Concrete Bridges in

Florida

A History of Innovation

by Lex Collins, Florida Department of Transportation

Florida has long been famous for its sunshine and beautiful beaches. So it is only natural that most of the state's population is located along the coastline. Florida is the fourth most populous state in the United States, yet it ranks only 22nd in land area. The Sunshine State is also the top travel destination in the world. Because of all it offers, the state's population is growing at a significant rate. All this means that large numbers of bridges continue to be required for so many people living in a relatively small area. However, the same warm weather and salt water that bring people to Florida also combine to create a severely corrosive environment for its infrastructure. Thus, concrete has been and remains a natural choice for the state's bridge designers. Florida has been using concrete for bridge construction for over 90 years. We have a reinforced concrete bridge built in 1915 and a series of precast, prestressed concrete I-beam bridges built in the mid-1950s, all of which are still in service.

Small arch bridge in Mexico Beach is fitting for the site. Photo: PB.

Bow-tie struts in the pylons at Dame Point Bridge are an example of form following function. Photo: HNTB.

Because all bridges tend to be a focal point for the landscapes in which they are placed, the state's citizens demand and deserve attractive structures that enhance their surroundings, instead of dividing and detracting from them. At the same time, public budgets are always tight and owners require bridges that are both affordable and durable. This is one of the major challenges of our day; to help create livable communities as urban areas become more densely populated. Concrete continues to be a versatile, economical, and weather-resistant material for the construction of bridges that are attractive and cost effective throughout the state. One example of an aesthetic, affordable, small structure is the recent replacement of a bridge carrying U.S. 98 in Mexico Beach. The use of a precast concrete arch opens the channel without raising the roadway profile so that local business access is unaffected. Pleasure boats once had to line up to pass beneath the structure, but now the passage is significantly wider because of the thoughtful arch design. On the other end of the spectrum, Florida is home to the longest span concrete bridge in the United States over the St Johns River at Dame Point, near Jacksonville. With a 1300-ft cable-stayed main span, this bridge is another example of an elegant design that meets the needs of the public.

Florida Embraces New Ideas

Because much of Florida's 1100 miles of coastline are protected by barrier islands on which people live, work, and vacation, many of the major water crossings in the state are between these islands and the mainland. The navigable Intracoastal Waterway is often spanned by these bridges, so the channel spans need to be longer than the typical shallow water approach spans. As Florida's population growth began to accelerate at a rapid pace in the late 1950s, engineers were faced with finding affordable, durable bridge types for its salt-water crossings. With the advent of prestressed concrete and the standardized AASHTO I-beam sections in the 1950s, they had a tool with which to construct the approach spans quickly and efficiently. At that time, the main spans were typically constructed using steel beams or trusses when they had to span more than about 120 ft. Moveable bridges were also often used, but as vessel and vehicular traffic increased, the inconvenience and expense associated with movable spans also increased.

In the late 1970s and early 1980s, U.S. 1 was being reconstructed out to Key West using a new technology for the United States: segmental concrete construction. Most of the longer bridges between the islands in the Keys were constructed using precast segmental box girders erected with the span-by-span method. This series of bridges was the first large-scale use of precast span-by-span construction in the world, and it introduced the economy of precasting continuous bridges to long viaducts in Florida. Then, the replacement of the Sunshine Skyway Bridge used span-by-span box girders spanning 135 ft in the high-level approaches, balanced cantilever spans of 240 ft in the main unit, and a cable-stayed main span of 1200 ft; thereby, proving that segmental

The versatility of precast segmental concrete was proven with the Skyway Bridge replacement. Photo: FIGG.

Spliced beams continue to be economical for main-span construction. Photo: PB.

Entire spans were moved during the I-10 repair.

Self-Propelled Modular Transporters moved spans on land for the Graves Avenue replacement.

concrete construction can be an economical method for virtually any span length. Soon, precast segmental boxes were also being used for long viaduct structures on land, as well as curved ramps at interchanges. The economical use of these various types of precast, segmental box girder bridges during the 1980s showed that Florida's large Intracoastal Waterway crossings could be constructed using concrete box girders in place of steel girders or trusses.

In the early 1980s, the Florida Department of Transportation introduced its bulb-tee girders, which were more efficient than AASHTO beams. These allowed for longer span lengths or fewer beam lines for Florida's simple-span, prestressed beam construction. Later in the 1980s, Florida's bulb-tee girders were married with segmental concrete design and construction techniques to form spliced bulb-tee spans. Early forms of this bridge type consisted of simply splicing girders at the piers with cast-in-place joints and continuous post-tensioning. Later, haunched pier segments were connected to standard bulb-tee drop-in segments with post-tensioning to form continuous three- to five-span units. These haunched, spliced girder units continue to be routinely constructed over the Intracoastal Waterways and navigable rivers. This type of segmental construction has proven to be extremely versatile and cost effective when the aesthetics of a box girder are not warranted. Main span lengths of 200 to 250 ft are typical, though the longest spliced girder span in the state is 320 ft. More recently, Florida's standard depth bulb-tee beams have been spliced in the same manner to provide 180 ft spans for standard highway overpasses. These longer spans have become increasingly necessary in urban areas, which require provisions for future widening of the interstate combined with increased clear zones to abutments.

In the late 1990s, Florida developed its concrete U-beam series, modeled after the U-beams that were being used in Texas. With no external diaphragms, wide girder spacing, and capable of simple spans up to about 150 ft, these bridges have an uncluttered appearance when viewed from underneath. They have proven to be quite competitive with steel box girders when enhanced aesthetics are called for in urban areas.

More recently, Florida has led the nation in the development of its structural requirements for post-tensioning materials and methods in order to combat our extremely aggressive climate for corrosion. No longer can grout be mixed on site using cement and water. Instead, prequalified, premixed grout that minimizes shrinkage and bleed water must be used. All post-tensioning ducts must be rigid plastic instead of galvanized metal. Post-tensioning anchorages must be inspected after grouting. Details such as enhanced corrosion protection at anchorages, requirements for anchorage placement, time to grouting, and grout injection/vent locations have been developed to fight corrosion and enhance the durability of the state's post-tensioned bridges. Also, post-tensioning systems must now be tested and approved for leak resistance and all grouting must be done by ASBI-certified grouting technicians. Further, requirements specifying the number of tendons in certain elements have been put in place to ensure that structures have more redundant load paths. All these items combine to contribute to what will be significantly more durable structures for Florida's future.

The graceful 630-ft-long span of the Acosta Bridge, in Jacksonville. Photo: T.Y. Lin International.

The Broadway Bridge pleases both an engineer's and an artist's eye. Photo: FIGG.

Accelerated Delivery

In use since the late 1990s, design-build is now a staple of Florida's construction environment. This system dramatically decreases delivery time, which is a requirement for some construction projects as Florida's population continues to grow at the rate of about 300,000 people per year. Precast concrete, with its relatively short lead times, has been the principal material used in most of Florida's design-build bridges.

In the wake of Hurricane Ivan's strike of the low-lying I-10 bridge over Escambia Bay near Pensacola in 2004, one of the twin bridges was cannibalized by moving entire spans to the bridge that faired better. Though significant portions of the miles of approach spans were damaged, the contractor used huge barge-mounted cranes and self-propelled modular transporters (SPMTs) to replace entire spans and open the one bridge in just a few days. Borrowing on that experience, the Graves Avenue Bridge replacement over I-4 just north of Orlando was built using SPMTs, as well. Old spans were removed in one piece using the SPMTs. Then, the two new bulb-tee spans were constructed off to the side of I-4 and moved in at night in just hours apiece. This type of erection may prove beneficial for congested urban areas where working room is limited and maintenance of traffic is at a premium.

Also, the final replacement bridges for I-10 over Escambia Bay have been constructed in a very short time using many precast concrete components. For the approach trestle spans, concrete cylinder piles support precast bent caps, which in turn, carry simple-span bulb-tee girders. At the taller sections near the main channel, the piles are capped with precast waterline footings. The main span unit is a spliced bulb-tee bridge. Construction of the approximately 3-mile-long twin bridges is on schedule to be completed soon.

Summary

A beautiful bridge can become a true source of pride for a community. Because concrete can be formed into virtually any shape imaginable, it can be used to accurately describe the form follows function requirements of an aesthetically pleasing structure. It is versatile enough to serve in major metropolitan areas as a canvas for artwork, and it can be cast-in-place or precast. Through the years, Florida has readily embraced new technologies and construction methods. Because we construct so many bridges each year, Florida intends to continue leading the way in the development of materials, details, and specifications that ensure durability without undue burden on project budgets. Concrete structures have been and will continue to be a mainstay of the transportation system in the state.

Lex Collins is Assistant State Structures Design Engineer, Florida Department of Transportation.

For more information on Florida's bridges, visit www.dot.state.fl.us.

Florida's

Measure of Prestressed Concrete Products Quality

by Thomas O. Malerk,
Florida Department of Transportation

The Florida Department of Transportation (FDOT) and the Florida Prestressed Concrete Association (FPCA) are working together to develop and initiate a flagship Quality Assurance Program for the production of prestressed concrete products. Through the combined efforts of the state and the prestressed concrete industry, Florida is now striving to further improve upon its existing high standards for prestressed concrete.

FDOT's Quality Assurance Program

The FDOT specifications are now a 100 percent Contractor Quality Control (CQC) system. All materials and construction operations for the state's highways and bridges are produced with the contractor and producer assuming direct responsibility for the quality of the product. The Florida prestressed concrete industry was the first in the state to implement producer CQC.

Prestressed concrete plants that produce products for FDOT construction projects are required to be on the current certified plant list of the Precast/Prestressed Concrete Institute (PCI) for the groups and categories of products that they produce. In addition, the plants are required to submit their Quality Control Plan (QCP) for department review. The QCP includes a copy of the plant's PCI approved Quality Systems Manual (QSM) and any additional specifications or contract document requirements that are not contained within the QSM. Upon the department's acceptance of a plant's QCP and satisfactory initial and annual inspections, the plant is qualified to begin or continue the production of the certified categories of prestressed concrete products for department projects.

Measuring Quality in Prestressed Concrete Products

Major defects are a possible occurrence in prestressed concrete products during the production process. These defects are usually correctable and the proper correction often results in the department's final acceptance of the product. The department, however, does not consider the quality of a corrected product to be as good as the quality of a product that needs no correction. Since the department seeks to place products with the very best quality into service whenever possible, the number of corrected or defective products must be kept to a minimum. In order to encourage prestressed concrete producers to establish and maintain efforts that minimize defects, the department compiles defect rates on a semiannual basis for each prestressed concrete product group. At each plant location, these rates are used as the basis for establishing a "Defect Rate Limit." A defect rate limit is the defect rate that a producer must stay below in order to achieve the required level of product quality that is acceptable to the department.

FDOT compiles the results of the defect rate data for each plant. The defect rate is then calculated and summarized every 6 months, referred to as the monitoring period, beginning July 1 each year. To ensure confidentiality, plants are assigned a blind plant number that is scrambled with each reporting period. An individual plant's defect rates and defect rate limit are reported to the plant only. A summary table, which is made available to all plants, shows prestressed concrete products organized by product type that have similar casting, stressing, and handling characteristics and, therefore, have defect rates and a defect limit that are also characteristic of the group.

Quality Results from a Quality Product

Conceivably repeated measures that exceed the defect rate limit would lead to the conclusion that a plant's QCP was inadequate for the continued production of acceptable products, and certainly inadequate for the production of high-quality products. However, the department has found the measures of quality to be far more valuable as a tool for continuous improvement.

The FDOT and the prestressed concrete industry are using these measures of quality to identify problem areas and to search for the root cause. Consistently measuring quality has shown that assumptions are often wrong. Problems are now known to arise from many parameters that can include the design, materials, production process, or any related combination. These measures also show that the overall quality of prestressed concrete products have been rated as very good to excellent with many of those products produced with no defects at all.

What's Next?

FDOT and FPCA's experience in the measurement of prestressed concrete product quality is proving to be a valuable tool in the process of continuous quality improvement. What began as possibly a negative program focused on defects is now viewed as a positive program that provides valuable insight into prestressed concrete products. The FDOT and FPCA's joint partnership has set the stage for a new era of teamwork in identifying and addressing problems where measures show they exist.

Thomas O. Malerk is Director, Office of Materials, Florida Department of Transportation.