I-10/SR 303L System Traffic Interchange

Arizona uses efficient concrete bridge geometry to ensure cost effectiveness for its largest system traffic interchange

by Andrew Baird, AZTEC Engineering

Anchoring the south end of Maricopa County, Arizona's, newest freeway is a multi-directional system traffic interchange linking State Route 303L (SR 303L) with Interstate 10 (I-10). The I-10/SR 303L System Traffic Interchange (System TI) is a five-level interchange with an embedded frontage road system. The five levels consist of SR 303L one level below grade, at-grade embedded frontage roads and local cross roads, I-10 mainline one level above, and two additional levels of system ramps resulting in structures as high as 90 ft above ground. The embedded frontage road system, a unique design in Arizona, not only enhances the operations of the traffic interchange, but increases the overall footprint to yield the largest System TI in Arizona.

Summary of Phase I Structures

At the project onset, the design team sought to use cast-in-place concrete box-girder bridges where feasible. Twelve of the 14 structures are cast-in-place, post-tensioned box-girder bridges of various widths and lengths as shown in Table 1. Four of the structures are freeway-to-freeway flyover directional ramps: east to-north (EN), south-to-east (SE), west-to-south (WS), and north-to-west (NW).

At more than 17 spans and 3412 ft, the longest structure is the Ramp EN bridge. It includes six columns that are 90 ft tall and have integral connections to the superstructure. The two bridges at I-10 over Sarival Avenue at the eastern end of the project are American Association of State Highway and Transportation Officials (AASHTO) Type V precast concrete girder bridges.

Collectively, all the major structures include more than 16,700 linear ft of drilled shafts ranging from 48 to 120 in. in diameter, more than 13.8 million lb of reinforcing steel and 71,200 yd^3 of structural concrete.

The post-tensioned structures used

Completed system traffic interchange. Note the frames for Phase II structures already completed over I-10. Photo: Visions in Photography.

profile

I-10/SR 303L SYSTEM TRAFFIC INTERCHANGE / GOODYEAR, ARIZONA

BRIDGE DESIGN ENGINEERS: Arizona Department of Transportation Bridge Group, Phoenix, Ariz.; AZTEC Engineering Group Inc., Phoenix, Ariz.; HDR Engineering Inc., Phoenix, Ariz.; and T.Y. Lin International, Tempe, Ariz.

PRIME CONTRACTOR: Pulice Construction Inc., Phoenix, Ariz.

PRECASTER: Royden Precast LLC, Phoenix, Ariz.—a PCI-certified producer.

POST-TENSIONING SUPPLIER: Dywidag Systems International USA, Long Beach, Calif.

Table 1. Summary of Phase I Structures–All bridges are post-tensioned, cast-in-place box girders except for Sarival Avenue Bridges, which are AASHTO girders with a composite deck.

Bridge	Spans	Length	Width	Depth
Sarival Ave (Two bridges)	3	245 ft 0 in.	253 ft 1 in.	6 ft 1 in.
Ramp EN	17	3412 ft 0 in.	43 ft 2 in.	9 ft 0 in.
Ramp SE	14	2527 ft 6 in.	43 ft 2 in.	8 ft 6 in.
I-10 EB OP	4	465 ft 6 in.	91 ft 2 in.	5 ft 6 in.
I-10 WB OP	4	465 ft 6 in.	91 ft 2 in.	5 ft 6 in.
I-10 WB Frontage Rd over Ramp WN	1	170 ft 0 in.	37 ft 2 in.	7 ft 9 in.
McDowell Rd. Over Ramp WN	1	105 ft 8 in.	144 ft 4 in.	5 ft 0 in.
I-10 WB Frontage Rd over Ramp SW	3	356 ft 4 in.	37 ft 2 in.	6 ft 8 in.
SR303L SB Frontage Rd Over Ramp SW	3	204 ft 11 in.	37 ft 2 in.	3 ft 9 in.
McDowell Rd TI UP	3	356 ft 8 in.	126 ft 4 in.	5 ft 6 in.
Thomas Rd TI UP	2	311 ft 0 in.	35 ft 0 in.	6 ft 9 in.
Ramp NW (Frames 3 and 4)*	4	873 ft 0 in.	43 ft 2 in.	9 ft 6 in. (max)
Ramp WS (Frames 3 and 4)*	5	971 ft 0 in.	43 ft 2 in.	9 ft 6 in. (max)

*Bridges added during Phase I Construction
Note: EN = east to-north, SE = south-to-east, WS = west-to-south, and NW = north-to-west.

0.6-in.-diameter, low-relaxation strands with tendons ranging from 20 to 25 strands. Jacking force per bridge ranged from 14,950 to 20,610 kips. All of the cast-in-place, post-tensioned, box-girder bridges used 4.5 ksi Class S concrete.

The cost per square foot for the AASHTO Type V bridge was $65. The total area of the cast-in-place, post-tensioned, box-girder bridges was 509,357 ft^2. The cost per square foot ranged from $72.67 to $131.06 with the average being $82.87.

With structures accounting for 30% of the overall construction cost and 72% of the overall construction schedule of the entire project, it was imperative for the structures to be designed as efficiently as possible. This included, but was not limited to, minimizing the height of the structures, reducing the number of spans, and utilizing on-site material for construction. Efficient bridge design is not just isolated to a structures team but rather the entire project team. This article summarizes how the design team worked together to create not only the largest System TI in Arizona, but the most cost-effective and efficient bridge geometry.

Optimize Geometry to Reduce Bridge Spans

As with all System TI, the first step in the design is geometry optimization to reduce bridge heights and lengths. This exercise was critical to ensuring the project was within the program budget as the embedded frontage road system meant that the traffic interchange was more expensive than originally planned. The result was an hourglass appearance where the northbound and southbound frontage roads were pulled closer to the SR 303L mainline, allowing the number of bridge spans to be reduced. Specifically the I-10 bridges over SR 303L—which at design start were each six-span, cast-in-place, post-tensioned, concrete box-girder bridges at a structure depth of 6 ft—were each reduced to four spans and a structure depth of 5 ft 6 in.

The horizontal and vertical alignments of the freeway-to-freeway ramps were also refined. The largest and tallest bridge on the project (Ramp

Post-tensioning for Ramp SE. Photo: AZTEC Engineering.

Ramp SE and Ramp EN where the new I-10 was shifted to the south to allow for construction of ramps from the north. Note the soffit fill usage of the lower profile Ramp SE. Photo: Visions in Photography.

North half of flyovers completed. I-10 detoured to completed westbound roadway with the southern section of bridges approaching I-10. Photo: Visions in Photography.

ARIZONA DEPARTMENT OF TRANSPORTATION, OWNER

BRIDGE DESCRIPTION: Twelve, post-tensioned, cast-in-place, box-girder bridges ranging in length from 105 to 3412 ft; two precast, prestressed concrete girder bridges with composite decks

STRUCTURAL COMPONENTS: 48- to 120-in.-diameter drilled shafts; 12 cast-in-place, post-tensioned box girder bridges; fifty-two 55-ft-long AASHTO Type V girders; forty 129-ft-long AASHTO Type V girders; and cast-in-place concrete abutments, pier caps, blade-shaped columns, and decks

BRIDGE CONSTRUCTION COST: $52 million

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EN) was reduced by over 400 ft from a 3866-ft-long, 20-span bridge to a 3412-ft-long, 17-span bridge.

Sequence Construction to Reduce Falsework

A mandate of this project was to maintain three lanes of traffic in each direction of I-10. As part of the geometry refinement, the design team shifted the I-10 alignment north approximately 200 ft. This enabled the construction of the entire westbound I-10 to be built without impacting existing I-10 traffic.

Once I-10 westbound was complete, six lanes of traffic (three in each direction) were shifted to the completed freeway section allowing the construction of eastbound I-10. Overhead flyovers (Ramp SE and Ramp EN) were sequenced to follow the shift of I-10, eliminating the need for falsework above live traffic. Both Ramp SE and Ramp EN were constructed from north to south, with the hinge ending just north of existing I-10. Once the concrete for the decks was placed and falsework removed, the traffic shift allowed the remainder of the two main flyovers to be constructed from south to north, meeting at the hinge point constructed in the previous stage.

To utilize the established construction-sequencing plan, the project added elements of a future phase to the Phase I construction. Frames of west-to-south (WS) and north-to-west (NW) were to be constructed while I-10 was detoured, ensuring there would be no more impacts to I-10 during future phases of the System TI. The project team collaborated with the Arizona Department of Transportation (ADOT) to choose the best approach to facilitate this addition. Ultimately, the project team implemented a design-build approach of planning the phasing and design of these bridge ramps in an expedited manner. Both the engineer and contractor worked side by side to meet the expedited schedule. The design and construction of these added features, which included high falsework bridge construction, was accomplished with a minimal 5-month impact to the critical path of the complex project.

Simplification of construction staging was another goal at the onset of the project. In order to accomplish this task and reduce the construction stages to four, both ADOT and the design team worked with the city of Goodyear to develop a crossroad closure plan and detour route to minimize the amount of travel through a work zone. Half-diamond traffic interchanges at Citrus Road and Sarival Avenue were constructed in the early stages of the project, creating a detour route for both freeway and local traffic, allowing for the full closure of Cotton Lane. This cleared an entire work zone for the ADOT contractor. Sarival Avenue is the only bridge on the project to use AASHTO Type V precast concrete girders to eliminate the need for falsework and expedite the bridge construction to meet the required schedule.

Utilize Material for Soffit Fill

The combination of basin, roadway, and structural excavation and the depressed SR 303L construction yielded a massive earthwork project with over 3.4 million yd^3 of excavation. Structural excavation for Ramp SE and Ramp WN resulted in over 1 million yd^3 of excavation alone. One of the primary uses of this material was as soffit fill for the structures up to 35 ft. Construction sequencing, detours and closures allowed the contractor to maximize the use of soffit fill, reducing bridge heights and falsework.

Aesthetics

As the majority of the construction was structures, the overall aesthetics of the system relied heavily on the structural elements. The three predominant features that contribute to the aesthetic appeal of a bridge are the superstructure type, span configuration, and architectural treatment.

Post-tensioned, box-girder bridges offer uniform simple lines, a relatively shallow structure depth and integral pier caps, which make for an aesthetically pleasing structure.

Type

Post-tensioned, box-girder bridges offer uniform simple lines, a relatively shallow structure depth and integral pier caps, which make for an aesthetically pleasing structure.

Use of excess material as soffit fill for one of the lower profile bridges. Photo: AZTEC Engineering.

Excavation for foundations of Ramp SE and Ramp EN adjacent to I-10. Photo: Visions in Photography.

Span Configuration

Maximizing the span length creates an appearance of openness and freedom for the traveling public.

Architectural Treatments

Bladed columns that are not highly visible, or with heights less than 50 ft, have a vertical mountain rustication treatment centered in the wide faces of the column. Bladed columns that are highly visible and have heights above 50 ft have the lizard icon treatment with an accent color. Piers, wingwalls, retaining walls, abutment faces, and outer faces of the barriers were designed to accommodate integral artwork designs and rustication patterns so that aesthetic compatibility can be maintained with the Phase I portion of the I-10/SR 303L System TI. In addition, all exposed bridge surfaces, with the exception of the roadway surface and inside face of barriers, were painted.

A complex project in both size and scope, the completion of this project serves as an example of how to successfully deliver a project that is both cost effective and aesthetically pleasing.

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