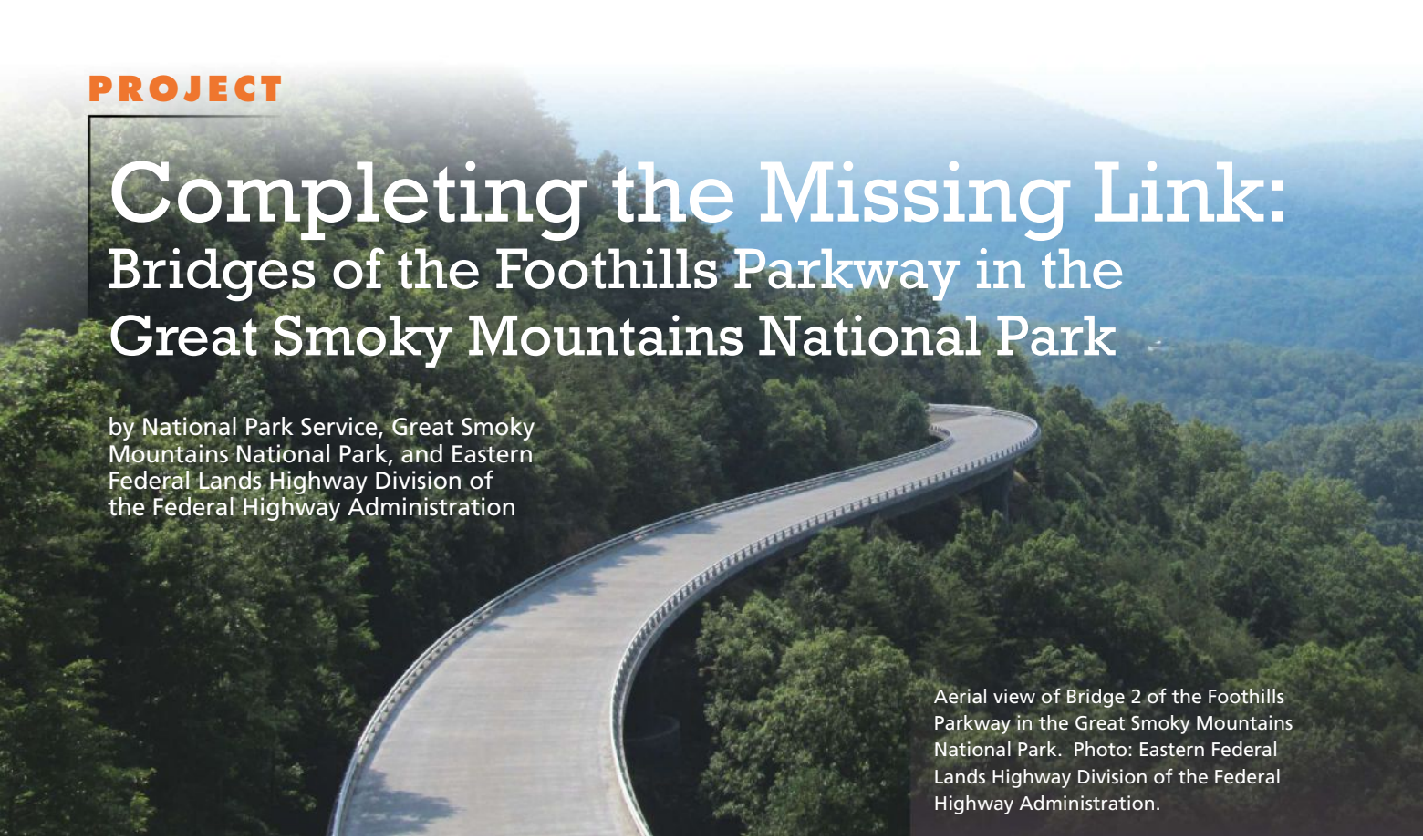
PROJECT

Completing the Missing Link:
Bridges of the Foothills Parkway in the Great Smoky Mountains National Park

by National Park Service, Great Smoky Mountains National Park, and Eastern Federal Lands Highway Division of the Federal Highway Administration



Aerial view of Bridge 2 of the Foothills Parkway in the Great Smoky Mountains National Park. Photo: Eastern Federal Lands Highway Division of the Federal Highway Administration.

Winding along the northern side of the Great Smoky Mountains National Park is the Foothills Parkway. Authorized by Congress in 1944, the parkway was originally envisioned as a 72-mile scenic route with breathtaking views of the park. Currently, 37.2 miles are open to public traffic, including Sections E and F, which are 15 miles long. Within those sections is a 1.6 mile stretch of particularly challenging terrain. Because this part of the roadway was left incomplete after the last period of active construction in the 1980s, it became known as the "Missing Link."

The Missing Link passage includes nine bridges constructed on very steep terrain that cross ravines and environmentally sensitive areas. This construction project represents a major milestone toward completion of the Foothills Parkway from Wears Valley to Walland, Tenn. The Eastern Federal Lands Highway Division (EFLHD) of the Federal Highway Administration (FHWA) worked in partnership with the National Park Service to administer the design and construction of this section of the parkway.

Site Challenges

The nine bridges, numbered 2 through 10, in the Missing Link section include multispan prestressed concrete beam bridges as well as more complex, cast-in-place (CIP) post-tensioned box-girder bridges, and CIP and precast concrete segmental bridges. Because of the mountainous terrain, all the bridges have challenging horizontal and vertical alignments, which include horizontal curves as tight as 650 ft in radius, reverse curves, and transition spirals.

The project sites were narrow. Disturbance had to be limited as much as possible to the footprint of the parkway and could not extend past the drip lines of the bridges. On some of the steepest terrains, access was very limited and top-down segmental bridge construction was implemented. The use of design visualization, prepared by EFLHD, played a key role in the planning necessary to ensure that the Missing Link bridges were constructed using the most environmentally sensitive methods available.

Bridge 2 has a horizontal alignment composed of a reverse curve with transition spirals and a vertical alignment with a sag curve. These features contributed to the complexity of bridge construction. Photo: Eastern Federal Lands Highway Division of the Federal Highway Administration.

Pier and superstructure segments for Bridge 2 in the precast concrete yard. Photo: Eastern Federal Lands Highway Division of the Federal Highway Administration.

Bridges 2, 9, and 10

Bridges 2, 9, and 10 are noteworthy segmental, single-cell box-girder bridges built using top-down construction.

On the east end of the Missing Link, Bridge 2 has a length of 790 ft with five spans (125 ft, 180 ft, 180 ft, 180 ft, 125 ft) (see the article in the Fall 2012 issue of *ASPIRE*®). The geometry of this bridge includes a horizontal alignment with a reverse curve and transition spirals and a vertical alignment with an 8% change in grade sag curve. Ninety-two precast concrete segments were used for the superstructure and twenty for the piers. The foundations are supported on micropiles that vary in length due to varying geotechnical conditions.

The typical superstructure segment is a single-cell box girder with a constant depth of 9 ft 0 in. and a width of 36 ft 10 in.; each of these segments weighs 50 tons. The top slab is transversely post-tensioned. The substructure segments have widths from 10 ft 0 in. to 13 ft 8 in., are hollow, and are post-tensioned.

The specifications for the structure, prepared by EFLHD, required that the segments be cast at a Precast/Prestressed Concrete Institute (PCI)–certified facility to ensure quality fabrication of the segments.

Located in steep terrain, Bridge 2 was accessible from only one end during construction. Site constraints prevented the contractor from erecting the precast concrete segments with traditional cranes or overhead erection trusses. A temporary trestle/falsework system was used to support the segments and the elevated rail system for the gantry crane that was used to erect them.

On the west end of the Missing Link, Bridges 9 and 10 each have lengths of approximately 475 ft. Each of these bridges has three spans (approximately 138 ft, 194 ft, 138 ft). These bridges are also on reverse-curved horizontal alignments with spirals. The vertical alignment includes a crest curve with a 9.6% change in grade.

Bridges 9 and 10 were constructed using CIP segmental, balanced-

Due to the steep terrain at the site for Bridge 2, a temporary trestle/falsework system was constructed to support a gantry crane to erect the precast concrete segments. The gantry is lifting a pier segment in this photo. The access hole in the segment is visible. Photo: Eastern Federal Lands Highway Division of the Federal Highway Administration.

Segment erection as Bridge 2 nears completion. Photo: Great Smoky Mountains National Park, National Park Service.

Aerial view of the "Missing Link." Bridge 2 is visible in the center. Photo: Eastern Federal Lands Highway Division of the Federal Highway Administration.

cantilever techniques. Pier segments were used for both the piers and superstructure. The foundations are supported on spread footings. The superstructures consist of 13 segments each. The typical superstructure segment is a single-cell box girder with a constant depth of 9 ft 0 in. and a width of 36 ft 10 in. The top slabs are transversely post-tensioned.

Bridges 3 Through 7

Bridges 3 through 7, the last five structures constructed in the Missing Link project, are cast-in-place segmental box-girder bridges. The cross-sectional geometries of these bridges are like those of Bridge 2.

Bridges 4 and 5 are multispan structures, and Bridges 6 and 7 have single spans. Even the single-span bridges cross steep terrains and ravines and accommodate a variety of curves and spirals. The foundations of these bridges are supported with spread footings and micropiles. Multispan, prestressed concrete AASHTO-type girder structures were used for the parkway bridges that did not require spanning over steep terrains.

Aesthetics and Maintenance

All nine bridges in the Missing Link blend with their local surroundings. Aesthetic design elements include integrally colored concrete on the superstructures; integrally colored, fiber-reinforced high-performance concrete overlays; stone faces on the substructures; piers that blend into the superstructures; and aluminum bridge rails.

Additionally, the structures have been designed to anticipate bridge inspection and maintenance needs. For example, access doors are large enough to accommodate large equipment inside the single-cell segmental bridges, and abutments have openings to provide for proper ventilation during inspection. The bridges are designed to require minimal maintenance with a design life of 75 to 100 years.

Next Steps

Building on prior planning efforts and environmental studies for the Foothills Parkway, the NPS and FHWA propose to reinitiate the National Environmental Policy Act planning process for the next section of the parkway, the 9.8-mile-long Section 8D. Section 8D is the next logical section of the Foothills Parkway to construct because it will connect Section 8E in Wears Valley to the Gatlinburg Spur (U.S. Route 441) in Pigeon Forge, Tenn. This will create a new connection to the northern boundary of the Great Smoky Mountains National Park.

EDITOR'S NOTE

Bridge 2 received a 2013 ASBI Award of Excellence and a 2014 PCI Design Award in the category Best Bridges with Main Span More than 150 ft.