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Development And Commercialization of Advanced Wood-Based Composites In Maine

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Final Report for Period: 01/2002 - 12/2005**Submitted on:** 05/02/2006**Principal Investigator:** Dagher, H. Joseph .**Award ID:** 0125343**Organization:** University of Maine**Submitted By:****Title:**

Development And Commercialization of Advanced Wood-Based Composites In Maine

Project Participants**Senior Personnel****Name:** Dagher, Habib**Worked for more than 160 Hours:** Yes**Contribution to Project:****Name:** Almquist, Heather**Worked for more than 160 Hours:** No**Contribution to Project:****Name:** Ward, James**Worked for more than 160 Hours:** Yes**Contribution to Project:****Name:** Davids, William**Worked for more than 160 Hours:** Yes**Contribution to Project:****Name:** Lindyberg, Robert**Worked for more than 160 Hours:** Yes**Contribution to Project:**

Management of commercialization demonstration Projects.

Successful \$245,034 grant award from partner Maine Technology Institute to support commercialization.

Success in spinning off new company Maine Marine Manufacturing.

Name: Grimnes, Martin**Worked for more than 160 Hours:** Yes**Contribution to Project:**

Support Commercialization efforts:

1. Development new business spinoff: 'Harbor Technologies', which produces composite pilings and composite pier structures. The company just moved into a new 5,000 ft² manufacturing facility.
2. Helped support development of new business spinoff Maine Marine Manufacturing
3. Developing a business spinoff on reinforced glued laminated beams

Name: Edgar, Russell**Worked for more than 160 Hours:** Yes**Contribution to Project:**

Graduate student at UMaine who is now Manager of wood composites manufacturing at the AEWC Center. He is working on commercialization of three UMaine developed technologies:

1. Delta Strand composite beams. Developing International Code Council building code approval for the product to allow commercialization.
2. Delta Strand composite poles and piles.
3. Netforms panelized roof systems

Name: Fiutak, Jon

Worked for more than 160 Hours: Yes

Contribution to Project:

Assist in commercialization of long-strand composites

Post-doc

Graduate Student

Name: Cherry, Carmen

Worked for more than 160 Hours: Yes

Contribution to Project:

Ph.D. student working on panelized roof systems R&D leading to commercialization. Carmen has written two commercialization proposals from the Maine Technology Insititute, one of which was funded at \$10,000 to conduct a market evaluation.

Name: MacDougald, Shane

Worked for more than 160 Hours: Yes

Contribution to Project:

Shane worked on commercialization of long-strand composites which as led to a Maine spinoff business, as well as on commercialization of composite molding panels with an industrial partner.

Name: Callahan, Stig

Worked for more than 160 Hours: Yes

Contribution to Project:

Name: Fortier, Kenneth

Worked for more than 160 Hours: Yes

Contribution to Project:

Undergraduate Student

Name: Faloon, Julie

Worked for more than 160 Hours: Yes

Contribution to Project:

Julie is an undergraduate student working on commercialization of delta strand wood composite poles

Name: Kenerson, Jonathan

Worked for more than 160 Hours: Yes

Contribution to Project:

Jon worked on commercialization of composite formwork for concrete

Name: Giffen, Matt

Worked for more than 160 Hours: Yes

Contribution to Project:

Matt worked on commercialization of composite formwork technologies for concrete

Name: Nye, Richard

Worked for more than 160 Hours: Yes

Contribution to Project:

Name: McNaughton, Adam

Worked for more than 160 Hours: Yes

Contribution to Project:

Name: Viselli, Anthony
Worked for more than 160 Hours: Yes
Contribution to Project:

Name: Kennerson, Jonathan
Worked for more than 160 Hours: Yes
Contribution to Project:

Name: Ferry, Zachary
Worked for more than 160 Hours: Yes
Contribution to Project:

Name: Tippett, Michael
Worked for more than 160 Hours: Yes
Contribution to Project:

Name: Watson, Gustav
Worked for more than 160 Hours: Yes
Contribution to Project:

Name: Achorn, Nicholas
Worked for more than 160 Hours: Yes
Contribution to Project:

Name: Udhedhe, Olakpe
Worked for more than 160 Hours: Yes
Contribution to Project:

Name: Trask, Keith
Worked for more than 160 Hours: Yes
Contribution to Project:

Name: Wener, Christopher
Worked for more than 160 Hours: Yes
Contribution to Project:

Name: Nash, Jesse
Worked for more than 160 Hours: Yes
Contribution to Project:

Name: Foster, Tony
Worked for more than 160 Hours: Yes
Contribution to Project:

Technician, Programmer

Name: Gibbs, Joel
Worked for more than 160 Hours: Yes
Contribution to Project:

Name: Darling, Vernon

Worked for more than 160 Hours: Yes

Contribution to Project:

Laboratory Operations Manager; mentored students; research support

Name: O'Neill, Shane

Worked for more than 160 Hours: Yes

Contribution to Project:

Name: Boynton, Christopher

Worked for more than 160 Hours: Yes

Contribution to Project:

Assistance with Business plan development

Name: Watt, Chris

Worked for more than 160 Hours: Yes

Contribution to Project:

commercialization specialist

Name: Sanchez, Olivia

Worked for more than 160 Hours: Yes

Contribution to Project:

Research engineer

Name: Crouse, Justin

Worked for more than 160 Hours: Yes

Contribution to Project:

industrial outreach

Other Participant

Name: Gould, Alan

Worked for more than 160 Hours: Yes

Contribution to Project:

Alan is an industry partner who worked on a successful Maine Technology Institute Grant to commercialize composite formwork for concrete. He spun off a new startup company.

Name: Adam, Stephen

Worked for more than 160 Hours: Yes

Contribution to Project:

business plan development

Research Experience for Undergraduates

Organizational Partners

Maine Technology Institute

Provided funding for 4 collaborative projects:

\$250,000 for commercialization of composites

\$10,000 for commercialization of panelized roof systems

\$10,000 for commercialization of composite formwork for concrete

\$10,000 for commercialization of composite molding

Composites Technology Centers

This is a State-funded business incubator who has two locations in Sanford and in Greenville, Maine. The incubators have partnered to assist in commercialization efforts, including connecting with industry, and providing space for spinoff businesses.

Hodgdon Yachts

Hodgdon conducted collaborative research and supported research leading to commercialization of wood composites boats. The R&D conducted at UMaine resulted in significant reduction in boat weight and labor costs.

Harbor Technologies

Harbor Technologies is a new spinoff business in Maine that developed their product line in the AEWG laboratory.

Maine Secure Composites

New spinoff business in Maine

Hancock Lumber

Worked collaboratively to develop/commercialize composite molding products

Other Collaborators or Contacts**Activities and Findings****Research and Education Activities: (See PDF version submitted by PI at the end of the report)**

This is a commercialization project with the goal to increase innovation and commercialization of technologies developed in the Advanced Engineered Wood Composites Center.

As a result of the NSF PFI award, the Center has been able to significantly grow innovation activities as follows:

1. Industrial partners grew from 12/year in 2000 to 38/year in 2004
2. Patents grew from 0 in 2000 to 8 cumulative by 2004
3. Undergraduate students supported in research and innovation activities grew from 29/year in 2000 to 75/year in 2004.
4. Graduate students supported grew to 20/year in 2004.
5. Total funding from industry grew from less than \$50,000/yr in 2000 to \$328,000 in 2004
6. Total Federal Funding for research and innovation activities grew from \$3,700,000 in 2000 to \$5,000,000 in 2004.
7. New spinoff businesses grew from 0 in 2000 to 4 in 2004

Findings:

The PFI grant resulted in the Advanced Engineered Wood Composites Center major leap in commercialization activities, new patent generation, student education in innovative activities, and external dollars leveraged for these innovative activities from the private and public sectors.

Training and Development:

1. Commercialization
2. Patent preparation
3. Industry needs
4. Business plan preparation
5. Composite materials research and development

Outreach Activities:

1. Organized two International Conferences on Advanced Engineered wood Composites
2. Participated in over 50 presentations/year throughout Maine and the US on importance of research, development, and its ties to education and economic development (see attached annual report).
3. Conducted public tours of the Composites laboratory, particularly with primary, secondary, and high-school students. Over 1,000 visitors participate every year,

Journal Publications

Lavery, R., "Advanced Engineered Wood Composites: Innovative Technologies for Maine's Forest Products Industry", Forest Products Journal, p. 18, vol. 52, (2002). Published,

Dagher, H.J., Bragdon, M.M., Lindyberg R. F., "Advanced fiber-reinforced polymer-wood composites in transportation applications", Transportation Research Record, p. 237, vol. , (2002). Published,

Books or Other One-time Publications

Web/Internet Site

URL(s):

www.aewc.umaine.edu

Description:

The commercialization activities, new laboratory facilities, new demonstration projects, new human resources, leveraged bhy the NSF PFI award are contained throughout the web site.

Other Specific Products

Product Type:

Other inventions

Product Description:

8 new patents which the NSF-PFI has helped leverage have been applied for or issued (please see web site www.aewc.umaine.edu)

Sharing Information:

A number of private entities and public entities have expressed interest or has funded more work related to the new patents. Please see FY 03 attached annual report)

Contributions

Contributions within Discipline:

1. Results of PFI success resulted in the development of a New Innovation Center at the University of Maine. The 50,000 ft² Center, to be constructed in 2005-2006, has been funded by a \$1.5 million State of Maine bond. Construction will start in Summer 04.
2. Two Composite materials incubators were constructed and funded in Maine. The first incubator (Sanford, Maine) is currengtly full at capacity. The second was just opened for business (2005), in Greenville, Maine.
3. A new Patent and Copyright Policy was Developed for UMaine (2002)
4. Over 30 private companies every year now utilize the Advanced Engineered Wood Composites Center's for development of Innovative technologies (see attached FY03 Annual Report)
5. New advanced composites were developed and approved by the International Code Council,
6. New Acceptance Criteria for reinforced wood composites were approved by the International Code Council (AC 128). This allows new companies to start producing and selling reinforced wood composites products.
7. A new ASTM Standard for reinforced wood composites are being balloted (2005).

Contributions to Other Disciplines:

See Activities and Findings

Contributions to Human Resource Development:

The PFI program has allowed the Advanced Engineered Wood Composites Center to leverage funding that supported the following faculty, graduate students, and undergraduate students to participate in innovation activities (2001-2005):

Cooperating Faculty leveraged:

'2001 =13
'2002 =14
'2003 =14
'2004 =13

Graduate Students leveraged Ph.D.

'2001 =2
'2002 =6
'2003 =4
'2004 =6

Graduate Students leveraged M.S.

'2001 =10
'2002 =11
'2003 =20
'2004 =17

Undergraduate Students leveraged

'2001 =52
'2002 =75
'2003 =86
'2004 =75

Contributions to Resources for Research and Education:

The AEWCC Center physical facilities for research were increased by 15,000 ft². The success in Innovation and Commercialization activities through the NSF PFI award has resulted in the State and University of Maine investing \$4,500,000 into the Advanced Engineered Wood Composites Center's physical facilities.

Contributions Beyond Science and Engineering:

See Findings and Activities

Conference Proceedings

Categories for which nothing is reported:

Any Book
Any Conference

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US Army Center



The Year in Review

July 1, 2003 – June 30, 2004

Research Leadership:

- **Awarded over \$9 million in external funding for research, facilities, and equipment** from the State of Maine Jobs Bond, U.S. Department of Agriculture, Office of Naval Research, U.S. Coast Guard, and individual donors.
- **Published 49 articles** in journals and scholarly publications including *Composites Part A: Applied Science and Manufacturing*, *Forest Products Journal*, *Wood and Fiber Science*, *Journal of Composites for Construction*, *Journal of Applied Polymer Science*, *Journal of Materials in Civil Engineering*.
- **51 presentations at conferences and meetings** including the *Progress in Woodfibre-Plastic Conference*, *Conference of American Composites Manufacturers Association*, *6th ASCE Engineering Mechanics Conference*, *14th International Conference on Composite Materials and the Forest Products Society 58th Annual Meeting*.

Interdisciplinary Education:

- **75 undergraduate student research assistants** from 17 academic departments.
- **24 graduate student researchers**
- Enrolled 4 students in the **Graduate Certificate in Advanced Engineered Wood Composites; two graduates.**
- 2 AEW publications, with graduate students as first authors, rated by ISI Web of Knowledge as **most outstanding articles published during the year** in the fields of engineering manufacturing and materials science/composites.

Economic Development:

- **Six start-up companies founded using AEW technologies:** Maine Marine Manufacturing of Boothbay Harbor; Strong and Weiland of Hampden; Maine Wood Innovations of Portland; Advanced Engineering Solutions of Veazie; and Entwood LLC of Brewer.
- **31 product testing and development projects** for 28 companies (15 of these companies based in Maine).
- Developed a **new testing program to assist Maine boatbuilders** comply with mandated Coast Guard specifications.
- **One patent granted:** Wood Composite Panels for Disaster-Resistant Construction; and **four patent applications pending:** Wood Pile Protection and Structural Restoration, Composites Pressure Resin Infusion System (ComPRIS); Sheet Piling Panels with Elongated Voids; and Long Strand Structural Composite Lumber.
- Implementation of Maine Technology Institute **Cluster Enhancement Award** to stimulate interaction and collaborative R & D activity among composite subclusters in Maine and to develop and implement a longterm plan to invigorate the Maine composites industry.
- **Collaborated with Maine companies to secure product development funding** through Maine Technology Institute awards; projects included extruded woodplastic lobster trap runners with Sealure; extruded plastic products from scrap materials with Gates Formed Fiber; composite roof system with NetForms, Inc.; and composite oars with Porter Woodworking.

Awards and Honors:

- **NEXT list**, a list produced by *Mainebiz* profiling a dozen successful Maine leaders who are shaping the state's future and making a difference in its economy, named Habib Dagher, AEW Center Director, to the first annual list in September 2003.
- **Governor's Award for Accomplishment in Maine's Natural Resource-Based Industry** presented November 17, 2003 to the AEW Center for leadership in developing sustainable uses of Maine's natural resources.
- **Finance Authority of Maine (FAME) Honorary Mention, Excellence in Business and Education**, presented November 18, 2003 to the AEW Center for its work in forming partnerships with Maine businesses.
- **New England Higher Education Excellence Award** presented February 17, 2004 to Habib Dagher, AEW Center Director, for exceptional leadership in behalf of higher education and the advancement of educational opportunity.
- **University of Maine Student Research and Creative Achievement Award** (April 12 – 13, 2004), First Place in the Engineering I category to AEW graduate student Diogo Baptista for his poster presentation, *A Simple Model to Predict the Dynamic Behavior of Spherical Sessile Droplets on an Impermeable Surface*; honors to Ben Herzog for his oral presentation, *The Composites Pressure Resin Infusion System (ComPRIS)*
- **2004 Markwardt Wood Engineering Award** for the most outstanding research paper in the field of wood as an engineering material presented June 29, 2004 to Stephen Shaler, AEW Associate Director, for his paper *Mechanical Properties of Individual Southern Pine Fibers. Part I. Determination and Variability of Stress-Strain Curves With Respect to Tree Height and Juvenility*, published in *Wood and Fiber Science* with co-authors L. Groom and L. Mott.

Other:

- **Visit by General Paul Kern, U.S. Army Materiel Command**, to review AEW for designation as a U.S. Army Center of Excellence on Advanced Materials and Structures in Construction.
- With funding from a State of Maine referendum bond issue the AEW **laboratories expanded from 33,000 ft² to 48,000 ft²**. The expansion will provide space for a state of the art Resin Infusion Composites Reliability (RiCoR) Laboratory, expanded extrusion process development area; and special projects in product development.
- **Groundbreaking Ceremony** for new construction on November 20, 2003 featured speeches by Governor Baldacci, Chancellor Westphal and President Hoff.
- With support from the Office of Naval Research, initiated an **exchange with Chilean wood researchers at the University of Chile and the University of Concepcion** which will lead to collaborative wood composite research and student and faculty exchanges.
- **Extensive broadcast and print media coverage** in both local and national press including: over 25 articles in Maine daily newspapers as well as features in several national trade publications including *Pallet Magazine*, *ForestWeb*, *Composites News*, and *Composites Technologies*.
- AEW disaster resistant housing OSB panels featured on Maine Public Broadcasting series, **Quest: Investigating Our World, The Inventors of New England**.
- **Hosted visiting scholars** from Monash University, Monash, Australia; U.S. Air Force Academy; Rutgers University; Virginia Technological University; Forest Research Institute, Rotarura, New Zealand; Beijing Forestry University; University of Tennessee; Clark Atlanta University; and the Norwegian University of Science and Technology, Trondheim, Norway.
- **Over 1200 people toured the AEW labs** in FY 2004 including students from Maine primary and secondary schools; public officials including Governor Baldacci and his cabinet, Maine's congressional delegation, state legislators; members of trade associations (Maine

Wood Products Association, Maine Forest Products Council, Maine Composites Alliance, Bangor Chamber of Commerce, and the National Association of Homebuilders), and numerous representatives of international as well as Maine-based composites manufacturers.

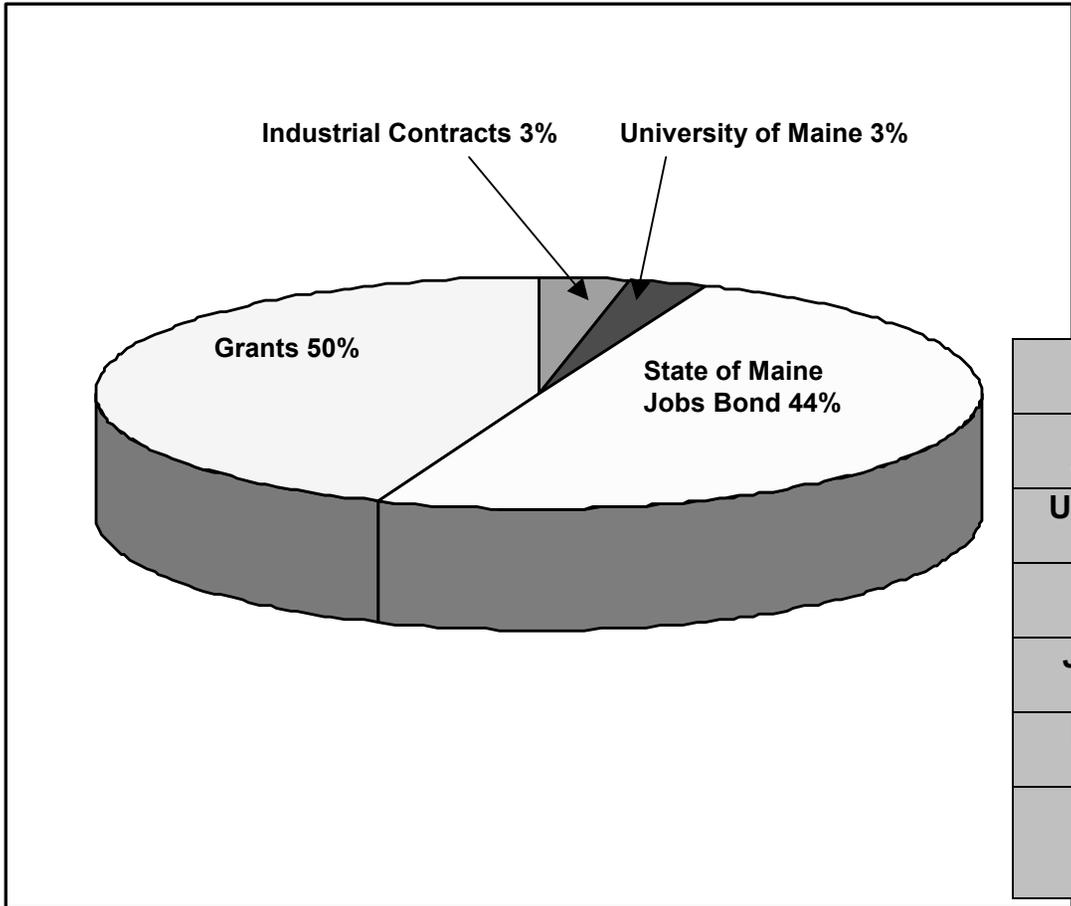
- Held three **professional development events**: *Advances in Engineered Wood Composites*, a two-day seminar for civil and structural engineers, architects and builders; *Putting Research and Development to Work for Your Wood Products Company* for members of the Maine Wood Products Association; and *Materials Technology Demonstration Day for Maine Boat Builders and Composites Manufacturers*; and sponsored the Forest Products Society Northeast Section Annual Conference, Opportunities in Wood Thermoplastic Composites.

Funding History

Date	Activity	Income from Grants and Contracts	State and UMaine Funding	Leveraging of State funds (State to out of state funds)
1997-2000	NSF EPSCOR Grant to start building a composites research program and laboratory	\$3 million	\$1 million	1 to 3
1997-2000	Fundraising for laboratory construction	\$3.8 million	\$0.35 million	1 to 10
1997-2001	Fundraising for laboratory equipment through a number of grants	\$ 3 million	\$ 1 million	1 to 3
FY 2000	External funding through grants and industry contracts	\$ 3.7 million	\$0.3 million	1 to 12
June 1, 2000	OFFICIAL OPENING CEREMONY FOR LABORATORY			
FY 2001	External funding through grants and industry contracts	\$4.3 million	\$0.3 million	1 to 12
FY 2002	External funding through grants and industry contracts	\$4.1 million	\$0.3 million	1 to 13
FY 2003	External funding through grants and industry contracts	\$4.1 million	\$0.3 million	1 to 13
FY 2004	External funding through grants and industry contracts	\$5.3 million	\$0.3 million	1 to 13
FY 2004	Funding for lab expansion Through Maine Jobs Bond	0	\$4.5 million	
Total Funding		\$31.3	\$8.35 million	1 to 4

Funding Sources for FY 2004

**Total Income FY 2004:
\$10,169,943**



Source of Funding	Amount	Percentage
Industrial Contracts	\$328,246	3%
University of Maine	\$299,000	3%
Grants	\$5,041,697	50%
Jobs Bond	\$4,500,000	44%
Individual Giving	\$1,000	-
TOTAL	\$10,169,943	100%

Awards

NEXT list, a list produced by *Mainebiz* profiling a dozen successful Maine leaders who are shaping the state's future and making a difference in its economy, named Habib Dagher, AEWCCenter Director, to the first annual list in September 2003.

Governor's Award for Accomplishment in Maine's Natural Resource-Based Industry presented November 17, 2003 to the AEWCCenter for leadership in developing sustainable uses of Maine's natural resources.

Finance Authority of Maine (FAME) Honorary Mention, Excellence in Business and Education, presented November 18, 2003 to the AEWCCenter for its work in forming partnerships with Maine businesses.

New England Higher Education Excellence Award presented February 17, 2004 to Habib Dagher, AEWCCenter Director, for exceptional leadership in behalf of higher education and the advancement of educational opportunity.

2004 Distinguished Maine Professor Award, given to Eric Landis, Professor of Civil and Environmental Engineering and member of the AEWCCenter faculty on April 13, 2004.

University of Maine Student Research and Creative Achievement Award, (April 12 – 13, 2004) First Place in the Engineering I category to Diogo Baptista for his poster presentation, *A Simple Model to Predict the Dynamic Behavior of Spherical Sessile Droplets on an Impermeable Surface*; honors to Ben Herzog for his oral presentation, *The Composites Pressure Resin Infusion System (ComPRIS)*.

AEWCCenter student researchers inducted into the **Francis Crowe Society** (May 2004), in anticipation of the future contributions they will make to society as practicing engineers: Kenneth Abbott, Brian Beaulieu, Sarah Blake, Carly Desjardins, Christopher Fournier, Ruth Gray, Adam Haskell, Smaanthe Perkins, Matthew Randall, and Luke Stinchfield.

2004 Forest Products Society Wood Award (2nd Place) to AEWCCenter graduate student William Tze on June 29, 2004 for his paper *Evaluation of Load Transfer at the Cellulosic-Fiber/Polymer Interphase Using a Micro-Raman Tensile Test*.

2004 Markwardt Wood Engineering Award for the most outstanding research paper in the field of wood as an engineering material presented June 29, 2004 to Stephen Shaler, AEWCCenter Associate Director, for his paper *Mechanical Properties of Individual Southern Pine Fibers. Part I. Determination and Variability of Stress-Strain Curves With Respect to Tree Height and Juvenility*, published in *Wood and Fiber Science* with co-authors L. Groom and L. Mott.

2004 Society of Wood Science and Technology Student Poster Competition (3rd place) awarded June 18, 2004 to AEWCCenter graduate student Diogo Baptista for his poster *A Simple Model to Predict the Dynamic Behavior of Spherical Sessile Droplets on an Impermeable Surface*.

Publications

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Davids WG, Richie M, Gamache C. Flexural Fatigue of Glulam Beams with Fiber-Reinforced Polymer Tension Reinforcing. In Proceedings of the ASCE Structures Congress 2004: Building on the Past, Securing the Future. 2004 May 22 - 26. Nashville, TN (CD-ROM).

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Herzog B, Goodell B, Lopez-Anido R, Muszynski L, Gardner DJ, Tascioglu C. Effect of creosote and copper naphthenate preservative treatments on properties of FRP composite materials used for wood reinforcement. Journal of Advanced Materials (in press).

Herzog B, Goodell B, Lopez-Anido R. Electron microprobe imaging for the characterization of polymer matrix composites. Composites Part A: Applied Science and Manufacturing. 2004 (in press).

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Davids WG, Richie M, Gamache C. Flexural fatigue of glulam beams with fiber-reinforced polymer tension reinforcing. ASCE Structures Congress 2004: Building on the Past, Securing the Future; 2004 May 22 - 26; Nashville, TN.

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Landis E. Using lattice models to bridge wood microstructure to mechanical properties. University of New Brunswick Forest Engineering Seminar; 2004 May 10

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Muszynski L, Lagana R, Shaler SM. Optical measurement of Poisson Effect in small spruce specimens in changing climate conditions. Forest Products Society, 58th Annual Meeting; 2004 June 27 - 30; Grand Rapids, MI.

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Muszynski L. Development of the AEW Center. Department of Mechanics and Thermal Techniques, Agricultural University of Poznan; 2004 May 28; Poznan, Poland.

Muszynski L. Optical deformation measurement methods in wood research", Chalmers University of Technology; 2004 June 7; Goteborg, Sweden.

Muszynski L. Optical deformation measurement methods in wood research", Tratek, the Swedish Institute for Wood Technology Research; 2004 June 8; Stockholm, Sweden.

Muszynski L. Optical methods in wood research. Department of Structural Engineering and Mechanics, Chalmers University of Technology; 2004 June 7; Goteborg, Sweden.

Muszynski L. Optical methods in wood research. Tratek, the Swedish Institute for Wood Technology Research; 2004 June 8; Sweden.

Muszynski L. Optical methods in wood research. VTT Building and Transport Department, VTT Technical Research Centre of Finland; 2004 June 11.

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Shaler SM, Landis E, Muszynski L, Cheng Q. X-Ray microtomography (XMT) and image analysis techniques for visualization and quantification of microstructural material features. Forest Products Society, 58th Annual Meeting; 2004. June 27 - 30; Grand Rapids, MI.

Son J, Gardner DJ. DMTA and DSC of extruded polypropylene wood-plastic composite lumber cooled at different post die temperatures. Progress in Woodfibre-Plastic Composites Conference; 2004 May 10 - 11; Toronto, Canada.

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Patents

Patents Awarded:

Title	Inventor(s)	Award Date	Number
Prestressing System for Wood Structures And Elements	Dagher, H.J. and Abdel-Magrid, Beckry	January 2001	6,170,209
Resin Starved Panel Application for Glulam Beams	Dagher, H.J. and Shaler, S.M.	August 2001	6,281,148
Modular Fiber Reinforced Polymer Composite Structural Panel System	Lopez-Anido, R. and GangaRao, H.V.S.	October 2001	6,309,732
Modular Fiber Reinforced Polymer(FRP)Composite Deck System	Lopez-Anido, R. and GangaRao, H.V.S	September 2002	6,455,131
Building Construction Configuration	Dagher, H.J.	December 2002	6,490,834
Wood Composite Panels for Disaster-Resistant Construction	Dagher, H.J. and Davids, W.	April 2003	European Patent Entitled
Modular Fiber Reinforced Polymer Composite Deck System	Lopez-Anido, R., GangaRao H.V.S. and Barbero, Ever J.	April 2003	6,544,624
Wood Composite Panels for Disaster-Resistant Construction	Dagher, H.J., Davids, W. G.	March 2004	6,699,575

Patent Applications:

Title	Inventor(s)	Application Date	Number
Wood Pile Protection and Structural Restoration	Lopez-Anido, R., Sandford, T.C. Michael, A.P.	July 2, 2002	10/188,553
Composites Pressure Resin Infusion System (ComPRIS) to produce Fiber	Goodell, B., Lopez-Anido, R. Herzog, B.	December 30, 2002	10/732,584
Sheet Piling Panels with Elongated Voids Application	Dagher, H.J., Lopez-Anido, R.	2003	Provisional
Long Strand Structural Composite Lumber	Edgar, R., Shaler, S., Dagher, H.	July 1, 2003	60/484,068

Proposals Submitted/Awarded

Date Submitted	Title	Agency	PI(s)	Amount Requested	Date Awarded	Amount Awarded
11/21/02	A Fiber-Based Approach for Connecting Wood Structure to Mechanical Properties	USDA	Davids, Landis	\$140,000	8/1/03	\$140,000
11/25/02	Hardwood Tree & Stand Attributes Relevant to Lumber Mechanical Properties	USDA	Lindyberg, Egan	\$50,700	8/1/03	\$50,700
2/27/03	Restressed FRP-Glulam Girder Bridge	MDOT	Dagher	\$345,000	12/1/03	\$345,000
4/30/03	Extruded Wood-Plastic Retaining Wall for Maine Maritime Academy	USDA	Lindyberg	\$40,448	10/1/03	\$40,448
7/18/03	New England Wood Utilization Research: 2003 – 2006	USDA	Dagher, Gardiner, Goodell, Shaler	\$807,486	10/1/03	\$807,486
8/6/03	Advanced Engineered Lumber Pier and Retaining Walls for USCG Shore Facilities	USCG	Dagher, Gardner, Lindyberg, Lopez-Anido Shaler,	\$975,000	9/10/03	\$975,000
8/20/03	Testing of Solid-Sawn and Wood Composite Timber Bridge Mats	USDA	Lindyberg	\$12,990	9/1/03	\$12,990
8/22/03	Resin Infusion Composites Reliability (RiCoR) Laboratory		Lopez-Anido, Dagher, Muszynski	\$490,184	Declined	
9/15/03	ONR International Field Office Visitor Support Program	ONR	Shaler	\$12,976	10/3/2003	\$12,976
9/15/03	REU Site in Advanced Engineered Wood Composites	NSF	Landis	\$244,861	Declined	
9/17/03	Development of Wood Plastic Lumber for Low-Temperature Exterior Applications	USDA	Gardner	\$42,200	11/5/04	\$42,200
10/24/03	Reliability of Sandwich Composites for Navy Structures	ONR	Dagher, Lopez-Anido	\$1,113,151	Declined	
10/28/03	In-Situ Characterization of the Dynamic Strength of Marine Sandwich Composites	DOD	Landis, Peterson	\$537,021	Declined	

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Date Submitted	Title	Agency	PI(s)	Amount Requested	Date Awarded	Amount Awarded
11/24/03	Lightweight Composite Decks	MDOT	Dagher	\$400,000	Pending	
12/17/03	Advanced Technologies and Processes for Manufacturing Energy-Efficient Wood Composite Lumber	DOE	Gardner	\$160,210	Declined	
1/23/04	Pan American Collaboration on Wood Composites	ONR	Shaler, Dagher, Gardner, Goodell, Lopez-Anido	\$150,000	3/17/04	\$150,000
2/16/04	Phase II: Effect of Processing Parameters on Reliability of VARTM/SCRIMP Composite Panels	ONR	Dagher, Landis, Davids, Lopez-Anido	\$1,510,000	3/29/04	\$1,510,000
2/16/04	Hygro-mechanical Characteristics of 12 North American Wood Species	USDA	Muszynski, Shaler	\$395,962	Declined	
2/16/04	Product and Process Modifications Allowing for Use of High Density Hardwoods as Furnish for Structural Composite Lumber	USDA	Shaler, Edgar, Boynton	\$439,495	Declined	
3/08/04	Improving the Seakeeping Performance of the MkV Patrol Craft	ONR	Lindyberg	\$860,000	3/30/04	\$860,000
4/29/04	IGERT: Biocomposite Materials in the Built Environment – Training	NSF	Goodell, Jellison, Landis, Lopez-Anido, Meyer, Peterson	\$2,912,141	Pending	
4/30/04	Nonconventional Ultra-Lightweight FOB Shelter Construction Phase I	DOD	Dagher, Davids, Gardner, Goodell, Landis, Lindyberg, Lopez-Anido, Shaler	\$49,904	6/30/04	\$49,904
5/28/04	Technology Transition Support Plan for Inflatable Composites	U.S. Army Natick Center of Excellence	Dagher	\$25,000	6/8/04	\$25,000
6/1/04	Nonlinear Nondestructive Evaluation of Sandwich Composites Yr 3	NASA	Peterson	\$19,993	6/1/04	\$19,993
			Total	\$11,734,722		\$5,041,697

Staff

Name	Position	Education
Beckry Abdel-Magid	Visiting Professor – Composite Materials Engineering	Ph.D. 1986 University of Wisconsin – Madison, P.E.
Chris Boynton	Grants Manager/Fiscal Officer	M.S. 2003 University of Maine
George C. Criner	Professor – Agricultural and Resource Economics	Ph.D. 1983 Washington State University
Justin Crouse	Research Associate; ISO Coordinator	B.A. 1995 Wesleyan University
Habib J. Dagher	AEWC Director, Professor of Civil/Structural Engineering, BIW Professor of Structural Engineering	Ph.D. 1985 University of Wisconsin – Madison, P.E.
Harold Z. Daniel	Associate Professor of Marketing	Ph.D. 1997 University of Connecticut
Vernon Darling	Laboratory Operations Manager	A.B. Troy State University
William G. Davids	Assistant Professor of Civil/Structural Engineering	Ph.D. 1998 University of Washington, P.E.
Russell Edgar	Wood Research Scientist	M.S., 2004 University of Maine
David Field	Professor of Forest Resources; Edwin L. Giddings Professor of Forest Policy	Ph.D. 1974 Purdue University
Douglas Gardner	Professor of Wood Science and Technology	Ph.D. 1985 Mississippi State University
Joel Gibbs	Laboratory Engineering Specialist	
Barry Goodell	Professor of Wood Science and Technology	Ph.D. 1983 Oregon State University
Mac Gray	Associate Professor of Civil Engineering Technology	M.S. 1975 University of Maine, P.E.

Name	Position	Education
Martin Grimnes	Composites Industry Specialist	
Eric N. Landis	Associate Professor of Civil Engineering	Ph.D. 1993 Northwestern University, P.E.
Roberta Laverty	Communications Specialist	M.P.A. State University of New York at Albany
Robert Lindyberg	Manager of Technical Services	Ph.D. 2000 University of Maine
Roberto Lopez-Anido	Assistant Professor of Civil and Environmental Engineering	Ph.D. 1995 West Virginia University
Ellen Manzo	Manager of Funded Accounts	Husson College 1976
Shane McDougall	Research Engineer	M.S. 2003 University of Maine
Robert Milner	Visiting Professor	Monash University, Monash, Australia
Lech Muszynski	Associate Scientist	Ph.D. 1997 Agricultural University of Poznan
Shane O'Neill	Research Associate	Graduate Certificate in Advanced Engineered Wood Composites, 2003, University of Maine
Doreen Parent	Administrative Associate	
Michael L. Peterson	Assistant Professor of Mechanical Engineering	Ph.D. 1993 Northwestern University
Ciprian Pirvu	Postdoctoral Research Associate	Ph.D. 2000 Gifu University
Robert W. Rice	Professor of Wood Science and Forest Engineering	Ph.D. 1988 Virginia Polytechnic Institute
Olivia Sanchez	Research Engineer	M.S. 2002 University of Maine

Name	Position	Education
Stephen Shaler	AEWC Associate Director, Professor of Wood Science and Technology	Ph.D. 1986 Pennsylvania State University
Marcy Smith	Administrative Associate II	
Jungil Son	Postdoctoral Research Associate	Ph.D. 2000 Seoul National University
Luke Stinchfield	Laboratory Engineering Specialist	B.S. 2004 University of Maine
James Ward	University of Maine Exec Dir of Research and Economic Development	M.S. 1989 University of New Hampshire
Chris Watt	Commercialization Manager	M.S. 1993 Mississippi State University
Steve Wrona	Network Specialist	Microsoft Certified Professional

Graduate Students

Name	Degree Program and Academic Department	Research Topic
Rui Diogo Baptista	M.S., Department of Forest Management	Surface Science & Wood Coatings
Joshua Botting	M.S., Department of Mechanical Engineering (awarded 2003)	Design of FRP Reinforced Timber Guard Rails
Jason Campbell	M.S., Department of Civil and Environmental Engineering	Composite Temporary Deck Panels
Qingzheng Cheng	M.S., Department of Forest Management	Damage Assessment of Wood Polymer Composites
Carmen Cherry	Ph.D., Department of Civil and Environmental Engineering	Model, Analyze and Design a Composite Panel Roof Diaphragm System for Lateral Loads
Matthew Dura	M.S., Department of Civil and Environmental Engineering	Development of Wood/Plastic Composite Sheet Walls
Russell Edgar	M.S., Department of Forest Management (awarded 2003)	Properties of Long Strand Structural Composite Lumber from Low Grade Northeastern Hardwoods
Fadi El-Chiti	M.S., Department of Mechanical Engineering	Structural Reliability of FRP Composites
Imad El-Chiti	M.S., Department of Civil and Environmental Engineering (awarded 2004)	Alternative Technology for the Design and Construction of Short-Apan Buried Concrete Arch Bridges
Fayad Ghassan	M.S., Department of Civil and Environmental Engineering	Probabilistic Analysis of FRP Composite Laminated Plates Using Monte Carlo Simulation
Adam Haskell	M.S., Department of Civil and Environmental Engineering	Fatigue Characterization of Sandwich Composite Panels using the Hydromat Test System with FOS Embedded Sensors and Full-Field 3D DIC Measurements
Benjamin Herzog	M.S., Department of Forest Management (awarded 2004) Graduate Certificate in Advanced Engineered Wood Composites (awarded 2004)	Composite Fabrication Processing

Name	Degree Program and Academic Department	Research Topic
Ratislav Lagana	Ph.D. Department of Forest Management (awarded 2004)	Mechanosorptive Properties of Wood
Keith Martin	M.S. Department of Civil and Environmental Engineering (awarded 2004)	Development of Disaster Resistant Structures Utilizing FRP Reinforced Sheathing Panels
Shane McDougall	M.S. Department of Civil and Environmental Engineering	Commercialization of Hardwood Glulam Product
Paul Melrose	M.S. Department of Mechanical Engineering (awarded 2004)	Durability of Scrimp Composites
Shane O'Neill	Ph.D. Department of Forest Management; Graduate Certificate in Advanced Engineered Wood Composites (awarded 2003)	Modification, Utilization and Characterization of Wood-Plastic Composites
Matthew Peterson	M.S., Department of Forest Management	Adhesive Bonding of Wood Plastic Composites
Matthew Richie	M.S. Department of Civil and Environmental Engineering (awarded 2003)	Fatigue Testing of Reinforced Structural Steel in Glulam Bridge Girders
Benjamin Souza	M.S., Structural Engineering	Fracture Mechanics Characterization of Wood-FRP Composite Materials Fabricated by a Resin Transfer Molding Process
Paul Stiglbauer	M.S. Department of Forest Management (awarded 2003)	Powder Coating Wood Substrates
William Tze	Ph.D. Department of Forest Management (awarded 2003)	The Effects of Interfacial Chemistry on the Deformation Micromechanics of Wood-Fiber/Polymer Composites
Xinfeng Xie	Ph.D. Department of Forest Management	Wood Carbonization
Xuelian Zhang	Ph.D., Department of Forest Management	Improved Adhesive Application System for Wood Strand-Based Composites

Undergraduate Students

Student	Hometown	State	Major
Kenneth Abbott	Readfield	ME	Mechanical Engineering
Nicholas Achorn	Bangor	ME	Civil Engineering
Alexander Baker	Frankfort	ME	Mechanical Engineering
Nicholas Baser	Old Town	ME	Forestry
Brian Beaulieu	Wells	ME	Civil Engineering
Nathan Belz	Readfield	ME	Civil Engineering
Adam Benedict	West Boothbay	ME	Electrical Engineering
Amanda Birmingham	Millinocket	ME	Civil Engineering
Sarah Blake	Old Town	ME	Mechanical Engineering
Matthew Bodwell	Long Valley	NJ	Mechanical Engineering
Lindsey Brangwynne	Rome	ME	Business Administration
Andrew Brinks	Portage	MI	Civil Engineering
Ethan Brush	Fairfax	VT	Mechanical Engineering
Stig Callahan	Orono	ME	Electrical Engineering
Jason Campbell	Bangor	ME	Civil Engineering
Michael Charette	Old Town	ME	Civil Engineering
Nicholas Charles	Augusta	ME	Mechanical Engineering

Student	Hometown	State	Major
Meghan Chute	Bowdoin	ME	Journalism
Mack Conachen	Racine	WI	Civil Engineering
Ryan Crawford	Freeport	ME	Mechanical Engineering
Michael Crowell	Charlotte	NC	Engineering Science and Mechanics
Seth D'Amour	Minot	ME	Electrical Engineering
Alberto Davilla	Orono	ME	Mechanical Engineering
Justin Dean	Brownville	ME	Business
Lydia Deere-MacLeod	Belfast	ME	Geology
Emily Ann Deane	Guilford	ME	
Carly Desjardins	Madawaska	ME	Civil Engineering
Justin Desjarlais	Otisville	MI	Physics/Mathmatics
Daniel Diffin	Oxford	ME	Civil Engineering
Jonathan Dvorak	Old Town	ME	Civil Engineering
Ryan Fisher	Oakland	ME	Mechanical Engineering
Christopher Fournier	Biddeford	ME	Civil Engineering
Matthew Giffin	Chelsea	ME	Engineering Physics
William Gramlich	Holden	ME	Civil Engineering
Keith Gray	Hollis	ME	Civil Engineering
Adam Greenlaw	Waterville	ME	Civil Engineering

Student	Hometown	State	Major
Joseph Grenier	Alton	ME	Civil Engineering
Benjamin Hall	Pittsfield	ME	Civil Engineering
James Hall	Machias	ME	Civil Engineering
Austini Harrell	Wilton	ME	Civil Engineering
Eben Henderson	Ellsworth	ME	Mechanical Engineering
Zachary Jones	East Boothbay	ME	Mechanical Engineering
Jonathan Kenerson	Levant	ME	Civil Engineering
Alan Kinne	Damariscotta	ME	Mechanical Engineering
Jay Kinzer	Orono	ME	Mechanical Engineering
Elizabeth Laverty	Milo	ME	Psychology
Adam McNaughton	Newport	ME	Mechanical Engineering
Matthew Morris	Milo	ME	Civil Engineering
Christopher Mundie	West Baldwin	ME	Civil Engineering
Richard Nye	Raymond	ME	Mechanical Engineering
Eoin O'Connor	Orono	ME	
Keith Pearson	Holden	ME	Mechanical Engineering
Samantha Perkind	Bangor	ME	Civil Engineering
Ryan Peters	Newport	ME	Construction Management Technology
Ian Pillsbury	Gardiner	ME	Civil Engineering
Matthew Randall	Kennebunkport	ME	Civil Engineering

Student	Hometown	State	Major
Nicholas Reil	North Berwick	ME	Mechanical Engineering
Ariel Reuning	Bangor	ME	Civil Engineering
Katherine Rice	Veazie	ME	Chemical Engineering
Krista Ricupero	Southwick	MA	Civil Engineering
Christine Riker	West Olive	MI	Mathmatics/Physics
Jonathan Robinson	Thornton	IN	Architectural Engineering
Michael St. Pierre	Bangor	ME	Civil Engineering
Katherine Stephens	Harpswell	ME	Civil Engineering
Luke Stinchfield	Anson	ME	Mechanical Engineering
Winfield Swanton	Holden	ME	Computer Engineering
Joshua Tomblin	Rockland	ME	Civil Engineering
Kevin Trainor	Bangor	ME	
Adam Turner	Gardiner	ME	Civil Engineering
James Upshaw	Norman	OK	Industrial Engineering
Anthony Viselli	Bangor	ME	Civil Engineering
Nicholas Walters	Mifflinville	PA	Parks, Recreation and Tourism
Guston Watson	Fryeburg	ME	Mechanical Engineering
Kyle Wentworth	Dover Foxcroft	ME	Civil Engineering
Henry Wong	West Palm Beach	FL	Math

The AEW Center
University of Maine
Activities and Findings

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Introduction: PFI Activities and Findings

Participation in NSF's Partnerships for Innovation program has been a catalyst for a theme of innovation permeating all aspects of the AEW Center's work – education, research and economic development. This focus on innovation has spread beyond the

Center and to the wider University of Maine campus as well as to the Maine composites industry. During the period of the grant, the Center has worked on campus and beyond with partners in private industry, government, and trade and business development organizations to integrate education, research and development into a coherent, focused initiative for strengthening Maine's wood/nonwood composites manufacturing sector.

Results of PFI funding have included:

➤ **Education for Innovation.**

An important component of the Center's success has been its ability to attract an interdisciplinary mix of hundreds of University of Maine graduate and undergraduate students who find support for their research and enhancement of their classroom experience as members of the Center's research teams. The AEWCCenter provides students with a rich and comprehensive introduction to R & D and innovation through: (1) an interdisciplinary, experiential learning environment; (2) an industrial laboratory which introduces students to issues of safety, regulation, cost efficiencies, project management, human relations, and leadership; (3) daily contact with faculty coaches; (4) teamwork focusing on goals and deliverables; (5) role models and an introduction to the wider economy through frequent contact with AEWCCenter's industrial partners including small companies as well as large multi-national corporations.

Students are involved in all aspects of Center operations. They participate in Center governance; they are full research partners included as inventors on patent applications and authoring scholarly papers; they participate fully in the Center's ISO testing (the only students in the nation to be included in this work); they often assume responsibility for research design; they perform public relations.

In the following supporting materials, details of AEWCCenter student activities in innovative R & D are provided. This student activity attests to the impact of AEWCCenter's focus on innovation. Many AEWCCenter students go beyond the paradigm of laboratory research and get caught by the excitement, the rewards and the feeling of efficacy which comes from innovative entrepreneurial activity.

One example which illustrates this student involvement is the case of Anthony Viselli who came to work at the Center with PFI funding. Anthony, an undergraduate civil engineering major, began working on a research team doing concept development work. This work led to the invention of a tamper proof, secure shipping container. Anthony's technical and professional skills grew along with the project which resulted in a spin-off business funded by a DHS SBIR award. As a full member of the research team, Anthony set up complex lab demonstrations; presented research findings to visiting scientists; and generally took personal responsibility for the success of the project. Recently, he was given responsibility to



design and manufacture a prototype shipping container which would demonstrate the properties of new materials being developed in the Center's labs. This prototype container was used to demonstrate the use of these new materials during a recent site visit by Dept of Homeland Security personnel. The University of Maine was well-represented by Anthony who projected not only talent and intelligence but also a professionalism and entrepreneurship unusual in an undergraduate student. In this case, Anthony did more than accomplish the task; his work enabled UMaine to acquire funding to continue this important homeland security work. Anthony was recently selected as UMaine's Student Employee of the Year; he has also been named the State of Maine's undergraduate student employee of the year and is now competing at the regional level. This undergraduate's personal growth and accomplishments as well as the success of a start-up composites manufacturing company are directly attributable to PFI funding.

➤ **Research for Innovation**

Specifics of AEW's research activities are explicated in the following material with details of publications and patents. During the period of PFI funding, the Center was able to take its research agenda to the next level – being awarded larger and more comprehensive research funding. Several months ago, AEW won a \$7 Million contract from the US Army to develop composite materials to protect the troops in Iraq, and to reduce the weight of construction materials. This funding was in great measure the result of AEW's ability to demonstrate the depth of its laboratory capacities, the breadth of its ongoing research projects, and its ability to be innovative – to respond to real world needs with dispatch and creativity. The U.S. Army research is needed now to protect soldiers in the field; AEW research is over a year ahead of schedule and commercialization activities are already in progress. PFI set the stage for this rapid response which will have the double benefit of protecting troops and creating new manufacturing opportunities in Maine.

➤ **PFI and Economic Development in Maine's Composites Manufacturing Sector**

Concern for the Maine economy is central to AEW operations. Because of PFI, the Center is a highly visible player in the future of the state's economy. PFI has enabled the Center to work with Maine's composites manufacturing sector in a number of ways:

AEW maintains an active schedule of industrial outreach. Typically this outreach begins with a manufacturer's visit to the Center's laboratories where visitors learn about the Center's capacities to do R & D in its pilot plants and testing laboratories. This leads to conversations about product development and/or diversification. Often, concepts from these conversations result in companies partnering with AEW to write proposals and obtain seed funding from the Maine Technology Institute. In some cases, this seed funding leads to larger (\$100,000+) development funding with companies eventually "graduating" to SBIR funding.

AEW maintains close ties with its PFI partners. As AEW became more and more involved in entrepreneurial development and innovation, it also became more and more involved with its PFI partners. Active, frequent and ongoing relationships exist with

Maine's Composites Technology Development Centers (incubators), the Maine Department of Economic and Community Development, the Maine Office of Innovation, regional economic development organizations, the Maine Composites Alliance, the Maine Forest Products Council and the Maine Wood Products Association. Collaborative innovation work with these partners takes many forms: AEWEC sponsored professional development events; meetings with companies which the Governor's Office and Maine DECD are attempting to attract to the state; technical assistance to Maine's composites incubators, to name a few.

AEWC has leveraged its PFI work to obtain additional innovation funding. A Cluster Enhancement Grant from the Maine Technology Institute (\$575,000) has enabled the Center to stimulate Maine composite manufacturers' communication and collaboration. Recently, the State of Maine was awarded \$11 million in workforce development funding to focus on the state's boatbuilding composites manufacturers. This competitive award (13 projects selected from over 150 proposals) was possible because of AEWEC's formative PFI work with Maine's boatbuilding sector.

Spin-off companies have resulted from AEWEC's innovation work. As AEWEC's innovation work has gained momentum over the latter months of the grant, several spin-offs have been realized.

Maine Marine Manufacturing, LLC (Boothbay, Harbor ME) is a new business spinoff resulting from a partnership between AEWEC and Hodgdon Yachts. Using designs developed at UM, MMM is currently producing the first prototype of the Mark V.1, an 83 ft US Navy Seals high-speed patrol boat. Unlike the current Mark V aluminum hull boat, UMaine's Mark V.1 advanced composite hull absorbs repeated impacts as it skims across the waves thus protecting crews from serious spinal injuries. MMM is being positioned to bid on ten Mark V.1 boats, in 1988 (over \$100 million in contracts).

Harbor Technologies Inc (Brunswick, ME) is a new business spinoff producing an advanced corrosion-resistant composite piling and pier system for waterfront construction. The new company just opened (Fall 05) a manufacturing facility in Brunswick, and just won a \$1 million order for the composite piles for the Belfast waterfront. The company is bidding projects around the US and the World. One project is a \$15 million piling program for the United Arab Emirates for the construction of a luxury offshore island. The advanced composite piling and pier systems, were developed and tested by AEWEC in partnership with Mr. Martin Grimnes.

Maine Secure Composites (Orono, ME) is a new AEWEC business spinoff that has won a Department of Homeland Security Advanced Research Program Agency contract to develop a next-generation 'smart' composite shipping container that can detect intrusions. The advanced container will prevent terrorists from placing bombs in containers coming to the US. MSC has competed with over 100 groups around the country for the contract, and is one of 6 recipients of the prestigious contract; the remaining 5 recipients include multi-billion \$ firms such as GE. DHS recently praised the AEWEC prototype composite container, and is preparing to award MSC a Phase II contract to produce full-size containers for limited testing.

➤ **Innovation on the UMaine campus.**

PFI has had spillover effects which have had an impact on the entire UMaine campus. At present an Innovation Center is being constructed and staffed. This Innovation Center will be a place where students, faculty and staff can find the information and resources to start a knowledge-based business. The goal of the Center is to give students the knowledge, tools and inspiration to become innovators and entrepreneurs. The Center will offer Innovation Engineering, a new curriculum at UMaine to teach innovation development skills, and entrepreneurship courses. Participants will receive support from the Center's staff, including an on-site business counselor.

Not only has the spirit of PFI driven campus innovation, also PFI funded research is being used in the design and construction of the Center. The roof of the building is being constructed using a panelized roofing technology developed by an AEWC student working with a Maine start-up company and funded by a Maine Technology Institute seed grant.

AEWC Center Timeline



**The AEW Center
 Summary 2002 - 2005**

Graduate Students M.S.	11	20	17	15
	23	20	25	15
Proposals \$ Requested	\$5,773,788	\$6,632,458	\$11,734,722	\$9,252,695
Proposals Funded #	16	10	15	12
Proposals Amount Funded	\$3,917,813	\$3,814,555	\$5,041,697	\$4,707,999
Industrial Coop # of contracts	38	38	31	45
Industrial Coop Total Revenue	\$169,067	\$280,237	\$328,246	\$259,662
Technical Reports	36	20	27	41
Publications #	33	56	49	46
Presentations #	37	41	51	38
Patents	2	4	1	0
Full Time Staff	16	16	22	21
Cooperating Faculty	14	14	13	13
Graduate Students Ph.D.	6	4	6	10

FY 2002: The Year in Review

Education Leader:

- **Employed 96 undergraduate students** from 12 different academic departments; 74 of these undergraduate students were from Maine.
- Provided a **living laboratory for 48 senior marketing students** from UMaine's School of Business. These senior business students developed marketing plans for AEWFC products in fulfillment of their senior capstone project.
- Site for the **National Science Foundation's Research Experience for Undergraduates** which brings 10 students from throughout the United States to do summer research projects at the University of Maine.
- **16 graduate students** from four academic departments – Civil and Environmental Engineering, Mechanical Engineering, Forest Management, and Wood Science and Technology.
- Initiated the **Graduate Certificate in Advanced Engineered Wood Composites**, a 16 credit advanced certificate program integrating civil engineering, composite technologies, wood science, and adhesives technology.
- Maintained an active schedule of **community education through on-site tours** for community organizations and schools, including the Economic Development Council of Maine, the Piscataquis County Economic Development Council, the Maine Forest Products Council, Belfast High School, Mount Desert High School, and the Wabanaki Center.
- Participated in **special educational events** including National Engineers Week, Expand Your Horizons, and FAME's College Awareness Project 2001.

Economic Development:

- **Product development and testing assistance to over 100 Maine companies** including Bath Iron Works, H & H Marine, Sherman Lumber, JSI Store Fixtures and Keiser Industries.
- **Partnerships** with the Maine Composites Alliance, Maine Science and Technology Foundation, Maine Forest Products Council, Maine Technology Development Centers, Maine Manufacturing Extension Partnership, the Legislative Roundtable on the Future of the Forest Products Industry and others.
- Organized the **Maine Bioproducts Initiative**, a working group including members of the UMaine faculty, the Governor's subCabinet for Natural Resources, the Northeast Governors' Coalition and industry partners, to foster sustainable bioproducts development in Maine.
- Selected as one of the **National Science Foundation's Partners for Innovation**, a program supporting innovation of new products, processes, systems and services to realize productivity and entrepreneurship in Maine's economy.

FY 2003: The Year in Review

Economic Development

- ◆ **Start-up of Engineered Materials of Maine (EMM)**, a commercial spin-off of AEW, licensed to produce Advanced Engineered Lumber (AEL), a wood composite construction product utilizing low grade hardwoods. AEW developed the product, obtained national building code approval, assisted with business planning and gaining access to start-up financing and continues to provide product testing and technical assistance to EMM. EMM, located in Bangor, will ramp up to 75 jobs with a \$4.7 million annual payroll within 3 years.
- ◆ Received \$250,000 **Maine Technology Institute Cluster Enhancement Award**: (1) to stimulate Maine composite manufacturers' communication and collaboration; and, (2) to invigorate Maine composite R & D activities
- ◆ **Product testing and development for 37 companies** (14 Maine-based) for a total income of \$280,237 from industrial contracts. Income from industrial contracts has doubled since FY 2001 and increased over \$100,000 from FY 2002.
- ◆ Developed a **facilities expansion plan** to accommodate increased laboratory and student and staff workspace; and **secured \$6 million in State of Maine funding** through the **Jobs Bond** to finance this expansion.

Research

- ◆ Ongoing **research and development** of composite materials and products including structural beams, construction panels, bridge and pier decking, structural components for ship hulls, water resistant coatings for wood, disaster resistant housing. "Near to market" products include composite wrapping for marine piling repair and composite I-joists.
- ◆ Secured **research funding totaling \$3.8 million** from federal and state of Maine sources including the Office of Naval Research, the United States Department of Agriculture, National Institute of Standards and Technology, the U.S. Coast Guard and the Maine Technology Institute.
- ◆ **Published 52 articles in journals** including *Composites Science and Technology*, *Forest Products Journal*, *Industrial Marketing Management*, *Journal of Adhesion Science and Technology*, *Journal of Composites for Construction*, and *Wood and Fiber Science*.
- ◆ **Forty invited presentations at scholarly meetings and conferences** including ASCE Structures Congress, 34th International SAMPE Technical Conference, 2nd International Conference of the European Society for Wood Mechanics, 7th World Conference on Timber Engineering, 10th U.S.-Japan Conference on Composite Materials, and the Forest Products Society 57th Annual Meeting
- ◆ **Awarded 4 patents** for inventions of a modular fiber reinforced polymer decking system, a building construction configuration, and wood composite panels for disaster resistant construction; 2 patent applications pending.

- ◆ AEWG faculty had chapters in or co-authored **3 books**: *Wettability and Adhesion*; *Fracture and Fatigue in Wood*; and *Biotechnology in the Pulp and Paper Industry*.
- ◆ Commenced a \$1 million multi-year research project for the **Office of Naval Research** to evaluate the effects of environmental conditions during processing on the structural reliability of VARTM/SCRIMP composite panels used in ship structures.
- ◆ In partnership with the College of Engineering and the College of Natural Sciences, Forestry and Agriculture, developed a plan for a **University Transportation Center for Waterfront and Multimodal Transportation Infrastructure**, presented the plan to the Maine Congressional Delegation, the U.S. House of Representatives Committee on Transportation and Infrastructure, and the Federal Highway Administration.
- ◆ Developed a plan for a **U.S. Army Center of Excellence** to support Army transformation through composites R & D and in collaboration with UMS Chancellor Westphal and UM campus administrators presented the plan to senior staff of the U.S. Army.
- ◆ **Faculty leadership and participation in scholarly organizations and societies** including editors for the *Journal of Materials in Civil Engineering*, *Journal of Advanced Materials*, and the *Journal of Adhesion Science and Technology*; and membership on working committees of the Society of Experimental Mechanics, Forest Products Society, American Chemical Society, Society of Wood Science & Technology, American Society of Civil Engineers, and the New England Transportation Consortium.
- ◆ Over **25 paper reviews for journals** including *Journal of Composites for Construction*, *Journal of Advanced Materials*, *Journal of Structural Engineering*, and *Journal of Materials in Civil Engineering*, *Journal of Engineering Mechanics*, *Forest Products Journal*, *International Journal of Adhesion and Adhesives*, and *Journal of Adhesion Science and Technology*.

Educational Innovation

- ◆ **Twenty graduate students and 86 undergraduate student workers** from 12 academic departments worked at the Center on funded research projects as well as industrial R & D.
- ◆ The **only ISO 17025 certified industrial testing laboratory incorporating students into research teams**.
- ◆ Developed a **Program for Student Innovation & Entrepreneurship** to provide entrepreneurial education for engineering, science, and business students and to forge new pathways for students to move from the classroom to the Maine economy. Implementation will commence in Fall 03 with the offering of **INT 598: Entrepreneurship**.
- ◆ Established the **Graduate Certificate Program in Advanced Engineered Wood Composites** which had one graduate in December of 2002 and two enrolled students during the Spring 2003 semester
- ◆ Hosted **distinguished lecturers** including: Dr. Jeremy Warnes of the Federal Forest Products Research Group for New Zealand; Dr. Chris Risbrudt, Director of the USDA Forest Products Laboratory; Drs. Heiko Thoeman and Christian Heinemann of the University of Hamburg; Dr. John Lesko, Virginia Tech.

- ◆ Hosted a **delegation from Universidad de Chile and other Chilean institutions** and initiated dialogue on potential cooperative activities between the University of Maine and Chilean universities.
- ◆ Hosted 11 students through the **National Science Foundation Research Experience for Undergraduates (REU) Program**. The program seeks to attract a diversified pool of talented students into careers in science and engineering and to help ensure that they receive the best education possible. It also provides University of Maine science and engineering units an opportunity to recruit outstanding graduate students who have been selected for the REU program.
- ◆ Maintained an **active and ongoing schedule of student recruitment through tours for prospective students** including Expanding Your Horizons, University of Maine Open Houses for Prospective Students, Forest Explorations Day, as well as tours for classes of students from Hampden Academy, Winthrop High School, Old Town, and John Bapst High School.
- ◆ **Off-campus outreach recruiting activities** including Asa C. Adams School Career Awareness Day, Maine Engineers Week Expo, Maine Science and Technology Fair, and Boothbay High School Composites in Shipbuilding Day.

FY 2004: The Year in Review

Research Leadership:

- **Awarded over \$9 million in external funding for research, facilities, and equipment** from the State of Maine Jobs Bond, U.S. Department of Agriculture, Office of Naval Research, U.S. Coast Guard, and individual donors.
- **Published 49 articles** in journals and scholarly publications including *Composites Part A: Applied Science and Manufacturing*, *Forest Products Journal*, *Wood and Fiber Science*, *Journal of Composites for Construction*, *Journal of Applied Polymer Science*, *Journal of Materials in Civil Engineering*.
- **51 presentations at conferences and meetings** including the *Progress in Woodfibre-Plastic Conference*, *Conference of American Composites Manufacturers Association*, *6th ASCE Engineering Mechanics Conference*, *14th International Conference on Composite Materials and the Forest Products Society 58th Annual Meeting*.

Interdisciplinary Education:

- **75 undergraduate student research assistants** from 17 academic departments.
- **24 graduate student researchers**
- Enrolled 4 students in the **Graduate Certificate in Advanced Engineered Wood Composites; two graduates.**
- 2 AEWC publications, with graduate students as first authors, rated by ISI Web of Knowledge as **most outstanding articles published during the year** in the fields of engineering manufacturing and materials science/composites.

Economic Development:

- **Six start-up companies founded using AEWC technologies:** Maine Marine Manufacturing of Boothbay Harbor; Strong and Weiland of Hampden; Maine Wood Innovations of Portland; Advanced Engineering Solutions of Veazie; and Entwood LLC of Brewer.
- **31 product testing and development projects** for 28 companies (15 of these companies based in Maine).
- Developed a **new testing program to assist Maine boatbuilders** comply with mandated Coast Guard specifications.
- **One patent granted:** Wood Composite Panels for Disaster-Resistant Construction; and **four patent applications pending:** Wood Pile Protection and Structural Restoration, Composites Pressure Resin Infusion System (ComPRIS); Sheet Piling Panels with Elongated Voids; and Long Strand Structural Composite Lumber.
- Implementation of Maine Technology Institute **Cluster Enhancement Award** to stimulate interaction and collaborative R & D activity among composite subclusters in Maine and to develop and implement a longterm plan to invigorate the Maine composites industry.
- **Collaborated with Maine companies to secure product development funding** through Maine Technology Institute awards; projects included extruded woodplastic lobster trap runners with Sealure; extruded plastic products from scrap materials with Gates Formed Fiber; composite roof system with NetForms, Inc.; and composite oars with Porter Woodworking.

Other:

- **Visit by General Paul Kern, U.S. Army Materiel Command**, to review AEW C for designation as a U.S. Army Center of Excellence on Advanced Materials and Structures in Construction.
- With funding from a State of Maine referendum bond issue the AEW C **laboratories expanded from 33,000 ft² to 48,000 ft²** . The expansion will provide space for a state of the art Resin Infusion Composites Reliability (RiCoR) Laboratory, expanded extrusion process development area; and special projects in product development.
- **Groundbreaking Ceremony** for new construction on November 20, 2003 featured speeches by Governor Baldacci, Chancellor Westphal and President Hoff.
- With support from the Office of Naval Research, initiated an **exchange with Chilean wood researchers at the University of Chile and the University of Concepcion** which will lead to collaborative wood composite research and student and faculty exchanges.
- **Extensive broadcast and print media coverage** in both local and national press including: over 25 articles in Maine daily newspapers as well as features in several national trade publications including Pallet Magazine, ForestWeb, Composites News, and Composites Technologies.
- AEW C disaster resistant housing OSB panels featured on Maine Public Broadcasting series, **Quest: Investigating Our World, The Inventors of New England.**
- **Hosted visiting scholars** from Monash University, Monash, Australia; U.S. Air Force Academy; Rutgers University; Virginia Technological University; Forest Research Institute, Rotarura, New Zealand; Beijing Forestry University; University of Tennessee; Clark Atlanta University; and the Norwegian University of Science and Technology, Trondheim, Norway.
- **Over 1200 people toured the AEW C labs** in FY 2004 including students from Maine primary and secondary schools; public officials including Governor Baldacci and his cabinet, Maine's congressional delegation, state legislators; members of trade associations (Maine Wood Products Association, Maine Forest Products Council, Maine Composites Alliance, Bangor Chamber of Commerce, and the National Association of Homebuilders), and numerous representatives of international as well as Maine-based composites manufacturers.
- Held three **professional development events**: *Advances in Engineered Wood Composites*, a two-day seminar for civil and structural engineers, architects and builders; *Putting Research and Development to Work for Your Wood Products Company* for members of the Maine Wood Products Association; and *Materials Technology Demonstration Day for Maine Boat Builders and Composites Manufacturers*; and sponsored the Forest Products Society Northeast Section Annual Conference, Opportunities in Wood Thermoplastic Composites.

FY 2005: The Year in Review

Research Leadership:

- Awarded \$4.7 million in extramural research funding resulting from 15 submitted proposals.
- Published 46 articles in journals and scholarly publications including Bioresource Technology, Composites Part A: Applied Science and Manufacturing, Environmental Science and Technology, Forest Products Journal, Holzforschung, Journal of Advanced Materials, Journal of Applied Polymer Science, Journal of Bridge Engineering, Journal of Composites for Construction, Journal of Testing and Evaluation, Wood and Fiber Science, and Wood Science and Technology.
- 38 presentations at conferences and meetings including the 8th International Conference on Woodfiber-Plastic Composites, 59th Annual Meeting of the Forest Products Society, 2nd Wood Fibre Polymer Composites Symposium, International Symposium on Wood Science - Education and Research Programmes, and American Composites Manufacturers Association COMPOSITES 2004.

Interdisciplinary Education:

- 68 undergraduate student researchers from 12 academic departments were on AEW C's payroll.
- Sponsored 25 graduate students from 5 academic departments.
- Developed an AEW C Student Handbook, a comprehensive introduction to university human resources policies and procedures, safety rules and training, and AEW C's ISO quality management system.

Economic Development:

- Awarded a \$6.2 million multi-year contract with the U.S. Army to conduct research on high-strength structures for military applications. This project will lead to better protection for U.S. troops, provide learning opportunities for AEW C students, open up business procurement opportunities for Maine companies, and create jobs for 35 additional research personnel at UMaine.
- 45 product testing and development projects for 34 companies (11 based in Maine).
- Five patent applications pending.
- New spin off company, Maine Secure Composites, awarded Department of Homeland Security competitive grant.
- Received Maine Technology Institute cluster enhancement award funding to **expand AEW C's wood polymer extrusion research and commercialization capacities** in six major categories: compounding and pelletization, agglomeration, injection molding, co-extrusion, foamed extrusion, and analysis and testing. This initiative enables AEW C to build on R & D work with Maine companies such as Hancock Lumber, Shape Global Technology and Correct Building Products.
- On May 6, 2005, opened **15,000 sq. ft. of new facilities** (funded by a 2003 state bond issue) including new polymer extrusion capacities, a resin infusion lab and an OSB/OSL pilot plant. These new capacities have led to product development initiatives for Maine businesses including:

A **new panelized roof system** uses panels that allow construction of cathedral ceilings with no roof trusses. The panels are insulated, internally vented and can accommodate long spans under heavy snow loads. This project is being conducted for a new startup Maine company, NETFORMS, located in Falmouth. The firm has received Maine Technology Institute (MTI) seed funding to evaluate the technology. MTI funds are being sought to complete the design and testing of the new roof system under snow and high wind loading.

Another research project uses what engineers call **Delta-strand wood composites** that are made from pulpwood-grade logs and are three times stronger than the original wood achieved by randomizing the defects in the wood structure and densely packing the strands by utilizing the delta geometry. The University has applied for a patent for this technology.

A third project underway in the new laboratory addition is a study of Maine wood species to develop **Oriented Strand Lumber (OSL)** studs, joists, beams, and headers. OSL consists of wood strands that are bonded together with the grain running parallel to the axis of the member.

- Formed **partnership with Hodgdon Yachts, East Boothbay, ME, to build a prototype special operations boat for the U.S. Navy**. The project will showcase the qualities of resin-fiber composite materials in military vessels and has the potential to position Hodgdon for future Navy construction as well as to propel Maine boat builders into an industry niche not currently being filled in the U.S.
- Worked with the **Greenville Business Incubator**, a composites technology development center, to identify and support tenants.
- Developed a process to **recycle float rope traditionally used in Maine's lobster industry but recently outlawed by federal regulations**; AEWEC researchers have perfected the process of grinding up the old rope, removing the sand and seaweed and producing a material which can be recycled into numerous other products. As a result of this innovation, millions of pounds of discarded line could be diverted from landfills, recycled products could be developed and Maine companies could benefit.

Other:

- Hosted Maine's congressional delegation, Maine's Commissioner of Economic and Community Development and representatives of the U.S. Army Corps of Engineers and the US Army Natick Solder Center at a **ceremony announcing \$6.2 million in army research funding and officially opening 15,000 ft² of composite manufacturing laboratory additions**.
- **Coverage in broadcast and print media** including: nearly 100 stories in local and state media as well as coverage in trade publications (Composites News International, netcomposites.com, Composites World, Plastics News) and national media including Fortune Magazine and the New York Times.

- Hosted **visiting scholars** from the University fur Bodenkultur (Vienna) and the University of Concepcion (Chile).
- Hosted **over 1,000 visitors to the AEWFC laboratories** including students from Maine primary and secondary schools; public officials; members of trade associations; and numerous representatives of international as well as Maine-based composites manufacturers.
- Collaborated with Maine Maritime Academy, Correct Building Products in Biddeford and the Cianbro Corporation in Pittsfield to build a **wood composite sea wall at MMA's campus in Castine**. The wall, the first such structure using Correct Building Products' wood/plastic composite structural members, provides a unique demonstration of new technologies being developed at AEWFC.
- **Reaccredited as an ISO 17025 certified research and development laboratory** by International Accreditation Service

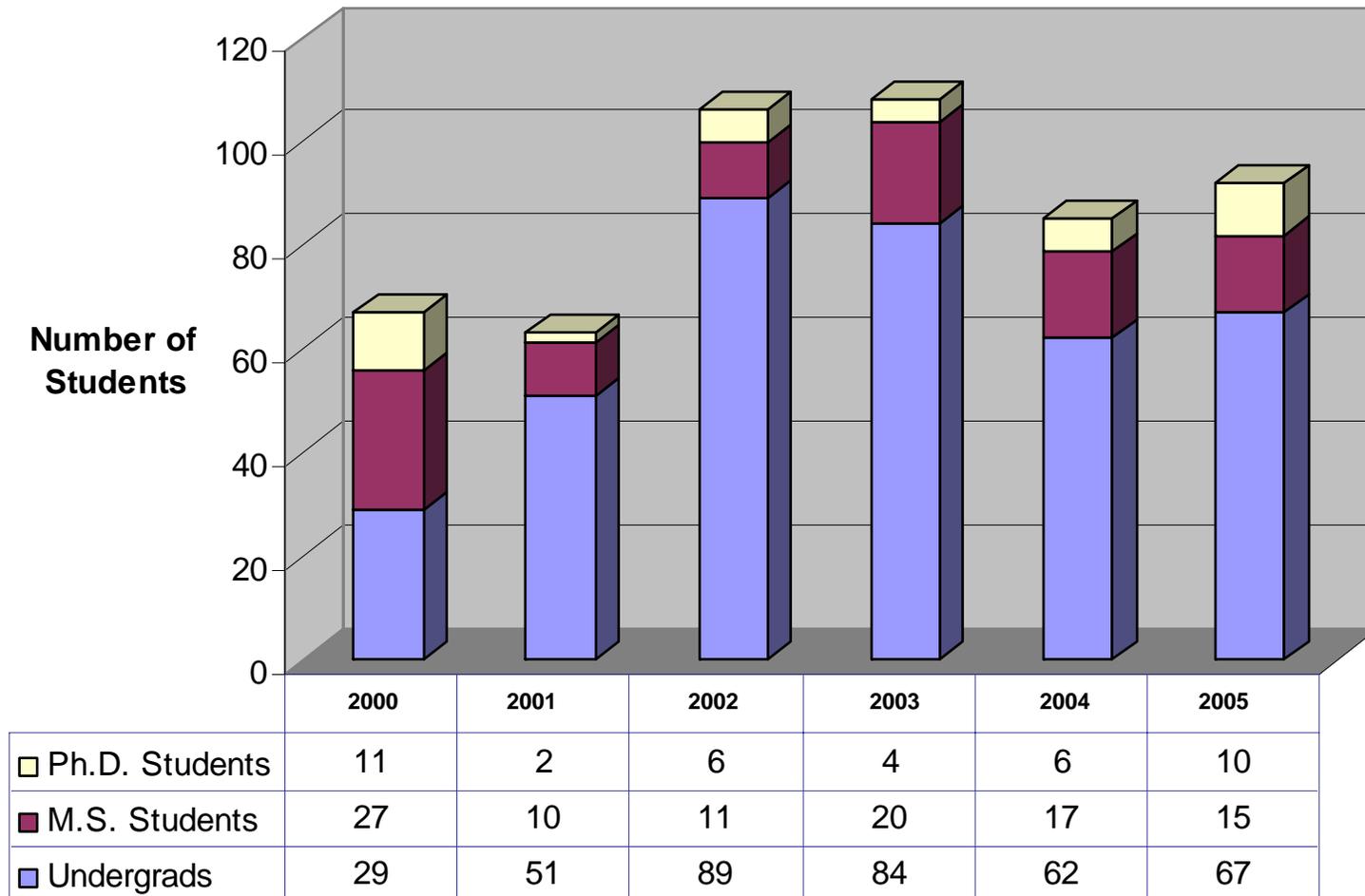
Education for Innovation

Each year, the AEW Center sponsors graduate student research and hires undergraduate student research assistants.

- From 2000 – 2005, 382 undergraduate students have worked in the AEW laboratories¹.
- 82% of AEW undergraduate students were Maine residents.
- AEW undergraduate students represent 38 different academic majors.
- 10 AEW undergraduate students have gone on to graduate school at UMaine and have continued their graduate research in the AEW laboratories.
- From 2000 – 2005, 81 graduate students did their research in the AEW laboratories.
- 55% of AEW graduate students were Maine residents.
- 54% of AEW graduate students majored in Civil Engineering; 30% of AEW graduate students majored in Forest Management or Wood Science.

¹ Some students have worked more than one year. This figure (382) represents “student years”, rather than individual students.

AEWC Center Students 2000 - 2005



Graduate Student Research 2001 – 2005

Name	Degree	Academic Dept	Research Topic	Graduation Date
Abbott, Steve	PhD	CIE	Concrete Decks on FRP-Wood Girders	
Alexander, Jonathan	MS	Wood Science	Comparison of Six mechanical procedures for ease-of-use and discrimination in measurement of FRP/Wood adhesive bond quality	
Baptista, Rui Diogo	MS	Forest Management	Surface science & wood coatings	2005
Battles, Eoin	PhD	CIE	Environmental Durability of FRP Reinforcement for Timber Bridges	
Benoit, Nathaniel	M.S.	CIE	Wood properties for nonlinear modeling	
Berube, Keith	PhD	Mechanical Eng	Effect of processing environment on reliability of VARTM/SCRIMP composite panels	
Botting, Josh	MS	Mech Eng	Design of FRP reinforced timber guard rails	
Bragdon, Melanie	MS	CIE	Milbridge Pier Project	2002
Bremer, Aaron	MS	CIE	FRP-Reinforced Wood Shear Walls for residential construction	
Breton, Joey	MS	CIE	Creep behavior of FRP-Reinforced glulam beams	
Campbell, Jason	MS	CIE	Composite temporary deck panels	
Cassidy, Eric	MS	CIE	NSF Shear Wall Project	2002
Cheng, Quingzheng	M.S.	Forest Management	Extrusion process conditions effects on wood thermoplastic durability	2005
Cherry, Carmen	PhD	CIE	Model, analyze and design a composite panel roof diaphragm system for lateral loads	
Dejarlais, Justin	MS	CIE	Determination of strain energy release rate for mixed-mode fracture in wood-frp bonds	
Dura, Matthew	MS	CIE	Development of wood/plastic composite sheet walls	2005
Edgar, Russell	MS	Forest Management	Properties of long strand structural composite lumber from low grade northeastern hardwoods	2004

Egan, Avril	Ph.D	Wood Science	Fracture and Micromechanics of Resin Coated Single Wood Fibers	
Eisenheld, Leo	MS	Forestry	Evaluate durability of frp-glulam through material level testing and modeling	2003
El-Chiti, Fadi	MS	Mech Eng	Structural reliability of frp composites	2005
ElChiti, Imad	MS	CIE	Alternative technology for the design and construction of short-span buried concrete arch bridges	2004
Fifield, Samantha	MS	CIE	Composites Structural health monitoring system using embedded sensors	2002
Fortier, Ken	MS	CIE	SCL Wood poles and piles	
Foster, Benjamin	MS	CIE	Flexural repair and strengthening of timber beams using fiber reinforced polymers	
Gamache, Christopher	MS	CIE	Fatigue resistance of FRP-Reinforced glulam girders	2001
Geotemartinez, Victor	MS	Forest Management	Image analysis and osb:process control, grading and quality control	
Ghassan, Fayad	MS	CIE	Probabilistic analysis of frp composite laminated plates using Monte Carlo simulfation	2005
Goodrich, Robert	MS	CIE	Non-thesis	
Goslin, Keenan	MS	CIE	Composite panel tent inserts for ballistic protection	
Haskell, Adam	MS	CIE	Fatigue characterization of sandwich composite panels using the hydrmat test system with FOS embedded sensors and full-field 3D DIC measurements	
Herzog, Ben	MS	Forest Management	Composite fabrication processing	2004
Hong, Yong	MS	CIE	Durability of FRP-Glulam thourgh material level testing and modeling	2003
Iqbal, Mohammed Asif	M.S	Structural Eng.	Fatigue behavior of FRP reinforcement for wood	2003
Jiang, Ting	MS	CIE	VOC emissions during particleboard notpressing with mixed hardwood furnish	

Jordan, Andrew	MS	CIE	Wetpreg reinforcement of glulam beams	
Kahl, Melissa	MS	CIE	Structural design of a wood plastic composite sheet pile wall	
Lagana, Rastislav	PhD	Forest Management	Determination of the mechano-sorptive properties of wood on material level	
Lindback, Sven	PhD	Wood Science	Use of Microtomography to Measure Resin Penetration and Strains in Wood/FRP Bonds	
Lindyberg, Robert	PhD	CIE	ReLAM: A Nonlinear Stochastic Model for the Analysis of Reinforced Blulam Beams	
Lowry, Christian	MS	CIE	Non-thesis	
Lu, Wei	MS	CIE	FRP-posttensioned timber bridge decks	
Malm, Chris	PhD	Mech Eng		
Marsh, Kenneth	MS	CIE		
Martin, Keith	MS	CIE	Development of disaster resistant structures utilizing frp reinforced sheathing panels	2004
McDougall, Shane	MS	CIE	Non-thesis	
Melrose, Paul	MS	Mechanical Eng	Durability of SCRIMP processed sandwich composites	
Michael, Antonis	MS	CIE	Reinforced Composites	2002
Mills, Ryan	PhD	Forest Resources	Developing uses for hemicellulose based polyester and substitution of glass reinforcement with bio-based reinforcement in sheet molded compounds	
Nader, Jacques	MS	Mechanical and Civil Engineering	Probabilistic finite element analysis for marine grade composites.	
O'Neill, Shane	PhD	Wood Science	Reducing VOC hot-press emissions from flakeboard manufacture: effect of pressing parameters and chemical additives	Grad Certificate-2002 MS - 2000
Oporto, Gloria	PhD	Forest Management	Characterizing the Mechanism of Improved adhesion on Modified Wood Plastic Composites Surfaces.	
Parades, Juan	PhD	Forest Management	Influence of Hemicellulose Extraction on Physical and Mechanical Performance of OSB	
Peterson, Matthew	MS	Forest Management	Adhesive bonding of wood plastic composites	w/drawn

Pirvu, Anca	MS	Forest Management	Carbon fiber wood hybrid composites	w/drawn
Poulin, John	MS	CIE	Laboratory tests on ninety frp-glulam beams	
Prall, Katharina	Ph.D.	Chem E	M:icromechanics of Highly Filled Polymer Coatings	
Reuning, Ariel	MS	CIE	Design of rapidly deployable high strength shelters	
Richie, Matt	MS	CIE	Fatigue testing of reinforced structural steel in glulam bridge girders	2003
Sanchez, Olivia	MS	CIE	Design, construct, monitor reinforced glulam bridges	2002
Silva-henriquez, Rodrigo	M.S.	CIE	Behavior of Prestressed FRP-Glulam Girders	
Silva-Munoz, Rodrigo	PhD	CIE	Study of durability of sandwich composite panels	
Souza, Benjamin	MS	Structural Eng	Facture mechanics characterization of Wood-frp composite materials fabricated by a resin transfer molding process	2005
Stephens, Katherine	MS	CIE	Impact Testing of Large Composite Hull Panels for the Mark V.1 Patrol Craft	
Stevens, Jonathan	MS	CIE	Non-thesis	
Stiglbauer, Paul	MS	Forest Management	Powder coating wood substrates	w/drawn
Stromdahl, Kenneth	Ph.D.	Wood Science	Water Sorption in Wood and Plant Fibers	
Tascioglu, Cihat	Ph.D.	Wood Science	Effects of wood preservative treatment on FRP reinforcement for wood	2002
Tomblin, Josh	MS	CIE	Buried Arch Structures	
Turner, Adam	MS	Structural Eng	Inflatable arches	
Tze, William	Ph.D	Wood Science	The Influence of interfacial chemistry on the deformation micromechanics of wood-fiber/polymer composites	2003
Wang, Huaijun	PhD	Wood Science	Modeling and measurement of three-dimensional fiber composite structures	
Wang, Wenlong	PhD	Wood Science(Michigan Tech)	Volatile organic compound (VOC) emissions during particleboard hotpressing with southern pine furnish	
Weaver, Craig	MS	CIE	FRP glulam concrete composite bridges	

West, Brent	MS	CIE	Fatigue tests of full-scale MPC trusses	
Whittaker, Douglas	MS	CIE	Application of acoustic emissions to measure fracture energy of wood	
Wood, Keith	MS	Structural Eng	A study of the effects of accelerated environmental aging on FRP bridge deck systems	
Xie, Xinfeng	PhD	Forest Management	Wood carbonization	
Xu, Han	MS	CIE	Load cycling response of frp-glulam wood panel	
Yelle, Daniel	MS	Wood Science	Bonding of wood fibers by lignin activation using free radical generating systems	
Zhang, Xuelian	PhD	Forest Management	Improved adhesive application system for wood strand-based composites	
Zhao, Hong	MS	Wood Science	Recycling creosote-treated wood in particleboard	

Graduate Certificate in Advanced Engineered Wood Composites

This 16 credit advanced certificate program which integrates civil engineering, composite technologies, wood science, and adhesives technology was initiated in 2002. Students in this program:

1. acquire knowledge of wood-polymer and fiber-reinforced hybrid composites;
2. conduct and analyze material property characterization of hybrid composites; and
3. develop skills in assessing technology for product development of low-cost, high-performance hybrid composites.

Since 2002, 4 students have completed the certificate program.

Community Education

Since opening its doors in June 2000, the AEW Center has conducted tours for thousands of visitors, introducing them to the University of Maine, the role of R & D in economic development, and technologies for producing composite materials and products. These visitors have included Maine primary and secondary schools; public officials including Governor Baldacci and his cabinet, Maine's congressional delegation, state legislators; members of trade associations; and numerous representatives of international as well as Maine-based composites and wood products manufacturers.

Androscoggin Valley Council of Governments, Alberta Research Council, American Society of Foresters, Bangor Region Chamber of Commerce, Bangor Regional Leadership Institute, Brewer Middle School, Bucksport High School, Department of Energy, Department of Homeland Security, Extension, Horizons, Forest Exploration Day, Hampden Academ, Jackson Laboratories, John Baptist High School, Lawrence Junior High School, Leadership Maine, Maine Applied Technology Development Centers, Maine Composites Alliance, Maine Department of Conservation, Maine Department of Economic Development, Maine Department of Transportation, Maine Forest Service, Maine Forest Products Council, Maine Manufacturing Extension Partnership, Maine Wood Products Association, Monmouth Academy, Noble High School, Noble Builders, Noble High School, Northeast Forest Service, Office of Naval Research, Old Town Fire Department, Old Town High School, Passamaquoddy Housing Council, Penobscot County Economic Development Council, Quebec Department of Transportation, Somerset Economic Development Council, University of Maine Board of Visitors, US Army Corps of Engineers, US Customs, USDA Forest Products Lab, Veazie Community School, Winthrop High School

**The AEW Center
has conducted tours
for thousands of visitors
since June 1, 2000**



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Patents

Patents Awarded:

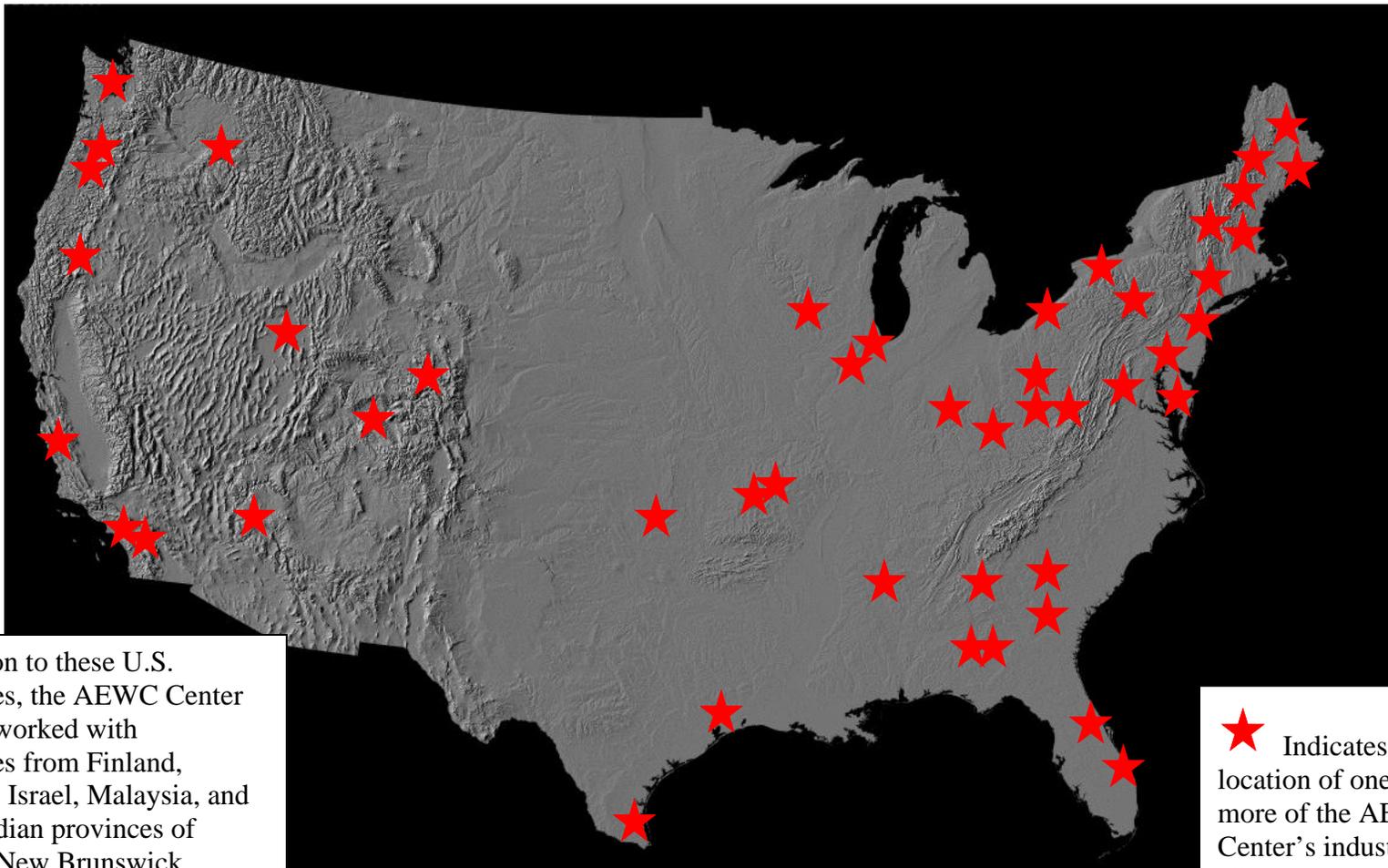
Title	Inventor(s)	Award Date	Number
Prestressing System for Wood Structures And Elements	Dagher, H.J., Abdel-Magrid, B.	January 9, 2001	6,170,209
Resin Starved Panel Application for Glulam Beams	Dagher, H.J., Abdel-Magid, B., Shaler, S.M.	August 28, 2001	6,281,148
Modular Fiber Reinforced Polymer Composite Structural Panel System	Lopez-Anido, R., GangaRao, H.V.S.	October 30, 2001	6,309,732
Modular Fiber Reinforced Polymer(FRP)Composite Deck System	Lopez-Anido, R., GangaRao, H.V.S	September 24, 2002	6,455,131
Building Construction Configuration	Dagher, H.J.	December 10, 2002	6,490,834
Wood Composite Panels for Disaster-Resistant Construction	Dagher, H.J., Davids, W.	April 2003	European Patent Entitled
Modular Fiber Reinforced Polymer Composite Deck System	Lopez-Anido, R., GangaRao H.V.S. and Barbero, Ever J.	April 8, 2003	6,544,624
Wood Composite Panels for Disaster-Resistant Construction	Dagher, H.J., Davids, W. G.	March 2, 2004	6,699,575

Patent Applications:

Title	Inventor(s)	Application Date	Number
Composite structural panel	Dagher, H	September 5, 2002	20020122954
Equilateral Strand Composite Lumber And method of making same	Edgar, R., Shaler, S., Dagher, H.	May 28, 2004	20050000185
Composites Pressure Resin Infusion System (ComPRIS) to produce Fiber Reinforced Polymer Composite Laminates And other Hybrid Composite Products	Goodell, B., Lopez-Anido, R. Herzog, B.	December 9, 2003	20040157519
Composite Anti-Tamper Container with Embedded Devices	Dagher, H	July 14, 2004	60/587,803
Sheet Piling Panels with Elongated Voids	Dagher, H.J., Lopez-Anido, R. Gardner, D., Dura, M., Stephens, K.	December 15, 2004	20050163575

Industrial Cooperation

From 2000 – 2005, the AEW Center worked with nearly 200 companies developing and testing new composite products. The Center realized over \$1 million in income from this work.



In addition to these U.S. companies, the AEW Center has also worked with companies from Finland, Scotland, Israel, Malaysia, and the Canadian provinces of Quebec, New Brunswick, Alberta, and Ontario.

★ Indicates the location of one or more of the AEW Center's industrial clients.

AEC ISO 17025 Accredited Testing

Field of Testing: Plastic Materials

ASTM Standard	Test Method
ASTM D 256	Determining the Izod Pendulum Impact Resistance of Plastics
ASTM D 635	Rate of Burning and/or Extent and Time of Burning of Plastics in a Horizontal Position
ASTM D 638	Tensile Properties of Plastics
ASTM D 695	Compressive Properties of Rigid Plastics
ASTM D 696	Coefficient of Linear Thermal Expansion of Plastics Between -30°C and 30°C with a Vitreous Silica Dilatometer
ASTM D 790	Flexural Properties of Unreinforced and Reinforced Plastics and Electrical Insulating Materials
ASTM D 792	Density and Specific Gravity (Relative Density) of Plastics by Displacement
ASTM D 953	Bearing Strength of Plastics
ASTM D 1693	Environmental Stress-Cracking of Ethylene Plastics
ASTM D 3350	Standard Specification for Polyethylene Plastics Pipe and Fittings Materials
ASTM D 3846	In-Plane Shear Strength of Reinforced Plastics
ASTM D 4812	Unnotched Cantilever Beam Impact Strength of Plastics
ASTM D 6109	Flexural Properties of Unreinforced and Reinforced Plastic Lumber
ASTM D 6110	Determining the Charpy Impact Resistance of Notched Specimens of Plastics

Field of Testing: Adhesives

ASTM Standard	Test Method
ASTM D 905	Strength Properties of Adhesive Bonds in Shear by Compression Loading
ASTM D 1101	Integrity of Adhesive Joints in Structural Laminated Wood Products for Exterior Use
ASTM D 2339	Strength Properties of Adhesives in Two-Ply Wood Construction in Shear by Tension Loading
ASTM D 2559	Standard Specification for Adhesives for Structural Laminated Wood Products for Use Under Exterior (Wet Use) Exposure Conditions
ASTM D 3165	Strength Properties of Adhesives in Shear by Tension Loading of Single-Lap-Joint Laminated Assemblies
ASTM D 5868	Lap Shear Adhesion for Fiber Reinforced Plastic (FRP) Bonding

Field of Testing: Structural Panels and Assemblies

ASTM Standard	Test Method
ASTM E 72	Conducting Strength Tests of Panels for Building Construction (transverse load only)
ASTM E 564	Static Load Test for Shear Resistance of Framed Walls for Buildings

Field of Testing: Wood Products and Materials

ASTM Standard	Test Method
ASTM D 143	Testing Small Clear Specimens of Timber
ASTM D 198	Static Tests of Lumber in Structural Sizes
ASTM D 245	Standard Practice for Establishing Structural Grades and Related Allowable Properties for Visually Graded Lumber
ASTM D 1037	Evaluating Properties of Wood-Base Fiber and Particle Panel Materials
ASTM D 2395	Specific Gravity of Wood and Wood-Base Materials
ASTM D 2555	Establishing Clear Wood Strength Values
ASTM D 3737	Standard Practice for Establishing Allowable Properties for Structural Glued Laminated Timber (Glulam)
ASTM D 4442	Direct Moisture Content Measurement of Wood and Wood-Base Material
ASTM D 4761	Mechanical Properties of Lumber and Wood-Base Structural Material
ASTM D 4933	Standard Guide for Moisture Conditioning of Wood and Wood-Base Material
ASTM D 5456	Standard Specification for Evaluation of Structural Composite Lumber Products

Field of Testing: Composite Materials

ASTM Standard	Test Method
ASTM C 393	Flexural Properties of Sandwich Constructions
ASTM C 666	Resistance of Concrete to Rapid Freezing and Thawing
ASTM D 2344	Short-Beam Strength of Polymer Matrix Composite Materials and Their Laminates
ASTM D 2584	Ignition Loss of Cured Reinforced Resins
ASTM D 3039	Tensile Properties of Polymer Matrix Composite Materials
ASTM D 3410	Compressive Properties of Polymer Matrix Composite Materials with Unsupported Gage Section by Shear Loading
ASTM D 3479	Tension-Tension Fatigue of Polymer Matrix Composite Materials
ASTM D 3518	In-Plane Shear Response of Polymer Matrix Composite Materials by Tensile Test of a $\pm 45^\circ$ Laminate
ASTM D 4255	Standard Guide for Testing In-Plane Shear Properties of Composite Laminates
ASTM D 5379	Shear Properties of Composite Materials by the V-Notched Beam Method
ASTM D 5528	Mode I Interlaminar Fracture Toughness of Unidirectional Fiber-Reinforced Polymer Matrix Composites
ASTM D 5766	Open Hole Tensile Strength of Polymer Matrix Composite Laminates
ASTM D 6115	Mode I Fatigue Delamination Growth Onset of Unidirectional Fiber-Reinforced Polymer Matrix Composites
ASTM F 1679	Using a Variable Incidence Tribometer (VIT)

AEWC Center Industrial Partners



Maine Marine Manufacturing, LLC – partnering with Hodgdon Yachts and the AEWC Center - is the prime contractor for the U.S. Navy for the construction of the full-scale technology demonstrator called the Mark V.1, and plans on competing for the \$200 million contract to replace the Mark V fleet. While the project is aimed at improving the original Mark V wherever possible, the primary goal is to use specialized composite materials in the hull and elsewhere that can absorb the shock created by high-speed travel across the water's surface. By dampening the affects of the boat's repeated impacts as it skims across the waves, the new materials can help to protect the crew from back, neck, and joint injuries.



Based in Biddeford, Maine, Correct Building Products is the manufacturer of CorrectDeck, a composite decking material made from 60% recycled hardwood sawdust and 40% polypropylene. Correct Building Product's 530% revenue growth during 2001 – 2004 was cited by Inc Magazine which listed the company as one of the fastest growing private companies in the United States.

Correct Building Products was founded in 1999 by two extrusion industry veterans with the goal of manufacturing technically superior, durable and sustainable composite building products for outdoor living. CorrectDeck products, including Classic, Signature and RapidRail™ are made from a patented wood fiber-polypropylene formulation.

Correct Building Products was the first and is the most experienced manufacturer of polypropylene based composite decking products. Correct Building Products continues to lead the industry with technical innovation in areas of design, formulation and automation.



Harbor Technologies, Inc.
Marine Composite Solutions

Composites innovator Martin Grimnes founded Harbor Technologies in 2003 in a small barn and sold his first composite dock system in 2004. The company has announced aggressive expansion plans, including a \$2 million to \$3 million investment in equipment and the creation of at least 40 jobs over the next several years.

Grimnes said, "We intend to become the overall answer to all marine waterfront challenges, from rust and rot to environmental concerns. Composite solutions will enable us to capitalize upon these issues. Thanks to the steadfast support we have received from the state and the town of Brunswick, we are on the fast track to growth and profitability."

AWARDS 2002

- Recipient of an **APA National Timber Bridge Award of Merit** for the design and rehabilitation of the Skidmore Bridge in Union/Washington, Maine.
- Nominated for the **Charles Pankow Award** for innovative bridge design.
- Dr. Eric Landis, Associate Professor of Civil and Environmental Engineering and a founding AEWFC faculty, received the **University of Maine's 2002 Presidential Outstanding Teaching Award**.
- Dr. Michael Peterson, Assistant Professor Mechanical Engineering and AEWFC faculty, received the **Early Career Research Award from the University of Maine College of Engineering**.
- Benjamin Herzog, Forest Management major and AEWFC student researcher, was named **Salutatorian of the University of Maine Class of 2002**.
- Karma Jamtsho, Civil and Environmental Engineering major and student of AEWFC researchers Dr. Lopez-Anido and Dr. William Davids, was named **Outstanding International Student in the College of Engineering**.
- Antonis Michael, AEWFC graduate student, received **First Prize for Creativity** for his poster presentation at the annual **University of Maine Student Research and Creative Achievement Week**.
- Seven AEWFC faculty members, Drs. Habib Dagher, William Davids, Douglas Gardner, Eric Landis, Roberto Lopez-Anido, Michael Peterson, and Stephen Shaler are listed among the top fifty faculty generating research funding for UMaine.

AWARDS 2003

- **Presidential Research and Creative Achievement Award** from the University of Maine to Habib Dagher, Professor of Civil Engineering, BIW Professor of Structural Engineering and Director of the AEW Center, for his innovative work in wood composites which has created technology positively affecting Maine's economy.
- **University of Maine Student Research and Creative Achievement Award** second place to Keith Martin for his outstanding poster presentation entitled *Development of Disaster Resistant Structures Utilizing FRP Reinforced Sheathing Panels*.
- **2002 Award for Outstanding Accomplishment in Research by Young Faculty** by the University of Maine College of Engineering to Dr. William Davids.
- **Franklin Wood Excellence in Design Award 2002** From the Bucks County Chamber of Commerce and the Bucks County Chapter of the American Institute of Architects. Presented for excellence in design of the Tohickon Aqueduct, an AEW demonstration project incorporating FRP glulam in historic reconstruction of a 19th century aqueduct.
- **2002 Award for Composites Excellence** in the Market Expansion category from the Composites Fabricators Association for development of FRP Composite Drain for Highway Bridge Decks which exhibits the potential to produce the greatest ongoing impact to open and expand markets for composite fabricators.
- **2002 National Timber Bridge First Place Award** in the category of Rehabilitation of an Existing Bridge by APA – The Engineered Wood Association, American Institute for Timber Construction, USDA Forest Service, Federal Highway Administration, American Wood Preservers Institute and *Roads and Bridges Magazine* for rehabilitation of the historic Tohickon Aqueduct with FRP glulam trusses.
- **2002 National Timber Bridge Award of Merit** in the category of Rehabilitation of an Existing Bridge by APA – The Engineered Wood Association, American Institute for Timber Construction, USDA Forest Service, Federal Highway Administration, American Wood Preservers Institute and *Roads and Bridges Magazine* for replacement of an aging bridge utilizing new FRP reinforced glulam bridge deck on the Skidmore Bridge located in Union, Maine.
- **Mara Award First Place** for excellence in writing and research from the Society for Wood Science and Technology to AEW Research Associate L. Muszynski, L.F. Wang, and AEW Assistant Director S. M. Shaler for their paper *Short Term creep tests on phenol-resorcinol-formaldehyde (PRF) resin undergoing moisture content changes*.

AWARDS 2004

- **NEXT list**, a list produced by *Mainebiz* profiling a dozen successful Maine leaders who are shaping the state's future and making a difference in its economy, named Habib Dagher, AEW Center Director, to the first annual list in September 2003.
- **Governor's Award for Accomplishment in Maine's Natural Resource-Based Industry** presented November 17, 2003 to the AEW Center for leadership in developing sustainable uses of Maine's natural resources.
- **Finance Authority of Maine (FAME) Honorary Mention, Excellence in Business and Education**, presented November 18, 2003 to the AEW Center for its work in forming partnerships with Maine businesses.
- **New England Higher Education Excellence Award** presented February 17, 2004 to Habib Dagher, AEW Director, for exceptional leadership in behalf of higher education and the advancement of educational opportunity.
- **2004 Distinguished Maine Professor Award**, given to Eric Landis, Professor of Civil and Environmental Engineering and member of the AEW faculty on April 13, 2004.
- **University of Maine Student Research and Creative Achievement Award**, (April 12 – 13, 2004) First Place in the Engineering I category to Diogo Baptista for his poster presentation, *A Simple Model to Predict the Dynamic Behavior of Spherical Sessile Droplets on an Impermeable Surface*; honors to Ben Herzog for his oral presentation, *The Composites Pressure Resin Infusion System (ComPRIS)*.
- AEW student researchers inducted into the **Francis Crowe Society** (May 2004), in anticipation of the future contributions they will make to society as practicing engineers: Kenneth Abbott, Brian Beaulieu, Sarah Blake, Carly Desjardins, Christopher Fournier, Ruth Gray, Adam Haskell, Smaantha Perkins, Matthew Randall, and Luke Stinchfield.
- **2004 Forest Products Society Wood Award (2nd Place)** to AEW graduate student William Tze on June 29, 2004 for his paper *Evaluation of Load Transfer at the Cellulosic-Fiber/Polymer Interphase Using a Micro-Raman Tensile Test*.
- **2004 Markwardt Wood Engineering Award** for the most outstanding research paper in the field of wood as an engineering material presented June 29, 2004 to Stephen Shaler, AEW Associate Director, for his paper *Mechanical Properties of Individual Southern Pine Fibers. Part I. Determination and Variability of Stress-Strain Curves With Respect to Tree Height and Juvenility*, published in *Wood and Fiber Science* with co-authors L. Groom and L. Mott.
- **2004 Society of Wood Science and Technology Student Poster Competition (3rd place)** awarded June 18, 2004 to AEW graduate student Diogo Baptista for his poster *A Simple Model to Predict the Dynamic Behavior of Spherical Sessile Droplets on an Impermeable Surface*.

AWARDS 2005

- **Diogo Baptista**, a graduate student in the Dept. of Forest Management and the AEWCCenter, received a third place award for a **poster he presented at the annual meeting of the Society of Wood Science and Technology** in Grand Rapids, Michigan.
- First annual **AEWC Director's Awards** presented to: **Tom and Linda Patrick** for their support which was instrumental in acquiring funding for AEWCC's partnership with Hodgdon Yachts; and **Dr. Robert Lindyberg**, AEWCC Manager of Technical Services, for his dedication and assistance to the Center during 2004.
- **Roberto Lopez-Anido**, an AEWCC researcher, has received a **Fulbright Scholarship** to lecture and do research at Universidad de Chile in Santiago, Chile, during the 2005- 2006 academic year.
- **Best Testing and Design Technical Paper Award** at the annual convention of the **American Composites Manufacturers Association**. Contributors to the paper were **Roberto Lopez-Anido**, AEWCC researcher, **Fadi W. El-Chiti**, AEWCC graduate student and **Habib Dagher**, AEWCC Director; co-authors were Lech Muszynski, formerly of the AEWCC, presently Assistant Professor of Composites in the Department of Wood Science & Engineering, Oregon State University; Larry D. Thompson of Applied Thermal Sciences, Sanford, Maine; and Paul E. Hess of the Naval Surface Warfare Center, Carderock, Division.
- 1st Place, Oral Presentation (Molecular, Chemical, and Earth Science Category). **Graduate Research Exposition: 2005**, Orono, ME. April 11-12, 2005, Manufacture of Extruded Wood-Nylon Composites: Processing & Properties, by **Shane O'Neill**, AEWCC Wood Plastic Composite Specialist.