Veterans' Glass City Skyway

Toledo's Newest Landmark Ready to Shine

by Michael Gramza, Ohio Department of Transportation and Jeff Walters, FIGG

By mid-2007 drivers on I-280 through the heart of Toledo will see the city from new vantage points 136 ft above the Maumee River. A striking cable-stayed signature bridge, featuring a single 400-ft-tall central pylon and twin 612-ft 6-in. spans, is the result of a vision begun nearly 20 years ago by the Toledo Metropolitan Area Council of Governments (TMACOG). The $220 million structure will soon be completed under the administration of the Ohio Department of Transportation (ODOT). The top of the sculpted pylon delivers on a public expectation to showcase glass, reflecting on Toledo's industrial heritage of glass manufacturing. Except for 3 ft at the top, the uppermost 199 ft of the pylon is clad on all four sides in specially manufactured glass. The glass is designed to reflect the sky during the day and shine with more than 16 million color combinations across the skyline at night, courtesy of hundreds of LED fixtures.

To deliver on the public's direction during FIGG Bridge Design Charettes™ required:

- Innovation to create the cable-stayed cradle that conveys the largest stays in the world (156 strands) through the pylon;
- Persistence to determine how glass could creatively be showcased on a transportation project;
- Exacting dedication to the idea that this landmark bridge would shine over Toledo for more than 100 years; and
- Be bid within the budget.

To create this unique and lasting landmark, the FIGG team worked closely with ODOT and the Program Management Consultant (PMC), a joint venture of HNTB and Parsons Brinckerhoff. Linda Figg, President/CEO of FIGG appreciated the importance of ODOT's overall plan, saying, "Through the vision and talent of the Ohio Department of Transportation, a team came together to achieve success for the community. ODOT understood the importance of the communities' voice in achieving a landmark bridge."

Interstate 280 currently crosses the Maumee River in the heart of Toledo on the Craig Memorial Bridge, one of the few remaining movable bridges on the interstate system. An average of

profile

VETERANS' GLASS CITY SKYWAY / TOLEDO, OHIO

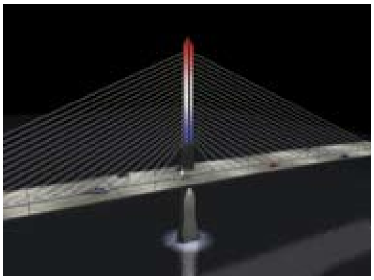
BRIDGE DESIGNER/CONSTRUCTION ENGINEERING INSPECTION: FIGG, Tallahassee, Fla.

PROJECT MANAGER CONSULTANT: HNTB/Parsons Brinckerhoff, Toledo, Ohio

CONTRACTOR: Bilfinger Berger Civil, Inc., Vancouver, Wash.

CONCRETE: Integrated Resources, Inc.—a division of The Stansley Group, Toledo, Ohio and Kuhlman Concrete, Toledo, Ohio

LED fixtures behind the 193 ft of glass on the pylon can be programmed for 16.7 million color combinations.



New engineering innovations are sure to be replicated on other projects.

900 annual openings of the bascule span stops interstate traffic. In 1988, TMACOG identified the replacement of the existing bridge as its highest transportation priority for the northwest Ohio region. A new high-level bridge would ease traffic congestion on I-280 and maintain shipping to the Port of Toledo. By retaining the existing bridge for local vehicular and pedestrian traffic, the project would also facilitate commerce within the City of Toledo by effectively adding another local crossing over the Maumee River.

The new high-level bridge would create a signature focal point and landmark for the city and the surrounding area. Toledo has a rich history in manufacturing, specifically in the production of glass. Several of the largest glass companies in America have been located, and continue to operate, in the Toledo area. Combining the two—a new bridge and an industrial heritage in glass production—would produce a new landmark and symbol for the future of Toledo.

The Community Speaks

In April and May of 2000, a series of community design charettes was held with representatives from ODOT, the Toledo Arts community, the PMC, the Maumee River Crossing (MRC) task force, neighborhoods, and the media. The MRC task force represented the cities of Toledo and Oregon, Lucas County, the Toledo-Lucas County Port Authority, TMACOG, and ODOT. They determined that the new bridge would have a precast concrete segmental superstructure, a cable-stayed main span providing 120-ft vertical and 400-ft horizontal clearances, a six-lane roadway, and world-class aesthetics built around a theme of "Glass."

Concrete was selected as the preferred material to meet the structural and aesthetic demands of the project. Precasting was preferred to allow for construction with minimal traffic disruption in the congested urban corridor of the project site. Further, the task force made several recommendations for the main span aesthetics, focused on achieving a structure that would be light, simple, and elegant in appearance. With that direction, FIGG presented options in the first design charette on which the participants voted their preference by scoring 1 for 'not preferred' to 10 for 'highly desirable.' By votes of nearly three to one, a single plane of stays was favored due to the resulting clean lines and dramatic appearance.

The participants selected a combined fan/harp arrangement for the stays, a classic layout that provided structural efficiency while building on the task force's adopted motto "Look Up, Toledo." Participants strongly preferred a structural scheme featuring a single pylon, rather than multiple smaller pylons, commenting that it would be more dramatic and make the strongest statement by providing the greatest visibility in the relatively flat Toledo area. As the participants began to weigh in on pylon characteristics, the enthusiasm in the room intensified—everyone recognized that this was perhaps the best opportunity to make a strong statement about Toledo. Participants nearly universally ranked the use of glass with a score of 9 out of a possible 10, and the upper pylon, with views from all parts of the city, as the preferred location.

Aesthetic lighting on the bridge was to be focused on the stays and the pylon, with the opportunity to create special lighting for events in the city. Two general pier shapes were selected for further development—curved and rectilinear, with those general shapes required to be consistent with the pylon's appearance. The design choices even focused on the driving experience, and participants selected a partially open traffic railing to balance openness of views with a desire to provide a 'safe' feeling for drivers.

Use of stainless steel as stay cable sheathing material was desirable because it further advanced and complemented the industrial theme of "Glass." The life-cycle costs relative to other sheathing materials also figured in the selection of stainless steel. Consistency of color between all concrete elements was deemed important to the project's overall aesthetic impact.

Based on these initial outcomes, FIGG developed numerous aesthetic schemes, which were reviewed by ODOT and MRC task force. The outcome of the second community design charette was to move into final design with the rectilinear pylon with a prismatic shape and octagonal piers for the approaches and ramps, resulting in consistent aesthetic characteristics carried throughout the 2.75 miles of ramps, elevated

SEGMENTAL / OHIO DEPARTMENT OF TRANSPORTATION, OWNER

BRIDGE DESCRIPTION: An 8800-ft-long structure including a cable-stayed bridge with a single 400-ft-tall pylon supporting twin 612-ft 6-in.-long spans with a single plane of cables.

STRUCTURAL COMPONENTS: 3050 precast concrete elements including 42 concrete delta frames, 185,000 cu yd of concrete, 1.9 million pounds of post-tensioning strand, and 32.6 million pounds of reinforcing steel

Work nears completion just prior to the erection of the final segments.

Erection of a precast concrete delta frame that transfers the loads from the segments to the cables.

roadway, and the cable-stayed main span. Marc Folk, Executive Director of the Arts Commission of Greater Toledo participated in the project design efforts and summed up the bridge design process by saying, "The willingness of FIGG to engage the community in the dialog of aesthetics of the bridge has been an overwhelming success. Not only have these aesthetics been integrated into the project, they have also led to new engineering innovations sure to be replicated on other projects. Incorporating these elements into the bridge has given this project a unique, forward thinking community identity that will be enjoyed by our citizens for generations to come."

Collaborative Process

The collaborative process on this project is best expressed by the words of Dave Dysard, now Deputy District Director for ODOT District No. 2 "The Veterans' Glass City Skyway demonstrates the strength of a truly collaborative process in an urban region. Staff and local government representatives worked through TMACOG, the metropolitan planning organization for the area, to identify and document the need for the project in the regional planning process. The regional plan placed the project as the top priority in the area. Local government agencies formed a broad-based task force with government business and neighborhood representatives to develop specific project alternatives. ODOT agreed to take on the project and continued working with the task force to design and build a landmark structure that will be an icon of the resurgence of this region."

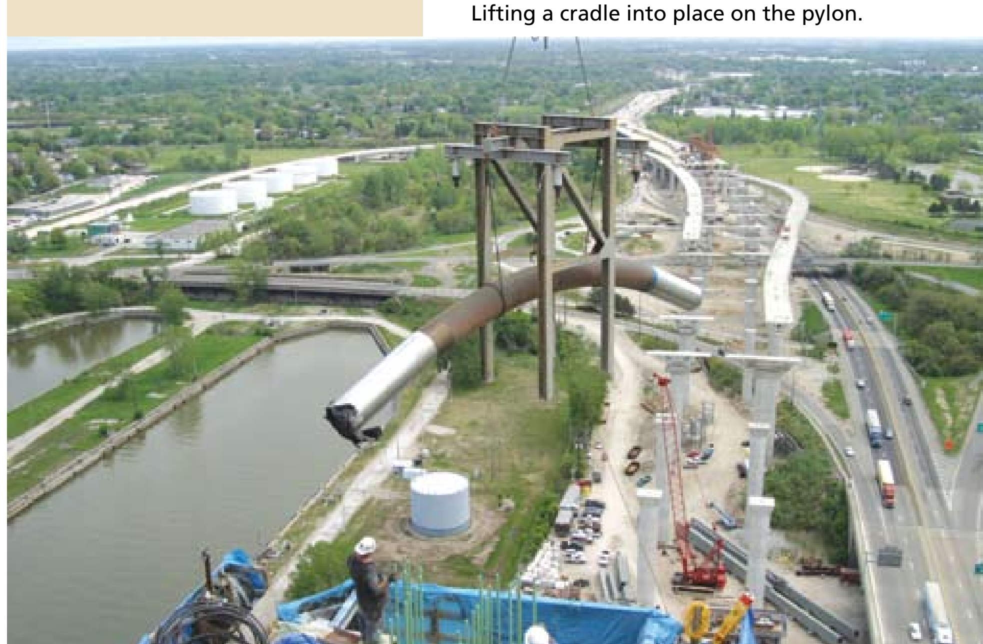
A Concrete Solution

Innovative solutions were necessary to deliver this unique bridge. Urban congestion and limited available right-of-way, typical in large cities, surround the bridge site. It was essential that construction be accommodated within a relatively small footprint and have minimal impact on the neighborhoods and businesses around the site. Precast concrete segmental technology minimized this impact by effectively moving much of the construction work to an off-site casting facility. The selection of concrete as the primary building material provided benefits to the local Toledo economy because local companies could provide materials and trades personnel to construct the bridge.

High performance concrete provided the means to achieve the structural requirements of strength, durability, and workability while providing the aesthetic features expected by the community. High compressive strength concrete was necessary to minimize structural member sizes while creating sculpted pier and pylon shapes. In the superstructure, a minimum compressive strength of 6000 psi was specified for the piers and superstructure segments, while 8000 psi was determined to be optimal for the main span segments. Once casting of the 3050 segments began, the contractor found that by using the 8000 psi mix for all superstructure segments, forms could be stripped more quickly, compressing the overall casting schedule. The pylon, which reaches 400 ft above the Maumee River, was cast from 10,000 psi high performance concrete.

Concrete for all superstructure segments, the piers, and the pylon was specified to have a maximum permeability of 1000 coulombs at 28 days and a plastic air content of 5 percent. The superstructure segments included a 1.5-in.-thick integral wearing surface, cast with the segments and post-tensioned along with the

Lifting a cradle into place on the pylon.



Specially designed and manufactured glass panels are being installed on the four sides of the pylon and installation will be complete prior to the bridge opening to traffic in early summer.

The Skyway demonstrates the strength of a truly collaborative process.

structural section, further enhancing driving surface durability by minimizing cracking. The use of an integral wearing surface also eliminated the need for a costly overlay to be applied during construction, saving both money and time.

Creating the Cradle

A single plane of stays could be accomplished utilizing precast concrete delta frames—FIGG had incorporated this innovation on other cable-stayed bridges including the I-295 Varina-Enon Bridge near Richmond, Virginia, and Delaware's Chesapeake & Delaware Canal Bridge. The challenge would be combining the slender pylon shape selected by the community with the largest bridge cable stays in the world—156 strands, an increase of more than 70 percent over that previously used in the United States.

Several previous cable-stayed bridge designs utilized a saddle in the pylon to carry the strands; however, given the significant increase in the number of strands, a new system was needed. Utilizing anchorages in the pylon would have resulted in increasing the pylon width by more than a third, from 23 ft to 31 ft. This would increase the overall quantity of materials and possibly the construction costs, but would stray from the preferred slender, elegant shape. Using anchorages in the pylon would also require that operations, critical to stressing, take place as much as 230 ft above the bridge deck, increasing the contractor's potential risk and the cost of the project.

By focusing on the need to allow each strand to act independently, Denney Pate, FIGG Senior Vice President/Principal Bridge Engineer, arrived at the idea of isolating each strand in its own curved 1-in.-diameter stainless steel sleeve within a steel cradle. Pate's approach resulted in a cradle design that allowed each epoxy-coated strand to act independently. While the spaces between the sleeves inside the cradle are grouted prior to the cradle being cast into the pylon, the individual strands remain ungrouted. The stay force—a sum total of the force in each strand—is then transferred into the pylon through radial compression, taking advantage of concrete's natural compressive strength, minimizing reinforcement requirements, and eliminating the need for a large and expensive steel anchorage box within the pylon.

"Cheese plates" at each end of the cradle, along with centering plates located in the curved section of the cradle, maintain the relative positions of the sleeve pipes containing the individual strands. The ends of the sleeves are flared to ease strand installation. The strands are housed within the stay cable sheathing for their free length, while the cheese plates and anchorages keep the strands parallel. ODOT prepurchased the entire stay cable system to facilitate the stay system fatigue testing required by the Federal Highway Administration, removing this testing from the contractor's list of responsibilities, and the project's critical path.

By December 2001, all fatigue tests were successfully completed, including:

- Axial fatigue and ultimate static tests on 82- and 156-strand specimens;
- Axial fatigue and leak test on a 119-strand specimen;
- Single strand cradle sleeve testing; and
- Axial/flexural fatigue test on a 119-strand stay and cradle specimen.

"Many other cable-stayed bridges will benefit from the advancements in technology achieved on this bridge," states FIGG's Pate.

Shining Brightly

During the public meetings, there was strong support for drawing attention to the upper pylon, using glass in the pylon, and incorporating feature lighting. By combining these ideas, a design that uses a 1.2-in.-thick laminated glass composite section incorporating layers of heat-strengthened glass and bonding materials will be installed over a height of 196 ft beginning 3 ft below the top of the pylon. This glass 'sandwich' is mirrored on 1/3 of its surface area to reflect the sky during the day and allow backlighting from LED fixtures behind the glass to illuminate the pylon and shine across the Toledo skyline at night.

A total of 384 low energy LED fixtures are located in the concave recesses behind the glass panels on all four sides of the pylon. LED technology has rapidly moved forward, increasing the durability and life of the fixtures, while becoming even more affordable, providing ODOT with an efficient feature lighting system that will shine brightly with minimal maintenance.

Each fixture is individually controllable via computer software and can produce up to 16.7 million different colors, giving the Toledo community the ability to select both static and moving light displays to mark any holiday or special event. Various color schemes are preprogrammed such as red and green for the Christmas holidays and red, white, and blue for the Fourth of July. Possibilities include showcasing regional sport team's colors on two sides of the pylon until game time and rewarding the victor with the entire pylon in their colors. The ideas and options for pylon lighting colors are nearly endless, providing Toledo with their much-desired landmark bridge to celebrate their city and industrial heritage.

Cast in Concrete

On January 15, 2002, ODOT opened bids for the project and subsequently awarded the construction contract to Fru-Con Construction Corporation (now Bilfinger Berger Civil, Inc.) for $220 million, making the new river crossing and its surrounding contracts the largest project ever undertaken by ODOT. Construction work began in earnest in the spring 2002, with the establishment of a casting yard to produce 3050 precast concrete elements, including 42 concrete delta frames, required for the approach, ramp, and main span. An average of 35 segments was cast each week during reasonable temperatures, 25 per week during cold weather. Approximately 32.6 million pounds of reinforcing steel and 1.9 million pounds of post-tensioning strand have been incorporated into the 185,000 cu yd of concrete to make Toledo's landmark bridge a reality.

On December 20, 2006, the final two segments were placed in the main span. The final main span closure on February 16, 2007, made the 8800-ft-long bridge continuous from end-to-end. Plans are being made by the MRC task force and ODOT for a ribbon cutting and opening of the bridge. The end is in sight—and it's shining brightly. Traffic is anticipated on Toledo's postcard-perfect bridge by summer 2007.

Michael Gramza is Project Manager with the Ohio Department of Transportation and Jeff Walters is Regional Director with FIGG.

For more information on this or other projects, visit www.aspirebridge.org.

AESTHETICS COMMENTARY

by Frederick Gottemoeller

The Veterans' Glass City Skyway has to be understood first of all as an expression of civic will and civic pride. The project aims to do more than build a bridge, as important as that bridge might be. Of course, the project will relieve traffic congestion caused by the original routing of I-280 across the Craig Memorial Bridge. However, it will also reconnect neighborhoods that were severed when I-280 was built, catalyze the shoreline development and redevelopment of an important stretch of the Maumee River, and give Toledo, Ohio, and all northwestern Ohio a new symbol of growth and optimism.

Public agencies are often unwilling to accept project objectives beyond the narrowest possible definition of functional transportation. The Ohio Department of Transportation and local communities are to be congratulated for recognizing that a major transportation facility in an urban area is an inseparable element of the urban fabric, that it, therefore, facilitates (or inhibits) transportation, land use, urban design, and symbolic functions; and that efforts to improve all of these functions are legitimate uses of public transportation funds.

With this in mind, the community helped to define parameters for both the bridge and for the areas below and beside it. Parks are being built as integral parts of the project to fill the land areas vacated by I-280 and the area directly below the bridge. By providing centers of positive activity and attractive amenities, the parks will stitch together the severed neighborhoods and provide an impetus for their improvement and redevelopment. They also will provide an attractive backdrop for the bridge itself.

The choice of segmental concrete box girders for the approaches supports the desired park development. The girders provide a smooth, solid, and light colored "ceiling" for the spaces in the park. The wide overhangs and the light color will promote the penetration of sunlight into the parks. The box girders allow piers with single, slim shafts that keep views through the parks open and unobstructed. The piers have been provided with graceful capitals that allow the shaft to stay thin while still accommodating two bearings at the top.

That brings us to the main span itself, and here the shift is from the neighborhood scale to the scale of the Maumee River, the city itself, and indeed all of the locations from which the bridge and its pylon are visible. The first thing to notice is that the deck girder is the same size and shape as the approach girders, so that the one flows smoothly into the other, and the entire bridge seems of a single piece. The second thing is how the tapered facets of the lower part of the tower simulate the piers of the nearby drawbridge, creating a similar image of graceful mass and solid support. The third thing to notice is how these facets smoothly transition above the deck into a needlelike tower made to appear even thinner by the vertical lighted glass. The details of the tower show that this is accomplished while still keeping the load-bearing elements of the tower structurally efficient. The full impact of the pylon will be at night when the lighting is functioning, making it even more memorable.

Finally, to fully understand the impact of the bridge one has to shift scales once again, to the scale of the whole greater Toledo region; everywhere within the advertising reach of the Toledo newspapers and broadcasting stations. The region's residents will see frequent images of the bridge in newspaper articles, in backgrounds of TV shots and in advertising brochures. It will become a symbol of the place where they live and, in some small way, part of their own self-image. It will also be recognized as a symbol of the Toledo region when it appears in national media. The Veterans' Glass City Skyway will join Boston's Zakim Bridge and Tampa Bay's Sunshine Skyway as new bridges that are now nationally recognized symbols of the places where they were built.