COLD SPRING CANYON BRIDGE
(Bridge No. 510037)
State Route (SR) 154 from Post Mile (PM) 22.95 to 23.19, just north of the San Marcos Pass
Santa Barbara vicinity
Santa Barbara County
California

HAER CA-2298
HAER CA-2298

PHOTOGRAPHS

WRITTEN HISTORICAL AND DESCRIPTIVE DATA

HISTORIC AMERICAN ENGINEERING RECORD
National Park Service
U.S. Department of the Interior
1849 C Street NW
Washington, DC 20240-0001

HISTORIC AMERICAN ENGINEERING RECORD

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Location: Cold Spring Canyon Bridge (Bridge No. 510037) is located on State Route (SR) 154 from Post Mile (PM) 22.95 to 23.19, approximately 13.5 miles northwest of the City of Santa Barbara, just northwest of the San Marcos Pass in Santa Barbara County, California.

USGS San Marco Pass Quadrangle 7.5 minute, 1995
UTM Coordinates: 11.239790.3824167

Date(s) of Construction: 1963; seismic retrofit 1997-1998

Present Owner: Caltrans - District 5
50 Higuera Street
San Luis Obispo, California 93401

Present Use: Bridge

Significance: Cold Spring Canyon Bridge was determined eligible for listing in the National Register of Historic Places in 2007. The structure is significant as an important example of bridge design and engineering that demonstrates maturation of steel arch bridge design and welded steel technology in California, and it represents a high aesthetic quality of contemporary design from its period. It is also an important work of the Division of Highways Bridge Department, which is considered a "master" engineer of the period, and it is an important work of the American Bridge Division of US Steel which is considered a "master" builder of the period. The bridge's period of significance is 1962-1964 from when it was built and opened to traffic.

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I. DESCRIPTION OF COLD SPRING CANYON BRIDGE

The Cold Spring Canyon Bridge (510037) is a steel arch deck bridge. Its construction was completed in December 1963 and it opened to traffic in February 1964. The bridge is located on SR154 from PM 22.95 to 23.19 just northwest of the San Marcos Pass, and approximately 13.5 miles northwest of the City of Santa Barbara. The structure has nine spans, which include one arch span and eight steel girder approach spans. Its total length is 1,218' with the middle arch spanning 700'. The bridge sits over 400' above the bottom of Cold Spring Canyon. The deck is supported by slender steel column bents and two 134' towers. The arch supports steel girder sub-spans on steel column bents. The towers have 4' squared legs connected by three cross struts. The column bents have 2' squared box legs that are hinged at the top and bottom to allow for relative movement of the deck during temperature changes and asymmetrical loading. The steel plates that form the towers, columns, floor beams, girders, and arches are welded. The foundations are reinforced concrete with one abutment on steel pilings. The arch and main towers are supported with pinned steel castings that rest on reinforced concrete skewbacks. The reinforced concrete composite slab deck is seven feet deep supporting a 28' wide roadway between curbs. The bridge deck is 34' wide between railings. Sections of the roadway's embankment at the bridge ends were constructed along with the bridge structure. The railings on the bridge are a Division of Highways standard type of their period, called Type II barrier railings. Each railing is 3' 7" tall and has 3' wide barrier curbs in front of them.[1]

The bridge's arch is made up of 1,440 tons of steel plating formed into curved box-shaped arch rib sections, each 9' deep and 3' wide. All shop splices for the steel members were welded and high-strength bolts were used for field connections of members. Steel truss K-bracing connects the two arch ribs, which are spaced 26' apart. The steel pedestals were welded to the ribs to form the column bases. The arch ribs were connected to the deck by cables located near the crown of the arch. The columns were designed to stand without bracing and fabricated full-length without field splices, which enhanced their slender qualities.[2]

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[1] I.O. Jahlstrom, "Report of Completion for the construction of Cold Spring Canyon Bridge, County of Santa Barbara," June 17, 1964; *California Highways and Public Works*, September-October 1963, 15-17.
[2] *California Highways and Public Works*, September-October 1963, 15-17.

II. HISTORICAL INFORMATION

San Marcos Pass Road and the Development of State Route 154

Cold Spring Canyon Bridge is located on SR154 (San Marcos Pass Road) approximately 13.5 miles northwest of the City of Santa Barbara in the Santa Ynez Mountains and is situated just northwest of San Marcos Pass. The Santa Ynez Mountains are a coastal range that separates the northern part of Santa Barbara County from its coastline, which generally runs east-west from the Ventura County line to the area west of Lompoc before turning north. Historically, travelers traversed the mountains at one of several passes, (from east to west) San Marcos Pass, Refugio Pass, and Gaviota Pass. SR154 ascends from US101 in Santa Barbara and proceeds in a northwesterly direction into the Santa Ynez Valley, passing Lake Cachuma, and through the communities of Santa Ynez and Los Olivos before intersecting again with US101 approximately six miles north of Buellton and Solvang. On the way up from Santa Barbara to San Marcos Pass, the highway is intersected and flanked by several smaller roads, some of which were bypassed when the contemporary roadway was constructed. After leaving the suburban area north of US101 in Santa Barbara, one ascends into the Los Padres National Forest. One sizeable intersection about halfway from US101 northwest to San Marcos Pass and the Cold Spring Canyon Bridge is with Old San Marcos Pass Road and Painted Cave Road. Several miles later one crests San Marcos Pass and begins to descend into the Santa Ynez Valley as the highway takes vehicles over the Cold Spring Canyon on the bridge that is the subject of this report.

The Native American Chumash are the first known people to traverse what are now the Santa Ynez Mountains through San Marcos Pass. The earliest historical records of San Marcos Pass date to the beginning of the nineteenth century, documenting the route that connected the Santa Barbara Mission with its farm on the San Marcos Rancho. The pass is noted as the location where, during the United States war with Mexico, John C. Fremont and his troops passed over the coastal mountains in 1846 on their way from Monterey to Los Angeles to meet up with forces on their way north from San Diego under the command of Commodore Robert F. Stockton. Some accounts state that Fremont chose the route through San Marcos Pass following a warning not to use the more traveled Gaviota Pass because of a possible ambush there by Mexican armed forces. Although much has been written about this event, there does not appear to be any specific evidence that such an attack was imminent.[3]

[3] Erwin G. Gudde, *California Place Names: The Origins and Etymology of Current Geographical Names* (Berkeley: University of California Press, 1949), 309; and Department of Parks and Recreation, *California Inventory of Historic Resources* (Sacramento: Department of Parks and Recreation, March 1976), 185. The story of Fremont proceeding through the San Marcos Pass is recounted in "How San Marcos Pass Saved California to U.S," *California Highways and Public Works*, August 1936, 6-8 and 30-32 and "Fremont and the San Marcos Pass," *California Highways and Public Works*, September 1950, 42-44. The early history of San Marcos Pass is also

The San Marcos Pass was used infrequently during the early period following California statehood in 1850, but by the late 1860s demand grew for improved roadways between Santa Barbara and areas to the north. In response, the Santa Barbara and Santa Ynez Turnpike Road Company incorporated in 1868 with Llewellyn Bixby as one of its directors. Bixby and Thomas Flint operated a stage coach company that was contracted to carry mail. The turnpike road company built the road over San Marcos Pass, completing the roadway around 1870.[4] Among the noted stops on the stage coach route was Patrick Kinevan's house, which was situated near the pass, and the Cold Spring Tavern, which is extant upstream from the Cold Spring Canyon Bridge. This tavern began operating in the 1890s and remains in operation as a restaurant today. The county acquired the road in 1898 following increased resistance to the roadway's high tolls, and the horse-drawn stage line ceased operation a few years later in 1901. Motorized stages and increasing use of private automobiles, as they became more widely available, replaced the old stage line along the county road.[5]

Public support for improved roads radiating outward from the town of Santa Barbara increased during the early twentieth century, including improvements to the highway over San Marcos Pass that served several communities that developed in the 1910s, 1920s, and 1930s. This included the residential development that accompanied the San Marcos Trout Club in the mid-1920s and Painted Cave Village, which began in 1930. As vehicle traffic increased along the San Marcos Pass Road and speeds increased with improved automobiles and trucks, this twisting, narrow, and largely unimproved road became very dangerous. Santa Barbara County made some improvements to the highway over San Marcos Pass in the 1900s-1910s.[6]

The California Division of Highways added San Marcos Pass Road to the state highway system in 1931 and it became State Route 80 (also referred to as Legislative Route 80). As was common at the time, the road signs referred to it as a different number and it was known as Highway 150. The Division of Highways upgraded and realigned portions of the roadway in 1935 and 1936 from Santa Barbara up to Painted Cave Road and in the vicinity of Los Olivos in the Santa Ynez Valley. The state moved the road's intersection with the coast highway from

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presented in Caltrans, Historic Resource Evaluation Report San Marcos Pass Road, January 1993. This HRER includes references to Maynard Geiger, "Some Observations on Santa Barbara County's Early Roads," *Noticias*, 10:2 (Spring 1964); John C. Fremont, "California Battalion Trip from Monterey to Los Angeles," excerpt from *Memoirs of My Life* (1887); and Walter A. Tompkins, "The Foxen-Fremont Fable," *Noticias*, 26:1 (Spring 1980).

[4] Newton H. Chittenden, *Health Seekers', Tourists' and Sportsmen's Guide, Health and Pleasure Resorts, Pacific Coast* (San Francisco: C.A. Mubdock & Co. Printers, 1884), 80.

[5] Caltrans, HRER San Marcos Pass Road (1993). The HRER references to the early history of the roadway include: Walter Tompkins, *Stagecoach Days in Santa Barbara County* (Santa Barbara: McNally & Loftin West, 1982) and Stella H. Rouse, "San Marcos Pass History," *Noticias*, 26:2 (Summer 1980).

[6] "Way It Was," *Santa Barbara News-Press*, February 5, 1989; Walter A. Tompkins, *San Marcos Pass*, Neighborhood Series, No., 11, Santa Barbara Board of Realtors, 1980, np; and Caltrans, HRER San Marcos Pass Road. The early road over San Marcos Pass began in Goleta. This road was alternatively called San Marcos Road.

Goleta closer to Santa Barbara. This project included construction of a new 24' wide asphalt surfaced highway, drainage features, and some small bridges. The new highway included excavated cuts through and along hillsides that created a roadway that was less steep and winding than its nineteenth century predecessor. The route westward from Painted Cave Road through San Marcos Pass and down through Cold Spring Canyon to the Santa Ynez Valley floor, however, remained largely unchanged during the 1930s and 1940s from the county highway the state had acquired.[7]

The county's population increased in the 1940s and 1950s and so too did traffic along San Marcos Pass Road. Much of the population growth occurred in the north county in Lompoc, Solvang, and around Vandenburg Air Force Base, with residents travelling to Santa Barbara and Goleta along the highway through San Marcos Pass. Residential development along San Marcos Pass Road further increased during this period, amidst growing demand for hillside houses with ocean views. The roadway also provided access from the coast to recreational areas at Lake Cachuma, which the United States Bureau of Reclamation built in the late 1940s and early 1950s as a water storage and flood control project. All of these changes placed significant strains on county infrastructure and roadways, promoting various improvements.[8]

The Division of Highways upgraded, realigned, and straightened San Marcos Pass Road in three phases, finally renumbering the roadway from SR80 to SR154 in 1963. The first phase occurred in 1951 when the Division of Highways built a new alignment to replace the old road that was to be inundated by the new Lake Cachuma. The second phase occurred in 1956 when the Division of Highways upgraded the portion of roadway between Painted Cave Road and San Marcos Pass. The latter portion was a 1.9 mile stretch of new highway that abandoned portions of the old San Marcos Pass Road and created a new straighter roadway.[9]

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[7] H.L. Cooper, "Building a Highway Over Santa Ynez Range Via Historic San Marcos Pass," *California Highways and Public Works*, February 1935, 4-5 and 15; L.E. McGougal, "Highway Completed Through Historic San Marcos Pass on New Alignment," *California Highway and Public Works*, January 1936, 4-5 and 16.

[8] "Cold Spring Canyon Arch," *California Highways and Public Works*, September-October 1963, 15; J.M. Sturgeon, "San Marcos Pass, Modern Highway Built Through Historic Area," *California Highway and Public Works*, May-June 1964, 13-14; A.M. Nash, "Report from District V," *California Highways and Public Works*, September-October 1958, 17; Ed Ainsworth, "High Bridge Aids Growth of City," *Los Angeles Times*, June 25, 1963, A2; California Department of Water Resources, Division of Flood Management, California Dams Database, Bradbury Dam, http://cdec.water.ca.gov/cgi-progs/damMeta?dam_id=160 (accessed January 2007); and E.J.L. Peterson, "Story of San Marcos Pass Told in State Highway Journal," *Santa Barbara News-Press*, September 1, 1955, B-2. Development of UC Santa Barbara and Vandenberg Air Force Base were covered well in the local press, as is evident in Dewey Scharman, editor, *Headlines: A History of Santa Barbara from Pages of Its News Paper, 1855-1982* (Santa Barbara: NewsPress Publishing Co, 1982).

[9] *California Highway and Public Works*, May-June 1964, 13; Caltrans District 5 records, "From Painted Cave Road to San Marcos Pass, EA 55-5VC18-F, Final Report, June 25, 1956."

By the end of the 1950s, the seven mile stretch of the old highway winding down from the crest of San Marco Pass to the Santa Ynez Valley floor, that included the area around Cold Spring Canyon, needed to be upgraded. This stretch included many sharp curves. The Division of Highways sought to reduce the number of curves and steep grades on the highway, concluding that the new alignment should be built uphill from the old route. For the segment through Cold Spring Canyon the highway designers decided, however, that an alignment following the old route could not sufficiently eliminate the sharp curve near the Cold Spring Tavern. Thus a bridge to span Cold Spring Canyon was necessary. The Division of Highways built the Cold Spring Canyon segment of highway between June 1962 and February 1964.[10] Realignment of San Marcos Pass Road near Cold Spring passed through both public and private land, including land owned by Emmet J. Kinevan, son of Patrick Kinevan who had operated the stagecoach stop near San Marcos Pass decades before.[11]

Construction of this seven-mile segment of SR154 completed the Division of Highways' more than a decade long upgrade to the highway, enhancing safety and speed of travel on this inland route to and from the City of Santa Barbara and communities in northern Santa Barbara County. The series of projects on SR154 from 1951 through 1964 coincided with similar developments on other state highways across Santa Barbara County, and were part of long-planned upgrades of former county highways. The highway improvement project on SR154 did, however, leave remnants of the old route in place, portions of which are extant and still in use for local traffic under the Cold Spring Canyon Bridge. These remnants are part of what is now Old San Marcos Pass Road / Stagecoach Road.[12]

Design of the Cold Spring Canyon Bridge

The Division of Highways designed and built the Cold Spring Canyon Bridge as an integral part of the 1962 to 1964 project to upgrade and realign the seven-mile stretch of SR154 from San Marcos Pass to the Santa Ynez Valley floor, but executed the bridge on a separate contract than the rest of the project. The 1956 announcement of the new alignment called for a 1,400' long

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[10] *California Highway and Public Works*, May-June 1964, 14-15.

[11] Kinevan's property is noted on the as-built plans for the Cold Spring Canyon Bridge. Emmet Kinevan is listed as son of Patrick Kinevan in the 1900 US Census. United States Census Bureau, *Twelfth Census of the United States, 1900,* 1900 Population Schedule, Township 3, Santa Barbara, California.

[12] State of California Division of Highways, District V, "1964 Highways Newsletter For Santa Barbara County," January 1964; and State of California, Department of Public Works, Division of Highways, *Statistical Supplement portion of Eighteenth Annual Report to the Governor of California by the Director of Public Works*, January 1965, list of completed contracts for Santa Barbara County. Also see, Santa Barbara County Planning Commission, *The Master Plan of County Roads & Highways, Santa Barbara County, California*, November 15, 1938. Many of the roads and highways proposed for improvement in this master plan were upgraded in the 1950s and 1960s.

bridge at Cold Spring Canyon.[13] The Division of Highways completed designs for the Cold Spring Canyon Bridge in fall 1961, approved the design in January 1962, and awarded the contract for construction in April 1962. Construction of the bridge began in May 1962 and was completed eighteen months later in December 1963. The bridge did not open for traffic until February 1964 when the Division of Highways completed the realignment project.[14]

The Division of Highways Bridge Department in Sacramento designed the Cold Spring Canyon Bridge with multiple engineers and bridge department staff contributing to its design and planning. Associate engineer Marvin A. Shulman was largely responsible for the design of the bridge, but he left the department prior to completion of its design. Raymond L. Whitaker completed the engineering on the structure and signed the project plans as the project designer. George A. Hood, Jr. was the department section supervisor for this bridge and is listed as the chief designer, although most of the engineering, planning, and design calculations were performed by Shulman and Whitaker. Among others who contributed to the design process were George Fung who checked the plans and C.F. Johnson who detailed the plans.

The Bridge Department engineers of the California Division of Highways designed the Cold Spring Canyon Bridge within an institutional culture that – for at least high-profile projects – promoted and placed a high value on quality, appearance, and good engineering performance to achieve not only structurally efficient and economically feasible bridges, but also aesthetically pleasing structures. The department encouraged its engineers to be innovative and to propose bridge designs that took advantage of various technologies that had been well-used for decades as well as those that emerged in prominence during the mid-twentieth century, such as welded steel and prestressed concrete. Among the structures that likely influenced the design of the Cold Spring Canyon Bridge was the US Bureau of Reclamation's (USBR) Glen Canyon Colorado River Bridge in Arizona, completed in 1959, which possesses a general configuration and column design similar to the Santa Barbara county structure.[15] The graceful lines and aesthetic appearance of Swiss engineer Robert Maillart's 1920s bridges also served as inspiration for the design.[16] The department's culture of quality is evident not only in the Cold Spring Canyon Bridge, but also in others, such as the Vincent Thomas Bridge (53 1471, also known as the San Pedro Terminal Island Bridge) in Los Angeles. Evidence of this pride of work is indicated as well by Shulman and the Bridge Department's having submitted the bridge to various industry organizations to compete for awards and recognition, which it received.[17]

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[13] "State Would Alter Route of San Marcos Pass Road," *Los Angeles Times*, November 11, 1956, A11.

[14] I. O. Jahlstrom, "Report of Completion for the Construction of Cold Spring Canyon Bridge, County of Santa Barbara, Contract No. 63-14V13C2, Road V-SB-80-B," June 17, 1964.

[15] Raymond L. Whitaker, oral interview with Christopher McMorris and Stephen Wee, JRP, March 12, 2007.

[16] Marvin A. Shulman, oral interview with Christopher McMorris and Stephen Wee, JRP, March 19, 2007.

[17] Whitaker, oral interview, March 12, 2007.

Marvin A. Shulman received his civil engineering degree from the University of California, Berkeley in 1951 and joined the Bridge Department at the Division of Highways the same year. His early career included recognition in the American Institute of Steel Construction (AISC) bridge design competitions, including awards for the design of a bridge on SR96 over the Trinity River in 1957 (04 0137) and for a steel girder overpass structure design in the "Steel Highway Bridge Design Competition," sponsored by the American Bridge Division of US Steel in 1959. He was recognized for his work on the Cold Spring Canyon Bridge and for several more bridges in the 1960s and early 1970s. Shulman remained with the Bridge Department until 1975, except for a few years when he worked for Aerojet Corporation in Rancho Cordova, near Sacramento, in the early 1960s after he had finished most of the design for the Cold Spring Canyon Bridge. He went to the State Architect's office structural safety section in 1975, where he engineered mostly hospitals and schools. He eventually became principal structural engineer of that office and retired from the state in 1992.[18]

Raymond L. Whitaker also joined the Division of Highways Bridge Department in 1951, following completion of his engineering degree from the University of Nevada, Reno. He worked in bridge construction supervision for a few years and then moved to the bridge design office in Sacramento. One of the best known bridges he helped design, prior to working on the Cold Spring Canyon Bridge, was the Vincent Thomas Bridge, which was also completed in 1963. He was one of the principal designers of the suspension system of that structure. In 1964, Whitaker moved to the California Department of Water Resources (DWR) where he headed up that department's bridge office. At DWR, he oversaw completion of the design computations and construction of the Bidwell Bar suspension bridge (12 0188, carrying SR162 over the Middle Fork of the Feather River), which was completed in 1965. During this period he also consulted on the SPINK Corporation's design of the pedestrian suspension bridge at California State University, Sacramento, known as the Guy A. West Bridge, which was completed in 1967. Whitaker became acquainted with a vice president of US Steel during the design of the Cold Spring Canyon Bridge who encouraged him several years later to investigate a position with Wilbur Smith Associates in South Carolina. Whitaker followed this advice and took a position with Wilbur Smith Associates in 1966, where he spent the rest of his career, eventually becoming chief structural engineer in the firm's home office in Columbia, South Carolina.[19]

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[18] *California Highways and Public Works*, November-December 1959, 45; *California Highways and Public Works*, September-October 1964, 59; and Shulman, oral interview, March 19, 2007. Mr. Shulman's name is mis-spelled as "Schulman" in various articles and documents.

[19] Whitaker, oral interview, March 12, 2007; and "The (Green) and Golden Gate," *Sacramento State Bulletin*, October 17, 2005, http://www.csus.edu/bulletin/bulletin101705/bulletin101705bridge.htm (accessed March 2007).

George A. Hood, Jr., joined the Division of Highways Bridge Department in 1948 after a short stint with the USBR in Denver. He joined the department's design division in 1953 and was promoted from bridge designer to section supervisor prior to his work on Cold Spring Canyon Bridge. Among his designs, prior to the Cold Spring Canyon Bridge, were two all-welded steel structures at Lake Berryessa on Knoxville-Berryessa Road. These bridges are the Pope Creek Bridge (21C0013) and the Putah Creek Bridge (21C0014), which were constructed in 1957. The latter of the two was widened in 1958. Hood retired from the Bridge Department in 1984.[20]

The Division of Highways district highways design division laid out the new route for SR154 and selected the site for the Bridge Department. Several factors went into the choice of the steel arch design for Cold Spring Canyon including consideration of construction costs, maintenance demands and costs, span layout, and designated design loads. In looking back on the project, Shulman noted that the magnitude of the site, including its picturesque location, demanded a structure to complement the setting. From an engineering perspective, steel arches were, and still are, a suitable and economical choice in steep canyons, such as the Cold Spring Canyon. There was also limited access to the lower canyon area for machinery and equipment, which made it all the more apparent that a long span structure was required. In addition, the Los Padres National Forest area around the bridge was susceptible to fire, so falsework could not be located in the canyon during construction. Such falsework would have been required for a reinforced concrete structure, for example.[21] Reinforced concrete and prestressed concrete designs were also not seriously considered because such structures would have been much heavier than the steel arch, and the allowable bearing pressure for the foundations would not have supported such structures.

With input from Hood and others, Shulman concluded that a steel arch was the most suitable and economically feasible structure for this site. Its selection, Shulman recalls, was "a natural for the site."[22] Shulman coordinated with the Bridge Department architects on the layout and design of the Cold Spring Canyon Bridge, taking advice on ways to enhance the aesthetic qualities of the bridge. In particular, Shulman received input from the architects regarding the appearance and spacing of the columns and other visual components, including the exclusion of cross bracing in the towers. He worked with Bridge Department cost estimators to evaluate construction costs, including calculating estimated quantities of materials based on preliminary layout designs and estimates for the cost of materials and labor, including provisions to account for the bridge's

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[20] George A. Hood, Jr., oral interview with Christopher McMorris, JRP, March 28, 2007.

[21] Marvin Allen Shulman, "California Scenic Bridge Features 700 Ft. Welded Steel Arch," *Modern Welded Structures*, Vol. II, (Cleveland, OH: James F. Lincoln Arc Welding Foundation, 1965), A-16; Shulman, oral interview, March 19, 2007; and Hood, oral interview, March 28, 2007. George Hood reiterated the restrictions for building falsework in the canyon because of fire hazards in a National Forest.

[22] Shulman, oral interview, March 19, 2007

location / setting and the quantity of work expected. The Cold Spring Canyon Bridge was also among the first structures for which the Bridge Department (and Shulman) used computers to provide data on the complicated computations required for the structural design.[23]

The emphasis of the design was on the arch structure and the stability of the structure to withstand the loads to be placed on it from traffic and possible seismic events, for example. In addition to the forces carried to the ground by the arch itself, the design of the structure's deck acted as a horizontal stiffening element. This, in turn, permitted the supporting columns and towers to be slender. In contrast to the intricate calculations and design necessary for the arch, towers, columns and deck structure, the railings used on the bridge were a standard type. No particular requirements were considered for their selection, besides those of the basic highway bridge engineering and safety that were inherent in the standard type design (Type II). There is no written record that the Bridge Department considered a specially designed railing for this structure, and Shulman, Whitaker, and Hood do not recall any emphasis placed on the design of the highway railing or specific consideration for the views that would be afforded from the structure once it was built.[24]

After Shulman's (temporary) departure from the department, Whitaker took over the project to complete the design. Whitaker changed little of the design and only had to complete computations of some design elements to improve the performance of the bridge under various types of loading. This included altering the design of the K-shaped cross bracing between the arch ribs from one to two sets of cross bracing, along with adding the cable system at the apex of the arch.[25]

As construction was coming to a completion, Whitaker assessed the structure's aesthetic qualities, describing the "two gracefully curved box-shaped arch rib sections" of the bridge and listing the structure's important qualities to include its all-welded sections, "unusual arch proportions," picturesque setting, and "generally pleasing appearance" as contributing to its

[23] Whitaker, oral interview, March 12, 2007; Shulman, oral interview, March 19, 2007. The Division of Highways' set standards for bridge type selection from the early 1960s is described in: Division of Highways Bridge Department, Manual of Bridge Design Practice, State of California: Highway Transportation Agency, Department of Public Works, 2nd edition, 1963, 1-3 to 1-21. The Division of Highways head Bridge Engineer for Planning, Arthur Elliot, also mentioned the use of computers in this project in a paper delivered to the Western Association of State Highway Officials (WASHO) conference in 1961, "Bridge Building in an Electronic Age," (available at the Caltrans Transportation Library, Sacramento). Elliot also described the general process for bridge design during this period in "California's Way to Aesthetic Bridges," *Esthetics in Concrete Bridge Design* (Detroit: American Concrete Institute, 1990), 119-131.

[24] Whitaker, oral interview, March 12, 2007; Shulman, oral interview, March 19, 2007; F. H. Yoshino and R.L. Whitaker, *California Highways and Public Works*, September-October 1963, 15 and 20.

[25] Whitaker, oral interview, March 12, 2007; Shulman, oral interview, March 19, 2007.

being a "notable addition to the California highway scene."[26] At the time of the bridge's construction, views of the canyon from the bridge and surrounding countryside were considered to be impressive and an asset to the structure.[27]

The bridge's design included all-welded components for the arches, girders, columns, towers, and floorbeam system. It was calculated as having saved at least $400,000 in comparison to other bridge designs and provided several other advantages in addition to cost savings. The use of all-welded components helped create a more functional design, quicker and easier shop fabrication, faster field erection of the structure, less dead load (weight of the bridge structure itself) resulting in smaller foundations, less expected maintenance, and a longer life expectancy for the structure. The all-welded design also was an important component of the aesthetic design, contributing to the trim, smooth, uncluttered appearance of the bridge.[28] Shulman used welded components, for example, because he did not want the complicated appearance that would have resulted with lattice-formed columns or diagonal bracing between the columns. The "open and clean" appearance of the bridge is formed by the slender individual components in the arch ribs, towers, and columns, all of which were more slender than they otherwise would have been if rivets and bolts had been necessary.[29]

<u>Construction of the Cold Spring Canyon Bridge</u>

The American Bridge Division of US Steel was the prime contractor for the erection of the Cold Spring Canyon Bridge, and Division of Highways engineer Fred Yoshino served as the project's resident engineer, with four assistant resident engineers. The Massman Construction Company of Kansas City, Missouri, was the contractor for construction of the approach fills, substructure excavation, concrete, and the concrete deck construction. Massman hired Coxco, Inc., for construction of the roadway embankment. The structural steel for the bridge was manufactured by Consolidated Western Division of US Steel in Los Angeles and by the American Bridge Division of US Steel in Gary, Indiana. The design and construction of the bridge cost over $2 million.[30]

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[26] *California Highways and Public Works*, September-October 1963, 15 and 20.

[27] *California Highways and Public Works*, September-October 1963, 15.

[28] Shulman, "California Scenic Bridge Features 700 Ft. Welded Steel Arch," *Modern Welded Structures*, A-16; Shulman, oral interview, March 19, 2007; Whitaker, oral interview, March 12, 2007; "Giant Slingshot Used to Help Build San Marcos Pass Bridge," *Los Angeles Times*, April 10, 1972, D1.

[29] Whitaker, oral interview, March 12, 2007; Shulman, oral interview, March 19, 2007.

[30] Jahlstrom, "Report of Completion for the Construction of Cold Spring Canyon Bridge" June 17, 1964; "Long Steel Arch Bridge to be Completed Soon," *Los Angeles Times*, November 28, 1963, 16; "Cold Spring Canyon Bridge Not Open Yet," *Los Angeles Times*, February 2, 1964, F2; *California Highways and Public Works*, September-October 1964, 59. Fred Yoshino died in Sacramento in 2002. Ancestry.com, *Social Security Death Index* (Provo, UT: The Generations Network, Inc., 2006). Shulman and Hood also stated that they believed Yoshino had died.

The American Bridge Company was originally founded in 1870 in Chicago, Illinois, and operated as an independent company in the Midwest. In the late 1890s independent bridge companies began consolidating, and in 1900 twenty-eight of the largest steel fabricators and constructors consolidated into the American Bridge Company, taking the name of one of the contributing companies. The following year American Bridge Company became a subsidiary of United States Steel Corporation, the corporation formed by J.P. Morgan that virtually controlled the United States steel industry. American Bridge Company became the American Bridge Division of US Steel and remained a subsidiary of the US Steel Corporation until 1987 and is now privately owned. Because of its financial backing, immediately after consolidation in 1900, the new company commanded a great percentage of steel bridge building projects across the country and won major contracts throughout the world, using the projects to further develop the use of steel in bridge construction. American Bridge constructed many bridges in California, including several of the most well known steel structures in the state, such as the I Street Bridge in Sacramento (22C0153) built in 1911, both the original 1927 Carquinez Strait Crossing (23 0015L) (now demolished) and the second Carquinez Strait bridge (23 0015R) built in 1958, the cantilever 1941 Pit River Bridge and Overhead (06 0021) on I-5 at Lake Shasta, and the Schuyler Heim Lift Bridge at the Port of Los Angeles (53 2618) built in 1946. American Bridge continued to build and repair bridges in California throughout the twentieth century, including the seismic retrofit of the Cold Spring Canyon Bridge in 1997-1998, discussed below.

The eighteen month construction of the Cold Spring Canyon Bridge between May 1962 and December 1963 occurred in four phases: substructure / foundations; erection of the steel structure and deck on the approach spans; erection of the steel arch span; and deck construction over the arch. The contractors were limited in their use of heavy equipment for excavation and construction of the bridge substructure because of the difficult locations of the footings. The contractors used a giant slingshot comprised of elastic rubber bands to fling the first line across the canyon in order to pull the initial chains across the divide.[31] American Bridge used a "stiff leg" derrick to erect the steel on the approach spans, and they used railroad rails mounted on top of the approach span girders to move a traveler for construction of subsequent bents and span girders. The bridge builders then used a highline approach on the arch portion of the structure, which included construction of two 117' tall temporary towers placed on top of the girders flanking where the arch span would be built. This was followed by the use of a cantilever method of support to build the arch ribs outward from either end towards the middle.

The towers were tied back to anchor blocks buried in the approach fill to counter the cantilever loads. American Bridge lifted the arch span sections into place by crane from trucks situated on

[31] *California Highways and Public Works*, September-October 1963, 18.

the road below the new bridge. Work occurred on both sides of the canyon so that the loads on the arches and tiebacks were balanced. The arch was completed in July 1963, three months behind schedule. This delay was because some of the arch ribs fabricated in Gary, Indiana, were flawed and required corrective work. Work was slower on this bridge than on conventional bridges because various operations could not be done concurrently, but rather had to follow a specific sequence. No portion of the concrete deck could be built, for example, until all steel for the arch span was in place, and painting of the steel had to wait until the concrete pours and curing on the deck stopped dripping water. The challenging location and design of the structure, as well as concerns to follow adequate safety procedures, prevented the contractor from speeding up the progress of construction.[32]

Steel Arches and Welding Technology

The Cold Spring Canyon Bridge is one of the few steel arch bridges on California roadways. It is the longest of its type in the state with its 700' long main span which, at the time it was built, was twice a long as the state's previously longest steel arch bridge.[33] It is also one of only two steel arch bridges on California roadways built with all-welded steel components. Generally, steel arches are more difficult and expensive to fabricate and erect than other types of bridges, such as the concrete box girder and prestressed concrete which were innovations developed in the mid-twentieth century. Some steel arches, however, were built as the most cost-effective and efficient design, particularly where construction of reinforced concrete was not economically feasible. In some circumstances, the arch form was chosen for aesthetic reasons. Although steel arch bridges built during the early to mid-twentieth century generally followed the forms developed for this bridge type in the nineteenth century, refinements to their designs and simplifications of their forms resulted from the application of increased scientific testing and mathematical rigor, as well as improved quality of steel and steel construction methods. Some of the best-known twentieth century steel arches in the country are massive structures with intricate

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[32] Division of Highways Bridge Department, As-built plans, Cold Spring Canyon Bridge, 1963; Jahlstrom, "Report of Completion for the Construction of Cold Spring Canyon Bridge, June 17, 1964. The roadway's new number is also provided in this report as V-SB-154. Also see, *California Highways and Public Works*, September-October 1963, 19; "Amended Plan on San Marcos Highway Okd," *Los Angeles Times*, January 8, 1962, A14; "Long Steel Arch Bridge to be Completed Soon," *Los Angeles Times*, November 28, 1963, 16; "Cold Spring Canyon Bridge Not Open Yet," *Los Angeles Times*, February 2, 1964, F2; "Bridge to Open at Cold Springs," *Los Angeles Times*, February 7, 1964, A2; *California Highways and Public Works*, September-October 1964, 59. Construction of the Cold Spring Canyon Bridge was covered by major newspapers. See, for example, "Bridge at Halfway Point," *New York Times*, March 26, 1963. The *Santa Barbara News Press* covered the bridge's construction at various points, but did not publish articles about the bridge when it was completed or when it opened. The newspaper also described the design and construction of Cold Spring Canyon Bridge in: Bill Griggs, "Dream Design Bridges Reality at Cold Spring," *Santa Barbara News-Press*, May 10, 1987, B-1 to B-2.

[33] The Pulga Bridge (12 0038), carrying SR70 over the Feather River in Butte County, was built in 1932 with a 350 feet main span and was the longest steel arch bridge in California when it was built.

webs of truss supports, such as the Hell Gate Bridge and Bayonne Bridge built in New York in 1916 and 1931, respectively. Others were built with more delicate forms, with slender support members, shallow deck girders, and open and light spandrel areas. Such improvements led to designs with greater purity of the arch form and a more refined appearance of structural elements, as is seen in the Cold Spring Canyon Bridge.[34]

There are two designs of steel arches found in California: spandrel-braced and solid-ribbed arches. Spandrel-braced arches have webbed triangular members like trusses, but with a rounded bottom chord that forms an arch. They are built in deck form with spandrel columns and lateral braces. Two of the other large steel arch bridges on California roadways, besides Cold Spring Canyon Bridge, are spandrel-braced arches. These structures are the Pulga Bridge (12 0038) in Butte County, built in 1932, that carries SR70 over the Feather River, and the Maple Canyon Bridge (57C0416) in San Diego, built in 1932. The oldest steel arch bridges in California are also spandrel-braced structures. They are the Edwards Bridge (17C0006) in Nevada County, built in 1904, and the San Lorenzo River Bridge (36C0085) in Santa Cruz County, built in 1912. Later examples include the Gerald Desmond Bridge in Long Beach (53C0065), constructed in 1968, and the Gault Bridge (17C0001) near Nevada City which is a 1906 bridge that was reconstructed in 1996. Solid-ribbed arches, like the Cold Spring Canyon Bridge, have girders cast in a curved form with the deck supported by metal posts or suspenders attached to the arch form. Other examples of this bridge type include the George E. Tyron Bridge (01C0005), built in 1948, carrying South Fork Road over the South Fork of the Smith River in Del Norte County, and the Bluff Creek Bridge (04 0225), carrying SR96 in Humboldt County, built in 1967. The Tyron Bridge is structurally similar to the Cold Spring Canyon Bridge, albeit much smaller, and is the other all-welded steel arch in the state. The Bluff Creek Bridge is much shorter than the Cold Spring Canyon structure and its arch is formed by a plate girder design. There are also solid-ribbed arches that carry the deck on the bottom chord, forming a through-style bridge. Examples of these type of solid-ribbed arches include the Sixth Street Viaduct over the Los Angeles River (53C1880), built in 1932, and the Howells Bridge (09 0009), carrying SR70 over the Feather River in Plumas County, built in 1934.[35]

Another large arch bridge, the San Roque Canyon Bridge (51 0104), was formerly located in Santa Barbara until it was demolished in the early 1980s and replaced in 1984 with a concrete

[34] Carl Condit, *American Building: Materials and Techniques from the Beginning of the Colonial Settlements to the Present*, 2nd ed. (Chicago: University of Chicago Press, 1982), 214, 228-233.
[35] JRP Historical Consulting, "Caltrans Historic Bridges Inventory Update: Metal Truss, Movable, and Steel Arch Bridges," Volume 1, prepared for Caltrans, March 2004, 36-37. Arch bridges can also be characterized by their degree of articulation, i.e. the number and location of pin connections or hinges at the supports and arch crown. The Cold Spring Canyon Bridge is a two-hinge arch. This characterization of arch bridges, however, is less generally important than the form of arch using either ribs or truss forms.

structure. The San Roque Canyon Bridge, built in 1931 in what was then an unincorporated area of the county, was a steel plate girder arch with steel stringer approaches. It had two sets of arches, carried two lanes, and was 482' long by 28' wide. Santa Barbara County Surveyor civil engineer Ulysses Sumner Grant designed the structure and it was built by C. B. Davison for the county. This bridge was constructed on a foothill route, SR192, between Santa Barbara and Goleta, and was built to help relieve traffic congestion on the coast highway, US101. The county chose the steel arch design, in part, because it was substantially less expensive at the time than the concrete arch bridge, suspension bridge, and truss bridge designs that were also considered.[36]

The Cold Spring Canyon Bridge was one of the ten longest steel arch bridges in the United States when constructed and one of the few with its arch units entirely fabricated from arc welded steel.[37] The Santa Barbara County structure was discussed in engineering publications from the 1960s and 1970s along with other steel arches built across the country during the mid-twentieth century, some of which were much longer. Among the Cold Spring Canyon Bridge's contemporaries is the structurally comparable Lewiston-Queenston Bridge over the Niagara River in Lewiston, New York, at the border crossing into Canada. This solid-ribbed deck arch was completed in 1962 over a large canyon and is strikingly similar in layout and form to the Cold Spring Canyon Bridge with its open uncluttered appearance formed by slender arch ribs, roadway deck, and columns with no cross bracing. Smaller steel arch structures with similar architectural qualities, but built as overpasses to highways for example, include the Old State Route 8 Bridge on the Ohio Turnpike, built in 1955, and the South Street Bridge over I-84 in Middlebury, Connecticut, built in 1964.[38] The New River Gorge Bridge in West Virginia, a deck style solid-ribbed arch with a truss-formed arch, was the longest steel arch bridge in the world from when it was constructed in 1975 until the steel arch Lupu Bridge was completed in 2002 in Shanghai, China.[39]

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[36] John Snyder, "Historic American Engineering Record, CA-17, San Roque Canyon Bridge," 1979.

[37] *World Almanac*, 1963 cited in *California Highways and Public Works*, September-October 1963, 14; *California Highways and Public Works*, September-October 1964, 59.

[38] Frederick S. Merritt, *Structural Steel Designers' Handbook* (New York: McGraw-Hill Book Company, 1972), 13-12, 13-22, and 13-40; The New York State Historic Preservation Officer determined the Lewiston-Queenston Bridge eligible for listing in the NRHP in 2001 under Criterion C and Criterion Consideration G. Claire Ross, NY SHPO National Register and Survey Unit Coordinator for Niagara County, personal communications with Christopher McMorris, JRP, March 9, 2007.

[39] National Park Service, "New River Gorge Bridge," informational pamphlet, New River Gorge National River, November 1998; "Superstar opens super bridge," *China Daily*, http://www.chinadaily.com.cn/en/doc/2003-06/30/content_241993.htm. The West Virginia State Historic Preservation Officer considers the New River Gorge Bridge eligible for listing in the NRHP, although no evaluation has been completed on the structure. Ginger Williford, Structural Historian, West Virginia, State Historic Preservation Office, personal communications with Christopher McMorris, JRP, March 8, 2007.

The use of all-welded components in the Cold Spring Canyon Bridge illustrates maturation of welding technology and its acceptance and use in major structures. Its implementation here was not innovative, but rather evolutionary in demonstrating confidence and proficiency in the application of this technology to achieve a structurally feasible, economically sensible, and aesthetically pleasing design. The established use of welding for major buildings and important bridges can be seen in other buildings and structures across the county contemporary with the Cold Spring Canyon Bridge. Among them, for example, are the Chicago Civic Center built in 1963-1965 and the Ash Street / Pillsbury Road Bridge on I-93 in New Hampshire. The Chicago Civic Center's bold design is apparent in the dimensions of spans (both in width and height) and the creation of a portal framing system that forms a rigid frame evenly dividing the tensile and compressive stresses among connected members.[40] New Hampshire Department of Transportation's engineer Robert Prowse designed the all-welded steel rigid frame Ash Street / Pillsbury Road Bridge as a conceptual bridge competition design, and the state of New Hampshire built the structure in 1964. It is composed of "five frames or bents designed to function as a series of parallel two-hinged rigid frames." Its design permitted the welded forms to take on sculptural qualities that reflected its internal stresses and to unite the overall structure.[41]

Acceptance and use of welding was an important development in steel bridge construction during the mid-twentieth century. Standard uses of welding for bridge repair evolved in the 1930s and became widely accepted by the 1950s. The technique of welding (electric arc-welding), whereby metal was joined in a manner that gave it structural qualities, was originally invented in the 1880s by French inventor Auguste de Meritens. Welding, however, was not introduced into building construction until the early-twentieth century. This construction was used sporadically in the United States during the 1920s and was first employed on California bridges during the 1930s. By the end of that decade, state engineers in California were studying and experimenting with welding for bridge repair and reviewing how it could be used for bridge construction. The potential for welded bridges was they could be lighter and easier to construct than conventional riveted structures because they did not require additional components such as tie plates, lacing bars, and rivets. Proponents noted that it would be possible for welded bridges to be constructed on the ground and moved into place, and their designs promised cost savings by decreasing the volume of metal necessary in construction. There were also some that

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[40] Condit, *American Building*, 193-195.

[41] Ken Story, Preservation Company, and James L. Garvin, New Hampshire Division of Historical Resources, "Ash Street Bridge (Robert J. Prowse Memorial Bridge) Bridge No. 140/120," New Hampshire Division of Historical Resources, Individual Inventory Form, NHDHR Inventory #LON0116, September 2001 and December 2002, available at the State of New Hampshire, Department of Transportation, Bureau of Environment; and Federal Highway Administration, "Final List of Nationally and Exceptionally Significant Features of the Federal Interstate Highway System" November 1, 2006, http://www.environment.fhwa.dot.gov/histpres/highways_list.asp (accessed March 2007).

promoted the aesthetic advantages of welded bridges because they could reduce the complex lattice work of steel seen on most bridges at the time. Implementing the use of welding, however, was challenged by lack of investment in welding equipment and skilled designers and builders. Furthermore, there were difficulties in externally inspecting welding for defects, and early welding techniques were, at times, structurally weak. Consequently, engineers in the 1930s and 1940s tended to shy away from welding for most bridge designs, preferring to use better known and long-proven methods.[42]

In the 1950s, welded bridges became more common in California as construction practices were improved and engineers recognized the safety of welded structures. Welding was boosted into a more prominent role in bridge construction during the early 1950s when the federal government limited the use of rolled steel in bridges during war restrictions for the Korean conflict. With fewer large rolled steel members available, the Division of Highways developed welding practices to build up structural elements of large bridge projects. The Bridge Department became instrumental in promoting the use of all-welded girders, largely for their potential economic benefit, as well as for the use of composite girders where bolts were welded to the top flange to improve the integration of the girder with concrete decks. The advantages of welding – including time savings in construction, reduced materials, improved durability of steel components, and aesthetic enhancements – became more readily apparent, and welded structures were increasingly considered for bridge designs. By the mid-1950s and early 1960s, the Division of Highways regularly constructed all-welded structures, like small girder-type bridges, but also larger structures such as the viaduct for the elevated Bayshore Freeway in San Francisco, built in 1954 (34 0077) and the George C. Cole Memorial Bridge carrying US101 over the South Fork of the Eel River at Myers Flat (04 0123), built in 1962, both of which won awards from the American Institute of Steel Construction.[43]

Dissemination of information regarding welding and promotion of its use was, in large part, the result of publications from and competitions sponsored by the James F. Lincoln Arc Welding Foundation. Established in 1936 to promote the art and science of arc welding, the foundation

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[42] Condit, *American Building*, 192-193; and "Three State Engineers Win Awards in Welding Design Competition," *California Highways and Public Works*, November 1938, 16, 17, and 28; Van Rensselaer P. Sax, F. ASCE, "Why Not More Welded Structures?" *Civil Engineering*, August 1960, 53; Omer W. Blodgett, *Design of Welded Structures* (Cleveland, OH: James F. Lincoln Welding Foundation, 1966), 1.1-1 to 1.1-3.

[43] H.D. Stover to F.W. Panhorst, letter regarding welding processes reports and list of welded bridges in California, November 2, 1944, Structures Maintenance Historical Collection, General Information File, California Department of Transportation Library, Sacramento; Division of Highways, *Sixth Annual Report*, 1953, 157; Arthur L. Elliot, "California Captures Four AISC Steel Bridge Awards," presentation ca. 1961, available in "aesthetics" file at the Caltrans Transportation Library Sacramento; and Shulman, oral interview, March 19, 2007. The award winning section of the Bayshore Freeway was at the 9th and 10th Street Viaducts, now considered part of the Central Viaduct in San Francisco.

was a spinoff of the Lincoln Electric Company in Cleveland, Ohio, which pursued this technology when it was relatively new, shifting its emphasis to manufacturing welding equipment. The company saw the need to encourage greater practical experience if the technology was to reach its potential. This led to the formation of the non-profit foundation that disseminated information and stimulated research by sponsoring awards programs for innovative uses and designs for welded structures. The first awards contest was held in 1938 with subsequent awards presented in 1943 and afterward. The foundation began publishing its own texts in 1954. The foundation later awarded Marvin Shulman and the Division of Highways Bridge Department an award for the Cold Spring Canyon Bridge.[44] In addition to providing engineers technical data to satisfy potential structural situations, the James F. Lincoln Foundation also promoted welding by illustrating its economic benefits and its applications in contemporary design. In 1966, a Lincoln Foundation publication explained that welding provided designers the freedom "to employ the most elementary or most daring concepts of form, proportion, and balance to satisfy the need for greater aesthetic value." It went on to describe contemporary buildings with exposed steel framing used as part of the "artistic scheme" that illustrated the "unencumbered simplicity of form essential to the modern look in architecture."[45]

It was in this environment, although not overtly recognized as such, that the Division of Highways Bridge Department engineers considered welding and its aesthetic benefits for creating a pleasing structure, such as occurred with the Cold Spring Canyon Bridge. Shulman, Whitaker, and Hood did not identify that they were working in a "Modernist" aesthetic, but their efforts to design an open, uncluttered, graceful steel arch design that took advantage of welding's various benefits are indicative of the era in which the Cold Spring Canyon Bridge was designed and built – a period when building and structural designers sought to achieve economy, efficiency, and functional and material honesty, along with appropriate structural balance.

Cold Spring Canyon Bridge illustrates a specific period of bridge design and construction in California and it is a rare structure of its type, with conditions on few other roadways necessitating such a design. The Cold Spring Canyon Bridge, moreover, was designed and built prior to other innovations and structural testing that are now prevalent in bridge construction. These include innovations in steel manufacturing that have allowed other structural types to be used for long spans, including "weathering steel" developed in the mid-1960s and "high-performance steel," which was developed in the early 1990s. The latter type has greater strength,

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[44] JF Lincoln Foundation, "About Us, History & Profile," J.F. Lincoln Foundation website, http://www.jflf.org/about/history.asp (accessed January 2007); "Award Winning Bridges," *California Highways and Public Works*, January-February 1965, 40.

[45] Blodgett, *Design of Welded Structures*, 1.1-1 to 1.1-7.

is lighter in weight, and has greater atmospheric resistance than conventional steel.[46] In addition, bridge design innovations such as large segmental prestressed concrete structures and cable-stay suspension structures were also likely responsible, in part, for few steel arches of similar size and scale as the Cold Spring Canyon Bridge being built subsequent to this bridge's construction.

None of the key engineers on the Cold Spring Canyon Bridge project, Shulman, Whitaker, and Hood, ever worked on another major steel arch bridge. Their work on the Cold Spring Canyon Bridge, however, provided insight and confidence in using all-welded designs in subsequent projects. Whitaker later used welded components for several major projects on the East Coast, including curved steel girder bridges built in Knoxville for the World's Fair in the early 1980s, a bridge widening over the Ashley River in Charleston, South Carolina, and in the William-Brice football stadium of the University of South Carolina in Columbia, South Carolina.[47] Shulman's later designs included many all-welded girder bridges. One of the most prominent of his later designs was the Elkhorn bridges on I-80 over the Sacramento River, built in 1969 (22 0025L and 22 0025R).[48]

Bridge Aesthetics and Modern-era Design

Cold Spring Canyon Bridge is a high point of bridge design and construction on California highways from the early 1960s. It illustrates attention given to aesthetics of major bridge projects during that period; an aesthetic that was greatly influenced by Modern design trends of the post-World War II era. It also demonstrates a collaborative effort in the Bridge Department that encompasses the engineering and architectural values of its period. The simple geometry, graceful lines, slender components, and open uncluttered appearance are indicative of the era in which the bridge was designed and built.

Bridge design in California generally corresponded with architectural trends of the twentieth century. By the mid-1930s, the architectural and design aesthetic for prominent new buildings and structures in California had started to shift away from the Classicism and historic period revival of the early part of the century towards the modernistic aesthetic that were more abstract, stripped-down, and unadorned, as seen in the architectural styles of Art Deco / Moderne and the International Style. The new styles promoted buildings and structures as symbols of twentieth century technological progress, their lack of ornament and straight-forward structural designs

[46] Shulman, oral interview, March 19, 2007; Whitaker, oral interview, March 12, 2007; Hood, oral interview March 28, 2007; Whitaker, oral interview, March 12, 2007; Robert A.P. Sweeney, Chairman of the Committee on Steel Bridges, "Steel Bridges," Transportation for a New Millennium. Transportation Research Board, "Millennium Papers," http://www.trb.org/TRB/publications/MillenniumPapers.asp (accessed January 2007).
[47] Whitaker, oral interview, March 12, 2007.
[48] Shulman, oral interview, March 19, 2007.

were a reaction to the perceived excesses of architectural embellishment adopted during the late nineteenth century and early twentieth century.[49] In this effort, bridge engineers avoided design and ornament that concealed structural essence of their designs and instead emphasized the simplicity of clean graceful lines formed by the materials themselves. Of course, many bridges across the state were, and continued to be, constructed using designs that were utilitarian with little focus for aesthetic enhancement. The Division of Highways Bridge Department, however, emerged during the mid-twentieth century as a national leader in the design of boldly engineered bridges and of bridges with aesthetic appeal that responded to the changing visual sensibilities of professionals and the public at the time. Such spectacular aesthetic examples of this shift in taste from the 1930s include the San Francisco-Oakland Bay Bridge, the Bixby Creek Arch (44 0019), and the Tower Bridge in Sacramento (22 0021).

As in many design fields during the mid-twentieth century, bridge engineers of the period sought to design structures that would not only be functional and efficient, but also represent the essence of their material, eschewing concealment and extraneous decoration for the simplicity, clean graceful lines. These efforts were inherent in their work, and while engineers may have not overtly recognized their work as such, these values expressed many of the tenets of Modern-era design. This was expressed by the Bridge Department starting in the mid-1930s as a desire to design bridges without "archaic bric-a-brac" adornment, aiming instead for bridges whose components were "pleasingly proportioned and harmoniously arranged."[50] Early on, the Bridge Department appears to have been influenced by the designs and concepts of Alfred Eichler, who worked for the Division of Architecture in the Department of Public Works from the 1920s to the 1960s. It was Eichler who pointed out that, not only did applied architectural elements such as moldings, cornices, brackets, and pilasters add cost to bridge design, it was difficult to properly apply those classical forms in bridge design, resulting in typically unsuccessful compositions. The trend, thus, was away from using historical precedents in hopes that the new structures would transcend the shifts of taste from one generation to another. Later, Bridge Department chief of bridge planning Arthur Elliot promoted serious consideration of aesthetics in bridge design that likely spread throughout the culture of the department.[51]

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[49] Arthur L. Elliot, "Fifty Years of Freeway Structures," 1988, Bridges file, California Department of Transportation Library, Sacramento, 3-5 [Edited version of essay printed in *Going Places*, July-August 1989, 12-17], 2; Wilbur J. Watson, "Architectural Principles of Bridge Design," *Civil Engineering*, March 1938, 181 and 184; and Aymar Embury II, "Esthetic Design of Steel Structures," *Civil Engineering*, April 1938, 262.
[50] *Civil Engineering*, March 1938, 183; and Division of Highways, *Eleventh Biennial Report*, 1938, 54.
[51] Leonard C. Hollister, "The Modern Highway Bridge, as Expressed by Recent Designs of the California Division of Highways," *Roads and Streets*, October 1937, 45-50; Arthur L. Elliot, "Aesthetics of Highway Bridges," *Civil Engineering*, June 1968, 64-69. See "aesthetics" file at the Caltrans Transportation Library in Sacramento for Arthur Elliot's presentations and documents pertaining to bridge aesthetics from the 1960s and 1970s.

Although one can see a shift in aesthetics and taste in mid-twentieth century bridge design, many bridges constructed during this period, particularly after World War II, were designed for the greatest economy with less emphasis on the aesthetics or their place as civic monuments. Some of the innovations, and the economies achieved through their application, led to increased standardization of bridge design across the state and thus, in the eyes of critics, greater visual monotony. The result was a dual effect. Bridge standardization coincided with post-World War II aesthetic values that sought form to follow function, yet Modern design qualities were co-opted for mass production of bridges in the postwar period. The Division of Highways was aware that some of its designs had aesthetic shortcomings and began to use their architects more frequently in the 1950s to work on enhancing the visual effects of bridges. This led to increased aesthetic review of new bridges at the Bridge Department in the 1960s.

Bridge Department's efforts in the 1960s to improve the aesthetics of bridge design centered on the concept of structures' compatibility with their surroundings. The department's chief of bridge planning Arthur Elliot promoted aesthetics in bridge design and freeway development. Elliot emphasized that aesthetics was not about concealing structures or adding unnecessary architectural treatment. He stressed the need for engineers to go beyond the basic computations to find the intuitive proportions of structures. He sought to not increase the cost of structures for the purposes of aesthetics, but rather to find forms and modest architectural treatment that would provide a more pleasing structure. District engineers in particular were sensitive to the issue of designing structures that would meet with approval from local governments and citizenry. Coordination between engineers and the staff architects in the Bridge Department became standard practice that was enhanced by the architects typically understanding the principals of bridge engineering. While structures like the Cold Spring Canyon Bridge were the result of this interaction, other results were more modest and largely go unnoticed now, such as textured concrete walls and tapered concrete columns for freeway overpasses.[52]

It was in this environment that the Division of Highways Bridge Department engineers designed the Cold Spring Canyon Bridge. While the engineers did not recognize this atmosphere as working in the "Modernist" aesthetic, their efforts to design an open, uncluttered, graceful steel arch design corresponded to the tenets of mid-twentieth century Modernism that sought economy and efficiency of form, functional and material honesty, and structural balance that was harmonious with its setting. Procedures initiated at this time for reviewing bridge design aesthetics continued, and some aspects of the trends that emerged in the mid-twentieth century have continued. Caltrans continues to assess the aesthetic compatibility of structures and

[52] *Civil Engineering*, June 1968, 64-69; Shulman, oral interview, March 19, 2007; Hood, oral interview, March 28, 2007. See "aesthetics" file at the Caltrans Transportation Library in Sacramento for Arthur Elliot's presentations and documents pertaining to bridge aesthetics from the 1960s and 1970s, such as "What Does Aesthetics Mean in the Division of Highways, Phase I, Aesthetics Program, January 25, 1966."

continues to strive for structures that are economical and structurally reliable.[53] The Cold Spring Canyon Bridge illustrates the maturation of the Bridge Department's designs meeting many of the Modern aesthetic goals and is an excellent representation of the Division of Highways' response in the late 1950s and early 1960s to produce pleasing structures that are designed with meticulous application of established engineering forms and fabrication methods.

Repairs and Alterations to the Cold Spring Canyon Bridge

The Cold Spring Canyon Bridge has been maintained and repaired over the years. In the early 1990s, bridge investigations revealed that the reinforced concrete skewbacks, at the base of the two towers at either end of the arch, had deteriorated with wide cracks visible in the concrete. Caltrans repaired the skewbacks by sealing the cracks in 1990 and 1995. The department also reduced the vegetation adjacent to the bridge, as a fire safety precaution, and sealed the bridge deck at that time. Caltrans laid new asphalt concrete on SR154 between PM 21 and 23.2, including over the Cold Spring Canyon Bridge, in 2000, and built an additional concrete K-rail along the roadway over the southwest abutment in 2006.[54]

The largest project on the bridge was when it was seismically retrofitted in 1997-1998. Buckland & Taylor, Ltd., Bridge Engineering designed and the American Bridge Company built the seismic retrofit of the structure under contract with Caltrans. Bridge investigations had indicated that the bridge's arch ribs and main towers could be overstressed in a seismic event and that the arches might not resist an uplifting force at the connection with the footing. The investigation also recommended stronger lateral cables between the deck and arch. This project included the installation of steel reinforcing plates constructed up from the arch ends on the top and bottom chords. The project also included installation of new bolts, bolsters flanking the abutment seats, and anchors placed diagonally along the tangent of the arch and below the anchor bent. The arch ribs and main towers were strengthened along with new concrete encased around the skewbacks and modifications to tie-downs for the arches.[55]

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[53] A.L. Elliot, "California's Way to Aesthetic Bridges," *Esthetics in Concrete Bridge Design* (Detroit: American Concrete Institute, 1990), 119-131; and James E. Roberts, "Caltrans Considers Aesthetics Important," *Roads & Bridges*, November 1988, 73.

[54] Caltrans District 5 records.

[55] American Bridge, "Cold Spring Canyon Bridge – Seismic Retrofit," online summary, http://www.americanbridge.net (accessed January 2007); Buckland & Taylor Ltd., Bridge Engineering, "Cold Spring Canyon Bridge," online summary, http://www.b-t.com/projects/cldsprg.htm (accessed October 2006).

Recognition for the Cold Spring Canyon Bridge

The Cold Spring Canyon Bridge has been widely recognized for its structural design and aesthetics. The bridge was noted as a "spectacular engineering feat" and as an "engineering marvel" in the popular press when it was originally constructed and for years afterward.[56] Engineers also referred to the structure as a "classically beautiful bridge," and the bridge was discussed along with other major steel arches nation-wide in engineering journals and manuals during the 1960s and 1970s.[57] Shulman recalled that one of the judges that awarded the bridge recognition remarked about the bridge's aesthetic quality by stating that "by its simplicity, it has beauty." This recognition came at a time when California was among the leading states receiving awards for their bridges from organizations like the AISC, James F. Lincoln Foundation, Portland Cement Association, Prestressed Concrete Institute, American Iron and Steel Institute, US Steel Company, and the Federal Department of Transportation.[58]

Marvin Shulman was honored with a national welding award from the James L. Lincoln Foundation for the Cold Spring Canyon Bridge, soon after completion of construction. AISC honored the bridge in 1963-1964 as the Most Beautiful Steel Bridge (Long Span); the plaque for this designation is on the west end of the bridge.[59]

The Cold Spring Canyon Bridge was also one of 77 awardees of Governor Edmund (Pat) Brown's Governor's Design Awards in 1966. Division of Highways' bridge designers Marvin A. Shulman and George A. Hood Jr. were honored for the structure. The jury included prominent designers of the period including Nathaniel Owings, of Skidmore, Owings, and Merrill, as well as T.Y. Lin, University of California Berkeley civil engineering professor and prominent bridge designer.[60]

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[56] Ed Ainsworth, "High Bridge Aids Growth of City," *Los Angeles Times*, June 25, 1963, A2; "Long-span bridge an impressive gateway to valley," *Los Angeles Times*, April 28, 1979, K5. Also see an appreciation of the bridge in: Joan Bolton, "Five Million Pounds of Steel," *Santa Barbara Magazine*, January-February 1989, 14-20.

[57] Cinco Linears, Vol. 2, No. 2, February 1, 1977; Leo J. Ritter, Jr. and Radnor J. Paquette, *Highway Engineering* (New York: Ronald Press Company, 1967), 203-204; Merritt, *Structural Steel Designers' Handbook*, 13-22 and 13-23; William F. Hollingsworth, "Fifty-Year Development: Construction of Steel Arch Bridges," *Journal of the Construction Division, Proceedings of the American Society of Civil Engineers*, Golden Jubilee Issue, No. 1, March 1975, 85-103.

[58] List of awards for California Bridges, as of June 1973 (available in the "Aesthetics" folder at the Caltrans Transportation Library in Sacramento). This list was likely compiled by Arthur Elliot, former head of Bridge Engineering Planning at the Division of Highways.

[59] "Long Steel Arch Bridge to be Completed Soon," *Los Angeles Times*, November 28, 1963, 16; "Long-span bridge an impressive gateway to valley," *Los Angeles Times*, April 28, 1979, K5; *California Highways and Public Works*, September-October 1964, 59.

[60] "Governor Presents 15 Design Awards," *Los Angeles Times*, January 1, 1967, H2. These so-called annual awards appear to have only been given out once at the end of the Brown administration. The Reagan administration, nor

Furthermore, SR154 itself was recognized. The State of California designated SR154 from Santa Barbara into the Santa Ynez Valley as a Scenic Highway in 1968. In addition, the non-profit organization Scenic America rated a 32-mile section on SR154 from Santa Barbara through the Santa Ynez Valley as one of the top ten most scenic highways in the United States.[61]

The American Society of Civil Engineers (ASCE), Santa Barbara-Ventura Section, designated the structure as Historic Civil Engineering Landmark #44 in October 1976. ASCE emphasized this recognition in 2004 by mounting a plaque on a monument located on Old San Marcos Pass Road, northeast of the bridge.[62] In addition, Buckland & Taylor, Ltd., was given two awards in 1999 for its work on the seismic retrofit of the bridge. The two awards were the CELSOC Engineering Excellence Award of Merit and the ACEC Engineering Excellence Honor Award.[63]

Most recently, Cold Spring Canyon Bridge was determined eligible for listing in the National Register of Historic Places in 2007. The structure is significant as an important example of bridge design and engineering that demonstrates a maturation of steel arch bridge design and welded steel technology in California, and it represents a high aesthetic quality of contemporary design from its period. It is also an important work of the Division of Highways Bridge Department, which is considered a "master" engineer of the period, and it is an important work of the American Bridge Division of US Steel which is considered a "master" builder of the period. The bridge's period of significance is 1962-1964 when the bridge was built and opened to traffic. Cold Spring Canyon Bridge possesses enduring value as an engineering accomplishment and one that design professionals and the public continue to appreciate for its engineering and aesthetic qualities.

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other subsequent administrations that followed, do not appear to have pursued recognition of engineering structures in this manner.

[61] *Santa Barbara News-Press*, January 3, 1995, 35A; Division of Highways, *Scenic Highway Corridor Survey*, 1968; and Santa Barbara Route 154 file at Caltrans Transportation Library. The scenic route designation signing occurred November 22, 1968.

[62] Russ Pyros, Chairperson, History and Heritage Committee, ASCE, letter to E.F. "Frank" Gregory, District Director of Transportation, Caltrans, December 21, 1976 on file at Caltrans District Five and Caltrans Transportation Library.

[63] Buckland & Taylor, Ltd. Bridge Engineering, "Cold Spring Canyon Bridge," http://www.b-t.com/projects.cldsprg.htm (accessed November 2005).

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IV. PROJECT INFORMATION

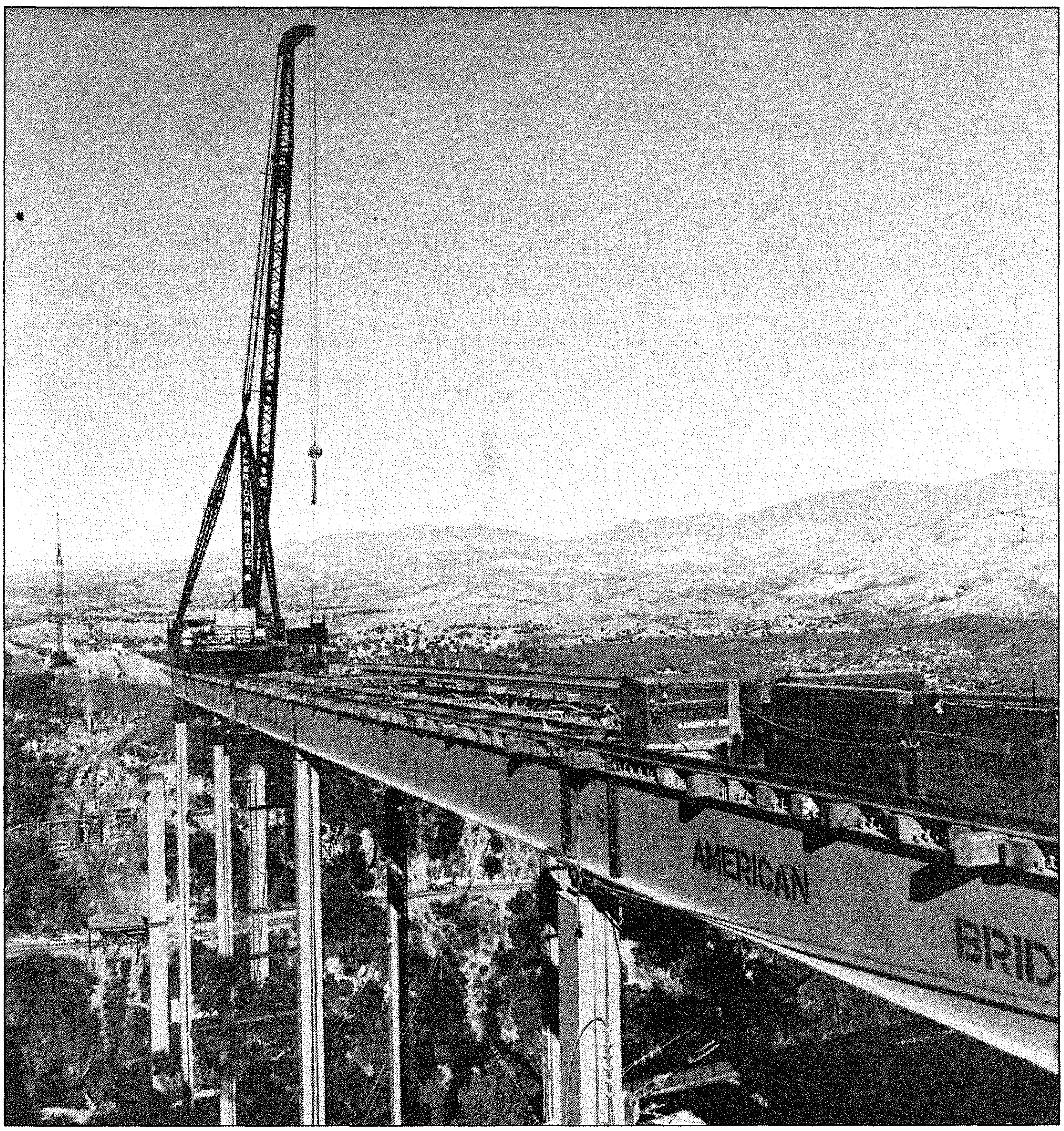
This Historic American Engineering Record report was prepared to fulfill, in part, requirements of the Memorandum of Agreement (MOA) between the California Department of Transportation (Caltrans), the California State Historic Preservation Officer, and the Advisory Council on Historic Preservation signed in March 2009, for the Caltrans Cold Spring Canyon Bridge Suicide Barrier Project to install a suicide deterrence barrier on the bridge. Caltrans District 5 was a concurring signatory on the MOA. Architectural historian Christopher McMorris of JRP Historical Consulting, LLC prepared this document for Caltrans. Mr. McMorris conducted the field inspection in February 2007. Caltrans Photography Unit photographers Don Tateishi and

Steven Hellon prepared the photographic images for the project. This documentation was reviewed by Caltrans Professionally Qualified Staff, Paula Juelke Carr, Principal Architectural Historian.

The narrative text in this report is based on the report entitled "Historical Resources Evaluation Report: Cold Spring Canyon Bridge (510037) Pedestrian Barrier Project, State Route 154, Santa Barbara County, California" completed by JRP Historical Consulting, LLC in May 2007. Research conducted for this report was undertaken at Caltrans District 5 offices in San Luis Obispo; Caltrans Transportation Library and History Center in Sacramento; California State Library in Sacramento; University of California, Davis; University of California, Berkeley; University of California, Santa Barbara; Santa Barbara County Historical Society; Santa Barbara Public Library. JRP also conducted interviews with former Division of Highways Bridge Department engineers who were key members of the team that designed the Cold Spring Canyon Bridge: Marvin A. Shulman, Raymond L. Whitaker, and George A. Hood, Jr.

LOCATION MAP

INDEX TO FIGURES – HISTORIC PHOTOS & ENGINEERING DRAWINGS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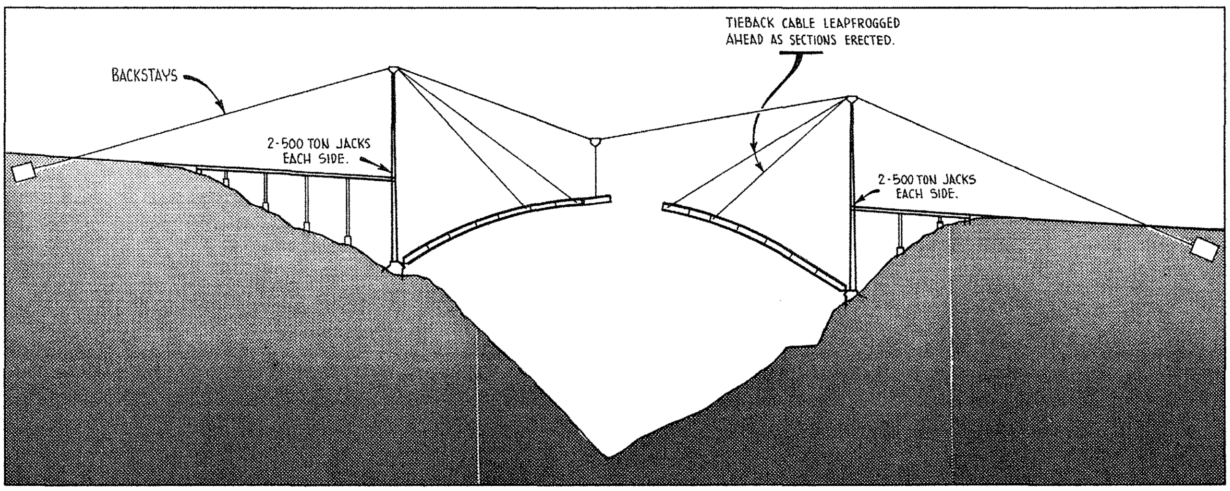
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FIGURE 3

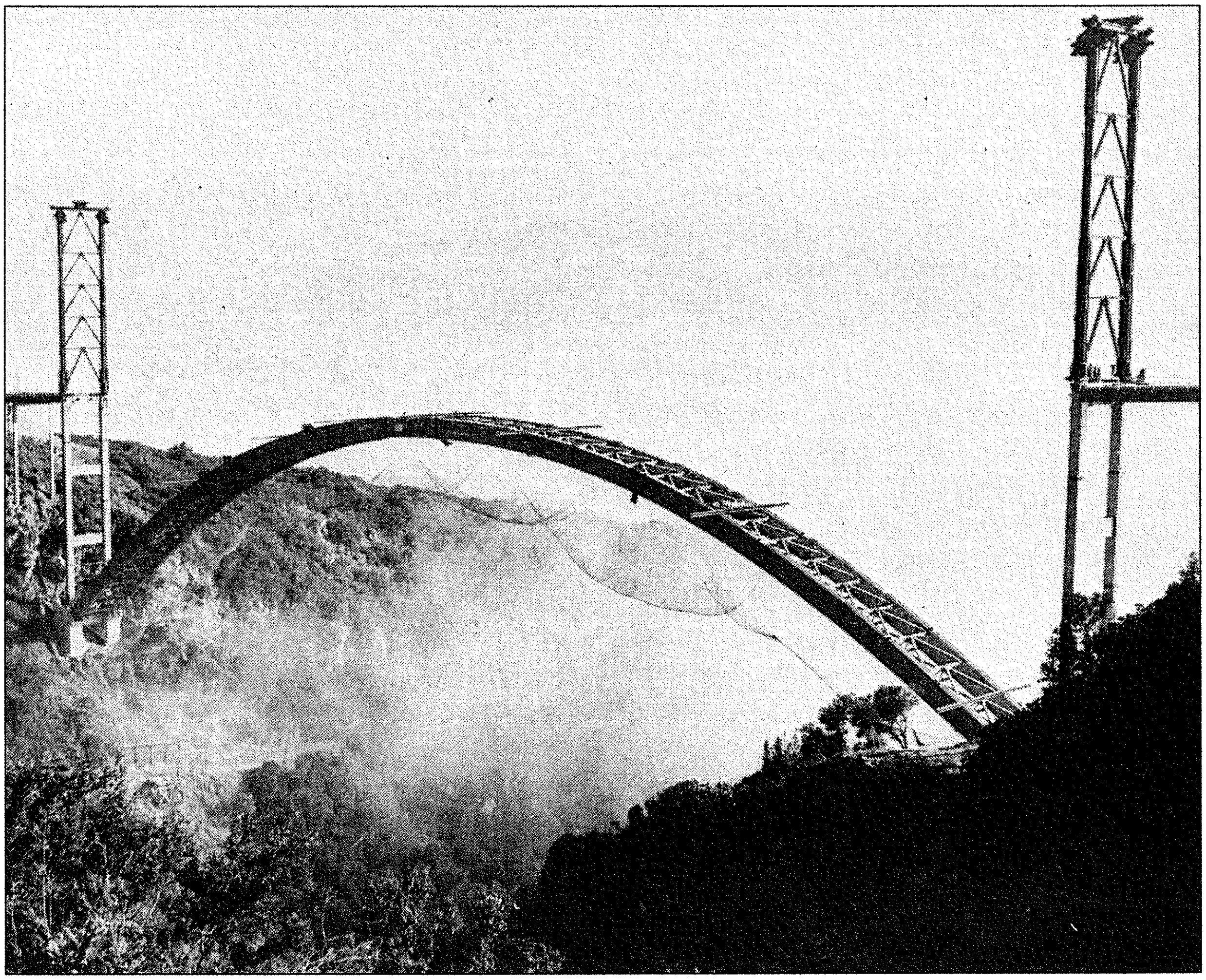

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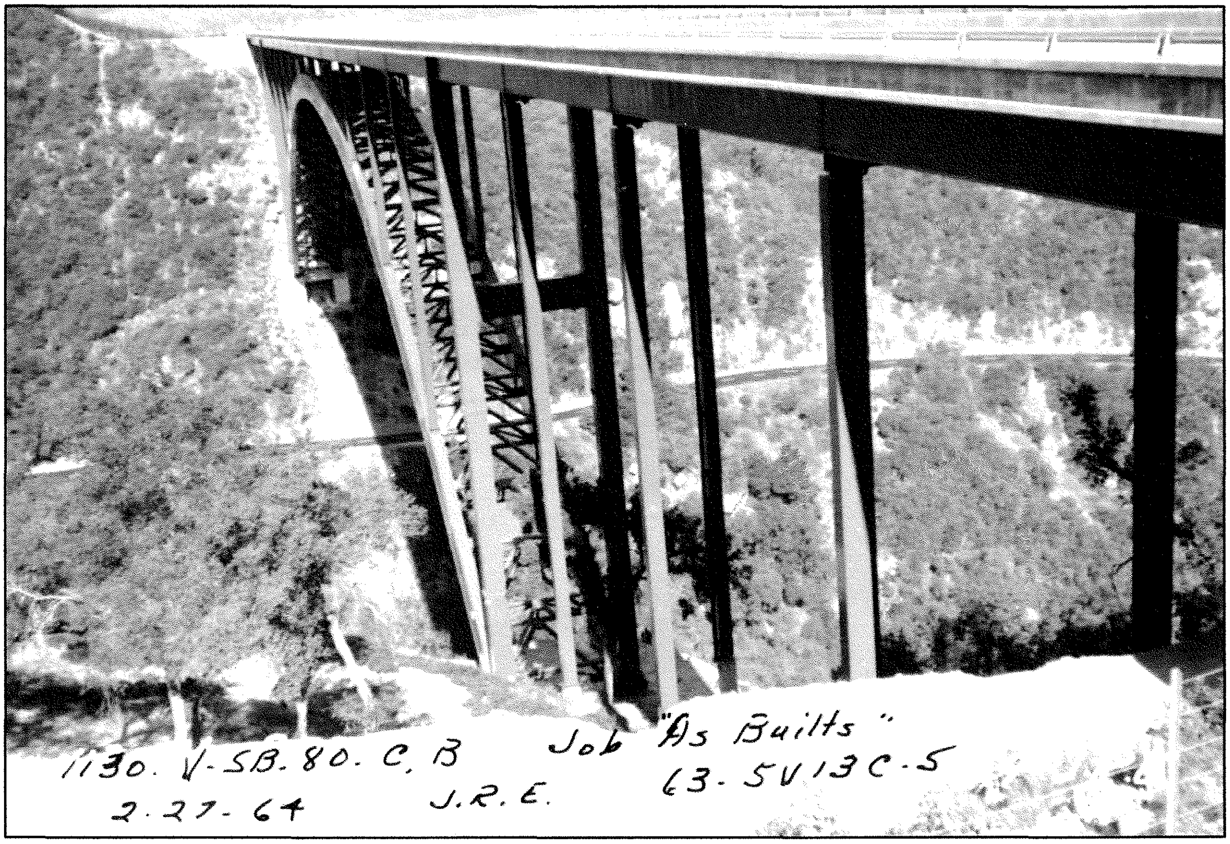
FIGURE 5



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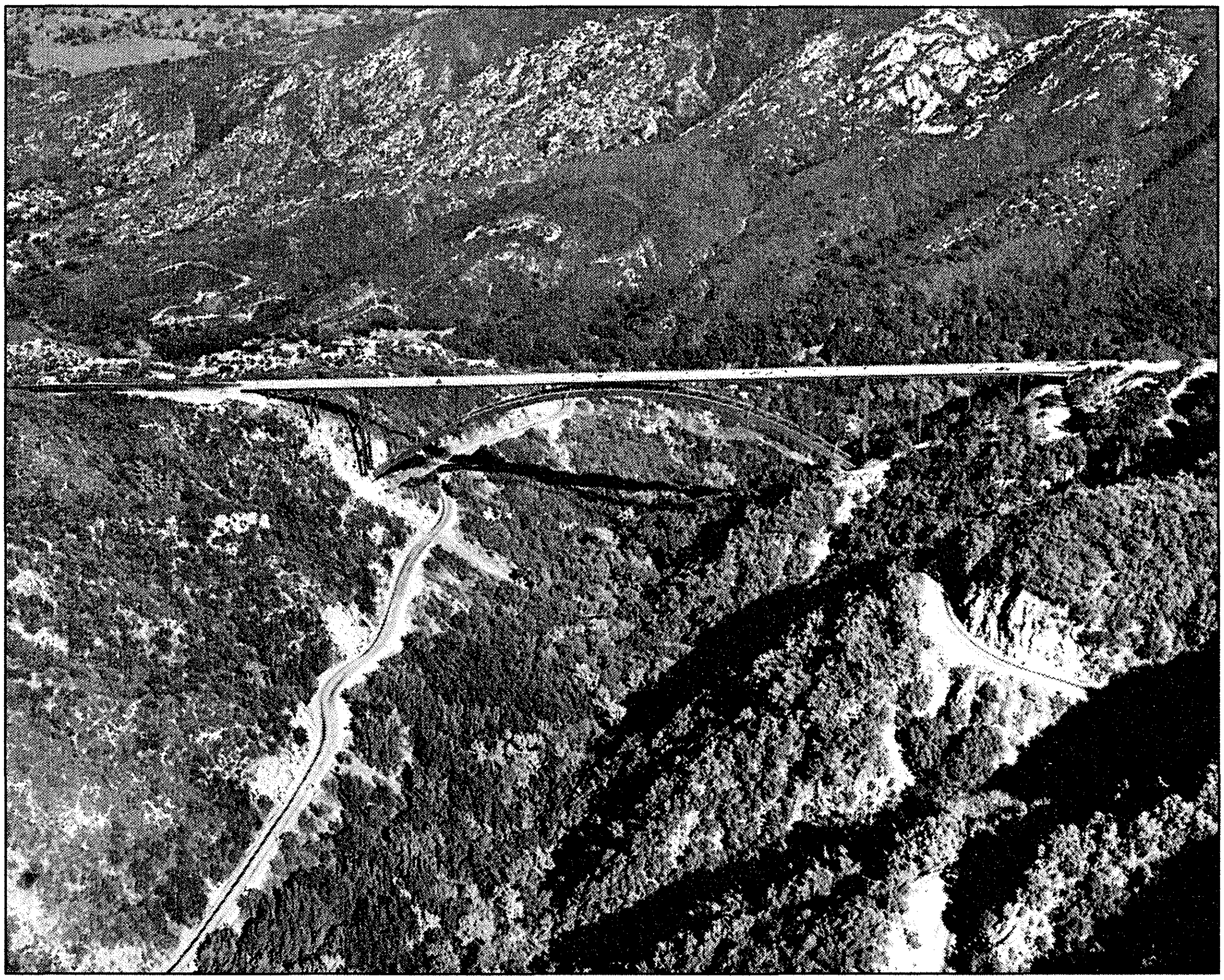

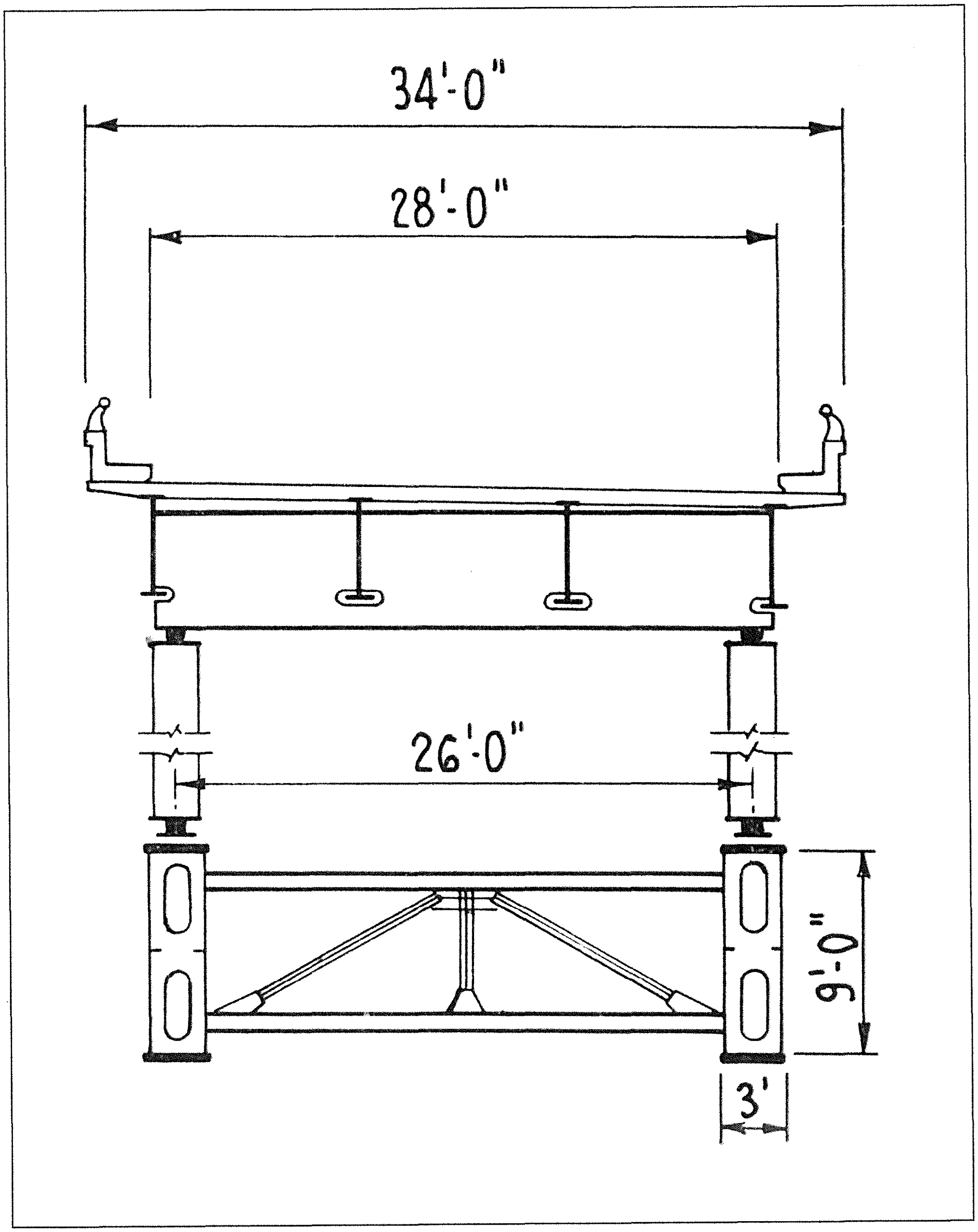
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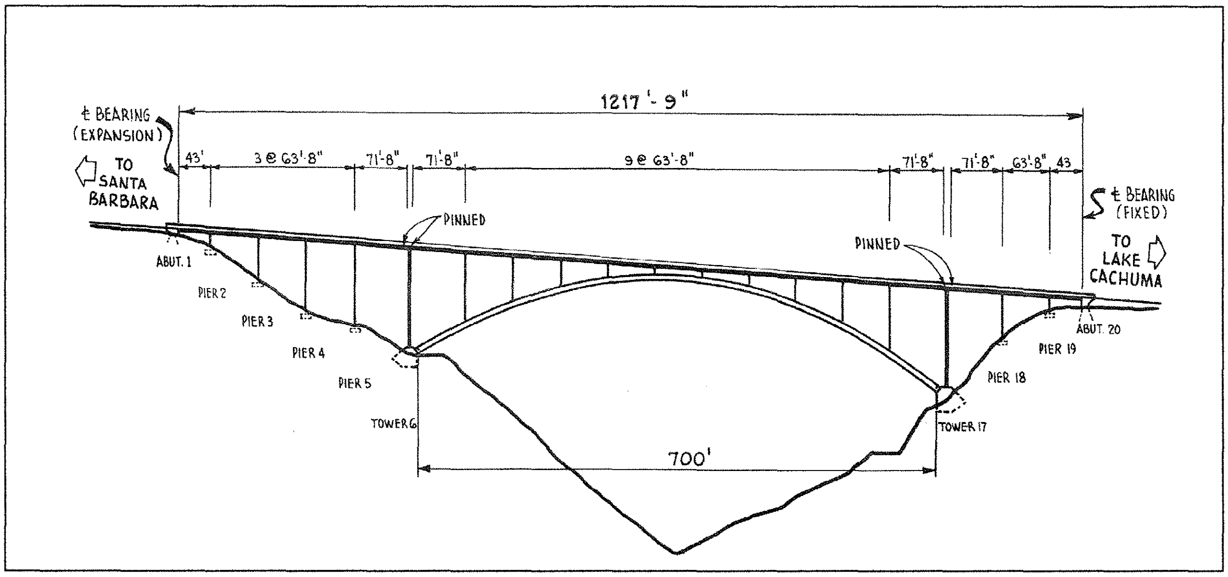
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43'
3 @ 63'-8"
71'-8"
71'-8"
9 @ 63'-8"
71'-8"
71'-8"
63'-8"
43
℄ BEARING (FIXED)
TO LAKE CACHUMA
PINNED
PINNED
ABUT. 1
PIER 2
PIER 3
PIER 4
PIER 5
TOWER 6
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PIER 18
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