Recycled Plastic Lumber Bridges

Recycled plastic lumber made from high-density polyethylene emerged in the U.S. marketplace in the early 1990s as a durable and environmentally friendly product. Despite its great potential as an attractive substitute for traditional lumber, early products made with this lumber were not widely used because they suffered from a low elastic modulus as well as significant creep. Since then, however, thermoplastic fabrication technology has improved exponentially, and the use of the material has expanded from simple railroad crossties to such major structures as bridges. Greater use of thermoplastic materials can greatly decrease the plastic that ends up in landfills.

Research carried out after the introduction of recycled plastic lumber focused on creating thermoplastic materials of greater durability. As a result, an improved version of recycled plastic lumber referred to as reinforced structural plastic composite was developed. This composite has a higher elastic modulus and better creep resistance than its predecessor, because it contains an immiscible polymer blend composite with such reinforcing agents as glass fibers coated with polypropylene. The ultimate tensile strength of thermoplastic material can reach 4,500 psi, but only 600 psi, a fraction of the ultimate strength, is utilized for an allowable stress in bridge design because of conservatism and creep control. It is predicted that if applied stress is within 600 psi, this material will not creep, even through 25 years of constant loading.

Thermoplastic materials are also environmentally safe, because they do not contain carcinogens or chemicals that could leach into soil or water over time. Other benefits include ultraviolet degradation of less than 0.003 in. per year and resistance to the types of acids and salts that are typically applied to highway bridges. The materials are also fire resistant, their ignition point being 660°F, and a fire-retardant coating has been developed to completely prevent ignition. Furthermore, the materials absorb little moisture, withstand skid and abrasion, and resist rot, insects, and marine borers.

Lightweight thermoplastic lends itself to accelerated construction. Thermoplastic is lighter than concrete or steel and has approximately the same weight as oak wood. As a result, thermoplastic products can be transported easily with standard trucks; no heavy or special equipment is necessary. This is also true at construction sites. Lighter equipment can be used to place thermoplastic components during construction, permitting accelerated schedules and increasing safety. Thermoplastic is advantageous in seismic design applications because of its low weight, ability to absorb energy, and high strain rate prior to failure.

The first vehicular bridge made of an immiscible polymer blend of high-density polyethylene was built at Fort Leonard Wood, Missouri, in 1998. For that project, the bridge's old deck was demolished, and a thermoplastic deck was placed over the existing steel girders. The deck has required little or no maintenance and has shown no signs of degradation since then. In 2002 another vehicular bridge was constructed of an immiscible polymer blend of high-density polyethylene, this one in New Jersey's Wharton State Forest. Designed to carry 36 tons of live load, it was the first to use I beams for main girders, and it replaced a chemically treated wood bridge. In 2009 two vehicular bridges were built at Fort Bragg, North Carolina. Those bridges were the first to use thermoplastic composites for nearly all of the bridge components, including decks, guardrails, girders, pier caps, and piles. They were designed to carry 71-ton M1 Abrams tanks.

Thermoplastic materials have since been used on other types of bridges. In December 2011 they were used for the first time to construct a bridge as part of the U.S. highway system, replacing a concrete culvert located west of York Harbor, Maine. The culvert was prone to flooding, and the road had been closed several times in recent years because of high water. The new two-lane bridge meets AASHTO load and resistance factor design specifications for bridges. The single span structure is approximately 26 ft wide and 14 ft long and includes girders, piles, pier caps, abutments, and wing walls made of recycled consumer and industrial plastics.

Thermoplastic composites have even been used on railroad bridges. The world's first thermoplastic railroad bridges were constructed in 2010 at the U.S. Army Transportation School, which is located in Virginia at Fort Eustis. The project replaced two nearly 60-year-old timber railroad bridges (Bridge No. 3 and Bridge No. 7) that cross a tidewater stream, because they could not support the weight of modern locomotives, 220 kips.

Using thermoplastics to construct everything from railroad crossties to bridges shows how far these products have come in the past 20 years through advances in materials and applications. Thermoplastic product use will continue to expand as research and development efforts bring improvements in material properties and manufacturing technologies. Given that consumers around the world discard 100 million tons of plastics annually, there will be no shortage of raw material for future applications of this virtually maintenance-free structural solution.

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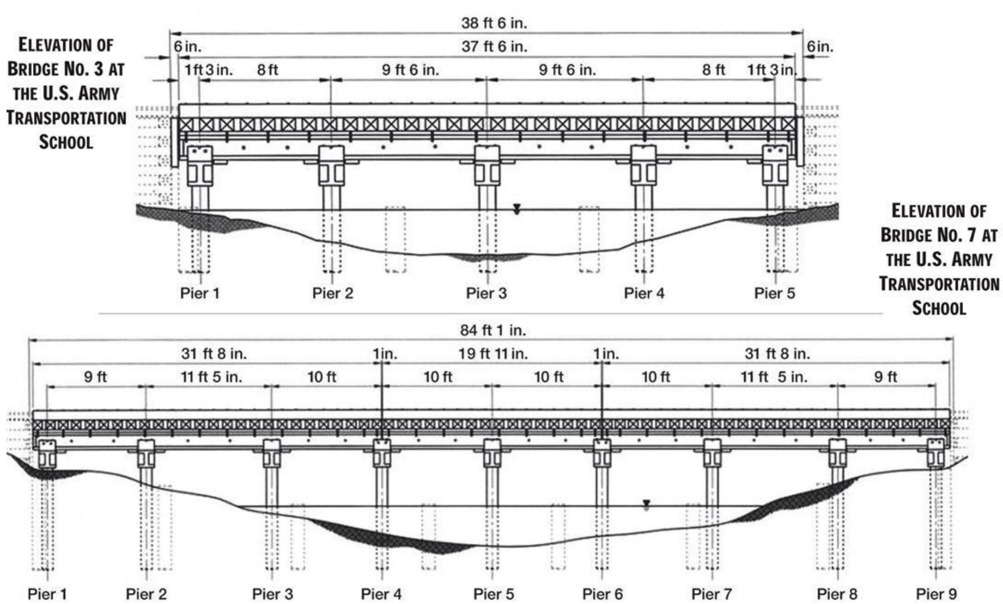

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