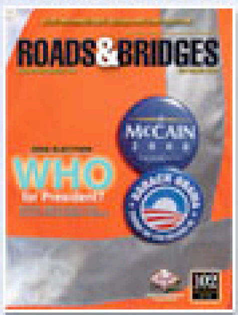

It answers 2 greatness

Historic Israeli highway has multiple names and successes

- By Craig Finley, P.E., and Jerry Pfuntner, P.E.

Israel's Highway 6 has never lacked for adjectives to describe it. Also known as the Trans-Israel Highway, the Cross-Israel Highway and the Yitzhak Rabin Highway, Highway 6 is the largest infrastructure project and the first major build-operate-transfer (BOT) project in the country's history. The 123-km roadway also is the first fully automated toll road in Israel.

Highway 6 serves as the main traffic artery connecting the periphery of the country to its center. Its primary purpose is to provide an efficient north-south transportation corridor, while allowing drivers to bypass the congested Tel Aviv region. Recently, the government estimated that over 80% of the cars in Israel had traveled on Highway 6 at one time or another since its first section opened in 2003.

Israel continues expanding Highway 6, including a 17-km, $210 million (U.S.) northward extension called Section 18.

Set to open completely in 2009, Section 18 includes the construction of five new twin precast segmental bridges. Each new twin bridge will initially carry two lanes of traffic, for a total of 10 structures and 20 lanes. The design also accommodates potential widening, with room for a third box girder between each twin structure.

As part of two different project teams, Finley Engineering Group performed redesigns of the Section 18 bridge structures to optimize the efficiency of materials and contractor construction equipment and operations. Contractor Danya Cebus is building two of the bridges—the Shelef and Nilly Bridges—while the other three—the Moed, Menashe and Dahlia bridges—are with contractor Solel Boneh.

The Shelef and Nilly bridges are viaducts, approximately 265 m long, with five spans each. The maximum span length is 66 m. The five-span Moed is 219 m long, the six-span Menashe is 246 m long and the five-span Dahlia is about 235 m long. They all share a deck width of approximately 12 m.

Each bridge design features external continuity post-tensioning systems and enhanced post-tensioning durability details, only the second time the Israeli construction community has ever used this method. The first time was a few months prior on Road 431, which also was a Finley-designed project.

Highlighted section

As with every major bridge project, the Section 18 bridges had a unique set of challenges and requirements. Derech Eretz Highways Ltd., the joint venture established to build and operate Highway 6 for the duration of the 30-year contract, wanted Section 18 to have the flexibility to accommodate increased traffic volumes when it became necessary.

That being the case, the Section 18 box girders were designed to accommodate an additional box girder to be built between the two side-by-side bridge structures for each distinct twin bridge.

The future interior box girder will connect to the current exterior box girders using a longitudinal closure pour. The design of the cantilever wings must accommodate current barrier and future deck slab live loading demands, all with reinforcing details compatible with both final designs. Additionally, the design of the longitudinal closure must accommodate the difference in creep behavior from the two current and one future box girders, particularly given the fact that there are likely to be several years between the current construction phase and the expansion.

Another uncommon aspect of the Section 18 bridges is that the company ultimately responsible for its construction, concessionaire Derech Eretz, also is charged with operating and maintaining the structures (along with the rest of Highway 6) for 30 years after their construction. Not surprisingly, durability and ease of maintenance were important considerations.

This is one true benefit of the BOT method: The design and construction team knew it had to build bridges that would last. (Perhaps bridge design and construction professionals should approach every project this way; the result would almost certainly be more durable, efficient bridges.)

When operation and maintenance are considered from the outset, there is even more pressure on the designer to focus on constructability. It is impossible to fathom how a structure will be operated and maintained for three decades without first considering how the contractor is actually going to build the design.

Achieving the goal of designing and building long-lasting bridges that are efficient to construct, operate and maintain over time required a true collaboration among the engineer, contractor and owner. Having the entire team together and focused on the same goal from the outset resulted in a somewhat innovative approach to reduce construction costs and increase speed of construction.

One example is that the project team settled on a precast segmental bridge design that incorporated external continuity tendons. This allowed for a reduction in the number of segments and quantities of material required, as well as increased standardization of precasting equipment. It also will help with ease of inspection and maintenance over the life cycle of the structures.

The team did not have to look far for a recent example of an Israeli bridge project that used external tendons. Finley and Danya Cebus had successfully pitched the concept to the concessionaire and Israeli governing body for Road 431 only a few months before.

Despite the fact that Israeli codes did not then allow for external tendons, the team was successfully able to articulate the benefits of the external tendons to the governing body, convincingly demonstrating that it was sound engineering and that it would ultimately benefit the project.

The external post-tensioning system reduces the segment cross-sectional area, including narrower web width and bottom slab thickness. The result is lower superstructure weight and foundation loads.

Also, with external tendons, fewer segments require post-tensioning details, so segment casting is faster and more efficient. The system reduces post-tensioning operations in the field, because there are fewer tendons to install, less anchorage hardware and fewer stressing operations. The continuous duct also reduces the number of connections.

In most cases, external tendons simplify the process of building the bridges, meaning the project goes faster and more smoothly.

If that was not convincing enough, the ease of inspecting and maintaining the external tendon system likely won over any remaining skeptics.

External tendons are not encased in concrete, but the entire box girder section protects them nonetheless. They are located above the bottom slab, so water that infiltrates the box girder cannot compromise durability. And by simple visual inspection of tendon ducts, maintenance teams can ensure that all strands remain protected against exposure.

External tendons can be inspected for nearly the entire length of the tendon as well, and repair teams can fix any defect from inside the box girder. This includes grout voids, split ducts and tendon damage.

Your basic success

The experience of the Shelef and Nilly bridges on Section 18 in Israel recalled a few other basic lessons of good bridge design and construction:

It never hurts to take another look. The Finley design of the Section 18 was radically different from the initial preliminary design. But the design also had the advantage of both time and a different perspective. It is self-defeating for a bridge professional to think that their design work cannot be improved upon. Value engineering provides the opportunity for a fresh set of eyes that can consider whether there might be a better way to build a bridge.

Cooperation is key. On Section 18's bridges, well-conceived decisions that addressed project-specific challenges resulted in money and time savings for the owner. But more to the point, these projects reinforce the fact that cooperation among the major players on a bridge project—owner, contractor and engineer—can produce great outcomes.

Innovation does not have to be new. Sometimes innovation is simply knowing when to use a certain part of your experience and skills. For example, Danya Cebus chose to use the cross-section design that they and Finley had previously used on the Road 431 project. Solel Boneh, on the other hand, decided that an older style that they had used previously, and for which they already had equipment, was the more efficient, economical approach.

Much of the time, great bridge projects do not even require great innovation. The techniques used on the Section 18 bridges are not extraordinary in and of themselves. They are, however, innovative, because the Israeli bridge community was unfamiliar with some of the proposed methods and was, thus, unlikely to initiate their use. To their credit, however, the Israeli government and the project owner were open to the concepts presented to them by their design and construction professionals, and they ultimately embraced these concepts for the sake of the overall project.

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