The Growing Threat of Substitutes: Wood Plastic Composites

Jeremy Warnes

Presentation Overview

- What are Wood Plastic Composites (WPCs)
  - Characteristics
  - Applications
- Markets
  - North America
  - Europe
  - Asia
- Technology Developments and Trends
What are WPCs

- Thermoplastic with:
  - wood filler (wood flour)
  - reinforcing fibre (wood, hemp, flax, sisal)
- Two similar products:
  - Plastic Lumber < 50% wood*
  - Wood Plastic Composites > 50% wood*
  (*ASTM definition)

WPC Characteristics

- Often substituting wood and made to look like wood
  - durability a key feature
- World market close to US $ 2 billion (2006)
- WPC can mean ‘Wood and Natural Fibre Composites’
- Based on lower melting point plastics; predominantly:
  - Polypropylene (PP)
  - Polyethylene (PE)
  - Polyvinyl Chloride (PVC)
Manufactured using plastics technology

Primary techniques:
• Extrusion
• Injection moulding
• Compression moulding

Trex curved decking and edging
Boardwalks - environmentally sensitive areas where no preservative leaching wanted

US Navy

- Many Navy Piers due for replacement.
- Looking for durable solutions.
- Large research project in USA - Washington State University

WPC with PVC co-extruded shell
WPC benefits

- Durability
  - Long life
  - Low maintenance
  - Wet area use
- Environmentally friendly
  - From waste material (generally)
  - No preservatives, no leaching (generally)
- Straight, consistent, stable
- Cost compared with plastic
- Stiffer than plastic
- Texture
- Able to paint, nail, screw, drill
- Lower density than inorganic filler plastic

Challenges

- Durability
  - Water absorption
    - at high wood loading (>50%)
  - Fungal attack
  - Crumbling
  - Weight loss
  - UV degradation
  - Freeze thaw resistance
- Low stiffness
- Creep resistance
- Fire performance
- Cost? (approx 2x pressure treated lumber)
Scion Study

Compared WPC decking with kwila and H3 treated radiata:
- WPC strength, stiffness down on wood.
- Freeze thaw cycling and UV reduced stiffness of WPC.
- WPC was best in Sutter test for decay.
- Fungal attack minimal for all 3 samples after 6 months.

UV Exposure – 2000hrs

2 exposed samples and control sample

- Treated radiata
- WPC – no splitting or checking
Relative Creep Performance

End Spans based on 90mm Effective Width

Time in Days

Deflection, mm

Plastic Soaked
Plastic Dry
Radiata Soaked
Radiata Dry
Kwila Soaked
Kwila Dry

North American Market

• Construction sector focused
• Using waste wood and plastic
  – Primarily HDPE and extruded product
• Decking has dominated and driven growth
  – 70% WPCs into decking and railing
  – 30% growth PA, last few years slowed to ~10% PA
• US $ 1 billion sales 2006
North American Market Trends

Emerging Opportunities in North America
- next 2 years

**Fencing**
- US $ 6 billion market in 2006
  - Residential US $ 3 billion
- Vinyl and WPCs replacing wood
- WPCs preferred for appearance

**Sidings**
- US $10 billion market 2006
- Concerns about risk and class action law suits

Sourced from Principia Partners 2008
**WPC Decking Growth**

<table>
<thead>
<tr>
<th>Year</th>
<th>Market ($ billion)</th>
<th>Share of (%)</th>
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<tbody>
<tr>
<td></td>
<td>Wood</td>
<td>Neat Plastic</td>
</tr>
<tr>
<td>1992</td>
<td>2.3</td>
<td>97</td>
</tr>
<tr>
<td>2002</td>
<td>3.4</td>
<td>91</td>
</tr>
<tr>
<td>2005</td>
<td>5.1</td>
<td>77</td>
</tr>
<tr>
<td>2006</td>
<td>5.5</td>
<td>73</td>
</tr>
<tr>
<td>2011 (forecast)</td>
<td>6.5</td>
<td>66</td>
</tr>
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Sourced from ‘Wood-Plastic Composites’ Anatole Klyosov

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**European Market**

- 110,000 tonnes WPCs (2007)
- Automotive prime application
  - Compression moulded panels
  - ~ 50% of WPC market
- Long natural fibre reinforced plastics
  - Compete with glass fibre reinforced plastics
- ‘High tech product of renewable raw materials with special applications’

10 to 15kg weight saving in C class Mercedes
Europe

- Virgin PP most common (cf waste HDPE in US)
- Slow to take off in decking/extruded products
  - seems to be starting to take off now.
- Bioplastics desired


Asia

- WPCs starting to emerge from Asia
- China 50,000 tonnes WPC (2005)
  - 25% advantage in ‘cost of goods sold’ – even with low volume processing
- Japan 30,000 (2003)
- Asia expected to have an impact on world WPC markets

Decking and pallet available from China
Technological Developments and Trends

- Draw extrusion
- Foamed extrusion
- Fibre reinforcement
- Injection moulding
- WPC boards or sheets
- Bioplastics

Draw Extrusion

- Draw through necked down die
- Gives polymer alignment
- Uses polypropylene and low loading wood flour
- Bought by Weyerhauser – technology ‘on hold’

<table>
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<tr>
<th></th>
<th>Relative density</th>
<th>Strength – MoR (MPa)</th>
<th>Stiffness - MoE (GPa)</th>
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<tbody>
<tr>
<td>Orientated PP WPC</td>
<td>0.68</td>
<td>83</td>
<td>2.3</td>
</tr>
<tr>
<td>Typical WPC in N.A.</td>
<td>0.97</td>
<td>10 - 25</td>
<td>1.8 - 5.1</td>
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</table>

Everarch Inc
Foamed Extrusion

- Reduced weight
  - e.g. density from 1000 to 700kg/m³
- Easier handling, nailing, fastening
- More like wood
- Issues with strength reduction
- Well suited for fence applications

Fibre Reinforcement

- Wood flour ‘fills’ but long natural fibres ‘reinforce’
- Agri-fibre reinforcement established in Europe
- Wood fibre reinforcement predicted to grow
- Emerging wood fibre technology examples:
  - GreenCore (Canada)
  - Scion (NZ)
  - Creafil (N.A.)
Strength Improvement from Fibre Reinforcing

Max Tensile Stress (MPa)

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<tr>
<th>Fibre Type</th>
<th>Percentage</th>
<th>Max Tensile Stress</th>
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<tbody>
<tr>
<td>Poly propylene</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Wood flour 40%</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Wood fibre 40%</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Flax fibre 30%</td>
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<tr>
<td>Glass fibre 20%</td>
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All samples polypropylene base and fibres ‘coupled’ to plastic

Injection Moulding

- Large increase been predicted
  - In both US and Europe
- Been slow to take up
- 2% of WPCs in 2005
  - US $ 15 million was predicted to rise to $300m in 2007
WPC Board/Sheet

- JER Envirotech (Canada) thermoplastic 4’ x 8’ sheeting
- Pallmann sell line for making WPC board
- WPC Wallboard out of China

Bioplastics

- Currently packaging focus
- Large growth
- Price getting close to petrochemical plastics

**Worldwide Manufacturing Capacity of Bioplastics**

<table>
<thead>
<tr>
<th>Year</th>
<th>Based on RRM</th>
<th>Based on Petrochemicals</th>
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<tbody>
<tr>
<td>1990</td>
<td>100,000</td>
<td>100,000</td>
</tr>
<tr>
<td>1995</td>
<td>200,000</td>
<td>200,000</td>
</tr>
<tr>
<td>2000</td>
<td>400,000</td>
<td>600,000</td>
</tr>
<tr>
<td>2002</td>
<td>600,000</td>
<td>700,000</td>
</tr>
<tr>
<td>2005</td>
<td>800,000</td>
<td>900,000</td>
</tr>
<tr>
<td>2006-8</td>
<td>1,000,000</td>
<td>1,200,000</td>
</tr>
<tr>
<td>2010</td>
<td>1,200,000</td>
<td>1,400,000</td>
</tr>
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Renewable Raw Materials (RRM) are the main feedstock.
Bioplastics contd.

- Expanding into niche products – often injection moulding
- Much research on bioplastic/fibre combinations
- Rettenmaier sell PLA wood flour pellet in Europe
- Area of rapid development

Summary

- WPCs are established materials
- Growth and further substitution of wood still occurring
- New WPC based technologies emerging
- Production in Asia may influence markets

⇒ Threat or synergistic product for wood?