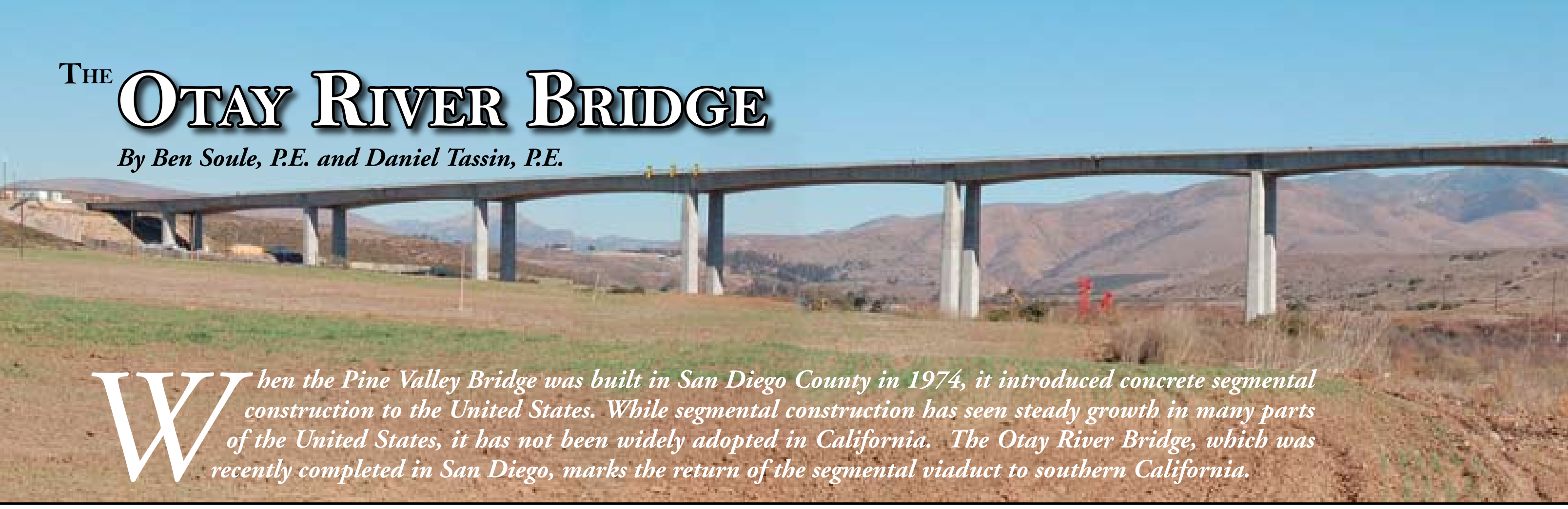

THE OTAY RIVER BRIDGE

By Ben Soule, P.E. and Daniel Tassin, P.E.

When the Pine Valley Bridge was built in San Diego County in 1974, it introduced concrete segmental construction to the United States. While segmental construction has seen steady growth in many parts of the United States, it has not been widely adopted in California. The Otay River Bridge, which was recently completed in San Diego, marks the return of the segmental viaduct to southern California.

The Otay River Bridge is a critical link in the South Bay Expressway, a major new highway being built in southern San Diego County. This 12.5 mile highway provides access from the busy Otay Mesa international border crossing to the existing freeway network, and will relieve traffic congestion in a rapidly growing region. The South Bay Expressway was developed by a private consortium through a public-private partnership, and will be operated as a toll road during the consortium concession period. At the end of that period, ownership will revert to Caltrans.

The alignment of the Expressway takes it across the Otay River valley. This valley is a large tract of open land, and is privately owned. It is one of the few remaining open spaces close to the city of San Diego, and is the home of many native plant and animal species. This unique, sensitive setting was a key driver in determining both the type of structure for the site, as well as the construction methods to be used.

The chief environmental goal for the site was to minimize the impact of the bridge on the valley. This expressed itself in two important ways.

The first was the effect of the completed bridge on the valley – there was a strong desire for a bridge that blended in with the setting, and did not create excessive noise or a jarring visual impact. This drove a high-level bridge, which would separate the valley from the highway noise. The resulting profile was coupled with long, repeating span lengths and a variable depth deck, creating a structure that is both graceful and unobtrusive.

The second consideration was the impact of construction on the valley. Construction is inherently disruptive; the agreed upon goal was to reduce both the footprint and the duration of the work. This was the primary reason for selecting a precast segmental structure over other alternatives. With precast segmental construction, the superstructure is cast in sections at a casting yard several miles from the site. The segments are transported to the site to be erected, in this case with an overhead gantry. The net effect of this method is that the superstructure is built from the previously erected structure, eliminating the need for falsework. This significantly reduces the construction footprint on the valley. An additional benefit is that the superstructure segments can be cast while the substructure is still under construction, allowing simultaneous progress on multiple fronts.

The resulting bridge is a 12-span structure, with typical span lengths of 90.5 meters (over 298 feet) and end spans of 53.5 meters (over 176 feet). It is a twin box girder structure, with a total deck width of 23 meters (75.9 feet), and will carry two lanes of traffic in each direction. The bridge was built by the balanced cantilever method, with segments erected in symmetric pairs about a central pier and secured with post-tensioning tendons. Each cantilever is 45 meters long (148.5 feet), with the cantilever tips from adjacent spans meeting at mid-span.

Segments wait in storage behind the completed spans.

The Otay River Bridge provides a critical link across an environmentally sensitive valley.

Design

The South Bay Expressway was a design-build project, which provided the opportunity for early integration of fundamental design decisions with specific construction methods. The four key parties to the design – Owner, State, Contractor and Designer – coordinated closely from the earliest design stage. This allowed key decisions to be made collectively, and late-stage changes were avoided. For example, the maximum segment size was limited both by a maximum height during transportation and by a maximum weight that could be carried by the erection gantry. Both of these limits were identified by the contractor during preliminary design and were incorporated into the final design.

A segment is swung into position at the cantilever tip.

An important consideration in the design was accommodating seismic loads and movements. The bridge is located in a seismically active region, with a peak ground acceleration of 0.4g. While precast segmental structures have been built in seismically active regions, this is only the second precast segmental bridge to be built in California. The bridge was designed in conformance with the Caltrans *Seismic Design Criteria*, which places a strong emphasis on structure ductility and detailing. While much of the focus in seismic design is on the performance of the substructure, there were also some special considerations for the segmental superstructure. One example was the need to provide some minimal capacity across every joint for both positive and negative bending. This resulted in longitudinal tendons in locations where a dead and live load analysis would not require them. However, seismic details required in the superstructure were integrated into the design without appreciable impact to segment cost or production rates, and the typical methods of segment production and erection were still available.

Substructure

The bridge is supported on flared reinforced concrete columns, which vary in height from 15 to 50 meters (49.5 to 165 feet). Each pair of columns is joined at the top by a cast-in-place beam, which also functions as the pier caps. Typically, the columns are hollow, with the corner regions confined by welded hoop reinforcement. Seismic demands drove much of the substructure design, and resulted in significant confinement reinforcement in the expected plastic hinge zones.

At each bent location, the two columns rest on a single 15-by 22-meter footing (49.5 by 72.6 feet). This, in turn, is supported by ten 1.83-meter (6-foot) diameter cast-in-drilled-hole concrete piles. The footings and pier tables were designated as mass concrete, and the concrete temperatures in those elements were closely monitored during curing. Special measures were taken to ensure that the concrete temperatures were not excessive, including insulated forms, concrete batched with ice in place of water, and post-cooling systems using chilled water.

Superstructure

A typical span consists of 28 precast segments, weighing up to seventy tons each. The segments were cast in an existing casting yard located in Perris, California, ninety miles north of the project site. A total of four forms were used to produce an average of 13 segments per week. The segments, which vary from three to five meters deep (9.9 to 16.5 feet), were trucked to the site in specially designed haul trailers. The segments were stored at the precast yard until they were needed at the project site. A week prior to their installation, the segments were delivered to a small staging area above the north abutment. This was organized to eliminate any delays to the erection schedule due to unforeseen complications in segment delivery.

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Steel beams are installed for the mid-span expansion joint.

Segments are delivered via an overhead gantry, eliminating the need for falsework.

An overhead gantry was used to erect the precast segments. The gantry had side-shift capability, which allowed erection of adjacent box girders in the same pass. A typical cycle consisted of erecting a pair of segments on one alignment, shifting the gantry transversely, and erecting segments on the adjacent alignment while tendons were installed and stressed on the first. This process had the advantage of allowing the gantry to stay continuously active, without interruption for tendon installation or stressing. Crews were able to erect from four to six segments a day, depending on the complexity of that day's tasks.

Because of the bridge length, three expansion joints were necessary to accommodate movements due to temperature variations and concrete shrinkage. The preferred method for constructing expansion joints in the region is a concrete hinge, located at the span quarter point. However, for the Otay River Bridge, a mid-span joint was selected, as it is more easily integrated with balanced cantilever construction. In this method, two steel beams are housed inside each concrete box girder. The beams are secured in internal diaphragms, and the supports are configured to allow transfer of moments and shears, while providing relief for longitudinal movements. The beams are placed inside the box girder after the completion of the downstation cantilever, then pulled across the joint and secured after the upstation cantilever is complete. This was among the most critical operations, and required the cantilever tips to be closely aligned.

The bridge structure was completed in March of 2007, and deck surfacing and hardware placement is underway. The highway is expected to open for traffic in the summer of 2007.▪

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Project Credits:

Owner: South Bay Expressway, Caltrans

Contractor: Otay River Constructors (ORC), a joint venture of Washington Group and Fluor

Precaster: Pomeroy Corporation

Construction Supervision: Parsons

Designers: International Bridge Technologies (IBT), Washington Infrastructure Services (WIS)

Dawn breaks as construction gets underway on the Otay River Bridge.