A SILVER BULLET FOR U.S. PRECASTERS

The time is ripe to make the investment in reusable segmental forms

by Craig Finley Jr., Finley Engineering Group Inc.

A combination of ingenuity, advanced planning, and open-minded teamwork among the owner, general contractor, and the engineer resulted in substantial construction cost savings and a much quicker schedule on the first (and three additional) bridge project as part of Israel's major highway development projects. It also gave Danya Cebus, which was the general contractor and precaster, a significant competitive advantage to win additional work.

The key component for this country's developing infrastructure systems was designing numerous segmental bridges to the same cross section and erection method that best met the contractor's expertise and available equipment. While not new to Europe and other parts of the world, the use of standard precast machines for multiple projects was a novel, and some considered risky, approach in Israel. Although designing to standard precast box cross sections had been proven to have limited interest in the United States in the past, the time may be ripe to reconsider.

The Initial Challenge

The precasting machines were originally designed for the $273 million Ein Ha'Kore Interchange on Highway 431, part of the Cross-Israel Highway, but now more than 1100 segments on three additional bridge projects have been built out of the same two precasting machines. The general contractor knew that efficient construction methods were a key element for success, and they were looking to apply innovative techniques to reach their goal.

Finley Engineering Group brought their international experience to the project to provide a simple solution to a complex problem. All the involved entities—including governmental officials, the owner's engineering representatives (who had completed the preliminary design), and the contractor's ownership group—considered the alternatives and were open to the innovative idea. They agreed that precast concrete segmental bridges, using external tendons with diabolos, were a safe, cost-effective, and reliable long-term solution for this project.

The use of external tendons provided simplified precasting details, rapid erection procedures, and improved long-term durability. They also added technical advantages in the bridge design, such as increased ductility for flexural moment resistance and a significant reduction in principle tensile stresses in the box-girder webs. These benefits allowed for longer, constant-depth span lengths for the bridges, while still meeting the interchange design requirements. External tendons also provided savings on long-term maintenance costs allowing for simpler tendon replacement and periodic inspections.

Casting yard. Photo: Finley Engineering Group Inc.

As a result, the general contractor, who was an experienced precaster but had no segmental bridge experience, was able to win the design-build-operate-transfer project based on its low bid, and finish ahead of the ambitious schedule. This was critical to

Precasting machine. Photo: Finley Engineering Group Inc.

Table 1. Project Details				
Project	**Span Length**	**Width**	**Number of Segments**	**Number of Bridges**
Highway 431	120 to 200 ft	41 ft	329	5
Section 18	70 to 200 ft	42 ft	352	4
Benyamina Bridges	130 to 220 ft	38 ft	262	2
Highway 722	110 to 200 ft	66 to 100 ft	248	2
		Total	**1191**	**13**

Table 2. Comparison of Quantities for External Versus Internal Continuity Post-tensioning		
Quantity	**External**	**Internal**
Web thickness	15 ¾ in.	19 ½ in.
Cross-sectional area	69.97 ft^2	77.38 ft^2
Cantilever post-tensioning	2.67 lb/ft^2	4.23 lb/ft^2
Continuity post-tensioning	3.32 lb/ft^2	2.14 lb/ft^2
Total post-tensioning	5.99 lb/ft^2	6.37 lb/ft^2
Vertical web post-tensioning bars	–	Segment 1
Web principal tensile stress	216 psi	285 psi

the group's public-private partnership concession agreement and project financing goals.

The general contractor invested in the more robust and flexible European style forms with the intention of searching out projects where these forms could be used again, providing the contractor with a competitive advantage.

Key to the general contractor's success was establishing the casting yard in a central location, which reduced transportation of precast concrete segments to no more than 75 miles. They used lessons learned from the first project and expanded their knowledge base for use on each successive project. The general contractor's precast segmental experience became an institutional capability and its first move into this market helped to make them the number one precaster in Israel today. Tables 1 and 2 show the flexibility and variability that standard concrete forms can offer.

Future Successes and Lessons Learned

By taking a long-term view—employing expertise where needed to maximize its strengths and having a willingness to employ innovative risk—the general contractor was able to aggressively target, bid at the lowest costs, and win three additional Cross-Israel Highway projects. All three of these additional projects used the standard concrete forms and construction methods that were employed on the Highway 431 project. They were the Highway 722 Bridge, the Section 18 Interchange (four bridges), and the Benyamina Bridges (two bridges). In all, the two precasting machines were used to build 1100 segments on 13 bridges totaling $471 million in construction costs.

The general contractor credits the following to its long-term success:

- Big picture, long-term approach to its projects, processes, and business development, rather than the norm of a project-specific focus
- Willingness to take on innovation risk to create a market leader position
- Implementation of casting and erection standards with current and future projects in mind
- Commitment to continuous quality improvement with each project, applying lessons learned incrementally to all future projects
- Substantial savings realized through the reuse of casting machines and equipment

The Question—Why Not in the United States?

For the United States to remain competitive in the global marketplace, it has to continue to find, develop, and employ innovative methods and ideas.

Segment erection. Photo: Danya Cebus.

Segmental bridges are prominent in the United States and are a construction methodology with design implications. Standard segment details are defined in the ASBI *Construction Practices Handbook for Concrete Segmental and Cable-Supported Bridges*. For instance, the key features include balanced cantilever details, 45 ft segment widths, 7 to 10 ft segment depths, and spans up to 200 ft.

The United States-style forms for a typical precast concrete segmental bridge can cost upwards of $400,000 each, with two forms usually required on a project, and designing and manufacturing forms are a time consuming portion of a project. In the United States, forms are built by the contractor for a specific project, used one time, and discarded, adding approximately $1 million dollars to the contractor's bid.

Precasters are in a unique position to expand their product line, and they can benefit greatly by offering contractors and owners a lower cost alternative while maintaining or improving quality and maintenance standards of our country's bridges. Reuse of forms also offers a more environmentally friendly option by using fewer resources and reducing the overall waste stream attributed to the project.

Precast concrete segmental bridges are widely accepted in the United States. The time has come for the United States precasters to make the investment in European-style forms to extend their product line and pursue these projects.