Bridge widenings in highly congested urban interchanges present a host of technical challenges for design teams, not the least of which is the ever-present accelerated construction schedule. Transportation agencies—and the customers they serve—expect their bridges to be open for traffic. Shut down a congested interchange for any period of time and what you get is even more congestion.
As far as congested urban interchanges go, southern California’s aptly named “Orange Crush” interchange is a leader. More than 200,000 cars per day flow through this interchange, which links I-5, Santa Ana Freeway, State Rte. 22, Garden Grove Freeway, and State Rte. 57, Orange Freeway, in southern California. Guinness World Records 2002 named it the most complicated highway interchange.

The Orange County Transportation Authority (OCTA), in cooperation with the California Department of Transportation (Caltrans), was determined to ease traffic congestion through the Orange Crush by undertaking a first-ever design-build project constructed on an active freeway in California, and the largest freeway-widening project in California. The project included three new bridges, nine replacement bridges and widening and retrofitting 22 bridges, in addition to constructing 88 retaining walls. Through a Granite-Myers-Rados joint venture, PBS&J was the lead structural design firm responsible for the State Rte. 22 widening.

Wide load

The contract with Caltrans called for widening the separation structure at Rte. 22/I-5, a five-span, cast-in-place, prestressed concrete box girder structure, by just over 20 ft to the south to accommodate new HOV lanes.

Rte. 22 spans 17 lanes of I-5 traffic at the Orange Crush, and closing down any lanes for an extended period of time was not an option. Conventional falsework was not feasible for the widening because the bridge spanned I-5 at a high skew (41°) with an extremely limited vertical clearance. This was especially true for span five, where the bridge crossed five lanes of northbound I-5 traffic with a cross-slope that varied up to 5% and a radius of curvature of 1,378 ft.

Structurally, the widened structure had to be designed to match the gravity and seismic response characteristics of the existing bridge. Aesthetically, it had to match the existing structure.

For the flow

In developing the structural design, PBS&J and the design team focused on options that would allow construction crews to complete the widening as quickly as possible in order to minimize any disruption to the flow of traffic. The option they would choose also had to meet Caltrans’ stringent performance and quality standards.

The design team evaluated two traditional approaches to the concrete

![Rapid Set Advanced Cement Technology](https://example.com/rapid-set-advanced-cement-technology.png)
During a one-night closure of the freeway, the contractor lifted the girders by crane into their final position.

Construction (cast-in-place and precast) and settled on a third that represents a hybrid of the two.

**Cast-in-place alternatives**

Cast-in-place bridges are economically competitive in California. Hence, the majority of newly constructed freeway bridges in California are cast-in-place concrete structures built on falsework. In spite of the severe falsework clearance limitations, the design team gave cast-in-place alternatives serious consideration.

To match the existing bridge with cast-in-place girders, falsework would have been required to span five traffic lanes along with temporary traffic barriers (span five of the widened structure). This falsework span would have been over 90 ft on a skew that effectively exceeds 45°. At this length, the falsework depths would have resulted in temporary vertical clearances well below the required 15 ft.

The design team considered using cast-high-and-lowered, post-tensioned box girders, where the superstructure is cast on elevated falsework and lowered into position using metal shims and hydraulic jacks. There is a significant level of risk associated with this alternative because of the potential for lateral movement during the lowering operation especially in a long and continuous multispan frame.

Suspended falsework also was considered, where main falsework girders are adjacent to the bridge girders and support transverse falsework beams at or near the bottom flange. However, this method was cost-prohibitive because the relatively wide soffit resulted in expensive connection details between the longitudinal girders and transverse beams.

**Precast concrete alternative**

The team considered using curved and spliced precast bathtub girders, using the standard shapes developed by Caltrans. In this alternative, dual bathtub girders span traffic openings, and splices consisting of 24-in.-long, cast-in-place regions are located at falsework supports. This alternative required sophisticated, expensive steel forms to accommodate the
curved alignment. The cost of these steel forms would have been spread over relatively few girders, making this alternative cost-prohibitive.

The hybrid solution

The team selected an innovative hybrid of cast-in-place and precast construction, where conventional falsework was used in all locations with the exception of the five-lane traffic opening in span five. For this span, the team chose precast concrete bathtub girders because of similarities to the adjacent cast-in-place girders.

To meet the rigorous project schedule, the team developed a construction sequence that allowed them to complete the span five work with just a one-night closure of I-5. Construction crews built footings, columns and abutments while the precast bathtub girders were being formed onsite. During the one-night closure, the contractor lifted the girders by crane into their final position. Later, the deck was cast on top of the hybrid girder system.

Compared with the time and money involved in building elevated falsework across five traffic lanes and using a jacking system to lower the superstructure, the cast-in-place/precast hybrid was an ideal option.

Although not necessarily new, the combination of these techniques allowed for construction of an innovative structure that was economical, fit the aesthetic requirements of the site and met the aggressive design-build schedule with minimum traffic interruptions.

The concept of using a hybrid of precast and cast-in-place methods evolved through a detailed analysis of site constraints for the Rte. 22/I-5 separation widening project. The design and approval process required the cooperation of Caltrans and the design team to find the right solution that would meet structural design and aesthetics requirements, while meeting an accelerated schedule.

As intended, drivers were inconvenienced for only a short period of time—one night—during the Rte. 22 widening, and with its completion, driving in Orange County became a lot easier.

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