Highlights

- An Engineer's View of the St. Louis Arch
- Grades K – 5 Art and Essay Contest

Items

- Original Structural Solution for an Unusual Structure
- Bridge Theme for 3rd Annual Art and Essay Contest
- Guest Commentary by Christine Beck

SPANS

Hillsborough County Florida
Public Works Department
Bridge Team

The Quarterly Newsletter of Inspired Bridge Technologies *July, 2003, Third Edition*

Jefferson National Expansion Memorial

(The Saint Louis Arch)

An Architect's Dream, An Engineer's Reality…

Eero Sararinen was born in 1910, Finland, to an architect father and a mother who was an accomplished sculptor. The family immigrated to the USA in 1923. Eero attended the Yale School of Architecture from 1930 to 1934 and after a two-year fellowship in Europe, he returned to the States to join his father's architectural firm as a partner in 1936. He entered the Jefferson National Expansion Memorial competition in 1947 seeking his own identity.

The people of St Louis had been trying to build this memorial since well before the war. Now, with a president from Missouri, they got solid financial backing from the U.S. Government and the project subsequently fell under the aegis of the National Park Service. The Memorial was to honor the westward movement, through St Louis, of the hundreds of thousands of brave souls who populated and developed this great land West of the Mississippi River. The selection was made and Eero Saarinen's solution was the winner. So, the prize was mailed to Eliel Saarinen, Eero's father.

In 1961, Eero choose the consulting engineering firm of Fred Severud of New York City to make his stainless steel clad arch stand up. A principal of this office was Hannskarl Bandel, D. Ing., P.E., who came to the U.S. from post-war Germany with two suit cases full of books, no money, but with the hope of designing one of America's great suspension bridges. With no luck landing a job with a bridge design office, he quickly became recognized by the architectural community as a very astute and creative structural engineer.

Dr. Bandel and Mr. Sararinen worked well together. The architect was trying to show the engineer the desired shape through the analogue of a chain suspended between his two hands. The architect knew in his

mind the shape, but that chain would not give him the satisfaction that he wanted.

Dr. Bandel asked for the chain and brought it back days later and, much to Eero's glee, the chain now had the desired catenary shape. Hannskarl had taken the chain and replaced the constant sized links with variable size links (with variable weights) in order to effect this shape. This translated into an arch whose cross section was an equilateral triangle having one leg on the outside of the arch and the other two legs focusing inward toward the locus of the arch. The sides vary in dimension from 54 feet at the base to 17 feet at the apex. The back to back dimension across the base of the arch is 630 feet and the height from grade to the top is also 630 feet. Dr. Bandel's structural solution uses Saarinen's stainless steel cladding as a ¼" thick sheet of stiffened plate for an outer structural membrane, and an inner skin of 3/8" thick stiffened carbon steel sheets (Fig 4).

This double skin is separated by an annular space filled with 5,000 psi, post tensioned concrete up to the three hundred foot level. The next 100 feet maintains the three foot separation of skins only with steel diaphragms. The remaining 230 feet of arch has the steel plates strutted apart with a space only 7-3/4" wide.

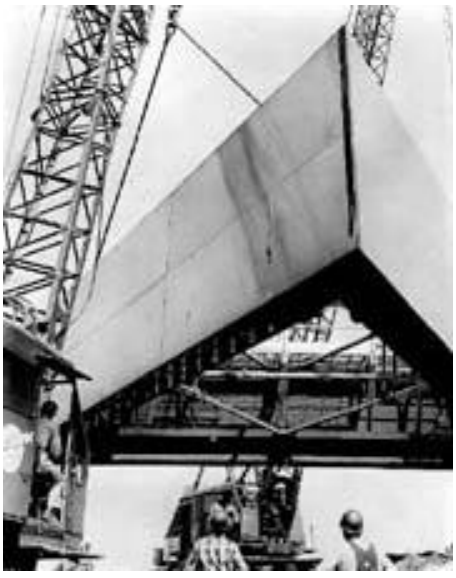


Fig. 1, Crawler cranes place the first 72 Feet.

It seems the media got wind of these engineering designs and went to the Mayor requesting that the closure be done in the daylight so they could record the historic event with their cameras. Of course, the Mayor relented and asked that the schedule be changed. Dr. Bandel agreed, disregarding the impending consequences.

Crawler cranes (Fig. 1) erected the segmented sections up to the 72 feet level. Rails were affixed to the flat, outer face of these triangular tubes and carried the 100 Ton climbing cranes up the backs of these cantilevers (Fig. 2). Dr. Bandel's calculations called for inserting the closure segments early in the morning when the temperature in the entire structure had equalized, thus facilitating closure of these two giant steel fingers reaching out in the dawn (Fig. 3).

Fig. 2, Climbing cranes on the back of the cantilevers.

These cantilevers were aligned for easy closure before daylight. But, as the sun rose, the juxtaposed elements began to reflect heat in different degrees from different areas with a subsequent differential movement preventing closure.

The fire department was called-out, literally, and told to direct streams of water onto the back of the drooping cantilever. This measure lead to the gratifying result of seeing the cantilever slowly rise into a matching position, permitting the closure segments to be eased into place.

Fig. 3, The workmen' elevator car would rise up the creeper derrick track.

All the structural steel was cut and fabricated in Pittsburg-Warren, Pennsylvania. It was hauled five hundred and seventy (570) rail-miles across the eastern part of the U.S.A. and delivered to the job-site at the west bank of the Mississippi River in St. Louis, Missouri. The one hundred and forty two (142) segments were re-assembled on site and hoisted into place for final welding to the preceding segment. These segments vary in width from 12'-0" to 8'-0" and their weights reduce from a maximum of 50 tons to a minimum of 33 tons. The total weight of the structural steel in the Arch is 5,199 tons which is stabilized by 12,127 tons of concrete between plates up to the 300 feet level. Below grade, the foundation draws the center of gravity of the Arch down to a stable position with 25,980 tons of foundation concrete.

This phenomenally unique structural solution, created by Dr. Bandel, is out of view to the casual observer. From enhancing the analogue with the variable size links in the chain's catenary, to remaining true to the Architect's geometry and vision of stainless steel cladding, he wove a structural solution that maintains the elegance of form striven for by both of these Master Builders.

Moreover, the structure had to

resist the erection loads sustained during construction while the Arch was in its open and weakest configuration. The design wind load of 150 MPH sways the top of the arch 18" about its North-South axis. The design dead and live loads along with the temperature and seismic influences on the stability and strength of the arch were carefully anticipated by the structure devised.

Dr. Bandel has said that he considers the Arch's Tram system the engineering marvel of the Arch. Dick Bowser left the University of Maryland in 1942 to join the US Navy during WWII. He was a second generation elevator man who worked with his Dad in developing an automatic parking garage that would be able to carry automobiles horizontally, vertically and diagonally through a parking structure. This experience lead to a concept. Mr. Browser delivered this

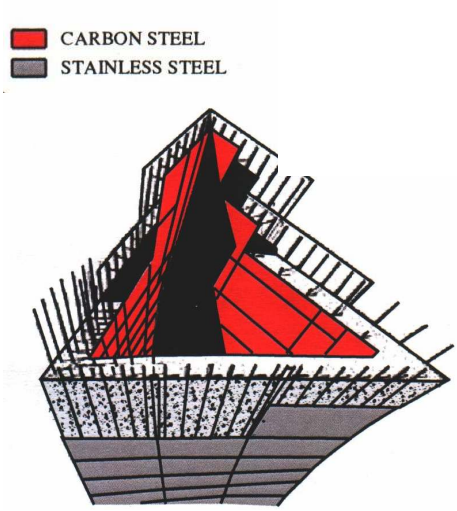


Fig. 4, Cross-section of Arch construction.

concept to the Architect's office where Congressmen, the Mayors of both St. Louis and East St. Louis, the contractor, the engineers, the Director of the National Parks Service and the Architect himself were present.

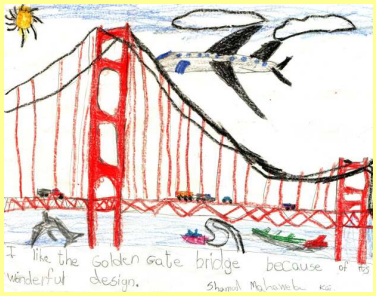
Mr. Bowser spent forty (40) minutes on his presentation and the questions lasted several hours. After the group had been advised that the restaurant could not delay dinner any longer, someone asked, "Mr. Bowser, what are you?" Dick said, "I was sure he was addressing my academic credentials. In an effort not to ruin what I felt was a successful presentation I answered, I'm thirty eight years old. This brought the house down and ended the meeting."

Dr. Bandel was a modest, self effacing gentleman whose work has been silently integrated into the world's architectural landscape. With no self aggrandizing effort on his part, he was nominated and elected into the National Academy of Engineering for his work on the St. Louis Arch.

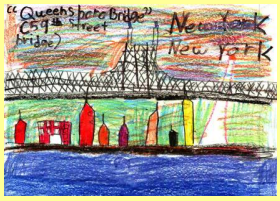
Third Annual Art and Essay Contest Winners
National Public Works Week, May 19 – 23, 2003

*This Year's Theme: **"BRIDGES"***

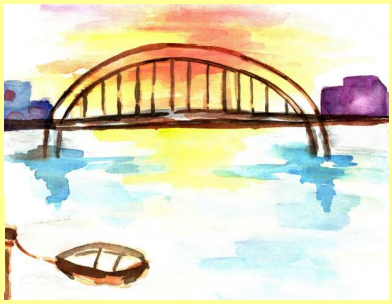
Organized by: Public Works Deparment's Stormwater Section



1st Place K– 2nd grade, *Shamod Mahawela , Tampa Palms Elementary*



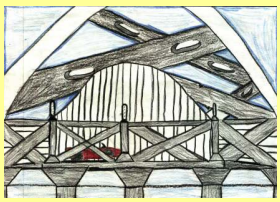
3rd Place K – 2nd grade, *Morgan Deak, Grady Elementary*



1st Place 3rd grade – 5th grade, *Christine Choe, Mary E. Bryant Elementary*

"*What are Bridges?*" -**3rd** Place Essay Contest Winner – by Tara Carrillo, The Cambridge School

"Bridges help connect people to get to know one another. The telephone is a type of bridge that connects people …People can act like bridges too... I think bridges are important for people to get to know each other. There is the telephone, people, and normal bridges. They all help people get to know other people"



3rd Place 3rd grade – 5th grade, *Xavier Mouton, Brooker Elementary-*

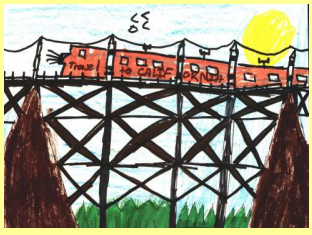
"*Bridges*" - **2nd** Place Essay Contest Winner– by Victoria Barnes, Maniscalco Elem

"…One thing I think about bridges is that it makes traveling easier. Bridges can be long or short. If you are on land and want to go over water to get to the other side, a bridge is good."

2nd Place K – 2th grade, *Catherine Choe, Mary E. Bryant Elementary*

"*What are Bridges?*" - **1st** Place Essay Contest Winner– by Kiona Branham, Villa Madonna School

"Life is an obstacle and trying to get past things in life isn't always easy, but there are a lot of things to help, bridges are one thing. A bridge is something you use to get over something else."



2nd Place 3rd grade – 5th grade, *Zach Jackson, The Cambridge School*

Guest Commentary

By Christine Beck, Chief Assistant County Attorney

"A Litigator's Thoughts About Bridges"

I have been asked to provide a few thoughts about "bridges." I was told that I could have free reign of the subject matter, and that as long as my comments concerned bridges that would be acceptable. Since I was a litigator for twelve years (ten representing the county in all sorts of law suits), my legal mind immediately focused on liability issues. I also considered doing a book review of Bridges of Madison County, a discussion of the card game "Bridge", or an analysis of the partnership between Hillsborough and Pinellas Counties in the operation of the Friendship Trail Bridge, but the legal side seemed the most appropriate.

For those governmental entities having responsibility for bridge maintenance, it is fairly obvious that the failure to maintain a bridge to an acceptable standard of care in accordance with the original design can lead to liability. Frequently, however, plaintiffs will allege a failure to maintain as a way of asserting obsolescence and the need to upgrade. The Florida Supreme Court has made it clear that these allegations will not lead to governmental liability. See *Department of Transportation v. Neilson*, 419 So.2d 1071 (Fla. 1982); *Perez v. Department of Transportation*, 435 So.2d 830 (Fla. 1983).

In Perez, the Plaintiff's vehicle was speeding on a wet roadway, hit the steel grating on the draw bridge portion of the bridge, turned abruptly and struck and vaulted through the pedestrian handrail into Biscayne Bay. The Plaintiff claimed that the Department of Transportation was negligent (1) in designing the bridge; (2) in failing to upgrade and improve the bridge; and (3) in failing to warn motorists of a dangerous condition existing on the bridge.

The Florida Supreme Court held that the Department of Transportation was immune from suit under § 768.28 Florida Statutes for the design of the bridge and for allegedly failing to upgrade and improve the bridge. These are judgmental, planning level decisions for which governmental entities are clothed with sovereign immunity. The Court held, however, that the Department of Transportation could be liable for the failure to warn of a known dangerous condition and allowed the Plaintiff an opportunity to file an Amended Complaint regarding this allegation. Specifically, "when a governmental entity creates a known dangerous condition, which is not readily apparent to persons who could be injured by the condition, a duty at the operational level arises to warn the public of, or protect the public from, the known danger." *City of St. Petersburg v. Collum*, 419 So.2d 1082 (Fla. 1982).

So…..when it comes to bridges there can be no liability for negligent design. However, once there are sufficient facts to allow a jury or a finder of fact to conclude that the State, County or City failed to warn of a known dangerous condition relating to the bridge then liability may attach.

Coming Issues:

- **Firth of Fourth Bridge**
- **Description of County's 241 Bridges**
- **A profile of the 1926 Platt Street Twin Bascule Bridge**
- **A Profile of the 1926 Columbus Drive Swing Span Bridge**
- **Streetcars and Bridges**

This newsletter was produced by:

Bridge Team
Design and Engineering Support Section
Public Works Department
601 E. Kennedy Blvd. 23rd Floor
Tampa, FL 33601
Phone number: (813) 272-5912

Hillsborough County Florida

Editor:
Nils Olsson, P.E., Bridge Team Leader
Phone number: (813)-307-1844
E-mail: OlssonN@hillsboroughcounty.org

Assistant Editor:
Mara Nelson, E.I., Bridge Team

Art/Technical Director:
An-Di Nguyen, Bridge Team

A Special Thanks to our Guest Commentator:
Christine Beck
Chief Assistant County Attorney
CATTY

A special Thanks also to:
Mariana Llanso for choosing "Bridges" as the Theme of this year's Art and Essay Contest, and to Marcia Romero, Leigh Ann Pyron, and Stacy Williams for the technical support provided.