### 2018 HPC Spring Meeting

**Friday, April 20, 2018**

Montesi Room, Buckman Hall, Christian Brothers University

650 East Parkway South, Memphis, TN 38104

<table>
<thead>
<tr>
<th>Time</th>
<th>Event</th>
</tr>
</thead>
<tbody>
<tr>
<td>8:30 a.m. – 9:00 a.m.</td>
<td>Check-in/Continental Breakfast</td>
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</tbody>
</table>
| 9:00 am – 9:30 am  | **Evolution of Cold Chain Packaging Materials: An Effort to Become More Sustainable**  
| (30 mins)         | David Nelson  
|                   | Packaging Project Engineer, FedEx                                       |
| 9:30 am – 10:30 am | **Thermoelectric Options for Cold Chain Packaging**  
| (60 mins)         | Sean June  
|                   | Associate Professor, Christian Brothers University                      |
| 10:30 – 10:45     | **Break**                                                              |
| (15 mins)         |                                                                      |
| 10:45 a.m. – 11:45 | **Advantages of Thermoelectric Modules for Active Shipping Containers**  
| (60 mins)         | Steve Scully  
|                   | Founder, Chairman, Chief Scientific Officer, Thaddeus Medical Systems, Inc. |
| 11:45 a.m. – 1:15 pm | **Lunch**  
| (90 mins)         | **New Developments @ the CBU Gadomski School of Engineering**  
|                   | Dick Gadomski  
|                   | CBU Engineering Advisory Board Chair                                    |
| 1:15 p.m. – 2:15 p.m. | **Two-Angle Corrugated Box Corner Design**  
| (60 mins)         | **Semi-Confined Compression Test of Drinking Water Bottles**  
|                   | Pong Malasri  
|                   | Dean of Engineering & Healthcare Packaging Consortium Director  
|                   | Jade Housewirth, Georgina Johns, Yuliana Sanchez-Luna, Brianna Jordan, Eduardo Aguilar, Hunter Howard, and Deliya Duckworth  
|                   | BS in Engineering Management (Packaging Concentration) Major  
|                   | Christian Brothers University                                           |

Campus Map: [http://www.cbu.edu/assets/2091/cbumap2017.pdf](http://www.cbu.edu/assets/2091/cbumap2017.pdf)

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**Active Members**

Bayer Consumer Care, Eethe, Evergreen Packaging, FedEx, GlaxoSmithKline, International Paper, Medtronic, Memphis Bioworks, MicroPort Orthopedics, Olympus Surgical Technologies America, Smith & Nephew, SweetBio, Thaddeus Medical Systems, The Pallet Factory, Wright Medical
Sponsors

FedEx
(www.fedex.com)

Thaddeus Medical Systems
(www.thaddeusmed.com)

Christian Brothers University
(http://www.cbu.edu)

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## Registered Participants

1. Aflaki, James  
   Christian Brothers University

2. Aguilar, Eduardo  
   Christian Brothers University

3. Bonner, April  
   Smith & Nephew

4. Brewer, Jim  
   Nefab Packaging South

5. Cervantes, Vanessa  
   Christian Brothers University

6. Choudhary, Divya  
   Christian Brothers University

7. Couling, Broc  
   Smith & Nephew

8. Davenport, Jazzmyn  
   Christian Brothers University

9. Deas, Jimmy  
   International Paper

10. Dover, Ian  
    Christian Brothers University

11. Duckworth, Deliya  
    Christian Brothers University

12. Edwards, Evan  
    FedEx

13. Ferrante, Joe  
    Smith & Nephew

14. Garcia, Luis  
    MicroPort Orthopedics

15. Gamez, Daniel  
    Christian Brothers University

16. Gadomski, Dick  
    Christian Brothers University

17. Gilman, Jay  
    FedEx

18. Haught, Paul  
    Christian Brothers University

19. Houseworth, Jade  
    Christian Brothers University

20. Jones, Deon  
    Olympus

21. Jordan, Brianna  
    Christian Brothers University

22. June, Sean  
    Christian Brothers University

23. Koch, Chris  
    Christian Brothers University

24. Liu, Henry  
    Christian Brothers University

25. Longo, Michael  
    Christian Brothers University

26. Malasri, Pong  
    Christian Brothers University

27. Martinez, Saira  
    Christian Brothers University

28. Moritz, Brad  
    Thaddeus Medical Systems

29. Nelson, David  
    FedEx

30. Nobes, Geoff  
    Evergreen Packaging

31. Ostrowski, Michael  
    Smith & Nephew

32. Payne, Christopher  
    Christian Brothers University

33. Pham, Rachel  
    Christian Brothers University

34. Ponnumasy, Gokul  
    Nefab Packaging South

35. Pourhashemi, Ali  
    Christian Brothers University

36. Quintanilla, Tino  
    Smith & Nephew

37. Ray, Asit  
    Christian Brothers University

38. Rix, Phillip Ashley  
    Phillip Ashley Chocolates

39. Rodriguez, Luis  
    Christian Brothers University

40. Sanchez, Yuri  
    Christian Brothers University

41. Saucedo, Salvador  
    Christian Brothers University

42. Scully, Steve  
    Thaddeus Medical Systems

43. Snow, Kevesha  
    Christian Brothers University

44. Stevens, Ryne  
    Smith & Nephew

45. Stokes, James  
    Bass River Advisors

46. Swaffer, Marea  
    FedEx

47. Ventura, John  
    Christian Brothers University

48. Waller, Alandria  
    Christian Brothers University

49. Wellford, Brandon  
    Memphis Bioworks

50. Williams, James  
    Smith & Nephew

51. Zhou, Joe  
    FedEx

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**Active Members**

Bayer Consumer Care, Eethe, Evergreen Packaging, FedEx, GlaxoSmithKline, International Paper, Medtronic, Memphis Bioworks, MicroPort Orthopedics, Olympus Surgical Technologies America, Smith & Nephew, SweetBio, Thaddeus Medical Systems, The Pallet Factory, Wright Medical
Evolution of Cold Chain Packaging Materials: An Effort to Become More Sustainable

David Nelson

Abstract: David will present information on the various insulated package materials that FedEx is seeing customers shifting toward in their efforts to be more sustainable with the packaging. He will also talk about some of the inherent risks and performance issues as a result of those changes.

Keywords: Cold Chain; Temperature Sensitive; FedEx; Sustainability

Presenter:

David Nelson - David graduated from the Rochester Institute of Technology with a BS in Packaging Science (1985). After college he took a position as a Packaging Engineer with Douglas Aircraft Company (now Boeing Aircraft) where he worked at specifying and engineering packaging for Spare and Repair parts for the commercial aircraft they manufactured. He also worked in the Integrated Logistics Support team while the Military C-17 Cargo Aircraft was in the Design and Development phase. After leaving Douglass Aircraft in 1991, he took a position with Western Industries Corporation in Oklahoma City, OK. While at Western Industries he engineered cushioned packaging systems for items ranging from computer hard drives to electronic medical devices to paycheck processing equipment. In 1994, he accepted a position with the FedEx Packaging Design and Development department. He has been with FedEx for the past 24 years where he has tested and engineered packaging for a hundreds of different customers’ products that are shipped via FedEx. During his tenure, he has focused more on the Temperature Sensitive aspects of shipping within the FedEx networks.

1 Packaging Project Engineer, FedEx Packaging Design & Development, 789 Progress Rd, Collierville, TN 38017. dlnelson@fedex.com
Thermoelectric Options for Cold Chain Packaging

M. Sean June

Abstract: Thermoelectric devices hold great promise for cold chain packaging. Challenges such as reliability, efficiency, operating range must be addressed before these devices are truly viable. This presentation will address efficiency and operating range as drivers of heat sink size and air moving device requirements. These in turn affect reliability. Finally, choice of thermal interface material may be one of the most critical decisions affecting both the cooling solution and reliability.

Keywords: Thermoelectric; Cold chain Packaging

Presenter:

M. Sean June – Dr. June is an associate professor in the Mechanical Engineering Department of CBU’s Gadomski School of Engineering. Dr. June has taught at the university level as an adjunct or full-time professor for 21-years, and was with IBM for 13 of those years. At IBM Dr. June’s specialty was cooling solutions and thermal interface materials for I, P, and Z-series servers as well as Intel-based servers and PCs.
Advantages of Thermoelectric Modules for Active Shipping Containers

Steve Scully, MD, PhD

Abstract: Thermoelectric modules (Thermoelectric devices, or Peltier devices) have been in use since the 1960’s and currently provide a solution in many industries where a low to moderate amount of heat must be handled. In some cases, they are the only viable solution. Thermoelectric modules often provide substantial advantages over alternative technologies, and can be useful in controlling temperature for temperature-sensitive products that need to be transported. Significant advantages of thermoelectric modules include their small size and weight, precise temperature control, high reliability, and reduced environmental footprint. These features, along with other factors will be discussed in the context of active shipping containers in the logistics space.

Keywords: Thermoelectric device, Thermoelectric module, Peltier device, Active shipping container, Active solution, Cold chain, Sustainability.

Presenter:

Steve Scully - Dr. Scully obtained his BS in Biochemistry at Boston College, continued his studies at MIT, and pursued his Medical degree at the University of College, Dublin, Ireland. After medical school, Dr. Scully went to Cleveland Clinic as an intern in Pediatrics and changed course towards Pathology. He completed his Doctorate in Molecular and Cellular Biology at the University of Massachusetts, Amherst, while focusing his thesis on the transdifferentiation of Glioblastoma Stem Cells and their resistance to current anti-angiogenic treatments. He subsequently went to Mayo Clinic where he was an NIH Fellow in Pharmacogenomics and Autoimmune Neurology. He is currently a Laboratory Director in Minneapolis, MN, and founded Thaddeus Medical Systems in 2014 to eradicate pre-analytical issues in Clinical Pathology (where the majority of all medical testing errors occur). Through creative engineering and the integration of multiple technology sectors, Thaddeus Medical Systems’s first product, the iQ+-ler, will improve diagnostic accuracy and treatment outcomes for patients, and stands to ameliorate the diagnostics and logistics industries.

Steve@thaddeusmed.com; Thaddeus Medical Systems, Inc., 3605 US Highway 52 North, Building 103, Rochester, MN 55901
New Developments @ the CBU Gadomski School of Engineering

Dick Gadomski

Abstract: The Gadomski School of Engineering has entered a major fundraising campaign to upgrade its engineering facility:

- Phase I: New 27K SF “Packaging & Engineering Applied R&D Center” building
- Phase II: Major upgrade/renovation of the existing Benilde Hall engineering lab building
- Phase III: Expansion of the Nolan Engineering Center

The vision and strategic plan for engineering will also be discussed.

Keywords: CBU Engineering; Facility upgrade

Presenter:

Dick Gadomski – Mr. Gadomski earned a BS in Engineering Chemistry from CBU in 1962 and a MS in Mechanical Engineering from UCLA in 1964. From 1964 to 1974, he worked for various companies including North American Aviation, Brown Engineering, Kraft Foods, and BASF. In 1974, he founded PSI Group of Companies in Memphis, TN, and served as its CEO. In 1998, he sold the company to Lurgi, the second largest General Contractor in Europe. He retired in 2001, after doing leadership transition and having company annual sales in excess of $100 Million. Mr. Gadomski, a member of the Memphis Society of Entrepreneurs, has served on the CBU Board of Trustees for over 20 years, including serving as its chair. He led the $70 Million Capital and Endowment Campaign for CBU. He has served as the CBU Engineering Advisory Board Chair since 2014. CBU named the School of Engineering after him in 2016.

1 rtgadomski@comcast.net
VISION
To be recognized for excellence in education locally, nationally, and internationally

MISSION
The mission of the School of Engineering at Christian Brothers University is threefold: (1) to continue the Lasallian tradition through excellence in teaching and focus on the individual student, (2) to prepare graduates for professional careers and advanced study in engineering, and (3) to encourage students to live with moral responsibility and constructive community involvement.

ENROLLMENT
• 500 undergraduate and 300 graduate engineering students
• 30% female students in undergraduate enrollment

QUALITY
• 100% placement rate of graduates within twelve months of graduation
• 100% of graduates will pass a nationally recognized examination/certification upon graduation
• 100% career related work experience involvement
• State-of-the-art engineering facility
• A minimum of four full-time faculty members for each undergraduate engineering program

COLLABORATION
• 25 formal industry partnership agreements

CORE VALUES
• Provide a world-class and relevant education in a faith-based environment
• Sustain a caring and vibrant campus community
• Ensure accessibility and affordability for our students of today and the future
• Embrace innovation in teaching and in all aspects of university life

GOALS
By 2022, the Gadomski School of Engineering will meet the following goals:
Two-Angle Corrugated Box Corner Design

Pong Malasri¹, Jade Housewirth², Georgina Johns², Yuliana Sanchez-Luna², Brianna Jordan², Eduardo Aguilar², Hunter Howard², and Deliya Duckworth²

Abstract: In this study regular corners (one-angle) of 16X12X12 single-wall RSC corrugated box was modified to two-angle corners as shown in Fig. 1. The effect of corner offset is shown in Fig. 2. The box compression strength increases up to certain value of corner offset due to the two angles are in the same vicinity and support one another. However, when the two angles are too far apart, they no longer support one another. The finding is very preliminary and more data is needed using different box sizes.

Keywords: Corrugated boxes; Compression strength; Box corner design

Presenters:

Pong Malasri – Dr. Malasri, ISTA CPLP (Professional Level), has worked on various packaging projects with undergraduate and graduate students at CBU. He currently serves as Editor-in-Chief of the International Journal of Advanced Packaging Technology and Faculty Advisor of CBU TAPPI Student Chapter.

Jade Houseworth, Georgina Johns, Yuliana Sanchez-Luna, Brianna Jordan, Eduardo Aguilar, Hunter Howard, and Deliya Duckworth – All are BSEM (Packaging Concentration) major with Business Administration minor at CBU. Jade, Georgina, Yuliana, Brianna, Eduardo, and Hunter are ISTA CPLP (Technician Level). Jade is President of TAPPI Student Chapter, Yuliana is President of SWE Student Chapter, Georgina is Vice President for both TAPPI and SWE Student Chapters. Jade also serves as Technical Assistant for the International Journal of Advanced Packaging Technology. Deliya is a freshman and starts early in packaging research. Hunter, a CBU baseball player, is double major in BSEM (Packaging) and BBA (Management).

1 Dean of Engineering, Gadomski School of Engineering, Christian Brothers University, 650 E. Parkway South, Memphis, TN 38104. pong@cbu.edu
2 BSEM (Packaging Concentration) Major, Gadomski School of Engineering, Christian Brothers University, 650 E. Parkway South, Memphis, TN 38104. jhousewi@cbu.edu, gjohns@cbu.edu, vsanche1@cbu.edu, bjordan3@cbu.edu, enguila1@cbu.edu, hhoward@cbu.edu, dduckwo1@cbu.edu
Semi-Confined Compression Test of Drinking Water Bottles

Pong Malasri¹, Brianna Jordan², Eduardo Aguilar², Hunter Howard², Jade Housewirth², Georgina Johns², Yuliana Sanchez-Luna², and Deliya Duckworth²

Abstract: The effect of lateral force on vertical compression strength of water bottles is investigated. Four bottles were crushed without later forces (unconfined condition – Fig. a) and with a stretched rubble band (semi-confined condition – Fig. b). A heavy-strength rubble band was used, and its stiffness curve was developed (Fig. c). Lateral force from the rubber band on the bottles can be adjusted by band stretch. Relationship of tension force in the rubber band and vertical compression strength of bottles is shown in Fig. d.
Keywords: Water bottles; Compression strength with lateral force

Presenters:

Pong Malasri – Dr. Malasri, ISTA CPLP (Professional Level), has worked on various packaging projects with undergraduate and graduate students at CBU. He currently serves as Editor-in-Chief of the International Journal of Advanced Packaging Technology and Faculty Advisor of CBU TAPPI Student Chapter.

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PACKAGING PROGRAM AT CBU

PACKAGING CONCENTRATIONS

Bachelor of Science in Engineering Management

Master of Science in Engineering Management

- UNDERGRADUATE & GRADUATE PACKAGING CERTIFICATES
- UNDERGRADUATE PACKAGING MINOR

ISTA
CERTIFIED LABORATORY
- CERTIFIED PACKAGE TESTING LAB

CBU
HEALTHCARE PACKAGING CONSORTIUM
- International Journal of Advanced Packaging Technology (official journal of HPC)

cbu.edu/packaging
Evolution of Cold Chain Packaging Materials: an Effort to Become More Sustainable

CBU Healthcare Consortium, April 20, 2018

Common Insulation Materials

- Radiant Barriers
- Mineral Wool
- Recycled Cotton Fiber
- Recycled PETE
- Paper / Paper Fibers
Some Inherent Concerns with the Materials

- No added Structural Integrity
- More Seams / Gaps
- Some Require Encapsulation
- Lower R-Values
- Core Material Compaction

1” Thick Recycled Cotton Fibers
Two Piece Liner in a Corrugated Box with Dry Ice
Thermal Image of the Exterior Bottom of the Box
24 Hours After Pack Out.

Dry Ice Block

Outer Box Edges

Dew Point
When air is at its dew point and it comes in contact with a surface colder than the air, water will condense on that surface.
Condensation on the Outer Box Surface

Condensation Leaking from Inside the Outer Box
Inside the Box is Saturated with
Water and Ice

How many Fluid Ounces of Condensed Water was Created?

End
2.39 #

Start
2.16 #

3.53 fl. - oz.

Not including water that leaked out of the box.
### Condensation Impact on Box Compression

12 x 12 x 12, 200# Burst Test, C-Flute RSC

<table>
<thead>
<tr>
<th></th>
<th>Peak Force (Lbs.)</th>
<th>Deflection @ Peak (in.)</th>
<th>% Compression Loss</th>
</tr>
</thead>
<tbody>
<tr>
<td>Control</td>
<td>1070</td>
<td>0.77</td>
<td>—</td>
</tr>
<tr>
<td>Empty Box</td>
<td>842</td>
<td>0.72</td>
<td>21</td>
</tr>
<tr>
<td>Test Box</td>
<td>147</td>
<td>0.27</td>
<td>86</td>
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</tbody>
</table>

### In Summary

Keep in mind the condition that your product and packaging will encounter in transit

- Seasonal changes can have an effect on the overall performance of the packaging
- Most Temperature Chamber Testing does not include humidity
- Don’t forget to also perform Dynamic (Drop / Impact, Compression and Vibration) testing on the packaging
- Don’t select your packaging solely on price, but also on performance
- It’s not just a package, it’s a system

**Thank you and enjoy the rest of the conference**
CBU Packaging: 
Present & Future

Pong Malasri

2018 HPC Spring Meeting
Friday, April 20, 2017
Christian Brothers University

Why Choose CBU Engineering?

Fast Growing & Vibrant

CBU Undergraduate Engineering Enrollment By Major

70% enrollment increase from 2012 to 2017
STRATEGIC PLAN 2017-2022

VISION
To be recognized for excellence in education locally, nationally, and internationally.

MISSION
The mission of the School of Engineering at Christian Brothers University is to
provide high-quality educational programs that prepare students for professional
and academic careers. The faculty and staff are committed to excellence in teaching
and learning, research, and community engagement.

ENROLLMENT
- 300 undergraduate and 300 graduate engineering students
- 20% female student in undergraduate enrollment

QUALITY
- 100% placement rate of graduates within twelve months of graduation
- 100% of graduates pass the nationally recognized examination/certification upon graduation
- 100% career related work experience involvement
- State-of-the-art engineering facility
- A minimum of four full-time faculty members for each undergraduate engineering program

COLLABORATION
- 25 formal industry partnership agreements

CORE VALUES
- Provide a world-class and relevant education in a safe, supportive environment
- Foster a caring and inclusive campus community
- Ensure accessibility and affordability for our students today and the future
- Embrace innovation in teaching and in all aspects of university life

GOALS
By 2022, the Gadomski School of Engineering will meet the following goals:

- State-of-the-art engineering facility

Approved by the School of Engineering Faculty & Staff (September 27, 2016)
Approved by the Engineering Advisory Board (August 1, 2017)
State-of-the-Art Engineering Facility

Phase I
Phase II
Phase III

Current & Future Lab Facility

Current
Future
Current Lab Facility

Benilde Hall
(About 20,000 SF)

ISTA Certified Packaging Lab

<table>
<thead>
<tr>
<th>LAB</th>
<th>SF</th>
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<tbody>
<tr>
<td>BE101 - Packaging/Polymer Lab</td>
<td>960</td>
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<tr>
<td>BE103 – Thermoformer Medical Device</td>
<td>515</td>
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<tr>
<td>BE104 - Development Shop</td>
<td>2,770</td>
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<tr>
<td>BE105 - Instrumentation</td>
<td>810</td>
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<tr>
<td>BE106 - Electronics</td>
<td>805</td>
</tr>
<tr>
<td>BE108 - Controls/Power</td>
<td>895</td>
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<tr>
<td>BE109 - Fluids/Heat Transfer (Incline</td>
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<td>Impact Tester)</td>
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<tr>
<td>BE110 - Process Control/Mass Transport</td>
<td>1,045</td>
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<tr>
<td>BE111 - Geotech</td>
<td>580</td>
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<tr>
<td>BE112 - Environmental/Biochem</td>
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<tr>
<td>BE113 - Solids/Packaging</td>
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Future ISTA Certified Thermal Transport Lab

Phase I Lab Facility

Packaging & Engineering Applied R&D Center
(About 28,000 SF)

ISTA Certified Packaging Lab

<table>
<thead>
<tr>
<th>FIRST FLOOR</th>
<th>SF</th>
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<tbody>
<tr>
<td>Additive Mfg</td>
<td>2,000</td>
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<tr>
<td>Corrugated Pkg</td>
<td>1,000</td>
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<tr>
<td>Delivery/Pick-up Area</td>
<td>600</td>
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<tr>
<td>Distribution Pkg Lab</td>
<td>2,000</td>
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<tr>
<td>Packaging Preconditioning Room</td>
<td>500</td>
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<tr>
<td>Thermal Transport Lab</td>
<td>1,000</td>
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<tr>
<td>Lobby</td>
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<tr>
<td>Office/Work</td>
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<tr>
<td>Storage</td>
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<tr>
<td>Circulation</td>
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<td>TOTAL</td>
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<table>
<thead>
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<td>Biochemical/Environmental Lab</td>
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<tr>
<td>Medical/Food/Beverage Pack &amp; Polymer Lab</td>
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<tr>
<td>Multipurpose R&amp;D Lab</td>
<td>1,000</td>
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<tr>
<td>Surface Water Research Lab</td>
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<tr>
<td>Research Group Space</td>
<td>2,000</td>
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<tr>
<td>Classroom 1</td>
<td>800</td>
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<tr>
<td>Classroom 2</td>
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<td>Office/Work</td>
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<tr>
<td>Circulation</td>
<td>3,525</td>
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<td>TOTAL</td>
<td>15,275</td>
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New Equipment

(Courtesy of FedEx Packaging Lab)

Current Packaging Curriculum

<table>
<thead>
<tr>
<th>BS in Engineering Management</th>
<th>Packaging Concentration &amp; Business Administration Minor</th>
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<tbody>
<tr>
<td><strong>Math/Science</strong></td>
<td>Calculus I, Physics I, Chemistry I</td>
</tr>
<tr>
<td><strong>Engineering</strong></td>
<td>CAD, Manufacturing, Mechanics</td>
</tr>
<tr>
<td><strong>Business</strong></td>
<td>Accounting, Finance, Economics, Marketing, Management, Law, Supply Chain, Computer Apps, etc.</td>
</tr>
<tr>
<td><strong>Art</strong></td>
<td>Business Writing, Speech, Moral Values, Digital Imaging, etc.</td>
</tr>
<tr>
<td><strong>Packaging</strong></td>
<td>PKG 101 Intro to Packaging (1 cr.)</td>
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<td></td>
<td>PKG 202 Packaging Lab (2 crs.)</td>
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<td></td>
<td>PKG 315 Packaging Materials (3 crs.)</td>
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<td></td>
<td>PKG 319 Principles of Packaging (3 crs.)</td>
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<td></td>
<td>PKG 321 Healthcare Packaging (3 crs.)</td>
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<tr>
<td></td>
<td>PKG 411 Packaging Development (3 crs.)</td>
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<td></td>
<td>PKG 490 Packaging Projects (3 crs.)</td>
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<td></td>
<td>PKG 495 Packaging Internship (3 crs.)</td>
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<td></td>
<td>PACKCON Magazine Article</td>
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<tr>
<td></td>
<td>ISTA CPLP Technician</td>
</tr>
<tr>
<td></td>
<td>IoPP CPIT</td>
</tr>
<tr>
<td></td>
<td>IESTOC and/or IJAPT Article</td>
</tr>
</tbody>
</table>

Hands-on Component
Workforce Development

PROGRESSION OF EXPERIENCE

EXTERNSHIP
Fall Break
Spring Break
PKG 101
PKG 202
PKG 315
PKG 319
PKG 321

INTERNSHIP
or COOP
PKG 495

PROJECT
PKG 490

FULL-TIME EMPLOYEE

Future Programs

EXISTING
BSEM (PKG)
MSEM (PKG)
ISTA Certified Packaging Lab

FUTURE
MS in Packaging Engineering
ISTA Certified Thermal Transport Lab

FUTURE
BS in Packaging Engineering

FUTURE
Dual Degree
BS in Packaging Engineering & BS in Mechanical Engineering

TIME
Two-Angle Corrugated Box Corner Design

Pong Malasri, Jade Housewirth, Georgina Johns,
Yuliana Sanchez-Luna, Brianna Jordan, Eduardo Aguilar,
Hunter Howard, and Deliya Duckworth

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Christian Brothers University

Corrugated Box Corner Design

Regular Slotted Container (RSC)
Box Compression Strength

A typical, regular slotted container (RSC), carries about 1/3 of load on its four side walls and about 2/3 of load on its four vertical corners.

Thus, improving a box corner would increase box compression strength.
Two-Angle Corner With Corner Offset
16X12X12 RSC Box

<table>
<thead>
<tr>
<th>a (in)</th>
<th>Side Wall Lengths (in)</th>
<th>Corner Wall Length 1.414 a (in)</th>
<th>Total Wall Length (in)</th>
<th>Saving From Original (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>16X12</td>
<td>0</td>
<td>2X16+2X12+4X0 = 56</td>
<td>0</td>
</tr>
<tr>
<td>1</td>
<td>14X10</td>
<td>1.41</td>
<td>2X14+2X10+4X1.41 = 53.64</td>
<td>4.21</td>
</tr>
<tr>
<td>2</td>
<td>12X8</td>
<td>2.83</td>
<td>2X12+2X8+4X2.83 = 51.32</td>
<td>8.36</td>
</tr>
<tr>
<td>3</td>
<td>10X6</td>
<td>4.24</td>
<td>2X10+2X6+4X4.24 = 48.96</td>
<td>12.57</td>
</tr>
</tbody>
</table>

\[(a^2 + a^2)^{0.5} = 1.414 a\]
All specimens were conditioned at 73°F 50% RH for at least 10 hours.
Discussion & Conclusion

• This preliminary study showed that by cutting each corner with a corner offset to form the two-angle corner configuration results in:
  • Shorter total wall length, i.e., saving of materials
  • Stronger box compression strength

• Box strength will increase up to a certain corner offset. It will be less effective if the corner offset passes an optimal value.

• Further study:
  • Different box sizes
  • General equation for finding optimal corner offset
Semi-Confined Compression Test of Drinking Water Bottles

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2018 HPC Spring Meeting
Friday, April 20, 2017
Christian Brothers University

Unconfined vs Confined Compression Tests of Reinforced Concrete Column
Unconfined vs Confined Compression Tests of Soil

Unconfined vs Semi-Confined Compression Tests of Drinking Water Bottles
Rubber Band Stiffness

\[ y = -0.0906x^2 + 2.2281x \]

\[ R^2 = 0.989 \]

<table>
<thead>
<tr>
<th>Displacement (in)</th>
<th>Force (lb)</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.00</td>
<td>0.00</td>
</tr>
<tr>
<td>0.50</td>
<td>1.50</td>
</tr>
<tr>
<td>1.00</td>
<td>2.50</td>
</tr>
<tr>
<td>1.50</td>
<td>4.00</td>
</tr>
<tr>
<td>2.00</td>
<td>4.50</td>
</tr>
<tr>
<td>2.50</td>
<td>5.50</td>
</tr>
<tr>
<td>3.00</td>
<td>6.00</td>
</tr>
<tr>
<td>3.50</td>
<td>6.90</td>
</tr>
<tr>
<td>4.00</td>
<td>7.70</td>
</tr>
<tr>
<td>4.50</td>
<td>8.40</td>
</tr>
<tr>
<td>5.00</td>
<td>9.00</td>
</tr>
<tr>
<td>5.50</td>
<td>9.30</td>
</tr>
<tr>
<td>6.00</td>
<td>9.70</td>
</tr>
<tr>
<td>6.50</td>
<td>9.90</td>
</tr>
<tr>
<td>7.00</td>
<td>10.80</td>
</tr>
<tr>
<td>7.50</td>
<td>11.00</td>
</tr>
<tr>
<td>8.00</td>
<td>11.80</td>
</tr>
<tr>
<td>8.50</td>
<td>12.30</td>
</tr>
<tr>
<td>9.00</td>
<td>12.80</td>
</tr>
<tr>
<td>9.50</td>
<td>13.30</td>
</tr>
<tr>
<td>10.00</td>
<td>13.90</td>
</tr>
</tbody>
</table>

Semi-Confined Compression Strength

<table>
<thead>
<tr>
<th>Stretch (in)</th>
<th>Tension Force in Band (lb)</th>
<th>Pmax 1 (lb)</th>
<th>Pmax 2 (lb)</th>
<th>Pmax 3 (lb)</th>
<th>Pmax avg (lb)</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>0.0</td>
<td>241</td>
<td>214</td>
<td>216</td>
<td>224</td>
</tr>
<tr>
<td>2</td>
<td>4.1</td>
<td>236</td>
<td>279</td>
<td>246</td>
<td>254</td>
</tr>
<tr>
<td>3</td>
<td>5.9</td>
<td>243</td>
<td>256</td>
<td>260</td>
<td>253</td>
</tr>
<tr>
<td>4</td>
<td>7.5</td>
<td>266</td>
<td>273</td>
<td>275</td>
<td>271</td>
</tr>
<tr>
<td>5</td>
<td>8.9</td>
<td>283</td>
<td>235</td>
<td>220</td>
<td>246</td>
</tr>
<tr>
<td>6</td>
<td>10.1</td>
<td>212</td>
<td>212</td>
<td>220</td>
<td>215</td>
</tr>
<tr>
<td>7</td>
<td>11.2</td>
<td>200</td>
<td>175</td>
<td>160</td>
<td>178</td>
</tr>
</tbody>
</table>

\[ y = -1.9915x^2 + 19.579x + 218.64 \]

\[ R^2 = 0.8565 \]
Discussion & Conclusion

• Rubber band stiffness curve is non-linear

• This preliminary study showed that by applying lateral pressure to a pack of drinking water bottles, it would increase the vertical compression strength up to some amount of lateral pressure.

• When too much lateral pressure is applied, the vertical compression strength drops. This is probably due to the fact that the vertical part of bottle wall was squeezed in and it was no longer vertical.

• Further studies:
  • Different band strengths for validation purpose
  • Different numbers of bottles in a pack
  • A way to keep bottles vertical