Structural Sustainability

sustainability and preservation as they pertain to structural engineering

MCEO estimates that $51,000 was saved on superstructure costs by using repurposed steel beams.

Sustainable Bridge-Building Practices

Repurposing Steel to Replace Short Span Bridges

By Douglas R. Davis, P.E., P.S.

Douglas R. Davis is a County Engineer in Muskingum County, Ohio. He can be reached at ***davis.mceo@rrohio.com****.*

County engineers face a daunting balancing act when it comes to keeping their roads and bridges in service. Today's transportation needs are much more demanding than what the current infrastructure can handle. This is especially true when it comes to repairing or replacing bridges. Most of the bridge inventory in state and local jurisdictions is classified as short span, less than 140 feet in length. Here's where the balancing act comes in – on one side of the scale is the safety of the people who travel across the bridges. On the other side of the scale is a very tight budget that makes it necessary to prioritize which bridges get fixed, and how quickly. Throw into that mix the increased demand for using sustainable products and strict environmental guidelines when federal funding is involved, and the county engineer must make some tough choices. Since safety is always the priority, it takes some creative thinking and innovative solutions to meet the ever-increasing public demand for efficient roadways.

The team at the Muskingum County Engineers Office (MCEO) in Zanesville, Ohio has come up with an effective sustainable solution for building more cost-effective short span bridges. MCEO selects steel for many of its short span bridges and, whenever possible, uses repurposed steel beams removed from bridges taken out of service. The Green Valley Road Bridge near Zanesville is a good example of this plan in action.

The Green Valley Road Bridge is the fifth structure to be replaced with repurposed steel beams in Muskingum County.

The original Green Valley Road Bridge, built in 1951, was a 52-foot span painted-steel pony truss with reinforced concrete deck.It was replaced due to its poor condition, a 10-ton load limit, and the need for a structure that would allow crane access to construct a bridge project and a new electric transmission line downstream.

The new bridge was fabricated with repurposed W33x141 beams salvaged from a previous bridge replacement in the county. The beams were cut to length, cleaned of previous attachments, and mocked up on skew at the county's facility. Two rows of bolted diagonal cross-frames were fabricated from angle members that were connected to web stiffeners welded to the beams. Upon completion of fabrication, the structure was disassembled, abrasive-blasted, primed and painted.

Completed in 2014, the new Green Valley Road Bridge is 52 feet long and 20 feet wide with five beam lines, four feet on center, covered with a nine-inch-thick composite reinforced concrete deck on a 10-degree skew installed on rehabilitated concrete and masonry abutments. It is the county's fifth bridge to be replaced with repurposed steel beams. MCEO estimates that $51,000 was saved in superstructure costs by using repurposed beams versus new beams for this project.

Requirements for Repurposing Steel Beams

MCEO chooses repurposed steel when the span length, beam size and hydraulic opening allow. The challenge in using recycled or repurposed beams is finding beams that are long enough and shallow enough to carry the required load for the span. Beam sizing may require several iterations to find the right application and is impacted by

the span, spacing, loading, required vertical clearance, water opening (if over water), beam self-weight, and steel strength.

The first step in the selection process is determining if the beam can carry the load. The age and strength of the salvaged beam must be considered when evaluating applications. The age of the steel can provide clues to the steel's strength; however, lab testing of beam samples should be used if no other information (such as record drawings or invoices) is available. A deeper/taller beam may be required for the same span if a weaker grade of steel is encountered. A few other selection requirements must then be verified, such as if the span is over a road, can traffic pass under the bridge? If the span is over water, can flow resulting from storms clear the bridge without flooding the way?

Saving Costs While Being Sustainable

The beams for the Green Valley Road Bridge were selected from MCEO's most successful salvage project – the 2005 repurposing of a 326-foot-long, three-beam line, five-span bridge on Pleasant Valley Road. From the Pleasant Valley Road Bridge, MCEO salvaged three W33x130, 33 ksi beams, approximately 48 feet long; and 12 W33X141, 33 ksi beams, approximately 60 feet long. In addition to the Green Valley Road Bridge, these beams were used to construct a 55-foot long x 24-foot-wide bridge on Rural Dale Road in 2005 and a 38-foot-long x 16-foot-wide bridge on North Branch Road in 2015 – essentially constructing three new bridges from one source.

Repurposing can save more than 80 percent of the cost of purchasing new beams while extending the life of a steel beam. At the end of the beam's extended life, it can be recycled again and again into new steel products.

MCEO saved $51,000 with the Green Valley Road Bridge and $40,000 with the North Branch Road Bridge. If not for the salvaged steel, the county would not have been able to replace the North Branch Road Bridge, but instead would have been forced to close it due to its condition and the lack of available funding to purchase new beams.

Availability of Steel Beams

Many large beams can be found on the state and federal systems. MCEO prefers to obtain them before they are cut into short lengths so they can be used for crossings that require deep beam sections. Most salvaged beams can be purchased for scrap steel price. It is ideal if the state has a salvage program because if the beams are taken off of a locally owned bridge that is being replaced with federal dollars and the state does not have a salvage program, then the county must pay for salvaged materials worth more than $5,000 in value. Ohio is considering the development of a salvage program to address this issue.

MCEO purchases excess inventoried beams from a local fabricator for reduced costs and rescues beams from the local iron recycling/scrap iron yard. The strong relationships forged over the years with local business owners enables MCEO to purchase beams that are designated as excess stock or slated for recycling.

Additionally, MCEO maintains a detailed inventory of existing bridges as part of its repurposing plan. The inventory includes the number, size, length, approximate age and condition of beams available in the yard and throughout the entire existing bridge inventory. MCEO then evaluates the hydraulics for each bridge replacement location to determine the required maximum depth of a repurposed steel beam. When the span length and required vertical clearance under the bridge have been determined, the repurposed beams can be matched for future bridge replacement locations.

continued on next page

Repurposed bridges in Muskingum County, Ohio

	Location	Span	Beam Size	Source	Year Replaced	Cost Savings
1	North Branch Road	38 feet	4-W33x130	Pleasant Valley Road	2015	$40,000
2	Green Valley Road	51 feet	5-W33x141	Pleasant Valley Road	2014	$51,000
3	Rural Dale Road	55 feet	6-W33x141	Pleasant Valley Road	2005	$55,000
4	Richey Road	23 feet	6-W12x79	Stock	2012	$20,000
5	Clay Pike Road	53 feet	4-W30-116 2-W27x102	Stock	2007	$52,000
6	Goosecreek Road	16 feet	5-W14x48	Scrap $0.20/lb	2014	$5,000
7	Bush Hill Road	28 feet	5-W14x48	Scrap $0.20/lb	2014	$7,000
	TOTAL SAVINGS					$230,000

Bridge owners can typically construct short span steel bridges with on-hand tools and equipment using local work crews, saving significant project costs.

Recycled steel provides superior durability with minimal impact to the environment.

Steel = Time and Cost Efficiencies in Design and Construction

Approximately 60 percent of Muskingum County's 409 bridges are constructed with steel. There are 42 steel truss bridges (one built in 1913), three steel girder bridges, 186 steel beam bridges and 19 buried steel structures (corrugated plate/pipe).

In addition to its recycling/repurposing advantages, MCEO prefers steel because it provides these cost-saving and time-saving benefits:

- Steel is readily available to MCEO as a construction material.
- It offers ease of handling, repairability and a uniform fabrication process by MCEO personnel or a local fabricator.
- It is ideal when using local crews. Many of the bridges in Muskingum County are over 50 years old. Several of those were built by county crews that set the steel beams with county equipment (no large cranes required, saving significant costs) and repair them with welding or bolting. Many of MCEO's concrete structures are unrepairable or more costly to repair once they begin to fail due to spalling and reinforcement deterioration.
- Steel facilitates ease of load rating. A steel beam bridge can be load rated simply by determining the steel section size and amount of section loss. A concrete structure is more difficult to load rate due to the lack of design drawings showing the amount and location of reinforcement in the structure.
- Because of steel's efficiencies in construction and installation, there is a shorter time required for road closures.

What's Involved When Using Federal Funding for Local Bridge Projects?

County engineers do not have enough local funds to properly maintain their infrastructure. As a result, they seek federal dollars, which brings with it federal environmental requirements and oversight by the U.S. Fish and Wildlife Service (USFWS), the U.S. Army Corps of Engineers (USACE), and the U.S. Environmental Protection Agency (USEPA).

Federally endangered and threatened species (such as bats) limit tree cutting from April through September, which can delay the start of projects. Waterways with over 10 square miles of drainage area may be habitat for freshwater mussels which require, at a minimum, a mussel survey. If mussels are located, then relocation and a check-up to determine their health one year after relocation are required. Small percidae fish (known as darters) spawn in the spring and can delay in-water work until after July 1st. Bald eagle nests can result in restrictions to work around nesting areas and may impact project limits.

Work in the waterway falls under the oversight of the U.S. Army Corps of Engineers. Depending on the size, quality and designation as a scenic waterway, permits may need to be obtained to protect water quality and to place fill material in the waterway.

The most common USACE permit is required when there is a need for the removal or placement of fill, and is related to section 404 of the Clean Water Act (commonly referred to as a 404 permit). Depending on the length of the waterway to be disturbed, requirements to obtain an individual permit or a general permit will apply. A general permit is straightforward and requires an application and design showing the volume of material to be removed or placed. For a fairly common project requiring only placement of rock channel protection, it can take up to three months to obtain a permit. The application for this permit typically takes 3-6 hours to submit and usually results in a few requests from the USACE for clarification and information before it is issued. An individual permit can take up to a year or more depending on the magnitude of the impact.

The Clean Water Act also applies to construction storm water discharges. Projects over one acre in size require a permit and a plan to prevent the release of sediment-laden water from the site. These permits are issued by the state EPA or equivalent.

Most bridge projects are located within the flood plain of a waterway and require coordination and a permit for floodplain management under the Federal Emergency Management Agency's (FEMA) National Flood Insurance Program. The goal of this review is to prevent an increase in the 100-year flood elevation upstream and downstream of the bridge.

While securing federal funding is important for rebuilding critical local infrastructure, it can create significant design and construction delays for local jurisdictions.

Training Opportunities and Design Tools Available at No Charge

County engineers are accustomed to meeting challenging demands with creative solutions. Repurposing steel beams is an effective method for MCEO, and Muskingum County will be using repurposed steel well into the future.

MCEO has benefited from several helpful training tools for constructing short span steel bridges that are available free of charge from the Short Span Steel Bridge Alliance (SSSBA). These tools include complimentary workshops for county engineers, Departments of Transportation (DOT) personnel, design firms and road supervisors that can be scheduled through each state's Local Technical Assistance Program/Tribal Technical Assistance Program Centers. Conducted by bridge engineers, the half-day or full-day format covers design tools, case studies, accelerated bridge construction options, practical and cost-effective fabrication, buried steel bridges, recent innovations in protective coatings, and more. Topics can be tailored to the needs and interests of the local agencies. For more information, visit **www.shortpsansteelbridges.org**.

A free web-based design tool developed by the SSSBA provides customized short span steel bridge designs. eSPAN140 delivers preliminary design solutions for individual projects, and the contact information for companies and people who can deliver the bridge. After the user inputs a minimum of three project parameters, a PDF document of steel solutions is delivered within seconds. Since 2012, approximately 2,000 preliminary designs have been generated. More information is available at **www.espan140.com**.▪