Recycled Plastic Lumber: Research and Development

Introduction

What Is Recycled Plastic Lumber (RPL)?
RPL is a wood-like product made from recovered plastic or recovered plastic mixed with other materials, which can be used as a substitute for concrete, wood, and metals.

Can RPL Be Substituted for Wood?
At the present time, RPL has only been used in a few structural applications. However, it is an excellent material for decking, landscaping, and recreational equipment.

Who Would Use This Fact Sheet?

- Designers and home renovators selecting plastic lumber
- New manufacturers creating markets for RPL
- Existing manufacturers expanding markets
- Local governments promoting plastic lumber.

Common Uses of RPL

- **Agricultural.** Vine stakes, ranch fences, gates, animal stalls.
- **Civil Engineering.** Retaining walls, sound barriers, car stops, walkways, railings.
- **Gardening.** Fences, flower pots, compost bins.
- **Industrial.** Flooring, pallets, truck flooring.
- **Recreational.** Park benches, picnic tables, playground equipment, informational kiosks, wetlands walkways, decking, park bridges, flower bed borders.
- **Transportation.** Noise barriers, sign posts, guard rail offset blocks, car stops, speed bumps.
- **Marine Engineering.** Piers, pilings, seawalls, and bulkheads, boat docks.
- **Other.** Roofing shingles or "cedar shakes."

Types of RPL

High Density Polyethylene (HDPE) RPL
This type of RPL consists of up to 95 percent of HDPE (The same material used to make plastic milk jugs).

- Advantages. Available in many colors. Well suited for decking and landscape applications.
- Disadvantages. Much lower stiffness than wood. Also, material sorting increases labor costs. This cost can be reduced by using automated sorting technology instead of hand sorting.

Commingled RPL
Commingled RPL is made from mixed recovered thermoplastic (plastic that can be remelted and remolded). Primarily consisting of 80-90 percent polyethylene (PE).

- **Advantages.** Lowest cost because sorting is reduced or eliminated. Also well suited for decking and landscape applications.
- **Disadvantages.** Only earth tone colors available in addition to having a stiffness much lower than wood.

Wood-Filled RPL
Wood-filled RPL is made of plastic mixed with sawdust or other recycled fiber, usually a mix of 50 percent polyethylene (primarily low-density polyethylene or LDPE) and 50 percent sawdust or other recycled fiber.

- **Advantages.** Fewest voids, best traction, best paintability, greater surface roughness.
- **Disadvantages.** Can absorb moisture, may have poor impact strength under low temperatures, may not be completely insect resistant, may become discolored in outdoor applications, may contain metal contaminants, much lower stiffness and strength than wood, can degrade, poor flexibility.

Fiber-Reinforced RPL
Fiber-reinforced RPL consists of plastic mixed with chopped or continuous strands of glass fiber.

- **Advantages.** Stiffer than other plastic lumber. Well suited for support structures.
- **Disadvantages.** Less flexible than other plastic lumber, and may irritate skin.

Other Combinations of Materials
Many other combinations of materials are possible, each with different properties, costs and applications. They should be investigated individually to determine the best product for its intended use. Some other formulations include:

- Glass-reinforced plastic lumber.
- Rubber-plastic lumber.
- Mixed plastics and peanut shells.
- Coextruded steel liner (e.g., metal pipe).
- Coextruded steel reinforcing rods.
- Multiple laminations of oriented HDPE.
- Reinforced concrete fill.
- Cross linking of PE molecules by thermoset processes

Manufacturing Process

In general, the RPL manufacturing process includes the following steps:

- **Material Preparation.** Sort and clean (optional), then grind the recovered plastic material into small flakes.
- **Extrusion.** Homogenize and rapidly melt the flakes using heat and pressure inside a rotating screw (extruder).
- **Forming.** Discharge or force the molten mixture into a mold, cool the mold in a water bath, and eject the finished product.

Development of Standards for RPL

The development of product specifications and standard testing methods is extremely important for the use of plastic lumber for structural applications—an expanding market. Standardization will allow the RPL to be graded into several levels of performance so that it can be used with confidence by the U.S. construction industry. Listed below are the most relevant advances in the development of product and standard testing specifications:

Product Specifications

Product specifications for RPL are preferred over method or material specifications because product specifications are based on performance characteristics. Method and material specifications sometimes limit the use of recycled-content products by disqualifying recycled feedstocks or recycling-based technologies and processes.

The American Society for Testing and Materials (ASTM) created a section on "plastic lumber and shapes (D20.20.01). This section is coordinating the development of industry standards, which includes test methods, specifications, recommended practices, and definitions for dimensional profiles made from recycled plastics. The United States Environmental Protection Agency (USEPA) provides some funds to support ASTM activities related to the development of RPL's standards and specifications.

Currently, ASTM is revising its specification for recycled plastic decking boards. ASTM is also working with the Plastic Lumber Trade Association (PLTA) and Battelle Memorial Institute to develop specifications for the preferred physical and mechanical properties of plastic lumber.

In Canada, the Ontario Ministry of Transportation developed specifications for the use of plastic lumber in highway applications. The results of this study were presented to the Woodfiber-Plastic Conference in May 1995. (For information contact Dr. A. Coomarasamy at 416/ 235-4678).

Standard Testing Methods

In consideration of the need of standard testing methods for RPL products, ASTM recently (July 1996) proposed the following draft test methods:

- Apparent overall density and specific gravity of manufactured RPL by displacement (ASTM D-20.20).
- Shear properties of plastic lumber and shapes.
- Compressive properties of plastic lumber and shapes.

- Flexural properties of unreinforced and reinforced plastic lumber.
- Compressive and flexural creep and creep-rupture of plastic lumber and shapes.
- Mechanical fasteners in plastic lumber and shapes.

Currently, ASTM is also working with U.S. Army Corp of Engineers, Rutgers University, Louisiana State University, PLTA, and Battelle to resolve issues regarding proper test methods on flammability, fasteners, and long-term creep characteristics.

Studies

California Department of Boating and Waterways
In 1993-1994, the Department of Conservation awarded a $100,000 grant to the Department and Waterways to demonstrate the effective use of recycled plastic materials. The study concluded that when specifying RPL, a maximum allowable warp should be included in the specification. Contact: John E. Middleton, (916) 322-1803.

California Department of Transportation (CalTrans)
In late 1993, CALTRANS contracted the construction of two soundwall noise barriers made of RPL. The study concluded that although the unit cost of these two installations was greater than the average unit cost for all soundwalls in the state, they appeared to function adequately. The study recommended CalTrans to promote the construction of soundwalls made of RPL. Contact: Allen Wrenn, (916) 653-6026.

Army Corps of Engineers (ACOE)
ACOE's Construction Productivity Advancement Research Program, along with Rutgers University and 20 plastic lumber manufacturers, has just finished a project that began in 1993. The study includes several demonstration projects and a set of recommendations about the applications of RPL. The report has not been published yet, but it will be available in 1997. Contact: Richard Lampo, (217) 373-6765.

Center For Plastics Recycling Research (CPRR)
In 1996, CPRR patented the process to manufacture railroad ties from mixed waste plastics. CPRR has also published several reports presenting mechanical and physical test data on RPL. Contact: Tom Nosker, (908) 445-3679.

Battelle Memorial Institute
Battelle, PLTA, CPRR, and McLaren Engineering are proposing a 3-year research program on structural uses of RPL. The objectives of the program include:

- Developing optimized design guidelines for use of RPL in load-bearing, structural applications.
- Addressing durability and service life prediction issues for RPL in structures.
- Creating a database of information that can be used by designers, architects, engineers and procurement agencies that will use RPL.

Contact: Prabhat Krishnaswamy, (614) 424-5998.

IWMB Contact

For more information about plastic lumber, contact Edgar Rojas of the IWMB at (916) 341-6518.

Disclaimer: The enclosed information may change at any time. The Integrated Waste Management Board (IWMB) is not liable for any information or errors in this fact sheet, nor does IWMB guarantee the accuracy of any information. For corrections, contact Edgar Rojas by phone (see above) or e-mail to erojas@mrt.ciwmb.ca.gov.

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