The Advanced Materials Industry in Maine: Examples of Innovative Products & Technology

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The Composite Industry in Maine

• Comprised of mostly small and medium size companies with a high level of quality, specialization and innovation
• Supplying the marine, automotive, aerospace, architecture and construction sectors
• Core of yacht and boat building industry:
  • manufactured the 155 foot / 47 meter Scheherazade (in 2003 the largest sailing vessel built in the Western hemisphere
  • U.S. Navy Special Operation Vessel Mark V
  • Products for Airbus Industries
• Expert use of resin infusion in closed mold processes such as vacuum infusion
• Annual growth of 7%
• R&D and Testing Support by the Advanced Structures and Composites Center at the University of Maine
Why Composites for Infrastructure and Energy Projects?

• Lightweight (For the same strength, lighter than steel by 80% and aluminum by 60%)
• Durable (non-corrosive)
• High strength including impact resistance
• Fatigue resistant
• Safe (non-conductive re. electricity; low thermal conductivity)
• Design flexibility
• Processability (complex shapes)
• Lower life cycle costs (reduced maintenance, longer life)
• Lower transportation and installation costs

Example:
Harbor Piles can be produced in any transportable length as they are considerably less weight than concrete, steel, timber and plastic piles. Projects require fewer truck load deliveries and consequently benefit from reduced costs, a greater efficiency in handling and a lower carbon footprint.
Infrastructure Composite Products by Maine Companies: Culverts and Culvert Repair Elements

- Abrasion of galvanized coating of steel culverts leads to degradation and weakness of the invert
- Replacement costs can be a 20x multiple of the rehabilitation costs
- Replacement disrupts traffic flow
- Reinforced concrete invert liners are common but labor intensive and require heavy equipment

Fiber-reinforced polymer (FRP) culvert rehabilitation Solutions offer:
- Overall lower project costs
- Less impact on traffic as well as stream flow
- Extended life span (75 years compared to 20-25)
- Minimized invert elevation increase
- Accommodation of fish passage
Infrastructure Composite Products by Maine Companies: Custom Weirs
Infrastructure Composite Products by Maine Companies:
FRP Fish Ladder built to Biologist Design Specifications

Properly formulated panels comply with FDA Regulation 21 CFR 177.2420 associated with food contact materials. No styrene or chemical leaching. No risk of elevated PH levels in water as often experienced with curing concrete.
Infrastructure Composite Products by Maine Companies: Harbor Piles and Floats

Applications:
Laterally Loaded Piles
• Pier & wharf fendering
• Bridge fenders
• Guide Walls
• Dolphin Clusters
• Navigation aids
• Retaining walls
• Marina pontoon guide piles

Axial Loaded Structural Piles
• Pedestrian piers etc.

Benefits:
• Does not rot, rust or spall
• Does not leach or pollute
• Concrete filling not required
• Efficient driving with standard equipment
• Flexibility to tailor pile performance
• Available in any transportable length and diameter
• Recyclable
Infrastructure Composite Products by Maine Companies:
Performance Verification by University of Maine Lab

- Static flexural
- Dynamic flexural
- Short beam shear
- Radial compression
- Axial compression
- Fastener Pull out
- Material flex strength testing
- Full scale static flexural testing
Infrastructure Composite Products by Maine Companies: Hybrid Composite Beam Technology (HCB)

SUSTAINABLE
- 100+ Year Service Life
- Maintenance-Free (Shell is same as a fiberglass boat)
- No Painting
- No Spalling

LIGHTWEIGHT
- HCB shipping and erecting weight is 10% of a concrete beam and 33% of a steel beam (for a typical 70’ span)
- HCB weight after filling is 33% of a concrete beam and same weight as a steel beam (for a typical 70’ span)
- Lighter weight greatly reduces shipping and erection costs
- Lighter weight reduces cost of supporting substructures

REDUCED CARBON FOOTPRINT
- Shipping multiple beams on a single trailer significantly reduces carbon emissions
- Smaller crane for erection of beams significantly reduces carbon emissions
- HCB uses 20% of cement amount compared to concrete beam.
Infrastructure Composite Products by Maine Companies: Hybrid Composite Beam Technology (HCB)

The world’s first Hybrid-Composite Beam Railroad Bridge at the Transportation Technology Center, Pueblo, Colorado. Since its test installation November 2007, more than 16 million gross tons have crossed the bridge to date.

HCB is manufactured by Harbor Technologies in Brunswick, ME.
Infrastructure Composite Products by Maine Companies: Hybrid Composite Beam Technology (HCB)

EXCESS CAPACITY
- HCB design is governed by serviceability criteria (deflections).
- HCB can be overloaded by 4 times legal load and remain elastic (i.e. no permanent damage)
- HCB will not sustain damage from illegally overloaded vehicles that damage concrete and steel beams.

INFINITE FATIGUE LIFE
- Since HCB is governed by serviceability criteria, live load stress range is very low
- Infinite fatigue life in HCB is inherent
- Infinite fatigue life in steel beams is generally cost prohibitive
- Low stress range is below fatigue cycling threshold
Infrastructure Composite Products by Maine Companies: ‘Bridge in a Backpack’

- Lightweight, corrosion resistant system for short to medium span bridge construction
- Using FRP composite arch tubes that act as reinforcement and formwork for cast-in-place concrete.
- Arches are easily transportable, rapidly deployable and do not require the heavy equipment or large crews needed to handle the weight of traditional construction materials.

To date five Maine bridges have been built using the Bridge-in-a-Backpack technology. Several bridge projects are planned for 2011 throughout New England and beyond.
Infrastructure Composite Products by Maine Companies: ‘Bridge in a Backpack’

Building a bridge cheaper and faster
A new composite bridge construction technology, developed at UMaine’s Advanced Engineered Wood Composites Center, employs a series of inflatable tubes that can be shipped in a bag to any construction site. They are filled with concrete and provide structural support for the finished bridge.

Arches are 12 inches in diameter and are spaced two feet apart.

Hollow carbon-fiber composite tubes are inflated at the bridge site, bent into arches to fit the necessary bridge profile and infused with a resin. They become rigid within hours and then are filled with concrete.

Corrugated fiber-reinforced plastic decking is installed on top of the arches and then is covered with fill, subbase and asphalt pavement.

Arches act as a stay-in-place, reinforcing form for the concrete filling inside, protecting it from corrosion and freeze-thaw damage.

Side retaining walls are made of composite materials and prefabricated concrete.

The new Neal Bridge in Pittsfield

SOURCE: The University of Maine; Maine Department of Transportation
Infrastructure Composite Products by Maine Companies: ‘Bridge in a Backpack’ - Examples

Standard Road Bridge in Pittsfield, Maine and Auburn, Maine

Snowmobile Trail Bridge in Hermon, Maine
Composite Manufacturing for Light Rail and Transportation:
Composite floor and Composite Panel Systems

Light weight composite panels:
Excellent fire, smoke and toxicity performance
Addresses problems inherent in traditional plymetal flooring

- ASTM C-297
- ASTM D-4060
- ASTM E-1354

- ASTM C-365
- ASTM E-119
- Bomardier SMP800C

- ASTM C-273
- ASTM E-162
- FRA 49 CFR 238
- ASTM C-393
- ASTM E-662

Images showing light rail and transportation systems.
Temperature Controlled Molding

**Concept:**
Use an efficient BTU transfer media to both heat and cool molds, thereby eliminating ambient conditions from the composite manufacturing equation.

**Process advantage with Controlled Radical Polymerization to experience:**
- Superior flow characteristics
- Faster production times
- Enhanced physical properties
- Extended gel times
- Managed exotherm temperatures
- Cure-on-demand control
Composite Products by Maine Companies for Energy Projects: Tidal Power Generator Blades

All key components such as frame and rotating blades are made out of composites:
- corrosion resistant
- light weight
- durable
Composite Technology and Fabrication R&D in Maine
The Advanced Structures and Composites Center (AEWC) at the University of Maine

- A world-leading center for advanced structures and composites R&D
- Opened June 2000; Rotor Blade Prototyping & Test Lab opened 2012
- Innovative and prolific research agenda
- Products developed at AEWC’s ISO 17025 accredited laboratories are utilized in
  - Civil Infrastructure
  - Troop Protection
  - Homeland Security
  - Residential
AEWC Projects: Sheet Piles

New Manure Pit Side Wall for Witter Farm
AEWC Projects: The Modular Ballistic Protection System (MBPS)

• Developed in partnership with the US Natick Army Soldier RD&E Center
• Provides soldiers with enhanced ballistic protection in their tents
• System consists of composite ballistic panels that are mounted to the inside of the tent frame using an energy-absorbing connection system
• Requiring no tools
• MBPS can be used to up-armor a 20ft x 32ft tent in less than 30 minutes with 4 soldiers.
AEWC Projects: ComPRIS
(Composites Pressure Resins Infusion System)

ComPRIS (Composites Pressure Resins Infusion System) is a new, patented technology for the production of composite materials through a novel resin infusion process. The method involves the use of applied pressure to infuse polymer resins into fabrics, wood, concrete, ceramics and other materials to produce stronger, more durable composites.

The board on the left has been reinforced using the ComPRIS process.
Cellulose from trees and plants represents Maine's largest natural resource. Cellulose nanofibrils are studied at AEWC in co-operation with the University of Maine’s Forest Bioproducts Research Institute (FBRI). The research program focuses on utilizing lower cost nanocomposites made from cellulose to develop the next generation of lightweight high performance, bio-based materials for a variety of defense, infrastructure, and energy applications.
Composite Work Force Education in Maine

In close cooperation with the Maine Composites Industry, Southern Maine Community College offers the following courses and workforce training programs:

• Introduction to Composites
• Introduction to Closed Mold Technology
• ACMA Certification class: CCT-VIP, Review and Exam
• Multi-Axis CNC Programming
• Multi-Axis CNC Machining
• Orientation to Composites
• Advanced Closed Mold Technology
• Temperature Controlled Molding
• Teaching Composites at the High School Level
• QA for Composites: Methods for Resin Infusion
• Composite Repair Workshops
• Marine Design
• ACMA CCT-VIP
Maine’s Advanced Materials Industry for Aerospace

Application Example: Insulation and Fire Blocking Materials for aircraft, aircraft seats etc.

- Burnthrough insulation
- Thermal acoustic insulation
- Carpet underlayments
- High-temperature ducting
- Fire-blocking layers (FBLs) for seating
- Cabin-divider linings

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Maine’s Advanced Materials Industry

Application Example Ballistic Materials - Soft Armor:
Ballistic fabric is covered with a layer of ballistic grade fiber batting

Applications Include:
- Soft and hard body armor
- Bomb blankets
- Ballistic shields
- Cockpit door security
- Fragmentation containment
Maine’s Advanced Materials Industry

Application Example: Woven and Non-woven Filtration and Geotextiles

Product composition ranging from polyester and polypropylene to such high-performance fibers as Nomex, Teflon, Rastex, and Kevlar
Maine’s Advanced Materials Industry

Application Example: Insulation and Fire Blocking Materials for various Industries, incl. Aerospace*, Welding protection, Industrial insulation, Safety apparel, Gaskets and seals MROP and OEM applications

* burnthrough insulation, over-the-frame blankets, thermal acoustic insulation, carpet underlayments, high-temperature ducting, fire-blocking layers (FBLs) for seating, and cabin-divider linings
Example of Co-Operation between Maine Businesses and Academia: Bio Fuels

- Development of a refining process to generated C5 and C6 sugars from wood.
- Pilot Plant at Old Town Fuel and Fiber, a paper mill in Maine.
- Extraction of hemicelluloses from wood chips and process of converting the resultant lingo-cellulosic extract to bio fuels and other chemicals.
Development of a simple two-step Process to produce Drop-in Fuels from Wood

This technology works for turning all ligno cellulosics into gasoline, diesel, and jet fuel.
Produce Poly Lactic Acid (PLA) from Wood Extracts and Maine Potatoes

Integrated Forest Biorefinery

Maine Biomass resources → Sugar extraction → Fermentation: *Bacillus coagulans* → Crude Lactic acid → Purification: Esterificat’n, Hydrolysis, Distillation → Dehydration, Dimerizat’n → Polymerization → Consumer plastics

- Wood Chips
- Extracted wood to pulping
- Sugars
- Pure Lactic acid
- Lactide
- PLA

PLA Lactide
Pure Lactic acid
Crude Lactic acid
Sugars
Sugar extraction
Fermentation: *Bacillus coagulans*
Maine Biomass resources