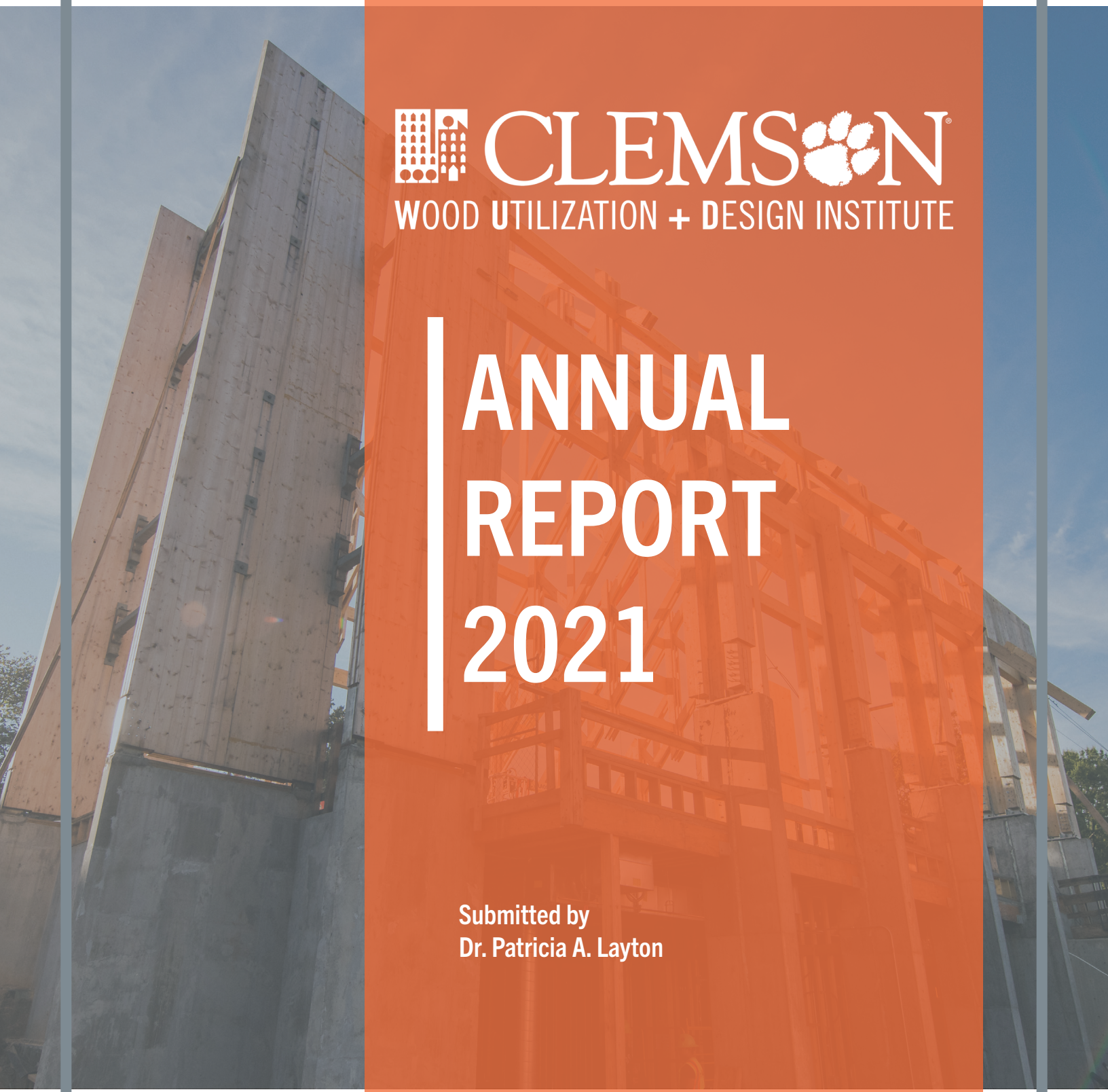

CLEMSON

WOOD UTILIZATION + DESIGN INSTITUTE

ANNUAL REPORT 2021

Submitted by
Dr. Patricia A. Layton

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INTRODUCTION

The following report outlines 2021 activities from the Wood Utilization + Design Institute, School of Architecture and Glenn Department of Civil Engineering (as well as other engineering activities across campus). Get to know several independent and collaborative studies, new and old (ongoing from previous years) research updates, faculty successes including grants, awards and published work, and much more.

We thank our faithful patrons for your continued support - and to our new members, welcome! We are looking forward to collaborating with you all.

New photos of Clemson's Samuel J. Cadden Chapel show landscaping in progress

ARCHITECTURE ACTIVITIES

Throughout 2021 the work of our WU+D faculty fellows and students from the Architecture department has continued to span between mass timber studies and innovative light framing using prefabricated, CNC-routed plywood components – a system we call Sim[PLY].

In the work with Sim[PLY], we continued our collaboration with the Vancouver and Victoria, BC offices of RJC Engineering, examining the advantages of the Sim[PLY] system for meeting the ambitious and evolving BC Energy Step Code. This research was included in the proceedings of the 2021 World Conference on Timber Engineering, which was held in August. It was also presented via pre-recorded video to the conference's virtual attendees.

We have 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. We have been planning and designing deployable health care modules as well as post-disaster housing, with an emphasis on flexibility and adaptability across uses. Our aim is to explore solutions that can transition from short-term to long-term recovery scenarios. Working with our WU+D colleagues from Civil Engineering our team has developed detailed designs for core housing and medical units which are expandable for growth. One solution utilizes the Sim[PLY] framing system, taking advantage of its speed and ease of on-site construction with unskilled laborers, while other solutions examine modular units framed with cross-laminated timber panels. We plan to wrap up this particular project in the coming months and share the work at the 2022 Mass Timber Conference in Portland.

We are excited to report that the work on disaster recovery housing will continue through a new, three-year grant from the National Science Foundation. The project, titled "An Integrated Housing Design and Logistics Operations Modeling and Analysis Framework for Hurricane Relief", is led by professors Yongjia Song (Industrial Engineering), Weichiang Pang (Civil Engineering), and Dustin Albright (Architecture). The main objective of the research will be to investigate the effectiveness of novel housing design solutions in disaster relief and recovery by creating an integrated modeling and analysis framework for disaster housing logistics planning and operations. We look forward to sharing future reports on this project.

Continuing now with Mass Timber, 2021 marked the beginning of our project titled "Advancing Mass Timber

Design and Education." For this work, which is supported by the U.S. Endowment for Forests and Communities, Clemson and its WU+D Institute is leading a consortium of university Architecture and Engineering faculty and students to study the application of mass timber systems to Department of Defense building typologies. Tectonics, production processes, and intrinsic attributes of mass timber, including unparalleled carbon offset and storage, offer opportunities for forward-thinking, integrated solutions, and we feel that the constraints typical to DOD projects, in particular, will be favorable to mass timber and can help drive innovation.

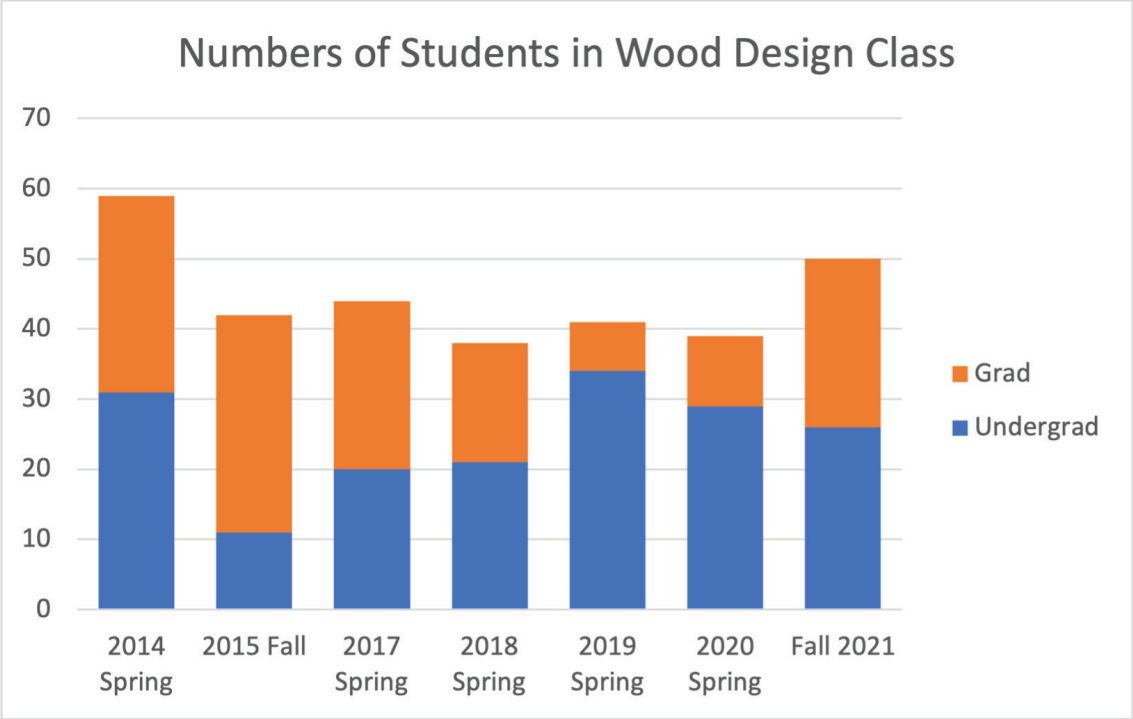
The Spring 2021 Graduate Comprehensive Studio was the first course in what will be a sequence of three studio courses examining this subject. It was taught by WU+D faculty fellows Dan Harding and Dustin Albright, and their colleague from Architecture, Ufuk Ersoy. The project was titled "Oriented Otherwise: Exploring Timber Prototypes for a Regenerative Future", and focused on the planning and design of various new buildings for Tyndall Air Force Base as part of its reconstruction following the devastation of Hurricane Michael in 2018. Working from Tyndall's master plan, students studied a wide range of facilities across the whole base, from dormitories and guest lodging, to aircraft hangars, training headquarters, testing/maintenance facilities, community centers, and others. Structural design was aided by consultation from Weichiang Pang and Michael Stoner of the Civil Engineering department, and their students. In April, the work was reviewed by guests from the Universities of Arkansas and Oregon, our partners in the consortium mentioned above. Two of the exceptional projects from the studio have recently been recognized with honor awards in the student design category by AIA South Carolina. One of these projects was also awarded by AIA Greenville and nationally by the Society of American Registered Architects.

This Fall, the second studio in the sequence is being taught by Dustin Albright. The project is once again sited at Tyndall AFB, this time focusing on a single building type, a headquarters office building for the 325th Fighter Wing. This is the final studio course for the eleven senior-level undergraduates, and the technical aspects of the mass timber utilization will provide a great bridge into graduate studies and/or the profession, whichever may come next. The work has again been informed by input from our colleagues in Civil Engineering, and also assisted through close case studies of exemplary mass timber office structures from locations across the U.S. We plan to involve the design professionals behind these case-study structures in the review of the student projects at the end of the semester.

Looking ahead, Dustin Albright, Dan Harding, Kate Schwennsen and Ulrike Heine, all WU+D fellows from Architecture, will be teaming up to teach the final mass timber studio in the sequence beginning in January. This time, the project is scheduled to be sited on the new Coast Guard Base planned for North Charleston, South Carolina.

ENGINEERING ACTIVITIES

Wood Design Class – Civil Engineering



The numbers of students educated in structural wood design since 2014 are shown in the bar chart. In this academic year (2021), 50 students took the Civil Engineering Wood Design class (26 undergraduate students and 24 graduate students). This course teaches 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). Over 300 students took the wood design course since 2014 and, on average, about 40 students enrolled in the wood design course each academic year.

Over the past several years and including this year, Charles Ingram Lumber sponsored the wood design class at Clemson with free NDS codes for our students. The kind support from Charles Ingram Lumber makes the Wood Design class among one of the most popular courses in Civil Engineering Department (Figure 1).

In Fall 2021, several civil engineering students in the wood design class and graduate students served as structural consultants to the architecture design studio class. The civil engineering students, served as consultants, provided technical advises and recommendations in terms of structural solutions to architecture students on their architectural designs (Figure 2).

Figure 1: NDS codes sponsored by Charles Ingram Lumber and distributed to students in the Civil Engineering Wood Design class.

Figure 2: Civil engineering students serving as structural consultants to architecture students.

Ongoing Research: Experimental and Analytical Investigations of the Lateral Behavior of Cantilever Cross-laminated Timber Diaphragms

By Bibek Bhardwaj

Cross Laminated Timber (CLT) has been gaining recognition from the construction industry as a versatile construction material with wide range of applications and an environmentally friendly alternative to steel and concrete. Although CLT has been formally introduced as a building material in the current US design codes, the actual behavior of CLT diaphragms as part of the lateral force-resisting system (LFRS) is not well understood. The lack of full-scale experimental test data and technical guidelines for CLT diaphragms may hinder the use of CLT in certain projects.

The main objectives of this research are: (1) to perform full-scale testing of two cantilever CLT diaphragms and use the test results to inform the development of CLT diaphragm design provisions in the US building codes; and (2) to create numerical models for predicting the behaviors of CLT diaphragms of varying configurations. The two full-scale tests were performed with the first test completed in October 2019 (see Figure 1), and the second diaphragm specimen tested in March 2021. The test results showed that the ultimate capacity of the diaphragm exceeded the LRFD design capacity by a factor of close to two (See Figure 2), which met the target ultimate-to-design strength ratio aimed in the latest NDS code. It was observed that the ductility of the diaphragm was greatly influenced by the ductility of the fasteners (i.e. CLT-to-CLT and CLT-to-glulam connections).

Figure 1: 20ft by 20ft cantilever CLT diaphragms; (top) Diaphragm Test Setup 1 with eight single-span 5ft x 10ft CLT panels and metal tension straps; (bottom) Diaphragm Test Setup 2 with four two-span continuous 5ft x 20ft CLT panels.

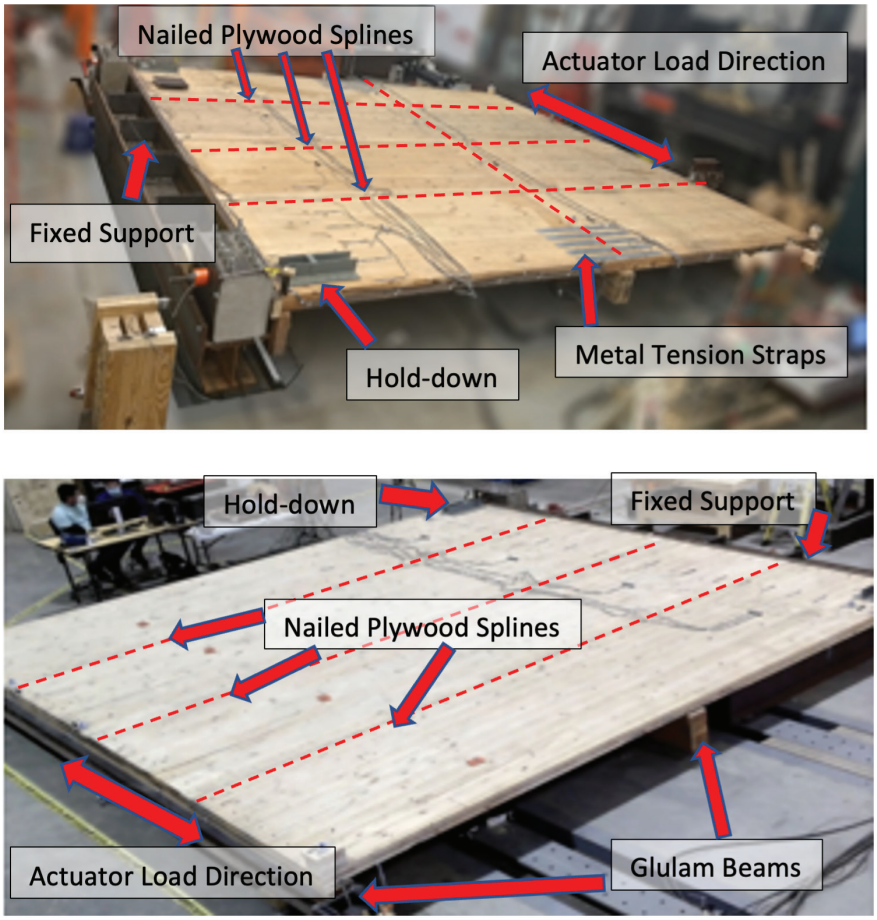


Figure 2: Hysteretic responses of (left) Diaphragm Test Setup 1, and (right) Diaphragm Test Setup 2.

An additional full-scale diaphragm test was also conducted to study the reparability of CLT diaphragms after major events such as earthquakes. Post-test damage survey of the second diaphragm specimen revealed that damages were primarily occurred at the CLT-to-CLT surface spline nailed connections and some at the CLT-to-glulam screwed connections. The second diaphragm specimen was repaired by replacing some of the damaged

CLT-to-glulam connections with new screws installed at locations away from the bearing damaged wood. In the repaired diaphragm, metal surface splines manufactured by Simpson Strong-tie were installed on the bottom face of the CLT-to-CLT joints. The test result for the repaired diaphragm revealed that it is viable to repair damaged CLT diaphragm from underneath and achieve the intended design strength (Figure 3).

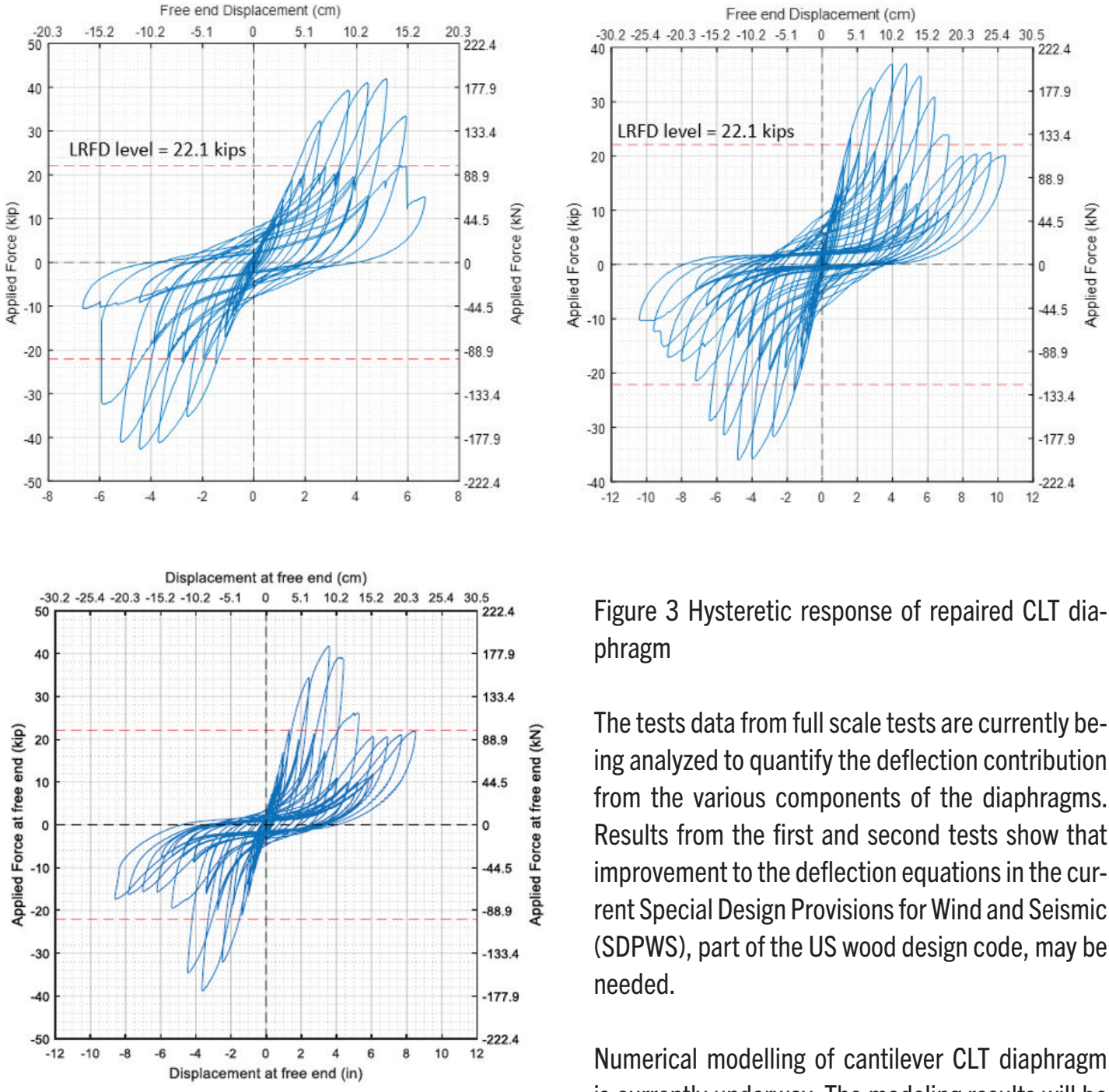


Figure 3 Hysteretic response of repaired CLT diaphragm

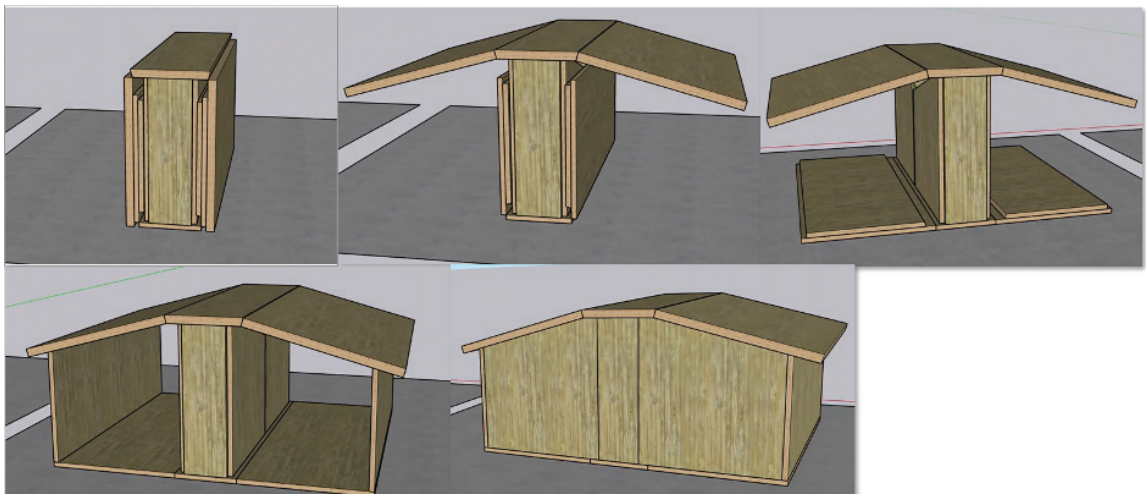
The tests data from full scale tests are currently being analyzed to quantify the deflection contribution from the various components of the diaphragms. Results from the first and second tests show that improvement to the deflection equations in the current Special Design Provisions for Wind and Seismic (SDPWS), part of the US wood design code, may be needed.

Numerical modelling of cantilever CLT diaphragm is currently underway. The modeling results will be compared to that obtained from full-scale tests. Once the computer model has been validated, diaphragms of different configurations (e.g. different aspect ratio and connection types) will be developed and analyzed using the computer model. The results of small-scale connection tests conducted at Clemson and Texas A&M University will be utilized in the computer model.

Ongoing Research: Deployable Rigid Wall Wood Structure for Disaster Relief and Rapid Response Applications

By Jayson Leonard

The goal of this research is to design a prefabricated foldable structure (Figure 1). Some benefits of a foldable structure include more easier transportation, more efficient storage, and quicker assembly. These structures can be used as housing or medical units in post disaster scenarios. They can also be used in the military sector as expeditionary structures. Originally, the research explores the use of CLT as the main building material. Due to cost and weight considerations, the research team also explore the use of light-frame wood for the deployable structure. Compared to the deployable CLT structure, it is anticipated that the light-frame structure to be easier to transport, quicker to deploy and be more cost effective. The main hurdle of this design is the folding mechanism. After exploring many possibilities, the research team has arrived with a solution which utilizes continuous hinges for the folding mechanism. A series of structural tests of hinges are currently being carried out to evaluate



the applicability of hinges as structural elements.

Figure 1: Foldable wood structure for disaster relief and other rapid deployment applications.

Ongoing Research: Enable the Use of Mass Timber Products for Non-Residential Buildings in High Velocity Hurricane Zone

By Sovanroth Ou

Florida is one of the areas prone to hurricane hazards. The International Building Code is a model building code

for the US. It governs the wind design requirement for all regions designated as wind borne debris regions. In Florida, stricter requirements applied to regions with high hurricane wind speed, referred as High Velocity Hurricane Zone (HVHZ). On the other hand, the ICC-500 is a standard for storm shelter. Recently experiments conducted at the Forest Products Laboratory (FPL) and Clemson showed that a 5-ply CLT is able to meet the ICC-500 requirements. While there are some similarities between the ICC-500 and the HVHZ standards, the Florida HVHZ requirements are different from the ICC-500 storm shelter requirements. In order to use CLT in educational and commercial buildings in Florida, the building products for the entire building envelope in HVHZ must be evaluated and meet Section 1626.1 of the Florida Building Code. All building products that meet this standard are listed in an online database maintained by the Florida Building Code (FBC). The main goal of this project is to enable the use of cross-laminated timber (CLT) in high velocity hurricane zone (HVHZ) by conducting the necessary test to qualify CLT for HVHZ applications.

The project has two main experimental tests, Cyclic Wind Pressure Loading and Debris Impact. These tests will be conducted in conformity to the FBC Test Protocols for HVHZ. The CLT panels will be impacted with 2x4 lumber to simulate the impact from wind-borne debris amd followed by cyclic wind pressure/suction tests. Figure 1 shows the pressure chamber for the Cyclic Wind Pressure Loading test. Figure 2 shows the set up for the Debris Impact test. The research team has completed the design and fabrication of a new vacuum test chamber and pressure control system. Preliminary tests were conducted to calibrate the pressure control system.

Figure 1. Pressure chamber for cyclic pressure/suction loading test
Figure 2. Debris impact test equipment and setup.

Masters Thesis: Development and Promotion of Mass Timber Noise Barrier

By Harsh Bothra

The team has completed the design and analysis of Mass Timber Noise Barrier. Using the noise barrier design requirements outlined in the AASHTO code and referring to FHWA guidelines, the team has proposed a design that utilizes a 3-ply southern yellow pine CLT panel and W 10x33 steel posts for a theoretical site n Georgia. The team also assessed the design of noise barrier against high winds and seismic regions. The analysis results proved that 3-ply CLT panels were structurally strong enough to withstand winds of up to 180 MPH, but for the steel post, we can expect to use a larger section than W10x33 in the region of wind speed of 180 MPH. Besides the wind speeds, there were analyses and considerations that had to be studied to make a full report about the usage of mass timber in designing noise barriers. The rest of these considerations included seismic analysis, cost, and environmental impacts. Seismic analysis was carried out on the steel post, and it was proved that W10x33 steel post should be sufficient for the very high seismic region with an Ss value of 2.25g.

The team also performed a cost study analysis for a project in Florida for a representative CLT noise barrier compared to a concrete noise barrier using the data from member of the Advisory Board. It was determined for the ½ mile case study length, a cost reduction of around 5.2% was achieved. Few assumptions were made while performing the cost analysis, detailed study can be performed on the cost of foundation and installation which may result in cheaper CLT noise barrier. While conducting the carbon impact analysis, Team found out that replacing a 20’ x 16’ concrete barrier with a CLT barrier would save around 6130 lbs. of carbon emission.
To mimic the construction sequence and connection details, team installed a prototype CLT noise barrier in BEL lab located in Pendleton, SC. Installation of prototype noise was quite smooth., the only equipment used for installation was forklift for couple of hours. Following the installation of steel posts with a forklift, angles were bolted into place and then CLT panel was lowered from the top and positioned in place.

One more aspect of using mass timber for noise barriers that had to be addressed by team is durability as it relates to long-term moisture exposure. Team coated the prototype noise barrier with two different coatings from the Sansin corporation. To measure the moisture and temperature data on the prototype noise barrier, eighteen moisture sensors and two temperature sensors were installed on the panel. The data is being monitored since mid-August 2021 and will be continually monitored. For the period of data observed, the MC in the CLT goes up to 28% in the event of rain and drops down to 10% in about 24 hours in normal weather. The team plans to install another CLT noise barrier at the same location with uncoated CLT panels to provide benchmark data of moisture content in CLT panels. They will also investigate additional treatment options for CLT panels. A pilot study and construction will be conducted including, in-situ sound insulation characterization and long-term moisture monitoring.

Harsh Bothra completed his MS study in November 2021. He is currently working as a structural engineer with PermaTrak in Charlotte, North Carolina.

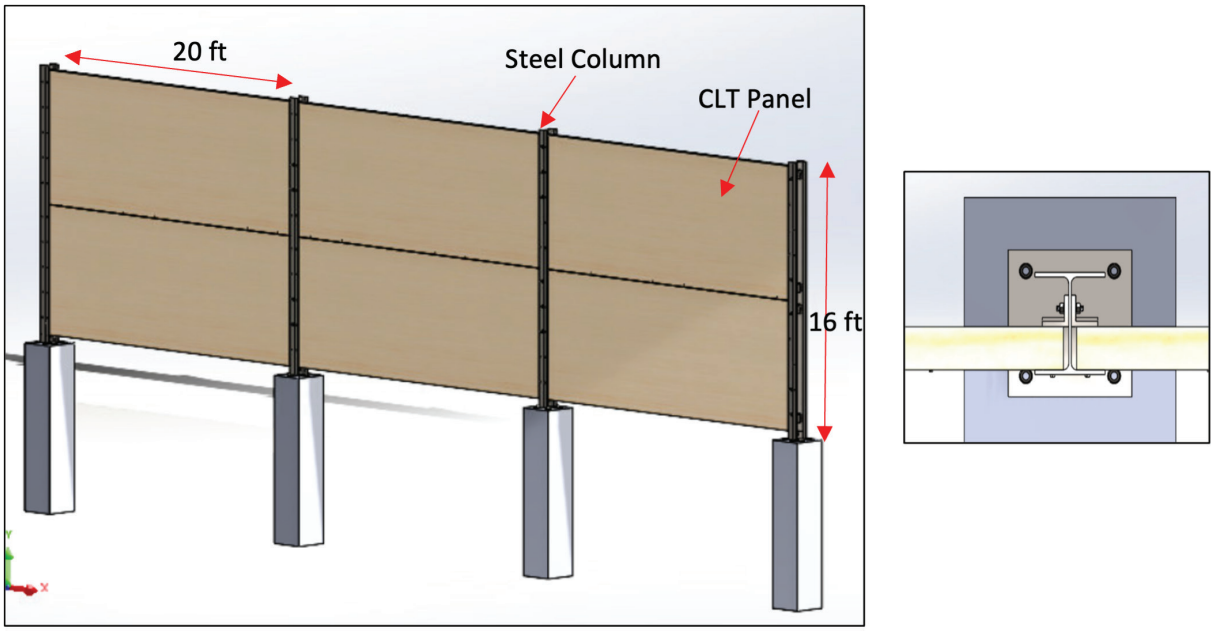
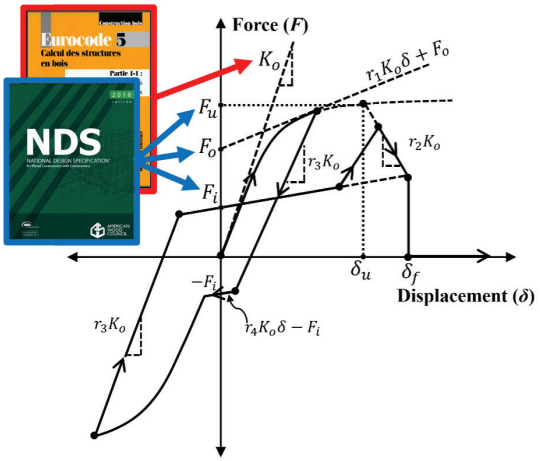


Figure 1: (left) 3D rendering of the proposed CLT noise barrier design, (right) details of steel column supports for CLT panels.

Figure 2: A mock-up construction of the proposed CLT noise barrier instrumented with moisture sensors and rain gauge for long-term moisture monitoring.

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

By Lancelot Reres

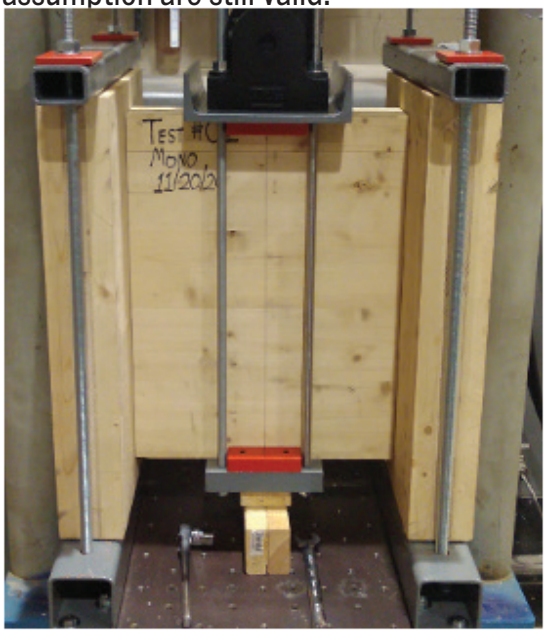


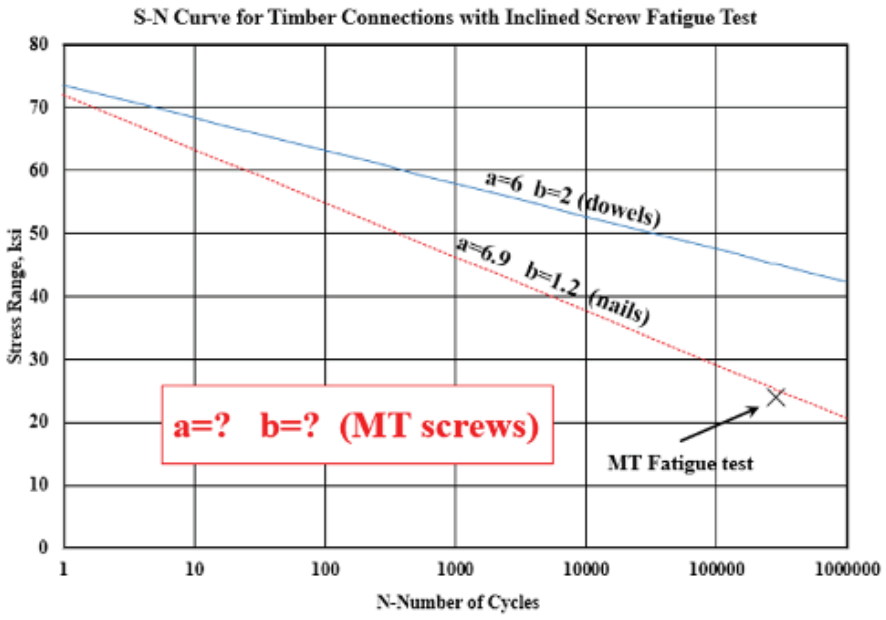
The changes to the 2021 International Building Code allow for cross-laminated timber buildings up to 270 feet. Based on in-situ modal data of CLT buildings, and trends seen in steel and concrete construction, the dynamic response of CLT buildings above ~180 feet should be considered in the lateral design. 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.





COLLABORATIONS

Clemson's School of Architecture and Glenn Department of Civil Engineering have spent a significant amount of time renovating the University's new **Built Environment Lab** in Pendleton, SC. The space now features a strong floor and crane, a variety of construction testing and design equipment, a beautiful bay door on one end and much more. Renovations continue as research dictates certain priorities for the space. Tours and partnerships are available for Clemson University's BEL.

For additional collaborations, please read the Architecture and Engineering sections.

OUTREACH

Presentations

With the advent of vaccines and lifting of travel restrictions, 2021 was marked with a rising number of in person opportunities to travel and present our work. That did not mean however that the number of opportunities for online meetings and presentations slowed during the year. This year, Pat Layton gave 11 presentations, with five of them in person (see publications and presentations). Other faculty fellows also continued with their outreach. Pat also moderated a live session of the International Wood-Based Construction Conference (IWBC 2021) entitled, Are Hybrid Solutions the Future for Mass Timber (https://www.iwbcc.com/agenda/).

Tours

Additionally, we had about 10 tours of the Andy Quattlebaum building. Our tours ranged from new Institute members to the Weyerhaeuser CEO and EVP. The largest tour was for the Council for Agricultural Research, Extension, and Teaching (CARET), composed of Administrative Heads of universities and colleges from around the nation. They held their summer meeting at Clemson University in July. Another tour was with David Bridges, President, Abraham Baldwin College. David has begun plans for a building on their campus forest and asked me to help over the next year to bring their building to life.

Pat has worked with Clemson to push for more mass timber buildings on campus. Currently, the new development and alumni building will have at least some mass timber components or sections. In February we hope for the Clemson Board to approve a new building for forestry instead of a renovation and we are planning for a mass timber building.

Building Codes

Paul Coats, AWC, retired last May. Paul had been handling building code adoptions for many of the southeastern states. South Carolina was just beginning the process for adoption of the 2021 building code and with the absence of Paul, Pat stepped into cover the adoption process. Pat worked closely with AWC's Ken Bland and Matt Hunter. She also coordinated with the Forestry Association of SC. Pat participated in most of the conference calls that the NAHB of SC committee held to both propose changes and review other proposals for changes during the summer and early fall. In September and October, she participated in the SC Building Code Study Committee meetings and the SC Building Code Council meeting to review all the proposals and to recommend for adoption the 2021 codes (IBC and IRC) by the Legislature. The adoption in October by the SC Building Code Council targets January 1, 2023, as the start date for the 2021 code implementation. There were no challenges or changes to the "mass timber sections" of the IBC which incorporates three Type IV buildings (the types vary by building height). This was a big success for mass timber in SC.

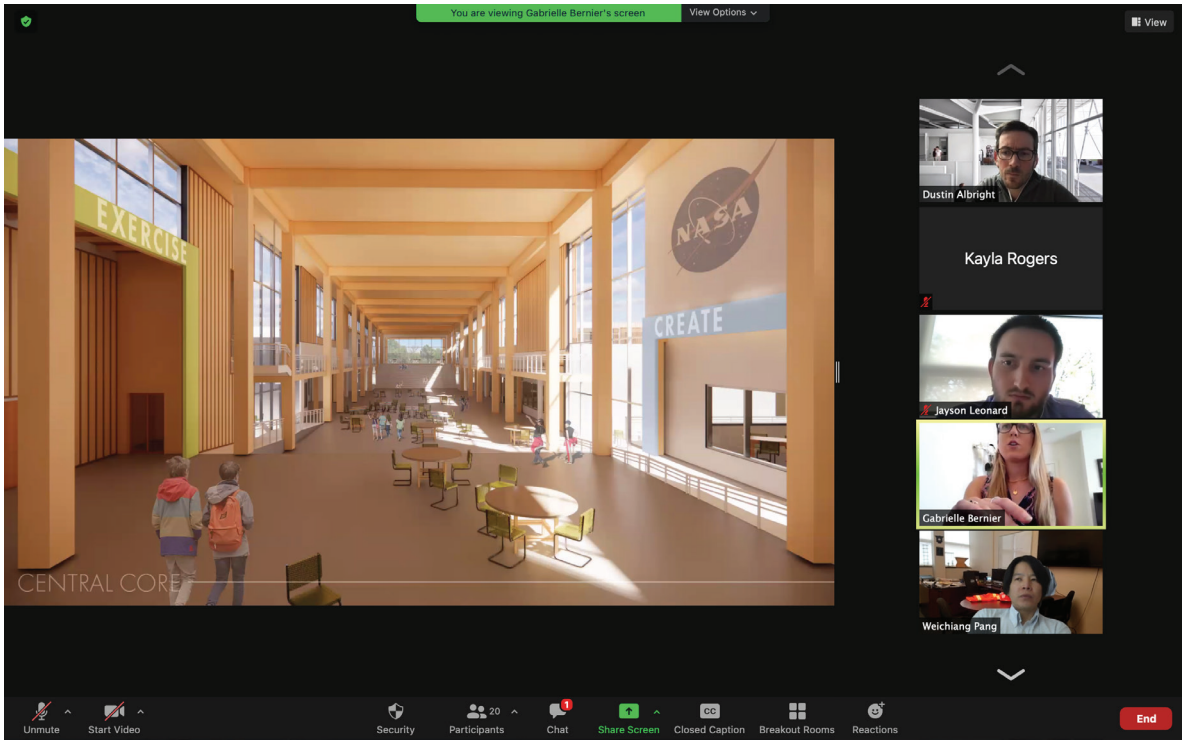
Pat worked with several governmental affairs organizations to push for more mass timber in federal buildings. Specifically, she provided information and support to an effort for language in the US Department of Defense's National Defense Authorization Act bill for each branch of the service to build a mass timber building. The NDAA bill should be passed this December and the language on Mass Timber was still in the bill at the time of this writing.

Pat participated in briefing to the staff members of the Working Forest Caucus. Other speakers for this briefing included:

Dave Tenny – President and CEO, NAFO
Rita Hite – Executive Vice President for External Affairs and Policy, AFF
Ara Erickson – Vice President Corporate Sustainability, Weyerhaeuser
Jackson Morrill – President and CEO, American Wood Council
Cynthia West, PhD – Station Director, Forest Service's Forest Products Lab/Northern Research Station

International Mass Timber Conference

This conference was online for 2021. The conference organizers did allow for participation by their exhibitors, and we were able to use our online exhibitor event portal to host interested parties to hear an update on our WU+D Institute Activities.



MEDIA

CLEMSON NEWS | www.clemson.edu/wud

"Clemson architecture students partner with top design firm to pioneer sustainable construction process,"
April 7, 2021

"How Clemson helped innovate the South Carolina wood industry and infleunce design,"
May 10, 2021

INDUSTRY PUBLICATIONS

"10 Examples of Cross-Laminated Timber Architecture,"
Green Building & Design Magazine, February 25, 2021

"Mass timber recreation center becomes University's 'finest front porch,'"
ThinkWood, May 2021

"Nine mass timber projects inspiring change in the industry,"
Green Building & Design Magazine,
July 2021

"Building Sustainably: Ask For Wood,"
Keeping Forests, How The River Flows Podcast, July 22, 2021

GRANTS + CONTRACTS

“An Integrated Housing Design and Logistics Operations Modeling and Analysis Framework for Hurricane Relief” National Science Foundation, $286,892, (2021-2024).

“Advancing Mass Timber Design and Education,” U.S. Endowment for Forests and Communities, $360,786. (2020-2021).

“Enable the Use of Mass Timber Products for Non-Residential Buildings in High Velocity Hurricane Zone,” United States Department of Agriculture, Forest Service (FS), $249,999, (2019-2022).

“Development and Promotion of Mass Timber Noise Barriers for Highways,” United States Department of Agriculture, Forest Service (FS), $248,809, (2019-2022).

“Integrated Housing Design and Logistics for Disaster Relief,” USDA, Forest Products Laboratory, $50,000, (2019-2021).

“Full-scale testing of cross-laminated timber diaphragm in-plane shear and development of a design guide for practitioners,” United States Endowment for Forestry and Communities, $305,000, (2017-2022).

“Utilization of Cross Laminated Timber (CLT) in Low and Mid-rise Buildings for Enhanced Wind Performance,” United States Department of Agriculture, Forest Service (FS), $244,956, (2016-2021).

HONORS + AWARDS

Srikanth Pilla wins the Green Chemistry Challenge Award in the Academic category from the EPA for synthesizing a fully recyclable biobased polyurethane foam from paper and pulp waste.

GREEN CHEMISTRY CHALLENGE

A U.S. EPA Program

The Spring 2021 Graduate Comprehensive Studio was the first course in what will be a sequence of three studio courses examining this subject. It was taught by WU+D faculty fellows Dan Harding and Dustin Albright, and their colleague from Architecture, Ufuk Ersoy. The project was titled "Oriented Otherwise: Exploring Timber Prototypes for a Regenerative Future", and focused on the planning and design of various new buildings for Tyndall Air Force Base as part of its reconstruction following the devastation of Hurricane Michael in 2018. Working from Tyndall's master plan, students studied a wide range of facilities across the whole base, from dormitories and guest lodging, to aircraft hangars, training headquarters, testing/maintenance facilities, community centers, and others. Structural design was aided by consultation from Weichiang Pang and Michael Stoner of the Civil Engineering department, and their students. In April, the work was reviewed by guests from the Universities of Arkansas and Oregon, our partners in the consortium mentioned above. Two of the exceptional projects from the studio have recently been recognized with honor awards in the student design category by AIA South Carolina. One of these projects was also awarded by AIA Greenville and nationally by the Society of American Registered Architects.

This year, Clemson University's Andy Quattlebaum Outdoor Education Center, a mass timber recreation center on campus, also won a WoodWorks Wood Design Award!

PUBLICATIONS + PRESENTATIONS

Bothra, Hash, "Development and Promotion of Mass Timber Effects of Heavy Topping on Vibrational Performance of Cross-Laminated Timber Floor Systems", M.S. Thesis, Clemson University (2021)

Stoner, M., and Pang, W., "Tornado Hazard Assessment of Residential Structures Built using Cross-Laminated Timber and Light-frame in the United States," Natural Hazards Review (2021)

Jalilifar, E., Koliou, M., and Pang, W., "Experimental and Numerical Characterization of Monotonic and Cyclic Performance of Cross-Laminated Timber Dowel-Type Connections," ASCE Journal of Structural Engineering, (2021).

Kircher, C., Filiatrault, A., Pang, W., Harris, J., Kingsley, G., Shing, P.B., Berman, J., Starr, L., Tong, M., Hanson, R., Moresco, J., and Heintz, J., "Solutions to the Short-Period Building Performance Paradox," 17th World Conference on Earthquake Engineering (17WCEE), Sendai, Japan, Sep 27-Oct-2, (2021).

Pang, W., Safiey, A., Majdalaweyh, S., Ziaei, E., Rokneddin, K., and Javanbarg, M., "Ground Motion Duration Effects on the Seismic Risk Assessment of Wood Light-frame Buildings," 17th World Conference on Earthquake Engineering (17WCEE), Sendai, Japan, Sep 27-Oct-2, (2021).

Bhardwaj, B., Pang, W., Rammer, D., Pryor, S., and Amani, O., "Experimental Performance Testing of Cantilever Cross-Laminated Timber Diaphragm Under In-Plane Shear," World Conference on Timber Engineering (WCTE), Aug 9-14 (2021)

Jalilifar, E., Koliou, M., and Pang, W., "Experimental and Analytical Response Characterization of Cross-Laminated Timber Connections," World Conference on Timber Engineering (WCTE), Aug 9-12 (2021)

Schwendy, B., Pang, W., and Smith, R., "Vibration Control of Cross-Laminated Timber Floor with Concrete Topping," World Conference on Timber Engineering (WCTE), Aug 9-12 (2021)

Stoner, M., and Pang, W. "A Performance Based Design Approach for Residential CLT Structures Subject to Tornadoes," World Conference on Timber Engineering (WCTE), Aug 9-12 (2021)

Layton, P. and B. Lindsey. 2021. Building Sustainably with Mass Timber. Moderated by Sam Cook. How the River Flows Podcast Episode 10. Keeping Forests. https://www.keepingforests.org/podcast July 2021.

Layton, P. and I. Ganguly. 2021 Carbon Accounting & How We Can Build More Sustainable: Sustainable Forestry and the Environmental Attributes of Wood. Presented at What's New and What's Next for Wood Design and Construction: Practical Education for Successful Projects, May 27, 2021, WoodWorks Symposium https://symposium.woodworks.org/?utm_source=Predictive&utm_medium=email&utm_campaign=ML%20Engineers%20&all_NOT_Arch_&Dev&utm_term=00v4P00002A6a0NQAR&org=2488&lvl=100&ite=593&lea=1253150&ctr=0&par=1&trk=a1M4P00000EosFLUAZ

Layton, P. 2021 Forestry Ethics Webinar. Sponsored by the Clemson University Forestry and Natural Resources Team. April 2, 2021

Layton, P. 2021. Mass Timber: How to Maximize Sustainability. Panel Moderator. TimberCon 2021 and online conference Hosted by The Architect's Newspaper. March 18, 2021 https://hopin.com/events/timbercon-2021

Layton, P. and R. Cantrell. 2021. Let's Keep Forests Replenished. Presented to the Southern Group of State Foresters virtual meeting. February 17, 2021.

Layton, P. 2021. Ask for Wood: Mass Timber Opportunities and Modular Construction. Webinar for Keeping Forests. https://forestrywebinars.net/webinars/ask-for-wood-mass-timber-and-modular-construction?sr=wp~mkt-dayOf. December 1, 2021.

Layton, P. 2021. Mass Timber Opportunities. Invited Presentation to the Forestry Association of SC. November 11, 2021. Greenville, SC.

Layton, P. 2021. Mass Timber Construction in the Market Place. Invited Presentation to the McCormick County Landowner's Association. McCormick, SC, November 8, 2021

Layton, P. 2021. WU+D Institute and Clemson's Mass Timber First-Hand Experience as a Building Owner. Invited presentation at the East Texas Mass Timber Symposium, Nacogdoches, TX, Stephen F. Austin State University and Arthur Temple College of Forestry and Agriculture. October 21, 2021.

Layton, P. 2021. Mass Timber Construction in the Market Place. Invited presentation at Re-Imaging Wood: The Sky is the Limit, Texas Forestry Association Meeting. October 21, 2021. Nacogdoches, TX.

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Sattler, A., Teuffel, P., Blok, R., Ross, B. E., McFarland, D. (2021). Im Bestand bauen und Bestand erhalten [Build in existing structures and preserve them]. Nachhaltigkeit, Ressourceneffizienz und Klimaschutz [Sustainability, resource efficiency and climate protection] (pp. 87-102). Berlin: Ernst & Sohn. https://www.ernst-und-sohn.de/

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Elsayed, M., Croker, G, Ross, B. E., Okumus, P., Kleiss, M. C. B. Elhami Khorasani, N., Finite element modeling of tessellated beams. Journal of Building Engineering. https://www.sciencedirect.com/science/article/pii/S2352710221014443

McFarland, D., Ross, B. E., Naser, M.Z., Blok, R., Teuffel, P. (in press). Quantitative Evaluation of the Relationship between Physical Parameters and Building Demolition or Adaptation Outcomes. Architecture, Structures and Construction.

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FUTURE PLANS

Looking ahead, Dustin Albright, Dan Harding, Kate Schwennsen and Ulrike Heine, all WU+D fellows from Architecture, will be teaming up to teach the final mass timber studio in the sequence beginning in January. This time, the project is scheduled to be sited on the new Coast Guard Base planned for North Charleston, South Carolina.

The team also has plans to lead an Architecture Timber Design Workshop for architecture faculty from across the county, in collaboration with the Softwood Lumber Board. Faculty will visit Clemson University for a four-day period (May 16-19, 2022) and, through presentations, tours and exercises, develop their knowledge of mass timber, equip them with creative and effective strategies for teaching courses involving mass timber, and also connect them to industry resources through providing contacts and materials specific to the locations of their universities.

Weyerhaeuser recently awarded funds for the School of Architecture and WU+D to begin work on the development of an educational 'wedge wall' in the architecture building (Lee Hall) that will be for media presentations and displays.

WU+D, its Fellows and graduate students will once again be participating in the 2022 International Mass Timber Conference in Portland, OR on April 12-14, with a booth (#223).

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