What is a tree?
PROPERTIES OF WOOD-BASED COMPOSITES

Dr. Stephen Shaler
Director, School of Forest Resources
March 13, 2017
OBJECTIVES

- Overview of wood-based composites produced - with focus on facilities in Maine and the region
- Develop understanding of resources needs for different wood-based composites
- A look ahead at new wood-based composites
WHAT IS A COMPOSITE?

- A composite material is comprised of two or more distinct materials joined together which exhibit properties superior to either of the materials used alone.
- Increased range of sizes and forms relative to base materials.
Fibers are completely encased by a “matrix” of plastic, cement, metal, or ceramic.

PARTICULATE COMPOSITES

Fibers or particles “spot-welded” by an adhesive

HYBRIDS

SINGLE-LAYER

MULTIPLE LAYERS

LAMINATES

FIBER-REINFORCED

COMPOSITE MATERIALS

Glu-laminated Beams

Structural Insulated Panels (SIP)
HOW ARE COMPOSITES MADE?

• No bark is good bark
• Make smaller sized “particles” from a tree (veneer, particles, lumber, fibers, …)
• Remove moisture
• Add adhesive, other chemicals
• Press composite (typically) with heat and pressure to densify final product
• Adhesives are typically thermoset.
• Polymers in WPC are typically thermoplastic.
COMPOSITES CAN USE

- High quality logs
- Low quality logs
- Pulpwood
- Softwoods
- Hardwoods
- Mill residue

- No bark is good bark

<table>
<thead>
<tr>
<th>Particle</th>
<th>Length</th>
<th>Slenderness Ratio</th>
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<tbody>
<tr>
<td>Wood Fiber</td>
<td>1-3 mm</td>
<td>~ 100</td>
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<tr>
<td>Wood Flour</td>
<td>-40/+60</td>
<td>4-6</td>
</tr>
<tr>
<td>Strands</td>
<td>4 - 13 inch</td>
<td>50 -&gt; 300</td>
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</table>

<table>
<thead>
<tr>
<th>Veneer</th>
<th>Lumber</th>
</tr>
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<tbody>
<tr>
<td>1/8”, 3/16”, 1/4”</td>
<td>2” x</td>
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</table>
STRUCTURAL WOOD-BASED COMPOSITES

- Glulam
- I-Joist
- OSB
- Plywood
- Rimboard
- Structural Composite Lumber (SCL)
- Cross-Laminated Timber (CLT)
INTERIOR WOOD-BASED COMPOSITES

- Particleboard
- Medium Density Fiberboard (MDF)
- Hardboard
- Engineered Wood Siding and Trim
- Decorative Surfaces

What’s the difference?
WOOD BASED COMPOSITES MANUFACTURERS

- JM Huber - OSB @ Easton, ME
- LP Building Products - OSB & LSL @ Limerick, ME
- DuraLife - WPC @ Biddeford, ME
- Columbia Forest Products - Veneer @ Presque Isle, ME
- Moosewood Millworks - Laminated Flooring @ Ashland, ME
- Arauco - Particleboard @ St. Stephen, NB
- Foard Panels - SIP - West Chesterfield, NH
Midrise Wood Frame Construction in Canada: the Journey…

- 2009: BC Building Code revised to increase height limit for wood-frame construction from 4 to 6 storeys
- 2013: Régie du Bâtiment du Québec (RBQ)
- 2015: Ontario Building Code
- 2015: Alberta Building Code
- 2015 National Building Code of Canada

Expecting 1000’s of midrise buildings in Canada next few years!!
EMERGING COMPOSITES
NANOCYTELULOSE AS THE PARTICLE
Preparation of Cellulose NanoFibrils

Plant Matter

- Wood
- Corn Stover
- Oat hulls
- Bagasse
- Tunicates

Pre-Treatment

- Kraft Pulping
- AVAP
- Enzymatic
- TEMPO
- Carboxy Methylation

Fibrillation

- Refining
- Grinding
- Homogenization
- Extrusion
- Micro-Grinding
- Steam Explosion

Post-Treatment

- Refining
- Grinding
- Cationization
- Siloxane treatment
- Drying

Cellulose NanoFibers
## Cellulose Nanofibrils (CNF) Capacity 2015

<table>
<thead>
<tr>
<th></th>
<th>Capacity (kg/day)</th>
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<tbody>
<tr>
<td>Paperlogic, USA</td>
<td>2,000</td>
</tr>
<tr>
<td>University of Maine, USA</td>
<td>1,000</td>
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<tr>
<td>Borregaard, Norway</td>
<td>1,000</td>
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<tr>
<td>American Process</td>
<td>500</td>
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<tr>
<td>Nippon Paper, Japan</td>
<td>150</td>
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<tr>
<td>Innventia, Sweden</td>
<td>100</td>
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<tr>
<td>NamiCell, France</td>
<td>100</td>
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<tr>
<td>Oji Paper, Japan</td>
<td>100</td>
</tr>
<tr>
<td>Stora Enso, Finland</td>
<td>Pre-commercial</td>
</tr>
<tr>
<td>UPM, Finland</td>
<td>Pre-commercial</td>
</tr>
<tr>
<td>FPInnovations, Canada</td>
<td>Pilot</td>
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<tr>
<td>Norske Skog</td>
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<tr>
<td>Daicel, Japan</td>
<td>Lab</td>
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<tr>
<td>Luleå University of Technology, Sweden</td>
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<td>US Forest Products Laboratory, USA</td>
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</tbody>
</table>
Rheology Modifier
- Cosmetics
- Food
- Adhesives
- ...

Additive Manufacturing
- Filaments
- Composites
- Powders
- ...

Foams
- Acoustic
- Structural
- Thermal
- ...

Continuous Fibers
- Reinforcement
- Textiles
- Woven
- ...

Building Products
- Wallboard
- Sheathing
- Panels
- ...

Flexible Electronics
- Self Powered
- Display
- Solar
- LED
- ...

Separators/Barrier
- Filtration
- Batteries
- Pumps
- ...

Rheology Modifier
- Cosmetics
- Food
- Adhesives
- ...

Coatings
- Epoxy resins
- Paints
- Sealants
- ...

Oil & Gas
- Drilling Muds
- Frac Fluids
- Clean-up
- ...

Yano et al.
Dong et al., 2012

Courtesy Dr. Robert Moon USFS

The University of Maine
SUMMARY

• Composites refer to a broad spectrum of materials, produced in a variety of ways, with a broad set of markets.

• Advantages include unique properties, wide variety of sizes and appearance, uniform behavior.

• Relatively low amount of composite production in Maine relative to other regions of North America (resource driven?)

Mass Timber Opportunities in Maine

1. European Market has figured it out
2. Plentiful SPF #2 or better stock
3. Existing Value Chain – Logging, Processing, lumber
4. Location - LEED

500 miles New York
500 miles Boston