COLLEGE OF NATURAL RESOURCES AND ENVIRONMENT
SUSTAINABLE BIOMATERIALS
VIRGINIA TECH

Fall / Winter 2023

Center for Packaging and Unit Load Design

CPULD News

As the year draws to a close, the Center for Packaging and Unit Load Design (CPULD) would like to thank all of our customers and our affiliate membership companies in particular. CPULD wouldn't have had such a successful year without all of you. Our researchers were able to work towards solving industry problems, and our students gained valuable life and career experience through their work in our state-of-the-art laboratories which exist in large part because of our members' support and financial donations!

Please read all of our stories below to stay up to date with everything that has happened in 2023 and everything planned for in 2024 at CPULD!

- Further investigation of last-mile grocery delivery in a suburban environment
- Shocks experienced during South Korean parcel delivery
- Evaluation and redesign of packaging for a Toshiba AC unit with a focus on sustainability
- Evaluation of packaging for the sponsor's products thru ISTA and ASTM testing standards
- Alumni Spotlight: Yu Yang Huang
- Graduate Student Spotlight: Lucia Contreras
- CPULD's fall short courses were successful!
- New grant received to model the quantity of wooden pallets in the U.S.
- CPULD received two new pieces of equipment to help with research and testing projects
- Congrats to Mary Paz Alvarez and Sean Hobbs on their graduations!

Alumni Spotlight – Yu Yang Huang

Image 1. Yu Yang Huang in New York City, NY.

Yu Yang Huang joined CPULD from Costa Rica. His parents migrated there from mainland China, and he is the first generation of his family to study in the U.S. Before completing his two master's degrees at Virginia Tech in 2021 (Industrial and Systems Engineering, and Sustainable Biomaterials), Yu Yang had studied at the Costa Rica Institute of Technology.

Yu Yang became engaged with VT through an internship program with Dr. Henry Quesada in the fall of 2018. The project/thesis that he worked on that semester was a requirement to complete his bachelor's degree at Costa Rica Tech. During this internship, his main focus was to develop a mathematical model to determine the cost of heat and vacuum treatments for log fumigation. However, thanks to this exchange program, Yu Yang had the opportunity to learn more about CPULD and the huge impact that we have on the industry.

Yu Yang received a scholarship to study with CPULD and while he worked in our labs, he became certified as an ISTA Technologist and was able to publish several papers in international journal to share his research findings with the scientific community.

Yu Yang explained that "the concept of packaging is not well-known in Costa Rica, this motivated me to explore more about this field, and therefore, to pursue a degree in the CPULD program. After graduating from their program and being able to work in the industry, I realized that CPULD was a life-changing experience. The program that VT offers is complete and prepares the students with the necessary problem-solving skillsets. Moreover, the program is focused on designing efficient and effective packaging, always taking into account distribution through the supply chain and the sustainability of the environment.

While he was earning his master's degrees, Yu Yang had the opportunity to write a thesis focused on the Evaluation of Maximum Pallet Deflection Under Dynamic Forklift Handling Conditions. Yu Yang described the some of the benefits of his time with CPULD. "This research project allowed me to work with an interdisciplinary team to develop a laboratory-scale simulation for pallet handling. CPULD also provided me with opportunities

to develop and improve my project management, teamwork, and leadership skillsets as you have the opportunity to work in a world-class laboratory. During my time working as a lab manager, I was responsible for supervising 2-4 laboratory technicians in order to complete laboratory testing projects which contributed to the packaging improvement of the companies. These experiences allowed me, later on, to lead important projects at my corporate job."

"I chose CPULD because of the impact it has on the industry. The program was well-known around the world and is taught by well-prepared faculty members. Honestly, I didn't know that packaging science was going to play that huge of a role in my professional career. I always knew that I wanted to be an engineer in a manufacturing company but not a packaging engineer."

"Currently, I'm working as an Industrial Engineer at Siemens Mobility in Sacramento California. My main responsibilities include the design and implementation of material PFEF (Plan for Every Part), including the design of supplier-warehouse-production material flow for Rolling Stock and Composites sites. I'm heavily involved in the design and implementation of disposable and returnable packaging and transport solutions to assure logistics needs are met and maintained through the project life cycle."

"Moreover, I lead negotiations with suppliers to define the supply chain and logistics specifications for new Rolling Stock projects (locomotive and coach projects). Previously, I also had the opportunity to work as a Logistics Engineer at Alstom Transportation in Hornell, New York. During that time, I had the opportunity to work on the first high-speed train in the US."

"CPULD provided me with all the necessary skillsets and knowledge to perform in a great manner in the corporate world. My piece of advice for future and current students is to enjoy the journey and don't be afraid to learn every day and challenge yourself to be outside of your comfort zone. Virginia Tech is a very challenging environment; however, it provides you with the necessary support and tools to succeed."

Image 2. Yu Yang Huang hiking in upstate NY.

Image 3. Yu Yang Huang in Washington DC.

Research Summary – Further investigation of last-mile grocery delivery in a suburban environment

Image 1. Undergraduate students creating frames to hold the decoy packages' sensors.

The objective of this investigation was to map the process that packaged goods go through, as well as any potential hazards that may occur from the moment they are picked up from the shelf to the moment they arrive at a consumer's doorstep. Looking at the existing studies into last mile grocery delivery services, a gap was identified in research regarding the potential effects of delivery on consumer-packaged goods.

Grocery delivery has been showing increasing prevalence and interest in recent years. Trends from a 2014 study showed that 25% of respondents in a global survey had already used online grocery delivery services and that 55% of respondents were willing to try it in the future. A more-recent 2019 survey showed 31% of respondents engaged regularly in online grocery shopping. An estimated one-third of the national grocery market now utilizes online delivery services, so investigating last mile grocery delivery will reflect the probable outcome for a large share of grocery packaging.

The increased handling experienced by packages being delivered presents a variety of potential hazards that need to be considered because these hazards may yield damaged, spoilt, or otherwise compromised products. Most grocery delivery services today are carried out in consumer vehicles which are built to provide a smooth and steady ride compared to delivery trucks. Since the vibration level of a consumer vehicle is significantly lower, for purposes of this investigation, shock hazards were the primary focus. This shock data will aid in simulating high-risk situations such as sudden stops, driving over potholes, sharp turns and maneuvers, as well as any drop scenarios that could compromise the packaged goods. Proper accounting of these factors will help to evaluate whether current packaging standards are sufficient to guarantee acceptable conditions during grocery delivery.

The mapping process was discovered through a series of interviews with grocery retail staff as well as independent drivers for the third-party services in order to develop a vision of the process both in theory and practice. Based

on interviews conducted, we found that there are several different ways a delivery may be conducted based on the drivers' preferences. Half of the drivers interviewed stated that they always put the groceries in the backseat of the car, whereas the other half said they always put them in the trunk. Most drivers indicated that they use self-checkout most of the time. Most delivery drivers said that when in transit they drive normally or more carefully to prevent products from falling out of bags.

After gathering sufficient information regarding the handling processes from different grocery delivery services, we were able create an outline for the general procedure for a delivery route. This outline was then used to create grocery delivery simulations.

The shock data collected for this experiment was taken using a decoy package containing a Lansmont Saver 3D15 sensor housed in a corrugated container. To account for an average sized product that is found in the grocery store, a 3.43" x 6.43" x 5.25" corrugated box was used as a simulated grocery item (Image 1). The box held an aluminum and wooden frame with the Saver 3D15 attached in it. The Saver 3D15 can record the duration of shock impacts as they occur either as timer-triggered or signal-triggered events. Dummy packages were also used to ensure the volunteers would not handle the decoy packages in a way that may skew the data.

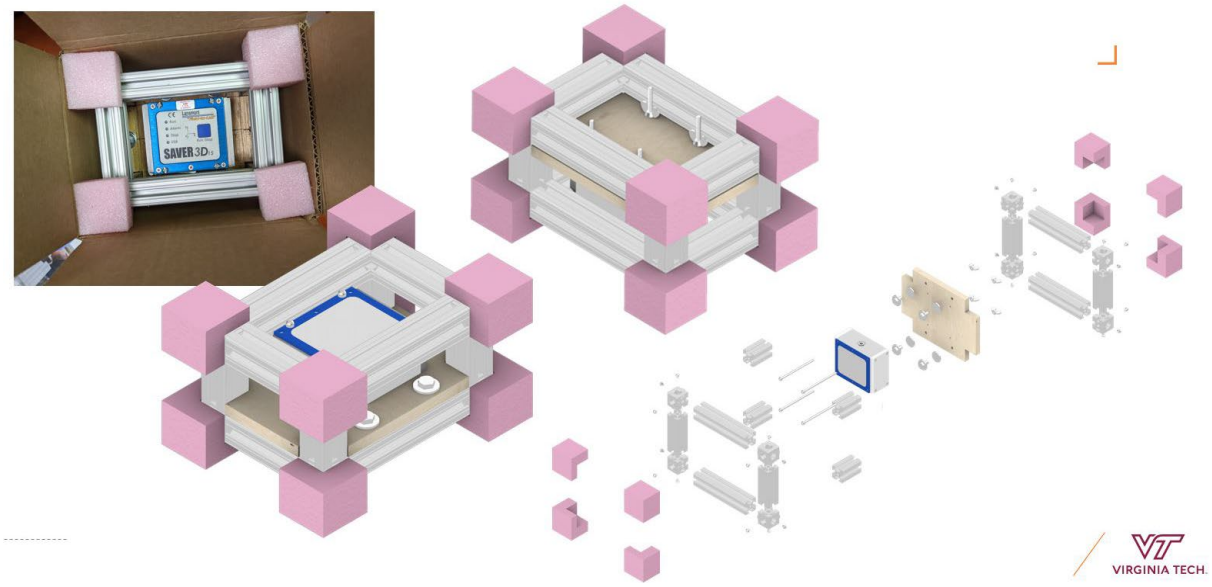

Image 2. Sensor setup in decoy box.

Using these packages, 18 simulated events, and 25 repetitions, were conducted using volunteers. The events simulated the grocery delivery process through four segments: picking, checkout, loading, and delivery. Picking was simulated with the volunteers choosing packages from various shelf heights and dropping them into shopping carts. Both self-checkout and regular belt-driven checkout systems were used. Then, using their personal vehicles, volunteers were instructed to put the groceries, with the sensor and dummy boxes, into either the cabin or trunk of their vehicle at random. Then they "delivered" the packages to various surfaces, such as concrete, wood, and welcome mats. The volunteers were instructed to conduct all of these trials at two different paces: normal and expedited. The purpose of this was to simulate a grocery delivery driver that would either be rushing to complete the order to taking their time to complete the order.

During picking, we saw that most of the drops were in the flat orientation because the volunteers would drop the packages holding the box by its sides, straight down into the cart, not allowing for the orientation to be

manipulated. During checkout, most of the drop orientations was either on the edge or flat orientations because the volunteers would attempt to place the box in the grocery bag on the flat orientation, but because of the creases in the bags, the box would reorient itself onto an edge. During loading, there was an equal distribution between the orientation types because as the volunteers would put the bag into their vehicle, they would often let go before the bag landed. This allowed the boxes to reorient while in free-fall, resulting in random drop orientations (Image 2).

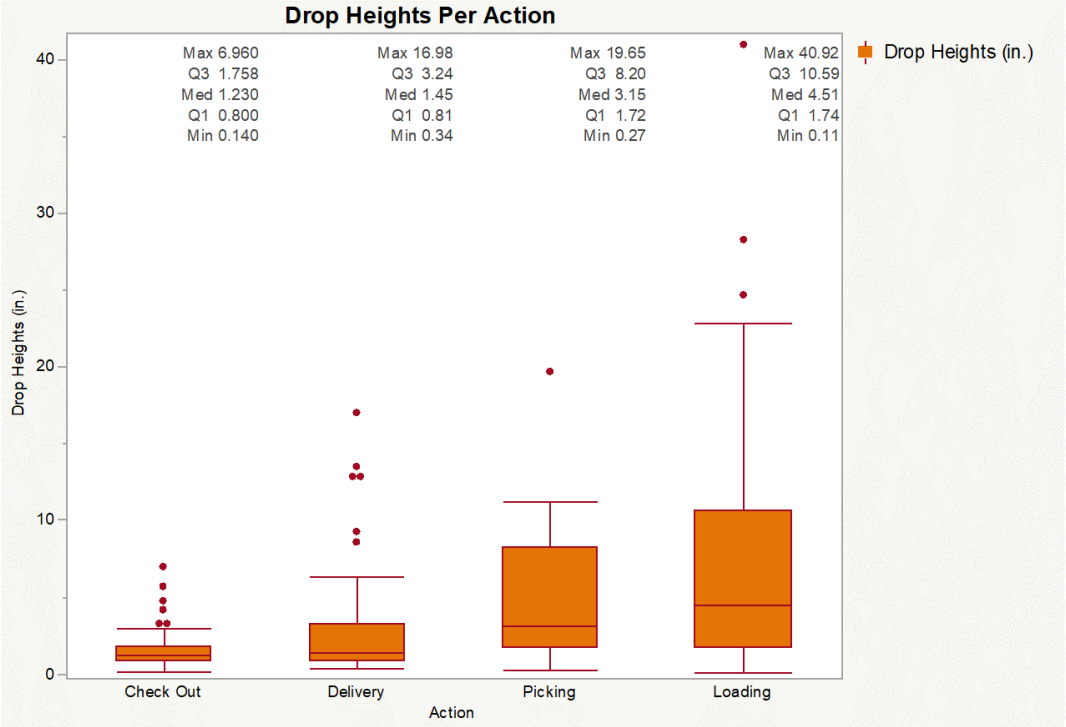

Image 3. Shock events during the different sections of this project.

Through the data, it was determined that the loading process has the highest potential to damage the products due to the increased drop heights. Most drops occurred between 0.89 in. and 4.09 in. with an average drop height of 3.59 in. and a COV of 70.25%. Compared to the ISTA 6a standard, last-mile grocery delivery has fewer overall hazards than e-commerce shipping.

Due to the lack of secondary packaging, we can assume that consumers and drivers handle the groceries more gently. The basic finding of this project was that primary packaging which was designed for e-commerce or commercial shipping, is overdesigned for last-mile grocery delivery services. A redesign of primary packaging may open the opportunity for cost savings and more sustainable designs.

In the future, we hope to increase the representativeness of the trials by refining the simulations and increasing the data samples. The approach moving forward consists of four primary goals: developing a decoy package with reduced volume, conducting simulations with the help of store employees, sending mass surveys to delivery drivers, and conducting simulations of grocery handling with the help of student volunteers.

Corporate approval is required to advance the investigation into the last-mile distribution environment for major grocery retailers. Until then, we are unable to work with local stores to run simulations or investigate their pickers' behavior. As things are currently, future simulations will either mimic store conditions as closely as possible, or the scope will be brought in to focus solely on third party delivery services.

Research Summary – Shocks Experienced During South Korean Parcel Delivery

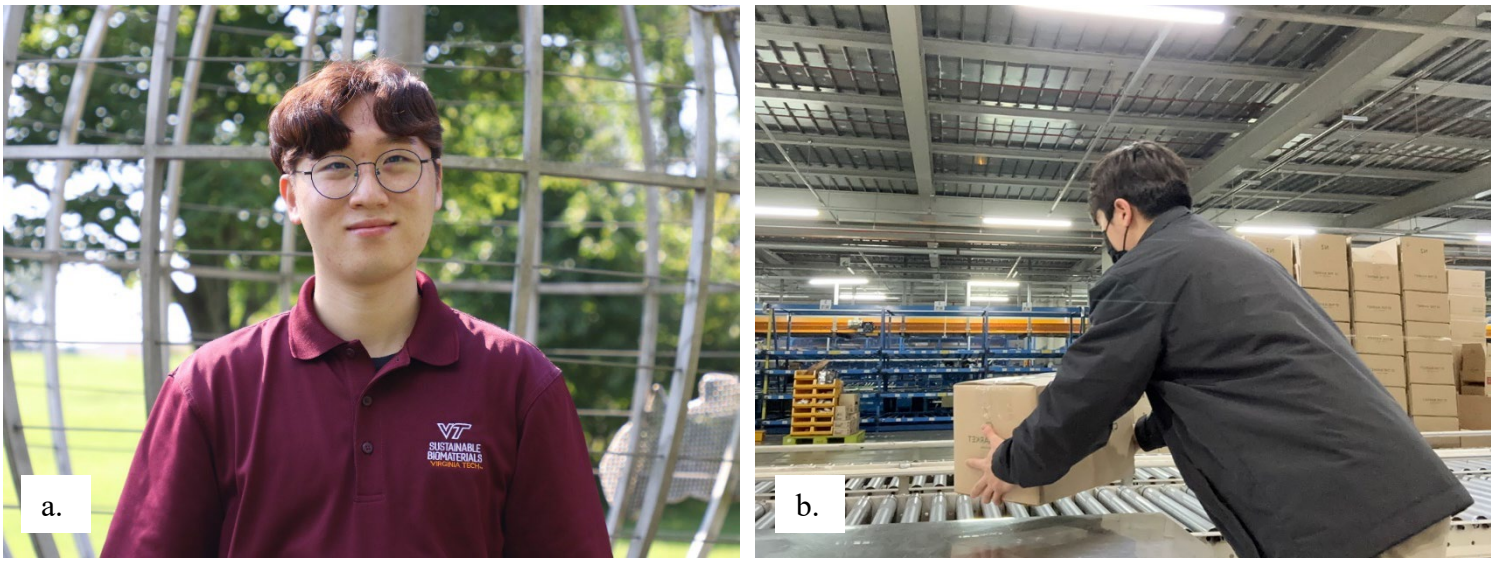

Image 1. a. Saewhan Kim and b. Kim placing decoy box into the supply chain.

Our director, Dr. Laszlo Horvath, received funding from a private international company to investigate the parcel delivery system in South Korea in order to be able to recommend testing protocols for their system. Graduate student, Saewhan Kim, PhD (Image 1a), was assigned to this research project. He collected information about the level of shocks and vibration experienced by packages transported throughout the South Korean parcel delivery system (Image 1b), particularly during the last-mile delivery portion of distribution. The collected data allowed the research team to use drop tests and vibration profiles that simulated the hazards actually experienced during South Korean parcel delivery. This data was then compared to internationally used packaging testing standards in order to help develop a proposed testing plan for Korean e-commerce package testing.

Before flying to South Korea, Kim built decoy packages to be used to test the parcel delivery systems (Image 2). These decoy packages took dozens of one-way trips between distribution facilities (Image 3) in order to collect the most data possible about the shocks that packages experience. The shock data was then analyzed and the equivalent drop heights calculated based on the measured delta velocities. Additionally, to collect the last-mile vibration environment, multiple parcel delivery vehicles were instrumented with Lansmont Saver 3x90 data loggers and GPS units. The vibration profiles of each transportation mode were recorded and used in the laboratory simulations.

The drop study aimed to create a laboratory test procedure that simulated the real-world parcel shipping environment of a one-way shipment. In this study, all data was analyzed as individual one-way shipments in order to ensure accurate results that could guide the creation of an effective laboratory test. Data points below a 6-inch drop height were excluded from the analysis since they tended to be caused by small shock events during vibration. The percentage of each impact orientation, including faces, edges, corners, on and around the bottom, on and around the top, vertical faces, and vertical edges, were also calculated. This analyzed data was then used to establish new laboratory test procedures for South Korea.

Image 2. Saewhan creating decoy boxes with sensors.

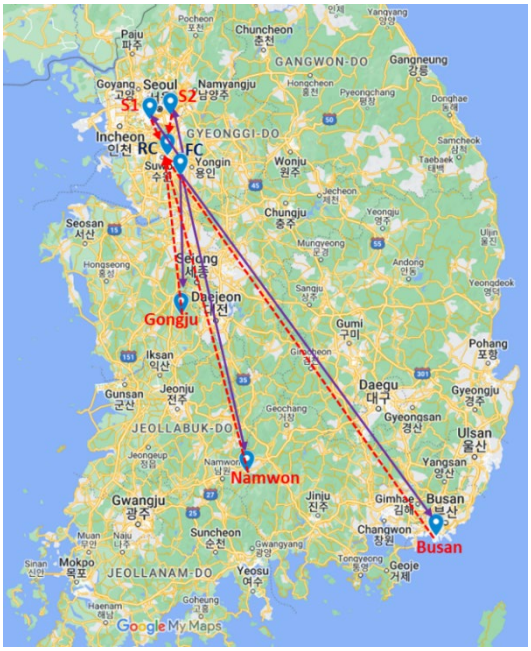

Image 3. Delivery routes the decoy packages took in South Korea.

In addition, the time stamp of each data point was compared with tracking information. This analysis allowed the researchers to determine which delivery stage produced the most impacts. It provided useful information for packaging engineers on what to target to optimize their packages and for courier engineers about which stages need to be improved to reduce their parcel damage rates.

The individual one-way shipments to five destinations were analyzed to calculate drop heights, number of drops, and impact orientations. Table 1 shows various percentiles, the average, and maximum number of drops as a function of the different package sizes and weights used in the current study. It also compares the current study's results with a past studies conducted in Europe and the U.S., and to the ISTA 3A testing standard.

Table 1. Shock/impact frequency observed depending on package size and weight, reported in the previous study, and ISTA 3A standard.

	Number of Shocks / Impacts					
Percentile	**Medium + Small**	**Medium Box**	**Small Box**	**Europe**	**USA**	**ISTA 3A**
90th	6.16 ≈ 6	6.44 ≈ 6	5.81 ≈ 6	16	-	
95th	6.85 ≈ 7	7.11 ≈ 8	6.50 ≈ 7	17	-	17
99th	8.17 ≈ 8	8.37 ≈ 8	7.81 ≈ 8	19	-	
Maximum	8	8	8	21	74	

The number of drops observed in the Korean parcel delivery environment was significantly lower than the similar studies conducted in Europe and the U.S., and the ISTA 3A testing standard. This seems to be due to fewer handling points in Korea than in countries with larger territory. Packages in Korea mostly go through only one hub terminal and one sub terminal during any trip. In contrast, packages in Europe and the U.S. have a higher chance of going through more handling points, such as multiple hub and sub terminals, before they get to customers.

It is also important to report the Equivalent Free Fall Drop Height (EFFDH) of Nth highest drop height at 95th percentile level since that is the recommended dataset to utilize when developing a drop test according to ISTA guidelines. The 95th percentile of the highest EFFDH in this study was at least 28% and 17% higher than those in Europe, or recommended by ISTA 3A for testing packages less than 37 kg, respectively. The Korean parcel delivery system also had a higher max EFFDH than most of the other compared regions. This trend indicates that packages shipped in the Korean environment will most likely experience higher shock levels compared to historically investigated regions.

Both the fewer number of drops and the higher EFFDH results prove the uniqueness of the Korean parcel delivery system and show the need to establish their own laboratory testing standards. Therefore, packaging engineers are encouraged to reevaluate their protective packaging designs when the packages are to be shipped through the Korean parcel delivery system. These researchers believe that the current ISTA 3A laboratory testing sequence should be modified to reflect the unique characteristics of the Korean parcel shipping environment.

Research Summary – Evaluation and redesign of packaging for a Toshiba AC unit with a focus on sustainability

Image 1. Drop testing AC packages.

CPULD believes in hands-on and mind-on education thus with the help of our corporate partners each year a group of undergraduate students are working on real-life industrial packaging design projects. The focus of 2023 Spring project was on the packaging redesign of a Toshiba portable air conditioner. Currently, the interior packaging of the portable AC unit consists of two Expanded Polystyrene (EPS) inserts that mold to the top and bottom of the unit. The project sponsor's interest is in switching to a more sustainable packaging solution. They tasked this research group with exploring sustainable options and if they could be used with similar cost and performance levels.

The first step in tackling this problem involved testing the current packaging that is used for this AC unit. The idea was to give a baseline from which to compare the performance of future prototypes. The testing procedures for the baseline and subsequent prototypes followed the ISTA Amazon 6B standard which simulates the hazards and damage that packages are susceptible to along the supply chain.

For this project, each package had to endure five separate ISTA test sequences before being considered a pass or fail. The first tests were drops and were a variety of edge, corner, and face drops (Image 1). The next test was a horizontal clamping test with wooden plates to separate the unit from the tester. The package was required to overhang 3 in. off the wooden plates in both directions and the standard requires clamping the unit at quadruple

its weight, giving us a clamping force of 292.8 lbs. The third test was a vertical compression test that was meant to imitate the weight a package would endure when being stacked in a warehouse. It is a good indication of the package's stacking strength. Next in line was the series of vibration tests. These tests are simulations of the vibrations that a package would experience in the back of a truck and when they are being picked up and delivered (Image 2).

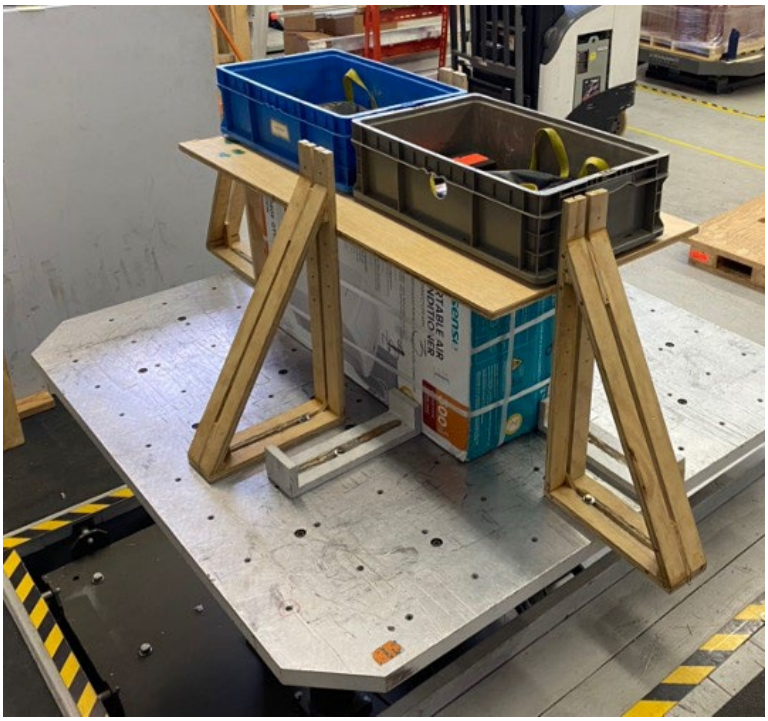

Image 2: Vibration test setup.

After testing the original Midea packaging thru these steps, the researchers began creating prototype packages for the AC unit (following the goals of less materials and sustainability). Their first attempt did not survive even the first set of drop tests, but they learned quickly and each subsequent prototype performed better. The two tests that did the most damage to the final prototype were the compression and vibration tests. The compression test completely buckled some of the edges and corners of the prototype packaging. The vibration tests amplified this buckling of the box, especially on Face 6, where the flaps were bent open.

At the end of the project the new packaging made of fully curbside recyclable protective packaging had equivalent performance than the original baseline. Also, the students calculated the cost of the prototype packaging system to be only $12.19 in materials which is only 3.5% of the current selling price of the product. The students were able to show the sponsor that moving to a more sustainable solution in the future benefits everyone without compromising performance and cost.

Research Summary – Evaluation of packaging for sponsor's products thru ISTA and ASTM testing standards

Image 1. Drop testing decoy packages to calibrate them before being sent on their data collection shipment.

A major specialty packaging company producing multilayer beverage packaging recently sponsored this undergraduate packaging engineering project. Recently, it came to the sponsor's attention that their packaging was not holding up well to the parcel distribution process; their customers were reporting leaks and other damages upon product arrival. The current testing that the company had been running on their products were the ISTA standards 3A and 6A, but they've determined that these test methods do not replicate the levels of damage found in their real shipments.

Damage caused by handling and sorting packaged goods is inevitable during distribution. Before reaching the customer, the package is subjected to a number of risks as it travels through the supply chain, including drops, impacts, crushing forces, vibration, climatic and pressure changes. If the product arrives damaged, all of the manufacturing, engineering, and quality efforts were in vain. Numerous factors can cause a product to be damaged during distribution and handling. In the context of shipping small parcels, shock is one of the more severe and prevalent dangers. The goal of this project was to address this issue; determine where in the shipping process these "risks" are occurring and at what volume, so the packaging can be altered in such a way that the product won't experience as much damage.

Over the past two decades, research around the events that happen to packages during transportation has consistently grown. Majority of the products being transported today are sold via e-commerce, and this ends up lengthening the overall transportation and shipping process. Ultimately, this may cause more damage to products

as their packaging was not designed to withstand extended transportation. With such demand in this field, it is vital that more accurate testing standards and improved packaging are found.

For this project, eight decoy boxes were created reflecting the correct dimensions and weight of packages that the sponsor ships regularly. Once these decoy boxes were made, sensors (Image 2) were placed in the decoy boxes, they were calibrated, and then shipped back-and-forth to Texas. During the calibration process, the decoys with the sensors were dropped from various known heights (Image 1), and the resulting G forces were recorded. This was a crucial step as the ISTA standards are written in terms of drop heights; whereas, most packages won't actually face any sort of harsh drops, but rather other types of impacts. Calibration is the conversion from the standards to real life impacts. The sensors kept track of which face, edge, or corner of the package the impact occurred to, the date and time of each impact, and the level of the impact that occurred.

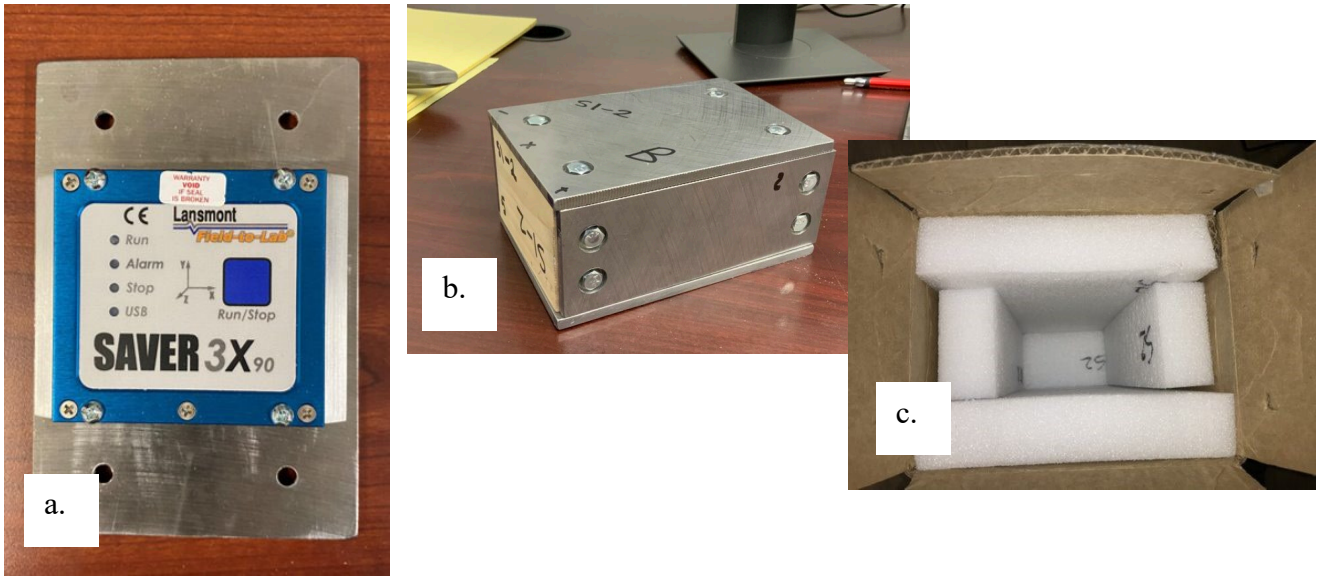

Image 2. a. sensor, b. sensor in frame, and c. decoy box with foam inserts, to be used for recording test shipment shocks and drops.

Using the data collected from all of the decoy boxes, this project analyzed and determined where in the shipping process the damages are most likely occurring and how much force caused said damage. From there, the laboratory tests for the packages can be altered to better reflect the actual shipping process.

Based on the field data, the majority of the shocks and drops occur on the bottom half of parcels. Interestingly, the shape of the packages has an effect on the frequency of shocks and drops. The package that was squarer than the others experienced less frequent shocks compared to the rectangular packages. Additionally, differences were observed between the three investigated couriers.

The results of this project were calculated and shown through data charts. There was a lot of data to be observed and analyzed between conducting calibrations and the shipment processes. Based on our results, the courier, the shape of the box, and how it is shipped all affect the number of drops, drop height, and orientation of drops it experiences.

The results revealed that at the 95% level the packages experienced 20 drops per trip which is more than the 17 drops required by the ISTA 6A. Also, 95% of the drops experienced by the packages were below 30 in. which is lower than the 36 in. maximum drop height required by ISTA 6A. The drop orientations discovered are shown in Figure 1. The four investigated packages sizes did not experience significantly different shock environments. Nor did any of the markings on the package affect the handling nor the magnitude or number of drops experienced by the packages (Image 3).

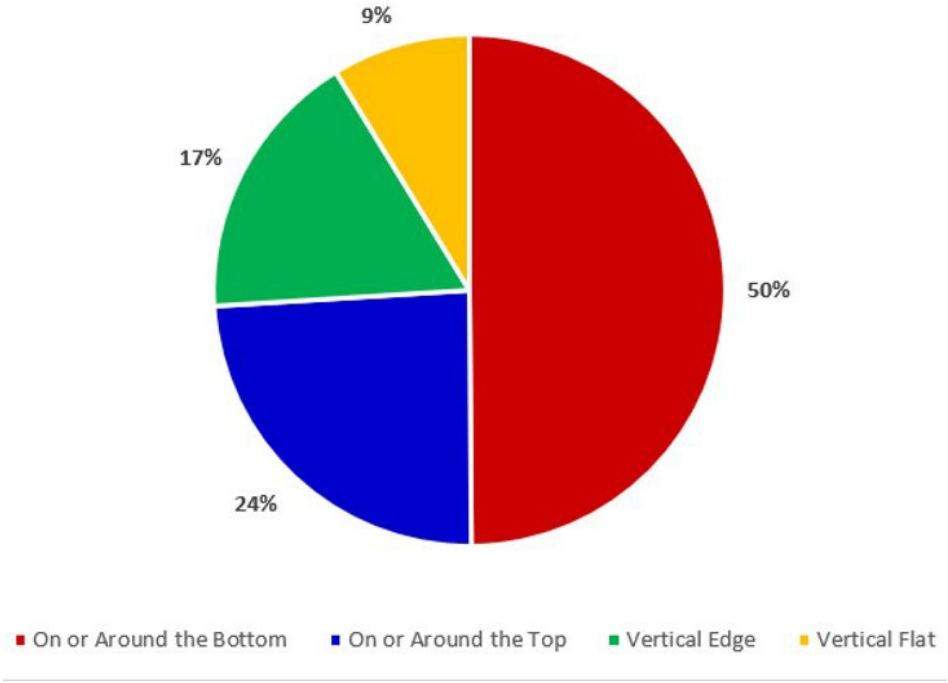

Figure 1. Graph showing drop orientations of decoy packages.

Image 3. Markings on packages that did NOT have any effect on drop heights or shock intensities.

However, different couriers do have different effects on the shipping process (Table 1). The three different couriers tested, FedEx, USPS, and UPS, have different processes such as sort centers, routes taken, and number of stops until the package has reached its destination. FedEx has an average of five stops, but UPS averages six stops before each package reaches its endpoint. This could also explain why the USPS has higher drop height average because the packages that are shipped through USPS experience more handling. This could also explain why the USPS has a higher coefficient of variation because of there being more opportunities for drops to occur. The difference in couriers influences the shock intensities as well.

Table 1. Different shock intensities for each Courier.

Courier	Mean (in.)	Standard Deviation	COV (%)	Q1(in.)	Q3 (in.)
FedEx	**12.562**	7.018	55.87	7.380	15.052
UPS	13.986	7.807	55.82	8.159	17.672
USPS	13.997	8.881	63.45	7.129	18.225

Graduate Student Spotlight: Lucia Contreras

Image 1. Lucia Contreras

Ana Lucia Contreras Porras (Lucia) came to CPULD from San Jose, Costa Rica where her family, including two siblings, still reside. She completed her bachelors in Industrial Production Engineering at the Tecnologico de Costa Rica. After graduating with her bachelors, she discovered an interest in data analysis which was fostered by her last job – when she spoke with Dr. Laszlo Horvath about the opportunities here, Lucia felt it was a good combination of her previous degree and her newfound interest in data analysis.

Lucia told us that one of the reasons she chose to join CPULD is because of "Virginia Tech's commitment to innovation, state-of-the-art technology, and its extensive research in sustainable biomaterials made it the ideal choice for pursuing advanced studies and a career focused on the whole packaging system. CPULD offered a unique opportunity to work in a highly specialized and influential research center in the field of packaging and unit load design."

Lucia told us about the research she's conducting for her Master's degree: "My current research will develop a model to estimate the number of wood pallets in circulation inside the United States. After this research, it will be possible to determine the impact of these wood pallets on the environment more accurately and will help to improve and optimize future production and use of this valuable and basic product essential for the transportation of good and products around the world." Her research project is sponsored by the Pallet Foundation of the National Wood Pallet and Container Association.

She went more in depth by explaining that "through my master's thesis, I aim to utilize econometric analysis and material flow analysis to estimate the total number of wooden pallets in circulation in the United States. This research is crucial for a comprehensive understanding of the sustainability and environmental impact of wooden pallets. As trees capture CO2 during their lifespan, this embedded carbon in wooden pallets is a significant factor in assessing their environmental footprint. Currently, industry estimates suggest a wide range (between 1.8 to 2.6 billion pallets), but no scientific study exists in this area. I expect my research to provide a more accurate and

detailed account of the total number of wooden pallets in circulation, enabling a more precise evaluation of their environmental impact."

In order to complete her research, Lucia will initiate data collection on historical inputs and outputs relevant to the wooden pallet supply chain. "As some data may be unavailable for certain years, I will then construct an econometric prediction model to estimate missing values based on their correlation with independent economic variables. Subsequently, I will conduct a material flow analysis, incorporating the predicted values, to estimate the accumulation of wooden pallets over the years. The research process will be meticulous, involving data analysis, model development, and the application of both econometric and material flow analysis techniques."

"This information is vital for making informed decisions regarding sustainability practices within the industry. It will enable stakeholders to quantify and reduce the carbon footprint associated with wooden pallets, fostering more environmentally-friendly practices and contributing to the industry's overall commitment to sustainability."

Lucia already has learned a lot through her research and work as a CPULD lab technician. "The most helpful knowledge and skills I have been learning is a holistic understanding of pallets, packaging, and material handling. This interdisciplinary approach is essential for addressing complex challenges in the field and developing comprehensive, sustainable solutions." Lucia believes that "the best part of my time at VT, so far, has been the invaluable combination of academic excellence and hands-on experiences. The university's commitment to cutting-edge research, interdisciplinary collaboration, and real-world applications has made my educational journey fulfilling and enriching."

Although she does not yet have a job lined up for after graduation in 2025, Lucia knows what type of work she'd like to seek out. "I am actively exploring opportunities that align with my academic background in industrial engineering, my master's degree in sustainable biomaterials, and my experiences working at CPULD. I anticipate engaging in many tasks relating to research and data analysis. This may involve collaborating with cross-functional teams, conducting experiments or analyses, and staying updated on industry trends and advancements. I also expect to play a role in decision-making processes that contribute to the overall sustainability goals of the organization."

Lucia keeps active and when she isn't working or studying she enjoys hiking, particularly the Huckleberry Trail, reading or listening to music while surrounded by nature, and learning to cook new recipes. If she had to pick one food to eat for the rest of her life, she'd pick french fries. And, one of her favorite animals is the meerkat "a small mongoose-like mammal. While not large or physically powerful individually, meerkats use their agility and quick movements for hunting and protection. They are more reliant on their cooperative behavior than physical strength."

News – CPULD's short courses throughout the fall of 2023 were great successes!

Image 1. Advanced Packaging Dynamics short course held in partnership with the Lansmont Corporation Oct. 3rd-5th (photo credit, Eric Joneson, Lansmont).

Throughout the fall of 2023, the Center for Packaging and Unit Load Design (CPULD) offered two short courses; one in partnership with Lansmont Corp. and the other in partnership with the NWPCA. Both were an intensive 2.5-days of classes that taught techniques to help save money when designing packages and unit loads by considering the interactions between all of the components of the material handling system.

The Advanced Packaging Dynamics (www.unitload.vt.edu/apd) short course was offered in-person, Oct. 3rd-5th, 2023. The instructors (Dr. Laszlo Horvath, CPULD Director; Eric Joneson, VP of Technology, Lansmont) informed attendees about the principles of shock, vibration, field data collection practices, and sensor selection. Laboratory simulations were conducted around how to collect field data and how to use the collected information to optimize packaging and eliminate damages. By the end of the course, attendees were able to instrument different transportation modes in order to collect vibration data, instrument decoy packages to collect distribution shock data, collect and analyze the collected data, and set up laboratory simulations to test new designs under the same conditions realized through the data collection processes.

This course had 16 people registered for it. Attendees flew in from all over the U.S. Everyone had great discussions about packaging! Advanced Packaging Dynamics received high grades on the satisfaction survey conducted. Of respondents, 100% felt that the course provided all the knowledge they had come to learn, and said that they would be recommending the course to others in their company and the industry. Participants even felt that 80%-100% of the topics covered would be useful for their day to day work.

We were told "I loved the course and you all did a great job on it!" – "Overall, I thought the course was great. Very well taught, very informative, and very relevant to my organization." And, another happy participant told us that "Dr. Horvath and Mr. Joneson were extremely professional and knowledgeable. All questions asked were met with thorough answers and explanations."

The Unit Load Design and Performance (www.unitload.vt.edu/uldp) short course was offered Nov. 7th-9th, 2023 to both in person and virtual attendees. The instructors (Dr. Laszlo Horvath, CPULD Director; Dr. Brad Gething, VP NWPCA; and Kristen DeLack, professional engineer, NWPCA) informed attendees how to use the interactions between wood pallets and packages to lower the cost of the unit load and improve the performance. By the end of the course, attendees were able to optimize their pallet designs for different types of packages, redesign the pallet to decrease the compression stress experienced by corrugated boxes, and design large pallets for flexible unit loads.

This course also had 16 people registered for it with people coming from all over the U.S. and Mexico! Unit Load Design and Performance received high grades on the satisfaction survey conducted. Of respondents, 100% felt that the course provided all the knowledge they had come to learn, and said that they would be recommending the course to others in their company and the industry.

We were told "Overall the information was relevant and well presented to the class. All in all, it was great." – "I thoroughly enjoyed the Unit Load Design and Performance short course, and it has significantly contributed to my professional growth." And, finally, "Thank you for providing such a valuable course."

If you are interested in attending these courses in 2024, or learning more about the other short courses that CPULD offers, please visit our continuing education page: https://www.unitload.vt.edu/education/continuing-education.html

Image 2. Dr. Laszlo Horvath speaking during the Unit Load Design and Performance short course, Nov. 7th-9th, 2023 (photo credit, Brad Gething, NWPCA).

News – New grant from the Pallet Foundation for Lucia Contreras research: "Modeling the quantity of wooden pallets in circulation in the U.S."

Image 1. Lucia Contreras

Wood pallets are a mode of carbon storage. Therefore, wood pallets are environmentally friendly and can help with emissions issues by capturing those emissions and storing them into the future, instead of allowing them to hurt the atmosphere. In order to estimate the impact that pallets are having for the environment, we need to collect data about how many pallets are in circulation and how long they remain usable.

Our director, Dr. Laszlo Horvath, has received a new grant from The Pallet Foundation to model the quantity of wooden pallets in circulation in the United States. The Pallet Foundation historically has funded many projects about the pallet market, dating back to the 1990s. Lucia Contreras (Image 1), who graduated with her bachelors in Industrial Production Engineering from the Tecnologico de Costa Rica, was selected to work on this graduate level research project for her Master's degree.

The goal of Lucia's research will be to model/estimate the number of wooden pallets that are in circulation in the U.S. As explained previously, in order to estimate the environmental impact of wooden pallets, we need to have this number. She will then also use this number to estimate how many times wooden pallets are repaired. The current published numbers state that there should be 2 billion wooden pallets in circulation; however, this comes from a study conducted by the Forest Service back in the 1980s.

Lucia's research will use a combination of material flow modeling and econometrics to consider all inputs (new pallets manufactured, pallets repaired and reintroduced, imported pallets), outputs (exported pallets, pallets landfilled), and pallets that are circulated in a system (closed pools and pool pallets). She will analyze all of the collected data to discover the environmental impact of the wooden pallet market.

News – Mary Paz Alvarez and Sean Hobbs graduated this semester!

Image 1. a.) Sean Hobbs and Laszlo Horvath and b.) Mary Paz Alvarez and Laszlo Horvath after their defenses.

The Center for Packaging and Unit Load Design congratulates Mary Paz Alvarez and Sean Hobbs for graduating this semester! Mary received her Ph.D. and Sean his Masters in December 2023.

Sean's research had focused on the "Investigation of new and recovered wood shipping platforms in the U.S. in 2021." He was also featured in a CPULD News article. The results of his research allow for the continued tracking of pallets over the decades. He investigated trends in the usage and types of new wood platforms used by the US pallet industry as well as the same trends for used/recovered pallets. He also looked into the size of manufacturing/remanufacturing companies and collected data on employee numbers, lumber used, and pallet output. After successfully defending his thesis, Sean is currently interviewing with companies.

Mary's Ph.D. research was titled "Predicting the strength of plastic pails supported on flexible pallet deckboards." Mary has been featured multiple recent CPULD News articles about awards she's won. Mary's research showed that symmetrical and asymmetrical loading created different trends when comparing pail/pallet deformation and pail compression strength. She also found that deckboard thickness is relevant when investigating pail failure. These factors should all be taken into account by unit load designers in order to create safer and more sustainable pallets. Mary already has accepted a faculty position at University of Wisconsin Stout and will begin her work as a tenure-track packaging Assistant Professor in January.

"One of the best part of my job is to mentor graduate students and have the privilege to see their professional growth over their time at Virginia Tech," said Laszlo Horvath, CPULD director and an advisor to both students, "and I am fully excited about seeing the accomplishments in the future."

News – New equipment installed in CPULD labs this semester!

Image 1. The new Lansmont TruMotion Unit Load Stability Tester that was installed this semester, Fall 2023, in the innovation space at CPULD labs.

CPULD is excited to announce the arrival of two new pieces of equipment to expand our testing capabilities!

First was our new Lansmont TruMotion Unit Load Stability Tester (Image 1) that was installed earlier this semester, Fall 2023, in the innovation space at CPULD labs. This unique equipment is the first stability tester housed in U.S. educational packaging program. The stability tester will allow CPULD to simulate over-the-road breaking and turning events and help companies create more stable and efficient unit loads. Due to this equipment, our lab is now able to conduct tests for the EUMOS international stability testing standard.

This new capability is part of our Unit Load Stability offerings that consist of field-testing equipment, vibration tables, stretch wrappers, and environmental chambers. In addition to using this equipment to help industry companies, one of our graduate students, Saewhan Kim, is focusing his Ph.D. research on understanding unit load instability during over-the-road transport. He will be helping to develop a design method that will allow companies to engineer unit loads for stability.

CPULD is also expanding our testing capabilities to offer product level shock and fragility testing. Our new Lansmont Model 65/81 shock tester just arrived (Image 2), and we are looking forward to starting to use it in January 2024! With this new equipment, we will be able to exert as much as 600g shock to products and develop damage boundary curves. Shock events can cause damages to the packaging, and the product or its more sensitive

components, and shocks can occur any time during manual handling. Our new shock test system can accurately simulate a range of shock durations and acceleration levels with high repeatability. In addition, the connected Lansmont Test Partner 3 Data Collection System allows us to collect acceleration values from various elements of the packaging system.

We will also use this new capability in our upcoming Advanced Packaging Dynamic (www.unitload.vt.edu/apd) short course that we are offering in March 2024 in collaboration with Lansmont Corporation.

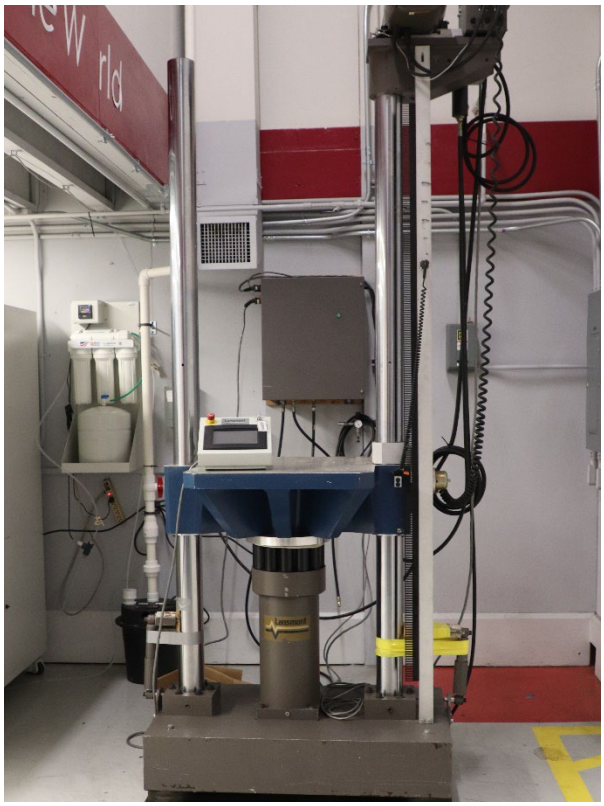

Image 2. CPULD's new Lansmont Model 65/81 shock tester.

News — CPULD students presented at the IAPRI 2023 conference and CPULD will be the host of the IAPRI Membership Conference in 2025

Image 1. Saewhan Kim (Ph.D.), Mary Paz Alvarez (Ph.D.) and Sean Hobbs (Masters) at the 31st IAPRI Members Conference in May 2023.

The 31st Annual International Association of Packaging Research Institutes (IAPRI) Members Conference was in Mumbai, India. Established in 1971, IAPRI is a "unique global network which allows organizations to communicate and develop ideas, exchange experiences and in many cases reduce duplication of effort." CPULD is a longstanding member of IAPRI and is one of its 90-member research/educational institutions from 31 different countries. Three of CPULD's graduate students presented at this year's conference.

Saewhan Kim (CPULD, Ph.D candidate) presented on research about "Predicting the effect of pallet overhang on box compression strength." This research has shown that pallet overhang has a significant effect on box compression strength (BCT); the magnitude of the overhang on the box's short and/or long side, whether adjacent overhang exists, the box size, and the pallet board type are all statistically significant factors in estimating BCT. Multiple linear regression models indicated a great potential for the prediction model to be able to predict the effect of pallet overhang on BCT as it is refined through future studies.

Mary Paz Alvarez (CPULD, Ph.D candidate) spoke on her research "The effect of wooden pallet characteristics on the compression strength of palletized plastic pails." She conducted research to investigate the interactions between pails/drums and pallets. She investigated the potential load bridging and unique stress distributions caused by pails and drums, and also explored how a pallet affects the strength of pails/drums; this research could offer significant cost reductions to the industry.

Seth Capizzi (CPULD, Masters student) explained his research entitled “The evaluation of maximum pallet deflection under dynamic forklift handling conditions.” To determine the dynamic load capacity, a calibration study was conducted using plastic pallets that are already safely used in the industry with a defined load capacity. The identified pallet designs were tested using the reported payload with the testing procedure described in ISO 8611. The deflections of the pallets after 30 min. of creep were recorded and aggregated. This aggregated deflection value was then compared to the values listed in ISO 8611. The research revealed that the deflection limits listed in ISO 8611 testing standard are not stringent enough to allow the movement of unit loads that are not stabilized with stretch film. Seth is currently expanding his research to investigate a wider range of boxes with the overall goal of determining the maximum safe deflection limit for the ISO 8611 standard.

CPULD is excited to announce that the 32nd Annual IAPRI Members Conference will be held in Roanoke, VA in 2025, being hosted by CPULD and VT. The title and theme of the conference is “The future of packaging is circular” (Image 2). It will focus on sustainability issues around the packaging industry. Stay tuned for more information to be distributed as it becomes available!

Image 2. IAPRI Roanoke Member’s Conference in 2025.

~ Continuing Education Opportunities ~

Crate Design and Performance, March 5th-7th, 2024

This is the newest offering of CPULD courses! It will be a 2.5-day, in-person course, held here at Virginia Tech and will inform attendees about the advanced principles of crate design, how to conduct material audits, the basics of packaging and crate design as well as how they work in material handling systems.

Attendees will learn about the interactions between material handling equipment and crates as well as how to go about diagnosing and solving material handling problems. They will also be taken on a tour of a working, state-of-the-art, pallet testing laboratory!

Wood Pallet Design and Performance, May 7th-9th, 2024

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 2.5-day short course (being offered both in-person and virtually) 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!

Advanced Packaging Dynamics, March 12th-14th, 2024

Advanced Packaging Dynamics: Measurements and Simulations teaches an approach that can significantly reduce the cost of distributing products to consumers by understanding how packaging protects products and designing packaging using the latest research data.

This intensive, 2.5 day, in-person (only) course and will inform attendees about the principles of shock, free, forced and random vibration, field data collection practices, sensor selection, laboratory simulations of field data and how to use the obtained information to optimize the packaging and eliminate damage. By the end of the course, the attendees will be able to collect field data, analyze the collected data, and setup laboratory simulations. Attendees will also be taken on a tour of working, state-of-the-art, packaging and pallet testing laboratories!

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

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