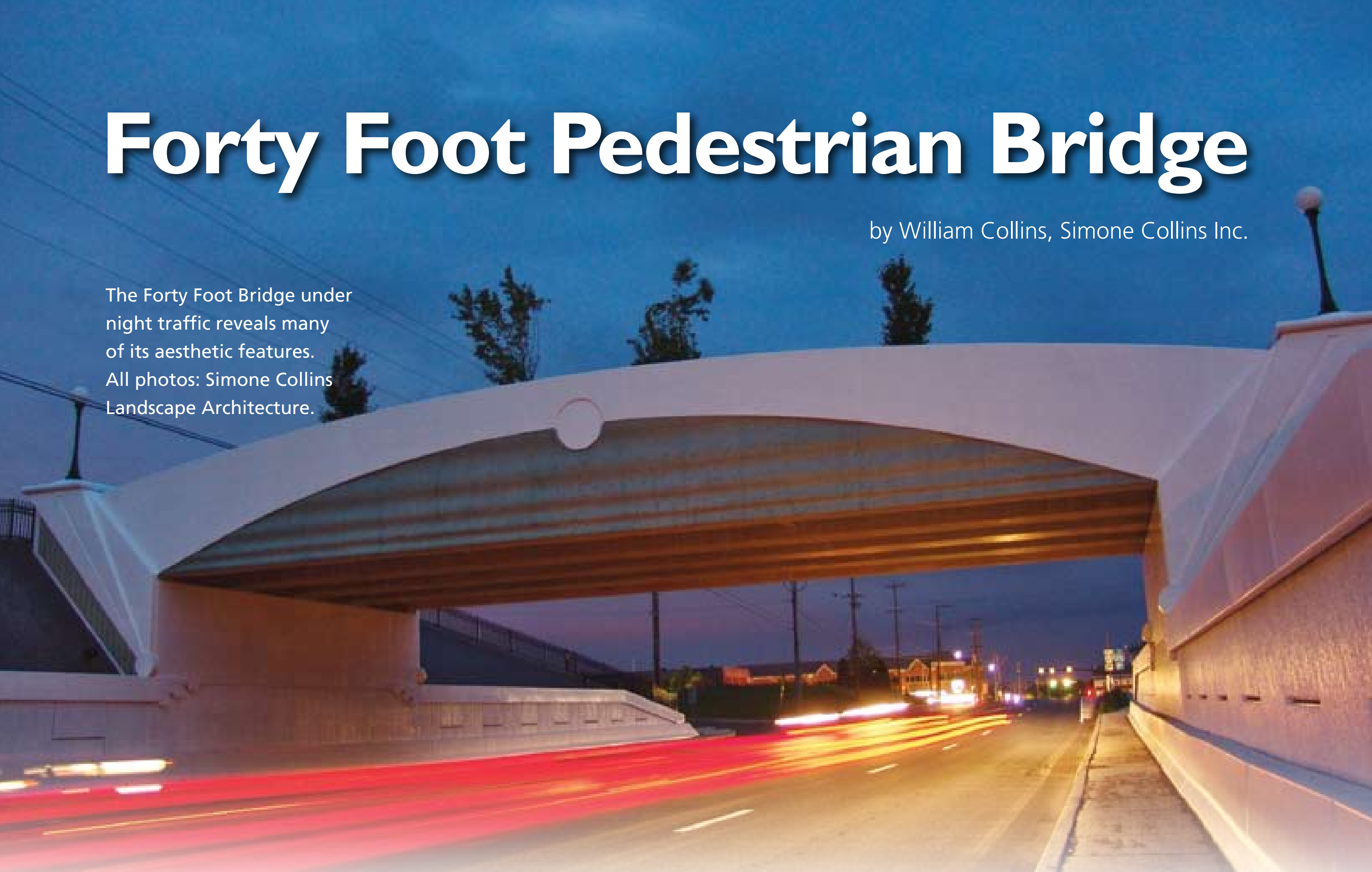
Forty Foot Pedestrian Bridge

by William Collins, Simone Collins Inc.



The Forty Foot Bridge under night traffic reveals many of its aesthetic features. All photos: Simone Collins Landscape Architecture.

Integrating Art and Engineering in Public Infrastructure

It took Towamencin Township over twelve years of planning, design, and construction to depress the alignment of State Route 63 and construct the new Forty Foot Pedestrian Bridge as the context-sensitive signature of an 8100-ft-long highway improvement project. The new 40-ft-wide by 80-ft-long concrete bridge spans the highway known as Forty Foot Road in Montgomery County, Pa. The bridge creates a safe and accessible pedestrian link over the five lanes of traffic that bisect the new Towamencin Town Center.[1]

The Pennsylvania Department of Transportation (PennDOT) served as the construction and funding partner for the transportation improvements that were planned and engineered by the township to integrate smart land-use strategies that included parks, trails, streetscape amenities, structured parking, and incentives for private mixed-use development.

Towmencin Township designed and built a municipal road around the project area as a bypass to maintain state highway and turnpike-bound traffic. This early investment in infrastructure allowed Forty Foot Road to be closed for roadway excavation and bridge construction with reduced traffic maintenance costs, and created a valuable new asset for motorists and local developers. The bridge was built as a turnkey element for Township ownership after completion in 2007.

profile

FORTY FOOT PEDESTRIAN BRIDGE / TOWAMENCIN TOWNSHIP, MONTGOMERY COUNTY, PENNSYLVANIA

FUNDING / CONSTRUCTION PARTNER: Pennsylvania Department of Transportation District 6

STRUCTURAL ENGINEER: QBS International Inc., Pennsauken, N.J.

BRIDGE DESIGNER: Simone Collins Inc. Landscape Architecture, Berwyn, Pa.

CIVIL ENGINEER: McMahon Associates Inc, Fort Washington, Pa.

GEOTECHNICAL ENGINEER: GeoStructures Inc., King of Prussia, Pa.

PRIME CONTRACTOR: RoadCon Inc., West Chester, Pa.

AWARDS: *Award of Excellence, 2008 – Portland Concrete Association (PCA); Project of the Year, 2007 – American Society of Highway Engineers (ASHE) Delaware Valley Chapter (projects over $5 million)*

FAR LEFT: View of pedestrian environment toward south portal showing the concrete deck with cast-in-place planters.

MIDDLE: Exposed aggregate structural deck. Planter wall forms were designed to echo the parapet line and the wingwall rustications.

RIGHT: Structural pylons are clad with architectural wingwall panels, mirrored inside and out. Globe lights were mounted on custom formed pylon caps.

Infrastructure as Community Fabric

From the start, Towamencin Township envisioned the highway project to be an essential part of the revitalized community landscape—in terms of walkability and physical character. When a central pedestrian bridge was selected as the preferred alternative for crossing the highway, the prominent location demanded functions and aesthetics above the ordinary.

Concrete was selected for its economy, durability, and plastic qualities that could deliver a seamless aesthetic in a single structural and artistic material. The sculptural potential of concrete inspired a collaborative process between the bridge designer and structural engineer to incorporate art considerations within the engineering decisions. The result is a practical synthesis of conventional materials and techniques with strategically selected, custom concrete treatments for aesthetics in high–priority elements.

Geometry as an Aesthetic Program Element

The Forty Foot Bridge design consciously features and mitigates specific geometric proportions. The clear span from center to center of bearings is 78 ft 6 in. Fascia beams are engineered as structural members up to 12 ft deep and 90 ft long, with integrally-formed architecture. Beam depths were selected to create parapets to cloister the pedestrian environment from the traffic below. The bridge's width is 40 ft with curving, cast-in-place planters on both sides of the concrete deck to modulate space within the inside faces of the parapets by defining a sweeping, variable-width promenade. Pedestrian lighting was designed for safety and ambiance. The cartway is wide enough to serve as a "civic" space for periodic functions within the town center. The cambered deck serves pedestrian and bicycle traffic only, but is engineered to support an H-20 truck load for maintenance and emergency vehicles.

The sculptural potential of concrete inspired a collaborative process between the bridge designer and structural engineer…

Engineering Innovation – Fascia Beams and Haunched Box Beams

The fascia beams are uninterrupted, full-span, full-height beams that extend above the deck elevation to create the appearance of a rigid frame. They are, however, simple span reinforced concrete beams designed to sit on cast-in-place concrete abutments with standard

PRECAST, PRESTRESSED CONCRETE BOX BEAMS AND CAST-IN-PLACE FASCIA BEAMS WITH INTEGRAL ARCHITECTURE / TOWAMENCIN TOWNSHIP, OWNER

CONCRETE SUPPLIER: Berks Products, Allentown, Pa.

WHITE CEMENT SUPPLIER: Lehigh White Cement, Allentown, Pa.

PRECASTER FOR BOX BEAMS: Schuylkill Products Inc., Cressona, Pa., a PCI-certified producer

PRECASTER FOR MSE WALL AND CAP FINIALS: The Reinforced Earth Company, Vienna, Va.

PRECASTER FOR FINIALS AND PYLON CAPS: Architectural Precast Inc., Burlington, Ky.

BRIDGE DESCRIPTION: An 80-ft-clear span by 40-ft-wide pedestrian bridge, exposed aggregate structural deck on conventional spread box beams, and ornamental fascia beams

BRIDGE CONSTRUCTION COST: $1 million for the bridge as part of a $13 million highway reconstruction project

The East fascia beam showing the rippled form, abutments, paver-faced sloped walls, MSE walls with precast cap finials, precast wingwalls, and pylon cap.

More and more modern infrastructure will be needed to relate to increasing numbers of people outside of vehicles and moving at the speed of foot traffic.

A view of portal with box beams, corrugated deck pans, and fascia beam in place. Note the haunch on the fascia beam to support the cast-in-place structural deck.

laminated neoprene bearing pads. Fascia beams were engineered to act as standard load-bearing concrete stringers. They serve as hybrid members with modified geometry that allows the beams to include the safety functions of concrete parapets, the sound-dampening functions of sound walls, and the expansive surfaces for art forms—all within the new concrete beam design. The L-shaped fascia beams vary in depth from 12 ft at midspan to 8 ft 8 in. over the supports and have a thickness that varies from 18 in. to 20 in.

Within each fascia, 15 epoxy-coated No. 7 bars provide the primary flexural reinforcement, and epoxy-coated No. 4 stirrups act as shear reinforcement. The ends of the beams cantilever behind the abutments toward structural pylons where both are clad with precast architectural wingwall panels. The structural concrete deck bears on interior haunches of the fascia beams. This design allows deck edges to be hidden behind the fascia beams, so that the structural deck is only exposed as the wearing surface with aesthetic treatments. Concrete buttresses hidden within the cast-in-place planters tie the fascia beams structurally to the deck.

The concrete deck is also supported by three interior 48-in.-wide by 39-in.-deep precast, prestressed concrete box beams. The beams were haunched 13 in. to simplify the forming and casting of the cambered deck. The beams varied in depth from 39 in. at the supports to 52 in. at midspan. The interior void form varied in depth as well, maintaining a constant 3-in.-thick top flange and 5½-in.-thick bottom flange.

Art and Architecture

The architecture of Forty Foot Bridge acknowledges typical structural features such as corbels, spring points, camber, hinges, and keystones. Art lines in the concrete are graphic interpretations of forces alive within the bridge, including tension, compression, bearing, and repose.

The Art Deco motif responds to the bold engineering by exploiting the concrete material to form elegant, archetypal arch shapes as shadowed relief, designed to "lighten" the apparent mass of the deceptively large fascia beams. Below the arches, the art of the ripple art forms change frequency to express the fluid nature of movements below a bridge, and functionally create horizontal shadow lines designed to subtly elongate the bridge visually and "de-emphasize" the sense of its vertical dimension.

CAD-generated documents for computer-cut, styrene formliners were used to create molds up to 4 in. deep for the surface topography within the fascia beams. The curved top of the fascia beams was an aesthetic decision accommodated by the engineering to soften the shape, reduce visual "mass," and create the top line of the perceived arch in the fascia beam.

Color for concrete surfaces was specified conservatively to allow for multiple field mock-ups and photo-rendering studies of the actual structure during construction. Color selections were simplified to two colors and bright white. A light green was used below the arch shape to make the rippled surface visually "recede," creating the effect from a distance that it blends with the sky and landscape beyond, making the slender white arch shape over the road appear to leap to the foreground. All finished concrete surfaces were treated with a transparent gloss urethane sealant.

Foundations, Retaining Walls, and Sloped Paver Walls

The substructures are conventional concrete abutments using standard formliners to match the rustications of the adjacent precast mechanically stabilized earth (MSE) retaining walls. Custom-cast finials terminate the lines of standard MSE wall caps at the abutments. Four 85-ft-long MSE retaining walls create the grade separation along the depressed Forty Foot Road.

The sloped paver walls above the MSE retaining walls were designed at a 1:1 gradient to be visible from all directions, and are essential to the success of the design—providing a sense of openness, light, and visual access between the roadway and pedestrian environments. The 45 degree walls also serve to limit the height of the retaining walls to 8 ft, prevent a "tunnel" effect under the bridge, and expose the wingwalls as visible "pylon" elements—all effectively elongating the visual sense of the bridge.

The arches formed in the fascia beams appear to "spring" from the sloped bearing line formed in the pylon panels. Structurally, the sloped walls act as compressive structures to bear against the MSE walls and are tied into grade using the same conventional geogrid reinforcement as the vertical walls. Concrete unit "brick" pavers were laid on a mortar bed in a fan pattern with dark mortar to reduce contrast.

Required roadway clearance below the bridge was achieved by partially depressing the highway and partially elevating the bridge to create subtle 3% approach gradients that allow complete visibility under the bridge to the surrounding town center landscape.

Conclusion

The highway project, including the Forty Foot Bridge, was let by PennDOT under the state contracting process, and the lowest prequalified bidder was selected. The product demonstrates that capable fine craftsmanship is available within the industry to deliver a project with exacting, custom aesthetic specifications.

The success of the fascia beam concept relied completely on engineering innovation to create an extraordinary venue for the proposed artwork, to achieve a rare collaboration where art considerations affect geometry, engineering, and construction methods. The jury for the 2008 PCA Concrete Bridge Awards said Forty Foot Bridge, "…is in itself a work of art." The visual harmony and scale of Forty Foot Bridge succeeds in creating an inviting civic "place" and a landmark for both motorists and pedestrians. The structure features modern engineering design infused with a restrained aesthetic that salutes the inspiration of the historic Merritt Parkway bridges built in the 1930s.

With a pending economic stimulus package and promised rush of infrastructure projects in 2009, we understand that what we build today lives with us for the next half century or more. Enduring infrastructure and quality jobs require smart choices to ensure that our special places are protected and improved by new projects that incorporate the combined talents of engineers, artists, and craftspersons. More and more modern infrastructure will be needed to relate to increasing numbers of people outside of vehicles and moving at the speed of foot traffic. Forty Foot Bridge is an example of a 21st Century project that borrows the best from two previous "eras of infrastructure" by incorporating humanizing art features that gave public works projects of the 1930s depression-era their unique personalities, with typical standardized, mass-produced efficiencies ushered in with the products of the Interstate Highway System of the 1950s.

Reference

1. Collins, William, John Ruff, Kristen York, and Bashar S. Qubain, 2008, "Forty Foot Road Pedestrian Bridge: Integrating Aesthetics and Engineering," Proceedings of the PCI-FHWA National Bridge Conference, October 5-7, Orlando, Fla., 22 pp.

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Photo: Simone Collins Landscape Architecture.

FORTY FOOT PEDESTRIAN BRIDGE / TOWAMENCIN TOWNSHIP, MONTGOMERY COUNTY, PENN.

Photo: Simone Collins Landscape Architecture.

The Forty Foot Bridge under night traffic reveals many of its aesthetic features. Photo: Simone Collins Landscape Architecture.

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The 13-in.-deep haunches on the box beams and fascia panels can be easily seen with the deck forms in place. Providing haunches simplified forming, tying reinforcement, and placing concrete for the cambered deck. Paint on the deck form outlines the shape of a cast-in-place concrete planter. Photo: Simone Collins Landscape Architecture.

Structural Components:

Abutments—conventional cast in place with structural pylons

Retaining Walls—conventional precast MSE panels and caps, with geogrid reinforcing

Superstructure—hybrid design – with three conventional precast box girders and two custom, cast in place fascia beams

Deck—Cast in place, exposed aggregate structural deck

Landscape Planters—custom, cast in place planter walls on structural deck

Architectural Wingwalls—custom, precast panels, caps and finials, cladding structural pylons

Sloped Walls—conventional concrete paver blocks

Photo: Simone Collins Landscape Architecture.

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Forty Foot Road Pedestrian Bridge:
Integrating Aesthetics and Engineering

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ABSTRACT

Forty Foot Road Pedestrian Bridge is an 80-foot long by 40-foot wide, single span, signature bridge over a 5-lane Pennsylvania highway, and the featured centerpiece of a "context sensitive design" highway infrastructure project completed in 2007 to create transportation improvements through a redeveloping town center. This case study offers:

- *Details of how aesthetics were incorporated into the structure during engineering, as an alternative to "applying" façade treatments after engineering.*
- *The attributes of concrete as the preferred structural and artistic material to achieve economy, longevity, and a seamless aesthetic between project engineering, bridge design, and site elements.*
- *Innovative engineering of a structural stringer beam to incorporate safety functions of concrete parapets and sound dampening functions of sound walls within the new architectural "fascia" beam design.*
- *Design of sloped "paver" retaining walls supported by MSE reinforcement.*
- *Brief context of how the local municipality conducted a 14-year process to comprehensively plan, justify, design, secure funding, and construct the $13 Million highway realignment and pedestrian bridge project in partnership with Pennsylvania Department of Transportation (PennDOT).*
- *Value-added design features, materials and techniques as smart, life-cycle investments to reduce maintenance costs, and create incentives for private development partnerships.*
- *Green investment in bridge infrastructure to save energy use.*

KEY WORDS

Forty Foot Road Pedestrian Bridge Aesthetics Context Sensitive Design Concrete Art Form Liners PennDOT MSE Simone Collins Landscape Architecture QBS Engineering McMahon Associates GeoStructures Towamencin Township RoadCon.

INTRODUCTION

Figure 1 *- Forty Foot Road Pedestrian Bridge is an 80-foot long by 40-foot wide, single span, signature bridge over a 5-lane Pennsylvania highway, and the featured centerpiece of a "context sensitive design" highway infrastructure project to create transportation improvements through a redeveloping town center. Completed in 2007.*

SITE / LOCATION

Figure 2 *– The new bridge is located in the heart of the town center project area and constructed as part of the roadway improvements* <u>*before*</u> *development of surrounding parcels. Aerial photo shows bridge and four pedestrian approaches that will be replaced with streetscape improvements as part of private developments within the adjacent quadrants.*

HISTORICAL CONTEXT OF THE TOWN CENTER

In the 1950's, the Northeast Extension of the Pennsylvania Turnpike (I-476) was cut through the heart of Kulpsville, in Montgomery County, Pennsylvania – razing much of the historic village to build the new superhighway and the local "Lansdale" exit." The Lansdale interchange is the first exit north of the primary east-west Turnpike, and the new highway access favored local commercial agribusinesses, resulting in increased truck and commuter traffic congestion on the connecting arterial roads. Local access to State Route 63 (aka Forty Foot Road) developed organically without an access management strategy to prevent traffic flow from slowing along the entire village corridor. Marginal businesses struggled in this degraded, highway "strip" environment. After 40 years, little integrity of the village fabric remained and much of the building stock within the project area was devalued.

By 1990, intense residential and industrial growth around this node had still not triggered improvements to state roads locally, as the Pennsylvania Turnpike Commission unveiled plans to increase the Lansdale toll plaza from four booths to ten, without proposing comparable improvements to the receiving roads. Facing a looming traffic gridlock, the local municipality, Towamencin Township, took responsibility as the lead partner to plan a solution.

COMMUNITY PLANNING ESTABLISHES NEED FOR A PEDESTRIAN BRIDGE

The Towamencin "Town Center" began with a vision in the early 1990's to integrate transportation improvements and land use planning. The Township commissioned economic studies to determine which market sectors could flourish in a new town center at this transportation hub. These economic projections were used to inform an iterative land use planning process and to refine highway plans, based on traffic projections for regional through traffic and traffic to be generated by a new town center "build out."

A new village "overlay" zoning ordinance and Town Center Design Manual were both created and adopted to address the proposed transportation improvements by establishing the parameters and level of quality for future village development.

The original purpose of the project was to improve the intersection and approaches of Sumneytown Pike and Forty Foot Road (both State Route 63), and to alleviate congestion and improve safety. Traffic studies determined that widening two-lane Forty Foot Road to five lanes would be necessary to accommodate projected traffic volume.

A new, signalized pedestrian crossing would be required to provide safe access across the new five lanes, but traffic analyses also demonstrated that a new signalized intersection would significantly inhibit both pedestrian crossing <u>and</u> highway vehicular movements.

Towamencin Township commissioned design/engineering studies to convince its partner, the Pennsylvania Department of Transportation (PennDOT) of the advantages to depressing Forty Foot Road as a means to create a 16.5 foot vertical clearance envelope for a new grade-separated crossing structure – a pedestrian bridge – over the highway to allow safe pedestrian and bicycle movements between the two halves of a new mixed-use town center district.

The new pedestrian bridge was designed to become the primary link and "spine" of a township-wide trail system within the village, in accordance with the Township's trails master plan. The new village transportation network was planned as multi-modal to encourage walking, biking, transit, and ride-sharing within the revitalized village. A mix of social, residential, office, civic, and commercial services were considered essential components of the new town center to justify and support the transportation investments.

The Towamencin Town Center Plan was implemented by municipal supervisors and supported by several consecutive boards over a 14-year period. The transportation element, including the pedestrian bridge, was completed in 2007 by PennDOT as the construction and funding partner.

The Township sought development proposals for the new town center that would capitalize on the new zoning overlay ordinance and the new transportation infrastructure. The bridge was designed to function for both "pre" and "post" town center development. Land development around the bridge continues today under the zoning ordinances developed as part of the Town Center planning process.

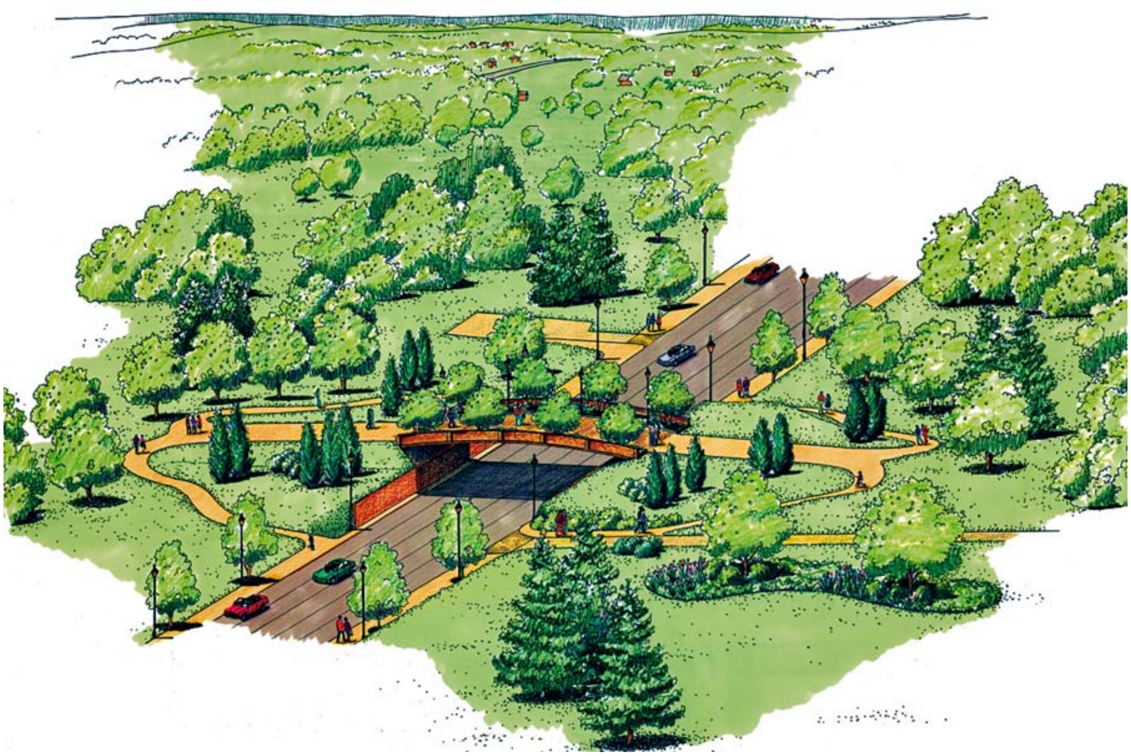

Figure 3 *– Concept design for depressed highway and pedestrian bridge with streetscape amenities and walkway access ramps in Phase 1 – <u>before</u> development of surrounding parcels. The general aesthetic program for the transportation infrastructure was developed in this stage of design.*

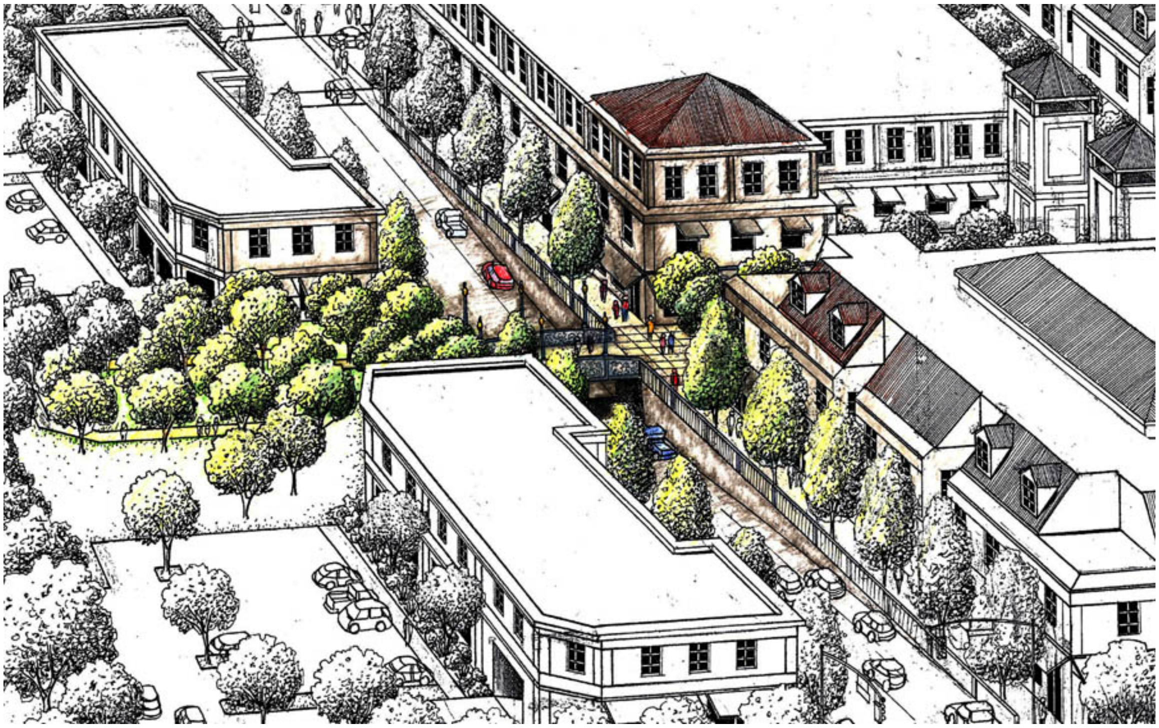

Figure 4 *– Concept design for Phase 2 development of parcels surrounding the depressed highway and pedestrian bridge with streetscape amenities at the level of the bridge deck. The adopted zoning overlay provided incentives for structured parking. The depressed highway alignment has allowed development proposals to utilize the lower roadway elevation for parking access below buildings.*

PROJECT DESCRIPTION

The Forty Foot Road Pedestrian Bridge is the keystone of the Towamencin Town Center plan and integrates municipal goals for parks, open space, trails and greenway systems with streetscape, transportation improvements, and incentives for mixed use development.

The pedestrian bridge and MSE highway retaining walls represent about 10.75% of a $13 Million project that extends roadway improvements for a total length of 8,165 feet.

Major roadway widening and reconstruction, concrete paving installation, bituminous paving overlay, medians, turning lanes, bike lanes, stormwater drainage facilities, utility relocation, lighting, planting, and intersection improvements represent the balance of the project scope. Signalization improvements include five intersections with interconnected fiber optic cable into the township closed loop system.

The combination of these technical achievements delivered a complete modernization program of safety and accessibility improvements within the state highway right of way, with the new context sensitive bridge as the most visible and popular feature.

BRIDGE ALTERNATIVES / SITE SELECTION

The basic bridge geometry and alignment was shaped by typical engineering considerations. Other architectural and humanizing context criteria were considered as early as possible in the design process.

Alignment

The central axis or “spine” of the new town center street grid was originally designed as an “at grade” crossing perpendicular to Route 63. This general alignment also suited the concept for a pedestrian bridge.

Topography

The topography of Route 63 near the proposed pedestrian spine appeared to be conducive to creating a pedestrian bridge that could land on modified grades on either side of the road. The bridge concept was proposed by the landscape architect, and the civil engineer concurred with the potential site suitability. The Township commissioned studies to determine the potential effects and cost/benefit comparison between alternatives of (a) no bridge, (b) a totally depressed alignment, and (c) a partially depressed alignment.

A minimum design clearance of 16.5 feet from roadway surface to bottom of structure was used to assess the alignments. Alternative highway gradients to create the depressed roadway were analyzed in terms of design speeds, sight distances, views, and maintenance of adjacent local access to the state highway.

Stormwater

Any new depressed roadway design required a stormwater low point to be set to allow gravity drainage to a detention facility within the town center project area. Potential effects of new land use development in the quadrants around the pedestrian spine were also assessed and included in the engineering of a stormwater piping system – sized to serve a future centralized facility that will accommodate high density development within the town center district.

Signalization

The engineering analyses considered the capital and operation costs of new Forty Foot Road traffic signal required by the surface crossing alternative. It was recognized that if highway traffic was not forced to make an additional stop at a new signalized pedestrian crossing, cost savings would be realized in terms of reduced travel times, energy consumption, and pollution.

Adjacent Land Use

The bridge symbolizes the commitment to the multi-phased plan by Towamencin for economic development within the Town Center. The bridge and pedestrian approaches are integrated within the highway geometry modifications to achieve optimum mobility in the near and long term, and are; universally accessible, a visual attraction, and catalyst for adjacent redevelopment. The bridge deck was conceived to serve as a civic plaza space after adjacent private development occurs.

Preferred Alternative

A partially depressed alignment was selected as the preferred alternative, based upon balanced grading, roadway and pedestrian approach gradients, aesthetics, and costs. The studies were submitted to PennDOT as the basis of negotiation by the Township. A successful case was made that the bridge would be safer and more efficient than a new surface crossing on Forty Foot Road.

BRIDGE DESIGN

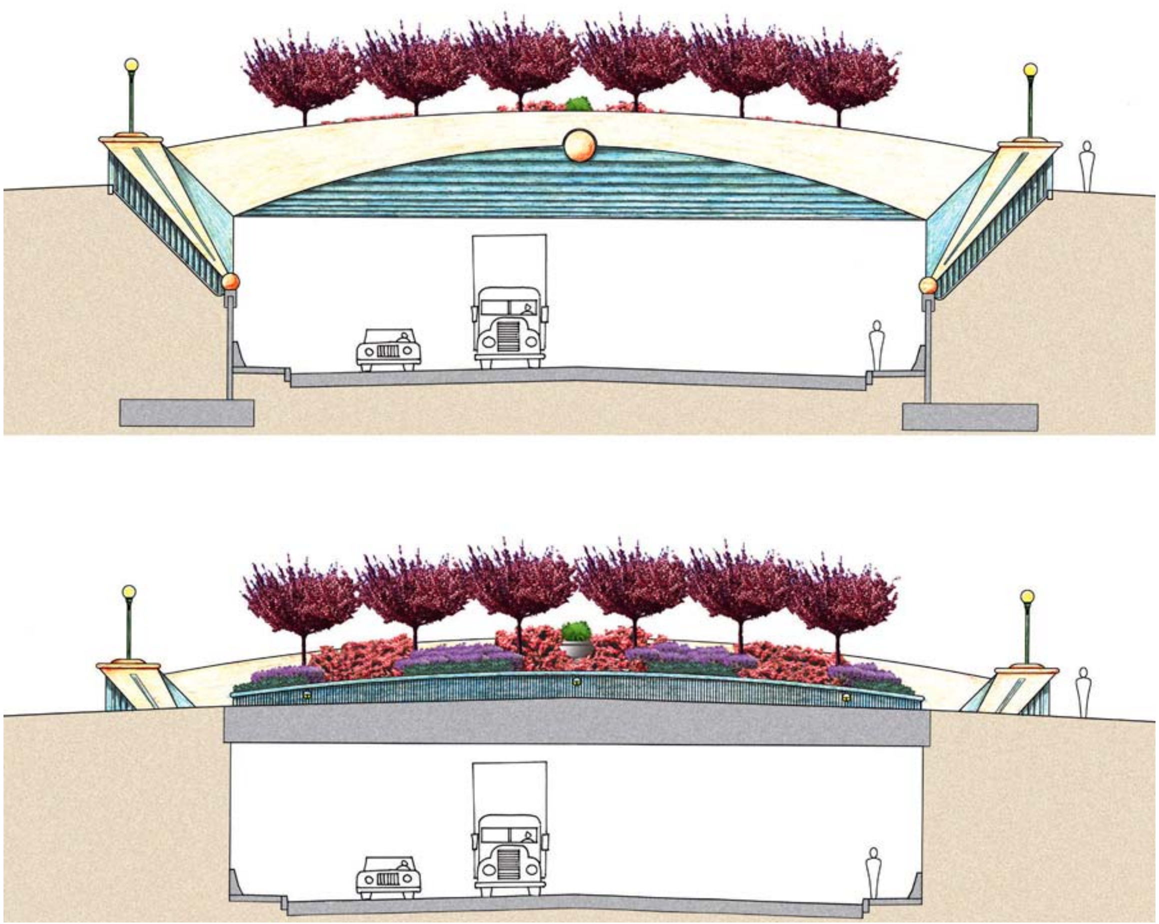

Figure 5 *– In this case the highway bridge becomes a "landscape" structure and features Art Deco detailing in concrete surfaces (above) elevation shows fascia beam and pylon ornamentation; (below) longitudinal section through center of deck shows built-in concrete landscape planters.*

Intent

Towamencin Township envisioned the new pedestrian bridge to be more than a simple pedestrian conduit over a busy highway. Expectations for the bridge included; high level of aesthetics, durability of materials, low maintenance, and multi-functional uses.
The wider bridge design “reclaims” some land taken by the highway expansion.
The new span also sets the standard for scale and service of the new town center streetscape. The bridge itself is designed as a civic “place,” both inviting and a landmark for motorists and pedestrians. Architectural features were designed to evoke the best tradition of historic parkway bridge design using modern techniques.

Geometry

The geometry of the bridge is visually deceptive. The clear span from center to center of bearings is 78’-6”over five traffic lanes, shoulders, and sidewalks on both sides of Route 63. The primary “fascia” beams are structural members up to 12 feet deep and 90 feet long, designed with integrally formed architectural features. The bridge is 40 feet total width with curving planters built into both sides of the deck to create a sweeping, variable-width promenade. The deck is for pedestrian and bicycle traffic only, however, the bridge is engineered to support an H20 truck load to serve maintenance and emergency vehicles.

Approach Grading

The site was sculpted to depress the state highway and to elevate the bridge structure. A subtle 3% gradient for both Route 63 approaches was designed by the civil engineers to allow complete visibility under and through the bridge to the town center landscape on either side. This feature eliminates any “tunnel” effect for roadway traffic. The pedestrian approaches are designed to meet ADA regulations from all quadrants.

Retaining Walls

Four, 85-foot long MSE retaining walls were designed by the geotechnical engineer to create the grade separation along the depressed Forty Foot Road. The MSE walls employ standard precast concrete materials and were engineered to support and drain paved, geogrid reinforced sloping walls above.

Pedestrian Environment

The bridge deck was designed as a generous pedestrian environment, cloistered by the fascia parapets from the sights and sounds of highway traffic below. The bridge serves as the “spine” of the Township pedestrian and bicycle network to connect the township-wide trail system to the future town center open spaces. The cartway is wide enough to serve as a “civic” space for periodic functions within the town center. Built-in planting beds establish a human scale and sensual amenity. Pedestrian lighting was designed for safety and ambiance.

Construction Considerations

To prepare for the Forty Foot Road / Bridge construction project, Towmencin Township designed and built a municipal road around the project area as a bypass to maintain state highway and Turnpike-bound traffic. With Forty Foot Road reopened and adjacent land redevelopment beginning, the bypass road will be re-striped to become "Towamencin Avenue," a town center street with on-street parking. This early investment in infrastructure allowed Forty Foot Road to be closed for roadway excavation and bridge construction with reduced traffic maintenance costs, and created a valuable new asset for motorists and local developers.

The structural engineer assessed the options for constructing the large fascia beams, including construction of the beams in place (standing and flat) and precast / delivered. All options were determined to be technically feasible. Ultimately, prefabricators did not respond to the project due to issues of transporting the fascia beams. The prime contractor elected to build the beams in place, with formwork set on scaffolding bearing on the asphalt sub-course of Forty Foot Road.

Figure 6 *– Forty Foot Road was excavated and utilities relocated. The contractor elected to build the roadway base course and erect scaffolding to support structural formwork for the fascia beams. The fascia beams were designed with haunches to bear the outer edges of the deck. Three interior stringer beams support a traditional structural concrete deck. Computer-cut foam art forms were used inside the structural forms to create the fascia art motif. Structural pylons were clad with formed concrete art panels.*

INTEGRATING AESTHETICS AND ENGINEERING DETAILS

Aesthetic Design Process

Determining the "context" and selecting the art features of the bridge was a rational design process that was fully integrated with engineering from the project conception.

Philosophy

The aesthetics of Forty Foot Pedestrian Bridge exceed the minimalist sensibility of beauty inherent in "pure" structural solutions. In this case, the added "architecture" creates a restrained aesthetic for the structure by evoking the archetypal language of engineering geometry.

Art lines are designed as graphic interpretations of forces active within the bridge, including tension, compression, camber, bearing, and repose. These symbolic acknowledgements respect real structural features such as corbels, spring points, hinges, and keystones. Scale was carefully considered to integrate structural requirements with visually pleasing proportions. The result is a subliminal sense of harmony and balance to the structure.

Fascia Beams as a "Canvas"

The fascia beams were selected as the primary members for art treatment for their visibility. A conventional concrete bridge design for this span would not normally provide the opportunity to create such a large uninterrupted canvas for art forms. Typically, a solid parapet would be created by either fastening a jersey barrier, cast in place wall, or precast sound barrier to a composite concrete box beam superstructure / concrete deck. In some cases, art treatments are applied to these vertical elements, but rarely does artwork affect their shapes, engineering, or construction methods. The challenge to the structural engineer was to create an uninterrupted full-span, full-height beam that could be constructed practically.

Engineering Innovation – Fascia Beams

The structural engineer created a hybrid beam member that acts as a standard load-bearing concrete stringer beam with geometry modified to include the safety functions of concrete parapets as well as the sound-dampening functions of sound walls within the new concrete fascia beam design.

The success of the aesthetic ideas for the fascia beams relied on this engineering innovation – not only to provide the venue for the proposed artwork, but to become the true artistic achievement. The art motif responded to the bold engineering in the form of elegant, sweeping arch lines and Art Deco-style detailing within the deceptively massive 80-foot span fascia beams.

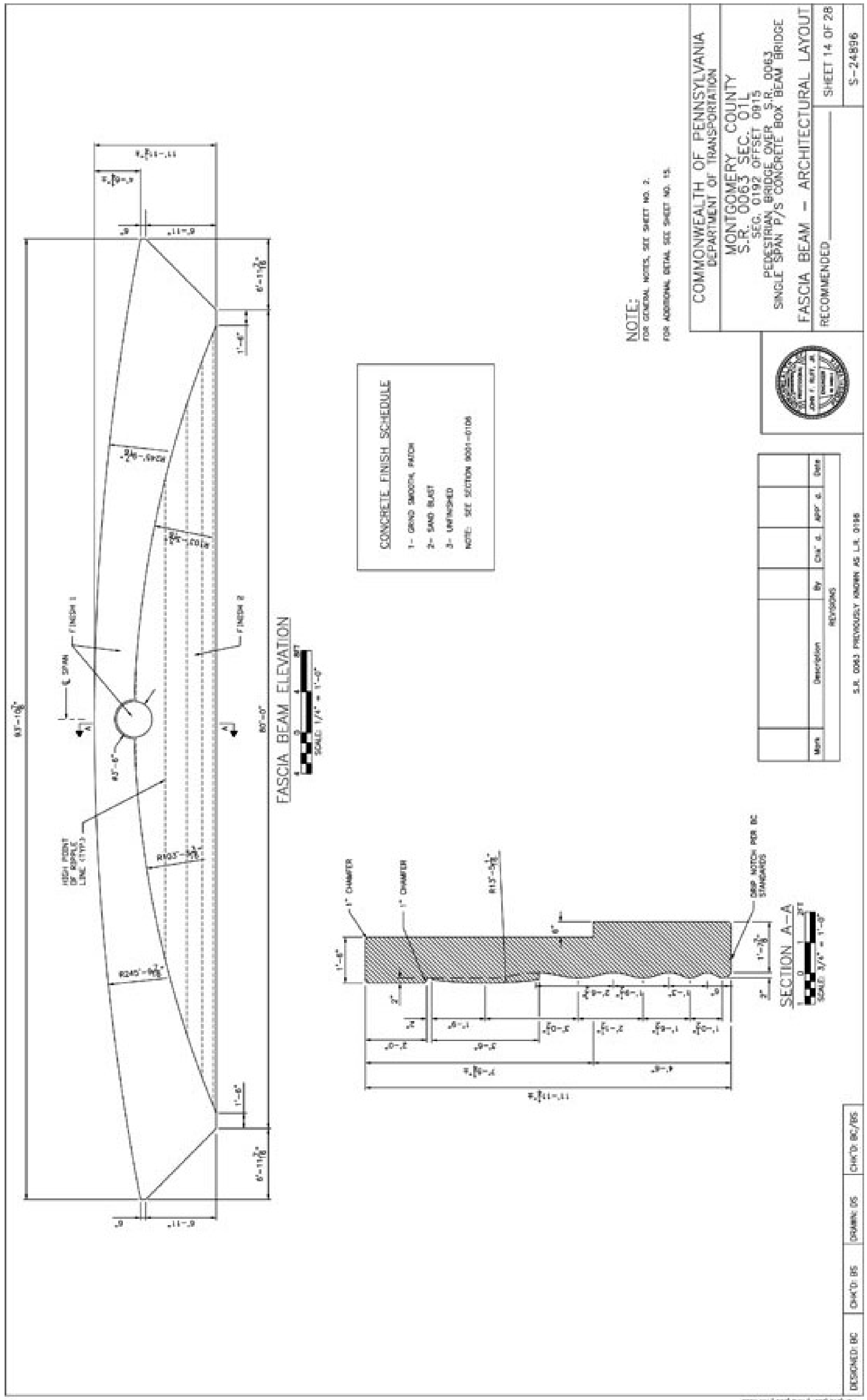

Figure 7 *– Landscape architect's construction document for fascia beam architectural treatment.*

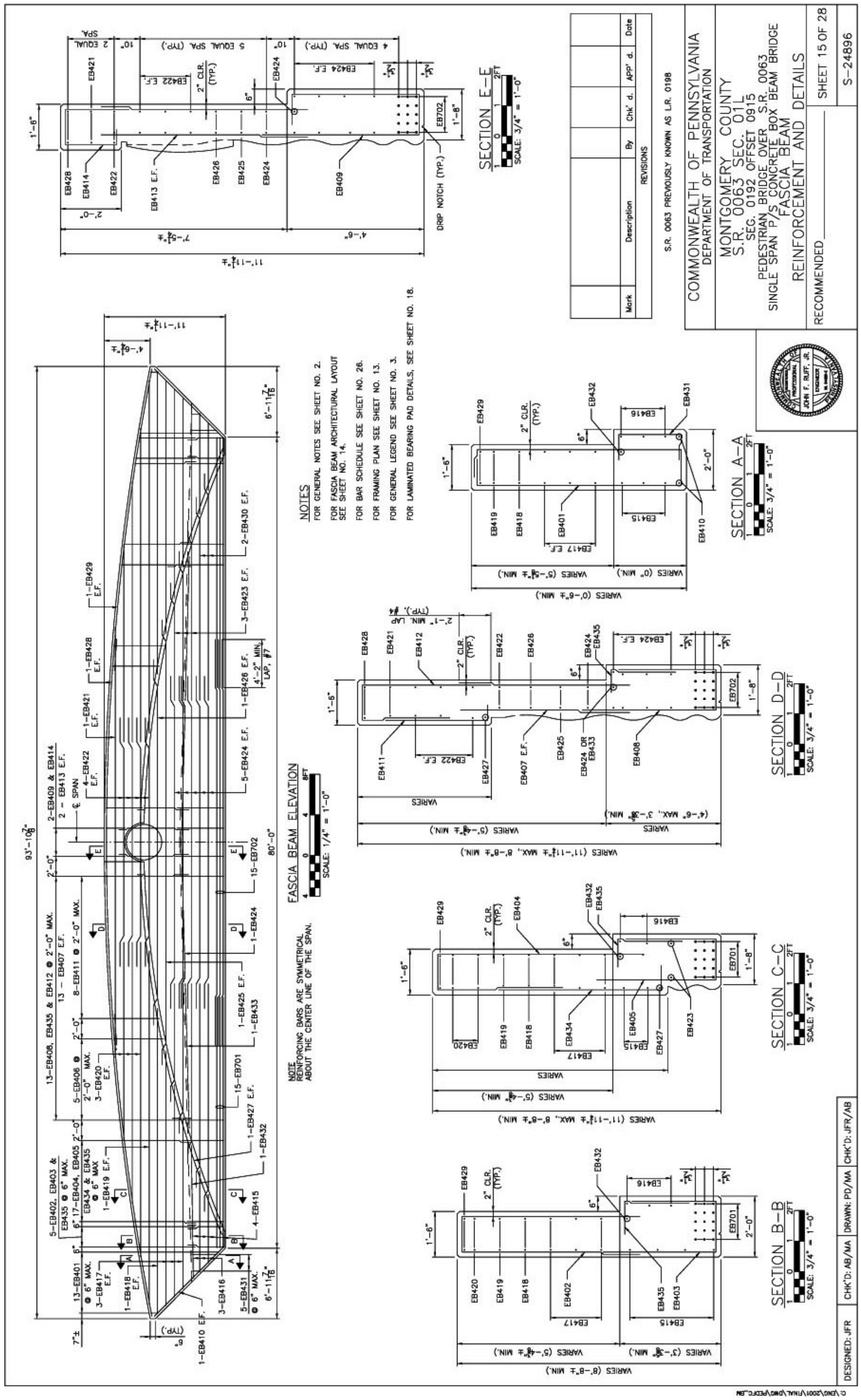

Figure 8 –*Structural engineers construction document for fascia beam..*

The fascia beams extend above the deck elevation to create the appearance of a rigid frame. The structural concrete deck bears on interior haunches of both fascia beams and three interior box beam stringers. This design allows deck edges to be hidden, with only the structural wearing surface exposed and treated. Concrete buttresses hidden within the planters tie the beams structurally to the deck.

The fascia beams are simple span reinforced concrete members designed to seat on cast in place concrete abutments with standard laminated neoprene bearing pads. Within each fascia, 15 epoxy-coated #7 bars provide the primary flexural reinforcement, and epoxy-coated #4 stirrups act as shear reinforcement. Both ends of the beams slope up behind the abutments to cantilever toward structural pylons that are supported on the substructure.

The curved top of the fascia beams was an aesthetic decision that the engineering accommodated to soften the shape and "reduce" the visual mass of the member. The curves at the top of the beams become part of the visual arch created by the art line formed below into the face of the fascia beam.

Art / Architecture Forms

The architectural design of the bridge exploits the versatile, plastic nature of concrete and employs a combination of treatments to the material.

The formed arch line and the shadowed relief that it creates in the fascia beams was designed to "lighten" the apparent mass of bridge structure. CAD-generated, computer controlled and cut styrene form liners were used to create the art features within the fascia beams. The art relief below the arch was designed to be simple and intriguing ripple forms that change frequency and capture the general fluid nature of movements below a bridge. The horizontal shadow lines created by the ripples were designed to subtly elongate the bridge and "de-emphasize" the sense of its vertical dimension. Maximum depth of relief in the structural beam is four inches.

Sloped Paver Walls

The most important architectural decision after the fascia beams was the engineering of the sloped paver walls, above the MSE retaining walls. The sloped walls were designed using geogrid-reinforced slopes at a 1:1 gradient to expand the sense of openness and provide visual relief from the roadway vantage point. The sloped walls allow the roadway environment to open up to light and views toward the pedestrian streetscape environment above, and are visible from all directions.

Without the sloped walls, the MSE retaining walls would have been much higher, and the roadway approaches to the bridge would have appeared much deeper and narrower. This would have created a severe "trough" effect in the roadway environment, and the bridge would have appeared shorter and higher.

Figure 9 *– The sloped walls above the MSE retaining walls reduced the sense of depth of the roadway and were constructed with standard concrete unit pavers and stabilized with geogrid reinforcement. The pavers were finished with dark mortar and urethane anti-graffiti treatment.*

The sloped walls allow the engineered abutment wing walls to be visible as they extend away from the bridge portals and to serve as “pylon” elements. The cantilevered ends of the beams slope up from the abutments to the structural pylons and are clad with architectural wing wall façade panels attached to the structural pylon cores. The sloped wall allows the formed arch in the fascia beams to appear to “thrust” from the 45-degree angle bearing line.

The material selected for treatment of the slopes was very important. The maintenance program eliminated the option to vegetate the steep 1:1 slopes. Conventional concrete unit “brick” pavers were specified on sloped concrete slabs and laid on a mortar bed in a fan pattern. The paver walls were designed and installed as compressive structures, bearing against the MSE walls and tied to grade using geogrid reinforcement. These reinforced slopes are reportedly the first to be designed and constructed using geogrid reinforcement within PennDOT District 6-0. A trench drain was engineered behind the cap of each quadrant of MSE wall to drain the sloped walls. Dark mortar was used in the paver joints to reduce contrast and the finished sloped surfaces were treated with a transparent urethane sealant.

The sloped walls will remain structurally intact, even as development occurs in the quadrants around the bridge. A new hotel complex in one quadrant uses the new building foundation to re-anchor MSE reinforcing ties.

MSE Retaining Walls

Precast MSE panels with vertical rustications were selected from in-stock materials as the most economical option for roadway retaining walls. At the deepest point, the MSE walls are exposed eight feet. The art design takes advantage of the line of MSE wall caps as an architectural corbelling feature by adding custom cast finials where MSE walls meet the abutments.

Abutments

The abutments are conventional cast-in-place, reinforced concrete with in-stock architectural rustication formwork to match the MSE wall panel rustications for visual continuity. Structural abutment wing walls support custom, precast concrete architectural panels that are used to unite the fascia beams visually to the pylons. Precast wing wall caps sit down over the architectural panels and support finial globe lights on each pylon.

Deck

The deck is 40 feet wide at the portals and narrows to 20 feet wide at center span between the cast-in-place landscape planters. The deck slopes away from midspan at 2% to direct water to trench drains at either abutment and to reinforce a subtle, ceremonial "camber." Concrete deck material was extended in semicircular aprons outside each portal to create a graceful approach and sense of spatial transition to the bridge.

A dark red aggregate was specified for the deck mix with an analogous red stain in the urethane surface coating to provide contrast to the lighter colors of the other bridge elements. The deck aggregate was exposed and a three-foot apron at the base of both planters was stamped to impress a fan pattern to match the sloped wall pattern. Both texture treatments were used specifically to inhibit the attractiveness of skate boarding on the desk. A construction achievement was creating the stamped patterns in the same deck using retardants to achieve an exposed aggregate texture finish for the primary walk area.

***Figure 10** – The portal elevation of the bridge reveals the sweeping forms of the concrete landscape planters that echo the curves of the fascia beams and deck. The planters are insulated, waterproofed for drainage and automatic irrigation. Plant material was selected for harsh microclimate extremes.*

Landscape Planters on Deck

The concrete planters formed into both sides of the deck are amenities that capture the elements of the surrounding landscape to temper the bridge deck environment. The size of the planters was designed to create vessels large enough to support medium-sized canopy trees and balance the need for a generous pedestrian cartway. The curved shapes reinforce the curving parapet shape of fascia beams. Planter wall rustications match the scalloped formwork in the wing wall panels.

The planters are insulated, membrane-lined, automatically irrigated, and plumbed for drainage – to create the most optimum growing environment possible. The trees and the insides of the fascia beams are up-lighted from within the planters for night effects. A custom planting soil medium was designed for optimum growing culture in harsh conditions. Hardy plant materials were selected to meet extreme wind, cold and heat conditions.

CONCRETE MATERIALS / TECHNIQUES / TREATMENTS

Material

Concrete was selected as the most practical and economical material for a bridge of this size and configuration. The entire bridge project is constructed of concrete, using many standard construction items to display a wide range of capabilities in mixing, forming, and treating concrete material for aesthetics – without any attempt to mimic other materials such as faux stonework.

Combination of Precast and Cast in Place Elements

The bridge design combines multiple fabrication techniques to take advantage of the wide variety of unique properties achievable with conventional precast, custom precast, and custom cast-in-place members, such as;

- conventional precast elements including: prestressed concrete box beams, MSE wall panels/caps, jersey barriers, and conventional sloped wall concrete unit pavers.
- custom precast elements including: pylon wing wall panels, pylon caps, and MSE Wall cap finials.
- cast-in-place elements including: reinforced concrete fascia beams with custom prefabricated architectural form liners, reinforced concrete abutments with architectural treatments, bridge deck, curved planter walls, and coping on deck.

A White Portland cement mix was specified for all cast-in-place structures and architectural elements to show off the colors of exposed aggregates and to provide the most pure concrete base for translucent color staining. This proved to be effective for treatment of the exposed aggregate areas of the planter walls, wing wall panels and fascia beams, where a lightly pigmented urethane coating allowed the white Portland cement mix to show off the selected color. This was not the case where the urethane treatment was applied without pigment and the bright white color of the raw concrete was darkened and uneven using a clear urethane. The remedy was to pigment the urethane treatment of exposed aggregate areas with translucent color and all other areas with opaque color.

Three classes of concrete were specified for the bridge. Class A (f'c=3000 psi) was used in the foundations, abutments, and wingwalls. Class AA (f'c=3500 psi) was used in the fascia beams, wingwall panels, and planter wall. Class AAA (f'c=4000 psi) was used in the reinforced concrete deck slab.

The superstructure also contains three standard prestressed concrete box beams. These 48" wide by 36" deep beams were fabricated using concrete with a 28-day strength of 7000 psi. The beams contain 50, 270 ksi low relax strands, 12 of which are debonded for 12 feet at each end. The beams were prestressed with an initial jacking load of 1691 kips.

Techniques

Architectural techniques employed include:

- sandblasting – to expose aggregates for aesthetics in specific surfaces in the fascia beams, wing wall panels, and planter walls. The contractor chose grinding and wire brushing for certain surfaces.
- retardant – to expose ornamental aggregate in the deck for aesthetics and non-slip texture. The contractor found the challenge was to use retardant in the mix to expose aggregate while stamping the surface of the same concrete pour without exposing the aggregate.
- Stamped concrete – to create architectural patterns in the concrete deck to match the patterns of the pavers laid for the sloped walls.
- form liners – custom-cut form liners fabricated using an automated shaping machine programmed to read the AutoCAD construction documents and to create precisely matched panels for the ripple forms in the fascia beams.
- water-resistance admixture – for deck and fascia beams concrete mixes, to improve water resistance of high-cost primary members where de-icing salts threatened longevity. This was considered a prudent investment with the fascia beams tied to the deck with structural buttresses and the steel of architectural concrete planter walls tied to the deck.

Concrete Treatments

A custom-colored, aliphatic urethane treatment was applied to all exposed surfaces of the bridge and retaining walls.

Color

Color for the concrete surfaces was specified extremely carefully to allow for multiple field mockups and photo-rendering studies of the actual structure during construction. Early concepts using several colors were simplified to two colors and a bright white.

The deck was stained a medium burnt red with dark red aggregate to reduce glare. A light sea green was selected as the translucent color to be applied to the exposed aggregate areas. The color hue and value were balanced to accent the rougher exposed aggregate textures and strategically set off the opaque bright white to emphasize specific art shapes.

In the case of the fascia beams, the light green is used below the arch shape to make the ripple forms visually "recede" and push the white arch forward. The effect from a distance is that the green tends to blend with the sky and landscape colors and the slender arch leaps across the road ahead.

COSTS / FINANCING

CONTRACT AMOUNT, PROJECT SCHEDULE, AND STATISITICS

The project was documented and bid using the standard PennDOT Electronic Contract Management System process and awarded to the lowest qualified bidder. The original and final contract award amount was $12,976,706.50, bid by Road Con, Inc. The project let date was September 9, 2004, and construction started in December 2004.

The Bridge was a lump sum cost of $1,039,845 (including rebar). The MSE walls were also lump sum items at $77,000 each ($308,000 for all four).

The project was constructed in five stages and several were built concurrently. Towamencin Avenue was built in 2001, as part of the Towamencin Township Village Plan and in advance of this project, to create a convenient detour for Forty Foot Road. Forty Foot Road excavation depressed the finished roadway elevation 8 feet to construct the pedestrian bridge and MSE walls. This plan also allowed for full width reconstruction with no maintenance of traffic on Forty Foot Road. Forty Foot Road was reopened to traffic in December 2006. Time extensions were granted to extend the construction schedule into June 2007 to complete the pedestrian bridge. A technical time extension was granted until spring 2008 to allow for final inspection/installation of the plantings, testing and municipal training for bridge maintenance.

PARTNERSHIP FINANCING

The project was structured as a local match between the Towamencin Township Infrastructure Authority (TTIA) and PennDOT. The TTIA was responsible for 100% of the engineering costs and PennDOT was responsible for 100% of the construction costs – using a typical 80% federal to 20% state matching ratio. The project was conducted as a phased process, with the municipality commissioning all planning, design, and engineering costs. Ownership was a structured as “turnkey” agreement, where the Township assumes ownership and maintenance of the bridge upon completion.

LIFE CYCLE INVESTMENTS

Higher capital costs were found to be acceptable for value-added features, materials, and techniques that were considered as smart life-cycle investments to reduce maintenance costs. Adding the water resistance admixture to major structural elements including the fascia beams and deck was considered prudent by the Township as the “turnkey” owner that would assume maintenance. PennDOT considered this investment prudent as part of the terms of ownership transfer that would remove the bridge from the state highway system in perpetuity.

Higher capital costs for context design features were found to be acceptable as a catalyst for local private investments to increase tax ratables to contribute as a perpetual source of bridge maintenance funding to the Township..

SUSTAINABILITY

The pedestrian bridge was conceived in 1994, on the early edge of investments in "green infrastructure." The merits of the bridge were considered in terms of energy and environmental savings as well as pedestrian and vehicular safety issues of a grade-separated crossing of Route 63. Sustainability considerations for the bridge included the following features:

- Walking Alternative – The new pedestrian bridge offers an inviting and convenient alternative to driving across the road, an option that significantly reduces costly fuel consumption, greenhouse gas emissions, and air quality pollutants generated from inefficient and dirty vehicular "cold starts" to otherwise drive across the road.

- Vehicular Efficiency – The new pedestrian bridge eliminates an additional traffic signal for a pedestrian crossing on Route 63, making it a green infrastructure capital investment that significantly reduces inefficient fuel consumption by eliminating the need for hundreds of dead stops, idling, and acceleration of highway vehicles daily within the town center. This is a major contribution to regional air quality and fuel efficiency for all citizens.

CONCLUSION

The Forty Foot Bridge project demonstrates how proactive land use planning by a small, but determined municipality can positively impact transportation infrastructure decisions.

Depressing an existing state highway alignment to accommodate a new pedestrian bridge is a rare achievement between PennDOT and local governments and reflects the growing emphasis within the Department toward creating highly functional, multi-modal context sensitive improvements.

Within the Towamencin Town Center, the new bridge serves as an icon and catalyst for future mixed-use, pedestrian-oriented development in adjacent parcels.

The successful execution of this bridge within the standard PennDOT procurement process demonstrates that there is the sufficiently high level of craftwork capability in the marketplace to construct such custom design and technically challenging projects.

The Forty Foot Pedestrian Bridge is a visible landmark and benchmark for excellence in the design of public infrastructure.

AWARDS

The Forty Foot Road Pedestrian Bridge and Roadway Improvement project received the

- *2007 Project of the Year Award* from the American Society of Highway Engineers (ASHE) Delaware Valley Chapter - for projects over $5 million.

The Forty Foot Bridge was acknowledged to receive the

- *2008 PCA Bridge Design of Excellence Award* from the Portland Concrete Association – to be presented on November 2, 2008.

The *Towamencin Town Center Plan* won three planning awards in 1996.

ACKNOWLEDGMENTS

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