TATUM BOULEVARD OVERPASS HYBRID PRESTRESSED CONCRETE BRIDGE

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ABSTRACT

A simple, innovative, hybrid superstructure was selected to carry ADOT's new SR101L freeway over Tatum Boulevard, a single-point urban interchange, in northeast Phoenix. The hybrid precast and cast-in-place concrete superstructure was selected due to its maintenance of traffic advantages over cast-in-place concrete and local cost advantages over steel. Precast concrete provided a cost effective solution without the need for extended closures or falsework over traffic.

The 320-foot three-span structure consists of 98-foot end frames, each encompassing a 72-foot end span and a 26-foot cantilever, with a 118-foot drop-in center section. The end frames were constructed with cast-in-place post-tensioned concrete on conventional falsework. The center section, between the end frames, was kept clear during construction for Tatum Boulevard traffic. The center drop-in span consists of precast prestressed AASHTO girders, set on the end-frame cantilevers during nighttime weekend closures.

To maintain the visual continuity of the structure, the precast girder ends were dapped, and the exterior web of the box girders were formed to match the shape of the precast girders. The bridge structure successfully integrates three concrete structure types (reinforced, pre-tensioned precast and post-tensioned cast-in-place concrete) to achieve the project operational, aesthetic, traffic protection, and cost efficiency goals.

Keywords: Prestressed, Concrete, Bridge, Phoenix, Tatum, Stanley, Precast, Hybrid, Pretensioned, Post-tensioned, Pima, Freeway, Davis, Dapped, Drop-in, SR101, ADOT, Arizona, Transportation, TPAC.

INTRODUCTION

The Tatum Boulevard Overpass Bridge demonstrates a simple, cost effective, hybrid concrete solution to some common challenges faced during urban freeway construction today.

Urban structures are increasingly wider, have longer spans to accommodate expanding roadways, and need to be constructed without major disruption to the existing roadway network. Agencies, traffic engineers, and the public expect this. New structures, and the many elements they are composed of, need to work together aesthetically as well as structurally. The Tatum Boulevard Overpass uses a mix of conventional precast, cast-in-place, prestressed and reinforced concrete structural elements to meet these goals.

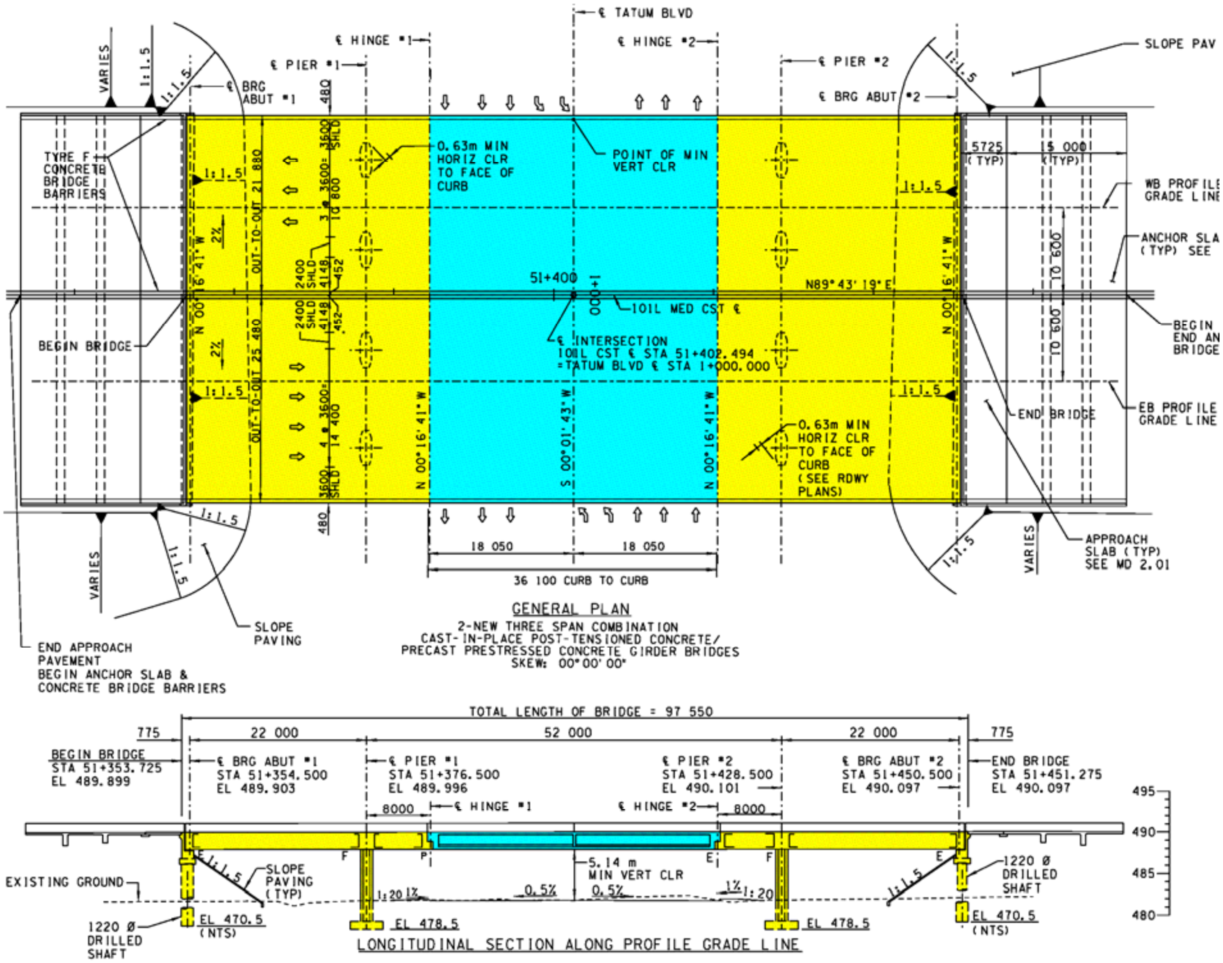
In 1985 voters approved a one-half percent sales tax to fund new freeways for the expanding Phoenix metropolitan area. Among those freeways were a series of loop freeways, SR 101L (Agua Fria, Pima and Price Freeways) and SR 202L (Red Mountain, Santan and future South Mountain Freeways). One of the last portions of SR 101L to be completed was on the Pima Freeway in Scottsdale and northeast Phoenix. The Tatum Boulevard Interchange Overpass is along the SR 101L Pima Freeway, “Cave Creek Road - Scottsdale Road, Phase B” design segment, in northeast Phoenix.

Many of the earlier segments of the SR 101L construction had the luxury of being constructed in areas that were not heavily developed. Bridges were frequently constructed over two-lane roadways or streets with low traffic volumes on the outskirts of town. Traffic on those roadways could be detoured on-site or off-site and bridges could be constructed as cast-in-place concrete box girders without falsework, using soffit fill, to support the bridge during construction. This has been a competitive construction method when feasible.

The rapid growth of the Phoenix metro area has had a significant impact on freeway and bridge design and construction methods. Bridge widening on existing freeways and new bridge construction over busy urban arterials require the bridge design engineers to explore innovative means for maintaining traffic during major bridge construction activities. The challenge for designers is to develop simple and cost effective solutions.

Tatum Boulevard is a major arterial in northeast Phoenix in one of the City's suburban core areas. Average weekday 1999 traffic volumes of 36,500 vehicles per day on Tatum needed to be accommodated during construction of the new eastbound (EB) and westbound (WB) Pima Freeway bridges. Traffic on of the four-lane interim Pima Freeway also needed to be maintained. The challenge of maintaining traffic during construction was complicated by the limited detour options. The high traffic volumes on Tatum precluded extended closures with off-site detours. On-site detours were not practical due to the presence of interim traffic on the freeway. Consequently, the final design of this bridge was substantially defined by the need to maintain traffic through this interchange.

The Pima Freeway Tatum Boulevard Overpass interchange was designed as a single-point urban interchange (SPUI) under the freeway. Tatum Boulevard was designed for an ultimate configuration of six through lanes and four left-turn lanes. The project was designed and detailed in SI units. The eight-lane roadway cross-section plus the curved interchange freeway ramps required a 170-foot center span. Pima Freeway was designed for an ultimate configuration of four WB lanes and five EB lanes, including one future high-occupancy-vehicle (HOV) lane in each direction. The final design consisted of a 320-foot long, 156-foot wide, three-span, dual structure configuration, with a 170-foot long center span and 72-foot end spans.



PRECAST NEEDED TO CLOSE THE GAP

A hybrid structure, consisting of conventional cast-in-place concrete end frames with a precast concrete drop-in segment, was selected due to the maintenance of traffic advantages over a fully cast-in-place concrete superstructure and cost advantages of concrete over steel in this region.

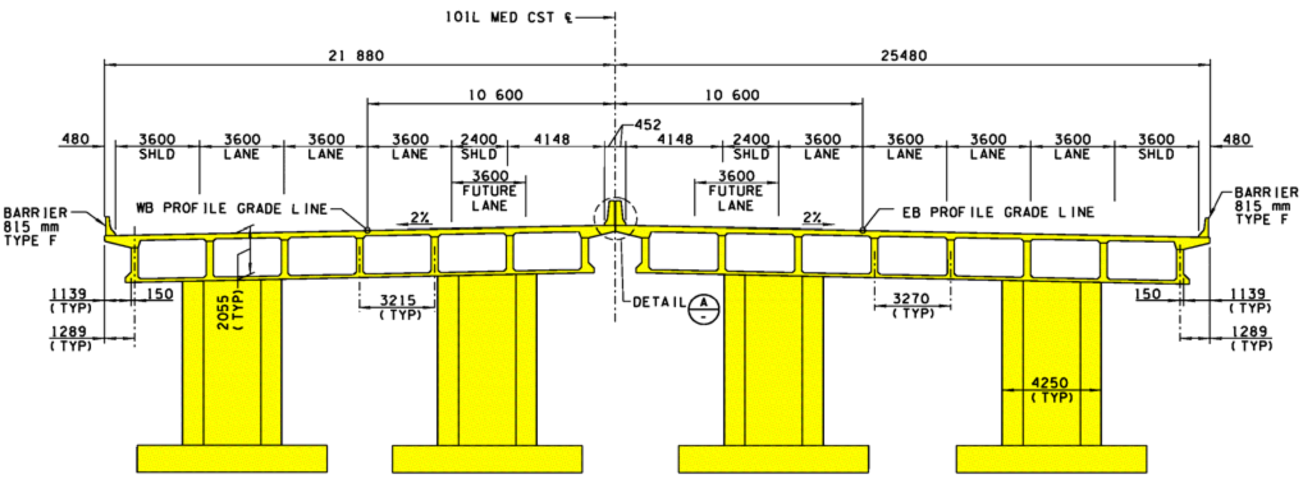
Prestressed Girder Design Data:
f'c = 6,000 psi
f'ci = 4,500 psi
Strands = Grade 270 Low Relax
No. of Strands = 50 (16 draped)
Prestressing Force = 1,550 k
Length = 120 ft (Span = 118 ft)
Producer: TPAC, Phoenix, AZ

The 170-foot center span length was beyond the capabilities of conventional precast AASHTO girders used and available locally. The center span could have been achieved with a typical cast-in-place post-tensioned concrete box or a continuous steel plate girder superstructure, however steel was not cost competitive, and a cast-in-place post-tensioned concrete box superstructure would have required falsework. In the absence of a practical detour, large openings would have been required through any falsework over Tatum Boulevard to maintain the required four lanes plus two left turn lanes on Tatum. Two separate falsework openings would have been likely, one each for northbound (NB) and southbound (SB) Tatum Boulevard traffic. Vertical clearance would have been temporarily impaired due to the falsework depth.

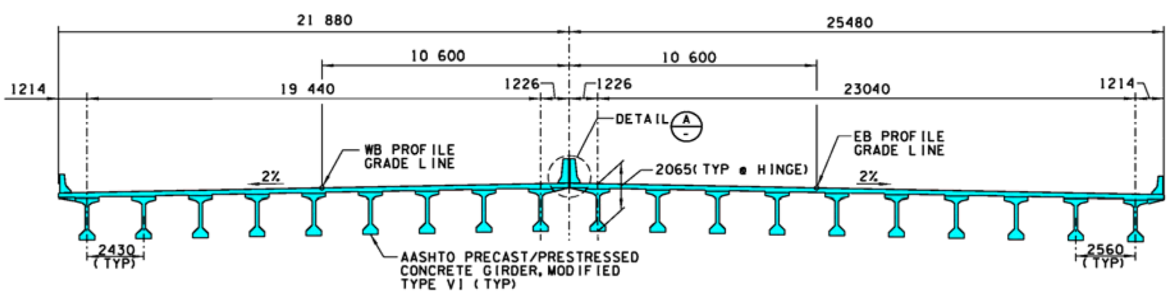
The hybrid concept of cast-in-place concrete with a precast prestressed concrete drop-in section was an ideal solution for this major interchange.

PARTIAL CAST-IN-PLACE SETS THE STAGE FOR PRECAST

To maintain traffic under the new middle span during construction, 98-foot end frames, consisting of a 72-foot end span and a 26-foot cantilever to a hinge, were constructed using cast-in-place concrete on falsework. AASHTO Type VI Modified precast prestressed concrete girders were produced concurrently with the end frame construction to speed the overall bridge construction schedule. The prestressed concrete girders, 120-foot long end-to-end, were set on the end-frame cantilevers during weekend night closures to complete the 170-foot center span.



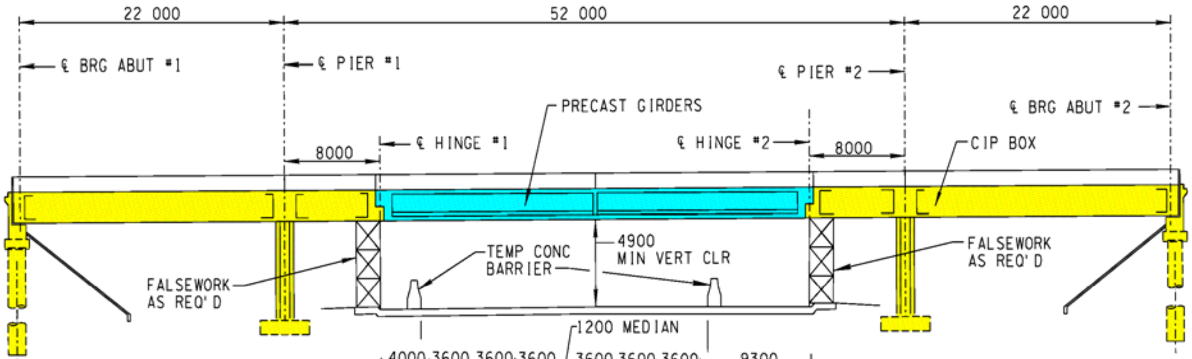
SPAN 1, SPAN 3
AND CANTILEVERS ON SPAN 2



DROP-IN PORTION OF SPAN 2

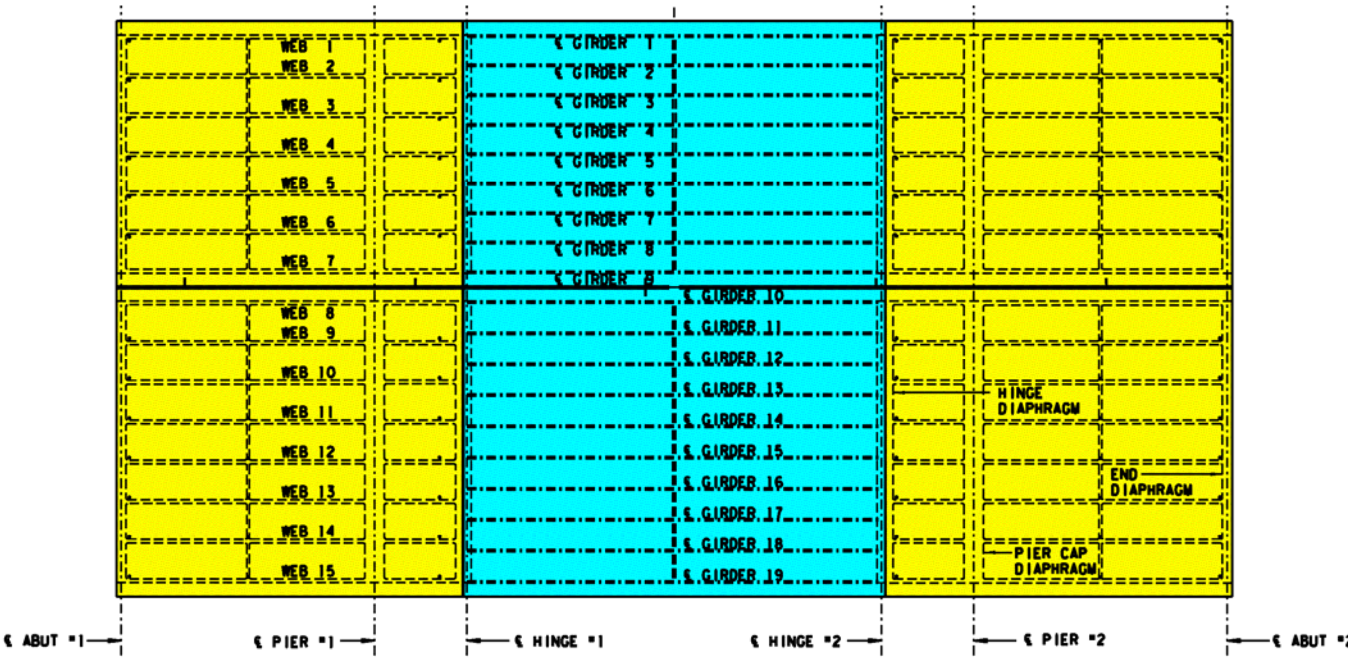
TYPICAL SECTIONS

During construction, the interim interchange operated as a conventional diamond interchange with temporary signals. Falsework for the 26-foot cast-in-place concrete cantilevers occupied the plan area where the ultimate SPUI sweeping left turn movements would eventually be built. Interim freeway through traffic was directed across Tatum at-grade through the temporary diamond interchange. Tatum Boulevard traffic was maintained on the existing roadway between the piers and the cast-in-place concrete end frames.



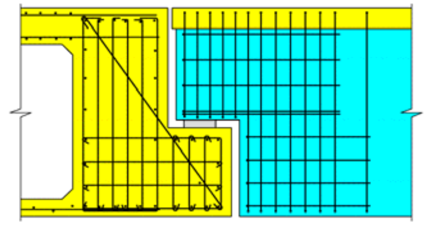
ELEVATION - BRIDGE CONSTRUCTION CLEARANCES

The hinge provided the critical link between the cast-in-place and precast construction. The web and girder layouts for the cast-in-place and precast sections did not need to be co-linear due to the hinge, and were optimized separately. The short end spans of the cast-in-place sections required fewer girder lines than the longer precast drop-in section. The hinge was designed to transfer precast beam reactions from the nine WB and ten EB precast beams to the seven WB and eight EB post-tensioned cast-in-place concrete girder webs.



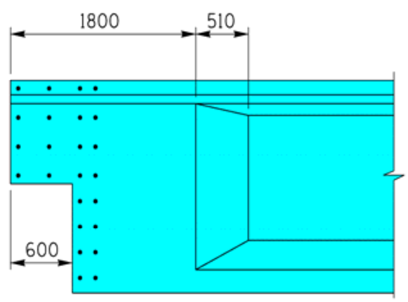
DECK FRAMING PLAN

Determination of the hinge locations balanced a number of design considerations, such as extending the hinge points as close as possible to the point of zero dead load moment, keeping cast-in-place construction and associated falsework clear of the Tatum Boulevard travel way, and limiting cantilever lengths to avoid uplift of the short end spans at the abutment bearings.



HINGE REINFORCEMENT SECTION

Dapped girder ends were used for setting the precast beams on the cast-in-place hinge seats and as a means of maintaining a uniform structure depth. The precast girder webs were flared to provide adequate bearing width and to increase shear capacity of the reduced depth dapped end. Exterior web flares, added on the cast-in-place concrete end frame sections, matched the precast girder dapped end flares.



GIRDER DETAIL AT NOTCHED ENDS

Dead-end prestressing tendons, in the first longitudinal prestressing application for an ADOT bridge, were used in the cast-in-place end frames. These tendons were jacked only from the abutment ends, to simplify the hinge seat construction and to reduce the number of concrete pours at the hinges.

The exterior webs of the cast-in-place box girder end frames were formed to match the bulb flange shape of the precast AASHTO girders, blending the two structure types to maintain the visual continuity of the structure. The span-to-depth ratio for the 170-foot center span was increased to 25 with the use of 26-foot cast-in-place cantilevers and the 118-foot precast drop-in span.

Reinforced concrete drilled shafts, 4 feet in diameter by 50 feet deep, were required to support the cantilever abutments constructed on embankment. The piers were designed with spread footings on existing ground, which provided significant cost savings over drilled shafts. The end frame superstructure and pier columns were designed to accommodate differential settlements due to the two different footing types. The hinges for the drop-in section can easily accommodate any differential settlements between the two piers.

CONCLUSION

Precast prestressed concrete provided an economical and simple solution to a common maintenance and protection of traffic challenge in urban freeway construction. The need for falsework for cast-in-place concrete construction over traffic was eliminated. Construction road closures and disruption to the existing traffic network was minimized.

Conventional, locally available, precast concrete AASHTO girders were used for a span arrangement that was not a typical configuration for precast girder superstructures, with the relatively long center span of 170 feet, and the short, 72-foot end spans.

<u>Bridge Data:</u>
Bridge Length = 320’ (3-span)
Width = 83’-7” EB, 71’-9” WB
Superstructure Depth = 6’-9”
Vertical Clearance = 16’-10”
Const. Completed: August 2001
Low Bid: $3.1 million

Visual continuity of the dissimilar cross-sections, of the cast-in-place concrete box girders and the precast concrete AASHTO girders, was enhanced by forming the exterior web of the cast-in-place concrete to mimic the standard AASHTO girder shape.

The bridge design successfully used conventional construction methods to integrate three concrete structure types, reinforced concrete, pre-tensioned concrete, and post-tensioned concrete, and two foundation types, shallow spread footings and deep drilled shafts, to achieve the project geometric, aesthetic, traffic protection, and cost efficiency goals.