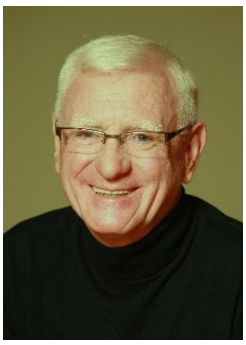
Engineered Timber Construction in North America

Ingenieurholzbau in Nordamerika

La construction bois d'ingénierie en Amérique du Nord

Gary Williams
Timber Systems Limited
CA-Markham, Ontario



Engineered Timber Construction in North America

1. A revolution?

"...there is a quiet revolution going on in Europe and Canada- a revolution that will likely change the way architects here view structural wood building systems"

so states Lisa Podesto, Senior Technical Director, Woodworks-Wood Products Council[1](AWPC) in a course prepared for the American Institute of Architects earlier this year.

Because of our common interest in things wood at this conference, many attending here come each morning to find in their inboxes a story or two about remarkable wood buildings reaching for the clouds, how building 42 storys with wood is feasible, how wood could ably frame the Empire State Building, how wood is "the future of construction" and on it goes.
Such stories are certainly stimulating, and even though sometimes idealistic, they tell of new work and research underway and project successes where wood is playing a role as structure as it has never done before.
What might constitute an actual "revolution" in the U.S. is yet to be seen, but this paper will describe some of the events that are stimulating not only interest in, but the actual construction of a new breed of wood buildings.

1.1. Expanding visions

Designers and builders in the U.S. have created many wonderful examples of buildings using both solid and glulam timber products over the years, however progress to engage the larger and higher structures being built elsewhere is really just getting underway.
As the AWPC presentation described, eyes in the U.S. are turning to experiences in Europe, the United Kingdom, Canada and New Zealand for inspiration. Advances there in design concepts and production techniques involving relatively new products and installation techniques have established wood as a realistic construction material choice for more than the single family residential sector that currently fuels the demand for North American fiber.

2. Engineered Wood Product developments in North America

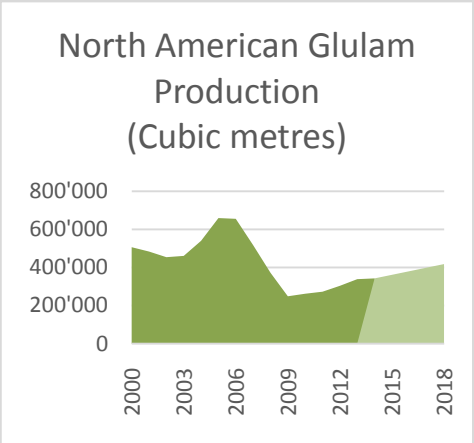
2.1. A brief history

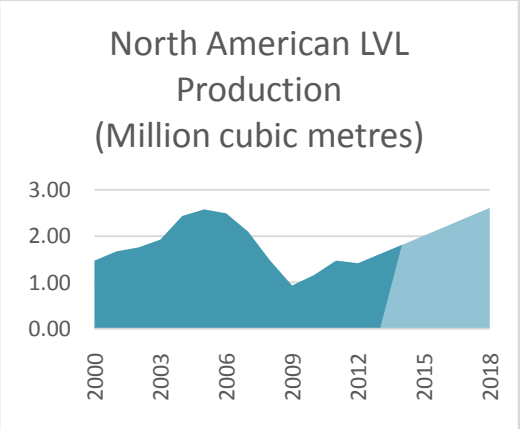
North American Engineered Wood started with the manufacture of Glulam in the 1940s. It was used mainly in non-residential projects such as schools, community buildings, and worship structures. Some bridge work adopted glulam in place of large solid timbers.
Glulam garage door headers and longer span interior beams became the primary applications in residential construction, and lumber distribution companies stock standard product sizes. APA-The Engineered Wood Association[2] currently lists 20 member glulam producers.
The 1980s saw Laminated Veneer Lumber (LVL) and Laminated Strand Lumber (LSL) established as viable high strength beam and rim board options for both residential and non-residential building. They integrated readily with traditional dimension lumber and allowed simple on-site build-up of 45mm wide planks to act as main beams and girders. APA reports 11 current producers of these products.
Most often North American residential buildings incorporate light metal plate connected wood trusses. Manufacturers include both glulam and LVL as part of their prefabricated roof and floor system packages.

Parallam® began to be produced in Canada and the U.S. in the mid 1980s as beam and column sections manufactured from aligned 2mm x 16mm bundled veneer strands. It serves many of the same functions as glulam, but provides a higher bending and significantly higher shear strength.

2.2. CLT - A game changer?

The most recent entry to the U.S. engineered wood products field (and what has become the focus of current activity in the wood standards and promotion community) is Cross Laminated Timber CLT). Because of the success of the product in Europe for more than 20 years now, North America can benefit from the lessons learned and experience gained abroad.
At this date Canada has had two CLT plants operating using domestic fiber for five years, with a third beginning production this year. There are now a good number of successful projects which are stimulating interest in the product and building confidence within the construction community. One manufacturing plant is located in the West coast province of British Columbia, the other is in Quebec towards the East coast.
On the U.S. side, a prototype plant in the West coast state of Oregon is being constructed in collaboration with the Oregon State University. A CLT plant now in production in Montana has received product certification from The American National Standards Institute (ANSI) and the American Plywood Association. The plant currently reports that it has contracts for, or has in design, more than a dozen projects along the West coast.
Oregon is currently offering $350,000 (which includes a $150,000 forgivable grant) to boost efforts to make the state a hub for cross-laminated timber production.
Panels for CLT buildings built in the U.S. to date have primarily been supplied by one of the Canadian plants, or have been shipped from a European producer.
The first U.S. CLT project was for a roof on a modest bathroom at the Oregon Zoo, however somewhat grander projects have followed, and a four story hotel is currently under construction with CLT at a U.S. Army lodging facility at Redstone, Alabama.
APA reports the current North American production of glulam and LVL in Figures 1 and 2.





3. Moving from a market down-turn and recognizing changing demands ahead

Other presenters in this U.S. block will be speaking specifically to the effect of the down-turn in residential construction as a result of the 2006 U.S. "housing bubble" and the subsequent credit crisis of 2007-2008 which led to years of dampened lumber demand and drove lower fiber prices. The reported production figures above show the major impact these events had on lumber producers.
The APA projections published in July of this year are for an increase in engineered wood product production of 20-25% for glulam and LVL and are reflected in the two figures.
Producers are moving to service new construction sectors. Significantly, both in the U.S. and Canada multi-family unit structures are accounting for a greater share of new residential construction compared with ten years ago.

APA expectations are that by 2019-2019 multi-family units will account for roughly 36% of the total residential starts in the U.S. and likely 40% in Canada.
Drivers for this trend to "build high" include land constraints in cities where families increasingly wish to live closer to not only their places of employment but other recreational and cultural facilities. Such lifestyle changes are affecting thinking among municipal planners and developers alike.
The Summer/Fall 2015 Allen Matkins/UCLA Anderson Forecast reports that California commercial real estate is booming. The report identifies demand coming from the technology, advertising, media and information sectors, as well as distribution center warehousing and a shortage of multi-family housing. The forecast anticipates multi-family construction to reach a 25-year high during the next three years. The West coast and California in particular are very wood-friendly regions, and such projections bode well for increasing opportunities for the industry to address that demand.

4. Managing Building Code limitations

The fact that U.S. building codes have limited wood construction to three or four storys is presenting challenges for the wood building industry to service this changing interest in building types.
Changes to codes this year in three Pacific Northwest states will permit five story construction with some limitations. Even slow increments such as this are beneficial.
For now, the U.S. is looking to examples set by Canadian designers and suppliers to shape the way forward in the mid-rise sector, and is taking advantage of the experience and resources there and of the successful strategies.
Vancouver-based architect Michael Green has been a very public figure both in Canada and internationally in ardently promoting such tall wood buildings. Structural engineering teams such as Equilibrium Consulting and Fast and Epp Consulting Engineers, also both from Vancouver, have supported such construction concepts with creative and practical strategies that have been translated into built projects.

4.1. Moving up to six storys

The groundbreaking change for mid-rise construction in North America came in 2009 when the premier of the province of British Columbia, to the surprise of many and the delight of the wood products industry, directed the B.C. Building Code staff to develop the work necessary to amend its provisions to allow six story wood buildings. The changes were based on work by a specially convened expert task force struck by the Provincial Engineer's Association. Legislation to enact the change was in place by 2010.
The Provinces of Ontario and Quebec followed suit and their building codes allow for six story wood buildings. Approval for six story buildings in Ontario requires that stairwells in such buildings must be built from non-combustible materials.

4.2. Moving beyond six storeys

Still in Canada, this August the Province of Québec published a technical guide entitled *Bâtiments de construction massive en bois d'au plus 12 étages* ("Construction of Mass Timber Buildings up to 12 storeys").
Quickly after that publication, a 13 storey, 41 metre high building is being proposed there with the blessing of the code regulators. A key component of the decision to build with wood is the lower foundation loads coming to poor soil conditions on the site.
Even more recently, what is being heralded as the largest CLT residential project in the world, with a floor area of almost 56,000 square meters, was announced for Montreal last month. Rental units are planned to be ready before the end of 2016. Provincially sourced Black Spruce will be used for the CLT components.
The six storey University of British Columbia Wood Innovation and Design Centre in Prince George, completed two years ago, currently lays claim to be the tallest mass-timber building in the Western Hemisphere. The project has built confidence in designers that such a building approach is viable.

Molving dramatically beyond that success, last month also saw the contract award for the construction of the glulam and CLT 18 storey University of British Columbia Brock Commons student residence. Completion is set for 2017.
Lateral loads in this high seismic location are resisted by two internal concrete stair towers.
This building obviously exceeded the six storey limit defined by the B.C. regulations, so the provincial Building Safety and Standards Branch had to conduct a special review of the project to provide the official go-ahead for the design.
This project will set the stage for greater North American interest in such construction and reflects, on this side of the Atlantic, the same eagerness to "build tall with wood" being demonstrated in a number of Europe countries.

5. The U.S. comes on board

5.1. Government stimulus

The wood products industry is vitally important to the U.S. economy as it employs more than547,000 people in manufacturing and forestry, with another 2.4 million jobs supported by U.S. private forest owners.
A recent high point for the wood products industry was to see the White House recognize an opportunity to support new developments in the industry. Secretary of Agriculture Tom Vilsack announced last year that the U.S. Department of Agriculture would join with the Binational Softwood Lumber Council[3] to provide a grant to support the research and development necessary to utilize engineered wood products in high-rise construction in the U.S.
This funding provided for a $1.5 million award made this September to each of the two winning proposals…an East coast and West coast winner of the National competition. The East coast project is proposed to be located in mid-town New York City; the West coast project in Portland, Oregon.
The design considered for the NYC project is for a 10-storey residential condominium, whereas for the Portland award, a 12-storey building of one level of ground floor retail, five levels of office, five levels of workforce housing and a rooftop amenity space has been proposed.
Both projects feature glulam and CLT as key structural components.

5.2. Independent momentum is building

Such incentives have not been necessary for other significant mass timber projects to get into the ground this year in the U.S.
On a somewhat smaller scale than the two projects receiving the USDA awards, the owner of a heavy timber framing operation in Tennessee brought CLT from Europe to build his recently completed new plant. His familiarity with the use of the product in his native Germany encouraged his decision to build this way.
Construction is now underway on two very large projects in the U.S.

1. The seven story North Loop building, Minneapolis, Minnesota.

   In this case, floor panels made up of 38mm wide boards nailed together (rather than using CLT) are supported by a glulam column and beam system. This product, is now tagged with a new name Nail Laminated Timber (NLT) rather that what was earlier called "mill deck"; it reaches into the past with the flooring system used in centuries-old commercial and industrial buildings. The decision to use this product was based on cost savings over the specified CLT system. The glulam is being sourced from Europe for this project.

2. University of Massachusetts Integrated Design Building, Amherst, Massachusetts.

   This $52 million building will be the first of its size in the U.S. to feature CLT as part of its glulam column and beam supporting frame when completed in 2017. The glulam and CLT components act as composite elements with the concrete floor slabs by engaging HBV mesh shear connectors sourced from Germany. The CLT and glulam are being sourced from Canada for this 8,100 square meter building.

6. Design Codes

Timber Construction in the U.S. is guided by the "National Design Specification (NDS) for Wood Construction" published by The American Wood Council as part of the American Forest and Paper Association. The publication has approval as an American National Standard.
It is the day-to-day tool of structural engineers designing in wood and provides strength values for sawn timber, structural glulam, timber poles and piles, prefabricated wood I-joists, structural composite lumber, wood structural panels, and connections and fasteners.

6.1. The North America approach to CLT production standards

In Europe CLT manufacturing standards are prepared on a proprietary basis by manufacturers, however the U.S. and Canada chose to harmonize design and production requirements in their National Standards.
A product performance standard for the manufacture of CLT based on North American fiber was first published as an American National Standards Institute (ANSI) Standard "ANSI/APA PRG320 *Standard for performance Rated Cross Laminated Timber"* in 2011.
Without modification to adhesives currently used and other changes to manufacturing processes, European CLT does not comply with the production requirements of the PRG 320 standard. Consequently approval for the use of European product is at the discretion of the consultants or jurisdictional regulators.

6.2. Design standards and support publications

FP Innovations of Canada published the first edition of the 11-chapter Canadian edition of a "CLT Handbook" in 2011. The publication introduced the product and proposed analytical design methods and addressed seismic, creep, floor vibration and acoustic parameters as well as addressing fire performance expectations. The release of a U.S. version of the handbook followed in 2013.
While not being a design standard, the guide has been very useful in educating designers in the potential applications for and construction with the product.
Some design direction was provided in the 2015 edition of National Design Specification (NDS) as the basis for introducing the product and process to U.S. users.
Canada chose to prepare a more complete design section as a new clause in the CSA Standard CSA-086, and this design information is expected to be published in 2016 as a supplement to the recently published 2014 edition of the standard.

7. Competing industry challenges

All of what this paper reports as generally positive developments in code approvals for wood construction in North America does not mean the initiatives are going unchallenged.
Last April representatives of the U.S. Cement industry lobbied the International Code Council to oppose the use of CLT in tall wood buildings.
A spokesman for the Steel Framing Industry Association said "for us, it's been a good reminder that we have to tell people that we have a good product and that it's superior to wood in so many ways."
Of course fire performance of wood buildings is regularly flagged as an impediment to safe buildings by opponents of the concept. Fire engineering consultants have been able to provide satisfactory documentation to allow mass timber to be approved for use on all of the projects referenced in this paper.
Amy Nordrum, writing recently for the International Business Times sums up things quite well with her article "*Can Wooden Skyscrapers revive U.S. Timber Industry*?" in saying:

> …"despite the challenges, supporters of tall wooden buildings say the idea is only just beginning to pick up steam. They counter the concerns of steel and concrete manufacturers by saying that the advantages of wood are just as clear from a construction standpoint. CLT is expected to be comparable in price to both steel and concrete, and can be installed faster. It's much lighter and can reduce the weight

of a building by 60 to 70 percent, which may be helpful in seismic zones such as Seattle because a wooden building can more easily absorb the impact of sudden shifts. Some architects are also heartened by the opportunity to incorporate its warmth and natural feel into their designs."

8. Conclusion

After a decade of depressed activity in the U.S. forest and secondary wood processing industries, the optimism encouraged by creative and aggressive efforts by researchers, code writers, regulators, and an industry keen to find new opportunities speaks to the possibility of improving times ahead for existing and new players.

9. References

[1] The Wood Products Council is a cooperative venture of major North American Wood Associations as well as government agencies and other funding partners. Operating as "Woodworks" it offers free technical support as well as educational and resources related to the design of non-residential and multi-family wood buildings.

[2] APA-The Engineered Wood Association is a non-profit trade association that represents US and Canadian manufacturers of structural wood products, including plywood, oriented strand board (OSB), glulam, wood I-joists and structural composite lumber (SCL). Its primary functions are product certifications and testing, applied research and market support and development.

[3] The Binational Softwood Lumber Council was established as part of the U.S. and Canadian Softwood Lumber Agreement.