Precast Segmental as an ABC Tool

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INTRODUCTION

While precast segmental bridge construction (PSBC) is not a new idea, its use as an ABC tool has created new interest in segmental bridge construction.

The construction methods used for PSBC are well-suited for congested urban environments and can be built using span-by-span or cantilever construction methods, with precast segments being erected by conventional cranes or specialized equipment. All these methods are very efficient and minimize the impact on the traveling public and surrounding neighborhoods.

Segmental bridges are easily adapted to a wide range of alignments and geometry. They are ideal for horizontal curves with tight radii and combinations of vertical and horizontal curves, allowing for corresponding super-elevation to be “built-in” when the segments are cast. Additionally, segmental bridges can easily accommodate a wide range of span lengths and, in many situations, this flexibility is required to work around existing infrastructure.

METHODS OF PRECAST SEGMENTAL CONSTRUCTION

There are currently two main methods of precast segmental construction: span-by-span and cantilever. Each of these methods has a sub-set of erection methods.

a. Span-by-Span
    i. Gantry
    ii. Crane
    iii. Falsework
b. Cantilever
    i. Launching Gantry
    ii. Lifting Frames
    iii. Cranes

Most of these methods of construction were used in the illustrative examples found below and each of these methods has its own merits with respect to ABC.

LESNER BRIDGE IN VIRGINIA BEACH, VIRGINIA

Located on the Shore Drive corridor and adjacent to the mouth of the Chesapeake Bay, the new Lesner Bridge crosses the Lynnhaven Inlet and serves as the gateway to the ocean front tourism center. These new structures delivered two signature bridges for the City of Virginia Beach and surrounding communities, providing a critical link across the inlet.

Each structure consists of ten spans: nine at 150 ft. with a channel span of 225 ft., including nine piers and two abutments. The new bridges greatly improve the corridor by providing wider lane widths, wider shoulders, new 10-ft. multi-use paths in each direction, landscaping improvements, improved signalization, and decorative lighting.

Providing a 45-ft. navigational clearance, each new bridge is 1,575 ft. long and consists of 168 segments which were pre-cast in Portsmouth Virginia. Segments were erected using span-by-span and balanced cantilever methods with an overhead, self-launching erection gantry.

The various segment types that encompass each structure included split pier segments, typical span-by-span segments, deviator segments, typical cantilever segments with internal post-tensioning and concrete blisters, and variable depth segments. Individual segments were match-cast using the short line casting method with strict, three level geometry control oversight. Contractor, designer, and owner performed geometry control oversight at the casting yard through “pre-cast” and “as-cast” survey.

Segments were cast and stored at the casting site and then individually delivered to the project, 20 miles away, on a 13-axle hauler through four different municipalities.

Rapid Construction

With a vehicle count of 20,000 ADT, the Lesner Bridge was required to be constructed without reducing capacity during temporary operations, inhibiting the overall construction duration. To help offset longer construction time, three of the four abutment foundations were changed from the designed 4-ft. diameter, 100+ ft. depth drilled shafts to driven piles, a change that resulted in fewer days to construct the foundations and footings and no additional cost. Additionally, footings in the water were constructed using pre-cast seal slab bottom forms. The pre-cast nature of the footing falsework expedited formwork and helped reduce the eight footing installation durations.

SECTION 5 PALMETTO SR826/836 INTERCHANGE (BRIDGES 9, 11, 15 AND 19), MIAMI, FLORIDA

The reconstruction of Section 5 Palmetto SR 826/836 Interchange created safer and less congested travel for 430,000 vehicles traveling through the interchange daily.

This $559 million design-build-finance project involved the construction of an interchange between SR 826 and SR 836, two limited access facilities, as well as the reconstruction of SR 826 at Flagler Street and SR 836 at NW 72nd Avenue interchanges. Capacity improvements included the reconstruction and widening along both SR 826 and SR 836, with the construction of 46 bridges. The project provides new direct connector ramps for major improvements and collector-distributor ramps that eliminated existing geometric and operational deficiencies.

Four high-level precast segmental bridges traverse the heart of the interchange and form the centerpiece of the intersection. These bridges are 46 ft. wide and range in length from 1,100 ft. to 2,450 ft.. Total deck area is 360,718 sq. ft., with 7,764 linear feet for the segmental bridges. The longest span is 266 ft., the tallest pier is 81 ft. and there are 783 total segments.

The curved segmental bridge ramps are the third level of the interchange with radii down to 590 ft. and a maximum superstructure deck height of 95 ft. above ground. All of the bridges are supported on 24-inch pile foundations and reinforced concrete piers and caps.

Rapid Construction

Early on, the design-build teamed realized that the critical path depended on speed of construction of the high-level segmental bridges. Most notable and significant among these design solutions was the decision to build the four segmental bridges “from the top down.”

Use of a 460-ft. self-launching overhead gantry to build the precast segmental bridges, using the balanced cantilever method over the main portion of the interchange, reduced the need for temporary supports on the ground, with segments stabilized off the pier caps.

The casting yard was located 8 miles away from the project and transportation time of the segments ranged from 30 to 90 minutes facilitating the contractor’s rate of production when erecting segments. For segment production, three casting machines were utilized: one for pier and expansion segments, two for typical segments, with no rejected segments.

Equipment and construction had to move quickly, and Quality Control was one of the keys to keeping the project on schedule. The design team understood these challenges and built them into the design of the project.

I-59/I-20 CENTRAL BUSINESS DISTRICT (CBD) BRIDGE REPLACEMENT, BIRMINGHAM, ALABAMA

The existing bridges in the Birmingham CBD were designed and constructed in the 1960's with a 30-year lifespan in mind. This facility was intended to carry 80,000 vehicles per day. Today the structures are some 60 years old and service more than 165,000 vehicles per day. Projections for 2035 estimate traffic will grow to 225,000 vehicles per day.

ALDOT determined it was not possible to re-route the interstate due to environmental justice issues, with an estimated 30 years of planning and a cost of nearly $2 billion it would take to do so.

The infamous "Malfunction Junction" as it was referred to by locals needed to be replaced. By rebuilding the existing bridges, new life could be brought into the facility that rehabilitation and re-decking could not provide. Rehabilitation was also estimated to take a full year longer than the proposed method for complete demolition and reconstruction. The new construction option was also found to be only $25 million more than rehabilitation.

Rapid Construction

With just 14 months allowed for complete closure of I-59/I-20, ABC was a necessity for this project. With a March 21, 2020, deadline for the interstate to be back open to traffic construction had to proceed rapidly.

ALDOT chose to use incentives and disincentives to help speed the construction of the project. For every day the bridges are open before March 21, 2020, the contractor will get a $250,000 bonus with a maximum bonus of $15 million. For every day the roadway opening is delayed after March 21, 2020, the contractor will forfeit $250,000.

In addition, ALDOT chose to require the use of precast segmental bridge construction for the project, including precast superstructure elements. However, the contractor, Johnson Bros Corp, went one step further by choosing to also use precast pier caps and column segments allowing for faster construction time. In all, 2,316 superstructure segments were needed, with each segment being 12 ft. in length, and over 5 miles of segments required.

By the middle of June 2019, about 600 of the 2,316 segments of the new interstate bridges had been erected (about one-quarter of all segments). Typical production for the project included the erection of nearly 400 segments each month. As of July 15, 2019, 1,014 segments had been placed. This is nearly half of all segments and was consistent with the contractor's schedule of 400 segments per month. This production rate was possible not only by using precast but also by working on multiple headings.

Using precast superstructure segments also allowed the contractor and owner to make the choice to re-cast several segments to ensure the bridges had the correct geometric profile – this would not have been possible with a cast-in-place structure. Despite the need to re-cast several segments, the overall project completion was not impacted, another advantage to using precast.

Since this is an ongoing project that will be nearing completion soon, updates on the current status of the project will be provided during the presentation at the International Accelerated Bridge Construction Conference.