Lasting Ditch effort

Recycled plastic used to address corroded Ohio bridge

By William Jordan
Contributing Author

Bridge LOG-TR 174-00.56 in Logan County, Ohio, was like thousands of simple-span vehicular bridges across the U.S. Beyond maintenance, it was rendered obsolete by the Federal Highway Administration (FHWA) definition.

Logan County had a difficult decision to make, since the bridge was determined to be in need of replacement, on what was the best way to get this job accomplished and how could the county pay for it.

In 2011, the FHWA reported 143,889 bridges as either structurally deficient or functionally obsolete, with a surface area exceeding 89 million sq meters. With such a task set before state departments of transportation, how do county engineers rebuild obsolete structures with no money? From where does the funding come? State and county budgets have been decreasing each year for the past five years. Structural engineers across the U.S. are seeking innovative ways to fund and build bridges.

Logan's problem

On Aug. 10, 2005, the FHWA answered part of the funding question,

establishing Public Law 109-59 "to promote, demonstrate, evaluate, and document the application of innovative designs, materials, and construction methods in the construction, repair and rehabilitation of bridges and other highway structures." The Innovative Bridge Research and Deployment Program (IBRD) was born, making funding available to state departments of transportation.

Ohio has approximately 27,403 National Highway System (NHS) and non-NHS bridges. As of December 2011, the FHWA designated 2,654 Ohio bridges as structurally deficient and 3,027 bridges as functionally obsolete. According to the FHWA, nine of the functionally obsolete bridges were in Logan County, a significant challenge for the engineer's office. Logan County resembles many counties across the U.S. Like others, the Logan County Engineer's Office asks these questions each year: Which bridges remain and which bridges do we replace with the limited federal funding? The IBRD Program offered the money, and plastic offered a long-lasting solution. With less than 10 bridges constructed from recycled plastic in the U.S., structural engineers are unacquainted with the technology.

Made of plastic

Structural thermoplastic composite lumber is not new. Beyond a novelty, its development began as an experiment in the early 1990s at Rutgers University. Could bridges be built that did not degrade or degraded at significantly lower rates than those constructed from legacy building materials? How do structural engineers design a bridge that is virtually free of maintenance and is unaffected by moisture, rot, insects, weather and corrosion?

With aging infrastructure and little funding for maintenance, the development of structural plastic lumber—also known as recycled structural plastic composite or structural thermoplastic—began as a potential solution. Combining durable and rigid post-consumer and post-industrial plastics, structural members were created for bridge superstructures. In 1998, a thermoplastic pilot bridge superstructure designed by McLaren Engineering—combining plastic composite technologies from four manufacturers—was installed at Fort Leonard Wood, Mo. Although the steel I-beams remained in place, structural plastic members were used for the joists, decking and railing. Designed for light vehicular loads—e.g., Humvees—the bridge shows little signs of wear today.

The use of recycled plastics in bridges has been developed, especially in terms of structural shapes. The rectangular

Measuring just over 25 ft in length with a full abutment system using recycled structural plastic composite material under AASHTO HL93 standards, the plastic bridge over the Onion Ditch is the longest clear span on the NHS constructed from recycled plastic. It is an integral-abutment bridge that translates thermal expansion of the structural thermoplastic material into rotation at the 12-in. round pile groups at each abutment. The plastic pilings were driven to an embedment depth to capacity and to a length that would ensure rotation.

members at Fort Leonard Wood have been replaced by I-beam and wide-flange members, the most important design change in recycled structural composite in the last 14 years. The Fort Leonard Wood pilot proved capability. The design, however, was not competitive, given the high price of recycled plastics used to make the material. Reducing the amount of material used in design—e.g., I-beams versus rectangular members—is among the most important recycled thermoplastic design considerations. The material has been put to use well beyond the Fort Leonard Wood pilot.

Longest of it's kind

Designing the world's first recycled plastic railroad bridges at Fort Eustis and the first recycled plastic bridge in the NHS in York, Maine, Vijay Chandra, P.E., and John Kim, Ph.D., P.E., of Parsons Brinckerhoff are familiar with recycled thermoplastic's properties, including its benefits and limitations. The team also released a standard design guide for thermoplastic bridges in 2012. The design for the bridge over Onion Ditch was a 25° skewed variation of the standard design created by the Parsons team.

The location of the bridge is on "the north side of the Lions Club Park in West Liberty, Ohio," described Logan County Engineer Scott Coleman, P.E., P.S. "This structure brings together long-lasting recycled plastic materials and the nostalgic look of timber construction to provide a highly visible attraction for the park and the annual Labor Day parade of antique tractors."

Measuring just over 25 ft in length with a full abutment system using recycled structural plastic composite material under AASHTO HL93 standards, the plastic bridge over the Onion Ditch is the longest clear span on the NHS constructed from recycled plastic. It is an integral-abutment bridge that translates thermal expansion of the structural thermoplastic material into rotation at the 12-in. round pile groups at each abutment. The plastic pilings were driven to an embedment depth to capacity and to a length that would ensure rotation. Due to live load, the bridge superstructure is designed not to exceed a deflection of Length/425. Coleman explained their excitement at having "the opportunity to build such a unique structure through the help of the Innovative Bridge Research and Deployment Program." Although initial costs are becoming more competitive, the decision to use plastic rested solely on funding. Since the IBRD money was granted, Logan County used it. Unlike the Fort Leonard Wood pilot bridge,

The abutment backwalls of the Onion Ditch Bridge are 3-in. x 12-in. planks screwed into pilings that were driven in a line 3.25 ft on center at each abutment. Bridge seats at both abutments are 18-in. structural plastic I-beams.

the Onion Ditch Bridge is all plastic, abutments to guardrail.

The abutment backwalls are 3-in. x 12-in. planks screwed into pilings that were driven in a line 3.25 ft on center at each abutment. Bridge seats at both abutments are 18-in. structural plastic I-beams. The beams act as a pile cap, resting on top of the pile group. Galvanized drift pins driven through the pile cap into each pile make a positive connection between the pile cap and piles. The deck and superstructure were designed to act together, allowing for best use of the material. The final asphalt roadway surface was applied over a 4-in. layer of aggregate base.

Coleman explained that the project incorporated "some new member shapes and wearing-surface treatments to make it truly the first of its kind." Chandra and Kim designed a new structural member for the project, a 6-in. x 24-in. x 18-ft tongue-and-groove plank that helps reduce material, aiding the fabrication of beam clusters by the manufacturer. With the exception of pile driving, the Logan County Engineer's Office was able to requisition county staff to install the bridge over Onion Ditch. Precision Pile Driving Inc. drove the piles using a standard timber pile-driving rig.

It is one thing to receive funding for the bridge material; it is another to consider the labor involved before and during installation. The Logan County Engineer's Office had to consider every fastener and every minute of labor: "Parsons Brinckerhoff partnered with Axion to design a bridge that met the site requirement as well as all design standards. Both companies worked closely with our bridge engineers to keep the design, manufacturing and construction costs within budget, and they were always receptive of our design and constructability input. Both companies worked on an expedited schedule to meet our deadlines with the Ohio Department of Transportation for the federal aid program," explicated Coleman. Local, county-level labor was critical in keeping the project within the budget allotted by the IBRD funding.

To reduce costs further, each beam cluster with pile caps was fabricated in Pennsylvania then shipped as one piece to Ohio for installation. The placement of the superstructure took one day, and the 24 6-in. x 24-in. x 18-ft tongue-and-groove deck panels were placed, glued and drilled to the superstructure in two days.

Using traditional equipment, only carbide-tipped blades and drill bits were required to cut and drill through the structural thermoplastic. Most of the fasteners were on hand, reducing the total installation cost further. Additional fasteners and special adhesive—needed for the plastic—were procured from a national fastener chain. The relationship between designer, manufacturer, owner and builder is one that helps reduce installation time and mitigate construction problems. To the Logan County Engineer's Office, the relationship was necessary to achieve success.

"After we were awarded funding, they [Axion] continued to have an active role in ensuring that we developed a bridge that would add to the aesthetics and character of the community," Coleman noted.

Historically the bridge rehabilitation-versus-replacement question has not been easy to answer at state departments of transportation and county-level engineering offices. Given the limited funding for rehabilitation and maintenance, alternative materials and construction methods have become increasingly important. Structural thermoplastic composites are one alternative. Combining accelerated pre-construction methods with low-maintenance material proved valuable in Logan County.

"This will be a great project for the designer, manufacturer and our community," said Coleman. It might be a solution for many functionally obsolete simple-span vehicular bridges across the U.S. **R&B**

Jordan is director of business development for Axion International.

For more information about this topic, check out the Bridges Channel at www.roadsbridges.com.