Precast Concrete Segmental Box Girders Arrive at the Chicago Transit Authority

by Carrie Wagener, Chicago Transit Authority

Over a decade ago, the Chicago Transit Authority (CTA) began in earnest to develop a massive construction program to replace aging infrastructure along the northern end of its busiest rail lines. Originally constructed in the early 1920s, the Red and Purple lines have seen nearly a century of use. Continuing to make costly repairs to stations, track, structures, traction power, and signaling systems was not only becoming increasingly inefficient but was also limiting CTA's ability to expand service to meet growing demand. The Red and Purple Modernization (RPM) program was developed to renew this infrastructure in several phases. In December 2018, CTA awarded a contract to Walsh-Fluor Design-Build Team (WFDBT) for design and construction work on the first phase of the program, RPM Phase 1. In this phase, a grade-separated bypass track is being constructed to eliminate the need for trains to stop and wait for other trains to cross at a flat junction and a four-track area, and support structures are being rebuilt to eliminate a series of speed-restrictive curves. In addition, four stations—Lawrence, Argyle, Berwyn, and Bryn Mawr—are being completely rebuilt along with the mile-long, four-track right-of-way and support structures adjacent to these stations.

The challenges associated with RPM Phase 1 are numerous. CTA train service operates 24 hours a day, 365 days a year, running through the construction zone as often as every 3 minutes during rush periods. The track structure runs through a city alley and is closely flanked by buildings on both sides, some of which touch the existing track structure, creating a very limited area for demolition and construction equipment. A densely populated neighborhood surrounds the project, and the effects of the project on schools, businesses, and large apartment buildings had to be considered. Consequently, when CTA issued the request for proposals for this design-build project, the goal was to find a team that could offer innovative solutions to maintain rail operations during construction, build within the extremely limited space, and maintain a safe working environment (see the Project article on page 12 of this issue).

View from the top of the gantry showing the proximity of in-service Chicago Transit Authority tracks and adjacent buildings to the new construction. Precast concrete segments are staged for erection on completed spans of the post-tensioned, precast concrete segmental box-girder structure. All Photos: Chicago Transit Authority.

Several precast concrete segments of the second span hang from the gantry as a new segment is hoisted from street level, all while a Chicago Transit Authority Red Line train proceeds unimpeded southbound past the work zone.

To encourage innovation, CTA included an alternative-technical-concept (ATC) process during procurement to enable teams to include creative approaches in their proposals, including any associated schedule and budget savings. This process enabled CTA to get the best-value proposal with the most-efficient solutions, means, and methods to build a transit infrastructure that will meet the demands of the next 100 years.

CTA's technical requirements were developed around a cast-in-place concrete substructure supporting a steel superstructure. Early in the procurement, WFDBT submitted an ATC for a post-tensioned precast concrete segmental box-girder superstructure. As CTA began its discussions, there were several key issues to be resolved: stray-current corrosion, erection means and methods, and CTA's lack of experience with the proposed structure type.

First and foremost, as an electric railroad, stray current is a huge concern for CTA. If the steel running rails and track fastening system are not adequately isolated, stray current can leak into the structure below, seeking the path of least resistance back to the substation. In a concrete structure, that path can be the steel reinforcement; in a post-tensioned structure, it can be post-tensioning tendons. Left uncontrolled, stray current can quickly corrode reinforcing bars and post-tensioning tendons. Consequently, CTA placed a variety of conditions on the approval of the ATC to ensure proper steps are taken to reduce and control

View from beneath a new segmental box-girder structure. The gantry enables top-down construction with very little lateral work zone and significantly reduces impacts to the neighborhood.

stray current as much as possible. CTA additionally required that WFDBT provide training and guided field assistance to the workforce responsible for ongoing stray-current monitoring.

Another concern was the gantry required for erecting a segmental box-girder structure. How would CTA train operators react when approaching a gantry over 280 ft long, towering above the adjacent in-service tracks? Furthermore, how would neighborhood residents react to a gantry right outside of the adjacent buildings, including schools and apartment buildings? After considering the benefits of an erection process using a gantry system, CTA ultimately decided that the challenges associated with the overwhelming size of the gantry could be overcome with the right amount of outreach. The gantry enables top-down construction with very little lateral work zone, making its use ideal for the narrow work area. Limiting swinging loads from cranes is also beneficial when work proceeds adjacent to active train service. Finally, the gantry significantly reduces impacts to the neighborhood in the form of street closures for crane staging.

The final hurdle for CTA was the simple fact that the structure would be concrete. CTA has a long history with steel, which began in the late 19th century with the first elevated open-deck track structures erected—such as the quintessential Chicago structures encircling the downtown Loop—and continues into the present. Steel is a known commodity for CTA, which has had over a century to refine design, construction, inspection, repair, and replacement techniques to ensure ongoing service as the infrastructure ages. CTA currently has few concrete structures and therefore little experience maintaining them. To overcome this hurdle, CTA added conditions to the ATC approval that the contractor provide not just classroom training on inspection processes but also field assistance to guide the CTA workforce through several rounds of inspection to ensure complete understanding.

Ultimately, CTA has realized many benefits from accepting the ATC for precast concrete segmental box girders. The segmental spans are longer and supported on fewer columns than the initially proposed steel superstructure, significantly reducing the number of foundations required, along with the associated construction risk and schedule impacts. Precasting at an off-site facility combined with top-down construction using gantries has greatly reduced the work-zone footprint in the tight confines surrounding the project. In addition, the overall duration of structural erection has been reduced. In fact, WFDBT completed the first of two segmental box-girder structures as 2022 drew to a close, and CTA looks forward to running the first trains over the structure in 2023.

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The gantry towers above the post-tensioned, precast concrete segmental box-girder structure that winds north through the city alley.