PROJECT

# California State Route 99 over 21st Avenue in Sacramento

by Dave Carlin, California Department of Transportation

California State Route 99 (SR 99), a remnant of what was once U.S. Route 99, spans more than 400 miles from the infamous Los Angeles "Grapevine" in the south to the city of Red Bluff, two hours north of Sacramento. In tandem with Interstate 5, it links the agricultural and industrial complexes of the Central Valley to commercial hubs including the Port of Stockton and Sacramento. Traffic studies conducted in 2019 indicated an average volume of 220,000 vehicles per day along the segment between Elk Grove and Sacramento, making that segment one of the most heavily traveled portions of SR 99 and a critical component of the region's transportation infrastructure.

Originally designed to expressway standards, the section of SR 99 within Sacramento County supports both heavy industrial and high-density commuter traffic, subjecting its bridges to a combination of impact and prolonged peak-hour static loading. The 21st Avenue undercrossing, located within this segment, was constructed in 1959 and consisted of two parallel cast-in-place (CIP) bridges spanning 21st Avenue between the Oak Ridge and North City Farms neighborhoods.

The structures were composed of traditionally reinforced voided slabs bearing on strutted abutments with spread footings. Subsequent retrofits in 1974 and 1983 filled the gap between the two bridges with a CIP post-tensioned voided slab deck on cantilever abutments, increasing overall capacity to five lanes in each direction. Updated barriers and soundwalls were also added.

## Project Need

California Department of Transportation (Caltrans) Structure Maintenance and Investigations (SM&I) records for the SR 99 bridge over 21st Avenue (which date back to 1962) detail typical deck surface wear throughout the 1970s and 1980s, with maintenance operations ranging from minor crack and spall patching to joint and seal replacements. Noted deficiencies increased significantly in the early 2000s, necessitating a 2011 contract to remove and replace unsound deck material and place a polyester concrete overlay.

Subsequent monitoring identified a more significant structural issue evidenced by delamination of the polyester overlay and soffit crack propagation. An initial recommendation for placement of a reinforced 4-in.-thick deck-on-deck slab was made, and more in-depth analyses of the structure commenced.

Originally constructed in 1959, the 21st Avenue undercrossing on State Route 99 is the primary vehicle and pedestrian route linking the Oak Ridge and North City Farms neighborhoods of Sacramento, Calif. Although the abutments and substructure were sound, delamination of a previous overlay, soffit cracking, and other deterioration led to the decision to replace the superstructure. All Photos: California Department of Transportation.

profile

21ST AVENUE UNDERCROSSING, STATE ROUTE 99 / SACRAMENTO, CALIFORNIA

**BRIDGE DESIGN ENGINEER:** California Department of Transportation, Sacramento, Calif.

**CONSTRUCTION ENGINEER:** California Department of Transportation, Unit 3665, Shingle Springs, Calif.

**PRIME CONTRACTOR:** Bridgeway Civil Constructors, Inc., Vacaville, Calif.

**ULTRA-HIGH-PERFORMANCE CONCRETE SUPPLIER:** LafargeHolcim, Chicago, Ill.

**PRECASTER:** Con-Fab California LLC, Lathrop, Calif.—a PCI-certified producer


Several on-site outreach meetings were conducted to educate the surrounding community and provide an open forum for discussion of project impacts and concerns.

SM&I determined that although the abutments and substructure were sound, the original and retrofit deck slabs had deteriorated to such an extent that a supplemental deck slab was not applicable and superstructure replacement was required. A project development team was assembled, and impacts on the surrounding community and traveling public were quickly identified as the driving forces in the design selection process.

## Structure Selection

Given the anticipated construction duration and the safety implications of working immediately adjacent to live traffic lanes, traditional multistage construction was ruled out and the focus shifted toward the application of accelerated bridge construction (ABC) techniques.

As the project development team continued down the ABC path, several design alternatives were reviewed, and each was critiqued with respect to the unique aspects of the site. Early on, the lack of adequate space adjacent to the site precluded the lateral deck-slide option. Input from regional precast concrete vendors eliminated the potential for larger deck panels because the complexity of casting and transporting panels increased exponentially with panel width. This feedback resulted in the selection of 4-ft-wide prestressed concrete box beams, which were readily constructable and afforded flexibility in transportation, staging, and erection.

Historical data related to adjacent precast concrete box-beam bridges using traditional grouted keyways, with and without transverse post-tensioning, indicated a tendency for differential shear to result in longitudinal deck cracking and degradation of CIP deck components, whether reinforced or polyester concrete. To address this issue, and based heavily on experience gained during the highly successful Echo Summit Sidehill Viaduct Replacement Project (7 miles west of the city of South Lake Tahoe on U.S. Route 50) in 2020, ultra-high-performance concrete (UHPC) was selected as the mechanism by which the beams would be connected, with a polyester concrete overlay provided as the finished driving surface.

## Contract Development

With the project design solidified as a single-stage, precast concrete box-beam bridge using UHPC connections, the project development team continued working to address concerns raised by the project stakeholders. Key items incorporated into the bid documents included the following:

- Mandatory prebid meeting—The high-consequence nature of the contract, along with a bid process occurring under newly established COVID-19 pandemic guidelines, made it critical that all bidders were clear on the requirements of the contract, conditions at the site, the working-day allotment, and the penalties associated with delay.
- Incentivized closure duration of 100 hours—The project team used input from a variety of sources to develop a closure schedule. A total project duration was selected based on a cost-benefit analysis weighing impacts on the community, return on investment, and the safety of all parties throughout the construction phase. A multitiered monetary incentive program for early reopening was included via a bid-period addendum.
- Allowable work window—Based on historical traffic data, regional event schedules, and desired conditions for the placement of UHPC, the relevant lane closure authorizations were restricted to the period from June 9 to August 11.
- UHPC prequalification and beam test fit—Lessons learned from Echo Summit and other projects using

### CALIFORNIA DEPARTMENT OF TRANSPORTATION, OWNER

**BRIDGE DESCRIPTION:** A 51-ft-long, single-span, precast, prestressed concrete box-beam replacement superstructure supporting 10 traveled lanes and shoulders, with a total width of 140 ft

**STRUCTURAL COMPONENTS:** 35 precast, prestressed concrete box beams (48 in. × 27 in. × 51 ft), with ultra-high-performance concrete-filled keyways and a cast-in-place polyester concrete overlay driving surface

**BRIDGE CONSTRUCTION COST:** $3.92 million ($550/ft$^2$)

Preassembly of the completed beams at the precaster's facility allowed verification of cumulative casting tolerances and fit-up.

UHPC and precast concrete deck elements were incorporated directly into the project specifications, including enhanced UHPC quality-control requirements and mandatory off-site preassembly of the completed beams to verify accumulated casting and fit tolerances.

- Delayed start clause—With 25 working days allotted to complete the work, a 120-day delayed start clause was included to provide sufficient time for the selected contractor and subcontractors to complete the relevant submittal, procurement, and casting processes.

Bidding for the project opened on October 29, 2020, with the award and contract approval following on November 16 and December 17, respectively.

## Construction

The project schedule centered on executing the 100-hour full closure on June 11, as early as possible within the allowable work window, to ensure favorable temperatures for UHPC placement and curing. The contractor mobilized several weeks in advance of this date and used allowable lane closures to complete all possible preparatory work, including barrier demolition and installation of the temporary abutment lateral-bracing corbels and brackets.

On the night of June 11, all traveled lanes, including those on 21st Avenue, were sequentially closed per the traffic management plan, and the remainder of the lateral-bracing system was installed. Crews welded full-span horizontal struts between the preinstalled corbels, maintaining the full width of 21st Avenue for equipment and material movement. Demolition of the existing superstructure, one of the most challenging aspects of the work, was completed in 15 hours. The existing abutments were cleared of debris, and a CIP seat extension was placed to the grades required to match the adjacent roadway.

Demolition of the southbound portion of the bridge has been completed and the temporary lateral-bracing system for the abutments has been installed. The existing northbound slab deck (foreground) has been slotted along the interior voids to create manageable panels that are ready for removal.

The tight window for installation of the prestressed concrete box beams required simultaneous setting operations on both sides of the bridge centerline. The 35 beams were set in less than five hours.

As this work took place, the beams were delivered and staged for installation on the morning of June 13. Installation of the 35 precast concrete units, completed in under five hours, was immediately followed by sealing and water-testing the beam joints to ensure mortar tightness and achieve a uniform saturated-surface dry condition for the UHPC placement operation.

Placement of UHPC began that afternoon and was completed in approximately seven hours. Multiple crews, working outward from the bridge centerline, used motorized buggies to transport and place the UHPC while project engineers oversaw installation of temperature-monitoring embeds throughout the project. As the UHPC was placed in each joint, cover plates with gravity-fed ports were installed. A separate crew monitored and maintained positive head pressure during the initial setup, ensuring that the self-consolidating UHPC completely filled the keyways. A heated cure tent was constructed to maintain optimum conditions, and the entire structure was isolated from vibration throughout the time required to achieve a compressive strength of 12.0 ksi.

Upon reaching the 12.0-ksi threshold in under 18 hours, the UHPC joints were stripped and ground flush, and the complete deck was media-blasted and prepared for placement of a 1-in.-thick

Immediately following installation of the box beams, crews installed joint caps and seals and performed the required surface saturation and leak testing before placing ultra-high-performance concrete in the joints.

As each successive joint was filled with ultra-high-performance concrete, secondary crews installed cover plates, positive head-pressure ports, and temperature-monitoring embeds.

polyester concrete overlay. Backfill of the abutments, approach and departure paving, and traffic striping were performed in sequence, and the completed structure reopened to traffic in both directions on Tuesday, June 15, at 10:00 p.m.—94 hours after the full closure of SR 99.

## Takeaways

Moving forward, Caltrans is actively pursuing opportunities to refine and apply its expanding ABC skill set to reduce the impacts of projects throughout the state. Key elements of the 21st Avenue project that are being incorporated into future projects include the following:

- Community outreach. A comprehensive campaign, spearheaded by the Caltrans Public Information Office, used a variety of media to educate and prepare the public for the impacts of the project. Multilingual radio broadcasts, streaming geofence messaging, community open house events, and door knocking were all used to gather public input as well as maximize the effectiveness of planned mitigation strategies. These strategies ranged from free light-rail access to temporary suspension of adjacent projects, extensive highway patrol support, and a traffic management plan spanning four counties.
- On-site preconstruction meetings. Both the development and review of the proposed 100-hour closure schedule involved real-time input provided by key parties during on-site meetings and walk-throughs. Optimum sequencing, activity durations, scope isolation, and identification of time-saving alternatives were all derived from these meetings.
- UHPC prequalification and mock-up. Caltrans's past successes with UHPC played a key role in the design selection process, and lessons learned on previous projects were reflected throughout the contract documents. Site-specific UHPC mixture prequalification, date restrictions, a required mock-up, and preconstruction strength verification were all used to ensure that the many variables associated with this application were accounted for in the contractor's work plan.

The success of the 21st Avenue project can be directly tied to the collaborative efforts put forth throughout the development and construction phases. From design, analysis, and selection, to community outreach and partnering, the project team sought and incorporated stakeholder input to produce a comprehensive design and contract that positioned the contractor to both succeed and deliver a high-quality product to the state.

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Batching, placing, and finishing processes for the ultra-high-performance concrete were all prequalified using the contract-specified mock-up assembly.

Returned to service in 94 hours and with no permanent impacts on the surrounding homes and businesses, the 21st Avenue undercrossing proved to be an ideal application of the accelerated bridge construction methodology.