National Museum Of Forest Service History

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NEWSLETTER

Mass Timber - What is it?

By Tom S. Chung, FAIA, Principal, Leers Weinzapfel Associates

Many of us may have heard of the term "Mass Timber" but are not sure of what it is, although I would say that many, if not all, of us know what a "wood building" is and have been inside one from log cabins to solid heavy timber office buildings to curved wood structured churches. A Mass Timber building is in one sense, simply a wood building that uses large pieces of wood instead of smaller pieces of wood like lumber (2x4s and 2x6s) that we see being used for single family houses and multi-family housing 5 stories tall or less, all over the country for the past sixty plus years. Mass Timber as the name implies is made of heavier (or larger) pieces of wood and its earliest examples are the solid heavy timber buildings that were built with old growth trees that made possible large cross sections of columns and beams often greater than 1' x 1' and more from a single tree trunk just debarked and cut to size.

But Mass Timber today is a highly engineered product that is assembled into even larger building elements with just lumber (2x4s and 2x6s) or even smaller laminations. Unlike solid heavy timber that relies much on the characteristics of a single tree and a large safety factor since no two trees are the same, mass timber today is much more predictable and precisely engineered to meet the necessary loads with material efficiency. It is also fabricated in a factory in a highly automated way using digital technologies and equipment and assembled on site quickly and quietly, instead of being constructed piece by piece on site with lots of construction time and material waste.

While most civilizations began building with wood, as it was plentiful and easy to shape with simple tools, our modern society and its need to build bigger and taller buildings over the late 19th and 20th centuries in urban centers, coinciding with the results of industrial revolution which began a century earlier resulted in wood being displaced as the main building material by steel and concrete.

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NEWSLETTER
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President's Note

Tom Thompson

In 1903, Wallace H. Pierce, the first administrator of the Shoshone unit of the Yellowstone Reserve built the Wapiti Ranger Station. It was the first ranger station built with Federal funding in the country. Pierce wanted a functional, durable, and affordable structure that would serve as a safe and comfortable place from which to conduct the Reserve's work in the North Fork of the Shoshone. The log structure that he built was just that. The peeled unhewn logs used in the ranger station were from the nearby forest and were not only functional, but also provided a warm feeling that felt like home. The building was intended to illustrate a sense of order, an official or professional look, and even though vastly improved over previous means of providing for the ranger's needs, the building was not spacious but amiable. It was the ranger's headquarters and thus expressed a sense of order and authority that reflected well on the ranger. The Wapiti Ranger Station building has proven its strength and durability and has endured much use and many winters.

Wapiti Ranger Station

The National Conservation Legacy Center that we envisioned building a few years ago has been designed with some of the same criteria that Pierce used a hundred and twenty years ago. We wanted a functional, durable, and affordable building. We also wanted a building made of wood that was locally sourced or of significant historic significance. We wanted a building that was attractive, gave a feeling of warmth, and reflected well on our organization. We wanted a building that people would want to come and see. Early on we leaned heavily on the idea of a Mass Timber building. Pierce would have thought mass timber was simply a big spruce log. Pierce would likely have grinned if he heard the word "aesthetic" or "biophilic", but we wanted a building that reflected on the environment and the warmth of wood. Pierce also would have had a puzzled look if he heard talk of "carbon storage" or "sustainability", but after a century Pierce's ranger station certainly has helped store some carbon and sustained its functionality for over a century.

Over these last hundred years, since the establishment of the Forest Product Laboratory in Madison, WI in 1908, there have been many changes in building construction and materials. Through science, research, and development, we continue to expand and appreciate the value of using wood for a better world. This newsletter edition features several stories that help us to better understand these ever-expanding uses of wood and we look forward to illustrating to our visitor at our National Conservation Legacy Center how these come together to create an amazing place to share the rich history and stories of the Forest Service and conservation. Special thanks to those who have contributed to the stories in this edition of the newsletter, where "wood" we be without them?

Tom Thompson

Mass Timber ~ What is it?

Though wood remained throughout the past century as a building material for smaller structures such as single family homes and small multi-family housing, the emergence of mass timber today makes possible the use of wood as a building material previously reserved for steel and concrete, allowing us to build these larger, taller and more complex buildings now in wood, with a renewable building material with less carbon emissions that helps address the building industry's responsibility towards climate change.

In addition to being a solution to build more responsibly with less carbon footprint, mass timber buildings, unlike light-frame wood construction often expose the wood since it doesn't need to be covered up by painted white drywall. This allows for the inherent biophilic attributes of wood to be experienced; visually appealing color and grain, the warmth to touch, the fresh pine scented smell with the humidity and moisture regulating properties of mass timber provides a full tactile experience that enrich the daily routines of those who live and work in these buildings.

Products

Among the commercially available products in the mass timber category are Cross-laminated Timber (CLT), Nail-laminated Timber (NLT), Dowell-Laminated Timber (DLT), Mass Plywood Panel (MPP), Glue Laminated Timber (GLT) and glulams, Laminated Veneer Lumber (LVL), Laminated Strand Lumber (LSL) and Parallel Strand Lumber (PSL). They range in costs, appearance and applications.

Nail-Laminated Timber or NLT are simply lumber (2xs) nailed together in a one way span between beams to make solid floors and usually require a layer of plywood on top for lateral stability. They are simple to build, do not require expensive factories and are on the less expensive end of mass timber product costs. But since there are nails, they cannot be cut with CNC machines and are more limiting structurally and architecturally in general. Dowell-laminated Timber or DLT can be seen as an evolution of NLT in that the steel nails were replaced by hardwood dowels so that it could be CNC cut and made in a highly automated factory like other mass timber products. It appears similar to NLT and also spans one-way between beams but also with increased structural and architectural possibilities at a higher cost.

Glulams, similar to NLT as mass timber products have been around for over eighty years. They have been used mostly as beams and columns (linear elements) and can be seen in many old churches and gymnasiums as large curved or arching elements. But they can also laid flat on their sides and with successive pieces become floor assemblies, similar to NLT or DLT.

In this configuration as floor panels, they are called "GLT." Seen often in combination with glulam beams and columns are Cross-laminated Timber or CLT panels.

CLT
Cross Laminated Timber

GLULAM
Glue Laminated Timber

NLT
Nail Laminated Timber

DLT
Dwell Laminated Timber

LVL
Laminated Veneer Lumber

LSL
Laminated Strand Lumber

PLS
Parallel Strand Lumber

MPP
Mass Plywood Panel

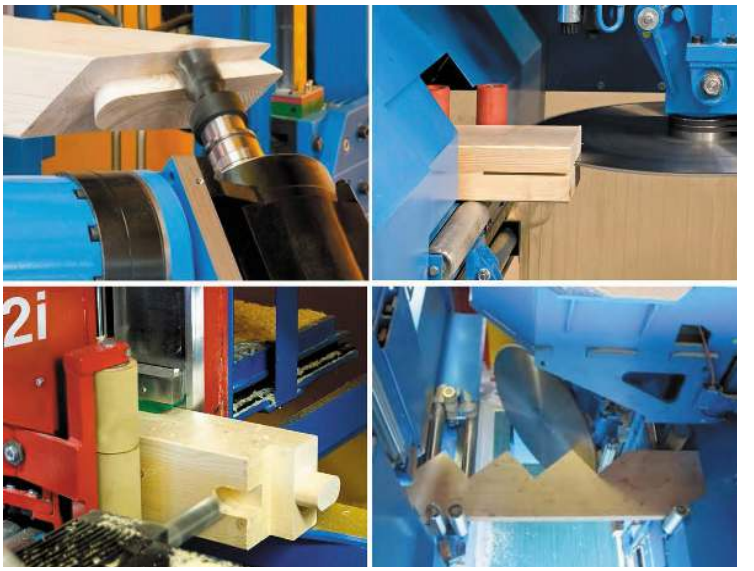
Mass Timber ~ What is it?

It is the most well known and most talked about mass timber product today given its versatility. It was first commercially developed in Europe with factories in Austria, Germany and Switzerland about 25 years ago, then to Canada and now gaining traction in the US over the past 5-7 years. CLT arranges lumber laid flat, with each successive layer in a perpendicular direction such that unlike NLT, DLT or GLT the grain of the wood is oriented in perpendicular directions rather than a single direction. This allows for a greater dimensional stability and a two-way span capability and possibility of being point-supported with just a column and without beams. However, most CLT floor panels are still used as primarily one-way systems in conjunction with beams and columns given the simpler engineering involved and greater spans and column spacing that it enables. But the two-way structural capacity of CLT panels also makes it ideal not only as floor or roof (horizontal) panels but also as wall (vertical) panels. Many buildings utilize CLT in this way as load bearing walls and even as building cores for egress stairs, elevators and mechanical, designed to also take on lateral loads such as wind and seismic loads.

As versatile as CLT but very different in appearance is Mass Plywood Panel or MPP. MPP are simply layers of plywood (usually 4'x8' and ~1" thick) laminated on top of each other to make thick, wide and longer panels of 8' x 40' or greater and from 4" to over 1' thick, similar to CLT, NLT and DLT. Like CLT, MPP can span in two directions, be point supported with just columns and are dimensionally more stable. It can also be used as floors or walls and take on lateral loads. But unlike CLT in which each layer is made of 2x boards which can be seen, it's made of plywood and one can see the whole or partial pieces of the 4'x8' plywood in its appearance.

Although CLT precedes MPP, as plywood preceded CLT and as they both can span in two directions as they have the grain of wood oriented in perpendicular directions, CLT is sometimes referred to as "plywood on steroids." Similarly, as CLT, like DLT and MPP are made in a highly automated factories with multi-million dollar investments in the production equipment-such as presses, CNC machines, glueing, dowelling, sorting and finger jointing machines with butterfly tables and vaccum lifts-all with associated costs.

CLT production with automated equipment and precise pre fabrication



Mass timber digital fabrication and versatile complexity

NLT has been referred to as "poor man's CLT" given its relatively low cost and low production factors.

Laminated Veneer Lumber (LVL), Laminated Strand Lumber (LSL) and Parallel Strand Lumber (PSL) are veneer or strand-based products with much higher glue to fiber ratio and mainly used for their additional strength properties as compared to lumber, often as columns or beams in conjunction with light frame wood construction where stronger members are needed. Though they can be exposed to view, they are often hidden behind drywall just like light frame wood construction. Though they are technically in the mass timber category, they are less associated with mass timber as they are not used for large floor or wall panels or columns or beams that support them as described earlier with with CLT, NLT, DLT, MPP, GLT and glulams.

The Forest Service Role in Advancing Mass Timber

by Steve Marshall, Founder Mass Timber Strategy

Mass timber construction is spreading across the U.S. at an extraordinary pace. In 2013 a Forest Service survey identified only five structures that used cross laminated timber in any part of the structure. Since then, 952 mass timber buildings have been completed or are currently under construction and another 1,083 are currently in design.The Forest Service has played a central role in making that happen.

The first showcasing of the Forest Service's role in the modern mass timber movement was at a March 2014 White House Summit which the Agency proposed and staffed. A key part of the Summit was the Secretary of Agriculture's announcement of the U.S. Tall Wood Building Competition. The Competition, also proposed and conducted by the Agency, awarded three million dollars in prize money which was provided by USDA Rural Development and the Softwood Lumber Board. The intent of the Competition was to help establish a national focus on mass timber at a time when there was hardly any awareness of it in the U.S.

Furthering that effort to create a national focus on mass timber, the Agency prompted and funded the National Building Museum's "Timber City" exhibition which was up for a year just blocks away from Capitol Hill.

Timber City Exhibition. Photo by Waugh Thistleton Architects, London, England

More than 100,000 people visited the exhibit and multiple private tours were held for Members of Congress and their staffs. Today, there are people active in mass timber nationwide that cite that exhibition as their first exposure.

Funding from both the State and Private Forestry and Research divisions of the Forest Service have gone into supporting WoodWorks. They provide free training and expert advisory support to architects, engineers, and developers looking at wood construction beyond the single-family home. WoodWorks' efforts have had an enormous impact on the demand for mass timber.

The Agency's Wood Innovations was specifically created by State and Private Forestry to support its focus on mass timber while updating how it supports wood product market development in general. The program was created administratively by the Forest Service, but it has been so successful that it was later incorporated into law in the 2018 Farm Bill. Wood Innovations funding has supported the design and engineering work on much of the first generation of mass timber buildings across the U.S. Multiple university buildings and affordable housing projects have been among those funded. It has provided key funding for mass timber factory start-ups and efforts by several States to strategize on how to move forward with mass timber. It also funded the creation of the International Mass Timber Conference held in Portland, Oregon each year.

One key Wood Innovations grant was the funding of blast testing of cross laminated timber structures by the Department of Defense. The results of those tests, in which the Forest Service's Forest Products Laboratory played a key role, have led to a series of Cross Laminated Timber on base hotels to be constructed. More recently, the U.S. Army Corps of Engineers issued a directive that mass timber will be considered as an option for all appropriate Defense Department construction projects. The blast tests have also influenced the private sector. Walmart is using mass timber for its new 5,000 employee headquarters in Arkansas. The company has credited the Department of Defense blast testing of cross laminated timber with getting them to take a serious look at using mass timber.

USFS Role in Mass Timber

Blast Testing CLT. Use Photo from USDA press release: https://www.usda.gov/media/blog/2018/03/30/blast-testing-shows-clt-can-take-heat All three structures remained standing after the testing – even tests designed to take the structures well beyond their design intent. (Photo courtesy of Air Force Civil Engineering Center AFCEC, Tyndall Air Force Base)

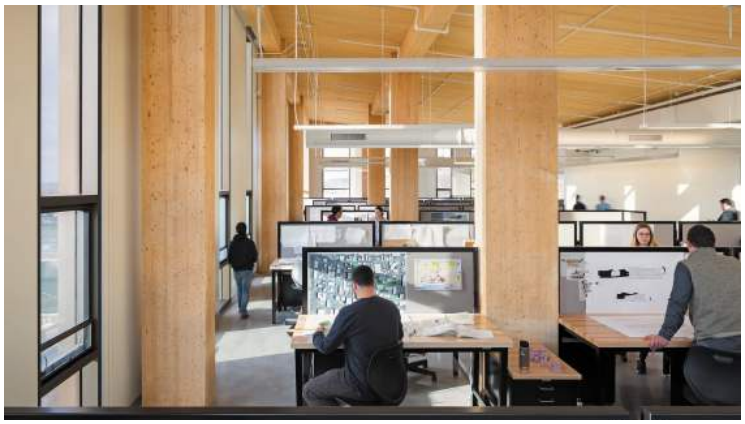
The Forest Products Lab in Madison, Wisconsin has had a long history of being involved in mass timber. In 1935 Building Two at the Lab was the second building in the U.S. to use glulam arches as its primary structural component. The Lab went on to help establish the glulam industry in the U.S. through testing and standards development.

In the current mass timber era, which is being driven by the advent of cross laminated timber, the Lab has again been highly involved. In addition to the blast testing work, the Lab played a key role in conducting the fire tests that paved the way for modifying the 2021 edition of the International Building Code to allow for construction of mass timber buildings up to 18 stories within code. They have also played a critical role in the development of life cycle analysis studies to determine the carbon consequences of building with mass timber versus using other construction materials. This work is hugely important as the market for mass timber products is largely driven by concerns about embodied carbon in building construction.

The influence of the Forest Products Lab has gone well beyond the projects that they themselves undertake. In recent years they have held three mass timber research summits in Madison where researchers and practitioners gather and identify the next generation of mass timber research issues.

John W. Olver Design Building at UMass. This building was designed by Leers Weinzapfel Associates. This is the building where FPL did the first mass timber building life cycle analysis in the U.S.

Photo by Albert Vecerka/Esto



John W. Olver Design Building at UMass Amherst
Photo by Albert Vecerka/Esto

Some of these are further pursued by the Lab, many of them become pursued by other institutions. Invaluable relationships within the mass timber community have also resulted from these FPL summits.

The Wood Innovations program and the Forest Products Lab have frequently played dual roles in mass timber. In addition to the support of WoodWorks and blast testing as mentioned earlier, this has included major initiatives such at the International Building Code changes and many specific leading-edge projects within the sector.

Among those leading-edge projects where both Wood Innovations and FPL played roles was the 25 story Ascent project in Milwaukee. It is the world's tallest timber building. It is largely built out of cross laminated timber and glulam. Wood Innovations funded some of the initial feasibility work and the Forest Products Lab conducted fire tests to verify that the uniquely designed glulam columns would be sufficient. Fire testing funded by the Tall Wood Building prize money for a project in Oregon was also used on Ascent.

Steve Marshall's Mass Timber Strategy provides advisory services to companies, agencies, and non-profits seeking to either enter the mass timber sector or expand their role within it. The MTS website features extensive information about mass timber. Some of it is specialized information and much of it is of general interest such as a large collection of mass timber videos.
Check it out at: www.masstimberstrategy.com

Ascent under construction Photo by Nate Vomhof

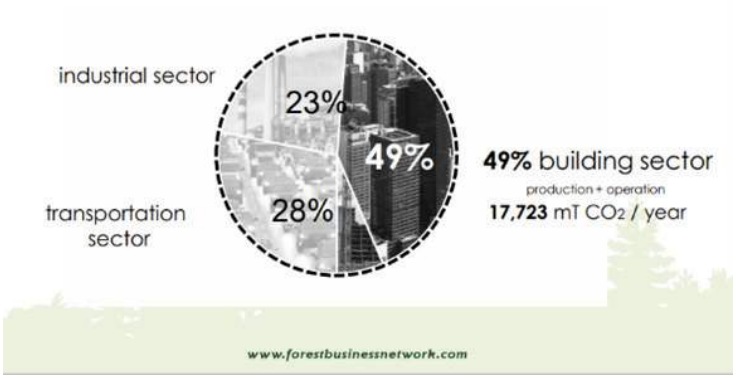
Above: Ascent completed, exterior photo –Photo by Nate Vomhof

Left: Ascent Interior – Photo provided by New Land Enterprises

Mass Timber - Climate Change & Forest Health

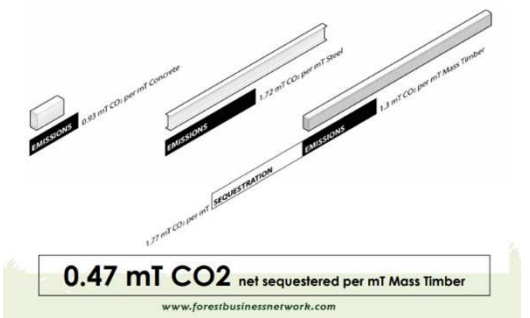
By Dave Atkins, an author of the Mass Timber Report and affiliate of FBN

Michael Green, a Canadian architect and the keynote speaker at the first International Mass Timber Conference, painted a vision of the 21st Century as the Timber Century. Subsequent keynotes have shared the vision of cities being carbon sinks rather than sources, and the basis of a circular economy rather than a linear one. Mass Timber sustainably grown is the foundational element of these visions.



The built environment is responsible for 49% of the energy used in the world, including materials used, building it, operation and maintenance. As building construction envelopes have become more energy efficient and fossil fuels are gradually replaced with clean energy, the operations part of the carbon/energy content of the building becomes smaller, while the proportion of fossil energy needed to create, deliver and erect the structure, called embodied energy/carbon, becomes greater. Steel and concrete are some of the most difficult materials to decarbonize. From the perspective of the urgent need to reduce emissions to stay close to the 1.5 degree goal of the Paris Accords, reducing the embodied carbon footprint is important because the benefits are immediate.

Source Timber City Research Initiative, Gray Organschi Architecture, timbercity.org



The carbon release from using steel or concrete is completely avoided and the operational energy/carbon savings accumulates over the lifetime of the building.

Mass timber is the ideal replacement from a carbon standpoint. The wood is created by energy from the sun, while the forest sequesters carbon from the atmosphere. Wood is fifty percent carbon by weight. The weight to strength ratio is much better than steel and concrete. Therefore the builder gets far more material per ton used. The manufacturing conversion of logs to wood is easier than steel and concrete. In fact some mills that are supplied with hydro power and use wood residues to dry their lumber have a much lower fossil carbon footprint. The structural elements of a building account for about 80% of the embodied energy/carbon content, so the substitution benefit is very significant when mass timber is used to replace steel and concrete.

Photo courtesy of Dave Atkins

The use of mass timber in mid and high rise buildings has opened up a new market for the use of wood. The fact that mass timber is made from smaller pieces of lumber allows for the use of smaller trees. A mill in Montana is creating the capacity to make even smaller scale cross-laminated timbers for use in smaller commercial and residential applications. In this example the core is made of 2”x 2” boards and the upper and lower laminates are about 3/8” thick. These types of value added products can be a significant opportunity to use very small trees.

Mass Timber - Climate Change & Forest Health

Every forester's dream is to have a higher value product for the smaller trees that are costly to thin from the forest. This kind of mass timber starts to make this a reality. It is also difficult to find a market for the residuals from manufacturing and logging. The development of wood fiber insulation as batts, blown-in and rigid board made from these by-products is another side benefit to mass timber production. A mill in Maine just started making this insulation last year. They provide another way to store wood fiber carbon in buildings.

Climate change has already made our fire season longer and more intense. The droughts make bark beetles more successful. We need to reduce the density of our forests to make them more resistant and resilient to these disturbances, so our forests can continue to sequester CO2 from the air and the remaining trees can grow larger in diameter and height. Prescribed burning after these harvests reduces the fuels and provides greater health for the forests. It is like eating a healthier diet and exercising so our bodies are more resistant and resilient to diseases.

The picture of the Portland Airport under construction illustrates the potential of mass timber has for creating cities that will become carbon sinks and also help us manage our forests to be healthier. The transition to this type of construction is essential to a sustainable low/no fossil carbon future.

Photo courtesy of Port of Portland / Stephen A. Miller

Forest Business Network is a consulting and communications business that helps forest products businesses grow and prosper. FBN produces:

Forest Industry Newsletter - weekly forest products industry newsletter providing the leading industry news.

International Mass Timber Conference, the largest gathering of mass timber experts in the world. IMTC attracts professionals from across the forest, manufacturing, design, development, and construction industries. 2024 is our 8th annual event in Portland, Oregon, USA.

International Mass Timber Report. Updated annually, the Report includes detailed information on the entire supply chain, the latest innovative technology, existing and planned production capacity, and market demand estimates for both North American and international markets.

For more information, visit:
https://www.masstimberreport.com/
https://www.forestbusinessnetwork.com/
https://masstimberconference.com/
https://treesource.org/

Mass Timber & the National Conservation Legacy Center

By Tom S. Chung, FAIA, Principal, Leers Weinzapfel Associates -Images provided by LWA

The Conservation Legacy Center for the National Museum of Forest Service History is a showcase and an example in itself in telling the story of the conservation efforts of the United States Forest Service. As such it maximizes the use of wood throughout the building as a story of the value our forests and trees have provided as building material over centuries of our nation's history. Use of Mass Timber is a huge part of telling this story.

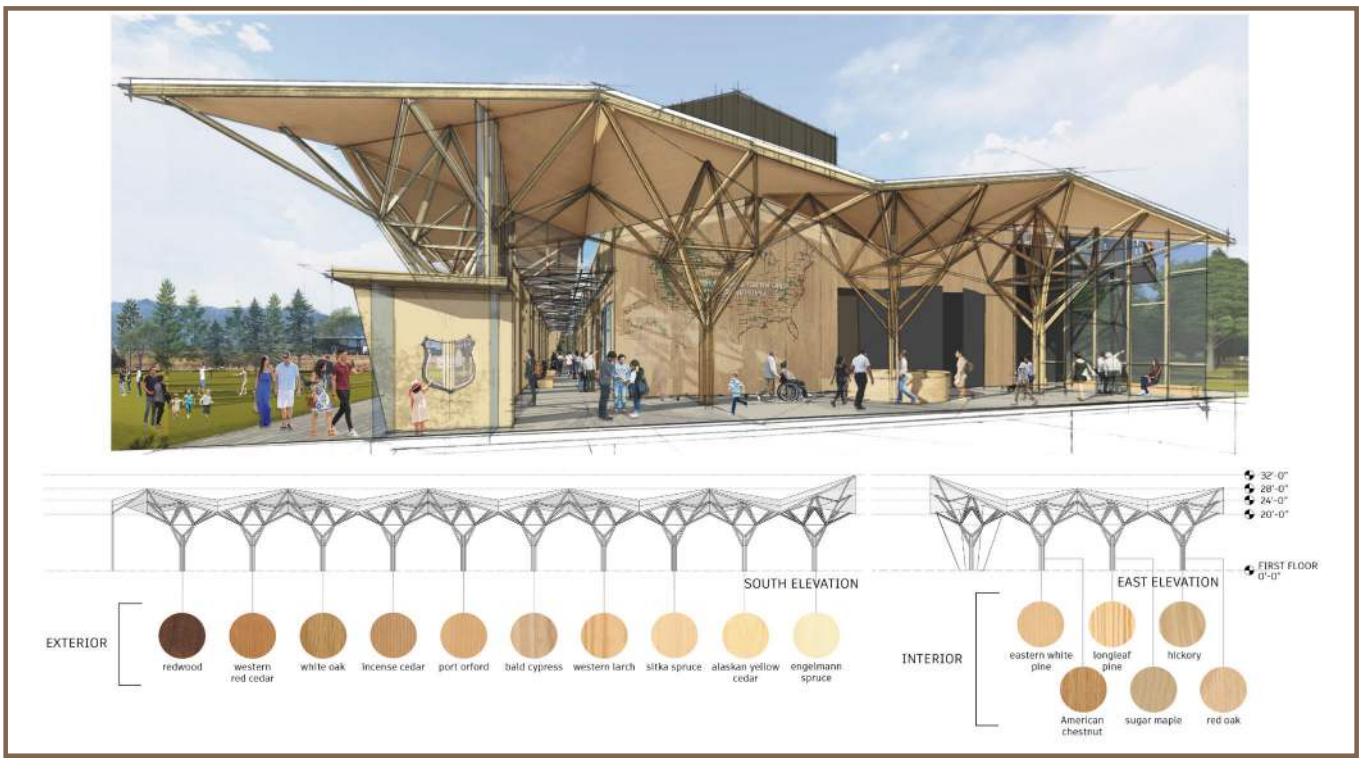
We begin with the signature design element of the Center which are the tree-like columns and the folded roofs. Each tree-like column is made of the "original or historic" mass timber – solid heavy timber beautifully crafted by expert heavy timber fabricators Brian Leisz and Mark Gantt. Furthermore, with 16 bays of these, each is made of a distinct species of wood selected for its significance in a particular region of the country. We have an array of species from Eastern White Pine from the Northeast to Longleaf Pine from the Southeast to Douglas Fir from the Northwest.

Both Hardwoods and Softwoods are represented and durable, weather resistant species such as Bald Cypress, Redwood and Alaskan Yellow Cedar are located along the south facing porch.

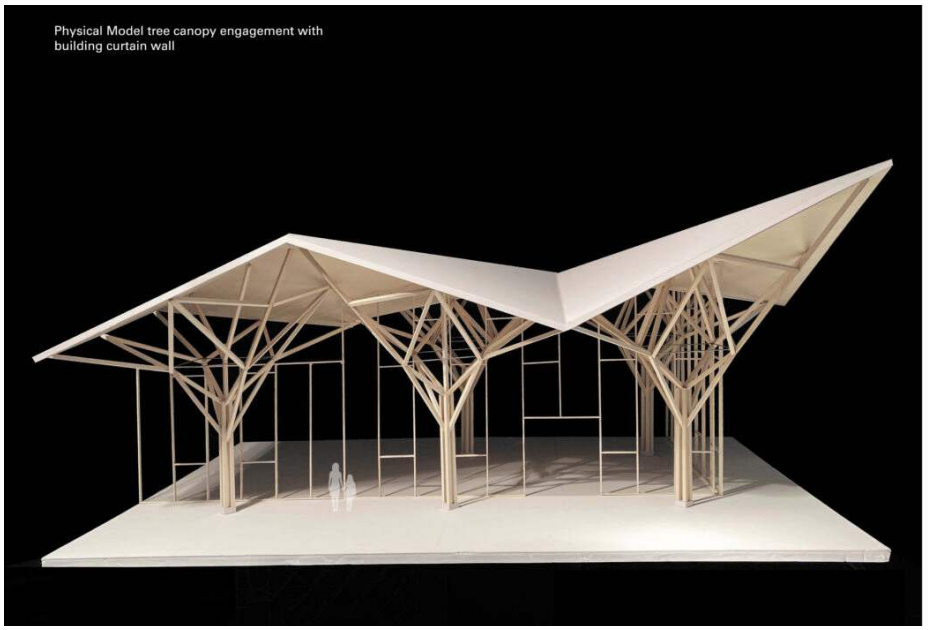
A generous donation by Freres Engineered Wood made possible the use of Mass Plywood Panels (MPP), one of the more recent mass timber products, made of Douglas Fir harvested from the local region, for the folded roof structure.

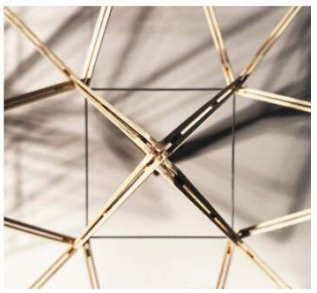
Showcasing its ability to span two ways and be point supported, like a tree canopy supported by its branches, the MPP is supported by the "branches" of the tree-like columns and its rotated but symmetric triangular shape

Mass Timber for the National Conservation Legacy Center is provided by Vaagen Timbers & Freres Engineered Wood. Thank You!



Mass Timber & the National Conservation Legacy Center


Physical Model tree canopy engagement with building curtain wall



in an mirror image array from bay to bay gives the entire entry lobby and the south porch a sense of being "under the trees" in a forest.

Continuing the use of Mass Timber is a prominent use of Cross Laminated Timber for the Center's main loadbearing walls forming the exterior and the main core. At both locations, these CLT panels, also made of the region's douglas fir, will be exposed on one side as a building finish to make visible its structure and harness its biophilic qualities. At the building's main stair and elevator core, the CLT panels also serve as a lateral structural system resisting wind and seismic loads and showcasing the structural versatility of CLT.

In conjunction with the load bearing CLT walls are glulam columns and beams, also made of local Douglas fir, where spaces inside needs to be opened up. As a complement to CLT, but as a more cost-effective solution, GLT is used for the building's mezzanine floor and roof. It is used in a simple one-way span while maximizing its structural efficiency and also exposed on the underside to take advantage of its biophilic qualities.

In addition to an array of mass timber materials mentioned above, wood adorns the Center throughout. The main exterior cladding will also be of locally harvested wood siding, clear coated where protected behind the south facing canopy and stained in a darker color where exposed to the elements, such as along the north and west sides of the building. In places that are secondary to the main public areas, use of light frame wood construction covered with drywall while providing a wall cavity for electrical outlets and data cables will be incorporated. Also, as an important product developed in conjunction with the USFS Forest Products Lab, Structurally Insulated Panels or SIPs will be used to span large areas of the roof combining wood with necessary insulation for building energy use efficiency.

All in all, as many areas as possible with as many wood products as possible, including the features made of mass timber will help realize the goals and aspirations of the NMFSH in this forward looking design that also harkens back to, respects and celebrates the history of wood as a building material of our past, present and future.

Tom S. Chung is a national leader in mass timber architecture. His designs for the Olver Design Building at UMass Amherst and Adohi Hall at University of Arkansas are among the first and largest mass timber buildings in the United States and have received prestigious national awards including AIA's Honor Award, COTE Top 10 Award and Housing Award. His mass timber projects can be found here: https://www.lwa-architects.com/projects/mass-timber/

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