Aerial view of completed project showing tiered retaining walls with artistic and architectural enhancements. Photo: City of Tucson.

KINO PARKWAY OVERPASS AT 22ND STREET

by Jim Glock and Claudia Perchinelli, Structural Grace Inc.

The Kino Parkway Overpass at 22nd Street was a vision of the Tucson, Ariz., community for decades. It was not until the passage of the Regional Transportation Authority's plan and a half-cent sales tax funding mechanism in 2006 that this overpass design could move forward.

Kino Parkway Overpass at 22nd Street is a six-lane divided arterial roadway with a 20-ft-wide median island; it is planned to widen 22nd Street to a six-lane divided arterial as well. Prior to the construction of the interchange, the intersection of these two roadways was at grade and one of the more congested intersections within the city limits.

To accommodate future traffic volumes, Kino Parkway now crosses over 22nd Street. The two roadways connect through a single-point urban interchange (SPUI). The SPUI (at grade) includes dual left-turn lanes for traffic from both 22nd Street turning onto the Kino Parkway on-ramps and Kino Parkway off-ramps onto 22nd Street. It is the first grade-separated SPUI constructed by the city of Tucson.

As this interchange is located in a densely populated area within Tucson's core, a citizens' advisory committee (CAC) was formed to guide the city and consultant team in their approach to the visual aspects of the structure. Concern over the size and appearance of the interchange led to a variety of features that influenced the structure type. In particular, there was an interest to include many scale-reducing elements into the design. The design also needed to integrate aesthetic features into the structure, as opposed to "plop art"—surface treatments that lack meaning. In this vein, the theme of "structure from nature" was embraced, leading to cactus-rib-inspired fluted columns and art elements incorporated into the design. The project team relied on the unique collaboration of the bridge architect with the project.

Close-up of bridge with fluted piers and art elements along with architectural enhancements in hardscape and superstructure. Photo: City of Tucson.

profile

KINO PARKWAY OVERPASS AT 22ND STREET / TUCSON, ARIZONA

BRIDGE DESIGN ENGINEER: Structural Grace Inc., Tucson, Ariz.

PRIME CONTRACTOR: The Ashton Company, Tucson, Ariz.

PRECASTER: TPAC (A Division of Kiewit Western Co.), Phoenix, Ariz.—a PCI-certified producer

POST-TENSIONING CONTRACTOR/SUPPLIER: Consolidated Rebar, Phoenix, Ariz.; Dywidag Systems Inc. (DSI), Long Beach, Calif.

OTHER CONSULTANTS: AECOM, Tucson, Ariz.; PSOMAS, Tucson, Ariz.; McGann and Associates, Tucson, Ariz.; GLHN, Tucson, Ariz.; EDAW, Phoenix, Ariz.; Barbara Grygutis, Tucson, Ariz.

OTHER MATERIAL SUPPLIER: CAID Industries, Tucson, Ariz.

The SPUI configuration prohibits a median in the intersection to accommodate the left-hand turn movements that are the basis of the SPUI function. The curb-to-curb width of 22nd Street varies from approximately 150 ft at the edge of the bridge to approximately 110 ft at the intersection with Kino Parkway. Safe sight distance requirements, along with other constraints, resulted in the minimum clear opening requirement of 175 ft.

Twenty-Second Street is a major arterial roadway that, prior to construction, carried over 35,000 vehicles per day on two travel lanes in each direction. This relatively high volume placed a premium on the maintenance of traffic during the construction.

In summary, the design had to include:

- A clear span length of 175 ft to accommodate the geometry of the SPUI and safe sight distances
- A typical section with an open median in the overpass
- Aesthetic design criteria established by the CAC
- Minimal structure depth
- A construction sequence that allowed a maximum number of lanes to remain open on 22nd Street

The culmination of these criteria and collaboration of the bridge architect and project artist with bridge designers resulted in the twin 344-ft three-span structures that carry the Kino Parkway Overpass at 22nd Street. Each of the twin bridges is 42 ft 8 in. wide with two lanes each to accommodate projected traffic volumes. These unique structures are a combination of cast-in-place (CIP) post-tensioned box girders and drop-in precast, prestressed concrete box girders of both standard and custom shapes. The CIP post-tensioned box girders, built on soffit fill and ranging from a depth of 9 ft 6 in. at piers to 4 ft 6 in. at abutments and cantilever end/hinge locations, make up the 80-ft back spans and 44-ft front cantilevers. The CIP box is comprised of an 8 in. top deck, a 6 in. bottom slab, and six webs that were each 1 ft thick. The total post-tensioning force for each 124 ft CIP box girder is 7910 kip, which is applied using 12 tendons with fifteen 0.6-in.-diameter strands per tendon. The design is based on a 28-day concrete compressive strength of 5.5 ksi, with a minimum strength of 3.5 ksi at time of stressing.

The design assumed the CIP portion of the bridge to be constructed on falsework, but the contractor opted

Construction of cast-in-place concrete box girder. Photo: Structural Grace Inc.

Erection of drop-in girder to complete main span. Note dapped end of girder. Photo: Structural Grace Inc.

CITY OF TUCSON, OWNER

BRIDGE DESCRIPTION: Twin 344-ft three-span bridges combine cast-in-place, post-tensioned concrete box girders for back spans and cantilevers and drop-in precast, prestressed concrete box girders of standard and custom shapes for the portion of the center span directly over the 22nd Street travel lanes. Each bridge is 42 ft 8 in. wide and carries two lanes of traffic.

STRUCTURAL COMPONENTS: Flared, fluted cast-in-place concrete single-column piers, nominally 10 ft in diameter at top and 8 ft at bottom. Stub abutments behind retaining walls on cast-in-place concrete spread footings. Cast-in-place, post-tensioned concrete box girders comprised of an 80-ft back span and a 44-ft cantilever. Drop-in precast, prestressed concrete box girders are 91-ft-long with topping slab. The interior girders are 4 ft wide and the exterior girders are a trapezoidal shape.

BRIDGE CONSTRUCTION COST: $2.8 million (not including retaining walls), $96/ft^2

AWARDS: American Council of Engineering Companies, Arizona Chapter – 2015 Grand Award Winner; American Public Works Association, Southern Arizona Branch – 2016 Public Works Project of the Year; Structural Engineers Association of Arizona – 2016 Excellence in Structural Engineering Award of Merit

to construct the CIP portions on soffit fill supported by jersey barriers. This required the abutment, piers and tier 2 walls to be buried within the temporary soffit fill.

The 4-ft-deep drop-in precast, prestressed concrete box girders are 91 ft long and fill in the center portion of the 179-ft-long center span directly over the 22nd Street lanes. The interior and exterior beams have dapped ends and are designed for a 28-day concrete strength of 6 ksi and 5 ksi minimum at time of transfer. The interior beams are standard 4-ft-wide beams with vertical webs. The exterior beams are custom shaped with a sloped exterior web to match the exterior web of the CIP box girder.

The use of precast, prestressed concrete box girders was paramount to the design so that 22nd Street traffic did not need to be detoured off its current alignment during construction. After the CIP portion of the bridge was complete and the soffit fill removed, 22nd Street traffic was shifted to the south under the CIP portion of the bridge. The precast, prestressed concrete girders were placed in 2 days—1 day for the southbound bridge and 1 day for the northbound bridge—with no 22nd Street traffic detours required.

The soil conditions at the site made it possible to utilize shallow foundations. A stub abutment founded on fill instead of a full-height abutment was made possible by using a tiered-wall system.

These complex and innovative three-span bridges that were built in multiple construction phases, were the culmination of approximately 10 years of planning and design with the city of Tucson and the project's CAC. The bridges met the primary design criteria of efficiency in cost, structural design, maintenance of traffic, material use, staging, and construction. Evidence of these efficiencies is the contractor's bid price, which was 25% less than the engineer's estimate, and the fact that no traffic detours were needed around the construction zone.

The CIP post-tensioned box back spans were designed to maximize span while minimizing concrete volumes. Precast concrete elements were used to avoid interrupting traffic and to limit direct labor for the CIP falsework, forming, and finishing. A longer bridge was designed to minimize fill and accommodate tiered retaining walls in front of the abutments, mitigating the appearance of a single, tall abutment wall. Spread-footing abutments were founded on fill behind these tiered retaining walls, avoiding the need for deep foundation types. Soffit fill was used in lieu of falsework for the CIP post-tensioned box construction, with stepped temporary retaining walls made from jersey barriers retaining the fill.

The structural design met the project's budget criterion: the engineer's estimate was $3.9 million while the contractor's bid price was $2.9 million, which equates to a very efficient $96/ft^2. The structural design met the critical maintenance of traffic objective by maintaining traffic operations at 80% of their typical volume throughout. The project also met all of Tucson's and the CAC's contextual objectives.

The structural design addressed three key and unusual challenges for the project:

- "No falsework over travel lanes" was a key requirement from a traffic flow and safety perspective.
- "No substantial impact/detouring of traffic operations through the intersection" was essential during construction.
- The use of a SPUI meant that the Kino Parkway bridge had to span the entire intersection, 175 ft, to accommodate all turning movements.

These led to the creative structural design and construction methodologies described. This unique structural system combination and its construction phasing allowed 22nd Street to remain open to traffic during the construction of the bridge. In the end, the structural design met the challenging SPUI requirements for a large clear span and minimal structure depth over the traffic

Stressing a post-tensioning tendon in the cast-in-place box. Photo: Structural Grace Inc.

lanes, and also met the length of span requirements to minimize high, lengthy retaining walls.

Throughout a five-year rigorous research and structure selection process, three different structure type alternatives were studied. To maximize efficiency in structural design the precast, prestressed concrete box was designed as a simply supported beam that connected the CIP post-tensioned box girders to complete the main span. This allowed for 22nd Street to be detoured under the new CIP post-tensioned box so that the precast, prestressed concrete box girders could be erected over the existing 22nd Street without detouring traffic off 22nd Street. The structural design of the bridge maximized the efficiency of CIP post-tensioned box cantilevers by using a phased construction program to account for staging of construction to build efficiency into the design.

The interchange was recently named after Mayor Robert Walkup, who served as mayor of Tucson from 1999 to 2011. Among his many achievements, he spearheaded the 2006 Regional Transportation Authority Plan that provided for $2.1 billion of vital transportation and transit improvements, including this magnificent interchange.

Jim Glock is the Tucson office manager and Claudia Perchinelli is the bridge designer and president of Structural Grace Inc. in Tucson, Ariz.