

ACHIEVING UNIQUE AND AESTHETICALLY PLEASING CONCRETE SHAPES FOR BRIDGES

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ABSTRACT

Through the careful selection of structural shapes and a great attention to detail, aesthetics can be economically achieved for bridges. By using concrete in different forms, textures, colors and patterns, a unique appearance can be developed for a given project. This paper will demonstrate through a number of case studies how concrete can be easily used to create sculpted works of bridge art. Projects will include:

- *Maumee River Crossing in Toledo, Ohio – This unique cable-stayed bridge was developed through extensive community involvement. The “Theme of Glass” was incorporated into all aspects of the design, including the concrete pylon that was shaped to simulate the angular features of glass. The reinforced concrete element is multi-faceted with concave surfaces that vary with increasing height.*
- *Indian River Inlet Bridge in Sussex County, Delaware – This concrete arch supports a 1,000’ span over an inlet in a scenic recreational area. The community selected a “Harmony with Nature” theme, resulting in concrete shapes, colors, and textures that are organic and appear to be born of the earth.*

Additional projects will be described to demonstrate how design features from structural form to concrete mix specifications were used to achieve world-class bridge aesthetics.

Keywords: Concrete, Bridges, Aesthetics, Community Involvement

INTRODUCTION

Bridges serve a great purpose in our communities: providing safe crossings over obstacles, connecting people that would otherwise be divided, speeding commutes by easing congestion in heavy traffic regions, to name a few. Another significant contribution of bridges is the image that they create for the people of that region. Consider the Golden Gate Bridge in San Francisco, the Brooklyn Bridge in New York, and the Sunshine Skyway Bridge in Tampa – all of these bridges are icons in their communities.



Figure 1: Sunshine Skyway Bridge: Icon for Tampa/St. Petersburg, Florida.

Serving as an icon does not provide any transportation function for a given community. However, a bridge that is considered aesthetically pleasing by its community becomes a source of great pride for those individuals. This helps in increasing tourism and potential economic development as well as improving the quality of life for the local residents.

CREATING BRIDGE AESTHETICS

There are a number of factors that are considered when developing bridge aesthetics. Concepts are evaluated based on shapes, shadows, colors, textures, vistas, native materials, lighting, and aesthetic features. The views of and from the bridge are considered from different perspectives. By creating a theme for the project, concepts can be evaluated based on how well they adhere to the theme.

During conceptual development, a bridge is considered a work of art if it can satisfy the following conditions:

- Be functional – fulfill the transportation needs for the project
- Be economical – design within the owner's budget

- Satisfy the cultural needs of the community – involve the local public to determine what they believe this bridge should be
- Be in harmony with the environment – create a bridge that belongs in its surroundings

It is a common misconception that aesthetics contradict the first two of these criteria – function and economy. In actuality, bridge aesthetics are derived from the careful selection of structural shapes. Extraordinary aesthetics evolve from the proper proportioning of elements, which is born naturally from the optimization of structural design. This combined with a keen attention to detail will result in a bridge that is optimized with regard to function, sensitive toward economy, and aesthetically pleasing in its form and detail.

In selecting structural forms, concrete is an ideal material for creating unique shapes. Concrete can be molded into virtually any shape with minimal increase in cost. Structurally, the shapes will behave as conventional reinforced or prestressed members, so the design is typically not more complex than a traditional shape. The concrete shapes can be molded in keeping with a given project theme or to harmonize within the environment.

Similarly, concrete can be given textures, patterns, and colors simply and economically. Form liners are readily available in standard patterns and custom designs. Color can be applied on the surface with a stain or coating or incorporated into the design with admixtures to make an integral color. Both color and texture can be achieved with minimal impact to the construction methods or schedule. Color and texture, when combined with specialized shapes, can be used to achieve economical, constructible and aesthetic solutions.

CASE STUDIES: CREATING BRIDGE AESTHETICS WITH CONCRETE

The following projects are presented as examples of how unique concrete shapes, colors and textures have been utilized to create aesthetic bridge designs.

LINN COVE VIADUCT, NORTH CAROLINA

The Linn Cove Viaduct wraps around Grandfather Mountain as a part of the scenic Blue Ridge Parkway. The rugged and environmentally sensitive terrain introduced many challenges into the construction of this portion of the parkway. It was decided to utilize one-directional progressive cantilever construction – the first application of this type of construction in the United States – so that the project could be built from the top to protect the environment. By using precast concrete, the segments could be tailored to create the horizontal s-curve that allowed the bridge to hug the side of the mountain.



Figure 2: Linn Cove Viaduct: Built from the top to protect the environment.

By protecting the environment and building alongside the mountain, the bridge was able to blend with the surroundings. This was further enhanced by the details of the shapes and concrete design. The precast concrete pier shape was developed with multiple concave faces to simulate the surfaces of the boulders on the mountain. Additionally, the concrete mix included black iron oxide, which created a marbled effect that matched the color and appearance of the concrete to that of the stone.



Figure 3: Linn Cove Viaduct: Concrete mix designed to blend with the mountain.

The Linn Cove Viaduct has received 12 design awards for the Federal Highway Administration and the National Parks Service. One of these awards is the inaugural 1984 Presidential Design Award through the National Endowment for the Arts. President Ronald Reagan, in presenting the award to FIGG, said "Linn Cove Viaduct is not just a roadway on North Carolina's Grandfather Mountain; the viaduct has been designed so that it belongs to, and is a part of, the mountain."

NATCHEZ TRACE PARKWAY ARCHES, TENNESSEE

The sculpted shapes of the Natchez Trace Parkway Arches create a work of art in this rural community near Nashville, Tennessee. This first-of-its-kind precast segmental arch has received 13 design awards including the 1995 Presidential Award through the National Endowment for the Arts. The main span arch has a 582' span with a side arch of 462'. The arches themselves are unique in that the typically seen spandrel beams have been removed, creating a single load point at the top of each arch. This resulted in a very open, uncluttered appearance by minimizing the number of elements in the structure.



Figure 4 – Natchez Trace Parkway Arches: First precast segmental arch in the U.S.

The concrete shapes of the arches and the piers vary proportionally with increasing height. The variable depth superstructure maintains a constant web slope, resulting in a variable width for the bottom soffit of the box girder. The project demonstrates that artful design can be achieved for a reasonable construction cost. This bridge was completed for \$11.3 million.

BROADWAY BRIDGE, FLORIDA

The Broadway Bridge in Daytona Beach, Florida was completed in July 2001 for the Florida Department of Transportation. The bridge has 262' typical spans with a variable depth box girder superstructure. The community selected a theme of "Timeless Ecology" for their project, and the design demonstrates a great attention to detail in keeping with this theme. One example of unique concrete applications is in the pedestrian railing, where form liners were used to cast seashell and wave motifs in the railing to coordinate with the ecology theme.



Figure 5 – Broadway Bridge: Recipient of 8 major design awards for FDOT.



Figure 6 – Broadway Bridge: Unique aesthetic details created with concrete shapes.

JFK LIGHT RAIL SYSTEM, NEW YORK

The JFK Light Rail System in New York City consists of nine miles of elevated structure in and around the congested JFK Airport. This project connects the various terminals in the airport to the subway system, commuter rail stations, long-term parking, and airport office buildings, all of which were previously separated from the Central Terminal Area.

Due to the high profile nature of this project, the Port Authority of New York and New Jersey wanted to create aesthetic bridges that were also built quickly and economically. The precast concrete segmental design was created with a sleek box girder superstructure that would be adaptable for construction within the congested areas and would also produce continuous smooth lines to enhance the aesthetics.

The concrete was specifically designed to ensure a uniform appearance of the color. The materials for the concrete – cement, sand, aggregate, and admixtures – were specified from the same sources and mixed in the same proportions. Concrete was mixed in three locations: the precast superstructure segments were cast in Virginia, the piers were cast-in-place on site, and the superstructure closure pours were hand mixed on the bridge deck. Despite the three locations, different crews, and variable conditions, the resulting concrete has the same color and appearance throughout the project. This demonstrates that an attention to detail with regard to design can drastically improve the aesthetics of bridges.



Figure 7 – JFK Light Rail System: Concrete mix designed for uniform concrete color.

LEE ROY SELMON CROSTOWN EXPRESSWAY, FLORIDA

The Tampa Hillsborough Expressway Authority (THEA) wanted their new 5-mile extension of the Lee Roy Selmon Crosstown Expressway to be the “Bridge to the Future”. Their desire was to build a unique addition to their toll facility that was functional, cost-efficient, and aesthetic. These criteria led the designers to a precast concrete segmental bridge with 142’ typical spans and a sculpted superstructure shape. Casting of this shape was no different than casting any other box girder section. Once the forms were made, the casting continued as with a more standard cross-section. The project is currently under construction and will be completed in 2005.



Figure 8 – Lee Roy Selmon Crosstown Expressway: Under construction, showing unique sculpted superstructure shape.



Figure 9 – Lee Roy Selmon Crosstown Expressway (rendering).

MAUMEE RIVER CROSSING, OHIO

The “Theme of Glass” was selected through the public involvement process for the Maumee River Crossing in Toledo, Ohio. This \$220 million bridge project will be the largest ever completed by the Ohio Department of Transportation. To implement this unique theme, a special pylon shape was developed to reflect the angular nature of glass. The multi-faceted pylon varied in cross-section through its entire height. On the upper portion of the pylon, the theme was further integrated by using glass on all four faces. Behind the glass are LED lights that can be customized for specific events or occasions. The project is currently under construction.

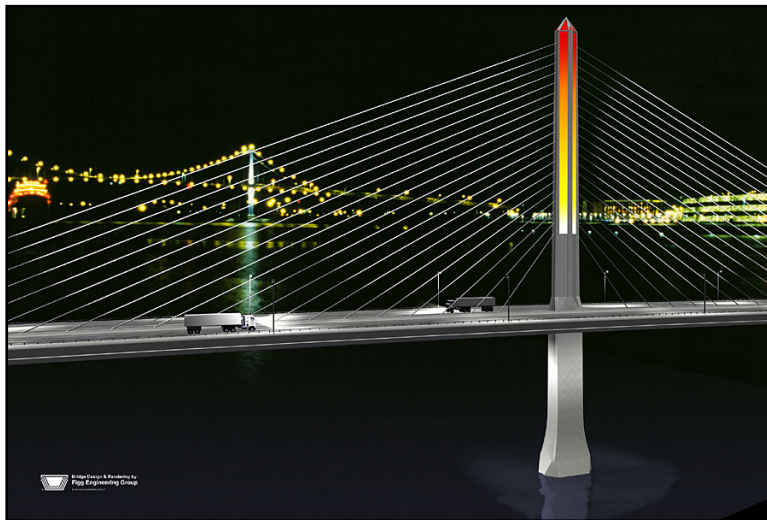


Figure 10 – Maumee River Crossing: Pylon incorporating “Theme of Glass”

INDIAN RIVER INLET BRIDGE, DELAWARE

The Indian River Inlet Bridge will replace an existing bridge in a scenic recreational site in Sussex County, Delaware. The site conditions required a 1,000’ main span and special attention to bridge aesthetics. Through an extensive community involvement process, a theme of “Harmony with Nature” was selected. This theme was introduced into all aspects of the design, including structural shapes, concrete color, and other aesthetic details.

The structural type for the bridge was selected as a concrete cable-supported arch with a single plane of stays anchored in the center of the bridge deck. The arch cross-section has an organic shape with rounded edges on the top and bottom and sloping faces that open toward the sky, corresponding with the theme of nature. The superstructure cross-section is created in free-flowing curves, in keeping with the organic qualities of the natural environment.

Concrete details are used in addition to the structural shapes to create an integrated theme. The color of the concrete surface coating was selected to identically match the native sand

from the beach so the arch would appear as if it were “born of the earth”. The sidewalk concrete surface will be textured with sand and patterns of seashells, grasses, and bird tracks, so pedestrians will feel as if they have never left the beach. Oceanfront landscape patterns will adorn the sides of the abutment and retaining walls to mimic the view seen from the site.

These details are easily incorporated into the structural design and construction due to the flexibility of working with concrete. The Indian River Inlet Bridge will be under construction starting in 2005.



Figure 11 – Indian River Inlet Bridge: Theme of “Harmony with Nature”

CONCLUSIONS

Through this analysis of successful bridge projects, it has been demonstrated that concrete can be used in a variety of applications to create and enhance bridge aesthetics. Each of these projects discussed has had different criteria, site conditions, and community needs that have all been met with these distinct concrete bridges.

Concrete is a versatile material with regard to design, constructibility, and economy. It can be easily cast into a variety of shapes to create unique and aesthetically pleasing appearances for bridge structures. Coordinated with options for color and textures, there are a limitless number of ideas that can be developed using concrete in bridge design. The application of good aesthetic design principals, engineering judgment, and a commitment to public involvement, combined with the versatility of concrete, result in unique bridges that are true works of art for their communities.