

Applying Recycled Plastic Lumber Technology to Short-Span Bridges

By George F. Assis, Ph.D., P.E.

Although a relatively new concept in bridge construction, recycled plastic lumber (RPL) is gaining acceptance as a lightweight, innovative and durable material for short-span bridges. As evidenced by the completion of several RPL bridges in the past few years, structural-grade reinforced plastic lumber is emerging as a technology of choice for use in load-bearing construction.

The world's first suspension bridge using recycled plastic lumber – a 31,000-pound capacity single-lane bridge in New Baltimore, NY, near Albany – has shown no signs of deterioration since being built in 2000. More recent examples include a pedestrian trail bridge in Montgomery County, MD, and a 70-ton capacity bridge designed to withstand fully loaded Army tanks in Fort Bragg, NC. The Fort Bragg bridge was completed in May 2009, and the pedestrian trail bridge was completed in September 2009.

Optimal Use of Sturdy, Lightweight Material

The bridge in New Baltimore is an arch truss structure built on the Hudson River Interpretive Trail. The addition of this bridge at the park allows improved access to the Hudson River side of the trail by hikers, visitors and maintenance vehicles. The bridge has a 30-foot-long main span that crosses a tidal estuary. The recycled material used to construct the bridge is equivalent to 70,000 plastic one-gallon milk jugs. Design of a bowstring, or arch, truss configuration represents an optimal use of the material.

The arched top chord of the bridge consists of laminated two-by-eight curved members, while the bottom chord is a standard dimensional eight-by-eight reinforced RPL. Although the bridge needed to be designed only for emergency vehicle loading up to 10 tons, it was designed and tested for loads up to 15 tons. A fully loaded dump truck weighing almost 32,000 pounds was used for testing the bridge.

Similar to the New Baltimore bridge, the pedestrian trail crossing in the Montgomery County park is a bowstring truss structure. Spanning 50 feet, the bridge was designed to allow safe passage for hikers and other foot travelers, and has a weight capacity of approximately 5,000 pounds.



This pedestrian trail bridge in Montgomery County, MD, was completed in September 2009. It is a bowstring truss structure with a weight capacity of approximately 5,000 pounds.

It is one of eight being built throughout several parks in Montgomery County. Other materials used for some of the bridges include fiberglass and structural steel, depending on the bridges' spans and widths.

Inspections revealed significant deterioration of the existing bridges, and several were unsafe for pedestrian use. A key to the design process was gaining access to the different bridge sites, as some of the bridges are located on nature trails and cannot be reached by vehicle. Using innovative, lightweight materials such as RPL, enables project teams to carry the bridge components by hand and construct the bridges on-site.

The Fort Bragg bridge consists of 94 percent recycled materials including glass, vehicle bumpers and some 85,000 pounds of high-density polyethylene plastic – the equivalent of roughly 550,000 one-gallon plastic milk jugs. Innovative plastic T-beam components were used to support the heavy loads, and to provide a design that is cost-competitive to standard treated-wood bridges designed to carry the same load.

Built to replace a dilapidated timber bridge with a load limitation of 4.7 tons, the Fort Bragg bridge diverts valuable materials from the waste stream, resists rot and damaging insects without the

use of chemical treatments, and requires minimal maintenance. The structure also has a life expectancy of 50 years – twice as long as a treated-timber bridge.

The Origins of Recycled Plastic Lumber

As alternatives were sought in the late 1980s to stabilize wood in the construction and remediation of piers, bridges and other timber structures, an industry using recycled plastics began to take shape. Polymer physicists at the Center for Plastics Recycling Research, at Rutgers University in New Jersey, developed a method for creating lumber out of recycled plastic and devised ways to reinforce the material.

The American Society for Testing and Materials (ASTM) International was enlisted to assist in creating specifications and standards for the resulting new material and, in 1998, a pilot project was carried out at Fort Leonard Wood, MO, to replace the superstructure of an existing timber bridge. The new bridge's lifecycle savings and minimal maintenance requirements were estimated to produce a full return on investment in less than eight years. However, the high upfront cost of the recycled materials made it improbable that the design would be competitive in mainstream construction markets.

The Rutgers University team – in partnership with the U.S. Army's Construction Engineering Research Laboratory (CERL), McLaren Engineering Group of New York and Axion International of New Jersey – responded to this challenge by developing a more resource-efficient beam design that would reduce the amount of material used in each beam without compromising its structural integrity.

A Multitude of Benefits

Most RPL is made of high-density polyethylene – commonly found in milk jugs and shampoo bottles. The plastic can be reinforced with other materials, such as fiberglass, to form a stronger composite. By using materials that have been taken out of the waste stream, RPL conserves landfill space. RPL was used initially in non-structural or low-stress applications that do not require critical load-bearing, such as picnic tables and park benches. The demand for such structures, however, has not been strong enough to divert a large volume of plastic from landfills.

Short-span RPL bridges, however, consume significant quantities of plastic that can be removed from the waste stream. Aside from being eco-friendly, RPL's suitability for short-span bridges is enhanced by a host of other

factors. Chief among its attributes is durability. Since plastic does not decay, structures built of recycled plastic can remain in top-grade condition for up to 50 years.

In addition, compared with wood, RPL rarely cracks or splinters. It also resists rot, mildew and termites, is weather- and graffiti-resistant, and is not affected by bacteria, worms, insects or rodents. RPL provides a good shock-absorbing surface for pedestrian traffic, requires no waterproofing, staining or regular maintenance, and is aesthetically pleasing. It can be manufactured to meet different design and appearance specifications.

A promising market also exists for RPL as an alternative to pressure-treated lumber in outdoor structures such as commercial and residential decks. Although RPL contains chemical additives, they are not released into the soil or water. For this reason, RPL can serve as a substitute for pressure-treated wood, which has been blamed for leaching hazardous materials, such as arsenic. The agreement between the U.S. Environmental Protection Agency and the U.S. lumber industry to phase out arsenic compounds from pressure-treated wood is giving impetus to the growing market of RPL in decking uses.

A Boon to the Environment

Although the initial cost to purchase RPL averages 20 to 50 percent more than the price of wood, the costs balance out in two to four years when accounting for reduced maintenance and replacement costs. While purchase prices of RPL are expected to fall as technology improves and demand increases, wood prices are expected to continue to rise.

RPL is no longer a novelty material championed by environmentalists but ignored by the construction industry. As green building practices become more prevalent, the use of structural-grade reinforced plastic lumber for short-span bridges and other structures is likely to grow. Moreover, greater understanding of RPL's performance through standard test methods and specifications can lead to broader acceptance of its use as a viable alternative to less environmentally sustainable products. ■

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