ACCELERATED BRIDGE CONSTRUCTION AND CMGC DELIVERY FOR THE SAN DIEGO GENESEE VIADUCT

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The Mid-Coast Corridor Transit Project (MCCTP) is the largest transit infrastructure project currently under construction in San Diego, California in the southwest corner of the continental United States. The project will provide an 11-mile light rail transit (LRT) link between downtown San Diego and the University Towne Center (UTC) business and education center, including the University of California San Diego (UCSD) campus.

The $2.2B project includes 4 miles of aerial structures, 12 bridge structures, 9 station facilities and 5 miles of retaining walls. It is being delivered in a partially shared corridor by a single contractor, encompassing two other major projects to double-track freight and passenger rail in the region. The corridor includes complex river crossings, seismic fault crossings, and viaducts over highway and local streets.

This project is being delivered through Construction Manager General Contractor (CMGC) approach using ABC method, an innovative contracting method approved by the Federal Highway Administration (FHWA). This method allows the engineering team and potential contractor (CMGC team) to work in partnership during the preliminary engineering and design phase. The CMGC team was involved during the design phase to provide input on constructability, cost, schedule and work planning and to develop a guaranteed maximum price (GMP), that was accepted to progress into the construction phase.

One of three major viaducts within the MCCTP is the 1.1 mile Genesee Viaduct. The viaduct runs in the median of Genesee Avenue, a six-lane arterial road with dense concentrations of residential, business and institutional land use and critical for accessing UCSD. Maintaining local traffic and minimizing impacts to the surrounding community were critical for this viaduct, and the primary driver of structure type and construction methods. For this reason, the Prefabricated Bridge Elements and Systems (PBES) of ABC technologies were used to reduce the overall onsite construction time for the viaduct.

The Genesee Viaduct will be the first curved spliced precast U girder bridge in California supporting LRT. It consists of 35 spans and carries two tracks of light rail vehicles. It provides support for two elevated side platform stations.

DESIGN GUIDELINES

The viaduct is designed in accordance with the American Association of State Highway and Transportation Officials' (AASHTO) Load and Resistance Factor Design (LRFD) Bridge Design Specifications with amendments by California Department of Transportation (Caltrans) as well as the project specific design criteria.

ALIGNMENT AND PROFILE

The viaduct begins on a 1,250-foot radius curve, continues into a 990-foot radius curve, followed by tangents and spirals until reaching the first aerial station on a tangent. The vertical profile was selected to provide adequate permanent and temporary vertical clearances over Genesee Avenue and the local crossing streets. A temporary vertical clearance of 15'-0" to Genesee Avenue is considered during construction, which is 1 foot less than the final clearance condition.

FRAME TYPES

The viaduct is divided into 12 frames separated by expansion joints and in-span hinges. The span lengths vary from 108 feet to 225 feet. The precast girder layout was designed to limit girder lengths and the hauling weight of each unit below 100 tons. This was to reduce hauling cost and prevent the need for self-propelled modular transporters (SPMTs) for transportation between fabrication yard and construction site. Spans were therefore each divided in two to four units of precast girders. The viaduct is made up of three frame types with varied construction methods, girder assembly, and splicing operation.

Type 1: Precast Girder Frames

There are nine precast girder frames in the viaduct, consisting of precast u-girders spliced by one-stage or two-stage prestressing (PS). For the five frames with traffic underneath, the first stage of prestressing is performed in two steps. Step 1 involves splicing girders for spans over the intersections in a staging area near the site. After this splice operation is complete, the entire spliced segment is lifted and placed on temporary shoring towers. In step 2, a second prestressing tendon is used to splice the remaining girders that are not crossing any traffic while supported on shoring towers. Once all girders are spliced within each segment, a second stage of prestressing is performed to connect all spliced segments in the frame together and form continuity between expansion joints. The remaining four frames, not crossing traffic, are spliced and prestressed in one stage. The cross section of these precast girder frames consists of two PCI 96 in deep U-girders (Figure 1).

Type 2: Precast-CIP Hybrid Frame

The longest span in the viaduct is 225 feet crossing over La Jolla Village Drive. Due to weight limits for precast girders, this span was too long to be spliced entirely at a staging area and lifted on temporary shoring towers in one piece. Instead, the team proposed a hybrid precast / cast-in-place superstructure to reduce the spliced length over the intersection and accelerate the construction and reduce traffic impacts. Short CIP cantilevered spans were built on both sides of the intersection integral with the columns in a shape of a hammer head outside of required traffic opening at the intersection. The superstructure depth varies from 8'-10 ½" at precast girder splice point to 11'-0" at the face of column (Figure 2).

Type 3: CIP Station Frames

The viaduct serves two aerial side-platform stations, each within a single structural frame. The side platforms are supported by a series of evenly spaced transverse beams connected to superstructure girders. Due to complexity of aerial station construction and presence of multiple transverse beams that require integral connections to superstructure, it was decided to use a cast-in-place box girder construction for the entirety of frames carrying aerial stations. The typical section consists of CIP box girder as the primary system and attached to it are station side platforms and transverse beam supports (Figure 3).

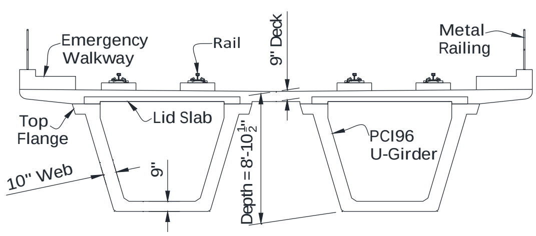

Figure 1*: PC* Girder Frame Cross Section

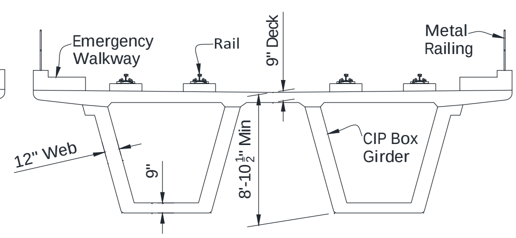

Figure *2*: Cast-in-Place Section at Hybrid Frame

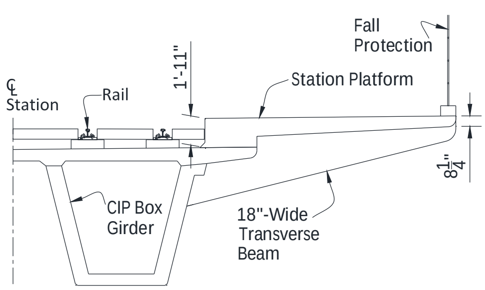

Figure 3: Station Typical Section (Half-Section)

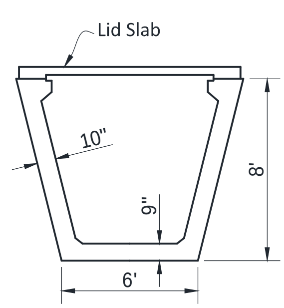

Figure 4: Precast Cross Section

SUBSTRUCTURE

The viaduct substructure consists of single columns supported on single cast-in-drilled-hole (CIDH) piles. Column to superstructure connections at precast girder frames are either expansion joints or pins. At the hybrid frame and the CIP station frames, columns are integrally connected to the superstructure to reduce negative moment demands near the bent and to better control seismic displacements of columns. Columns are circular with diameters of 7 feet, 8 feet or 9 feet. The viaduct includes one straddle-bent that is post-tensioned transversely and is supported on two columns fixed to the cap. Columns utilize either one-way or two-way flares to meet different aesthetic requirements. In California, two pile types are considered for seismic design. For Type 1 piles, the same rebar cage is continued from the column into the pile foundation typically forcing the seismic plastic hinge to form below the ground. Type 2 piles are oversized in the ground and ensure the plastic hinge forms above ground. A combination of Type 1 and 2 shafts were used throughout the viaduct to balance the stiffness between adjacent bents and to better control the dynamic behavior of frames under seismic loading.

INNOVATIVE ABC STRATEGIES

Spans Over Intersections

Full closure of the intersections was only allowed during night time and could only happen at one intersection at the time. Six locations were identified where precast girder spans were crossing over live traffic where this criterion applied. In these locations, the design team developed an innovative approach to splice the precast girders at a staging area near the site, then transport the spliced segment to the site at night for erection. The spliced segment was erected and placed on shoring towers during a one-night closure of intersection. The length of the spliced segments varied from 140 feet to 180 feet.

Use of PBES to Reduce Cost & Schedule

(1) The precast U-girder was selected for the viaduct to reduce construction duration, minimize falsework construction and alleviate traffic impact. Precast construction allowed for a simplified shoring tower system to be used as opposed to extensive falsework structure typically used in cast-in-place concrete construction. Construction schedule was also reduced by allowing fabrication of precast girders in a remote site while substructure work and other construction activities continued simultaneously at the main site.

(2) The same precast girder type and constant girder depth were selected for all precast spans. This was done to maximize repetition in girder fabrication and to reduce the cost and fabrication time associated with use of multiple girder types and precast forms. The 8-foot deep precast U section provided an efficient girder type for satisfying the depth to span ratio for various span configurations in the viaduct.

(3) A fixed plan radius was selected for all the curved precast girders in the viaduct. With this option, the fabricator could use a single form with a constant radius for all the curved girders.

(4) The lid slabs were being casted in precast yard as a second pour after casting the precast girders. By advancing construction activities related to lid slab, the contractor could accelerate the schedule for casting CIP deck, CIP end diaphragms and performing the continuity prestressing operation.

(5) The top flanges of precast girders were turned inward (Figure 4) to match the cross section of standard California bath tub girders. Web thickness and bottom flange thickness remained the same as the original design. This was done to allow the fabricator to use the available local forms in California reducing cost and eliminating the need to buy expensive forms.

CONCLUSION

For this viaduct, innovative design and construction methods were incorporated by the design and the CMGC team that benefited the project in many ways resulted in reduced traffic, construction cost and environmental impacts**.** Number of ABC strategies were employed to accelerate the construction, optimize construction schedule, improve design quality, and improve work-zone safety.