U.S. Route 2 Lohman East & West Roadway and Bridge Improvements

New Deal–era Civilian Conservation Corps construction crews built about 3000 miles of new roads and more than 1200 timber bridges in Montana. Photo: Origin unknown.

by Stephanie Brandenberger, Dan Maze, and Mike Moore, Montana Department of Transportation

The Great Depression began in 1929 with the stock market crash and was made worse by the 1930s Dust Bowl. When President Franklin D. Roosevelt took office in 1933, he responded to the nation's economic disaster with programs known as the New Deal. Among other initiatives, the New Deal directed funds to stimulate recovery through public works construction programs that aimed to employ as many people as possible and connect developing markets in agriculture and natural resources with an improved transportation network. This program changed Montana's transportation landscape. Through funding from the New Deal, about 3000 miles of new roads and more than 1200 timber bridges were built in Montana.

Timber was the construction material of choice in Montana in the New Deal era for several reasons: concrete and steel were costly and limited in availability; high-quality timber was regionally available; timber construction could be achieved using a standard design and modular approach. At one time, timber bridges were built at a rate of 100 bridges per year. More than 400 of these timber bridges are still in service on Montana's state highways, including many structures that are well over 80 years old.

Project Location and Description

The northern Montana communities in Blaine County were beneficiaries of the historic New Deal program with the construction of what is now U.S. Route 2 (U.S. 2), which runs east to west across Montana's "Hi-Line" region through

The Clear Creek timber bridge, which had abutment and bank scour and previously repaired timber members, needed replacement. Photos: Montana Department of Transportation.

profile

LOHMAN EAST & WEST PROJECT BRIDGES AT CLEAR CREEK, RED ROCK WEST OVERFLOW, RED ROCK COULEE, AND RED ROCK EAST OVERFLOW / **BLAINE COUNTY, MONTANA**

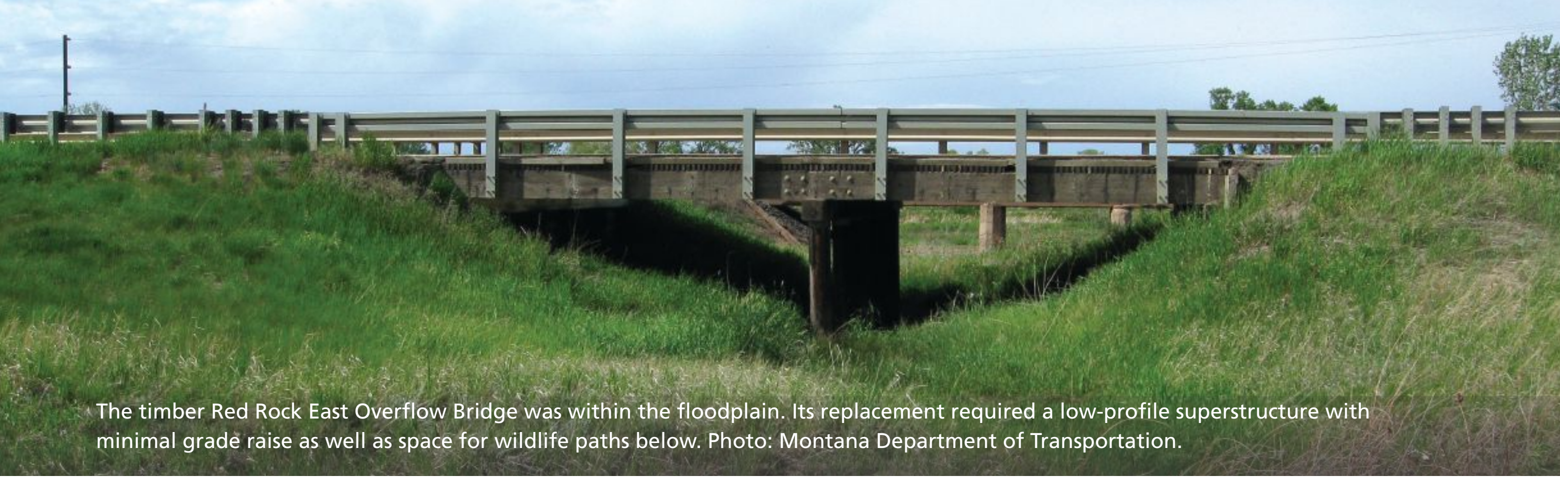
BRIDGE DESIGN ENGINEER: Montana Department of Transportation, Helena, Mont.

CONSTRUCTION ENGINEER: Montana Department of Transportation, Havre, Mont.

PRIME CONTRACTOR: Schellinger Construction Co. Inc., Columbia Falls, Mont., and Sletten Construction, Great Falls, Mont. (bridge subcontractor)

CONCRETE SUPPLIER: Havre Sand & Gravel, Havre, Mont.

PRECASTER: Forterra Building Products, Billings, Mont.—a PCI-certified producer



The timber Red Rock East Overflow Bridge was within the floodplain. Its replacement required a low-profile superstructure with minimal grade raise as well as space for wildlife paths below. Photo: Montana Department of Transportation.

wide, open spaces and rich farm and ranch land. The Montana Department of Transportation's (MDT's) Lohman East & West project reconstructed 10.4 miles of U.S. 2 just west of the town of Chinook and through the community of Lohman. This section of roadway was originally constructed in 1938, and although it had been upgraded several times throughout the decades, it needed significant capital investment to improve the condition, safety, and operational efficiency of the roadway and bridges. Most of the roadway and bridges in this section were just 28 ft wide.

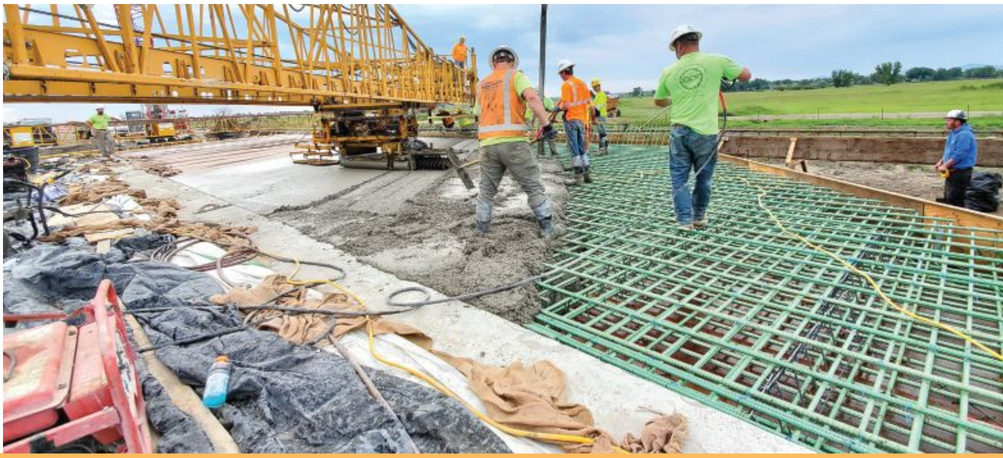
The 10-mile stretch of roadway covered by the Lohman East & West project originally included 10 bridges. One of them, over the Milk River, had been reconstructed in 2004 following severe flood damage and was incorporated into the project; five of the minor timber structures would be replaced with culverts; and four timber bridges would be replaced with new concrete bridges. The project design also included new passing lanes, turning lanes, wider shoulders, and flatter roadway side slopes to improve safety, address run-off-road crashes, narrow bridges, and wildlife-vehicle collisions. The project section is located within the limits of the Clear Creek, Red Rock Coulee, and Milk River floodplains. Limiting grade raises and floodplain impacts were other significant criteria for the types of bridges selected.

Cast-in-Place Concrete Flat-Slab Bridges

Two perennial streams within the project limits, Clear Creek and Red Rock Creek, have relatively narrow channel bottom widths (13 and 19 ft, respectively), and the combined project needs at these locations presented significant challenges for the geometric design and engineering of the new concrete bridges. The meandering channels of these two waterways approached the roadway centerline at a significant skew angle and wound around the abutments, creating oxbows and pools adjacent to the roadway that needed to be addressed. To minimize grade raise and hydraulic impacts on the floodplain, a shallow superstructure was required. The bridge type and span arrangement also needed to accommodate wildlife passage underneath the bridge on the channel banks. The existing timber bridges were just 59 ft long with 20-ft spans. Longer bridges and different span arrangements were needed to address the numerous natural resource needs.

Ultimately, a three-span, cast-in-place concrete flat-slab bridge was selected as the structure type at these two sites. The configuration of this bridge type can be customized to the complex geometry and provides the shallow

Placing concrete for a 1-ft 4½- in.-thick cast-in-place flat-slab bridge. Low-slump concrete with 4000-psi design strength was specified to minimize cracking and reduce the permeability of the concrete for improved deck durability Epoxy-coated reinforcement was used in the deck to improve corrosion resistance and service life. Photo: Montana Department of Transportation.



MONTANA DEPARTMENT OF TRANSPORTATION, OWNER

BRIDGE DESCRIPTIONS: Two 94-ft-long, 3-span, cast-in-place, flat-slab bridges with 45-degree skew; and two 2-span, precast, prestressed concrete flat-slab beam bridges, 50 and 62 ft in length

STRUCTURAL COMPONENTS: Reinforced concrete pile caps and abutment walls; cast-in-place reinforced concrete flat slabs; precast, prestressed concrete flat-slab beams; cast-in-place concrete barrier rails and concrete-filled pipe piles

BRIDGE CONSTRUCTION COST: Clear Creek $762,830 ($210/ft² cast-in-place concrete); Red Rock West Overflow $766,765 ($180/ft² precast concrete); Red Rock Creek $1,185,747 ($200/ft² cast-in-place concrete); Red Rock East Overflow $464,810 ($183/ft² precast concrete) depth required to minimize grade raise and floodplain impacts. The two bridges have the same span arrangement and overall length, which simplified design and construction. The final design was a three-span, continuous flat-slab bridge with a total length of 93 ft 9 in. built on a 45-degree skew to follow the channel orientation as closely as possible. The Clear Creek bridge is 42 ft 9 in. wide to accommodate two travel lanes, 8-ft-wide shoulders that provide safe passage for bicyclists and vehicle recovery zones, and a cast-in-place concrete barrier on each side. The Red Rock Creek bridge, which is within a four-lane passing section of the roadway, is 66 ft 9 in. wide. Each span of the continuous flat-slab bridges is 31 ft 3 in. long and 1 ft 4½ in. thick and is supported by integral concrete pile caps. A high-molecular-weight methacrylate sealer was applied after construction to seal shrinkage cracks, which is MDT standard practice for bare concrete decks.

Precast, prestressed concrete flat-slab beams were selected to replace the 38-ft-long timber bridges at two sites. Photo: Montana Department of Transportation.

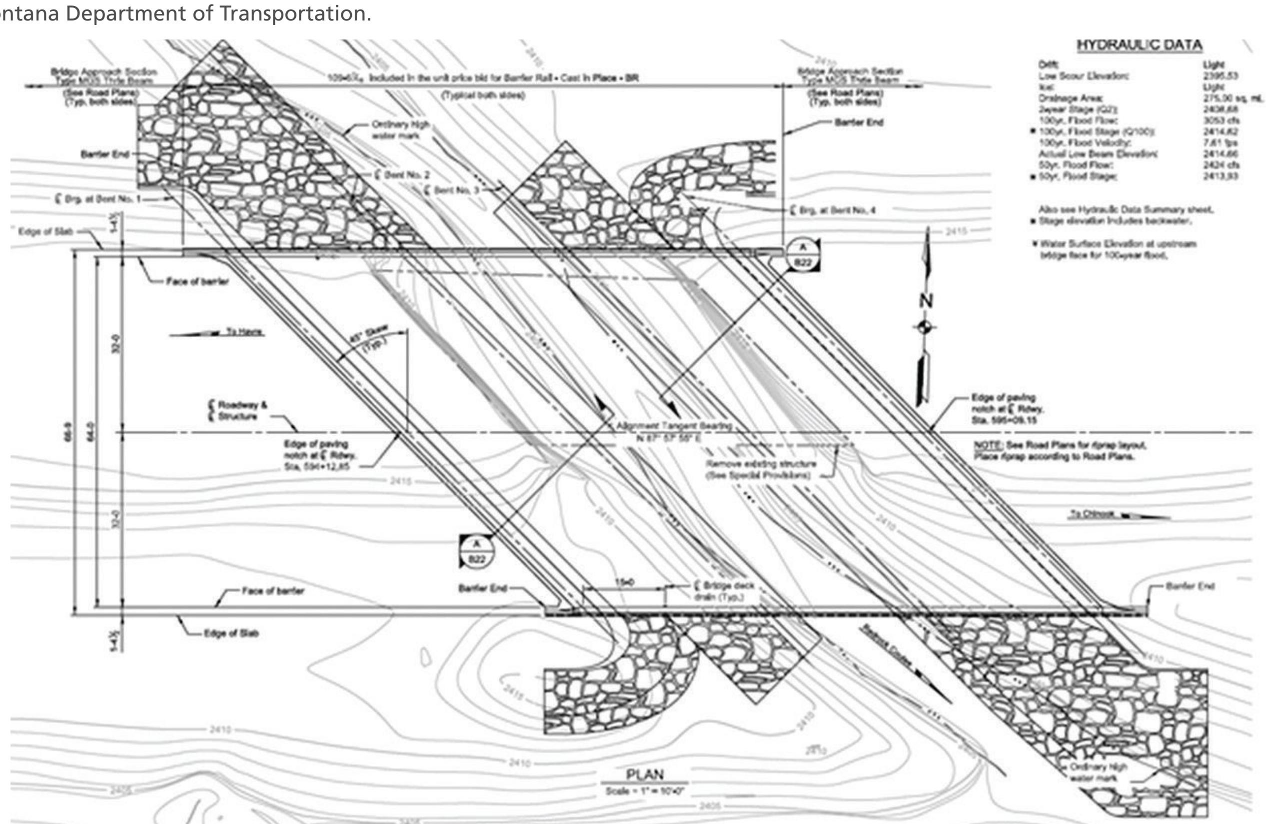
The engineering and reinforcing steel design of the two flat-slab bridges was challenging due to the extreme skew angle of the supports. The significant width of the Red Rock Coulee bridge compounded the skew effects, and the relatively shallow span-to-depth ratio added even more complexity to the design. This seemingly simple, reinforced concrete section design required more than just the classic engineering textbook solutions or approximate methods. Finite element analysis software was used to develop a three-dimensional finite element model to perform a refined analysis that accounted for the skew effects and placement of live loads in multiple lanes. The ability of the program to represent the orientation of the slab and supports, apply dead loads and vehicular live loads to the model, and analyze numerous load cases quickly was key to making this a practical approach to a challenging design. The analysis results showed that in certain locations on the bridge, design stresses in the slab and pile cap were likely to be significantly larger than those determined through simplified, approximate design methods.

The slab was constructed with four layers of epoxy-coated reinforcement to resist longitudinal and transverse flexure in the slab and torsional stresses in the integral cap sections. The reinforcement design balanced the maximum bar sizes (typically, no. 8 or 9 epoxy-coated reinforcing bars) with an optimized spacing to facilitate concrete placement. Low-slump concrete with 4000-psi design strength was specified to minimize cracking and reduce the permeability of the concrete for improved deck durability. With the dense mats of reinforcement, the low-slump concrete proved challenging to place, and repair of voids and honeycombs was required in some areas.

Precast, Prestressed Concrete Solid Flat-Slab Beams

Two ephemeral drainages within the project limits presented less-complex geometry than the perennial creeks, allowing a more straightforward design solution. The Red Rock West Overflow and the Red Rock East Overflow were also within the floodplain and required low-profile superstructures with

Red Rock Coulee flat-slab bridge design was challenging due to the extreme skew, significant width, and relatively shallow span-to-depth ratio. Finite-element analysis was required instead of classic engineering textbook solutions or approximate methods. Figure: Montana Department of Transportation.



minimal grade raise as well as space for wildlife paths below. A precast, prestressed concrete, solid flat-slab beam superstructure with a waterproof membrane and asphalt overlay was selected to replace the 38-ft-long timber bridges at these two sites. The two-span Red Rock West Overflow bridge, which is in the five-lane passing and turning section of the roadway, is 52 ft long and 80 ft 1 in. wide. The design for the Red Rock East Overflow has the same two-span superstructure arrangement, but the bridge is 60 ft long and 42 ft 9 in. wide. Although of different span lengths, the depth and width of the prestressed concrete slab beams were the same at all locations, which allowed for the use of typical details for each structure. The asphalt overlay served the dual purpose of protecting the concrete surface of the beams from wear and improving the ride quality over the cambered prestressed concrete sections of each span and simple supports at the intermediate bent. The beams included integral reinforcement for a cast-in-place concrete bridge barrier.

The challenges related to these two structures mostly involved construction scheduling, sequencing, and material delivery within the broader context of the project. Because of the remote location of the project, the volume of concrete delivered had to be carefully considered in the timing of construction. The use of precast concrete elements rather than cast-in-place bridges, allowed for more sequential and overlapping work at all four bridge locations and accelerated the project schedule overall.

Foundations

Deep foundation systems primarily consisting of friction piles were used at all of the new bridge locations. Given the subsurface conditions, evaluation of the driven pile capacity using typical methods could result in widely variable tip elevations and pile lengths. Having estimated that more than 7000 ft of concrete-filled, 16 × ½-in. steel-pipe pile would be installed for the bridge foundations, MDT determined that performing a static load test on a pile during construction would benefit the project in numerous ways. The purpose of a static load test is to verify the pile capacity at the test location and take advantage of the lower design factor of safety (which is equivalent to a higher resistance factor), and use these verified test results to refine the pile design lengths at other locations on the project. The load test provided economic benefit by reducing risk and uncertainty of pile driving for both the contractor and MDT.

Conclusion

Concrete has replaced timber as the bridge construction material of choice for Montana's rural highways. Although the 80-year lifespan of the timber bridges from the New Deal construction era is remarkable, the concrete bridges constructed for the Lohman East & West project will become part of a new, resilient, safe, and effective "Hi-Line" highway that will provide at least another 80 years of service to the people of Montana.

Stephanie Brandenberger is the chief bridge engineer of the Montana Department of Transportation Bridge Bureau. Dan Maze is a bridge engineer for the Great Falls Area bridge design unit and was the bridge engineer for the preconstruction phase of this project. Mike Moore is an engineering project manager for the Great Falls District Field Construction division and was the engineer for the construction phase of the project.