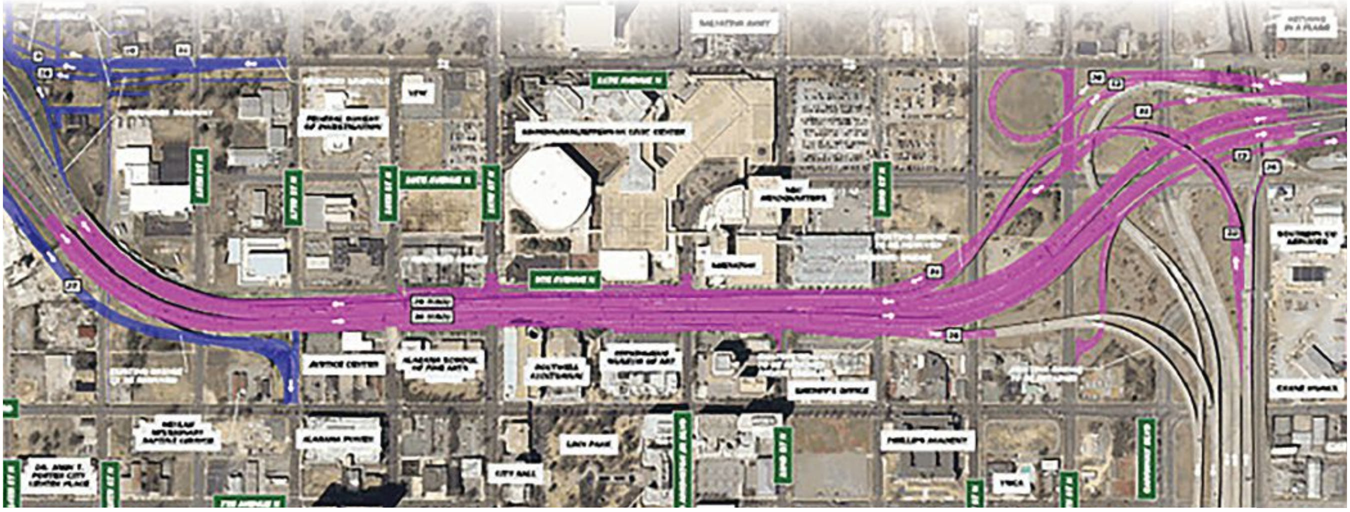
PROJECT

Alabama's Largest Transportation Project Renews Birmingham's Central Business District

by Lloyd Pitts, Volkert Inc., Eric Johnson, Corven Engineering Inc., and William (Tim) Colquett, Alabama Department of Transportation



Aerial view of the Phase III segmental bridge site, shown here in magenta. Five miles of segmental box girders with a total of 2316 segments were erected in only 217 days, and the bridges reopened to traffic ahead of schedule. Figure: Volkert Inc.

For nearly 50 years, millions of motorists have traveled the Interstate 59/Interstate 20 (I-59/I-20) from Meridian, Miss., to Birmingham, Ala. Once the interstates reach Birmingham, a city with a legacy built on steel and iron, they are now supported by elevated concrete structures over the downtown area.

Serving Birmingham's central business district (CBD), this artery has the highest rate of traffic flow in the state of Alabama. Built in 1973, the original elevated structures were designed for 80,000 vehicles per day. Current traffic exceeds 160,000 vehicles per day, and traffic forecasting suggests that this route may be subject to over 225,000 vehicles per day by 2035.

As a result of the age and heavy use of the facility, the bridge decks had begun to deteriorate, often requiring costly repairs that resulted in lane closures. The original bridges featured left-lane entrance and exit ramps, with minimal or no shoulders. Three of these ramps were considered outdated and forced motorists to make unanticipated and unsafe lane crossings, sometimes resulting in accidents that forced traffic slowdowns or stoppages (see the State article on Alabama in the Spring 2019 issue of *ASPIRE®*).

Rebuilding the Bridges

Considering the safety concerns, traffic congestion, and maintenance issues, the Alabama Department of Transportation

profile

INTERSTATE 59/INTERSTATE 20 BIRMINGHAM CENTRAL BUSINESS DISTRICT BRIDGES / BIRMINGHAM, ALABAMA

BRIDGE DESIGN ENGINEERS: Volkert Inc., Mobile, Ala. (prime consultant, substructure and foundations); Corven Engineering Inc., Tallahassee, Fla. (segmental superstructure)

CONTRACTOR'S CONSTRUCTION ENGINEERS: McNary-Bergeron & Associates, Broomfield, Colo.; Infrastructure Consulting & Engineering, Columbia, S.C.

PRIME CONTRACTORS: Johnson Bros. Corp., a Southland Company, and Oscar Renda Contracting Inc. Joint Venture, Roanoke, Tex.

(ALDOT) deemed this infrastructure functionally obsolete and determined that immediate action was required. Multiple options were considered, including burying the interstates, rerouting the corridor, or simply redecking the existing bridges. Some of these options were projected to take 20 years and billions of dollars to complete, and yet they would not adequately solve the corridor's problems.

ALDOT determined that the best course of action would be to replace some CBD bridges and widen others, with the interstates completely shut down during construction. Compared to long-term construction phasing, this plan required the shortest turnaround time and thus would cause the least disruption to the traveling public.

ALDOT engaged a single consulting firm team to provide the engineering design and construction inspection services for the $710 million megaproject. The project, with 36 bridge sites for either new bridges or widening of existing bridges, was separated into four bid packages—Phases A, I, II, and III. The concrete bridges for the project totaled 14.3 miles of precast, prestressed concrete girders and 5 miles of segmental box girders. The $440 million Phase III project included the segmental box girder bridges.

Work on the Phase III CBD bridge replacement project was performed in concert with many other improvements in the CBD region to improve traffic movements, replace or modernize existing facilities, and revitalize the downtown experience for the citizens and visitors of Birmingham.

Substructure Challenges and Solutions

To minimize the impact of the project on downtown Birmingham, a diverse

A typical span after erection of the four lines of box-girder segments. A longitudinal closure pour about 3 ft 6 in. in width was used to join the segments for each of the two bridges. The completed eastbound and westbound structures are separated by a 6 in. gap. Photo: Volkert Inc.

Falsework towers were used to support segments during erection. Photo: Volkert Inc.

ALABAMA DEPARTMENT OF TRANSPORTATION, OWNER

POST-TENSIONING CONTRACTOR: Structural Technologies, Columbia, Md.

CASTING MACHINES AND ERECTION SYSTEM: Structural Technologies, Columbia, Md.

BRIDGE DESCRIPTION: 6500-ft-long precast concrete segmental box-girder bridges with 2316 segments total

STRUCTURAL COMPONENTS: Five miles of precast concrete segmental box girders, 172 spans, and 2316 segments, precast concrete piers

SEGMENTAL BRIDGE CONSTRUCTION COST: $195 million

A precast concrete pier cap with fluted aesthetic detailing is erected on a column element. Segments are connected using grouted couplers. Photo: Volkert Inc.

business hub with a bustling food and art scene, only 14 months of full interstate closure were allowed for construction; also, access to certain CBD public venues was required throughout the project. Additional challenges included limited right-of-way, utility conflicts, varying geotechnical conditions along the project corridor, and limited vertical clearance under the existing structures to perform foundation work before the interstates were closed.

Aesthetics were a priority for ALDOT, so the design team decided to use single-column piers under each segmental girder line. The piers are accented with vertical fluted lines in the near and far faces, and the pier caps flare out at the top to complement the sloping lines of the segmental girders. The contractor elected to precast the piers as two separate pieces, columns and caps, for faster construction. The reinforcement for the pier sections was made continuous with grouted couplers. This allowed the piers to be constructed efficiently once the demolition and removal operations for the existing structures were completed.

The first two-thirds of the project had sound rock for foundation design. Near 22nd Street North, there was a

AESTHETICS **COMMENTARY**

by Frederick Gottemoeller

Faced with a request for a viaduct that would "revitalize the downtown experience for the citizens and visitors of Birmingham," the project's designers thought creatively about the appearance of the space below the structure. Such spaces are often dark and uninviting, filled with haphazardly parked cars and drifting waste paper, depressing the activities around them. Improving the appearance of such a space requires conceiving of it as a huge outdoor "room," with the superstructure as its ceiling and the bridge piers articulating the room-like impression.

The attractiveness of this "room" depends, first of all, on long, uninterrupted sight lines in both the transverse and longitudinal directions, so that the whole area can be seen and understood at once, so that it can be organized for uses beyond parking, such as farmers markets and art fairs, and so that there are few opportunities for concealment. The concrete box girders contribute to this goal by minimizing the number of pier legs both longitudinally (by allowing relatively long spans) and transversely (by requiring only four pier legs per pier line). The thin piers also avoid a problem that sometimes results when designers are asked to provide a structure with architectural grandeur: They attempt to do so with physical mass and "architectural" detail. The result can be an agglomeration of massive piers with nonstructural decorative details. Thus, an individual looking along the bridge sees the piers line up one behind the other, visually filling the "room" with concrete. In contrast, the thinness of the Birmingham piers keeps the long views open, and the "room" inviting. The piers' only architectural details are the closely spaced vertical grooves that visually reinforce their thin appearance.

The concrete box girders also keep the longitudinal views simple. The sight lines are not blocked by transverse pier caps, and there are no braces or diaphragms to catch the eye. The wide spacing between box webs means that light can reach to the underside of the deck slab, and the whole underside of the bridge stays bright. Finally, a reflective white coating on the underside of the structure keeps light bouncing around the "room," meaning the space is brighter during the day and easier to light at night.

It is heartening to see this high level of aesthetic quality achieved within the discipline of accelerated bridge construction. Birmingham has met its schedule while achieving an "aesthetically pleasing area for public events"—all at the same time.

Erection of a precast concrete box-girder segment on temporary support towers for the first span of the central business district bridges. Photo: Volkert Inc.

geological shift, and the last one-third of the project had karst limestone conditions. In areas with sound rock, the footings used either drilled shafts or micropiles. In karst conditions, the foundations used steel H-piles with driving shoes. The span layouts for the project considered existing foundation locations and minimized conflicts for the new substructure locations.

Prior to the closure of I-59/I-20, the contractor built as many of the footings as possible. Because of the limited vertical clearance, low-overhead equipment was used to install the drilled shafts, micropiles, and steel H-piles. The footings were then covered with fill to protect them during the demolition of the existing overhead structures.

Creating the Superstructure

When ALDOT decided to allow I-59/I-20 to be closed for 14 months of construction, the designers had to find a design solution that could be achieved within this tight schedule. The contractor was allowed to fully close the interstates for 14 months without penalty, and would be awarded bonuses of $250,000 per day for finishing early, with total bonuses capped at $15 million. However, at the end of the 14-month window, penalties would be assessed at a rate of $250,000 per day, with no cap. These time constraints led the design team to choose a precast concrete segmental superstructure for Phase III of the project.

Because of the limited right-of-way and the need to preserve existing buildings along the project corridor, the replacement bridges were built within the same footprint as the original bridges. The eastbound and westbound structures are each approximately 6500 ft in length and are separated by a 6 in. gap.

Each bridge comprises twin precast concrete segmental box girders, and every mainline bridge includes entrance and exit ramps. Along the transition regions for these ramps, the mainline structures comprise three segmental box girders.

With a total deck area of over 1 million square feet, the bridges are composed of 172 spans, with nominal lengths of 165 ft. There are 2316 precast concrete segments, with typical segment lengths between 11 ft 6 in. and 12 ft 6 in. The overall box-girder segment depth is 9 ft, with an additional ½ in. of sacrificial deck surface that was milled to achieve a smooth deck surface after segment erection.

The lane configurations for the bridges vary along the project corridor from four to six lanes, resulting in a variation of out-to-out bridge width. To accommodate this variation in overall bridge width, the individual box girders were categorized into three groups: 33 ft 6 in. wide for the four-lane configuration; 39 ft 6 in. wide for the five-lane configuration; and 45 ft 6 in. wide for the six-lane configuration. Individual box girders were joined with a longitudinal deck closure strip approximately 3 ft 6 in. wide to make up the total deck width for one bridge. To facilitate the precasting operations, all box girders used a constant core dimension with only the wing lengths varying.

The top slab of each box-girder segment was transversely post-tensioned with four-strand tendons that anchor at the end of each segment wing. To accommodate the variation in the width of the top slab, two transverse post-tensioning spacings were used: four tendons per segment for box-girder widths of 39 ft 6 in. or less, and five tendons per segment for box-girder widths greater than 39 ft 6 in.

The longitudinal post-tensioning in each box-girder span consists of external draped tendons. Eight permanent tendons (four per web) were anchored at the ends of the spans in the pier segment or expansion-joint segment diaphragms. The longitudinal post-tensioning tendon sizes vary depending on demand, with hardware sized to accommodate a maximum of 22 strands per tendon. Wider sections with longer span lengths feature one additional 12-strand tendon per web, anchored

The area beneath the completed mainline spans after painting. City officials intend to use this area for public events. Photo: Johnson Bros.

at the deviation diaphragms. Each span also includes hardware to accommodate two 12-strand future post-tensioning tendons. Project-specific specifications for the installation and grouting of the post-tensioning tendons included many aspects of the *PTI/ASBI M50.3-12 Guide Specification for Grouted Post-Tensioning*.[1] (A newer version of this specification is now available—see the Concrete Bridge Technology article in the Summer 2019 issue of *ASPIRE*.)

Advantages of the Precast Concrete Segmental Design

The precast concrete segmental bridge design was chosen for several reasons stemming from ALDOT's decision to completely shut down I-59/I-20 during construction. In particular, the selected design minimized the time of interstate closure by using off-site fabrication and rapid construction methods.

The casting yard was located approximately 4 miles from the project, which allowed efficient transport of the precast concrete segments to the construction site for placement. This expedited the construction process compared to the traditional methods for building bridges. By the time the interstates were closed to traffic, approximately 1000 of the 2316 segments were already cast and ready for erection.

Segment Erection

The original design assumed a traditional span-by-span erection method, with all precast concrete segments supported by longitudinal erection trusses. The contractor elected to use a unique technique, for which the design was verified, erecting each precast concrete segment within a span on individual shoring towers. This erection technique meant the contractor could work on as many as eight spans at any given time and facilitated nonlinear construction. The method proved to be successful, with all 2316 segments (172 spans) erected in only 217 days. (For more details on this technique, see the Concrete Bridge Technology article on page 30 of this issue of *ASPIRE*.)

The Finish Line

The challenges and time constraints of this project proved how beneficial precast concrete segmental bridge design and construction can be. The I-59/I-20 CBD bridges reopened to traffic ahead of schedule on January 17, 2020, with a closure of only 12 months compared with the 14 months allowed in the contract.

Reference

1. Post-Tensioning Institute (PTI) and American Segmental Bridge Institute (ASBI). 2012. *PTI/ASBI M50.3-12: Guide Specification for Grouted Post-Tensioning*. Farmington Hills, MI: PTI.

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