USING ABC TECHNIQUES UNDER PHASED CONSTRUCTION

Thomas Anthony, P.E., CBSI
Structures and Bridge Inspection Department Manager
The Markosky Engineering Group, Inc.

MARKOSKY

Introduction

- East Busway
  - Port Authority of Allegheny County's transit system
  - 20,000 passengers per day
  - Emergency services
  - Constructed 1980
  - Original busway alignment circa 1904
  - Existing structure consisted of 3 simple spans supported on reinforced concrete abutments and concrete encased steel bents

Introduction - Continued

- East Busway
  - Center span built-up riveted steel plate girder
  - End spans rolled steel beams
  - Superstructure fully encased in concrete
  - Beam spacing approximately 2’-6”
  - Overlaid with several feet of embankment for roadway

Original structure elevation

Original Superstructure

Introduction - Continued

- East Busway
  - Numerous defects noted in previous structure inspections
    - Spalling of the underside of the concrete encasement
      - Fall hazard to vehicles and pedestrians
    - Underside of the unpainted girders exposed to salt spray - signs of deterioration
    - Widespread spalling and delaminations on abutments and pier bents

Preliminary Engineering

- Markosky & GAI Roles
  - Open-end agreement with PAAC through GAI Consultants
  - Evaluation of bridge to determine rehabilitation costs versus costs for a superstructure replacement
  - Markosky provided bridge and roadway design
  - GAI provided traffic control services, project management and QA/QC

Preliminary Engineering - Continued

- Preliminary Design Phase
  - Performed the 2013 NBIS inspection and conducted a follow-up rehabilitation inspection
  - Core samples for concrete strength and chloride ion testing
  - Developed 2 options:
    - Rehabilitation including concrete repairs
    - Superstructure replacement using conventional construction methods with phased construction

Preliminary Engineering - Continued

- Rehabilitation Option
  - Higher cost
  - Significant unknowns including the extent of repairs required for the concrete encasement of the superstructure
  - Failed to provide a physical separation between the busway structure and the railroad structure – requirement of Port Authority

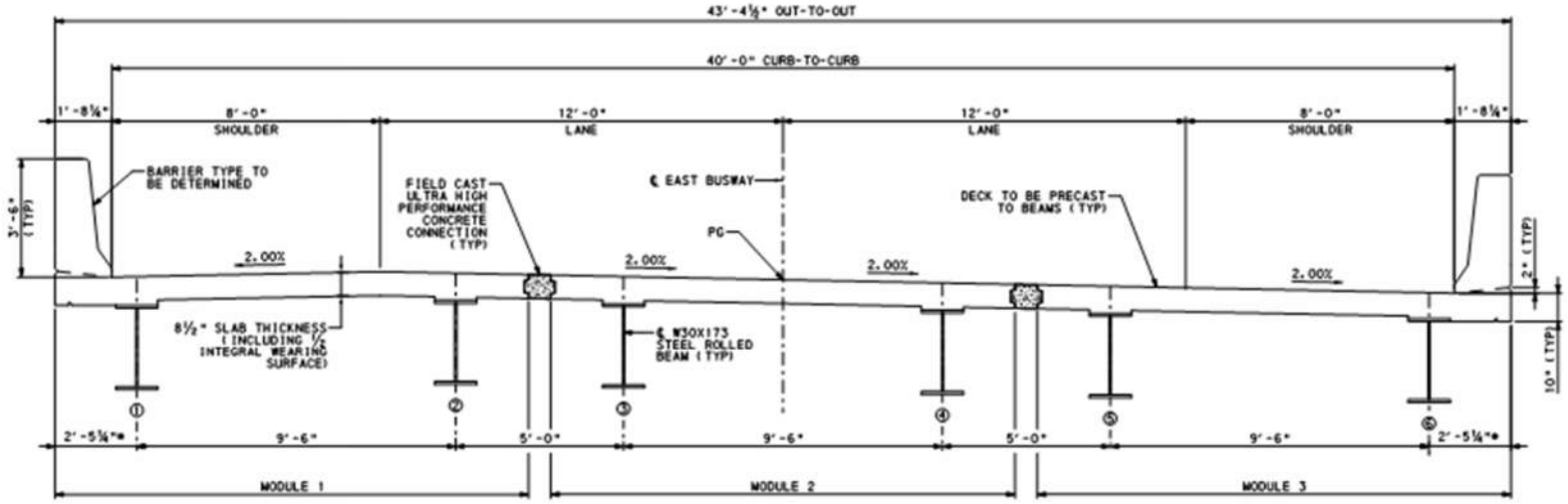
Preliminary Engineering - Continued

- Superstructure Replacement Option
  - More predictable costs
  - Scope of work similar to other recently completed bridges on the busway
  - Authorization to proceed with superstructure replacement
  - Port Authority then approached Markosky about the feasibility of using accelerated construction methods

Preliminary Engineering - Continued

- Incorporation of ABC into Superstructure Replacement
  - Single span rolled steel beam superstructure had been proposed
  - Investigate the use of modular type construction
    - Recent projects completed in the Pittsburgh region
    - Minimize the duration of the single lane, alternating traffic
    - Proposed structure consisted of a curb-to-curb width of 40' with two 12' lanes and two 8' shoulders – out-to-out dimension of 43'-4 ½"

Preliminary Engineering - Continued



* APPROXIMATE OVERHANG WIDTH. OVERHANG WILL VARY DUE TO HORIZONTAL CURVE.

LEGEND

UHPC ULTRA HIGH PERFORMANCE CONCRETE

TYPICAL SECTION
(LOOKING STATIONS BACK)

1 0 1 2 FEET

Proposed Typical Section

Design Challenges

- Section with 3 Modules About 14' Wide
  - Module Transportation
    - Contacted PennStress to discuss delivery in an urban setting
    - Several alternatives were identified using local streets and accessing the busway
  - Module Erection
    - Erection analysis for single and dual crane picks
    - Utility coordination to avoid overstressing any underground utilities and to identify aerial utilities

Design Challenges - Continued

- Chosen method
  - Design recommended placement of a single Terex AC 500-2 crane on the busway with picks from the busway
  - Contractor chose to erect the structure with a crane on North Braddock Avenue
- Best Practices Based on Feedback
  - Precasting the modules without the barriers
  - No precasting of approach slabs

Design Challenges - Continued

- Accelerated Construction
  - Accelerated Bridge Construction (ABC)
    - Estimated 30% increase in cost
    - 60 – 80 days faster than conventional method
    - Port Authority authorized the use of the precast modular construction for the superstructure to offset cost increase
  - Conventional Construction
    - Used conventional methods for approach slabs, substructures and other repairs

Final Design

- Other Design Features
  - Reconstruction of stepped beam seats
    - Required to account for the superelevation of the roadway
    - Proposed superstructure used shallower beams
    - Chorded construction to account for large horizontal curve
  - Retaining walls
    - Aid in the separation of the busway and railway structures
  - Coordinated with Norfolk Southern on design of the toe wall for the ballast

Final Design – Continued

- Traffic control
  - Single lane alternating traffic pattern in the first phase
    - Temporary shoulder reinforcing and temporary shoring for the roadway surface in the first phase
  - Closure pours and approach roadway, bi-directional traffic were re-established on the busway

Construction

- Let on March 28, 2018
- Joseph B. Fay Construction
- Notice to proceed, July 9, 2018
- All work was to be completed in 2019 due to adjacent construction and to permit material acquisition
- Bid price, $2,837,872.

Construction – Continued

- Mobilization began March 11, 2019
- First Phase
  - Alternating traffic control pattern established April 10, 2019
  - Bus layover area used for staging of contractor equipment and materials.

Construction – Continued

- Excavation of the Fill

Excavation of Pavement and Subbase

Demolition of First Phase

Construction – Continued

- During excavation it was discovered that the existing 3 span bridge did not consist of a constant depth beam
- Center span consisted of built up girder sections
- End spans were rolled beam sections with the beam seats at the same elevation as the deeper girder, resulting in more fill above the end spans
  - Required modifications to the temporary shoring

Construction – Continued

- Construction of Modules - PennStress
  - All modules were cast at the same time

Module Casting Operations

Module in Casting Plant

Construction – Continued

- Lesson Learned
  - Previous projects using modular construction specified a smooth finish to the decks in accordance with PennDOT standard specifications
  - Epoxy overlay applied to the full width of the completed deck
    - Problem - poor slip resistance of first two modules with traffic
  - Shot blasting on first two modules prior to switching traffic
  - Re-blast the modules prior to epoxy overlay

Construction – Continued

- First Phase of Module Erection, April 27, 2019
  - Following construction of the new beam seats
    - Contractor erected the modules using a single crane pick with the crane placed on North Braddock Avenue
    - Weekend closure on city street
    - Work was conducted at night to facilitate a short-term closure of the busway

Construction – Continued

Module Delivery

Erection of First Module, Note the Bearings on the New Beam Seats

Construction – Continued

Setting of Second Module

Construction – Continued

- Ultra High-Performance Concrete (UHPC) used in the joint between the modules
- End pours and diaphragms were constructed with accelerated concrete mixes

Typical Joint Between Modules

Construction – Continued

- Differential deflection between the first phase modules and the final module was considered
- The differential dead load deflection between the two completed modules and the final module was insignificant
- Two-day closure of busway for final pour to avoid vibrations or live load deflections acting on the final longitudinal joint

Construction – Continued

- Minor UHPC material pocketing occurred during the placement of the first joint
- Sounding of the concrete was performed and recommendations were obtained from the supplier.
- Second placement of the material achieved more consistent results

UHPC Material Placement

Construction – Continued

- Rehabilitation of existing abutments and restoration of sidewalks
- Depth of concrete deterioration was found to be greater than estimated
- More extensive jacketing detail was developed

Existing Wingwall Jacketing

Construction – Continued

- Completion of end diaphragms occurred on May 15, 2019
- Traffic shifted to the new portion of the bridge on June 3, 2019
- Traffic pattern was bi-directional with a speed reduction, but allowed full operation of the busway with minimal delays

Second Phase Traffic Control Pattern, Note Traffic is Bi-Directional to the Left of the Barrier

Construction – Continued

- The remaining construction tasks could then be completed under a less aggressive schedule

Construction of Second Phase Beam Seat Structure Girder on the Right

- Final module placement on June 22
- Placement of the epoxy overlay on July 27

Application of Epoxy Overlay

Construction – Continued

- Lack of existing structure plans presented several issues, including the discrepancy in the superstructure depth
- Two other issues which resulted from this lack of information were the limits of the existing pier removal and encasement details for the railroad portion of the steel superstructure to remain

Encasement of Remaining Beam and Pier Column – Note the Railroad Ballast Toe Wall

Conclusion

- Project is an example of the ability to adapt accelerated bridge construction methods to projects that are not "full" ABC projects
- Cost-effective solution that minimized disruptions

Completed Structure

Conclusion – Continued

- The final cost was less than the bid cost at $2,649,783
- While the jacketing details were an added cost, other balancing costs including final quantities negated those costs
- Normal traffic patterns were restored on August 30, 2019