Historic Bridges in Arizona and Their Engineers

November 3, 2011
NACE / AACE Conference

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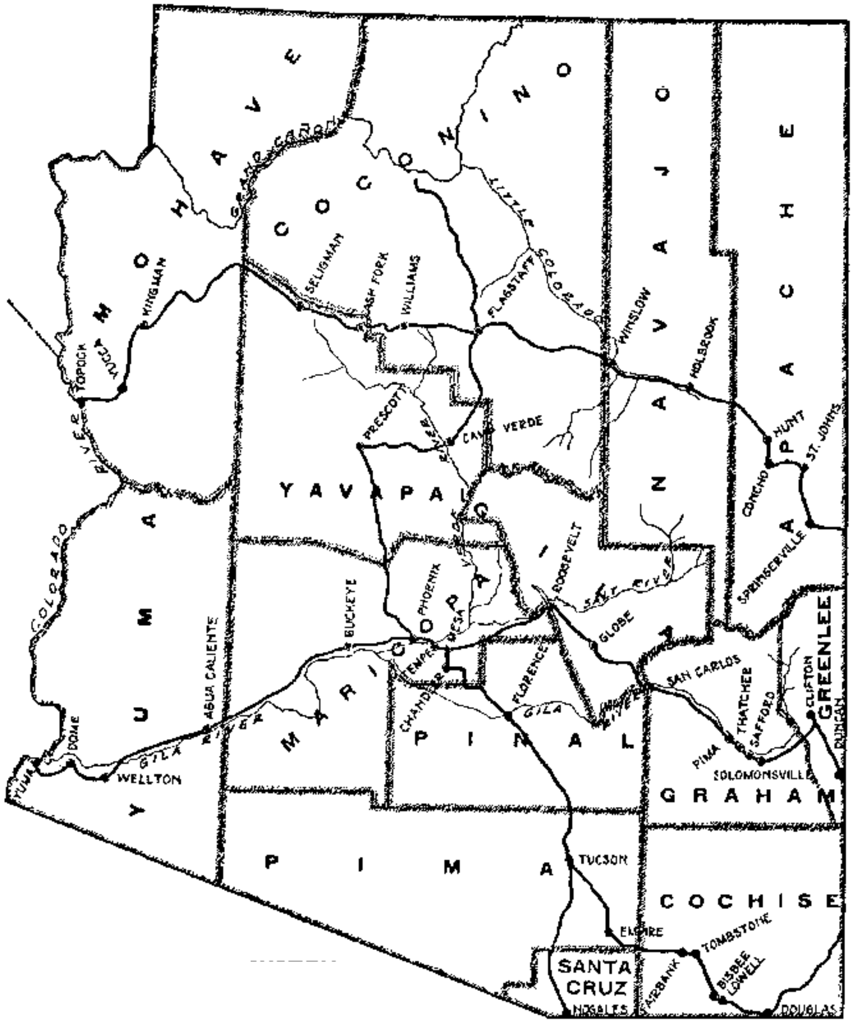
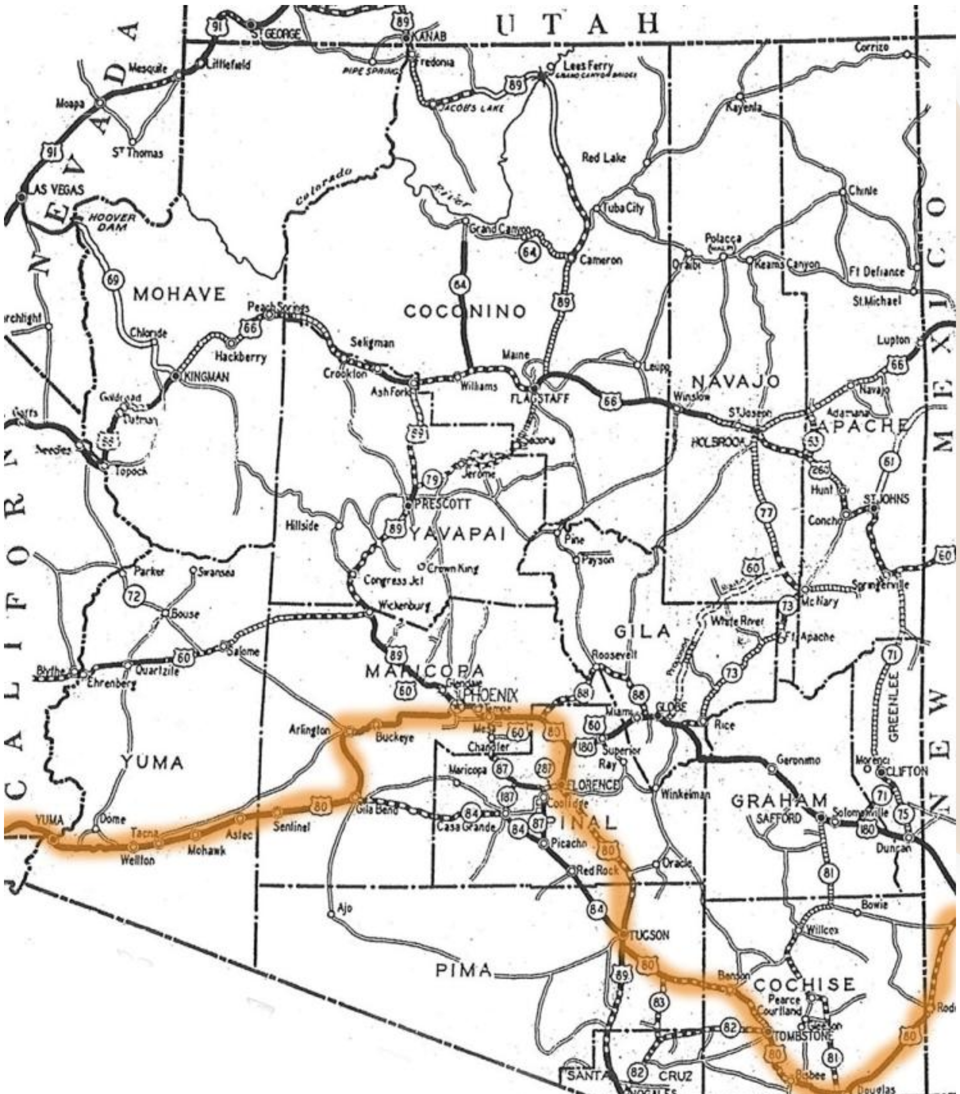
Who Designed Arizona Bridges
Mill Ave Construction Site 1928 – Photo Hoffman Collection - (Mary Lou Vaughan)



- Mexican American War 1848 Treaty of Hidalgo & Guadalupe
- Gadsden Purchase 1853 – Southern Part of AZ
- Northern Boundary of AZ along 37th Parallel
- Separated from New Mexico by 1863 Federal Organic Act

Arizona Territory 1863

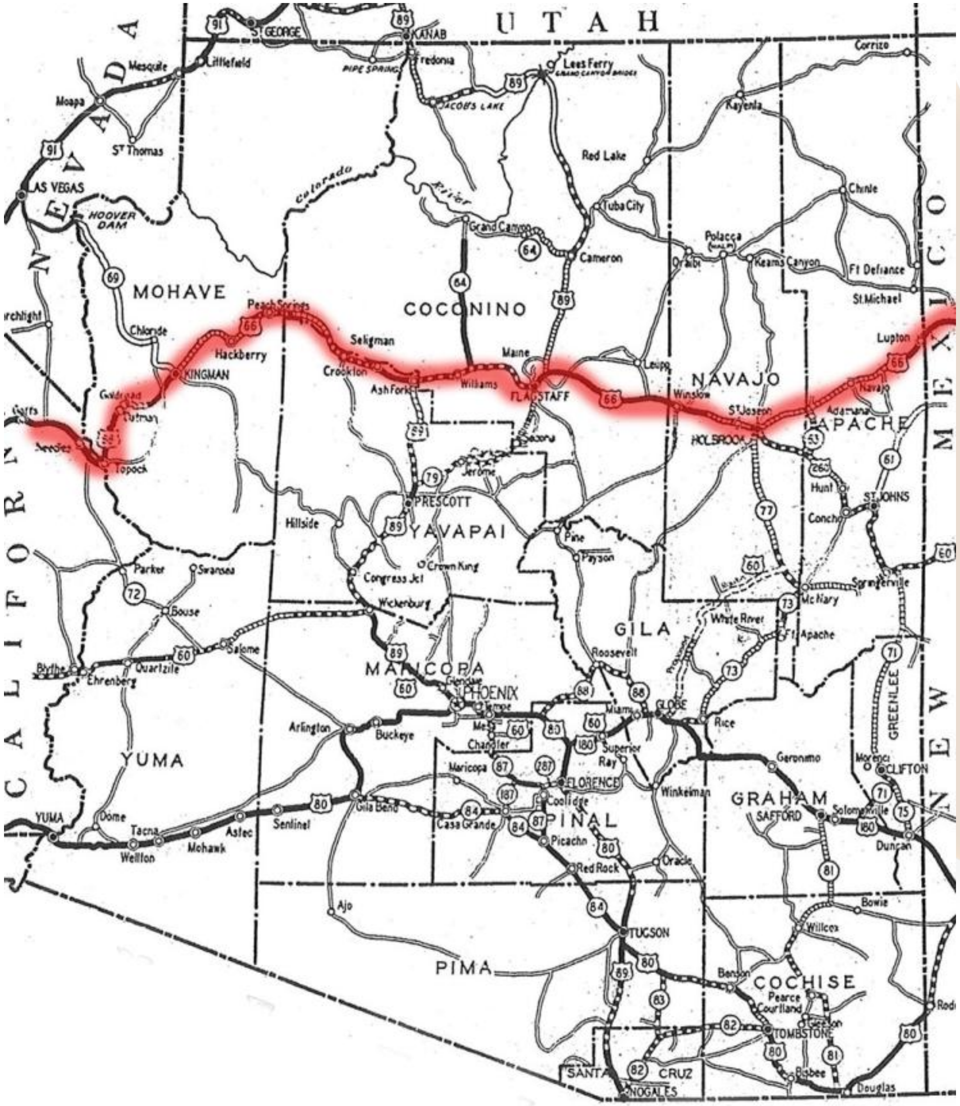


1846 – Cooke's Wagon Road

(Ocean to Ocean Highway US 80)

- Was the southern route crossing the Colorado River in Yuma
- Built by Capt Cooke and the Mormon Brigade during the war with Mexico.
- Largely paralleled the Gila River

Arizona Territory Two Major Transportation Routes



1859 – Beale's Road

(Old Trails Highway and US 66)

- Was the northern route that crossed the Colorado River at Topock.
- Route was built before the construction of the railroad in 1883
- Road maintenance was performed by travelers
- Bridges were non existent

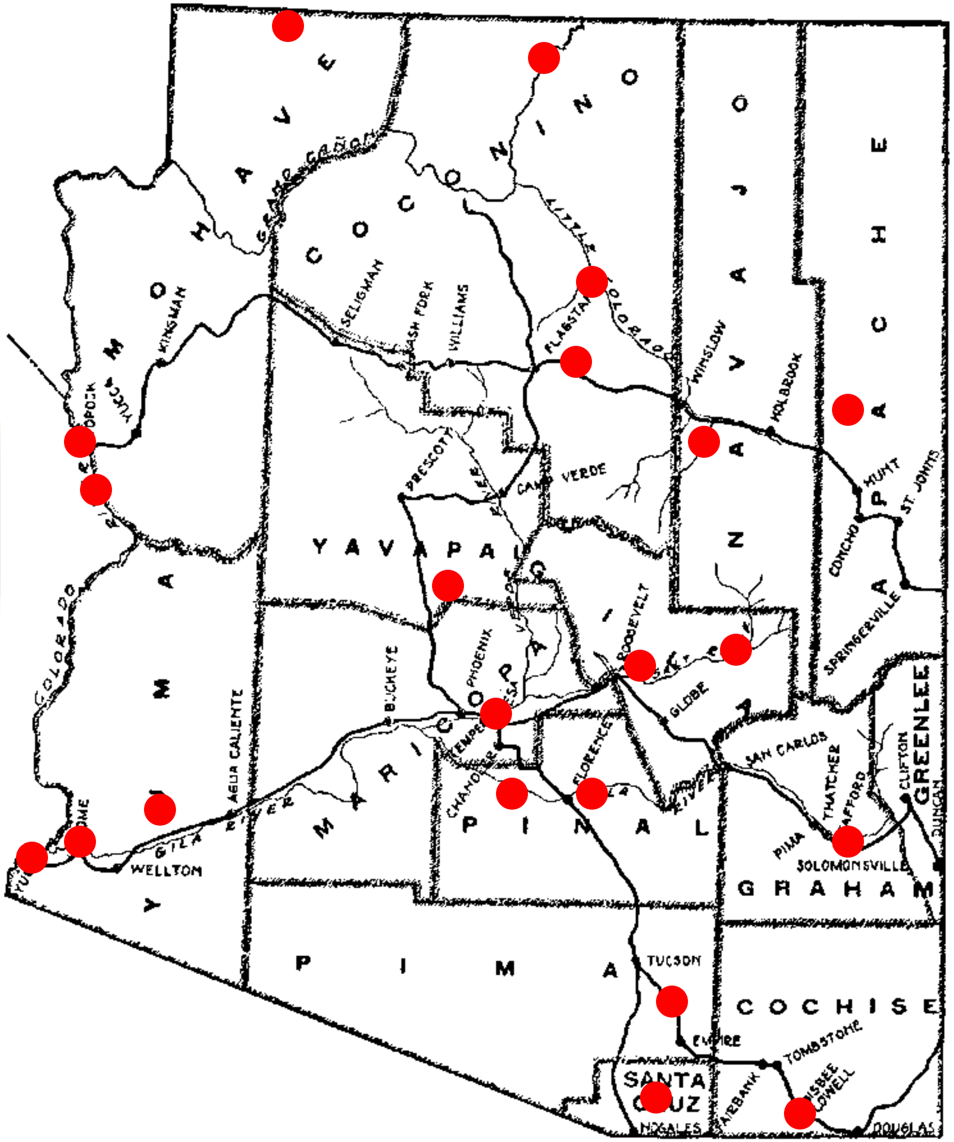
Alchesay Canyon Bridge (1905)

Solomonville Road Overpass (1907)

Lowell Arch Bridge (1911)

Cameron Bridge (1911)

Only Remaining Bridges from the Arizona Territory (1863-1912)



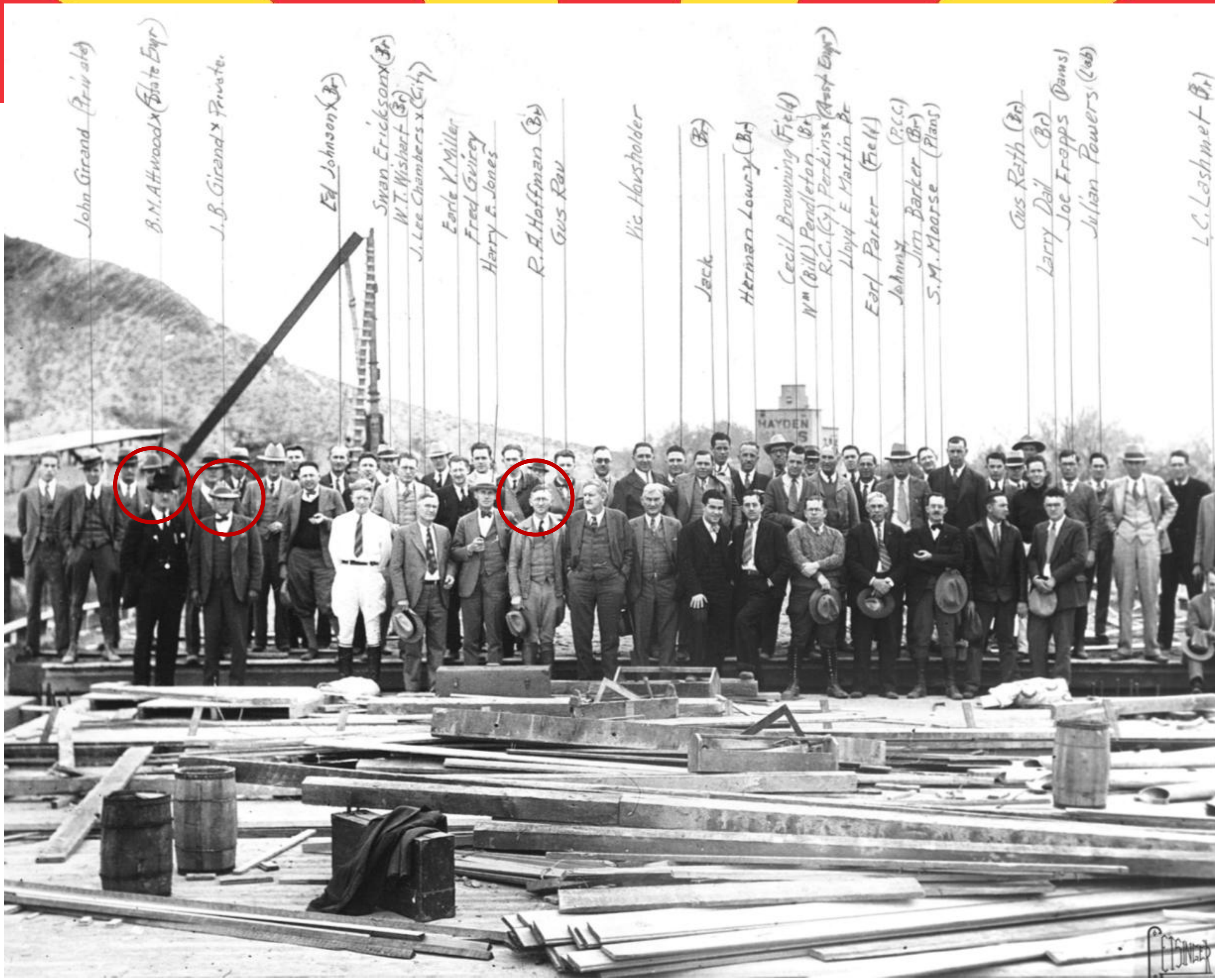
Arizona’s Historic Bridges

J.B. Girand	1909 - 1912 Arizona's First and Only Territorial Engineer Florence Bridge Replacement; Lowell Bridge US80, Ash Ave. Bridge Over Salt River in Tempe
Lamar Cobb	1912 Arizona's First State Highway Engineer Antelope Hill Bridge – Yuma and Aqua Fria River Bridge
Daniel Luten	1914 Canyon Padre Bridge – Canyon Diablo Bridge (Two Guns) Old Safford Road Bridge, Kevin Bridge, Miami Bridges and others
BM Atwood	1916 Santa Cruz River Bridge – Nogales Chevlon Creek Bridge – Navajo County
Merrill Butler	1919 Arizona's first full time state bridge engineer

Who designed Arizona's Historic Bridges

Who designed Arizona's Historic Bridges

Ralph Hoffman	1927 – 1955 State Bridge Engineer Gillespie Dam Bridge, Navajo Bridge, Mill Ave Bridge, Salt River Canyon Bridge & Others
Ralph Modjeski	1929 McPhaul Bridge
Bureau of Indian Affairs	1911 – 1925 Cameron Suspension Bridge, Ocean to Ocean Highway in Yuma, Old Trails Bridge, Sacaton Dam Bridge
County Engineer	1913, 1915, 1926 Hereford Road Bridge 1917 Obed Road Bridge 1924 Walnut Grove Bridge
John Rennie Mott, Hay & Anderson	1831 London Bridge (London) 1971 London Bridge (Lake Havasu City)



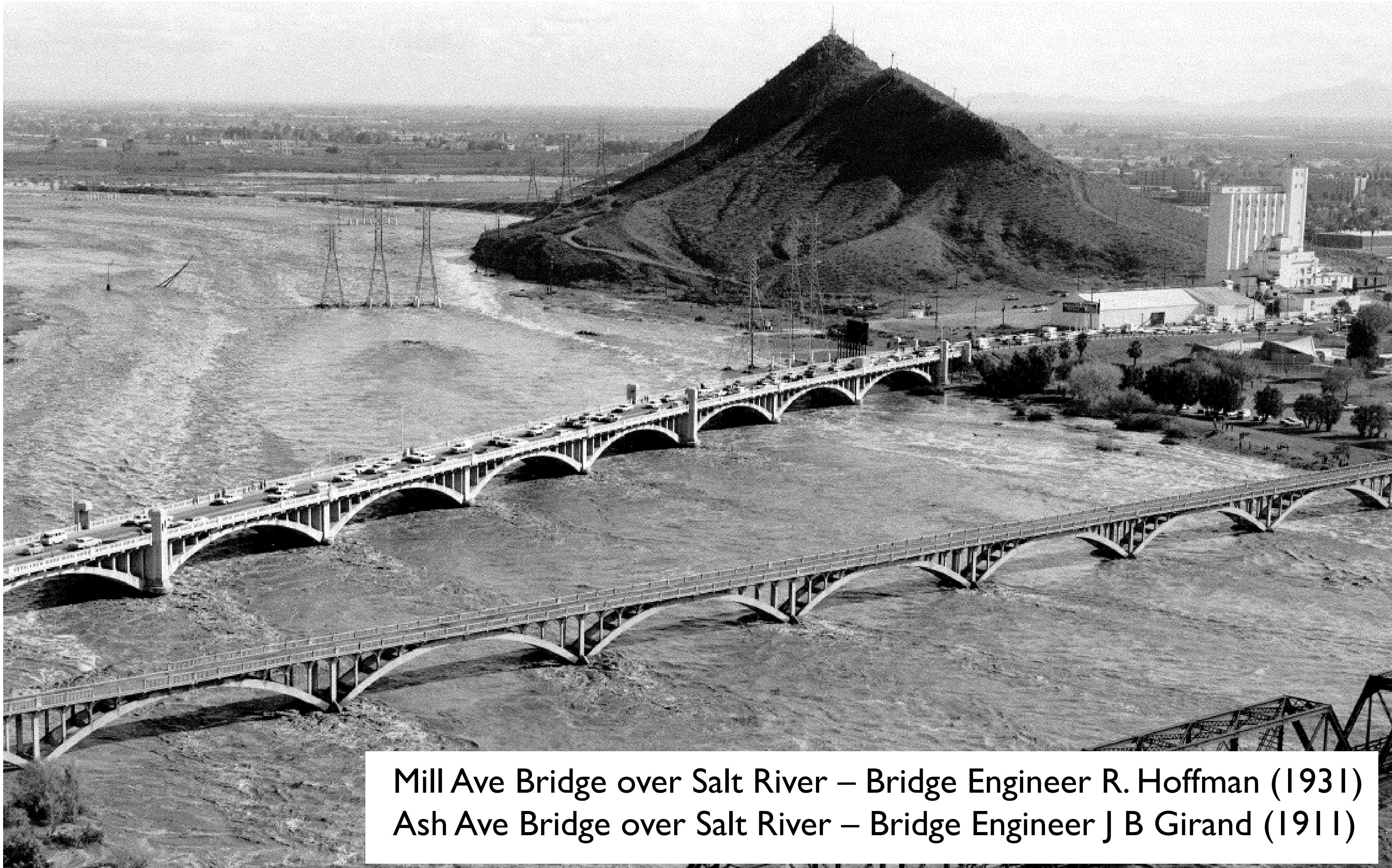
Who Designed Arizona Bridges

Mill Ave Construction Site – 1928 Photo Hoffman Collection - (Mary Lou Vaughan)

J B Girand (1873-1949)

- Girand studied engineering at Texas A&M College
- Girand was Arizona's first Territorial Engineer 1909 – 1912
- Girand designed a variety of projects such as the railroad from Williams to the Grand Canyon and Gillespie Dam
- Girand used convict labor to reduce the cost of bridge construction projects

Photo from Girand Collection (Jon Girand)



Mill Ave Bridge over Salt River – Bridge Engineer R. Hoffman (1931)
Ash Ave Bridge over Salt River – Bridge Engineer J B Girand (1911)

J.B. GIRAND - Ash Avenue Bridge

- Tempe Bridge opened to traffic in 1913 and was called the Ash Ave Bridge. The bridge carried traffic until the completion of the parallel Mill Ave Bridge in 1931, Ash Ave Bridge was demolished in 1990.

- Girand becomes Arizona's first territorial engineer.
- 1909 – 1911 – Girand designs the Florence and Lowell Bridges (on US 80)


Florence Bridge (1909)

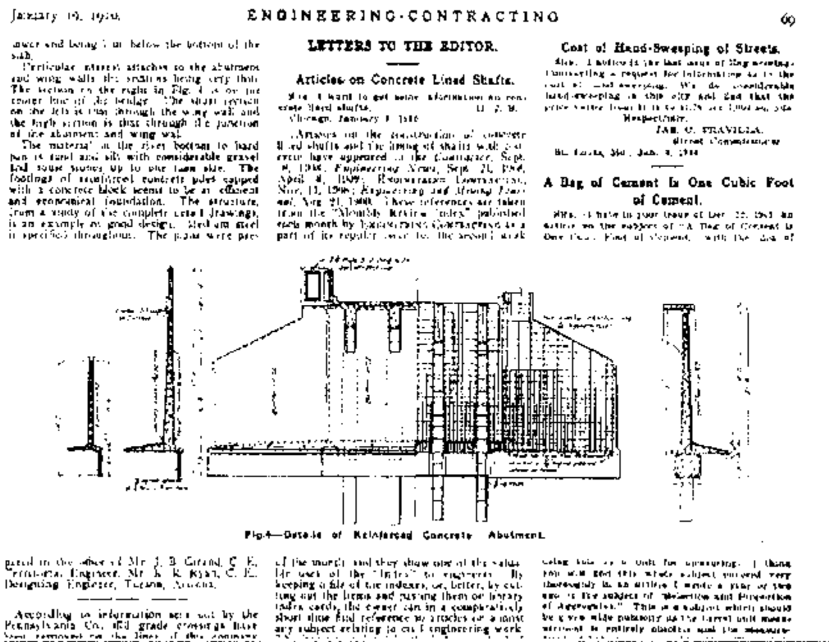

Lowell Arch Bridge (1911)

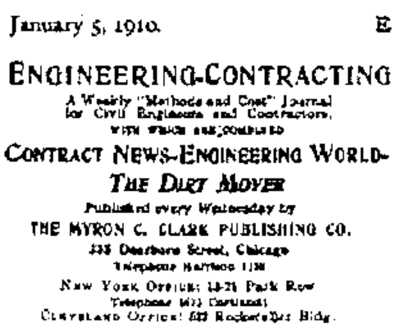
GIRAND – Florence and Lowell Bridges

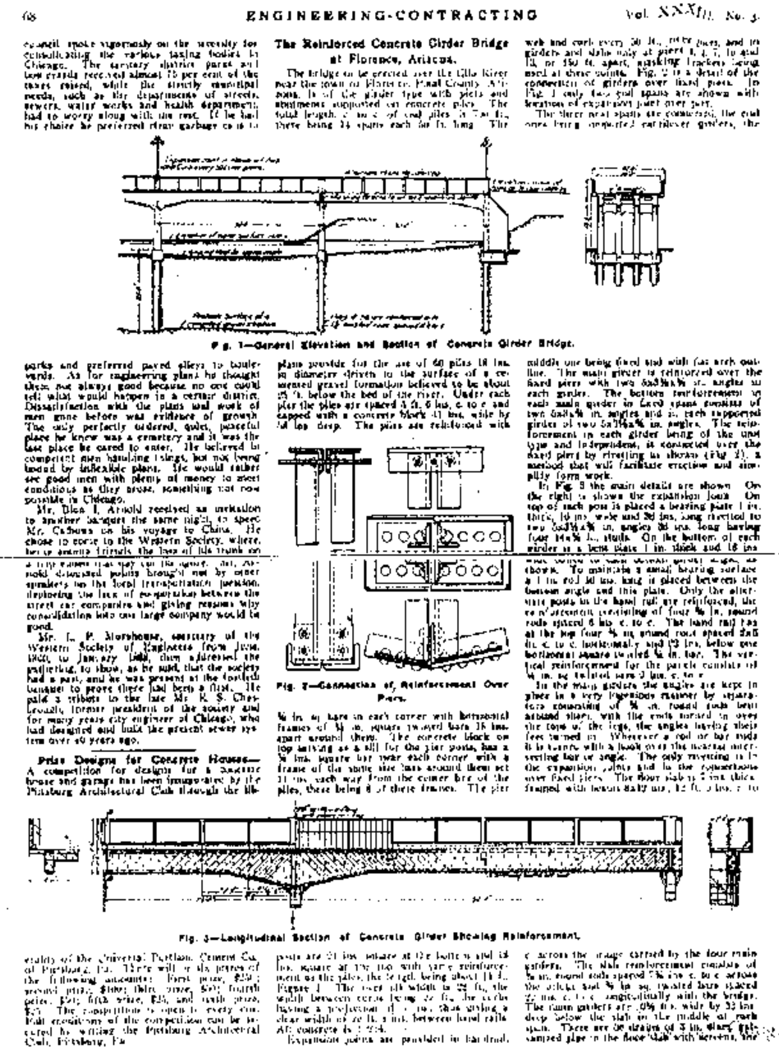
First built in 1885, rebuilt in 1909 and rebuilt in 1950's.

Bridge pier with shallow concrete foundation from earlier bridge construction. Bridge design by JB Girand in 1909.

GIRAND - Florence Bridge over Gila River







GIRAND - Florence Bridge over Gila River

Structure No 130

Location – Mule Gulch / US80 Highway (Cochise)

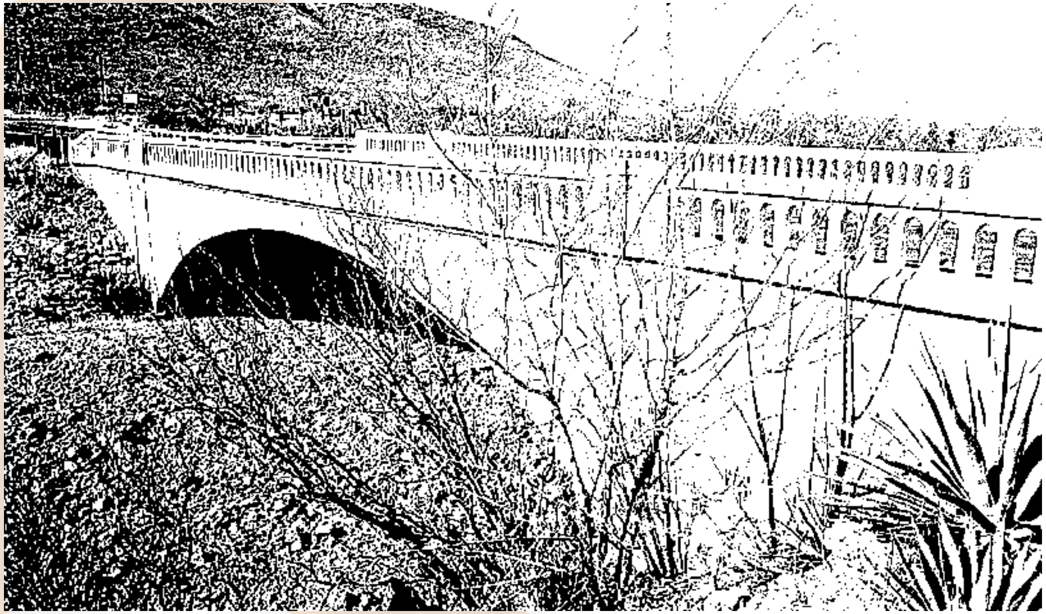
Construction Date : 1911

Engineer : JB Girand Arizona Territorial Engineer

Contractor : R. Tooney & Sons

Max Span Length 60 feet

Owner: ADOT



The Lowell Arch provided an important crossing between Bisbee and Douglas. It was the only filled spandrel arch bridge designed by Arizona Territorial Engineer. The bridge has been widened but remains as one of the states more noteworthy bridges.

GIRAND - Lowell Arch Bridge US80

US 80 Lowell Arch Bridge

Lowell Arch Bridge remains in use by widening the bridge rather than replacing it.

GIRAND - Lowell Arch Bridge

- February 12 was a holiday (Lincoln’s Birthday)…..

- The thirteenth was considered unlucky….

President Taft Signed Arizona into Statehood in the Oval Office
Credit: American Legacy Collection

February 14, 1912 - Arizona Becomes a State

- Lamar Cobb
- First Arizona State Engineer in 1912
- Political appointment by Governor W.P. Hunt
- Directed by Arizona first road law to establish a state highway system.

Structure No: Abd

Location – US 80 Highway Abd / Gila River (Yuma)

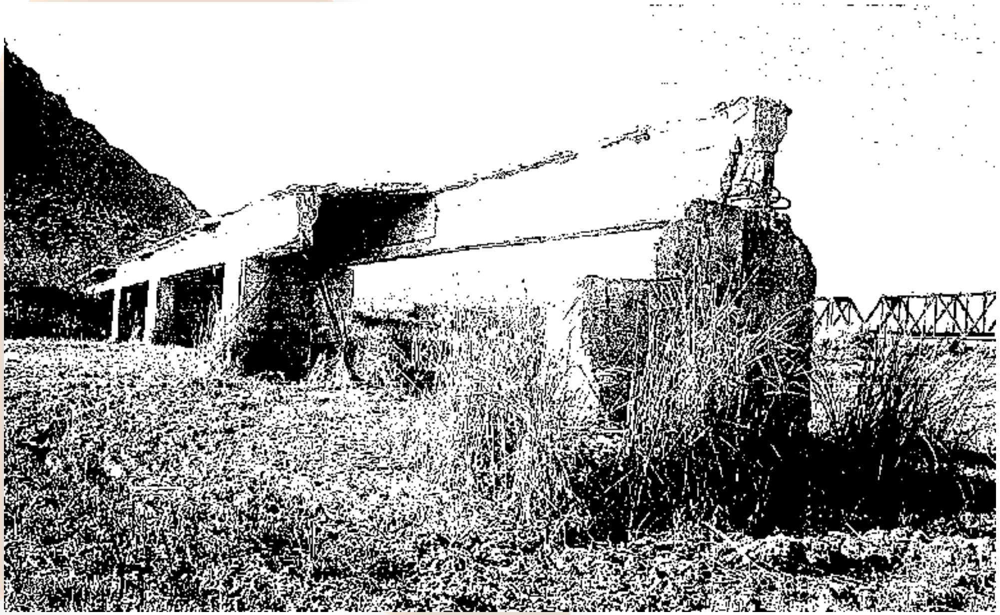
Construction Date : 1915

Engineer : Lamar Cobb – Arizona State Engineer

Contractor : Perry Borchers and Convict Work Force

Max Span Length : 65 Feet

Owner: Yuma County



As a major crossing on a nationally important route, the Antelope Bridge is significant for its role in early Arizona transportation. The bridge is an outstanding example of a concrete girder structure type.

LAMAR COBB - Antelope Hill Bridge

- 1915 – Cobb designed Antelope Hill Bridge over the Gila River near Dome, AZ. This bridge substructure failed. He also designed Agua Fria River Bridge, it also failed.

COBB – Antelope Hill Bridge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Bridge over Tygarts Valley River at Grafton, W. Va.—Consisting of 6 spans with 18 ft. roadway and one 7 ft. sidewalk. Built by Luten Bridge Company for the County Court of Taylor County, W. Va. Steel trolley bridge in background.

Daniel Luten (1869-1946)

- Patented concrete arch
- Claims to have designed 14,000 bridges in USA
- Founded National Bridge Co. 1902
- Professor at Purdue University
- 13 Luten Arch Bridges in AZ

Location – RT66 and Canyon Padre (Coconino)

Construction Date : 1914

Engineer : Daniel Luten

Contractor : Topeka Bridge and Iron Company

Max Span Length : 125 Feet

The first Arizona Luten arch bridge designed by Luten and erected by his western firm Topeka Bridge and Iron. The bridge was on RT66 Highway.

Daniel Luten - Canyon Padre Bridge Rt 66

Daniel Luten - Canyon Padre Bridge Rt 66

Daniel Luten - Canyon Padre Bridge Rt 66

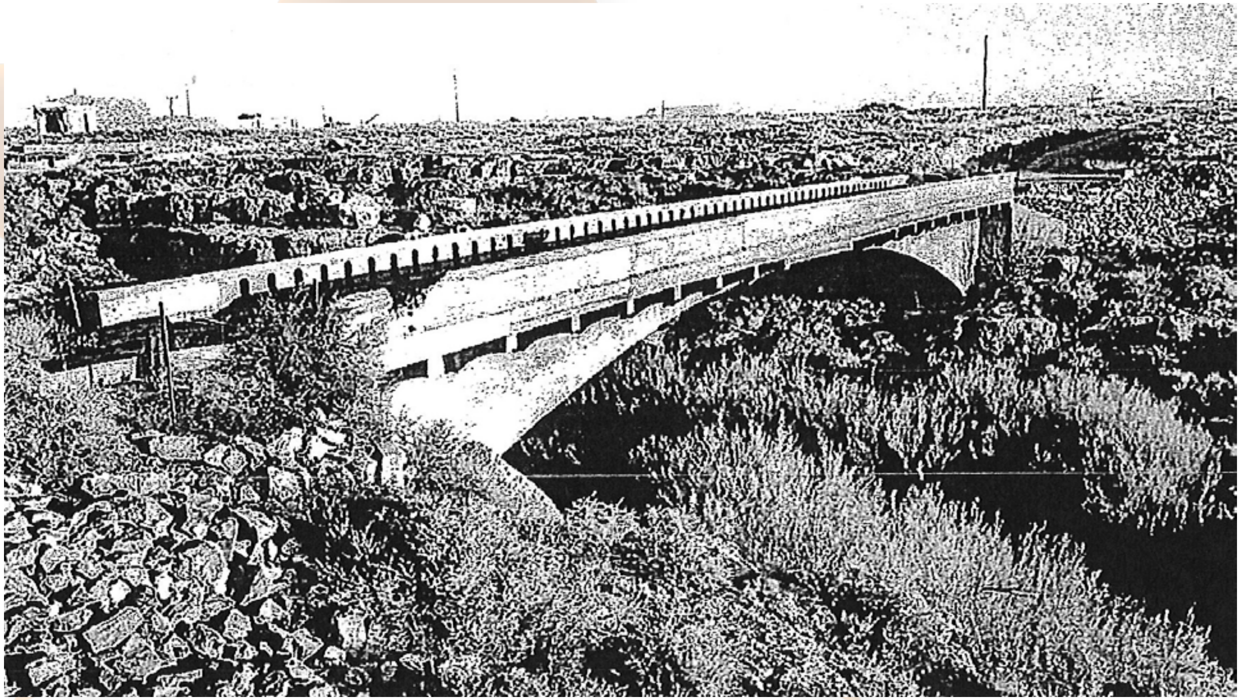
Location – US66 and Canyon Diablo (Coconino – Two Guns)

Construction Date : 1915

Engineer : Daniel Luten

Contractor : Topeka Bridge and Iron Company

Max Span Length : 128 Feet



Important early example of vehicular bridge construction in Arizona using a proprietary design.

DANIEL LUTEN - Canyon Diablo Bridge – Two Guns Rt. 66

- Two Guns – Just south of I-40 between Winslow and Flagstaff
- Ruins of town remain
- Town of Canyon Diablo further north where railroad bridge was built

DANIEL LUTEN - Canyon Diablo Bridge – Two Guns Rt. 66

- Canyon Diablo Bridge (Canyon is 550’ wide and 225’ deep).
- Three versions built in the same location: 1881 (one track width, iron); 1900 (one track width, iron); 1947 (two track width, steel, still exists)
- Canyon Diablo – A lawless town of 2000 near railroad bridge

BNSF Canyon Diablo Railroad Bridge

Structure No 8227

Location: Old Safford Road / Gila River (Greenlee)

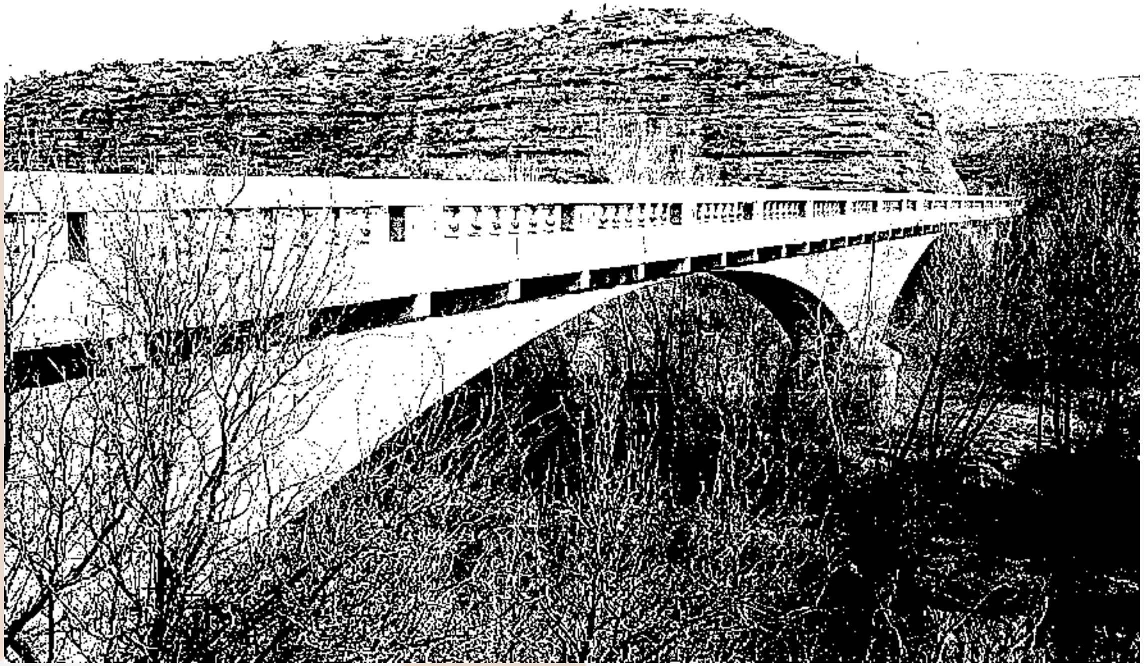
Construction Date: 1918

Engineer: RV Lesson and Daniel B Luten

Contractor: Convict work force

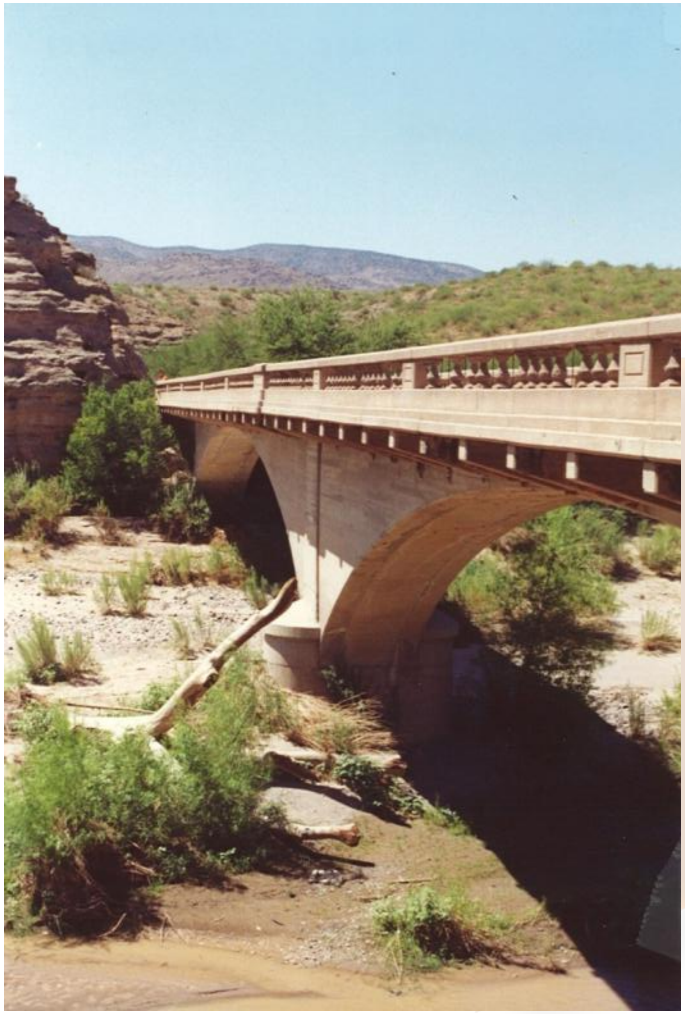
Max Span Length: 123 feet

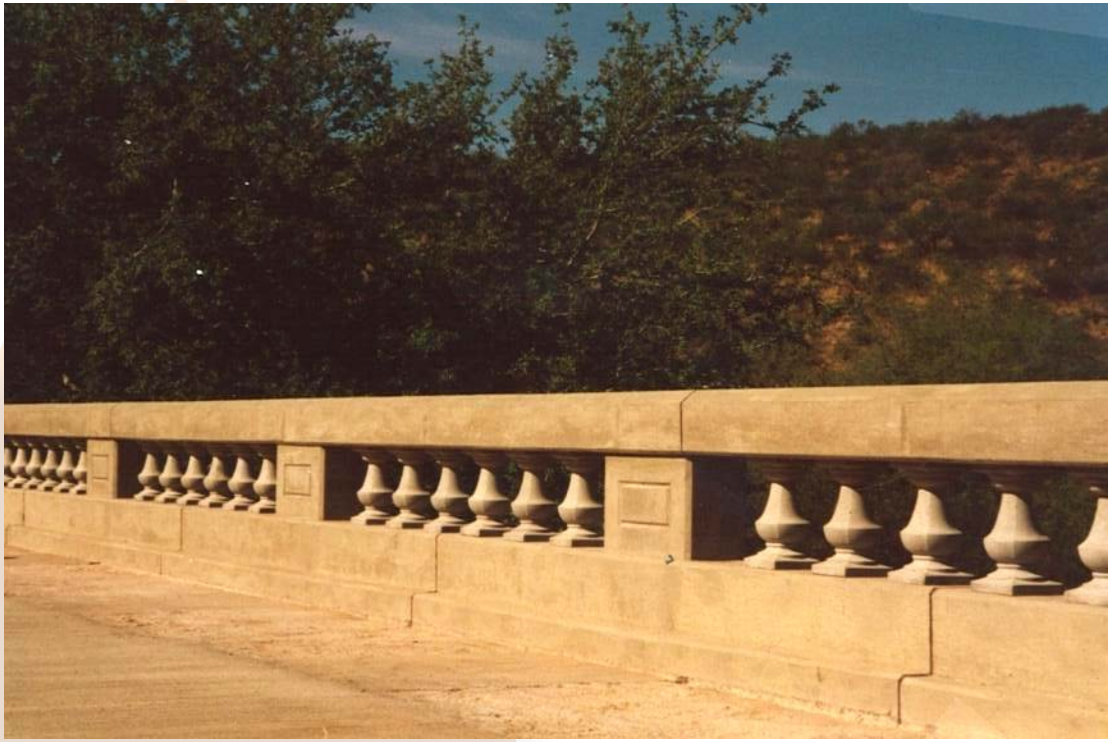
Owner: Greenlee County



The Gila River Bridge built by convict labor, outstanding long span example of the Luten arch design, patented and modified by Daniel B. Luten. One of the most significant vehicular bridges in Arizona.

LUTEN – Old Safford Road Bridge Over Gila River





- Replaced barrier rail with near replica of historic railing – added solid piers to strengthen rail for traffic loads

LUTEN – Old Safford Road Bridge

Location: City of Miami / Bloody Tanks Wash

Construction Date: 1921

Engineer: Topeka Bridge and Iron Company (Daniel Luten)

Contractor: City of Miami workforce

Max Span Length: 50 feet

Owner: City of Miami

The Inspiration Avenue Bridge is one of five identical bridges that span Bloody Tanks Wash. Their distinctive designs is significant as the only short span application of Luten arch bridges in AZ.

LUTEN – Town of Miami Bridge Over Bloody Tanks Wash

Deteriorated barrier rail in need of repair

Replaced barrier rail with near replica of Historic railing. Precast balusters in place and ready for placement of concrete top rail.

LUTEN - Town of Miami Bridges

- Bridge barrier rail with decorative lights
- Luten Arch Bridge – Cambered Bridge posted speed / no trucks

LUTEN - Town of Miami Bridges

Location – Holbrook – Winslow Road / Chevelon Creek (Navajo)

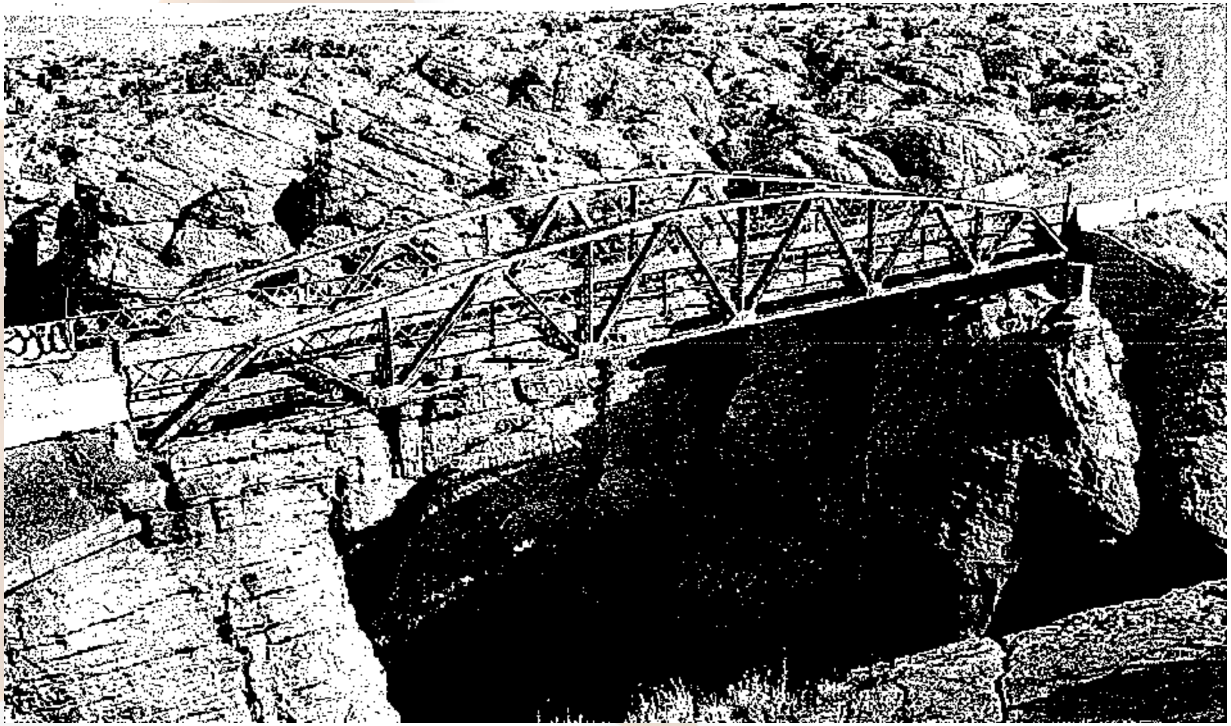
Construction Date : 1913

Engineer : BM Atwood Arizona State Engineer

Contractor : Missouri Valley Bridge and Iron

Max Span Length : 102 Feet

Owner: Navajo County



This bridge is one of Arizona's most historically and technologically important spans.

B.M. ATWOOD - Chevelon Creek Bridge RT 66

ATWOOD - Chevelon Creek Bridge Rt 66

ATWOOD - Chevelon Creek Bridge Rt 66

ATWOOD - Chevelon Creek Bridge Rt 66

Structure No 8166

Location: South River Road / Santa Cruz River (Santa Cruz)

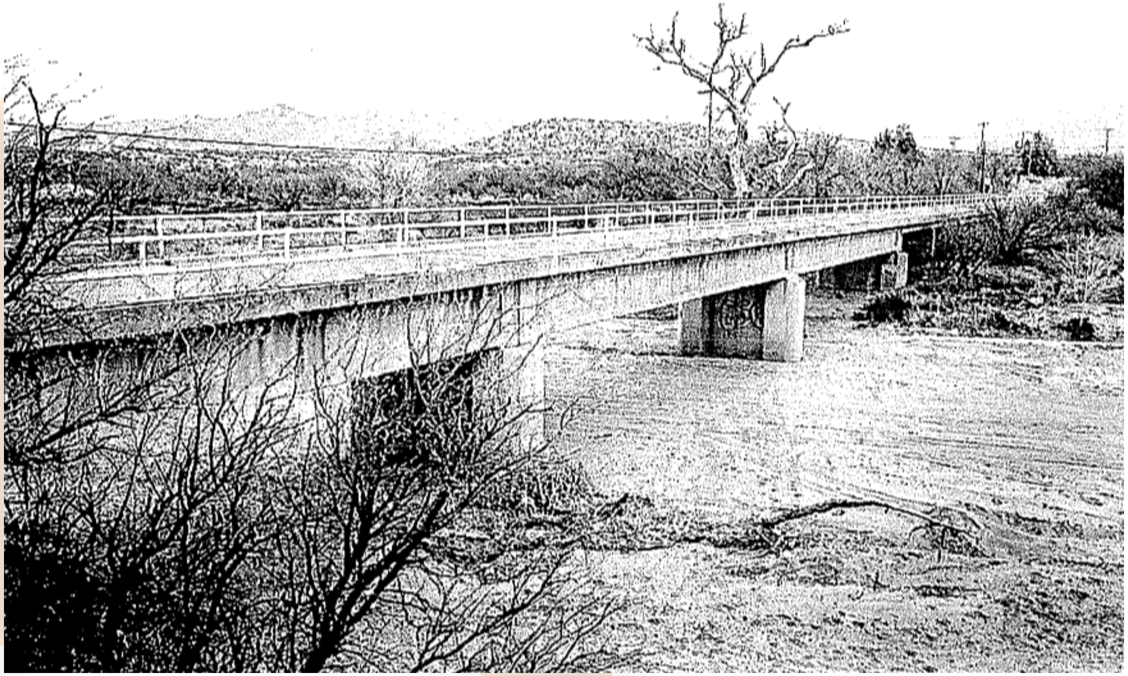
Construction Date: 1917

Engineer: BM Atwood – Arizona State Engineer

Contractor: State workforce

Max Span Length: 65 feet

Owner: Santa Cruz County



The Santa Cruz River Bridge is the earliest and longest span concrete girder bridge still in use on a county road system. "It is a significant early Arizona Bridge"

ATWOOD – Santa Cruz River Bridge

ATWOOD – Santa Cruz River Bridge Repair

Location – SR88 / Boulder Creek (Maricopa)

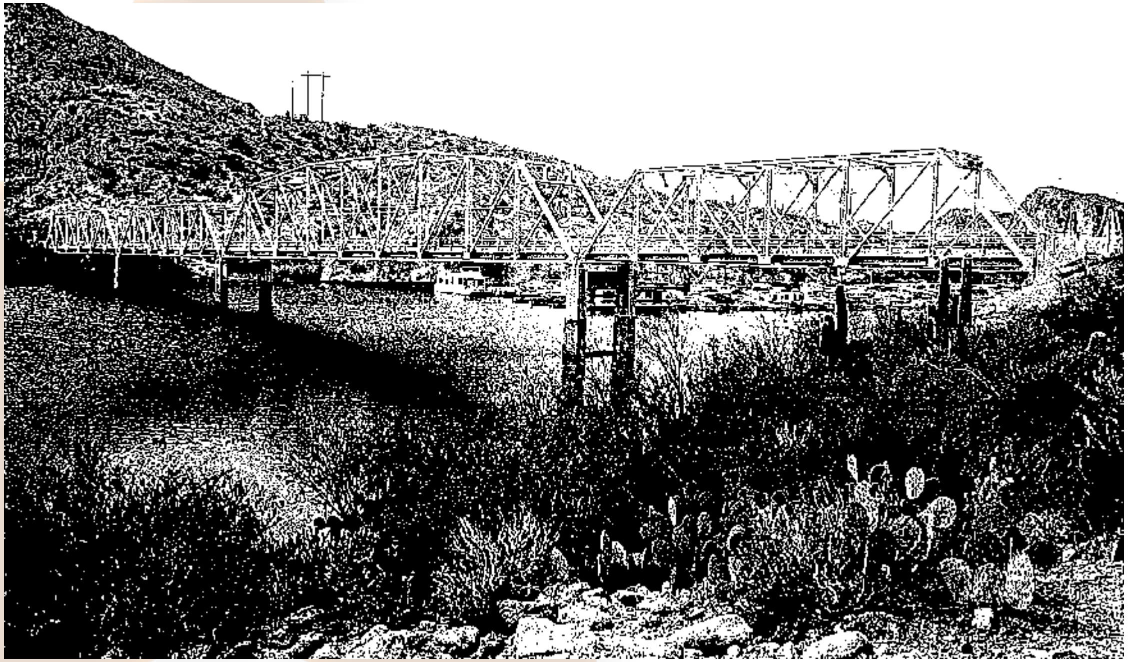
Construction Date : 1914

Engineer : Merrill Butler – Arizona's First State Bridge Engineer

Contractor : State Workforce

Max Span Length : 180 Feet

Owner: ADOT



The Boulder Creek Bridge built to carry Ocean to Ocean Highway at Wickenburg moved in 1920 to Boulder Creek on the Apache trail. One of Arizona's most important highway bridges in the 1920's.

MERRILL BUTLER - Boulder Creek Bridge

BUTLER - Boulder Creek Bridge

Ralph Hoffman (1894 – 1967)

AZ State Bridge Engineer 1927 - 1955

- Succeeded Merrill Butler
- Changed the way bridges were designed
- Focus on economy, efficiency less concrete
- Engineered over 200 bridges
- Built bridges to fit roads
- Hoffman was State Bridge Engineer until 1955 and went into private practice firm Hoffman and Miller

Ralph Hoffman

HOFFMAN – State Bridge Engineer

Photo: Hoffman Collection (Mary Lou Vaughn)

Structure No. 8293

Location: Marsh Station Road (Pima) US80

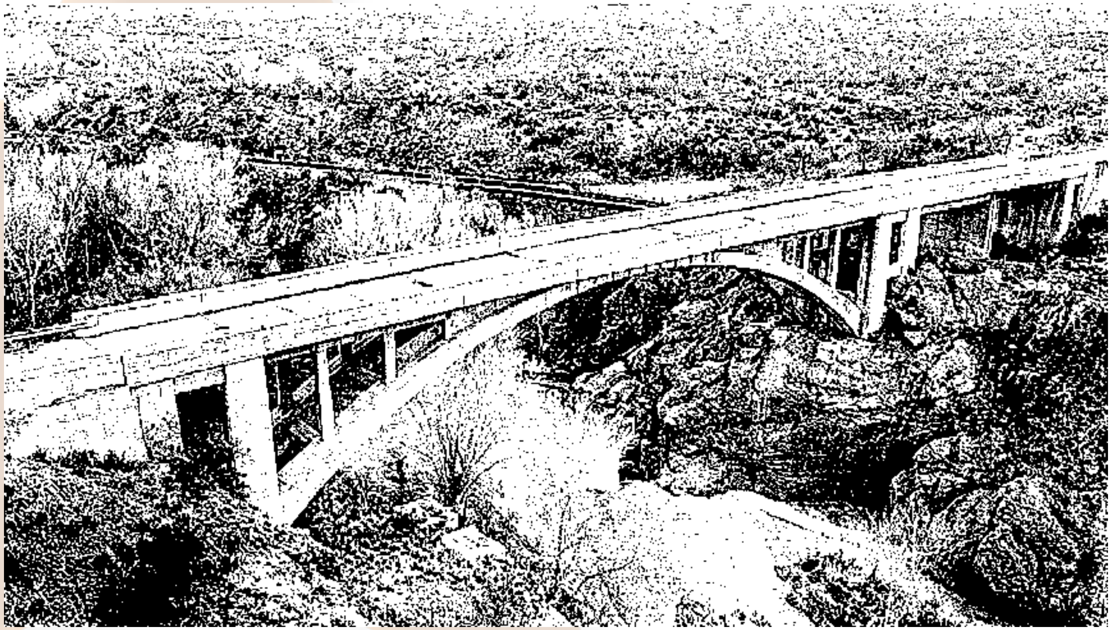
Construction Date: 1921

Engineer: Ralph Hoffman – Arizona Highway Department Bridge Engineer

Contractor: English and Pierce

Max Span Length: 146 feet

Owner: Pima County



The Cienega Bridge is an excellent example of an uncommon structural type and integral link on Borderland Highway. The Cienega Bridge is one of Arizona's more historically and technologically significant vehicular structures.

HOFFMAN – Cienega Bridge – (US80)

HOFFMAN - Cienega Bridge – (US80)

Structure No 3073

Location: Indian Route 9402 – Rio Puerco River – Apache County

Construction Date: 1923

Engineer: Ralph Hoffman – Arizona Highway Department – Bridge Engineer

Contractor: Midland Bridge Company

Max Span Length: 90 feet

Owner: Bureau of Indian Affairs

Allentown Bridge the earliest steel trusses built by Arizona Highway Department, and one of the earliest deck trusses with Cantilevered ends.

HOFFMAN - Allentown Bridge (Rt 66)

HOFFMAN - Allentown Bridge (RT 66)

HOFFMAN - Allentown Bridge (RT 66)

Structure No 8021

Location: Old US80 Highway on Gila River

Construction Date: 1927

Engineer: Ralph Hoffman – Arizona State Bridge Engineer

Contractor: Lee Moor Construction Co.

Max Span Length: 200 feet

Owner: Maricopa County

The Gillespie Dam Bridge carried main line traffic on the Ocean to Ocean Highway (US80). The Gillespie Dam Bridge is one of the most important examples of early bridge construction in Arizona.

HOFFMAN - Gillespie Dam Bridge (US 80)

Historic Photo – Before the bridge was built vehicles traveled over the concrete apron on the down stream side of Gillespie Dam.

HOFFMAN - Gillespie Dam Bridge Looking North

Bridge Rehab Work 2011 – 2012

- Pressure grouting pier footings
- Replace truss roller bearings
- Heat strengthening steel
- Interpretive center

Structure No 51

Location: US89A Over Colorado River (Coconino)

Construction Date: 1929

Engineer: Ralph Hoffman – Arizona State Bridge Engineer & LC Lashmet Design Engineer

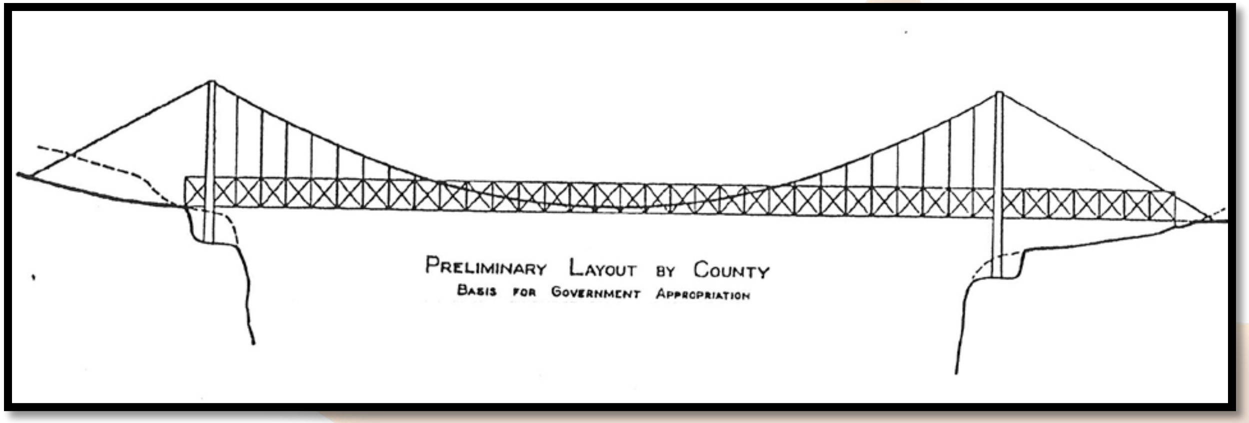
Max Span Length: 616 feet

Owner: ADOT

Spanning over the Colorado River and the Grand Canyon National Park. The Navajo Bridge is Arizona most aesthetically and successful example of civil engineering.

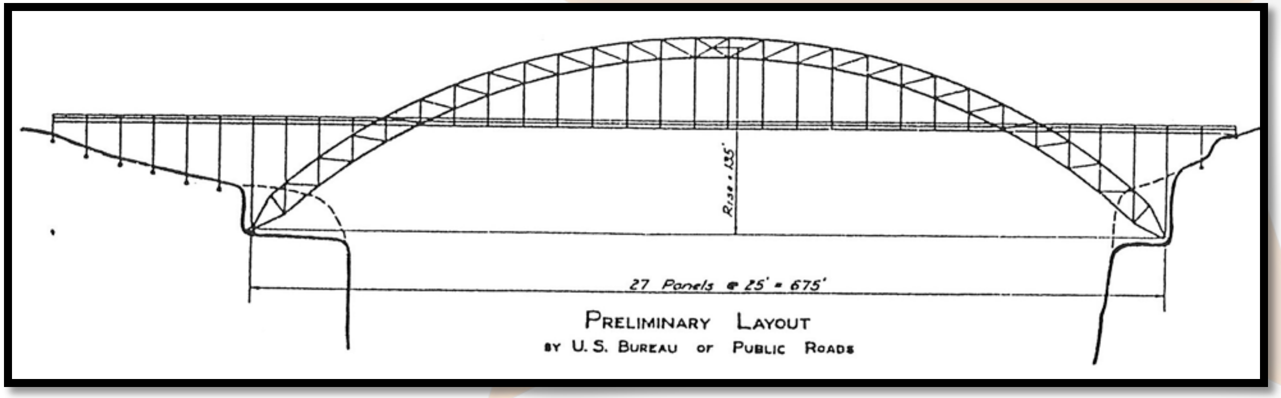
Ralph Hoffman - Historic Navajo Bridge

Alternative Bridge Designs



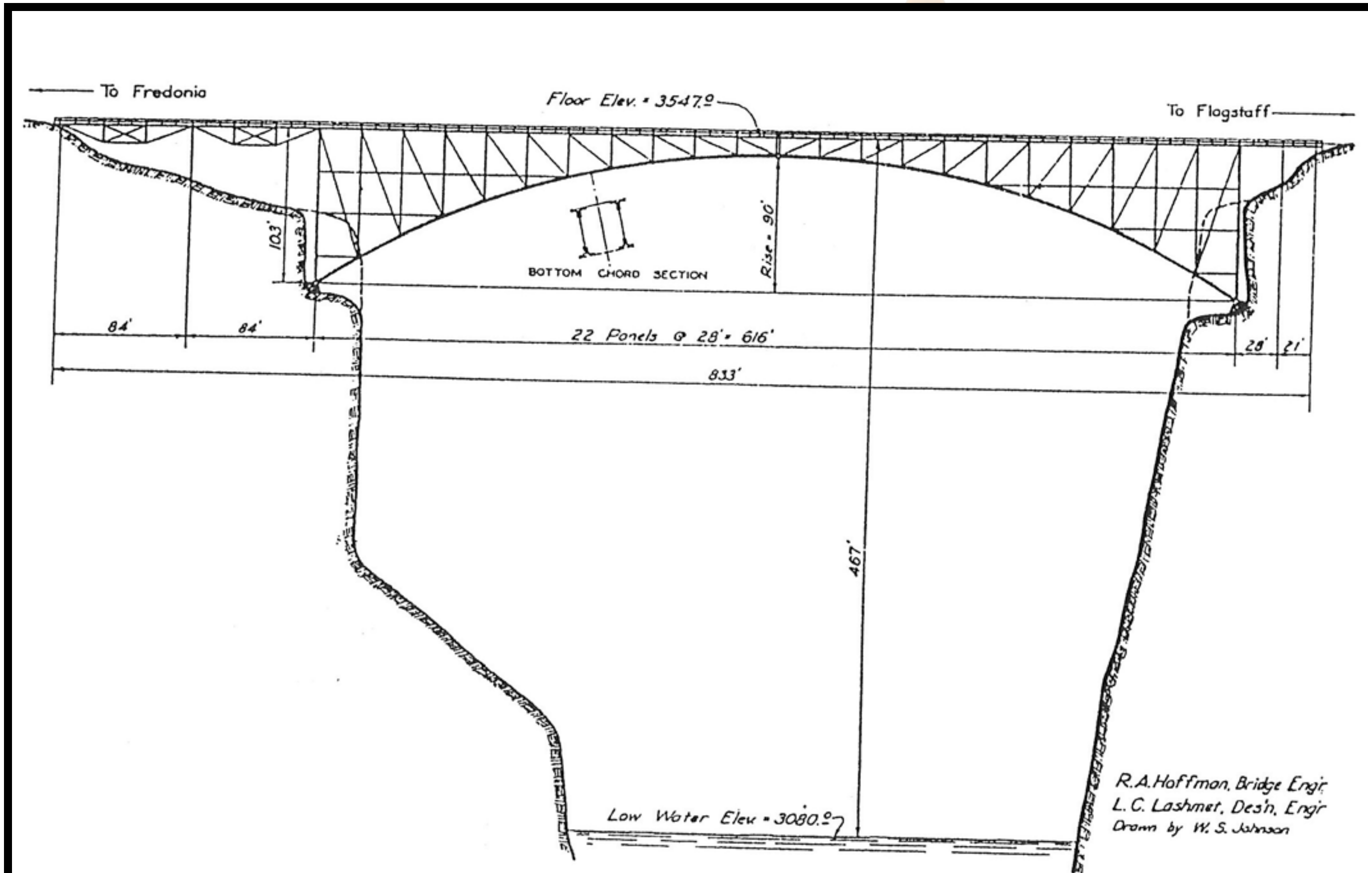
Suspension Bridge – JB Wright, Coconino County Engineer 1923

- Suspension bridge too costly + flimsy



Through Arch Bridge Bureau of Public Records 1924

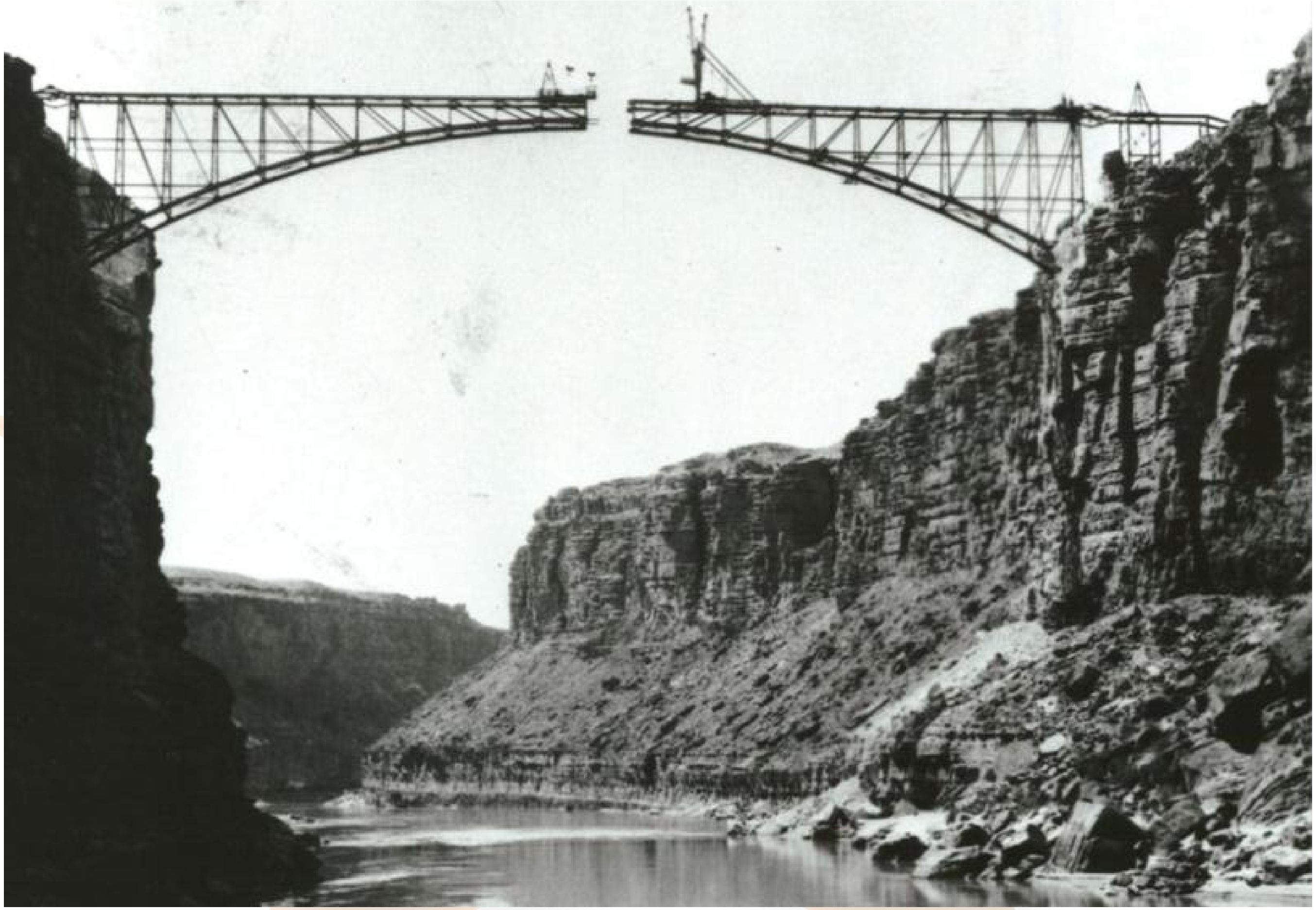
- Through Arch Bridge too costly and needed heavy overhead cableways



Deck Arch Bridge – Hoffman & Lashmet 1927

Hoffman / Lashmet Design

- Creative design & Hoffman's most successful
- Bridge harmonized with canyon
- Uninterrupted views of canyon
- Arch thrust taken by canyon walls



- The Navajo Bridge was Ralph Hoffman's most important design providing views of Marble Canyon uninterrupted by any significant human artifact as far as the eye can see

Navajo Bridge over Colorado River (vehicular) Bridge Engineer Cannon - 1995
Historic Navajo Bridge over Colorado River (Pedestrian) Bridge Engineer Hoffman 1929

HOFFMAN – Historic Navajo Bridge

Structure No. Private

Location: RT 66 / Querino Canyon (Apache)

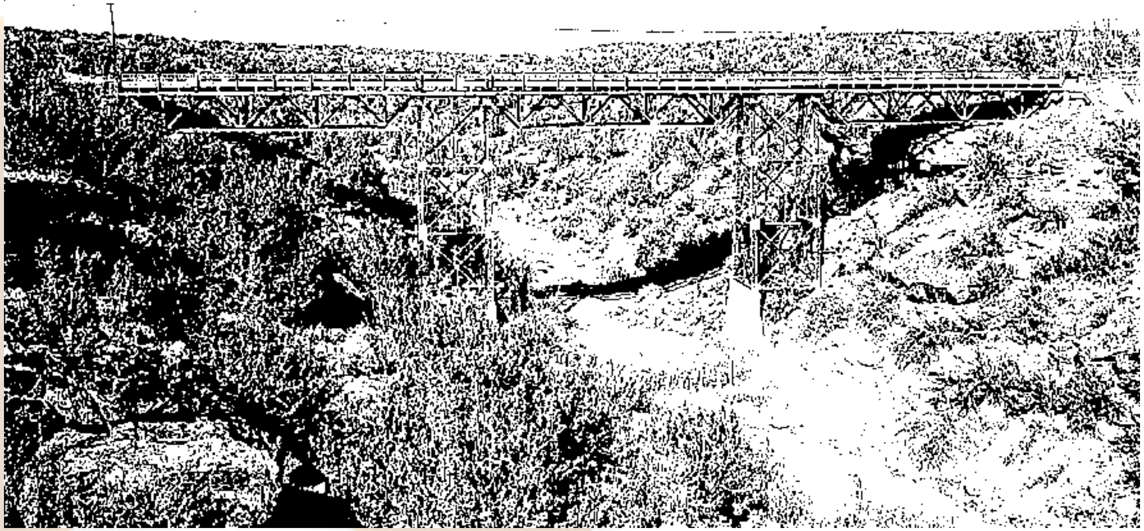
Construction Date: 1930

Engineer: Arizona Highway Department – Ralph Hoffman Arizona State Bridge Engineer

Contractor: FD Shufflebargn - Phoenix

Max Span Length: 77 feet

Owner: Apache County



As an important crossing on RT 66, it was an integral link of one of Arizona's transportation routes. The linkage is technologically significant as one intact example of construction in Arizona.

HOFFMAN - Querino Canyon Bridge (RT 66)

HOFFMAN - Querino Canyon Bridge Rt 66

Structure No. 9954

Location: Mill Ave / Salt River Tempe

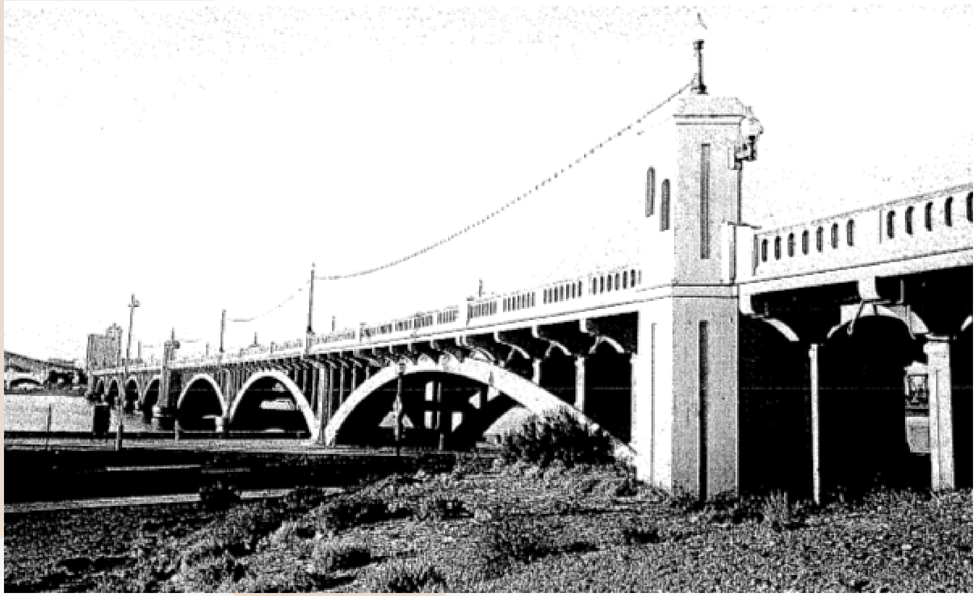
Construction Date: 1931

Engineer: Ralph Hoffman Arizona State Bridge Engineer & Swan Erickson Design Engineer

Contractor: Lynch Cannon Engineering Company

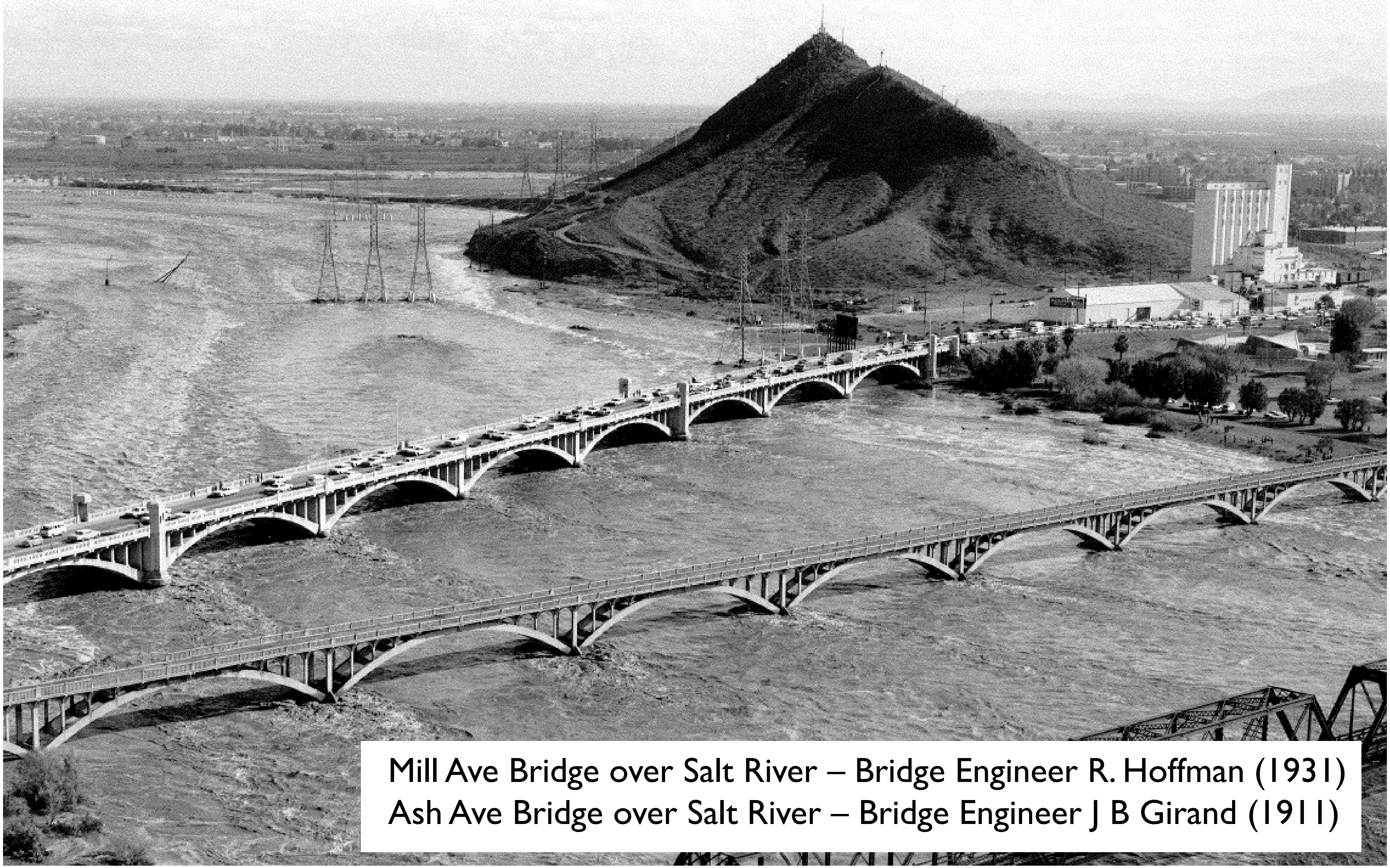
Max Span Length: 150 feet

Owner: City of Tempe



The Mill Ave bridge is technologically significant as having the longest span length of open spandrel and was the longest highway bridge in Arizona it is one of Arizona's most historically and technologically significant vehicle structures.

HOFFMAN - Mill Avenue Bridge (US80)



Mill Ave Bridge over Salt River – Bridge Engineer R. Hoffman (1931)
Ash Ave Bridge over Salt River – Bridge Engineer J B Girand (1911)

HOFFMAN - Mill Avenue Bridge (US80)

HOFFMAN - Mill Avenue Bridge (US80)

ARIZONA HIGHWAYS

CIVILIZATION FOLLOWS THE IMPROVED HIGHWAY

olume VII. June, 1931 Number 6

Tempe Bridge Soon To Be Ready For Traffic

By RALPH HOFFMAN, Bridge Engineer.

The completion of the new Tempe Bridge, Arizona's largest and most magnificent causeway, adds another triumph of engineering skill and closes another chapter in the history of Arizona highway construction.

Many readers will recall the dedication of that spectacular structure, the Grand Canyon Bridge, and now just two years later plans are being carried forward for the dedication on July 4th, 1931, of the Tempe Bridge.

This new structure, although not so spectacular as the former, is the largest bridge ever built in the state of Arizona, both in length and width of roadway. The total length is 1577 feet; the width of the roadway is thirty-six feet between curbs and provides room for four lanes of traffic. In addition a five-foot sidewalk is provided on each side, making a total width, inside the concrete ndrails, of forty-six feet.

Comparing the above dimensions with those of the old bridge,—an 18-foot roadway and no sidewalks,—those who have driven over it in periods of heavy traffic will realize the easy comfort of driving on the new structure.

The old bridge, designed for the traffic of 20 years ago, has been replaced with a modern structure in which the engineers have attempted to visualize the future needs of this highway.

Within City Limits

The bridge is located at the south end of Mill Avenue within the city limits of Tempe, and carries the traffic of three main U. S. Highways, namely: U. S. Route 89, the only north and south highway through Arizona; U. S. Route 80, a transcontinental highway, and U. S. Route 60, the new transcontinental route recently established through Arizona. Thus it will be seen that, with the completion of Route 60, a large percentage of the tourist traffic must pass over this bridge in addition to the ever increasing local traffic.

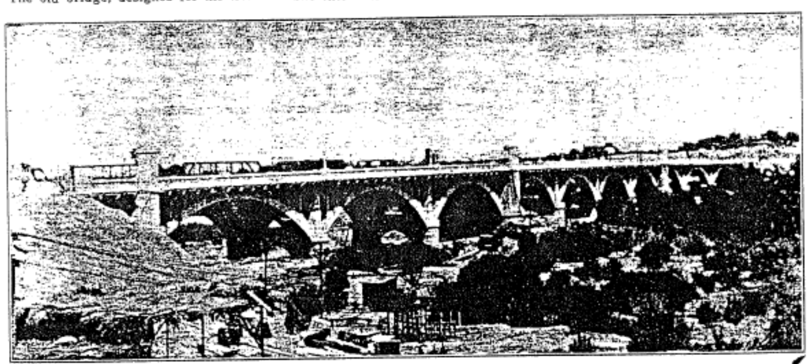
The recent traffic counts show a total of about 8,000 vehicles each 24 hours traversing this section of the highway; and this total has been increasing rapidly. If the old bridge carried this traffic it is safe to say that the new one will handle three or more times this total on account of the width of roadway and the increased speed made possible by that width.

The extension of Mill Avenue was the only logical location, as it maintains the present line of travel through the main part of town and eliminates two right angle turns in the town of Tempe.

A survey was made first extending the center line of Mill Avenue straight across the river and re-entering the present highway with a long curve on the north side of the river, and a contract was let for foundation borings. The results of these borings were at first very discouraging. The data obtained showed shallow rock foundation for less than half the length of the bridge and the remaining portion a soft caliche. The rock apparently dipped abruptly and was not encountered at depths up to 75 feet beyond the center of the channel.

Side Found Unfavorable

The experience with the railroad bridge only 300 feet up stream, on which two steel spans were lost by the failure of a pier, was sufficient evidence that the caliche material was not adequate for foundations except at a depth which would preclude all possibilities of scour under the footings. This depth was considered to be 40 to 45 feet below low



View of new Tempe Bridge looking down stream, showing arch construction. Each arch has a span of 140 feet.

water elevat on, which meant only one tyre of d-si-n —long steel spans.

In addition to the deep foundations thi- site required extensive bank protection and a long, high fill at the north end of the bridge and the loss of con-i erable length of the existing paved highway on that side.

The profile plotted from the test borings did, however, show a high point in the rock formation toward the center of the channel. In studying this profile of the ground it was discovered that the high point lined with an outcrop of rock on the north bank under the old bridge and a ridge extending out from the Tempe Butte.

This discovery indicated the possibility of a rock ridge or dyke extending across the river diagonally across our line. The indication of the existence of such a formation was so strong that our own drilling force was moved on the job to prove our theory.

Located Diagonal Ridge

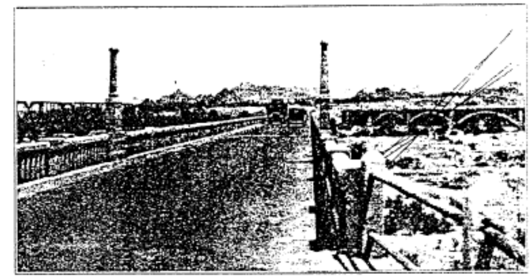
An extensive drilling program was laid out and the ridge located as expected. Contours of this formation under the bed of the river were plotted and a paper location for the new center line laid out.

This location, by spanning a small underground channel in the rock near the north bank, made possible a fairly shallow rock foundation for the entire length of the bridge and also made possible the adoption of the concrete arch design. The line extends from a point on Mill Avenue on the south bank diagonally across the river to an intersection with the present highway at the north end of the old bridge. An easy curve (one degree) extending onto the bridge from each end was not difficult to take care of in the design.

The estimated saving of this line over the original was more than $100,000 on foundations and roadway.

For economy the design was practically limited to the deck type structure on account of the width of roadway to be provided. It was also desirable to keep the roadway on as low a level as possible, which limited the span length on account of available head room. For these reasons only two types were considered: the concrete arch and the steel plate girders.

The limit of the span length for the concrete arches was about 140 feet and for the steel girders about 100 feet; the problem resolved itself into the comparison of relative merits of two designs on this basis.



The old Tempe Bridge, which the new structure, to be seen at the right, will soon supplant. It was a close squeeze for a truck and auto to pass on this old bridge. On the new bridge 5 cars can pass, as shown on cover scene.

Prevailing steel prices at that time and the additional piers required for the steel design resulted in a slightly lower cost for the concrete arch type. The concrete structure was to be preferred on account of the inherent architectural effects to be secured without additional cost and probably would have been the accepted design even at a slightly higher cost.

Ten Spans in Bridge

Final plans were worked up for the arch bridge consisting of ten spans, 140 feet each. The spans were of the two rib open spandrel type, with the concrete roadway supported on beam and webbed columns above the two ribs.

Each rib is two feet nine inches in thickness by nine feet wide at the crown, seven feet thick in the vertical plane at the piers.

The reinforcement consists of 1¼ inch square bars at 12 inch centers in the top and bottom of the rib throughout its length, except that this steel is doubled in the extractors (top) at each end for a distance of about 30 feet out from the pier.

The ribs were designed as hingeless arches fixed at the piers and the stresses analyzed by the elastic theory involving long, tedious calculations and a mass of figures which have no place in this article.

Two types of piers were used in the design. It was considered advisable to provide at least two abutment piers for convenience and safety in construction. With this in view the spans were divided into three groups of three, four and three spans each and the groups separated by abutment piers. The piers are of the same general design below the top of the arch except in size, the abutment pier being 15 feet in girth at the spring line of the arch while the intermediate piers are only 7½ feet. These are constructed with two separate shafts on separate footings and the shafts are tied together with an arched tie strut., built intergral with the pier cap at the junction with the arch rings.

Above the arch the intermediate piers carry a typical column construction, while the abutment piers are surmounted by a sand box extending the entire length of the piers, to give additional weight. The ends of these boxes are carried up above the roadway in a hexagonal tower effect, terminating in a canopy over a retreat bay in the pier end. These piers are capable of resisting the full deal load thrust of the arches from one side only.

On account of the height of 32 feet from the spring line of the arch to foundation some degree of flexibility was anticipated in the intermediate piers. The movement of the pier top under live load on the bridge was calculated and its effect on the stresses in the arch ring analyzed. The result required an increase in the size of reinforcement in the rib.

Open Type Abutments

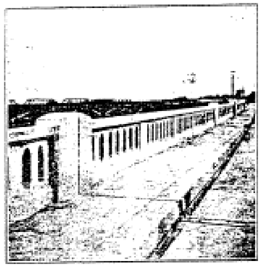
The abutments are of the open type with the earth fill spilling around the end columns. The same effect as at the abutment piers has been maintained with a tower on each side of the roadway with the addition of a hexagonal pylon at the ends of the railing.

The roadway slab is reinforced as a continuous slab between expansion joints with bent steel providing for negative moment over the supporting beams. Four expansion joints are provided to each span at about the third points of

HOFFMAN - Mill Avenue Bridge (US 80)

...e span and at each pier. A feature of the design is the elimination of all sliding joints by supporting all ends on separate columns.

The handrail details were worked out after a careful study of those built in other cities and a design arrived at



The hand rail and sidewalk on the new brige adds beauty to the bridge, and safety for pedestrians.

which is sturdy as well as distinctive and in keeping with the rest of the structure.

The lighting fixtures and poles were selected to harmonize with the rest of the handrail structure. Mounted upon handrail block over each intermediate pier is a spun concrete pole surmounted by a standard street lighting unit. At the towers these units are supported on heavy bronze brackets mounted on each side of the tower.

In all there are thirty-four of these units on the bridge. The bracket lights on the towers are specified to be arranged in a circuit to burn all night and the rest to be controlled by an automatic time clock, so that they will burn only during the early hours of the night. In this manner ample lighting will be assured at all times.

The lighting will not be maintained by the state but is placed there for the use of the city of Tempe, as the bridge is within the city limits.

The sections of the members throughout the bridge were designed to a minimum required for the stress and practically no concrete was added for mass affect or architectural treatment except in the work above the deck,—handrails and towers.

The contract was awarded January 22, 1930, to the Lynch-Cannon Engineering Co. of Los Anglees, the low bidder on the job. This company began work under their contract in March, 1930.

Anchored In Solid Rock

The first work was that of excavating for the piers and abutments. Cofferdams of heavy steel sheet piling were driven to rock and the sand and gravel taken out with a crane. The design required the concrete footings to be anchored three feet into the solid rock, which required blasting the rock out to the footing lines.

While the excavation of the first hole was in progress a central mixing plant was erected adjacent to a commercial gravel plant ,which was to furnish the sand and gravel for the entire job. Belt conveyors transported the material from the plant to large storage bins above the mixer. From these bins the sand and gravel were weighed in a batcher and dumped into the mixer. The cement was supplied from an adjacent storage shed by means of a skip which dumped directly into the hopper.

From the mixer the concrete was hauled on an industrial railroad to the job. Here the batch boxes were lifted from the cars and dumped into the forms. For the footings and piers the gasoline operated crawler crane was used in depositing the concrete.

In concreting the arch rings and deck it was necessary to have a machine which could reach the entire height and width of the structure so that concrete could be deposited at any desired point with a minimum of moving. For this purpose a traveling gantry crane was constructed, consisting of a four heavy post frame mounted on four flanged wheels. Supported on top of this frame at deck level was a boom derrick, operated by a gasoline hoisting engine. Two steel rails laid parallel to the bridge permitted this crane to be shifted to any span in a short space of time.

Each rib was poured in five main sections and four keys, each five feet six inches long, which were omitted until the other sections of concrete had taken shrinkage. Two of these keys were near the crown and two at the haunches and were placed at the lap in the reinforcing steel. The purpose of the keys was to eliminate as much of the initial stress in the ring as possible.

Fooled by Big Boulder

The sections of rib were poured symmetrically about the center of the span to balance the load and the timber false work and prevent distortion.

The two abutments were completed first, as specified, in order to allow a contract to be let for approach fills. Then the piers were completed in order, beginning at the Tempe end.

When pier number 9 was reached in the process of construction, rock foundation was found at plans elevation on the upstream side and extending over about one-half the area of the pier. Original tests for rock made at this pier showed rock at the same elevation at both ends, but developments showed that the drill had struck a large boulder at one end and the crew, confident in the discovery of bed rock, had moved on without the usual check.

Steel rails were at once driven on the perimiter of the pier and a profile of the solid rock plotted to determine its actual location and slope. On the low side the rock was found at an elevation about 30 feet below the high side.

The construction here called for special treatment. The work on this pier was the most difficult encountered on the entire job and required very careful preparations. In order not to delay the rest of the construction the work on this hole was carried on in three eight-

One of the eight rest stations on the new bridge.

hour shifts until the pier was finished. More than 3,000 cubic yards of material were excavated from the hole, of which about 25 per cent was solid rock.

The last concrete was poured in the deck during May, 1931, and the last concrete in the bridge, a small dado in the handrail, was poured on Wednesday, June 3, 1931—just fifteen months after starting the work.

Throughout the entire job is reflected

(Continued on page 23)

NEW TEMPE BRIDGE SOON TO BE READY FOR TRAFFIC

(Continued from page 7)

a careful and excellent workmanship which is a credit to the engnieers and contractors. A full measure of credit should be given to the engineering force under the direction of A. F. Rath and to the general foreman, E. C. Moore and his men for the pride they have taken in a piece of work well done.

The Lynch-Cannon firm was represented by F. L. Holser, general manager of the company, who by frequent contacts with the work made it his duty to promote harmony and give the state a finished product in which there could be no fault.

HOFFMAN - Mill Avenue Bridge (US80)

Structure No. 129

Location: US60 Highway and Salt River (Gila County)

Construction Date: 1934

Engineer: Ralph Hoffman Arizona State Bridge Engineer

Contractor: Lee Moor Contracting Co

Max Span Length: 162 feet

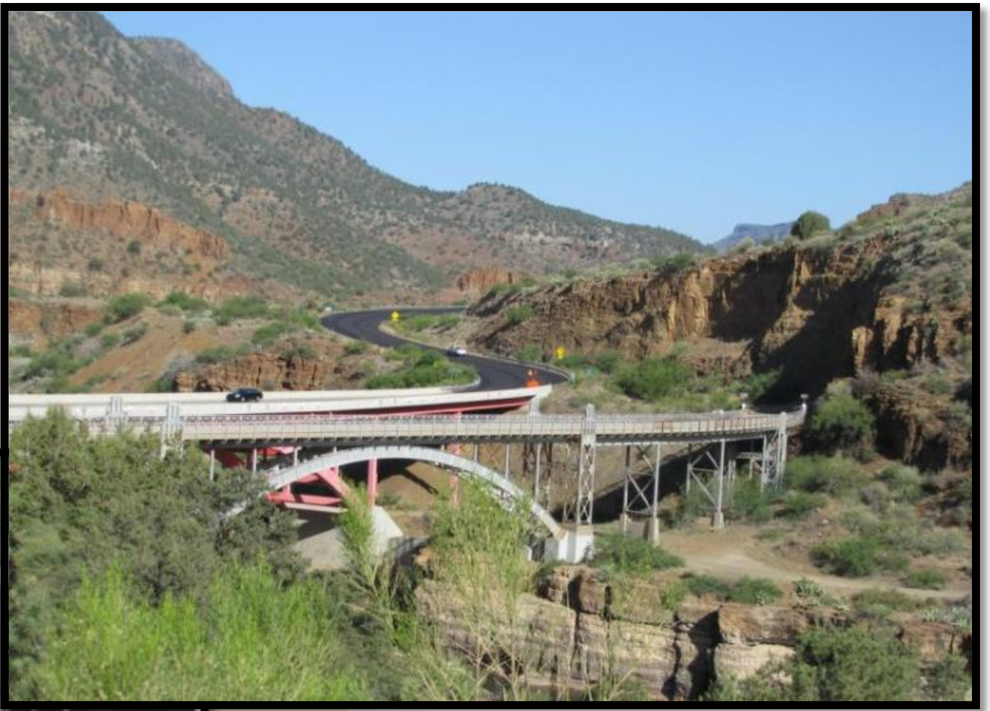
Owner: ADOT

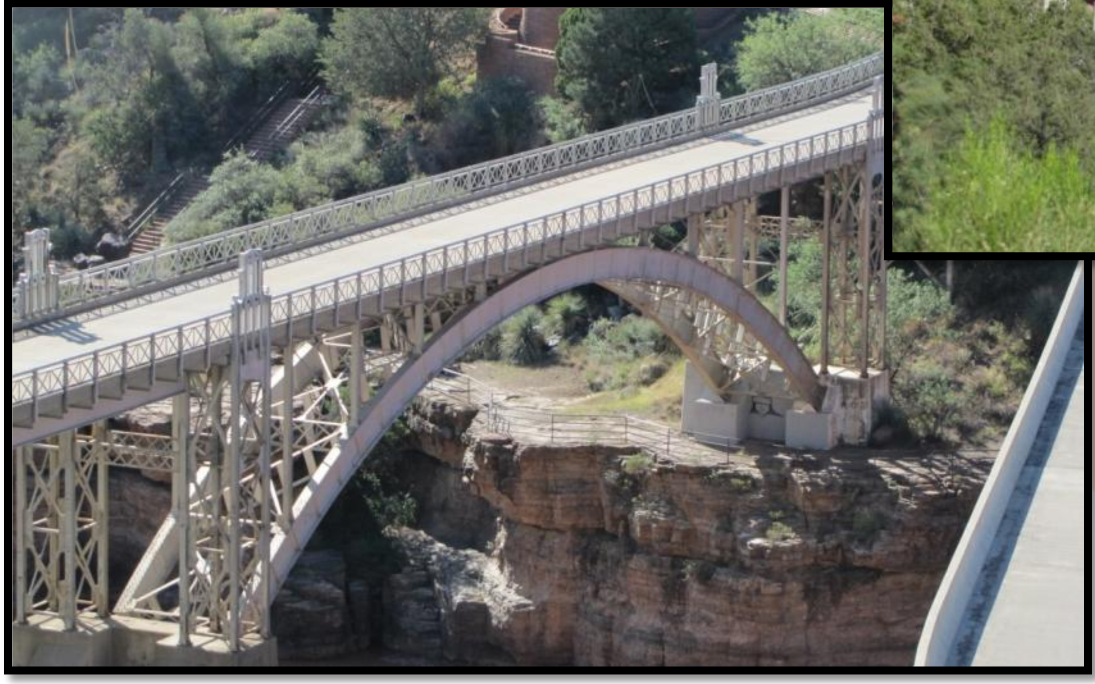
The Salt River Canyon Bridge is one of Arizona's visually striking and technologically note worthy vehicle bridges and the state's first girder-ribbed steel arch bridge.

HOFFMAN - Salt River Canyon Bridge (US60)

Photo – Hoffman Collection (Mary Lou Vaughan)

HOFFMAN - Salt River Canyon Bridge (US60)





HOFFMAN - Salt River Canyon Bridge (US60)

Salt River Canyon Bridge (Vehicular) Bridge Engineer ADOT 1997
Salt River Canyon Bridge (Pedestrian) Bridge Engineer Hoffman 1934

HOFFMAN - Salt River Canyon Bridge (US60)

Structure No. 3003

Location: US Highway 60 at Cedar Canyon (Navajo)

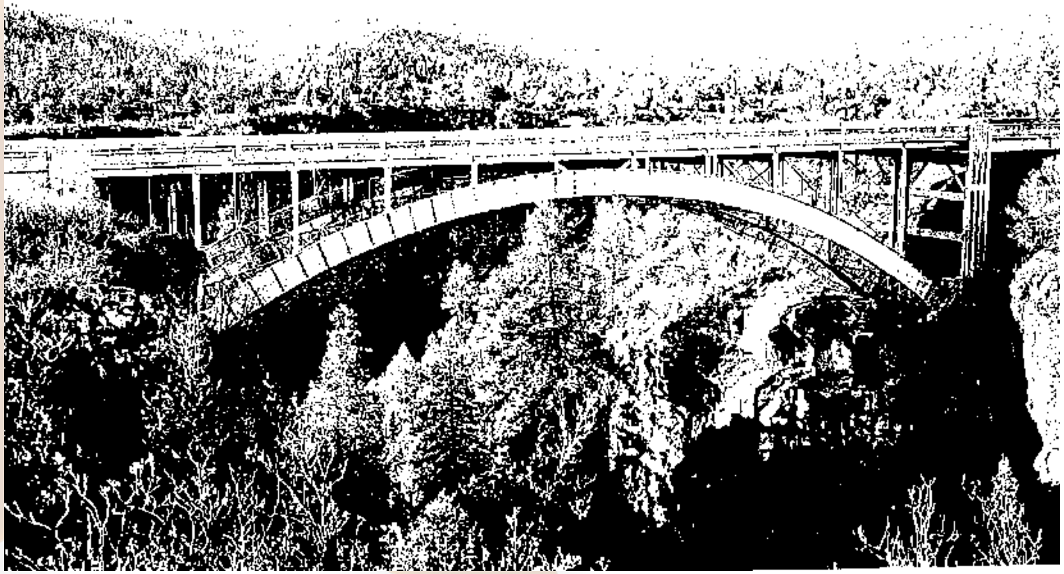
Construction Date: 1938

Engineer: Ralph Hoffman – Arizona State Bridge Engineer

Contractor: Pleasant-Hasler Construction Company

Max Span Length: 180 feet

Owner: ADOT



The Cedar Canyon Bridge is an important example of an uncommon structural type – the moving of the Corduroy Creek Span to this location represents an innovative approach to historic preservation.

HOFFMAN - Cedar Canyon Bridge – US60

- Cedar Canyon Bridge Steel Arches relocated for Cedar Canyon Bridge Widening

HOFFMAN - Cedar Canyon Bridge – US60

Structure No. 351

Location: US Highway 60

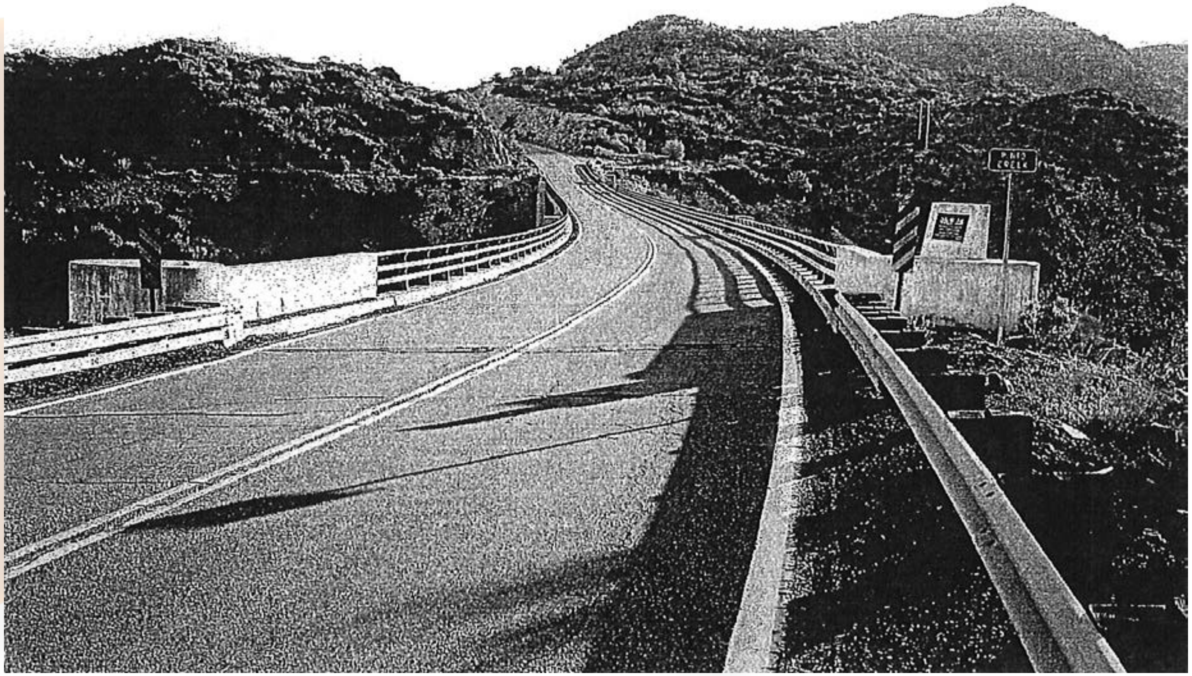
Construction Date: 1949

Engineer: Ralph Hoffman – Arizona State Bridge Engineer

Contractor: HJ Hagen (Foundation), Fisher Contracting, Allison Steel Manufacturing

Max Span Length: 371 feet

Owner: ADOT



This bridge is one of Arizona's most spectacular steel spans

HOFFMAN – Pinto Creek Bridge (US60)

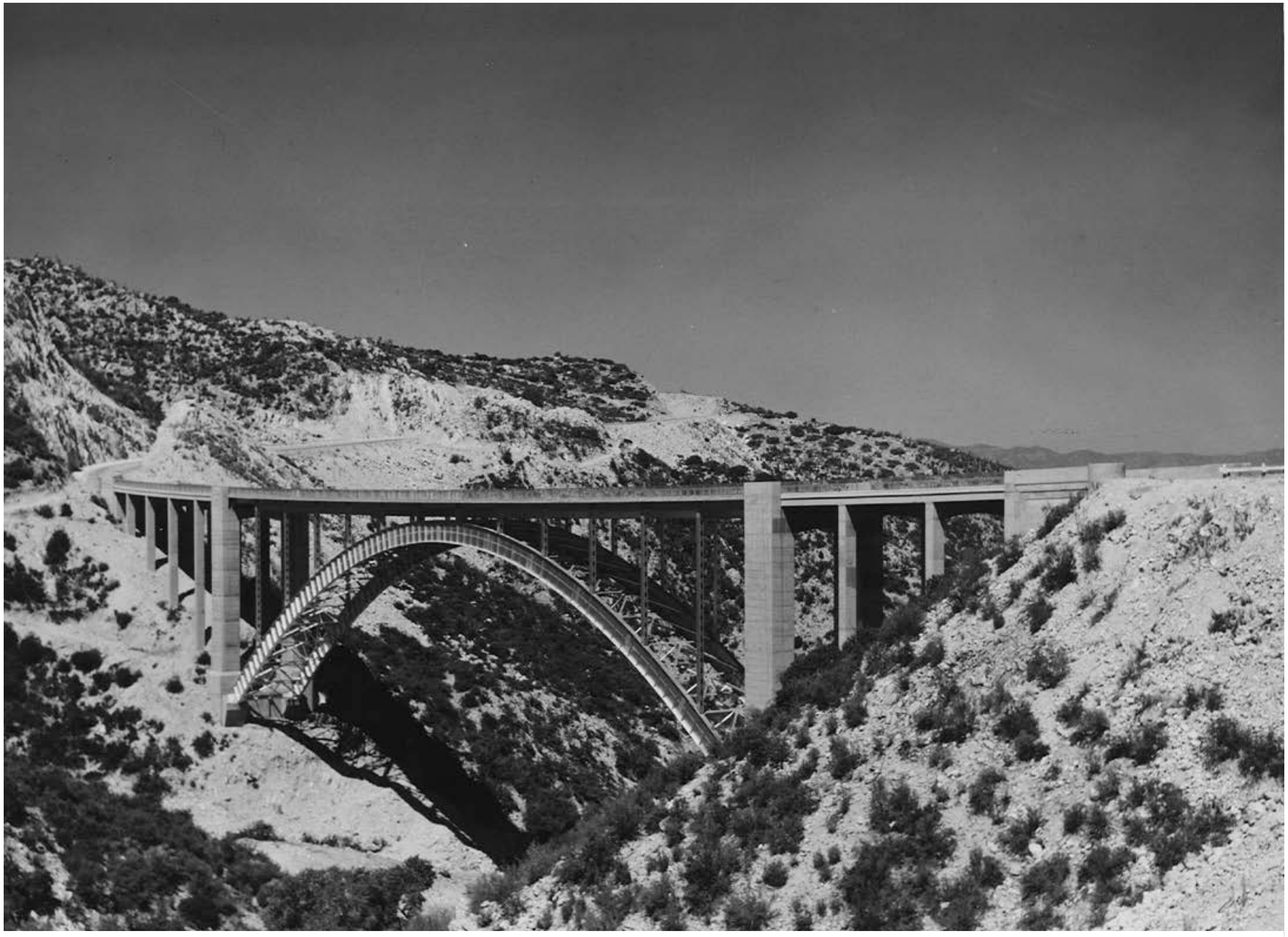
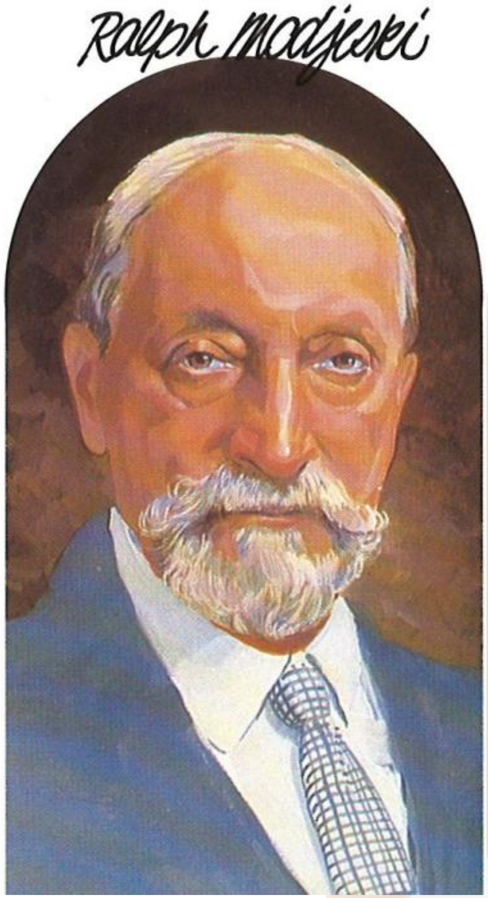


Photo: Hoffman Collection (Mary Lou Vaughan)

HOFFMAN – Pinto Creek Bridge (US60)

- Curved bridge deck on steel arch span causing bearings to fail

HOFFMAN – Pinto Creek Bridge (US60)



Ralph Modjeski (1861 – 1940)

- Born in Austria, studies in Paris at School of Bridges and Roads
- Flunks out and studies piano before coming back and graduating at the top of his class
- Starts firm in Chicago
- First project was bridge over Mississippi at Rock Island
- Pioneer of suspension bridges; San Francisco – Oakland Bay Bridge, Benjamin Franklin Bridge

Structure No. Abandoned

Location: US 95 – Gila River (Yuma)

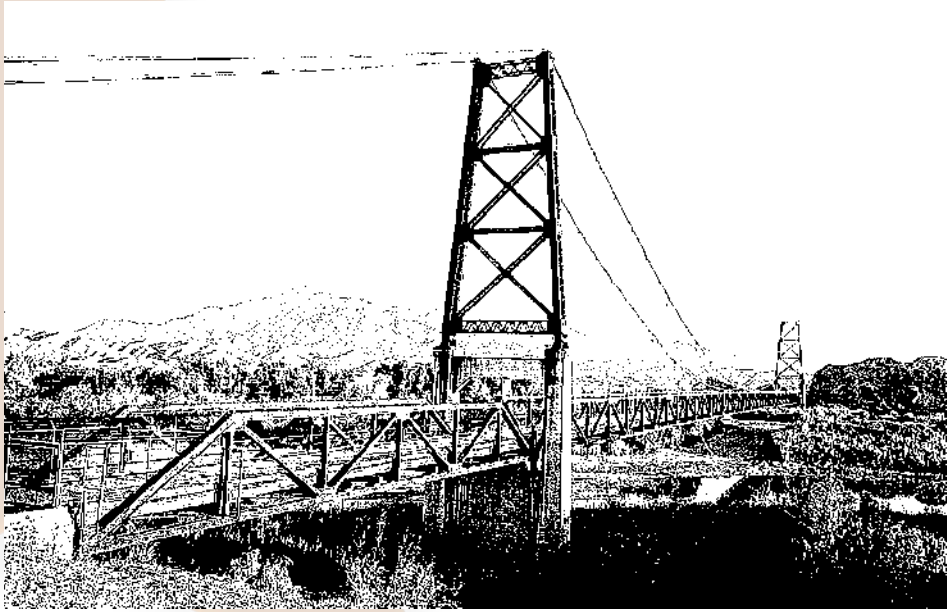
Construction Date: 1929

Engineer: Arizona Highway Department. Levy Construction. Ralph Modjeski

Contractor: Levy Construction Company

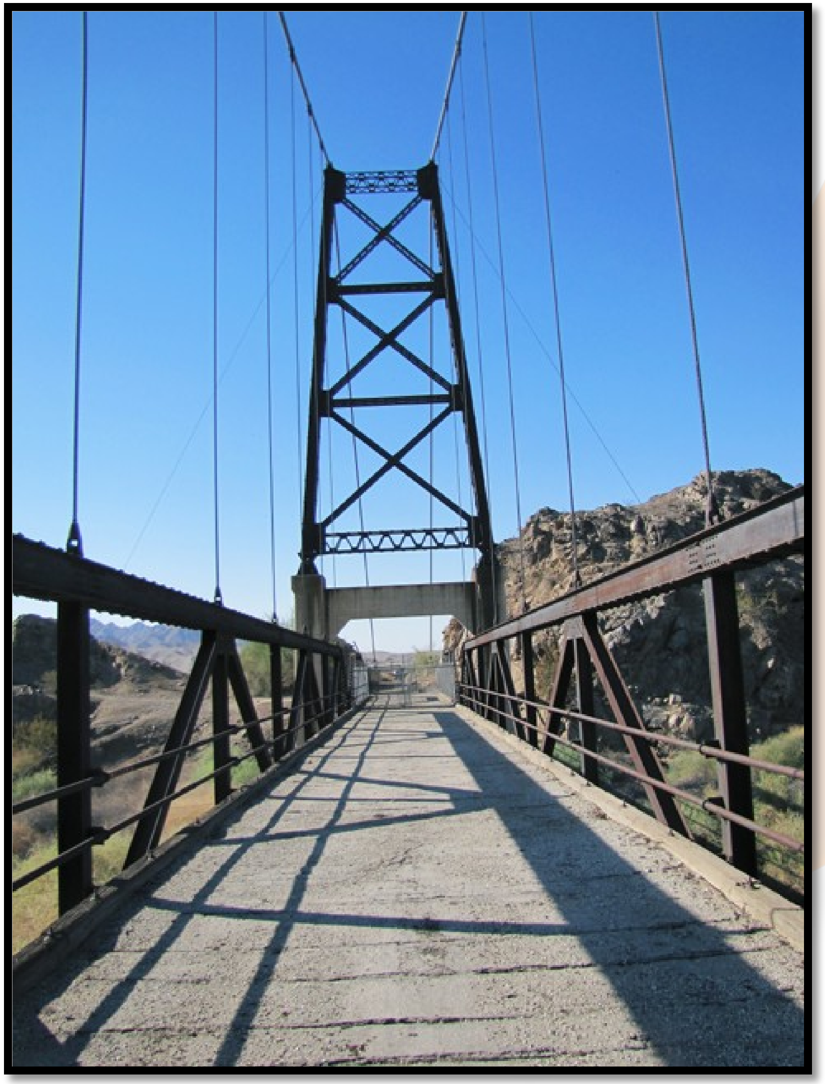
Max Span Length: 798 feet

Owner: Yuma County



At the time of its completion, the bridge had the longest span length of any bridge in Arizona. As well as historically and technologically important the bridge is among Arizona's most important vehicular bridges.

RALPH MODJESKI - McPhaul Bridge (over the Gila River)



MODJESKI - McPhaul Bridge

MODJESKI - McPhaul Bridge

Office of Indian Affairs

- Office of Indian Affairs funded four major Arizona bridges.
- These four major bridges were built to benefit the native americans and played an important role in the development of Arizona.
- All four bridges remain in use today.
  - Cameron Bridge
  - Ocean to Ocean Highway Bridge
  - Old Trails Bridge
  - Sacaton Bridge

Structure No: Private

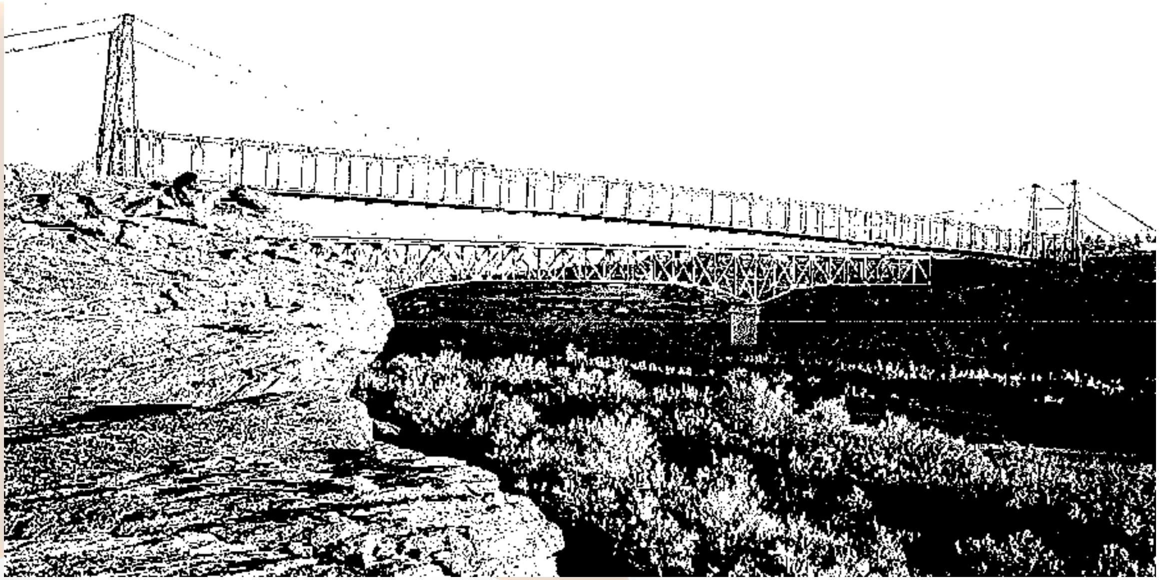
Location – US89 and Little Colorado River (Coconino)

Construction Date : 1911

Engineer : WH Code – Midland Chief Engineer

Contractor : Midland Bridge Company

Max Span Length 660 feet



The Cameron Bridge over the Little Colorado River is one of the states most historically and technologically significant early Arizona Territorial Bridges.

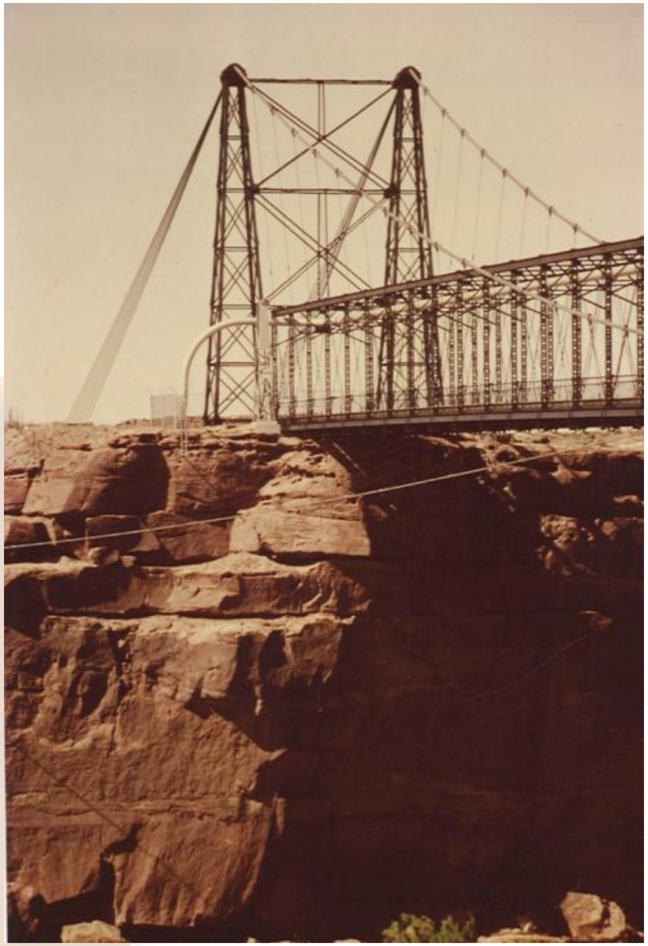
B.I.A. - Cameron Suspension Bridge

Cameron Bridge (1911)

- One of two suspension bridges in AZ
- Bridge linked Hopi and Navajo reservations with Flagstaff
- Bridge closed to vehicular traffic – supports pipe line.

B.I.A. - Cameron Bridge over the Little Colorado River (US89)

Cameron Suspension Bridge
(US89 Truss Bridge Shown Beyond)



Cameron Suspension Bridge
Tower

B.I.A. - Cameron Suspension Bridge

Structure No: 8533

Location – Penitentiary Ave / Colorado River (Yuma)

Construction Date : 1915

Engineer : US Office of Indian Affairs

Contractor : Omaha Structural Steel Works

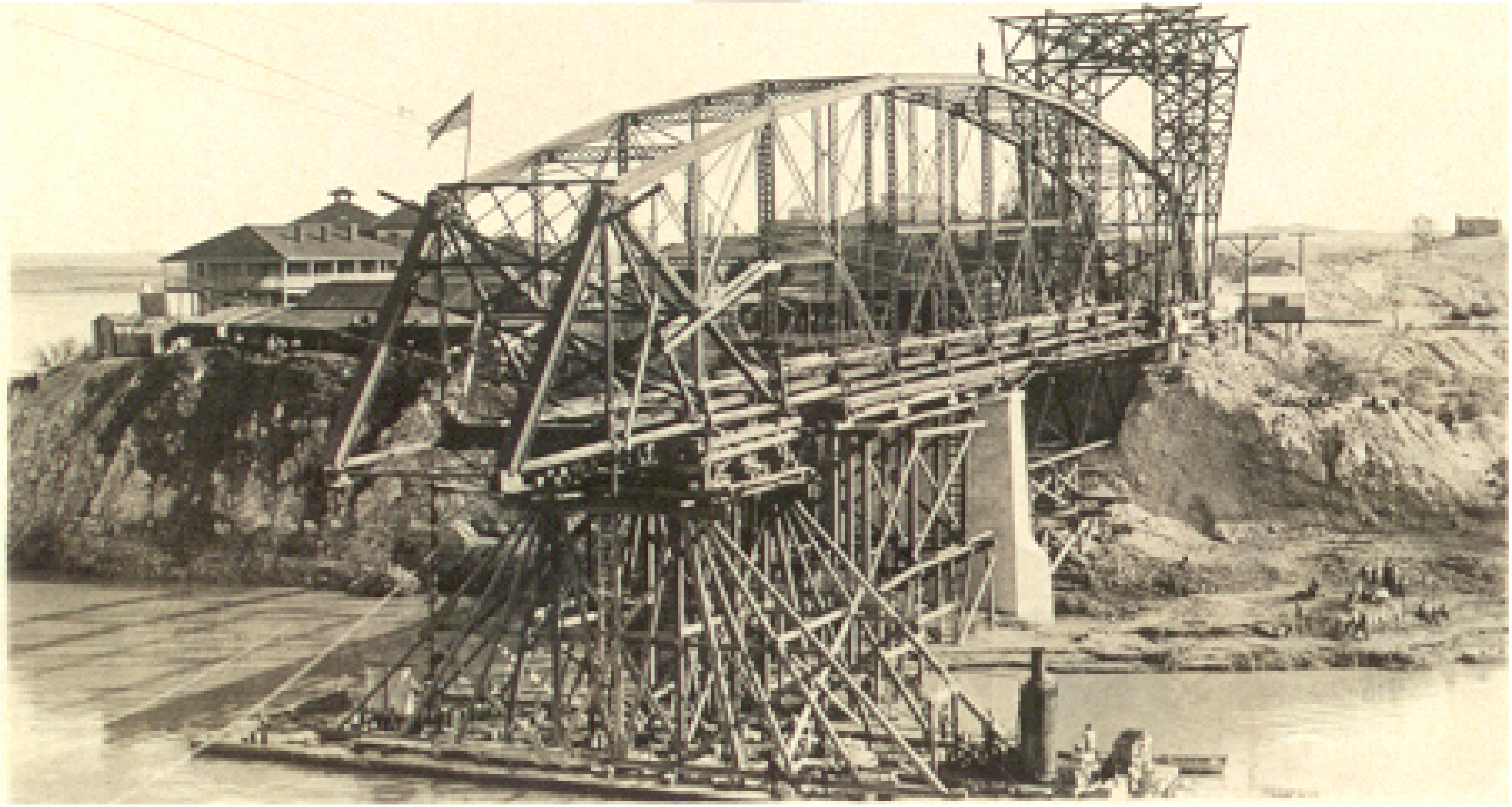
Max Span Length : 336 Feet

Owner: City of Yuma

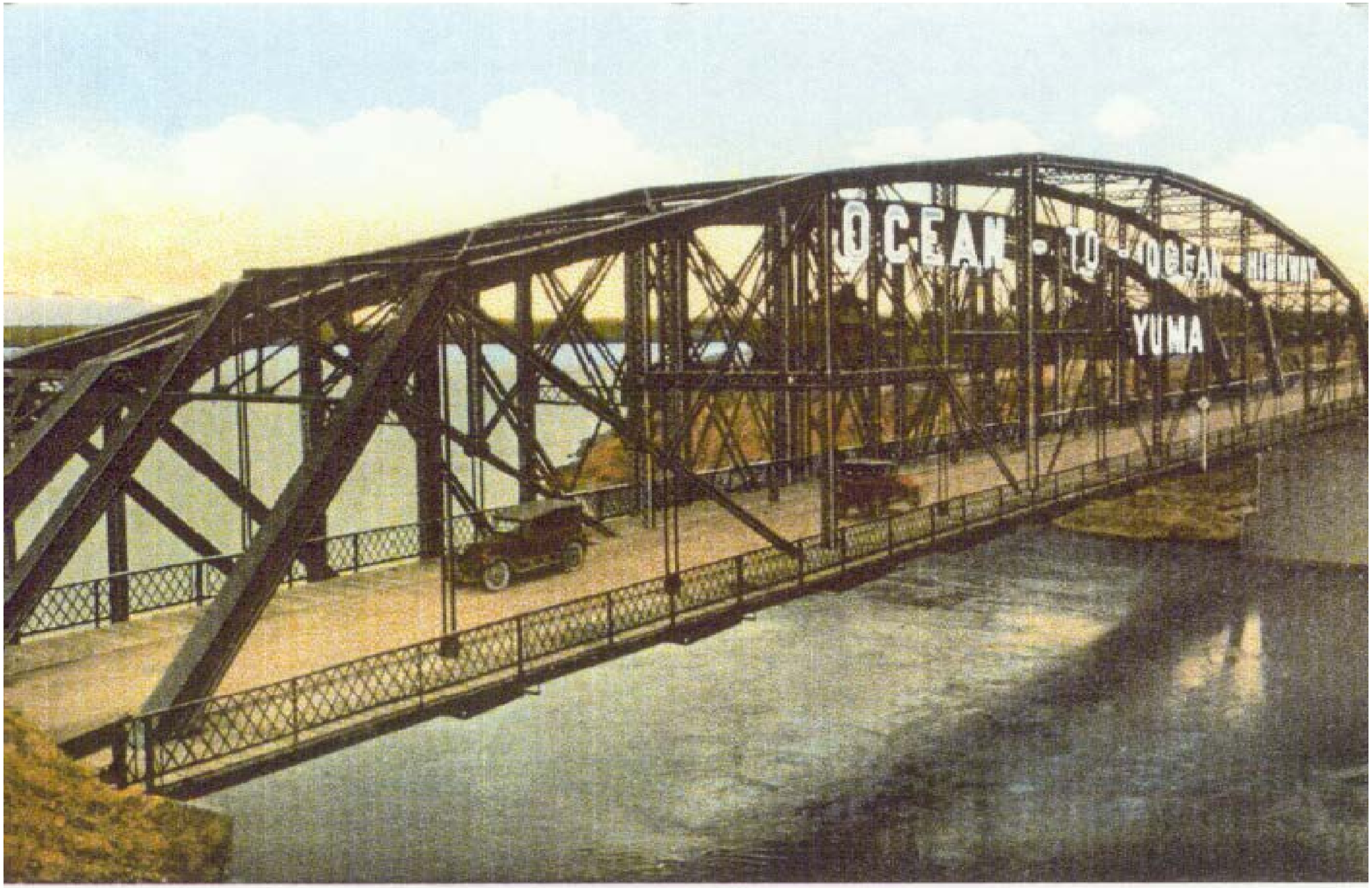
The Ocean to Ocean Highway bridge was a critical link for the Ocean to Ocean Highway (US80). The bridge is significant as an early through truss in Arizona. Today distinguished as one of the most important early spans in the Southwest.

B.I.A. - Ocean to Ocean Highway Bridge (US 80)

Using shoring to support the span during construction.



B.I.A. - Ocean-to-Ocean Bridge (US 80)



OLD COLORADO RIVER BRIDGE

YUMA COUNTY

B.I.A. - Ocean-to-Ocean Highway Bridge (US 80)

BIA Ocean to Ocean Highway Bridge US80
& Union Pacific Railroad Bridge

Traffic Signals

- Vehicles travel one-way over bridge
- Video cameras installed to detect traffic; all signals will flash red if vehicle stops on bridge

January 2001: Project was awarded to The Ashton Company in the amount of $1,638,000. Bridge was re-opened on Feb. 28, 2002.

B.I.A. - Ocean-to-Ocean Highway Bridge (US80)

Steel truss bearing on Concrete Plan Wall

Steel Truss Attachment to Pier Wall

- Existing bolts rusted or missing – added new bolts

Bridge Deck Construction

Existing asphalt topping replaced with concrete topping slab to prevent rusting of steel rail

Pedestrian Walkway –
- Steel grating replaced wooden deck.

Openings in pedestrian
- railing reduced to 6" to meet AASHTO (left)

Bridge barrier rail added
- to meet AASHTO (right)

B.I.A. - Ocean-to-Ocean Highway Bridge (US80)

Structure No Private

Location: US66 / Colorado River (Mohave County)

Construction Date: 1916

Engineer: San Bernardino County Engineer

Contractor: Kansas City Structural Steel

Max Span Length: 592 feet

Owner: El Paso Natural Gas Company

The old trails bridge when completed was the longest arch bridge in America. The bridge remains as one of the longest three hinge arch bridges.

B.I.A. - Old Trails Bridge RT 66

- Bridge closed to vehicular traffic – supports pipe line

B.I.A. - Old Trails Bridge over Colorado River – Topock, AZ (RT66)

Structure No 3165

Location: Gila Indian Reservation / Gila River (Pinal)

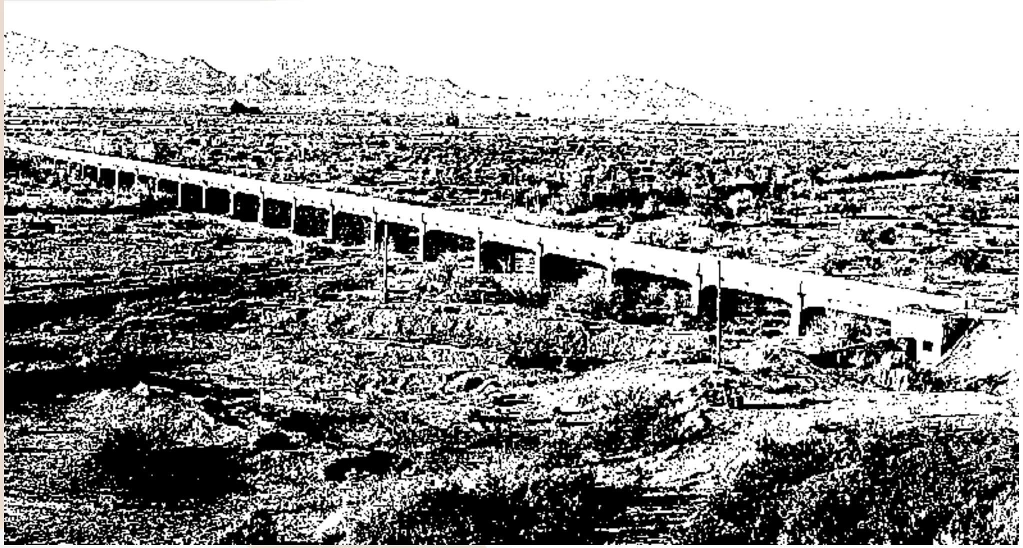
Construction Date: 1925

Engineer: US Indian Irrigation Service (Charles Washburn)

Contractor: Native American Work Force

Max Span Length: 50 feet

Owner: US Bureau of Indian Affairs



The diversion dam has deteriorated but the bridge remains in good condition. As one of Arizona's longest bridges, the Sacaton Dam Bridge is an important early transportation related resource.

B.I.A. - Sacaton Dam Bridge Over Gila River

B.I.A. - Sacaton Dam Bridge

B.I.A. - Sacaton Dam Bridge

Location – Cochise County – Hereford Road over San Pedro River

Construction Date : 1913, 1915, 1926

Engineer : Cochise County Engineer

Contractor : Midland Bridge Co. and Virginia Bridge and Iron Co.

Max Span Length : 102 Feet

Owner: Cochise County

Hereford Road Bridge is a typical county built truss bridge and an important representation of early Arizona truss construction until two spans collapsed in 2003.

Bridge survived largest flood ever on San Pedro River – (100,00 cfs)
Hereford Road Bridge made up of three bridges post load limit 15 tons.

April 25, 2003 - 32 ton fully loaded concrete truck. Driver new on the job went over the bridge once and then turned around and went over it once again. The middle 100 foot span collapsed into San Pedro River.

County Engineer - Hereford Road Bridge

New three span steel truss bridge dedicated March 6, 2006

County Engineer - Hereford Road Bridge

Location – Navajo County – Obed Road Bridge over Little Colorado River

Construction Date : 1917

Engineer : County Engineer

Contractor : Omaha Structural Steel Works

Max Span Length : 83 Feet

Owner: Navajo County

Obed Road Bridge (Joseph Bridge) is a typical county built truss bridge and was an important early example of truss construction. The bridge trusses and piers were replaced in 2010. The abutments remain.

New six span steel truss bridge dedicated Jan 26, 2011

Structure No 8227

Location: Wagoner Road / Hassayampa River (Yavapai)

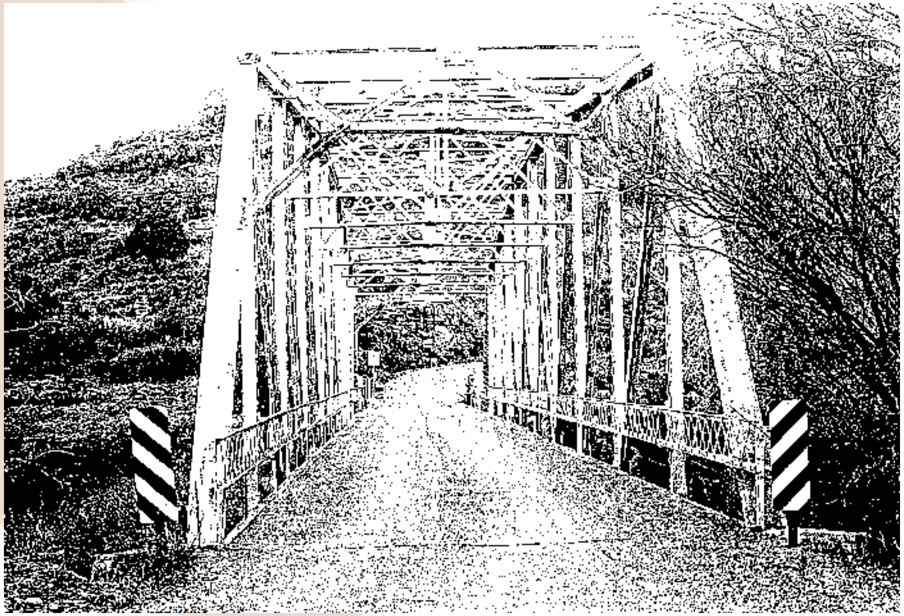
Construction Date: 1924

Engineer: El Paso Bridge and Iron Company

Contractor: El Paso Bridge and Iron Company

Max Span Length: 150 feet

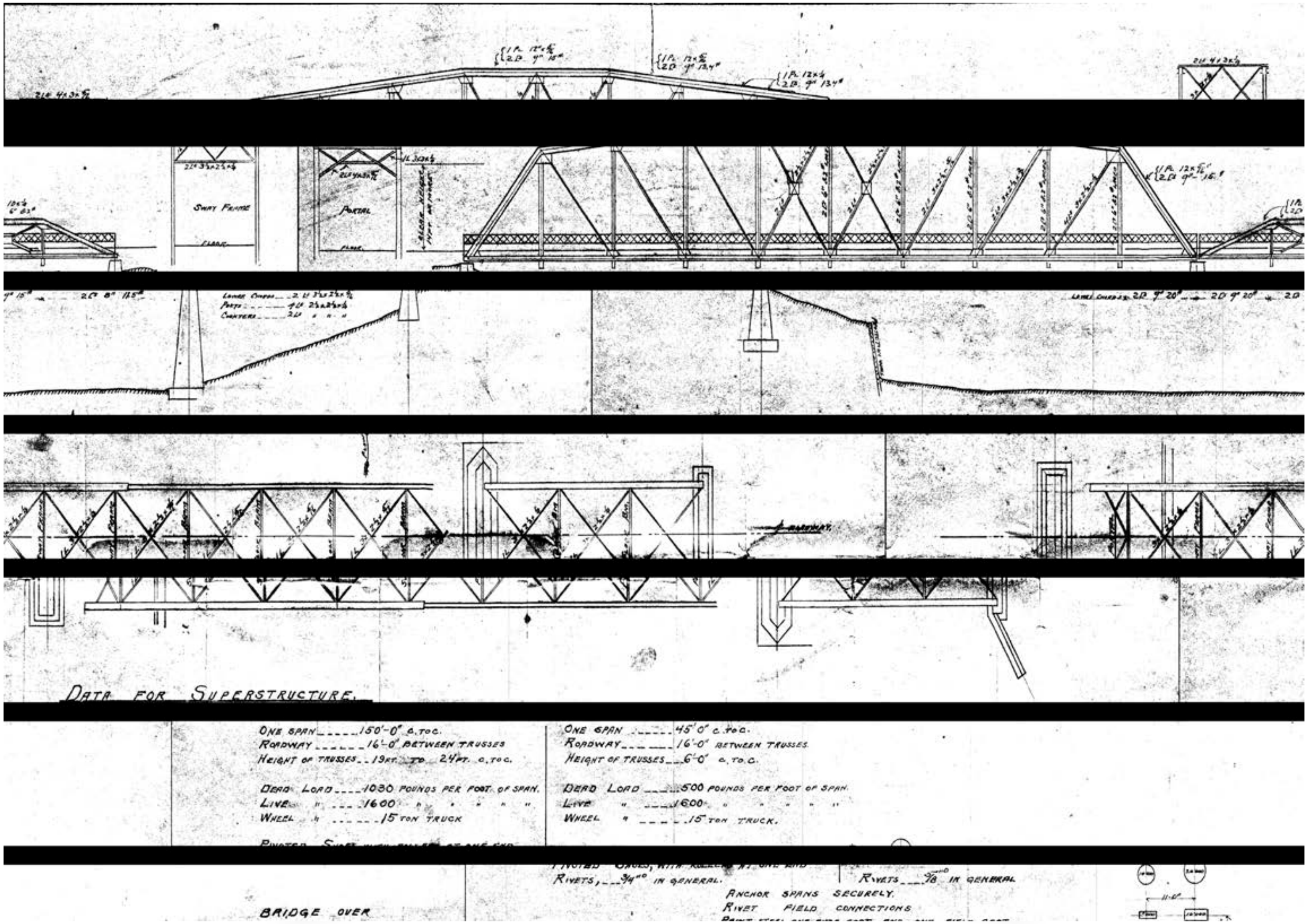
Owner: Yavapai County



The Walnut Grove Bridge is a representative example of a county built bridge. The bridge is essentially unaltered condition at this remote crossing of the Hassayampa River. It is a significant remnant of Arizona early bridge construction.

County Engineer - Walnut Grove Bridge over Hassayampa River

County Engineer - Walnut Grove Bridge



County Engineer - Walnut Grove Bridge – Original Construction Plan

EL PASO BRIDGE AND IRON COMPANY

ENGINEERS - DESIGNERS - CONTRACTORS

STRUCTURAL STEEL FOR EVERY PURPOSE

PLEASE REFER TO OUR FILE 0-902-Y
Hassayampa River Bridge

EL PASO, TEXAS — June 30, 1924.

Mr. R. L. Merritt, County Engineer,
Yavapai County,
Prescott, Arizona.

Dear Sir:

We are enclosing herewith two complete sets of detail drawings 1 to 7 inclusive, and erection plans E-1 for bridge over Hassayampa River for your approval.

Please return to us at your earliest convenience one set of the above details, indicating thereon your approval or corrections desired.

All materials for the bridge are now on hand, and would appreciate your early advices in order that we may proceed with the fabrication.

On sheet E-1 we have shown the elevation of bridge seats required on the basis of tops of floor beams or bottom of stringers being flush with tops of abutments and pier. However, this cutting out of the bridge seats could be obviated to some extent by raising the fixed shoe of the 150 ft. span to the elevation of the pier. This would, however, make it necessary to bolster up from the top of foundations to the bottom of stringers.

This is merely a suggestion on our part, as we leave up to you the method to be used in preparing the foundations for the steel spans.

Thanking you in advance for your promptness in this matter, we are

Yours very truly,

EL PASO BRIDGE AND IRON COMPANY

Structural Engineer.

AWB.T
Encl.

EL PASO BRIDGE AND IRON COMPANY

ENGINEERS - DESIGNERS - CONTRACTORS

STRUCTURAL STEEL FOR EVERY PURPOSE

PLEASE REFER TO OUR FILE 0-902-Y

EL PASO, TEXAS

August 8, 1924

Mr. R. L. Merritt,
County Engineer,
Yavapai County,
Prescott, Arizona

Dear Sir:

We acknowledge and thank you for the return of the shop details on the Hassayampa Bridge together with your letter of the 6th inst. enclosing a copy of Mr. Hoffman's letter to you concerning those details.

Most of the corrections noted by Mr. Hoffman are minor and we will be pleased to take care of them in accordance with his wishes. However, in some instances he has increased the size of members from those shown on the contract drawing supplied us and where any additional weight has been added to the structure by reason of increased size of members we feel we should be allowed payment for it.

The shops have undoubtedly made arrangements for all of this material on the basis of the original plans and we are writing them today giving them the necessary information concerning these revised sizes with the request that they advise us promptly what additional material will be required to comply with the revised plans.

Just as soon as we can advise you further in this connection we will do so and in the meantime will get revised plans in Mr. Hoffman's hands as soon as possible for his final approval.

Yours very truly,

EL PASO BRIDGE & IRON COMPANY

Engineer.

LWR.p

County Engineer - Walnut Grove Bridge

F. R. GOODMAN
STATE ENGINEER

SAM B. JONES
CHIEF CLERK

ARIZONA HIGHWAY DEPARTMENT

PHOENIX, ARIZONA

RALPH A. HOFFMAN
BRIDGE ENGINEER

August 4, 1924.

Mr. R.L.Merritt,
County Engineer,
Prescott, Arizona.

Dear Sir:

We have completed a check on the steel details for Hassayampa River Bridge, and make the following recommendations referring to the sheets on which the notations are made:

Sheet - General elevation and plan. The lower laterals in the two end panels at each end, are a little light as specified, and for wind stresses, as called for, should be increased as shown. This was an oversight on the original plan as we did not analyze the stresses due to the wind as a moving load.

Sheet #1 - Details of 180' span- Believe the tie plates in the top chord should be maintained as originally drawn instead of the ink correction, i.e. all end plates mark (ta) instead of some (tax). Also, we find no detail for a cover splice plate at the 4th panel point in the top chord.

Web member (D 4) requires two additional rivets each side at the ends and (D 5) requires one additional rivet each side.

Web members D_7, D_8 and D_9, as specified, require 5/8" rivets as they are carrying calculated stress. But by the specification, the least angle for members carrying such stresses is ~~3x2x3~~ inch. Believe you should insist on these being changed to the above-size angles instead of using 5/8" rivets and increasing the number of same.

The first joint marked L_0 (in red) in the lower chord should be supplied with a web to distribute the stress of the lower laterals.

Joint L_3 - the splice plate should be extended to include two more rivets on each end.

Joint L_5- This joint does not seem to have been designed on a par with the others, and should be re-designed somewhat as shown.

These joints should be designed with rivet stresses reduced 1/3 for field rivets as per specifications.

Also, on this sheet are shown the connections for the lower laterals with required number of rivets.

Mr. R.L.Merritt- Aug.4,1924. Page 2.

Sheet #2- Details of pony truss.

The change of plates as noted in ink on the top chord is O.K., but the rivet spacing for this new plate was not corrected.

One dimension on the lower chord 19'-11", is questioned, as noted in red.-

Also, a dimension of 5-11/16 on the vertical post.

Sheet #3 - Details 45' pony span-

The end handrail post as designed, gives no lateral support to the rail and as the distance from the end post of the bridge to this rail post is considerable, would suggest that you require a bracket design for the post as shown-- the angle brace is preferable to the plate bracket.

Sheet #4 - Lower and upper laterals.

Believe that according to the specifications for riveting, the long leg of the L_S should be riveted at the connections, although this is not essential.

Have also shown increase in size of L_S angles two end panels of lower laterals.

Sheet #5.

Believe that on this long a span, the shoe for the expansion end should be extended and the anchor bolts passed thru a slotted hole, as shown. This would make a change in the bed plate also.

The minimum pin for this size span should be 4 inches, turned down not more than 3/32 inch. This size will provide ample shear area.

Sheet #6.

The only change on this sheet would be to require that the long legs of the bracing angles be riveted instead of the short legs.

Sheet #7.

The same suggestion would be advisable on riveting of the bracing angles.

Also, as on the pony truss, the handrail post provided no lateral support although the length of the handrail supported is not as great- believe a bracket design more satisfactory.

When the above corrections are made, would be pleased to have a set of these plans for our files.

Trusting that the suggested changes can be satisfactorily adjusted, we remain,

Very truly yours,

ARIZONA HIGHWAY DEPARTMENT

R.A.Hoffman
R.A.Hoffman,
Bridge Engineer.

RAH:K

County Engineer - Walnut Grove Bridge

Wooden Deck Replacement

- New wooden deck being installed on bridge

- New wooden deck used to replace existing wooden deck - SHPO

Repainting Bridge

- Containment tarps for red lead abatement and repainting the bridge.

John Rennie (1761-1821)

- Pioneered use of level bridge roadways
- Designed New London bridge using elliptical arches
- Combined stone with new cast iron techniques to create elliptical arches
- Born in Scotland
- Died before London Bridge was built

John Rennie – London Bridge

Structure No. 8630

Location: McCulloh Blvd – Colorado River (Mohave County)

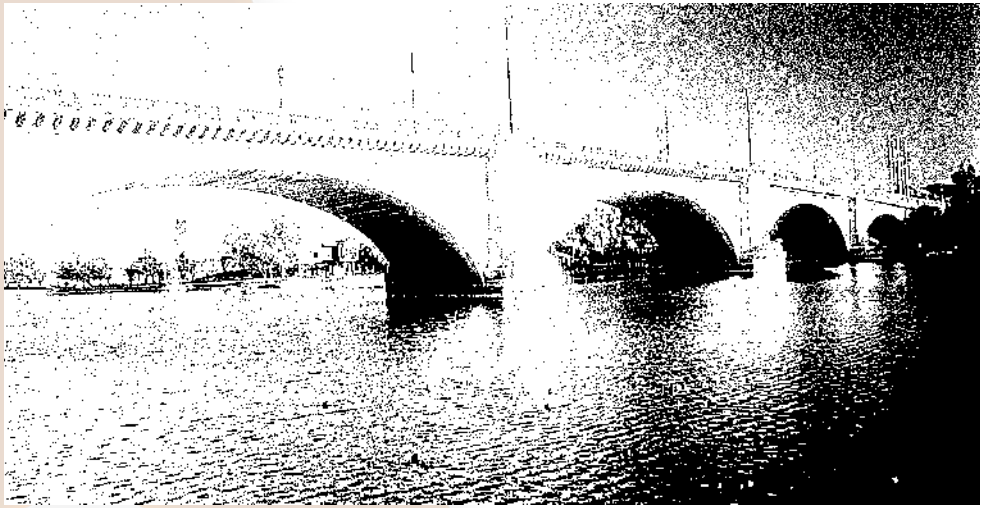
Construction Date: 1831 (1971)

Engineer: John Rennie (1831) / Mott, Hay, and Anderson (1971)

Contractor: City of London Work Force (Sundt Construction)

Max Span Length: 152 feet

Owner: City of Lake Havasu City



As a pivotal crossing of the Thames in the heart of London, the historical significance of the London Bridge can hardly be overstated. The bridge is the focal point for Lake Havasu City and a well known tourist attraction. The moving of the stone masonry bridge represents a great exercise in logistics and engineering.

John Rennie - London Bridge

John Rennie - London Bridge

Bridge Lamp Post Repairs

Coping stone cracking at each lamp post

Removed lamp post to find why stone was cracking

Remove rusted lamp support post

Replaced existing rusted lamp support post with new epoxy coated steel post

Bridge Deck Repairs

Removal of deteriorated concrete

Forming edges and placement of microsilica concrete to protect reinforcing steel

How and what these bridges are being used for today

- Bridges Widened – US80 Lowell Arch & US60 Cedar Canyon Bridge
- Bridges for Pedestrian Use – Navajo and Salt River Bridges
- Bridges Abandoned – Alchesay Canyon Bridge, Canyon Padre, Canyon Diablo, Antelope Hill, Allentown, McPhaul Bridges
- Bridges Utility Use – Cameron and Old Trails Bridge
- Bridges Still in Use as Originally Designed – Solomonville Road Overpass, Chevelon Creek, Querino Canyon, Pinto Creek, Sacaton Dam Bridge
- Bridges Demolished – Ash Ave Bridge

How and what these bridges are being used for today

- Bridges Rebuilt – Florence Bridge and Hereford Road Bridge
- Bridge Rehab or Repaired – Old Safford Road, Town of Miami, Santa Cruz River, Cienega Bridge, Gillespie Dam, Mill Ave, Ocean to Ocean, Walnut Grove and London Bridge
- Bridge Relocated to New Site – Boulder Creek Bridge

<u>1863 – 1912   Arizona Territory Bridges</u>

1905 – Alchesey Canyon Bridge

1907 - Solomonville Road Overpasses

1909 – Florence Bridge

1911 – Lowell Arch Bridge

1911 – Cameron Suspension Bridge

1911 – Ash Ave Bridge

<u>February 14, 1912 – Arizona Becomes a State</u>

1913 – Hereford Road Bridge

1913 – Canyon Padre Bridge

1913 – Chevelon Creek Bridge

1914 – Boulder Creek Bridge

1915 – Antelope Hill Bridge

1915 – Canyon Diablo Bridge

1915 – Ocean to Ocean Bridge

1916 – Old Trails Bridge

1917 – Santa Cruz River Bridge

1918 – Gila River Bridge

1921 – Cienega Bridge

1921 – Bloody Tanks Wash Bridges

1924 – Walnut Grove Bridge

1925 – Sacaton Dam Bridge

1927 – Gillespie Dam Bridge

1929 – Navajo Bridge

1929 – McPhaul Bridge

1930 – Querino Canyon Bridge

1931 – Mill Ave Bridge

1934 – Salt River Canyon Bridge

1945 – Pinto Creek Bridge

1938 – Cedar Canyon Bridge

1831(1971) – London Bridge

Question and Answer

Railroads in Arizona

- Many proposals for route in the 1850's. Civil war interrupted these.
- Southern route had the earliest start in 1878 – 1883 (in Colo.) via Gila Trail, deviated from that route in SE AZ.
- Northern route followed 35th parallel began in 1880 by the Atchison, Topeka and Santa Fe (bought from Atlantic & Pacific RR who had the rights to build and 11.5 million acres of land).
- By 1885 there were two railroads through the State.

- Multi span steel truss railroad bridge over Colorado River near Topock, Arizona – (Needles California).
- Built 1890's Waddell's Cantilever truss bridge.

BNSF Colorado River Railroad Bridge

- Union Pacific RR Colorado River Crossing Yuma, AZ
- Built in 1923
- Through Truss Bridge over Colorado River

Union Pacific – Colorado River Railroad Bridge

- Arizona Eastern Railroad Bridge over Salt River – Tempe, AZ
- Built 1915
- Pratt through truss on UP Railroad and Amtrack

Salt River Railroad Bridge

- Railroad bridge over Gila River – Pinal County
- Built 1925 – American Bridge Company
- Through Steel Truss Bridge

Gila River Railroad Bridge

- Five span railroad bridge over Cienega Creek and UP Main Line near Tucson, AZ

Union Pacific – Cienega Creek Railroad Bridge

- 1927 Steel Truss bridge over San Pedro River near Benson, AZ

Union Pacific – San Pedro River Railroad Bridge

- Railroad bridge over Gila River – Antelope Hill – Yuma County
- Steel Trusses with Wooden Approach Spans

Gila River Railroad Bridge