Enhancing the 'Bread and Butter'

by Joan D. Bowser, Zann Jones, Jimmy D. Camp, and Robert Meyers, New Mexico Department of Transportation

Typical New Mexico bridges use innovative designs featuring precast concrete U-beams and cast-in-place concrete decks

Intricate and creative designs for once-in-a-lifetime bridges garner awards and acclaim, but designers are most in need of ideas for the typical bridges they design and build every day. The Guadalupe County I-40 Overpass bridges, a set of three structures, gave designers with the New Mexico Department of Transportation an opportunity to solve recurring problems, create strong aesthetic appeal, improve durability, and stay under budget. The design, featuring precast concrete U-beams and cast-in-place concrete decks, provides a strong option for many future bridges.

The new structures, which cross I-40, replaced bridges that were functionally obsolete and structurally deficient. Two of the bridges carry local traffic on minor arterial roads, while the third carries U.S. Route 84. The new structures were offset from the original bridges allowing free design within standard roadway parameters. A cross section consisting of two 12-ft-wide lanes with 6-ft-wide shoulders, for a total roadway width of 36 ft and a bridge width of 39 ft, met the standards for the arterial roads. Eight-ft-wide shoulders were required on the U.S. Route 84 bridge, creating a total roadway width of 40 ft and bridge width of 43 ft.

Interstate 40 carries many travelers and tourists, and the bridges welcome people to the state and to Guadalupe County. To enhance that welcome, strong aesthetics were desired for these bridges. The design also had to reflect the local color of the area and be tied together to establish continuity.

Identical Structures Created Efficiency

The designers decided that the easiest way to approach this challenge was to create identical structures for all three bridges, so artwork could then reflect each locality, while the bridges provided continuity. As a result, the design had to fulfill the requirements for all three bridges. This task was simplified because the interstate highway maintained a consistent width throughout the project length. After considering a variety of options, the designers decided to create two-span bridges with a pier in the center of the median.

Large, unconstrained areas of slope paving on steep slopes have created problems in the past, so the team was asked to avoid using steep slopes constrained by slope paving as the support at abutments. Using self-stable slopes would have added 50 to 60 ft to each roadway side, creating spans of about 150 ft, which would have required an increase in road height of 9 in. or more. Mechanically-stabilized earth (MSE) walls proved to be a better value economically and were thought to have better aesthetic potential for the given

profile

GUADALUPE COUNTY I-40 OVERPASS BRIDGES / GUADALUPE COUNTY, NEW MEXICO

ENGINEER: New Mexico Department of Transportation, Santa Fe, N.M.

PRIME CONTRACTOR: Reiman Corp. subcontracted to James Hamilton Construction Co., Silver City, N.M.

MSE WALL SUPPLIER: Costillo Ready Mix Concrete, Inc., Belen, N.M.

PRECASTER: Coreslab Structures Inc. (formerly Rinker Materials), Albuquerque, N.M., a PCI-Certified Producer

situation. MSE support was chosen using a 9-ft 6-in. setback from the face of the support to the centerline of the bearing, creating two spans of 105 ft 8 in. for each bridge.

Prestressed concrete U-beams were selected because of their form as well as for structural stability. Four 54-in.-deep U-beams were used rather than five 63-in.-deep I-beams to obtain the required clearance with minimal fill requirements. The U-beams were designed using a concrete compressive strength of 9500 psi with a release strength of 5500 psi—a standard New Mexico mix design. An 8½-in.-thick deck continuous for live load was made composite with the beams. The deck was built using 4000 psi cast-in-place concrete. The deck and integral diaphragms were placed at the same time.

Strand Congestion Alleviated

The beams contain 0.6-in.-diameter prestressing strands, which allowed fewer strands to be used. This approach reduced congestion, especially at the ends. U-beams do not accommodate strand harping easily because the webs slope at 1.5:1 vertical to horizontal and are wider at the top than the bottom. Discussions with staff at Rinker Materials (now Coreslab Structures) indicated that harping the strands for these beams presented difficulties, since the strand position relative to the web edge is not constant throughout the length of the harped section. A stress analysis indicated that the condition could also cause unwanted torsional stresses in the webs.

The other alternative was to debond strands at the ends of the beams. The increased bursting force, however, due to the larger diameter strands required special consideration. The solution was to add strands in the top flange and debond them in the midspan region. The debonded top strands were cut at the center after release and before beam erection. The timing of the cutting was decided by the supplier to assist with control of beam camber. The top strands also made placement of other reinforcing steel easier. The supplier now recommends the use of top strands in U-beams whether required by design or not.

The torsional stability of the U-beams eliminated the need for exterior diaphragms, making construction easier and enhancing the form of the bridge. Interior diaphragms were provided at third points along the length of the beam to prevent beam rotation. Solid interior diaphragms also were provided at the ends of the beams to accommodate the reinforcement required for the integral abutments and confinement for the anchorage zones.

Three-Point Bearing System Used

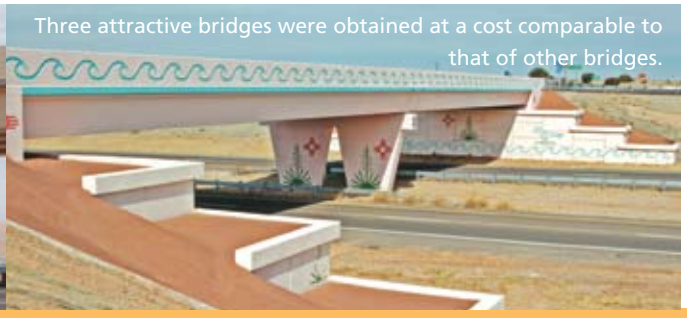
New Mexico has experienced several problems relating to bearing and torsional rigidity with both U-beams and large box girders. To address these issues, a three-point bearing system was designed for the U-beams. Two bearings per beam were placed at the pier and one bearing per beam was placed at each abutment. The arrangement allowed the beam to rotate on the single bearing and provided uniform bearing on the remaining two. Small, lightweight angles were added at a distance away from the bearings to retain the bearings if displacement occurs. To date, there has been no displacement and the bearings are performing well.

By grouping the three projects together, incredible time savings in construction were achieved. The three projects were completed in approximately one year. In addition to the time savings from working simultaneously on all three projects, the uniform design eliminated the learning curve on two of the bridges, reducing construction time for each activity. Producing similar beams also saved time in reconfiguring molds, jigs, etc.

The approach slabs used New Mexico's standard design, which consists of a 14-ft-long by 11-in.-thick slab that moves with the deck. The slabs are supported by the abutment on the bridge end and by a sleeper beam on the roadway end. Abutments are semi-integral with a short stub wall supported on spread footings. A diaphragm poured integrally with the deck is placed across the entire stub wall, developing integral movement between beam ends, deck, and approach slab. Elastomeric bearings are used to ensure uninhibited movement of the superstructure.

The wingwalls are also integral with the deck and diaphragm. To alleviate the problems of movement between the fixed stubwall and the movable wingwall, the stub wall was shortened on each end. The wingwalls were designed to be alongside the stubwall instead of behind it. Bituminous bond breakers were placed

U.S. 84 over I-40 in New Mexico uses precast U-beams with a cast-in-place deck.



Three attractive bridges were obtained at a cost comparable to that of other bridges.

BRIDGE TYPE: PRECAST, PRESTRESSED CONCRETE U-BEAMS / NEW MEXICO DEPARTMENT OF TRANSPORTATION, OWNER

BRIDGE DESCRIPTION: Three similar bridges consisting of precast, prestressed concrete U-beams and a continuous cast-in-place concrete deck

STRUCTURAL COMPONENTS: Four 54-in.-deep U-beams per span, MSE walls, abutments, and wing walls

BRIDGE CONSTRUCTION COST: $84 psf

between the wingwalls and the stub wall ends and footings. The design allows the wingwalls to slide back and forth freely beside the stub walls. The location of the wingwalls also locks the superstructure to the substructure transversely aiding in the elimination of sole plates.

Artwork Added

To fulfill the aesthetic requirements of welcoming visitors, 3D modeling with a basic rendering assisted with visualization of the completed form. Girders, piers, and MSE walls were designed to complement one another and provide an overall pleasing form.

Artwork was incorporated into the MSE walls, wingwalls, piers, and barrier curbs, using a technique of disposable foam or plastic of a given thickness to create recessions in the concrete. The recessed areas were painted in contrasting colors to the background. Recessed areas give definitive paint boundaries, which provide ease in initial and maintenance painting. The cost for forming and painting with this system was minimal with respect to the cost of other art systems.

The average unit costs for bridge structures on this project was $84 psf, slightly less than the average unit cost of $86 psf for all bridges in New Mexico that year. The cost effectiveness can be attributed to several factors, including simplicity and construction considerations in design; consultation during design with suppliers and contractors to develop easy-to-build and economical details; use of repetitive parts and materials throughout all three bridges; and a creative bid process that let contractors bid one bridge, any combination of two bridges, or all bridges on this project.

The New Mexico Department of Transportation was very pleased to get three attractive bridges at a cost that was comparable to that of other bridges. The careful planning and good communication throughout the design and construction process was responsible for the creation of three bridges that are aesthetically pleasing, structurally efficient, cost effective, and durable.

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Credit:
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