





Photos: (above) Brad Gething, NWPCA, lecturing during the Wood Pallet short course in April. (below, left to right) Mark White, ISTA TransPack Conference, Chandler Quesenberry.

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course has been ongoing for over 10 years through the center, and has been a collaborative effort with NWPCA for the last five years. This spring, the course attracted a dozen participants from 10 different companies, including GAF, Universal Forest Products, Lexmark, and even Home Depot.

The class focuses on learning about the principles of wood pallet design, how wood properties affect pallet performance, and how to avoid common mistakes. Through our collaboration with NWPCA, we are also able to teach attendees how to use the PDS software to design pallets more effectively. It is a great networking opportunity for people across various distribution packaging industries.

CPULD Director Laszlo Horvath traveled to the Marine Corp base of Camp Pendleton North in San Diego to give a short course on packaging. He was enlisted to help teach newer, better packaging techniques to the Marines. With the constant movement of troops, proper packaging and shipping of their equipment is important in making sure our Marines stay well supplied with non-damaged goods while they're out in the field.

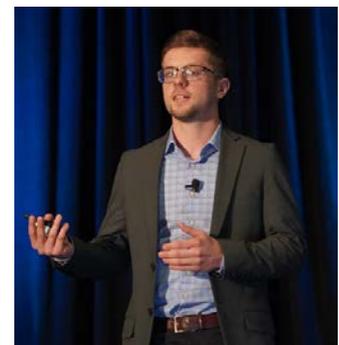
## ISTA 2019 TransPack Conference

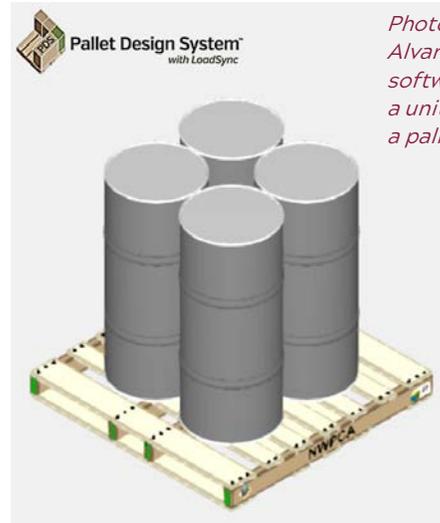
Chandler Quesenberry, one of our outstanding graduate students, completed his research faster than expected and was invited to present his findings at a 2019 International Safe Transit Association (ISTA) event – the TransPack and TempPack joint conference in Denver. He recently traveled with Professor Emeritus Mark White to attend the event, which hosted over 350 attendees from around 45 companies and universities. Many well-known companies, such as Apple, IBM, and Amazon, had a presence at the conference.

Chandler enjoyed attending the presentations and learning how his education and research is applicable to the real world of the distribution packaging industry. His favorite lectures were the case studies on technological topics, including the Internet of Things (IoT). In the packaging industry, IoT is the idea that all aspects of distribution packaging can be connected through wireless tracking sensors. The industry is advancing quickly towards the reality that all packaging and shipping can be handled and tracked by computers.

Chandler found it interesting that his presentation was the only one at the conference that focused on the pallet portion of distribution packaging. He presented his research on the effect of pallet top deckboard stiffness on the strength of corrugated boxes. The differences in box compression strength can be attributed to the level of bending of the pallet's top deckboard. A thicker deckboard, acting as a support beam, deflects less than a thin deckboard under the same load. In short, box compression strength can be increased by up to 30%-37% by increasing the stiffness of the pallet. As part of his research, Chandler conducted sustainability and cost studies to quantify this effect.

In addition to presenting these findings, Chandler represented Virginia Tech in the exhibitor reception, where he shared information about our packaging program and the capabilities of Virginia Tech.





*Photos: (left) Mary Paz Alvarez, (right) PDS software rendering of a unit load of drums on a pallet.*

## NWPCA/The Pallet Foundation Graduate Fellowship to Research the Interaction Between the Components of Palletized Drums and Pails Throughout Storage and Distribution

Mary Paz Alvarez, who has recently been awarded the NWPCA/The Pallet Foundation Graduate Fellowship, will be starting her master's studies at Virginia Tech during the 2019 summer session. Mary is coming to us from North Carolina State University, where she just completed her bachelor's degree in sustainable materials and technology.

NWPCA/The Pallet Foundation have awarded this fellowship so that a highly qualified graduate student can conduct research to investigate the interaction between pails, drums, and pallets. The research investigates the potential load bridging and unique stress distribution caused by pails and drums, and also explores how a pallet affects the strength of pails/drums; this could offer significant cost reductions to the industry.

This research will require Mary to conduct hands-on work within CPULD's testing laboratories using multiple data acquisition systems, software, and testing machinery. Processing and understanding her testing results will require Mary to show off her excellent data analysis abilities. Through this fellowship, Mary will be given the opportunity to publish, make presentations at conferences, and represent CPULD at industry trade shows.

The results of Mary's research will be implemented in NWPCA's unit load design software, PDS. Her results will dramatically improve both the safety and efficiency of unit load material handling.

## The Center for Packaging and Unit Load Design Joins the Amazon Packaging Support and Supplier Network (APASS)

Virginia Tech's Center for Packaging and Unit Load Design (CPULD), a packaging, pallet, and unit load testing and design consultancy, has recently joined the Amazon Packaging Support and Supplier Network (APASS).

The APASS program was developed by Amazon to support vendors in certifying their products under Amazon's Frustration-Free Packaging Programs and 3 Tiers of Certification: Frustration Free Packaging (FFP), Ships-in-Own-Container (SIOC), and Prep-Free Packaging (PFP). All APASS network companies have received guidance from Amazon on how to test, design, and supply packaging in line with meeting Amazon's Packaging Certifications.

CPULD is pleased to now offer packaging testing and design services to any product or packaging manufacturers interested in reducing their ecommerce costs, minimizing Amazon prep chargebacks, and improving the overall customer/consumer ecommerce experience with their products in line with Amazon's guidance. [To learn more about CPULD's APASS testing capabilities, follow this link!](#)

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designs. Each updated version of PDS includes the latest research data collected from studies sponsored by NWPCA/The Pallet Foundation. It is a great collaboration that allows NWPCA to help the students gain experience while the students are helping them to obtain essential research knowledge and test data for PDS. For more information, read [“History of the Pallet Design System” by John McLeod III, director of PDS.](#)

In addition to the in-depth graduate research studies, NWPCA/The Pallet Foundation also sponsor shorter undergraduate studies. There are many different factors to consider when designing pallets and unit loads, and the more knowledge that is collected, the better pallet and unit load designing abilities will become.

Recent undergraduate research at Virginia Tech includes topics such as determining the effect of temperature changes on the containment strength of the stretch wrap that hold unit loads together, and discovering which variables affect the Coefficient of Friction between a pallet and corrugated box. (Both of these studies are summarized later in this newsletter.)

The most recent graduate research initiatives funded by NWPCA and The Pallet Foundation have been focused on load bridging studies, starting with Page Clayton’s “Investigation Into the Distribution of Stresses on the Top Surface of Stringer Class Pallets as a Function of Package Size and Pallet Stiffness” (which was outlined in the [Fall 2018 issue of CPULD News](#)) and continuing with Steven Morrissette’s research, which focused on block class pallets and is summarized later in this newsletter.

The overall goal of this graduate research study is to help decrease the overdesigning of pallets by taking into account the newly discovered fact that pallets carrying larger boxes can hold much more weight than those pallets carrying small boxes. Pallets can also be designed to better support their cargo and thus reduce packaging costs.

In short, this means that either more product can be moved per pallet, or less material can go into the pallets carrying large boxes. Either way, these types of findings have the potential to save pallet manufacturers money and improve the sustainability of wooden pallets!

These new load bridging statistics will be included in

the next version of PDS, meaning that NWPCA/The Pallet Foundation sponsored research will soon be making a direct impact in the pallet industry around the world.

Laszlo Horvath, director of the Center for Packaging and Unit Load Design, is looking forward to the new version’s release: “It’s been great to see that all of our research will soon have a direct cost benefit impact on the pallet industry.”

NWPCA finds great fulfillment in working with the next generation of pallet industry professionals. Kristen DeLack, NWPCA lead engineer, says, “It has been a pleasure and a privilege to work with our sponsored graduates and undergraduates. Their energy and enthusiasm in discovering new things takes me back to the days when I started in engineering. I had a lot of great mentors and role models who helped me tremendously in realizing all that engineering has to offer. I hope that I have also served to inspire the next generation as they start their careers.”

NWPCA and The Pallet Foundation are continuing their support by awarding a new fellowship opportunity to Mary Paz Alvarez, who is a recent NC State graduate. She will begin research into the interactions between the components of palletized drums and pails during storage and distribution.

Once Mary’s research is complete, this knowledge will then be built into the next version of PDS. The pallet manufacturing and distribution industry will benefit once again from the collaboration between NWPCA/The Pallet Foundation and CPULD!



**THE PALLET FOUNDATION, INC.**



**National Wooden Pallet & Container Association**

*Pallets Move the World®*

## Mountain Lake Retreat Kicks Off the Distribution Packaging Internship Program

*by John Bouldin*

The Center for Packaging and Unit Load Design (CPULD) recently welcomed this year's group of interns and kicked off the yearlong program with a three-day retreat at the Mountain Lake resort. Every year, the CPULD selects several candidates for participation in the internship, which includes hands-on work experience in the testing laboratory learning test methods, standards, and equipment use, and a two-semester course sequence designed to enhance the students' professionalism and preparation for a career in the packaging industry.

This year's interns – Meredith Brooks, Luke Guyre, Michael Phelps, and Owen Wright – began with a team-building exercise at the Escape Room at Mountain Lake and transitioned to other team-enhancing exercises. The team also took time to go hiking and enjoy the beautiful scenery around Mountain Lake.

During the course of the [Distribution Packaging Internship](#), these interns will gain useful experience in what testing procedures actually mean and how they are applied in the real world of packaging. During the summer component of the internship, students work 40 hours per week in the lab conducting actual research and testing projects for corporate clients from around the world.

Throughout their year in the internship, lean management will be emphasized along with continuous improvement principles. Just before the beginning of the fall semester, each intern will have earned the professional designation of Certified Packaging Laboratory Professional (CPLP) from the International Safe Transit Association, one of the standard-authoring entities and a leader in the field of packaging and distribution.

Previous intern graduates tell us that the experience gained during the internship helped them obtain jobs, build on the knowledge they acquired through their coursework here at Virginia Tech, and learn how to be professionals in the distribution packaging industry.

Graduate students also participate in the life of CPULD, performing valuable management of lab projects and personnel. This year's grad student cohort includes Mary Alvarez, Dorina Bugledits, Alina Mejias, Nicholas Navarro, and Chandler Quesenberry.



*Photos: (above) Interns and grad students, hiking and enjoying dinner. (below) Interns and grad students figuring out the Escape Room at Mountain Lake Resort.*



~ Graduate Research Highlights ~

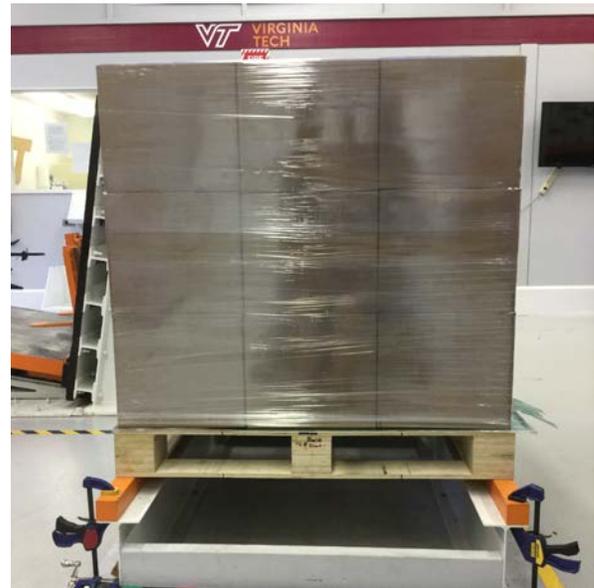
Investigation Into the Distribution of Stresses on the Top Surface of Block Class Pallets as a Function of Package Size and Pallet Stiffness

*By Stephen Morrisette*

Our economy is heavily dependent upon the distribution of material goods at both a national and international level. Due to this fact, companies are constantly looking for the cheapest packaging and shipping options to transport their product from manufacturing plants to the final consumer as quickly as possible, yet in a safe manner. Unit loads, consisting of a pallet, the product on the pallet, and a form of load stabilization, have become the preferred method of shipping. Both wooden pallets and corrugated boxes quickly became favorites in unitization throughout the packaging industry due to the low cost of materials, ease of customization, and speed of manufacturing.

There are important interactions between boxes and pallets that can affect unit load performance. Currently, these interactions are ignored during pallet design, resulting in the over designing of pallets and the waste of raw materials. Understanding the interactions that exist in a unit load is important in optimizing pallet performance, reducing the amount of raw materials used, and, ultimately, reducing costs.

Historically, studies have focused on understanding the mechanical properties of the components of a unit load individually in an approach called “Component Based Design.” Considering the components of a unit load separately oversimplifies the design process as it ignores the



interactions between components. This can result in higher material costs associated with overdesign, product damage due to inadequate design, and costly downtime associated unit load failures. More recently, a “Systems Based Design” process, which attempts to analyze the performance of the unit load by considering the interactions of all of the components with each other and with the material handling equipment, has been proposed by several industry leaders.

Recent studies have focused on understanding which factors affect pallet performance. Pallets are currently designed and tested assuming a uniformly distributed load. However, unit loads behave more like a series of discrete concentrated loads and are affected by the interactions between the unit load components. The redistribution of pressure away from the center and towards the supports of the pallet based on these unit load interactions is called load bridging.

Various researchers have identified several factors that influence the extent of load bridging. As a complete knowledge base of load bridging is developed, unit load design can be optimized, and unit loads can be designed with the intended



*Photos: (left) Stephen Morrisette, (right) a stretch-wrapped unit load being tested.*

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product in mind. Customizing unit load design for individual scenarios saves material costs while ensuring desired performance and safe transportation.

This research project is specifically focused on the interactions between corrugated boxes and block class wooden pallets. The effects of headspace (the gap between products and the top of the box) and box size were investigated as functions of pallet stiffness, support conditions, and bottom deck design. Both the pallet's deflection and the pressure distribution on the top surface of the pallet were examined to evaluate overall pallet performance.

The test sequence included moving a wrapped unit load through a cycle of four support conditions, including warehouse racking across the width (RAW), warehouse racking across the length (RAL), single stacked floor storage, and double stacked floor storage. Deflection measurements and pressure mat readings were taken for each support condition.

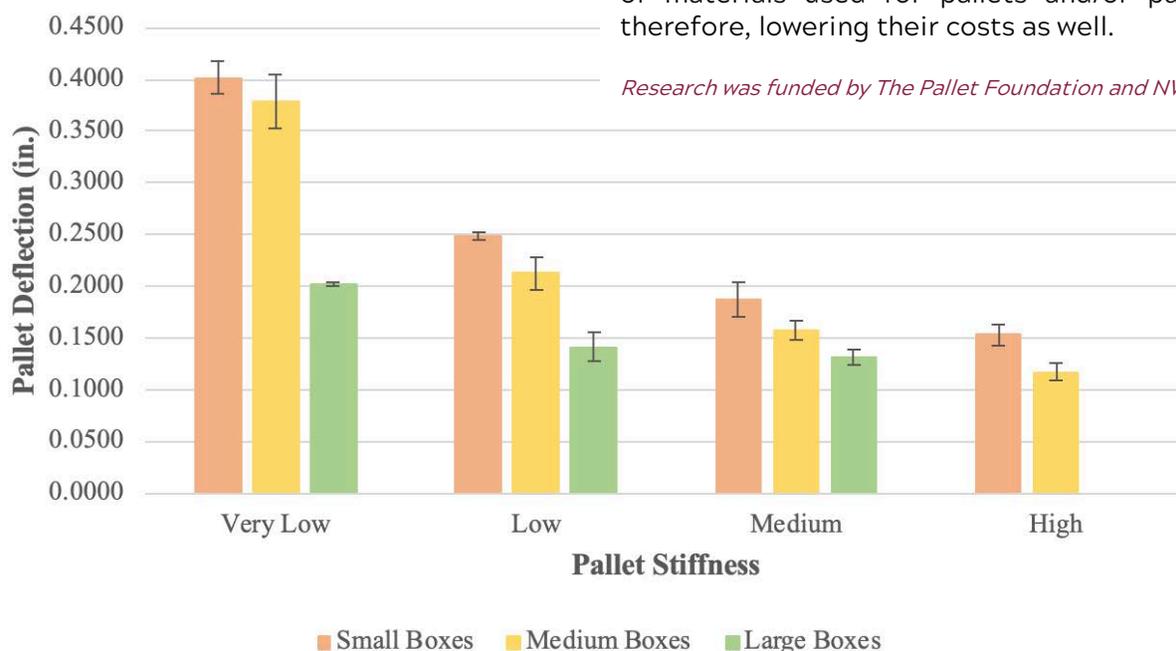
It was found that headspace does not have an effect on pallet deflection unless the weight of the unit load exceeds 3,500 lbs. for small boxes and 1,750 lbs. for large boxes. Base design showed no significant effect on pallet deflection for all of the support conditions evaluated. However, the effect of box size on pallet deflection was found to be significant, especially when small and large boxes were

compared. The effect was most prominent on low stiffness pallets in support conditions that allow more pallet bending. Large boxes showed the greatest change, especially when lower stiffness pallets were used. Increasing the box size can reduce the deflection of the pallet as much as 50%, which means that pallets supporting larger boxes could support much more weight than currently estimated. It also indicates that the boxes are under significantly higher stress when low stiffness pallets are used. Box strength will need to be evaluated in conjunction with the pallet design to arrive at the most optimum overall unit load design.

The pressure distribution across the top surface of the pallet showed a greater redistribution of pressure towards the supports as box size increased. This pressure redistribution towards the supports explains the reduction in pallet deflection as a function of increasing box size. More pressure is applied to the pallet section on the top of the supports; therefore, less pressure is available to cause pallet bending. This finding validates the observed reduction in pallet deflection as a function of box size.

The results indicate that the load capacity of pallets could potentially be increased for certain support conditions depending on box size. This finding will allow designers to optimize packaging and pallet designs by incorporating the interactions between the packages and the pallet into their design process. This will allow them to reduce the amount of materials used for pallets and/or packaging; therefore, lowering their costs as well.

*Research was funded by The Pallet Foundation and NWPCA.*



~ Undergraduate Research Highlights ~

The Effects of Time and Temperature on the Containment Force of Stretch Wrap Film on a Unit Load

By Madison Reynolds and Jack Lumley

Palletized unit loads often depend on stretch wrapping to provide stability for products as they are transported all over the world. The containment force, or the combination of a film's resistance to stretch and its compression of the load, is especially important to consider as it compresses and affects the ability of a unit load to resist movement. Linear low-density polyethylene (LLDPE) films are the most common throughout the industry in different gauges and production methods. There are also different films that may be marketed as high performance and contain additives to help improve mechanical properties. In addition, there are cast and blown films, which are manufactured using different methods that give properties such as better puncture resistance or gauge control.

Containment force is affected by the amount of pre-stretch and post-stretch applied to the film through different settings on the wrapping machine. Pre-stretch is the stretch a film experiences as it is going through the first two rollers of the wrapping machine; post-stretch is the elongation of the film as it exits the film carriage and contacts the load being wrapped. The pre- and post-stretch that a film experiences is the main component that manipulates containment forces applied to unit loads.

The effects of temperature on the containment force are not well explored, but it is speculated that if a wrapped unit load is heated up for a prolonged amount of time, containment force will decrease. This is already observable with standard temperatures as the film relaxes over time, but it is



unknown if heat will cause a heightening of this phenomena. Failure of containment force on unit loads is already a hot topic issue that affects many companies financially because it causes many safety issues.

However, very few research investigations have been completed to specifically measure and observe films' containment performance, stretch, and stabilization regarding temperature over time. This does not include how other variables impact the film itself and only includes its overall performance compared to a uniform and rigid unit load. Due to this lack of data, it is worthwhile to investigate these areas, especially considering how widely stretch film is used. If it is learned that a unit load is significantly affected by heat, research into how much it is affected can help in taking preventative maintenance for future situations.

The objective of the study was to investigate the change in containment force as a function of time and temperature. Multiple commonly used stretch film types and widely used containment forces were used.

These results conclude that heat and time do have a significant impact on the final containment force exerted on a unit load, more so at higher starting containment forces. The containment force decreased as much as 55% after 12 hours when greater containment force was used. There was no observable difference between the performance of films manufactured using different methods. The findings of the research can have a significant consequence to the way we design unit loads for stability. Thus, more investigation is needed to fully characterize the effect.



Photos: (left) Jack and Madison stretch wrapping a unit load, (right) Madison connecting sensors for the temperature study.

Research funded by NWPCA's Gold Level membership in CPULD.

~ Undergraduate Research Highlights ~

Influence of Deck Board Orientation, Corrugated Flute Orientation, Rate of Loading, and Top Load On the Static Coefficient of Friction Using Quarter-Sized Pallets

*By Dianjin Xu and Logan Tallman*

Coefficient of Friction (CoF) tests are designed to observe and quantify how the factors between a C-flute corrugated sheet and a quarter-sized pallet affect the CoF of the quarter pallet. The factors examined include rates of loading, the orientation between corrugated fiber direction and deck board width of the test pallet, and the face of the pallet (equal spaced deck board versus single piece panel deck board). The quarter-sized pallets were pulled from the length side and the width side throughout the entirety of the testing, and data were collected for both orientations.

In order to determine the most conservative CoF value for a southern yellow pine pallet interacting with corrugated board, a test setup for an MTS machine was designed. This allowed for the testing of a quarter-sized pallet being pulled on a sheet of C-flute corrugated. The pallet had both a single panel deck and a spaced deck board side. The corrugated could be placed in a parallel direction to the pull of the pallet or oriented so that it was perpendicular to the pull.

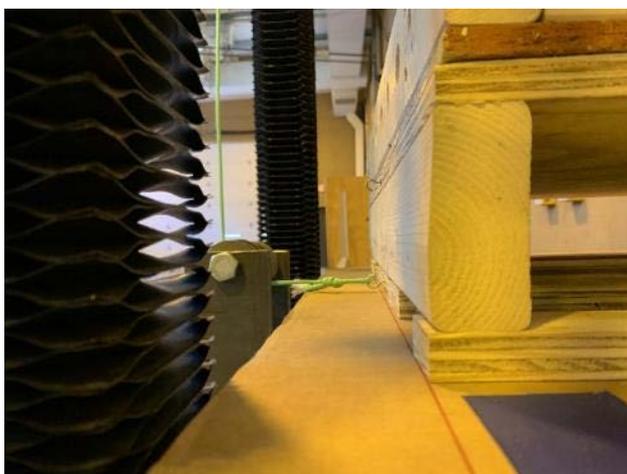
To conduct the CoF testing, the wooden platform is loaded onto the back of the MTS machine and attached to the hooks on the back wall. This serves as a level base for the corrugated and pallet to be placed on. The weight box is then placed on top of the test pallet. The pallet is centered on the corrugated board with the desired testing weight,

and the rate of loading profile is selected from the MTS machine software. The test is run with the string pulling the pallet across the corrugated toward the front of the MTS machine. The operator watches the load curve on the software, looking for the pallet to reach the peak load and then decrease. This means that the pallet has lost friction with the corrugated, and the repetition is complete.

After each set was finished, the set-up would then change for one or more of these variables until all combinations of the weight, flute orientation, and rate of loading profile were completed with 10 repetitions for each. In order to further understand the material properties of the southern yellow pine pallet interacting with a corrugated sample, a Technical Association for the Pulp and Paper Industry (TAPPI) Coefficient of Static Friction incline plane method test was also performed.

Data analysis was run on all sets of data to determine which factors in the coefficient of friction testing were significant. It was found that the weight, rate of loading, flute orientation, and pallet face all have significant impacts on the coefficient of friction value. The levels tested in each factor were significantly different. A significant difference was seen between the 1 inch per minute and 12 inch per minute rate of loading. Additionally, the 25 lbs. and 75 lbs. weight levels were significantly different. The panel deck face of the pallet showed a higher coefficient of friction value versus the spaced deck board side. The orientation of the corrugated board also showed a significant difference between the parallel and perpendicular orientations.

In the scope of this testing, it was found that the conditions that give the lowest coefficient of friction values were a 1 inch per minute rate of loading, under a 25 lbs. load, with the corrugated flute orientation running perpendicular to the direction of the pull, when the spaced top deck boards were in contact with the corrugated board, and the pallet was being pulled from the width side.



*Photo: CoF testing on a quarter-sized pallet.*

*Research funded by NWPCA's Gold Level membership in CPULD.*

Meet the [2019 Distribution Packaging Interns!](#)



**Luke Guyre**  
**Hometown:** Hot Springs, VA  
**Graduation:** Spring 2021  
**GPA:** 3.79  
**Skills:** Forklift driving, Microsoft Office Suite, Artios CAD, Illustrator, CAPE



**Meredith Brooks**  
**Hometown:** Virginia Beach, VA  
**Graduation:** Spring 2021  
**GPA:** 3.96  
**Skills:** Artios CAD, Illustrator, CAPE, Microsoft Office, ISO and ASTM testing, forklift driving, Spanish language



**Michael Phelps**  
**Hometown:** Baltimore, MD  
**Graduation:** Spring 2020  
**GPA:** 3.62 (in major)  
**Skills:** Microsoft, Auto CAD, Wood ID and forest products, forklift operation, hand tools, light machinery, CPR certified



**Owen Wright**  
**Hometown:** Washington, DC  
**Graduation:** Spring 2021  
**GPA:** 3.81  
**Skills:** Artios CAD, CAPE, forklift driving, ISO and ASTM testing

~ Personnel Spotlight ~  
**John Bouldin, Ph.D.**



John Bouldin is the managing director of the Center for Packaging and Unit Load Design. He obtained his Ph.D. in engineered wood products for residential construction. He believes that it's his history in this related field that helps him bring new ideas to his job with CPULD. The carryover effect of having dealt with building codes is that Bouldin is very familiar with exacting test protocols and the application of testing principles to wood products. "Besides," he says, "what is a pallet, but a small wooden construction that deals with what amounts to earthquakes on a daily basis!"

Bouldin's inherent fascination with the applied sciences, "which turn pure science into reality for most people," helps him focus on the details that make the continual development, accuracy, reliability, and repeatability of testing procedures possible. But it is "the students that make this work worthwhile," Bouldin admitted. "Helping to sculpt the future professionals of the distribution packaging industry, one student at a time, is a very fulfilling career." He also participates in ISTA technical committees for the continual evaluation of the current testing protocols and the constant building of up-to-date standards.

Bouldin believes that CPULD's status as a university entity is what makes it unique among testing labs. "We don't just have testing technicians here; our clients get the benefit of multiple Ph.D.s looking over their test results. We are able to give our customers detailed, technical reports from testing done following the latest standards and based on a wealth of research knowledge. Our customers are given insight into the "whys" of their results, and we can also always suggest the right direction for improvement."

John Bouldin's vast knowledge and experience helps gives CPULD an edge in the distribution packaging testing industry!

## ~ Continuing Education Opportunities ~

### 2019 Webinar Series

CPULD is pleased with the response to our new webinar series. Director Laszlo Horvath gave two separate lectures this spring, which were free for our members. Both webinars had around a dozen participants and received high satisfaction ratings from the survey sent out to attendees!

Before beginning this series, we collected topic suggestions from our members and have tailored the lectures to meet their desires. The first webinar, which was offered in April, was titled “How Pallet Stiffness Influences the Cost of Packages Carried by Pallets.” It was followed in May by a webinar on “The Current Status of the U.S. Pallet Market.”

We hope to offer a few more webinars in this year’s series and ramp up to offering one at least every other month by 2020. If there is any topic in particular that you or your company would be interested in, please feel free to suggest it to us!

Stay tuned to learn when the next round of webinars is announced!



### Unit Load Design and Performance Short Course, Aug. 13-15, 2019

Unit load design is a revolutionary, systems-design approach that significantly reduces the cost of distributing products to consumers by understanding how pallets, packaged products, and handling equipment mechanically interact. Unit load design is a new and valuable service that pallet, packaging, and handling equipment suppliers can offer their customers.

This intensive three-day short course will teach techniques that pallet and packaging designers can use to save money on corrugated board and plastic packaging materials when designing pallets and packages by considering the interactions between all of the components of unit loads. The course will use a state-of-the-art unit load design software called Best Load to better demonstrate the steps of unit load design process. You will also be taken on a tour of a working, state-of-the-art, packaging and pallet testing laboratory!



### Wood Pallet Design and Performance Short Course, Spring 2020

Pallet design is an integral part of the material handling system. Wood pallet suppliers, sales professionals, professionals responsible for pallet purchases, packaging engineers, and pallet specifiers will all benefit from an understanding of how to design pallets that will last longer and perform better.

This intensive three-day short course will teach techniques that pallet designers can use to save money when designing pallets by considering the interactions between all of the components of the material handling system. The course will use state-of-the-art pallet design software called the Pallet Design System (PDS) to better demonstrate the steps that go into the pallet design process. You will also be taken on a tour of a working, state-of-the-art, pallet testing laboratory!



To learn more or register for these courses, visit:  
[www.unitload.vt.edu/education/continuing-education/](http://www.unitload.vt.edu/education/continuing-education/)



## 2019 Calendar of Upcoming CPULD Events

Aug. 6-7:	CPULD Annual Membership Meeting
Aug. 13-15:	Unit Load Design and Performance Short Course
Aug. 26:	Classes begin at Virginia Tech
Sept. 19:	CNRE Career Fair
Sept. 23-25:	Virginia Tech Exhibits at Pack Expo in Las Vegas
Nov. 23-Dec. 1:	Thanksgiving Break
Dec. 11:	Classes end at Virginia Tech

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### Contact Our Team:

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