First segmental viaducts opened for northbound traffic on Boston Central Artery/Tunnel project

The first precast segmental viaducts and interchange ramps were opened for northbound traffic on the Central Artery/Tunnel (CA/T) project in Boston this winter marking another milestone for a project that has been under construction since 1991. The new structures are part of a major interchange for I-90/I-93 and provide access for traffic from the underground artery tunnel to the new cable stayed Zakim Bunker Hill Bridge.

Segmental viaducts and interchange ramps, some with radii as tight as 200’, have been used extensively on the project. When the sixth and final contract with segmental structures is complete for the total project in late 2004, almost 4,000 segments will have been incorporated in the CA/T.

A project review on the American Segmental Bridge Institute (ASBI) website notes there are 10 viaducts on the I-90/I-93 contract. They are parallel, above or below I-93 northbound and comprise frontage roads, mainline lanes and various turning ramps within the interchange.

On this contract alone, a total of 1062 precast segments were cast by Unistress Corp at their plant in Pittsfield, MA, and trucked to the jobsite. The segment lengths varied between 7.5’ and 11’ and weighed between 35 and 55 tons each. They were match-cast using a casting machine. Unistress used four machines, one for the end segments and one for each of the three segment types. The casting cycle was one segment per day per machine for the typical segments and one segment per five days for the end segments. Job credits are as follows;

Owner: Massachusetts Turnpike Authority
Management Consultant: Bechtel/Parsons Brinkerhoff
Design of Concrete Viaducts: DMJM + Harris
General Contractor: Slattery, Interbeton, J F White, and Perini
Construction Engineering: Parsons Bridge and Tunnel
Precaster: Unistress Corp

See story on page 2 for information on other contracts of the project.

2003 ASBI Design and Construction seminar July 21-22 at Newark airport

This year, the 2003 ASBI, "Design and Construction of Segmental Concrete Bridges Seminar" will be held on July 21-22 in the Marriott Hotel at the Newark International Airport in New Jersey. The seminar is co-sponsored by the New Jersey Department of Transportation.

ASBI is the American Segmental Bridge Institute which was founded in 1989 to provide a forum for owners, designers, contractors and suppliers to refine the design and construction, and advance the quality and use of concrete segmental bridges.

The seminar program includes presentations on the following:
Applications and Advantages
Analysis and Design
Time Dependent Affects
AASHTO Guide Specifications
Span by Span Bridges
Precast Cantilever Bridges
Cast-in-place Cantilever Bridges
Cable Stayed Bridges
Special Applications
AASHTO-LRFD Design
Grouting Technology
Durability, Speed and Life Cycle Cost

A number of ASBI Committees are active in development of design and construction specifications for segmental bridges. A PCI-ASBI Joint Committee Developed “AASHTO-PCI-ASBI Segmental Box Girder Standards for Span-by-Span and Balanced Cantilever Construction.”

Additional details of the seminar are available on the ASBI website at www.asbi-assoc.org. Registration for the seminar may be made with ASBI by phone at 602-997-9965. The cost is $250 for Transportation Officials and $450 for Non-Members. Reservations for the Marriott may be made by phone at 973-623-0006.

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Segmental box girder standards for span-by-span or balanced cantilever design from AASHTO-PCI-ASBI comm

Segmental box girder standards for span-by-span or balanced cantilever bridges are available in a report that was published by a joint committee of AASHTO, PCI and ASBI in the late 90s. The standards are recommended for spans from 30.5 to 61.0 m (100' to 150') for span-by-span design, 30.5 to 61.0 m (100' to 200') for balanced cantilever design, and deck widths from 8.55 to 13.65 m (28' to 45').

The standard sections are available in depths of 1800, 2100, 2400, 2700, and 3000 mm. The balanced sections have thicker top, bottom and web dimensions to allow for higher prestress forces that are required with balanced design. Shear key details for bulkheads on each segment are also included.

Post-tensioning details

Post-tensioning details are dependent on a number of factors including the type of design, required post-tensioning forces, and size of the tendons. Tendons can be internal, which are placed inside the segment webs or slabs or external, which are placed inside the segment void. Some designs on the CA/T project used both internal and external tendons. Access and erection conditions will determine whether the design will be a balanced cantilever or span-by-span design.

The photo above, is taken inside the void of a span-by-span section of ramp, during post-tensioning of the span. It shows temporary post-tensioning bars (top corners and center of bottom slab) used for anchoring and alignment of segments during erection. It also shows deviation blocks (bottom corner of the slab) that will receive the final external post-tensioning. These tendons will extend from the pier segment at one end, into a deviation block in the void, thru a portion of the bottom slab, exit back into the void from a second deviation block, and finally terminate at the opposite end pier segment. Internal tendons are totally encased in concrete.

Miscellaneous details

Temporary tendons on the project have been typically 1.375" Dywidag post-tensioning bars. Final post-tensioning tendons have been made up from varying numbers of 0.6" diam strand with Dywidag anchorages. The standards also include specifications for concrete, rebar, grouting, epoxy joining of segments and shop drawings.

J FK, BQE & CA/T confirm plusses of segmental design

Three recent projects, here in the Northeast, have confirmed the plusses or advantages of precast segmental design for complex urban sites. They are the JFK Airport light rail guideway in New York City, the Brooklyn Queens Expressway (BQE) ramp also in New York City and the Central Artery Tunnel (CA/T) project in Boston.

Selection of segmental design for all three projects was based on the flexibility of segmental to meet complex site constraints, the advantages of top down construction to solve traffic and access problems at the site, and finally the long term durability of concrete.

Here is a summary of the projects;

- JFK Light Rail Guideway: 5,195 segments
  Precaster: Bayshore Concrete Products
- BQE Connector Ramp: 278 segments
  Precaster: The Fort Miller Co
- I-90/I-93 Interchange & I-93 NB, (A4) CA/T: 1062 segments
  Precaster: Unistress Corp
- I-93 Viaducts and Ramps, (B1) CA/T: 1935 segments
  Precaster: Sanford Precast
- I-93 Southbound I-90 Mainline, (C1) CA/T: 430 segments
  Precaster: Unistress Corp
- I-93/I-90 SB Viaducts & Ramps, (C4) CA/T: 200 segments
  Precaster: Unistress Corp
- I-93/I-90 Interchange at Albany St, (C2) CA/T: 510 segments
  Precaster: Unistress Corp
- Demolition and Ramp SA-CN, CA/T: 170 segments
  Precaster: Unistress Corp

Curvature (some radii as tight as 200') is shown for interchange ramp on CA/T.  photo by CA/T
Performance of segmental and cable stayed bridges in Europe

Segmental and cable stayed bridges were being built in Europe in the 1950s, and some 10 years later in the United States. A report from the Federal Highway Administration (FHWA), issued as FHWA-PL-01-019, is a comprehensive account of the technology of segmental and cable stayed bridges in four countries including Switzerland, Germany, Denmark and France.

Problems eliminated thru new codes and practices

The report notes that performance problems in Europe, from the 1960s and 1970s have been eliminated through new codes and practices. Corrosion of prestressing tendons or reinforcing steel is attributed to poor quality grouting of tendons or honeycombed concrete allowing water, oxygen and chlorides to enter. European policy is to use protective overlays on all types of construction and this seems to be working.

More stringent controls and practices are being used to insure that ducts are sealed and free of voids. The report notes that procedures are similar to specifications being recommended by the Post-Tensioning Institute (PTI), American Segmental Bridge Institute (ASBI), and the Florida Department of Transportation (FDOT). The ASBI Design and Construction Seminar to be held in Newark, NJ will include a presentation on “Grouting Technology.” See the story on page 1.

Commitment to effective maintenance, repair & up-keep

There is a greater commitment to implementing effective maintenance, repair and up-keep of bridges in Europe, even though inspection and condition assessments of existing structures are made in a similar manner to the US practice.

Europeans are satisfied with their segmental and cable stayed bridges. A worldwide survey of 17,612 post-tensioned bridges conducted by the Danes notes that 351 (only 2%) have durability problems due to corrosion in the tendons. Therefore with appropriate attention to grouting procedures, they expect segmental bridges will serve well into the foreseeable future.

The report was authored by a team of engineers from FHWA, Texas DOT, California DOT, Florida DOT, NY Lin International, Parsons, HNTB Corporation and Figg Engineering. Further information is available at www.international.fhwa.dot.gov.

Elaborate construction engineering, key to precasting and erection of segmental work on the Central Artery

Elaborate construction engineering has been key to the installation of precast segmental interchange ramps on the Central Artery/Tunnel project in Boston. Complicated ramp geometry has been common with vertical and horizontal curves and superelevation. Spans for ramps have ranged from 100’ to 200’, with horizontal curve radii from 200’ to 6,500’. In some locations, multi level ramps are supported by straddle bents. Even more complicated have been the erection schemes necessitated by limited access for erection equipment, interference of existing utilities, active rail tracks and highways, and the close proximity of other structures.

Span by span and balanced cantilevered schemes have been employed with segments set by crane or rolled into position. In the photo above, segments for a balanced cantilever section were set by crane on one (far) side and rolled into position on the opposing (near) side. The temporary bents on the near side spanned four active tracks for commuter trains entering South Station. Shoring adjacent to the pier head, and visible in the photo, provides stability for the balanced cantilever section until it is complete.

Developing geometry control

External loads are considered in the geometry control used for casting segments. The control is determined by a phased analysis of the erection scheme including initial camber, deflection of the erection equipment, and the final profile of the span. In typical match casting procedures, the previous casting for each casting setup is used as a bulkhead for the current cast. The previous cast can then be adjusted vertically and horizontally to achieve the required three dimensional orientation required.

The adjustments are made using a fixed theodolite oriented with the casting machine or form. Measurements are based on elevations and alignment to the top of bolts and hairpins precisely set in the top of each segment. Elevation checks, to the same bolts and hairpins, are made in the field as the erection proceeds, and the segments may be adjusted with jacks or devices incorporated into the erection equipment.

Six contracts on project

Construction engineering for all of the segmental interchange ramps has been provided by Parsons Bridge and Tunnel Group with offices in Essex CT. Their work has included construction analysis, integrated shop drawings, erection equipment and falswork design and geometry control for the segments. The interchange ramps are part of six contracts on the CA/T project which will have a total contract value in excess of $950 million when the project is complete. The first viaducts and interchange ramps to be opened to traffic are described in the story on page 1.

The size and breakdown of the contracts is noted in another story on page 2.
Evolution, one segment at a time:

We continue to be fascinated with the evolution of segmental technology as evidenced by work covered this month in our newsletter. Precasting and erection on the CA/T in particular, have been most innovative. The project sets a new standard for solving problems of a congested urban site and advancing the evolution of segmental technology.

An article that will appear in the 3rd Quarter issue of PB Network Magazine entitled “US Precast Segmental Casting Yards” by Arthur Palmer would suggest there is more to come. The article notes the high cost and a casting life of 400-600 uses for individual forms. Greater use of AASHTO/PCI/ASBI standard cation programs with either the Precast/Pre-cast segments would reduce these costs. Further savings are foreseen with material evolution, including the use of welded wire fabric, high performance concrete (HPC), self-compacting concrete (SCC), and a new generation of SCC with polycarboxylates.

The article also envisions geometric alignment of forms controlled by computerized hy-