Historic Context for Louisiana Bridges, 1971-1985

Louisiana Historic Bridge Survey Update (1971-1985)

LOUISIANA Historic Bridge Inventory

Prepared for

Louisiana Department of Transportation and Development

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1. Introduction

In 2012 the Louisiana Department of Transportation and Development (LADOTD), in coordination with the State Historic Preservation Office (SHPO) and the Federal Highway Administration (FHWA), commissioned a project to identify and determine the historic significance of approximately 5,400 structures across Louisiana built through 1970. The first major component of this statewide effort was preparation of a *Historic Context for Louisiana Bridges* in 2013, which provided historic background on the major trends and initiatives in road and bridge building during the twentieth century, including the influence of the Good Roads Movement, early federal funding, the Great Depression, World War II, and development of modern highways and the Interstate Highway System in the post-World War II era. The historic context included an overview of bridge types, including timber, steel beams, trusses, concrete arches, reinforced-concrete slabs and girders, and movable types with examination of materials and technological advances through 1970, such as the use of high-strength bolts and arc-welding, prestressed concrete, precasting, lightweight concrete, cantilevering, and composite decks. The context also discussed bridge aesthetics and bridge engineers, designers, and fabricators that worked in Louisiana through 1970.

In September 2015 the LADOTD, FHWA, Advisory Council on Historic Preservation (ACHP), and SHPO executed a Programmatic Agreement (PA) for managing historic bridges in Louisiana that included a stipulation for future evaluation of bridges built after 1970. The *Historic Context for Louisiana Bridges, 1971-1985* is the first component of that update and serves as an addendum to the previous context for the period of 1971 through 1985. Most of the pre-1971 established bridge types and technological innovations continued in use through 1985. Themes, bridge types, materials, and technological advancements discussed in the original context will not be reexamined in detail. Rather, this *Historic Context for Louisiana Bridges, 1971-1985* examines national and statewide legislation and trends that emerged during this period and the factors that influenced the design and engineering of Louisiana's bridges during the 1970s and early 1980s.

Research conducted as part of this historic context included online research, including review of available historic newspaper articles, industry magazine and journal articles, environmental compliance reports for specific bridges, and various documents obtained through the Louisiana State Library and the Louisiana State University Special Collections. In-person research at individual repositories was not conducted due to closures related to the COVID-19 pandemic; however, the Louisiana State Library and the Louisiana State University Special Collections electronically delivered several documents to Mead & Hunt, Inc. (Mead & Hunt) for use in this historic context. Documents available at the Louisiana State Archives could not be viewed due to limitations in sending documents electronically. Interviews were conducted in May and June 2020 by Mead & Hunt via telephone with previous employees of the LADOTD to gain an understanding of overall trends in bridge design, materials, and specific innovations of the period, as well as topics related to long-term maintenance. Interviewees included Brian Buckel (May 12, 2020), Joseph Smith (May 12, 2020), Paul Fossier (May 19, 2020), Hossain Ghara (May 21, 2020), and Wayne Aymond (June 5, 2020).

2. National Background in Bridge Funding and Construction, 1971-1985

A. Legislation, standards, and transportation trends

Federal legislative efforts passed in the 1960s set the stage for additional changes in the 1970s and 1980s that reshaped the process by which state agencies planned, built, and maintained roadway infrastructure, including bridges. Such legislation varied in scope and application, including laws that standardized bridge inspections and the introduction of design standards to increase safety.

Throughout much of this period, construction continued on the Interstate Highway System, and as rural sections were completed, work turned towards construction through urban areas. While many new bridges were needed to carry the Interstate, the standards developed for the system mandated at least two lanes in each direction, as well as minimum lane, median, and shoulder widths, necessitating wider bridges to carry the Interstate Highways and longer bridges for roads that crossed them.

In 1973, the American Association of State Highway Officials (AASHO) was renamed the American Association of State Highway and Transportation Officials (AASHTO) to broaden its mission and membership to include all forms of transportation.[1] This goal was furthered in 1976 when AASHTO established committees to represent various multimodal forms of transportation, including aviation, water, and public transportation.

Through the 1970s, the Federal Highway Administration (FHWA) continued to oversee the federal funds provided for construction and maintenance of a vast network of Interstate, U.S., and State Highways. Various changes to FHWA responsibilities and funding appropriations occurred throughout the next two decades, including two Federal-Aid Highway Acts—the Federal-Aid Highway Act of 1970 (1970 FAHA) and the Federal-Aid Highway Act of 1973 (1973 FAHA)—which followed the impactful Federal-Aid Highway Act of 1968 (1968 FAHA) that brought about large-scale changes to bridge safety, repair, and replacement, as well as federal oversight on these matters. The Federal Aid Highway Amendments Act of 1974 established the Federal Aid Off-System Bridge Replacement Program, also known as the Off-System Roads Program, which provided additional funding to meet federal and state goals to improve bridge safety through improvements such as reconstruction or repairs.[2]

Specific programs and legislation impacting bridge construction during the period are discussed in chronological order.

[1] Richard F. Weingroff, “100th Anniversary - An Evolving Partnership,” *Public Roads Magazine* 78, no. 3 (n.d.), https://www.fhwa.dot.gov/publications/publicroads/14novdec/03.cfm.

[2] United States Senate, “The Federal-Aid Highway Amendments of 1974, Report of the Committee on Public Works United States Senate Together With Minority Views to Accompany S. 3934, Report No. 93-1111” (U.S. Government Printing Office, 1974).

(1) National Bridge Inspection Program

The National Bridge Inspection Program created the nation's first standard for bridge inspection, establishing unified bridge inspection procedures for decades to come. Enacted as part of the 1968 FAHA and implemented in 1971, this legislation established a set of National Bridge Inspection Standards (NBIS), including inspection procedures, frequency of inspections, qualifications of personnel, and a state-maintained inventory of federal-aid highway system bridges.[3]

This federally mandated program was created in direct response to the catastrophic failure of the Silver Bridge between Ohio and West Virginia in 1967.[4] Considered one of the most tragic highway bridge collapses in the United States, this event highlighted the need for more comprehensive bridge inspection programs. Completed in 1928, the 2,235-foot, eye bar-chain suspension bridge spanned the Ohio River between the communities of Point Pleasant, West Virginia, and Gallipolis, Ohio.[5] Due in part to the unusual construction method, deterioration of the bridge had gone undetected, and in December 1967 it collapsed unexpectedly during rush hour, killing 46 of the 64 drivers and passengers on the bridge at the time.[6] In the immediate aftermath, the collapse highlighted the need for more comprehensive bridge inspection programs, resulting in swift action by lawmakers and officials at the state and national level.

At the time of enactment, the National Bridge Inspection Program applied to all bridges over 20 feet in length located on federal-aid highway systems (including the Interstate and other primary State Highways, as well as secondary and feeder routes, including county and local roads). The required inventory of federal-aid highway system bridges took form as the National Bridge Inventory (NBI), which required states to comply with the new law by maintaining detailed data records for each bridge under standardized categories.

Requirements of the program were amended in 1978 as part of the Surface Transportation Assistance Act, which extended the National Bridge Inspection Program to all bridges on public roads over 20 feet in length.[7] With AASHTO and FHWA revising manuals in 1978 and 1979, more direct guidance was established for states to better comply with the provisions of the NBIS.

(2) Lasting impact of environmental legislation

Growing environmental and social concerns in the 1960s led to the enactment of environmental legislation that affected the process by which local, state, and federal governments identified potential environmental impacts to various projects aided by federal funding, including bridge construction. The National Historic Preservation Act of 1966 (NHPA), the National Environmental Policy Act (NEPA) in 1970, and Section 4(f) of the U.S. Department of Transportation Act (Section 4(f)) in 1966 were laws that

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[3] Jacob Feld and Kenneth L. Carper, *Construction Failure* (N.p.: John Wiley & Sons, 1997), 144.

[4] Federal Highway Administration, "Highway Bridge Inspection: State-of-the-Practice Survey" (McLean, Va.: U.S. Department of Transportation, April 2001), 1, http://www.fhwa.dot.gov/publications/research/nde/pdfs/01033.pdf.

[5] Feld and Carper, *Construction Failure*, 142.

[6] Stephan G. Bullard et al., *The Silver Bridge Disaster of 1967* (Arcadia Publishing, 2012), 31.

[7] Federal Highway Administration, Department of Transportation, "23 CFR Part 650 [FHWA Docket No. FHWA-2017-0047] RIN 2125-AF55, National Bridge Inspection Standards" (Federal Register, Vol. 84, No. 218, November 12, 2019).

had a lasting impact on maintenance and replacement of bridges aided by federal funding. Under these laws, responsible agencies are required to identify bridges having potential for historic significance and evaluate any impacts that a project may have on those resources. The NHPA, NEPA, and Section 4(f) legislation affected bridge replacement in the subsequent decades, as compliance with these three laws applied to historic bridges proposed for replacement with federal funds. To better prepare for compliance when replacement projects arise, state departments of transportation responded by conducting statewide bridge surveys to identify historic bridges.

(3) Federal-aid Highway Act of 1970 and Special Bridge Replacement Program

The 1970 FAHA brought about multi-faceted changes to highway and bridge projects throughout the country, influencing the study period. Changes to funding allocation were enacted as part of this legislation, with federal funding for non-Interstate Highway projects increasing from 50 percent to 70 percent and federal funding for bridge replacement set at 75 percent.[8]

Aside from funding changes, this legislation brought about a comprehensive program aimed to address bridge safety through rehabilitation and replacement. The Special Bridge Replacement Program was created as part of the 1970 FAHA specifically for upgrades to or replacement of federal-aid highway system bridges. With $816 million apportioned for bridge improvements through 1978, the Special Bridge Replacement Program established a process for classifying bridges for replacement priority, based on categories such as serviceability, safety, and essentiality for public use.[9] This program was extended in 1978 to include rehabilitation of existing bridges, as part of the Highway Bridge Replacement and Rehabilitation Program, which applied to both on-system and off-system bridges.[10]

(4) Federal-aid Highway Act of 1973 and Highway Safety Act of 1973

In 1973, Congress passed another Federal-aid Highway Act (1973 FAHA), which provided additional funding to complete the Interstate Highway System and to construct new urban and rural primary and secondary roads.[11] One provision of the law, known as the Highway Safety Act of 1973, provided funding to research safety improvements for roadway and bridge design, and established the Safer Roads Demonstration Program specifically to improve safety through the removal of roadway obstacles on off-system roads. To continually improve highway and bridge construction standards under this law, the U.S. Department of Transportation was mandated to collect data, research, and conduct demonstration programs aimed at improving safety.

[8] The Louis Berger Group, "The Interstate Highway System in the United States: Draft Final Historic Context Report" (East Orange, N.J.: prepared for U.S. Department of Transportation, Federal Highway Administration, December 2004), 8.

[9] Elliott Himelfarb, "Unsafe Bridges," *Transportation USA*, Summer 1978, 27.

[10] Federal Highway Administration, Office of Engineering, Federal-Aid and Design Division, *A Guide to Federal-Aid Programs, Projects and Other Uses of Highway Funds, Publication No. FHWA-PD-92-018* (US Department of Transportation, Federal Highway Administration, 1992).

[11] Richard F. Weingroff, "Busting The Trust," *Public Roads* 77, no. 1 (August 2013), http://www.fhwa.dot.gov/publications/publicroads/13julaug/03.cfm.

The 1973 FAHA also included new provisions that incentivized mass transit projects, and represented what historian Richard F. Weingroff termed "landmark intermodal legislation" as federal priorities shifted from large highway projects to focus on mass transit and improved metropolitan transportation planning efforts.[12] Despite this broader, multi-modal focus, the law also provided $175 million in additional funds for states to replace or reconstruct bridges on the federal-aid system. This provision defined the federal-state relationship as a "federally assisted State program," preventing the availability of federal-aid highway funds from infringing on states' rights to select projects.[13] The program did not allocate funds for use at a state's discretion, but instead evaluated individual projects nationwide and provided a 75/25 percent federal/state match.[14]

Federal funding allocation for state highway projects was also changed through provisions of the 1973 FAHA, which were directly influenced by the gasoline shortage that defined the Energy Crisis of 1973-1974. To encourage fuel conservation, the 1973 FAHA set restrictions that limited federal funding for highway and bridge projects to those state governments that implemented a statewide 55 mile per hour speed limit.

(5) Surface Transportation Assistance Acts of 1978 and 1982

The Surface Transportation Assistance Act of 1978 (1978 STAA) established the Highway Bridge Replacement and Rehabilitation Program (HBRRP), replacing the similar Special Bridge Replacement Program.[15] The HBRRP intended to rehabilitate or replace bridges that were both on and off the federal-aid system, and which met priority criteria set by the U.S. Department of Transportation Secretary of Transportation.[16] Funds for these activities would be acquired through an 80:20 federal to state ratio, with funding under the law set to expire at the end of fiscal year 1982.[17]

The Surface Transportation Assistance Act of 1982 (1982 STAA) was also known as the Highway Revenue Act of 1982 and had several provisions, including a five cent per gallon gas tax. Of these five cents per gallon, four cents were set aside for funding of Interstate Highways and bridges and the remaining one cent for public transit initiatives. Under the STAA, emergency relief funds were appropriated for bridge replacement and rehabilitation projects carried out to improve safety and the HBRRP was extended through fiscal year 1986.[18] Signed into law in 1983, the legislation revised funds appropriation for the Interstate Highway System, and required 10 percent of the funds be expended on

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[12] Weingroff.

[13] Richard F. Weingroff, "Busting The Trust Supplement," Federal Highway Administration, July 2013, http://www.fhwa.dot.gov/publications/research/general/busttrust/index.cfm.

[14] E.S. Preston and Associates, *Ohio Transportation Development Program Report: A Focus on Highways* (N.p.: Ohio Department of Transportation, 1974), 5–2.

[15] 95th Congress of the United States, "Surface Transportation Act of 1978, Public Law 95-599 - Nov. 6, 1978, 92 STAT. 2689" (United States Government Printing Office, November 6, 1978).

[16] 95th Congress of the United States.

[17] 95th Congress of the United States.

[18] Glenn M. Anderson, "H.R. 6211 (97th): Surface Transportation Assistance Act of 1982" (United States Congress, 1982), https://www.congress.gov/bill/97th-congress/house-bill/6211; Federal Highway Administration, Office of Engineering, Federal-Aid and Design Division, *A Guide to Federal-Aid Programs, Projects and Other Uses of Highway Funds, Publication No. FHWA-PD-92-018*.

the services or goods produced by small or disadvantaged businesses.[19] Additionally, it established a five cent per gallon addition to the existing gas tax set in 1961.[20]

B. National trends in bridge building from 1971 to 1985

The years from 1971 to 1985 were a period of continuity in bridge design and materials nationwide. Technological advancements in preceding decades set the stage for bridge design and engineering during the subject period. Although the basic types and materials utilized by bridge engineers remained constant, noteworthy variations gained widespread use nationally during the 1970s and early 1980s.

(1) Bridge types

Most established bridge types, including concrete slabs and girders, steel beams and girders, prestressed-concrete beams and box beams with longitudinal void, trusses, timber trestles and mud sills, and various movable bridge types, continued to be built across the country during this period. The use of truss bridges was increasingly limited nationally during the 1970s and early 1980s. They had been most economical for medium-length crossings between 500 and 1,500 feet and had previously been chosen for spans that extended beyond the recommended lengths for plate girder structures. However, improved technology and material advancements enabled the use of steel and concrete girders for increasingly longer span lengths and trusses continued in only limited use compared to previous decades, often incorporating continuous and cantilevered designs.[21]

Cable-stayed girder bridges provided an alternative to trusses for medium-length crossings and were a new type introduced in the U.S. in the study period.[22] Widely used in Europe since the 1950s, the first example in the U.S. was constructed in Sitka, Alaska, in 1971.[23] This bridge type could be constructed using either steel girders, a one-piece deck in the form of a solid prestressed-concrete slab, or variations on a concrete box girder. Cable-stayed girder bridges were also considered more attractive than trusses, particularly for certain lengths of crossings.[24] Unlike a traditional suspension bridge, the cables in this type ran directly from the tower to support the deck below.

(2) Bridge materials

The basic materials for bridge construction, including steel, reinforced concrete, prestressed concrete, and timber, remained in use nationwide throughout the 1970s and early 1980s. Prestressed concrete had developed into a significant bridge-building material by the 1960s and its use of high-tensile steel and high-strength concrete, which required a smaller quantity of steel and concrete to carry the same loads as reinforced concrete, provided a more efficient and economical use of materials.[25]

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[19] Anderson, "H.R. 6211 (97th): Surface Transportation Assistance Act of 1982."

[20] Anderson.

[21] Thomas L. Saaty and Luis G. Vargas, *Models, Methods, Concepts & Applications of the Analytic Hierarchy Process* (N.p.: Springer Science & Business Media, 2012), 98.

[22] Saaty and Vargas, 98.

[23] William L. Gute, "First Vehicular Cable-Stayed Bridge in the U.S.," *Civil Engineering - ASCE* 43, no. 11 (November 1973): 51.

[24] Gute, 51.

[25] Tung Y. Lin, Design of Prestressed Concrete Structures, 2d ed. (New York: John Wiley & Sons, 1963), 30-33.

Ongoing research conducted by national organizations, including the American Society of Civil Engineers (ASCE), Precast/Prestressed Concrete Institute (PCI), and American Concrete Institute (ACI), resulted in a significant body of research on bridge engineering and design.[26] By the 1970s, the popularity of prestressed concrete was eliminating the need for on-site forms to cast bridge elements and the precasting and pretensioning of I-beams eventually became a standard production method that occurred in a factory or a casting yard near the job site using reusable forms.[27] By 1974, precast, prestressed concrete production in the U.S. and Canada was a $1.4 billion dollar industry.[28]

Another development in bridge materials already underway by the subject period was the use of low-alloy steel, which had more strength than mild steel and allowed for reduced steel beam depths and the amount of steel required for a comparable-strength beam. Design requirements for high-strength, low-alloy steel were addressed by AASHO in 1969.[29] Despite the continuity of basic bridge materials, several variations introduced in the preceding decade gained widespread acceptance during the 1970s and early 1980s and influenced bridge design and construction during this period, as discussed below.

(a) Corrosion resistant steel

Corrosion resistant materials such as galvanized and weathering steel served as notable variations used during the 1970s and early 1980s that provided an alternative to the ongoing maintenance challenge for steel structures, such as frequent repainting.[30] The first all-galvanized steel bridge in the U.S.—the Stearns Bayou Bridge, a steel beam bridge in Ottawa County, Michigan—was completed in 1966 and was only the second in the world at that time. By 1970, however, galvanization—the practice of hot-dip galvanizing all elements in a steel bridge—was becoming widespread, and the zinc coating could enable a structure to complete its service life without the need for maintenance painting at all.[31] Galvanizing also provided protection from salt corrosion, and the FHWA encouraged states to try galvanized rebar in concrete bridge decks as well. The problem of protecting reinforcing steel from corrosive salt remained, and in 1973, the FHWA also began to advocate for the use of epoxy-coated rebar in experimental bridges.[32]

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[26] *Standard Specifications for Highway Bridges* (Washington, D.C.: American Association of State Highway Officials, 1961), xxiii.

[27] Parsons Brinckerhoff and Engineering and Industrial Heritage, “A Context for Common Historic Bridge Types” (prepared for The National Cooperative Highway Research Program, Transportation Research Council, and National Research Council, October 2005), 3:101, http://onlinepubs.trb.org/onlinepubs/archive/NotesDocs/25-25(15)_FR.pdf.

[28] Tung Y. Lin and Felix Kulka, “Fifty-Year Advancement in Concrete Bridge Construction,” *Journal of the Construction Division* 101, no. 3 (1975): 494–95.

[29] American Association of State Highway Officials, Standard Specifications for Highway Bridges, 5th ed. (Washington, D.C.: American Association of State Highway Officials, 1949a), xix; American Association of State Highway Officials, Standard Specifications for Highway Bridges, 10th ed. (Washington, D.C.: Association General Offices, 1969c), xxviii.

[30] Kneeland A. Jr. Godfrey, “The 1970’s: Civil Engineering Forecast Part I, Structures and Underground Construction,” *Civil Engineering - ASCE* 40, no. 4 (April 1970): 68.

[31] P. C. Birkemoe and D. C. Herrschaft, “Bolted Galvanized Bridges - Engineering Acceptance Near,” *Civil Engineering - ASCE* 40, no. 4 (April 1970): 42.

[32] Gene Dallaire, “Designing Bridge Decks That Won’t Deteriorate,” *Civil Engineering - ASCE* 43–48, no. 8 (August 1973): 46–47.

Weathering steel was another attempt to create low-maintenance, corrosion-resistant steel bridges. Like the centuries-old process of “browning” gun barrels with a thin coat of iron oxide, this process created a rust-like, corrosion-resistant layer of oxide film on an exposed steel surface and eliminated the need for painting. The first weathering steel bridge in the U.S. was constructed over the New Jersey Turnpike in 1964, and other states soon followed suit, including Iowa, Ohio, and Michigan. By 1980, the use of weathering steel in bridges accounted for approximately 12 percent of the total steel market, and all but four states (Arizona, Hawaii, Nevada, and South Dakota) had adopted the material for use where practical. Due to performance issues in some areas, however, weathering steel quickly fell out of favor. By the late 1980s, it was discontinued in Indiana, Iowa, Michigan, Washington, West Virginia, Alabama, Florida, Georgia, Oklahoma, New Mexico, South Carolina, California, and South Dakota.[33]

(b) Lightweight concrete

Another material variation that extended into the 1970s and early 1980s was the use of different concrete mixes to reduce the weight of structural elements and achieve lighter structures. Lightweight concrete was created by using a synthetic aggregate that enabled the concrete to weigh less per cubic foot than conventional concrete. Field investigation and analysis ultimately determined lightweight concrete was highly susceptible to failure due to shrinkage and expansion of the concrete in relation to the steel girder and the overall flexibility and oscillation of the bridge superstructure under live loads.[34] As such, the use of lightweight concrete was limited during the subject period. Air-entrained concrete was another lightweight concrete employed by engineers during the 1970s. This type of concrete was actually in use for most bridge decks by the 1960s in an attempt to avoid the spalling that occurred due to road salt.[35] Air-entrained concrete, made by trapping tiny bubbles of air within the concrete mixture, improved workability and reduced separation of water from the mix (known as “bleeding”). Far more watertight than conventional concrete, it was also easier to use in cold weather.[36] While lightweight aggregates such as expanded shale had also been available for several decades by the subject period, California began incorporating the material into concrete box-girder structures in the mid-1970s. The Napa River Bridge, near Napa, California, was constructed from 1975-1977 using lightweight concrete in a post-tensioned, segmental, box-girder structure.[37] The Parrots Ferry Bridge, completed in 1979 near Columbia, California, was the longest such span constructed prior to 1980, with an approximately 640-foot main span utilizing a

[33] Bashar McDad et al., “Performance of Weathering Steel in TxDOT Bridges” (prepared for Texas Department of Transportation, June 2, 2000), 2–5, http://www.smdisteel.org/~/media/Files/SMDI/Construction/Bridges%20-%20WS%20-%20Report%20-%20Performance%20of%20WS%20in%20TX%20DOT%20Bridges%20by%20B%20McDad%20-%2006-02-2000.ashx.

[34] Humphreys Turner and Rodolfo Aguilar, *Performance of Composite Lightweight Concrete Decks on Steel Stringers* (prepared for the Louisiana Department of Highways, 1965), 86-88; James Porter, interview by Robert Frame of Mead & Hunt, Inc. July 19, 2010.

[35] Dallaire, “Designing Bridge Decks That Won’t Deteriorate,” 44.

[36] R. T. Kreh, *Masonry Skills* (N.p.: Cengage Learning, 2003), 521.

[37] James E. Roberts, “Lightweight Concrete for California’s Bridges,” *Engineered Concrete Structures* 10, no. 3 (December 1997): 1–2.

variable-depth box girder. In both cases, the lightweight concrete mix provided a substantial cost savings over standard weight concrete or a steel box girder design alternative. [38]

(3) Design and construction

Computer-aided design was highly influential during the 1970s and early 1980s. By this period, bridge engineering practices were an increasingly scientific discipline that stressed a calculated approach to the demand for affordable and efficient bridge designs and construction methods. Standard bridge designs and cost analysis accompanied the use of early computer programs capable of performing calculations quicker and more efficiently than humans and automated the engineer's work. It also sped up the design process for both standardized structures and made possible the analysis of complex spans. By the early 1970s, engineers frequently used computers to perform calculations necessary to design superstructures, as well as pile and spread footings for abutments and retaining walls.[39]

In the early years of computer-assisted bridge design, engineers developed programs to perform specific analytical or design functions. Most calculations were performed on large mainframe computers using punch-cards, and programs were typically written in order to solve particular problems dealing with specific span types.[40] Despite the cumbersome nature of the computing process, the 1970s saw the emergence of software programs that could handle multiple aspects of structural analysis. The forerunners of modern structural analysis software, these so-called "general purpose" programs enabled users to modify and extend the program as new elements were developed.[41] By the mid-1970s, computer programs for analysis and design were considered one of the most significant advances in the field of bridge engineering.[42]

(a) Design variations

Noteworthy design variations established prior to the study period that continued in limited use between 1971 and 1985 included curved girders and segmental construction. Horizontally curved steel girders, which could be of the plate girder or box girder type, accommodated curved highway alignments. Curved steel box girder bridges were used especially in urban highway interchanges and Interstate Highway structures, where long-span continuous structures were desired and solutions for dealing with site conditions was necessary. Horizontally curved steel girders were in use in California, New York, Kansas, Kentucky, Michigan, and Minnesota by the early 1970s, most having been fabricated using plate girders

[38] K.D. Raithby and F.D. Lydon, "Lightweight Concrete in Highway Bridges," *International Journal of Cement Composites and Lightweight Concrete* 3, no. 2 (1981): 133–46.

[39] E.F. Roberts and M. Lohrmann, "Designing Computer Programs for Bridge Foundations," *Civil Engineering - ASCE* 41, no. 12 (December 1971): 64; TranSystems Corporation, "Historic Context for Construction of 1959-1968 On-System Bridges in Colorado" (prepared for Colorado Department of Transportation, August 2014), 11.

[40] John Rathke, Mead & Hunt, Inc. engineer, Interview with Mead & Hunt, Inc., January 12, 2016.

[41] E. L. Wilson et al., "SAP — A Structural Analysis Program for Linear Systems," *Nuclear Engineering and Design* 25, no. 2 (July 1973): 257.

[42] Lin and Kulka, "Fifty-Year Advancement in Concrete Bridge Construction," 508.

or rolled beams.[43] In some cases, a highly skewed design was necessary to accommodate multi-freeway interchanges and on- and off-ramps, which required challenging and complex designs.[44]

Precast segmental construction methods developed during the 1960s continued into the subject period and made long-span, prestressed-concrete bridges practical, economical, and quick to erect. Segmental construction consisted of precast segments of concrete transported to the site and joined in the field, often connected by post-tensioning. Segmental construction was used for numerous standard bridge systems, including simple-span, cantilever-suspended span, and continuous girder.[45]

Bridge engineers also utilized orthotropic steel decks throughout the 1970s and early 1980s, although they were in widespread use by the late 1960s. The orthotropic deck system was applied to a variety of bridge types, including plate girders, suspension bridges, and arches. All orthotropic bridges had lightweight steel decks that were one continuous steel plate reinforced by a system of longitudinal ribs and transverse floor beams. This system offered good load-bearing capacity, lighter dead weight, and shorter erection time.[46] Orthotropic design cut superstructure weight by 50 percent, and overall cost by 10 to 15 percent in bridges longer than 150 feet.[47] Orthotropic steel decks represented an entirely new design technique for the integration of a bridge deck with superstructure girders. This type of bridge deck was popular for long spans and movable bridges—wherever conditions required rapid construction and/or extended service life or where cold weather made the use of cast-in-place concrete difficult.[48] By the subject period they were in widespread use as improvements to computer technology enabled more sophisticated design and analysis. In 1963, the American Institute of Steel Construction (AISC) published a design manual for orthotropic steel plate deck bridges and the first steel orthotropic structure in the U.S., the Poplar Street Bridge, was constructed the following year over the Mississippi River in St. Louis.[49] The 680-580 Test Bridge was built in 1965 and named for the numbered highways it carried in Dublin, California. This bridge was an early example of a plate girder span with orthotropic deck and remains in service today. Three examples of steel box girder bridges incorporating orthotropic decks in California and Michigan were also constructed in 1967, including the San Mateo-Hayward Bridge. In addition to several girder spans built in the mid-to-late 1960s in St. Louis, Missouri, California, and Michigan, the orthotropic deck design's light cross section was also well-suited for suspended spans

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[43] Federal Highway Administration, *Manual for Design, Construction, and Maintenance of Orthotropic Steel Deck Bridges*, FHWA-IF-12-027 (U.S. Department of Transportation Federal Highway Administration, 2012), 11, https://www.fhwa.dot.gov/bridge/pubs/if12027/if12027.pdf; Subcommittee on Curved Girders: Joint AASHO-ASCE Committee on Flexural Members, "Survey of Curved Girder Bridges," *Civil Engineering - ASCE* 43, no. 2 (February 1973): 54–55.

[44] Romano, Marty. Interview with Mead & Hunt, Inc. Minneapolis, Minn. 18 September 2009.

[45] Gerwick, "Precast Segmental Construction for Long-Span Bridges," Civil Engineering, 43-47.

[46] Roman Wolchuk, "Steel Deck Bridges with Long Rib Spans," Civil Engineering 34, (February 1964): 53-55.

[47] Condit, American Building: Materials and Techniques from the First Colonial Settlements to the Present, 228; "How to Design Orthotropic Plate Bridges," Engineering News-Record 170, (20 June 1963): 200; M. S. Troitsky, Orthotropic Bridges Theory and Design (Cleveland, Ohio: James F. Lincoln Arc Welding Foundation, 1967), 7.

[48] Federal Highway Administration, *Manual for Design, Construction, and Maintenance of Orthotropic Steel Deck Bridges*, 10–11.

[49] W.A. Milek, Jr., "AISC Orthotropic Plate Design Manual," *AISC Engineering Journal*, April 1964, 40; Carl Condit, *American Building Materials and Techniques from the First Colonial Settlements to the Present* (Chicago: University of Chicago Press, 1968), 227.

(cable-stayed, suspension, and arch), and a prominent early example in the U.S. is the Fremont Bridge in Portland, Oregon, constructed in 1973.[50]

(b) Construction methods

On-site construction methods for bridges did not change considerably between 1971 and 1985. With steel bridges, for example, construction crews continued to rely on the same basic methods of lifting complete spans into position, constructing partial spans using falsework or other temporary supports, or using cantilever construction.[51] A slow but steady shift away from rivets toward high-tensile bolts for steel bridge connections occurred throughout the 1960s and 1970s. By the late 1970s, high-strength, or high-tensile, bolts manufactured from carbon steel and heat-treated for strength were the preferred connection method for steel plate girders instead of rivets or welding.[52] In 1979, the Research Council on Riveted & Bolted Structural Joints changed its name to Research Council on Structural Connections, partly "in recognition of the diminished importance of rivets as a fastener for structural connections."[53]

Another noteworthy construction method utilized during the subject period was composite construction. Composite construction involves pouring a concrete deck on top of steel girders so the deck supplements the capacity of the top flange. The concrete slab is anchored to steel girders with shear connectors and, thus, concrete is used in conjunction with steel for a fully composite design.[54]

(c) Aesthetic considerations

In the latter half of the twentieth century, beauty and aesthetics in bridge design were realized through simple and clean lines, with little or no applied ornamentation, that seamlessly fit into the expanding network of highways. In earlier designs, aesthetic treatments served to call attention to the bridge, in order to make it stand out from its surroundings through the artistic or ornamental treatment of structural elements.[55] Bridges were often used as symbolic entry points or gateways into cities or as memorials to important individuals and events. During the subject period, cost and safety were the primary factors in

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[50] Federal Highway Administration, *Manual for Design, Construction, and Maintenance of Orthotropic Steel Deck Bridges*, 12–15.

[51] Edward A. Burroughs, "Fifty-Year Development Construction of Steel Girder Bridges," *Journal of the Construction Division* 101, no. 3 (1975): 465.

[52] Federal Highway Administration, "Post-1945 Highway Bridge Engineering," FHWA | Environmental Review Toolkit, n.d., https://www.environment.fhwa.dot.gov/histpres/post-1945_engineering/this_bridge.asp.

[53] "Research Council on Structural Connections, Background and Scope," Research Council on Structural Connections, <http://www.boltcouncil.org/files/RCSCApplication.pdf> (accessed 29 February 2008); "Minutes of [First] Meeting, Research Council on Riveted & Bolted Structural Joints, New York City, January 15, 1947," Research Council on Structural Connections, <http://www.boltcouncil.org/files/OriginalMinutes.pdf> (accessed 29 February 2008).

[54] Fisher et al. "Steel Bridges in the United States: Past, Present, and Future," Transportation Research Circular, 38; Kerensky, "Critical Survey of Bridge Design," Engineering, 180; Ben C. Gerwick, "Precast Segmental Construction for Long-Span Bridges," Civil Engineering 34, (January 1964): 44.

[55] Lichtenstein Consulting Engineers, The Third Ohio Historic Bridge Inventory, Evaluation, and Management Plan for Bridges Built 1951-1960 and the Development of Ohio's Interstate Highway System (Ohio Department of Transportation, 2004), 26-27; Phil Patton, Open Road: A Celebration of the American Highway (New York, 1986), 133-135.

the design selection process and, as a result, aesthetics continued to play only a minor role in bridge design decisions. Technological advancements in materials and refinements to structural analysis using computer-aided design enabled engineers to create longer, lighter, and more graceful structures. As a result, aesthetics in bridge design were often unintentional, a product of economy of design and through the technological refinement of structural members rather than through applied ornamentation.

Overpasses (particularly for freeways) had to accommodate vehicular traffic both upon and below the structure, requiring some additional considerations in contrast to structures over water crossings or other natural features. The 1967 recommendation by AASHTO's Traffic Safety Committee in favor of eliminating bridge piers adjacent to roadway shoulders when constructing highway overpasses for improved safety influenced the design of bridges during the subject period. In the early 1970s, the FHWA was encouraging states to eliminate hazards by increasing median and shoulder widths, improving horizontal and vertical clearances, and eliminating columns, piers, and other fixed objects adjacent to travel lanes. The elimination of piers on the right-hand side of the roadway required construction of two-span structures with a single pier in the median on structures spanning Interstate Highways and other divided roadways. These recommendations often resulted in more aesthetically pleasing structures with clean and sleek designs.[56]

Engineers nationwide sought to eliminate intermediate piers and provide a single span. Even though these designs were often more costly, they were preferable both for safety and offered a bit of aesthetics in their form. Decked bulb-tee structural members with inclined struts and cantilevered side span girders could be used to achieve the needed spans (typically in the 150-200 foot range), but engineers also began to select concrete and steel box girders for this reason, and by the mid-1970s, examples had already been constructed in Florida and Arizona.[57] States such as California and Virginia eventually created aesthetic guidelines, adapting existing standard designs to provide an improved appearance at a minimal additional cost.[58] These guidelines emphasized clarity of design with simple lines, symmetry, proportions between elements, and gentle transitions for variable span depth.[59]

In addition to the more common adaptations of standardized highway bridge design, unique designs intended to meet site constraints also incorporated a simplified, minimalist aesthetic. Completed in 1978, the Lilac Road Overcrossing in San Diego County, California, is a 695-foot, posttensioned, prestressed-concrete box girder supported by a reinforced-concrete cellular arch. Straddling Interstate Highway (I-)15 across an unusually wide, deep cut, the bridge was designed to frame the motorists' vista and form a gateway. The gateway aesthetic is complemented by a decorative Gothic arch framing of the chain-link safety fencing along both sides of the bridge deck. Continuous, cast-in-place, prestressed-concrete bridges provided an economical and aesthetically pleasing means of constructing long spans, and

[56] John J. Kozak and Thomas J. Bezouska, "Twenty Five Years of Progress in Prestressed Concrete Bridges," *Journal of the Prestressed Concrete Institute* 21, no. 5 (n.d.): 98–100.

[57] Kneeland A. Godfrey, "Cutting the Cost of Short-Span Bridges," *Civil Engineering - ASCE* 45 (July 1975): 45.

[58] William Zuk, "Bridge Esthetic Guidelines" (prepared for the Virginia Highway & Transportation Research Council, 1975), 1; Edward P. Wasserman, "Aesthetics for Short- and Medium-Span Bridges," in *Bridge Aesthetics Around the World* (Washington, D.C.: Transportation Research Board, 1991), 61.

[59] Zuk, "Bridge Esthetic Guidelines," 3–4.

engineers increasingly utilized this type during the subject period.[60] Four bridges constructed at Vail Pass, Colorado, also exemplify both the technological advances and environmental and aesthetic considerations of the study period; their alignment was carefully selected based on geology and ecology, and the bridges' design utilized box-girder spans with beveled parapets and diamond-section piers to provide an aesthetically balanced structure.[61]

[60] Kozak and Bezouska, "Twenty Five Years of Progress in Prestressed Concrete Bridges," 99–100.
[61] Paul C. Harbeson, "Architecture in Bridge Design," in *Bridge Aesthetics Around the World* (Washington, D.C.: Transportation Research Board, 1991), 115–19.

3. Bridge Building in Louisiana, 1971-1985

A. Legislation, funding, standards, and transportation developments

(1) Establishment of the Louisiana Department of Transportation and Development (LADOTD)

The Louisiana Department of Highways continued to operate in its general capacity until 1976, when Louisiana Governor Edwin Edwards initiated a reorganization of state agencies to consolidate and improve efficiency. As part of the 1976 Louisiana Reorganization Act, the state followed the federal trend for combining multi-modal transportation under a single department. This resulted in the state Department of Highways rolling into a larger new agency—the Louisiana Department of Transportation and Development (LADOTD)—which combined 17 existing transportation-related state agencies, including state-owned and operated ferry services, aviation, and public works.[62] Despite some changes to staffing and budgeting during this transition, bridge-related projects and general organizational structure at the Bridge Design Section carried on without noticeable changes.[63]

(2) Funding sources for bridge construction

In the 1970s, much of the federal funding given to the state and parishes for bridge replacements was in response to statewide and nationwide studies demonstrating the critical need to repair or replace structurally deficient bridges. Programs for bridge replacement in the study period are discussed below.

(a) Federal funding

Some of this funding came in the form of federal appropriations, with local parishes receiving funds through the Special Bridge Replacement Program created as part of the 1970 FAHA, as well as the 1973 FAHA and subsequent Federal Aid Highway Amendments Act of 1974. These pieces of legislation provided federal grants to parishes for the construction, reconstruction, and improvements to parish-owned and maintained bridges. The Off-System Roads Program provided parishes with additional funding for the 1976 fiscal year to better meet federal and state goals of improving bridge safety through reconstruction or repairs projects.[64] Mandated under the 1976 FAHA, the Off-System Roads Program was eventually combined with the Safer Roads Demonstration Program, which renamed the joint program the Safer Off-System Roads program.[65]

In 1978, the Federal Highway Bridge Program enacted as part of the Surface Transportation Act provided an 80/20 federal/state match basis for replacement of structurally deficient bridges. While this provided funding for off-system bridges, certain qualifications were required to receive this funding.[66]

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[62] "State Agency Economizing," *Town Talk*, December 22, 1976, sec. C; "Transportation Secretary Cuts Costs," *Banner-Tribune*, December 22, 1976.

[63] Wayne Aymond, Phone interview with Mead & Hunt, Inc., June 5, 2020.

[64] United States Senate, "The Federal-Aid Highway Amendments of 1974, Report of the Committee on Public Works United States Senate Together With Minority Views to Accompany S. 3934, Report No. 93-1111."

[65] Federal Highway Administration, Office of Engineering, Federal-Aid and Design Division, *A Guide to Federal-Aid Programs, Projects and Other Uses of Highway Funds, Publication No. FHWA-PD-92-018*, 290.

[66] "New Business," *The Daily Review*, June 19, 1979, sec. 2.

Federal legislation enacted decades earlier continued to provide funding for bridge replacement for those structures that met certain requirements. This included the Truman-Hobbs Act of 1940, which granted federal funds to replace bridges that were obstructions to marine traffic. This was used in Louisiana for bridges that were shown to have been involved in marine traffic collisions, oftentimes the result of older bridge piers remaining after waterways were widened or recently designated for marine travel.[67]

(b) State funding

While these federal programs aided with bridge replacement across Louisiana, legislation passed at the state level also had impacts of varying degrees on funding for parish- and LADOTD-constructed bridges. State funding for bridge replacement came about in several spurts over the course of the 1970s, through several transportation-focused bills, capital improvements bills, and annual budgetary appropriations. In 1969, the Highway Emergency Fund was established by the Louisiana state legislature to serve as a quick source of funds for the most critical and time-sensitive highway and bridge projects, which continued to be used through the 1970s.[68] By the mid-1970s, the state's backlog of bridges needing emergency repairs reached a high point; however, to utilize the Highway Emergency Fund, projects were required to be considered individually by the state, with the funds remaining out of reach for parishes to distribute where they saw fit.[69]

In 1980, the Louisiana governor signed into law a $1.2 billion capital outlay program that apportioned $20 million to a Parish Bridge Replacement Program, which was to work in concert with federal grants.[70] However, available funds from all sources were inadequate, as the state estimated it would cost $220 million to replace all structurally deficient bridges over five years, with aggregated federal and state funds proving far short of this estimation.[71] Advised by the LADOTD, the state legislature continued to make bridge replacement one of its priorities. In 1982, a $1.1 billion capital construction bill was signed into law by Louisiana Governor Dave Treen, which appropriated 71 percent of those funds to highways and bridges.[72]

(3) Bridge design standards

Louisiana adapted national bridge building standards into its state-level code, with other state-specific changes to the code based on successful bridge designs. In the 1970s, changes in building technology, material innovations, and a greater understanding of fatigue issues and impacts of loads on bridge connections and materials influenced continual changes to bridge design codes and standards. Bridge design standards varied over time during this decade and the early 1980s based on changes to codes by AASHTO and various industry organizations.

AASHTO code changes during this period ranged from specific welding details, as a result of a greater understanding of connection stresses, to changes to overall steel bridge member design as a response to

[67] "Board Supports New Bridge," *The Daily Advertiser*, September 1, 1980.
[68] "Solon's 'Slush Fund' Fight Fails," *Town Talk*, June 17, 1975, sec. A.
[69] "Solon's 'Slush Fund' Fight Fails."
[70] John M. Hill, "Outlay Bill: Showdown in Baton Rouge," *The Times*, September 7, 1980, sec. B.
[71] "Treen Says 100 Acadia Bridges Deficient; CWEL Funds Needed," *The Crowley Post Signal*, June 2, 1982.
[72] "Capital Outlay Proposal Filed," *The Daily Advertiser*, April 27, 1982.

improved stress testing.[73] Continued Interstate Highway construction during this period required many new bridges, with new standards developed for the system that mandated at least two lanes in each direction, as well as minimum lane, median, and shoulder widths, necessitating longer bridges to carry other roads across the new highways, sometimes in the form of elaborate interchanges. AASHTO also published design guidelines for freeway interchange construction in 1973; known as the "Red Book," it provided general principles for interchange design, such as determining the number of lanes to and from a highway based on desired service volume and estimate peak traffic volume. The Red Book did not dictate the specifics of design and construction for the interchange bridges and instead left this at the discretion of state highway departments for both Interstate and State Highway bridges.[74]

Industry organizations made changes to bridge design codes that were also implemented nationally and in Louisiana. The AISC developed code changes for steel bridge construction based on ongoing efforts to create safer, cheaper, and more efficient construction methods for steel bridge designs.

(4) Bridge inspection and maintenance efforts

Bridge maintenance remained a constant challenge throughout the 1970s and early 1980s due to the large number of aging structures and increased traffic loads. In some cases, the LADOTD identified some bridge deficiencies as being potentially dangerous and posted lower load limits on those awaiting repair or replacement. These decreased load limits sometimes hindered transportation of farm-produced commodities in rural Louisiana, lowering economic efficiency, with increased transportation costs passed on to the consumer.[75] The large backlog of necessary maintenance and replacement projects created a constant tension among the LADOTD, the parishes, the governor's office, and the state legislature over funding and project priorities.

Between 1975 and 1977, Louisiana apportioned the third highest amount of bridge replacement funds in the nation, utilizing a 75/25 federal-aid match; however, this funding was not sufficient to carry out critical replacement projects in a timely manner.[76] A 1975 report by The Road Improvement Program (TRIP) covering 11,938 bridges across Louisiana reported 150 bridges having major structural issues, with 3,486 classified as "functionally obsolete"[77] under federal inspection standards.[78] Despite ongoing bouts of funding at both the state and federal level during this period, the backlog of bridge maintenance and replacements outpaced the resources of the LADOTD and local parishes.

In 1978, the LADOTD Secretary spoke in front of the state legislature to rally for additional funds for bridge repair, stating the urgency to perform routine maintenance on 1930s era bridges to avoid growing the list of bridges in need of replacement. Louisiana Governor Edwin Edwards reiterated this point: "The

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[73] John Fisher, et al., "Steel Bridges in the United States," in *50 Years of Interstate Structures: Past, Present, and Future*, Transportation Research Circular, E-C104 (Transportation Research Board, 2006).

[74] The Louis Berger Group, "The Interstate Highway System in the United States: Draft Final Historic Context Report," 31–32.

[75] "Bad Roads in Louisiana Contribute to High Prices," *The Eunice Times*, August 6, 1974.

[76] "State Dept. Gains Nat'l. Recognition," *Rayne Acadian Tribune*, October 27, 1977.

[77] "Functionally obsolete" bridges are considered inadequate to handle the traffic of the road (e.g., the bridge is more narrow than the road, including shoulders), although they are structurally sound.

[78] "Many State Bridges Are Deficient," *Shreveport Journal*, August 11, 1975.

condition of Louisiana's bridges is one of our most serious problems. I can think of no more important undertaking from a standpoint of the safety of Louisiana's citizens and for the general commercial well-being of this state."[79] That year, the state apportioned more than $16 million for bridge work, including special funds for strengthening timber bridges, repairing major bridges, and painting steel bridges.[80] Despite tens of millions of dollars assigned for bridge repair and replacement, the backlog of deficient bridges continued to remain steady through the beginning of the 1980s. As such, dozens of bridges were closed to traffic during this period due to inadequacies in supporting loads of normal traffic.[81] Many of these closures were out of concern that full school buses posed load limit issues for certain bridges.[82]

B. Bridge design and construction[83]

This section explores the bridge types and materials used in Louisiana between 1971 and 1985. Louisiana has 3,116 extant bridges and bridge-class culverts built in this period. Inclusion of a bridge in this section serves as an example but does not necessarily indicate significance under any National Register of Historic Places (National Register) criteria. Instead, the bridge is identified to assist in understanding historical themes and associations within Louisiana's bridge-building history.

The period between 1971 and 1985 primarily saw consistency in bridge building from years previous, with relative evolutions in bridge design, rather than revolutions. Deviations from established bridge construction methods were born out of unique environmental challenges and implemented on a situational basis. Concrete also replaced steel as the favorable material for bridge building during this period, as a more economical material that could provide longer spans at lower costs.[84] Along with steel, timber bridges were also built in fewer numbers than in earlier decades. Previously built in large numbers, movable bridges dropped substantially in popularity in favor of fixed bridges, with many movable bridges being replaced with fixed spans during this period. Despite continued use of materials such as lightweight concrete and weathering steel, their use was not widespread nor standardized. Other less common bridge types, such as aluminum pipe culverts, cable-stayed bridges, and railroad car bridges, together consist of less than 0.5 percent of total extant bridges built during the period.

While select bridges exhibited nontraditional techniques or materials, Louisiana generally retained their tried and true designs while making incremental adjustments over time. Except for a few bridges and highways around the New Orleans area, the LADOTD did not put aesthetics as a priority for bridges in the state. Rather, economy of manufacturing members, ease and timeliness of construction, and long-term maintenance costs influenced the design more than attention to aesthetics.

[79] "Edwards Announces Work to Begin on La. Bridges," *Abbeville Meridional*, August 21, 1978.
[80] "Edwards Announces Work to Begin on La. Bridges."
[81] "Bad Bridges," *Daily World*, May 11, 1980.
[82] "Bad Bridges."
[83] Bridge type counts and statistics throughout this section are from the bridge inspection database provided by the LADOTD in March 2020.
[84] Hossain Ghara, Phone interview with Mead & Hunt, Inc., May 21, 2020.

(1) Development of bridge types and materials in Louisiana

Most bridge types and materials established prior to 1971 continued to be constructed through this period, with some general widescale changes prompted by materials testing and greater understandings of long-term performance of bridge designs in various regions of the state. Figures 1 and 2 and Tables 1 and 2 provide a breakdown of the 1971-1985 extant bridges by material and type.

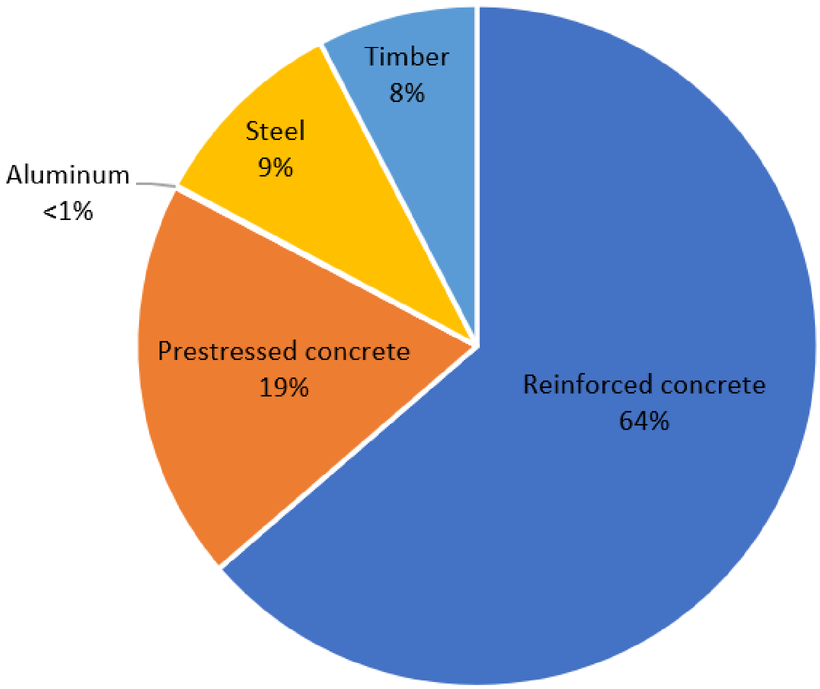

Figure 1. Breakdown of 1971-1985 bridges and culverts in Louisiana by material.

Table 1. 1971-1985 bridges and culverts in Louisiana by material

Bridge material	Total bridges	% of Total
Reinforced concrete	1,984	64%
Prestressed concrete	593	19%
Steel	299	9%
Aluminum	3	<1%
Timber	237	8%
Total	**3,116**	**100%**

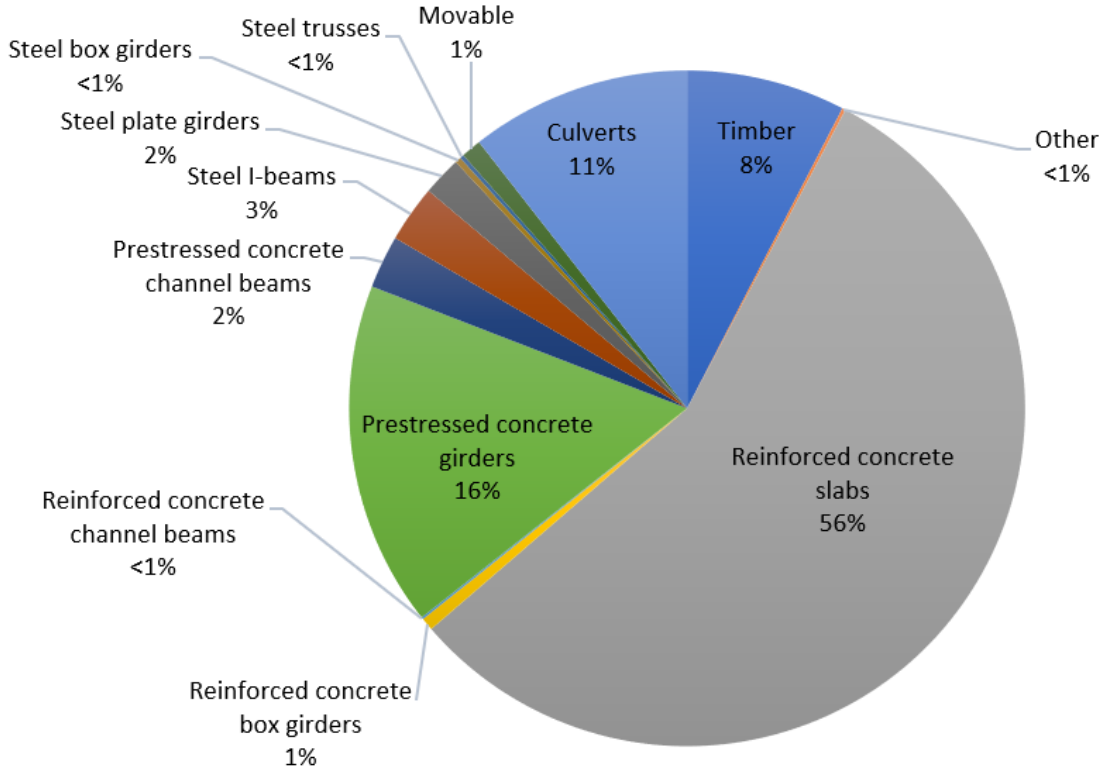

Figure 2. Breakdown of 1971-1985 bridges in Louisiana by type.

Table 2. 1971-1985 bridges and culverts in Louisiana by type

Bridge type	Total bridges	% of Total
Reinforced concrete slabs	**1,742**	**56%**
Concrete slab (including continuous)	569	
Concrete precast slab units	1,023	
Concrete voided slab (including continuous)	22	
Lightweight concrete precast slab units	128	
Reinforced concrete box girders	**19**	**1%**
Concrete box girder	18	
Concrete box girder – segmental	1	
Reinforced concrete channel beams	**3**	**<1%**
Concrete precast reinforced channel units	3	
Prestressed concrete girders	**514**	**16%**
Concrete Prestressed Girders (AASHTO Type)	395	
Concrete Prestressed Girders w/ Continuity Diaphragms & Continuous Cast-in-Place Deck	92	
Concrete Prestressed Girders w/ Precast Monolithic Deck	27	
Prestressed concrete channel beams	**79**	**3%**
Concrete Prestressed Channel Units (Welded)	79	
Steel I-beams	**85**	**3%**
Steel I-beam (rolled), including continuous	21	
Steel I-beam (rolled) – suspended	2	
Welded I-beam with steel bents and floor	1	

Table 2. 1971-1985 bridges and culverts in Louisiana by type

Concrete deck with composite welded I-beams, including continuous	50	
Steel I-beam with removable span	4	
Timber trestle with I-beam stringers	7	
Steel plate girders	**58**	**2%**
Steel plate girder, including continuous	42	
Steel plate girder - suspended	7	
Steel curved plate girder	9	
Steel box girders	**9**	**<1%**
Steel box girder	8	
Steel box girder (cable stayed)	1	
Steel Trusses	**6**	**<1%**
Steel high truss (cantilevered through truss)	5	
Steel low truss (pony truss)	1	
Movable	**30**	**1%**
Steel plate girder bascule span	4	
Steel plate girder swing span	13	
Steel vertical lift span	9	
Pontoon Bridge	4	
Other	**5**	**<1%**
Railroad flat car	3	
Bailey, ACRO, or other Portable Army Type Bridge	2	
Timber	**237**	**8%**
Treated timber trestles	228	
Treated timber trestles with concrete deck	8	
Treated timber mud sill	1	
Culverts	**329**	**11%**
Aluminum pipe culvert	3	
Concrete frame culvert	1	
Concrete box culvert (s) (over 20 ft. total opening)	185	
Concrete pipe culvert(s) (over 20 ft. total opening)	28	
Precast concrete box culvert	6	
Steel/metal pipe culvert	103	
Steel /Metal arch culvert	3	
Total	**3,116**	**100%**

(a) Concrete bridges

Concrete was the predominate bridge building material between 1971-1985, with most bridges designed and constructed with reinforced concrete. During the period, Louisiana was using more prestressed concrete than in previous periods, with reinforced-concrete bridges continuing to be used for smaller spans. See Table 2 for the numbers of each extant concrete bridge subtype constructed during the period.

Reinforced concrete

Of the extant bridges constructed in Louisiana between 1971-1985, 56 percent were reinforced precast concrete slabs, channel beams, and girders. During this period, the state continued its general trend from previous periods to construct precast concrete bridges over relatively smaller crossings—40 feet or less for the main span length, according to data in the LADOTD's bridge database.

Concrete voided slabs

A semi-experimental bridge type of Louisiana is the concrete voided slab, which was introduced nationwide in the mid-twentieth century; however, it was used infrequently in Louisiana during the period compared with other concrete bridge types due to issues encountered during the casting process.[85] Like other concrete bridges in Louisiana, concrete voided slabs often followed standard plans with standard sizes, typically with a 40-foot span length.[86]

Segmental box girders

When first implemented in Louisiana, the long-term maintenance issues of the segmental box girder design were not yet well understood. Completed in 1984, the Red River Bridge at Boyce (Recall No. 037532) was the first segmental box girder bridge built in Louisiana and the only bridge of this type constructed during the period.[87] The original precast segmental bridge design was altered by the bridge contractor to become a cast-in-place segmental bridge by means of a value-engineering proposal. Value engineering involves analysis of a project in the concept and design phases to improve the quality of the project and eliminate unnecessary costs.[88] As part of a research effort by Louisiana State University (LSU) and the LADOTD, this bridge was fitted with instrumentation to measure time-dependent deflections, deformations, and temperature changes of the superstructure over a five-year period. Due to the structural dependency on the post-tensioned cables in the concrete box girders, corrosion to the cables could have a detrimental effect on the structural integrity of the bridge; therefore, monitoring any changes was key to understanding how this bridge type would perform. While corrosion was detected at some other early segmental box girders in the country, the Red River Bridge was concluded to have performed well without signs of detrimental corrosion or other critical issues.

Prestressed concrete

NBI data suggests that the parishes constructed a larger percentage of total bridges with prestressed concrete than the state between 1971 and 1985. While parish-owned bridges over smaller spans frequently used prestressed concrete, by contrast the LADOTD primarily used prestressed concrete for larger on-system bridges, while preferring precast concrete slabs for its smaller bridges. Other prestressed-concrete bridge subtypes constructed in the period include post-tensioned concrete girders and segmental box girders, though both subtypes were constructed in far fewer numbers than prestressed girders and prestressed channel units.

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[85] Brian Buckel, Phone interview with Mead & Hunt, Inc., May 12, 2020.

[86] Ray Mumphrey, LADOTD, "Email Correspondence with Mead & Hunt, Inc.," April 13, 2020.

[87] Paul Fossier, Phone interview with Mead & Hunt, Inc., May 19, 2020.

[88] "The Value Engineering (VE) Process and Job Plan," Federal Highway Administration, June 27, 2017, https://www.fhwa.dot.gov/ve/veproc.cfm.

Many prestressed concrete bridge designs during the period utilized standardized bridge plans, that varied by 20- or 30-foot increments, up to a 90-foot span for a prestressed-concrete girder.[89] Most bridges were designed with standard details, and bridge engineers could follow a table of standard plans to identify which precast girders and piles to use based on site-specific information such as crossing length and geometry.[90] Prestressed concrete for Louisiana bridges was mainly produced by the company Gulf Coast Prestress Partners, located in Pass Christian, Mississippi. This precast plant manufactured members for easy transport via barge to the site for assembly, easily proving more economical to use for longer spans rather than transporting steel from outside of the region.[91]

Maintenance issues prevented the post-tensioned girder bridges from gaining widespread popularity in Louisiana, especially in the southern part of the state.[92] Inspections for this type of prestressed-concrete bridge required costly expertise from external contractors, as certain equipment and skills were necessary to inspect the post-tensioned steel cables, which were locked in concrete. As these inspections occurred on an annual or biannual basis, the inability of the LADOTD to inspect the bridge made post-tensioned girder bridges less than desirable.[93]

(b) Steel bridges

Despite a general statewide shift to prestressed-concrete bridges, steel structures were often the best option for long span bridges over deep waterways, some railroad bridges, and in urban areas with complex layouts. Steel bridge types built during the period include steel box girder, steel box girder with cable stays, steel plate girders, steel I-beam, steel trusses, and steel arch and steel pipe culverts. Fixed steel bridges account for approximately five percent of extant bridges constructed in Louisiana between 1971-1985, according to available NBI data. See Table 2 for a breakdown of fixed, non-culvert steel bridges built during the period.

In Louisiana, some of the large steel girder spans were introduced in the form of large-scale grade separation Interstate Highway bridges, and bridges for roadways and highways that crossed the Interstate system. One example is the I-10 to I-12 connection (Recall No. 612090) completed in 1975 in Baton Rouge; a curved interchange bridge that provided an approximate 145-degree turn and utilized welded and rolled steel girders. Another example is the curved flyover bridge carrying I-220 NB to I-20 WB (Recall No. 015462), constructed in 1980 as a rolled steel girder bridge with horizontally curved steel girders, with an overall structure length of 1,238 feet and a main span length of 438 feet.

Trusses

Very few truss bridges were constructed between 1971 and 1985 in Louisiana, despite serving as one of the more common bridge forms in the state in the early and mid-twentieth centuries. Most truss designs for shorter crossings during this earlier period utilized standard plans, while longer

[89] Aymond, Phone interview with Mead & Hunt, Inc.
[90] Buckel, Phone interview with Mead & Hunt, Inc.
[91] Ghara, Phone interview with Mead & Hunt, Inc.
[92] Ghara.
[93] Ghara.

spans crossing major waterways were constructed with more customized continuous and cantilevered designs. Prestressed-concrete bridges began to replace new construction of truss bridges for long crossings due to several factors, including aesthetics and ability to withstand corrosion.[94] By the 1970s, new small-span truss bridges were nearly nonexistent in Louisiana.

Transportation costs for steel also influenced the state's trend away from truss bridges during this period. Primarily manufactured in states to the north such as Tennessee and Pennsylvania, steel bridge members could not compete with regional-manufactured prestressed concrete due to the high costs of transporting steel from the mill to the site in Louisiana.[95]

Between 1971 and 1985, only five extant through truss bridges (also categorized as a "high-truss") were constructed during the period, with four of the five constructed as new twin spans to existing truss bridges. All five of these bridges are cantilevered Warren through trusses over either the Mississippi River or the Atchafalaya River. The only non-twin through-truss bridge constructed during this period is the Louisiana Highway (LA) 1 Bridge (Recall No. 036110) over the Atchafalaya River at Simmesport, constructed in 1971 approximately 2,000 feet downstream from the existing 1928 Simmesport Bridge, a through truss swing bridge that served both vehicular and railroad traffic. Upon completion of the 1971 bridge, vehicular use was eliminated from the 1928 bridge, and LA 1 was rerouted to traverse the new bridge.

The four extant through-truss twin spans bridges constructed between 1971 and 1985 include the Crescent City Connection, the E.J. "Lionel" Grizzaffi Bridge, the Krotz Springs Bridge, and the Vicksburg Bridge, which are described below.

The Crescent City Connection (Recall No. 001710), also known as the Greater New Orleans Bridge #2 (GNO #2), on U.S. Highway (US) 90 across the Mississippi River in New Orleans was constructed in 1985 parallel to the existing 1958 Greater New Orleans Bridge (now known as GNO #1). Despite some differences in appearance, the GNO #2 was designed to closely match GNO #1 to maintain visual cohesiveness between the twin spans.

The E.J. "Lionel" Grizzaffi Bridge (Recall No. 302500), named for Louisiana State Representative E.J. "Lionel" Grizzaffi, was constructed in 1977 adjacent to the existing 1933 Long-Allen Bridge carrying US 90 across the Atchafalaya River in St. Mary Parish. Unlike the Crescent City Connection, the truss of the E.J. Lionel Grizzaffi Bridge was not designed to match the existing 1933 truss span.

The Krotz Springs Bridge (Recall No. 007284), now known as the Frank & Sal Diesi Bridge, on US 190 over the Atchafalaya River was constructed in 1973 parallel to an original 1934 bridge at that crossing. The Krotz Springs Bridge was not designed to match the truss type or design of the existing bridge. The original 1934 span was demolished in 1985 and replaced with a truss bridge in 1988 that was designed to be identical to the 1973 span. Today the dual spans consist of the 1973 span and the 1988 span.

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[94] Ghara.

[95] Ghara.

The Vicksburg Bridge (Recall No. 500590) on I-20/US 80 over the Mississippi River at the state border between Louisiana and Mississippi was constructed in 1973 parallel to the existing 1930 Mississippi River Bridge (now known as the Old Vicksburg Bridge), which served both vehicular and railroad traffic. Upon completion of the twin span, the 1930 Mississippi River Bridge continued to serve both vehicular and railroad traffic for 25 years, until vehicular use was removed in 1998. The overall structure length of the 1973 Vicksburg Bridge is 11,052 feet.

Cable-stayed bridge

One of the monumental steel bridges constructed during this period was the Hale Boggs Memorial Bridge (Recall No. 206000) also known as the Luling Bridge. Constructed in 1983 along I-10 over the Mississippi River, the Hale Boggs Memorial Bridge was the first cable-stayed bridge built in Louisiana, designed with box girders, weathering steel, and an orthotropic deck. However, the Hale Boggs Memorial Bridge did not initiate a wave of cable-stayed bridges for long spans. Instead, only one other cable-stayed bridge has been constructed to date: the John James Audubon Bridge, completed in 2011.

(c) Movable bridges

While Louisiana has a high number of movable bridges relative to the rest of the country, few were constructed in the state during this period. The typical movable bridges continued to be constructed to cross relatively short spans, and include types such as a vertical lift, bascule, swing span, pontoon, and removable span bridges. The movable bridges from this period account for approximately 1 percent of the total extant bridges constructed in the state during this time, with 34 examples. One of the larger movable spans built during this period is the Lapalco Bridge (Recall No. 100238), a steel plate-girder bascule bridge constructed in 1972 over the Harvey Canal in Jefferson Parish, with an overall structure length of 2,660 feet.

Designing movable bridges required multiple teams working on various components, with mechanical, electrical, and hydraulic engineer teams working together.[96] Very few private firms specialized in movable bridge design, with most state-constructed bridges being designed in-house by the LADOTD during this period.[97] Additionally, increased automobile traffic and high maintenance costs of intricate mechanical and electrical systems proved to be downsides to constructing new movable bridges in the 1970s and early 1980s.[98] While movable spans were favorable during early decades of the twentieth century, Louisiana continued to replace them with fixed high-rise spans or mid-rise movable bridges wherever possible during this period.

Mid-rise movable span bridges

Where replacing movable bridges with fixed high-rise spans was not feasible due to challenges for constructing long approaches, the LADOTD instead selected designs for mid-rise movable bridges. This provided a middle ground to compromise between benefits and drawbacks of the standard movable bridge and the high-rise fixed bridge. With a mid-rise movable bridge, the

[96] Fossier, Phone interview with Mead & Hunt, Inc.
[97] Fossier.
[98] Ghara, Phone interview with Mead & Hunt, Inc.

elevation of the main span is lower than a typical high-rise fixed bridge but continues to retain a movable component, typically a vertical lift span. In this case the movable span would only be opened for marine vessels at the taller end of the spectrum, such as sailboats with high masts, as the mid-rise height would allow shorter vessels to freely pass under. This design requires shorter approach span lengths, with a movable span that opens with less frequency than a typical bascule, vertical lift, or swing span at the same location.

One example of a mid-rise movable bridges built during this period is the Ellender Bridge (Recall No. 031751), a steel vertical lift span bridge constructed in 1977 over the Intracoastal Waterway in Calcasieu Parish.

Replacing movable bridges with high-rise fixed bridges

During the 1971-1985 period, the LADOTD and general public began to favor fixed bridges over movable bridges for increased traffic efficiency, decreased maintenance, and elimination of operator staffing. In some cases, the public cited the need for uninhibited hurricane evacuation routes from the southern portions of Louisiana, with high-rise bridges providing the best option for efficient egress.[99] As such, dozens of movable bridges were categorized for replacement by high-rise fixed bridges, despite engineering challenges and environmental constraints.

Fixed high-rise bridges were most often typical prestressed-concrete girder or steel girder bridges. However, designing high-rise fixed bridges often presented design challenges, as the height of the main span may require substantial approach span lengths to accommodate safe grades to reach the bridge's height apex. Longer approach spans requires more land for construction on each side of the bridge, which creates environmental concerns or taking of private property, and can be incredibly difficult or infeasible to construct in heavily built-up urban areas. Additionally, this requirement would eliminate high-rise fixed bridges from consideration in areas where traffic across smaller waterways needed direct connections between shorelines.

An example of a fixed high-rise bridge constructed in the study period is the bridge on LA 308 (Recall No. 001052) across the intracoastal waterway at Larose. Constructed in 1977, this continuous, steel, plate-girder bridge was chosen over a lower, movable-span bridge despite requiring a substantial amount of land to construct approach spans.[100] Another notable example during this period is the Algiers Cut Off Canal Bridge (Recall No. 002439), a steel plate-girder bridge constructed in 1985 over the Intracoastal Waterway in New Orleans.

[99] Dave Precht, "State Won't Wait For U.S. On Evacuation Routes," *The Daily Advertiser*, April 19, 1973.

[100] Louisiana Department of Highways and United States Department of Transportation, Federal Highway Administration, "Final Environmental Statement, Administrative Action for State Project No. 407-02-89, Federal Aid Project No. S-495-3(001), Intracoastal Waterway Bridge and Approaches (Larose), Lafourche Parish, Louisiana, State Route LA 308" (United States Department of Transportation, Federal Highway Administration, December 4, 1972).

(d) Timber trestle bridges

Treated timber trestle bridges were the second most popular bridge choice for parishes between 1971 and 1985, behind precast concrete slabs. By contrast, very few timber trestle bridges were constructed by the LADOTD during this period. While serving as a popular bridge design choice earlier in the century, the impermanence of wood was an accepted fact in Louisiana as timber bridges were prone to rapid decay in the humid climate. As such, steel and concrete required less maintenance and were favored over timber by the 1970s.

C. Design and fabrication techniques and developments

At the state level, the LADOTD participated in a continual effort to improve bridge designs for greater efficiency and economy in construction, and with attention to improved material resiliency and lower maintenance over time. While some new material and design developments came through research partnerships between the LADOTD and LSU, many of the new materials and construction techniques were introduced to the LADOTD by the FHWA for projects that received federal funding or were located along Interstate Highway routes.

Other new techniques and materials were marketed by the private sector to The New Products Evaluation Committee, an internal committee of the LADOTD. Currently named the Specialty Products Evaluation, this body was established to hear and evaluate sales pitches from private sector industries to determine if the proposal was fit for further exploration. If approved, this concept would receive funding for LADOTD development and testing in bridge applications.[101] Some variations to traditional bridge designs, such as the prestressed-concrete “double-tee” beam, had a successful track-record in building construction, and were marketed to the New Products Evaluation Committee for use in bridge building. However, few of these ideas made it past the conceptual phase, as the LADOTD was hesitant to try methods or materials that had not already been successfully implemented in bridge construction in other states.[102] Those that made it to design and trial construction, like the double tee-beam, often failed to develop into any sort of successful standardized design.

(1) Application of nationwide techniques in Louisiana

Between 1971 and 1985, very few bridges exhibited new design methods or techniques that made a lasting impact on bridge construction in the state. The use of weathering steel, lightweight concrete, and orthotropic decks in Louisiana during the subject period represented the first widespread application of these established, nationwide techniques in the state, and were implemented with mixed results.

(a) Weathering steel

Weathering steel was a preferred material in bridge design for its ability to partially corrode on its outer layer, creating a protective coating for the interior of the steel member. However, weathering steel encountered severe issues when constructed in the southernmost part of Louisiana.

[101] Aymond, Phone interview with Mead & Hunt, Inc.
[102] Aymond.

In contrast to northern Louisiana, the southern part of the state is defined by its high-chloride marine environment. In at least two bridges in the southern part of the state (south of I-10[103]), corrosion of weathering steel would not cease due to high humidity and high salt content in the air. In these cases, the steel would “weather” to produce a protective oxide coating, then the coating would flake off, exposing the underlying steel. The underlying steel would then oxidize and flake off, repeating the cycle. The maintenance division of the LADOTD identified this failure as having potential to lead to a dangerous amount of material loss and allow moisture to infiltrate the connection joints. This prompted the maintenance division to paint certain weathering steel bridges that exhibited this deficiency, most notably the Doullut Canal Bridge (Recall No. 002562) in Empire constructed in 1975 and the Larose Bridge (Recall No. 001052) on LA 308 over the Intracoastal Waterway constructed in 1975.

For those bridges, use of weathering steel led to increased maintenance costs and this material was abandoned for that region of the state. Other instances of weathering steel bridges, primarily in the northern regions of Louisiana, performed as expected and required no remediation. In all, 16 bridges were constructed in Louisiana with weathering steel between 1975 and 1983.[104]

(b) Lightweight concrete

Already in widespread national use by the start of the 1970s, lightweight concrete was adopted by Louisiana for a relatively small number of bridge decks prior to the study period. However, due to cracking over time, the LADOTD largely abandoned use of this material, though parishes continued to use lightweight concrete into the early 1980s. Out of a total of 25 state-owned concrete slab bridges constructed during the period, 21 were constructed in 1971, showing a sharp drop by the mid-1970s.

(c) Orthotropic decks

Orthotropic decks were introduced to the United States in the 1950s, but were not utilized on bridges in Louisiana until construction of the Hale Boggs Bridge (Luling Bridge) in Luling in 1983.[105] The orthotropic deck was used in the bridge’s design for its flexibility, utilizing steel plates with gusset connections and an epoxy asphalt deck overlay. However, over time the epoxy asphalt on the right-hand traffic lanes of the deck could not withstand the frequent truck traffic, and exhibited sloughing, while the steel itself eventually succumbed to severe cracking. As a result, orthotropic decks were used infrequently beyond the period of study.

(2) LADOTD partnerships with LSU and other regional universities

During the 1970s and 1980s, the state continued its existing research and testing partnership with LSU, as well as other regional universities with engineering departments, prior to the formal partnership with universities established by the Louisiana Transportation Research Committee (LTRC) in 1986. While some LSU developments were integrated into the LADOTD’s bridge design practices to overcome specific climatic and geologic limitations, other new design and construction concepts were introduced to Louisiana that had been established in other regions of the country prior to the 1970s.

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[103] South of I-10 is a widely recognized general boundary for considering the high-chloride, high-humidity marine environment when bridge building in southern Louisiana.

[104] Transportation Research Board, “National Cooperative Highway Research Program Report 314: Guidelines For the Use of Weathering Steel in Bridges” (National Cooperative Highway Research Program, 1989), 15.

[105] Ghara, Phone interview with Mead & Hunt, Inc.

The research-based partnership between LADOTD and LSU was, and continues to operate as, a laboratory setting for designing and testing new ideas in highway construction and bridge building.[106] The laboratory assisted with full-scale testing of these new innovations, where new materials and structural improvements were put through stressors that would simulate real-world use, including a computer-controlled hydraulic ram that could replicate the maximum loads anticipated on a bridge. Electronic monitoring equipment would measure deflections and other changes to understand how these trial materials and features might perform.

(3) Developments in precasting

In response to the challenges in transporting large precast bridge members and difficulties in casting large concrete members in-place, Louisiana continued toward finding new precasting construction methods to improve efficiency and limit transport-related damage to materials. One of the more non-traditional construction methods developed during the period was the full precasting of bridge spans.[107]

With regular prestressed concrete work, individual girders were cast in a prestressing yard, then transported to the site and assembled on piers, with the deck cast in place. However, swamp land presented challenges in on-site assembling and casting. To overcome these difficulties, the LADOTD fully cast entire prestressed spans in large individual units at a casting plant, then transported these precast spans to the site. The span units, along with precast piles and pier caps, traveled 250 miles via barges along canals dredged from a clearing in the swamp to the appropriate site. Stationary barges provided working platforms for on-site construction, with barge-mounted cranes used for bridge member assembly.[108]

The fully precasting system was used between 1971 and 1973 for construction of the parallel Atchafalaya Basin Bridges, an elevated roadway along I-10 over the Atchafalaya Basin.[109] During construction, the state documented the process and aired it through a film titled *Swamp Expressway*.[110] Cheaper and more environmentally friendly than building a berm for a highway, an elevated roadway was chosen with extensive research conducted on the best methods for building a bridge in this area, with fully precasting chosen as the best option. As this method was developed for very expansive and difficult swamp crossings, there were few bridge projects located in such environments where fully precasting was the economical and most appropriate method.[111]

(4) Substructure design

Marine vessel collisions were a longstanding issue with bridges in Louisiana. The 1980 collapse of the Sunshine Skyway Bridge in Florida, caused by a ship collision, spurred an increase in testing for bridge

[106] This research partnership currently operates as the LTRC, the formalized LSU-LADOTD partnership established in 1986.

[107] Aymond, Phone interview with Mead & Hunt, Inc.

[108] Aymond; *Swamp Expressway* (Louisiana Department of Highways, 1971), https://www.youtube.com/watch?v=CLmT41GZ40A.

[109] The Atchafalaya Basin Bridges are recorded in the LADOTD's database as six bridges, with the following structure numbers: 612404500700651, 612404500700652, 035004500609932, 035004500609931, 035004500614951, 035004500614952.

[110] *Swamp Expressway*.

[111] Aymond, Phone interview with Mead & Hunt, Inc.

pier designs and pier protection devices. In 1984, the LADOTD implemented design criteria for bridge piers into its standard design practices with the intent to minimize vessel collisions with bridges, and protect bridge piers if collisions were to occur.[112] In 1985, the Naval Civil Engineer Laboratory published recommendations and guidance on pier design, based on minimizing collision damage. On a national level, specific pier design changes were not incorporated into AASHTO codes until 1991.[113] Given these shifts occurred in Louisiana toward the end of the period, no notable examples of pier design improvements were constructed prior to 1986.

Pile design in Louisiana is influenced by the geological conditions in the southern part of the state, with various new designs tested between 1971 and 1985 to overcome limitations for driving piles in the southern part of the state. The soil composition in the southern part of the Louisiana does not provide much support for piles, in contrast to the shallower sand or bedrock layer in the northern part of the state. A replacement to the traditional pile, termed a ring-step taper pile, was devised to increase pile friction in these difficult soil types. While several shapes and design modifications were implemented, none had a particular influence on subsequent construction in such environments. One example was the use of a triangular precast concrete pile used in the construction of the approaches at the Crescent City Connection (Recall No. 001710) in 1983; however, this type of pile was abandoned from future bridge designs due to extensive issues.[114]

(5) Impact of new methods on aesthetics

Except for a few bridges and highways around the New Orleans area, the LADOTD did not put aesthetics as a priority for bridges in the state. Rather, economy of manufacturing members, ease and timeliness of construction, and long-term maintenance costs influenced the design more than attention to aesthetics. Some minor aesthetic developments in Louisiana include segmental box girders, inverted T-caps, and Y-shaped piers.

Segmental box girders not only offered lightweight superstructures, but also exhibited a flat underside, proving to be preferable for aesthetic-focused projects. This was utilized first in Louisiana at the Red River Bridge at Boyce, constructed in 1984.

Aesthetics were considered when designing piers for the Crescent City Connection (Recall No. 001710) in New Orleans. Inverted T-caps are T-caps that sit nearly flush with the girders they connect, allowing for a flush plane along the underside of the bridge and the elimination of visual girder ends and pier endcaps.[115] Combined with tapered piers, the inverted T-caps were used during the period on the approach to the Crescent City Connection bridge on the downtown New Orleans side in order to make for a more aesthetically pleasing structure for pedestrians at the street level.[116]

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[112] Z. Pruca and M. Knott, "Vessel Collison Design of Bridges," in *Bridge Engineering Handbook*, ed. Wai-Fah Chen and Lian Duan (Boca Raton, Fla.: CRC Press, 2000), 4.

[113] Michael Knott and Mikele Winters, "Ship and Barge Collisions with Bridges Over Navigable Waterways" (Permanent International Association of Navigation Congresses - World Congress, 2018), 3.

[114] Buckel, Phone interview with Mead & Hunt, Inc.

[115] Buckel.

[116] Buckel.

D. Bridge engineers and designers

While most bridges constructed by the state were designed in-house at the LADOTD, longer-span bridges were almost always designed by consulting engineers.

(1) LADOTD designers

Interviews undertaken for this historic context resulted in a consensus that David S. Huval, Sr. was one of the most prominent engineers at the LADOTD between 1971 and 1985, serving as the Chief Bridge Design Engineer.[117] Huval is noted for his lead role in the design of several bridges constructed during this period, including the Hale Boggs Memorial Bridge (Recall No. 206000) across the Mississippi River at Luling and the Atchafalaya Basin Bridges that carry I-10 across the Atchafalaya Basin, which was, upon completion, the longest Interstate bridge in the United States at 96,095 feet, and the second longest bridge of any type in the country behind the Lake Pontchartrain Causeway.

Beginning as an Engineer-In-Training at the Louisiana Department of Highways in 1965, Huval worked through other roles including Senior Bridge Designer until he was promoted to Chief Bridge Engineer in 1970. At 32 years old, Huval was the youngest employee to be promoted to lead a section in the Department of Highways in its history to that point. After departing the LADOTD in 1978, Huval organized a private consulting firm, Huval & Associates. In 2018, Huval was given a Wall of Fame honor by the Louisiana Section of the American Society of Civil Engineers.[118]

(2) Consulting engineers

Consulting engineers were commissioned from around the country to design some of the larger bridges in Louisiana constructed during the period. Some of the consulting engineers noted for bridge designs in Louisiana during this period are described below.

One of the most prolific consulting engineering firms working for the LADOTD was Modjeski and Masters, a large national civil engineering firm that has a long history of bridgebuilding in Louisiana and the United States. Formerly Modjeski, Masters and Chase, this firm was instrumental to the development of many large-scale bridges erected in the 1930s over the Mississippi River, with a role in the designs of major bridges through the 1970s and early 1980s. Consulted through its Baton Rouge office, some of the major Louisiana bridges designed by this firm include the Crescent City Connection (Recall No. 001710) and the substructure design of the Hale Boggs Memorial Bridge (Recall No. 206000). Modjeski and Masters continues to have a Louisiana bridge design and building presence, including rehabilitation and renovation of existing bridges constructed by the firm in earlier years.

Another consulting engineering firm that worked on designs for Louisiana bridges during this period was the HNTB Corporation. Formerly known as Howard, Needles, Tammen & Bergendoff, the HNTB Corporation has a strong presence in Louisiana's bridge history. In cooperation with Barnard and Burk of Baton Rouge, HNTB designed the Atchafalaya Basin Bridges and the I-10 Bridge over Whiskey Bay Pilot Channel (Recall No. 300330) in Iberville Parish.

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[117] Huval was interviewed by Mead & Hunt in preparation of the context and evaluations for pre-1971 bridges in Louisiana.

[118] "2018 ASCE Louisiana Section Awards and Officers Installation Luncheon," *Louisiana Civil Engineer* 27, no. 1 (November 2018): 12.

4. Conclusion

The period from 1971 to 1985 saw a continuation of established bridge types and materials and some noteworthy variations that gained use in Louisiana and across the nation. Federal and state legislation during this period also influenced the way state agencies planned and constructed roadway infrastructure, including bridges. This historic context provides a framework for identifying and evaluating bridges built from 1971 through 1985 that have potential for listing in the National Register.

The evaluation methodology developed as part of the *National Register Eligibility Determination Report: Pre-1971 Louisiana Highway Bridges* and information learned through development of this supplemental historic context will be used to apply the National Register Criteria to bridges from this period. Bridges identified for potential significance will be field surveyed to document and complete a National Register evaluation and develop a list of bridges built from 1971 through 1985 that are eligible for listing in the National Register. Interstate bridges will generally be exempt from National Register eligibility evaluation during subsequent steps of this project. The *Exemption Regarding Historic Preservation Review Process for Effects to the Interstate Highway System* issued by the Advisory Council on Historic Preservation in 2005 effectively excluded the majority of the Interstate Highway System and associated elements, including bridges, from consideration as historic properties under Section 106 of the National Historic Preservation Act unless they are at least 50 years old, possess national significance, and meet the National Register eligibility criteria, and are of exceptional importance; or were listed in the National Register.

Evaluation of bridges built from 1971 through 1985 will also enable the LADOTD to implement the *Program Comment for Common Post-1945 Concrete and Steel Bridges,* which considers post-World War II common bridge types exempt from Section 106 review unless they have exceptional significance for being a very early or particularly important example of their type in the state or for having distinctive engineering or architectural features that depart from standard designs. These types include reinforced-concrete slabs, reinforced-concrete beam and girder bridges, prestressed-concrete bridges, steel multi-beam or multi-girder bridges, and steel and concrete box culverts and box culverts.

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