Ohio Department of Transportation

Office of Environmental Services

2007-08 Ohio Historic Bridge Inventory Update

Phase 1A

Historic Context and Phase 1A Recommendations for Previously Excluded and Re-evaluated Bridge Types

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Ohio Historic Bridge Inventory Update, Phase 1A

Historic Context and Recommendations for Previously Excluded and Re-evaluated Bridge Types

Purpose

The purpose of the 2007-08 Ohio Historic Bridge Inventory Update historic context is to facilitate application of *A Context for Common Historic Bridge Types (NCHRP Project 25-25, Task 15, Oct. 2005)* and ODOT=s previous historic bridge contexts to the extant population of previously excluded bridge types and previously inventoried bridges that merit re-evaluation (see below lists). The context will be used to inform and develop Ohio-specific criteria for eligibility evaluation within each of the bridge-type populations, for example, bridges built before a certain date or using a particular method of construction. It is designed to assist with making ODOT=s inventory all-inclusive and current, especially developing the state and local significance of the bridge types that were in the excluded categories of previous inventories.[1]

Previously Excluded Types

Steel Girder-Floorbeam
Reinforced Concrete Thru Girder
T Beam
Reinforced Concrete Slab
Steel Rigid Frame
Reinforced Concrete Rigid Frame
Simple Steel Stringer
Wood Stringer

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[1] *The Ohio Historic Bridge Inventory, Evaluation, and Preservation* Plan (1983); The *Second Ohio Historic Bridge Inventory, Evaluation, and Preservation Plan* (1990); *The Concrete Arch Supplement to the Ohio Historic Bridge Inventory, Evaluation and Preservation Plan* (1994); *The Third Ohio Historic Bridge Inventory, Evaluation and Management Plan for Bridges Built 1951-1960 and the Development of Ohio=s Interstate Highway System* (2004). Internet on-line, http://www.dot.state.oh.us/oes/hist_bridges.htm [September 2007].

Wood Slab	<u>Previously Inventoried Types for Update/Re-evaluation</u>
Wood Girder-Floorbeam	
Culverts	
Reinforced Concrete Box Beam	Metal Truss
Other	Wood Truss
	Continuous Steel Stringer
	Arch (all materials)
	Suspension
	Movable (all types)

<u>Notes on the Study Population & Database</u>

At this stage of the 2007-08 update project, the context is designed to guide decisions about eliminating from further consideration those large numbers of bridges that clearly have no historical or technological significance from those that have potential significance. A critical tool in this analysis is the historic bridge inventory=s electronic database.

The inventory database was populated with a download from ODOT=s Bridge Management System (BMS) of all bridges with dates of construction before 1961. Rail-over-highway bridges (508 bridges) and Ohio Turnpike-owned bridges (501 bridges) were separated out because they had been determined to be beyond the scope of this study. The remaining data was then merged with the data fields from the *Third ODOT Historic Bridge Inventory* (2004), which were for the pre-1961 non-excluded bridge types and interstate bridges. The data was merged only for matching Structure File Numbers (SFN) so that no duplicate records were created and bridges that had been replaced since 2004 were accounted for. After the merger, the total number of bridges in the database rounded to about 14,500 bridges.

Upon review, it was determined that about 4,800 of the 14,500 bridges have span lengths of less than 20'. These were separated from the study population since they do not meet the Federal Highway Administration (FHWA) definition for a bridge. It was noted that seven (7) of these short-span bridges, all arches, had been previously evaluated Aselect@ or Areserve@ by ODOT=s prior inventories. Those seven were returned to the active inventory database. Upon further research and development of the contexts, it is recommended that a selection of the less than 20' bridges, inclusive of the stone slabs, stone arches, and pre-1921 concrete arches (110 bridges total), be returned to the study population. Justification for this recommendation can be found in the section on culverts (below).

Overview

Structural techniques for many years after 1900 lived exclusively off the legacy of the previous century. Nearly all the essential modes of contemporary building had been developed and given practical demonstration before the new century appeared.

B Carl W. Condit, American Building Art: The Twentieth Century (1961)

This historic context addresses the significance of common highway bridge types dating mostly from the first half of the 20^{th} century in Ohio. One of the salient characteristics of these bridges is their relatively large numbers and similarity and uniformity in design over many decades of use. In many ways, the significance of these bridges is best represented by the examples that mark the introduction or refinement of successful standardized design concepts that would go on to make geographically widespread and long-term contributions to Ohio=s highway systems.

These bridges were built at a time when engineers nationally and in Ohio worked feverishly to replace outmoded bridges from the days of horse and buggy with modern bridges better suited to the demands of cars and trucks. Broadly speaking, this meant bridges with wider roadways, higher load capacity, and improved safety features. Under most conditions, Ohio=s engineers favored materials and designs that had proven track records, were economical to construct, and easy to maintain, thus stretching the available public finances to improve as many crossings as possible. By the late 1950s, the transformation was nearly complete with the remaining 19^{th}-century bridges relegated mostly to low-volume roads and non-arterial streets. Many of the bridges of the early 20^{th} century were themselves being replaced by mid-century because they too had become outmoded.

Established in 1904, the Ohio Department of Highways prided itself on being technologically progressive, and this meant that its Bureau of Bridges, created in 1911, had the responsibility of ensuring that the state=s bridges had greater uniformity of design. State engineers worked cooperatively to improve Ohio=s state highway system and to offer technical support to the counties and cities that maintained local roads and bridges. The engineers produced guidelines, specifications, and standard plans for everything from road surfaces to signage, but bridges were a particular concern since they were among most expensive of all features to design and construct, and highway officials were very concerned that revenues be used wisely. Among the bridge bureau=s first activities was issuing written bridge specifications and standard bridge drawings. The oldest drawing on record is August 1, 1911 for a reinforced-concrete box culvert. Within the next several years, the bureau prepared standard drawings for the most common highway bridge types of the first half of the 20th century, including steel girder-floorbeam (1911), steel stringer (1912), reinforced-concrete slab (1912), steel truss (1913), reinforced-concrete T beam (1913), and reinforced-concrete thru girder (1916).[2] Ohio=s engineers and contractors quickly came to rely on these readily standardized and economical bridge types. Many county engineers used the state standard drawings while others developed their own standards, but almost always using one or more of these common types standardized by the state. Other less-common bridge types were also employed, but these were typically reserved for long-span bridges (span lengths over about 150'), for crossings with special topographical considerations (such as movable bridges over navigable waterways), or for sites with special aesthetic concerns (e.g., parks, parkways, urban settings, and prominent crossings).

By 1918, Ohio state law required that all bridges on state highways and all bridges costing over $10,000 on county roads be in compliance with the published specifications of the Ohio Department of Highways.[3] Specifications, once tried and proven, had predictable costs, promoted the efficient use of engineering manpower, and helped to ensure quality and uniformity across a large number of bridge projects in all regions of the state. They

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[2] ODOT, Bureau of Bridges & Structure Design, Index of Standard Drawings, November 1981.

[3] Ohio Department of Highways, Specifications for Highway Structures (Columbus), 1918.

were not so rigid that engineers and contractors could not adapt them, within limits, to local conditions on a project-by-project basis. This approach proved so successful that it remained the dominant approach into the 1960s and, in many ways, up to the present day.

Ohio was often at the forefront of national trends in bridge-building practice due to the progressive posture of the Ohio Department of Highways. The department worked cooperatively and pro-actively with the federal Bureau of Public Roads (BPR, predecessor agency to the Federal Highway Administration), both as a funding partner in the federal-aid highway program, established in 1916, and as a professional partner in the American Association of State Highway Officials (AASHO), established in 1914. The BPR and AASHO promoted the long-term goal of uniformity in highway and bridge design and the use of best engineering practices across the nation. AASHO=s bridge committee, made up of federal and state bridge engineers, issued findings and guidance, which formed the basis upon which most states, including Ohio, developed and updated their own statewide bridge specifications. Ohio=s state bridge engineers were often viewed as leaders among their national peers in AASHO. They also joined with the American Society for Testing Materials (ASTM), the American Society of Civil Engineers (ASCE), the Ohio County Engineers Association of Ohio (CEAO), and other professional societies to promote standards in other critical areas, such as the manufacture and grading of materials or the education and training of engineers. The bridges resulting from this cooperative organizational structure offered good value, but were only rarely innovative or outstanding on their individual merits.

A good rule of thumb for this study of common bridge types is that previously excluded bridge types dating to before 1911 belong to Ohio=s era of pre-standardization and may merit careful consideration of their technological significance. These bridges have a higher likelihood to be representative of innovative technology or of early local efforts to experiment with bridge types that would eventually lend themselves to standardization. Bridges dating from 1911 to 1921 are from the initial period of statewide standardization when most of the common bridge types that would be used over the course of the next

40-50 years were adopted by the Bureau of Bridges or variations of them adopted for use by county and city engineers. Unaltered examples from this period may be significant as prototypical examples of standardized bridge types that went on collectively to make widespread contributions to the improvement of Ohio=s state or local road systems. The most common bridge types built after 1921, such as the steel stringer, T beam, and slab, were based on earlier precedents and usually reflect refinements, such as wider roadways or higher live-load capacity that are not considered technologically significant.

Exceptions to the rule of thumb are evident within specific bridge-type populations. The rigid frame, for example, was not used in Ohio until the late 1920s; it did not lend itself to standardization, and it was often used in urban settings where an economical but aesthetic bridge was desired. A few bridges built after 1921 may represent important leading-edge refinements in standardization, such as the adoption of continuous designs or welded connections in steel bridges during the 1930s. Other bridges are the work of prominent engineers, such as D. H. Overman, the state highway department=s principal design engineer, who sometimes produced exceptionally well-proportioned and aesthetic bridges, reflecting outstanding use of architectural styles and tastes of the time as applied to otherwise prosaic bridge types such as the T beam. These cases are further explained below in the summary contexts and recommendations for each bridge type.

A. PREVIOUSLY EXCLUDED BRIDGE TYPES

Steel Stringer Bridges

Steel stringer bridges consist of a series of parallel longitudinal steel beams supporting a deck, usually of reinforced concrete. They are by far the most common inventoried highway bridge type over 20' long in Ohio with approximately 3,700 extant examples dating from circa 1890 to 1961. The reasons for this are several, including simplicity and adaptability to standardized designs, economy of construction, and the ability to re-use beams when a bridge is widened or replaced. Also not to be discounted is the fact that Ohio historically is a steel state with numerous mills. The steel stringer bridge continues to be built today, making it one of the longest-lived bridge technologies in modern times.

Ohio=s potentially significant examples of the steel stringer technology tend to be those unaltered examples dating to the early period of use and development in the late 19th century and standardization during the first decades of the 20th century. Later examples may represent important refinements, particularly the first applications of continuous designs in the early to mid 1930s, but the tendency is for the population to be highly undifferentiated; only a very few steel stringer bridges rise to levels of historical or technological distinction.

The evolution of the stringer bridge type is closely allied with technological improvements in ferrous metallurgy since it intrinsically relies on the bending strength of the beam material to resist loads. In the mid 19th century, the transition from wood to wrought iron was a significant advancement, perhaps even more so than the transition from wrought iron to steel in the late 19th century since structural steel technology built directly on iron. The wrought-iron beams were either rolled sections (beams shaped by passing hot metal through rolls with a succession of grooves) or built-up sections (beams composed of rivet-connected plates for the web and angles for the flanges, i.e., girders). The wrought-iron beams were, however, expensive and mostly used on railroad, not highway, bridges. Ohio has no confirmed wrought-iron stringer highway bridges, but there are several examples reported to be old enough to be wrought iron. They will be investigated in the next phase.[4]

The steel stringer=s heyday came with improvements in open-hearth steel manufacture and the increased capacity of mills to economically produce large quantities of structural steel starting in the 1890s. This was followed by a significant advancement in rolling technology: the Grey mill at Pennsylvania=s Bethlehem Steel Company in 1908. Named after inventor Henry Grey, the mill produced wide-flange beams up to 36" deep and 75' long with a significant savings in material and no loss of strength in comparison to traditional I-beams. The economical and strong wide-flange beams had become standard by 1920 and proved ideally suited for the campaigns to improve highway bridges. The length, depth, and spacing of beams were picked off charts depending on the characteristics of the desired crossing. Rubber-tired trucks and improved heavy construction equipment eased the problems of transporting beams and on-site erection.[5]

The Ohio Department of Highways adopted its first standard drawings for steel stringer bridges in 1912. The stringers were encased in concrete to protect them against the elements. Encasement could be used in any location, but it was popular near factories or over railroads where the corrosive effects of exhaust were a concern. Pittsburgh was among the first cities nationally to make use of concrete-encased stringer, girder-floorbeam,

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[4] None of the stringer bridges in ODOT=s Bridge Management System (BMS) are coded wrought iron although several have dates of construction in the 1880s. This could be a coding anomaly related to using substructure, not superstructure, for the original date of construction. If the beams really do date to the 1880s, they would in all likelihood be wrought iron.

[5] Thomas Misa, AScience, Technology, and Industrial Structure: Steelmaking in America, 1870-1925,@ Ph.D. Dissertation, University of Pennsylvania, 1987.

and even truss bridges in the 1890s. Encasement may also have been popular in Ohio steel cities like Youngstown (to be determined).

The concrete jack arch deck was a variation on steel stringer design used mostly on rural county roads in Ohio and in many other states from the 1900s to the 1930s. A strong jack arch deck was easily formed with little skill and a minimum of reinforcing bars by using a form liner, usually corrugated metal pipe half-sections, placed in an arched shape between the stringers. Their use on the county level was promoted by federal and state engineers through "how-to" pamphlets.

The steel stringer came to be the dominant standardized bridge type in Ohio during the economic depression of the 1930s. Anticipating the federal New Deal by several years, Ohio=s state government initiated the Winter Relief Bridge Program in the fall of 1931 as a means of putting unemployed men to work, as well as assisting cash-strapped county and municipal governments. The Ohio Department of Highways prepared standard drawings for steel stringer bridges with timber substructure, decks, and railings that could be built during winter, thus not requiring the pouring and curing of concrete substructure units or decks. The winter program ended in 1933, but the standard design continued to be used with federal New Deal works programs (e.g., Works Progress Administration) until the advent of World War II in 1941. It is unknown whether unaltered examples of this standard survive since wood railings, deck, and substructure are unlikely to have survived without replacement. It will be investigated in the next phase.[6]

Perhaps the most important advance in the early 1930s was the use of continuous designs where the beams continue uninterrupted over one or more piers. Continuous designs have significant economic advantages because they use less material (smaller section beams) for a given span length than simple spans (those where the beams do not continue over the

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[6] ODOT, AThe Ohio Historic Bridge Inventory (1983), p. 171.

piers). A simple span must accommodate the entire load within the span, whereas the continuous span distributes loads from bearing to bearing over two or more spans. Continuous designs also allow for the reinforced-concrete deck to be continuous over the interior substructure units, thus reducing the number of expansion joints, which are frequent sources of deterioration and thus maintenance costs.

The Bureau of Bridge=s principal design engineer D. Henry Overman is credited with designing some of Ohio=s first significant continuous steel stringer bridges and developing continuous specifications and standards during the early to mid 1930s. He was on the cutting edge of national trends in taking advantage of the economy of continuous designs. Prior to the 1930s, few bridge engineers used continuous designs because of the challenges involved in analyzing the indeterminate structures and the lack of professional agreement on acceptable specifications.[7] In 1932, the American Society of Civil Engineers (ASCE) published standard methods and tables for calculating stresses based on the pioneering work of engineering professor Hardy Cross at the University of Illinois, and the American Association of State Highway Officials (AASHO) added its approval to continuous-design guidelines in 1941. Continuous steel stringer bridges became very popular in Ohio and nationally after World War II.[8]

Overman had joined the state highway department in the early 1920s and had been recognized by chief bridge engineer J. R. Burkey as a talented designer. During the late 1920s, he had emerged as the bridge bureau=s Aarch specialist,@ which involved some of the most complex calculations, as well as attention to aesthetic detail. Although Overman

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[7] Engineers classify bridges as either Adeterminate@ or Aindeterminate.@ The stresses induced by loads in an indeterminate design cannot be solved or determined using the traditional principles of statics, i.e., the study of forces.

[8] U.S. Department of Transportation, Federal Highway Administration, America=s Highways, 1776-1976 (Washington, D.C.: U.S. Government Printing Office, 1976), p. 432.

designed all types of bridges, his attention eventually turned to the challenge of continuous bridges, including several T beam bridges in the mid to late 1920s (see below). When Overman was promoted to principal design engineer in 1930, it was not long after that he persuaded the department to adopt standard design and erection procedures for continuous steel stringer bridges.[9]

A distinctive detail of Ohio=s early continuous steel stringer bridges was the use of welded splice connections for the fascia beams. Overman considered riveted connections Aunsightly@ and for architectural reasons desired the smooth lines possible with welding. Former ODOT bridge engineer Martin P. Burke, Jr., P.E., who has written and studied Overman=s work, notes that it was Aa bold step in welding technology, a type of construction that was to be continually improved to the extent that butt-welded field splices were to dominate field connections for the Ohio Department of Highways for many decades.@ Recognizing the significance of these early continuous steel stringer and girder-floorbeam bridges, ODOT took an historic inventory of them in the 1990s and identified eight select examples dating from 1931 to 1936, of which five remain on-system.[10]

The continuous steel stringer bridge became the workhorse bridge type of the Ohio Department of Highways from the late 1930s through the 1980s with as many as 5,000 examples built. Standard drawings were always in the process of being updated for various roadway widths, live loads, and span lengths. By the 1960s, computers were significantly cutting down on the time needed to perform continuous-design calculations allowing engineers to more easily design across a wider range of span lengths, roadway widths,

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[9] Martin P. Burke, Jr., AEngineering Artistry in the U.S. Depression: Henry Overman=s Bridges,@ Proceedings, International Historic Bridges Conference (Columbus, 1992), pp. 147-180.

[10] ODOT, Environmental Section. Background of Continuous Steel Bridges in Ohio. Memorandum. Feb. 8, 2001. In the notebook Continuous Steel Beam and Continuous Deck Girder Saga; Burke (1992), p. 168.

skews, and super-elevations. Collectively these later steel stringer bridges have played a significant role in the development of Ohio=s state highway system, but they are individually undifferentiated.

Phase 1A Recommendations for Further Research of Steel Stringer Bridges

$ Previously unevaluated steel stringer bridges built before 1921 (1,007 bridges)
$ Previously unevaluated simple-span steel stringer bridges built from 1931 to 1933 to determine if any are unaltered AWinter Relief@ bridges (65 bridges)
$ Re-evaluate continuous steel stringer bridges built prior to 1937 (78 bridges)
$ Check status of already select continuous steel stringer bridges (3 bridges)

Steel Girder-Floorbeam Bridges

The inventory includes 273 examples of pre-1961 girder-floorbeam highway bridges. The potentially technologically significant examples will tend to be those unaltered examples that date to the early period of use in the 19th century and standardization during the first decades of the 20th century. Later examples may represent important refinements, particularly the application of continuous-design principles in the 1930s.

The history of the steel girder-floorbeam shares a context very similar to the stringer with the primary technological difference being the framing pattern; girder-floorbeam bridges have two or more longitudinal beams (i.e., girders) supporting transverse floorbeams and a deck. The longitudinal girders are typically built-up to achieve a greater depth than economically available from rolled sections. The technique of building up the girders has historically been riveting. Welding became a more common alternative after 1945 with the advancement of welding technology.

Girder-floorbeam bridges may be either through or deck designs, but the difference is not historically significant, merely reflecting a choice in where to connect the floorbeams. The through girder is where the floorbeams are placed in line with the bottom flanges of the girders with the roadway passing between the paired girders. The deck girder is where the floorbeams are placed near the top flanges of the girders and the roadway located at the top of the girders. All things being equal, the through girder has the advantage over the deck girder of increasing the available vertical clearance under the bridge.

The girder-floorbeam was developed in the late 1840s and first used by railroads. In fact, it was the only serious competitor to metal truss railroad bridges during the mid to late 19th century. Railroads continued to be the leading builders of girder-floorbeam bridges in Ohio through the early decades of the 20th century. Not only did railroad engineers develop the bridge type, but they also had the heavy equipment (flat cars and cranes) to move and place the girders.[11] The oldest and most technologically significant girder-floorbeam bridges in Ohio are likely to be rail-carrying or highway over rail. The rail-carrying examples are outside the scope of this survey.[12]

The Ohio Department of Highways issued its first set of standard drawings for steel through girder bridges in 1911-15. The bridges measured 50', 60', and 70' long, and their details were similar to and based on more than 50 years of railroad experience with the bridge type. State specifications covered such details as the thickness of plates and flange sections, placement of rivets, and the spacing of web stiffeners.[13]

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[11] Carl W. Condit, American Building, 2nd ed. (Chicago: University of Chicago Press, 1982), pp. 225-226.

[12] There are over 300 steel girder-floorbeam rail-over-highway bridges in ODOT=s BMS data.

[13] Specifications (1918), p. 14.

The department used through girder bridges into the 1930s, but as longer and deeper rolled wide-flange beams became economically available, the steel stringer gained cost advantage over girder-floorbeams and they gradually fell from use. Girder-floorbeam bridges had also proven to be impractical to widen. After 1930, the department built a small number of continuous deck girder bridges of about 90' to 150' span. In this range, engineers in Ohio and throughout the nation found that built-up, haunched, longitudinal girders could be shaped to be deepest over the piers where stresses are greatest in a continuous design. This offered sometimes significant savings in steel, and thus cost, over other available steel bridge types. The two extant pre-1941 continuous-design examples in the study population have already been identified as eligible.

Phase 1A Recommendations for Further Research of Steel Girder-Floorbeam Bridges

$ Previously unevaluated steel girder-floorbeam bridges built before 1921 (91 bridges)
$ Check status of already select continuous girder-floorbeam bridges (2 bridges)

Reinforced-Concrete T Beam, Slab, & Thru Girder Bridges

Reinforced-concrete T beam, slab, and thru girder bridges were common bridge types that collectively played a significant role in the development of Ohio=s road systems beginning in the early 20th century. Ohio=s technologically significant examples of these types tend to date to the period of experimentation and innovation prior to 1910 or standardization during the 1910s. Some later examples, such as those designed by D. H. Overman in the 1920s and 1930s, are noteworthy for their architectural details that take full advantage of concrete=s moldable qualities.

Reinforced concrete relies on the placement of steel reinforcing bars to accommodate tension (stresses that pull apart) and shear (loads acting across a slab or beam near its bearings) to make up for concrete=s poor tensile strength. Reinforced concrete as a building material went through a period of experimentation and innovation from the late 1880s to 1900s. The experimentation period was characterized by a variety of ideas about proper design and competing reinforcing systems using steel beams, bars, and mesh, mostly based on European precedents. The use of reinforced concrete was initially slow to spread to the United States, but it had extended to most states, including Ohio, by the early 1900s, after which architects, engineers, and builders rapidly embraced it for a variety of applications. They were impressed by successful demonstrations of reinforced concrete=s versatility, including long-span arch bridges and Afire-proof@ buildings where much of the early experimentation took place. Ohio=s first significant reinforced-concrete structure was the 1902-03 Ingalls Building in Cincinnati, a 16-story skyscraper that was designed by the Ferro-Concrete Construction Company, a firm that also specialized in arch bridges.[14] The early development of reinforced concrete was closely associated with arch bridges, but the material also proved ideally suited to the development of beam bridges, including the T beam, slab, and thru girder.

The period of experimentation in reinforced concrete was followed in the 1910s by consolidation around standardized bridge types using deformed (twisted or textured) bars that had proven to offer the best bond between concrete and steel. The slab and T beam emerged as the dominant bridge types for short to moderate span lengths because of their ease of standardization and economy under a variety of site conditions. The thru girder held early promise but faded from use in the mid 1920s, mainly because it proved difficult to widen and less economical than T beams.

T beam, slab, and thru girder bridges in Ohio are technologically indistinguishable from those in other states. The earliest documented examples date from before 1910 when county and city bridge builders began making use of reinforced concrete, often modeling their efforts after examples in engineering journals and textbooks. The bridges appeared in

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[14] Carl W. Condit, American Building, 2nd ed. (University of Chicago Press, 1982), p. 241.

increasing numbers during the mid 1910s with the general pattern of use reflecting the specifications of the Ohio Department of Highways. The department adopted its first standardized drawings for T beam, slab, and thru girder bridges from 1912 to 1916.

T Beam Bridges

T beam bridges are a common bridge type in the study population with 471 examples dating from circa 1900 to 1961. In Ohio, it is the early and complete prototypical examples that best represent the T beam=s technological significance.

T beam bridges are composed of cast-in-place beams with integral monolithic flanking deck sections. They are used for spans of about 25' to 60', but they have been known to reach about 100' at their upper limit. The primary reinforcing steel is placed longitudinally in the bottom of the beam stem, and the deck or flange reinforcing is placed perpendicular to the stem. The T beam proportions the deck thickness and longitudinal beam size and spacing to achieve a light, strong, and economical section. Some T beam bridges have shear details (haunches) at the ends. The basic technology of the T beam bridge did not change from the 1910s through the 1960s.

T beams were first used in Ohio prior to 1910 by counties, cities, and railroads. The Bureau of Bridges prepared the first state standard drawings for T beam bridges in 1912. Its engineers would go on to prepare at least another 80 sets of standard T beam drawings prior to 1941. These standards covered various span lengths, roadway widths, and loads. The early state standard T beam bridges consisted of three lines of longitudinal beams, while the wider and later examples usually consisted of four or more beams. The 1910s standards had narrow roadways of 16' and 18'; these widths were adequate for their time but eventually were found to be too narrow for the increasing size and number of cars and trucks using the roads. For this reason, few early examples have survived intact. If they were not replaced, they were widened with original railings removed and additional superstructure added to one or both sides.

T beams and slabs were the first bridge types for which the Bureau of Bridges developed continuous-design specifications. In 1918, the bureau stipulated that T beams and slabs could be continuous over the piers using moments Aequal to two-thirds of the moment for simple beams of the given span@ and Aadequately reinforced [over the pier] to resist the resulting negative moment.@ This specification allowed engineers to design continuous T beam and slab bridges using less material for the given span length (a cost savings) without having to attempt an accurate analysis of the indeterminate continuous structure. It was a conservative approach, limited to modest span lengths where negative moments and secondary stresses were unlikely to be great, but this was an early attempt, more than a decade before a national engineering consensus had emerged on specifications for continuous designs. ODOT bridge inventory data suggests that the continuous-design T beam was not used frequently since there is only one extant example dating to the 1910s, 14 dating to the 1920s, and nine dating to the 1930s. These bridges will be carried over for further research.[15]

The T beam continued to be a popular bridge type into the mid 1940s, but was phased out in Ohio during the 1950s, much earlier than in some neighboring states, like Michigan and Indiana, which used T beams on the development of their interstate systems into the 1960s. The cast-in-place T beam bridges were labor intensive owing to the requisite form work, and Ohio=s state bridge engineers judged that they had increasingly high on-site labor costs as compared to other bridge types including continuous slabs and steel stringers.[16]

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[15] ODH, Specifications (1918), p. 17.

[16] Annual Reports (1917), p. 33; (1924), pp. 62-63; Ellling and Witherspoon (1993), pp. 39-43; Box 43DN, AVery Old Design Notes.@

Phase 1A Recommendations for Study Population of T Beam Bridges

- $ Previously unevaluated T Beam bridges built before 1921 (104 bridges)
- $ Previously unevaluated continuous T Beam bridges built before 1941 (23 bridges)
- $ Previously unevaluated post-1920 non-continuous T Beam bridges over 70' long (3 bridges)
- $ Check status of already select T beam bridge (1 bridge)

Slab Bridges

The inventory includes over 2,300 slab bridges dating from circa 1900 to 1961. The technological context of the slab is nearly identical to the T beam with potentially significant examples from the periods of experimentation and standardization dating prior to 1921. The slab bridge concentrates reinforcing steel in the lower portion and ends where tensile forces and shear are the greatest. The amount of steel and depth of the slab is predicated on its length and live-load capacity. Simple slab spans rarely exceeded 30' long, above which other bridge types, like the T beam or steel stringer, were a more economical use of material.

As with T beam bridges, the oldest extant slab bridges were built by counties, cities, or the railroads in the 1900s. The state highway department adopted its first standard drawings for cast-in-place slab bridges in 1913. The bridge bureau issued more than 50 slab drawing sets over the next 60 years for various span lengths, roadway widths, and live loads. As with other types that lent themselves to continuous designs, continuous slabs allowed for longer spans (up to about 50') using less material than a simply supported span of comparable length. The state adopted a very widely used, standard, two-span, continuous slab design in 1946, but it had been issuing specifications for continuous slabs since 1918.

Phase 1A Recommendations for Study Population of Slab Bridges

- $ Previously unevaluated slab bridges built before 1921 (361 bridges)
- $ Previously unevaluated continuous slab bridges built before 1941 (52 bridges)

Reinforced-Concrete Thru Girder Bridges

The inventory includes 67 reinforced-concrete thru girder bridges dating from ca. 1900 to 1950. Unlike the reinforced-concrete T beams and slabs, thru girders were not as successful over the long run and fell from use in the late 1920s. The pre-1921 examples have the greatest potential to be technologically significant, but further investigation of all of the extant examples is recommended given their relatively small numbers. This will also provide the opportunity to investigate the local contexts of a few counties (Allen, Columbiana, Lawrence, and Wood) that have a disproportionate number of extant examples.

Thru girder bridges are composed of a pair of cast-in-place longitudinal girders and transverse floorbeams or deck slab that are connected by the arrangement of the steel reinforcing bars. The roadway passes between the girders, which are commonly very large in appearance (18" to 30" wide and 4' to 6' deep) and have deep, flat panels to save on weight. The girders actually serve as the parapets, as well as the main supporting members. Sometimes in longer span examples the top flange of the girder is curved to provide the greatest depth at mid-span where it is needed to support the loads.

Like the slab and T beam, the thru girder appeared nationally in the first decade of the 20th century. It, however, proved to be the least successful of the standardized reinforced-concrete bridge types, mainly because it proved less economical than T beams for the same range of span lengths (about 30' to 60' long) and it was limited to relatively narrow roadway widths (less than 24'). In 1928, George A. Hool, an authority on reinforced-concrete bridge construction, expressed the opinion that Afrom a standpoint of economy, the thru girder should not be built except where insufficient headroom or other local conditions prevent the use of the deck girder [T beam].@ The Ohio Department of Highways adopted standard drawings for 30' to 40'-long reinforced concrete thru girder bridges in 1915 and had also developed plans for thru girder bridges in increments of 5' up to 60' long by the mid 1920s.[17]

Phase 1A Recommendations for Study Population of Thru Girder Bridges

$ Previously unevaluated thru girder bridges built before 1961 (67 bridges)

Rigid Frames

Reinforced-Concrete Rigid Frame

Most of Ohio=s 88 reinforced-concrete rigid frame bridges date from the late 1920s to early 1940s and were built by counties or municipalities. This is in keeping with the national context of common use in urban, park, or parkway settings where an economical but aesthetic bridge was desired. Nearly a third of the reinforced-concrete rigid frame bridges in Ohio are in Cuyahoga County. Since reinforced-concrete rigid frame bridges often have site-specific local contexts, it is recommended that the entire population be reviewed for potential significance.

The basic engineering principles behind the rigid frame are that the top member and the legs are integral and the legs perform useful work in supporting the loads. One of the advantages to the rigid frame type is that it reduces the mass of the abutments and thus

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[17]George A. Hool, Reinforced Concrete Construction Vol. 3, 2nd ed. (New York: McGraw Hill, 1928), p. 414; Annual Report (1924), pp. 62-63.

costly work in the ground. It is an economical use of materials, and it works well in settings with limited vertical clearance, such as overpasses. Rigid frames are indeterminate structures, meaning that the stresses are difficult to predict. Accurate stress analysis relied on post-1930 advances in engineering theory. Span lengths are generally between 30' and 70'.

Reinforced-concrete rigid frame bridges have an intrinsic, shallow arch profile because of the material required at the knees where the top and legs meet and where the stresses (moments) are the greatest (In fact, it=s not uncommon for them to be misidentified as arches by laymen). Reinforced-concrete rigid frame bridges were considered to have Aextreme adaptability to architectural expression as compared with ordinary types of construction...,@ according to Arthur G. Hayden of the Westchester County (NY) Park Commission. Hayden is credited with introducing the bridge type into the United States for Westchester=s pioneering parkway system, which he helped to develop starting in the early 1920s. The rigid frame technology originated in Europe during the last part of the 19th century, but it was Hayden who popularize the bridge type through technical articles, an influential 1931 textbook <u>The Rigid Frame Bridge</u>, and many handsome bridges that demonstrated the seemingly infinite variety of possibilities to accent the graceful, cast-in-place bridge type. Beginning in the early 1930s, rigid frame bridges were employed throughout the country for bridges in parks, along parkways, and even for major highways. The bridge type, however, found limited use in the development of statewide highway systems in Ohio and other states because it does not lend itself to standardization. The Ohio state highway department built a handful of rigid frame bridges from the late 1930s to early 1950s, mostly as grade separations at interchanges.

<u>Phase 1A Recommendations for Study Population of Reinforced-Concrete Rigid Frame Bridges</u>

$ Previously unevaluated reinforced-concrete rigid frame bridges built before 1961 (83 bridges)[18]

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[18] The 1951-60 rigid frame bridges on IR-280 in Lucas County were evaluated not eligible as part of the *Third Ohio Historic Bridge Inventory* (2004). They do not require re-evaluation.

Steel Rigid Frame

The steel rigid frame shares the same basic engineering principles, but rarely the same aesthetic qualities, as its reinforced-concrete counterpart. Although known nationally since the 1920s, it did not come into its own until after 1945, for both reasons of aesthetics and constructability, but it was never a widely popular bridge type in the United States or Ohio. Steel rigid frame bridges consist of a series of parallel, longitudinal frames, supporting the deck. Longer examples are often multi-span with the legs slanted to accommodate the high stresses at the knees, and they were used in some states, like Connecticut, for expressway overpasses. The Ohio Department of Transportation has used the bridge type for overpasses, but only in the post-1960 modern era. The inventory includes three steel rigid frame bridges dated from 1936 to 1940. They are all recommended for further research.

Phase 1A Recommendations for Study Population of Steel Rigid Frame Bridges

$ Previously unevaluated steel rigid frame bridges (3 bridges)

Wood Stringer, Slab, and Girder-Floorbeam Bridges

The inventory includes 27 wood stringer, slab, or girder-floorbeam bridges dated from ca. 1900 to 1961. Given the small numbers, it is recommended that the bridges be carried into the next phase for further assessment, particularly of integrity of design and materials, since many older wood bridges have very little original fabric. In general, these bridge types are not considered technologically significant, but it is possible that some extant examples have older elements, like a truss line, or represent important refinements, such as early use of glue lamination, that have potential technological significance.

Wood=s primary advantages as a bridge material are its natural abundance and its ability to be acquired and worked with but a few simple tools. Its inherent disadvantages are susceptibility to natural deterioration from fungi, insects, and moisture; high maintenance requirements; lack of resistance to fire; and strength properties, which depend on the species of tree but generally limit its effective use to bridges carrying, by modern standards, relatively lightweight loads over short spans. The shortcomings of timber bridges were among the primary impetuses to the development of iron bridges for railroad usage during the 19th century, and timber bridges also became less desirable for use on highways with increased motor vehicle usage during the 20th century. Nonetheless, they have continued to be built primarily for reasons of economy, although usage has been mostly relegated to low-volume roads in sparsely developed settings.

As a general rule, the state highway department did not build timber bridges on the state highway system during the 20th century, considering the material too Aimpermanent@ and maintenance intensive for use on the primary routes. As far as is known, the bridge bureau never prepared standard drawings for timber bridges. Eliminating timber bridges from the state highway system was a goal that had been largely achieved by the 1950s. Many Ohio counties pursued a similar goal, especially those in populated areas, but some counties continue effectively to use timber bridges to the present day.

Although the use of wood as a bridge material declined during the 20th century, interest continued to evolve with most of the technological refinement confined to (1) the development of wood preservatives to extend the life of timber structures, and (2) the use of laminates to increase the strength and quality of members. From time to time, these refinements have found application in Ohio helping to keep wood competitive for use on local bridge projects, but not resulting in such advances that timber bridges have enjoyed a major resurgence.

The most common type of post-1945 wood slab or girder-floorbeam bridge in Ohio and elsewhere is glue laminated (glulam). Glue lamination is a process of bonding layers of lumber together with an adhesive. The key technological breakthrough in glulam bridges was the development of waterproof adhesives that could withstand outdoor environments. These adhesives became available through the efforts of the U.S. Forest Service=s Forest Products Laboratory (based in Madison, Wisconsin), university research labs, and chemical companies during the late 1940s. One of the prime advantages of glulam over other lamination techniques is that it always uses kiln-dried lumber, meaning that better control over dimensional stability is achieved but at an added cost. In glulam slab bridges, a series of laminated panels, usually from 8@-15" deep, 3'-5' wide, and up to 35' long, are placed side-by-side directly on the substructure units. The panels are joined together with transverse beams bolted to the deck underside. The low profile of these bridges makes them desirable where vertical clearance is limited.

Phase 1A Recommendations for Study Population of Wood Stringer, Slab & Girder-Floorbeam Bridges

$ Previously unevaluated pre-1961 wood bridges (26 bridges)[19]

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[19] One (1) laminated girder-floorbeam bridge in Champaign County (1130978) was evaluated not eligible as part of the third inventory. It does not require re-evaluation.

Box Beam Bridges

The study population includes 63 pre-1961 reinforced-concrete box beam bridges. Box beam bridges of reinforced concrete were never built in great numbers in the United States, and this number of old examples is unexpected. It is thought that some of these may actually be prestressed concrete, not reinforced concrete, as was discovered in the *Third ODOT Historic Bridge Inventory* with the 1952 Main Street Bridge in Roseville, Muskingum County, which was coded a reinforced concrete stringer but was actually an early prestressed concrete stringer. It is known that prestressed-concrete box beam bridges began to be built in Ohio during the 1950s, and the context for them was developed as part of the prior inventory. Any examples identified as prestressed concrete will be evaluated using that context and in comparison with the entire 1951-60 population. Some may also be new superstructures on old substructures accounting for the early date of construction. It is recommended that the box beam bridges be carried into the next phase for verification. The box beam context will be updated following the review.

Phase 1A Recommendations for Box Beam Bridges

$ Previously unevaluated pre-1961 box beam bridges (63 bridges)

Culverts

ODOT=s BMS culvert classification does not refer to a distinct bridge type or design, but structures that provide an opening beneath a roadway embankment. This definition reflects that the soil or embankment material surrounding the culvert plays a structural role regardless of the type/design or material of the culvert. The majority of the 465 pre-1961 structures coded in ODOT=s BMS as culverts over 20' long are multi-cell pipe culverts or box culverts.

In addition, the BMS data includes over 4,800 pre-1961 structures under 20' long that are classified as tunnels, rigid frame bridges, slab bridges, arch bridges, or culverts. These short-span structures do not meet the FHWA definition of a bridge as a structure over 20' long whether it is under fill or not. There is no significant technological or contextual difference between these short-span bridges and their longer counterparts; therefore they are best evaluated in comparison with their respective populations. For purposes of this evaluation, the ODOT definition of a culvert as a structure under fill will be used.

Pipe Culverts

A very common type of drainage structure on roadways and railroads throughout Ohio and the nation is the pipe culvert. In general, pipe culverts are not considered potentially significant for their technology. Pipes have been used since time immemorial to direct the flow of small streams and runoff. Early builders used materials such as wood and terra-cotta, while builders of the 19th century made increasing use of cast iron. During the 20th century, pipe culverts have been made of reinforced concrete or steel. Pipes of either material are characterized by prefabrication at factories and shipment to construction sites. The pipes are manufactured in standard lengths and diameters unless a custom order is made by the contractor. Once delivered to the construction site, the pipes are placed in stream beds and backfilled with earth. Pipe culverts may be single or multiple cells (one or more openings).

Reinforced-concrete pipe culverts in precast units ranging from 15" to 6' diameters have been available to builders since the first decade of the 20th century. The history of reinforced-concrete pipe manufacturing parallels the development of reinforced concrete as a building material, and it was a mature technology by the 1910s. The amount of reinforcement in the pipe depends on its size and the load to be carried by the pipe.

Corrugated steel pipe culverts were introduced in the United States about 1905. They were quickly adopted by railroad and highway builders, especially as pipe manufacturers increased capacity and the price of pipes fell through the 1910s to 1930s. The pipes were found to resist cracking and disjointing under a load, as well as to have ease of handling and installation, freedom from maintenance, and adaptability to extension and reuse. Corrugated steel pipes were produced in diameters ranging up to a maximum of about 9' by 1930. The Ohio Department of Highways began issuing standard drawings for corrugated steel pipe culverts in 1931.

Pipe culverts are still built today with little change in the technology of manufacturing or placing pipes. Pipe culvert design has advanced in the last 40 years with more sophisticated site analysis, particularly in the area of hydrology, where culvert openings are now more closely sized to match peak stream flows and where embankment materials are analyzed to determine lateral soil pressures and the embankment=s ability to support loads.

Box Culverts

Reinforced-concrete box culverts appeared on American and Ohio roadways during the first decade of the 20th century, and they were increasingly ubiquitous by the early 1910s. Their history is nearly identical to the development of other standard reinforced- concrete bridge types/designs, such as T beam and slab bridges. As with those bridge types, those that represent early applications of the material (pre-1911) or early standardized designs (pre-1921) have the greatest likelihood of potential significance as prototypical examples.

A box culvert derives its name from its similarity to a box with open ends, and it is usually distinguished by a cover slab (top) that is integral with the side walls and floor. Historically, however, the term box culvert has referred to both open (no floor) or closed (with floor) examples.

Box culverts are adapted to minor streams and locations where headroom is limited. They require little expensive form work or foundation work and may be placed in trenches. The cover slab may directly support the roadway or be placed under a fill, and it is proportioned to carry both live load and the entire weight of the fill, if any. Box culverts may be single or multiple cells with the single-cell span length rarely exceeding twice the height. Since the 1910s, box culverts have been found to be economical and practical under the majority of conditions for spans in the range of 6' to 15'. The technology has changed little since the early 20th century. The only change worth mentioning is the increasing substitution of precast box sections for cast-in-place sections in the last thirty years. The Ohio Department of Highways issued its first reinforced-concrete box culvert standards in 1911 and it has continued to update them to the present day.

The most common box culvert material is reinforced concrete, but there are other materials that can be used including wood, stone, or brick, which were more commonly used in the 19th century.

Phase 1A Recommendations for Culverts

$ Previously unevaluated pre-1921 reinforced-concrete culverts over 20' long (26 bridges)

$ Previously unevaluated pre-1961 culverts over 20' long with material listed as other, cast iron, or stone, including several described as Atunnels@ in the feature crossed field (8 bridges)

- $ Concrete arches less than 20' long and built before 1921 (23 bridges)*
- $ Stone arches less than 20' long (18 bridges)*
- $ Stone slab or stone arch culverts less than 20' long (69 bridges)*

* Note: if recommendation is accepted, the less than 20' long bridges will need to be moved into the active inventory database.

Other Bridge Types

ODOT=s BMS records use the code Aother@ for bridge types that do not fit the established categorization scheme. All of these bridge records will be reviewed to determine their historic type. Contexts will be developed as necessary.

Phase 1A Recommendations for Other Bridge Types

- $ Previously unevaluated pre-1961 other bridge types (9 bridges)

Other Potentially Significant Contexts

Grade Separations in Cleveland

Although other Ohio cities grappled with the problems of separating rail and street traffic, none had as sustained or extensive a record as Cleveland.[20] These projects were typically in response to the railroads= need to improve the efficiency of their operations by

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[20] Cincinnati was also reviewed, but there was not the concentration or pattern of highway-over-rail bridge building as found in Cleveland.

eliminating delays and improving access to warehouses, factories, and terminals, but they also were in response to Progressive-era attitudes for public safety and sometimes also incorporated the aesthetic tenets of the City Beautiful Movement. The City of Cleveland worked with the half-dozen or so major railroads to build grade separations from the mid 1900s to 1930s. One of those railroads, the Nickel Plate, successfully grade separated its lines from 1909 to 1913, with the city passing a bond issue in 1910 to help pay for the depressed section through Cleveland=s west side. This led to further developments, including the Union Terminal Tower (1922-27), a massive complex with depressed trackage and bridges to bring the city=s major railroads to the center of downtown via electrified rail. The pre-1921 bridges that might fall within this context have already been included within the Phase 1A study populations for their respective types, but it is recommended that the highway-over-rail bridges dating from before 1942 in Cleveland also be included.

Phase 1A Recommendations for Pre-1942 Urban Grade Separations

$ Cuyahoga County (30 bridges total)
  - Girder-floorbeam (4)
  - Slab (2)
  - Steel stringer (23)
  - T beam (1)

Aesthetic Bridges by D. H. Overman and the State Bureau of Bridges

It is recognized that Henry Overman was an outstanding bridge designer who did some of his most accomplished work during the 1920s and 1930s. While many of his arch and continuous-design bridges have been previously identified, there may be some unidentified examples, especially of the more common bridge types, like T beam and steel stringer. This was brought to light recently when ODOT identified a 1926 T beam in Scioto County

(7360073) as his work. For this reason, the photos that are available on-line for the state-owned bridges will be reviewed by the team=s historians to check that no bridges are being overlooked. This will be a quick spot check; no data entry or photo attachment will occur unless a bridge of potential interest is found.

B. PREVIOUSLY INVENTORIED BRIDGE TYPES FOR STATUS UPDATE OR RE-EVALUATION

ODOT desires to update its historic bridge inventory by reviewing and re-evaluating the population of previously inventoried Anon-excluded@ bridge types inclusive of truss, arch, movable, suspension, and continuous steel stringer/girder-floorbeam bridges.[21] This review is in recognition that most of the pre-1951 non-excluded bridge types were last surveyed in the 1980s to early 1990s (1st & 2nd inventories and arch supplement). ODOT tracks some of the historic bridges, especially those that come up for bridge rehabilitation or replacement projects, but many bridges have not been checked since the initial survey. The purpose of this review is to ascertain that the population of eligible bridges still adequately represents the significance of specific bridge types/designs in light of more than 20 years of bridge projects and advances in the scholarship of Ohio=s bridges and their contexts. It is also desired to check on the status of historic bridges that have been taken off-system to provide as complete an accounting of the extant populations as possible. Evaluation will begin with a review of inspection files, environmental files, and requests for information and photos from bridge owners, with all data compiled in the electronic database to facilitate search/retrieval of information and sorting/comparison within specific populations by type and design. All relevant historical data, including alterations or modifications, that might effect integrity, and hence eligibility, will be entered into the database.

The following are brief reports on the bridge types with a summary of the number of currently known extant examples in the database and the issues likely to impact the evaluations. These summaries will become more fully developed and specific contextual issues addressed based on the Phase 1A inventory.

[21] The continuous steel stringer/girder-floorbeam bridges are covered in previous sections of this report.

Metal Truss Bridges

The study population includes 535 pre-1951 truss bridges, of which 66 are reported as Aselect@ (i.e., eligible) and 40 as Areserve.@[22] ODOT=s prior historic bridge inventories evaluated metal truss bridges because of the important role that the many Ohio-based fabricators had played in the development of a variety of truss designs, including patented designs of the 19th century and state highway department standardized designs of the early 20th century. In general, the earliest, most complete and significant examples were recommended select or reserve as a result of those inventories.

Approximately 385 of the 535 pre-1951 truss bridges are confirmed as Anon-select@ from previous inventories, and there is no record that the remaining 44 were previously inventoried. Meaningful comparisons are not currently possible within the population of non-select and un-inventoried trusses because basic data such as design (Pratt, Warren, Parker, etc.) and connection details have not been entered into the database. This will be done during the Phase 1A data entry and review of the old survey forms and current photos. Further complicating the review are estimated dates of construction, sometimes reflecting the date a truss was relocated, not its actual date of fabrication, since truss bridges are often moved and re-used. Anomalies in construction date will be investigated and resolved. Furthermore, some later truss bridges, although tending to be more standardized, may have significant details, such as welded connections in the late 1920s or early 1930s.

For the above reasons, it=s important to gather and verify the data on all truss bridges to be certain that the appropriate evaluations have been made. Once the data is collected, verified, and analyzed, it will be possible to make judgments about which bridges require

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[22] The 2nd inventory (1990) reported approximately 200 select or reserve metal truss bridges, suggesting that about half of the trusses have since been replaced or moved off-system.

further research or re-evaluation in Phase 1B based on the surviving numbers of particular bridge designs, details, and examples of the work of significant builders/fabricators.

The third Ohio historic bridge inventory (2004) reviewed the truss bridges dating from 1951 to 1961. In general, the postwar period is not known as an era of technological innovation in truss bridge engineering. Some examples of standardized welded truss bridges, such as those fabricated by the Ohio Bridge Company, were selected as eligible, and major truss bridges, such as the cantilevered trusses on the state highway system, were appropriately evaluated. It is not recommended that the 1951-60 truss bridges be revisited at this time.

Phase 1A Recommendations for Metal Truss Bridges

- $ Compile data and current photos for all truss bridges dating to before 1951 (535 bridges).
- $ Confirm the status of off-system truss bridges that may not currently be in the database (up to approximately 50 bridges - about 50 are already in the database)

Wood Truss Bridges

Ohio=s wood truss population is the best known due to the long-standing historical interest in covered bridges and a range of published sources including statewide covered bridge guidebooks and ODOT=s covered bridge website. Many of these bridges are off system and not currently in the BMS or historic bridge databases. The database will be updated to include each of the extant 140 wood-truss bridges, a current photo, and record of NR status. It is anticipated that no further contextual research or evaluation will be required during Phase 1B.

Phase 1A Recommendations for Wood Truss (Covered) Bridges

$ Confirm the status of each of the wood truss bridges (140 bridges)

Arch Bridges

The inventory database currently includes 392 pre-1951 arch bridges of which 63 are Aselect@ and 47 are Areserve.@[23] Another 206 of the 393 pre-1951 arch bridges are confirmed as Anon-select@ from previous inventories, and there is no record that the remaining 76 were previously inventoried. The arches are inclusive of all materials, including 254 reinforced-concrete arches, 115 stone or brick arches, 19 steel arches, and 5 arches with material as either wood or other (the wood arches are probably actually arch-truss covered bridges).

As with the truss bridges, meaningful comparisons are not possible within the non-select and un-inventoried arches due to the need to verify and enter data related to design, date of construction, and history of alterations/modifications. Once the data is collected, verified, and analyzed, it will be possible to make judgments about which bridges require further research or re-evaluation in Phase 1B based on the surviving numbers of particular bridge designs, details, and examples of the work of significant builders/fabricators.

Phase 1A Recommendations for Arch Bridges

$ Compile data and current photos for all arch bridges dating to before 1951 (392 bridges).

$ Confirm the status of off-system arch bridges that may not currently be in the database (up to approximately 30 bridges)

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[23] The Arch Supplement (1994) reported approximately 140 select or reserve arch bridges, suggesting that about 30 of the arches have since been replaced or moved off-system.

Movable Bridges

There are nine (9) movable bridges in the pre-1961 study population - one (1) swing span, four (4) bascules, and four (4) vertical lifts. These bridges span navigable streams along Lake Erie and its tributaries. Movable bridges are inherently complex structures that have historically required the design expertise of specialist engineers and firms. They often have patented designs. All of these bridges have been previously researched and evaluated as Aselect.@ The status of the bridges will be verified and the database records updated, but no further work is required or anticipated.

Phase 1A Recommendations for Movable Bridges

$ Confirm the status of each of the movable bridges (9 bridges)

Suspension Bridges

The study population includes four pre-1961 suspension bridges. All of the bridges have been previously surveyed with three evaluated select and one determined not eligible. The status of the bridges will be verified and the database records updated, but no further work is required or anticipated.

Phase 1A Recommendations for Suspension Bridges

$ Confirm the status of each of the suspension bridges (4 bridges)