Applications and Opportunities for Construction Materials made from Rigid Plastic Packaging Containers

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Integrated Waste Management Board

Outline

- The Problems
- Potential Solutions
- Material Descriptions
- Example Applications & Future Markets
- Conclusions
- What Are You Waiting For?

The Problems

- Over-abundance of solid waste
- Plastics contribute >22 million tons to the total waste stream
- California landfilling >17 million cubic yards of plastic waste

The Problems

- Approx. 11 billion pounds of plastic containers manufactured annually in the U.S.
- Nationally, <10 percent of the total is recovered for reuse
- And the rate of recycling is in a downward trend!
- The volume of plastics in landfills is estimated at almost 25 percent
- Plastics are made from fossil fuels which are in finite supply

The Problems

- Chemically treated lumber can be hazardous to the environment and people (e.g., recent ban on the use of CCA-treated wood)
- Most types of wood need the chemical treatments in order to be resistant to moisture, rot, and insects
- In some states, creosote-treated wood is a hazardous material upon disposal

Solutions

- Recover and recycle the waste plastics
- Use materials that blend-in with the natural environment and that do not require hazardous chemical treatments to be resistant to moisture, rot, and insects
- How do these relate to each other?

Material Substitution

- **Plastic Lumber Industry Started By Making Use Of Cheap Feedstock Materials**

Recycled Plastics

Dimensional Plastic Lumber

Advantages Of Plastic Lumber and Related Products

- Comparable Strength to Wood
- High Toughness
- Doesn’t Rot And Not Attacked By Insects
- Not a Hazardous Material
  - Ban on CCA-Treated Wood
  - Is Creosote Next?
- Recyclable - Disposable
- Made From Otherwise Landfilled Materials
- Lower Lifetime Costs
- Properties Can Be Improved -- Engineered

Mechanical Property Differences

e.g., Bending – Wood Compared to Plastic Lumber

	σ_c (psi)	E_f (ksi)	ε_{fr} (%)
WOOD (Douglas Fir)	1,700	1,700	0.7
PLASTIC LUMBER (Typical)	1,700-3,500	90-130	600-800

σ_c = compressive stress (strength)

E_f = flexural modulus (bending stiffness)

ε_{fr} = strain at fraction

Types of Plastic Lumber

- Plastic lumber, recycled-plastic lumber, composite lumber, wood-plastic composites, and thermoplastic composite lumber are all used synonymously to describe similar products
- Can be reinforced/modified with glass fibers, wood flour, and even other polymers (of course, moisture sensitivities increase with increased percentages of wood fillers)
- Other additives to modify properties include UV stabilizers, pigments, foaming agents, etc.

Related Recycled-Plastic Products -- Pilings and RR Ties

Recycled-Plastic Pilings

Recycled-Plastic RR Cross Ties

Example Applications and Future Market Opportunities

Plastic Lumber Picnic Table

First Large All-Plastic Civil Structure

Plastic Lumber Tiffany Street Pier, New York City
Designed by the New York City Dept. of General Services

Plastic Lumber Bridge At Fort Leonard Wood, MO

- Existing Wooden Bridge 24 Feet Long, 26 Feet Wide
- New Bridge Designed by McLaren Engineering, New York
- Uses Plastic Lumber Structural Members
- Designed for Light Vehicular Loads

Failing Wood Timbers

First Plastic Lumber Vehicular Bridge

Humvee Driving Across Plastic Lumber Bridge, Fort Leonard Wood

Benefits Of Using Plastic Lumber for Fort Leonard Wood Bridge

- USED 13,000 LBS POST-CONSUMER PLASTICS
  - 78,000 One-Gallon Milk Jugs
  - 335,000 8-oz. Foam Coffee Cups
- NO PRESERVATIVES / COATINGS NEEDED
- LIFE EXPECTANCY
  - Treated Wooden Bridge = 15 Years
  - Untreated Wooden Bridge = 5 Years
  - Plastic Lumber Bridge = 50 Years
- LIFECYCLE COST ANALYSIS
  - Break Even in Less Than 8 Years

Plastic Lumber Structures At Jackson Abbott Wetlands, Fort Belvoir, VA

Handicap Access Fishing Piers

Boardwalk/Observation Deck

Meadowbrook Pond, Seattle, WA

- Located 35th NE and 105th Street – Lake City
- Actually a Seattle Public Utilities Detention Pond
- Converted sanitary treatment plant
- Now home to songbirds, waterfowl, amphibians, and beavers
- Plastic lumber boardwalk and observation areas
  - Reinforced plastic lumber framing and pilings
  - Wood-plastic composite decking

Meadowbrook Pond, Seattle, WA

Overview of site

Meadowbrook Pond, Seattle, WA

Entrance to boardwalk

Arch-Truss Plastic Lumber Bridge

- Designed and constructed by McLaren Engineering
- Arch design very efficient load-carrying member
- Field construction using laminated arch design
- Constructed in limited access area
- Bridge required H15 rating

Arch-Truss Plastic Lumber Bridge

Constructing arch truss bridge in park near Albany, NY

Arch-Truss Plastic Lumber Bridge

Load testing bridge with 16 ton truck – 30 foot gap

Plastic Lumber I-Beam Design

- Plastic lumber I-beam design equates to less material to carry the same load
- Interlocking members speeds construction
- Demonstration bridge at Wharton State Forest, NJ
- Designed and constructed as a cooperative effort between McLaren Engineering and Rutgers University, NJ

Innovative I-Beam Design

Plastic Lumber I-Beam Profiles for Bridge at Wharton State Forest, NJ

US Army Corps
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Engineer Research & Development Center

Innovative I-Beam Design

Nested I-Beams for Efficient Design and Rapid Construction

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Innovative I-Beam Design

Completed I-Beam Design Class H-20 Bridge

Innovative I-Beam Design

Initial test with pickup truck driving over bridge

Plastic Lumber I-Beam Design

- The success of this bridge is significant since it shows the concept works at <u>both time and materials savings</u>
- Preliminary analysis shows the plastic lumber I-beam design can be cost competitive on a first cost basis to a treated wood design
- The durability and low-maintenance requirements of the plastic lumber structure make life-cycle cost considerations a plus benefit
- Used 30,000 lbs of recycled plastics
  - 179,000 One-Gallon Milk Jugs
  - 770,000 8-oz. Foam Coffee Cups

Plastic Marine Pilings and Fenders

12x12 Timbers, San Rafael Bridge, CA

Plastic Pilings and Camels

US Army Corps
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Engineer Research & Development Center

WOOD IS TRADITIONAL RR TIE MATERIAL

- When Railroads First Developed in U.S., Had Abundance of Trees Available
- Useable Mechanical Properties -- Works Well
- Long-time History of Performance
- Holds > 90% of Current Tie Replacement Market
- However, Wood Subject to Rot and Wear

DRIVERS TO INVESTIGATE WOOD ALTERNATIVES

- **Increased Wheel Loads (32 Tons → 39 Tons) Per Axle**
  - Wood Ties Wear Out Faster
- **Changing Environmental Regulations Directed At Chemically Treated Wood**
  - Manufacture / Use Of New Ties
  - Disposal Of Old Ties
- **Lesser Quality Of Present Day Wood Ties**
- **Rising Cost Of Wood**
- **Large Number Of Trees Needed To Meet The Demand For Replacement Ties**

Track Statistics & Potential Market

- **Roughly 175,000 Miles Of Track In U.S.**
- **Average 10-15 Million Ties Replaced Annually**
  - Laid End-to-end, 15 Million Standard Ties Would Stretch Almost 24,000 Miles!
- **~150 lbs RPPC per Tie – at 10% Market Share, Would Use ~75,000 Tons**
- **Army Has Approximately 2,000 Miles Of Track**
- **Estimated 10,000 - 12,000 Turnouts Within Those 2,000 Miles Of Track**

WOOD ROTS

Badly Deteriorated Wood Crossties

Wood requires chemical treatments to resist rot and insect attack.

PLASTIC RR TIES IN CTA TRACK

CTA Has Installed Plastic Ties in Both Elevated & Ballasted Track

PLASTIC RR TIES IN CLASS 1 TRACK

On One of UP's Mainlines, Plastic Ties Have Accumulated >850 MGT of Traffic

PLASTIC RR TIES IN CLASS 1 TRACK

Union Pacific Installing Plastic Composite Ties on Bridge Structure

PLASTIC RR TIES IN CLASS 1 TRACK

Railroads Currently Seeking Alternative Materials for Bridge Ties
Potential Growth Area for Recycled Plastic Composites

Recycled Plastic Composite Ties on NS Open Deck Bridge

Greenhouse Gas (GHG) Benefits

EPA-Sponsored Study

- Units are Metric Ton Carbon Equivalent (of gas) per short ton of (solid) material used, or MTCE/ton
- Compare:
  - MTCE/ton "cost" of producing and using a recycled-plastic crosstie, with
  - MTCE/ton "cost" of producing and using a wood tie.
- Estimate:
  - MTCE/ton for producing recycled-plastic crossties is 0.28
  - MTCE/ton for producing wooden crosstie is 0.02
  - Additional factor for wood because of carbon sequestration is 0.73

MTCE/Ton Benefit For Using Recycled-Plastic Crossties

(0.73 + 0.02) – 0.28 = 0.47 MTCE/ton

Assumes plastic tie lasts only as long as wood tie

HOWEVER

If Assume Plastic Composite Ties Last For 60 Years:

- For a 30 year wood tie replacement cycle:
  2 x (0.73 + 0.02) – 0.28 = 1.22 MTCE/ton
- For a 15 year wood tie replacement cycle:
  4 x (0.73 + 0.02) – 0.28 = 2.72 MTCE/ton
- For a 5 year wood tie replacement cycle:
  12 x (0.73 + 0.02) – 0.28 = 8.72 MTCE/ton

GHG Benefit for recycling of aluminum is about 3 MTCE/ton

Conclusions

- Can Use Large Quantities of Otherwise Waste Materials
- Use Can Help Reduce Greenhouse Gases
- Plastic Lumber and Related Products Can Be Effectively Used in Wet/Damp Environments with No Added Chemicals
- Plastic Lumber and Related Products Can Be Used in Structural Applications

Conclusions Cont.

- While Similar to Working with Wood, Need Minor Adjustments to Techniques/Operations
- Need to Account for Differences in Mechanical and Physical Properties as Compared to Wood
- Higher Initial Materials Costs Can Be Recouped Very Quickly on a Lifecycle Basis
- Innovative Arch and I-Beam Designs Offer a Means to be Competitive on a First-Cost Basis

Barriers to Realizing the Full Potential Benefits

- People Unaware of These Products
- Tradition – Resistance to Change Current Practice
- Unknown Long-Term Durability
- Higher Initial Cost on a Component to Component Basis
- Incomplete Understanding of Mechanical Properties and Designs
- Unverified "Assumptions."

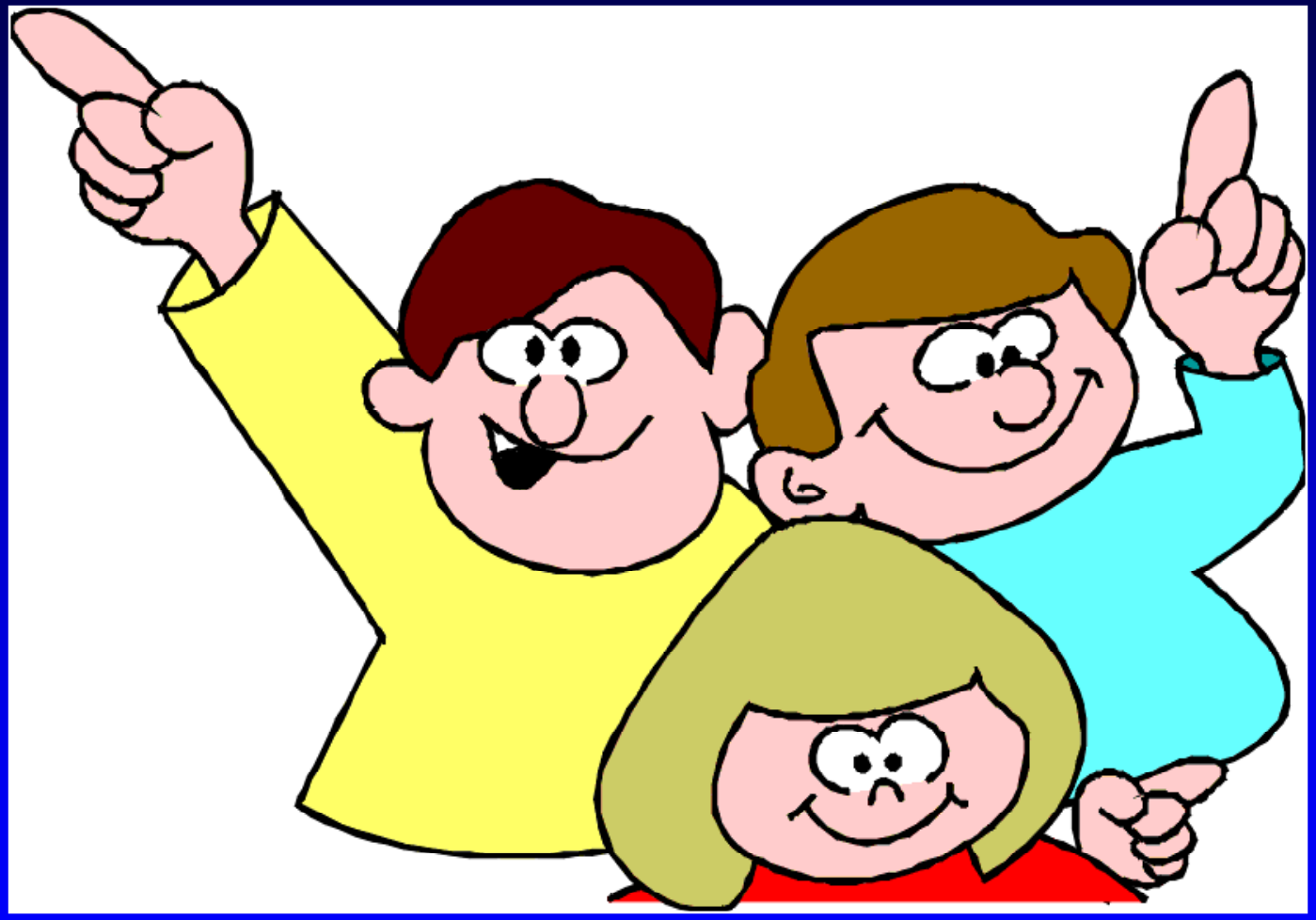
The Future

- Plastic Lumber Market Currently Growing About 40% per Year
- Growth in Advanced Structural Plastic Lumber
- Use of Optimized Structural Profiles (e.g., I-Beams) and Arch Designs
- Further Development of Standardized Designs & Procurement Guidance
- Significant Opportunities for Growth in Railroad Industry Applications
- Development of PET-Based Plastic Lumber and Related Products for Structural Applications?
- Can We Achieve 100% Recovery and Recycling of Waste Plastics?

What Are You Waiting For?

The key to success is to increase the demand and production capacity for recycled-plastic construction materials in order to increase the collection and use rate of waste plastic containers in a manner that is economically viable.

Questions ???



FOR FURTHER INFORMATION

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