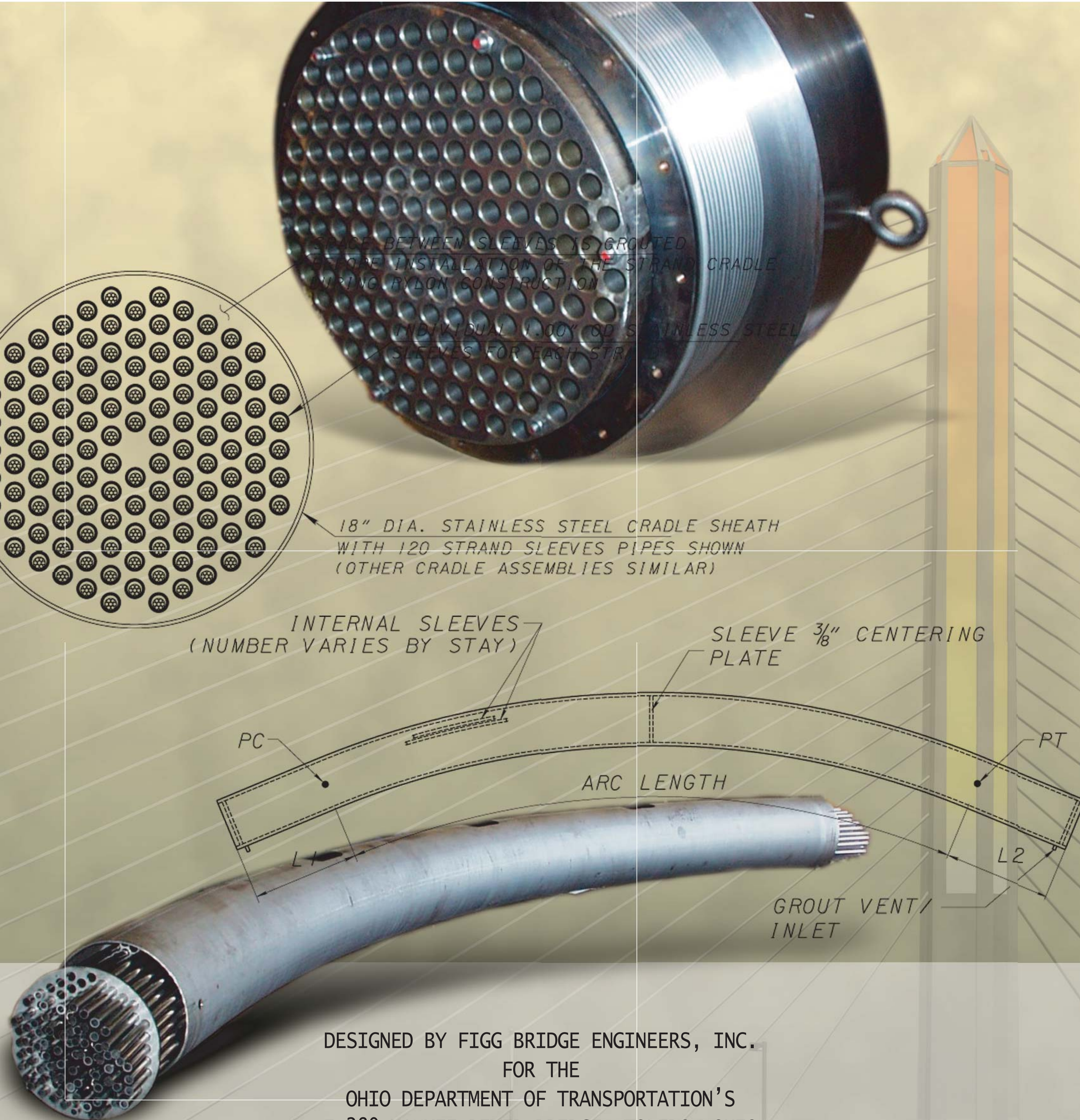


DESIGNED BY FIGG BRIDGE ENGINEERS, INC.
FOR THE
OHIO DEPARTMENT OF TRANSPORTATION'S
I-280 MAUMEE RIVER BRIDGE, TOLEDO, OHIO

NEW CABLE-STAY CRADLE SYSTEM

New Cradle Stay System to Improve and Save Money for Future Cable-Stayed Bridge Designs....Worldwide

INTRODUCTION

December 2001 brought the successful completion of all testing associated with the innovative new cradle stay system designed by Figg Engineering Group (FIGG) for initial use on the Maumee River Crossing Bridge (1.2 million square foot bridge deck) in Toledo, Ohio for the Ohio Department of Transportation (ODOT).

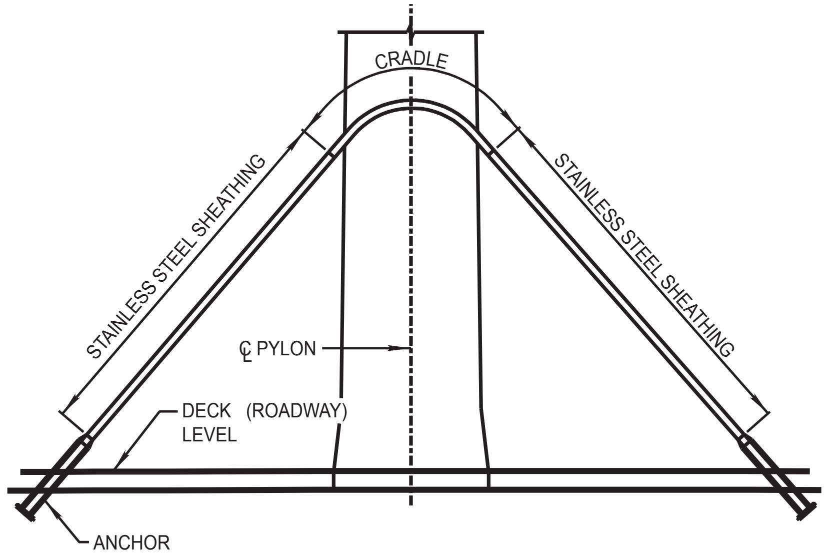


Figure 1. The new cable stay system provides a continuous strand from the bridge deck, through the cradle on the pylon, and back down to the bridge deck.

The new cradle stay system provides a continuous cable stay from the bridge deck, through the cradle on the pylon and back down to the bridge deck (Figure 1). Each strand passes through it's own individual stainless steel sleeve in the cradle assembly (Figures 2 and 3) and is housed within stainless steel sheathing for it's free length.

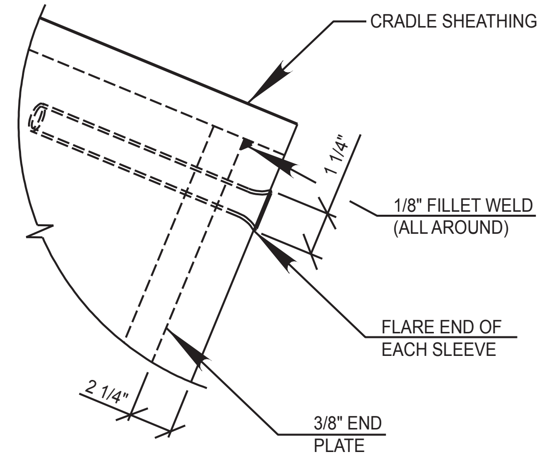
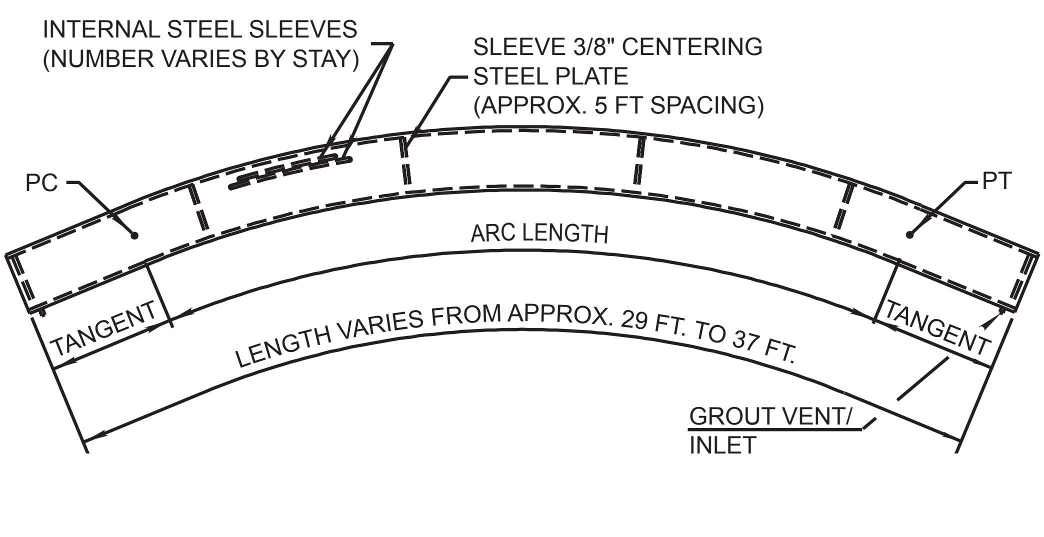


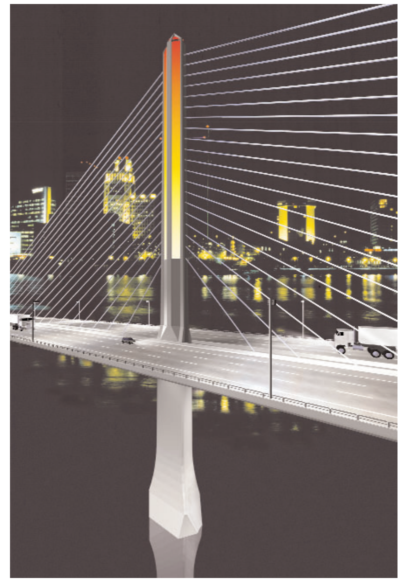
Figure 2. Cradle detail showing flared end of strand sleeves designed to protect epoxy coating on strands.

The primary benefit of the new system is to allow engineers to design pylons that will be slender and aesthetically-pleasing by eliminating the anchors previously required in a typical pylon design. Additional benefits include cost-effectiveness, reduction in required construction time and the provision of 40 test strands which may be fully removed and inspected at 25 years, 80 years, etc. to verify the condition of the stays, without compromising the design's integrity.

Figure 3. Each strand passes through it's own individual stainless steel sleeve in the cradle assembly and is housed within stainless steel sheathing for it's free length.



Testing of the new system included material/production/acceptance testing for the components of the stay cables, along with fatigue and strength testing of full-scale cable assemblies and was conducted by CTL (Construction Testing Laboratories, Inc.) under contract to ODOT. All tests were conducted in accordance with the PTI requirements and reviewed in advance by the FHWA.



The Maumee River Crossing has a single pylon with a single plane of stays. The 156 strand cables are the largest used on a cable stayed bridge.

MAUMEE RIVER CROSSING - an initial application

For the Maumee River Crossing, the main span cable -stayed unit consists of a single pylon with a single plane of stays and a 612'-6" span on each side of the pylon. During community design charettes, led by Figg Bridge Engineers, the participants selected the theme of glass, based on the city's rich heritage in the glass industry. The decision to incorporate glass into the bridge design was manifested by facing four sides of the top 196' of the pylon with glass. Without the new cradle system, this aesthetic treatment of the pylon would have been impossible, as would the slender design of the pylon itself. Utilization of traditional anchor systems would have required the pylon to be at least an additional ten feet in width. The series of 20 stay cables, each inside stainless steel sheathing for their free length, will run through the cradle within the pylon to support the bridge deck. Stay sizes vary from 82 to 156 strands. *The 156 strand cable is the largest ever used on a cable-stayed bridge.* This stay cable size and load capacity is a significant increase over the largest US stay cables in existence. Additionally, the Maumee River Crossing includes the use of stainless steel material in lieu of HDPE or carbon steel for the sheathing and incorporates epoxy-coated strands.

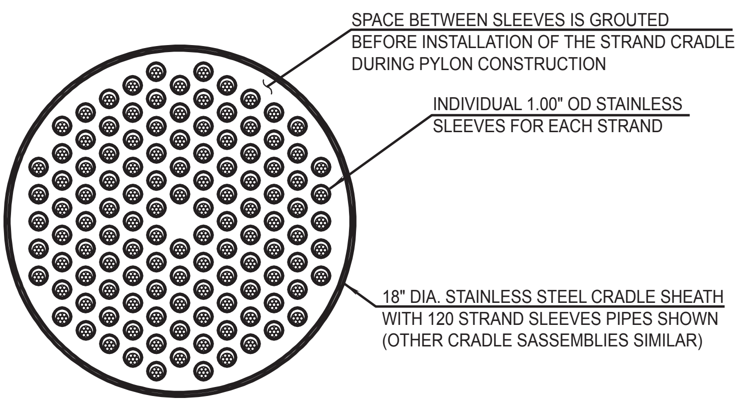


Figure 4. Within each cradle, sleeves separate the individual strands. All strands run parallel from deck level anchor to deck level anchor.

TESTING

Given the significance of the new system, along with additional innovations on the Maumee River Crossing, the Ohio Department of Transportation (ODOT) and the Federal Highway Administration required a comprehensive testing program before approval to proceed. ODOT pre-purchased the stay cable system from DYWIDAG-Systems, International, USA, INC, (DSI), including all strands, anchors, sheathing and miscellaneous components for the testing phase. The stay cable system will be provided to the successful Contractor. Under this delivery system, the Contractor is not responsible for the stay-testing program. (This pre-purchase of the entire stay system is a first for America and will become a FIGG standard on future cable stayed bridge to save money and time.)

The acceptance testing program consisted of the following tests:

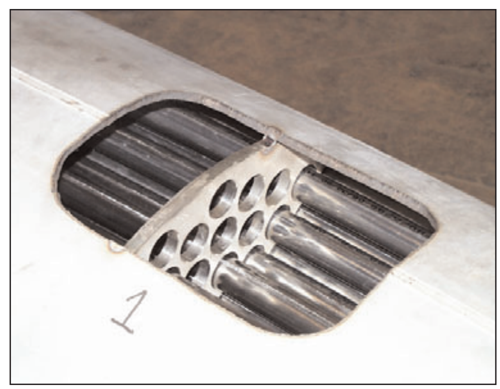
- **Axial fatigue and ultimate static test of an 82-strand specimen** that is fully representative of all materials, details, fabrication and assembly procedures proposed for production anchorages. Each specimen consisted of two anchorages with a clear space of approximately 180 inches between anchor faces.

- **Axial fatigue and leak test of a 119-strand specimen.** In addition the the fatigue testing of the specimen and, as part of the corrosion protection qualification of the anchorage assembly, the stay cable anchorage specimen, complete with transition zone, a minimum of one meter of free length, and all seals, coatings and coverings that will be installed in the actual application were subjected to a leak test.

Full scale test of the 119-strand cradle in the CTL testing lab. The cradle stay system was pre-purchased from DSI.

- **Axial fatigue and ultimate static test of a 156-strand specimen** (a world record for stay size) that is fully representative of all materials, details, fabrication and assembly procedures proposed for production anchorages. Each specimen consisted of two anchorages with a clear space of approximately 180 inches between anchor faces.

- **Single strand cradle testing.** Prior to conducting a test of the full size cradle specimen for the combined axial/flexural fatigue test, three similar tests (each with a different radius) were conducted one one-strand specimens. The purpose of these single strand tests was twofold. First, it provided a value for the friction coefficient between the epoxy-coated stay cable strand and the stainless steel sleeve inside the cradle. Second, it provided an initial indication of the fatigue behavior of the epoxy-coated stay cable strand interaction with the stainless steel sleeve.



119-strand test cradle centering plate and interior sleeves.

- **Axial/flexural (Cradle Test) test of a 119-strand specimen.** The specimen for the test was fully representative of all materials, details, fabrication and assembly procedures proposed for the production anchorages and stay cable cradles. The specimen consisted of two anchorages and one complete stay cable cradle assembly.

Acceptance testing was done in accordance with the 1993 PTI Recommendations for Stay Cable Design, Testing and Installation (and included the leak test which was adopted from the 2000 edition). All testing was completed successfully in early December, 2001.

OUTCOME

The successful completion of the testing phase validated the FIGG-designed cradle system and allowed the Maumee River Crossing to move forward to bid on January 17, 2002. It also offers ODOT many benefits:

- Cost-effectiveness with savings of over $3 million on the Maumee River Crossing Bridge. When cable stay anchors are used in pylons, the pylons need to be large enough to permit internal access during construction for stressing operations of the stays and for inspection of the anchors after construction. Also, significant additional reinforcing is needed to overcome the large splitting stresses in the concrete pylon. By using our cradle internal to the pylon, access requirements are eliminated allowing the use of a smaller pylon cross section, saving not only concrete and steel, but also construction time. Additionally, the unit cost of a cradle is lower than that of the two anchors it replaces.
- Perceived concerns about strand-to-strand interaction in the curved portion of the cable are eliminated by the use of individual sleeves inside the cradle for each strand. All strands run parallel from anchor at deck level to cradle to anchor at deck level.

- Allows use of a continuous primary tensile element from deck level anchor to deck level anchor.

- The load transfer to the concrete pylon occurs in a natural compressive contact stress applied vertically to the pylon. Not only is this a more desirable structural condition, but it also saves time and money since no additional reinforcing is required in the pylon to control the high splitting forces introduced into a pylon by the use of anchors in the pylon.

- Provides the flexibility of 40 "reference" strands that can be removed in entirety at desired time intervals for inspection...15 years, 50 years, etc. so that ODOT will always know the condition of the stays. This is the only cable stay system with this “fool proof” stay inspection system.

CONCLUSION

“The new system that we have designed will revolutionize the design of cable-stayed bridges. This system provides a solution that eliminates stay anchors in the pylon and allows designers to create slender pylons with unique shapes, saves money and provides pleasing aesthetics. It also allows for easy inspection of the stays at 20 years, 75 years, etc. in the future.”, W. Denney Pate, P.E., senior vice president and principal bridge engineer at Figg Bridge Engineers.

The innovative cable stay cradle system designed by Figg Engineering Group, initially for the Maumee River Crossing, and for use on future cable stay bridges, will revolutionize cable stay bridge design. It will allow this type of bridge to be even more economical, thus attractive for many major spans around the world. The elimination of pylon anchors allows the designing engineer to utilize a wide variety of shapes and aesthetics in designing the pylons of cable-stayed bridges. This greater freedom will encourage engineers to design bridges as art.


18" DIA. STAINLESS STEEL CRADLE SHEATH
WITH 120 STRAND SLEEVES PIPES SHOWN
(OTHER CRADLE ASSEMBLIES SIMILAR)
INTERNAL SLEEVES
(NUMBER VARIES BY STAY)
SLEEVE 3/8" CENT
PLATE
PC
ARC LENGTH
GROUT VENT
INLET