WCTE 2020
WORLD CONFERENCE ON TIMBER ENGINEERING
SANTIAGO, CHILE | 24 - 27 AUGUST

NORTH AMERICAN RESEARCH NEEDS ASSESMENT FOR MASS TIMBER

Samuel L. Zelinka[1], Tom Williamson[2], Karen L. Martinson[3], Michael A. Ritter[4]

ABSTRACT: The 2nd Mass Timber Research Needs Assessment Workshop was held on November 13-14, 2018 at the US Forest Service, Forest Products Laboratory (FPL). The purpose of the workshop was to convene a group of experts on cross laminated timber and mass timber to develop a list of prioritized research needs for the North American mass timber industry. The workshop had over 100 attendees including design professionals, academics, industry leaders, and government employees. The attendees generated a list of over 117 research needs. After the workshop, the list of 117 research needs was prioritized through the use of an online survey. This paper presents highlights of the top research needs generated at the 2nd Mass Timber Research Needs Assessment Meeting.

KEYWORDS: Mass timber, cross laminated timber (CLT), North America, seismic performance, fire performance

1 INTRODUCTION

Mass timber, especially cross laminated timber (CLT), is becoming rapidly adopted in North America. While certain mass timber products such as glued-laminated timber have been used for over 100 years, CLT is changing the way that timber buildings are constructed, with buildings as high as 18 stories constructed in the past decade in North America [1-4].

Currently there is a large investment in the North American mass timber industry through several different federal and state government programs, as well as non-governmental organizations. Because the money for research is fragmented across many different partners, it is important that a comprehensive research needs assessment be developed so that the research dollars can be focused on the highest priority needs.

Three years ago, The US Forest Service, Forest Products Laboratory (FPL) held the first mass timber research needs assessment workshop [5]. This workshop laid the groundwork for understanding potential research needs for the industry. The 2018 workshop focused on developing a prioritized list of research needs for the North American mass timber industry.

[1]Samuel L. Zelinka, US Forest Service, Forest Products Laboratory, samuel.l.zelinka@usda.gov
[2]Tom Williamson, Timber Engineering, LLC, tomwilliamson@live.com
[3]Karen L. Martison, US Forest Service, Forest Products Laboratory (retired), klmarti3@wisc.edu
[4]Michael A. Ritter, US Forest Service, Forest Products Laboratory (retired), mritter@wisc.edu

2 OBJECTIVE

The objective of the workshop was to develop a comprehensive, prioritized list of research needs that, when accomplished, will advance the North American mass timber industry.

3 SCOPE

The scope of the research needs assessment was purposely chosen to be as broad as possible as it pertains to mass timber. While much of the discussion focused on CLT, the research needs assessment encompassed research needs on other mass timber products as well. Non-building applications of mass timber were also examined. In addition to engineering aspects of mass timber, environmental and economic aspects were also discussed.

4 METHODOLOGY

4.1 WORKSHOP

The workshop was held in Madison, WI, USA at the FPL and consisted of 105 attendees. The attendees included representatives from industry, trade associations, non-governmental organizations, academia, and governmental officials and scientists from both the United States of America and Canada.

The workshop consisted of three keynote presentations and panel discussions. The three keynote presentations, were:

1. *Mass Timber Research Needs From the FPL Perspective*- Mike Ritter, FPL. This presentation summarized the objectives of the meeting: (a) Better understand what research is currently in progress for mass timber. (b) Identify research gaps that must be

filled to further advance mass timber structural systems. (c) Formulate an international network to share research information and compile non-refereed research in progress summaries

2. *Mass Timber Market Update*- Jennifer Cover, WoodWorks. This presentation summarized the number of mass timber projects in design and construction across the United States. At the time of the presentation there had been 157 completed projects using mass timber. The presentation went on to summarize the drivers for mass timber adoption in the United States.
3. *Overview of Completed/Ongoing Mass Timber Research*- Sam Zelinka, FPL. This presentation summarized research on Mass Timber that had been completed since the first Mass Timber Research Needs Assessment Workshop in 2015 [5]. Major research accomplishments included the progress on the development of seismic performance factor using the FEMA P-695 methodology and the fire testing in support of the ICC Ad-hoc committee on tall wood buildings to expand the 2021 IBC to permit mass timber in buildings up to 18 stories in height.

4.2 PANEL DISCUSSIONS

The majority of the workshop was spent in seven panel discussions. For each panel discussion, four or five panelists were selected to start the discussion. Each panelist was given approximately ten minutes to present his or her top research needs within the topic. Following these comments, the panelists interacted with other panelists and the audience. During this time new research needs ideas were generated. The research topics were recorded by two scribes.

4.2 PANEL TOPICS

The seven panel topics were:

1. Structural Resilience
2. System Design and Construction
3. Fire Performance
4. Durability and Building Physics
5. Materials and Manufacturing Process
6. Sustainability and Economic Analysis
7. Non-Building Applications

The panel topics were chosen to be inclusive of all potential mass timber research areas and were based largely off of research needs developed at the first Research Needs Assessment Workshop [5]. Several research priorities were discussed in multiple topic areas. For example understanding fastener performance as CLT undergoes moisture cycling was brought up in panels and 1,2, and 4.

4.3 ONLINE SURVEY

After the completion of the workshop, the scribes refined their notes into a list of one sentence “research topics” with input from the Workshop coordinators. Special care was taken to ensure that each topic mentioned at the meeting was included in the survey. Therefore, in some categories, the list contains multiple items that could potentially be grouped into a single, larger project. Additionally, each instance of research topics that appeared in multiple panel groups were included in the survey. This allowed the topics to be ranked among the topic area groups and again across the overall group.

These one sentence research topics were then sent to the list of workshop participants for an on-line response.. For each topic, participants rated the level of the research need from 1 to 5, where 1 is the lowest research priority and 5 is the highest research priority.

4.3 PRIORITIZED NEEDS ASSESMENT

The prioritized list was created by averaging the scores for each topic area over responses from all participants. The scores were then ranked from highest to lowest priority. Two rankings were developed. Each research topic received an overall ranking (across all different panel topic areas). Research topics were also ranked within other topics that were generated in the same panel discussion.

5 RESULTS

The results consisted of tables of the prioritized research needs. The full list of results is included in the official research needs assessment report [6]. The top 10 research priorities from each panel are listed in Tables 1-7. Table 8 summarizes the top 10 overall priorities from across all panels.

Table 1: *Top 10 structural resilience research needs*

Panel Rank	Overall Rank	Research Topic
1	1	Complete research on CLT shear wall performance and publish seismic design coefficients.
2	2	Develop building-code-approved prescriptive designs for CLT diaphragms and shear walls.
3	10	Conduct CLT diaphragm research that specifically addresses the effect of aspect ratios.
4	15	Evaluate performance of connections and panels as panels shrink and swell because of moisture exposure.
5	20	Evaluate the effects of openings on the performance of CLT shear walls.
6	21	Evaluate lateral force resisting systems for multi-story mass timber open floor plan buildings.
7	28	Research CLT diaphragms with concrete topping over CLT.
8	31	Determine the performance of self-tapping screws under moisture cycling.
9	40	Further evaluate the performance of wood/concrete composite systems from a seismic perspective.
10	42	Conduct research to evaluate different timber/concrete composite connector systems.

Table 2: *Top 10 system design and construction research needs*

Panel Rank	Overall Rank	Research Topic
1	6	Conduct CLT diaphragm research based on needs determined by design professionals.
2	9	Conduct research to develop design methods for point-supported and two-way spanning CLT panels.
3	16	Develop approaches to enhance CLT performance in low seismic regions.
4	22	Conduct vibration testing of CLT–concrete panel systems (e.g., nonstructural topping concrete over panels and structurally connected concrete over CLT).
5	38	Conduct detailed testing on CLT panels to investigate the size/volume effect of CLT in edgewise, flatwise, and shear loadings.
6	43	Improve vibration, acoustic and connection performance of wood/concrete composite systems.
7	49	Develop design methodologies for the reinforcement of notched glulam beams that will permit their use beyond the National Design Specification and International Building Code limits.
8	58	Determine the cyclic wetting and drying behavior of wood/concrete composite panels.
9	60	Develop approaches to minimize CLT crushing in high loading areas.
10	65	Conduct acoustic testing of 3-ply CLT assemblies.

Table 3: *Top 10 fire performance research needs*

Panel Rank	Overall Rank	Research Topic
1	5	Perform 2-h fire testing on a wide variety of connections and mass timber connection configurations.
2	8	Research improvements to the American Wood Council 2018 TR-10, Calculating the Fire Resistance of Wood Members and Assemblies, regarding more efficient testing and design methodology for protection of connections in wood.
3	11	Develop guidance for detailing assembly intersections, assembly fire stop systems, and penetration fire stops for up to 3-h fire ratings.
4	33	Conduct research to evaluate the impact of gaps between CLT and NLT boards on fire performance and calculated fire resistance of these systems.
5	36	Research fire performance of embedded steel in mass timber connections.
6	41	Research viability of using more fire-retardant treatment products in mass timber buildings to reduce the use of gypsum and other fire protective methods.
7	44	Develop intermediate scale qualification tests for adhesives to verify that the adhesive doesn't lead to delamination and fire regrowth.
8	52	Conduct additional testing of non-gypsum board non-combustible protection options to establish their performance when used in mass timber construction.
9	55	Carry out compartment fire testing under office loads and with exposed timber ceilings and define benchmarks for acceptable performance.
10	56	Research fire performance of timber/concrete composite floors with varying shear connectors and panel connections.

Table 4: *Top 10 durability and building physics research needs*

Panel Rank	Overall Rank	Research Topic
1	3	Determine how duration and severity of wetting affect mass timber products (dimensional change, surface mold, biological deterioration, corrosion of connections, etc.).
2	4	Develop written specification language that incorporates best practices for moisture management during and after construction.
3	17	Develop improved moisture and structural condition assessment methods for mass timber products (e.g., infrared thermography, ground-penetrating radar).
4	19	Develop methods for repair and remediation of mass timber products in the field.
5	23	Characterize the performance of mass timber construction in southern high-moisture climates.
6	24	Establish and validate detailed wood protection methods for mass timber construction.
7	25	Evaluate the effectiveness of protective coatings and membranes at limiting moisture uptake during construction.
8	26	Evaluate the integrity of fasteners and structural connections between mass timber products after moisture cycling.
9	29	Quantify mass timber energy performance and develop specific energy code provisions that account for benefits (e.g., less continuous insulation than similar concrete or steel walls).
10	30	Evaluate acoustic performance of mass timber building assemblies.

Table 5: *Top 10 materials and manufacturing research needs*

Panel Rank	Overall Rank	Research Topic
1	12	Develop nondestructive evaluation techniques to evaluate the structural condition of CLT panels in service.
2	18	Develop nondestructive evaluation techniques that evaluate bond line integrity in CLT panels.
3	39	Develop models to predict properties of CLT that can minimize the need for physical testing of multiple species–grade–adhesive options.
4	51	Quantify the CLT volume size factor such that it can be used for performance-based designs.
5	73	Develop and evaluate ways to optimize mills for usage of available wood resources for mass timber production.
6	76	Develop CLT stress grades that are based on assembled panels rather than the constituent lumber properties.
7	80	Determine the most efficient layups for CLT, similar to the work previously completed for glulam.
8	81	Develop layups and design values for CLT panels that include low value and underutilized wood species.
9	84	Develop and conduct fire tests that evaluate adhesive performance rather than panel performance.
10	95	Develop improved estimates of panel strength in the minor strength direction.

Table 6: *Top 10 sustainability and economic analysis research needs*

Panel Rank	Overall Rank	Research Topic
1	7	Further evaluate cost-effective detailing, such as standardized connections, to improve the cost effectiveness of mass timber buildings.
2	13	Complete research to determine if 8- to 12-story mass timber buildings will be cost effective against competing materials.
3	14	Conduct whole-building life-cycle assessments to compare mass timber buildings with those constructed of steel and concrete.
4	27	Conduct whole building life cycle assessments and building service life studies to better quantify the carbon sequestration and environmental impacts from mass timber buildings.
5	32	Quantify the long-term energy characteristics of mass timber buildings.
6	46	Evaluate methods to use more low quality wood in mass timber systems to help promote forest health.
7	53	Compare similar buildings using different building materials to determine the operational capacity and energy profiles over a 2-3 year period.
8	69	Document the costs of assemblies and cost-effective standard assemblies and details.
9	74	Determine the optimal design for mass timber systems, instead of just a conversion from steel and concrete designs.
10	77	Identify and quantify carbon benefits of different mass timber building products.

Table 7: *List of all non-building application research needs*

Panel Rank	Overall Rank	Research Topic
1	92	Investigate CLT dimensional stability, strength, creep, temperature, and ultraviolet radiation effects during long-term exterior exposure such as in bridge applications.
2	104	Develop a strategic plan outlining laboratory testing, analytical modeling, and field evaluations necessary for adopting CLT bridge designs into AASHTO Bridge Design Specifications.
3	106	Develop nondestructive evaluation techniques that can be used to improve inspections of mass timber bridges.
4	111	Conduct feasibility and cost-effectiveness study for utilizing CLT components in other transportation structure applications including noise barrier walls, box culverts, crane mats, and marine facilities.
5	112	Investigate the feasibility of composite CLT systems utilizing concrete or steel components in bridge applications.
6	113	Investigate the fire performance of CLT primary bridge superstructure components using untreated material and material treated with oil-type and waterborne preservative treatments.
7	115	Explore mixed and/or naturally-durable species for use in CLT bridge applications.
8	116	Review existing international literature for validity and applicability of mass timber for North American bridge applications.

Table 8: *Top 10 overall research needs*

Rank	Average Score	Research Topic
1	4.24	Complete research on CLT shear wall performance and publish seismic design coefficients.
2	4.10	Develop building code approved prescriptive designs for CLT diaphragms and shear walls.
3	3.88	Determine how duration and severity of wetting affect mass timber products (dimensional change, surface mold, biological deterioration, corrosion of connections, etc.).
4	3.78	Develop written specification language that incorporates best practices for moisture management during and after construction.
5	3.73	Perform 2-h fire testing on a wide variety of connections and mass timber connection configurations.
6	3.67	Conduct CLT diaphragm research based on needs determined by design professionals.
7	3.65	Further evaluate cost effective detailing, such as standardized connections, to improve the cost effectiveness of mass timber buildings.
8	3.59	Research improvements to the American Wood Council 2018 TR-10, Calculating the Fire Resistance of Wood Members and Assemblies regarding more efficient testing and design methodology for protection of connections in wood.
9	3.58	Conduct research to develop design methods for point supported and two-way spanning CLT panels.
10	3.55	Conduct CLT diaphragm research that specifically addresses the effect of aspect ratios.

6 CONCLUSIONS

The 2nd Mass Timber Research Needs Assessment Workshop resulted in a list of prioritized research needs. These needs will be widely circulated with the goal of coordinating mass timber research in North America. While some research needs are unique to building codes within the US, much of the fundamental science represents global research needs and may represent opportunities for international collaboration.

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