CREATIVE CONCRETE BRIDGE SOLUTIONS FOR THE HICKORY STREET BRIDGE

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ABSTRACT

The Hickory Street Bridge, crossing over the Allegheny River in Warren, PA., represents a unique context sensitive approach for bridge design by the Pennsylvania Department of Transportation (PennDOT). Opened to traffic in September of 2005, this bridge received acclaim for its visual impact on the city of Warren.

Through the public involvement process, consensus on a bridge type, simulating the former concrete deck arch structure, was obtained. The creative approach to this bridge was to utilize a typical 4-span concrete adjacent box beam bridge and create an appearance of a Venetian arch bridge. This was accomplished through the use of innovative pre-cast concreted arch facade panels attached to the bridge fascia box beams combined with Renaissance styled concrete handrails. Circular alcoves were used at each of the three piers to view the stunning vistas of the Allegheny River. Aesthetic lighting includes innovative bridge accent lighting below the alcoves. Exposed aggregate finish on the panels and traffic barriers completed the full Venetian appearance.

Keywords: Context Sensitive, Bridge Aesthetics, Adjacent Box Beam, Arch Bridge, Pre-cast Concrete, Arch Facade Panels, Balusters, Alcoves, Stainless Steel, Exposed Aggregate

INTRODUCTION

The Hickory Street Bridge, crossing over the Allegheny River in Warren, PA., project began with a thorough evaluation of the 4-span concrete earth filled deck arch bridge, constructed in 1918. The decision to replace the bridge was based on a condition survey report that identified severe structural deterioration, functional obsolescence, and established a 15-ton weight restriction, far below the current standard of 45 tons.

In the development of this project, several alternative bridge location and bridge type alternatives were considered. With the closing of the existing bridge in March 2003, due to poor structural condition and its demolition/replacement being advanced under an Emergency Declaration, the City of Warren and the Warren County Commissioners issued resolutions in support of the Hickory Street Alternative (existing bridge location) as the preferred alternative alignment.

Through a proactive public and agency involvement program, consensus on a bridge type and span arrangement to cross the Allegheny River was obtained. The preferred replacement bridge would be a 4-span concrete adjacent box beam bridge structure with simulated arch features. The four equal spans of 129 feet replicate the spans of the old concrete deck arch structure. Spans of 129 feet are pushing the limits of 66 inch deep by 48 inch wide concrete box beams. The use of innovative arch facade panels attached to the bridge structure was advanced as a cost-effective approach to providing the appearance of a concrete arch bridge. The bridge would also have typical section to accommodate 5-ft. shoulders / bicycle lanes, a low profile concrete barrier between traffic and pedestrians fitted with a handrail cap, 7-ft. sidewalks, alcoves over each pier, an innovative concrete balustrade hand railing, light standards matching those used in the adjacent historic district, and innovative bridge accent lighting. See Figure 7.

The demolition of the existing bridge was completed in 2003. The construction of the new replacement bridge began with The Pennsylvania Department of Transportation issuing a notice to proceed (May 5, 2004).

This paper presents how the use of innovative arch facade panels, alcoves over each pier, concrete balustrade hand railings and bridge accent structure lighting can make a conventional cost-effective concrete adjacent box beam bridge look spectacular as the focal point of the central business district in Warren, PA.

BRIDGE HISTORY

There have been a number of bridges crossing the Allegheny River at Warren, Pennsylvania. In 1871, a suspension bridge was constructed just east and upstream of the present alignment. The replacement bridge was constructed in 1918 by a crossing, which carried S.R. 3005 over the Allegheny River. See Figures 1 and 2. This was a four-span, closed spandrel concrete arch bridge approximately 500 feet long. It served as a major community connector, linking businesses on the

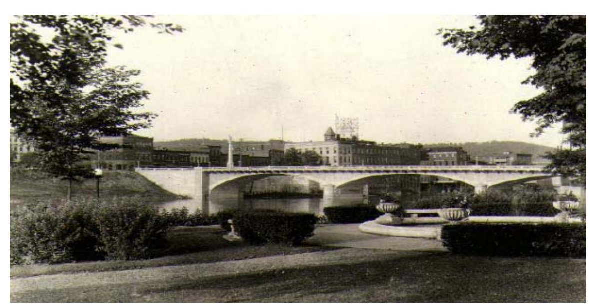

Figure 1: Concrete Arch Bridge Built in 1918

north side with neighborhoods and the regional hospital on the south side of the Allegheny River. However, after more than 85 years, the bridge was structurally deficient, functionally obsolete, and had restrictions for pedestrian and vehicular traffic. The new Hickory Street Bridge was completed in September, 2005. See Figure 3.

The goal of the new bridge was to preserve the arch shaped appearance of the previous bridge that had become a visual landmark linking the community to its past. Special architectural treatments where therefore provided to accomplish this as well as to complement the city of Warren's adjacent Historic District. The completed bridge represented a unique, very striking, and graceful structure.

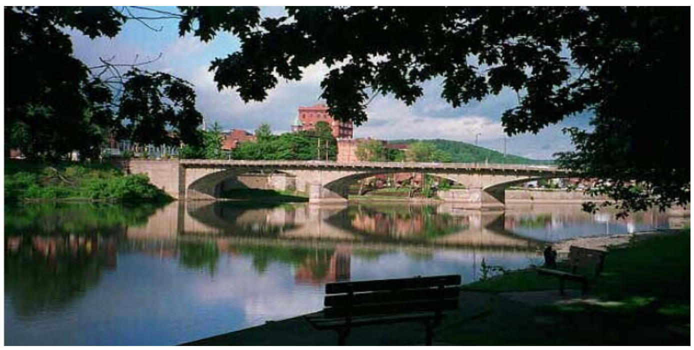

Figure 2: Concrete Arch Bridge 2002

Figure 3: New Bridge September 2005

NEW BRIDGE HIGHLIGHTS

Given the strong community affinity with and the identity provided by, the original structure, great attention was given to the aesthetic treatments of the bridge. Architectural treatments included arch facade panels with an exposed concrete aggregate surface to replicate the look of the original bridge; an ornamental concrete balustrade handrail; alcoves extending from the sidewalk over the piers; ornamental lamp posts; and accent lighting beneath the alcoves. See Figure 4.

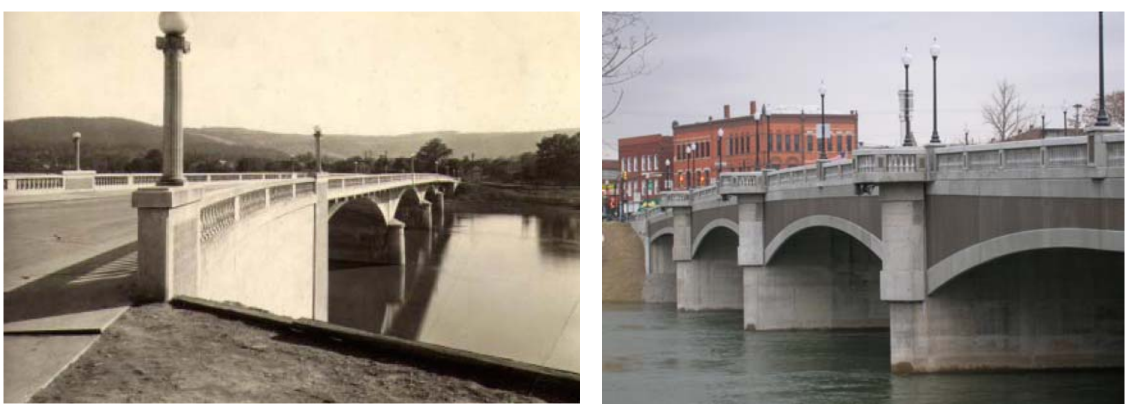

Figure 4: Light Poles and Baluster Railing - 1918 (Left) and 2005 (Right)

- **Concrete railings/balusters** – The pre-cast concrete railings and balusters enhanced the appearance of the bridge and helped to maintain the design integrity of the original structure. See Figure 5.
- **Alcoves** – Alcoves were added to the walkway above each of the structure's three piers. The alcoves provided for scenic views of the river. See Figures 4 and 6.
- **Arch facade** – The arch facades applied to the exterior of the structure completed the period appearance of the bridge. See Figures 3 and 4.

Figure 5: Baluster Railing

Figure 6: Alcoves with Light Poles

- **Exposed aggregate** – The exposed aggregate used throughout the structure added to the visually pleasing nature of the bridge by adding depth and aesthetic detail to the design. A dark colored epoxy coating not only enhanced the aesthetics of the bridge, but helped to prevent moisture from infiltrating the concrete; preventing damage to the concrete panels resulting from freeze-thaw cycles. See Figure 6.
- **Lamp posts/lights** – Ornamental lamp posts compatible with those of the city's historic district, rather than the more common high-mast street lighting, were employed on the bridge to replicate the period appearance sought in the design of the bridge. See Figures 4 and 6.

DESIGN AND AESTHETIC INTERFACE

Community input clearly indicated that the residents of the community did not want a "standard PennDOT" bridge to replace the original structure. However, it was also essential to ensure that the final structure was economical, could be adequately maintained using current PennDOT practices, and could be evaluated for standard truck and permit loading. The solution was to utilize a common adjacent box beam structure, but then to attach architectural facade panels to it.

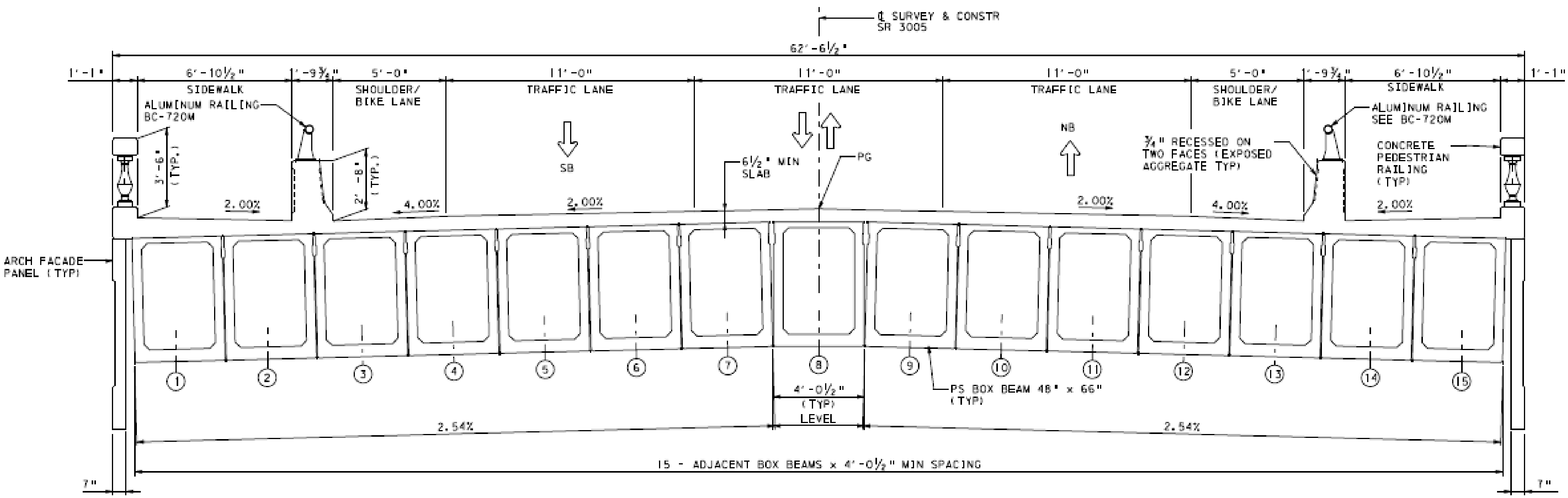

Figure 7: Adjacent Box Beam Cross Section with Panels.

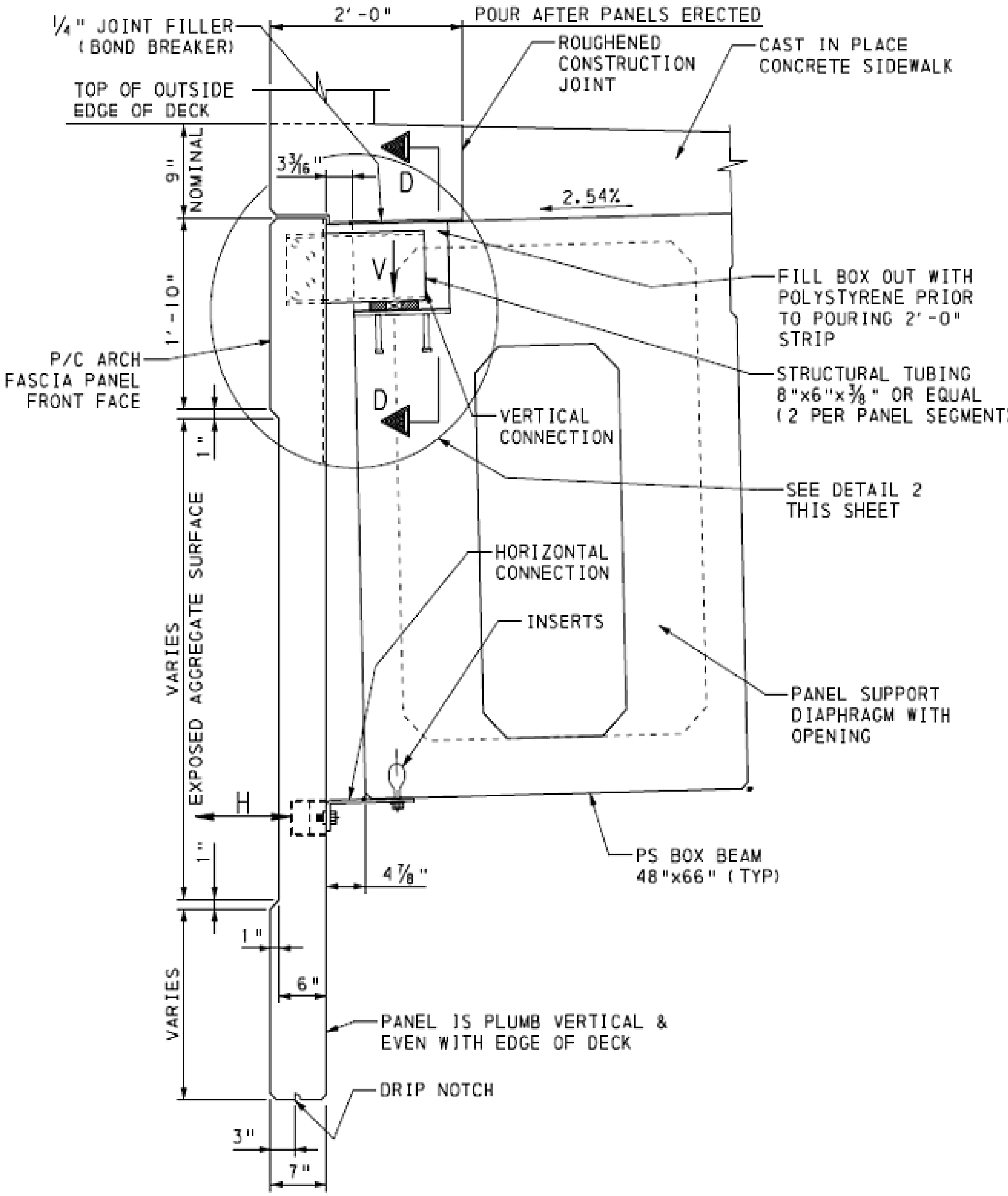

Figure 8: Façade Panel Connection Arrangement.

To accomplish this the connection between the panels and the adjacent boxes had to be designed to do the following:

- **Allow No Locked-in Panel Stresses** – Provision for adequate permanent longitudinal sliding movement of the panels relative to deflection of the concrete boxes needed to be made in the panel connections.
- **Durability** – Both the panels and connections needed to be designed for longer than normal maintenance life.
- **Constructability** – A panel erection procedure needed to be developed that would allow the main superstructure to be constructed without delay and also facilitate ease of panel installation.
- **Visibility** – The panels, connections and adjacent concrete boxes needed to fit together with tighter tolerances so the whole structure would appear integral.

DESIGN AND ERECTION DETAILS

The design of all panel connections utilized stainless steel. The durability provided by this material was considered essential to provide an extended maintenance life of the panels. Pockets were designed into the top corners of the concrete adjacent box edge beams with embedded stainless steel plates and greased sliding bars to provide an area for the vertical connection between the panels and the box beams and to provide for longitudinal movement of the panels. See Figure 11. The vertical connection was provided by structural tubes with stainless steel plates embedded into the back face of the panel that were set into the pockets in the edge beams. See Figure 8, 9 and 10. The greased sliding bar connection, along with vertical joints between panels, assured that there would be no locked-in stresses produced in the panels as the structure deflected.

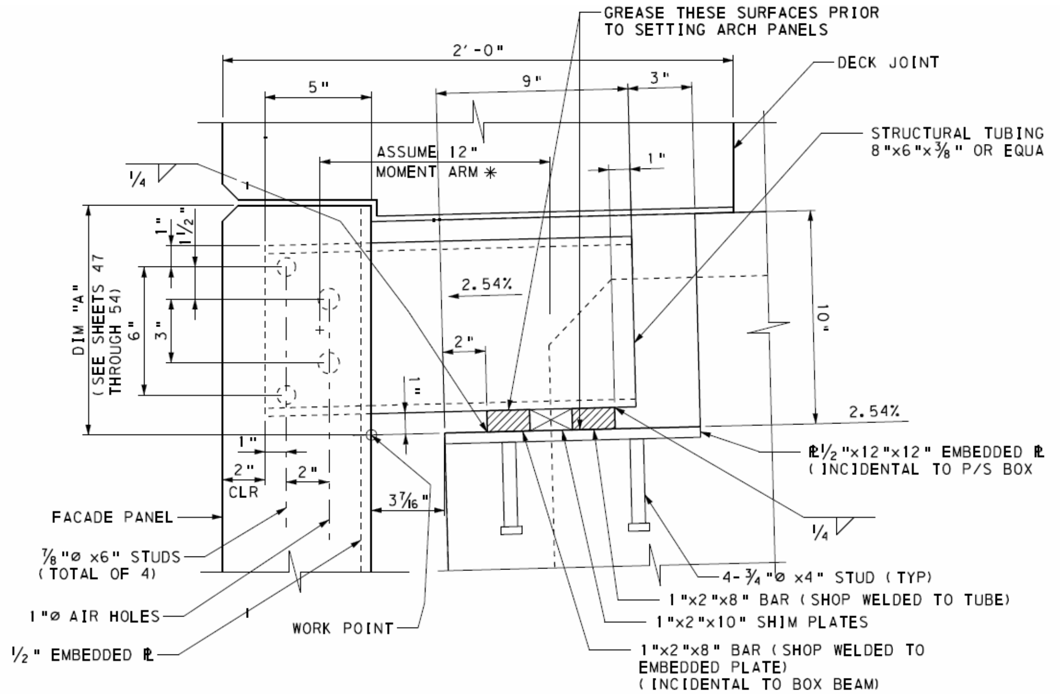

Figure 9: Facade Panel Connection Detail 2.

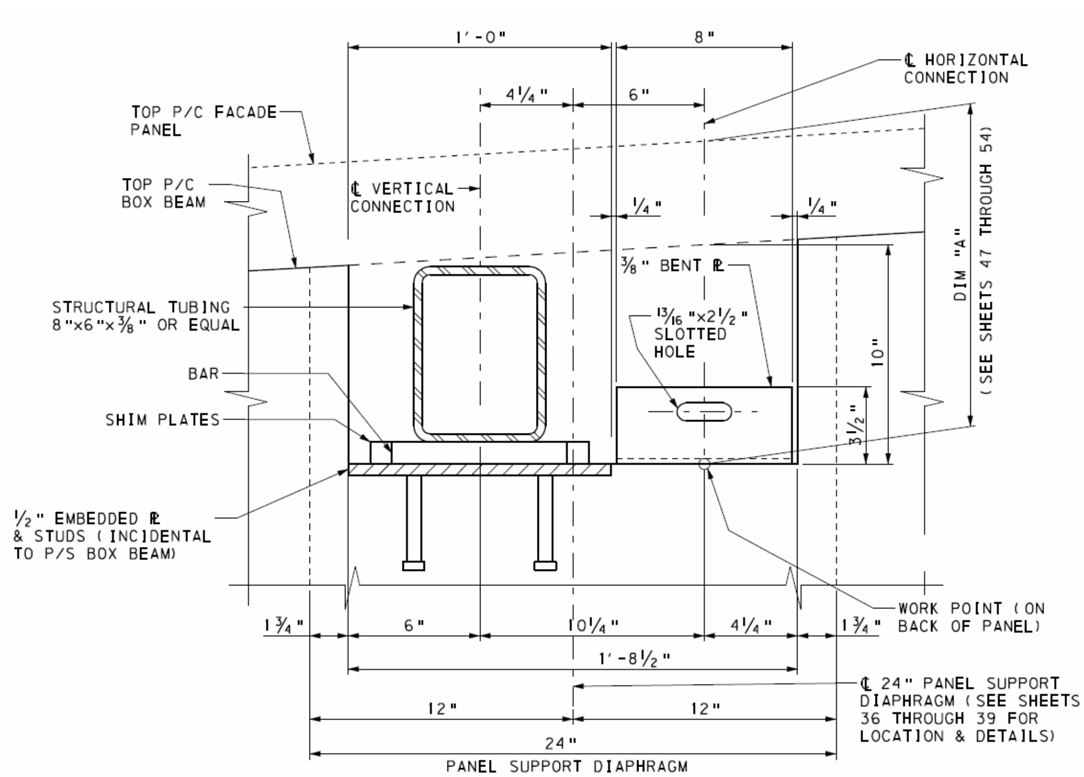

Figure 10: Facade Panel Connection Section D-

Figure 11: Box Beams with Pockets for Panels Connection

Figure 12: Panels Dropped In From Above

The panels and connections were designed for self-weight eccentricity, wind loads, and to support a portion of the concrete deck above. A ½ stainless steel plate with studs was welded to the structural tube and anchored into the back face of the panels to provide the connection for vertical panel dead loads. See Figures 9 and 12. Horizontal loads are taken by bent horizontal plate type connections located at the top and bottom of the edge beam. See Figures 10, 14 and 16. A two foot wide edge portion of the concrete deck was not placed until the panels were erected. This allowed for the strucutral tube vertical panel connection to be set into the beam pockets from above. See Figures 12 and 14.

Once the panels were installed, the pockets in the edge beams were filled with polystyrene to prevent concrete from filling and fixing the connections in the pockets. The the two foot strip of deck with baluster curb was poured over top to produce a smooth integral look between the deck and the panels. See Figures 15 and 17. The cast-in-place concrete light pedestals and intermediate handrail columns were then poured and holes field-drilled in the handrail curbs for setting the reinforcing steel protruding form the balusters. See Figure 18. The balusters were then grouted in place and the pre-cast pre-drilled concrete handrail was dropped over the balusters. See Figures 19 and 20. Before the handrail sections were set into place over the balusters, the holes in pre-cast pre-drilled concrete handrail were packed with grout. Grout was also place on top of the balusters to ensure an adequate grouted connection. See Figure 20. The handrailing connection design to resist horizontal loads was provided for by the vertical reinforcing steel connection between the handrail, bausters, and crub. The pedestrian railing did not have to be designed for vehicular loads because there are barriers on the bridge between the sidewalks and roadway. The final result produced a clean, easy to construct, Renaissance style appearance that the client was looking for. See Figure 21.

Figure 13: Panels Being Secured Into Pockets.

Figure 14: Panel Connection Secured in Pocket.

Figure 15: The Two Foot Deck Strip Ready To Be Poured.

Figure 16: Panels Secured at Bottom of Box Beams.

Figure 17: Pouring of Two Foot Deck Strip Over Panels.

Figure 18: After Deck, Curb and Columns Are In Place.

Figure 19: Baluster Grouted In Place.

Figure 20: Drop In Of Pre-cast Handrail.

Figure 21: Everything In Place.

CONCLUSIONS

This project provided PennDOT with a number of positive results. The constructed bridge has known maintenance and inspection characteristics typical of a composite adjacent concrete box beam superstructure. Also, this type of bridge could be easily load rated with PennDOT standard bridge programs. Additionally, the community would have a bridge replacement that replicates the appearance of the original arch structure and enhances the character of the community. All of this was accomplished in a rather cost efficient manner. The aesthetic details only accounted for 15% of the 11.5 million dollar construction cost of the project. PennDOT provided the additional funding for aesthetics to satisfy the community's expectation of an arch-like aesthetically pleasing structure. The aesthetic features provided on this structure did not significantly impact the construction schedule.

REFERENCES

Terrence J. Tiberio and Robert W. Bondi, "Hickory Street Bridge – A Unique Context Sensitive Approach", International Bridge Conference, IBC-06-17, June 2006