Bridge over Culvert on SR 210 (US 231)

by Paul E. Froede and Brantley Kirk, Alabama Department of Transportation

Ross Clark Circle is a divided four-lane highway carrying State Route (SR) 210 that coincides with U.S. Highway 231 in a circle around Dothan, Ala., in the southeastern corner of the state. Originally constructed in the 1950s, Ross Clark Circle has seen average daily traffic increase from 5000 vehicles per day to approximately 40,000 vehicles per day and is expected to exceed 73,000 vehicles per day in 20 years.

On the west side of the city, Ross Clark Circle crosses Beaver Creek supported by a triple-barrel, 6-ft-rise-by-10-ft-span cast-in-place concrete box culvert. This culvert, under 18 ft of fill, has serious cracking and was slated for replacement in a consultant's original contract plans to widen Ross Clark Circle from four to six lanes.

The Constraining Risk

The decision to replace the culvert with another was made by the state's bridge hydraulics engineer during his site evaluation and was based on the culvert's drainage history. Much development has occurred inside Ross Clark Circle without regard to water runoff or detention. This has resulted in complete immersion of the opening with upstream flooding in severe rain events because the culvert was not designed to carry the increased flow of the creek.

Changing anything with regard to the culvert's cross-sectional drainage area has the potential to change downstream drainage characteristics, which could result in legal liability and civil lawsuits against the state. A culvert the same size as the existing has to be in that location.

The Consultant's Dilemma

Going with a new box culvert was easier said than done. In order to accommodate the additional roadway width and a 3:1 backslope, the culvert would have to be lengthened 25 ft at one end and 30 ft at the other. Above-ground water and sewer pipes at both ends within those ranges prohibited this approach.

The next plan was to consider building a shorter culvert with a retaining wall running over the ends. This idea was not considered feasible due to settlement and cost issues. In addition to these problems, the culvert would have to be built in two stages—half the culvert length at a time with traffic shifts.

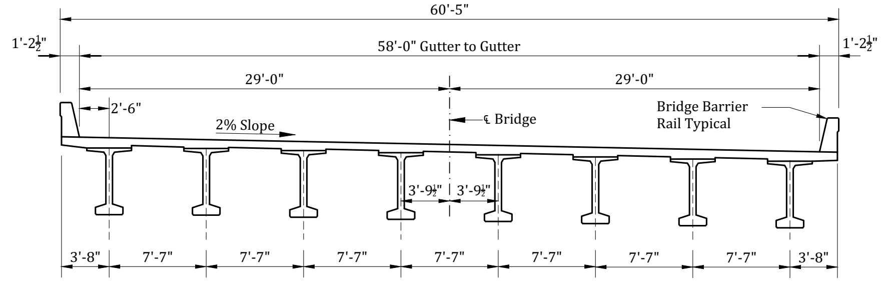
To do this the contractor would have to drive sheet piles on both sides of the culvert for soil retention and then drive unembedded sheet piles over the culvert. These unembedded sheet piles would have to be supported laterally with whalers, which would have to be secured to sets of nested piles driven on both sides of the culvert.

After stage one completion, the sheet piles and the nested piles would have to be pulled and redriven and the whalers reattached at least 10 ft away to allow for construction of stage two. The perceived cost and constructability issues presented serious obstacles to moving forward.

An Innovative Solution

When Alabama Department of Transportation (ALDOT) structural engineers were presented this scenario, they recognized the opportunity to apply an accelerated bridge construction (ABC) innovation as the solution.

They determined that although the culvert was cracked, the cracks could be corrected and the culvert could continue to carry water without further concern



Typical section for northbound bridge. All Photos and Figures: Alabama Department of Transportation.

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BRIDGE OVER CULVERT ON SR 210 (US 231) / DOTHAN, ALABAMA

BRIDGE DESIGN ENGINEER: Alabama Department of Transportation, Montgomery, Ala.

PRIME CONTRACTOR: McInnis Constructs, Montgomery, Ala.

PRECASTER: Forterra Building Products (Pelham), Pelham, Ala.—a PCI-certified producer

OTHER MATERIAL SUPPLIERS: Hilman Rollers, Marlboro, N.J.

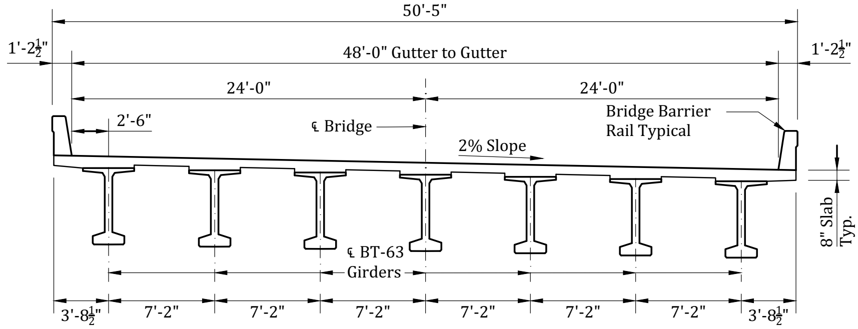
if traffic and a substantial amount of dead load were removed. This could be accomplished by constructing two bridges over the culvert, maintaining the same roadway grade, and then removing half the fill over the culvert.

In order to keep traffic moving on Ross Clark Circle, the bridge superstructures would be built adjacent to the roadway and the abutments for the single-span bridges would be built under traffic. To accomplish this, steel boxes (fabricated from H-piles) were installed over a weekend and provided working space in which to build the caps. The boxes were designed to hold back the lateral soil load and support traffic loads. Once installed, the lids were removable and the contractor was able to construct the caps while traffic continued uninterrupted above. When both sub- and superstructures were complete, traffic could be diverted to a detour for up to 7 days while the soil between the abutments was cleared and the bridges were slid or rolled into place.

Designing for Accelerated Constructability

Bridge geometry and design were controlled by roadway constraints, as well as the intent to allow the bridges to be constructed using ABC principles. The southbound bridge would carry three lanes with a gutter-to-gutter width of 48 ft and the northbound bridge would carry three through lanes and one left turn lane for a total gutter-to-gutter width of 58 ft. Both bridges would be 120 ft in length. This span length was determined so that a line drawn from the bottom corner of the cap to the bottom corner of the culvert would have a slope no steeper than a 2:1 ratio, which allows for future work on the culvert.

The horizontal curve, though slight, is still enough to require the roadway and bridge deck to be in a constant 2% cross-slope. Typically this is addressed with either pedestals or stepping the cap. But in this case, neither option is suitable because the superstructure needs to be



Typical section for southbound bridge.

slid on a horizontal surface. The plan then was to require the girders to be placed on steel blocks or plates in order to achieve the necessary deck slope.

Alabama uses a standard abutment with cap and backwall and bridge joint between the backwall and bridge deck for conventional bridge construction. This project required something that would take considerable less time to build, especially since the abutments were to be built under traffic and the risk of racking the deck during the bridge slide and damaging a backwall was too great.

Instead, ALDOT engineers used a semi-integral abutment. Jacking bays between the girders were part of the design to facilitate the vertical jacking operations necessary to move and set the bridge. The 3-ft thickness of the diaphragm required that it be modelled using the strut-and-tie method. Using a semi-integral abutment also allowed the expansion joint to be moved between the approach slab and the lug. The lug is a pavement seat and a part of the substructure because it supports the approach slab. The lug was necessary in this project because the fill behind the diaphragm was not to be compacted and settlement was expected, leaving a gap between it and the fill. Therefore, the approach slab was designed as a one-way slab to account for this. Since

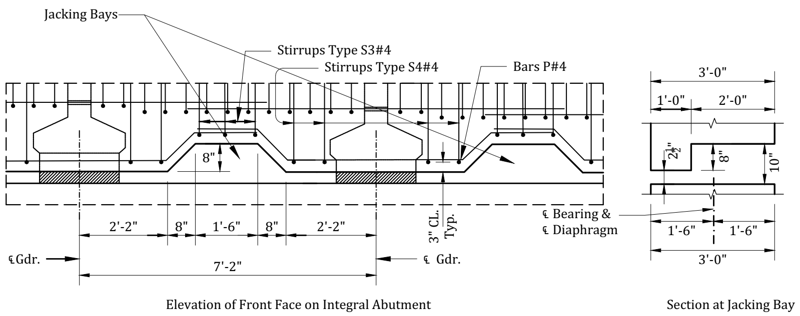
Cap construction for the bridge over culvert on State Route 210 (US 231).

STATE OF ALABAMA, OWNER

BRIDGE DESCRIPTION: Twin 120-ft-long, simple-span, prestressed concrete girder bridges

STRUCTURAL COMPONENTS: Fifteen BT-63 bulb-tee girders with a 7-in.-thick cast-in-place concrete deck, semi-integral abutments, and pile-supported abutments

BRIDGE CONSTRUCTION COST: \$2.43 million/\$182.69 per ft^2 (\$1.98 million engineer's estimate)



Details of jacking bays between girders in semi-integral abutment diaphragm.

One of two 100,000 lb hydraulic jack assemblies used to push the bridge.

thermal expansion could be absorbed by the fill behind the abutment, it alleviated the need for the contractor to compact the backfill behind the abutment, saving more time.

Although the abutment caps and superstructure were built with standard 28-day, 4 ksi concrete, the lugs and approach slab bridges would have to use a 4 ksi high-early-strength mixture. This plan, as opposed to precast concrete, was the unanimous approach taken by contractors invited to a 60% plan complete design meeting with ALDOT engineers. Additionally, the concrete for the approach slabs had to be placed and cured during the 7-day closure period.

ABC Guidance

One special provision was used to guide the three aspects of ABC—the temporary shoring necessary to house cap construction, the temporary bearing supports for the superstructure during construction and sliding, and the slide/roll itself.

The shoring design was to be provided by the contractor, engineered according to the American Association of State Highway and Transportation Officials' *AASHTO LRFD Bridge Design Specifications*. Temporary supports were controlled by the latest interim edition of AASHTO's *Guide Design Specifications for Bridge Temporary Works*. All aspects of the slide itself were developed from similar special provisions provided by the Utah and Iowa departments of transportation.

Southbound bridge on rollers.

Resiliency

Alabama typically employs a nonstructural bridge end slab to handle traffic loads on the roadway at the bridge ends. But for this project, the bridge end slabs were designed as a one-way slab bridge. This provided resiliency during a severe rain event one week after the bridge was opened. The bridges are in the bottom of a long, shallow sag vertical curve. Roadway drainage boxes had not yet been completed and the existing drainage was inadequate to handle the high rate of flow, causing runoff to collect in the narrow median space between the bridges, soaking through the sand backfill under the southern slab on the northbound bridge. Construction inspectors discovered the runoff had soaked all the way to the other side of the bridge and had eroded a substantial amount of the sand backfill under the slab bridge. They closed the bridge immediately and contacted design engineers.

After photos were reviewed it appeared the soil beneath the lug was still intact. Onsite inspection personnel confirmed the integrity of the lug foundation, leading designers to give the go-ahead to reopen the bridge. A plan was later developed to fill the space opened by the loss of fill material.

Fill washed out under approach slab after large rain event.

A Perfect Execution

ALDOT bridge engineers worked toward developing a strong positive relationship with the contractor and its engineers; clarifying the objectives of the special provisions; and making suggestions that worked to the contractor's, and ultimately the state's, advantage. When it came time to move the bridges into place, the contractor was fully aboard with the ABC concepts—it was able to successfully roll both bridges into place and completed the approach slabs before the end of the 7-day (per bridge) incentive/disincentive period. Traffic was returned to Ross Clark Circle over the new bridge in 3 days for the southbound direction and 3 days in the northbound direction.

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