concrete podium).[13] [14]

Use of CLT in building construction in the United States has been slower to develop, in part because of building code restrictions that limit wood use in tall structures, and because of a general lack of familiarity with the product. The U.S. scene may soon change, however, spurred by joint US Department of Agriculture and industry sponsorship of a 2015 tall wood buildings design competition[15], with two projects receiving financial awards in October. Although at least twenty-one wood structures over 6-stories have been built around the

[8] Weirer (2010); Brandner (2013)
[9] Schickhofer (2010)
[10] Canadian Wood Council (2015)
[11] Wilmsen (2009)
[12] Mohammad (2015)
[13] Alter (2015)
[14] O'Kane (2015)
[15] https://tallwoodbuildingcompetition.org/

world in recent years (Table 1), the two planned projects – one in Portland, Oregon and one in New York City – will be the first in the U.S.

Table 1: Tall Wood Building Examples Globally

Name	Location	Stories	Year
Limnologen (Figure 2)	Växjö, Sweden	8	2009
Stadthaus	London, UK	8	2010
Bridport House	London, UK	8	2010
Holz8	Bad Aibling, Germany	8	2011
E-3	Berlin, Germany	7	2011
Forte	Melbourne, Australia	10	2012
LifeCycle Tower One	Dornbirn, Austria	8	2012
Pentagon II	Oslo, Norway	8	2013
Wagramerstrasse	Vienna, Austria	7	2013
Cenni di Cambiamento	Milan, Italy	9	2013
Panorama Giustinelli	Triste, Italy	7	2013
Treet(Figure 3)	Bergen, Norway	14	2014
Strandparken	Stockholm, Sweden	8	2014
Wood Innovation Design Centre	British Columbia, Canada	8	2014
Contralaminada	Lleida, Spain	8	2014
St. Die-des-Vosges	St. Die-des-Vosge, France	8	2014
Puukuokka	Jyvaskyla, Finland	8	2015
Trafalgar Place	London, UK	10	2015
Banyan Wharf	London, UK	10	2015
Dalston Lane	London, UK	10	2015
Shoreditch	London, UK	10	2015
Maison de I'Inde	Paris, France	7	TBA
Wood City	Helsinki, Finland	8	TBA
Abrora	Montreal, Canada	8	TBA
Carbon 12	Portland, OR, USA	8	TBA
Framework/Beneficial Bank	Portland, OR, USA	12	TBA
475 West 18th	New York, NY, USA	10	TBA
HoHo Vienna	Vienna, Austria	24	2017
Origine	Quebec City, Canada	13	2017

Source: reTHINK Wood (2015); USDA/SLB/BiNational SWLC (2015); various other sources.

Expanding the use of wood into high-rise and more commercial structures is being supported by a variety of interests – government, architects, engineers, industry, researchers – and for a range of reasons – economic development, design innovation, climate change mitigation, and positive implications for forest health. Among the climate change related benefits of greater use of wood in construction are low carbon emissions associated with manufacturing wood products as well as long-term carbon storage within these products.

One of the actions supporting these developments is the implementation of policies intended to increase the use of wood in construction. As shown in Table 2, a variety of governments around the world have implemented diverse wood building initiatives and policies. Most of these have appeared within the last decade.

Table 2: Wood Building Initiatives Around the World

Initiative	Location	Pilot Year	Description
Timber Sales Promotion Fund Act 1990	Germany	1990	This program works much like a check off program in the U.S., with provisions for promotion of wood products, but differs in that the government mandates participation.
Land Use Planning Incentives for Wood in Construction	Finland	2004	Encourages increased use of wood in small house construction.
BC Wood First Initiative Wood First Act	British Columbia, Canada	2009	As of December 2014, 53 communities across B.C. had passed or endorsed resolutions or policies indicating their intent to adopt wood in public buildings. On average, the Province annually funds almost $3 billion worth of capital investments in buildings such as hospitals, schools and social housing.
Wood Use Strategy for Construction in Québec	Québec, Canada	2009	This measure specifically aims to increase the use of wood products in the nonresidential sector in Québec and in the construction of multifamily homes as well as to intensify the use of appearance wood products. The initiative encourages environmental performance as well as use of wood. Under this policy, construction project proposals that use wood instead of other materials and fall within 5% of the cost of other proposals will be considered the same.
Threshold of wood use in construction. (Decree 2010-273)	France	2010	Required new public buildings to have at least 0.2 m^3 of wood building materials for every 1 m^2 of occupancy. Subsequently rescinded.
Wood First Law	Japan	2011	Patterned after the law in British Columbia, this measure requires that wood be considered as the primary building material for any government funded building of up to 3-stories, and for any privately funded buildings used in a public manner.
Construction Product Regulation	EU	2011	While not mandating the use of wood, two requirements of this regulation favor wood use. One requirement relates to greenhouse gas emissions of construction products and another requires the use of "environmentally compatible materials." The metric is the carbon footprint as determined using EU-level calculation rules for all construction materials over the entire life cycle of a building.
Timber First	Hackney Borough Council, London, UK	2012	Encourages use of timber as a first choice building material for construction projects.
Wood First	Ontario, Canada	2012	The Act aims to facilitate a culture of wood by requiring the use of it as the primary building material in the construction of provincially funded buildings. The Act also increased the maximum allowed height for wood framed construction from 4-stories to 6-stories. The measure as originally envisioned did not gain legislative approval, although the proposed increase in maximum allowed height was ultimately approved.
Dutch Design Initiative – A Dime for a House	Netherlands	2013	Measure makes it compulsory to provide environmental impact information for all new buildings. This will largely benefit wood building materials due to their significantly lower environmental impact.
USDA Tall Wood Building Competition	United States	2014	This initiative is designed to encourage and promote greater use of wood in building construction with the objectives of helping to mitigate climate change, facilitate forest health, and support jobs in rural America.
Wood Encouragement Policies	Australia (City Councils of Latrobe, Wellington Shire, and Wattle Range)	2015	Ensures that all new Council projects are required to use timber as the preferred material for both construction and interior finishing, where wood is deemed a suitable material for the proposed application, and ensures that all comparisons to the cost of building with other materials take into account all long-term and life cycle benefits of using wood products.
Wood First Policy	Rotorua District Council, New Zealand	2015	Provides for development of an assessment toolkit for all council-led building projects to see how wood might be incorporated in design and encourages contractors to include wood options in their proposals to Council.

Source: Oliver and Venables (2012); Make it Wood (2015); reThink Wood (2015).

TALL WOOD BUILDINGS POTENTIAL

While wood is used to a greater extent in construction of commercial buildings today than in most of the last century, there remains considerable potential for greater wood use in commercial buildings of all sizes. With regard to tall buildings, although recent studies and design initiatives have demonstrated the potential for very tall buildings made dominantly of wood, it is buildings of less than 10-stories in height which represent the greatest opportunity for market expansion (Figures 5-7).

There is also opportunity for application of wood construction in projects to increase the height of existing buildings.[16] The lighter weight of wood can allow additions to building height without foundation reinforcement that might be required if other building materials were used.

The potential impact of policies designed to encourage increased use of wood in all buildings was recently estimated, taking into consideration only the near-term potential of greater wood use.[17] Findings indicate the potential for an increase in annual wood consumption of 6.8-7.6 billion board feet (Bbf) (Table 3). The near-term potential increase anticipated from use of wood in constructing buildings to heights over 6-stories is 1.6-2.4 billion board feet. As described in detail below, these figures equate to less than 4% of net annual wood growth in the United States and approximately 7% of the current available growth that occurs each year in excess of existing market demands.

Figure 5
U.S. Commercial Building Stock: Number of Buildings by height, 2012

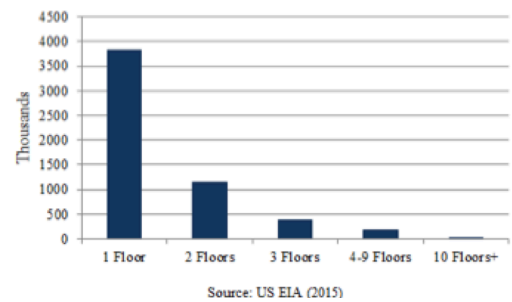


Figure 6
U.S. Commercial Building Stock: Total Floor Space in Buildings by Height, 2012

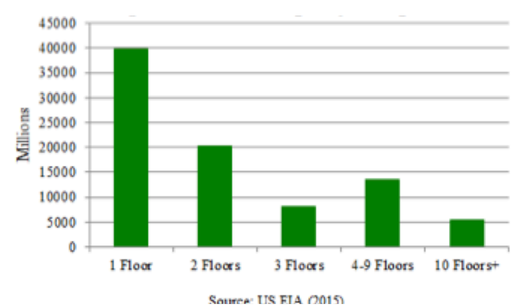
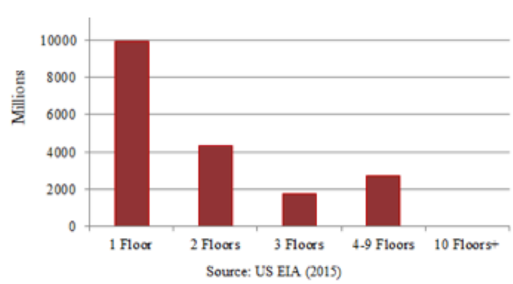


Figure 7
U.S. Commercial Building Stock: Floor Space in Buildings by Height Constructed 2000-2012



[16] Manninen (2014), p. 30
[17] Forest Climate Group (2015)

Table 3: Potential Increase in Annual Use of Wood in U.S. Construction

	Approximate additional wood volume needed	
	Billion board feet (Bbf)	Million cubic meters (m^3)
Low-rise nonresidential [a/]	4.5	10.6
Multifamily [b/]	0.7	1.7
U.S. buildings 7-15 stories	1.6-2.4	3.8-5.7
Aggregate	6.8-7.6	16.0-17.9

Source: Forest Climate Group (2015)

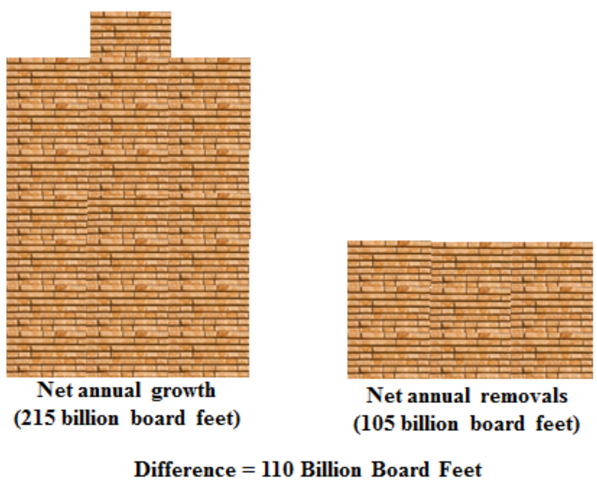
[a/] *Non-residential includes non-residential low-rise buildings like offices, stores, schools, public buildings and hotels. For simplicity, 100% conversion of only the near term opportunity to wood was assumed, a figure expected to increase as the U.S. economy continues to recover from the deep recession of 2007-2009.*

[b/] *Multi-family includes multi-family residential buildings such as 3-5 story apartment buildings and condominium-style buildings. Market penetration for wood in this market is approximately 80% currently, and increased wood volume potential was based on an assumption of 100% conversion of near term opportunities to wood. 0.7 Bbf is the increase in wood use expected from the additional conversion of 20%. Potential volumes are expected to increase as the U.S. economy continues to recover from the deep recession of 2007-2009.*

Any proposal for increased use of wood almost inevitably raises questions about the sufficiency of the wood resource base. In this case, there is considerable opportunity for sustainable increases in wood use given that:

- Net annual growth[18] in U.S. forests is at or near double annual removals (Figure 8).

Figure 8
Net Annual Growth vs. Annual Removals in U.S. Forests, 2012



Source: Oswalt et al. (2014)

- Production of mass timber products such as CLT can utilize standing dead and dying timber, such as that impacted by the mountain pine beetle over vast areas of western North America, for which there are few other markets.
- Small diameter timber can be used in producing mass timber panels, providing a potential source of revenue to support badly needed thinning of overstocked forests and stands in some regions.

[18] Annual production of new wood minus losses due to fire, insects, disease, and all other losses.

With regard to differences between annual growth and removals, the most recent estimate (2012) shows net annual growth to removal ratios for all species at 2.1, and for softwood species at 1.9.[19] Expressed differently, the difference in net annual growth and annual removals for all species is 13.6 billion cubic feet (or 110 Bbf); and for softwoods it is 7.3 billion cubic feet (or 59 Bbf). Thus, when viewed from this perspective, a potential increase in harvest volume of 6.8-7.6 Bbf (Table 3) provides a considerable margin within the bounds of sustainability.

TALL WOOD BUILDINGS AND CARBON

All wood and paper products store carbon throughout their life. Dry wood is one-half carbon by weight, with the result that concentrated wood use translates to massive carbon storage. Residential houses, which in North America are dominantly wood construction, store large quantities of carbon long-term. Consequently, it is not only the trees growing within neighborhoods that store carbon for long periods of time, but also the homes that make up those neighborhoods.

Use of wood in constructing tall buildings presents another opportunity for sequestering and storing carbon. The previously discussed estimate of the potential for increased use of wood in construction also examined impacts regarding avoided carbon emissions. It was estimated that the near term carbon benefit could be as high as 32.7 million metric tons (mmt) of CO_2e[20] per year in the United States with increased wood use in multifamily and non-residential buildings, and 7-10 mmt specifically resulting from construction of buildings over 6-stories in height (Table 4).

Table 4: Carbon Implications of Increased Use of Wood in U.S. Construction

	Approximate additional wood volume annually (billion board feet)	Additional annual carbon benefit [b/] (million metric tons CO_2e)	Equivalent number of passenger vehicles off the road for a year	Equivalent number of coal fired power plants shut down for a year
Low-rise nonresidential [a/]	4.5	19	4,100,000	5
Multifamily [a/]	0.7	3	700.000	1
U.S. buildings 7 to 15-stories	1.6-2.4	7-10	1,500,000 - 2,200,000	2-3
Aggregate	6.8-7.6	29-33	6,300,000 - 7,000,000	8-9

[a/] *See footnotes, Table 3.*
[b/] *A portion of this carbon (CO_2e) would be stored within the wood used, with the remainder representing avoided carbon emissions as a result of using primarily wood in place of more energy intensive materials such as concrete and steel.*

As shown above, the effect of using an additional 1.6-2.4 billion board feet in construction of 7-15 story buildings would be avoided emissions of 7-10 million metric tons of carbon dioxide (CO_2e). Of this, 2-3 mmt would be stored within the wood products, and 5-7 mmt of emissions would be avoided due to use of wood in place of more energy intensive (and particularly fossil energy intensive) building materials. The effect is significant, equivalent to removing 1.5-2.2 million vehicles from U.S. streets and highways or shutting down 2-

[19] Oswalt et al. (2014)
[20] The heat trapping potential of all greenhouse gases is not the same. The term CO_2e takes into consideration all greenhouse gases including carbon dioxide, methane, nitrous oxide, and others and expresses warming potential equivalent to a given volume of carbon dioxide.

3 coal fired power plants for one year. Greater wood use across all multistory and non-residential construction would result in an even greater carbon benefit.

Estimates of potential carbon benefits of greater wood use in construction are confirmed by recent comparative life cycle assessments of buildings made of various materials. One example is a comparative life cycle assessment of construction of a mid-rise office building using laminated timber (CLT and glulam) or reinforced concrete.[21] Examined were all impacts related to construction of a 153,000 ft^2, 5-story office building in British Columbia, Canada. Analysis showed significantly lower impact for the laminated timber building across a wide range of impact estimators, including global warming potential (GWP). In this study, the GWP of the laminated timber building was less than one-third that of the reinforced concrete building.

TALL WOOD BUILDINGS AND COST

Relatively little has been published regarding the cost of tall wood structures in comparison to buildings built of other materials. What has been published suggests comparable to lower costs of construction for wood structures. In the book "*The Case for Tall Wood Buildings*"[22] a comparison is made between 20-story functionally equivalent CLT and concrete buildings, with costs estimated to be the same, even though the marketplace for CLT panels was non-competitive; it was noted that costs of CLT construction could be expected to fall with a greater number of material suppliers and greater familiarity with CLT construction. Another comparison was made in 2014[23] of CLT and concrete in a 10-story building with the finding that overall costs involved with CLT construction would be four percent lower. A number of anecdotal reports suggest that the primary savings in CLT construction is in labor costs, with smaller crews, involvement of fewer trades, and faster erection times than construction using other materials. A case study of a hotel building in Bordolino, Italy estimated a construction time of three months using CLT as compared to two years using traditional concrete construction.[24] In construction of London's Stadthaus project, an 8-story CLT structure, Architect Andrew Waugh reported that it took just 27 days for four men, working three days a week, to erect the timber portion of the structure, about 30 percent faster than a comparable steel-and-concrete structure.[25] A time-lapse video of construction of this building is available on-line.[26]

Figure 9
Wood City
Helsinki, Finland

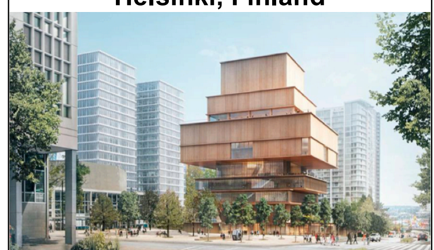


Figure 10
Vancouver Art Gallery
BC Canada

DIVERSE OBJECTS FOR PROMOTION OF TALL WOOD BUILDINGS

It is not only the wood products industry that has interest in greater wood use in construction. Because of the positive carbon aspects of using wood from sustainably managed forests, many in society are now promoting increased wood use and innovative designs are in evidence around the world (Figures 9 and 10). Renowned Canadian architect Michael Green views wood as a key to creating more sustainable cities, and his designs are reshaping the way wood is viewed within the architectural community. Seattle-based architect Joseph Mayo, author of "*Solid Wood: Case Studies on Mass Timber Architecture, Technology, and Design*," recognizes wood

[21] Robertson et al. (2012)
[22] Green (2012)
[23] Mahlum/Walsh/Couglin Porter Lundeen (2014)
[24] Hackenthal (2014)
[25] Bracaglia (2014)
[26] http://www.youtube.com/watch?v=5ddgkdBVRE0

as a more sustainable choice, explaining that it is not only renewable, but also less carbon-intensive to produce than other materials like steel, aluminum and concrete.[27] And, as summarized in Table 2, a number of governments are promoting greater wood use because of its recognized environmental benefits and economic development potential.

As recently explained by U.S. Secretary of Agriculture Thomas Vilsak, using wood can help struggling rural forest communities where many wood products manufacturing facilities are located.[28] He noted that if next-generation wood products could capture just five to fifteen percent of the non-residential North American market, it would mean tens of thousands of additional jobs in rural America.

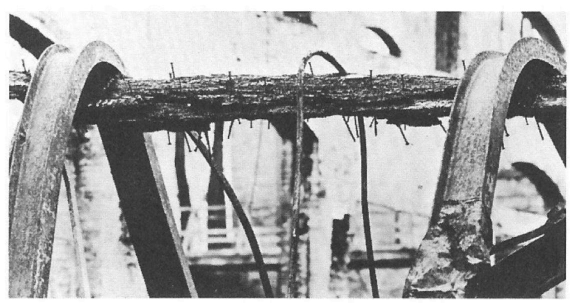
CAUTIONS

As with diffusion of any new technology or practice, market growth of engineered wood products and their use in creating tall buildings is receiving considerable scrutiny. The tall wood buildings movement also has its detractors. Not the least of these are competing industries, such as concrete and steel which do not want to lose commercial building market share. These industries have also understandably expressed concerns that policies favoring wood create unfair advantages in the marketplace. This issue has been addressed in the EU and in Japan through implementation of environmental performance measures expected of all new buildings. Such measures nonetheless tend to favor wood due to its inherent environmental attributes.

More broadly, concerns have been raised regarding fire safety in tall wood buildings and the suitability of these structures in regions that may experience high winds, hurricanes, earthquakes or other types of natural disasters. The bottom line is that all tall wood buildings have to address and comply with all relevant code requirements. To meet these requirements research and testing has been conducted and is underway to address a range of questions about construction details and building performance. Some new tall wood buildings are equipped with monitoring equipment to measure real-time performance.

Perhaps the most questioned aspect of tall wood buildings is that of fire performance. People are well aware that wood burns and steel does not, so intuitively wood buildings are often assumed to be inherently more dangerous in a fire. Less generally known is that unprotected steel reacts immediately to the high temperature of a fire, exhibiting both linear expansion that can buckle support walls, and then ductility leading to a complete loss of strength and then collapse. On the other hand, wood of large cross section and mass forms an outer char layer when heated that allows exposure to fire for extended periods of time without sacrificing structural integrity. The result is that wood of large cross-section, such as CLT, will retain its strength long after other materials have failed (Figure 11).[29] This is true even without encapsulation with non-combustible materials as is required when using steel. If extra protection from fire is desired, wood can be covered with sheetrock providing even greater fire resistance. Some building codes require sprinkler systems.

Figure 11
Crossing Roof Support Beams
After a Severe Fire
Large wood beams are severely damaged, but retain sufficient strength to support failed steel beams



Source: USDA-Forest Service, Forest Products Laboratory.

[27] Mayo (2015)
[28] USDA/Binational SWLC (2015)
[29] Dagenais et al. (2012)

Areas that are the subject of ongoing research include performance of various panel adhesives under prolonged exposure to extreme heat and the influence of large areas of exposed wood surfaces on fire behavior.

Because CLT systems are new, there are also questions regarding earthquake performance. To date, tall wood buildings have been shown to perform well in a full range of tests, including a full 7-story building shake test[30], and may offer unique benefits in addressing specific concerns such as earthquake resilience. However, as pointed out in a recent report[31] a lateral force resisting system with solid panel wood shear walls like CLT is not defined at this point in American Society of Civil Engineers (ASCE) 7 or the International Building Code, and establishment of required seismic coefficients will be necessary before practicing structural engineers can routinely design tall wood buildings.

NOT JUST ABOUT WOOD

Architect Michael Green recently commented[32] that the tall wood building movement is not just about wood buildings, but about shifting wood back into the tall building/non-residential discussion as one of many materials available to the design community. He noted that as an architect he seeks to select the proper material for each application so as to take advantage of the best attributes of each material. He also pointed out that on a mass basis, a tall "wood" building on a concrete foundation is likely to contain more concrete than wood. So what is likely to be seen in the future are "wood" buildings with concrete elevator shafts or shear walls, and/or with steel beams when needed for reinforcement or long spans, or other combinations of materials as needed to optimize design.

THE BOTTOM LINE

Wood has captured the imagination of building designers and engineers around the world, presenting new options for creation of tall structures. Made possible by innovation leading to a family of engineered wood products, including CLT, wood buildings of 18-stories and more are now under development, with concept buildings having been designed to more than twice that height.

Tall wood buildings offer an opportunity to connect rural resources with urban communities in a manner that has the potential to support forest restoration, drive green building, and address carbon emission reduction objectives. Wood is also renewable, further enhancing its attractiveness as a 21st century building material.

The extent to which tall wood buildings will be developed in the U.S. remains to be seen, but there is little doubt that wood use will increase in high-rise structures. Wood has now reentered the tall building discussion as one of many materials available to the design community. Its many attributes ensure a greater role in buildings of all kinds going forward.

[30] Tobin (2009)
[31] Mahlum/Walsh Construction/Coughlin Porter Lundeen (2014)
[32] American Wood Council (2015)

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