PROJECT

The Two Medicine River Bridge

Segmental box-girder bridge complements surroundings, improves access to Glacier National Park

by Bruce Kates, Jacobs Engineering

U.S. Highway 2 is the northern-most, east-west highway crossing the United States and the Rocky Mountains. It runs along the southern edge of Glacier National Park and provides access for visitors to both the east and west entrances. On the eastern side, just outside the community of East Glacier Park, Mont., U.S. 2 crosses the Two Medicine River and the gorge that the river has carved through the ages.

Rising majestically from the steep banks of the Two Medicine River are two "twin column" piers reaching high above the stream bed to support the new, graceful, variable-depth, segmental box girder bridge. This beautiful structure is the first of its type in Montana. The box girder unit has spans of 290, 520, and 350 ft, while the three east approach spans have precast, prestressed concrete girders made continuous over the intermediate bents and span lengths of 120 ft.

Planning

During the planning stages of the project, the prices of steel and concrete were quite volatile making it difficult to estimate the cost of the structure or to reliably predict which material would result in the most cost-effective alternative. This was part of the reason that two different structures were designed for the replacement: a concrete box girder and steel deck truss using weathering steel. Both alternatives were included in the bidding plans and contractors were encouraged to bid on either or both structures. A second aspect of the bidding process required a price for the construction cost as well as a number of days of construction to complete the project. The number of days multiplied by a specified cost per day combined with the construction cost constituted the total bid. As a result, the Montana Department of Transportation (MDT) was able to get the best value in capital cost as well as minimize the inconvenience to the traveling public.

Substructure

Concern for the slope stability of the steep river banks prompted a significant geotechnical exploration program and the borings into rock dictated careful consideration for the location of the supporting piers and bents. All substructure members are founded on drilled shafts 6 to 8 ft in diameter taken down and socketted into rock. The main piers (piers 2 and 3) feature four, 8-ft-diameter shafts with a 36 by 36 by 12 ft cap, with heavy reinforcing steel and draped post-tensioning to help resist the loads from the columns located between the shafts.

The twin column main piers are rectangular in cross section (6 by 15 ft) with tapered corners on the long sides and rustication running vertically up the center. They rise higher than the trees, then splay outward from the centerline of the pier as they approach the superstructure and transition smoothly to meet the bottom of the box section with its sloping webs. Both main piers are fixed piers so the connections

profile

THE TWO MEDICINE RIVER BRIDGE / EAST GLACIER PARK, MONTANA

BRIDGE DESIGN ENGINEER: Jacobs Engineering, Seattle, Wash.

PRIME CONTRACTOR: Ralph L. Wadsworth Construction Company, Draper, Utah

CONSTRUCTION ENGINEERS: Jacobs Engineering, St. Louis, Mo., and Nutt, Redfield and Valentine, Orangevale, Calif.

PRECAST CONCRETE SUPPLIER: Montana Prestressed Concrete, Billings, Mont.— a PCI certified producer

POST-TENSIONING AND FORM TRAVELER SUPPLIER: Schwager Davis Inc., San Jose, Calif.

MODULAR EXPANSION JOINTS AND DISC BEARINGS: D.S. Brown Company, North Baltimore, Ohio

General view of the structure nearly complete. The existing bridge is in the foreground. All photos: Jacobs Engineering, with permission from the Montana Department of Transportation.

Superstructure

The new superstructure features a single-cell, box girder with web walls sloping at 5:1 (vertical:horizontal). The depth of the box varies from 30 ft at the main piers to 11.5 ft at midspan and the ends of the side spans. The variable depth of the box provides a graceful appearance as it soars over the canyon high above the treetops. The finished deck reaches a height of about 195 ft over the streambed. It then merges with the trees as it approaches the abutment at the west end of the bridge.

The variable depth of the box provides a graceful appearance as it soars over the canyon high above the treetops.

between them and the box are continuous, with column reinforcing reaching fully through the interior diaphragms to the top slab of the box girder. With significant reinforcing steel in the box, columns, and diaphragms, and provisions for future post-tensioning and its associated reinforcement, integrated drawings were required. These drawings combined all of the details into a single three-dimensional drawing file, which could be viewed from various angles to check for spacial conflicts.

The column of bent 4 (4 by 12 ft) supporting the transition cap between the box girder and the approach spans has a similar cross section as the main pier columns with the tapered corners and vertical rustication and a hint of a flare as the column reaches up toward the cap. The superstructure transitions from the box girder terminating in span 3, to the precast, prestressed concrete girders (MTS-72) continuing on in span 4. This requires a transition bent cap to provide bearing seats at significantly different elevations to support the special bearings beneath the 11.5-ft-deep box and the transverse shear blocks, and the smaller bearings beneath the 72-in.-deep, bulb-tee girders. Walls were cast on each end of the cap to soften the appearance of the many details coming together in this transition region.

The sloping web walls and variable-box-depth characteristics result in a bottom slab width that varies from 26.25 ft at mid-span to 18.86 ft at the piers. The web walls are 28.60 ft apart center-to-center beneath the 49.33-ft-wide top slab, which serves as the deck of the bridge. The web walls are 16 in. thick and transition to 24 in. thick through the end segment near bent 4. The top slab thickness varies with a minimum thickness of 10 in. midway between the webs and at both fascias. The bottom slab is 10 in. thick through the end segments and the outer halves of the cantilever segments, but thickens to 24 in. approaching the main piers.

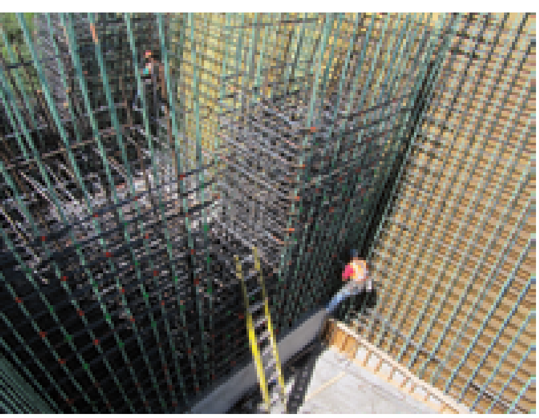
MONTANA DEPARTMENT OF TRANSPORTATION, OWNER

BRIDGE DESCRIPTION: A 1160-ft-long, single-cell, post-tensioned, cast-in-place, concrete segmental box girder bridge with spans of 290, 520, and 350 ft built by the balanced cantilever method with three 120-ft-long, precast concrete, bulb-tee girder approach spans

STRUCTURAL COMPONENTS: Drilled shafts socketed into rock, twin column main piers, single cell box girder superstructure, and MTS-72 precast, prestressed concrete girders with a cast-in-place deck

BRIDGE CONSTRUCTION COST: \$24,137,375 (\$322/ft^2)

Pier 2 columns complete.



Pier 2 diaphragm, column, and web reinforcing steel, all part of the pier table.

Post-tensioning is provided for cantilever construction in the top slab above the web walls using thirteen 0.6-in.-diameter strands providing 571 kips of force in each tendon, with one tendon over each web. With the non-symmetrical pier table, two tendons are added with each segment completed, with the tendons run back through the pier table to the end of the opposite cantilever. Thus each segment ultimately has two tendons anchored over each web.

In the bottom slab, continuity tendons consist of seventeen 0.6-in.-diameter strands providing 747 kips of force in each tendon. Transverse tendons in the top slab consist of four 0.6-in.-diameter strands spaced at about 3 ft providing 176 kips of force per tendon. The superstructure contains approximately 128 miles of post-tensioning strand.

The deck of the new bridge includes a 12-ft-wide traffic lane and an 8-ft-wide shoulder in both directions, with a 6-ft-wide sidewalk on the north side of the structure. The traffic rail on both sides of the bridge is comprised of a 1.67–ft-wide reinforced concrete curb with a three-beam galvanized steel guard rail mounted on top, making the total deck width 49.33 ft. This rail provides greater visibility of the surrounding scenery and the river below while protecting the motoring public.

Concrete

With respect for the relatively harsh climate of the northwest Montana winters, the specifications for the concrete of the box girders included the use of high-performance concrete. The design strength for the concrete was 6 ksi and the specifications required a value less than 1500 coulombs at 28 days based upon the rapid chloride permeability test. This required the use of silica fume and fly ash in the concrete to reduce permeability and to improve the resistance to chloride penetration (from road salts used for de-icing). The material for the box girder consistently reached a compressive strength of 9 to 10 ksi at 28 days and permeability of 1300 to 1500 coulombs at 28 days and 700 to 900 coulombs at 56 days.

With the relatively rough finish of the box girder deck, a concrete overlay was placed to provide a smooth riding surface and an additional layer of protection for the epoxy-coated reinforcing steel in the deck and the post-tensioning system. Silica fume and fly ash were also included in the overlay to reduce its permeability, and when combined with grout pumped through all of the post-tensioning ducts the durability of the structure is enhanced.

Overhead view of the Pier 2 pier table top slab forms.

Bearings

Disc bearings with polished stainless steel and polytetrafluorethylene sliding surfaces allowing low friction movement were used to support the box girder at abutment 1 and bent 4. Modular expansion joints were installed in the deck at the ends of the box girder unit. These stout joints combined with neoprene glands between the transverse rails of the joints provide significant movement capacity without allowing water to leak or flow through the joints. This prevents damage and maintenance problems for the structural elements.

With improvements to the roadway that include a straighter horizontal alignment, grades at each end of the structure were reduced from 7% to 5%, improving drainage. Local residents and visitors to Glacier National Park will enjoy this much needed improved structure for generations to come.

Bruce Kates is a project manager and technical consultant with Jacobs Engineering in Seattle, Wash.

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