CLEMSON

WOOD UTILIZATION + DESIGN INSTITUTE

6TH ANNUAL REPORT

December 16, 2020

Submitted by

Patricia A. Layton

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EXECUTIVE SUMMARY

WU+D staff and faculty fellows started out 2020 in a full sprint with plans to participate in educational events across the country every month promoting the use of mass timber. When the COVID-19 pandemic hit in early March, we did not lose all footing as many of our plans pivoted to an online format (both events, like the Industrialized Wood-Based Construction Conference [IWBCC], and one-on-one meetings).

The biggest win in 2020 has been the opening of Clemson University's first mass timber building, the Andy Quattlebaum Outdoor Education Center, followed up very quickly with the start of construction on Clemson's second mass timber building, the Samuel J. Cadden Chapel (see the outreach section on page 15 for photos of each).

Overall, we are very grateful for a productive 2020 and look forward to even more progress and opportunity for mass timber promotion in 2021. The following report summarizes research and project updates from the schools of architecture and engineering concerning the use of mass timber in 2020, as well as general updates and future plans form the Wood Utilization + Design Institute. Contact wudclemson@gmail.com for more information.

News Stories

ENR Southeast Announces 2020 Best Projects Award Winners
https://www.enr.com/blogs/6-southeast-constructions/post/49842-enr-southeast-announces-2020-best-projects-award-winners

Rare Air at Clemson University https://campusrecmag.com/rare-air-at-clemson-university/

Quattlebaums become Cornerstone Partners, naming Outdoor Education Center
https://newsstand.clemson.edu/mediarelations/quattlebaums-become-cornerstone-partners-naming-outdoor-education-center/

(2019) Video: Clemson Wood Utilization + Design Institute celebrates year of success, new members https://newsstand.clemson.edu/wud-video-2019/

Visit clemson.edu/wud to read more.

Samuel J. Cadden Chapel, Clemson University, 2020

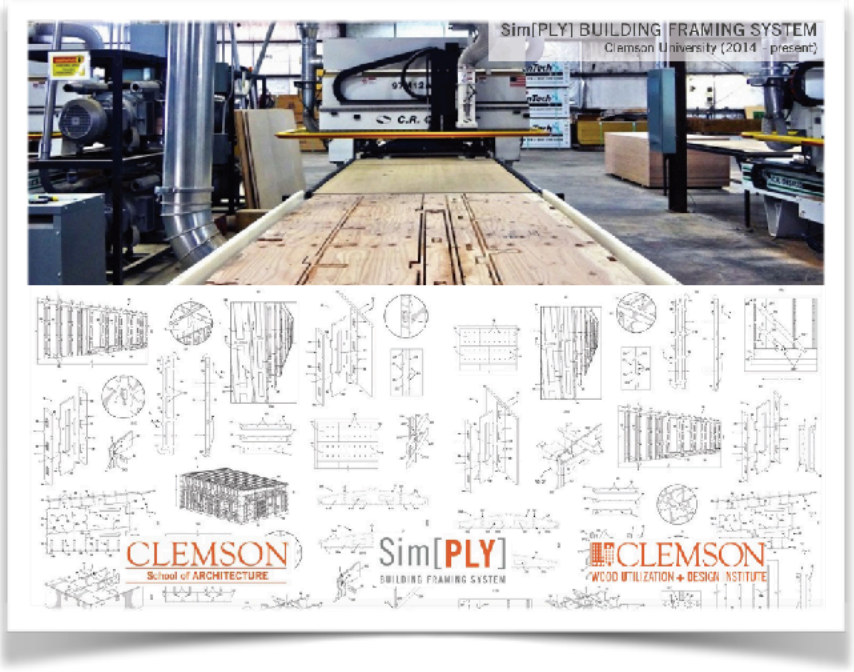
REVIEW OF ACTIVITIES

ARCHITECTURE ACTIVITIES

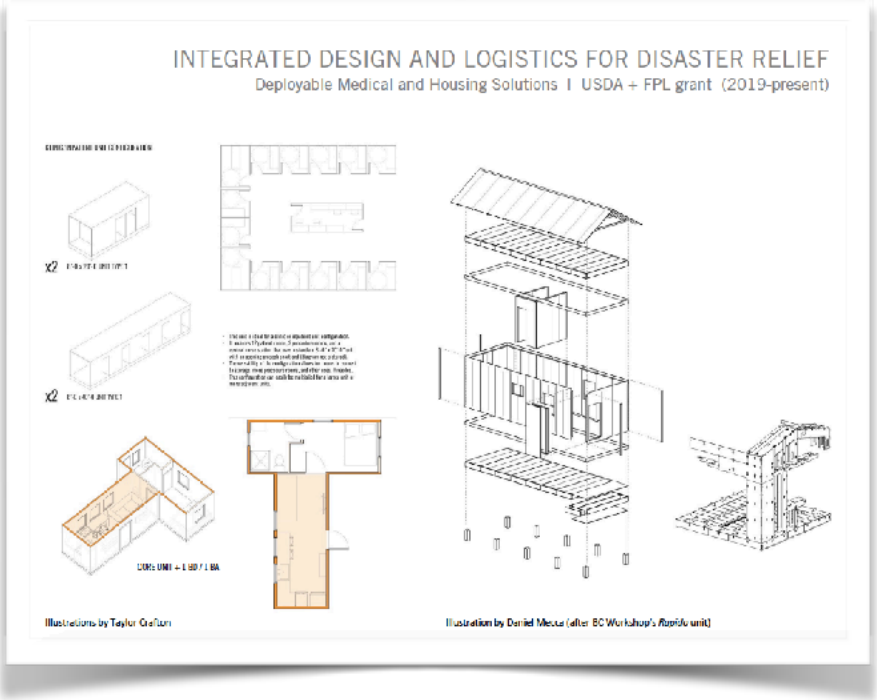
2020 has been another active year for our WU+D faculty fellows and students from the Architecture department, with the continuation of a couple of projects mentioned in last year's report, plus some new collaborations and a flurry of project proposals.

Last year, we described our work with the Anomura Housing Society, a non-profit in Victoria, British Columbia who has been studying our unique Sim[PLY] light framing system as a potential solution for affordable, workforce housing. This work culminated in a built demonstration structure on the campus of Camosun College. This year, we broadened this partnership and worked closely with RJC Engineering (an advisor to Anomura) to examine the advantages of the Sim[PLY] system for meeting the ambitious and evolving BC Energy Step Code. This work is scheduled to be presented at the 2021 World Conference on Timber Engineering in Santiago, Chile.

The Sim[PLY] system also served as a touch point for a unique design project in the Spring Graduate Comprehensive Studio course, which dealt with the need for affordable, energy-efficient housing in the mill communities of neighboring Anderson, SC. This gave us the opportunity to introduce Sim[PLY] to City of Anderson officials and an array of community stakeholders, including residential developers and builders. These conversations have continued and we are engaged in a study of Sim[PLY] housing prototypes for a former mill neighborhood adjacent to the downtown. This work has also been integrated into a recent grant proposal to the U.S. Department of Energy, spearheaded by Professor Vincent Blouin.



This year, we also continued our work on a project titled "Integrated Housing Design and Logistics for Disaster Relief." The project is being supported by the USDA through the Forest Products Laboratory. Building upon the initial research and literature review conducted last Fall, we have been engaged in design studies for deployable health care clinics as well as post-disaster housing, with an emphasis on flexibility and adaptability across uses. The project includes modular units framed with CLT, as well as pop-up units framed with Sim[PLY], and we are coordinating closely with Dr. Pang and his advisees in the Civil Engineering department. Ultimately, the designs can serve as reference points for disaster recovery logistics modeling being performed by colleagues in Clemson's Industrial Engineering department. This work, which is ongoing, has led to connections with South Carolina's Emergency Management Division, and is the subject of an additional grant proposal recently submitted to the National Science Foundation.



Throughout this Fall semester (2020), Dustin Albright has directed a mass timber-themed design studio, in collaboration with LS3P a multidisciplinary design firm with offices throughout the Carolinas and Georgia. LS3P is currently working with mass timber for multifamily housing and sought to study the application of these systems in the design of schools. This led the firm to sponsor an upper-level research studio. The resulting project was called *Learning Environments: Schools from Forests*. The studio was comprised of 13 undergraduates (seniors) and 5 graduate students, and led to ten unique design proposals for the new Forest Lake Elementary School in Columbia, SC, which served as our prompt. The semester began with an initial research phase, looking at the related topics of The Forests, Timber Products, and Building with Timber. This formed the groundwork for the subsequent school design project, for which students utilized mass timber systems as the main structural framework. For all but a couple of the students, this marked the first time designing with timber. The packaging of the work from the studio will continue into next semester and will be complimented by a series of closer case studies (ongoing) examining a set of exemplary mass timber schools in the U.S. and Europe.

Fall 2020 Architecture Design Studio partnered with LS3P

Looking ahead, Dustin Albright, Dan Harding and a third professor from Architecture (Ufuk Ersoy) will be teaming up to teach another mass timber studio beginning in January, this time looking at building typologies common to the Department of Defense. This studio will be the first in a series under a sponsored project titled “Advancing Mass Timber Design and Education.” The work will be interdisciplinary throughout and is set to draw on the involvement of additional investigators Pat Layton, Kate Schwennsen (Architecture), and Weichiang Pang and Michael Stoner (Civil Engineering), as well as collaborators from the University of Arkansas and University of Oregon. Read more at the end of this report.

ENGINEERING ACTIVITIES

Natural Disaster Research Update

Dr. Yongjia Song, Assistant Professor, Industrial Engineering

SUMMARY:
We study the disaster relief logistics operations planning problem from an engineering optimization perspective. We have created and validated disaster housing supply chain and logistics optimization models, which can be used to quantify and benchmark the impacts of novel disaster housing solutions in hurricane response and recovery: (i) new solutions in the resulting finite and infinite-horizon stochastic dynamic programs and chance-constrained stochastic optimization problems will provide new policy insights; (ii) New architecture/housing hazard analysis may be informed by trading off different design options from a logistics planning perspective using cost/benefit analysis. Our research products have been submitted for journal publication and appeared in conference proceedings. We also created new Creative Inquiry projects in industrial engineering to integrate our research and educational efforts.

PAPERS: (*: graduate student)

- Yanbin Chang*, Yongjia Song, and Burak Eksioglu, "A Stochastic Lookahead Approach for Hurricane Relief Logistics Operations Planning under Uncertainty", under 1st round revision, Annals of Operations Research, 2020.
- Yanbin Chang*, Yongjia Song and Burak Eksioglu, "A Stochastic Look-ahead Approach for Disaster Relief Logistics Operations". Proceedings of INFORMS-TSL Conference 2020, https://www.informs.org/Publications/Proceedings-of-the-TSL-Second-Triennial-Conference.
- Murwan Siddig* and Yongjia Song, "Adaptive Hurricane Relief Logistics Planning: A Multi-stage Stochastic Programming Approach", submitted to Proceedings of IISE Annual Conference and Expo, 2021.

RESEARCH PROPOSALS:

- CAREER: An Adaptive Stochastic Look-ahead Framework for Disaster Relief Logistics under Forecast Uncertainty, NSF, Submitted in August 2020.
- An Integrated Housing Design and Logistics Operations Modeling and Analysis Framework for Hurricane Relief, NSF, with Dustin Albright and Weichiang Pang, Submitted in September 2020.

COURSES:

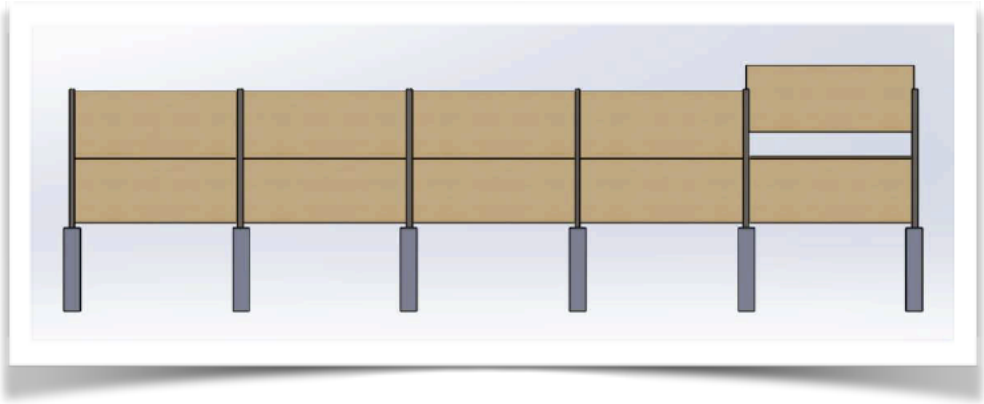
- Creative Inquiry: IE 4040 Disaster Relief Logistics, Fall 2019 and Fall 2020 (seven undergrad students are enrolled)

Mass Timber Noise Barrier Research Update

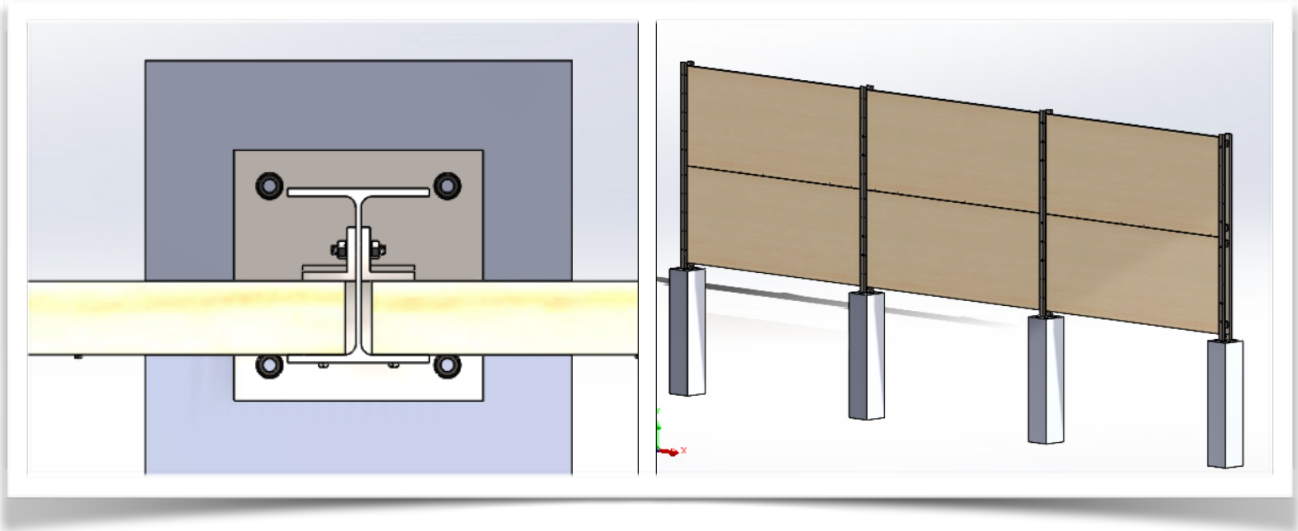
Laura Redmond, Assistant Professor, Civil Engineering

Development and Promotion of Mass Timber Noise Barriers for Highways

The team initially focused on collection of data related to existing noise barrier projects, design standards, and state requirements. Using the noise barrier design requirements outlined in the AASHTO code, the team has proposed a design that utilizes a 3-ply Southern Yellow Pine CLT panel and steel posts for a theoretical site in Georgia. Construction sequence and connection details were selected to mimic details from concrete and timber noise barriers and to minimize labor costs. The team is in the process of ordering steel to assemble a mock-up panel and demonstrate the constructibility of the proposed design. The drawings for the mock-up panel are shown below.

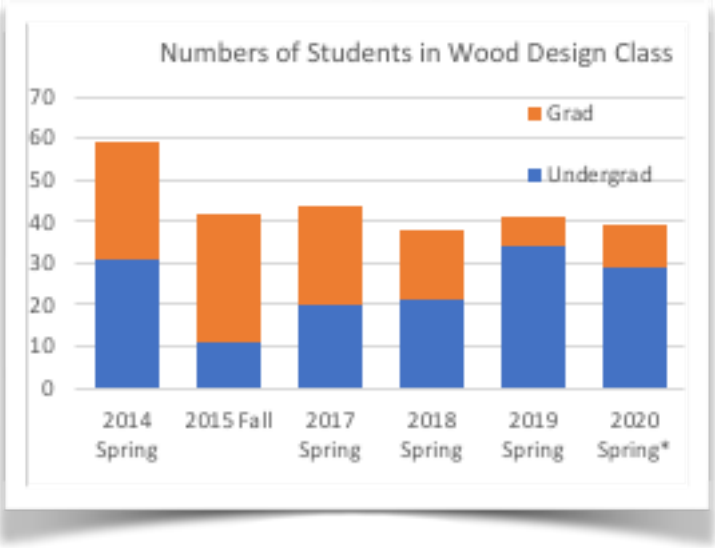


To address durability concerns, the team has also collected data about possible treatment options for the CLT panels and have begun to collect pricing data. We will engage the advisory board in further discussions of treatment options for the proposed CLT noise barriers. In addition to design and durability, much attention has been given to the collection of cost data related to materials, transportation, and placement of the proposed noise barriers. The team has been in communication with many CLT producers, contractors, and DOTs to collect this information. Ultimately, we aim to compare expected costs of the proposed CLT noise barriers to commonly used precast concrete or timber noise barriers.



Wood Design Class

Civil Engineering



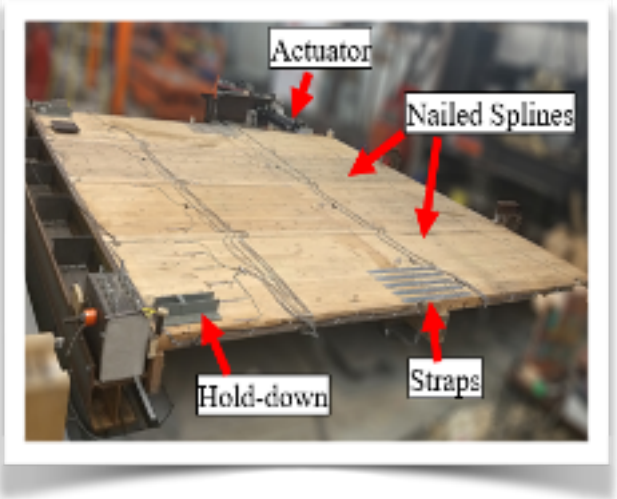
In academic year 2020, 39 students took the Civil Engineering Wood Design class. 29 undergraduate students and 10 graduate students completed the wood design course. The course taught engineering students on how to design wood buildings and other structures following the *National Design Specifications for Wood Construction*, (commonly known as the NDS code). On average, about 40 students take the wood design course every year.

The Spring 2020 Wood Design class was taught by Michael Stoner via a WUD Teaching Fellowship sponsored by Weyerhaeuser. In order to encourage students to take the wood design course, I always reached out to the industry (American Wood Council) to solicit sponsor for my class. Over the past several three years, Charles Ingram Lumber was kind enough to sponsor the wood design class at Clemson. The kind support from Charles Ingram Lumber makes the Wood Design class among one of the most popular courses in Civil Engineering Department.

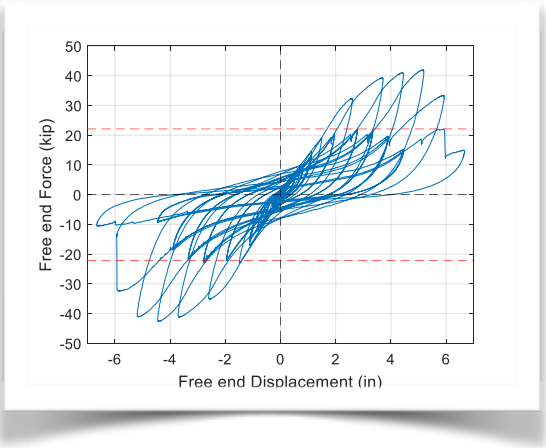
Research Activities

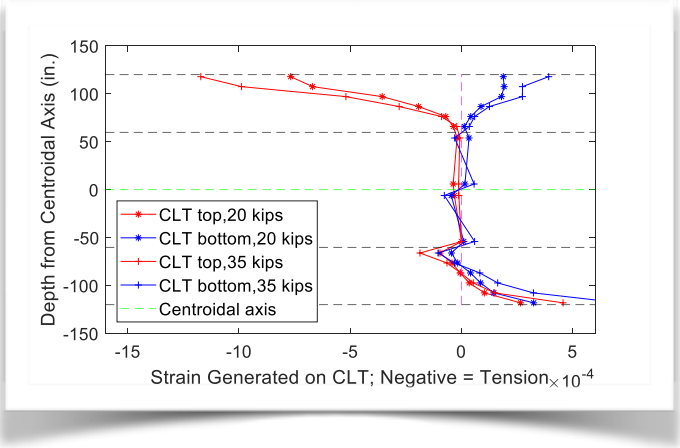
On-going: Understanding the in-plane shear behavior of Cross Laminated Timber (CLT) diaphragms

By Bibek Bhardwaj



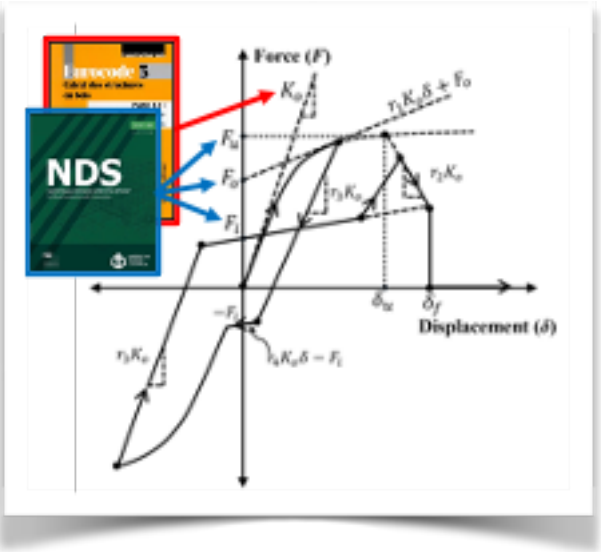
The goal of this research is to characterize the in-plane shear strength, stiffness and deflection behavior of CLT diaphragms. Of the three full-scale tests planned, the first diaphragm was tested on October 2019 and the second diaphragm is scheduled to be tested in January 2021. Data analysis from the first test revealed the ultimate capacity of the CLT diaphragm exceeded the LRFD capacity by a factor close to two. The primary energy dissipation mechanism was via the ductile fasteners used in the surface spline connections of the





diaphragm. Furthermore, strain data showed the tensile and compressive strains to be concentrated close to the diaphragm edges.

The results from the first test will be compared and contrasted to that of the second test, which will be CLT diaphragms of similar scale but different layouts. The observations made from the tests can be utilized to verify and validate the current design procedure. Preliminary results from the first test show that improvement to the deflection equations in the Special Design Provisions for Wind and Seismic (SDPWS) may be needed.



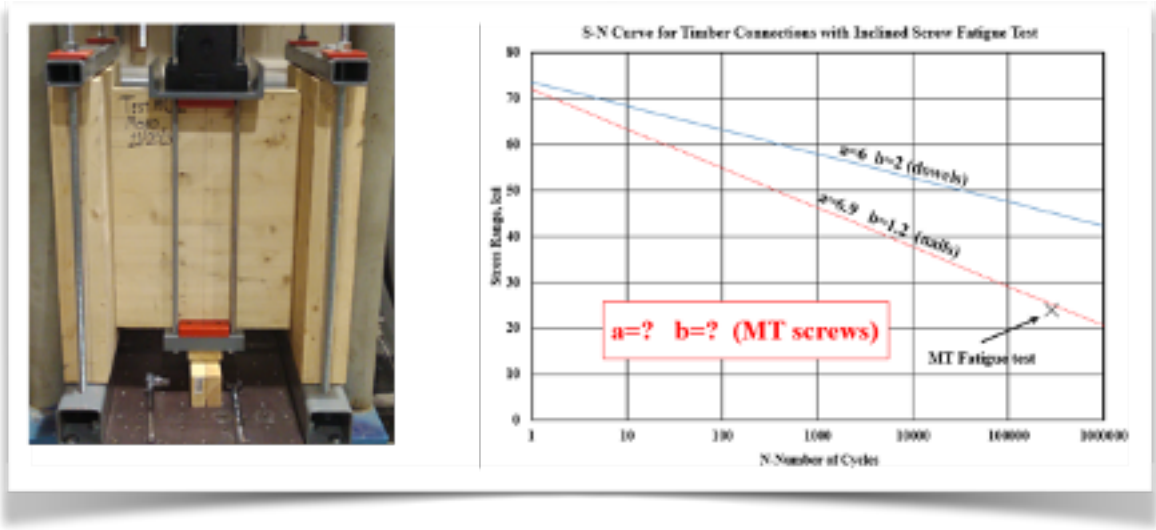
On-going: Dynamic Response of High-Rise CLT Buildings to Wind Loads

By Lancelot Reres

The proposed changes to the 2021 *International Building Code* would allow for cross-laminated timber buildings up to 270 feet. Based on in-situ modal data of CLT buildings, and trends seen in steel and concrete construction, the dynamic response of CLT buildings above ~180 feet should be considered in the lateral design. This entails including a dynamic component when calculating drift and checking the peak acceleration.

The goal of this research is to (1) develop numerical methods to estimate connection stiffness in order to aid in the modeling, analysis, and design of CLT buildings; (2) evaluate the fatigue characteristics of mass timber screws; and (3) perform nonlinear time-history analysis' to assess the long-term performance and design of high-rise CLT buildings with regard to the ASCEs 2021 *Prestandard for Performance-Based Wind-Design.*

An analytical method for estimating the Modified Stewart Hysteretic (MSTEW) parameters of nailed connections was developed. The method presented utilizes design



code equations and is calibrated using published MSTEW data. This method can be used for light-frame design or coupled with a connector model to assess other dowel-type connections used in CLT construction.

Previous research at Clemson indicates that the fatigue performance of mass timber screws may fall below design expectations. A fatigue study is currently underway at BEL in order to determine if the current design assumption are still valid.

Ph.D. Dissertation: Performance of Cross-laminated Timber as a Residential Building Material Subject to Tornado Events

By Michael Stoner

Innovations in the use of wood as a structural material have included the invention of engineered wood products including Cross-Laminated Timber (CLT) for which markets are expanding. One such market is residential construction where many structures are built using light-frame construction techniques. These structures have shown vulnerabilities to hazards such as tornadoes; whereas, CLT has shown potential to withstand these hazards.

The project had two main components: an experimental test phase and an analytical phase. Results from experimental debris impact testing demonstrated that 3-ply CLT could reliably resist the debris associated with EF-2 and EF-3 level events while failing approximately 50% of the time when subject to EF-5 level hazards. CLT shear wall tests on assemblies with and without out-of-plane walls sought to quantify the performance of configurations that would likely be present in residential structures with more box-like geometries and behavior. In

Experimental setup for debris impact tests CLT and composite CLT wall tests

addition, it was determined that out-of-plane walls could resist the uplift forces that develop due to lateral loads. A simplified analytical method for determining the capacity of CLT shear wall assemblies was proposed based on the connection capacities of the assembly.

The analytical phase of the project included the development of a structural performance model for residential archetypes designed using CLT. Results from this study indicated that the archetypes experienced a 10% probability of failure in EF-4 events. In comparison, light-frame construction has shown vulnerabilities to EF-0 and EF-1 level events. In addition, the hazard assessment of light-frame structures based on historical tornado data showed that significant portions of the United States exhibited a reliability index less than the target reliability described in ASCE 7-16, dropping to nearly 0% when built using CLT. A comparative cost analysis shows that for locations with high tornado hazard, it would take up to 100 years for CLT construction to be economically competitive with light-frame construction considering only the differences in upfront construction costs and tornado-induced losses.

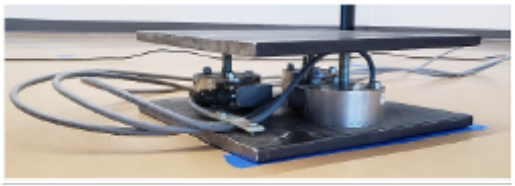
Ultimately, CLT exhibits an increased level of performance compared to light-frame residential construction in tornado events. Further developments in the mass timber market could make such an alternative to light-frame construction more realistic.

Michael Stoner completed his PhD study in May 2020. He is currently a Lecturer at the Glenn Department of Civil Engineering at Clemson University.

M.S. Thesis: Effects of Heavy Concrete Topping on Vibrational Performance of Cross Laminated Timber

By Benjamin Schwendy

Cross-Laminated Timber (CLT) is gaining momentum as a competitor to steel and concrete in the construction industry. Being still relatively new to North America, CLT is still being held back from its full potential by a lack of research. A lack of research in various areas, such as vibration serviceability, can result in vague design guidelines, leading to either overly conservative designs, hurting profit margins, or overly lenient designs, leading to occupancy discomfort. Eliminating these design inefficiencies is paramount to expanding the use of CLT, and creating a more sustainable construction industry.



Walking excitation test-experiment at the Andy Quattlebaum Outdoor Education Center

This thesis focuses on the effect of a heavy topping, in this case 2" of concrete, on a CLT floor. To this end, modal analysis was performed on

two spans of three CLT panels in the Andy Quattlebaum Outdoor Education Center at Clemson University. By performing a series of instrumented heel-drop tests with a roving grid of accelerometers, the natural frequencies, mode shapes, frequency response functions, and damping coefficients were able to be determined. By comparing the results to several different numerical models, the most appropriate model was able to be selected for use in future design. In addition, a walking excitation test was performed to calculate the root mean square acceleration of the floor for comparison to current design standards.

This study found that, with a layer of rigid insulation separating the topping and the panel, the system behaved predictably like a non-composite system. The resultant mode shapes also verified that the boundary conditions behaved very close to "hinged", and showed that the combination of the surface splines and the continuous topping provide significant transverse continuity in terms of response to vibrations. Lastly, the results of the walking excitation test showed that, with some further study, the current design standards for steel vibration serviceability can be applied to great effect to CLT systems.

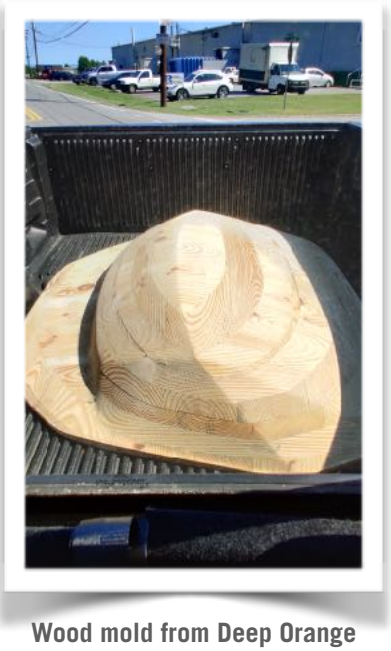
Benjamin Schwendy completed his MS study in August 2020. He is currently working as an engineer with 1200 Architectural Engineers in Alexandria, Virginia.

OUTREACH ACTIVITIES (WOOD PROMOTION)

The year 2020 started out at a fast pace with plans for the International Mass Timber conference; hosting meetings for the Southern Group of State foresters Environmental Services, Utilization & Marketing (SUM) Committee and the Southeastern Region of the Forest Resources Association; planning four workshops on Building Sustainably with Mass Timber in association with Keeping Forests; a TX/LA Society of American Foresters keynote address; and a number of other events throughout the year.

Before March, we participated in a number of events including three county forest landowner meetings in SC, the SUM meeting and one of the four events for Keeping Forests (New Orleans in March just before everything closed down). Additionally, we were able to secure CLT panels for Deep Orange, the ICAR prototype car, to use in molding/ fabricating the car body.

COVID-19 did not stop many other things that we were involved with as many proceeded to move to online, including a regional four-hour webinar event to replace the Building Sustainably with Mass Timber events. Please see the list of presentations and tour list for many of the events that were either done in person or were moved to webinar or zoom meeting formats.



Wood mold from Deep Orange

One huge win we are experiencing is use of the Andy Quattlebaum Outdoor Education Center (AQOEC), the Samuel J. Cadden Chapel, and other mass timber buildings to continue to bring attention via tours, social media posts, presentations and publications to Mass Timber in the Southeast. We continue to education and encourage more mass timber in Clemson's buildings (Lehotsky Hall, the new CUF building for development and alumni) and other private and public buildings. The AQOEC has already received one regional award and has been submitted for several others. It was also featured in a the centerfold of Campus REC Magazine in a nine-page spread showcasing everything Clemson University's first (but not last) mass timber building has to offer.

All of the faculty fellows in the Wood Utilization + Design Institute continue to find themselves called upon to represent our work on mass timber and their novel, patented Sim[PLY] system.

2020 Mass Timber Tours

Clemson University Campus

- **Nov. 11, 2020:** Rob Green, Simpson Strong-tie
- **Oct. 6, 2020:** Britt, Peters & Associates and their clients
- **Sept. 24, 2020:** Britt, Peters & Associates and their clients

- **Feb. 12, 2020:** Southern Group of State Foresters, Environmental Services, Utilization & Marketing (SUM) Committee

Digital Online Report

157 new, organic followers
500+ reactions
1,000+ link clicks
22,000+ organic impressions

17.83% followers increase
9.15% likes increase
200+ organic reach

65+ retweets
100+ link clicks
300+ likes
41,000+ impressions

100+ post likes
4.18% followers increase
150+ accounts reached

GRANTS & CONTRACTS

GRANTS AWARDED

FY'21

P. Layton, D. Albright, W. Pang, D. Harding, K. Schwennsen. Advancing Mass Timber Research and Education. US Endowment for Forests and Communities ($370,000) and USFS Forest Products Lab ($25,000). Starting Spring 2021; Concluding by August 2022. See page 18 for details.

Patricia A. Layton. Development and Promotion of Mass Timber Noise Barriers for Highway (U.S. Forest Service Wood Innovations Grant) - continued.

FY'20

Patricia A. Layton. Development and Promotion of Mass Timber Noise Barriers for Highway (U.S. Forest Service Wood Innovations Grant).

Weichiang Pang. Enable the Use of Mass Timber Products for Non-Residential Buildings in High Velocity Hurricane Zone (U.S. Forest Service Wood Innovations Grant).

Patricia A. Layton. Integrated Housing Design and Logistics for Disaster Relief (USDA, Forest Service Forest Products Laboratory).

PROPOSALS SUBMITTED

Weichiang Pang. Sustainable Development of Urban and Rural Systems by Balancing Urbanization & Demand for Mass Timber Buildings with the Flow of Forest-based Ecosystem Services in U.S. South (National Science Foundations Grant; Sub-contract with University of GA).

Patricia A. Layton. Advancing Mass Timber Design and Education. Communications Plan Development and Implementation with Keeping Forests. (Region 8 USDA Forest Service Grant).

MEMBERSHIP

FOUNDING MEMBERS

COLLUM'S LUMBER PRODUCTS, L.L.C.

HUBER ENGINEERED WOODS

Weyerhaeuser

Forestry Association OF SOUTH CAROLINA

McLEOD RHODES
WELL ROOTED FORESTRY
W. MCLEOD RHODES CO., INC

lendlease

SIMPSON Strong-Tie

KATERRA

MiTek

CORPORATE MEMBERS

BRITT, PETERS AND ASSOCIATES INC.
consulting engineers

storaenso

SWINERTON MASS TIMBER

ASSOCIATE MEMBERS

SOUTHERN LUMBER AND MILLWORK CORP
2031 KING STREET CHARLESTON, SC
843.744.6281

Franklin International

SHERMAN CONSTRUCTION

INDIVIDUAL MEMBERS

Scott May, LS3P **- Jared Coffin,** Hanbury **- Allen Wood,** Retired **- Bo Shaw,** Retired

PUBLICATIONS & PRESENTATIONS

FY'21

Stoner, M., and Pang, W. (2020), "Simulated Performance of Cross-Laminated Timber Residential Structures Subject to Tornadoes," Frontiers in Built Environment Wind Engineering and Science, https://doi.org/10.3389/fbuil.2020.00088

Stoner, Michael W. (2020), "Performance of Cross-Laminated Timber as a Residential Building Material Subject to Tornado Events" (2020). All Dissertations. 2639. https://tigerprints.clemson.edu/all_dissertations/2639

Schwendy, B. (2020) "Effects of Heavy Topping on Vibrational Performance of Cross-Laminated Timber Floor Systems" (2020). All Theses. 3416. https://tigerprints.clemson.edu/all_theses/3416

Layton, P. 2020. Mass Timber and Sustainability. Presented to Building Sustainably with Mass Timber Virtual Workshop. December 10, 2020.

Layton, P. 2020. Mass Timber: Why the Sudden Increase in Demand? Panel Moderator. Industrialized Wood Based Construction Conference. December 2, 2020.

Layton, P. 2020. Professional Ethics Training in University Forestry and Natural Resource Programs: Status and Needs. Panel Moderator, Society of American Foresters National Convention, Oct. 31, 2020

Campa, B. and Layton, P. 2020. Mass Timber Design: Advantages, Challenges, Analysis, and University Engagement. 2020 Virtual Fall Owners Leadership Conference. Construction Owners Association of America. November 12, 2020.

Layton, P. 2020. Mass Timber: Innovating in Sustainable Buildings. Presented online to Edisto Chapter, Society of American Foresters, October 8, 2020.

Layton, P. 2020. Wood is the Answer: Sustainable Building Materials. Wood and Everything After, Architecture Class at University of Miami Studio. September 28, 2020. Online Lecture.

Layton, P. 2020. Questions and Answers – Wood Carbon Seminar Series. Webinar sponsored by the Carbon Leadership Forum, June 11, 2020. http://carbonleadershipforum.org/news-and-events/wood-carbon-seminars-course-page/ PW: woodcarbon4ever!

Layton, P. 2020. Economics of Wood – Wood Carbon Seminar Series. Webinar sponsored by the Carbon Leadership Forum, June 11, 2020.

http://carbonleadershipforum.org/news-and-events/wood-carbon-seminars-course-page/ PW: woodcarbon4ever!

Layton, P. 2020. Building Sustainably with Mass Timber. Webinar sponsored by the American Wood Council. May 21, 2020. https://awc.org/education/main/lists/gb-green-building/gb720-building-sustainably-with-mass-timber

Layton, P. 2020. Andy Quattlebaum Outdoor Education Center. Presented at the Building Sustainably with Wood/Mass Timber Workshop. Sponsored by the Southern Group of State Foresters. Homes2Hotel, New Orleans, LA March 11, 2020

Layton, P. 2020. Mass Timber What everyone should know about it. Presentation to the Greenwood County Forest Landowners Association. March 2, 2020.

Layton, P. 2020. Mass Timber What everyone should know about it. Presentation to the Laurens County Forest Landowners Association. February 25, 2020.

Layton, P. 2020. Andy Quattlebaum Outdoor Education Center. Presented to the Annual Meeting of the Carolinas Chapter of Urban Land Institute. Charlotte, NC. February 13, 2020 https://urbanland.uli.org/development-business/crane-watch-six-cutting-edge-developments-across-the-carolinas/

Layton, P. 2020. Mass Timber. A presentation to the SUM committee of the Southern Group of State Foresters. Madren Center, Clemson SC. February 17, 2020.

Layton, P. 2020. Mass Timber -- The Role of Foresters in This New Competitive Industry, Invited Presentation at the Appalachian Society of American Foresters Annual Meeting, January 31, 2020. Norfolk, VA.

Layton, P. 2020. Mass Timber What everyone should know about it. Keynote address to the Alabama Forestry Council. Millbrook, AL. January 28, 2020.

FY'20

Layton, P., Villegas, A. (moderator), Heagy, J., de St. Aubin, B., Mitchell, J. 2019. Panel discussion on mass timber as an emerging sustainable building product Georgia Forestry Foundation Event at Greenbuild. Atlanta, GA. November 21, 2019.

Layton P. 2019. Mass Timber: Why, What, Who, Where and When. Presented to the Abbeville County Landowners Association, Abbeville, SC. November 18, 2019

Layton, P. and Fiocchi, C. 2019. The Clemson Outdoor Recreation and Educational Building. Presented to the Clemson Presidential Leadership Institute, November 14, 2019.

Layton, P. 2019. Mass Timber: Why, What, Who, Where and When. Presented to Texas Forest Service and Guests at Texas A&M University. College Station, TX. November 8, 2019

Layton, P. 2019 Popcorn and Policy - New Innovations. A Panel discussion at the SAF National Convention. Louisville, KY November 1, 2019

Layton, P. and Cantrell, R. 2019. No Markets, No Money, No Management, No Conservation! Presented at the SAF National Convention. Louisville, KY. November 1, 2019.

Layton, P. 2019. Mass Timber: The Role of Foresters. Invited Presentation to the Alabama Society of American Foresters annual meeting. Birmingham, AL. September 20, 2019.

Layton, P. 2019. Mass Timber Building Codes in 2021. Presented at workshops in Dallas and Austin, TX. September 10-11, 2019.

Stoner, M., Raymond, A., and Pang, W. 2019. "Utilization of Cross-laminated Timber in Residential Construction to Resist Tornado Hazards," The 15th International Conference on Wind Engineering (ICWE15), Beijing, China. September 1-6, 2019.

Layton, P. 2019. Update on the Wood Utilization & Design Institute. Presented at the Timberland Legacy Committee meeting, Columbia, SC. August 9, 2019.

Layton, P. 2019. Panel presentation on protecting heirs' property and promoting the sustainable use of land to provide increased economic benefit to historically under-served landowners. Center for heirs Property. 4th Annual SC Rural and Limited Resources Landowner Symposium. Charleston, SC. August 2, 2019.

FUTURE PLANS

Our vision for the future still centers around our three core areas of teaching, research and outreach.

EDUCATION: With the beginning of the US Endowment funded grant this January, we will be expanding our teaching efforts in Architecture at Clemson and with our partners at the Universities of Arkansas and Oregon.

RESEARCH: Our research continues to grow even as we wrap up a lot of what was done previously. We are part of an NSF proposal lead by UGA to do more mass timber research, however this chance of our group receiving this $15 million grant may be extremely low. However, the effort in developing the grant has raised some interesting ideas to develop even if we do not get the grant.

OUTREACH:

Our noise barrier project shows progress but lags because of COVID-19. We hope to see great progress on this project as we move forward. There are many processes moving forward to push mass timber. Some of these are lobbying and legislative that we have helped with or supported. A large number of efforts are part of the collaboration of us and many of our partners continuing to push for mass timber and use of light frame construction in the non-residential or multifamily housing arena. Watch for more efforts in the green building and carbon sequestration arena over the coming year.

Upcoming Collaboration: Advancing Mass Timber Research and Education

Thanks to the support of a **US Endowment for Forests and Communities** ($370,000) and a **USFS Forest Products Lab Grant** ($25,000), Clemson University will be creating and leading a consortium of university architecture and engineering faculty and students to advance mass timber design and education, through a series of collaborative design studios and research seminars. Starting in Spring semester 2021 and concluding by August 2022, a series of architecture design studios will be conducted (three sequential studios at Clemson, and one or more at the two collaborating universities), supported by engineering students and faculty collaborators, and engineering courses. The design studios will focus on a few U.S Department of Defense "archetypical buildings."

CLEMSON PARTICIPANTS

- Dustin Albright, AIA, LEED AP, Associate Professor of Architecture
- Dan Harding, Associate Professor of Architecture and Director Community Research + Design Center
- Weichiang Pang, PhD, Professor of Civil Engineering
- Kate Schwennsen, FAIA, Professor of Architecture
- Pat Layton, PhD, (PI) Professor of Forestry and Director, Wood Utilization + Design Institute
- Other architecture and engineering faculty, tbd

OTHER UNIVERSITY COLLABORATORS: (Subawards are being finalized)

- University of Oregon: Judith Sheine and Mark Gillem (plus Mikhail Gershfeld at Cal Poly Pomona)
- University of Arkansas: Peter McKeith and faculty tbd

OTHER COLLABORATORS:

- Conversations have begun with interested and knowledgeable DOD collaborators.
- Manufacturers of mass timber will be asked to provide information and services to students
- WoodWorks and the American Wood Council will be engage to support the students as needed.
- Design and construction firms who work with the DOD, and/or with advancing CLT design, will be engaged as consultants, contributors, critics.
- Tri-County Technical College will be a key local partner.
- Clemson's Built Environment Lab (BEL) will provide critical facilities.

EXPECTED OUTCOMES

- Development of innovative mass timber design systems with an emphasis on efficient assembly and disassembly;
- Comprehensive integration of environmental performative building systems into mass timber design and construction;
- Development of optimized, prototypical schematic building designs using these systems;
- Educating the future generation of timber designers, who will understand the nature and opportunities of wood design and construction, especially timber.
- Administration of MOU to form Architectural/Engineering Consortium for Timber Education and Design (ACTED), with three founding university signatories.