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67

The Evolution of Bridges in the United States

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67.1 Introduction

American civilization with its bridges is relatively recent compared with the ancient civilizations of Asia, Europe, and even South America. The Americas are the last continents to have become heavily populated and industrialized.

The evolution of bridges in the United States is probably not much different from anywhere else in the world. Civilizations have borrowed their bridging ideas from each other for centuries. Fallen logs across streams served as primitive bridges that led to the concept of girder spans in use today. Suspension spans across deep chasms is a primitive idea used throughout the world. The stone arch introduced by the ancient Romans is a naturally occurring, efficient, and pleasing structural shape that has been used with various evolving materials.

FIGURE 67.1 The aqueduct bridge at La Purisima Mission, Santa Barbara County, California, is an example of a primitive bridge, a short-span stone slab. Built in 1813, it is the oldest bridge in California. (Courtesy of California Department of Transportation.)

Bridge practice evolves as user needs, traffic, and vehicles change, technology progresses, and new materials are developed. But span length is still the primary determining factor for bridge type selection.

67.2 Early U.S. Bridges

The first recorded bridge in the United States was built at James Towne Island, Virginia in 1611. This is the site of one of the earliest European colonies. It was a timber structure, actually a wharf accessing ships anchored in deeper water (Figure 67.1).

67.3 The Canal Era

By water was an early method of heavy transport as the United States began to expand inland from the Eastern Seaboard. Canal builders in the late 1700s and early 1800s were the first to construct U.S. bridges of any consequence. The concept of stone arches, borrowed from Roman aqueducts, was common during this era. Besides, the stone arch readily adapts to the loads imposed (Figure 67.2).

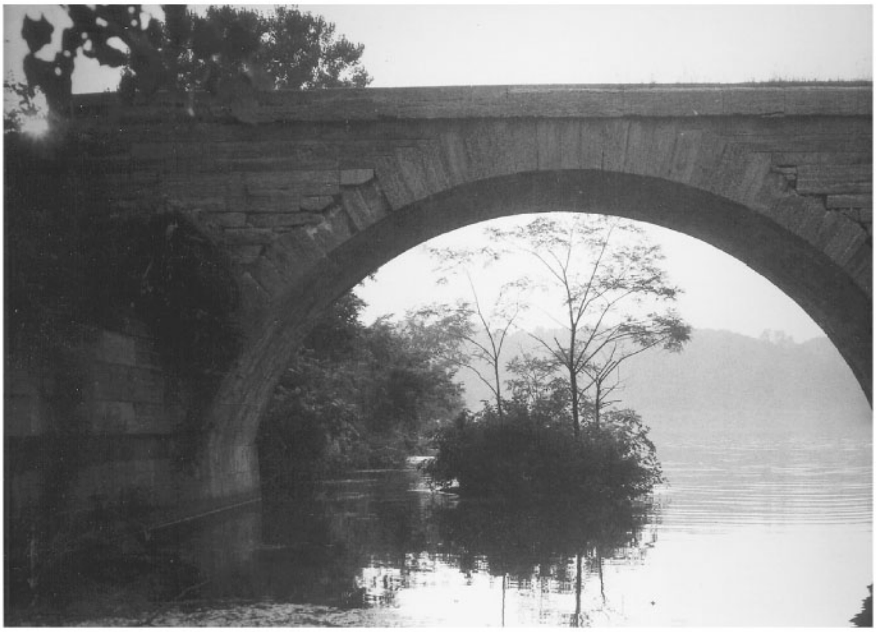

FIGURE 67.2 Scholarie Creek Aqueduct is the Erie Canal over Scholarie Creek at Fort Hunter, New York. It was built by John Jervis in 1841. Canals were the first major users of bridges in the United States. (Courtesy of American Society of Civil Engineers.)

Turnpikes

Private toll roads during the colonial period, 1600s and 1700s, often built timber structures. Logs are natural beams and their ready availability made them natural materials for early bridges.

Timber Bridges

Timber is easy to work and build with. But timber bridges require constant maintenance; joints loosen as the wood shrinks and vibrates from traffic, and wood must be protected from the elements (Figure 67.3).

FIGURE 67.3 Dolan Creek Bridge on the Monterey Coast in California was built in 1932. This is one of only two three-pin timber arch bridges ever built on the California State Highway system. It lasted only a few years, and has since been replaced with a concrete bridge in 1961. (Courtesy of California Department of Transportation.)

Covered Timber Bridges

Many timber bridges of the 19th century were covered to protect the wood from the elements and in northern climates to keep snow off the decks (Figures 67.4 and 67.5).

FIGURE 67.4 The Bridgeport Covered Bridge in California may be the longest single-span, 70.1 m, covered bridge in the world. The superstructure is a Burr arch superimposed on a Howe truss. It was a toll bridge built by David Wood in 1862, and was later purchased by the Virginia Turnpike Company. (Courtesy of California Department of Transportation.)

FIGURE 67.5 The Cornish–Windsor Covered Bridge is a two-span town-lattice truss crossing the Connecticut River between Cornish, New Hampshire and Windsor, Vermont. Built in 1866 it is the longest covered bridge, 140.2 m, in the United States. It has been designated a National Civil Engineering Landmark by the American Society of Civil Engineers. (Courtesy of American Society of Civil Envineers.)

Iron Bridges

Cast-iron bridge members were first considered due to the proximity of several foundries near the National Road. The material turned out to be quite strong and very durable. Cast iron is resistant to normal corrosion associated with ferrous metals (Figures 67.6 and 67.7).

FIGURE 67.6 Dunlap's Creek Bridge, built in 1839, is the first iron bridge in the United States. It was built for the National Cumberland Road, at Brownsville, Pennsylvania, by Captain Richard Delafield of the Army Corps of Engineers. The bridge is still in service today. (Courtesy of Federal Highway Administration.)

FIGURE 67.7 Bow Bridge in Central Park, New York, is the oldest surviving wrought-iron bridge in the United States, built in 1862. It has the longest span, 26.5 m, of five ornately decorated bridges in the park, all designed by Calvert Vaux and Jacob Wrey Mould. (Courtesy of American Society of Civil Engineers.)

67.4 The Railroad Era

The age of steam ushered in an era where bridge building in the United States came of age. Railroads became the dominant mode of transportation for both passengers and freight. Easy grades required for railroads, in turn, required lots of bridges. Canals were all but forgotten and wagon roads went into a 50-year period of neglect (Figure 67.8).

FIGURE 67.8 Starrucca Viaduct, built in the form of the ancient Roman aqueducts, was designed by James Kirkwood for the New York and Erie Rail Road in 1848. It is located over the Starrucca Creek plain at Lanesboro, Pennsylvania. This was the first bridge to use a concrete foundation. This bridge is still in service. (Courtesy of American Society of Civil Engineers.)

Trusses

Squire Whipple and Herman Haupt, two American railroad bridge engineers, are credited with being the first to calculate methods for determining stresses in truss members and were thereby able to determine their appropriate sizes. Each worked independently of the other, in the mid-19th century, using ancient knowledge of mathematics, physics, and strength of materials.

The knowledge to engineer trusses made their construction popular. They provided strength with considerable savings in materials and weight. The concepts of rational principles are equally applicable to both timber and metal trusses. Many other engineers quickly embraced the concepts and patented various truss diagonal configurations for their own use. Many of their names are familiar today: Pratt, Parker, Howe, Burr, Fink, and Warren, to name a few.

Railroad Trestles

See Figures 67.9 through 67.11.

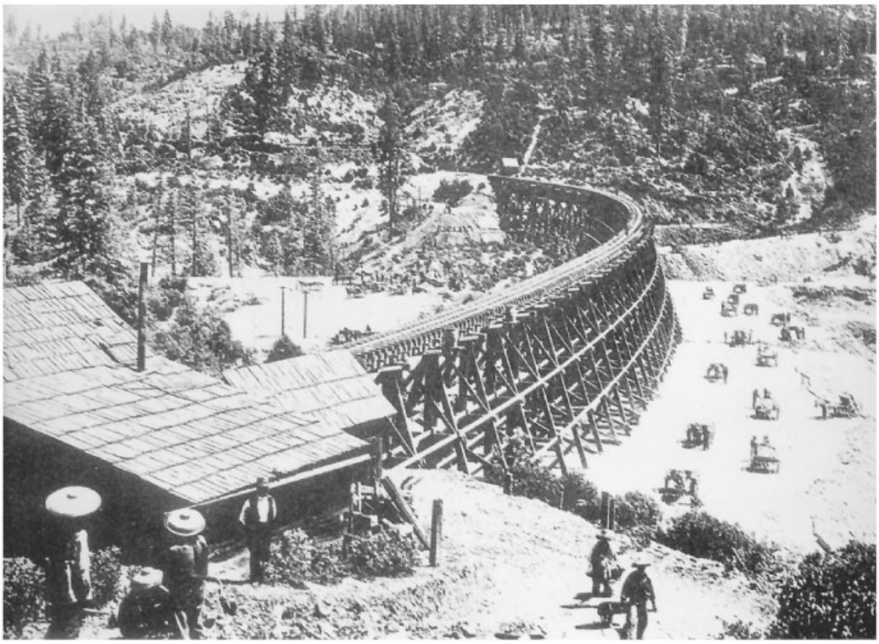

FIGURE 67.9 Theodore Judah took advantage of timber to build trestles quickly and move on, while racing to build the Central Pacific Railroad, the California end of the Transcontinental Railroad. He solved the long-term maintenance problem by later filling in the trestle with cut and tunnel spoil, forming an embankment which would remain long after the timber had rotted away. This is the Secrettown Trestle in the California Sierras, built in 1865, being buried in earth fill. (Courtesy of California State Library.)

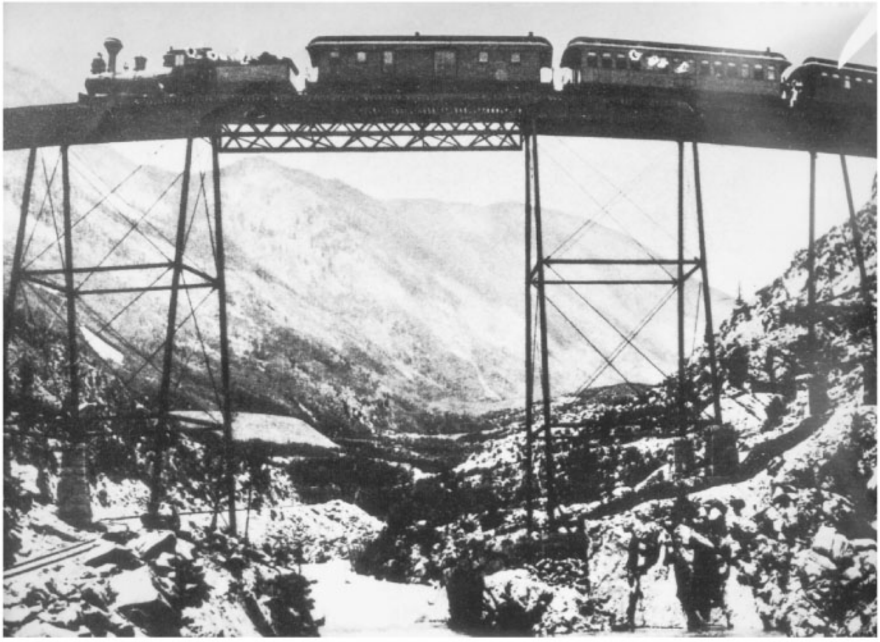

FIGURE 67.10 The Devil's Gate High Bridge at Georgetown, Colorado, appears too spindly to support a railroad. But clever use of tension counters distributes the reversing loads throughout the towers. The bridge was prefabricated by Clark Reeves and Company of Phoenixville, Pennsylvania, for the Colorado Central Railroad in 1884. The trestle was in continuous use until torn down in 1939. A replica rebuilt in 1984 is now in use by the Georgetown Loop Mining and Railroad Park. (Courtesy of Missouri Historical Society.)

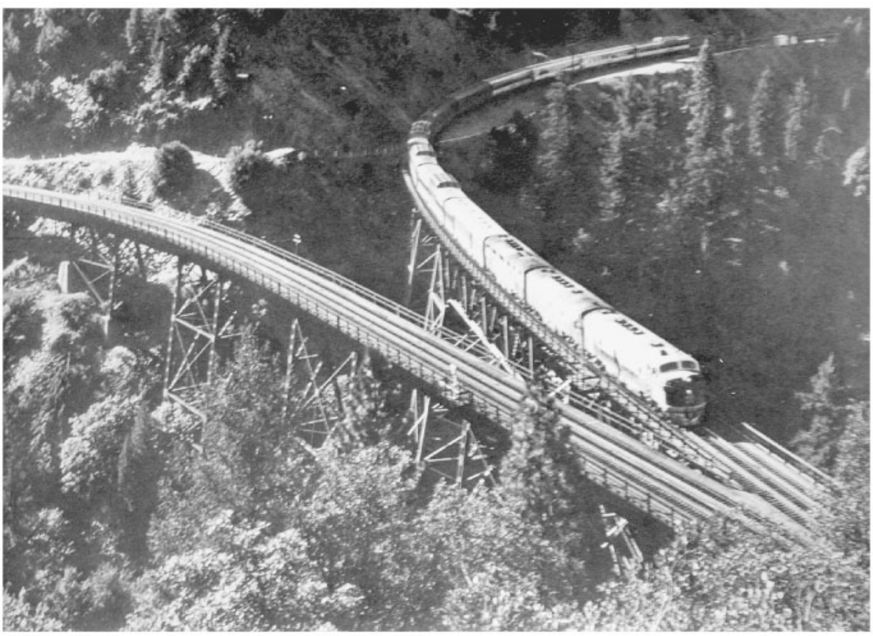

FIGURE 67.11 Keddie Wye is a unique steel tower trestle built by the Union Pacific Railroad in California's rugged Feather River Canyon in 1912. The wye trestle emerges from a tunnel in the south wall of the canyon splitting rail traffic over the river; one leg heads north to meet with the Burlington Northern Railroad and the other is the main line heading east toward Chicago. (Courtesy of the Feather River Rail Society.)

Steel Arch Bridges

See Figures 67.12 through 67.14.

FIGURE 67.12 Eads' Bridge over the Mississippi River at Washington Street in Saint Louis shattered engineering precedents of the time. It was the first extensive use of steel for bridge construction. The three 175+ m arch spans are each four 464-mm steel truss-stiffened wrought iron tubes. The spandrels are extensive steel truss and lattice work. Built by James B. Eads in 1874. Eads' Bridge is pictured on the two dollar denomination United States postage stamp series commemorating the Trans-Mississippi Exposition of 1896. (Courtesy of U.S. Bureau of Engraving and Printing.)

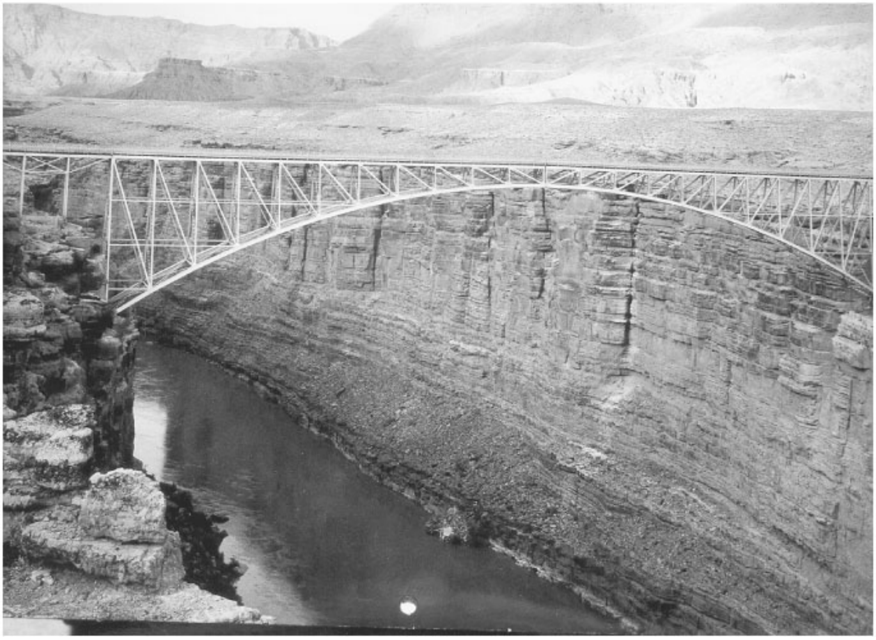

FIGURE 67.13 Navajo Bridge at Marble Canyon, near Lee's Ferry, Arizona, is the classic example of an arch sprung between canyon walls. This is also an example of a deck truss, an evolution for automobiles, beyond the through truss. When built, in 1929, it was the highest bridge in the world, 162.5 m, from deck to water. It was designed by Ralph Hoffman of the Arizona Highway Department. A parallel twin designed by Cannon Associates has since been constructed, in 1996. (Courtesy of American Society of Civil Engineers.)

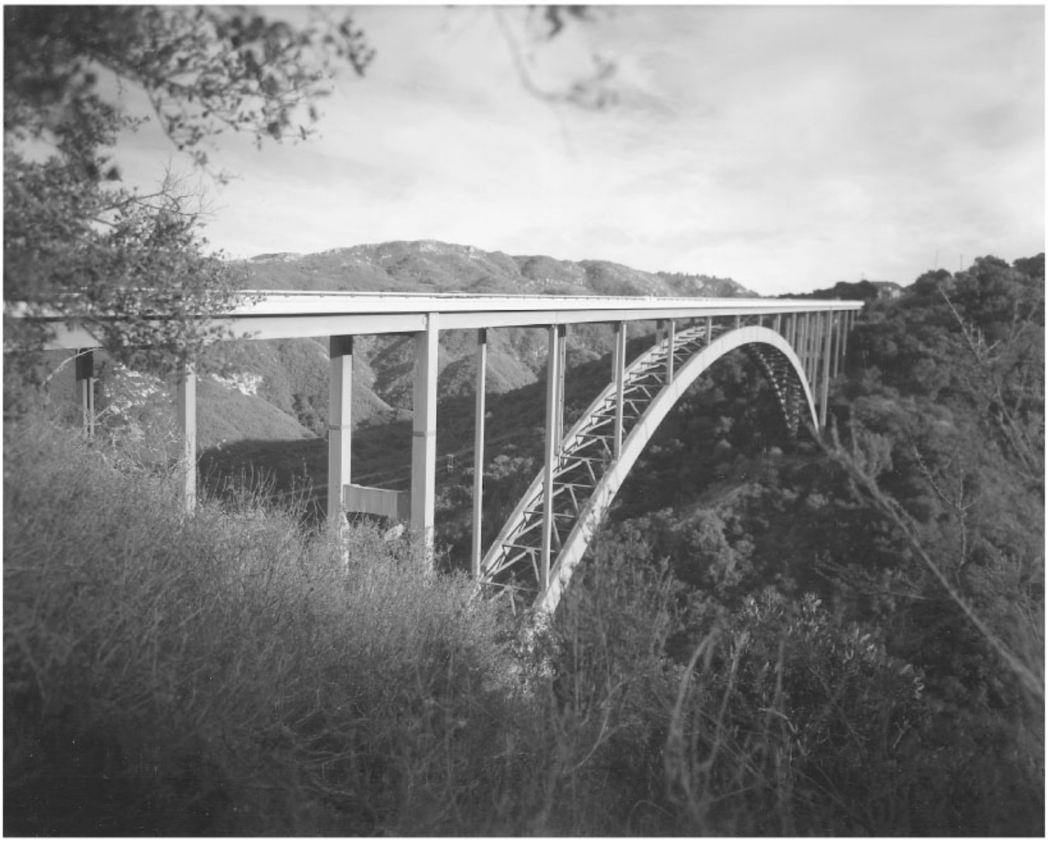

FIGURE 67.14 The Cold Springs Canyon steel plate girder arch, in Santa Barbara County, California, is the longest arch span at 213.4 m, and a rise of 121.9 m. The bridge has won a Lincoln Foundation welding award, American Institute of Steel Construction beauty award, and the Governor's Design Award. Built in 1963, it was designed by the California Division of Highways, Marv Shulman, design engineer. (Courtesy of California Department of Transportation.)

Kit Bridges

During the late 19th and early 20th centuries, several bridge companies sold "American Standard," prefabricated wrought iron bridge pieces (bridge in a box), of given span lengths that could be erected on site. All one had to do was order a bridge from a catalog, build abutments for the appropriate span length, and assemble the pieces erector-set-style. Kit bridges are readily adaptable to disassembly, transport, and reuse elsewhere, as has been the case for many of these bridges still in use (Figures 67.15 and 67.16).

FIGURE 67.15 Laughery Creek Bridge, near Aurora, Indiana, was built by the Wrought Iron Bridge Company of Canton, Ohio, in 1878. Its 92-m span was unprecedented. This bridge appeared on the cover of the company's catalog in 1893. (Courtesy of American Society of Civil Engineers.)

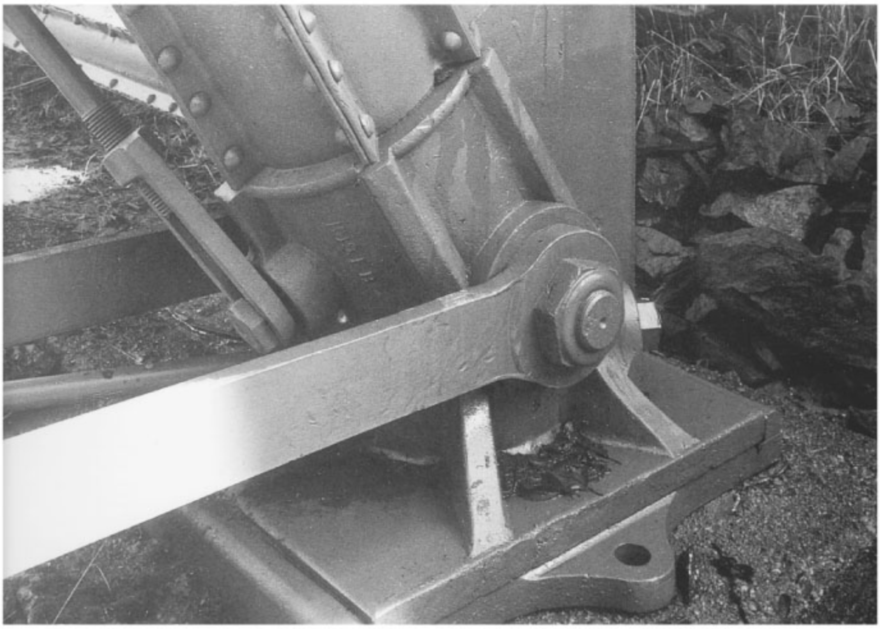

FIGURE 67.16 This detail at Haupt Creek, in Sonoma County, California, shows a typical pin connection of a kit bridge and a "Phoenix Column," a patented cast-iron member built exclusively by the Phoenix Iron Works of Pennsylvania. This bridge was built in 1880. (Courtesy of California Department of Transportation.)

67.5 The Motor Car Era

Almost instantaneously, at the turn of the 20th century, the nation was swept up into the automotive age. Long-neglected wagon roads became important once again. State Highway Departments sprang up and road and bridge building, under the "Good Roads Movement," took on a new fervor. Railroad engineering became almost stagnant. Most new highway bridge engineers were former railroad bridge engineers, so many of the early highway bridges looked just like railroad through-truss bridges.

Steel Truss Bridges

See Figures 67.17 through 67.19.

FIGURE 67.17 The Carquinez Straits Bridge in California, built by the American Toll Bridge Company as a private toll bridge in 1927, is an example of a cantilevered truss with eye bar tension members. A parallel twin using welded hybrid high-strength steels was designed and built in 1954 by the California Division of Highways, Roger Sunbury, engineer. Steel truss bridges are considered by many to be ugly. Carquinez is not one of the worst examples, but when a candidate bridge architect interviewing for the California Department was shown a picture of the twin spans and asked for comments, he answered, "Why make the same mistake twice?" He got the job as Chief Bridge Architect. (Courtesy of California Department of Transportation.)

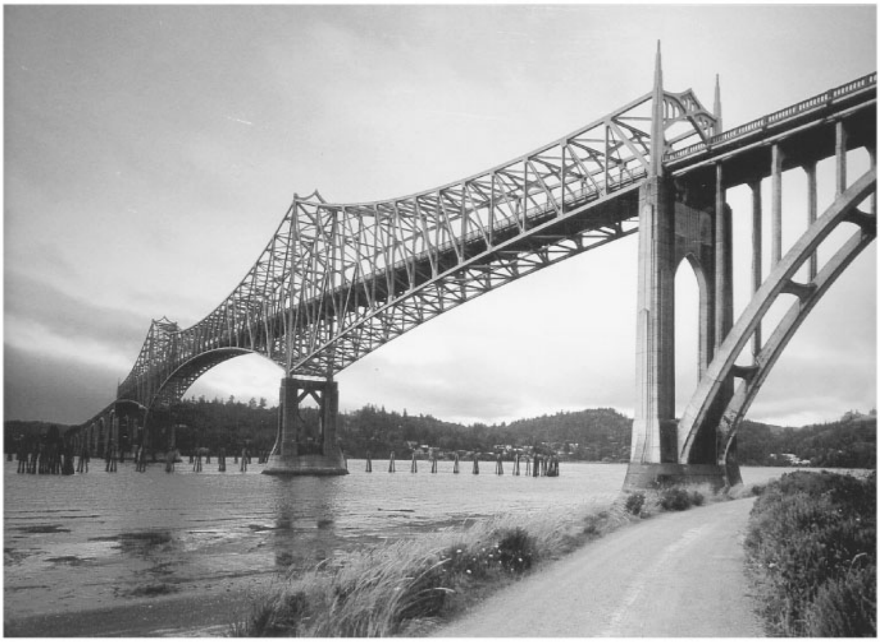

FIGURE 67.18 Coos Bay Bridge on the Oregon Coast Highway is one of several landmark bridges designed by Conde B. McCullough of the Oregon Highway Department. The 225.2 m main span is a classic example of a cantilever truss. Built in 1936, it is the largest of McCullough's coastal gems. The concrete arch end spans and spires are a McCullough trademark. The bridge is now named the McCullough Memorial Bridge in honor of the engineer. (Courtesy of American Society of Civil Engineers.)

FIGURE 67.19 The San Francisco–Oakland Bay Bridge east, is part of the longer 13.3 km crossing composed of the west suspension span, a tunnel through Yerba Buena Island, and this cantilever truss east span. The seismic retrofitting solution at this site is to replace the bridge. There is local controversy over the type of span to be used. There are cost concerns, fear by San Francisco that an east side signature span could overshadow their west suspension span, and aspirations by Oakland that their city is also deserving of a signature span on their side of the Bay. (Courtesy of California Department of Transportation.)

Reinforced Concrete

About the same time as the motor car era began, the turn of the 20th century, the concept of reinforced concrete was introduced. It was generally unaccepted until the San Francisco earthquake of 1906. The few reinforced concrete buildings were the only structures to survive. From that time on, reinforced concrete has been widely used (Figure 67.20).

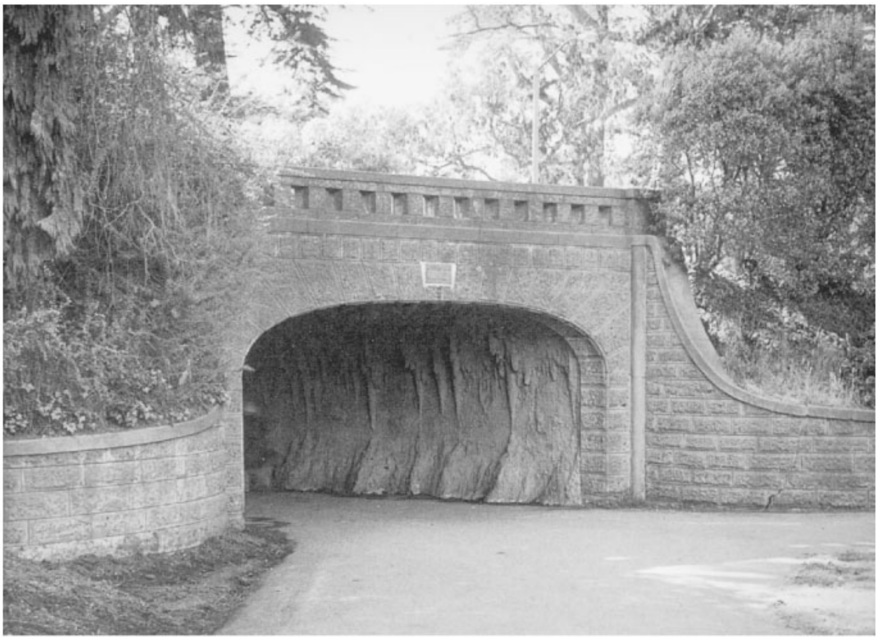

FIGURE 67.20 Alvord Lake Bridge is the first reinforced concrete bridge, built by Ernest Ransome, the developer of reinforced concrete, in 1888. This bridge is still in service carrying State Route 1 over Golden Gate Park in San Francisco. The facia is hammered to resemble familiar stone arch work. The bridge is a National Historic Civil Engineering Landmark. (Courtesy of California Department of Transportation.)

Concrete Arches

Reinforced concrete arches were popular during the early part of the 20th century. Reinforced concrete was the modern material, and arches were a comfortable, tried, and true shape. Thousands of reinforced concrete arches were built until the 1950s (Figures 67.21 through 67.27).

FIGURE 67.21 The Colorado Street Bridge over the Arroyo Seco in Pasadena, California, is the highest scoring bridge for historical significance in the state. The main span is 46.6 m with a height of 45.7 m. The structure is highly adorned with Beaux Art ornamentation. It was designed in 1912 by John Waddell, the "Dean" of American bridge engineering. The bridge served the famed Route 66 for many years. Seismic retrofitting was a challenge in trying to maintain the bridge's historic aesthetic features. (Courtesy of California Department of Transportation.)

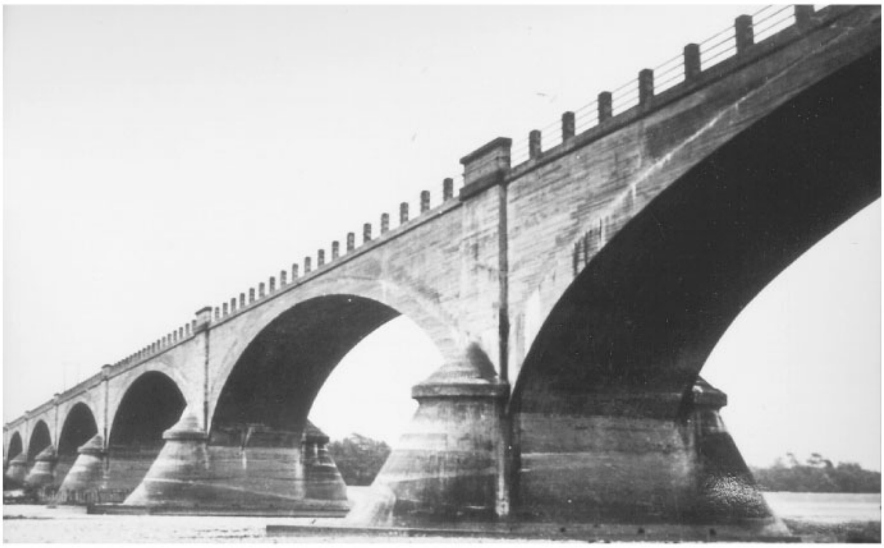

FIGURE 67.22 Fern Bridge near Ferndale, California, is a remarkable structure that has withstood the test of time. Six major floods since it was built have washed out other bridges on the lower Eel River, but Fernbridge still stands. It is composed of seven 61-m rubble-filled closed spandrel concrete arches, each on 250 timber piles. it was designed by John B. Leonard in 1911 for Humboldt County. It is now part of the California State Highway system. (Courtesy of California Department of Transportation.)

FIGURE 67.23 Harlan D. Miller (Dog Creek) Bridge is an example of state-of-the-art bridge development by the State of California under Bridge Engineer Harlan D. Miller in 1926. The State Legislature named the bridge in his honor for the great strides he accomplished with state bridges. Miller died only a week after receiving the honor, so the bridge became the Harlan D. Miller Memorial Bridge. (Courtesy of California Department of Transportation.)

FIGURE 67.24 Bixby Creek Bridge on the Monterey Coast in California is one of the most picturesque and photographed bridges in California. This Monterey Coast Highway was the first designated Scenic Highway in California, in 1961. The route is also the first to be designated an All American Road. Built in 1932, it has a main span of 109.7 m and is 79.2 m above the streambed. Construction required 26 stories of falsework. It was designed by Harvey Stover of the California Division of Highways. Seismic retrofitting is complicated due to aesthetic restrictions established by historical preservation codes. (Courtesy of California Department of Transportation.)

FIGURE 67.25 Conde McCullough, of the Oregon State Highway Department, designer of the two bridges shown in Figures 67.25 and 67.26, gained fame as the designer of several landmark bridges on the Oregon Coast Highway. The Rogue River Bridge at Gold Beach, Oregon, is a typical open spandrel concrete arch. The monumental spires at the abutment piers are a McCullough trademark. Both of these bridges were built in 1932. (Courtesy of Oregon Department of Transportation.)

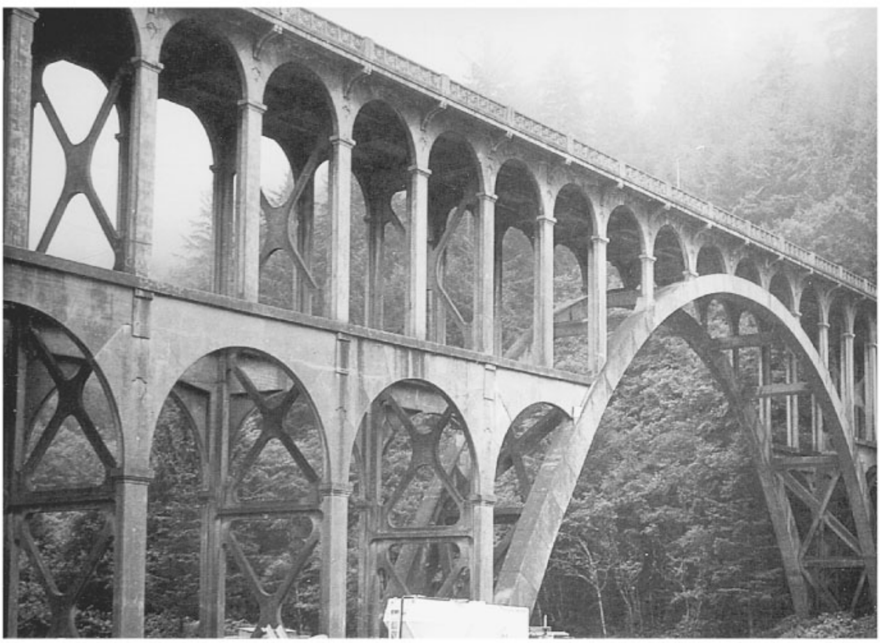

FIGURE 67.26 The double-tiered concrete arch end spans at Cape Creek, on the Oregon Coast, are reminiscent of Roman aqueducts. The north-bound highway at this point emerges from a tunnel providing a picturesque view of the Heceta Head Lighthouse, as the traveler glides out over Cape Creek. (Courtesy of American Society of Civil Engineers.)

FIGURE 67.27 The Lilac Road arch gracefully frames the southern entrance to the fertile San Luis Rey Valley, of Southern California. It was built over Interstate Route 15 in San Diego County in 1978. The designer was Fred Michaels of the California Department of Transportation. (Courtesy of California Department of Transportation.)

Concrete Girders

See Figures 67.28 and 67.29.

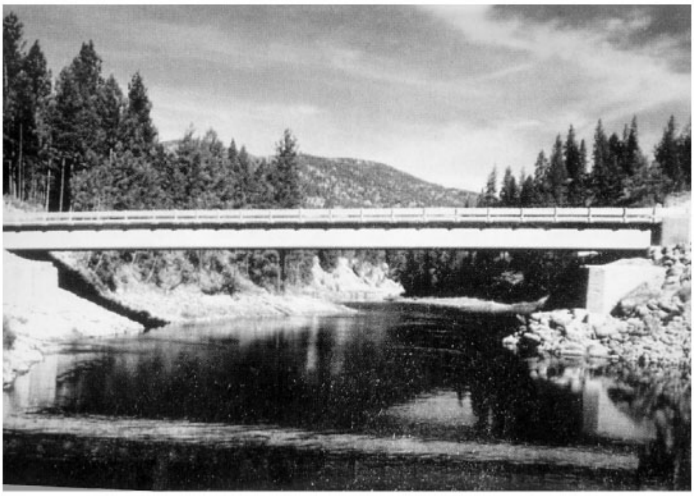

FIGURE 67.28 Rockcut Bridge, owned by Stevens and Ferry Counties, earned a Portland Cement Association design award in 1997. The designer was Nicholls Engineering. (Courtesy of Portland Cement Association.)

FIGURE 67.29 The North Santiam (Gates) Bridge, in Marion County, Oregon, earned a Portland Cement Association design award in 1997. It was designed by the Oregon Department of Transportation. (Courtesy of Portland Cement Association.)

Canticrete

See Figure 67.30.

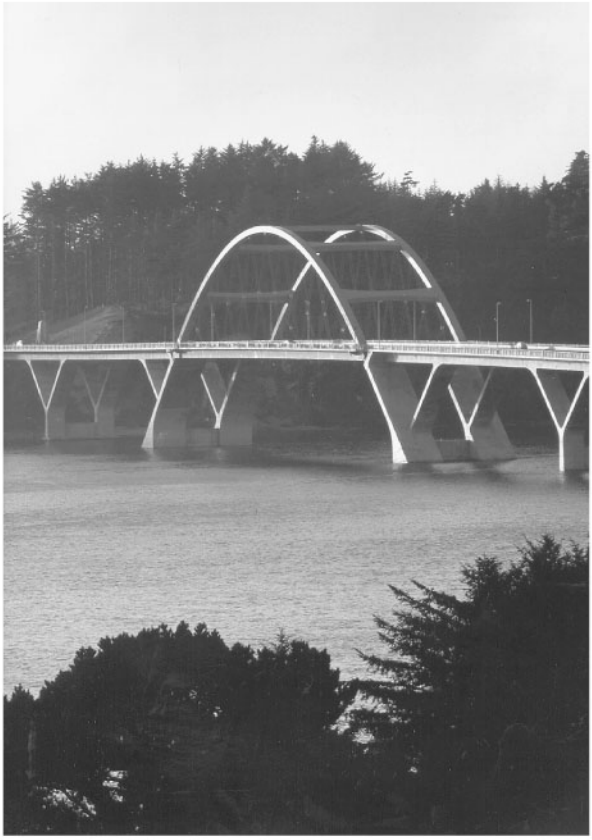

FIGURE 67.30 The landmark Alsea Bay Bridge at Waldport, Oregon, is the only Conde McCullough bridge that has required replacement due to deterioration. The new structure is reminiscent of McCullough's style and utilizes the best of the two most popular building materials, concrete and steel. The concrete-covered steel members are called canticrete. This new span, built in 1992, was designed by Howard Needles Tamman Bergendoff. It won awards from both the American Institute of Steel Construction and the Portland Cement Association. (Courtesy of Howard Needles Tamman Bergendoff.)

Suspension Bridges

Suspension bridges are one of the oldest concepts in the world. The first recorded suspension bridge in the United States was a chain-link catenary over Jacobs Creek in 1801 at Uniontown, Pennsylvania. Suspension bridges have continued to be a favored type into modern times. They are graceful and especially practical for long spans (Figures 67.31 through 67.35).

FIGURE 67.31 The Brooklyn Bridge is probably the best known of the classic U.S. bridges. It is one of the early uses of wire rope, being a combination suspension and cable-stayed span. Designed and built in 1883 by John and Washington Roebling for the City of New York. (Courtesy of American Society of Civil Engineers.)

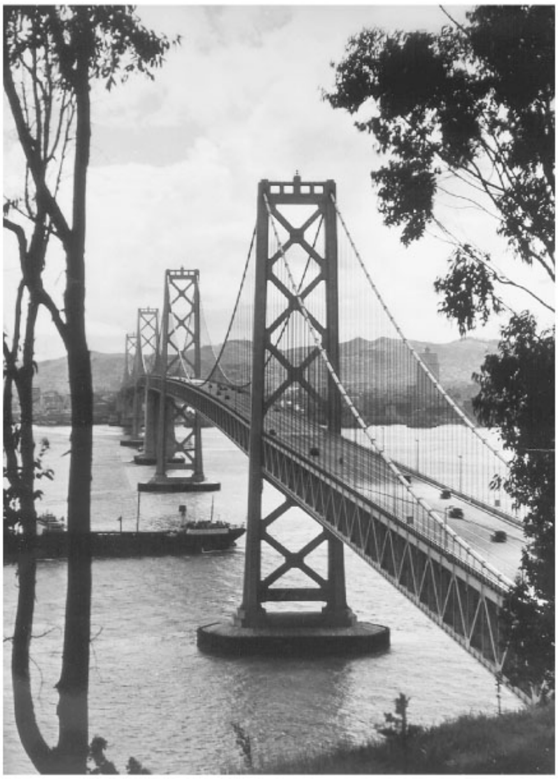

FIGURE 67.32 The west span of the San Francisco–Oakland Bay Bridge is really two suspension bridges end to end with a central anchorage between the two. It is the only double-suspension bridge in the world. Opened in 1936, it is owned by the California Department of Transportation and designed by its predecessor, the California Division of Highways, Charles Andrew, Chief Bridge Engineer. (Courtesy of California Department of Transportation.)

FIGURE 67.33 The Golden Gate Bridge is one of the best-known landmarks in the United States. It spans the entrance to San Francisco Bay. It held the longest span, 1280 m, record for 27 years. Designed and built in 1937 by Charles B. Strauss. It is owned by the Golden Gate Bridge, Highway and Transportation District. (Courtesy of California Department of Transportation.)

FIGURE 67.34 The Mackinac Straits Bridge was the winner of the 1958 American Institute of Steel Construction's Artistic Bridge Award and several gold medals. Its design provided a level of aerodynamic stability never before attained in a suspension bridge. It has a main span of 1158 m. It was designed by David Steinman and is owned by the Mackinac Bridge Authority in northern Michigan. (Courtesy of David Steinman.)

FIGURE 67.35 The Verrazano Narrows Bridge, in New York City, has the longest span, 1298 m, of any bridge in America. Designed by Amman and Whitney, it was opened in 1964. (Courtesy of Metropolitan Transportation Authority, New York.)

Movable Bridges

See Figures 67.36 and 67.37.

FIGURE 67.36 The Tower Bridge in Sacramento earned an AISC design award in 1936, the year in which it was built. This unique lift span is clad in steel plate to cover the moving parts. It was designed by Leonard Hollister of the California Division of Highways. (Courtesy of California Department of Transportation.)

FIGURE 67.37 The double-swing span George P. Coleman Bridge over the York River in Yorktown, Virginia, was recently widened. To minimize impacts on heavy traffic flows, new truss sections were built in dry dock and floated into place as the old were floated out. The replacement designed by Parsons, Brinckerhoff, Quade and Douglas won the 1997 George P. Richardson Medal for outstanding achievement. (Courtesy of Parsons Brinckerhoff.)

Floating Bridge

See Figure 67.38.

FIGURE 67.38 The 2377-m-long Lacey V. Murrow Floating Bridge across Lake Washington near Seattle is composed of hollow concrete pontoons. The depth of water, 45.7 m, precludes piers, but there are some bridge spans over shallow water near the shore that can pass small vessels. It was designed by Charles Andrew and Clark Elkridge in 1940. The bridge is listed on the National Register of Historic places. (Courtesy of American Society of Civil Engineers.)

67.6 The Interstate Era

The Federal System of Interstate and Defense Highways following World War II gave another boost to highway and bridge building. The system designed to be nonstop, separated, and controlled access requires many bridges in order to function as planned. Old-time bridge engineers had a difficult time trying to adapt. Their experience up until then had been to bridge the low spot in valleys crossing over waterways. Now, bridge engineers found themselves building bridges over dry land, at ridges, and over the highways themselves. Several new innovations were spawned during this prolific period. Composite steel, concrete box girders, and prestressed concrete became routine.

Concrete Box Girders

This superstructure type, developed by Jim Jurkovich of the California Division of Highways, has good torsional stability and provides exceptional wheel load distribution across the girders. Concrete structures evolved into the preferred types, starting in California. California has an abundant source of aggregates and cement. Contractors learned to build them at costs competitive with steel (Figures 67.39 and 67.40).

FIGURE 67.39 The Four Level Interchange in downtown Los Angeles, built in 1950, is the first multilevel interchange of two freeways. It is a reinforced concrete box girder, a type developed by, and to become the hallmark of, the California Division of Highways. (Courtesy of California Department of Transportation.)

FIGURE 67.40 Mission Valley Viaduct sweeps Interstate Route 805 over the San Diego River floodplain in southern California. (Courtesy of California Department of Transportation.)

Prestressed Concrete

Prestressed concrete is a natural evolution of concrete girders. It makes the best use of the compressive qualities of concrete and the tensile properties of steel. Prestressing allows shallower structure depth, and a tremendous savings in approach roadway earthwork for interstate separations. Prestressed concrete can be either pretensioned or post-tensioned, precast or cast in place. All of these options have their place under different situations. The California Division of Highways pioneered this system in the 1940s and has since made extensive use of cast-in-place post-tensioned concrete box girders. The type has become so prevalent that construction contractors are able to build them for the same or less cost than normal reinforced concrete structures (Figures 67.41 and 67.42).

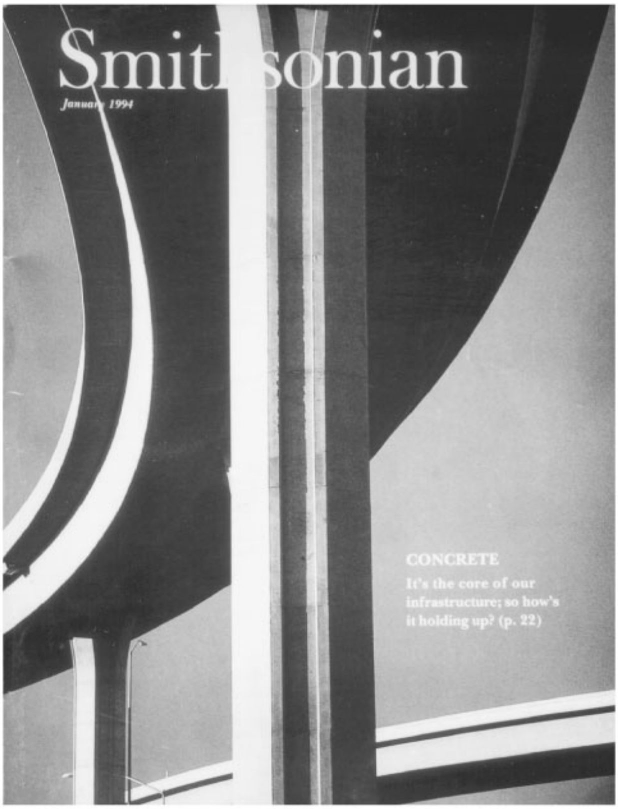

FIGURE 67.41 The Interstate Routes 105/110 Interchange in Los Angeles, California, is a massive forest of concrete columns supporting intertwined roadways. The *Smithsonian Magazine* highlighted the edifice as an artistic concrete creation in their January 1994 cover story. It was designed by Elweed Pomeroy of the California Department of Transportation. (Courtesy of Smithsonian Institution.)

FIGURE 67.42 Kellogg Central Business District Viaduct in Wichita, Kansas, designed by Howard Needles Tamman Bergendoff, won a Portland Cement Association award in 1996. (Courtesy of Howard Needles Tamman Bergendoff.)

Composite Steel

Composite steel girders, where a concrete deck is attached to the top flange of a steel girder through mechanical connectors, utilizes the best advantages of the compressive properties of concrete and the tensile properties of steel. While concrete was dominating the California and western bridge scene, steel remained the primary building material in the eastern and midwestern states (Figures 67.43 and 67.44).

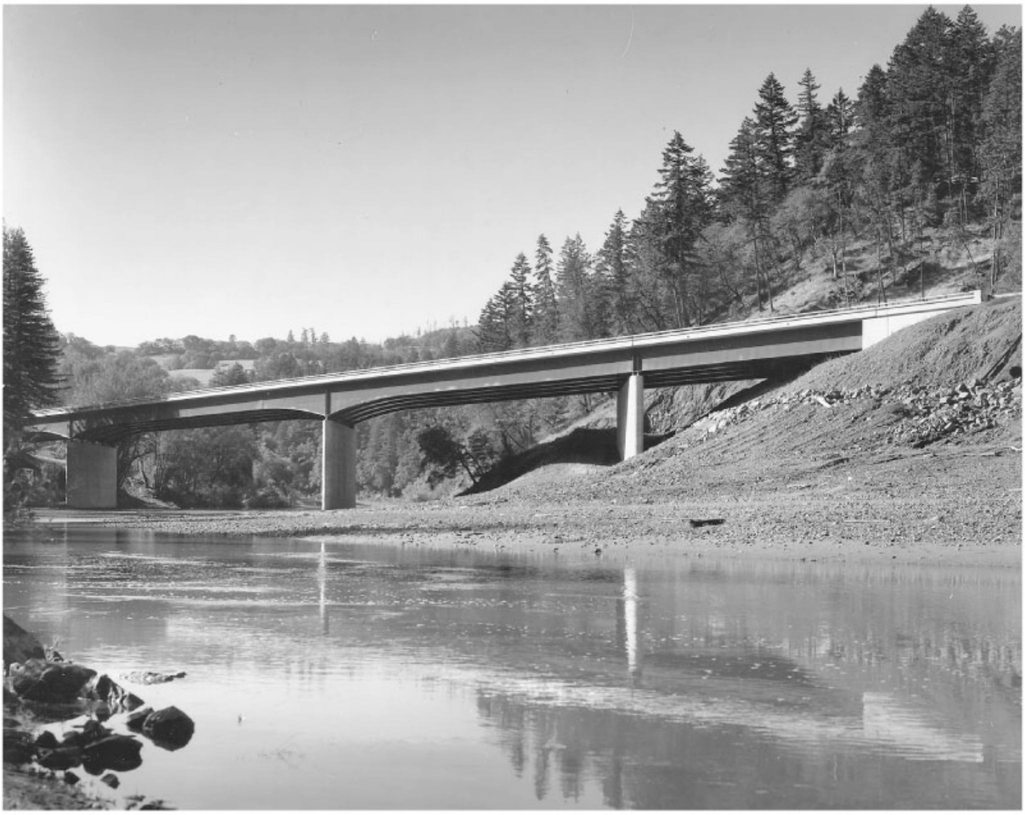

FIGURE 67.43 The South Fork of the Eel River Bridge in Northern California exemplifies the virtues of composite steel structures. This 1958 bridge won an AISC award that year. (Courtesy of California Department of Transportation.)

FIGURE 67.44 The Cuyahoga River Valley Bridge built in 1980 for the Ohio Turnpike Authority earned an AISC award that year. It was designed by Howard Needles Tamman Bergendoff. (Courtesy of American Institute of Steel Construction.)

A Resurgence of Steel

As the Interstate Highway program began to utilize more and more concrete structures, during the 1960s, the steel and welding industry struggled to maintain its share of the bridge market. Many innovations were introduced for the use of steel through this campaign, by the development of exotic steels, distribution of design aids and examples, and conducting of design contests.

Steel Girders

See Figures 67.45 and 67.46.

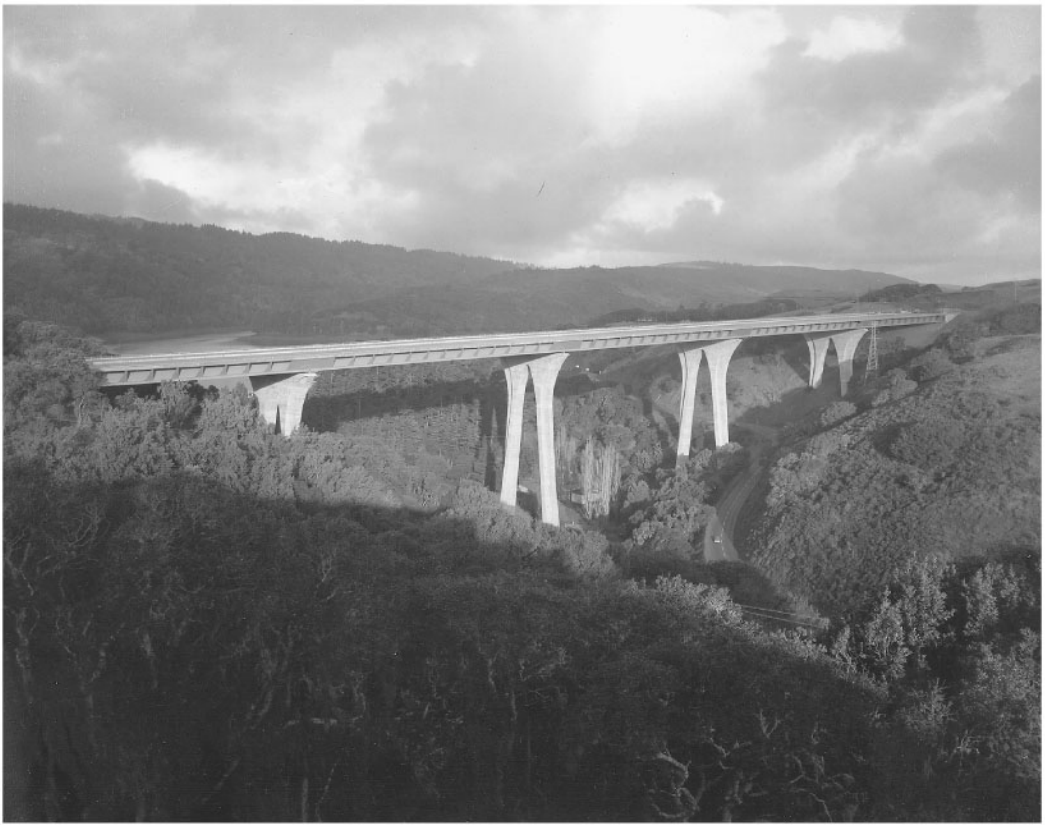

FIGURE 67.45 The Eugene A. Doran Memorial (San Mateo Creek–Crystal Springs Reservoir) Bridge is a prize-winning bridge in a park setting. Sloping exterior facia plates provide web stiffening and aesthetic treatment. This welded plate steel girder bridge, built in 1970, was designed by Bob Cassano of the California Division of Highways. (Courtesy of California Department of Transportation.)

FIGURE 67.46 The Sacramento River Bridge at Elkhorn is a steel girder utilizing high-strength steel. Built in 1970 for Interstate Route 5, the bridge earned an AISC award that year. It was designed by Bert Bezzone of the California Division of Highways. (Courtesy of California Department of Transportation.)

Steel Box Girders and Orthotropic Steel Decks

See Figures 67.47 through 67.49.

FIGURE 67.47 The Klamath River crossing at Orleans in Northern California is a picturesque setting on a back road. There have been seven structures at this site, one burned and five have been washed away during major floods. The current steel box girder suspension span has lasted longer than any of its predecessors. Built in 1967, it was designed by Bert Bezzone of the California Division of Highways. (Courtesy of California Department of Transportation.)

FIGURE 67.48 San Mateo–Hayward Bridge over the San Francisco Bay, not only has composite steel approach spans, but the main span has an orthotropic steel deck. Listed among distinctive bridges, it won an American Institute of Steel Construction prize in 1968. It was designed by the California Division of Bay Toll Crossings. (Courtesy of California Department of Transportation.)

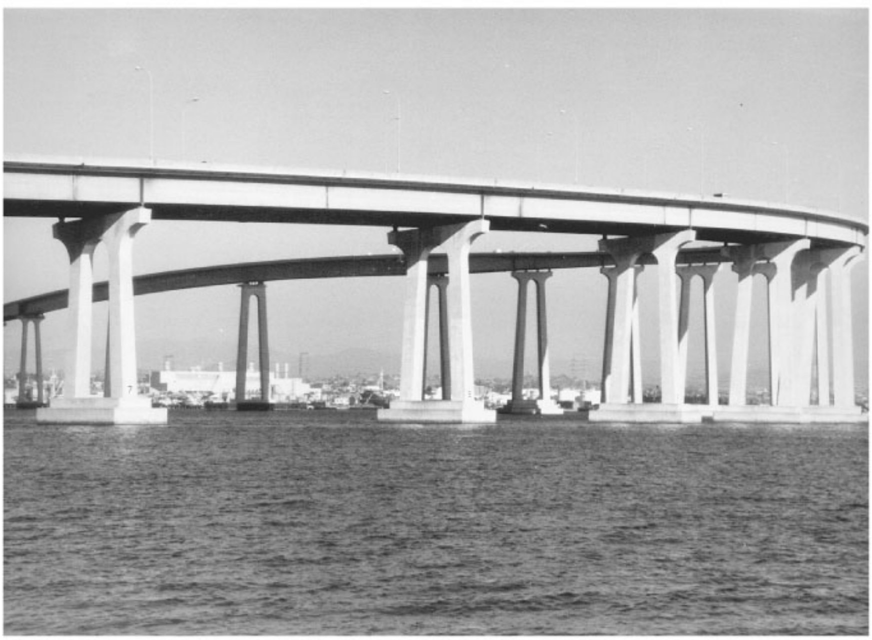

FIGURE 67.49 The Coronado Island Bridge over San Diego Bay in Southern California is a steel box girder. It earned an AISC award in 1970. It was designed by the California Division of Bay Toll Crossings. (Courtesy of California Department of Transportation.)

67.7 Era of the Signature Bridge

With the energetic vision of the great Interstate Era virtually complete, and the ensuing rush of the Seismic Retrofit Age winding down, bridge engineers turned their imaginative minds toward the building of great monuments.

Segmental Prestressed Bridges

Advanced technology of high-strength concrete and prestressing allows the cantilevering of structures out over deep valleys and bodies of water (Figures 67.50 and 67.51).

FIGURE 67.50 The California Department of Transportation experimented with and built its only segmental bridge, on Interstate Route 8 over Pine Valley in San Diego County in 1974. Bert Bezzone was the design engineer. The bridge received an American Society of Civil Engineers award in 1974. (Courtesy of California Department of Transportation.)

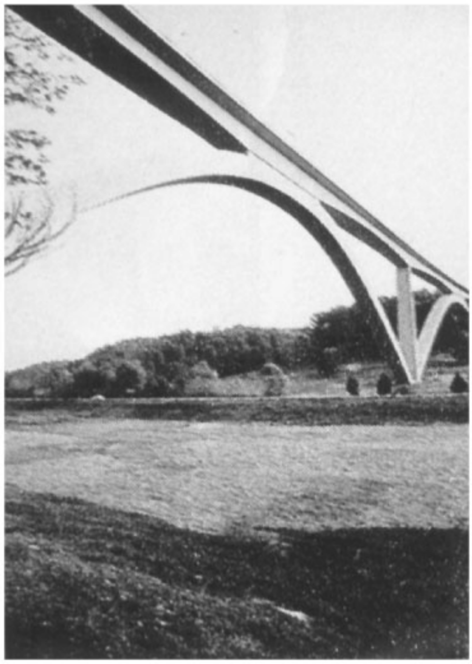

FIGURE 67.51 This graceful arch by Figg Engineering, carries the historic Natchez Trace over the park in Tennessee. It is the first and longest, 317 m, precast segmental arch. It received a design award of excellence in 1996. (Courtesy of Figg Engineering.)

Cable-Stayed Bridges

See Figures 67.52 and 67.53.

FIGURE 67.52 The new cable-stayed Sunshine Skyway, built in 1987, clearly a signature bridge, makes a bright statement over the entrance to Tampa Bay, Florida. This structure by Figg Engineering replaced the former Sunshine Skyway truss brought down by an errant barge that weighed more than that bridge. The new piers are protected by caissons as big and heavy as that barge. (Courtesy of Figg Engineering.)

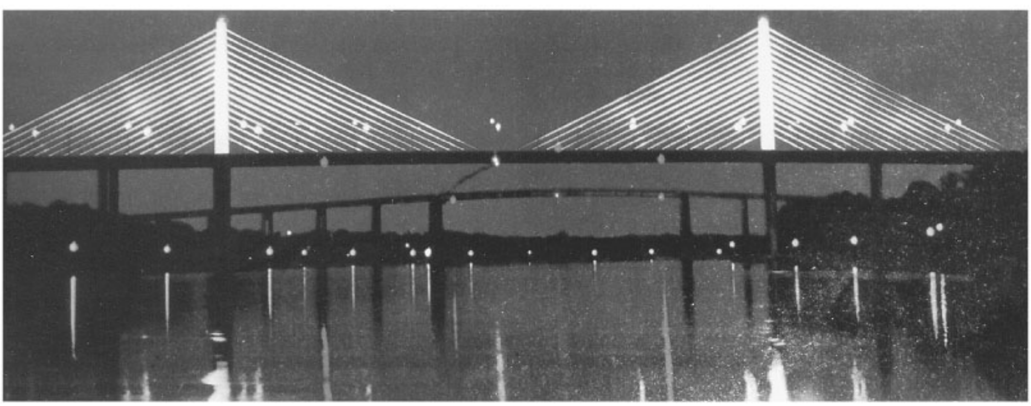

FIGURE 67.53 The Cheasapeake and Delaware Canal Bridge owned by Delaware Department of Transportation was designed by Figg Engineering. It received an Excellence in Design Award in 1996. (Courtesy of Figg Engineering.)

Composites

The new definition of composite bridges has nothing to do with steel or concrete. Composites in modern usage refer to groups of organic chemical polymers commonly known as plastics. These are still experimental materials as far as bridges are concerned, but have been used successfully in other industries for some time now. Composites are now being used with fiber-wrap bridge columns as a seismic retrofit technique. The California Department of Transportation is currently designing an experimental span which will be concrete-filled composite tube girders with a composite deck.

FIGURE 67.54 Laurel Lick Bridge is the second all-composite bridge to be completed It is owned by the West Virginia Department of Highways and was built experimentally in conjunction with West Virginia University, in 1997. (Courtesy of West Virginia Department of Highways.)

67.8 Epilogue

All superstructure types are seen in combination, and with many variations. Even though seemingly prevalent during evolving eras, type periods greatly overlap, with type selections being more dependent upon crossing length and foundation conditions. In fact, every superstructure type is still being built today in response to various needs.

Let us all admire and learn from those Americans who have contributed, pioneered, and those who have consistently created award-winning structures of which all in the bridge-building profession can be proud. These include Squire Whipple, James Eads, Theodore Cooper, Gustav Lindenthal, Othmar Amman, David Steinman, Ralph Modjeski, Leon Moisseiff, John and Washington Roebling, Joseph Strauss, John Waddell, Conde McCullough, T.Y. Lin, Eugene Figg, the California Department of Transportation, and Howard Needles Tamman Bergendoff.