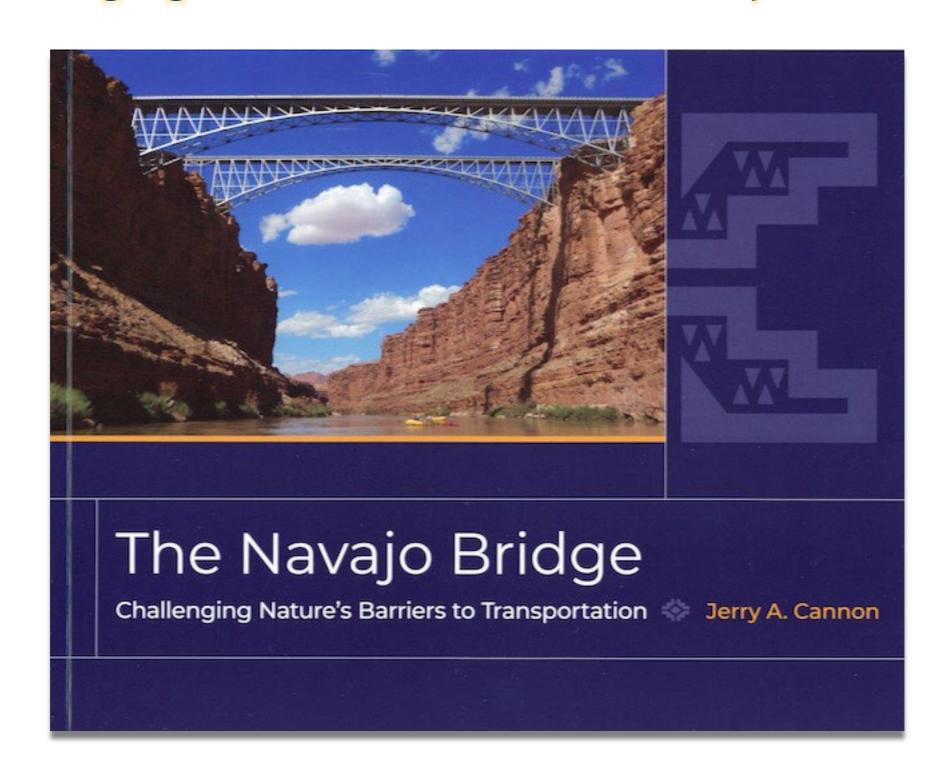
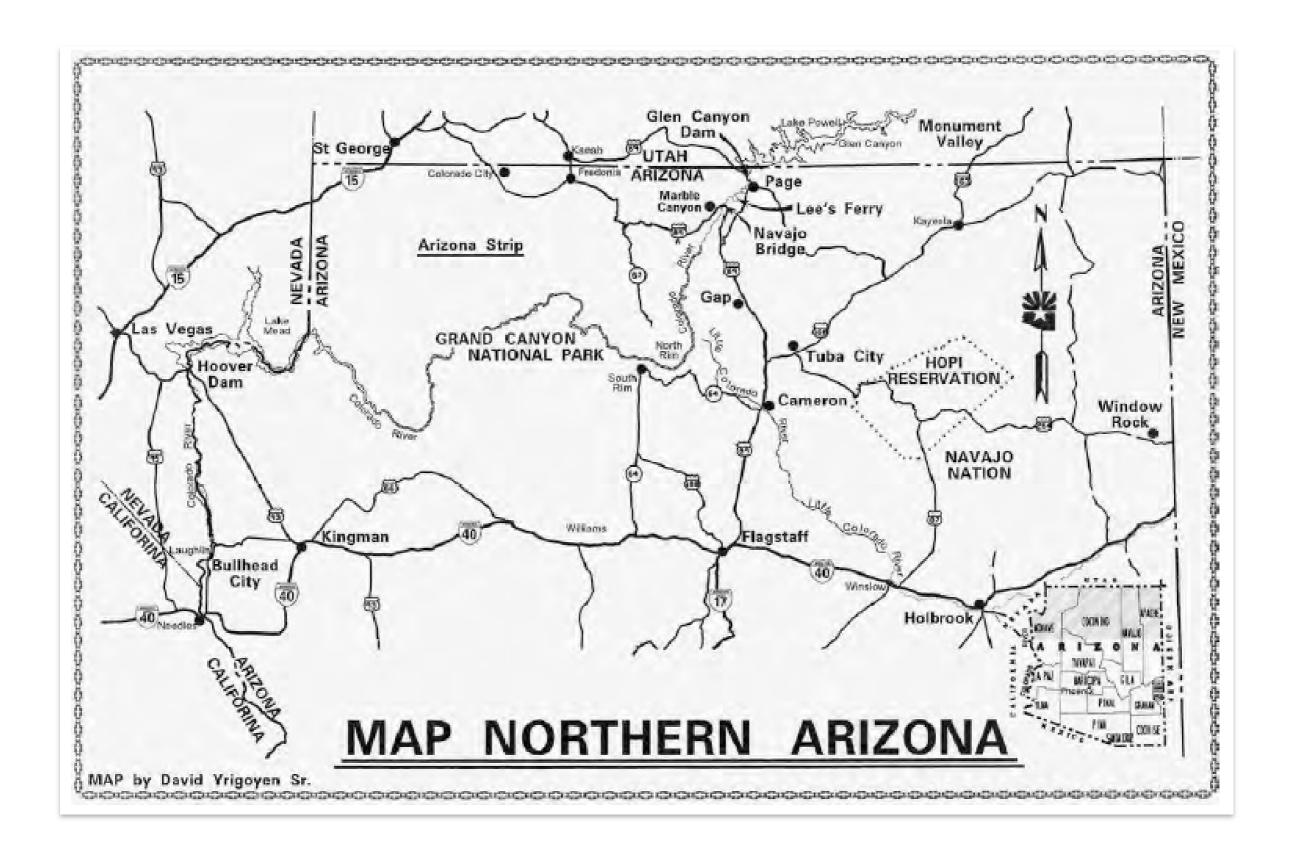
The Navajo Bridge Challenging Nature's Barriers to Transportation





Who Designed Arizona's Bridges



Mill Avenue Construction Site (1928)

Chapter 1 Honoring Two Arizona Engineers

→ Two engineers who distinguished themselves during the early days of Arizona's transportation system were honored posthumously on Friday, March 25, 2016, at the Westin La Paloma Resort, in Tucson, Arizona. The American Council of Engineering Companies of Arizona (ACEC Arizona) presented Legacy Awards to these esteemed engineers, James Bell Girand (1873-1949) and Ralph Austin Hoffman (1894-1967).

James Girand, Territorial Engineer

James Girand was Arizona's first and only territorial engineer, serving from 1909 until Arizona became a state in 1912. He managed the design and construction of Arizona's early highway system with the goal of linking county seats to cities and towns across the territory.

Ralph A. Hoffman, Bridge Engineer

Ralph Hoffman was AHD's chief bridge engineer for 31 years, from 1923 to 1954. During his tenure he planned and supervised the design of every new bridge in the Arizona highway system and was considered one of the nation's finest bridge engineers.

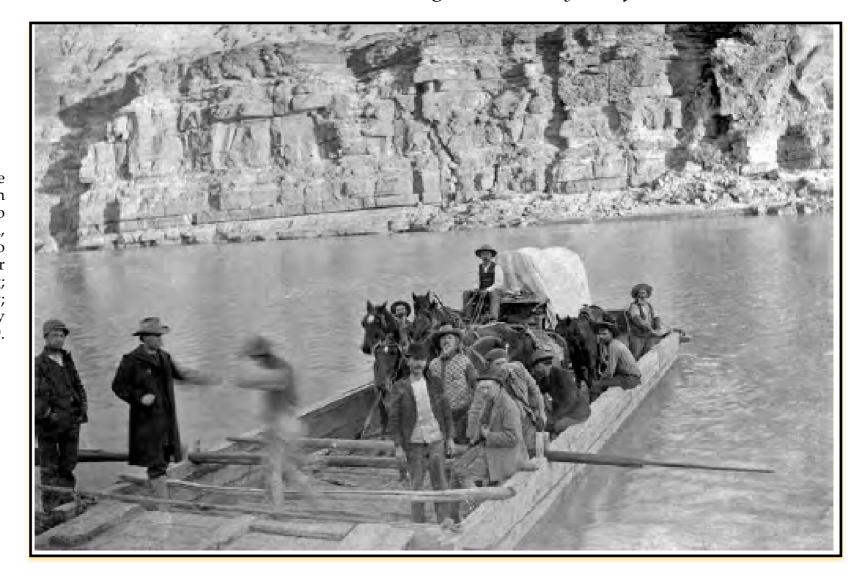
The Ralph Hoffman and James Girand families at the Arizona Transportation Legacy Awards Event in 2016. L-R: Sherry Barrett, Cindy Shepardson, Scott Shepardson, Mary Lou Vaughan (Hoffman's daughter), Mike Girand, Barbara Girand, Jon Girand, and Jerry Cannon.



Chapter 2 Natural Barriers to Transportation

→ In 1926 Arizona State Engineer, William C. Lefebvre, wrote:

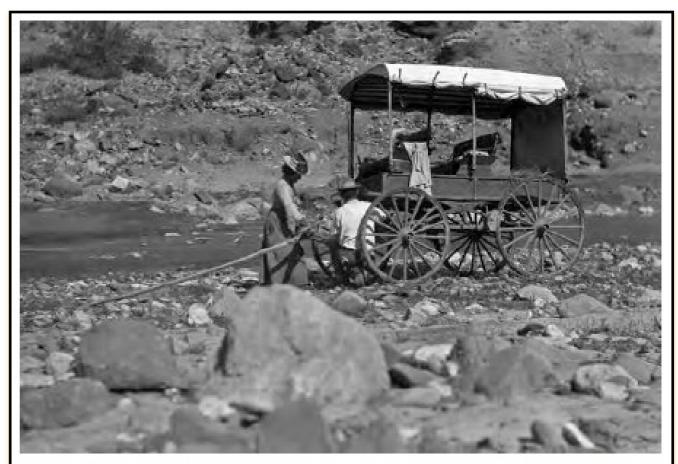
"Nowhere in the United States of America and in very few localities in the world, are there such barriers to road building as these canyons of the Colorado."



Lees Ferry crossing of the Colorado River. The man in the checkered vest is Buffalo Bill Cody, the showman, crossing in 1892. Photo courtesy of Buffalo Bill Center of the West, Cody, Wyoming; McCracken Research Library; MS006 William R. Cody Collection; P.69.1099.

Chapter 3 The White Man's Tourist Bridge

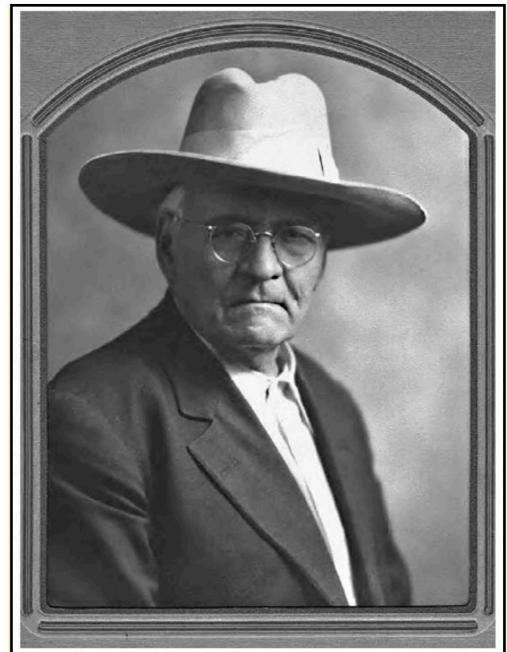
- ◆ Sharlot Hall was the territorial historian and she visited the Arizona Strip in 1911.
- ◆ There was concern that Utah would annex the Arizona Strip as the State of Nevada had earlier done in 1866 to a small piece of the Strip. She was one of the first to support building a bridge over the Colorado River for connecting the Arizona Strip to the rest of the state.
- ◆ Late in 1923, Gov. Hunt of Arizona took his first trip to the Arizona Strip; he came back saying that two bridges were needed – one at Lees Ferry and another in western Arizona.



Sharlot Hall and Al Doyle on their 1911 trip to the Arizona Strip. Photo courtesy of Sharlot Hall Museum Library and Archives/Sharlot Hall Photos/#1928-0001-0311.

Chapter 3 The White Man's Tourist Bridge

- ◆ Funding for the bridge started when U.S. Representative Carl Hayden introduced legislation allotting \$100,000 from Navajo Tribal funds with the State of Arizona matching those funds.
- → Henry Chee Dodge, the Navajo Tribal Chairman, opposed the taking of Navajo Tribal funds for what would later be used as a tourist bridge for the white man and be of very little benefit for the Navajos.



Henry Chee Dodge, the first tribal chairman of the Navajo. Courtesy of Library of Congress.

Chapter 4 Hoffman's Design of the First Bridge

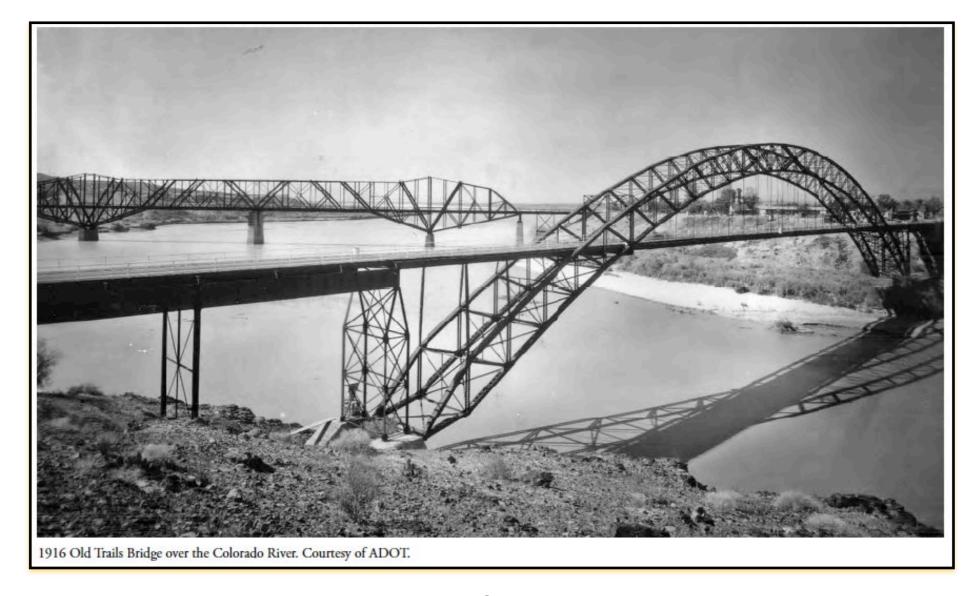
- Coconino County suggested a suspension bridge similar to the bridge that had been built at Cameron in 1911.
- Hoffman felt it was too flimsy for the Marble Canyon site.



1911 Cameron Suspension Bridge over the Little Colorado River. Photo courtesy of ADOT.

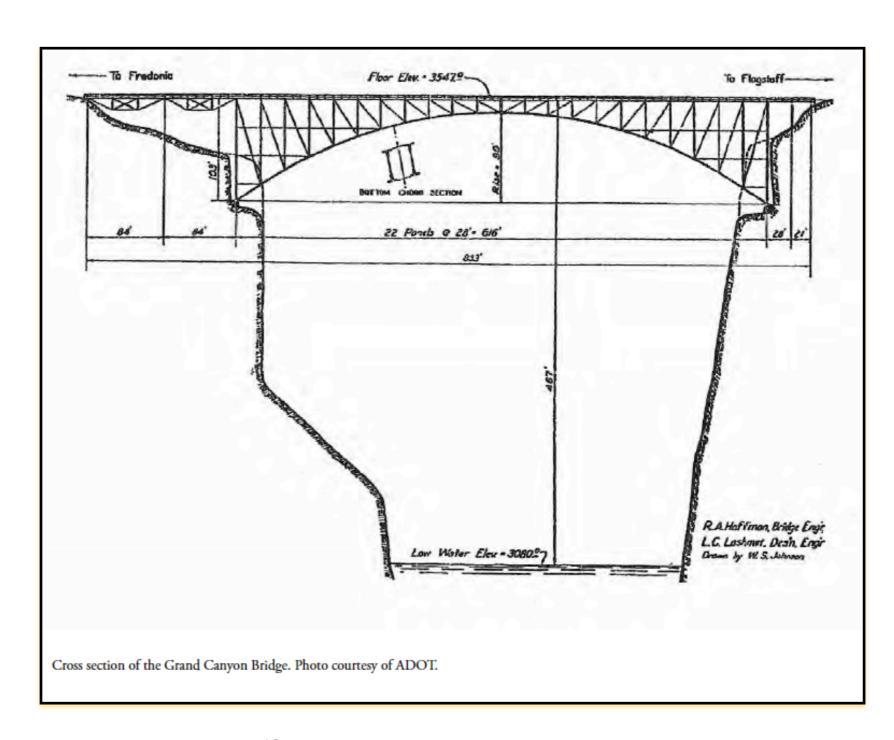
Chapter 4 Hoffman's Design of the First Bridge

- ◆ The Bureau of Public Roads suggested a steel arch similar to the bridge that had been built at Needles in 1916.
- ♦ Hoffman felt it would be too costly because of the need for a cableway used to erect the bridge.

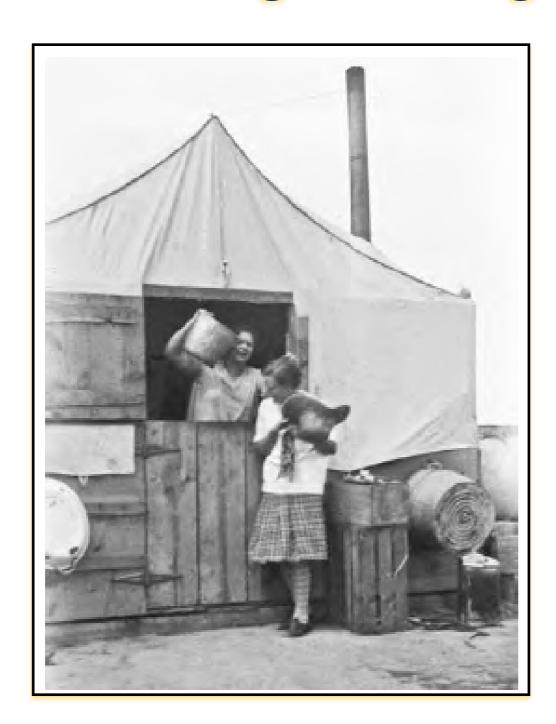


Chapter 4 Hoffman's Design of the First Bridge

- → Hoffman did not agree with them and suggested a three hinged steel deck arch with a concrete deck. He felt that a more durable bridge type was needed for this remote bridge site.
- On June 7, 1927 the AHD received four bids from contractors. The low bidder was Kansas City Structural Steel for 323,290 dollars.
- ♦ With funds from Coconino County and the Department of Interior, they went ahead with the project using AHD workers for some of the work.



Chapter 5 Hauling the Bridge to the River



Mellie Barkeley (left) jokes with Sophronia Moores at the Camp Moenkopi kitchen, Spring 1928. Photo courtesy the E. M. Moores family.

Chapter 5 Hauling the Bridge to the River



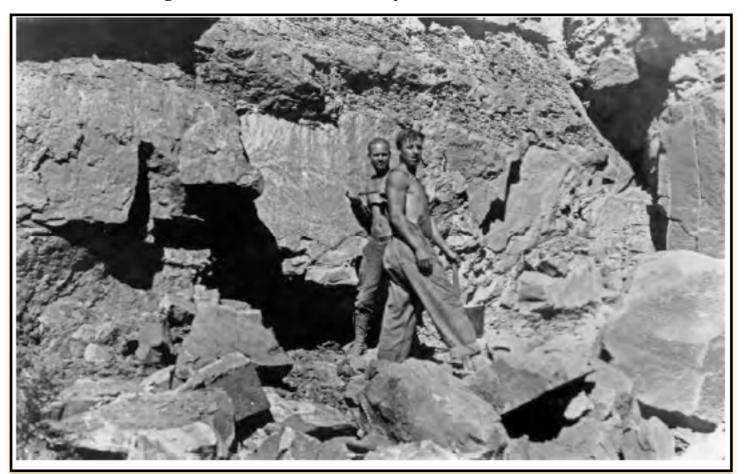


Above left and Left - The Fageol 370 taking "short" pieces of steel down the Emett Dugway and onto the Ferry, Spring, 1928. Photos courtesy the Alfred Meyers family.



Dynamite was used to blast notches into the canyon walls in order to anchor the bridge into solid rock. Since there were no environmental requirements, the excavated rock was allowed to fall into the Colorado River. Photo courtesy of ADOT.

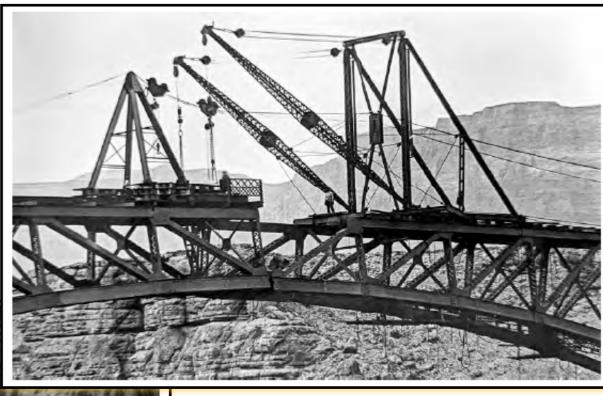
→ The Arizona Highway Department used their workers to excavate rock from the canyon walls and build the concrete foundations for the bridge. This is not done today, but worked then.



AHD workers removed the loosened rock with shovels and other hand tools after dynamiting the rock from the canyon walls. Photo courtesy of ADOT.



The Flagstaff half bridge cantilevering out 308' over the Colorado River as construction on the other half bridge begins on the Fredonia side of the river. Photo courtesy of ADOT.



Above- Final pieces of steel being placed. Photo courtesy of Alfred Meyers family.

Left - Kansas City ironworking crew. Photo courtesy of Neil G. Lilley family.

Chapter 7 Dedicating the First Bridge, June 14-15, 1929

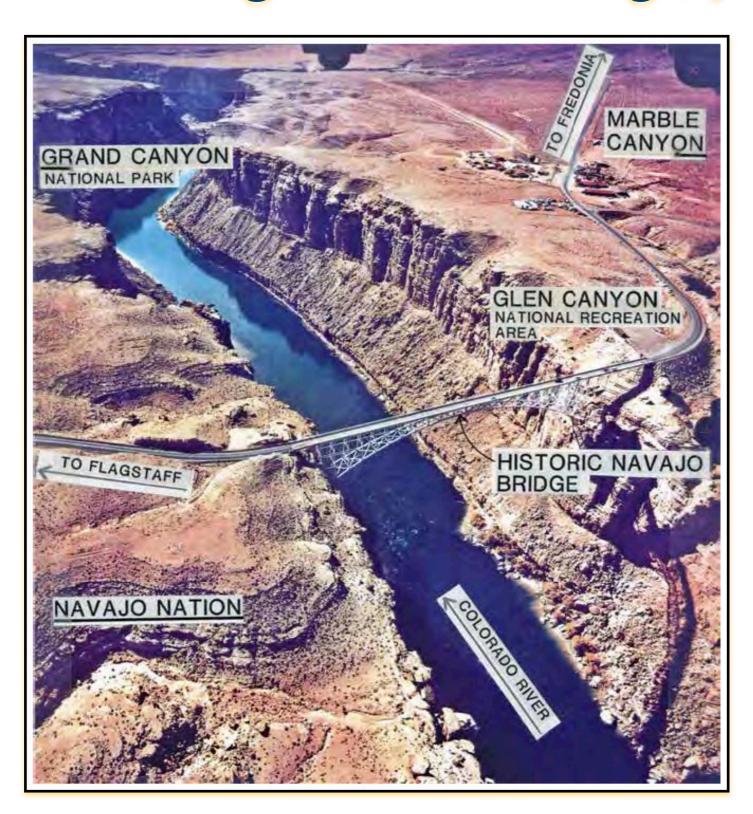
Cars arrived all morning, and the place was soon packed with more than 2,200 vehicles lined bumper to bumper on the dirt roads on either side of the bridge. The ever-swelling crowd was estimated at 6,000 to 8,000 people, amazingly large for a bridge dedication in this remote corner of northern Arizona. The cars carried license plates from more than 20 states from California to New Jersey.

Excitement filled the air with four state governors and many Native Americans, including Henry Chee Dodge, in attendance. Although the press under-reported his role, Dodge served as the liaison between the Navajos and AHD during bridge construction.



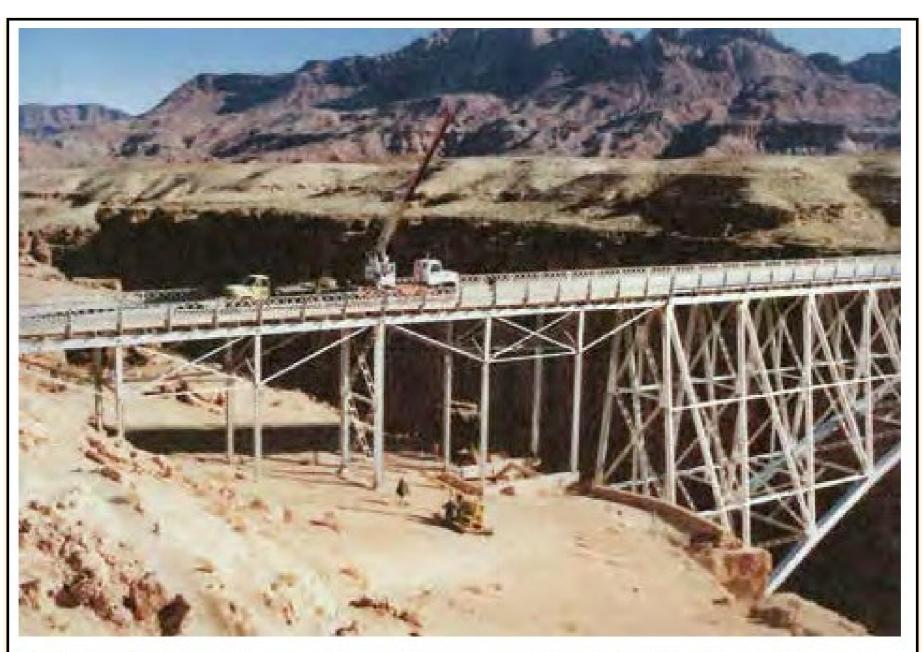
These cars were parked near the bridge as the marching band prepared for the dedication. Photo courtesy of The Huntington Library, San Marino, California.

Chapter 7 Dedicating the First Bridge, June 14-15, 1929



Historic Navajo Bridge spanning the Colorado River.

Chapter 8 Time Between Two Bridges



Fredonia side approach spans after repairs were completed in 1970. The addition of new columns shortened the spans to 28 feet, which increased their loadbearing capacity. Photo courtesy of ADOT.

Chapter 8 Time Between Two Bridges

Narrow road – no space for pedestrians.



Tourists stopping their vehicle on the bridge to view the Marble Canyon gorge.

Heavy truck loads.



Trucks crossing the gorge on the narrow historic bridge.

Chapter 9

Selecting the Design Team

Cannon & Associates, Inc. (Cannon) was a small Arizona structural engineering firm specializing in bridge design and rehabilitation of historic bridges and buildings. I started the company with my wife, Dolores, in 1979, opening a modest office in Tucson. By 1986, we had expanded our Tucson office and opened a second in Phoenix. Our staff of about 16 was divided between Tucson and Phoenix, and I commuted between the two offices. The firm did about \$2 million of business a year, and we had a good reputation in the local transportation industry. We had designed major bridges for ADOT, the cities of Phoenix and Tucson, and Pima County.

We had been in business for six years when ADOT requested statements of interest for the second Navajo Bridge project. The request described the first phase of the 0.1-mile-long project as a feasibility study for widening or replacing the existing Navajo Bridge, including traffic handling and construction methods. The project's second phase would be design of the study's selected alternative. The short project description piqued my interest.

Barbara Winters, Cannon's marketing coordinator, called State Bridge Engineer Ron Brechler to ask about the project and to express our interest. Knowing my attraction to historic bridges, Ron described the old steel arch as "a fun bridge that Jerry would really like." After talking with Ron, we requested ADOT's construction plans for the bridge so we could study its design. We became even more enthusiastic about the project when we found



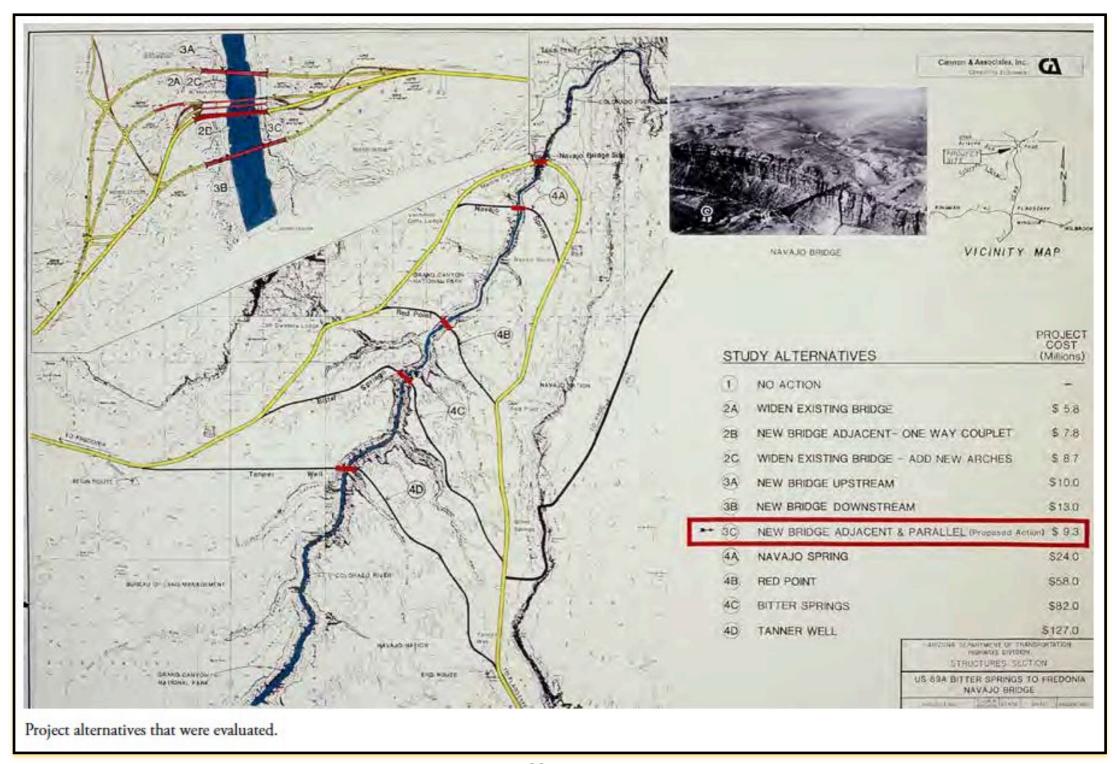
The Cannon staff during the dedication of Kino Boulevard overcrossing of the railroad and State Route 210, Tucson. This major bridge was designed by the Cannon team.

the old articles Ralph Hoffman had written for Arizona Highways magazine. I realized no single engineering firm would have all the expertise necessary for a project as complex and sensitive as this one. We needed a team of specialists with each member's skills fitted to particular needs of the project. I began calling other firms to ask if they would like to team with us to pursue the project.

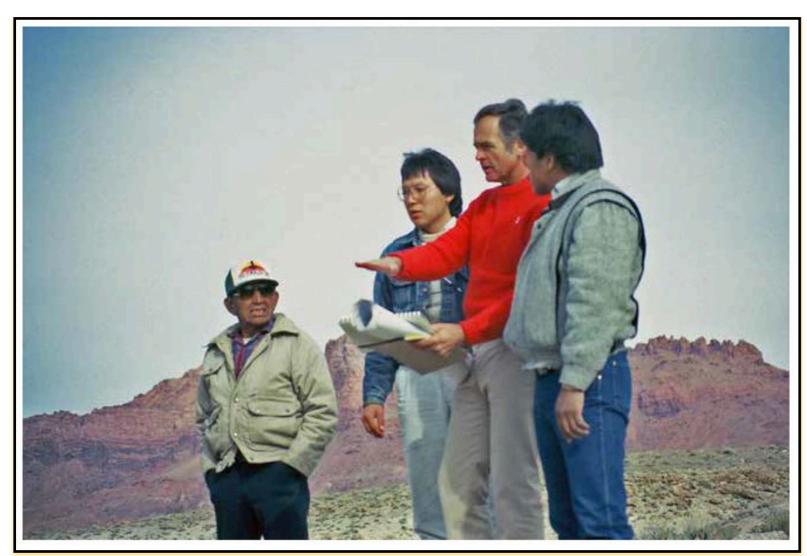
My First Trip to Marble Canyon

I had lived in Arizona a long time, but had never seen Navajo Bridge. I decided to drive to Marble Canyon to check things out. After traveling from Tucson to Flagstaff, I went north on US Highway 89, the same two-lane road used to haul construction material for the first bridge. As the roadway climbed through ponderosa pine forest, it passed the cinder cone of Sunset Crater and the prehistoric ruins of the Sinagua people at Wupatki National Monument. On the west side of the highway, the San Francisco Peaks, 12,637 feet high, loomed as the predominant physical feature. The Peaks are one of the four sacred mountains defining the traditional boundaries of the Navajo Nation.

Chapter 10 Planning for a New Crossing



Chapter 10 Planning for a New Crossing



Meeting at the bridge site with the Bodaway/Gap Chapter Grazing Committee of the Navajo Nation. Chairman Henry Lane on the left with two others and Jerry Cannon, in the red sweater, pointing to the proposed bridge site. Photo courtesy of Barbara Winters.

Chapter 10 Planning for a New Crossing

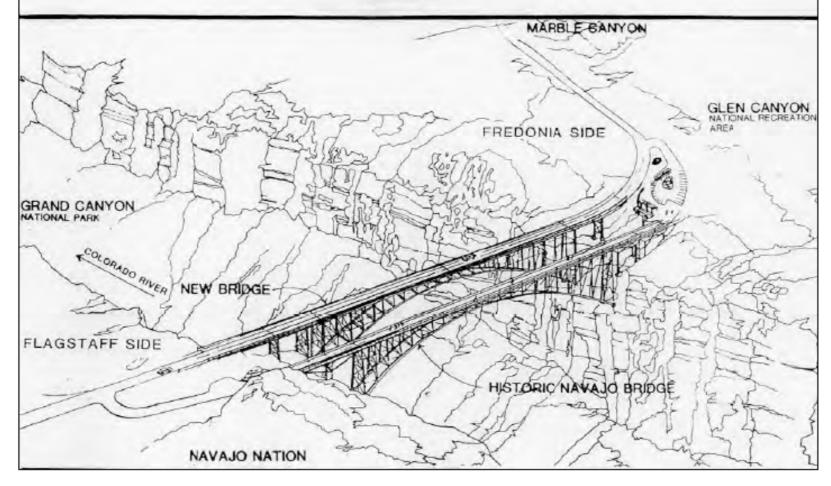


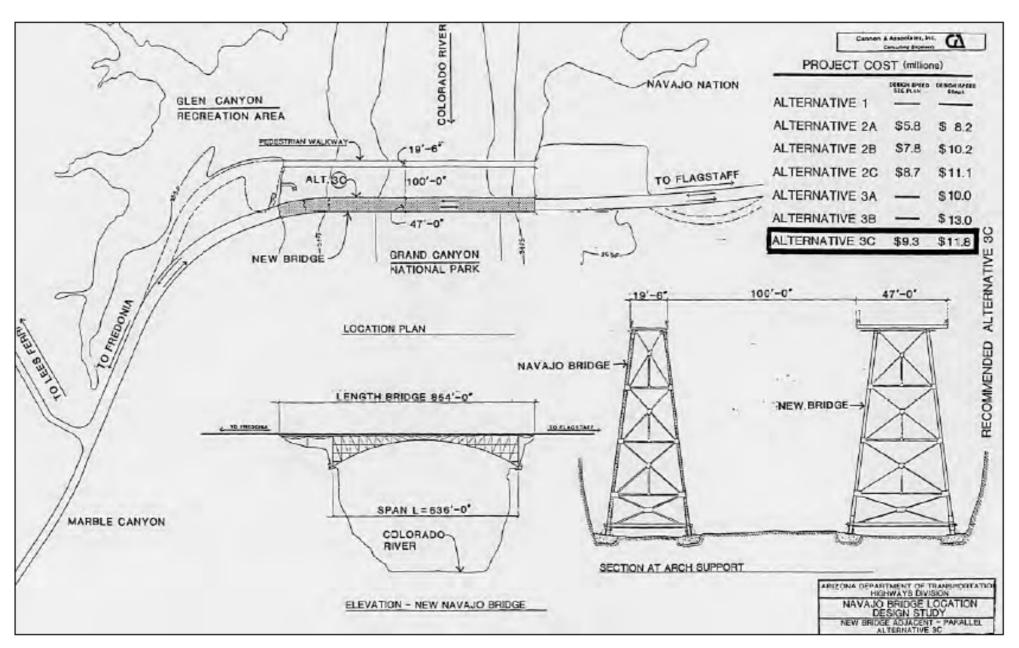
Pauline Wilson, a member of the Bodaway/Gap Chapter and the Cannon team's interpreter, making a presentation at a chapter meeting.

NAVAJO BRIDGE

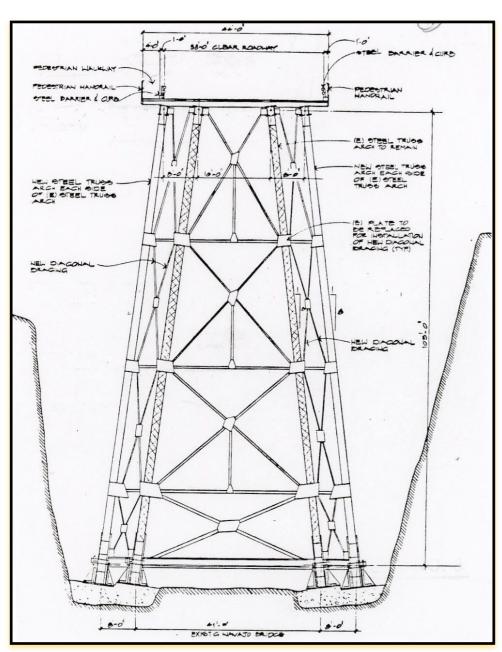
U.S 89A BITTER SPRINGS - FREDONIA HWY. PROJECT NO. BRF-037-3(10)







Preferred Alternative 3C. The space between the two bridges was increased to 150 feet to not conflict with the wayside shelter.



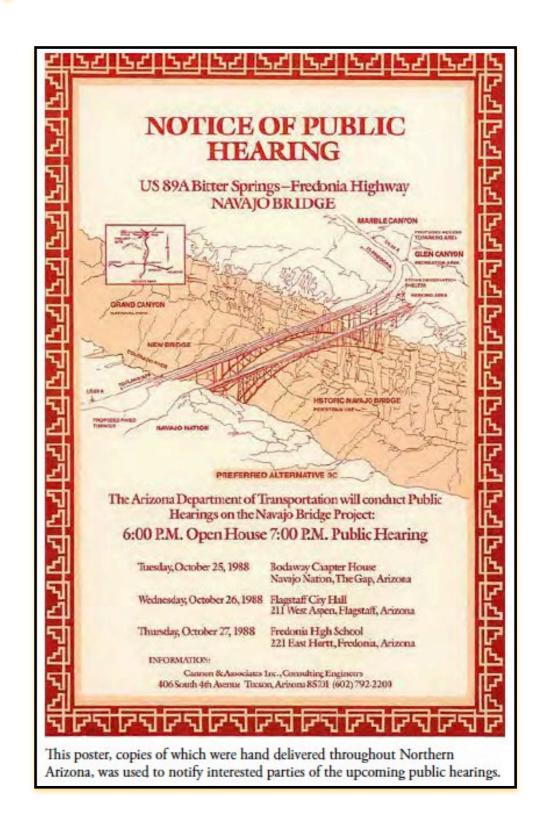
Cross-section of the 'ugly bridge' alternative.

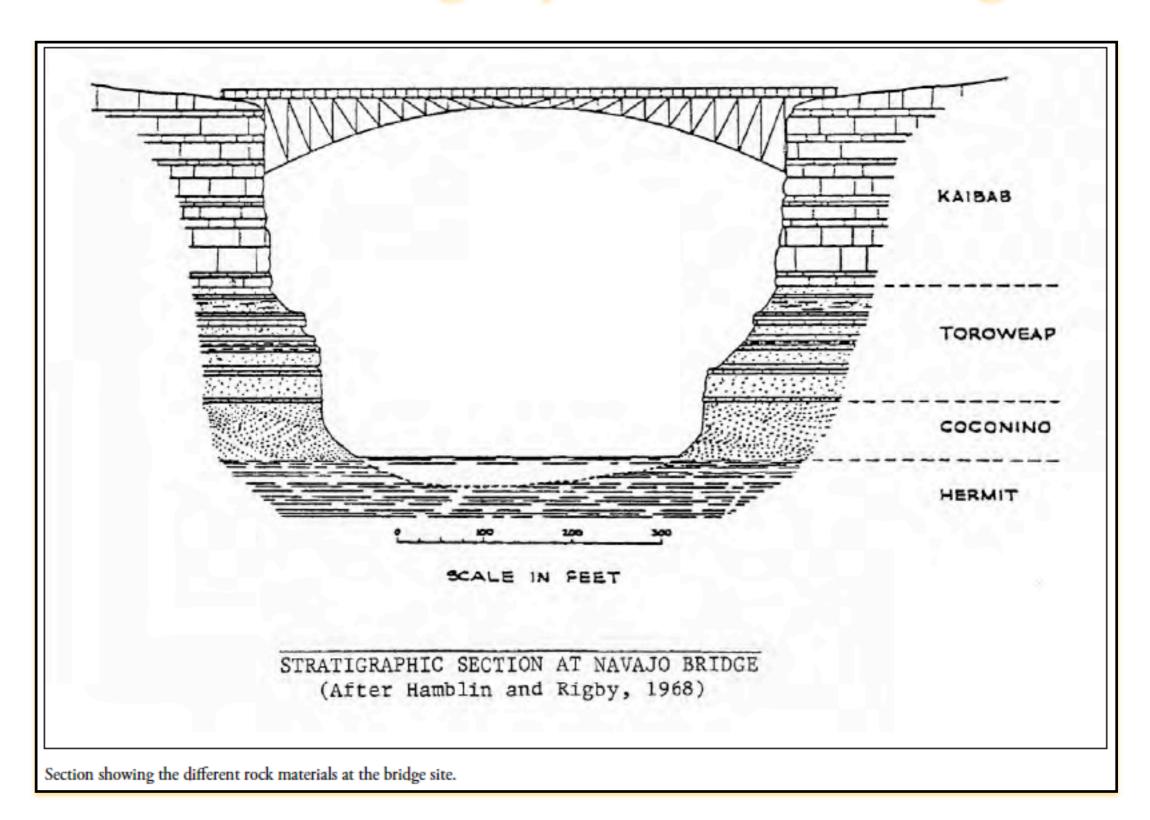


This photo of the Carquinez Strait Bridges, in the San Francisco Bay Area, was used at a public meeting to show the attendees the two-bridge concept.

The were no objections to

Alternative 3C at any of the Public Hearings.

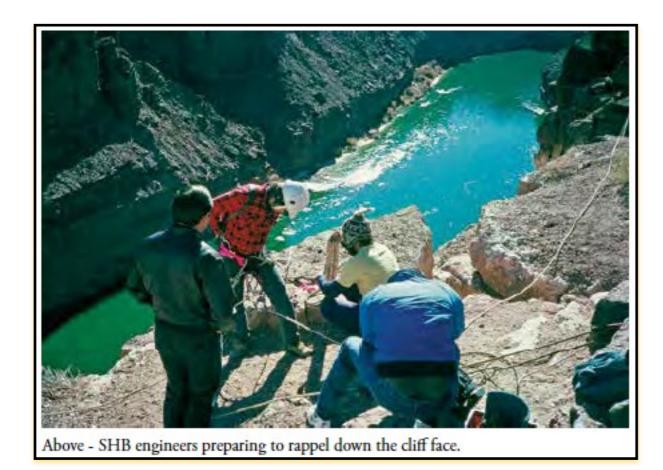




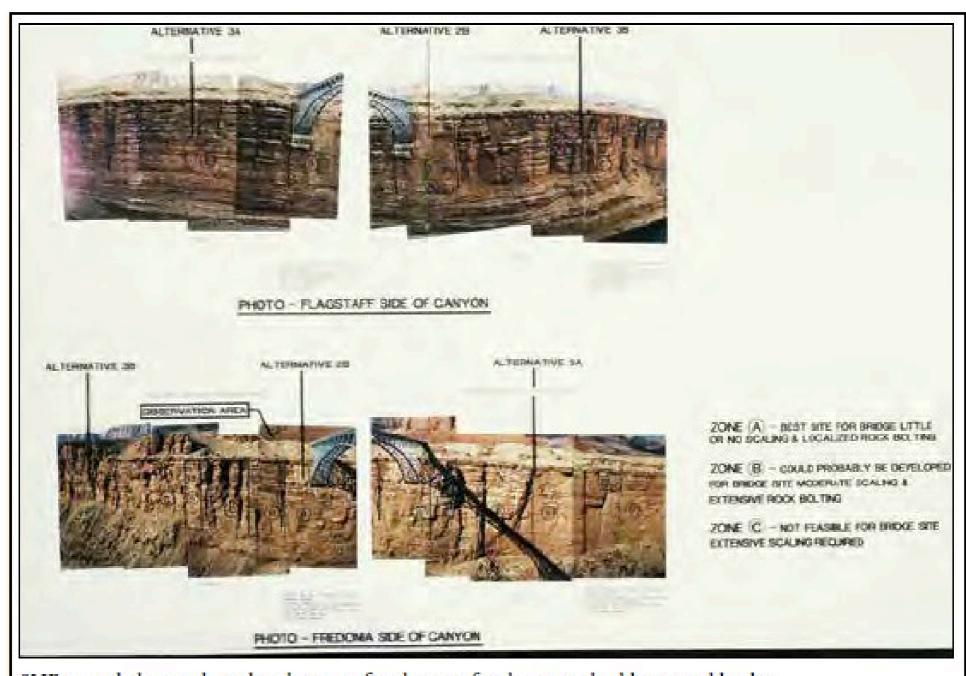
- ◆ FHWA and ADOT approved the Environmental Assessment and the Section 4(ft).
- ◆ Funding the project
- Acquiring the right-of-way
- ◆ Geological and geotechnical investigations
- ◆ Selecting the bridge type
- ◆ Design innovations for the second bridge



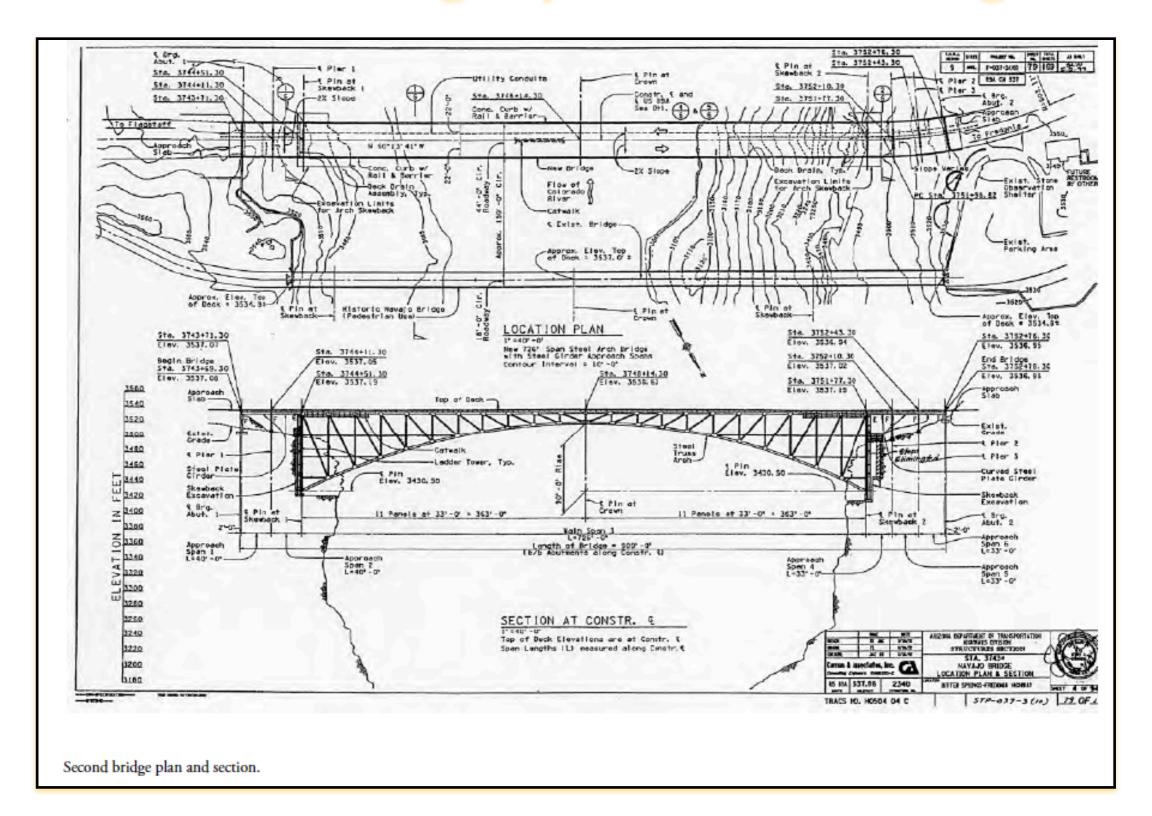
Geotechnical Investigation

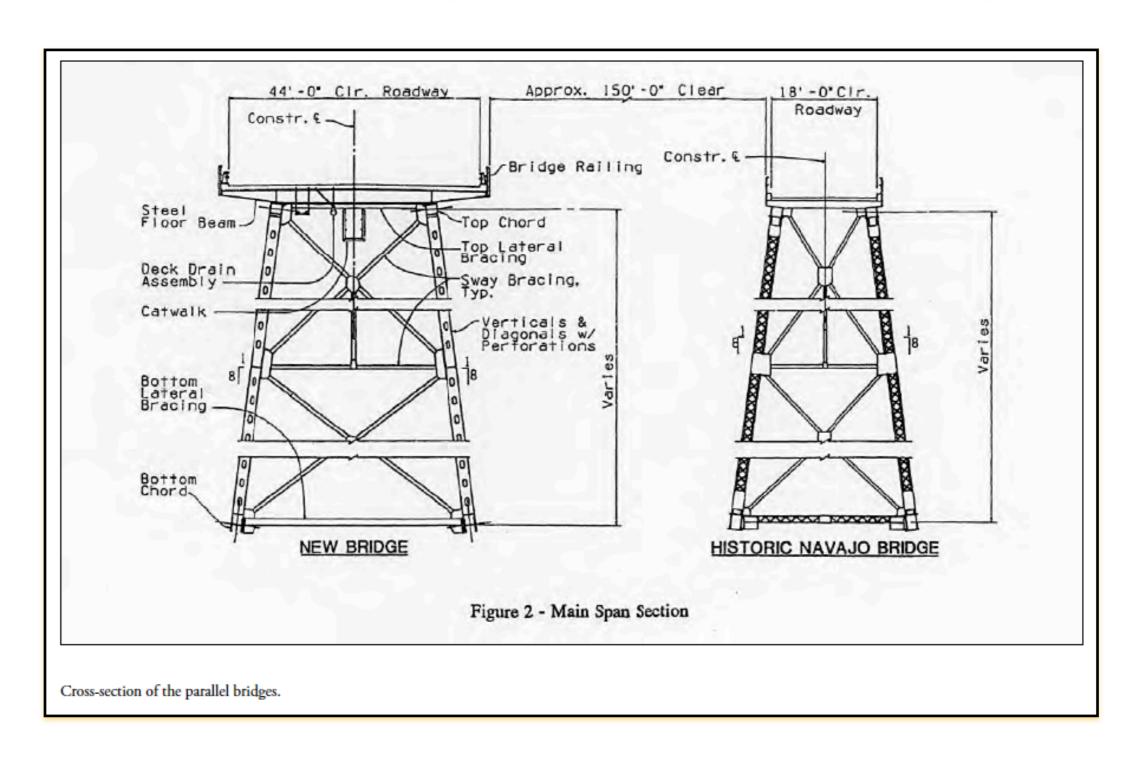


George Beckwith with SHB loading the boat prior to a trip down the river to observe the Coconino sandstone at river level.



SHB provided geotechnical evaluation of rock zones for the site to build a second bridge.

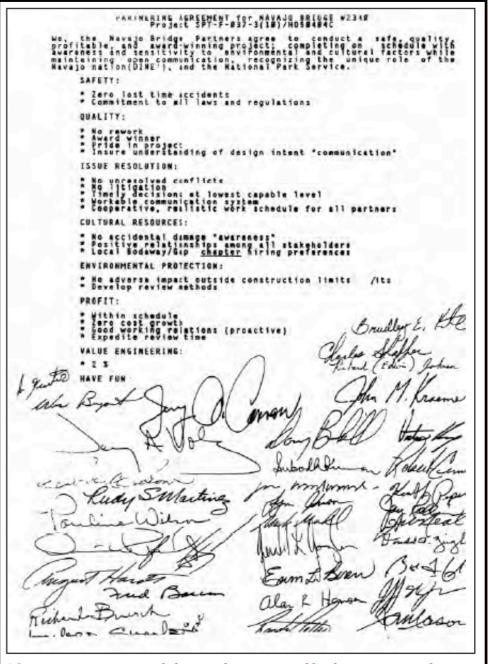




Chapter 13 Building the Second Bridge

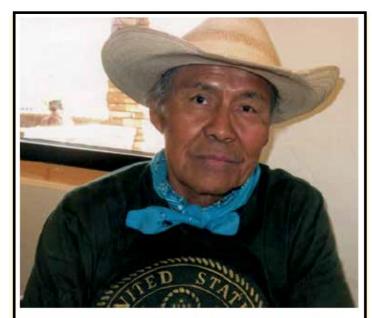


The historic Marble Canyon Lodge, originally known as the Vermilion Cliffs Lodge, was opened for the dedication of the first bridge and was used for the pre-bid meeting for the second bridge.



The Partnering Meeting ended on April 28, 1993, and by then, we were working as a team. The Partnering Agreement was prepared and signed by those in attendance.

Chapter 13 Building the Second Bridge



Leonard Sloan worked on the second bridge from start to finish. He served as the liaison between the Bodaway/Gap Chapter and the contractor.

Skewback Excavation





Blasting was directed toward the canyon walls and not the river.

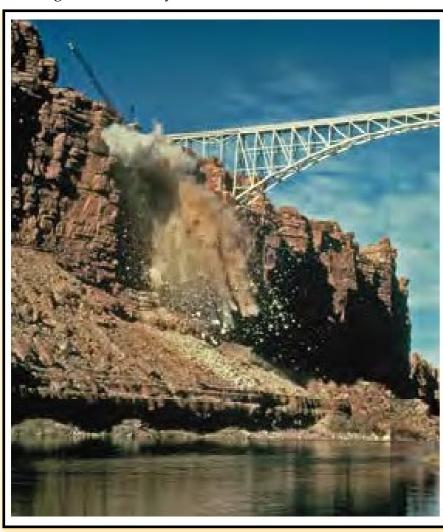


Failure of containment system.



The failure brought ADOT engineers to the bridge site in a hurry.

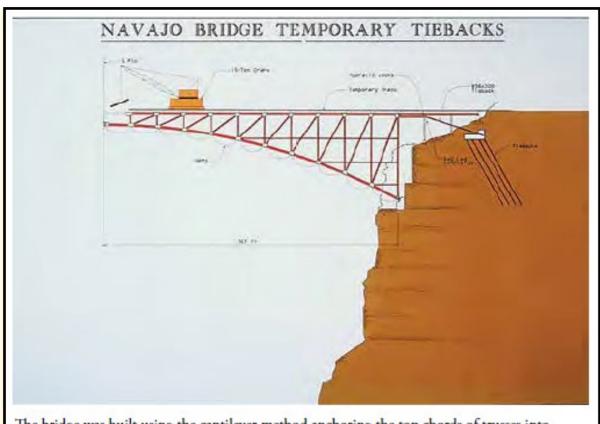
Blasting rock from canyon walls.



The notch in the canyon wall on the right side of the first bridge. The white colored rock was later stained to match the rock in the adjacent canyon walls.



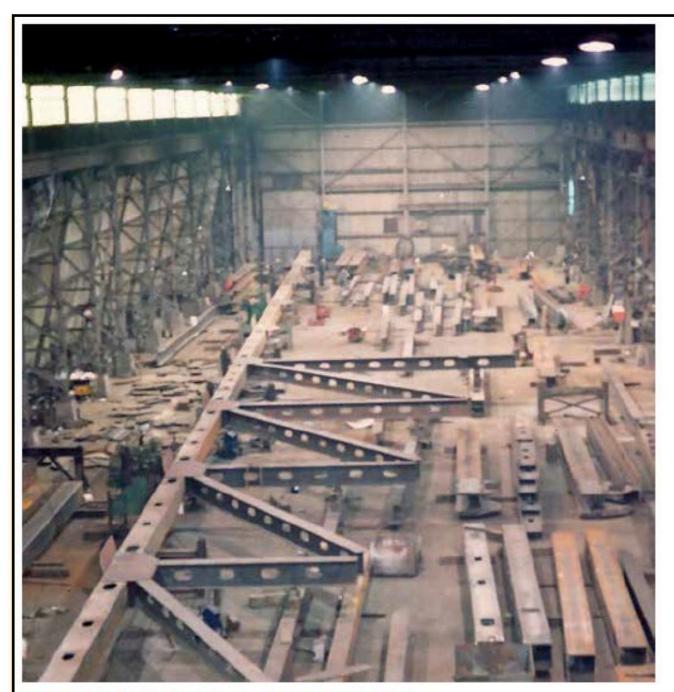
Using cantilever erection method to erect steel over canyon.



The bridge was built using the cantilever method anchoring the top chords of trusses into the canyon walls.



The top chord of the steel truss was anchored to a tieback footing by steel cables embedded into the rock.



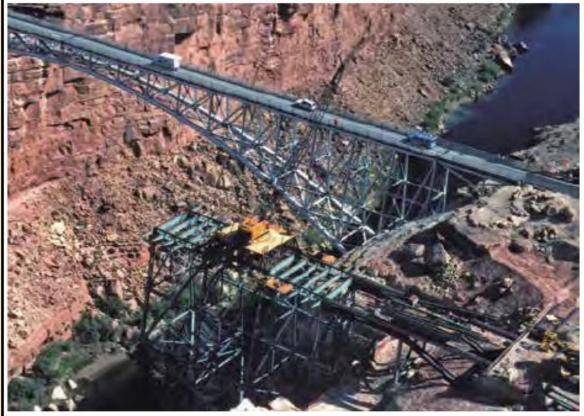
Vincennes Steel Corp. lays out structural steel at their factory.



Erection of the first panel. Started on the Flagstaff side, May 1994.

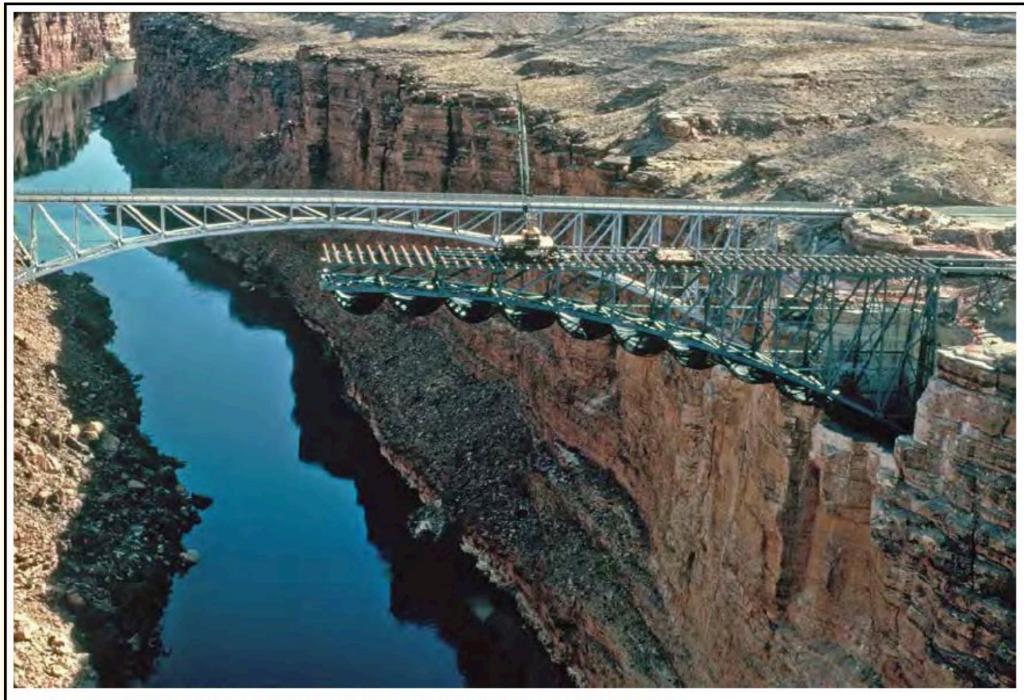
Setting the cast iron shoe.





Ed Kent (L) and David Meche (R) maneuver a steel member on to the cast iron shoe.

Cantilever erection of bridge.



The Flagstaff one-half bridge cantilevering 383 feet out from the canyon wall. Photo courtesy of Jim Woodward.

Setting the pin at midspan.



Jerry Cannon (L) and colleagues watch the pinning.











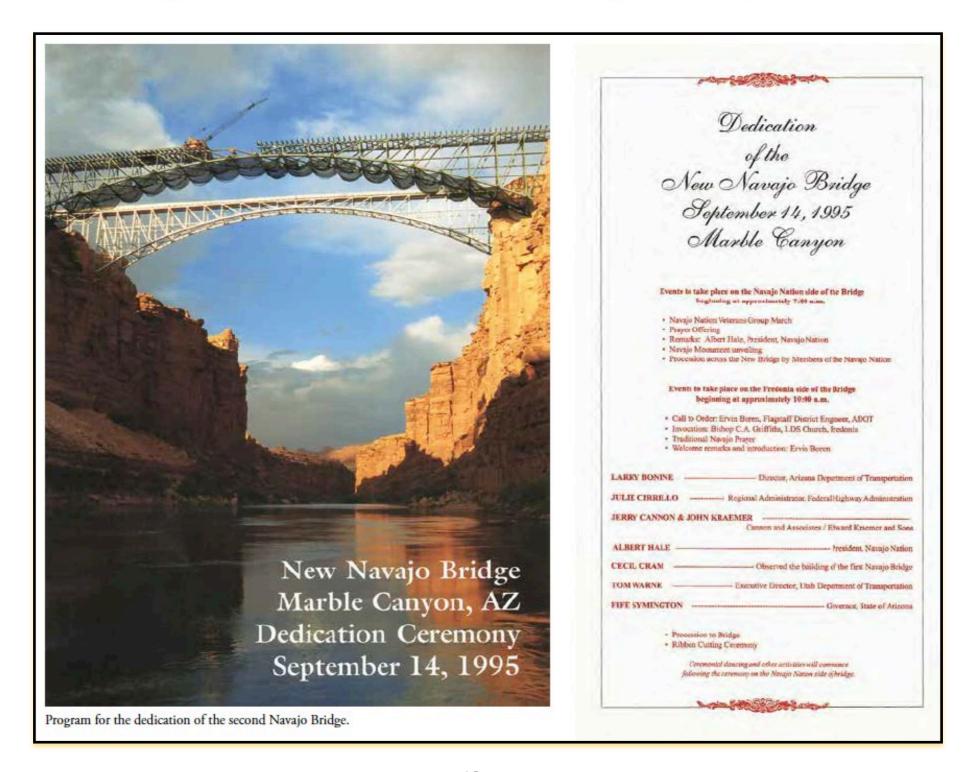
Concrete deck placement.

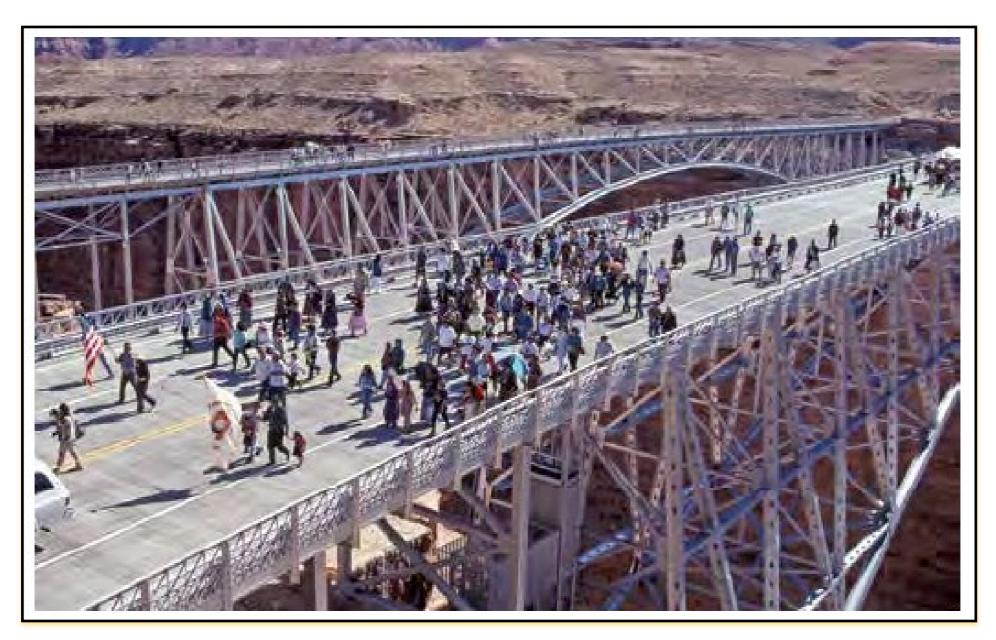




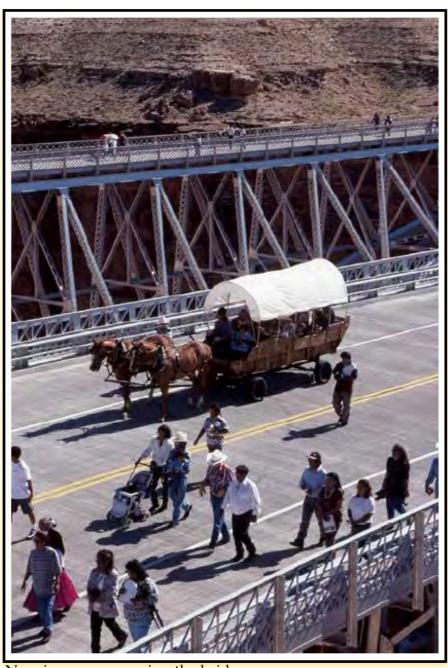
See-through crash tested steel barrier rail.



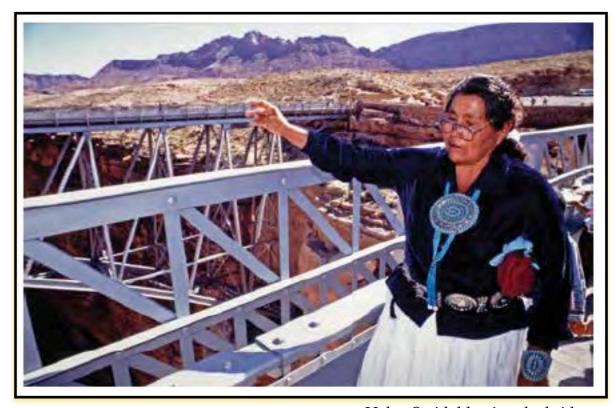




Navajo veterans march over second bridge.



Navajo wagon crossing the bridge.

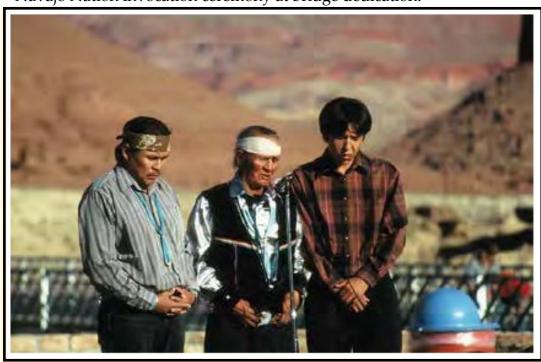


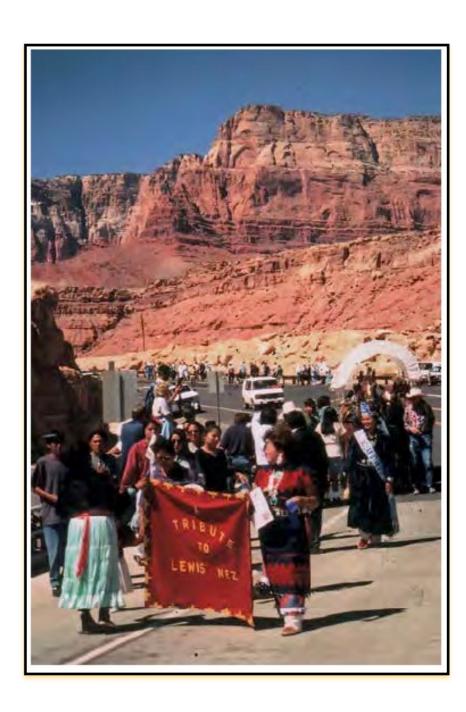
Helen Smith blessing the bridge.

Navajo Nation dedication ceremony.



Navajo Nation invocation ceremony at bridge dedication.





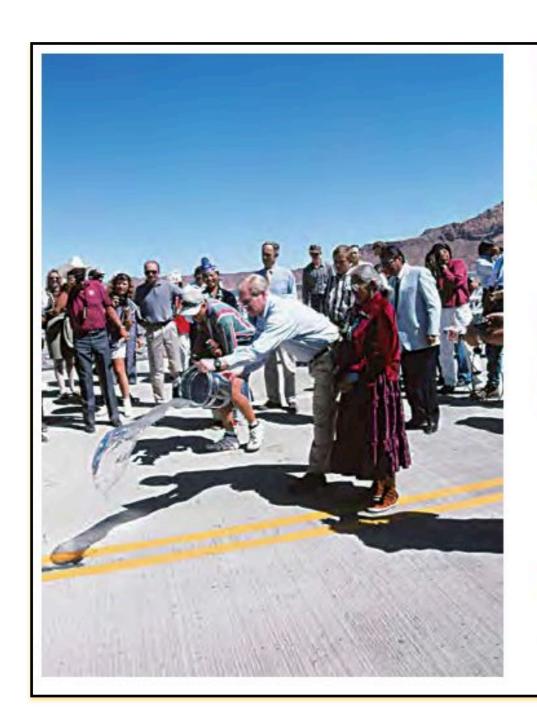
ADOT at the Dedication Ceremony.

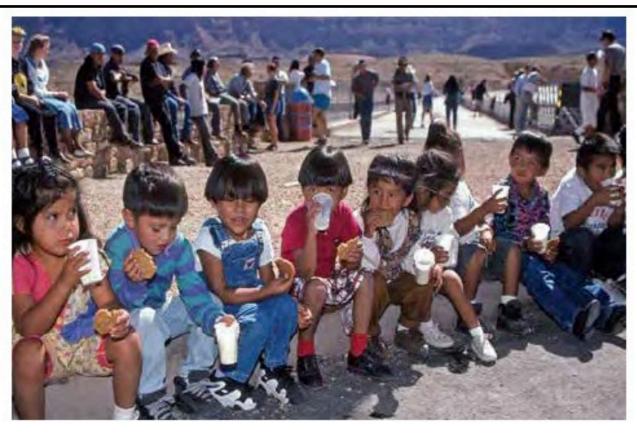




Governor Fife Symington at Dedication Ceremony.







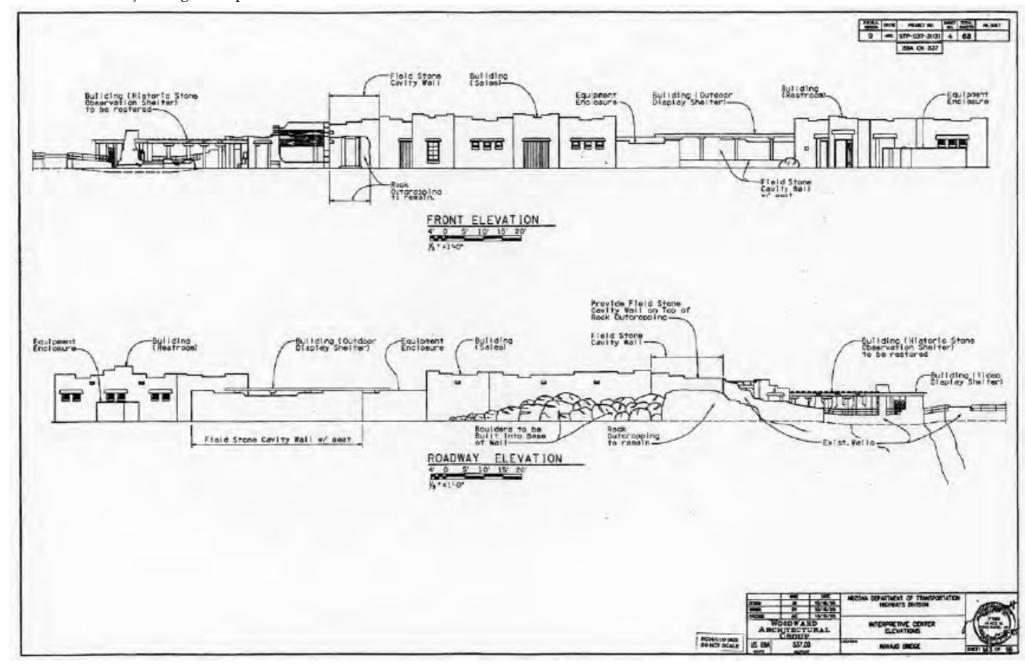
Left - Having crossed the bridge in an antique vehicle, Arizona Governor Fife Symington christened the second bridge with a bucket of Colorado River water. Irene Sanders, standing next to the governor, awaits the ribbon cutting.

Above - Young Navajo children taking a lunch break, waiting for the ceremony to end. Both photos courtesy of Gary Ladd.

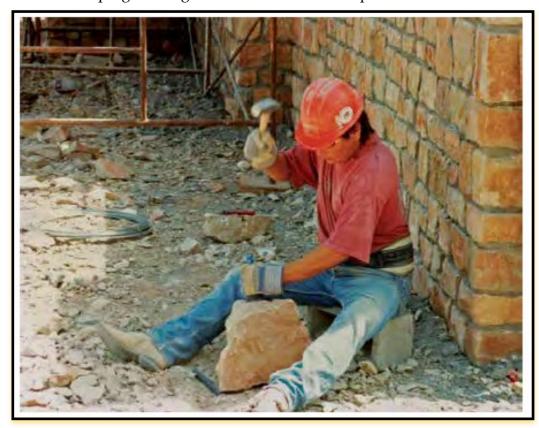
Aerial photo showing Marble Canyon and the Navajo Bridge Interpretive Center on the Fredonia side (left) and the Antelope Trails Interpretive Market on the Flagstaff side (right).



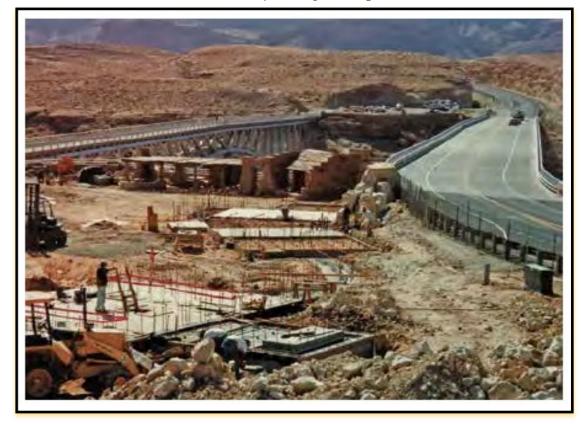
Section of Navajo Bridge Interpretive Center



Shaping existing rock for use in the Interpretive Center.



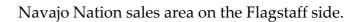
Construction of Navajo Bridge Interpretive Center.

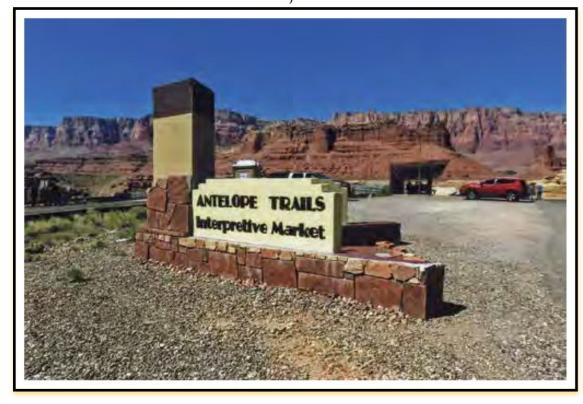


Navajo Bridge Interpretive Center. The building's walls were built into the existing rock.



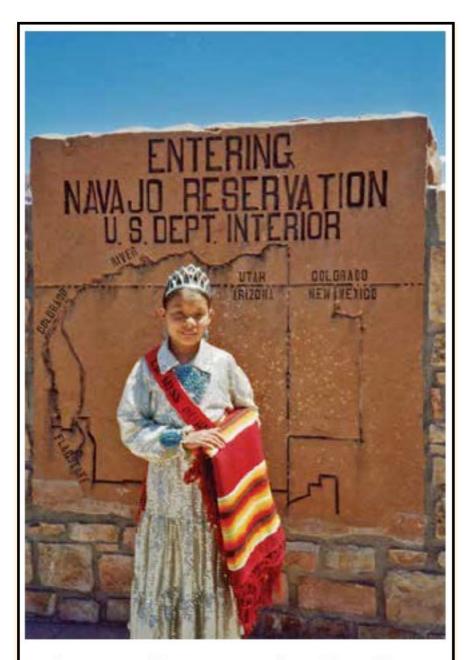
Antelope Trails Interpretive Market on Flagstaff side built by the Navajo Nation.



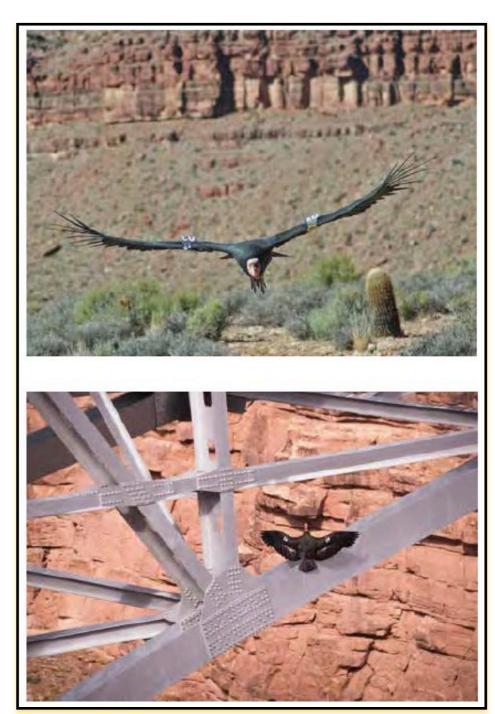




Epilogue



At the ASCE Award Ceremony. Standing in front of the Department of the Interior historic marker is Trisha D. Tsinigine, Miss Bodaway-Gap Chapter of the Navajo Nation.



California Condor at the bridge site.

Epilogue



National Historical Civil Engineering Plaque / May 1998

Epilogue



Presentation made to the Bodaway/Gap Chapter for their help in building the two bridges.



Framed photo of Navajo veterans marching over the second Navajo Bridge gifted to the Navajo.

AWARDS AND RECOGNITION for the FIRST NAVAJO BRIDGE

National Register of Historic Places, listed in 1981 American Society of Civil Engineers, Historic Civil Engineering Landmark, 1998

AWARDS for the SECOND NAVAJO BRIDGE

Federal Highway Administration Award of Excellence, 1996

Arizona Consulting Engineers Association Award for Technical Excellence, 1996

Arizona Masonry Guild Excellence in Masonry Award, 1996

American Public Works Association Project of the Year, 1996

Arizona Masonry Guild Award for Craftsmanship in Stonework, 1997