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Project News

Road 431: Advancing Segmental Bridge Technology in Israel

The use of external tendons on a segmental bridge project is not a revolutionary concept. But by assessing the contractor's needs and introducing proven segmental bridge technologies to the Israeli construction practice, this approach provided recognized benefits to the owner and contractor with simplified precasting details, rapid erection procedures and improved long-term durability. The Road 431 project offers another case study in the benefits of meeting challenges by seeking solutions that go beyond standard practice.

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Figure 21a


Figure 21b


Figure 21c


Figure 21d

This project involves many challenges common in today's construction environment, including a rapid construction schedule and budgetary restrictions. Additionally, the contractor required details that enhanced the long-term durability of the structure; they must own and maintain these bridges in satisfactory condition for 30 years before transferring ownership to the government. Due to the span lengths and size of the segments, FEG's technical director, Jacques Combault, proposed a combination of internal and external tendons to maximize the efficiency of these precast box girder bridges. Internal tendons are used in the top slab in support of the crane-based balanced cantilever construction, and external tendons are utilized for all continuity post-tensioning. This system was developed with the contractor for more consistent segment precasting configurations, rapid installation of continuity tendons and fewer tendon stressing operations.

The use of external tendons also provided 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. The large anchorage zones required for external tendons presented a challenge in keeping the pier segment weight within the 65 ton lifting capacity of the contractor's equipment. FEG utilized a volume element finite element analysis to optimize the pier segment diaphragm design and keep the segment weight within the contractor's requirements. (Fig. 20) Along with the introduction of external tendons, FEG incorporated several other innovations on this project, including the use of diabolos in the pier segments and deviators to simplify the external tendon details. These post-tensioning details allow for replacement of the external tendons should this be required in the future. FEG also specified the use of pre-packaged grouts, multiple levels of protection and enhanced duct systems to improve post-tensioning system performance. Erection photos for the Road 431 Bridges are shown in (Fig. 21a-d).

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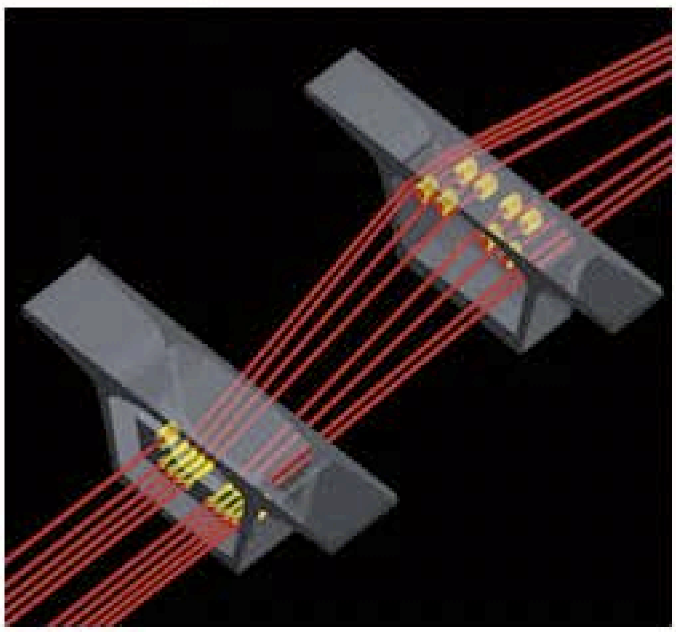

Figure 19 – Tendon layout Road 431 Bridge (photo courtesy of FEG).

Figure 20 – Pier Diaphragm Segment Road 431 Bridge (photo courtesy of FEG).

The Country of Israel clearly has an affinity for segmental bridges. Though it is only about the size of New Jersey, Israel has constructed more than 25 segmental bridge structures in the last 20 years.

Despite the country's considerable experience with segmental bridges, the Road 431 Project (Fig. 19) will be the first in Israeli bridge construction history to use external tendons. A Design-Build-Operate-Transfer venture, the Road 431 project consists of an interchange with six precast segmental bridges. These 12.5m wide bridges will have span lengths ranging from 30m to 66m and will consist of 501 precast segments with a total deck area of more than 18,000 square meters.

Finley Engineering Group, Inc. (FEG) is providing final design and construction engineering services for the segmental bridges in this interchange. The contractor, Danya-Cebus, Ltd., was challenged with a tight construction schedule to meet concession agreement requirements and project financing goals. As a result, FEG proposed the use of external tendons to allow for simplified precasting of the segments, reduction in segment cross-sectional area and foundation loads, fewer tendon stressing operations and a reduced design schedule. FEG worked with the contractor during a streamlined final design process that began in February 2006 and resulted in the casting of the first segment in July.

The design process included a technical review by Israeli General Consultant engineers to confirm that the external tendon system adequately met the project requirements. To assist the Israeli engineers in evaluating external tendon post-tensioning systems, FEG produced a technical white paper that included details of previous projects, excerpts from technical articles, and a list of benefits that the external tendons bring to the project. It also included FEG's analysis of tendon loss scenarios to meet strict bridge security requirements and design methodology for service and ultimate limit state design with external tendons.

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