United States Department of the Interior
National Park Service

National Register of Historic Places Multiple Property Documentation Form

This form is used for documenting property groups relating to one or several historic contexts. See instructions in National Register Bulletin *How to Complete the Multiple Property Documentation Form* (formerly 16B). Complete each item by entering the requested information.

___X____ New Submission ________ Amended Submission

A. Name of Multiple Property Listing

Historic Highway Bridges of Maryland, 1694-1965

B. Associated Historic Contexts

(Name each associated historic context, identifying theme, geographical area, and chronological period for each.)

Early Road Bridge Construction, 1694-1783
Post-Revolution Bridge Building 1783-1898
Roadway Improvements, 1898-1918
The Rise of Automobile Ownership, 1918-1945
The Age of the Modern Highway, 1945-1965

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D. Certification

As the designated authority under the National Historic Preservation Act of 1966, as amended, I hereby certify that this documentation form meets the National Register documentation standards and sets forth requirements for the listing of related properties consistent with the National Register criteria. This submission meets the procedural and professional requirements set forth in 36 CFR 60 and the Secretary of the Interior's Standards and Guidelines for Archeology and Historic Preservation.

Elizabeth Hughes Director/SHPO October 24, 2024
Signature of certifying official Title Date

Maryland Historical Trust
State or Federal Agency or Tribal government

I hereby certify that this multiple property documentation form has been approved by the National Register as a basis for evaluating related properties for listing in the National Register.

____________________ ____________________
Signature of the Keeper Date of Action

Table of Contents for Written Narrative

Create a Table of Contents and list the page numbers for each of these sections in the space below.
Provide narrative explanations for each of these sections on continuation sheets. In the header of each section, cite the letter, page number, and name of the multiple property listing. Refer to *How to Complete the Multiple Property Documentation Form* for additional guidance.

Page Numbers

E. Statement of Historic Contexts

(If more than one historic context is documented, present them in sequential order.)

F. Associated Property Types

(Provide description, significance, and registration requirements.)

G. Geographical Data

H. Summary of Identification and Evaluation Methods

(Discuss the methods used in developing the multiple property listing.)

I. Major Bibliographical References

(List major written works and primary location of additional documentation: State Historic Preservation Office, other State agency, Federal agency, local government, university, or other, specifying repository.)

Paperwork Reduction Act Statement: This information is being collected for applications to the National Register of Historic Places to nominate properties for listing or determine eligibility for listing, to list properties, and to amend existing listings. Response to this request is required to obtain a benefit in accordance with the National Historic Preservation Act, as amended (16 U.S.C.460 et seq.). We may not conduct or sponsor and you are not required to respond to a collection of information unless it displays a currently valid OMB control number.
Estimated Burden Statement: Public reporting burden for each response using this form is estimated to be between the Tier 1 and Tier 4 levels with the estimate of the time for each tier as follows:

Tier 1: 60-100 hours (generally existing multiple property submissions by paid consultants and by Maine State Historic Preservation staff for in-house, individual nomination preparation)
Tier 2: 120 hours (generally individual nominations by paid consultants)
Tier 3: 230 hours (generally new district nominations by paid consultants)
Tier 4: 280 hours (generally newly proposed MPS cover documents by paid consultants).

The above estimates include time for reviewing instructions, gathering and maintaining data, and preparing and transmitting reports. Send comments regarding these estimates or any other aspect of the requirement(s) to the Service Information Information Collection Clearance Officer, National Park Service, 1201 Oakridge Drive Fort Collins, CO 80525.

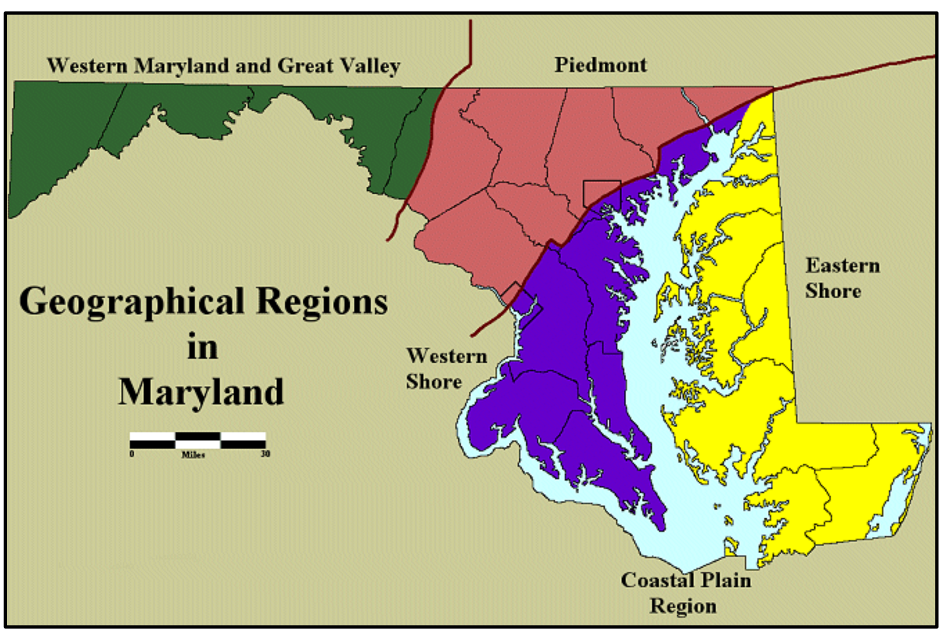
E. Statement of Historic Contexts

Introduction

Philosopher Blaise Pascal said, "Rivers are roads that move and carry us whither we wish to go." This statement explains how the early colonists of Maryland traveled before increased development and population led to improved travel routes over land (Sioussat 1899: 109). Bridges in Maryland were constructed for multiple travel methods: railroad, automobile, water, and pedestrian usage, but highway bridges are highlighted in this Multiple Property Documentation Form.

"There can be little doubt that in many ways the story of bridge building is the story of civilization. By it we can readily measure an important part of a people's progress." Franklin Roosevelt stated this in 1931, and it strongly reflects the history of bridges and the development and expansion of the state of Maryland (Fraser 2000: 6).

Maryland is divided into several topographic regions: the Coastal Plan, the Eastern Shore, the Western Shore, the Piedmont, and the Appalachian Mountains (see Map 1). The topography, along with other factors such as government legislation and funding, technology, and social events, affected the development of transportation including bridge construction. Early bridges were constructed of timber and stone, which limited the design and load capabilities. With the introduction of cast iron, wrought iron, concrete, and steel, bridge designs could be diversified from the stone arch and timber types.



Map 1: Geographical Regions of Maryland (Maryland Archaeological Conservation Lab 2003)

Background

Maryland was established as a colony in 1634 with the arrival of Lord Baltimore, his brother Leonard Calvert, and 200 colonists to the area now known as St. Mary's County (Greenwood 1927: 1). Initially, the colonists followed Native American pathways and settlement patterns by traveling along the Maryland coast by rivers and tributaries, limiting their land travel to easy terrain and settling near water (Sioussat 1899: 110). Traveling across the colony's lands was dangerous; the landscape was unknown. The terrain was difficult for wheeled transportation, and there was danger of attack. Colonial law established a corps of rangers to patrol water routes to ensure safe water travel around Maryland (Spero 1995: 8).

After 1634, settlements began to expand, and overland travel increased using routes that followed Indian paths or "traces," such as the Seneca Trail, a path that extended through the Appalachian Valley. Within Maryland, the Seneca trail linked the Potomac and Susquehanna Rivers (Spero 1995: 8). Another important trail was the Monocacy Path, which stretched from the Susquehanna River Valley to the Anacostia River. These paths usually connected areas of important resources and served as a basis for early roads. Many of these early roads in the mountainous areas followed elevated ridges along less arduous river valleys.

The earliest colonial roads were paths from plantations to river landings or outlying settlements to St. Mary's (Greenwood 1927: 4). The earliest public road in St. Mary's County extended from St. Mary's to the Patuxent River Landing was known as Mattapany Street or Mattapany Path, and was mentioned as early as 1639 (Greenwood 1927: 4). It was mentioned in the 1637/1638 Assembly that several of the members were absent from the St. Mary's session because of the lack of a ferry across St. George's (later St. Mary's) River; a ferry was established by the next session (Sioussat 1899: 111).

Colonial Road Legislation

In 1658, Maryland legislation required each county to maintain at least one ferry to ease the transportation needs throughout the colony. The best roads were primarily located along the Eastern Shore. George Fox, founder of the Society of Friends, noted a trip from Maryland's Eastern Shore to the north:

> *We took horse at the head of Tredaven Creek, and traveled through the woods, till we came a little above the head of Miles River, by which we passed, and rode to the head of Wye River; and so to the head of Chester River; where making a fire, we took up our lodgings in the woods. Next morning we traveled through the woods till we came to Saxifrax River, which we went over in Canoes causing our horses to swim by. Then we rode to Bohemia River: where in like manner swimming our horses, we ourselves went over in Canoes. We rested a little while at a plantation by the way, but not long for we had thirty miles to ride that afternoon, if we reach a town…* (Sioussat 1899: 113-114).

In 1666, Maryland passed the first legislation regarding the colony's roadways, which instructed county commissioners to determine where new roads could be established and created road overseer positions. The law also gave the commissioners power to levy tobacco or labor, which supported the construction of tracks through the forested colony. Overseers or laborers who did not complete work were fined; much of their work included removing underbrush, chopping trees, and draining marshes found along the new roadway (Greenwood 1927: 5 and Sioussat 1899: 112).

The earliest major roads were well-used county, privately built, or maintained farm roads. These generally ran north-south along both sides of the Chesapeake Bay (Spero 1995: 11). One early road stretched from Leonardtown to Allens Fresh to Chaptico to Port Tobacco. The first post road began at Newtons Point and continued through Allens Mill, Benedict, Annapolis, and New Castle and terminated in Philadelphia, Pennsylvania, an important colonial port. Postal service along the road ended three years later after the death of its sole postal carrier (Sioussat 1899: 119).

In 1696, the corps of rangers was authorized to mark roads and double mark the best travel roads in portions of the colony (Spero 1995: 9). Three years later, the colony established a colony-wide system of road marking and required that all public and main roads be cleared and maintained at the discretion of county justices (Spero 1995: 9-10). Some of these early "notched" roads still exist in Maryland. MD 235 (Three Notch Road, or Patuxent Path, Phenix Path) near Laurel Grove Road in St. Mary's County may have been an earlier Indian path taken over by the colonists (Babcock 2006).

Early Road Bridge Construction, 1694-1783

The earliest mention of bridges within Maryland occurred in 1694 in a Baltimore County court proceeding, which recommended "good and sufficient bridges for man and horse to pass over." Three years later, bridges were mentioned in a Charles County road summary noting an adjacent landowner by the name of Piles and bridges over Zachyah or Zekiah Swamp (Spero 1995: 7).

The Maryland Assembly passed an act in 1704, similar to the law of 1666 but provided that public and main roads be "cleared, well-grubbed [removal of roots and stumps by digging], fit for traveling, twenty- foot wide; and good and substantial bridges made where such were necessary, at the discretion of the County Courts." The act also required the counties to keep yearly records of their roadways and to maintain road overseers (Sioussat 1899: 120). Overseers began to find it difficult to repair bridges along these roads because adjacent landowners refused to allow the removal of local trees to be used as repair material. As a result, twenty years later (1724), a supplemental law authorized the overseers to utilize local trees found near bridge projects (Sioussat 1899: 121).

Between 1730 and 1745, Maryland's settlers moved westward, and roads began to carry more traffic and heavier loads, from individual horsemen to wagon loads. The Great Wagon Road and its branches were extended in the 1730s to accommodate the western expansion (Spero 1995: 13). The road, which stretched from Pennsylvania to Georgia, extended through Baltimore, Carroll, and Frederick counties in Maryland.

Braddock Road in Allegany and Garrett Counties was built in 1755 as a military road during the French and Indian War to connect Fort Cumberland to Fort Duquesne, roughly following Nemacolin's Path, a Native American trail. The road's rough terrain was later superseded by the National Road, the first major highway built by the federal government. Rolling roads were constructed to carry the large casks (or hogsheads) of tobacco from Maryland's Tidewater and lower Piedmont plantations to markets in Cecil and Talbot Counties; Rolling Road (MD 166) is now a heavily trafficked road in Baltimore County that was originally established for this purpose.

In 1774, Maryland passed legislation for the repair and construction of the following important market roads in Anne Arundel, Baltimore, and Frederick Counties:

- Mouth of Conococheague Creek to Frederick, crossing Turner's Gap
- Frederick to Georgetown
- Watts Branch (Rockville) to Georgetown
- Frederick over Monocacy and Patuxent Rivers to Annapolis
- Frederick over Monocacy and Patapsco River to Baltimore
- Catoctin Mountain through Reisterstown to Baltimore
- Roysters to Hanover

The law required road supervisors to clear, grub, and stone the public roads that were to be 40 feet wide, except the road to Annapolis, which was 30 feet wide. Bridges, causeways, ditches, and trenches were also to be constructed where needed (Sioussat 1899: 144).

The Act of 1779 was the first law concerning roadways passed by Maryland's newly established state government. Property owners and their work force were required to devote time to constructing Maryland's roads, but many refused. The 1779 Act established new fines for labor refusal and repealed the previous law that exempted iron workers from laboring in the road projects. The law was passed to improve the process of road work and increase the number of men involved (Sioussat 1899: 153).

<u>Post Revolution Bridge Building, 1783-1898</u>

The Revolutionary War highlighted the poor travel conditions in Maryland and across the colonies. The rough roads led to delayed and arduous military supply trips (Spero 1995: 14). The 1780s and 1790s brought the Internal Improvements Movement, the statewide improvement of roads and their associated structures by county governments. Roads leading to churches, forges, iron-works, mills, and plantations (now categorized as long private driveways), were established by new county laws after the Revolutionary War (Sioussat 1899: 141). In his 1899 dissertation, St. George Leakin Sioussat grouped roads into the following categories:

- Connecting a town with an existing important highway, waterway, or town (Hagerstown, MD to Yorktown, PA, Talbot to Cow Landing on Third Haven Creek, or Annapolis to Washington DC)
- Recognition of existing roads as public highway (Baltimore to Frederick)

- Roads marking the boundary line between two adjacent counties (Dorchester/Caroline Counties and Somerset/Worcester Counties)
- Later constructed roads as cross-connections between two earlier turnpike roads (between Hanover turnpike, now MD 30 and York turnpike, now MD 45)
- Historical interest (1789 enacted Old Monocacy Road and one of the oldest roads: Port Tobacco to Leonardtown, now MD 234)
- Post roads (Baltimore to Havre de Grace, later to become a turnpike, now MD 7)

New state roadway legislative acts passed after the Revolution also had provisions for Maryland's bridges. Bridges were erected or repaired under the legislation depending on the county where the project was located. Some bridges were dependent upon corporations or individuals. Some of these groups were early turnpike companies like the Cumberland Road Turnpike Company (Sioussat 1899: 142-143).

Despite the improvements, roads in Maryland were still rough for traveling in 1787. A petition was established to advocate for additional improvements; it described some of the road conditions:

> *The public roads leading from Baltimore-town to the western parts of this state, by means of the great number of wagons that use the same, are rendered almost impassable during the winter season, and the ordinary method of repairing said roads is not only insufficient, but exceedingly burdensome; and the establishment of several turnpike roads in the said county would greatly reduce the price of land-carriage of produce and merchandise, and raise the value of the land in the said county, and considerably increase the commerce of the state* (Hollifield 1978: 2).

Maryland passed an act that same year for internal improvements in response to the petition. The act established three factors that made it successful: 1) it improved surface and road beds; 2) it established a system of toll gates at regular intervals; 3) and it incorporated a company to provide capital for construction projects (Cashell 1928: 3). The law was amended at least 10 times over a 14-year period and established five toll roads:

- Baltimore to Frederick (Old Frederick Road was replaced by Baltimore and Fredericktown Turnpike in 1812, now MD 144)
- Baltimore to Reisterstown
- Baltimore towards York to the Baltimore County line
- Reisterstown to Westminster
- Reisterstown to Hanover

Another act was passed in 1790 to improve primary market and post roads in Cecil, Baltimore, Frederick, Montgomery, and Washington Counties, which were in great disrepair:

- Susquehanna Lower ferry to Ford at the Furnace to Charlestown to North East through Elktown towards Christiana to Delaware line

- Mouth of Elk River to Rock Creek to Bohemia to Warwick to Sassafras
- Baltimore to Randallstown to Libertytown to Frederick to mouth of Israel's Creek
- Patrick Street, Frederick to Hagerstown
- Middletown through Turner's Gap to Williamsport
- Williamsport to Elizabethtown
- Elizabethtown through Charlton's Gap (South Mountain) to Libertytown
- Elizabethtown to Hancock
- Frederick over Rice's Ford on Monocacy through Baltimore County to Anne Arundel line
- Frederick to Harper's Ferry
- Frederick to Georgetown
- Georgetown to mouth of Monocacy to its Courthouse
- Elizabethtown to Nicholson's Gap at Pennsylvania line (Sioussat 1899: 145)

Maryland passed a law in 1794 putting the responsibility of the majority of the road work upon the counties with bridge repair completed by laborers hired by the courts. The funds to support these projects were raised through taxes up to £30 a year or £100 for bridge construction. A drawbridge over the East Branch of the Potomac (Anacostia) was constructed in 1795.

Turnpikes, Canals, and Railroads in the Nineteenth Century

By the early nineteenth century, private toll roads, turnpikes, the National Road, the Chesapeake and Ohio Canal (C&O), the Chesapeake and Delaware Canal (C&D), and the Baltimore and Ohio Railroad (B&O) were established (Spero 1995: 16). Between 1805 and 1825, at least 150 miles of stone roads and turnpikes were completed and used within the state, including the following turnpike roads (State Road Commission [SRC] 1927-1930: 9):

- Baltimore to Cumberland (Baltimore and Cumberland Turnpike, MD 144 in Hancock County)
- Baltimore to Westminster
- Baltimore to Hanover (Hanover Pike, MD 30)
- Baltimore to York (Baltimore and Yorktown Turnpike, MD 45/York Road)
- Falls Road (MD 25, north of Baltimore to almost the Pennsylvania line)
- Belair Road

The National Road, also known as the Cumberland Road, included some of the state's most significant bridges. The road was authorized by Congress in 1806 to stretch from Cumberland, Maryland to Wheeling, Virginia (now West Virginia) and was extended to the Ohio River between 1811 and 1818. Semicircular stone arch bridges and culverts ran along this road (Spero 1995: 20).

The state's turnpikes, which needed bridges to cross Maryland's waterways, were to be 66 feet wide and were to be placed on a straight line and "goodness of ground" as the natural landscape permitted (Sioussat 1899: 163). Along the Frederick Pike, four substantial bridges were constructed across Gwynns Falls, the Patapsco River, the Monocacy River, and Catoctin Creek. The "Jug Bridge," which carried the Frederick Pike over the Monocacy River, was constructed of stone in 1808 and was used until 1942. It originally cost $56,000, a large sum in the 1800s, but it was thought the road's tolls would defray the cost. However, tolling was not authorized by the state and no additional money was available to improve the old Frederick Road (Spero 1995: 17).

The Piedmont and Appalachian Plateau regions of Maryland needed sturdy structures to carry roads over water crossings, so stone arch bridges were favored over timber structures. These bridges needed to withstand heavy and frequent wagon traffic, as well as water, ice, and flood debris. The Parkton Stone Arch Bridge over Little Gunpowder, built in 1809, is an example of one of these much-needed bridges (see Figure 1). Stonemasons and engineers such as the Shriver and Latrobe families initially worked for turnpike companies to construct these bridges (Spero 1995: 19).

Figure 1: Parkton Stone Arch Bridge over Little Gunpowder Falls in Baltimore County (SHA Bridge No. 0310500 and MIHP BA-593). Photo courtesy of Skelly and Loy, Inc.

During the first half of the nineteenth century, heavily used turnpike roads were straightened, rebedded, or resurfaced with broken stone or gravel, and new routes were constructed to improve transportation across the state and the country (Spero 1995: 21). The city of Baltimore, the third largest city in the United States in 1825, was the terminus of nine major turnpike roads. Wooden bridges were built within the city to ease the transport of freight and goods.

According to Sioussat, "a gentleman traveling thirty-five miles on the road between Baltimore and Frederick met or passed 235 wagons in his journey, nearly seven for every mile. These wagons were generally of the largest size and very heavily loaded" (Sioussat 1899: 176). By the time the 60-foot-wide National Road was macadamized between 1832 and 1835, it was in severe disrepair.

The new modes of transportation, canals and railroads, began to supplant turnpikes (Sioussat 1899: 177). The Chesapeake & Ohio (C&O) Canal, incorporated in 1823, paralleled the Potomac River and operated until the 1910s despite the railroads surpassing the canal's use. The canal constructed stone arch bridges and aqueducts from Georgetown, District of Columbia, to Cumberland, Maryland, between 1824 and 1825. The Chesapeake & Delaware Canal (C&D) was completed in 1829 as a "ship canal" and continues to be an operational canal. The canal runs east to southwest, connecting the Delaware River to the Chesapeake Bay. The canal included several covered timber bridges and an early moveable bridge (Spero 1995: 21). Steam railroads introduced in 1829, threatened the role of both turnpikes and canals (Cashell 1928: 8).

By the end of the nineteenth century, many of the turnpike roads proved unprofitable and reverted to state ownership (Sioussat 1899: 178). The State Roads Commission acquired private toll roads or turnpikes that remained by 1915 (Spero 1995: 27).

Bridge Innovations

The introduction of the Baltimore & Ohio Railroad (B&O) in the 1820s and the evolution of bridge technology from 1830 to 1900 changed the built landscape of Maryland. The B&O Railroad constructed stone viaducts, metal truss bridges, and various high masonry arch, Long truss, Bollman truss, plate girder, and timber trestle bridge types. The initial line of the B&O Railroad located west of Baltimore had a double span, granite arch bridge. Known as the Carrollton Viaduct over Gwynns Falls (NR# 71001032, MIHP B-21), the structure was constructed between 1829 and 1830. The bridge is the oldest surviving railroad bridge in the United States (Spero 1995: 56).

Other bridges constructed by the B&O Railroad were the Patterson Viaduct at Ilchester on the Patapsco River (NR# 76002221, MIHP HO-63) and the Oliver Viaduct at Ellicott City (MIHP HO-332). The oldest multiple arch railroad bridge in the United States, known as the Thomas Viaduct (or Latrobe's Folly) over the Patapsco near Elkridge (NR# 66000388, MIHP BA-143), was constructed between 1833 and 1835 along the Washington Branch of the B&O Railroad and was designed by Benjamin Latrobe. Covered wood truss bridges designed by Latrobe were constructed between 1840 and 1850 at Elysville (or Daniels) on the Patapsco and at Harpers Ferry, West Virginia, on the Potomac. Cast iron was used for some of the bridge's joints and wrought iron was used for some of its tensile members (Spero 1995: 22-24).

By 1849, Latrobe was constructing new bridges with iron superstructures and stone abutments. These new bridges were Bollman trusses, a design patented by the B&O Railroad Master of Road Wendel Bollman. The Bollman truss, initially designed as a railroad bridge, and subsequent metal bridge designs like the Pratt and Warren trusses and plate girder structures, became popular in Maryland as highway bridges because of their ability to carry substantial weight (Spero 1995: 24). The US 40 over Casselman River Bridge in Garrett County is a good example of a steel Pratt through-truss design (MIHP G-II-C-

101, Figure 2). The last known surviving Bollman truss, located in Savage, Maryland, was constructed for the B&O Railroad spur and has been designated a National Civil Engineering Landmark and a National Historic Landmark (NR # 72000582, MIHP HO-81).

Bollman was one of the earliest people to actively market patented bridge designs for easy assembly. After the Civil War, marketing bridge designs increased considerably. Out-of-state firms such as the King Bridge Company, the Wrought Iron Bridge Company, the Pittsburg Bridge Company, the Penn Iron Bridge Company, Nelson and Buchanan, the Roanoke Iron and Bridge Company, and the York Bridge Company heavily marketed their designs from 1865 to 1900. Other significant bridge engineers that worked in Maryland were Theodore Burr, Lewis Werwag, James Finlay, Benjamin Latrobe, C. Shaler Smith, J.E. Greiner, and Daniel B. Luten.

By the end of the nineteenth century, new technologies in concrete were competing with metal truss bridges. In some counties, such as Baltimore, it gave officials another option; other counties were not so willing to immediately accept the new reinforced concrete bridge types. Eventually, as the state developed standard plans for reinforced concrete bridges; metal truss bridges began to decline in number and popularity.

Figure 2: US 40 over Casselman River Steel Pratt Through-Truss Bridge in Garrett County (SHA Bridge No. 1100700 and MIHP G-II-C-101)

Roadway Improvements, 1898-1918

In 1898, an act was passed to investigate the state's road conditions and determine methods of improvements, construction, and maintenance. The act also allocated $10,000 annually to support highway projects. The Maryland Geological Survey was authorized to establish a highway division to manage the improvements and construction of the state's roads.

According to Arthur Newhall Johnson, author of *The Present Condition of Maryland Highways*, the common method of road maintenance in 1899 was plowing and the road would be shaped with a scraper afterward, resulting in loose dirt and flat roadways. With continual wagon loads compacting the road material, the roadway would revert back to having ruts. At this time, the state had 890 miles of stone roads: 500 miles were toll roads operated by various turnpike companies, 130 miles had been abandoned, and 260 miles were constructed by counties.

Stone and gravel roads also suffered grading and draining issues, and many were eventually surfaced with macadam, a broken stone of even size used in compacted layers for surfacing roads covered in tar. Roads in the Eastern Shore region were often surfaced with shells, a material that was readily available in the coastal area. Shells were placed on the roadway or used to fill muddy areas (Johnson 1899: 198-202).

The 1904 State Aid Law provided that the state and its counties would cooperate to share the cost of road improvements, and each would provide $200,000 annually to the improvements project. Plans, specifications, and general supervision would be monitored by the state engineers (Bittner 1927: 1). The first road under this law was completed in 1905 and the last road built under this law was completed in 1921, totaling 472 roads within Maryland. An example is the Baltimore-Washington Boulevard (US 1), which was constructed between 1906 and 1915, rebuilt with concrete and concrete shoulders in 1918/1919, and was widened and straightened in 1928-1930 (SRC 1927-1930: 10).

The 1908 act, passed with support from Governor Austin Crothers, leader of Maryland's Good Roads movement, established a $5 million bond issue along with creating the State Road Commission (SRC). The agency was one of the earliest state highway agencies, established before the passage of the 1916 Federal Aid Road Act, which provided strong incentives for states to establish state road agencies (Spero 1995: 26). The act provided funding to surface rural roads to be incorporated with the larger national roadway system (URS 2011: 3-8).

Despite the establishment of the SRC, new road construction continued to be supervised by the Maryland Geological Survey's Chief Engineer. Two years later, the General Assembly transferred all road work to the SRC. One million dollars was allocated for construction, which included simple grading, drainage, bridge work, sand-clay construction, shell macadam, gravel macadam, brick, stone block, sheet asphalt pavements, and large concrete bridges (Blakeslee 1929: 3). At this time, the SRC constructed a road from Baltimore to Annapolis, purchased the Conowingo Bridge over the Susquehanna River, and built a bridge over the Nanticoke River at Sharptown (SRC 1908-1911: 15).

As automobile and truck travel increased, the state determined that improved surfaces were needed and the SRC incorporated wider widths, pitch in and on top of the road surfaces, paved gutters, and macadam containing stone instead of shell. Roadways were generally constructed 14 to 16 feet wide. The SRC determined that the old stone bridges were physically and historically important to the state and began preserving the structures along its turnpikes.

Between 1908 and 1911, the SRC completed several road construction projects including construction of large concrete bridges. Thirty-seven bridges and 569 culverts were built along state roads and 12 bridges and 169 culverts were constructed under the state aid highway law.

The following large concrete bridges were constructed in 1911:

- Herring Run Bridge on Hartford Road
- Deer Creek Bridge along the Belair-Conowingo Road, which was noted to be impassable during certain times of the year.
- Rock Creek Bridge along the Kensignton and Norbeck Road
- Marshy Hope Creek Bridge at Federalsburg which replaced a timber structure
- Two long steel draw bridges at Dover Bridge and Sharptown (SRC 1908-1911: 57)

Standardized Plans

The earliest standardized bridge plans in Maryland were drafted by the SRC in 1909 and included plans for reinforced concrete beam, slab, and girder bridges. In 1912, the state established the Department of Surveys, which managed the creation of "surveys, plans and estimates for bridges and roads, all test borings, soundings and the testing of all stone, brick, sand, gravel, cement, bituminous materials, pipe culverts, paints, etc." The department created standardized plans for concrete slab and metal girder bridges with spans up to 36 feet. Bridge spans greater than 36 feet were designed on an individual basis. Standardized plans were initiated by railroad companies during the nineteenth century and were found to reduce project time and costs. Bridge engineers realized with the increase of highway construction and the introduction of the automobile, standardized plans for bridges would ease the construction of the large number of structures required for highway projects (SRC 1912: 79).

In 1912, 1919, 1920, 1924, 1930, and 1933, the SRC produced updated standardized plans and specifications for concrete culverts and bridges spanning 6 to 42 feet in length. The SRC encouraged the use of these standardized plans when non-complex, straightforward intersections were involved (Spero 1995: 33).

In 1914, the SRC was a co-founder of the American Association of State Highway Officials (AASHO later known as AASHTO, when "Transportation" was added to the title). The "standardizations" aided the SRC, other similar organizations, engineers, and contractors to construct roadways or structures in a secure manner. The SRC constructed nine bridges at this time, some serving to eliminate railroad crossings. By 1915, the SRC had completed 1,000 miles of highway and bridge construction throughout the state (Blakeslee 1929: 6).

The commission's first large bridge replacement involved a structure along Hanover Street in Baltimore in 1916. The timber bridge was replaced with a 2,290-foot-long, 38-span Beaux Arts-style steel and reinforced concrete structure spanning the Middle Branch of the Patapsco River (MIHP B-4530). It was considered one of the largest reinforced concrete bridges in the state with 12 cantilever spans and a Rall-type bascule bridge. The bridge was designed by John E. Greiner whose firm, Greiner Engineering, worked with the SRC on several projects within the state (SHA website).

Maryland's highway system suffered during the years 1916 to 1919 due to heavy traffic related to World War I. The SRC struggled to construct and maintain these highways because of the limited labor force and supply of construction materials. Prior to the war, road material was 5 to 7 inches thick with 14 feet wide roadways; and after the war, the SRC improved the state's roads to 6- to 8-inch-thick material on 22 feet wide roadways with concrete shoulders. These roadways that had previously been constructed of concrete were now being converted to asphalt (Blakeslee 1929: 8).

As roads were made to withstand heavier loads, standardized bridge and culvert plans were also improved to carry the war time weight. The Baltimore-Washington Boulevard (US 1) was widened to provide greater capacity for war traffic travelling to military installations such as Fort Meade (Spero 1995: 27). Inadequate wooden bridges were replaced with various concrete designs that could support larger traffic loads. Pipe and box culverts 3 feet or less received wider head walls of 28 feet. Concrete box, slab, and girder bridges with 3- to 22-foot spans were widened to have 24-foot widths and to hold maximum loads. Standardized plans were made for bridges containing 32-foot spans or larger with necessary piers and provisions for expansion and contraction of concrete slabs. Individual designs were created for bridges that necessitated piers located in the waterway (Blakeslee 1929: 8-10).

<u>The Rise of Automobile Ownership, 1918-1945</u>

With the end of World War I, the state resumed construction and maintenance of its highways and bridges. The state highway system continued to expand with new roads, parkways, and expressways. A testing lab was set up to experiment with new roadway materials and many bridges were built, replaced, or repaired during this time. The SRC whitewashed curbs, shoulders, road lines, and adjacent telephone poles to increase road visibility and decrease road accidents. The SRC also eliminated one-way bridges located on main highways (SRC 1924-1926: 13).

Roadway planning also increased with the standardization of highway bridge plans during the 1920s and 1930s. The Olmsted Brothers studied park roads for Baltimore and Washington, DC, in the 1920s, and during the Great Depression, federal funding provided statewide surveys of roads and right-of-way structures. The Rock Creek and Potomac Parkway (1920s-1935) was the first parkway in Maryland and was influenced by the 1923 Bronx River Parkway.

By 1930, interstate travel was booming with the rise of automobile ownership. Maryland had 50 highways connecting with neighboring states (SRC 1927-1930: 12). At this time, the SRC had 614 bridges across the state to maintain (SRC 1927-1930: 116).

Between 1931 and 1934, the SRC constructed or reconstructed 170 bridges and structures (SRC 1931-1934: 11). Some of the bridges constructed during this period included:

- The South River Bridge, which carries MD 2 over the South River at Edgewater in Anne Arundel County (MIHP AA-762). The substructure consisted of concrete within steel cylinders, eliminating the use of cofferdams and the superstructure consisted of steel I-beams with a reinforced concrete deck (SRC 1931-1934: 11).
- The Bohemia River Bridge on Route 213 between Chesapeake City and Cecilton, consisting of reinforced concrete pile trestle with a reinforced concrete girder superstructure (MIHP CE-996). It also contains a double-leaf bascule span, making it a movable bridge. The bridge also has a bridge house on its northeast corner (Hnedak, 1980).
- The Nanticoke River Bridge, carrying US 50 and connecting Dorchester and Wicomico Counties in Vienna. It consisted of reinforced concrete piling with reinforced concrete girder superstructure.

In the mid-1930s, Maryland received funding through the Works Progress Railroad Grade Crossing allocation from the National Industrial Recovery Act of 1933. The funds of $2 million allotted to Maryland supported contracts for structures providing grade separations at numerous intersections across the state and at intersections where separation of railroad and highway grades was not required. This fund was part of several national make-work initiatives passed by President Franklin D. Roosevelt's New Deal program, which established agencies like the Works Progress Administration (WPA). Congress increased federal aid for highways from $75 million to $125 million. The National Industrial Recovery Act of 1933 was one of the emergency funds that earmarked $400 million for highway projects not requiring matching state funds (URS 2011: 3-2).

The SRC published its 1935 Railroad Grade Crossings in the State of Maryland in response to the federal legislation establishing a nationwide study of all railroad crossings intersecting roads at grade because of the great number of fatal accidents. Maryland underwent a large construction project to establish grade crossing elimination structures across the state with assistance from the Emergency Relief Appropriation Act of 1935 (Spero 1995: 31 and URS 2011: 3-4). By 1938, Maryland completed 70 grade elimination projects; 150 remaining projects were located outside incorporated towns and cities.

The SRC, studying each crossing and the accident records, noted that the majority of these crossings only had a warning sign. The SRC determined that instead of constructing new overpasses or underpasses at every grade, flashing lights or a warning sign could provide a quicker, more economical, and improved way to utilize minimal funds during the Great Depression (URS 2011: 3-4).

In the spring of 1936, Maryland experienced severe weather, which created extensive road and bridge damage. The weather and improper drainage led to highway and bridge deterioration. The SRC widened highway shoulders and established adequate side ditches. Flooding damaged several bridges along the Potomac River and across the state including Point of Rocks, Harper's Ferry, Shepherdstown, Hancock, and Wiley's Ford. Temporary timber trestles were constructed to maintain travel during reconstruction of these bridges. Maryland's counties repaired and rebuilt many of their bridges because of these weather events.

In 1936, the Bath-Orleans Street Viaduct in Baltimore was completed while a new stone-faced concrete arch bridge replaced an old steel bridge carrying Wilkens Avenue over Gwynns Falls. The granite sided bridge spanned 115 feet with a 54-foot-wide roadway and 2 6-foot-wide sidewalks (SRC 1935- 1936: 51-52).

In Frederick County, along the Hagerstown-Myersville-Frederick Road, many masonry bridges built in the early nineteenth century were replaced with concrete counterparts, many of which were faced with stone veneers. The replacement of these bridges coincided with the improvement and realignment of US 40 between Baltimore and Frederick. The reinforced concrete arch bridge carrying US 40 over Middle Creek in Myersville, Frederick County, is among several in the state that were clad with stone veneer (MIHP F-4-116, Figure 3):

- A single span, 32-foot concrete rigid frame bridge over Landis Springs Branch, Washington County
- A single span, 50-foot concrete arch bridge over Little Catoctin Creek, west of Myersville
- A two span, 40-foot concrete rigid frame bridge over Beaver Creek, Frederick County
- A two span, 58-foot concrete arch bridge over Catoctin Creek, Frederick County
- A single span, 38-foot concrete arch bridge over Little Catoctin Creek at Harmony (SRC 1935-1936: 52)

Figure 3: US 40 over Middle Creek Reinforced Concrete Bridge with a stone façade in Frederick County (SHA Bridge No. 1003100 and MIHP F-4-116)

Along with constructing the stone-faced concrete bridges, the SRC also constructed a number of concrete box culverts, slab, girder bridges, and pipe culverts in Frederick County. Sixteen bridges were rebuilt and 43 bridges were repaired (SRC 1935-1936: 88). The SRC also completed numerous bridge projects in neighboring Carroll County; 58 bridges were rebuilt and 72 bridges were repaired (SRC 1935-1936: 89).

New bridges also were constructed along the Philadelphia Road (most of MD 7):

- A three span, 70-foot steel beam bridge over the Baltimore and Ohio Railroad near Golden Ring, Baltimore County
- A three span, 63-foot steel beam bridge over Gunpowder Falls, Baltimore County
- A two span, 45-foot concrete girder bridge over Gunpowder Falls, Baltimore and Harford Counties
- A two span, 63-foot steel beam bridge over Winter's Run, Harford County
- A two span, 53-span steel beam bridge over Bush River, Harford County
- A single span, 40-foot concrete girder bridge over Swan Creek, Harford County (SRC 1935-1936: 52-53)

In 1935/1936, the SRC contracted for the construction of a 180 foot, single span, open spandrel arch bridge over the Patapsco River at Union Dam (MIHPs HO-1018 and BA-2557). The bridge connected the city of Baltimore to western counties along the US 40 corridor (SRC 1935-1936: 2 and Wallace et al 1997). The Choptank River Bridge at Cambridge, which connected Dorchester and Talbot Counties, measured 8,747 feet long and 100 feet wide with a swing span allowing for water traffic (MIHP D-583). In 1935, it was the longest bridge in Maryland and it shortened the travel distance between Cambridge and Easton.

By the 1930s and early 1940s, the SRC began to branch away from the standardized bridge plans and instead used standardized bridge elements to construct rolled and plate girder or reinforced concrete bridges for simple crossings. This method allowed the SRC to streamline the costs and construction of bridges across the state (Bruder 2011: 8). This was partially in response to the increase of tractor trailers on Maryland's roadways (Spero 1995: 27). The metal girder bridge became the chosen standard design in the 1930s (Bruder 2011: 25). Several major state highway projects were completed during this period, including:

- US 40, Baltimore to Aberdeen (new Philadelphia Road or Pulaski Highway) (1930s)
- US 40 west of Baltimore to Frederick (1935-1940; double lanes added in 1955)
- Annapolis Boulevard (Ritchie Highway) (1934-1938)
- Access roads to wartime facilities (1940-1945)
    - Martin Boulevard
    - MD 235 to Patuxent Naval Air Test Center

US 40, known as Pulaski Highway east of Baltimore and as Baltimore National Pike west of Baltimore, was considered a modern highway with 20-foot wide lanes and large medians. The Pulaski Highway utilized concrete encased metal girder or concrete beam bridges with open railing parapets, whereas the Baltimore National Pike used two open spandrel concrete arch bridges over the Patapsco River and the Conococheague Creek (Bruder 2011: 18).

Closed arch and concrete rigid frame bridges were also constructed along US 40, with architectural treatments on wingwalls, buttresses, parapets, and use of stone veneers emulating the National Pike's stone arches. A Public Works Administration (PWA) grant and transportation bonds funded the construction of the Thomas J. Hatem Bridge (US 40 over the Susquehanna River, MIHPs CE-1550 and HA-2182) and the Governor Harry W. Nice Bridge (US 301 over the Potomac River, MIHP CH-376). These bridges, steel trusses that spanned more than a mile each, were turned into toll bridges, which allowed the state to pay off the expense of the projects and provide funding for further highway projects (Bruder 2011: 18).

In addition, two major parkway projects, which were collaborative efforts between the SRC or federal authorities and local municipalities, were constructed in the 1930s and 1940s:

- George Washington Memorial Parkway (1930s-1950s)
- Suitland Parkway (partially opened 1942) (wartime route to communities near Camp Springs [Andrew airfield])

In response to the growth of interstate travel in the 1930s, several reports were produced concerning state planning studies including the *Ten Year Highway Construction Program* (1935), the *Report of the Highway Advisory Committee* (1937), *Preliminary Report of the Statewide Highway Planning Survey* (1938), and the *Primary Bridge Program* (1938) (Spero 1995: 31).

In 1938, Maryland hired Greiner Engineering to provide a report of recommendations for the state's highway and bridge system. The engineering firm recommended the construction of four large bridges to be located across the Potomac, the Susquehanna and the Patapsco Rivers, and the Chesapeake Bay. World War II led to rationing of the country's resources, limiting construction including any proposed major bridge projects in Maryland (Bruder 2011: 11, 18).

In 1940, the SRC published the *Maryland Highway Needs, 1941-1960, A Report of the State-wide Highway Planning Survey*, which recommended that future road construction needed a source to allocate necessary funds to meet the state's increasing development. The report proposed that the SRC would control all planning, financing, constructing, improving, and maintaining of the state's highway system while local city and county roads remained under municipal or county control. The SRC hoped that new zoning laws would allow the commission to control commercial development and limit access to state roads (URS 2011: 3-4).

The SRC planners investigated the condition of the state's road system and concluded that 703 bridges 20 feet or more in length were located along the rural state highway system. Twenty-four of these bridges were in poor condition, and 120 were in fair condition. Engineers determined that 20 feet was the minimal width for safe passing on lightly traveled two-lane roads, but 30 feet was preferred. One third of the bridges contained 27-foot-wide decks and were deemed inadequate for 3 or 4 lane roads. Twenty percent of the state's bridges were consequently posted with load and speed restrictions. The SRC's Modernizing Maryland Highways noted that the state contained 600 sharp curves, 1,500 steep grades, 16,000 sites with view obstructions, and 400 or more inadequate bridges (URS 2011: 3-5)

Highway traffic continued to increase across the state and further highlighted the need to improve Maryland's roads. The Pennsylvania Turnpike, America's first "superhighway" opened in 1940. The four-lane highway was perceived as a successful interstate model with no cross streets, railroad crossings or traffic lights to shorten travel time. Other states later followed suit and state superhighways were established in Colorado, Florida, Indiana, Kansas, Maine, Maryland, New Hampshire, New Jersey, New York, Ohio, Oklahoma, Texas, and West Virginia.

Beginning in 1938, the Bureau of Public Roads (BPR) worked with state highway agencies to complete planning surveys and needs studies for future road infrastructure improvements. In 1941, President Franklin D. Roosevelt established the National Interregional Highway Commission to improve the 1938 interregional plan and solve the nationwide issue of traffic congestion. The results of these studies led to the development of a 1944 master plan that urged state road agencies to plan for a 40,000-mile network of express roads to begin construction after World War II (URS 2011: 3-4). The Federal-Aid Highway Act of 1944 was passed by Congress and included urban highway improvements involving federal, state and local governments. Supplemental legislation in 1948 authorized Congress to significantly fund studies of urban traffic and congestion problems (URS 2011: 3-8).

The onset of World War II prevented major movements to improve highway conditions nationwide or statewide. War rationing decreased the majority of vehicular traffic on the state's highway systems, allowing war related traffic to utilize the roads (Bruder 2011: 19-20). Road construction or improvements within the state were generally war-related projects because of Maryland's location within the nation's Strategic Network of Highways, which supported defense needs of a national inter-regional highway system. Maryland constructed or improved the following during World War II, totaling $28 million in project costs:

- Suitland Parkway
- Indian Head Highway (MD 210)
- MD 235 extension to the Patuxent River Naval Air Station, St. Mary's County
- All roads connecting military bases to Washington, DC
- Roads linking military bases near Solomon's Island with Prince Frederick, Calvert County
- Camp Ritchie-Pen Mar Road, Washington County
- Road to Sparrows Point, east of Baltimore with double lanes
- Access to Aberdeen Proving Grounds

By the end of World War II, the need to construct a new highway system and improve existing systems was imperative. The minimal road maintenance and highway construction during the war, as well as the influx of land development, automobile usage, and population (a one-third increase to 3.1 million) after World War II demanded the rebuilding and expansion of the state's road system. Railroads, which had carried the majority of the nation's commercial traffic before the war, experienced a decline in favor of trucks, adding strains to the obsolete roadways (URS 2011: 3-7 and 3-9).

The Age of the Modern Highway, 1945-1965

After World War II, highway and bridge construction underwent advances in technology and materials. Welding and the introduction of high-strength bolts improved the capacity and lifespan of steel bridges, making them popular for highway use. These innovations eliminated the use of rivet gangs and wood false work which was replaced with metal after 1930 (URS 2011: 4-2).

Crossings of the Chesapeake Bay and the Baltimore Harbor, along with the construction of a new highway from Washington, DC to Baltimore, were urgently needed before World War II (Bruder 2011: 7). Decisions on site locations for the Chesapeake Bay Bridge and the Baltimore Washington Parkway could not be resolved during the war and deliberations continued for a few years after the war. The increases of the gas tax, car registration and highway user fees, highway bonds, and federal monies after the war allowed Maryland to expand its transportation system (Bruder 2011: 12).

The SRC hired Greiner Engineering in 1948 to construct the Baltimore-Washington Expressway and the road segment between Baltimore City and Jessup's Road (MD 175). Jessup's Road was completed in 1951 and opened the following year. The segment included 17 stringer/multi-beam girder or concrete rigid frame bridges, which resulted in minimal intrusion for the cross roads. The eighteen- mile federal portion was completed in 1954 by the BPR and the National Park Service (NPS). The federal segment included 28 bridges and overpasses with granite masonry veneers over concrete rigid frame or steel girder and beam designs. The underpasses were constructed with minimal decoration.

The Chesapeake Bay Bridge (MIHP AA-47) project began in 1949 and included the US 50 approaches near Annapolis and the Eastern Shore near Queenstown. The four-mile multi-span bridge with concrete beam approaches incorporated the Wichert and simple deck truss design and two types of cantilever trusses, plus a suspension bridge at the main crossing between the two towers. The bridge was completed in 1952 with one lane in each direction (Bruder 2011: 26).

Many bridge projects between 1948 and 1960 involved high-level bridges with long approaches to ensure the road and river systems worked efficiently and enabled easier travel for private and commercial traffic.

> *The design of bridges in this period was relatively homogeneous and was driven primarily by cost, constructability, future maintenance, and environmental concerns. Bridges in this period exploited the latest technologies, yet the use of innovative and artistic designs was not common. Maryland bridges in this period can be described as a group being designed in a way to exhibit a*

clean, uncluttered appearance with minimal decoration, many of them with elements of the streamlined form characteristic of the Moderne style of the 1930s and 1940s (URS 2011: 3-16).

Historian Charles LaViness opined that the high-level bridges were a distinguishing bridge type. The Chesapeake Bay Bridge, as well as other high-level bridges across the state including the Keyser-McCool Bridge in Allegany County (MIHP AL-VI-E-222), the "Blue Ridge" bridge in downtown Cumberland (MIHP AL-IV-A-153), the 1953- constructed US 50 Bridge across the Severn River (DOE-AN-0271), the 1949 MD 213 Bridge (Chesapeake City Bridge, MIHP CE-1536), the 1951 Kent Narrows Bridge carrying US 50/US 301 (now MD 18B, MIHP QA-542), and those that spanned the Potomac River, were noted as important bridges because they connected formerly isolated communities to larger communities and thoroughfares (URS 2011: 3-16, 17).

Another innovation that occurred after World War II was the use of prestressed concrete in the 1950s; the Walnut Lane Bridge (1950) in Philadelphia was the first bridge constructed to utilize this technology. The idea may have begun with American P.A. Jackson in 1872, but Frenchman Eugene Freyssinet established the use of prestressed concrete as a building material (URS 2011: 4-2).

Concrete can be prestressed in two ways: pretensioning, where the concrete is cast around the tensioned steel cables; or post-tensioning, where concrete is poured and hardened with intentional voids to allow the installation of steel cables to be tensioned. Both are used in bridge construction (URS 2011: 4-1-4-2). Maryland began constructing prestressed bridges in 1954 and inventoried 20 bridges constructed with this innovation four years later. The SRC constructed the Shawan Road overpass on the Baltimore-Harrisburg Expressway using the post-tensioning system. The bridges on the Princess Anne and Flintstone bypasses contain pretensioned concrete (URS 2011: 4-3).

During the two decades following World War II, further forecasts, feasibility studies, and engineering evaluations were completed including the *Proposed 12-Year Program for Road Construction and Reconstruction, 1954-1965*, and the *Maryland's Highways: A Report on an Administrative Survey* (1952). The twenty years between 1945 and 1965 proved to be one of the most active road and bridge construction periods for Maryland. During this period, the SRC's Division of Bridge Design reorganized the state into six engineering districts to better control the responsibility of the fast-growing highway system. By 1952, they had divided the districts further, creating seven engineering districts (URS 2011: 3-11).

The following were major highway projects that were started in the 1950 as part of Governor Lane's 5-Year Program, the plan to improve and enlarge the state's road system:

- Baltimore-Washington Parkway (1954) (Jessup to Baltimore segment constructed by SRC)
- I-70, Baltimore to Frederick (1956)
- I-270, Washington, DC to Frederick (1957)
- Baltimore Harbor Tunnel and approaches (1957)
- I-83, Baltimore to Harrisburg (1959, later linked to Jones Falls Expressway in 1962)
- I-695, Baltimore Beltway (1950s-1962)

- I-95, John F. Kennedy Memorial Highway (1950s-1963)
- I-495, Washington or Capital Beltway (1950s-1964) (Spero 1995:27-29 and URS 2011:3-14-15)

In 1951-1952, Governor Theodore Roosevelt McKeldin commissioned a study, which concluded that 67 percent of Maryland's roads were in need of improvement or reconstruction in order to reach the SRC's 1948 standards. Road improvements included flattening steep grades, reducing dangerous curves, providing longer sight lines, widening pavement, adding more traffic lanes, and building medians to separate oncoming lanes in high volume traffic areas. The study recommended a twelve-year program to rebuild the state's road infrastructure.

The *Proposed 12-Year Program for Road Construction and Reconstruction, 1954-1965* was a revision of the previous Governor's Five Year Program. The new 12-Year plan projected road improvements in four-year intervals to lessen the immediate project costs. Improvements began with the Primary Highways, which connected Baltimore to county seats, and established a "program of fixed priorities" (Bruder 2011: 28-29).

With the *12-Year Program*, the SRC proposed to bypass several downtown areas with construction of new highways by acquiring less expensive and less populated land outside of the town limits. As part of this program, bypasses were built around Glen Burnie, Berlin, and Pocomoke City, and high-level bridges were built to connect these communities to the state's highway system (URS 2011: 3-16).

Construction of the Capital Beltway began in 1955 with a series of segment projects and was finally completed in 1964. The SRC designed metal girder bridges at both the Wisconsin Avenue and Kenilworth Avenue interchanges. Before the beltway was built, some of its multi-beam bridges were constructed. The Woodrow Wilson Bridge over the Potomac River between Oxon Hill and Alexandria, Virginia required a modified design. The memorial bridge was a steel girder and double bascule span bridge with a tender's house near the Virginia shoreline's draw span (Bruder 2011: 40-41).

The 17-mile Harbor Tunnel Thruway was completed in 1957 and consisted of two tubes that carried two-lane traffic under the Baltimore Harbor. The highway portion contained 55 metal girder or stringer/multi-beam or girder bridges. The Thruway connected the Baltimore-Washington Parkway, US 1, and US 40, bypassing downtown Baltimore. The K-Truss Bridge, carrying I-895 over the CSX – Curtis Bay branch railroad in Baltimore, was also constructed at this time (Bruder 2011: 32).

The Federal-Aid Highway Act of 1954 provided $175 million for the construction of an interstate highway system. A nationwide highway system was a topic discussed for twenty years. The well-known Federal Aid Highway Act of 1956 affected Maryland and states across the country. The Act established a budget of $25 billion for the 41,000-mile nationwide road system to be completed by 1969. The act allowed states to pay for ten percent of the project costs within their state and federal funds would pay ninety percent (URS 2011: 3-8). According to the SRC's *Forging Ahead, An Interim Report FY 1960-1962*, Maryland was to have 354 miles of interstate and by 1962, 120 miles were completed (Bruder 2011: 35).

Considered a bypass for Hagerstown, Interstate 81 (then US 11 in Washington County) was the first highway project in Maryland that received funding under the 1956 Act. Steel mill labor strikes, construction issues, and rising prices slowed other interstate projects within Maryland. MD 51 (Allegany County), US 301, MD 2 (Anne Arundel County), and MD 404 (Caroline County) were primary roads that received improvements in 1959 and 1960.

By 1958, Maryland had 350 miles of interstates and received $10 million from the federal government for primary highway system improvements. The state also was chosen to be one of the first transportation agencies to test the BPR's tellurometer, a surveying instrument that measured distance by measuring round trip travel of reflected microwaves. The SRC tested the instrument for its effectiveness to plot new highways, which resulted in extremely accurate designs that were faster and more economical to produce than the traditional triangulation or traverse methods. Aerial photography and photogrammetry was also used in 1950s highway design, which allowed alternate routes to be developed without the use of additional survey crews. The Rising Sun Bypass, the three-mile relocation of US 1, was the first project in Maryland to incorporate photogrammetry in its plan (URS 2011: 4-1).

In 1958, the state was also approved to receive over $56 million in 1960 for its share of the cost to construct interstate roads in Maryland (URS 2011: 3-9). Despite the SRC's goal to improve primary and secondary routes, the construction deadline for the federal interstate project in 1969 was imperative.

In 1960, the *Go Roads* program was instituted and required the SRC to complete 100 miles of primary and interstate highway construction in every region of Maryland by 1965. These were largely secondary highways, feeder roads connecting to arterial roads (Bruder 2011: 37). Between 1948 and 1960, the state constructed approximately 586 bridges on state and county roads and 203 interstate bridges (URS 2011: 3-1; 3-2).

By 1960, the SRC had completed the Baltimore-Harrisburg Expressway (I-83) and portions of the Capital Beltway. The four lane, divided Baltimore Beltway and its interchanges were constructed and completed in 1962, a solution to the congested old turnpike roads that ran through Maryland's downtowns. The SRC planned to complete interstates Washington Beltway (I-495) and the Northeast Expressway (I-95) between White Marsh Road and the Delaware State line. The Northeast Expressway was finally completed in 1963 (Bruder 2011: 41-43).

Conclusion

By 1965, Maryland had completed its 12-Year Program and had a modern road system of primary and secondary highways. The interstate and highway system had dramatically changed Maryland's landscape from what it was at the turn of the twentieth century. Maryland, like other states, became more populated and spread out in the twentieth century, necessitating the expansion of its roadways to meet the continued suburban development of its landscape. The majority of the state's roadways and associated structures including bridges continue to be used and adapted to provide travel routes for the growing development within Maryland.

F. Associated Property Types and Registration Requirements

Registration Requirements

These general requirements may be utilized for determinations of National Register eligibility in addition to the specific requirements described for each bridge type. The National Register criteria can be applied to the historic contexts as described in Section E:

1. Early Road Bridge Construction, 1694-1783
2. Post-Revolution Bridge Building, 1783-1898
3. Roadway Improvements, 1898-1918
4. The Rise of Automobile Ownership, 1918-1945
5. The Age of the Modern Highway, 1945-1965

Criterion A

A bridge may be eligible under Criterion A if it is associated with an event or pattern of events that made a significant contribution to the broad patterns of its historic context. Specifically:

A bridge may be eligible if it were associated with an early transportation route that linked Maryland to the rest of the country during its early history. An example would be the National Road or one of the early turnpikes. Likewise, a bridge may be associated with the steady expansion of a transportation network throughout Maryland in the documented period of significance. A bridge may be considered eligible if it were an early example of a significant and innovative transportation route in Maryland. Examples include bridges constructed under the Good Roads Movement and the federal highway program.

Bridges may be associated with specific transportation-related events of significance that occurred over time, such as improvements of specific highways. Similarly, bridges may be associated with technological advancements, such as association with local and state governmental efforts to improve Maryland's road system. Some bridges may be associated with events important in the history of bridge engineering, such as the evolution of specific proprietary or patented bridge designs.

A bridge may be significant under Criterion A if it directly contributed to the growth of a community or region. Additionally, bridges may be evaluated for specific association with maintenance of important stream and river crossings (if applicable, for association with navigation on a relevant water body) near individual communities, farmsteads, mills, commercial sites, or industrial sites.

A bridge may be associated with the efforts of specific individuals or groups significant in the history of a Maryland community, region, the state itself, or the nation. If a group includes members of individual distinction, a bridge associated with the group may be eligible. Otherwise, a bridge associated with a group should be evaluated for association with specific Maryland political, economic, social, or military events associated with that group.

Some bridges may be eligible for significant association with specific Maryland political, economic, social, or military events. To be eligible for association with such specific events, a particular bridge must have played a direct, documented historical role at such events. For this kind of specific event association, it is not sufficient for the bridge to be a successor to the actual bridge where the event took place.

A bridge eligible under Criterion A would have to retain enough integrity to convey the historic period, although it would be understood that such modern additions as an asphalt deck surface would be present. Likewise, alterations due to routine maintenance and modern needs would be expected; however, the majority of materials should be present, and these additions and alterations should not detract from the bridge's character defining elements (CDEs), setting, and location.

For a bridge to be listed under Criterion A, intensive research on the individual bridge should be undertaken and should focus on previous structures at the location, the community's and associated roadway's history, and the history of that structure's construction. The association with an event as stated above needs to be specific and not general (Spero 1995: C-4 and URS 2011: 6-1).

Criteria especially useful in evaluating the significance of bridges in the "The Age of the Modern Highway, 1945-1965" context include:

- Association with statewide transportation planning efforts
- Association with large transportation infrastructure projects
- Scale
- Safety improvements
- Technology
- Integrity and type (Spero 1995 and URS 2011: 7-4 and 7-5)

Criterion B

This criterion would rarely apply to historic bridges. To be eligible under Criterion B, the bridge would have to be directly associated with a person who contributed to significant local, regional, or national events. One example in Maryland may be Governor William Preston Lane who was instrumental in getting the first Chesapeake Bay Bridge (eastbound, MIHP AA-47) built between 1947 and 1952 before he was voted out of office. The bridge is named in his honor.

A bridge may usually be significant under Criterion B if it is the only remaining, tangible entity related to the person. Typically, if the bridge is associated with a person, it is associated with an engineer, contractor, or designer, and its eligibility would fall under Criterion C.

Bridges may be associated with specific persons of local, state, or national importance, through association with specific political, economic, social, or military events, in which case the bridge would be eligible under Criterion A.

Evaluating a bridge under Criterion B involves conducting intensive research on the bridge's construction history, and its association with prominent individuals.

Criterion C

A bridge may be eligible under Criterion C if it embodies the distinctive characteristics of a type, period, or method of construction, or that represents the work of a master, or that possesses a high artistic value, or that represents a significant and distinguishable entity whose components lack individual distinction. Bridges may be considered eligible if they reflect a unique design or a significant development in the history of bridge engineering.

A bridge may be eligible under Criterion C if it were constructed by a master builder or engineer. As bridges grew more sophisticated during the nineteenth century, skilled engineers and builders were required to design and erect these structures. To be considered eligible under Criterion C, the engineers or builder must have contributed in some way to the development of the bridge. An original design or patent would give an individual a trademark to the significance of their bridge.

Bridges may be evaluated for a significant association with specific builders, engineers, or architects. These may include individual professionals, engineering or architectural firms of local, state, or national importance, as well as significant nonprofessional builders. Also included are governmental (state, county, city, or local) and corporate (railroad, canal) engineering departments. Some bridges known to have been built by local labor are not eligible through such association alone.

A bridge also may be eligible for the National Register if it is associated with designers who developed patented or proprietary bridge features, whether rare or common.

To be eligible under Criterion C, the bridge should possess enough original material to define the bridge as a strong example among other bridges of its type in Maryland. It should also possess enough of its materials to illustrate construction techniques unique to its context. For example, decorative parapets or other features should remain intact. Bridges whose superstructures have been completely replaced should not be considered eligible as they do not reflect the materials and the construction methods of the bridge's original period of significance within its historic context.

For the bridge to be significant under Criterion C, research must be conducted on that individual bridge's construction history as well as its engineer, designer, or contractor (URS 2011: 6-2). This may include company and patent records as well as community data such as county commissioner records. The research should establish the rarity and/or importance of the bridge type during the period of significance. For example, metal truss technology is increasingly rare in Maryland after World War II, and thus a truss bridge from this period would be more likely to be considered eligible under Criterion C than a similar bridge built prior to World War II.

Bridge Builders in Maryland

The earliest records do not document the names of bridge builders in colonial Maryland. The names of certain stone arch builders were known. As technology advanced, and bridges were built to serve turnpikes, canals, and railroads, engineers under those company's auspices were typically responsible for the construction of those particular structures.

During the development of metal truss bridges, the number of bridge building companies increased, and certain bridges were known to have been constructed by companies or named builders. During the early twentieth century, more bridges in Maryland were associated with standardized plans and with the State Highway Administration.

Criterion D

Properties can be eligible for the National Register if they have the potential to yield information important in prehistory or history. Because Criterion D ordinarily applies to archaeological resources, eligibility under this Criterion is not likely for bridges constructed in Maryland. Criterion D eligibility has two initial requirements, both of which must be met:

1. The bridge must have or have had information important to our understanding of human history or prehistory (if it has been used as a source of data and contains more unretrieved data, or is a likely source of data), and
2. The information must be considered important (which should be carefully evaluated within an appropriate context to determine its importance. Information is considered important when it is shown to have a significant bearing on a research design that addresses current data gaps, new theories, or priority areas identified under a State or Federal agency management plan).

In addition, the bridge must be considered the principal source of this important information;

1. Bridges of types rarely represented in the state, region, or nation.
2. Bridges of technologically innovative types or designs, where little or no additional information is available about the innovations employed.
3. Bridges built or designs by little-known persons, groups, bridge builders, engineers, or firms.
4. The oldest Maryland examples of each particular bridge type and subtype (including twentieth century structures of standardized plans). These are eligible as the principal sources for information concerning the introduction and early development of bridge technologies within Maryland.

Integrity

Maryland's historic bridge resources should be evaluated using NRHP eligibility criteria and aspects of integrity, as outlined in *National Register Bulletin 15, How to Apply the National Register Criteria for Evaluation*.

According to NRHP Bulletin 15, a bridge "must" be considered in its entirety for eligibility; this includes both the super- and substructure. The level of integrity that an eligible bridge should retain can vary based upon its significance and its age. Older resources are generally expected to retain less integrity of materials, design, workmanship, and setting than those constructed more recently.

The seven aspects of integrity include: location, setting, design, workmanship, materials, feeling, and association. A bridge retaining its integrity will more than likely possess several of the seven facets if not all. However, some aspects will be more important than others. For example, where materials are of such high importance because of their engineering significance, other elements may be less important such as the setting (NCHRP 2005: 1-8). In determining whether a bridge retains its integrity, it is important to ascertain whether the structure retains its "identity" within its significance.

A bridge eligible for listing in the NRHP under Criterion A or Criterion B for its historic association should retain sufficient integrity of association, materials, feeling, setting, and location in order to convey information regarding its relationship with the historic event, trend, or person. A bridge significant under Criterion C, for illustrating a particular style or construction technique or the work of an engineer or architect must retain integrity of materials, design, workmanship, and setting.

Although a bridge may be in poor condition or may be functionally obsolete, this should have no bearing on its integrity (NCHRP 2005 C-9); the bridge may still retain its integrity of setting and location as it has not been moved. It may still retain its integrity of materials, workmanship, and design in that it retains original materials and no alterations to its design. In keeping these five or even three of these characteristics the bridge still would retain its integrity of feeling and association.

Although a bridge's use can alter throughout the course of time, such as a railway to highway bridge; it must continue operate in its intended way. Exceptions to this rule are rare, such as a bridge that was moved to another location to be preserved (NCHRP 2005: 1-8). In rare instances, an existing bridge was strengthened by another structural system. If the original structure remains largely intact, that will lessen the degree of compromise. This would require a case-by-case evaluation (Spero 1995: C-30).

For a bridge to be evaluated for National Register eligibility, a study of past alterations and changes since construction must be completed. Information can be gained from existing official bridge records, plans, and historical resources. The assessment of alterations should gauge the impact of the alterations upon overall significance and historic integrity and should be made on a case-by-case basis. Alterations made within the period of significance may be considered significant or contributing to the historic and technological significance of the bridge. For example, a recent alteration is more serious than one that occurred in the period of significance, excepting replacements in-kind (Spero 1995: C-30-31).

If a bridge has been altered through damage or repair, its integrity could be compromised. Depending on what was done and how it was done, the alterations would be considered major or minor. If repairs were done in-kind, this would be considered minor. However, replacements or repairs with unsuitable materials would be considered major. Like-dimensioned elements may replace materials when the original has been damaged whether by accident or through material deterioration, however the fundamental material should be the same. Materials with increased strength and/or reliability may be substituted if safety or availability requirements dictate the change. For example, untreated wood may be replaced with treated wood, iron replaced with steel, stone with concrete that has a stone veneer, etc. The replacements should not be visually intrusive to the structure. Replaced materials that are not in-kind but not disruptive to the bridge's visual impact are considered a moderate loss of integrity. Inappropriate replacements are considered a major loss of integrity (Spero 1995: C-30).

Character Defining Elements

To assist in deciding if the bridge retains its integrity, the structure needs to be evaluated to see if its Character Defining Elements (CDEs) convey the time that bridge was built (NCHRP 2005: 1-8). CDEs are those components of a particular bridge type that contribute to its design. Each bridge type is unique in possessing its own CDEs. These would include parapets, arch rings, and barrel vaults on a stone arch bridge while including chords, verticals, and endposts on a truss bridge. Furthermore, each bridge type has primary CDEs that are more important to the design of the bridge, with secondary and even tertiary CDEs that are not as relevant. CDEs are outlined for each of the bridge types in Section F.

Each bridge type comprises a hierarchy of elements that can be narrowed into primary importance [P], secondary importance [S] and tertiary importance [T]. Primary elements contribute in a major way to the structure's essential characteristics. Secondary elements are less crucial to those characteristics and tertiary elements are incidental to the structure's essential characteristics. Some elements such as bridge plaques are desirable when extant because they play a major role in establishing a bridge's significance. Applied ornamentation is considered as a separate element (Spero 1995: C-29).

In some cases, bridges may exhibit additional functional features that are tertiary [T] in conveying a bridge's integrity unless they are a primary design co-objective, in which case they are primary [P]. These additional functional features include, but are not limited to (Spero 1995: C-32):

- Lamp posts – [P] if designed for bridge and integrated into design, their loss or disharmonious replacement becomes more serious, importance declines with technological interest in bridge type.
- Streetcar tracks – [P] if provisions for streetcars was a primary design co-objective, tracks increase importance.
- Streetcar catenary supports and lines – [P] if provision for streetcars was a primary design co-objective, catenary supports and lines increase in importance.
- Toll houses – [P] if designed as an important architectural element of the bridge, toll houses increase in importance.

- Signage and traffic control devices – gates for movable bridges are more important than signage on other types of bridges.
- Manhole covers – [S] if designed especially for bridge, manhole covers increase in element importance, but never exceed secondary importance.
- Utility pipes and conduits – if integrated into design as visually or structurally important element, their loss is important; otherwise, they are of negligible importance, unless the retrofitting of them has seriously compromised design.
- Waterflow control devices – if the bridge was designed with the control of water flow as a primary co-objective.

Bridge Types and Registration Requirements

This section will describe Maryland's roadway bridge types, their registration requirements, and Character Defining Elements. The bridge types include:

- Timber Bridges
  - Uncovered (beam or trestle)
  - Covered
  - Timber and Concrete Composite
- Stone Arch Bridges
- Metal Truss Bridges
  - Pratt Truss
    - Double Intersection Pratt Truss (Whipple, Whipple-Murphy, or Linville)
    - Pratt Half-Hip Truss
    - Parker Truss
    - Camelback Truss
    - Baltimore (Petit) Truss
    - Pennsylvania (Petit) Truss
  - Warren Truss
  - Bowstring Arch Truss
  - Bollman Truss
  - Wichert Truss
- Movable Bridges
  - Swing, Bascule
  - Vertical Lift
  - Traversing/Retractile
  - Pontoon/Floating
- Metal Girder
  - Rolled Girder
  - Rolled Girder (Concrete Encased)
  - Plate Girder
  - Plate Girder (Concrete Encased)

- Metal Suspension, Arch, and Cantilever Bridges
- Concrete Bridges
  - Concrete Arch (filled spandrel, closed spandrel, open spandrel, through/rainbow)
  - Standardized Types
    - Concrete Slab Bridges
    - Concrete Beam Bridges
    - Rigid Frame Bridges
    - Culverts

Timber Bridges

Background

The earliest bridges built in North America were timber bridges. The earliest recorded timber bridge-like structure built by European settlers in America was constructed in 1611 on James Towne Island, Virginia which extended approximately 200 feet into the water and provided docking facilities in a 12-foot-deep channel (Spero 1995:36). The timber bridge was functionally popular in Maryland from the European settlement era to the twentieth century. The earliest timber bridges were constructed with simple beam-types and king and queen post truss types. These could be constructed rapidly and cheaply over Maryland's small streams and rivers (Spero 1995:44).

Early techniques, with modifications, were built extensively throughout the seventeenth and eighteenth centuries. When an increase in span was needed, master carpenters and builders began to experiment with new bridge designs that utilized timber arch and truss forms. Timothy Palmer designed the Piscataqua Bridge, also known as the "Great Arch," in Portsmouth, NH in 1794 with an arch-truss section and a vertically curved floor system supported by three concrete ribs. Theodore Burr developed a truss-arch combination, which he patented as the Burr truss in 1817. This design enabled the increase of the length of individual spans by reducing the sag of the road surface. Itiel Town is known to have designed the first true truss bridge in 1820, the Town lattice truss, composed of a stiff web of closely spaced diagonal timbers. The Long truss was patented by Colonel Stephen Long in 1829 and was a lattice truss that was refined to its essential elements (Spero 1995: 41).

In the early nineteenth century, Maryland took advantage of the evolving bridge truss technology, and the major river crossings attracted significant bridge builders to Maryland. In 1817-1818, Theodore Burr built the Rock Run Bridge over the Susquehanna at Port Deposit, which was rebuilt in 1824 (Spero 1995: 44).

Wood members were prone to deterioration from the elements, so the majority of these bridges were covered with roofs and wood siding to protect them (Spero 1995: 41). This resulted in the bridge we know of today called the covered bridge. By the 1860s, the problem of wood deterioration was under better control with the invention of pressure creosote treatment, which extended the life of the wood members (Spero 1995: 42).

The combination of timber with other materials began with the invention of the Howe truss in 1840, which utilized iron verticals as tension members and wood diagonals as compression members (Spero 1995:42). Timber bridges remained popular through the 1880s even with the ascension of iron and steel. Timber bent pile structures remained popular, especially in tidal areas, and were most often used in combination with concrete (Spero 1995:42). A significant technological development in the 1930s permitted construction of timber-concrete composite structures, featuring decks utilizing both timber and reinforced concrete (Spero 1995: 42).

Description

Uncovered Bridges

Historically, Maryland had an abundance of small, uncovered bridges of the timber beam and king-post and queen-post truss varieties. The shortest spans were simple beams to which flooring and rails were nailed. For spans that were 10 to 30 feet, a simple triangular frame with a central tension rod or post formed the supporting truss. Many of these bridges were replaced by the metal truss and later by the concrete spans that supported the growing traffic demands (Spero 1995: 45).

Timber Beam Bridges

Timber beam bridges consist of timber beams (stringers) supported by timber, masonry, or concrete abutments. Intermediate supports may be timber pile bents, while railings and floor system are usually wood (Spero 1995: 47).

Timber Trestle Bridges

Timber trestles were frequently used as railroad bridges and consisted of timber beams supported by a system of high timber piers or pile bents (Spero 1995: 47).

Timber Covered Bridges

Covered bridges consist of a structural timber truss covered by wood roofing and siding which serves to protect the structural components from the weather. A variety of truss types were used, including king-post, queen-post, Town, and Burr. The truss systems include vertical and diagonal elements, between horizontal upper and lower elements called top and bottom chords. In the Burr arch-truss variant, a timber arch is added to provide further structural support (Figure 5). In the Town truss variant, also called a lattice truss, the truss consists of timber members crossing at 45- to 60-degree angles, connected with wooden pins or trunnels. Timber covered bridges often feature wood plank decking supported on a system of timber stringers and floor beams; wheel guards and plank runners are sometimes installed on the decking. Typically, timber covered bridges are supported on masonry abutments and (if more than one span) piers (Spero 1995: 47).

Smaller covered timber bridges were more common, including the Roddy Road Covered Bridge over Owens Creek in Frederick County MD (NR # 78003176, MIHP F-6-6) which is a single-span, king-post truss bridge that has stood in its current location since circa 1850. This bridge is listed on the National Register of Historic Places under the *Covered Bridges in Frederick County, Maryland* Multiple Property Documentation Form.

A 1937 survey of the state's covered bridges found 52 covered bridges, 35 of which were extant at the time of the survey, including Burr, bowstring, queen-post, and king-post truss-type bridges (Spero 1995: 44). Storms, fire, development, and vandalism reduced this number to seven known covered bridges in Maryland as of Spero's 1995 historic context.

Timber and Concrete Composite Bridges

Timber and concrete composite bridges include a superstructure consisting of a composite timber and concrete slab. The timber and concrete materials work integrally to carry the deck loads. These composite decks are typically supported on timber piers or piles. Railings may be of wood or concrete (Spero 1995: 47).

Many of the timber bridges constructed in the twentieth century in Maryland were timber and concrete composite structures, which were especially favored in the flat terrain of the tidewater region. This type was introduced in Maryland by the State Roads Commission engineers. The earliest of this type was built in 1937-1938 in tidewater Maryland. Three were built in Wicomico County, and one each in Calvert, St. Mary's, Queen Anne's, Kent, and Caroline Counties (as of the 1993 State Highway Bridge Inventory, seven of these eight bridges were extant). The longest of these was the timber and concrete composite bridge over the Tony Tank Pond on the road from Salisbury to Princess Anne near Salisbury in Wicomico County (Spero 1995: 45-46). This bridge type continued to be built under state authority between 1939 and 1960, primarily on Maryland's eastern shore and southern Maryland (Spero 1995: 46).

Registration Requirements

In addition to the general requirements outlined in the beginning of Section F, the following specific associations may be utilized for determinations of National Register eligibility for this bridge type.

Timber-beam bridges in single span and multi-span variants are generally associated with the steady expansion of the rural road network throughout Maryland in the period of significance, 1724-circa 1900, under local government authority. Multiple span timber beam roadway bridges may be associated with the growing professionalism of highway engineering in Maryland during the later part of the period. In Maryland, timber beam bridges may be expected to have been built throughout the state, but with a likely preponderance in low-lying Tidewater areas. This bridge type embodies a craftsman tradition deriving from colonial and European sources (Spero 1995: C-4-5).

Ca. 1800-ca. 1900 is the period of significance for **covered timber** bridge construction in the state, which includes major long span river crossings by significant bridge builders Theodore Burr and Lewis

Wernwag, as well as a large number of smaller timber covered bridges built with different truss configurations; simple king-post and Burr arch-truss are known to have been utilized (Spero 1995: 47).

Timber-truss (uncovered) bridges were built throughout the state but with a predominance in the Piedmont and Appalachian Plateau areas. Like timber-beam and stone arch bridges, they do embody a craftsman tradition deriving from colonial and European sources. Associated with the craftsman tradition as well as proprietary or patented designs, timber-truss (uncovered) bridges represent the nineteenth century transition toward professional bridge engineering. Timber-truss uncovered bridges are generally associated with the steady expansion of the transportation network between 1800-1900, under local governments. Long-span timber-truss road bridges were built during the early part of the period for major river crossings. These are also associated with the transition to professionalism within American civil engineering during the period of significance. Since these were built to popular proprietary or patented designs (Burr, Town, and others) developed during the early 19th century by bridge builders, this kind of bridge may retain significance as a good or representative Maryland example of a particular proprietary or patented type (earliest and longest examples included). (Spero 1995: C5-7-8).

Timber-trestle bridges are generally associated with the steady expansion of the rail transportation network during 1840-1900 and are therefore not included in this MPDF.

Timber-concrete composite bridges were built primarily in the lower-lying Tidewater area, where conditions favored their construction by the State Roads Commission at road crossings over water bodies. Timber and concrete composite bridges are specifically associated with the expansion and improvement of the Maryland state roads network, under the aegis of the State Roads Department during the period of significance (1935-1960). Many of these bridges derive significance from association with the effort of engineers of the Maryland SRC to improve Tidewater highways. Those known to have been built by local labor are not eligible through such associations alone (Spero 1995: C-10-11).

Small timber beam and metal beam structures, generally less than 20 feet, may be eligible under Criterion C if they date between 1933-1947 and have all their CDEs present (Spero 1995: 4-18).

Character Defining Elements

All timber bridge types may be used as culverts (bridges with spans of less than 20 feet). The following are CDEs and primary (P), secondary (S), and tertiary (T) elements for timber bridges in Maryland (Spero 1995: C-32-38):

- Beam Bridges
    - Superstructure
        - Longitudinal beams (stringers) [P] [CDE]
        - Floor system [S]
        - Deck [T]
        - Railing [P] [CDE]

        - Applied ornamentation (rare) [T]
        - Identifying plaques, plates, or imprints [P]
    - Substructure
        - Abutments [P] [CDE] – timber, masonry, or concrete
        - Pile bents or piers of timber, masonry, or concrete [P] [CDE]
        - Applied ornamentation [S]
        - Identifying plaques, plates, or imprints [P]
        - Endpost section of railing, attached to abutment [S]
- Truss – Uncovered
    - Superstructure
        - Truss (types: king-post, queen-post, Pratt [timber and iron], Haupt [e.g. 1866 Susquehanna River bridge, w/swing span])
            - Endpost [P] [CDE]
            - Bottom chord [P] [CDE]
            - Vertical(s) [P] [CDE]
            - Top chord (not present on king-post) [P] [CDE]
            - Floor beams [P]
            - Stringers [P]
        - Deck [S]
        - Railing [S]
        - Applied ornamentation [T]
        - Identifying plaques, plates, or imprints [P]
    - Substructure
        - Abutments of timber, masonry, or concrete [P] [CDE]
        - Pier(s) of timber, masonry, or concrete [P] [CDE] (when present)
        - Applied ornamentation [T]
        - Identifying plaques, plates, or imprints [P]
        - Endpost section of railing, attached to abutment [S]
- Truss – Covered
    - Superstructure – structural
        - Truss (types: king-post, queen-post, Town, Burr, Burr-arch, Long)
            - Endpost [P] [CDE]
            - Bottom chord [P] [CDE]
            - Vertical(s) [P] [CDE]
            - Top chord (not present on king-post) [P] [CDE]
            - Arch (present in Burr-arch) [P] [CDE]
            - Floor beams [P]
            - Stringers [P]
        - Deck [S]
        - Railing (NA)
        - Applied ornamentation (probably not an issue)
        - Identifying plaques, plates, and imprints [P]

- Superstructure – covering
  - Framing [S]
  - Roof [P] [CDE]
    - Roofing material [S]
  - Siding [P] [CDE]
  - Portals [P] [CDE]
  - Applied ornamentation [S]
  - Identifying plaques, plates, and imprints [P]
- Substructure
  - Abutments of masonry or concrete [P] [CDE]
  - Pier(s) of masonry or concrete [P] – when present [CDE]
  - Applied ornamentation [T]
  - Identifying plaques, plates, and imprints [P]
  - Endpost section of railing, attached to abutments [S]

- Trestle
  - Superstructure
    - Beams [P] [CDE]
    - Railing of timber [S]
  - Substructure
    - Abutments of timber, masonry, or concrete [P] [CDE]
    - Piers of timber [P] [CDE] (or)
    - Bents of timber [P] [CDE]
  - Applied ornamentation [T]
  - Identifying plaques, plates, and imprints [P]
- Timber and Concrete Composite
  - Superstructure
    - Composite timber and concrete slab [P] [CDE]
    - Railing of timber or concrete [P] [CDE]
    - Applied ornamentation [T]
    - Identifying plaques, plates, and imprints [P]
  - Substructure
    - Timber piers [S] [CDE] (or)
    - Timber bents [S] [CDE]
    - Applied ornamentation [T]
    - Identifying plaques, plates, and imprints [P]
    - Endpost section of railing, attached to abutment [S]

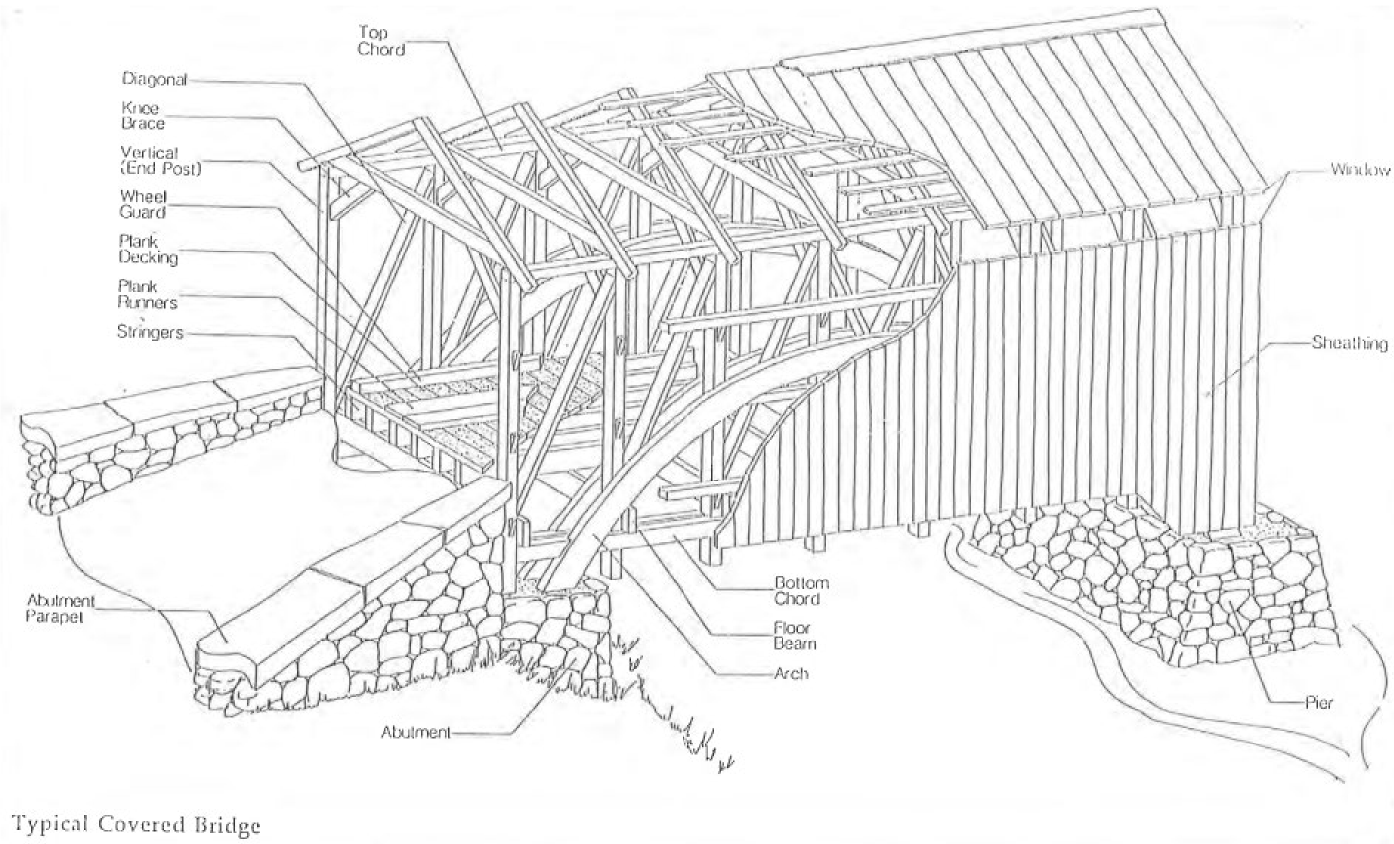


Figure 4: A Typical Covered Bridge (Pennsylvania Historical and Museum Commission and Pennsylvania Department of Transportation 1986)

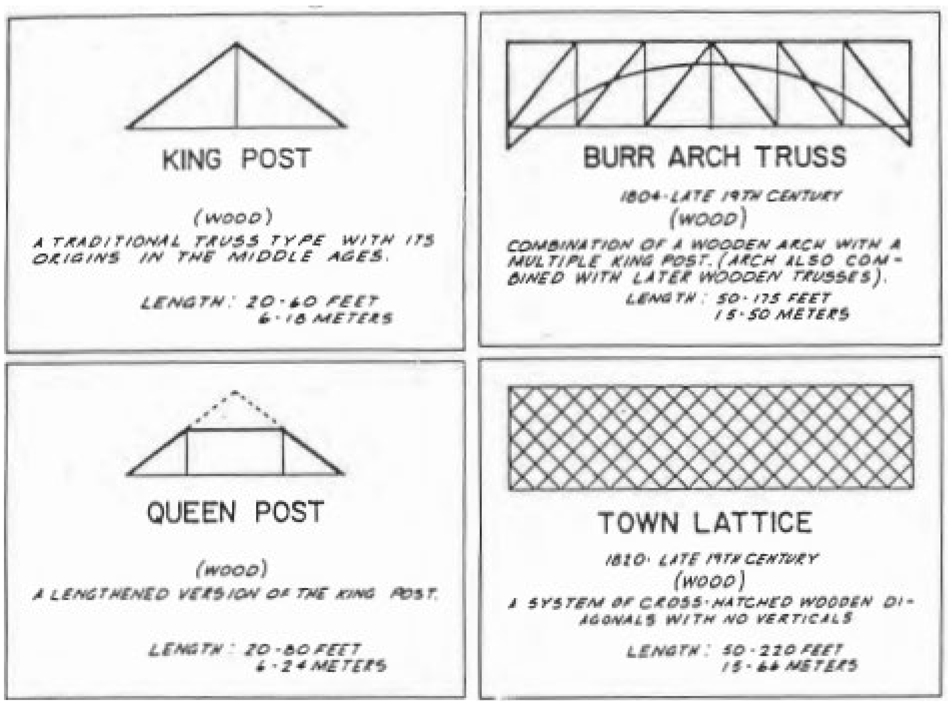


Figure 5: Wood Truss Types (Allen and Jackson 1975)

Stone Arch Bridges

Background

The stone arch bridge represents one of the earliest recorded advances in bridge building as the use of the structural arch form better supported loads. Early stone arch bridges would have been relatively small structures spanning culverts and waterways; however, as engineering techniques improved, stone arch bridges would span greater distances and withstand the weight of trains (Spero 1995: 49). Turnpike companies would typically hire experienced masons to construct stone arch bridges. However, the maintenance of the bridge would become an issue with deterioration problems eventually developing.

The earliest arch-like structures were found in ancient Mediterranean lands and were perfected during the Roman Empire (Trachtenberg and Hyman 1986: 117). Proto types of arch construction started from post and lintel structures and progressed to corbelled arches (Spero 1995:49). It was not until the Roman republic that the sophisticated barrel arch was perfected and used in bridge construction and other civil works as the empire grew.

European colonists brought stone arch bridge traditions with them to the New World. The earliest stone bridge in the 13 colonies dates to 1697 in Philadelphia (NCHRP 2005: 3-48, 49). The earliest mention of stone arch bridges in Maryland was in a 1794 law that stated the maximum length of a stone arch bridge to be constructed by a "common laborer" was less than 15 feet (Spero 1995:50). However, it was not until the first decades of the nineteenth century that stone arch bridges were readily constructed in the country (NCHRP 2005: 3-48). What makes the stone arch bridge one of the most popular historic bridges is its construction, strength, and its durability throughout the years. Many stone arch bridges were constructed between 1790 and 1840 along turnpikes where there had been earlier wooden bridges or ferries along the previous roadway (Spero 1995: 49).

In Maryland, stone arch bridges were primarily built in the Piedmont and Appalachian Plateau areas, where building materials were readily found and site conditions were favorable, examples being along long-standing fords and mill sites (Spero 1995: C-13).

Between 1811 and 1825, the construction of the National Road between Cumberland, MD and Uniontown, PA (a landmark federal public works project) involved the design and construction of numerous stone arch culverts and larger bridges. This road construction spurred the extension of the Baltimore and Frederick Turnpike to meet the National Road in Cumberland, resulting in the construction of more stone arch culverts and bridges (Spero 1995: 55).

Stone arch bridges constructed to span canals were generally associated with the C&O Canal (Spero 1995: C-11). Canals required a variety of bridge structures, including short spans to carry the towpath from one side to the other at tight places, and culverts and aqueducts to take the canal itself over rivers and roads (Spero 1995-51). Stone arch bridges constructed to serve early railroads (1825 and 1850) would have been associated with the early development and expansion of these transportation routes in Maryland. The B&O Railroad built a large number of early stone arch bridges. The Frenchtown & New Castle Railroad in Cecil County also included a stone arch bridge built in the 1830s. Stone arch bridges associated with the railroad after 1850 and until 1910 reflected the growth of the railroad industry and the continuing development of bridge techniques (Spero 1995: C-11). Stone arches over canals and railroads were typically designed by a trained engineer compared to turnpike bridges (Spero 1995: 49-50). Stone arch bridges built to carry canals or railroads are not included in this MPDF.

The Good Roads Movement began in the late nineteenth century and ended at the creation of the National Highway System in 1926. The Movement aimed to build and improve the condition of roads in the country. In Maryland, an 1899 comprehensive report of the Highway Division of the Maryland Geological Survey reported that there were many stone arch bridges in deteriorated condition, one of the factors being moisture entering the structure and freezing, thus creating internal bulging (Spero 1995: 56). The State Roads Commission purchased almost 190 miles of old turnpike rights-of-way in 1910 and 1911 and implemented a program to save the old stone arch bridges, noting that many were “important and valuable both physically and historically (Maryland State Roads Commission 1912b: 80).

Turnpike stone arches were likely to deteriorate from poor design and not receiving regular maintenance (Spero 1995:51-52). Private turnpike companies did spend considerable capital building masonry arch bridges under the direction of experienced masons (Spero 1995: 51). After the coming of the automobile, many older stone bridges were destroyed or seriously altered (Spero 1995: 52). As technology progressed, stone arch bridges might have been constructed by companies and professional masons and not by local craftsmen.

Stone arch bridges were built less frequently as metal truss bridges became more popular. With the technological advancement of reinforced concrete during the early twentieth century, stone arch bridges requiring specialized skills were no longer built (NCHRP 3-49). The stone arch bridge made a modern contribution to the development of concrete bridge technology, providing the precedent for arches constructed of both unreinforced and reinforced concrete (Spero 1995:52).

Description

A typical stone arch bridge possesses a barrel vault or ring, spandrel wall, fill material, the deck (roadway), and parapet walls. The spandrel walls on the outermost edges of the arch serve as retaining walls to contain the fill material, which can include rubble, large rocks, or dry soil, that is deposited over the arch. The arch is in compression and carries the loads via the deck and spandrel walls, which typically extend above the roadway deck level to form the parapet walls. Occasionally, a belt course may be included to give a greater definition to the parapet. This bridge type may also feature a date stone placed within the parapet. Substructural supports include masonry abutments and wingwalls, and if the bridge is multi-span, masonry piers. Many stylistic variations are possible both in form and in treatment (Spero 1995: 64).

The arch ring is usually decorated with voussoirs (wedge shaped cut stones) each of which exerts a downward energy. To keep the voussoirs from collapsing while the arch is being constructed, a wooden, scaffolded falsework is utilized. The top voussoir, called a keystone, is placed and the falsework is removed (Trachtenberg and Hyman 1986: 117). The keystone may be more elaborate than the other voussoirs.

The stones utilized in a stone arch bridge may consist of rubble masonry (rough unfinished and untooled stones), squared masonry (stones which have been tooled to a rectangular shape and roughly finished), and ashlar masonry (squared stones given a further tooling for a more refined finish). Construction of the substructure (piers and abutments from which the arch is said to “spring”) was first accomplished, followed by the initial building of the “arch ring” (the basic ring composed of adjacent, usually wedge-shaped stones, or voussoirs, arranged in a radiating circle or ellipse) on the temporary system of wood falsework. With the arch rings in place across the intended width of a span (the rings together comprising the arch “barrel”), the remainder of the structure, including spandrel walls built on the arch at its outermost edges, could then be erected. Fill composed of dry earth or ballast was usually consolidated on top of the arch barrel for stability and was contained within the solid spandrel walls (Spero 1995: 49).

The deck arch is characterized by the roadway or deck being carried atop the arch (Spero 1995: 123). Vertical supports called spandrels distribute the weight on the deck to the arch below. The arch is strong because the whole structure is under compression. The oldest type of the deck arch is the stone arch, which was later surpassed by concrete and steel. As observed with the bridge at MD 68 over Antietam Creek (MIHP WA-II-009), the closed spandrel deck arch consists of a solid arch barrel with solid side walls containing fill to support the roadway and its traffic load. The open spandrel arch consists of two or three ribs that transfer the loads to the arch foundations (Bruder 2011: 54). Charles Latrobe and

Associates designed several deck arch bridges in the City of Baltimore for the Jones' Falls Improvement Commission between 1870 and 1900 (Spero: 1995: 131).

The design characteristics of Maryland's extant historic stone arch bridges vary in number of spans, shape of piers and parapets, rise-to-span ratio, type of stone employed (brick was also utilized in some cases), and in the treatment of the masonry (coursed rubble, squared, or ashlar).

Registration Requirements

In addition to the general requirements outlined in the beginning of Section F, the following specific associations may be utilized for determinations of National Register eligibility for this bridge type.

Existing stone arch bridges represent the transportation trends of the late-eighteenth and early-nineteenth centuries. Stone arches may be associated with specific transportation related events of significance that occurred over time, such as the construction of the National Road or specific turnpikes (Spero 1995: C-12). For example, the oldest documented stone arch bridge in Maryland is the Parkton stone arch, a two-span masonry bridge over the Little Gunpowder Falls, built in 1809 for the Baltimore and York Turnpike (MIHP BA-593). The state's second-oldest documented stone arch turnpike bridge is the Casselman River Arch, erected in 1813 on the National Road near Grantsville (NR# 66000391, MIHP G-II-C-014) (Spero 1995: 57).

The earliest period of significance for stone arch bridges in Maryland is 1790-1830, when this bridge type was first constructed along turnpikes and the National Road. In Maryland, stone arch bridges are associated with the early development of the state's transportation system, which included roads, canals, and railways, but only stone arch bridges built for roadways are eligible under this MPDF. Early stone arch bridges constructed during this period would be associated with the improvement of Maryland's road system through construction of turnpikes and the National Road. Those stone arch bridges serving roads constructed after this date would have reflected further construction techniques and refinements of engineering and construction (Spero 1995: C-11).

Stone arch bridges built for roadways between 1790 and 1830 are often associated with locally prominent craftsmen such as the Lloyds and their associates. The Lloyd family of Chambersburg, Pennsylvania, and their associated masons dominated construction of the early nineteenth century stone arch highway bridges of Washington County (Spero 1995: 53).

Stone arch bridges built between 1825 and 1850 are most associated with railroad stone arch bridge construction. Bridges built between 1850 and 1910 are associated with the continued use of railroad bridge construction and expanded use on the roads of the Piedmont and Appalachian Plateau regions of Maryland. Stone arch bridges and aqueducts were constructed for the C&O Canal between 1828 and 1924 (Spero 1995: 64).

Stone arch bridges embody a craftsman tradition derived from colonial and European sources. Refining the basic earlier craftsman tradition, these bridges built after 1850 may be associated with specific engineers or highway engineering departments (Spero 199: C-13).

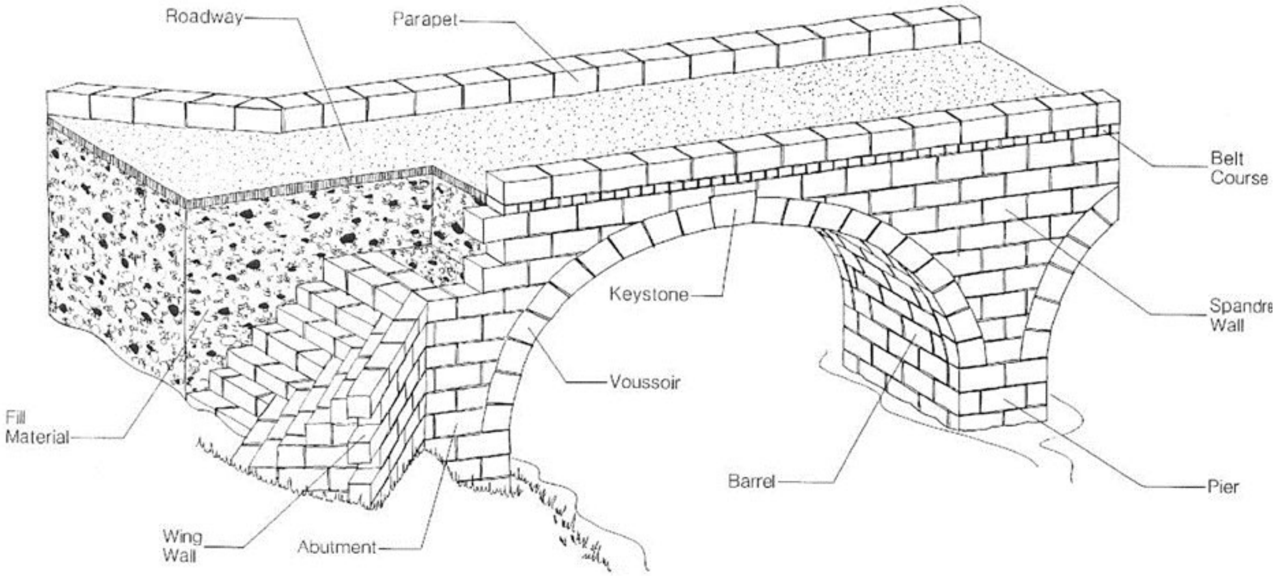
Small masonry arches generally less than 20 feet may be eligible under Criteria A, C, and D if they were constructed before 1800 or between 1800-1850 and have most of their CDEs present (Spero 1995: 4-18).

Character Defining Elements

Stone arch bridges may be used as culverts (bridges with spans of less than 20 feet). Stone arch bridges are most often constructed of stone, but in rare instances are constructed of brick. The fabrication of the stone may be rubble (rough unfinished and untooled stones), squared (stones tooled to rectangular shape and roughly finished), or ashlar (squared stones with more refined finish).

The following are CDEs, primary (P), secondary (S), and tertiary (T) elements for stone arch bridges in Maryland (Spero 1995: C-36, C-37):

- Superstructure
  - Arch ring [P] [CDE]
  - Barrel [P] [CDE]
  - Spandrel wall [P] [CDE]
  - Parapet [P] [CDE]
  - Fill [S] [CDE]
  - Roadway [T]
  - Applied ornamentation [T]
  - Identifying plaques, plates, and imprints [P]
- Substructure
  - Abutments [P] [CDE]
  - Wing walls [P] [CDE]
  - Pier(s) [P] [CDE]
  - Applied ornamentation [T]
  - Identifying plaques, plates, and imprints [P]
  - Endpost section of parapet, attached to abutment [S]



Typical Stone Arch Bridge

Figure 6. Elements of a Stone Arch Bridge (PHMC and PennDOT 1986).

Figure 7. MD 68 over Antietam Creek Stone Arch Bridge in Washington County (SHA Bridge #2103800 and MIHP # WA-II-009)

Metal Truss Bridges

Background

As Maryland's traffic volume increased, timber bridges were no longer adequate to meet traffic requirements, and soon metal bridges were replacing the older bridges (Spero 1995: 79). The success of the metal truss bridge spread throughout the state when counties realized that the bridge type was able to withstand heavy loads and did not have the deterioration problems that timber bridges faced (Spero 1995: 80). Metal truss bridges were also more likely to survive flooding at water crossings than timber bridges.

The advancement of the truss bridge in Maryland grew directly out of the burgeoning railroad industry (Spero 1995: 78). Metal truss bridges continued the truss technology that had been evolving in wooden truss bridges, especially as stronger bridges were required to support the weight of trains. The Baltimore and Ohio Railroad would be the first to experiment and fully develop how well a metal truss bridge could function; the Bollman Truss bridge in Savage (NR 72000582, MIHP HO-81) is one such example of bridge engineering experimentation (Spero 1995: 78).

There were a variety of modifications to basic early metal truss types due to refinement of mathematical analysis and empirical observation of existing bridges.

Unlike masonry and timber bridges, metal trusses required the importation of expertise and materials from urban areas (Spero 1995: 88). Originally, a representative from a chosen firm would visit the bridge site, gather necessary information on bridge type and span needed. The process became streamlined with order forms that local officials could fill out. Firms would then fabricate the truss members and ship them to the bridge site with detailed instructions. Local officials would hire local masons to construct masonry abutments prior to the erection of the truss members (Spero 1995: 88). This system of development in the latter four decades of the nineteenth century brought the improvements in metal truss technology to a peak (Spero 1995: 75).

Metal truss bridges were first constructed of wrought iron; however, as the cost of steel dropped and technological improvements to refining steel were developed during the later decades of the nineteenth century, truss bridges were constructed of steel (NCHRP 2005: 2-14, 19). Connection points also varied in metal truss bridges. As technology developed, pins were replaced with rivets which proved to be more stable. The concern with pins was that they would "wear at the point of connection." Eventually, by the twentieth century, welding replaced both pins and rivets (NCHRP 2005: 3-4).

With the advancements in iron and steel technology, the Pratt truss became a standard for mid-size spans during the last decades of the nineteenth into the twentieth century. "In 1916, bridge engineer J.A.L. Waddell claimed that the Pratt truss was the most commonly used truss for spans less than 250 feet" (NCHRP 2005:3-25).

Numerous companies in Baltimore initially served the metal truss building needs of Maryland. The W. Bollman and Company was the first company in the nation to design, fabricate, and erect bridges. They ceased operations in 1860 due to the Civil War, reopened in 1865 as the Patapsco Bridge and Iron Works, and dissolved upon Wendel Bollman's death in 1884 (Spero 1995: 86). The Smith, Latrobe and Company was organized in 1866, reorganized as the Baltimore Bridge Company in 1869, and dissolved in 1880. H.A. Ramsay & Co. operated in the 1870s and 1880s, Campbell and Zell Company operated from 1896-1899, A. and W. Denmead and Sons operated in the 1850s, and Murray and Hazelhurst constructed bridges between 1857-1869 (Spero 1995: 87).

The bridge building business was competitive, and therefore companies located out of state also built bridges in Maryland, including the Wrought Iron Bridge Company (Canton, OH), King Iron Bridge Company (Cleveland, OH), Pittsburg Bridge Company (Pittsburg, PA), Smith Bridge Company (Toledo, OH), Groton Bridge and Manufacturing Company (Groton, NY), York Bridge Company (York, PA), Vincennes Bridge Company (Vincennes, IN), and John Stauver McIlvane (Philadelphia, PA) (Spero 1995: 88-89).

By the turn of the twentieth century, reinforced concrete technology was gaining popularity, providing local officials more options for bridge types. After 1910, the State Roads Commission committed to developing standard plans for reinforced concrete bridges and intensified its efforts in the 1920s. This new technology brought the decline of the metal truss bridge. Small companies rapidly disappeared or were absorbed by larger companies including Bethlehem Steel (Bethlehem, PA), American Bridge Company (Ambridge, PA), McClintic-Marshall (Pittsburg, PA), and Roanoke Iron and Bridge Company (Roanoke, VA) (Spero 1885: 90-91).

After WWII, stronger and lighter steel, high strength bolt technology, crane efficiency, and improved falsework were developed and applied to metal truss bridge building projects. These advancements improved the metal truss building economy, yet they are only rarely built today (URS 2011: 5-3-4).

Description

Metal truss bridges are comprised of two parallel trusses and a floor system that is supported on a concrete or masonry substructure. Each metal truss consists of individual components connected in a series of triangles. The particular type of metal truss bridge is defined by the arrangement of individual members and the way in which those members are stressed with either compression or tension. A variety of configurations are possible, many of which were proprietary or patented variants (Figures 11 & 12) (Spero 1995: 92).

The horizontal portions of the truss are the top and bottom (also upper and lower) chords; vertical and diagonal members are also present. The verticals and diagonals are connected to the top and bottom chords at joints (pin connections or rivet connections are both possible). Minor web components may include sub-struts or sub-types. These members may be in tension or compression. The other components of a truss include the portal, stringers, floor beams, and deck. Portal bracing provides lateral bracing for the two parallel trusses at the top of the end posts. Stringers are longitudinal members which transmit loads to the floor beams. In turn, this transmits the loads to the trusses at each panel point (joint connection), where the floor beams, chords, verticals and diagonals are connected (Spero 1995: 92). In other words:

> *A truss is a framework composed of individual members so fastened together that loads applied at the joints produce only direct tension or compression. The triangle is the only geometrical figure in which the form is changed only by changing the lengths of the sides. In its simplest form every truss is a triangle or a combination of triangles. The members of the truss are either fastened together with pins, pin-connected, or with plates and rivets, riveted* (Ketchum 1908:1).

The simplest truss was the king post truss. It was constructed of an equilateral triangle with a vertical member bisecting the triangle at its center and would support a span of 20 to 60 feet. The queen post truss was developed from the king post and supported a span of 20 to 80 feet. The physical difference from the former was that a top chord, paralleling the bottom chord, cut the apex of the triangle with a vertical member extending down from each edge of the top chord (Figure 5).

Metal truss bridges can also be classified as through, pony, and deck trusses according to the relation of the deck (roadway floor) to the rest of the superstructure (Figure 8). In a **through** truss, the deck passes between the trusses, which also include a portal strut and top lateral bracing. A through truss bridge was designed to carry heavier loads and was able to reach longer spans than a pony truss. Some through trusses were able to reach nearly 400 feet in length (NCHRP 2005: 3-4). A **pony** truss, or **half-through** truss, does not have the top bracing that connects the side trusses:

> *In a pony truss the travel surface passes between trusses on either side that constitute the superstructure. These trusses are not connected above the deck, and are designed to carry relatively light loads* (NCHRP 2005: 3-4).

A **deck** truss bridge carries the deck on its top chord, allowing loads to travel on top of the main structure. The deck is similar to the through truss in that it can carry relatively heavy loads and fairly long spans (NCHRP 2005: 3-4).

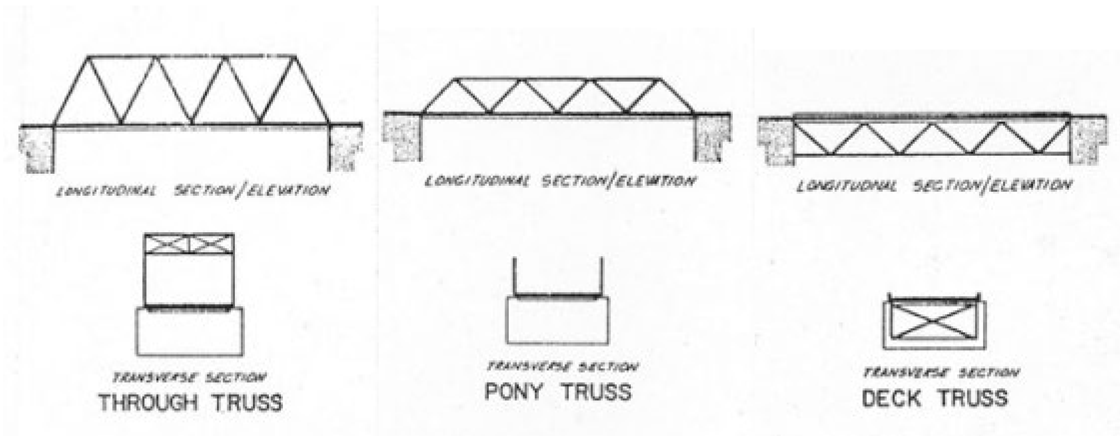


Figure 8: Through, Pony, and Deck Truss Variants (Allen and Jackson 1975)

Pratt Truss

In 1844 Thomas and Caleb Pratt patented a truss that would be used widely until the mid-twentieth century. With the Pratt truss, the diagonals are in tension and the verticals, except for the hip verticals directly adjacent to the end posts of the bridge, are in compression (Figure 11). The Pratt truss was first constructed of a combination of wood and iron and then iron. With the refinement of steel, the Pratt and its subtypes became very popular (Spero 1995:77). The advantage of the truss was that it was relatively simple to calculate the “distribution of stress throughout the structure” (NCHRP 2005: 3-25).

At first, this type was not popular because its design required more metal which was more expensive than timber. However, as the railroads expanded, they began to prefer iron bridges, and the Pratt truss was used more than other trusses. It became one of the most widely used truss types for both roadways and railways with spans measuring 250 feet or less. Through the last decades of the nineteenth and the first decades of the twentieth century, the Pratt design was the truss commonly used until the Warren truss replaced it (NCHRP 2005: 3-25). The majority of Maryland’s metal truss bridges are pin-connected or pinned and riveted Pratt through and pony truss bridges (Spero 1995:77).

Major subtypes of the Pratt design can be further categorized as follows:

<u>Double Intersection Pratt Truss (Whipple, Whipple-Murphy, or Linville):</u> This subtype was patented by Squire Whipple in 1847 and modified in 1863 by the Lehigh Valley Railroad Chief Engineer John Murphy; the modification included the addition of crossed diagonals. This bridge type is characterized by additional diagonals extended across two panels of the basic Pratt truss. It was most prevalent in the late nineteenth and early twentieth centuries and was widely used for long-span railroad bridges (Spero 1995: 77). An example of a roadway bridge of this subtype in Maryland is the Poffenberger Road Bridge over Catoctin Creek in Frederick County (NR# 78001459, MIHP F-2-5).

Pratt Half-Hip Truss: This subtype was developed during the latter part of the nineteenth century. It is characterized by included end posts that do not extend the length of a full panel. It became popular in the 1890s into the early twentieth century (Spero 1995: 77-78). An example of this subtype in Maryland is the Newcomer Road Pratt Half-Hip Truss Bridge over Beaver Creek in Washington County (MIHP WA-II-475).

Parker Truss: This subtype was developed by C. H. Parker in a series of patents he filed between 1868 and 1871. It is characterized by Pratt design but with an included top chord. It was popular for longer spans well into the twentieth century (Spero 1995: 78). One Maryland example is the Bullfrog Road Bridge over the Monocacy in Frederick County (NR# 78001461, MIHP F-6-8).

For this bridge, the top chord is curved, which creates a lighter bridge that does not lose any strength. Because of the top chord, the ends of the bridge have less dead weight giving more strength to the center portion of the structure. It is also able to span longer crossings (*Pittsburgh Bridges: A Spotter's Guide to Bridge Design.* http://pghbridges.com/basics/htm. Accessed June 2, 2006; Spero 1995: 73).

Charles H. Parker was an engineer with the National Bridge and Iron Works Company in Boston, Massachusetts. His design and patent came from his belief that less "depth of truss" was needed at the ends of the bridge than at the center of the bridge, thereby creating the polygonal truss with the shortened diagonals at the end. Because of the use of less metal, it is more economical than standard Pratt bridges when it comes to longer spans. The cost of the bridge was higher because of the required different vertical and diagonal lengths. Because the price of metal truss bridges was typically driven by the weight of the materials, the polygonal structures would offset the fabrication costs (NCHRP 2005: 3-34).

During the early years of the twentieth century, the Parker replaced the Pratt as the preferred truss for longer trusses. Many state highway departments standardized plans for pony trusses between 30 and 60 feet and for through trusses between 100 and 300 feet (NCHRP 2005: 3:34).

Camelback Truss: One variation of the Parker is the camelback truss, which is a Parker with exactly five slopes within the upper chords and endposts (NCHRP 2005: 3:35). It was popular for through-spans from its inception through the mid-twentieth century. The State Roads Commission built several of this subtype in the 1920s and 1930s. The bridge carrying MD 214 over the Patuxent River in Anne Arundel and Prince Georges Counties is a good example of this five-sloped configuration (MIHP AA-761),

Baltimore (Petit) Truss: This subtype was developed in 1871 by engineers of the Baltimore and Ohio and Pennsylvania Railroad. This subtype is characterized by Pratt design featuring additional, auxiliary sub-struts or sub-ties linking the chords and diagonal and vertical members. This type was popular into the early twentieth century (Spero 1995: 78). One Maryland example of a road bridge was in Harford County, the Old Post Road Bridge (MIHP HA-1580), which was replaced in 1979.

Pennsylvania (Petit) Truss: This subtype was introduced during the mid-1870s as a variant of the Parker truss. Similar to the Baltimore (Petit) subtype, this bridge was characterized by the addition of stubstruts to resist stresses or sub-ties to transmit stresses to a demonstrable useful form. These were constructed well into the twentieth century (Spero 1995: 78). A known Maryland example is the Glendale Road Bridge over Deep Creek Lake in Garrett County, which comprises of two spans built by McClintoc-Marshall (MIHP G-III-B-083).

Warren Truss

The Warren truss was developed by two European engineers, a Belgian named Neville and a British engineer named Francis Nash. It was designed with only diagonal members within the two chords and no verticals. A subtype of a Warren is the subdivided Warren, an adaptation, which includes a distinctive crosshatched appearance at elevation and may have vertical members. Each equilateral triangle created a truss where the diagonals acted in both compression and tension. The first Warren trusses were constructed of wrought iron and were the first all wrought iron bridges built in Europe (NCHRP 2005: 3-39).

In the United States, Warren trusses were very popular as pin-connected bridges used as both railroad and roadway bridges. By the late-nineteenth century, these types were riveted or bolted. They remained popular well into the twentieth century, occasionally seen with a polygonal top chord and as both a pony and through truss (NCHRP 2005: 3-39).

Bowstring Arch Truss

This bridge type includes an arched upper chord (either tied or rigidly fixed at the abutments) with diagonals serving as bracing and supporting the roadway. The arch-truss in the bowstring configuration (with Pratt or Warren trusses) was not frequently built until the late nineteenth century and at that was only primarily used for lightly traveled rural roads requiring smaller spans (Spero 1995: 81). The development of metal bowstring arch structures is discussed in greater detail in the suspension arch and cantilever bridges section.

Bollman Truss

The Bollman truss type is considered by some to be Maryland's most significant contribution to metal truss design. The only extant example in the world is the Bollman Truss Bridge in Savage, Maryland (NR# 72000582, MIHP HO-81). This design was patented by Wendel Bollman in 1852 and was utilized extensively for bridges supporting the B&O Railroad. The design features vertical members in tension with diagonals also in tension and running from the top corner of each truss endpost to every panel point (the joint where verticals met the lower chord) on the truss. It was a composite suspension-and-truss bridge with a non-structurally functional lower chord and diagonals performing much like the suspenders or hangers on a suspension bridge (Spero 1995: 82).

Wichert Truss

The Wichert Truss is a continuous truss and therefore has a chord and web configuration that continues uninterrupted over one or more intermediate supports. Continuous trusses were not generally used until the early twentieth century due to concerns over potential stresses caused by intermediate pier settlement. E. M. Wichert of Pittsburg addressed the problem with his Wichert truss in 1930. This was a continuous truss in which hinged quadrilateral sections were included over the intermediate piers (Spero 1995: 83).

The James Rumsey Bridge (MIHP WA-II-1122) is an early example of the Wichert truss built between Shepherdstown, WV and Washington County, MD between 1937-1939. This 1,020-foot-long structure includes six spans of Wichert continuous deck trusses with a 24-foot clear roadway. The Wichert truss is unique in that it is not its own bridge type. It is a hybrid of a truss and a girder system (Figure 10):

> *The Wichert Truss, designed by E. M. Wichert of Pittsburgh, PA in 1930, is a cantilever spandrel-braced deck arch that is not a 'true arch' bridge. The curved lower chord gives the bridge the form of an arch, but it does not rely on arch action to carry the load. The open diamond panel above each pier is the easily recognized mark of this truss type; without a vertical truss member in this hinged location* (Bruder 2011: 88).

The bridge type in Maryland was perfect for long spans and became a popular choice during the late-1930s and continued into the 1950s when portions of the Chesapeake Bay Bridge utilized the Wichert Truss (Spero 1995: 76). Several examples of Wichert Truss bridges are found in Washington County, including US 522 over MD 144 and Tonoloway Creek (WA-HAN-349), and US 40 over Licking Creek (MIHP WA-V-416, Figure 15).

The Wichert Truss bridge was constructed during the expansion of highway networks and railways throughout the state during the early- to mid-twentieth century. It was constructed to span large crossings, many over 1,000 feet.

Registration Requirements

In addition to the general requirements outlined in the beginning of Section F, the following specific associations may be utilized for determinations of National Register eligibility for this bridge type.

Metal truss bridges were built throughout the state (Spero 1995: C-15). They may be associated with specific transportation-related events of significance that occurred over time, such as improvement of specific turnpikes and highways (Spero 1995: C-14). Earlier examples of Pratt trusses that retain their CDEs would naturally be considered more significant. As the Pratt became a common bridge type, remaining examples from the early twentieth century would be less significant (NCHRP 2005: 3-25). Pin-connected Parker trusses constructed during the nineteenth century would retain the highest amount of significance. Parker trusses constructed during the early twentieth century after state highway agencies standardized plans for them would retain significance; however, it would not be as high (NCHRP 2005: 3-35).

Bridges built between 1840-1860 are significantly associated with the initial development of metal truss bridge design and the transition from truss building solely in timber to iron truss design and construction. Truss bridges built in this period may also be associated with early proprietary or patented designs (Spero 1995: C-13).

Metal truss bridges built between 1860-1900 are associated with the late nineteenth century popularization and scientific standardization of truss design and construction for highway use. This period's bridges are also associated with a wide variety of proprietary or patented designs. This period also includes an association with the movement toward all-steel trusses rather than iron bridges (Spero 1995: C-13, 92).

Although very few nineteenth-century Warren truss bridges remain, those that remain would be highly significant. Also significant would be those standardized bridges constructed during the early decades of the twentieth century. Many examples of pony and through Warren trusses constructed by state highway administrations and railroad companies during the early twentieth century exist (NCHRP 2005: 3-39).

Bridges built between 1900-1960 are associated with the increasing standardization of highly useful simply designed truss types (primarily Pratt and Warren variants) and are associated with select use in Maryland's monumental highway spans and their approaches (Spero 1995: C-14). This period is also significant for the replacement of metal trusses by metal girder bridges, which could be readily widened (Spero 1995: 93; Spero 1995: C- 13).

Character Defining Elements

The following are CDEs and primary (P), secondary (S), and tertiary (T) elements for metal truss bridges in Maryland (Spero 1995: C-38; C-39):

- Superstructure
  - Truss
    - Truss elements (built-up members composed of channels, angles, lacing bars, gussets, and cover plates)
      - Endpost [P] [CDE]
      - Bottom chord [P] [CDE]
      - Top chord [P] [CDE]
      - Verticals [P] [CDE]
      - Diagonals – looped bottom or eyebars [P] [CDE]
      - Floor beams [P] [CDE]
      - Stringers [S]
      - Bottom lateral bracing [T]
      - Sub-struts [S] [CDE]
      - Sub-ties [S] [CDE]
      - Portal strut [P] [CDE] (through truss bridges)

            - Portal bracing [P] [CDE] (through truss bridges)
            - Top lateral bracing [S] [CDE] (through truss bridges)
        - Method of truss connection
            - Pinned [S] [CDE] (cotter pins, square nuts, or hexagonal nuts)
            - Riveted [S] [CDE]
    - Deck (timber) [T]
    - Railing [S]
    - Applied ornamentation [T]
    - Identifying plaques, plates, or imprints [P]
- Substructure
    - Abutments of stone, cement, or timber [P] [CDE]
    - Bearing seats and shoes [S]
    - Pier(s) (when present) of stone or concrete [P] [CDE]
    - Applied ornamentation [T]
    - Identifying plaques, plates, and imprints [P]
    - Endpost section of railing, attached to abutment

Wichert Truss Bridges

The following are CDEs and primary (P), secondary (S), and tertiary (T) elements for Wichert truss bridges in Maryland: As the Wichert is a hybrid bridge, additional consideration should be taken.

- Superstructure
    - Steel girder/truss system [CDE]
    - Ornamental bridge railings [CDE]
- Substructure
    - Concrete abutment and piers [CDE]

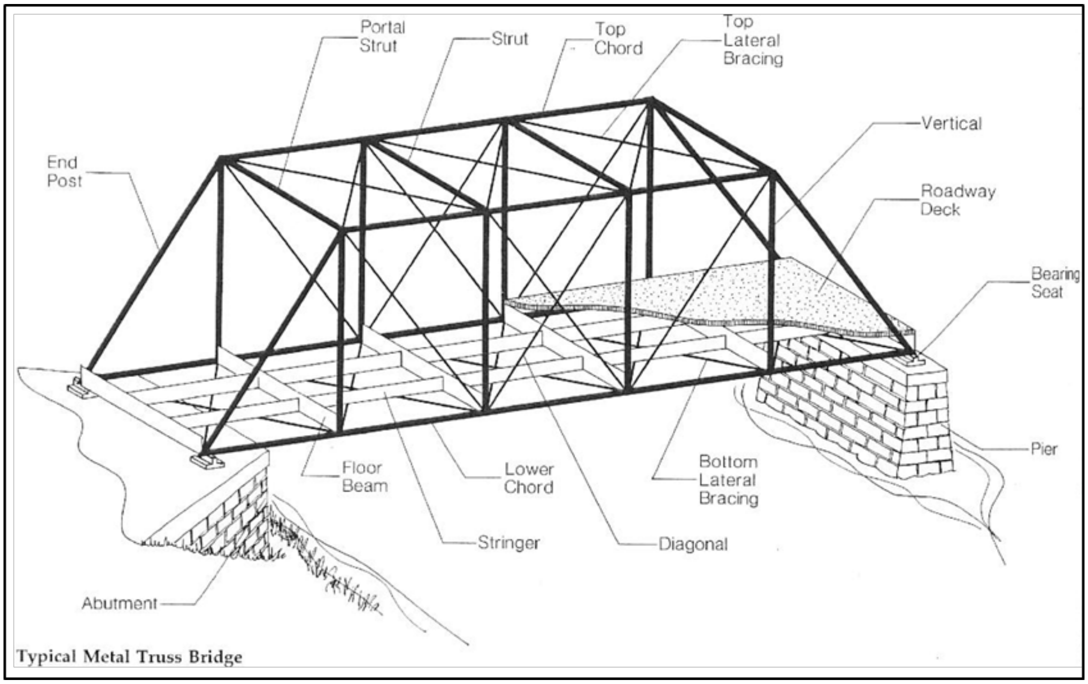


Figure 9. Elements of a Metal Truss Bridge (PHMC and PennDOT 1986).

Figure 10. Wichert Truss. (NCHRP 2005: Appendix B).

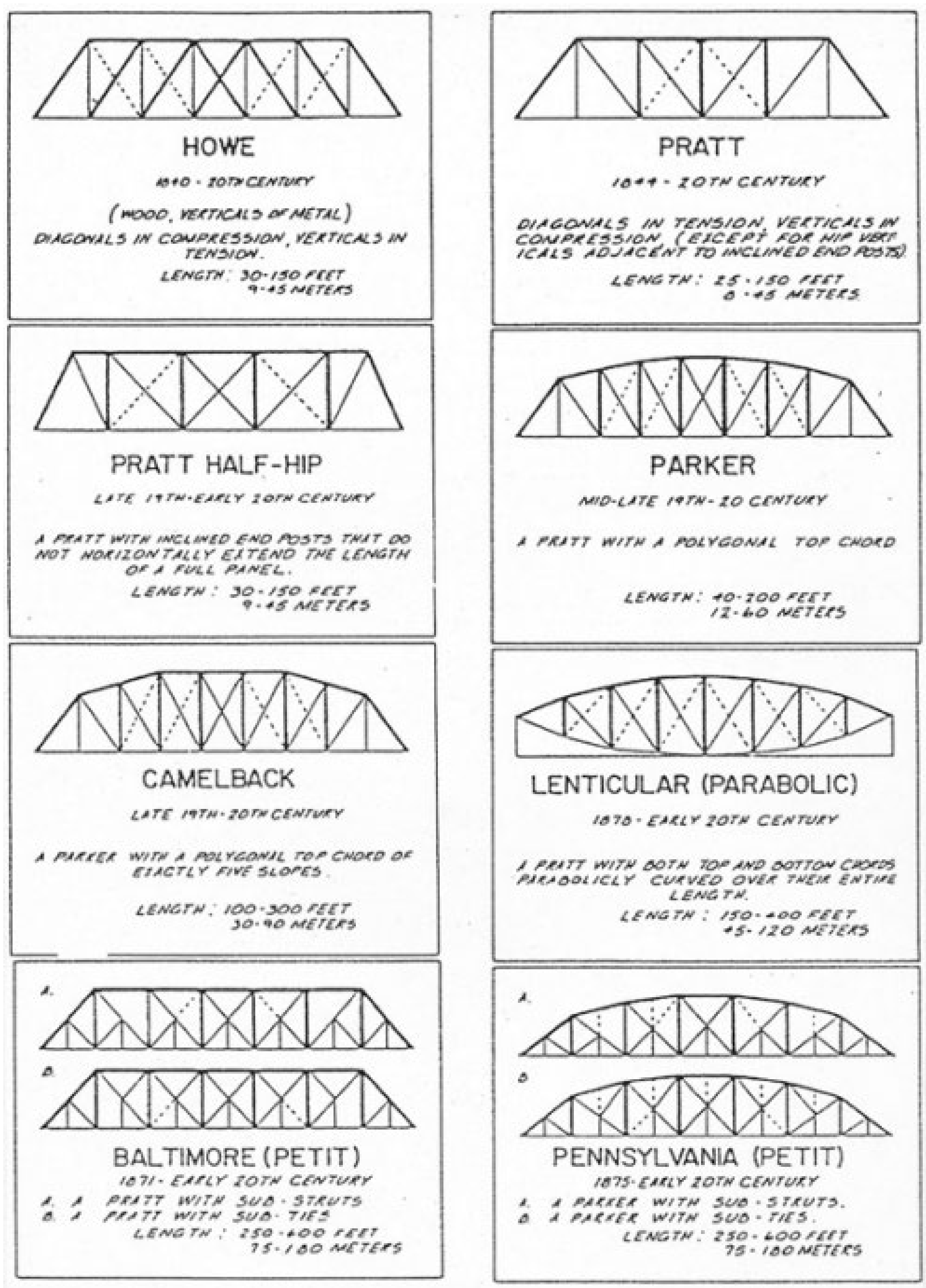


Figure 11: Metal Truss Bridge Types Part 1 (Allen and Jackson 1975)

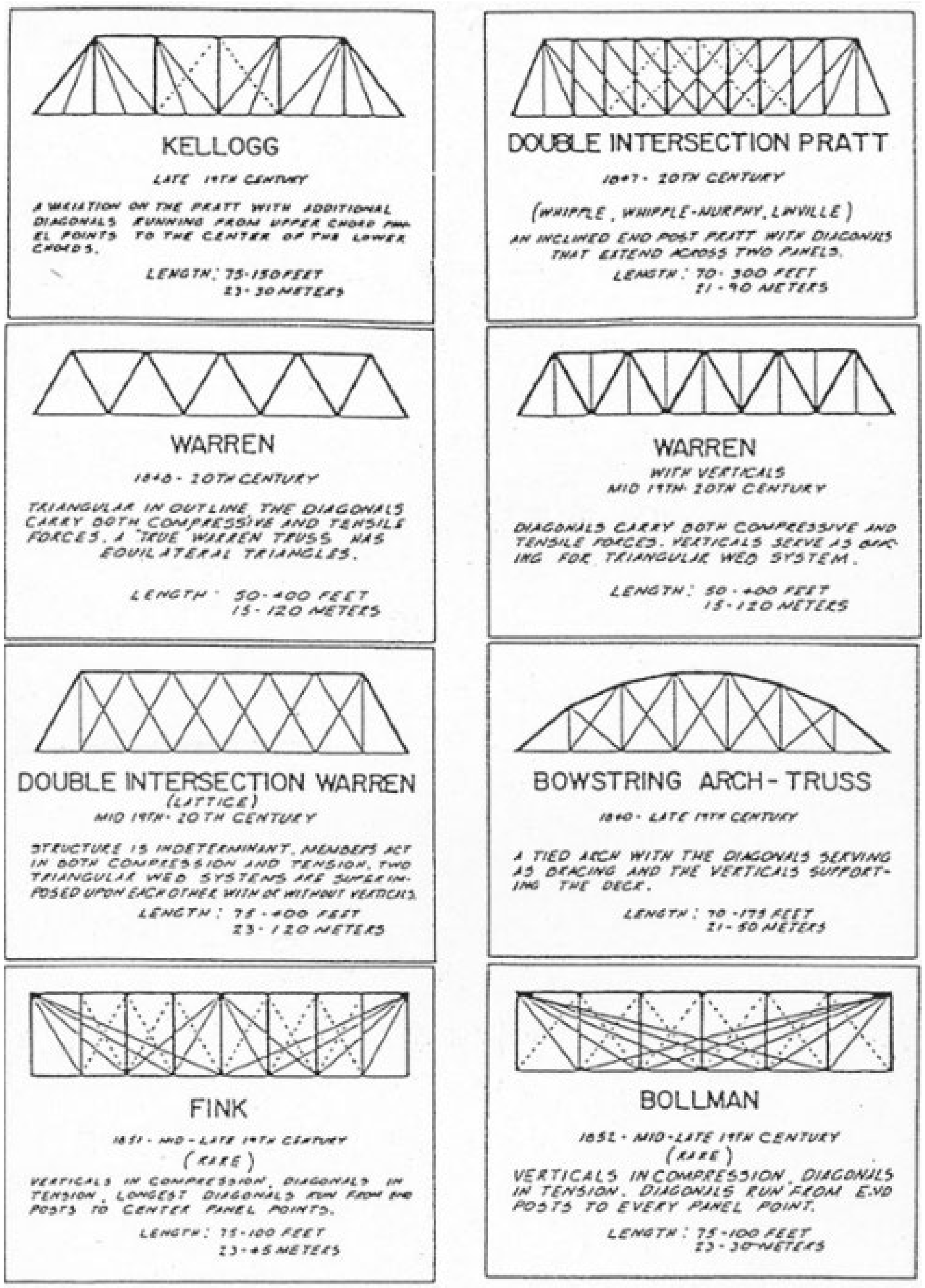


Figure 12: Metal Truss Bridge Types Part 2 (Allen and Jackson 1975)

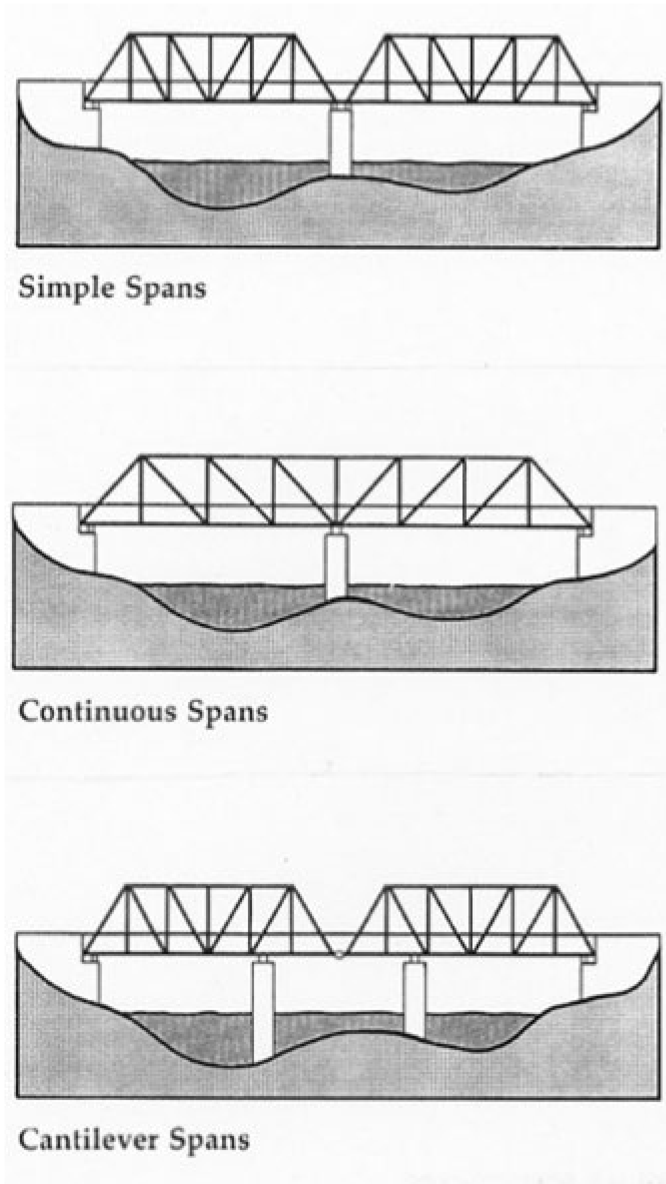


Figure 13: Metal Truss Span Types (Pennsylvania Historical and Museum Commission and Pennsylvania Department of Transportation 1986).

Figure 14. MD 214 over the Patuxent River Steel Parker Thru Truss Bridge in Anne Arundel and Prince Georges Counties (SHA Bridge #0205400 and MIHP# AA-761)

Figure 15. US 40 over Licking Creek Steel Wichert Girder Bridge in Washington County (SHA Bridge# 2101000 and MHIP# WA-V-416)

Movable Bridges

Background

Waterways have always been a principal means of transportation in Maryland. In the early days of settlement, roads only augmented the transportation network of rivers. Many families, planters, and towns in the Tidewater region were dependent upon the navigation of rivers prior to new roads, ferries, and bridges (Spero 1995: 104).

As roadways were constructed and expanded, water crossings became a challenge when the waterway also required transportation of water born vessels. To allow ships or boats to continue traveling along these waterways, either a high or movable bridge had to be constructed. A high bridge usually required extensive approach work and very high grades; therefore, moveable bridges became the predominant technological solution for bridging navigable waterways (Spero 1995: 94).

The first legislated movable bridge in Maryland was in 1795 when the General Assembly authorized the Eastern Branch Bridge Company to build a bridge over the Eastern Branch of the Potomac River. This was likely a bascule bridge, as the act's reference to "raising the draw" if it is to be understood in its specific rather than generic sense. It is not known whether this was the first movable bridge constructed in Maryland. Early movable bridges in Maryland were probably bascule or retractile types of bridges. The earliest documentation of the retractile bridge did not occur until 1858 when the first bridge at Miles River Neck was constructed as a retractile with a navigation clearance of 30 feet (Spero 1995: 104).

Early bridges likely featured simple-span beam superstructures supported by timber bents, however the bridge for the Eastern Branch of the Potomac River had stone piers. Early, nineteenth century movable bridges also had multiple short spans. 100 spans would not have been unusual due to the length of the timbers and the riverbeds consisted of soft mud which required greater loads of multiple spans for stability (Spero 1995: 105). Movable bridges were increasingly being constructed on the eastern shore and throughout the Baltimore area at the end of the nineteenth century and the beginning of the twentieth century. By 1925, there were 41 movable bridges in the state (Spero 1995: 106-107).

In 1894, Congress gave the authority to regulate the operation of movable bridges to the U.S. Army Corps of Engineers. Some movable bridges offered 24-hour service because the operator lived near the bridge and was able to respond to boat's whistles or horns. Other bridges required notice ranging from 4-24 hours. Some bridge spans included operators houses for the tender's convenience (Spero 1995: 99).

Description

Movable bridges are categorized by their ability to change position in order to permit waterway navigation. This may comprise of a single moving span or multiple moving spans with fixed approach spans. Generally, they consist of a metal super structure supported on a concrete or masonry substructure, although this may vary (Spero 1995: 108).

In 1907, C.C. Schneider categorized movable bridges as follows:

1. Swing bridges, which turn about a vertical axis
2. Bascule bridges, which turn about a horizontal axis or roll back on a circular segment
3. Lift bridges, which lift vertically
4. Traversing or retractile bridges
5. Transporter or ferry bridges
6. Pontoon or floating swing bridges (Spero 1995:94).

Movable bridges are uniquely used in situations where the static span would impede the movement of objects in the waterways below the span. The most frequently used types are the vertical lift and bascule bridges. Between 1924-1974, construction was refined through technological improvements. Many patented designs became available after the expiration of the owner's patents in the 1940s and 1950s. After that, plan standardization economized the fabrication. Welding replaced riveting, new metal types and alloys were used, gear efficiency and bearings were improved, all of which played a vital role in the development of movable bridges. Electrical power was incorporated into bridge movement devices and later, remote controls of these electrical devices were adopted into the control mechanisms of the bridges (URS 2011: 5-5).

Swing Bridges

Swing bridges turn about a vertical axis which is generally located on a center pier. This may be center-bearing or may bear on the rim of a track located on the pier, called rim-bearing (Spero 1995: 108).

Otis Hovey, the Assistant Chief Engineer of the American Bridge Company, described swing bridges in his 1926 publication *Moveable Bridges*:

> *A swing bridge consists of a superstructure arranged to turn about the vertical axis of a pivot anchored to the center pier. In ordinary cases the pivot is at the center of a span of two equal arms which balance each other when the bridge is open, thus providing two equal openings for navigation. It is sometimes necessary to place the pivot near one end. The shorter arm must then be counterweighted to balance the longer arm when the bridge is open* (Spero 1995: 88).

On larger bridges, two trusses would make up the swing where on smaller bridges the swing would be constructed from one truss. The power of the bridge is generated by electric or hydraulic motors. Some smaller, older bridges were even manually operated (NCHRP 2005: 3-115).

In the United States, one of the first swing span movable bridges was constructed in 1856 in Chicago. Carrying Rush Street over the Chicago River, the iron bridge swung on a rim-bearing pivot, where the span's weight was supported by a series of wheels or bearings that ran in a circular track or drum on the top of the pier that bore the swing span (Spero 1995:92).

Because of its simplicity and economy, the center-bearing design grew more popular than the rim-bearing design (Figure 16). Except for the widest highway bridges, by the 1930s, the center- bearing swing bridge had taken over the rim-bearing swing bridge. It was economical and simple in cost and maintenance. However, disadvantages included it was slow to operate, channel interference could occur during operation, and navigational issues could arise if several swing spans were close to one another (Spero 1995: 93). The MD 331 bridge over the Choptank River connecting Talbot and Caroline Counties is a subdivided Warren truss bridge with a center swing span (MIHP T-487 Figure 18).

The earliest known swing bridge in Maryland was the Light Street Bridge constructed by the King Iron and Manufacturing Company of Cleveland, Ohio, in 1856 across the Middle Branch of the Patapsco River which was replaced in 1891 (Spero 1995: 105). No specific plans for the bridge exist. Another early swing bridge was located on Block Street near Baltimore's city docks. This was clearly depicted in the 1869 bird's-eye view of Baltimore. Earlier versions of a movable bridge at this location are less specific (Spero 1995: 106).

The first fully documented swing bridge in Maryland was constructed at Havre de Grace and spanned the Susquehanna River. The bridge was constructed in 1866 for the Philadelphia, Baltimore, and Wilmington Railroad and was 3,273 feet in length with a navigable clearance of 174 feet, 9 inches. The piers and abutments were constructed of granite while the superstructure was constructed of twelve timber spans. The bridge underwent several rounds of reconstruction starting sometime between 1870 and 1880 (Spero 1995: 106).

Although bascule bridges were the earliest movable structures in Maryland, swing bridges were constructed more frequently by the mid-nineteenth century through the end of that century (Spero 1995: 107).

Bascule Bridges

Bascule bridges rotate about a horizontal axis and feature decks that may be raised to a vertical or inclined position by various mechanical means. Bascule bridges are bridges in which one end rises as the other falls, but the term is commonly applied to any bridge type moving about a horizontal axis, either fixed or moving, as well as to those that roll back on a circular segment (known as rolling lift bascule spans). The bascule bridge was a popular choice because ships and boats would be able to pass quickly under the bridge (Spero 1995: 100). This bridge type attracted engineers due to their scientific nature and provided an alluring challenge of ingenuity (Spero 1995: 101).

There were two types of bascule movable bridges in the nineteenth century: Trunnion bascules move about a fixed center of rotation located at the center of gravity of the rotating part. A roller-bearing bascule moves about a fixed center of rotation that coincides with the center of gravity, but the trunnion is eliminated, and the load is carried by segmental circular bearing on rollers in a circular track. A rolling lift bascule continually changes its center of rotation and shifts its load application points as the center of gravity moves in a horizontal line. Any of these variations may be single leaf with one movable deck section or double leaf with two movable deck sections (Spero 1995: 108). They may consist of a single leaf spanning the channel, called a single leaf, or two symmetrical leaves, called a double leaf, meeting at the center. The double leaf is generally needed at crossings where more clearance is needed. (Spero 1995: 100).

The trunnion bascule is a sub-type in which the movable span swings upward around a fixed-axis trunnion or pivot at the center of rotation which coincides with the center of gravity. This originated as the medieval drawbridge and evolved in the United States in the late nineteenth and early twentieth centuries with the development of the simple trunnion or "Chicago" type and the multiple trunnion or Strauss type. The former was patented by the Chicago Bascule Bridge Company and was a refinement of the bascule mechanism with an integral counterweight. The multiple trunnion was complex and included three subsidiary trunnions (in addition to the main trunnion) which were all connected by struts that formed a rectangle when the span was closed and a parallelogram when the span was open (Spero 1995: 101-102).

The rolling lift bascule is a sub-type in which the center of rotation (and gravity) moves away from the opening as the span swings upward (Spero 1995: 101). This subtype added an additional movement – the span retreated from the opening as it was swung up, providing even more clearance for navigation. This was accomplished by attaching the span to a segmental girder, which simultaneously tilted the span upwards as it rolled back on its track (Spero 1995: 102). Two versions of this subtype were patented: The Scherzer and the Rall.

The Scherzer was developed in 1893 by William Scherzer of the Scherzer Rolling Lift Bridge Company. This became the most popular bascule of all types by 1916. It is characterized by its large concrete counterweight and segmental circular moving girder. The movement occurs as the span rotates on a short circular segment along a horizontal track girder. The counterweight is attached to the shoreward section of the moving leaf. The main pier, which is below the counterweight, receives the counterweight when the bridge is open. Three piers are necessary: one for the main pier, the rest pier for the free end of the leaf, and the shoreward pier for the approach span (Spero 1995: 102).

The Rall design was constructed by the Strobel Steel Construction Company and utilized a roller of a smaller diameter. As the span opens, it first revolves about a pin until the main roller comes into bearing with the track girder, rolls along this track, the swing strut tilting the span as the roller causes it to recede from the opening (Spero 1995: 102). While specific information about types of bascule bridges built in Maryland is rarely available, the Scherzer predominated. The 1916 Hanover Street Bridge over the Middle Branch of the Patapsco River (MIHP B-4530) featured a Rall rolling lift provided by the Strobel Steel Construction Company of Chicago this was designed by John Edward Greiner (Spero 1995: 107).

Early bascule bridges were not counterweighted until the eighteenth century. The first modern bascule bridge in this country was the Van Buren Bridge in Chicago (Spero 1995: 94). The MD 991 bridge over Wicomico River in Wicomico County is an example of a bascule bridge in eastern Maryland (MIHP WI-117, Figure 19).

Although bascule bridges were the earliest movable structures in Maryland, swing bridges were constructed more frequently by the mid-nineteenth century through the end of the century (Spero 1995: 107). The bascule regained popularity with Maryland State Roads Commission engineers, who constructed at least 17 bascule bridges in Maryland, including at the Chester, Choptank, Miles, Patapsco, Sassafras, Severn, Nanticoke, and Bohemia rivers (Spero 1995: 107). The renewed interest coincided with the development of standardized reinforced concrete bridges during the same period. The SRC did not develop standardized plans for movable bridges; however, they did develop a standardized plan for a two-story reinforced concrete operator's house (Spero 1995: 107).

Vertical Lift Bridges

Lift bridges moving vertically consist of simple spans resting on piers when closed. Usually, the weight of the lifting span is counterweighted by means of ropes or chains attached to the ends of the span and the counterweights, which pass up and over sheaves on top of towers at the ends of the bridge (Spero 1995: 95). The vertical lift bridge moves out of the way through machinery that lifts both ends of the movable span horizontally to a raised position about the ordinary roadway deck level (Spero 1995: 109).

After 1908, there was a surge in interest in the design which led to approximately 70 of this subtype being built throughout the nation in the following two decades. Advantages of this type included economy, rigidity, reliability, and ease of operation (Spero 1995: 103). Few vertical lift bridges were built in Maryland. A four-span vertical lift bridge was constructed by the State Roads Commission between 1910 and 1919 over the Pocomoke River in Pocomoke City (MIHP WO-177) and at least two were constructed over canals: the Chesapeake and Ohio Canal at Williamsport and the Chesapeake and Delaware Canal at Chesapeake City (Spero 1995: 107).

Retractile Bridges

A retractile bridge is also known as a traversing bridge. This subtype moves horizontally. When it is closed, it forms a simple span across the waterway. Some spans telescope inside of the adjoining spans, others recede above the approaches, the rear end being tilted upward and the free end downward. Sometimes, the approach span is the first moved aside, transversely, to permit the draw span to recede in its place (Spero 1995: 95).

With this type of movable bridge, the movable span is typically drawn up and over the approach span, although other arrangements were also built. The design was not efficient. The force required to operate such a span exceeded that of any other type of movable bridge. The design found application in the U.S. on smaller bridges where the effort required was not prohibitive. This span remained a vernacular design to which no noted engineer took credit. In 1926, the type was described as "nearly obsolete" (Spero 1995: 103).

Transporter/Ferry Bridges

This bridge sub-type is rarely used. It includes a fixed span across the channel which is supported on shore towers at a sufficient height to clear navigation. A platform, or car, is suspended under the span and arranged to travel across the channel from shore to shore (Spero 1995: 95).

Pontoon/Floating Bridges

Pontoon bridges were adapted for use when local conditions prevented the construction of stable, permanent structures. They were used when a temporary water crossing needed to be made quickly, such as with military operations. They consisted of small boats, or pontoons, latched together for temporary use, or more elaborate and stable pontoons for permanent structures (Spero 1995: 95).

The one recorded non-military instance of a pontoon bridge in Maryland was in the late eighteenth or early nineteenth century. This pontoon bridge featured a movable section that allowed vessels to navigate to and from Elkridge Landing. This was built by William Hammond after the ferry service across the Patapsco River (initiated in the 1770s) was put out of business by the construction of a nearby bridge (Spero 1995: 105).

Registration Requirements

In addition to the general requirements outlined in the beginning of Section F, the following specific associations may be utilized for determinations of National Register eligibility for this bridge type.

Movable bridges in Maryland are associated with not only the highways they carry, but also with statewide and local maritime history, and specifically with the maritime and navigation history of particular navigable bodies of water or canals (Spero 1995: C-15). Movable bridges may be associated with specific transportation-related events of significance that occurred over time, such as the improvement of specific highways, or the improvement of navigation along a specific body of water or within a specific jurisdiction (Spero 1995: C-16). In Maryland, movable bridges are located primarily in the Tidewater area where it was important to preserve the “commercial navigability” of the waterways (Spero 1995: C-17).

Movable bridges from 1790 to 1850 would be associated with the initial movable spans (primarily swing and bascule bridges constructed of timber) at key roadway crossings of navigable bodies of water. Later movable bridges (1850-1900) would be associated with technological improvements including the use of iron and steel and “the development of new variants of bascule, swing, and vertical lift designs and patents” (Spero 1995: C-16, 109). Movable bridges from the 1900-1940 period are generally associated with the design and construction of major moveable spans built by the State Roads Commission and other governmental authorities (Spero 1995: C-16).

Center bearing swing bridges are less common than other types of movable bridges and are, for this reason, considered significant. Constructed during the last decades of the nineteenth and the first decades of the twentieth centuries, the bridges are considered significant if they retain their CDEs and retain a high level of integrity (NCHRP 2005: 3-115).

Like swing-bridges, bascule bridges are one of the less common types of movable bridges. Those constructed during the late-nineteenth and early-twentieth centuries that retain integrity are considered significant (NCHRP 2005: 3-118).

Character Defining Elements

The following are CDEs, primary (P), secondary (S), and tertiary (T) elements for movable bridges in Maryland (Spero 1995: C-41-48):

- Swing Bridges
  - Superstructure
    - Swing span (beam or truss)
      - Pivot girder [P] [CDE]
      - Pivot [P] [CDE]
        - Center-bearing type includes discs, balance wheels, circular track
        - Rim-bearing type includes loadbearing wheels or bearings, circular track or drum
      - Drive machinery (including motive power, if not hand operated) ([P], except motive power, which is [S])
      - Wedge end lifts (or equivalent mechanisms) [P]
    - Approach spans [S]
    - Operator's house (optional) – [P or S]
    - Deck [T]
    - Railing [S]
    - Applied ornamentation [T]
    - Identifying plaques, plates, and imprints [P]
  - Substructure
    - Swing span related
      - Central pier (supports center of swing span) [P] [CDE]
      - End rest (supports end of swing span) [P] [CDE]
      - Fenders (protects central pier and end rests) [T]
    - Approach span related
      - Piers [S]
      - Timber piles [S]
      - Abutments [T]
    - Applied ornamentation [T]
    - Identifying plaques, plates, and imprints [P]
    - Endpost section of railing, attached at abutment [S]
- Bascule Bridges

- Superstructure
  - Trunnion (or)
    - Single trunnion (simple) or three trunnions (multiple) [P] [CDE]
    - Integral counterweight [P] [CDE]
    - Struts (multiple trunnion [P] [CDE]
    - Drive machinery, including motive power [P] (except motive power, which is [S])
  - Rolling lift
    - Segmental girder [P] [CDE]
    - Track [P] [CDE]
    - Counterweight [P] [CDE]
    - Drive machinery, including motive power [P] (except motive power, which is [S])
  - Operator's house (optional) [P or S]
  - Deck [T]
  - Railing [S]
  - Applied ornamentation [T]
  - Identifying plaques, plates, and imprints [P]
- Substructure
  - Bascule span related
    - Piers or piles [P] [CDE]
    - Fenders [T]
  - Approach span related
    - Piers [S]
    - Timber piles [S]
    - Abutments [T]
  - Applied ornamentation [T]
  - Identifying plaques, plates, and imprints [P]
  - Endpost section of railing/parapet, attached to abutment [S]

- Vertical Lift Bridges
  - Superstructure
    - Movable section
      - Towers (2) [P] [CDE]
      - Lifting span [P] [CDE] (supported by deck or through truss) – consult relevant span type)
      - Overhead truss [P] [CDE] (optional; not needed if towers alone were sufficiently stable)
      - Drive machinery, including motive power if not hand-driven [P] [CDE] (except motive power, which is [S])
      - Operator's house [P or S] (optional)
      - Applied ornamentation [T]
      - Identifying plaques, plates, and imprints [P]

        - Approach spans [S]
        - Applied ornamentation [T]
        - Identifying plaques, plates, and imprints [P]
    - Substructure
        - Movable span related
            - Piers or piles [P] [CDE]
            - Fenders [T]
        - Approach span related
            - Piers [S]
            - Timber piles [S]
            - Abutments [T]
        - Applied ornamentation [T]
        - Identifying plaques, plates, and imprints [P]
- Retractile Bridges
    - Superstructure
        - Movable span related
            - Stationary support span with track (supports movable span when open) [P] [CDE]
            - Movable span (beam or truss) equipped with load-bearing wheels or bearings [P] [CDE]
            - Drive machinery, including motive power if not hand driven [P] (except motive power, which is [S])
        - Approach spans [S]
        - Applied ornamentation [T]
        - Identifying plaques, plates, and imprints [P]
    - Substructure
        - Movable span related
            - Piers or piles [P] [CDE]
            - Fenders [T]
        - Approach span related
            - Piers [S]
            - Timber piles [S]
            - Abutments [T] (unless immediately adjoining movable span, then [S])
        - Applied ornamentation [T]
        - Identifying plaques, plates, and imprints [P]
- Pontoon Bridges
    - Superstructure – deck timber [P] [CDE]
    - Substructure
        - Boats (or pontoons) [P] [CDE]
        - Abutment, or bank anchor [P] [CDE]
    - Applied ornamentation [T]
    - Identifying plaques, plates, and imprints [P]

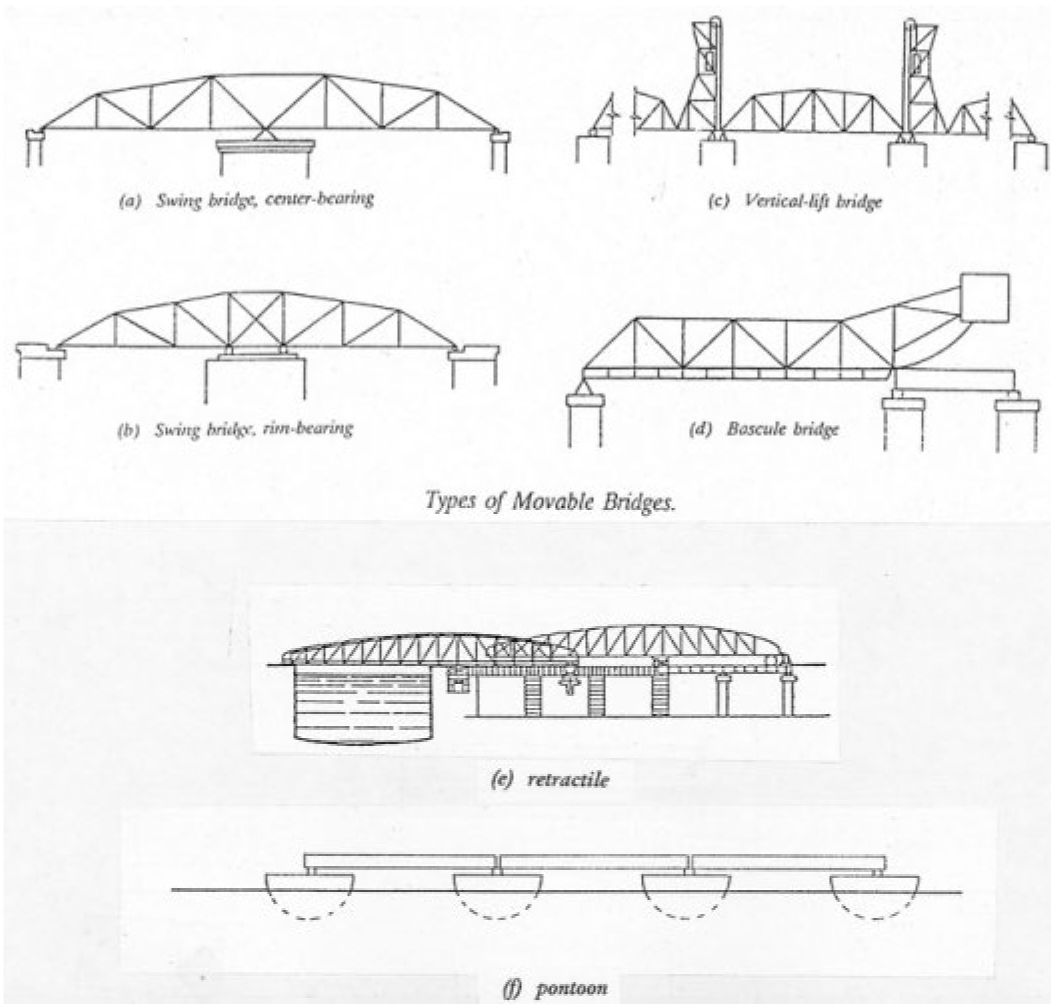


Figure 16: Types of Movable Bridges (P.A.C Spero & Company, 1991).

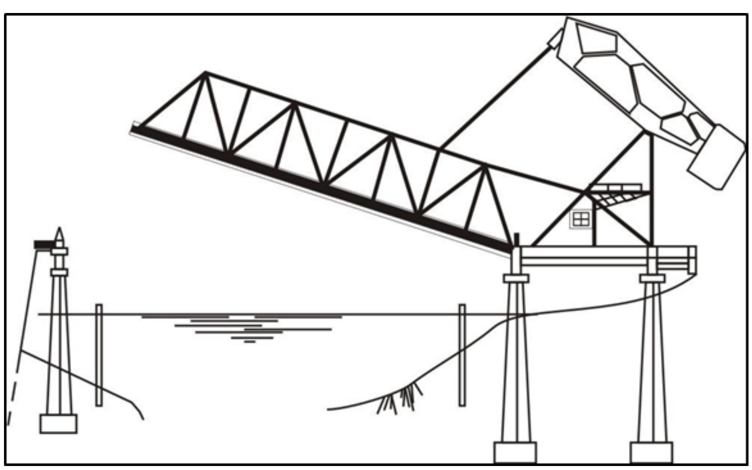


Figure 17. Multiple Trunnion Lift (NCHRP 2005: 127).

Figure 18. MD 331 over Choptank River ("Dover Drawbridge"), a Warren through truss bridge with center swing span in Talbot and Caroline Counties (SHA Bridge #2002300; MIHP# T-487).

Figure 19. MD 991 over Wicomico River Double-Leaf Trunnion Movable Bascule Bridge in Wicomico County (SHA Bridge #2200900; MIHP# WI-117).

Girder Bridges

Background

During the nineteenth century, refinement processes of iron helped with its stability. By 1861, major bridge components included rolled iron, which was iron passed through one or more rollers to alter its thickness. Rolled iron became mass produced by 1870 and included different structural shapes like beams or girders. This led to the construction of many iron girder spans throughout the US, especially on railroads. By 1895, structural wrought iron pieces were becoming unavailable as steel became more prominent (Spero 1995: 110).

Iron girder bridges were constructed during the middle of the nineteenth century due to these industrial and manufacturing advances. Full development was reached during the last quarter of the nineteenth century due to the railroad impetus. By the 1880s, rolled I-beam and plate girders were popular. By 1905, standard design plans and specifications for all girder brides were available through such organizations as the American Railway Engineering Association and the American Society of Civil Engineers, as well as prominent private bridge building firms including the American Bridge Company (Spero 1995: 112).

With increased automotive traffic, design for girders became increasingly standardized in the early twentieth century. Plate girders were usually riveted in the shop and shipped by rail to the intended sites. The introduction of the portable pneumatic riveter allowed some early twentieth century plate girders to be riveted in the field (Spero 1995: 112).

Between 1900 and 1930, the spread of concrete – encased rolled I-beam structures and the introduction of the highway bridge in which steel beams support a deck of reinforced concrete further developed girder bridge technology. After World War II, economical highway girder bridges were readily built by county and municipal officials throughout the country. Some technological advances, such as the use of aluminum, characterized some of the post-World War II girder bridges (Spero 1995: 116).

In Maryland, this bridge type was popularized by the nineteenth century railroad. The first plate girder bridge in the United States was erected by James Milholland on the Baltimore and Susquehanna Railroad in 1846 at Bolton Station near present day Mount Royal Station in Baltimore. By 1861, the Northern Central Railroad maintained an inventory of more than 50 girder bridges in Maryland (Spero 1995: 118).

Due to limited documentation of this bridge type, and varying labels used in historic surveys, it is difficult to know how many girder bridges were built in the state. The earliest steel girder bridge listed in the state bridge inventory was the US 11 bridge over the Potomac River and the Western Maryland Railway (1909, MIHP WA-I-737, altered). Only one steel girder or beam structure is dated between 1910 and 1920: Bridge #3092 on State Route 147 over Long Green Creek (MIHP BA-2737, considerably altered in 1969). 13 extant bridges were documented in 1993 that were built between 1920-1930 and included steel girders, beams, or bridges that incorporated such elements. This number includes two significant movable bridges – the 1924 Severn River Bridge on State Route 450 and the 1929 Bridge 2081 that carries State Route 436 over Weems Creek (both of which have since been replaced). By 1921 most girder bridges erected by the State Roads Commission included reinforced concrete decks (Spero 1995: 119-120).

The 1930s saw a continuation of these trends; more than 40 steel girder or steel beam structures are listed on the 1993 state inventory. Of note, a highly ornamented steel girder bridge encased in concrete was built to carry US 40 over AMTRAK tracks near Elkton (MIHP CE-998, replaced c.1991-92). The parapets were highly ornamented with Art Moderne details. This bridge type continued to be built by county, municipal, and state auspices until World War II.

Postwar, the trend of design was the development of aluminum girder bridges, which is a rare type throughout the country, with only one example in Maryland (Spero 1995: 120). The first fully aluminum bridge in the country was constructed in 1946 in Massena, New York crossing the Grasse River (Spero 1995:109). The 100-foot bridge was built for railroad traffic and was a single-track span constructed of plate girders. The first all-aluminum roadway bridge in North America was constructed in 1950 in Canada over the Saguenay River. The bridge had a 290-foot span (Das and Kaufman 2007: 62).

During the 1950s and 1960s in the United States as highway and bridge construction was at its peak due to suburban growth, engineers were trying to find economical ways of improving highways while also keeping them safe. During this period, aluminum bridges were considered, and five bridges using this material were constructed in the United States between 1958 and 1967 (Das and Kaufman 2007: 63). Aluminum alloys compared to iron and steel were lighter in weight, had a high strength to weight ratio, and resisted corrosion. Although an aluminum bridge would have a lower maintenance cost, its initial construction cost would be higher (Das and Kaufman 2007: 61).

A unique girder system to "maximize the live loads of bridges" was developed. One of these was constructed in Sykesville, Maryland to carry Old MD 32 over the CSX Railroad tracks and the South Branch of the Patapsco River (MIHP HO-673, Figure 21).

> *The Sykesville Bypass Bridge, which carried MD Route 32 over the Patapsco River parallel to River Road and CSX Railroad (then the B&O), was the longest of this design ever built. The three nearly equal length spans total about 293 feet. The Maryland State Highway Administration (SHA) engineers undertook the design of such a bridge for the planned new bypass of MD 32 around Sykesville, MD. Primarily because of (a) galvanic corrosion resulting from failure to maintain the isolation of the aluminum components and the settle bearings plus (b) an inadequate internal drainage system permitting water to lay inside the hollow sections, the Sykesville spans experienced galvanic and pitting corrosion; because of the high expense to repair it, the bridge was taken out of service in 2004 and replaced by an adjacent steel bridge* (Das and Kaufman 2007: 63-4).

Description

Metal girders are sections of metal usually shaped as an "**I**" or a "**W**" and are either exposed or encased in concrete; they span the length between the main supports of a structure. The transverse members are floor beams while the smaller structural members parallel to traffic are stringers. Beams carry their load by bending, with the upper fibers in compression and the lower fibers in tension. The span length is dependent on the strength of the materials and the depth of the cross section (Spero 1995: 103, 110). The girders support the floor system and roadway; the girders in turn are supported by concrete, masonry, or metal supports as abutments or piers (Spero 1995: 121). Some bridges may have brick facing on their abutments, such as with the Queenstown Bridge that carries US 50 over US 301 in Queen Anne's County, Maryland (MIHP QA-523).

Both iron and steel girder bridges developed in the nineteenth century can be categorized by the relationship of the roadway/deck to the position of the girder or girders (Spero 1995: 110). When the girders are located below the deck or roadway, the bridges are called **deck girder bridges**, while bridges with girders that extend above the roadway level are termed **through girders** (Spero 1995: 121). There is also a **half-through girder** variant (Spero 1995: 110).

Plate girders are bridges in which the girders consist of built-up riveted sections with a deeper "web" between the top and bottom flanges of the girder, rather than single rolled sections of metal. Plate girders may be placed beneath the bridge deck in a deck girder configuration, or may rise above the level of the roadway, as with the half-though variant (Spero 1995: 110). Flanges are the horizontal portions of the bridge while webs are the vertical portions (Spero 1995: 121).

Registration Requirements

In addition to the general requirements outlined in the beginning of Section F, the following specific associations may be utilized for determinations of National Register eligibility for this bridge type.

These bridges exemplify the modern application of traditional bridge technology. Metal girder bridges are typically associated with the continuing development of both railroad and roadway networks throughout the state. The earliest metal girder bridges constructed between 1846 and 1870 are generally associated with the introduction and early spread of metal girder bridge technology for railroads. These bridges built between 1870 and 1920 are generally associated with popularization for highway use and scientific standardization of metal girder design (Spero 1995: C-18).

Later metal girder bridges constructed between 1920 and 1965 would be associated with increasing use for highway bridges by government authorities including the State Roads Commission and county and municipal agencies, and occasionally corporate organizations. Many bridges of this period are associated with the state and national grade crossing elimination movement, which was an attempt to provide safer roads and eliminate at-grade crossings at railroads by road traffic to increase safety (Spero 1995: C-18). This period is also associated with the State Roads Commission utilizing metal I-beams and metal plate girders, many of which were encased in concrete, for both highway bridges and grade crossing elimination structures (Spero 1995: 121).

Character Defining Elements

Metal girder bridges may be used as culverts (with spans under 20 feet). The following are CDEs and primary (P), secondary (S), and tertiary (T) elements for metal girder bridges in Maryland, including rolled girder bridges, rolled girder bridges encased in concrete, plate girder bridges, and plate girder bridges encased in concrete (Spero 1995: C-48-52):

- Rolled Girder Bridges
  - Superstructure
    - Rolled longitudinal I-beams or wide flange beams [P] [CDE]
    - Floor system [S]
    - Deck [S]
    - Applied ornamentation [T]
    - Identifying plaques, plates, and imprints [P]
  - Substructure
    - Abutments of stone, cement, or timber [P] [CDE]
    - Pier(s) (when present) of stone or concrete [P] [CDE]
    - Applied ornamentation [T]
    - Identifying plaques, plates, and imprints [P]
    - Endpost section of railing, attached to abutment [S]
- Rolled Girder Bridges (Concrete Encased)
  - Superstructure
    - Rolled longitudinal I-beams or wide flange beams [P] [CDE]; concrete encasement [P] [CDE]
    - Floor system [S]
    - Deck [S]
    - Applied ornamentation [T]
    - Identifying plaques, plates, and imprints [P]
  - Substructure
    - Abutments of stone, cement, or timber [P] [CDE]
    - Pier(s) (when present) of stone or concrete [P] [CDE]
    - Applied ornamentation [T]
    - Identifying plaques, plates, and imprints [P]
    - Endpost section of railing, attached to abutment [S]
- Plate Girder Bridges
  - Superstructure
    - Plate girders [P] [CDE]
    - Floor system [S]
    - Deck [S]
    - Applied ornamentation [T]

        - Identifying plaques, plates, and imprints [P]
    - Substructure
        - Abutments of stone, cement, or timber [P] [CDE]
        - Pier(s) (when present) of stone or concrete [P] [CDE]
        - Applied ornamentation [T]
        - Identifying plaques, plates, and imprints [P]
- Plate Girder Bridges (Concrete Encased)
    - Superstructure
        - Plate girders [P] [CDE]
        - Concrete encasement [P] [CDE]
        - Floor system [S]
        - Deck [S]
        - Applied ornamentation [T]
        - Identifying plaques, plates, and imprints [P]
    - Substructure
        - Abutments of stone, cement, or timber [P] [CDE]
        - Pier(s) (when present) of stone or concrete [P] [CDE]
        - Applied ornamentation [T]
        - Identifying plaques, plates, and imprints [P]

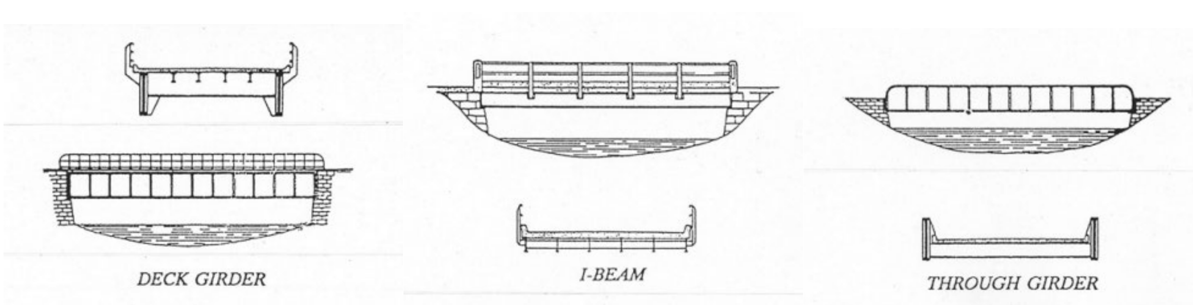


Figure 20: Types of Metal Girder Bridges (P.A.C. Spero & Company 1991)

Figure 21: Old MD 32 over CSX Railroad Aluminum Box Girder Bridge, River Road, and Patapsco River in Carroll and Howard Counties (SHA Bridge # 1304600 and MIHP # HO-673).

Metal Suspension, Arch, and Cantilever Bridges

Background

Maryland has few extant metal suspension, metal arch, and metal cantilever bridges; those that do survive are well represented by important bridges built between 1940 and 1955. The extant examples exemplify the development of these three types (Spero 1995: 112).

Metal Suspension

Suspension bridges are significant in America because they were the earliest all-iron bridges constructed in the United States. The first known suspension bridge in America was built over Jacob's Creek at Uniontown Pennsylvania in 1801. These early American suspension bridges were considered "chain bridges," wherein the cables were composed of wrought iron chains made of square bars that were formed into links. These links ranged from 5-10 feet in length. The roadway's timber floor beams were held via a stirrup-like arrangement. Construction of these bridges involved lifting the cables above the masonry towers and securing them to various abutments (Spero 1995: 124).

Wire ropes instead of chains were first used in 1816 for a private toll footbridge over the Schuylkill River in Pennsylvania. The first large scale suspension bridge was constructed over the Menai Straits in England in 1826. In 1828, the first all-steel suspension span was constructed over the Danube Canal in Vienna, Austria. These advancements led to American adoption and making the designs even better. Twentieth century bridge technology has been characterized by scientific analysis of suspension, stiffening, and anchoring principles that over time resulted in the design and construction of increasingly larger suspension spans (Spero 1995: 124).

Nineteenth century suspension bridges are a rarity within Maryland's bridge inventory, while twentieth century development of large-scale wire cable suspension bridges is more represented. The first suspension bridge in Maryland was the 1820 bridge over Will's Creek, a turbulent Potomac River tributary, in Cumberland in Allegany County. It survived until April 28, 1838, when the bridge collapsed. The best-known suspension bridge in Maryland, the first Chesapeake Bay Bridge (MIHP AA-47), built between 1947-1952 is an example of a culmination of nearly a half century of planning and engineering discussion (Spero 1995: 127).

The first Chesapeake Bay Bridge is the earliest extant suspension bridge in Maryland, and it fully represents the latest techniques and engineering innovations in mid-twentieth century American suspension bridge engineering design. It was constructed by the J.E. Greiner Company under an agreement with the Maryland State Roads Commission. In 1907, various merchants and manufacturers associations sponsored consideration of the issue. In 1937, the State Roads Commission was directed to formulate a plan for the erection of four "primary bridges" needed in Maryland. The Bay Bridge was one; the remaining three consisted of a bridge to carry US 301 into Virginia, a span to take US 40 across the Susquehanna River at Havre de Grace, and a proposed Baltimore Harbor crossing, which in 1957 opened as the first Harbor tunnel instead of a bridge. The 1952 Bay Bridge was constructed of 123 fabricated steel spans including the central cable suspension span, its side spans, and a series of cantilever trusses, simple trusses, and plate girder and beam spans and is 4.03 miles long. Its suspension cables are 14 inches in diameter (Spero 1995: 130). A second parallel bridge was built in 1969-1973 (MIHP AA-48).

Swinging footbridges were also constructed in the state, essentially as suspended footbridges with narrow walkways (Spero 1995: 129). This subtype is not included in this cover.

Metal Arch Bridges

Iron and steel bridges from the nineteenth and twentieth centuries generally incorporate some form of truss or a metal girder system. However, some metal bridges utilized iron or steel arches as their central structural element. One metal arch bridge was constructed on the National Road in western Pennsylvania in the late 1830s (Jackson 1988: 33-34, 220-222).

Thomas Telford, an English engineer during the late-eighteenth and nineteenth centuries, helped develop the metal arch. Instead of iron voussoirs, he developed cast-iron latticed trusses to build the arch (Spero 1995:133-4). In the United States, the earliest metal arch bridge was the Dunlap's Creek Bridge in Brownsville, Pennsylvania, constructed in 1838 by the U.S. Army Corp of Engineers under the guidance of Captain Richard Delafield. By the 1870s, steel was being used in metal arch bridges. The first bridge to utilize a steel arch was the Eads' Bridge in St. Louis, Missouri (Spero 1995: 134).

The spread of the metal arch form in Maryland occurred primarily after the Civil War as iron and steel making technology progressed; this also led to bridge building firms being founded to take advantage of a growing market. Such firms as the King Iron Bridge Company and the Smith Bridge Company marketed small pony bowstring arch truss bridges to county commissioners in Maryland. Baltimore City constructed a number of metal arch bridges between 1880 and 1900, which was concurrent with the 1888 annexation of a large area surrounding the city; none of these survive (Spero 1995: 139).

Two examples of twentieth century metal arch bridges exist in Baltimore City: Howard Street (MIHP B-4529) and Guilford Avenue (MIHP B-4528) bridges were both built over Jones Falls and railroad tracks during the 1930s; they were built to conform with the built landscape of a group of through arches that were extant in the 1930s that crossed Jones Falls and the railroad tracks (Spero 1995: 139-140)

Two other metal arch bridges exist in Maryland. The first, the Chesapeake City Bridge (MIHP CE-1536) is a high-level, two-lane tied arch structure with steel hangers that was constructed in 1948 to replace a vertical lift movable bridge. The second, the Blue Bridge (MIHP AL-IV-A-153) is a two-span tied through arch built in 1955 under the State Roads Commission authority to cross the Potomac River between Cumberland, Maryland and Ridgely, West Virginia (Spero 1995: 141).

The steel arch design profited from post-war advances including steel production improvements, strength and corrosion resistance, planning, plan standardization, prefabricated materials, and bolt and welding technology. The innovation of the cable-stayed bridge decreased construction of the steel arch (URS 2011: 5-4).

Metal Cantilever

Cantilever construction of a bridge defines a specific form of support of the bridge rather than a particular bridge type, like a truss or girder. The cantilever support occurs when the support is at one end of the span and the other end is free, which is different from other bridge spans wherein the support is provided by piers and abutments or continuous along one or more intermediate supports. Cantilever bridges are composed of a series of cantilever spans that include a main span and two anchor spans that flank it (Spero 1995: 145). For example, cantilevered truss construction methods were pioneered in which sections of a truss bridge were built out from piers with sometimes complex anchorage systems holding back the upper parts of the unfinished span (Spero 1995: 75).

Bridge historians date the major advent of modern cantilever bridges to the design and construction of the high bridge over the Kentucky River at Dixville in 1876-1877, which was built by Charles Shaler

Smith of the Baltimore based Baltimore Bridge Company. The only known bridge in Maryland to have used a cantilever system is the Governor Harry W. Nice Memorial Bridge (MIHP CH-376) which was built between 1938-1940 as part of the state's primary bridge program (Spero 1995: 145). This bridge carries US 301 over the Potomac River in Southern Maryland to Virginia's Northern Neck.

Description

Metal Suspension

Metal suspension bridges consist of a suspended superstructure that is anchored into a masonry or concrete substructure. The structural system consists of flexible cables with stiffening trusses or girders suspended from them which carry the deck system. This bridge type may comprise of various combinations of cables, towers, suspenders, and girders or trusses added to stiffen the bridge against stresses caused by wind and load. Typically, the towers are built upon piers and cables are carried high above the deck in cradles located at the top of the towers. The cables run downward to anchor spans form the towers of the main span. Cables are usually anchored in heavy concrete or masonry abutments or anchorages. The deck is carried by suspended stiffening structures, girders, or trusses (Spero 1995: 132).

Metal Arch

Metal arch bridges have two or more parallel arches of iron or steel that span between masonry or concrete piers or abutments. The arch member may be a curved girder or may include a truss system between curved top and bottom chords. Other elements of a metal arch bridge include lateral bracing and columns/hangers for supporting the deck and floor system (Spero 1995: 143).

Metal arch bridges can be categorized through the relationship of the deck to the arch. A through arch is when the deck is suspended from the arch by means of vertical suspenders. When the deck is carried atop the arch crown, it is a deck arch. If the deck is carried at intermedial level, it is a half-through variant. In a tied arch, a tension member (tie) is included between the ends of the span and the arch thrust is carried through the tie (Spero 1995: 143). A tied steel arch, also known as a tied through arch, developed from the iron bowstring trusses that were popular during the mid-nineteenth century (NCHRP 2005: 3-69). Steel tied arches do not require "large abutments to counter the thrust of the arch action." Typically, the floor system ties the ends of the arch together. "The tied arch is a variation of a through arch in which the horizontal thrust of the arch reactions is transferred to the horizontal tie, which acts in tension" (NCHRP 2005: 3-69).

This bridge type may be further categorized according to the bridge's hinges. If no hinges are present, the bridge is a fixed arch, however there is a one hinge variant wherein a single hinge is at the top center, or crown, of the arch. There is also a two hinged variant where the hinges are at the points where the arch joins the abutments, and a three hinged variant where the hinges are at the crown of the arch and at the abutments (Spero 1995: 143).

There are three categories of steel arch bridges. The first is the solid-ribbed arch bridge which is constructed of plate girder ribs. Solid arches can be deck or through configurations. The second is the brace-ribbed arch bridge with two parallel or near-parallel arch chords illustrated in Figure 23. The chords are connected by open webbing of trusses. The third category is the spandrel-braced arch, where the roadway is carried on top of the arch. The main arch has curved bottom members, and the road is carried on the top chord, while the top chord is attached to the arch by trusses (Spero 1995:133). In a bowstring metal arch, the arch ribs ascend above the roadway deck (Spero 1995: 137).

Metal Cantilever

This bridge type is defined by its structural support of the bridge rather than the individual configuration of the structural elements. Cantilevered structures are directly supported at one end and free at the other end. They consist of two anchor arms that are directly supported on two piers, two cantilever arms, one of which is supported on one end by the anchor pier, and a central suspended span which is carried by the two anchor arms. These bridges may also include cantilevered truss or girder spans (Spero 1995: 147).

Registration Requirements

In addition to the general requirements outlined in the beginning of Section F, the following specific associations may be utilized for determinations of National Register eligibility for this bridge type.

Metal Suspension

Metal suspension bridges built between 1800-1840, the formative era of suspension bridge development, are generally associated with the introduction of metal cable and wire rope suspension span technology by suspension bridge pioneers Finley and Ellet and associates (Spero 1995: C-20, 132).

These bridges built between 1850 and 1900 may be associated with the popularization and spread of metal cable and wire rope suspension span technology in Maryland and surrounding states (Spero 1995: C-20).

Metal suspension bridges built between 1900-1960 are generally associated with the refinement of wire rope suspension bridge technology, reflecting the influence of master engineers such as the Roeblings and Othmar Ammann. Bridges in this time period may also be associated with specific transportation-related events of significance that occurred over time, such as improvement of specific highways. Specific associations can be with Maryland State Roads Commission's continuing effort to improve significant and major water crossings. A monumental example of this is the Chesapeake Bay Bridge (Spero 1995: C-20).

Metal Arch

Metal arch bridges were constructed during the expansion of highway networks and railways throughout the state during the mid-twentieth century. Metal arch bridges constructed between 1870 and 1900 would be associated with the introduction of the bowstring and deck arch technology. These arches would be either small, simple structures in more rural areas or larger, more ornamented structures in larger communities such as 1880s structures in Baltimore City (Spero 1995: C-22).

Metal arch bridges constructed between 1930 and 1960 may be associated with the design and construction of modern through bowstring arches by the State Roads Commission, Baltimore City, and other authorities. This type of bridge in this time period may also be specifically associated with the Maryland SRC's continuing effort to improve significant major water crossings (Spero 1995: C-22). "Rainbow" arches, metal structures with through bowstring arches featuring overhead bracing, were built by Baltimore City and the SRC in this period of significance (Spero 1995: 144).

Metal arch bridges constructed during the early twentieth century would be associated with designs from the SRC as well as other government agencies throughout the state (Spero 1995: C-22). Tied steel arches dating to the second quarter of the twentieth century were notable because of their form. They were not built in large numbers. Therefore, their CDEs help them to retain any significance (NCHRP 2005: 3-68).

Metal Cantilever

Metal cantilever bridges that were built between 1900-1940 may be associated with the scientific development and refinement of cantilever truss design and construction. This is exemplified by a monumental cantilever in Maryland, the 1940 Governor Harry W. Nice Memorial Bridge (Spero 1995: C-24).

Metal cantilever bridges may also be associated with specific transportation-related events of significance that occurred over time, such as improvement of specific highways. These bridges of the 1900-1940 time period are specifically associated with the Maryland State Roads Commission's continuing effort to improve significant water crossings (Spero 1995: C-24).

Character Defining Elements

Metal Suspension Bridges

The following are CDEs, primary (P), secondary (S), and tertiary (T) elements for metal suspension bridges in Maryland (Spero 1995: C-52-53):

- Superstructure
  - Tower [P] [CDE]
  - Cradles [P] [CDE]
  - Cable (or chain) [P] [CDE]
  - Suspenders [P] [CDE]
  - Stiffening truss [P] [CDE]; if absent [NA]

  - Floor system [S]
  - Deck [T]
  - Applied ornamentation [S]
  - Identifying plaques, plates, and imprints [P]
- Substructure
  - Anchors (abutments) [P] [CDE]
  - Piers [P] [CDE]
  - Applied ornamentation [S]
  - Identifying plaques, plates, and imprints [P]

Metal Arch Bridges

The following are CDEs, primary (P), secondary (S), and tertiary (T) elements for metal arch bridges in Maryland (Spero 1995: C-53; C-54):

- Superstructure
  - Arch member
    - Curved girder [P] [CDE] (or)
    - Curved truss [P] [CDE]
      - Top chord [P] [CDE]
      - Bottom chord [P] [CDE]
      - Post (truss diagonal) [P] [CDE]
  - Suspenders [P] [CDE]
  - Ties [P] [CDE]
  - Floor System [S]
  - Deck [T]
  - Applied ornamentation [T]
  - Identifying plaques, plates, and imprints [P]
- Substructure
  - Buttresses (abutments) [P] [CDE]
  - Pier(s) (when present) [P] [CDE]
  - Applied ornamentation [T]
  - Identifying plaques, plates, and imprints [P]

Metal Cantilever Bridges

The following are CDEs, primary (P), secondary (S), and tertiary (T) elements for metal cantilever bridges in Maryland (Spero 1995: C-55):

- Superstructure (truss or girder)
  - Anchor arms (2) [P] [CDE]
  - Cantilever arms (2) [P] [CDE]

    - Central suspended span (carried by anchor arms) [P] [CDE]
    - Applied ornamentation [T]
    - Identifying plaques, plates, and imprints [P]
- Substructure
    - Piers supporting anchor arms [P] [CDE]
    - Anchor piers supporting cantilever arms [P] [CDE]
    - Abutments [S]
    - Applied ornamentation [T]
    - Identifying plaques, plates, and imprints [P]

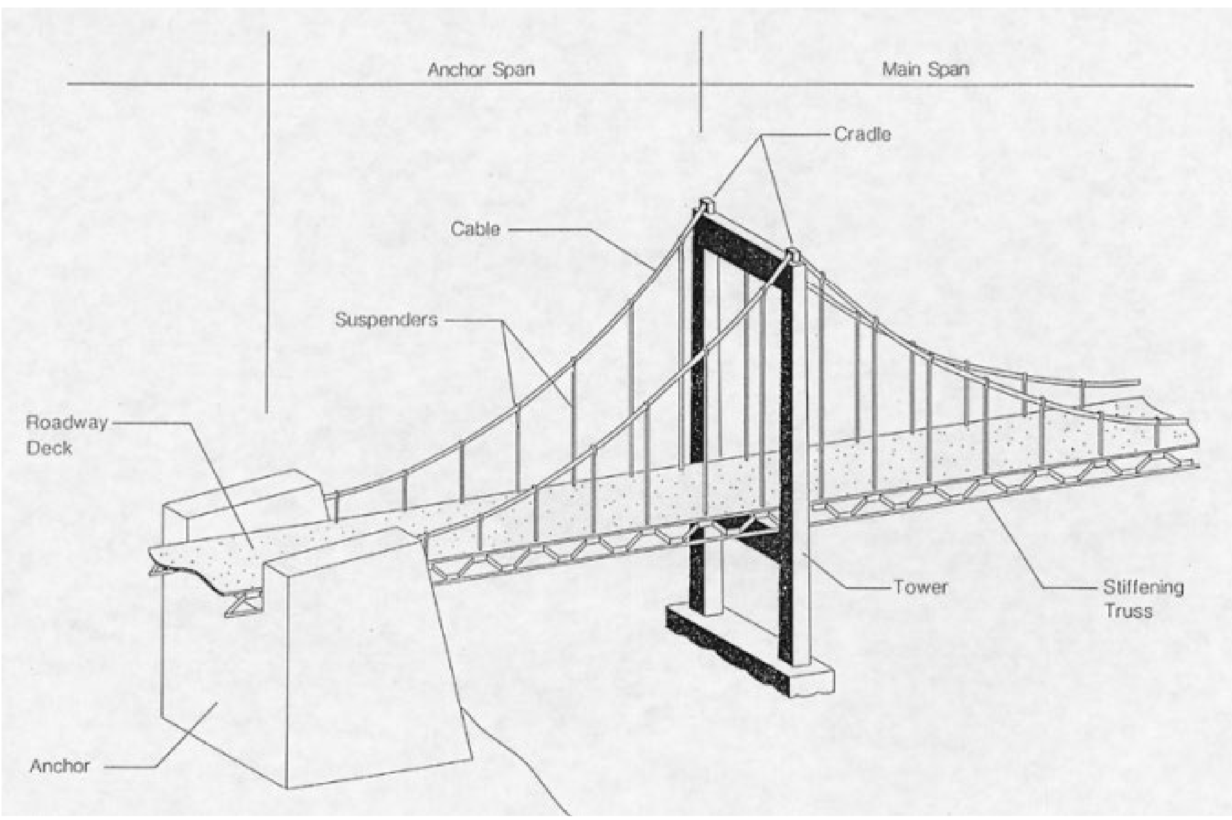


Figure 22: Elements of a Suspension Bridge (Pennsylvania Historical and Museum Commission and Pennsylvania Department of Transportation 1986)

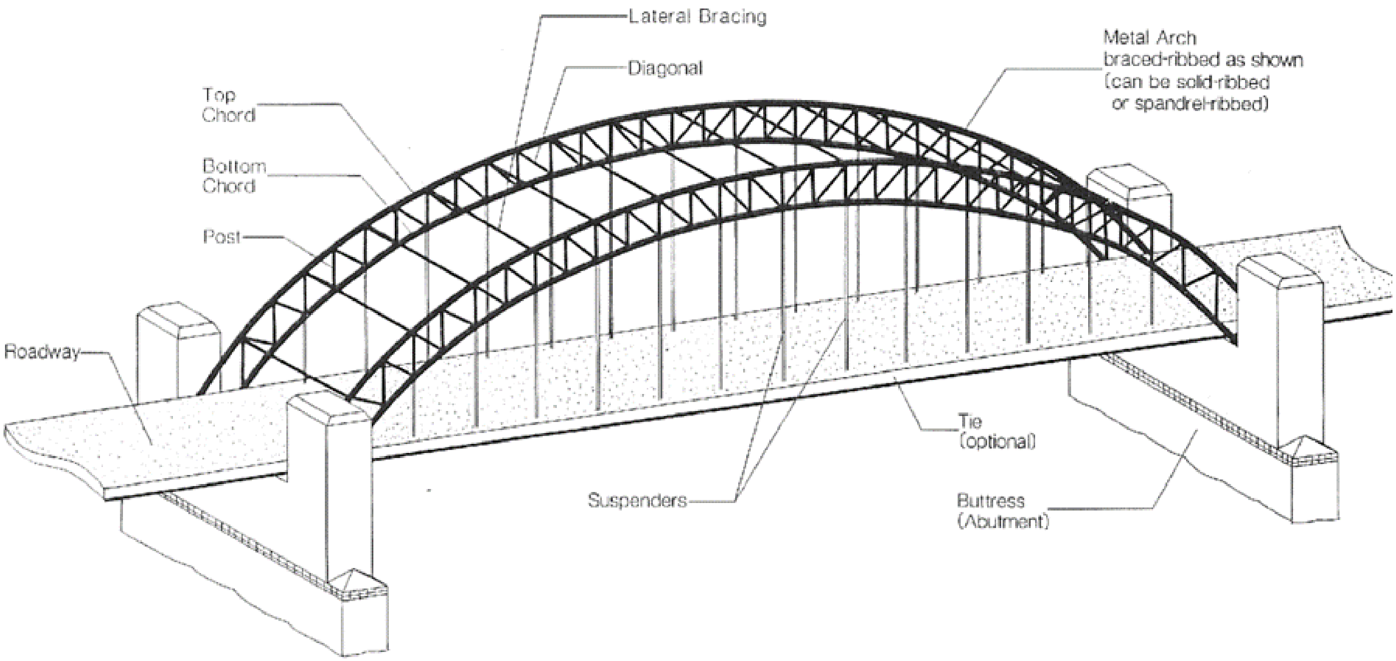


Figure 23: Elements of a Metal Arch Bridge (PHMC and PennDOT 1986)

Figure 24: MD 942 over the Potomac River Steel Tied Thru Arch Bridge in Allegany County, MD and Cumberland County, WV (SHA Bridge #0106600 and MIHP AL-IV-A-153)

Concrete Bridges

Background

British engineer George Semple was the first to use hydraulic cement to construct a bridge's pier foundations for the Essex Bridge in Dublin, Ireland in the mid-1500s. Approximately 300 years later, Joseph Aspdin developed an artificial cement of calcium rich limestone and clay mixture in England, known as Portland cement (Fraser 2000:73). Production of the new building material began the next year but was not introduced into the United States until 1865 (Lesley 1924: 68). In 1871, David O. Saylor patented his own Portland cement mixture and established the first cement plant in the United States (Fraser 2000: 73). For thirty-one years, use of Portland cement was minimal because of its high costs to import, until 1896 when the domestic cement industry began producing one million barrels a year (Lesley 1924: 68).

Because of its compressive strength, concrete is an excellent bridge material. However, because of its inherent tensile weakness, steel is used to reinforce concrete structures (National Highway Institute October 2002: 2.2.6). By 1871, engineer W.E. Ward found that inserting iron bars into the concrete material added tensile strength. This configuration allowed the use of the cheaper concrete material to dominate the structure with minimal use of costly iron bars that would be protected from corrosion (Fraser 2000: 73). The bars are placed close to the tension face where they can provide the most reinforcement. Vertical and diagonal reinforcement members are also used to prevent cracking from shear tension (National Highway Institute October 2002: 2.2.6).

Constructing concrete arch bridges was similar to the process of constructing stone arch bridges. First, foundations, abutments, and piers were constructed. Second, temporary bracing or centering was erected and reinforced. The concrete was placed in the forms from each end moving toward the crown. Short spans could be completed in one pour while longer spans (more than 80 feet) had to be poured in sections. Next, the spandrel walls, posts, or arches were formed, and the centering was released after the concrete had set (usually within 28 days depending on conditions). The last step was to finish the concrete surface. Some treatments included applied brick or stone or stone-imitation. If left exposed, the surface was rubbed to produce a smooth surface or worked with tools to create a texture (Spero 1995: 157).

In 1871, the first concrete arch bridge in the United States was completed in Brooklyn, New York. The footbridge had a 31-foot span. Although the use of concrete gave the bridge great plasticity without reinforcement, the bridge had very little tensile strength and, therefore, other bridges of its type were restricted. In 1889 the Alvord Lake Bridge in San Francisco was constructed. It was designed by Ernest L. Ransome who was a pivotal pioneer in the development of reinforced concrete. In 1884 he patented a method of reinforcing concrete by twisting the iron bars and placing them only in zones where tensile strength was needed (NCHRP 2005: 3-53).

Another engineer had developed a reinforcing system using parallel I-beams that were curved to the shape of the arch and placed into the concrete. This was developed by Joseph Melan from Austria and was patented in the United States in 1893. The difference between his patent and Ransome's was that Melan's was not truly reinforced concrete; they were more metal arches that were "encased" in the concrete. However, many preferred Melan's system, as calculating the tensile strength from the rods was extremely difficult. Melan soon founded the Melan Arch Construction Company in New York City (NCHRP 2005: 3-54).

The first Melan design concrete arch bridge was in Rock Rapids, Iowa in in 1894. The closed-spandrel arch bridge had a span of approximately 30 feet. The next year a 70-foot span bridge was constructed in Cincinnati (NCHBS 2005: 3-54). Von Emperger, an associate of Melan, improved the patent and continued to build Melan arch bridges (NCHRP 2005: 3-54).

The reinforcement of concrete with I-beams used more steel during construction than using steel bars which could be strategically placed in "areas of high tensile strength." Eventually, more patents using bars over beams were developed and began to be preferred over the Melan system (NCHRP 2005: 3-55).

During the first decades of the twentieth century, Daniel Luten further developed the reinforced concrete arch bridge. After teaching for only five years at both the University of Michigan and Purdue University, he began developing designs for reinforced concrete bridges. He soon formed the National Bridge Company (NCHRP 2005: 3-57). As an innovator, Luten developed nearly fifty patents for reinforced concrete bridges, creating for himself a near-monopoly in design. Eventually, other builders and engineers organized against him and some of his patents were invalidated. Although his monopoly on reinforced concrete bridges was stopped, he was, according to himself, responsible for designing 17,000 bridges in every state except three (NCHRP 2005: 3-59). Luten built a number of arch bridges throughout Maryland beginning at least by 1908, including the 1919 Sandy Island Bridge over the Choptank River at Goldsboro for the Caroline County Commissioners (MIHP CAR-257, replaced 2013) (Spero 1995: 175).

The construction of concrete bridges in Maryland relied on local materials and labor, which made it more attractive than truss bridges which were fabricated out-of-state. The Sherwood Station bridge in Baltimore County was constructed in 1903 and was the first concrete bridge featuring reinforcing steel rods to be built in Maryland. Because of the bridge's success, the Maryland Geological Survey adopted a plan for reinforced concrete bridge construction to replace wood bridges with pipe culverts or concrete bridges in order to move towards a maintenance-free solution. In 1906, this plan was first implemented with the construction of a 200-foot-long multiple span reinforced concrete deck girder bridge over the Choptank River. Several concrete bridges were built in Washington County from 1906-1909 (MIHP WA-II-128, WA-V-063, WA-I-344, WA-II-176). Baltimore City likewise constructed more concrete arch bridges, including the Hollins Street over Gwynn Run, University Parkway over Stony Run, and Edmondson Avenue over Gwynns Falls (Spero 1995: 174-175).

Prestressed concrete bridges became popular after World War II and especially after the Bureau of Public Roads published the *Criteria for Prestressed Concrete Bridges* in 1955. These bridges can be created via pre-tensioning, in which the concrete is cast around steel cables that are already in tension or it can be post-tensioned, where the concrete is poured with intentional voids that allow for the threading, stretch, and anchoring of cables after the concrete has set. Pre-casting was economical because it allowed structural members to be fabricated off-site and the member-forms re-used. Forms could also be used at the construction site (URS 2011: 5-5). A pretensioned concrete bridge in Maryland is Bridge 0802200 which carries MD 225 over Mattawoman Creek near Indian Head in Charles County (MIHP CH-781).

Standardized Plans

The concept of standardized bridge designs was one of the most important developments of engineering in the twentieth century. It reduced the nearly infinite number of possible bridge designs to a finite set of interchangeable modules which were combined in different ways to accommodate almost any requirement (Spero 1995: 158).

The first issuance of standard plans for Maryland bridges occurred in 1912, concurrent with the reorganization of the State Roads Commission. The reorganization consolidated the construction and maintenance departments and established eight districts with their own Resident Engineers, which greatly increased effectiveness and was more cost effective than the former, centralized approach. In order to reduce design time for the construction of new bridges to replace older bridges, standard plans were used. After the Resident Engineer investigated the foundations and siting of the bridge, he could select from the standard plans (Spero 1995: 176).

The standard plans of 1912 included slab spans, deck girder spans, box culverts, box bridges, abutments, and piers. New standard plans were published in 1919 which included changes to the slab bridges and a design for a movable bridge operators house (Spero 1995: 177). By 1923, the SRC decided to adopt the T-beam design for slab and girder bridges. The 1924 standard plans for the T-beam spans remained in effect until 1930 when the roadway width was increased to 27 feet to accommodate the increasing demands of automobile and truck traffic. Some changes were designed to increase the load bearing capacities of the bridge to support this. The 1930 design also introduced the pierced concrete railing. New plans were introduced in 1933 when the roadway again increased to 30 feet. A system for standard nomenclature was introduced at this time as well (Spero 1995: 178).

Description

Concrete arch bridges are classified into four groups based on how the dead load is carried: filled spandrel (consisting of a barrel arch which carries filling material and terminates in closed longitudinal walls that act as retaining walls for the fill), closed spandrel (carries the roadway loads to the arch ribs, contains no fill, and carries the deck loads by spandrel walls resting on the arch ribs), open spandrel (carries the roadway loads to the arch ribs, contains no fill, and carries the roadway loads to the arch ribs by spandrel columns), and through arches (which consists of ribs extending above the roadway and carry the deck loads by vertical hangers) (Spero 1995:152).

Filled Spandrel

The spandrel is the area of the arch between the ring and the roadway. In a filled spandrel, the outermost edges of the arch barrel are built spandrel walls which serve as retaining walls to contain the fill material (rubble, stones, or dry soil) that is deposited over the arch. These walls may extend above the roadway to form parapet walls (Spero 1995: 181).

Closed Spandrel Arch Bridges

The closed spandrel arch is the most fundamental of reinforced concrete bridges as they resemble masonry arch bridges as illustrated on the left side of Figure 25 (NCHRP 2005: 3-65). In a closed spandrel arch, the space between the deck and the arch ring has been filled in while the spandrel walls serve as retaining walls. “Live loads are borne by the fill material and, to a lesser extent, by the spandrel walls.” The load weight is transferred down to the arch and substructure. The closed spandrel arch was found throughout the country; however, it was more popular in those states that already had a tradition with masonry arch bridges (NCHRP 2005: 3-65).

The primary members of a closed spandrel arch include the arch rings and the spandrel walls (National Highway Institute October 2002: 7.5.7). The reinforcement of a closed spandrel arch stays along the arch from each support. The primary tension within the spandrel walls is located principally at the inside of the wall. The exposed wall has both temperature and shrinkage steel running both vertically and diagonally (National Highway Institute October 2002: 7.5.9).

Open Spandrel Arch Bridges

The open spandrel arch bridge was introduced in this country during the first decade of the twentieth century and was widely used throughout the nation during the 1920s and 1930s (NCHRP 2005: 3-67).

> *Open spandrel concrete bridges evolved, as the span length of reinforced concrete arches increased and the weight and cost of the material of spandrel walls of the closed spandrel type bridge became prohibitive. By eliminative these walls and the fill material inside them, not only could dead loads be reduced, but cost savings were seen in materials* (NCHRP 2005: 3-67).

The open spandrel arch bridge was lighter and more aesthetic in appearance and was a good choice for either a focal or a scenic location, as demonstrated in the bridge carrying US 40 over the Patapsco River (see Figure 26). The arch may be constructed either as a single structural element (an arch barrel) or in separate parallel longitudinal ribs, which are usually braced with “cross ties” (NCHRP 2005: 3-65). The barrel design is typically found on smaller and older bridges, and the rib design is typically found on larger bridges. The type was at its height during the 1930s and 1940s, by which time it was being replaced by more economical concrete girder bridges (NCHRP 2005: 3-67).

The construction of an open spandrel bridge includes pierced spandrel walls with no fill. The spandrel columns “transmit dead and live loads from the…deck to the arch.” The arch ring is either a solid barrel, as seen in the closed spandrel arch, or ribbed. During construction the open spandrel requires more formwork; however, it also does not require as many materials, especially for longer spans, as the closed spandrel (NCHRP 2005: 3-67).

Through Arches

The through arch is a special variant that is characterized by a concrete arch extending above the level of the roadway and supports the deck by means of concrete posts or suspenders (Spero 1995: 181). It consists of two arch ribs that rise from piers and carry the deck on vertical members suspended from their crowns. Sometimes, they are referred to as "Rainbow Arches" or "Marsh Arches" after German-born engineer, Marsh, who patented his through arch design and built it between 1912-1930 (Spero 1995: 157).

Standardized Types

Concrete Slab

In the early twentieth century, the reinforced concrete slab bridge type was lauded for its usefulness for both single and multiple spans. Early on in their development, they became subject to a variation that was similar to a through girder design. The slab was reinforced using parapets functioning as girders, a large portion of the load was carried via the girder to the abutments. In its simplest form, it consisted of a slab spanning between the main girders and was best used for narrow bridges as the load would be too heavy for wider crossings. A variation developed in the 1930s was the continuous slab bridge, in which a single slab extends over several spans. This design has some advantages, including simpler arrangement of reinforcement and better distribution of lateral and longitudinal loading but the greater cost of materials and larger dead loads reduced the advantages (Spero 1995:159-160).

Concrete Beam

The earliest of this bridge subtype were deck girder spans that features concrete slabs which were supported by longitudinal concrete beams. These were widely used through at least 1920. A variation was developed in the 1930s as a continuous girder bridge where a single set of girders extends over several spans. This required a smaller amount of steel and concrete, fewer bearings and expansion joints, and reduced deflection and vibration. However, these comprised of a more complicated design and an increased emissivity to the uneven settlement of foundations. The T-bean span featured a series of reinforced concrete beams integrated into the concrete slab, which forms a monolithic mass that appears in cross section like a series of upper-case "T"s. By 1920, T-beam construction was applied broadly in standardized bridge design across the US. This subtype was widely built in Maryland and Virginia by the 1930s (Spero 1995: 164-165).

Rigid Frame

The rigid frame concrete bridge subtype was a continuous structure, unlike other options where the superstructure and the substructure were separate units. The supporting members in a rigid frame bridge provided flexure and worked as a unit with the superstructure. It was argued that they were more economical and possessed more strength and rigidity than other options. They also required less steel or concrete, the center of the span could be shallower, fewer expansion joints were required, deflection and vibration were reduced, no bearings were required at the supports, and the stability of the vertical supports was greater than independent piers. Disadvantages included that they were only suitable at sites where unyielding foundations could be ensured, they required additional skill, concrete placement and formwork removal was complicated, and that the design was more complex (Spero 1995: 167-169).

The earliest extant rigid frame bridge in Maryland is Bridge 6031, carrying State Route 97 over Big Pipe Creek near Union Mills in Carroll County (MIHP CARR-1462). The longest rigid frame structure in Maryland is Bridge 11018, a 120-foot, two span built in 1937 to carry State Route 135 over the Savage River near Bloomington in Garrett County, Maryland (MIHP G-I-E-199) (Spero 1995: 180).

Culverts

A culvert is a small bridge, generally under 20 feet, that does not run parallel to the roadway as with other bridges. Culverts are constructed through embankments to allow the movement of small streams or surface water. They may be single span or multiple span structures. The subtypes include box culverts and arch culverts. Box culverts have square or rectangular openings while arch culverts have a Roman or semicircular arch. Both forms were standardized at an early date. The U.S. Bureau of Public Roads had examples of standard designs by 1920 (Spero 1995: 171).

Registration Requirements

In addition to the general requirements outlined in the beginning of Section F, the following specific associations may be utilized for determinations of National Register eligibility for this bridge type.

Concrete bridges in Maryland were constructed as the highway and railway network grew and expanded throughout the state at the turn of the twentieth century. Early concrete bridges constructed between 1890 through 1910 would be associated with “the introduction of concrete and reinforced concrete technology to the state, under the leadership of Baltimore City, Baltimore County, the Maryland Geological Survey Highway Division, and the State Roads Commission” (Spero 1995: C-26).

Bridges constructed during the 1910-1940 period would be associated with the standardization of small concrete bridges throughout the state (notable beam bridges, simple arches, and culverts). In addition, some concrete bridges would also be associated with the “further refinement of concrete bridge design and technology (notably open-spandrel ribbed arches and rigid frames).” These bridges may also be associated with the City Beautiful movement that was prevalent throughout the nation at this period in history. Finally, concrete bridges at this time could also be associated with the elimination of grade crossings, which was a continuing public effort to eliminate dangerous at-grade crossings of railroad tracks by road traffic (notably concrete beam bridges) (Spero 1995: C-26).

Concrete bridges constructed between 1940 to 1965 would be associated with continuing improvements to concrete bridge technology and the continuing standardization of concrete bridge design along with the development of prestressing techniques (Spero 1995: C-26).

"Filled" spandrel concrete arch bridges are among the earliest concrete bridges. The earliest bridges of this type were constructed during the early 1890s through the 1920s when reinforced concrete was introduced. These early examples are not as common as concrete girders and slab bridges and are significant in that they represent the evolution of concrete technology. Furthermore, early filled bridges constructed under the earliest standardized plans would also be significant, illustrating the development of standardization in state highway administrations (NCHRP 2005: 3-65).

Like their closed spandrel counterparts, open spandrel arch bridges are not as common as early standardized concrete bridge types. When engineers realized that materials and costs could be saved by removing the triangular portion between the deck and arch, the open spandrel concrete arch was developed (NCHRP 2005: 3- 65). This type is significant as an early concrete bridge type and depicts the developing technology and early innovation in reinforced concrete bridges (NCHRP 2005: 2-65).

For small structures with spans of less than 20 feet, the following may apply:

- Concrete slab culverts may be eligible under Criteria C if they were built between ca. 1900-1911 or 1912-1947 and have all of their CDEs present.
- Concrete girder culverts may be eligible under Criteria C if they were built between 1912-1923 and have all of their CDEs present.
- Concrete arch culverts may be eligible under Criteria C if they were built between ca. 1900-1911 and have all of their CDEs present.

Character Defining Elements

Concrete bridges may be used as culverts, with spans of less than 20 feet.

Concrete Arch Bridges

The following are CDEs and primary (P), secondary (S), and tertiary (T) elements for concrete arch bridges in Maryland (Spero 1995: C-56; C-57):

- Filled spandrel bridges
    - Superstructure
        - Arch ring [P] [CDE]
        - Barrel [P] [CDE]
        - Spandrel wall [P] [CDE]
        - Fill [NA]
        - Railing or parapet [P] [CDE]
        - Applied ornamentation [S]

        - Identifying plaques, plates, and imprints [P]
    - Substructure
        - Abutments [P] [CDE]
        - Wing walls [P] [CDE]
        - Pier(s) (when present) [P] [CDE]
        - Applied ornamentation [S]
        - Identifying plaques, plates, and imprints [P]
- Closed spandrel bridges
    - Superstructure
        - Arch ribs [P] [CDE]
        - Spandrel wall [P] [CDE]
        - Railing or parapet [P] [CDE]
        - Applied ornamentation [S]
        - Identifying plaques, plates, and imprints [P]
    - Substructure
        - Abutments [P] [CDE]
        - Wing walls [P] [CDE]
        - Pier(s) (when present) [P] [CDE]
        - Applied ornamentation [S]
        - Identifying plaques, plates, and imprints [P]
- Open spandrel bridges
    - Superstructure
        - Arch ribs [P] [CDE]
        - Spandrel [P] [CDE]
            - Spandrel column [P] [CDE]
            - Spandrel arch [P] [CDE]
        - Arch ribs [P] [CDE]
        - Railing or parapet [P] [CDE]
        - Applied ornamentation [S]
        - Identifying plaques, plates, and imprints [P]
    - Substructure
        - Abutments [P] [CDE]
        - Wing walls [P] [CDE]
        - Pier(s) (when present) [P] [CDE]
        - Applied ornamentation [S]
        - Identifying plaques, plates, and imprints [P]
- Through (or rainbow) arch bridges
    - Superstructure
        - Arch ribs [P] [CDE]
        - Ties [S] [CDE]
        - Lower chord [P] [CDE]
        - Suspenders [P] [CDE]
        - Floor beams [P] [CDE]

        - Deck [S]
        - Railing [T]
        - Applied ornamentation [S]
        - Identifying plaques, plates, and imprints [P]
    - Substructure
        - Abutments [P] [CDE]
        - Wing walls [P] [CDE]
        - Pier(s) (when present) [P] [CDE]
        - Applied ornamentation [S]
        - Identifying plaques, plates, and imprints [P]
        - Endpost section of railing, attached to abutment [S]

Concrete Slab Bridges

The following are CDEs and primary (P), secondary (S), and tertiary (T) elements for concrete slab bridges in Maryland (Spero 1995: C-60-61):

- Superstructure
    - Slab [P] [CDE]
    - Parapet or railing [P] [CDE]
    - Roadway [T]
    - Applied ornamentation [S]
    - Identifying plaques, plates, and imprints [P]
- Substructure
    - Abutments [P] [CDE]
    - Wing walls [P] [CDE]
    - Pier(s) (when present) [P] [CDE]
    - Applied ornamentation [S]
    - Identifying plaques, plates, and imprints [P]
    - Endpost section of railing, attached to abutment [S]

Concrete Beam Bridges

The following are CDEs and primary (P), secondary (S), and tertiary (T) elements for concrete beam bridges in Maryland (Spero 1995: C-62):

- Superstructure
    - Slab [P] [CDE]
    - Longitudinal beams (on T-beam bridges, slab and longitudinal beams are integrated) [P] [CDE]
    - Parapet or railing, when integral [P] [CDE]
    - Roadway [T]
    - Applied ornamentation [S]

    - Identifying plaques, plates, and imprints [P]
- Substructure
    - Abutments [P] [CDE]
    - Wing walls [P] [CDE]
    - Pier(s) (when present) [P] [CDE] (large multi-span rigid frame bridges feature stiff towers and slender expansion piers)
    - Applied ornamentation [S]
    - Identifying plaques, plates, and imprints [P]
    - Endpost section of railing, attached to abutment [S]

Rigid Frame Bridges

Rigid frame bridges are designed as monolithic structures, in which the superstructure and the substructure are of one continuous fabric. This can include culverts, which can have spans of under 20 feet. The following are CDEs and primary (P), secondary (S), and tertiary (T) elements for rigid frame bridges in Maryland (Spero 1995: C-63-64):

- Superstructure
    - Deck [P] [CDE]
    - Parapet or railing [P] [CDE]
    - Applied ornamentation [S]
    - Identifying plaques, plates, and imprints [P]
- Substructure
    - Abutments [P] [CDE]
    - Wing walls [P] [CDE]
    - Pier(s) (when present) [P] [CDE] (large multi-span rigid frame bridges feature stiff towers and slender expansion piers)
    - Applied ornamentation [S]
    - Identifying plaques, plates, and imprints [P]
    - Endpost section of railing, attached to abutment [S]

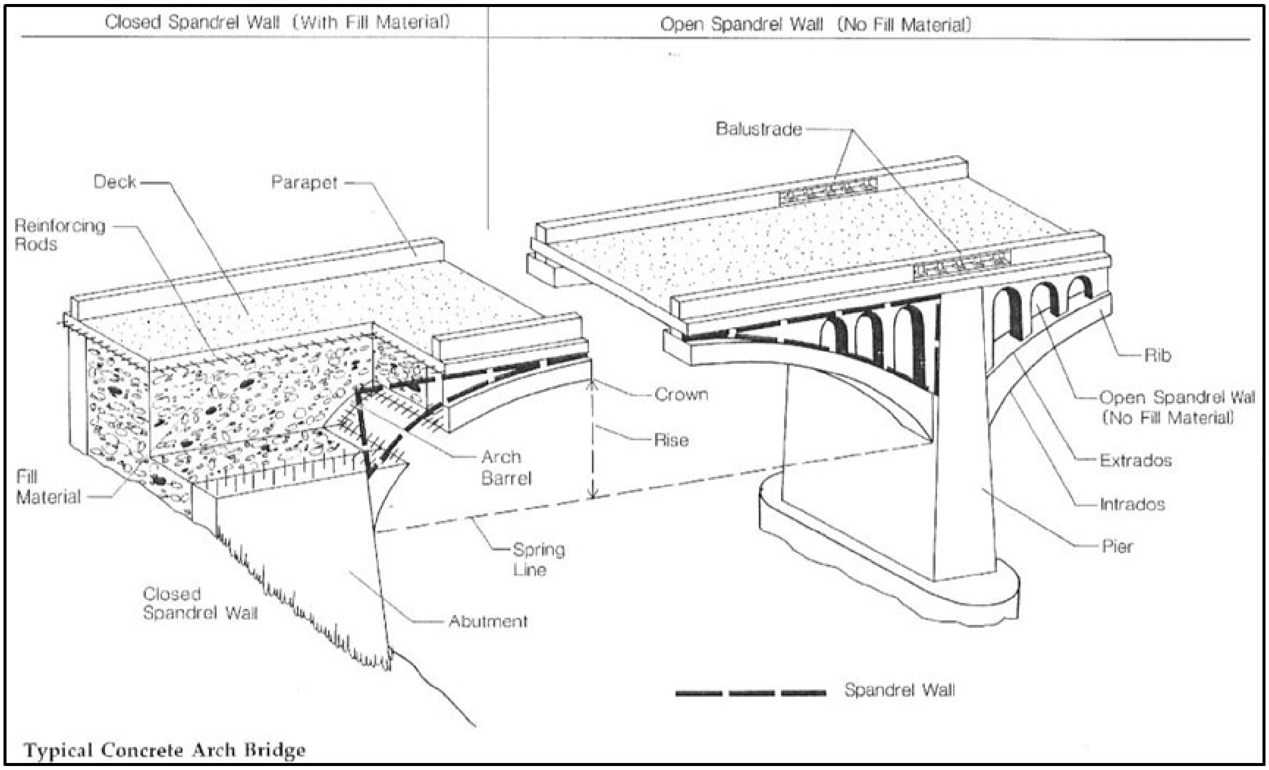


Figure 25. Elements of a Concrete Arch Bridge (PHMC and PennDOT 1986)

Figure 26. US 40 over Patapsco River Open Spandrel Reinforced Concrete Arch Bridge in Baltimore and Howard Counties (SHA Bridge #0310900 and MIHP # BA-2557)

G. Geographical Data

The geographic extent of this Multiple Property Documentation Form covers the entire state of Maryland and is not limited to a specific county or municipality within the state.

H. Summary of Identification and Evaluation Methods

In 1995, the Maryland State Highway Administration (SHA) joined with the Maryland Historical Trust (Maryland's State Historic Preservation Office) and the Federal Highway Administration (FHWA) to inventory Maryland's state, county, and city highway bridges as part of SHA's cultural resources initiative. Through that process, 855 bridges built between 1809 and 1947 were identified as historic resources; 415 of which were determined to be eligible for the National Register. 168 of the eligible bridges were owned by the State of Maryland. The initial effort to identify bridges eligible for the National Register resulted in the preparation of the *Historic Highway Bridges in Maryland: 1631-1960: Historic Context Report* (Spero & Company and Berger & Associates, 1995). A second comprehensive evaluation of bridges owned by SHA and built between 1948-1965 resulted in the preparation of the *Phase II State Historic Bridge Context & Inventory of Modern Bridges, Survey Report and Assessments of Significance* (URS 2004) and *"Tomorrow's Roads Today," Expressway Construction in Maryland 1948-1965* (Bruder 2010).

In order to determine the best candidates for long-term preservation, SHA reevaluated its NRHP eligible bridges in 2007 using twenty-first-century historic preservation standards and practices. As a result of the reevaluation, SHA selected 17 bridges to be classified as "Preservation Priority Historic Bridges," 91 bridges as "Eligible Historic Bridges," and 60 bridges as "Non-Priority Historic Bridges." The 17 Preservation Priority bridges are further described in Appendix A.

This Multiple Property Documentation Form was a result of the *Programmatic Agreement Among the Federal Highway Administration, the Maryland State Highway Administration, the Advisory Council on Historic Preservation and the Maryland State Historic Preservation Officer Regarding SHA's Historic Highway Bridges in Maryland* (Section XII, item A) which was executed in 2013. The agreement determined that the 17 preservation priority bridges would be nominated to the National Register of Historic Places as funding was made available.

From 2023-2024, this MPDF was expanded to support the nomination of all Maryland's eligible bridges, whether owned by SHA, privately (by residents and/or corporations), by city and county governments, by the federal government, or owned by other state agencies.

Commented [GD1]: Programmatic link if need to reference: https://www.roads.maryland.gov/OPPEN/Maryland%20SHA%20Historic%20Bridge%20Programmatic%20Agreement.pdf

Commented [GD2R1]: Management plan if need to reference: https://www.roads.maryland.gov/OPPEN/Maryland%20SHA%20Management%20Plan%20for%20Historic%20Highway%20Bridges.pdf

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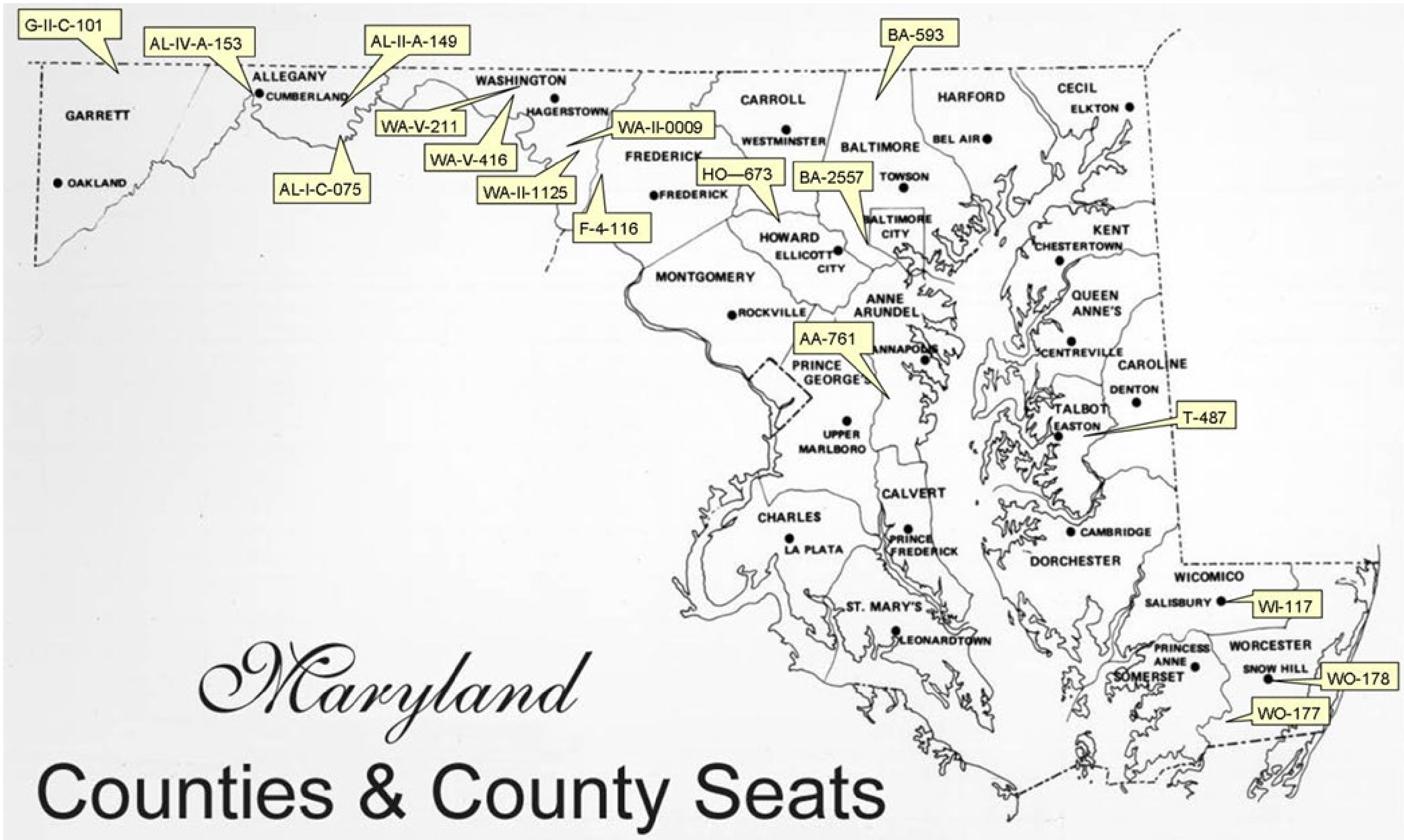
Table 1. 17 Priority Bridges in Maryland: Location, Builders/Designers, And NRHP Eligibility

County	Bridge No.	MIHP No.	Route	Crossing	Year Built	Bridge Type	Builder/Designer	Eligible under Criterion
Allegany	0103500	AL-II-A-149	MD 144AE	Town Creek	1925	Reinforced Concrete Arch, Filled	SRC/Unknown	A & C
Allegany	0104800	AL-I-B-075	MD 51	C&O Canal	1932	Steel Warren Pony Truss	Attributed to Roanoke Iron & Bridge Works/Roanoke Iron & Bridge Works	A & C
Allegany	0106600	AL-IV-A-153	MD 942	Potomac River	1955	Steel Tied Through Arch	Unknown/Ned Wroe, SHA	C
Anne Arundel	0205400	AA-761	MD 214	Patuxent River	1935	Steel Parker Through Truss	Roanoke Iron & Bridge Works/Unknown	A & C
Baltimore	0310500	BA-593	MD 463	Little Falls	1809	Stone Arch	Small et at[1]/John Davis[2]	A & C
Baltimore	0310900	BA-2557	US 40	Patapsco River	1936	Reinforced Concrete Arch, Open Spandrel	SRC/SRC	C
Frederick	1003100	F-4-116	US 40	Middle Creek	1936	Reinforced Concrete Arch, Filled (Stone Façade)	SRC/SRC	A & C
Garrett	1100700	G-II-C-101	US 40 Alt	Casselman River	1932	Steel Pratt Through Truss	Unknown	A & C
Howard	1304600	HO-673	Old MD 32	Patapsco River, CSX	1963	Aluminum Box Girder	SRC & International Aluminum Structures[3]/Harry Kahn[4]	C
Talbot	2002300	T-487	MD 331	Choptank River	1933	Movable Swing Span,	SRC/J.E. Greiner	A & C

[1] John Small, George Small, Michael Gardner, and Jonathan Jessup were contracted to build five stone arch bridges for the Baltimore and York-Towne Turnpike which superseded this road.
[2] John Davis was the first superintendent of the Baltimore Water Company.
[3] Successor to Kinetics Division of Fairchild Engine and Airplane Corporation, Hagerstown, Maryland.
[4] Engineer at Kinetics Division of Fairchild Engine and Airplane Corporation, Hagerstown, Maryland, predecessor of International Aluminum Structures, Inc.

County	Bridge No.	MIHP No.	Route	Crossing	Year Built	Bridge Type	Builder/Designer	Eligible under Criterion
						Steel Subdivided Warren Through Truss		
Washington	2100400	WA-II-1125	MD 845A	Little Antietam Creek	1927	Reinforced Concrete Arch, Filled	SRC/SRC	A & C
Washington	2101000	WA-V-416	US 40	Licking Creek	1938	Steel Wichert Girder	SRC/SRC	A & C
Washington	2101200	WA-V-211	US 40	Conococheague Creek	1936	Reinforced Concrete Arch, Open Spandrel	SRC/SRC	A & C
Washington	2103800	WA-II-009	MD 68	Antietam Creek	1833	Stone Arch	Charles Wilson/Unknown	C
Wicomico	2200900	WI-117	MD 991	Wicomico River	1928	Movable Bascule, Double-Leaf Trunnion	SRC/John MacKall, of SRC & J.E. Greiner	A & C
Worcester	2300200	WO-178	MD 12	Pocomoke River	1932	Movable Bascule, Single-Leaf Trunnion	SRC/H.D. Williar, of SHA & J.E. Greiner	A & C
Worcester	2300400	WO-177	US 13 Bus	Pocomoke River	1920	Movable Bascule, Double-Leaf Trunnion	McLean Contracting/J. N. Mackall of SRC & J.E. Greiner	A & C



Map 2: Map of Maryland Counties and County Seats and the Distribution of the 17 Priority Bridges across the state referenced in Table 1 (SHA, Maryland State Archives, 2009). Bridges are noted by their MIHP Number.