Sourcing Eastern Hemlock CLT for Northeastern Mass Timber Building Construction

FUNDED BY USDA FOREST SERVICE Wood Innovations Grant (*Eastern Hemlock Cross Laminated Timber Certification and Demonstration Project*)

A **Report** from:

North East *State* Foresters Association

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Lead Partners:

Eastern Hemlock CLT installed in the Fairbanks Museum addition, St. Johnsbury, VT built 2023-2024

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Executive Summary

The overall goal of this project was to move use of a northeastern local timber species for cross-laminated timber – eastern hemlock – from the conceptual to the pilot installation stage and ready for commercial production. This was accomplished and not without some challenges and significant learnings.

The strong financial support from the USDA Forest Service, the State of Massachusetts and the developers of the two eastern hemlock CLT pilot projects was key to the success of this effort. Also critical was the interest and strong support from our key eastern hemlock supply chain businesses: Cersosimo Lumber, Parker Lumber, White Mountain Lumber, SmartLam, APA, Sterling Structural, ICC-ES, and NeLMA who provided the lumber graders at Cersosimo.

The challenges experienced in the supply chain have already progressed to the point of multiple supply sources of eastern hemlock lamstock being available to Sterling Structural, a CLT manufacturer in Illinois, as they move their commercial offerings forward with northeastern timber species.

Eastern hemlock is now part of the species mix available for those seeking to construct CLT buildings in the northeast and beyond.

Finally, although there are no CLT manufacturers yet located in the northeast, a manufacturer is making CLT using northeast sourced eastern hemlock and spruce-fir. This is a great interim step to facilitate the necessary demand for a CLT manufacturer to move to the region.

Introduction

Mass timber, specifically, buildings constructed with glulam beams[1] as the wood "frame" to the structure and cross-laminated timber[2] (CLT) as the structural floors and walls, is growing in popularity in the U.S. as an alternative to concrete and steel in larger multi-story commercial buildings and as an alternative to traditional "stick-built" (2x4 & 2x6) structures. According to Woodworks (www.woodworks.org), as of December 2023, New England has 74 known mass timber buildings built or under construction and another 119 in design. Nationally, there are over 2.035 built, under construction or in design phase.

According to Forisk (https://forisk.com) North America has 38 mass timber production facilities in the U.S. and Canada, including 24 that can produce CLT. The production capacity of mass timber in North America is over 62 million cubic feet annually, with announced expansions that bring the total to almost 67 million cubic feet by 2024. At full capacity, these facilities could use 1.4 billion board feet of lumber, equivalent to 2.4% of total North American lumber production for 2022 if at capacity. The U.S. West has the largest installed capacity with 51% located in the region followed by the U.S. South at 24% and the U.S North at 4%. Mass timber capacities for West Canada and East Canada are 10% and 11%, respectively for the North American region.

At present, there are no CLT manufacturing facilities east of Chicago in the northeast U.S. and only one glulam beam manufacturer in New York State. This gets to the heart of the reason this project was conceived: to jump start the development of mass timber manufacturing in the northeast U.S. using local softwood species.

The "Eastern Hemlock Cross Laminated Timber Certification and Demonstration Project" was completed from 2021-2024 as a partnership between the North East *State* Foresters Association (www.nefainfo.org), a non-profit organization of the state government top foresters (state foresters) in the northeastern states and the University of New Hampshire Cooperative Extension. Funded primarily through a grant from the USDA Forest Service Wood Innovations grant program (https://www.fs.usda.gov/science-technology/energy-forest-products/wood-innovation), additional direct funding and support was also provided by the State of Massachusetts and the University of

[1] Glulam beams - Glulam is a stress-rated engineered wood beam composed of wood laminations, or "lams", that are bonded together with durable, moisture-resistant adhesives. The grain of the laminations runs parallel with the length of the member. Glulam is versatile, ranging from simple, straight beams to complex, curved members. Glulam is available in both custom and stock sizes and one of four appearance classifications: premium, architectural, industrial, or framing.

[2] Cross-laminated timber - Cross-laminated timber (CLT) is a large-scale, prefabricated, solid engineered wood panel. Lightweight yet very strong, with superior acoustic, fire, seismic and thermal performance, CLT is also fast and easy to install, generating almost no waste onsite. CLT offers design flexibility and low environmental impacts. For these reasons, cross-laminated timber is proving to be a highly advantageous alternative to conventional materials like concrete, masonry or steel, especially in multifamily and commercial construction. A CLT panel consists of several layers of kiln-dried lumber boards stacked in alternating directions, bonded with structural adhesives, and pressed to form a solid, straight, rectangular panel. CLT panels consist of an odd number of layers (usually, three to seven,) and may be sanded or prefinished before shipping.

Massachusetts. The latter played an instrumental part in the development of the project as Dr. Peggi Clouston, Professor of Wood Mechanics and Timber Engineering, Building and Construction Technology, conducted a study, the paper for which was published in 2019 that proved eastern hemlock (and to a lesser extent eastern white pine) was a viable softwood species from which to make cross-laminated timber. Further support was provided by lumber supply chain partners Cersosimo Lumber of Vermont, Parker Lumber of Maine & White Mountain Lumber of New Hampshire; and the CLT manufacturers at SmartLam of Alabama and Sterling Structural of Illinois. And for use of their buildings as installation pilot sites for eastern hemlock CLT; developers Fairbanks Museum of Vermont and CMD Construction Management and Development, developer of 154 Broadway project in Somerville, Massachusetts.

Project Process

Purpose of Project and Grant Funding

As stated in the introduction, the ultimate goal of *Eastern Hemlock Cross Laminated Timber Certification and Demonstration Project* was to move forward the commercialization of using eastern hemlock in cross-laminated timber in the northeast, hopefully leading to the development of a mass timber manufacturing facility in the northeast U.S. The initial engineering work of Dr. Peggi Clouston at the University of Massachusetts to prove that the species was capable of being used for cross-laminated timber, was instrumental in confirming the viability of this project.

In recent years, the USDA Forest Service Wood Innovations grant program, with increased funding from the Congress, has been one of the few sources of funding to accomplish a project like this. The North East *State* Foresters Association, the recipient of the $250,000 grant for this effort, is indebted to the Forest Service as the project would not have been possible without their grant. We must also thank the State of Massachusetts for some additional direct funding for the project.

Lastly, the partnership with the University of New Hampshire Cooperative Extension, and its forest industry specialist Andrew Fast, was critical in actually getting the work done.

Step 1: Securing Partners

After securing funding sources, it was essential to develop partnerships with several individuals and companies in order to complete the effort, led by NEFA Executive Director Charles Levesque. The partner list includes:

- University of Massachusetts and Dr. Peggi Clouston for counsel throughout the project;
- University of New Hampshire Cooperative Extension as a technical partner throughout the project through their forest industry specialist Andrew Fast;
- SmartLam and their Dothan, Alabama mass timber plant and personnel
- APA for providing their ANSI PRG-320 Standard testing and certification at their Tacoma, WA facility;
- Cersosimo Lumber of Brattleboro, VT for their hemlock lumber supply, kiln drying, planing and grade stamping of hemlock lumber feedstock;
- Northeastern Lumber Manufacturing Association (NeLMA) for eastern hemlock lumber grading services;
- Parker Lumber of Bradford, Maine for eastern hemlock lumber supply;
- White Mountain Lumber Company of Berlin, New Hampshire for eastern hemlock lumber supply;
- Fairbanks Museum in St. Johnsbury, Vermont for using eastern hemlock CLT in their building addition;
- CMD Construction Managers and Developers, LLC of Somerville, Massachusetts for using eastern hemlock CLT in their 154 Broadway multi-use building construction in Somerville;

- Boston Society of Architects for helping find a commercial building to pilot eastern hemlock;
- American Society of Architects, local chapters, for sponsoring training with use of eastern hemlock CLT;
- Woodworks for their support of the project and helping spread the word about the use of eastern hemlock for CLT.
- Sterling Structural and their Phoenix, Illinois mass timber plant and personnel
- UMaine for providing their ANSI PRG-320 Standard testing
- ICC-ES for certification of Sterling Structural's Phoenix, Illinois's facility and product.

Step 2: Eastern Hemlock Supply Chain for PRG-320 testing

In order for eastern hemlock to meet the ANSI/APA PRG-320 Standard for Performance Rated CLT, the project needed to identify a cooperating CLT manufacturer, a certified tester/certifier to the Standard and a hemlock lumber source to supply the raw material for the testing manufacturing. SmartLam, through their Dothan, Alabama CLT/glulam beam manufacturing plant, agreed to serve as the manufacturer.

Eastern hemlock lumber being graded and packaged after planing at the Cersosimo Lumber planer mill, Brattleboro, VT

Cersosimo Lumber, with headquarters in Brattleboro, Vermont agreed to supply some eastern hemlock lumber to the project along with kiln drying, planing and grading with the leadership of the NeLMA graders. Parker Lumber of Bradford, Maine provided the balance to Cersosimo green, rough 2x6 hemlock lumber for this testing supply.

Step 3: ANSI PRG-320 Testing and Certification

Once dried, planed, graded and packaged – approximately 34,000 board feet (34 MBF) – the lumber was shipped to the SmartLam CLT plant in Dothan, Alabama on December 15, 2021 from Cersosimo Lumber's planer mill in Brattleboro, Vermont by Jewell Trucking of Lebanon, New Hampshire.

Eastern hemlock lumber loaded for shipment from Cersosimo Lumber to SmartLam, Dothan, Alabama

Manufacturing of the eastern hemlock lumber into CLT for the testing phase (the CLT pieces are called "billets" at this point) at the SmartLam Alabama facility occurred on January 13, 2022.

Eastern hemlock CLT panels manufactured at SmartLam, Dothan, Alabama – ready for cutting into testing smaller panels or "billets" to be shipped to the APA testing lab in Tacoma, Washington.

The APA testing lab in Tacoma, Washington received the testing CLT billets on January 22, 2022 and proceeded with testing in the two weeks following. The tests found eastern hemlock CLT manufactured at SmartLam met the requirements of the ANSI/APA PRG-320 CLT certification standard. Initial finger jointing and other manufacturing testing was done by APA at the SmartLam manufacturing facility when the hemlock CLT was made. A link to the entire APA report dated June 13, 2022 can be found in the Appendix of this report.

Eastern hemlock CLT billets manufactured at SmartLam, Dothan, Alabama arriving at APA Testing Lab in Tacoma, Washington for PRG-320 CLT testing and certification

In the APA testing, a series of dozens of tests, each with 10 sample billets, were conducted to test the following (from the testing report) on both 3-ply and 9-ply hemlock CLT billets:

> This study is intended to evaluate the CLT manufactured with visually graded Eastern Hemlock-Tamarack laminations, which is a new wood species used for CLT grades by IB X-Lam. The CLT was evaluated for the following properties:
>
> - Block Shear: Block shear tests were conducted in accordance with ANSI/APA PRG 320.
> - Delamination: Face bond delamination properties were evaluated in accordance with ANSI/APA PRG 320.
> - Mechanical Properties: Mechanical properties were evaluated in accordance with ANSI/APA PRG 320.

The following example photo shows one test billet in the 9-ply sheer capacity transverse test.

APA testing lab (Tacoma, WA) for eastern hemlock PRG-320 certification in the 9-ply sheer capacity transverse test.

The results, showing eastern hemlock met the requirements of the CLT PRG-320 certification standard are all found in the testing report. The conclusion to the report says:

> The face bond test data shows that the 3-alt and 9-alt Eastern Hemlock-Tamarack CLT manufactured by IB X-Lam USA, LLC, Dothan, Alabama using No. 2 Eastern Hemlock-Tamarack lumber laminations in both directions met block shear and delamination requirements in accordance with ANSI/APA PRG 320. The bending and shear properties of the 3-alt and 9-alt Eastern Hemlock-Tamarack CLT met the theoretical design values as determined based on ANSI/APA PRG 320.

A note about the testing procedure: the PRG-320 testing certification certifies both the species group, which is officially eastern hemlock/tamarack (even though no tamarack was included in the testing) and the manufacturing process. The result, then, applies only to this species at the SmartLam plant in Dothan, Alabama. Other CLT manufacturing facilities wishing to use this species group, must re-test the species at their manufacturing facility.

Step 4: Pilot Installations Eastern Hemlock CLT

Originally, the grant application to Wood Innovations envisioned a contest for developer/architect teams to determine which building project would receive eastern hemlock CLT from the project budget. At the time the Forest Service awarded the grant, the original grant ask amount of $320,000 was trimmed to $250,000 so the contest approach was eliminated.

Instead, we enlisted the help of both the local American Institute of Architects local chapters and individual architects to identify possible mass timber projects that were in the planning stages where the hemlock CLT might be placed. In the end, two projects were chosen based on the likely visibility of the project to the public and architects, builders and developers and timing that synced with the grant project timeline.

Project one was in St. Johnsbury Vermont at the Fairbanks Museum (https://fairbanksmuseum.org/. This old natural history museum[3] was in the final fundraising stages for an already decided mass timber design in 2022. Since no local species CLT or glulam beams were available, the plan was to use Canadian glulam beams from Nordic in Quebec, almost local given the location of St. Johnsbury near the Canadian border and hire out the production of nailed CLT using local softwood species and nail guns. The actual glued CLT from local eastern hemlock (the hemlock for this pilot came from Vermont and New Hampshire) was a welcome substitution for the project team.

[3] The Fairbanks Museum was founded in 1889 by St. Johnsbury industrialist Franklin Fairbanks.

Fairbanks Museum addition near completion in early 2024 (inset during construction). Inset photo Adam Kane

Interior Fairbanks Museum with eastern hemlock CLT exposed ceiling.

The second building chosen was a more conventional five-story retail (first floor) and apartments (upper 4 floors) commercial building using a hybrid mass timber construction technique with CLT floors and more conventional stick wood framing instead of glulam beams. This project, from developers Construction Managers and Developers (http://www.cmdboston.com/) is in Somerville, Massachusetts, just outside of Boston with the Boston skyline viewable from the Main Street location.

Photo: Richazaire Francisque / Haycon

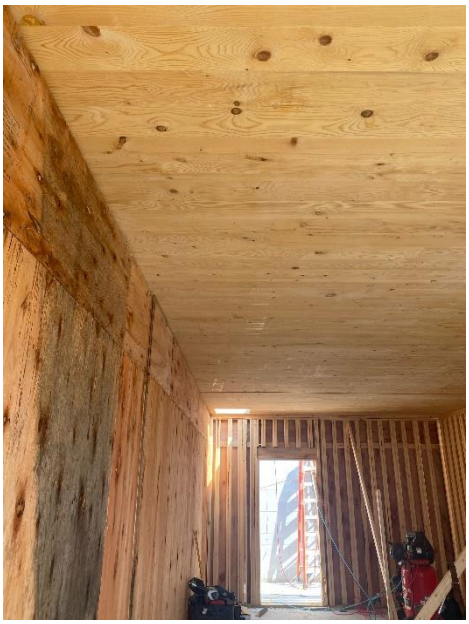

Photo: Richazaire Francisque / Haycon

154 Broadway, Somerville, MA (left and above) and interior eastern hemlock ceiling during construction phase

It should be noted that the eastern hemlock CLT panels provided by the project were used in spaces where the exposed ceiling would be viewed by the public because the project could not supply all the CLT needed for the 154 Broadway structure. The rest of the building CLT was from spruce-fir produced in Canada.

Step 5: Outreach

Outreach on the two pilot projects has begun and will continue after the project end in 2024. In addition to formal open houses at the two buildings, both have been featured in numerous presentations to forest related and building community audiences (developers, architect, builders) through American Institute of Architect trainings. More will take place in the coming years.

Additionally, as a result of outreach from the project, Sterling Structural, the largest CLT plant production-wise in North America, located in Phoenix, Illinois, has decided to take on the commercial production of eastern hemlock CLT sourced from the New England region and marketed to the northeastern construction market. Sterling will also be using northeast sourced spruce-fir in its efforts. Sterling's decision was essential to commercialization of eastern hemlock as the original CLT manufacturer for the project, SmartLam, decided, at this time, not to pursue producing and selling eastern hemlock CLT after this Wood Innovations funded grant project ended.

Findings

Overall major learnings

Without question the major learning from the project is that the northeastern eastern hemlock supply chain does not generally supply kiln dried, planed and grade stamped lumber to the marketplace. While there are over 20 sawmills in the northeast that specialize in sawing eastern hemlock, most are very small and only one has its own dry kilns and planer mill. Even that mill has not grade stamped the hemlock it has dried and planed. In order to meet the requirements of the PRG-320 standard, all hemlock used as lamstock for CLT must be dried, planed and grade stamped.

Several major eastern hemlock players in the northeast stepped up to move the supply chain forward in order to supply the dried, planed, grade stamped 2x6 hemlock lamstock needed for both the testing and pilot installation components of the project. Key to the effort was Cersosimo Lumber with headquarters in Brattleboro, VT. They took on the challenge, having never dried, planed and grade stamped hemlock to lead the effort. Initially they also supplied some rough, green hemlock for the certification phase. For that phase and for the later pilot stage, both Parker Lumber of Bradford, Maine and White Mountain Lumber in Berlin, New Hampshire supplied rough, green lumber for finishing at Cersosimo. Another player didn't supply for these two phases but is ready to do so – NC Hunt of Maine – the only hemlock manufacturer with kilns and planer mill.

Detailed Findings

In addition to the major finding described above relative to the supply chain, several other findings are worth noting here:

- **Cost** - Eastern hemlock in the dried, planed and graded form generally is price-challenged relative to the competing species: spruce-fir from the northeast and southern yellow pine from the southern states. Because of anomalies in the market brought on by the COVID pandemic, during the testing and certification phase of the project in 2021-22, hemlock was competitive with northeastern spruce-fir. Today as this is being written in 2024, hemlock is a little less competitive with spruce-fir, although prices have come down in projects Sterling Structural is beginning to supply using the species. Southern yellow pine is generally less expensive than both hemlock and spruce-fir from the northeast. Architects, builders and developers we partnered with, however, have shown a preference for eastern hemlock over spruce-fir because of the aesthetics. One architect said that compared to "very light and indistinct spruce-fir" and "the very yellow, hard look of southern yellow pine", eastern hemlock has a "warm, darker, richer tone" when viewed side by side. Will that aesthetic preference continue and is it strong enough to warrant a price premium over spruce-fir and southern yellow pine? It is too early to know.
- **Strength** – Dr, Peggi Clouston of the University of Massachusetts found that both eastern hemlock and eastern white pine could meet the PRG-320 standard for CLT. In her work, eastern hemlock was stronger than eastern white pine – not a surprise. In the official PRG-320 testing and certification done for this project, hemlock showed adequate strength characteristics to

meet the PRG-320 standard but the design values – i.e. the various strength measurements done during testing and certification – showed the species to be not quite as strong as spruce-fir or southern yellow pine. Since the species met the standard, this should not be a problem but project engineers may choose 5 or 7 ply with hemlock when 3 or 5 ply might do with other species.

- **New species for engineers** – While this minor issue should pass with time and eastern hemlock CLT installations, most design build teams – architects, engineers, builders and developers – have never worked with eastern hemlock for commercial or residential projects. This project had engineers doing their research on the timber species and asking questions. Those working with the two pilot projects and now a full commercial installation supplied by Sterling Structural in Maine in 2024, have gotten over that lack of knowledge. Trainings through the American Institute of Architects, WoodWorks, and other venues for this community will allow more to gain the species knowledge to make them comfortable requesting eastern hemlock.

- **Builder knowledge of mass timber building techniques** – Perhaps not an eastern hemlock CLT issue but a general mass timber building issue, there are not yet many builders that have worked constructing mass timber buildings in the northeast, though the numbers are growing. For both the Fairbanks Museum and 154 Broadway projects, this was the first time the builders at those sites constructed using mass timber components. There were specific key learnings like: how to keep the exposed CLT surfaces protected against weather in the construction phase; understanding how to move the material around and get it in place; as well as the hardware connections needed that were all new to first-time mass timber installers.

To some degree, all of these findings or challenges, tie back to cost. There are small “risk premiums” for each unknown associated with early stage development of a new product – like eastern hemlock CLT. These can be compounded across an entire project affecting bids and project cost. Over time, as the market and supply chain matures, many barriers should be mitigated and costs should come down.

Summary and Conclusion

The strong financial support from the USDA Forest Service, the State of Massachusetts and the developers of the two eastern hemlock CLT pilot projects was key to the success of this effort. Also critical was the interest and strong support from our key eastern hemlock supply chain businesses: Cersosimo Lumber, Parker Lumber, White Mountain Lumber, SmartLam, APA, Sterling Structural and NeLMA who provided the lumber graders at Cersosimo.

The project met its goal of moving eastern hemlock from a pilot mass timber phase to full commercial as Sterling Structural chose to offer the species in its CLT manufacturing and has several projects using hemlock moving forward in 2024. The challenges experienced in the supply chain have already progressed to the point of multiple supply sources of hemlock lamstock being available to Sterling as they move their commercial offerings forward.

Eastern hemlock is now part of the species mix available for those seeking to construct CLT buildings in the northeast and other regions. The next step is to facilitate the construction of a mass timber manufacturing plant in the northeast using local species.

Finally, although there are no CLT manufacturers yet located in the northeast, the fact that a manufacturer has stepped forward to make CLT using northeast sourced eastern hemlock and spruce-fir is a huge leap forward. A missing link is that there are no glulam beam manufacturers yet offering these northeastern species. Several developers attempting to develop mass timber manufacturing plants in the northeast as of this writing assure us that those plants will also manufacture glulam beams as well as CLT.

February 2024

Sources

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Photos – Charles Levesque unless otherwise noted.

Appendix

The complete APA PRG-320 testing report can be found at https://www.dropbox.com/scl/fi/5dvim57cerzdlsztcqh0p/T2022-10A-P-IB-X-Lam-Eastern-Hemlock-Tamarack-CLT-evaluation.pdf?rlkey=x0180zdjis01cydzen9y2c0c4&dl=0