Secretary of the Interior's Standards for the Treatment of Historic Bridges

Purpose

The purpose of this document is to assist in the application of the Secretary of the Interior's Standards (the Standards) to projects involving historic bridges. The Standards are consulted during project planning and delivery to assess if a historic bridge can be rehabilitated in a manner that preserves sufficient historic character while meeting project purpose and need. Specifically, the National Historic Preservation Act (NHPA) requires that federally sponsored projects include consideration of the effect of the project on historic properties through consultation. If the rehabilitation project can be designed to meet the Standards, then it is possible to avoid or minimize an adverse effect under Section 106 and a use under Section 4f.

I. Background: Secretary of the Interior's Standards (The Standards)

The Secretary of the Interior's Standards for the Treatment of Historic Properties (the Standards) are a series of broad concepts for conducting work on historic resources. While not technical or prescriptive in nature, they provide general guidance and are intended to be applied to a wide variety of property types. This document offers more specific guidance on the consideration and application of the Standards to historic bridges in Pennsylvania.

A. The Standards: Four Treatments

The Standards outline four distinct approaches to the treatment of historic properties: Preservation, Rehabilitation, Restoration, and Reconstruction.[1] The choice of treatment depends on a variety of factors, including the property's historical significance, physical condition, and proposed use.

- Preservation—Emphasis on retention of historic materials through conservation, maintenance and repair of distinctive materials and features that convey the bridge's historic significance.

- Rehabilitation—Acknowledge the need to alter or add to a historic resource to meet continuing or new uses while retaining the property's historic character. Emphasis is on retention and repair of historic materials, features, finishes, spaces, and spatial relationships with more latitude provided for replacement of deteriorated or missing features.

- Restoration—Emphasis on a particular time in a resource's history by preserving materials from the period of significance and removing materials from other periods.

- Reconstruction— Emphasis on depicting by means of new construction, the form, features, and detailing of a non-surviving bridge for the purpose of replicating its appearance. This may include the reuse of materials salvaged from the non-surviving bridge.

Historic bridge projects that utilize the Standards generally fall under two treatments: *Preservation* (routine maintenance of bridges) or *Rehabilitation* (for bridges to continue under transportation use). The focus of the remainder of this document is on appropriate application of the Standards for Rehabilitation for historic bridges that are to continue to serve the roadway network or other

[1] The Secretary of the Interior's Standards definition of Preservation, Rehabilitation, Restoration, and Reconstruction is different from the engineering definition of these activities.

transportation uses.

B. The Standards and National Register Significance

The Standards embody two goals when conducting work on historic resources: 1) the preservation of historic materials and 2) the preservation of a resource's historic character. Therefore, when considering preservation or rehabilitation of a historic bridge, it is important to understand 1) why it is significant and considered eligible for or listed in the National Register, 2) what materials and features are historic, and 3) among the historic materials and features, which are critical to a bridge's ability to convey historic character (known as character defining features).

A brief discussion of the National Register and those features critical to conveying significance follows.

National Register Eligibility

The National Register is the official list of the nation's historic properties considered worthy for preservation. Any property listed in or eligible for listing in the National Register, is considered historic. The types of properties recognized by the National Register include buildings, objects, sites, structures, and districts. Bridges are considered to be structures and may also be part of historic districts. A historic bridge is one that is listed in or eligible for listing in the National Register, either individually or as part of a historic district.

Whether National Register listed or eligible, a historic bridge receives the same level of consideration in project planning under NEPA, Section 106 and Section 4f. In order to be eligible for listing in the National Register, a property must meet the National Register Criteria for Evaluation. The criteria include consideration of a property's age, significance, period of significance, and integrity as outlined in more detail below.

Age: Generally, a property must be at least 50 years old to meet the age requirements for the National Register.

Significance: The National Register criteria for significance assess if a property is historically, culturally, architecturally, or technologically significant within a relevant historic context. Properties qualify for the National Register under at least one of four criteria:

- Criterion A. Association with events that have made a significant contribution to the broad patterns of our history; or
- Criterion B. Association with the lives of persons significant in our past; or
- Criterion C. Embodiment of the distinctive characteristics of a type, period, or method of construction or that represent the work of a master, that possess high artistic values, or that represent a significant and distinguishable entity whose components may lack individual distinction; or
- Criterion D. Have yielded, or may be likely to yield, information important in prehistory or history.

Historic contexts provide a perspective from which to evaluate a property's National Register significance and are organized by theme, geographical limits, and chronological period. The Statewide Bridge Inventory provides a context in which to evaluate the significance of the bridges

of Pennsylvania. The context for the bridge inventory addresses the history of bridge technology in Pennsylvania and includes a discussion of bridge types and the evolution of materials and methods of design and construction. The historic bridges identified in the bridge inventory are generally eligible under Criteria A or C, as discussed in more detail below. The survey did not identify any bridges with National Register significance under Criteria B or D.

Finally, while relocated properties are not commonly National Register eligible, some types of bridges could be individually eligible under Criteria Consideration B: Moved Properties. Metal trusses were marketed as portable, and many of these bridges have historically and more recently been relocated to off-system uses, such as pedestrian bridges. If these bridges retain their historic appearance and function in the manner for which they were designed, then they may continue to be National Register eligible despite relocation.

Period of significance refers to the span of time during which significant events and activities occurred. Events and associations with historic resources are finite; most resources have a clearly definable period of significance. To understand which features of a bridge are important to conveying significance, it is important to know the National Register period of significance for a bridge.

Integrity refers to the ability of a property to convey how it appeared during the period of significance. For a bridge to have sufficient integrity to convey significance, it must retain its historic appearance and materials and its ability to function in the way it was designed. A bridge would no longer be considered eligible for the National Register if it can no longer convey the character or appearance of the period of significance. The inability of a historic property to convey significance is usually directly related to the loss of integrity.

A property has a high level of integrity if it possesses characteristics that convey its significance through its setting, materials, design, location, workmanship, feeling, and association. More detail on the seven aspects of integrity is provided below.

1. Setting is the physical environment of a historic resource. This includes the character of the location and how the bridge is situated in relationship to other features, such as the roadway and landforms.
2. Materials are the elements that were originally combined to construct the structure and are an important aspect for historic bridges.
3. Design is the combination of elements that create the form, plan, space, structure, and style of a resource. Historic bridges are often significant as reflections of the technology of bridge design.
4. Location is the place where the bridge was originally constructed or where a historic event occurred.
5. Workmanship is evidence of the builder's craft skills and technology.
6. Feeling is the appearance of the bridge in terms of its expression of the aesthetic or historic sense of a particular time period.
7. Association is the direct link between an important historic event or person and the bridge.

The evaluation of integrity must be grounded in an understanding of a property's physical features and how they relate to its significance. Bridges do not need to retain all seven aspects of integrity to be able to convey their significance and certain elements of integrity may have more importance.

Therefore, when a project has the potential to affect a bridge, it is necessary to determine which aspects of integrity are most important and worthy of preservation in order to avoid significant changes in historic character. In accordance with the Standards, alterations that have occurred over time do not necessarily diminish the integrity of historic design, materials, or workmanship, as long as the alterations were made using similar materials, design methods, and techniques of construction.

Note historic integrity does not equate to structural integrity which is associated with a structure's state of repair or any structural deficiency.

Character Defining Features: Character refers to all those visual or aesthetic aspects and physical features that comprise the appearance of a historic resource. The essential physical features are those features that define both *why* a property is significant (Applicable Criteria and Areas of Significance) and *when* it was significant (Periods of Significance). These are the features without which a property can no longer be identified as historic. Every bridge is unique, with its own identity and distinct appearance. If the materials, features and connections that give a bridge its visual character are not recognized and preserved, then historic character is lost.

Character defining features are the most important components of the bridge to consider when planning rehabilitation. While all historic fabric, including all period materials and physical features should be considered, character defining features should receive the highest priority for preservation. Prior to conducting work on historic bridges, it is necessary to ascertain whether the structure retains the elements of design and the materials necessary to convey significance, i.e., its character defining features. Any features or original elements that are no longer presented should also be documented. Once the character defining features are identified, proposed changes to the bridge can be carefully examined using the Standards to determine if they would change the appearance, design, or the way a bridge functions in a manner that would compromise historic or engineering significance.

Certain members of the bridge may be considered more significant than others and therefore features can be referred to as primary and secondary character defining features. Usually among the primary character defining features for historic bridges are the structural elements or prominent or unique aesthetic features. Secondary features may less important structural elements (bracing on truss bridges) as well as abutments, piers, or wing walls. When primary and secondary features are identified, the focus should first be on how the primary features can be retained, with the goal of rehabilitation retaining as much original fabric as possible.

Bridges Eligible for Engineering Significance (Criterion C):

Significance: Most of the bridges in Pennsylvania evaluated as part of the Statewide Bridge Inventory possess individual National Register significance under Criterion C in the Area of Engineering. These bridges embody distinctive characteristics of a type, period, or method of construction; are the work of a master (noted engineers, engineering firms or bridge companies); or possess high artistic value. Bridges that possess high artistic value may be common types with applied decorative finishes, parapets or railings that are notable. Bridges may also have engineering significance given their unusual construction details; as rare surviving examples of a type that was significant in the development of a bridge technology; or as designs of a prolific bridge company. Among common bridge types, those examples that mark the introduction of a technology or illustrate engineering

advances within a technology and possess distinguishing details are considered eligible. Early examples of standardized bridge designs are also identified as significant in the bridge inventory.

Period of Significance: For bridges that qualify for the National Register for their engineering significance, the notable time period of significance is generally limited to the date of construction and/or the date of any subsequent alterations that may also have significance.

Integrity: For bridges that possess engineering significance, retention of integrity of materials, design, and workmanship are most important. If a bridge is significant for engineering as an early and intact example of its type, given the inherent significance associated with retention of original materials, special consideration needs to be given to integrity of materials.

Character Defining Features: Character-defining features for bridges that qualify for engineering significance can be expressed in terms of type, proportion, structure, style, or materials. Among the most important features to consider in the rehabilitation of historic bridges are structural elements that are key to conveying the structure's type and construction era, such as design features (essential load bearing components), materials, craftsmanship, decorative details, and connections among members.

To remain National Register eligible as an example of a type of bridge, the structure must retain those characters defining feature that are commonly found on the bridge type and design and enough of those features to be a considered a representative example of the type, period, or method of construction. Occasionally a bridge is extraordinarily rare and may be the last remaining example of a type or design, in those cases, a lower threshold for integrity may be acceptable. For more specific guidance on the character defining features of common bridge types, please consult Section II.D below as well as *A Context for Common Historic Bridge Types* (NCHRP 25-25), and PennDOT's Historic Bridge Inventory.

Bridges Eligible for Historic Significance (Criterion A):

Significance: Bridges may also possess National Register significance under Criterion A for their association with an important event. Examples include roadway bridges that may possess historic significance for their association with crossings important in the development and growth of a community or roadway bridges built by historic railroads and were critical to operations. These bridges generally qualify for the National Register in their associated historic significance. Bridges eligible for historic significance most commonly reflect the following National Register Areas of Significance: Transportation, Community Planning and Development, or Commerce. In addition, there are numerous bridges that are eligible under Criterion C ("a significant and distinguishable entity whose components may lack individual distinction") as contributing to a larger historic district.

Period of Significance: For bridges that qualify for the National Register for their historic significance as contributing resources to historic districts, the period of significance is generally a span of time. If a bridge was built within a district's period of significance, is related identified areas of significance, and generally retains its integrity and character defining features, it qualifies for the National Register as a contributing element of the district.

Integrity: Integrity of setting, feeling, and association are among the more important aspects of integrity for bridges that contribute to a historic district. Integrity of materials and workmanship can also be important when the bridge conveys local construction materials and techniques. For those bridges significant under Criterion A in the area of Transportation, integrity of location and association with the roadway that the bridge served is among the most important aspects of integrity.

Character Defining Features: A property that is significant for its historic association is eligible if it retains the essential physical features that made up its character or appearance during the period of its association with the historic district or event. Before character defining features can be identified for contributing properties within the district, it is necessary to identify the character of the district itself which serves as the framework for contributing properties. More specific guidance on the character defining features of a specific historic district may be found in the historic district file available at the State Historic Preservation Office or local historical societies or planning offices. If this information has not been previously recorded, a documented site visit to the bridge and the surrounding area is critical to the identification and documentation of character defining features that warrant consideration during the development of bridge projects.

Typical character defining features of contributing bridges that should be considered in application of the Standards include the immediate setting of the bridge, spatial relationships to surrounding resources, landscaping or vegetation, and use of local building materials. Retention of the overall appearance of the bridge, including material and physical features, contributes to the character of the district and should be considered during rehabilitation of contributing bridges. Those portions of the bridge not visible from the street or public access are generally not called out as character defining features in a historic district.

II. Application of The Secretary of the Interior's Standards

The Secretary of the Interior's Standards for Rehabilitation, written and periodically revised by the National Park Service, include 10 standards. Those Standards most relevant to bridge rehabilitation projects are bolded below.

1. A property shall be used for its historic purpose or be placed in a new use that requires minimal change to the defining characteristics of the building and its site and environment.
2. **The historic character of a property shall be retained and preserved. The removal of historic materials or alteration of features and spaces that characterize a property shall be avoided.**
3. Each property shall be recognized as a physical record of its time, place, and use. Changes that create a false sense of historical development, such as adding conjectural features or architectural elements from other buildings, shall not be undertaken.
4. Most properties change over time; those changes that have acquired historic significance in their own right shall be retained and preserved.
5. **Distinctive features, finishes, and construction techniques or examples of craftsmanship that characterize a historic property shall be preserved.**
6. **Deteriorated historic features shall be repaired rather than replaced. Where the severity of deterioration requires replacement of a distinctive feature, the new feature shall match the old in design, color, texture, and other visual qualities and, where**

possible, materials. Replacement of missing features shall be substantiated by documentary, physical, or pictorial evidence.

7. Chemical or physical treatments, such as sandblasting, that cause damage to historic materials shall not be used. The surface cleaning of structures, if appropriate, shall be undertaken using the gentlest means possible.
8. Significant archeological resources affected by a project shall be protected and preserved. If such resources must be disturbed, mitigation measures shall be undertaken.
9. **New additions, exterior alterations, or related new construction shall not destroy historic materials that characterize the property. The new work shall be differentiated from the old and shall be compatible with the massing, size, scale, and architectural features to protect the historic integrity of the property and its environment.**
10. New additions and adjacent or related new construction shall be undertaken in such a manner that if removed in the future, the essential form and integrity of the historic property and its environment would be unimpaired.

A. Guidelines for Applying the Standards

The National Park Service provides guidelines to assist in the application of the Standards for Rehabilitation. Similar to the Standards, the guidelines are broad principles that provide recommended approaches, treatments, and techniques to do the least amount of harm to a historic resource. The guidelines essentially create a hierarchy for conducting work from the least to the greatest level of intervention, ranging from identification of character defining features to design of missing features, as outlined below. Whatever treatment is chosen, it is important to provide written justification for changes as well as record existing conditions prior to making the alterations.

1) Identify Character Defining Features. Application of the Standards begins with the identification of materials and features that are important to defining historic character. These features are discussed in more detail above.

2) Protect and Maintain. After identifying the character defining features that are important and must be retained in the process of rehabilitation work, measures for their protection and maintenance should be developed. Protection generally involves the least degree of intervention, commonly classified as preventive maintenance. Examples of protection include posting a roadway for weight restrictions and the use of headache bars in front of covered bridge portals. Examples of maintenance relevant to historic bridges include removal of rust, cleaning of scuppers, washing bearings, reapplication of protective coatings or spot painting, and the addition of other protective measures, such as fire retardant on timber bridges.

3) Repair In Kind. When the physical condition of character defining features does not allow for maintenance, repair is recommended. Repair should be undertaken in a manner that has the least degree of intervention (such as splicing, consolidating, straightening, or reinforcing through additional material) using recognized preservation methods. If features are extensively deteriorated or missing, repair can also include limited replacement in kind or with compatible substitute materials of the same visual appearance.

4) Replacement In Kind. Following repair in the hierarchy is replacement of an entire character

defining feature. Replacement is allowed only if the level of deterioration or damage of materials is too great to allow for repair. Like repair, the preference is to replace the material in kind using the original material with the same visual qualities and function as the original.

5) Using Substitute Materials. When the feature is extensively deteriorated, or needs to be stronger to accommodate new or continued use or there is no source for original materials, substitute materials for repairs or replacements are acceptable if the new material can convey the same visual appearance as the old. The preference is replacement of the features using the same material. However, this approach may not always be technically or economically feasible; in these cases, allowances are made for compatible substitute materials.

   Replacement work reduces to some degree the historic character of a resource. While substitute material on a bridge is acceptable, there comes a point at which there is too much replacement material, and the overall sense of a historic bridge is lost and the structure's character is diminished. At what point historic character will be lost depends on how successfully the historic materials, methods, and construction techniques can be replicated without affecting historic character in the process.

   It's also important to note that when a feature contributes significantly to the historic character of a bridge, the material or materials that make up that feature are likely to require a closer replacement match than materials making up a feature of lesser importance. The overall visibility of a character-defining feature or material is an important factor in determining whether substitute materials will be appropriate. Generally, the more visible a feature and the more important that feature is to the bridge's historic character, the greater the potential for any changes to negatively affect character.

6) Design of Missing Historic Features. When an entire feature is missing from a bridge, it no longer defines the historic character of the bridge. If it is a significant feature in the bridge's historic appearance, then the new feature should be accurately replicated based on adequate historical, pictorial, and physical documentation. If there is no adequate documentation of the feature, especially if it is a secondary feature, a second acceptable option for the replacement feature is a new design that is compatible with the remaining character defining features of the bridge. The new design should take into account the size, scale, and material of the bridge. The new work should be clearly differentiated from the old so that a false historical appearance is not created.

B. Applying the Standards: Questions to Be Asked

After historic properties are identified as part of the Section 106 process, it is necessary to consider the effect of the project on historic bridges and to evaluate a range of alternatives. This includes consideration of rehabilitation using the Secretary of the Interior's Standards. The Standards and associated guidelines cannot be applied broadly to bridges but rather on a case-by-case basis within the context of Section 106 consultation. The following list of questions is designed to guide engineers and historians in applying the Standards to specific bridge rehabilitation projects. These are not yes-no questions but are meant to guide the decision-making process and to ensure consideration of a range of information. These questions can also be part of documentation showing due diligence in the consideration of rehabilitation options.

1) Why does this bridge have National Register significance?

2) What are the key aspects of integrity that allow this bridge to convey its significance?

3) What are the character defining features that need to be retained for the bridge to convey its significance including distinctive engineering and stylistic features, finishes, construction techniques, and examples of craftsmanship (Standard 5)?

4) Does the bridge have historic alterations (more than 50 years old) that contribute to the overall significance of the bridge (Standard 4)?

5) Are there levels of importance among the character defining features? If so, what are they? (More significant/distinctive features should receive greater levels of consideration for preservation or rehabilitation.)

6) Can the character defining features of the bridge be preserved while accommodating the project purpose and need and safety requirements (Standard 1)?

7) If it is not possible to repair the character defining features of the bridge, can you replicate historic materials, methods, and construction techniques without affecting the historic character of the bridge (Standard 5)?

8) Can the new work on the character defining features match the old work in terms of size, design, color, texture, architectural detailing, and other visual qualities (Standard 6)?

9) For missing features that will be replicated, is there documentary, physical or pictorial evidence (Standard 6)?

10) Do new features, such as lighting, railing, or other decorative elements, give a false sense of the bridge's history (Standard 3)?

11) If new work is required, such as strengthening or reinforcement, can it be designed not to compromise the historic engineering significance of the bridge (Standard 10)? Can the new work be hidden from view?

12) Are new features, such as guiderails, differentiated from the old and compatible in terms of massing, size, and scale (Standard 9)?

13) Would a lay person viewing the bridge after it is rehabilitation be able to understand its original use, design, function, materials, engineering, and/or association (Standard 2)?

C. Applying the Standards: Execution

Successful execution of plans designed in accordance with the Standards is critical to retention of integrity and avoidance, minimization, or mitigation of adverse effects. Successful execution of plans ensures compliance with and meets the purpose and intent of the Section 106 process. Indeed,

certain treatments if improperly applied may cause accelerated physical destruction or loss of integrity, such as improper repointing or masonry cleaning techniques. Comprehensive plans and specifications; communication between engineers, historians, and construction personnel; the use of qualified construction personnel; and controlled construction monitoring are paramount to obtaining high quality rehabilitations.

Detailed guidance documents should be developed during project planning and preliminary design. This includes project plans and contract specifications and/or special construction provisions that clearly specify project components relevant to the application of the Standards. It is useful to include conditions to be met during each stage of project execution (preliminary engineering, final design, during construction, post construction), the parties responsible for each condition, and anticipated monitoring milestones.

Repairs and rehabilitations should be completed under the direction of a professional engineer with experience with historic or older structures of the same type. Construction personnel supervising the rehabilitation should have demonstrable experience and training working with the relevant historic materials.

Construction personnel should coordinate closely with cultural resources specialists and engineers at pre-construction field views to ensure they are aware of the historic nature of the bridge and the character defining features. Emphasis should be placed on the importance of conducting the work in accordance with specific measures outlined in the plans and specifications through the use of construction milestones and monitoring. A clear chain of command should be established, with specific tasks and contact information identified for each responsible party. If it does not appear that strategies to avoid, minimize, or mitigate adverse effects outlined under the plans can be executed, then it may be necessary to reopen consultation under Section 106.

D. Applying the Standards: Most Common Bridge Types

To assist in the application of the Standards and Guidelines for historic bridge rehabilitation projects, guidance specific to the most common historic bridge types in Pennsylvania is provided below. This guidance includes a brief discussion of the form and materials of the bridge type; lists of characters defining features and their relative importance in conveying historic significance (primary or secondary); a discussion of how character defining features relate to integrity of design, materials, and workmanship and the type of changes that do or do not meet the Standards; and protective measures to ensure long-term preservation. Sources for more detailed information are also noted including Preservation Briefs developed by the National Park Service to assist in the application of the Standards for rehabilitation projects. The briefs are generally specific to historic buildings and how to preserve character but can be applied to a variety of property types. Sources of information relevant to historic bridges include AASTHO's *Guidelines for Historic Bridge Rehabilitation*. This guidance is not meant to be overarching and should to be applied on a case-by-case basis, within the confines of the Section 106 consultation process for each bridge project.

Covered Bridges

Covered bridges are relatively prevalent in Pennsylvania, and many were built between the years of 1830-1880.

Character Defining Features: Among the most important character defining features of a covered bridge are the heavy timber trusses that support a deck and carry loads. Secondary features include the floor system which spans between the longitudinal trusses, distributing and carrying the load between the trusses, as well as the overhead bracing which connects each side or truss of the bridge and enables the structure to resist lateral load. The connections between the trusses, the floor system, and the lateral bracing are also important. The trusses of covered bridges are protected by siding and roofing and are among the most visible features at the exterior of the bridge. Abutments and piers, especially those constructed of stone, can enhance the visual aesthetics of a historic covered bridge and are considered secondary features unless they enhance the setting and feeling of a historic district.

Covered bridges can be eligible as notable examples of specific truss types under National Register Criterion C. Covered bridges may also be eligible under Criterion C as examples of the work of a specific bridge builder. Covered bridges may also be eligible under Criterion A as an important bridge crossing in the local community. For more information on the character defining features of specific timber truss types, please consult *A Context for Common Historic Bridge Types* (NCHRP 25-25) available at: http://onlinepubs.trb.org/onlinepubs/archive/NotesDocs/25-25(15)_FR.pdf

Materials: Timber bridges were built with coverings to protect the structural system, as regular maintenance and occasional replacement of the coverings was easier and cheaper than building a new bridge. Thirty-five (35) to 40 years is the general life expectancy of exposed wood bridge members. Therefore, it is highly unlikely any covered bridge retains its original siding, roof, or deck. Portions of the original truss or floor system may have also been replaced as part of routine maintenance. Therefore, replacement of the deck, siding, roof, truss, or flooring system, does not automatically eliminate the structure from National Register eligibility, as repairs are common and necessary and were likely done periodically throughout a bridge's history.

The preferred method of repair of a covered bridge truss is to replace deteriorated components in-kind using acceptable preservation methods such as splicing or consolidating through the use of epoxies. When repairing portions of members or replacing entire members, it is important to use timbers of similar size and maintain original connection details. Substituting a stronger wood species is sometimes necessary as it may provide additional strength and service life or because the original species is no longer available. Glue-laminated timbers are not traditional building materials for construction of covered bridges and are not considered acceptable for rehabilitations conducted in accordance with the Standards.

Replacement siding, roof, and decking surfaces should convey the same appearance as existing conditions unless there is documentary evidence that there was a different material in use during the period of significance of the bridge. The plank decking of covered bridges should be laid in its original configuration, either transverse or longitudinally, and should include running planks if they were an original feature. Abutments and piers should also be reconstructed in kind. As their significance is largely aesthetic in nature, for purposes of economy and durability, stone abutments can be rebuilt of concrete and faced in stone veneer. It is preferable that the veneer consist of stone taken from existing abutments or piers. It should be noted that concrete form liners do not sufficiently mimic the appearance of stone and should not be considered stone veneers. Portals with notable architectural features or other non-load bearing elements should be repaired or replaced in kind.

Design: Covered bridges were originally designed to carry a limited live load. If a bridge can perform satisfactorily using its original structural design, then there is no need to make changes to the structure of the bridge. For example, where there are alternative routes for heavy truck traffic, it may be possible to weight restrict a bridge to its original carrying capacity and rehabilitate the bridge accordingly.

For bridges that continue under vehicular use, increasing the carrying capacity to accommodate heavier vehicles often requires upgrades to the structural system, such as the addition of steel beams beneath the floor beams. The steel members serve as a supplemental structural system, carrying live loads, while the timber members continue to function as trusses or arches carrying the dead weight of the bridge, wind forces, and snow loading. To minimize the visual effects of the supplemental structural system, the steel beams should be covered by the weatherboard siding that protects the timber trusses. In some cases the siding may extend lower than it did historically but extension of the siding to hide the floor beams is deemed a necessary compromise. Steel beams should also be painted the same color as the siding to minimize their appearance. Most the remaining covered bridges in Pennsylvania are supported by steel stringers. A notable exception is bridges under the ownership of Lancaster County which utilize longitudinal chords that connect into the truss or flooring system to reinforce bridges for the loading associated with vehicular traffic.

Workmanship: The method of preparation of the timbers (hewing or sawing) and connection methods, such as mortise and tenons, are primary character defining feature of covered bridges that should be replicated during covered bridge rehabilitation.

Protective Measures: Given their limited height, covered bridges usually have limited vertical clearance that prevents taller vehicles from passing through the bridge. Despite postings related to height restrictions, it is common for portals of covered bridges to be damaged by attempting passage of over-height vehicles. Covered bridges may also be posted for weight restrictions. To protect the bridge from damage, allowances are made for the introduction of horizontal bars (headache bars) or speedbumps at or before the portals of the bridge. Warning signs that notify drivers of the heaviest weight or greatest height allowed over the bridge can help to minimize the potential abuse associated with heavy vehicles. Timber curbing at the interior of the bridge can provide protection to the trusses as railings are not usually installed on covered bridge.

Fire, whether by arson or from natural causes, has destroyed many covered bridges. Potential options for protection against fire loss include the treatment of wood with fire retardant chemicals, the installation of fire alarms or suppression (sprinkler) systems, and video cameras. Video surveillance may also be used to deter vandalism. Preservative treatments are available to protect against damage caused by insects and fungi.

Sources for Additional Information:

FHWA Covered Bridge Manual available at:
http://www.fhwa.dot.gov/publications/research/infrastructure/structures/04098/index.cfm

For more information on the maintenance and repair of wood, please consult the education tools

available on: http://www.woodworks.org.

Metal Truss Bridges

Manufactured by bridge-fabricating companies, the ubiquitous metal truss solved the need for long-lived, inexpensive, and efficiently manufactured bridges. Metal trusses are characterized by prefabricated parts made from standard mass-produced shapes and materials. They were easily and inexpensively erected using unskilled labor. Agents representing bridge-fabricating companies would traverse the countryside, meeting with local officials to hawk their product line with claims of low cost, high durability, and ease of erection. These bridges were called "catalogue bridges" because they were sold to township supervisors and county commissioners from catalogues. Many of these trusses were based on specific, proprietary patents. While Andrew Carnegie's Keystone Bridge Company (later the American Bridge Works) in Pittsburgh and the Reeves brothers' Phoenix Bridge Works in Phoenixville were two of the largest, dozens of smaller firms also existed throughout the Commonwealth.

Metal bridges are usually wrought iron or steel, with cast iron used alone given its limited tensile strength. Wrought iron is generally found on older truss bridges, usually in conjunction with cast iron, and tends to rust very little. Steel, used on post circa 1895 truss bridges, is stronger but is more susceptible to rust. Rolled iron and steel used in historic metal truss bridges comes in a variety of forms including beams, bars, angles, rods, channels, and plates. On earlier bridges, before technology was in place to roll larger and stronger beams, elements were often riveted together or built up to form larger and stronger beams. A common way to hold the larger beams (i.e., channels and angles) was to use bars and/or plates to connect them. These connections are usually made in one of three ways: with battens, v-lacing, or lattice. Special types of built-up beams were developed in the 1800s and patented by their respective companies. Two of the more widely recognized columns are called Phoenix and Keystone columns, named for their respective manufacturers.

Character Defining Features: Among the most important features are the truss form, structural members, and method of connecting the structural members. The most important structural members are top and bottom chords and vertical and diagonal members. For through trusses, the lateral top bracing, sway bracing, and features of the portal (e.g., struts and bracing) are considered secondary character-defining features except in cases where these features may be executed in an uncommon manner or provide ornamentation. The pieces of the framework of a truss bridge are held together by connections, sometimes called joints. The earliest bridges were assembled in the field using pins which were later replaced by riveted connections and bolts and eventually welding. V-lacing and lattice used to hold larger beams together can add to the geometric appearance and aesthetic complexity of metal truss bridges. Unique details, such as decorative portals, bridge plaques that list the bridge builder, and railings, may be among the aesthetically significant secondary features that should be preserved.

Generally, the bearings, floor beams and stringers are not considered to be character defining features although the connections between the flooring system and the truss are usually significant. As designed, metal truss bridges were made to be manufactured, shipped, and assembled on site. Therefore, the character defining features do not usually include the abutments or piers, although the abutments can enhance the overall aesthetics of the bridge and may be important to a bridge's ability to contribute to a local historic district.

Metal truss bridges can be eligible as notable examples of specific truss types or designs. Often this significance is based on the number of a truss type that were originally constructed or the number that remain the country, state, district, or region. Metal truss bridges may also be significant as early examples of their type or as a record of the evolution to a significant technology. Some metal truss bridges are notable as examples of the work of specific bridge companies. Significance assessments conducted by PennDOT for metal truss bridges as part of a management plan should be consulted when establishing character defining features. Additional information on the character defining features of specific truss types can be found in *A Historic Context for Common Bridge Types* (NCHRP 25-25) available at: http://onlinepubs.trb.org/onlinepubs/archive/NotesDocs/25-25(15)_FR.pdf.

Design: Metal truss bridges were originally designed to carry a limited load. If a bridge can perform satisfactorily using its original structural design, then there is no need to make changes to the structure of the bridge. For example, where there are alternative routes for heavy truck traffic, it may be possible to weight restrict a bridge to its original carrying capacity and rehabilitate the bridge accordingly.

The preferred method of repair of a metal bridge truss is to repair deteriorated components in-kind using acceptable preservation methods such as strengthening through the addition of plates or supplemental supports. If the levels of deterioration or loading requirements for proposed use dictate replacement, then members may be replaced. Deteriorated members should generally be repaired or replaced in kind, using members of the same size, shape, material, and dimensions. If necessary to accommodate continued use, the new members can have slightly larger dimensions, if the difference is not visually discernable. It is important that the original pinned or riveted or bolted connections be maintained to preserve the appearance of the bridge and how it functions.

Rivets that are a part of the built-up members of a metal truss bridge contribute to the historic character of the bridge. Riveted bridges that remain in use today are a testimony to the durability of rivets. While bolts may be a more recent technology that replaced the function of rivets in bridge construction, the endurance of rivets points to their continued strength and useful application, particularly for work on historic bridges. In addition, rivets and the tools needed to drive them remain available today. Button head bolts of a similar shank diameter used in place of rivets is possible if they mimic the appearance of rivets. While button head bolts have a rounded head instead of a hex shaped head and resemble rivets, they still use a washer and hex shaped nut. When installed, button head bolts resemble a rivet on one side and standard bolt with nut on the other side. Button head bolts require special installation procedures, in some cases requiring more clearance than a standard bolt. Since the button head bolt only resembles a rivet on one side and has restricted installation requirements, the use of button-head bolts to replace and resemble a rivet has a limited range of application. The Standards for Rehabilitation advocate for replacement in kind, using like materials and methods, provided it is technically and economically feasible. Given cost concerns, the most appropriate approach for projects involving a limited number of rivet replacement or replacement of rivets on a smaller bridge, would be replacing rivets with rivets, or replacement in kind. The overall visibility of a character defining feature is an important factor in determining whether the use of substitute materials will be appropriate. Rivets should be used in those locations with the highest levels of visibility (e.g. railings, along sidewalks, at portals, and at vertical and diagonal members above the deck). The use of button head bolts would be appropriate

when only the button head will be visible. If replacement fasteners can be hidden from public view the use of hex-head bolts could be an appropriate compromise.

Generally, bearings are not considered to be significant and can be replaced if the type of bearing (pin connected or rigid bearing) is maintained. Decks, the flooring system, and wearing surfaces are not among the most important features for metal truss bridges and altering them to lighten loads and thereby preserve the truss system is generally acceptable. It is common for stringers and floor beams to be the weakest truss members, and most can be strengthened or replaced without affecting integrity of design except for floor beams that are executed in an uncommon manner (e.g. fishbelly floor beams) and are considered character defining features in which case care should be taken to retain these features. It is important that the floor beams are connected in the original manner. Stringer-to-floor beam connections are not as critical.

Increasing the vertical clearance of through-truss structures is not usually feasible without affecting the structural and historic integrity of the bridge. Minor widening (less than a lane width or through the extension of a sidewalk) also affects the structural and historic integrity of the bridge.

Materials: It is important to be aware of the type of metal of which the bridge is constructed and its physical properties. If necessary to accommodate continued use, the material used to replace deteriorated members can be of higher strength assuming the new material can replicate the detailing of the old. Given the corrosive nature of steel, galvanizing of steel to provide enhanced resistance against corrosion is considered acceptable.

Location/Setting: While retention of a metal truss bridge in its historic location for continued use is the preference, relocation is an acceptable alternative for metal truss bridges as they were designed to be disassembled and reassembled. For those bridges that contribute to historic districts, location and setting are so much a part of their historic significance that relocation to another site would not be considered acceptable.

Workmanship: For metal truss bridges, integrity of workmanship can refer to the details associated with a particular bridge builder, such as the Phoenix Bridge Company's use of the Phoenix column. Integrity of workmanship can also reflect a particular engineering technology.

Protective Measures: The best maintenance and preservation strategy for preservation of steel truss bridges is to keep them painted and free from accumulated debris. Washing of truss bridges is most important after the winter to remove corrosive salting treatments.

Protective measures for metal trusses can include the installation of traffic railing or guide rail to protect the truss lines from impact damage. Whenever possible, any original railings should be left in place and traffic railings that meet current safety standards should be installed just inside the existing railings. The railings should be attached to the flooring system rather than the trusses. Attaching guardrail to historic iron or concrete railings will affect their physical integrity and greatly obscure them from view; this treatment is only preferable when the option is to remove the historic railings entirely.

Sources for Additional Information:

PennDOT Historic Metal Truss Bridge Maintenance Manual, available at: https://www.paprojectpath.org/docs/default-source/penndot-crm---general-documents/truss-maintenance-manual-rev-2015-01-09-incorporated-epds-bomo-bqad-comments.pdf?sfvrsn=2

Ohio Historic Bridge Preservation Manual, available at: http://www.dot.state.oh.us/Divisions/Planning/Environment/Cultural_Resources/HISTORIC_BRIDGES/Documents/OhioHistoricBridgePreservationManual910.pdf

Stone Arch Bridges

The following information is condensed from the *PennDOT Stone Arch Bridge Maintenance Manual.*

Stone arch bridges are built using courses of local stone. The stone varies in form and can be rubble stone, squared course stone, and ashlar. The load is carried by the arch barrel. The outer rings of the barrel are generally composed of cut-and-matched, wedge-shaped stones called voussoirs. The voussoirs are held in place by the keystone. The spandrels are exterior walls that surround the arch barrel and act as retaining walls for fill material, which carries the roadway. The portions of the spandrel walls above the roadway are called the parapets. In most cases, flat stones known as coping top the parapets. On some bridges, a decorative band of stone work called the belt course or stringcourse differentiates between the spandrels and the parapets. Abutments and piers, substructure elements, absorb the thrust placed on the arch and transfer it to the ground. Wing walls are extensions of the abutments designed to retain side slope material from the approaches. The bridge's stones are bonded together by a cementitious mixture called mortar. Early mortars consisted of sand, lime, and water. After 1880, Portland cement was usually added to mortar mixes resulting in a more rigid and non-absorbing mortar.

Character defining features: The primary character defining features for stone arch bridges are the voussoirs, arch barrel(s), and the stone material, including the cut and the coursing or the way in which it was laid up. Secondary character defining features include parapet height and shape, spandrel walls, abutments, piers, and wing walls. Decorative elements, like coping, string courses or bridge plaques, are prominent aesthetic features that should be preserved, repaired, or replaced during rehabilitation.

The roadway surface and the fill material supporting the roadway are not considered character defining features. Replacement of these components to strengthen a bridge or improve its drainage does not adversely affect historic character.

Design: Arches are the main structural elements of the stone arch bridge, supporting the load and transferring the forces to the substructure elements. Failure of the arch means the structural failure of the bridge. Every effort should be made to preserve the material and workmanship of the arch ring and arch barrel.

Parapets are also one of the most frequently damaged parts of a stone bridge, primarily due to vehicle impact. Coping stones and or concrete caps are also frequently missing or damaged. If documentation of the appearance of the bridge exists, parapets should be rebuilt using original stones or stones of similar type, size, cut, color, and texture. While the preference is to rebuild the parapet using stone, if

necessary to meet engineering or safety standards, rebuilding the parapet walls using stone-faced reinforced concrete is an acceptable treatment. The stone facing should replicate the color, size, texture/finish, coursing, and cut of the stone on the rest of the bridge and should be applied to both the vehicle and steam sides of the parapets.

For spandrel walls that are severely bulging, out of plumb, or partially or completely collapsed, the rehabilitation should address the root causes of the problem as well as the basic wall repair. Correction of the problem often involves the replacement of fill and installation of drainage prior to the reconstruction of the spandrel wall. When rebuilding spandrel walls, care should be taken to use old and new stone in a random coursing pattern so there is no visual distinction between the original and new stone work.

Materials: There is great variety in building stone. Structural stone varies in content, color, structure, workability, strength, and durability. When rehabilitating historic stone arch bridges, the bridges should be repaired or replaced using the original stones, if possible. If it is not possible to use the original stones, the replacement stones should match the existing stones in type, size, texture/finish, and color. Stone in historic bridges typically came from a local or regional quarry, so the search for matching stone should begin with masonry supply dealers in the area. Architectural salvage yards may be another useful source. When possible, a mix of new and original stone should be used to ensure a proper blending of the new and the old. All stones should be clean, durable, properly quarried, and free from structural defects. Masonry should only be cleaned using the gentlest methods possible. The stones should be laid up in a similar coursing pattern to the original bridge. For stones that have experienced spalling or delamination, the stone should be removed and replaced using one of similar visual characteristics.

When treating historic stone arch bridges, repair or repointing of mortar is only necessary when there is evidence of deterioration (disintegrating mortar, cracks in the mortar joints, gaps between stones, or loose stones). Repointing should be limited to those portions of the bridge where deterioration is present; sound mortar that is well-bonded to the adjacent masonry should not be removed. Deteriorated mortar should be removed by hand raking the joints to avoid damage to stone. The new mortar should be compatible with historic mortar in terms of appearance (width, joint profile, color, and texture).

The composition of the mortar should be compatible with the type of stone used to construct the bridge. Mortars with high lime content also have the ability to re-seal small hairline cracks, provide greater prevention against rain penetration, and allow moisture that has penetrated the masonry to escape. However, they take longer to cure and reach full compressive strength. By contrast, mortar mixes containing high Portland cement ratios cure and reach full compressive strength quickly, but they lack the flexibility of lime-based mortars and tend to form hairline cracks as the mixture dries, which allows moisture to penetrate the structure.

The application of exterior coatings, such as shotcrete, are historically inappropriate treatments for repairing historic bridges that obscure historic materials and can also trap moisture. Rehabilitations of stone arch bridges should include removal the exterior coatings carefully using hand tools and small pneumatic-powered chipping hammers to expose but not damage the stone faces.

Workmanship: Workmanship in stone arch bridges usually refers to the way in which the stone was faced prior to construction or to the coursing of the stone in the construction of the bridge. Examples of the most skilled masonry craftsmanship are found in the arrangements of voussoirs and keystone in the arch ring. Care should be taken to retain notable cut stone or placement of stones if any repairs are needed. The original treatment of the mortar (existing or documented previous conditions) should also be replicated.

Protective Measures: Among the most important protective measures for stone is protecting it from moisture. Appropriate treatments can include keeping the roadway and drains in good condition; removing vegetation and accumulated debris; and keeping mortar joints watertight. Maintaining a clear waterway by removing debris from the substructure and adding scour protection are other measures that should be implemented to ensure the longevity of the structure.

Sources for Additional Information:

Guidance - PennDOT Stone Arch Bridge Maintenance Manual available at:
https://www.paprojectpath.org/docs/penndot-crm---general-documents/stone-arch-bridge-maintenance-manual.pdf?sfvrsn=2

Guidance - PennDOT Stone Arch Bridge District 6-0 Management Plan available at:
https://www.paprojectpath.org/docs/penndot-crm---general-documents/stone-arch-bridge-management-plan.pdf?sfvrsn=2

Preservation Brief 1: Assessing Cleaning and Water-Repellent Treatments available at:
https://www.nps.gov/tps/how-to-preserve/briefs/1-cleaning-water-repellent.htm

Preservation Brief 2: Repointing Mortar Joint in Historic Masonry Buildings, available at:
http://www.nps.gov/tps/how-to-preserve/briefs/2-repoint-mortar-joints.htm.

Concrete Bridges

The development of concrete as a popular construction materials occurred about the same time as the rise of the use of steel. By itself, concrete can only work in compression but when reinforced with iron or steel bars, the elastic metals assume tensile stresses. Concrete bridges can be described as having an open spandrel or a solid or closed spandrel. In the open spandrel, loads are carried to the arch ribs by spandrel columns. Closed spandrel concrete arches are similar to stone arches wherein a barrel arch carries the loading and solid spandrel walls serve as retaining walls for the fill materials. Due to the moldability of concrete, other architectural and aesthetic elements were often incorporated into concrete bridges including but not limited to open spandrel arches, parapets with urn shaped balusters, solid parapets articulated with scored lines, overlooks, obelisks, light standards, and aesthetic surface treatments. In some cases, the stark appearance of the concrete surface was embellished using forms that imitated stone. Weathered finishes created using acid washes and other abrasives applied to newly poured concrete.

As a result of the City Beautiful Movement that began in the 1890s and the professionalization of public works departments, cities like Pittsburgh, Harrisburg, and Philadelphia moved to the forefront of American highway bridge building practice, both in terms of the application of new

materials, especially concrete and reinforced concrete, and emphasis on bridge aesthetics.

Late 1890s advancement in the understanding of steel reinforcing placement to accommodate tension and shear forces resulted in reinforced concrete being used more frequently for slab, T beams, and girder bridge types. The appropriateness of one bridge type over another was predicated on several factors, such as length of span, roadway profile, and economical use of steel. The rigid frame bridge, where the top member and the verticals are integral, was introduced in the 1920s, capable of spanning greater lengths than a slab bridge.

Character Defining Features: The primary character defining features of concrete bridges are the structural system (such as open or closed arch, t-beam, slabs, girders, rigid frame, and box beams). For concrete bridges designed with aesthetics in mind, decorative features can be considered among the primary character defining features that should be preserved, repaired, or replaced during rehabilitation. Secondary character defining features include abutments, piers, and wing walls.

Concrete bridges can be eligible as notable examples of specific types or designs. Additional information on the character defining features of specific concrete bridge types can be found in *A Historic Context for Common Bridge Types* (NCHRP 25-25) available at: http://onlinepubs.trb.org/onlinepubs/archive/NotesDocs/25-25(15)_FR.pdf.

Design: The simplest measure that can be undertaken to increase capacity without affecting integrity of design is the removal of historic fill and the introduction of light weight fill, thereby decreasing the dead load of the bridge. The live load capacity may also be increased by the introduction of relieving slabs over the arch. Increasing the capacity of an arch bridge must be done in an unobtrusive manner and should preferably be performed internally to avoid any adverse visual effects.
http://www.trb.org/NotesDocs/25-25(15)_FR.pdf

If there is a demonstrated need to increase the roadway width, concrete arch bridges can be widened using cantilevered decks. This requires removal of the existing railings which are often prominent visual elements on concrete bridges that may contribute to their significance. If the railings are a character defining feature, the original or existing railing design should be reproduced or serve as the point of reference for the design of new railings that conform to current design and safety guidelines.

For T beam and slab bridges because the deck is integral with the T beams and slabs, it is more difficult to increase the structural capacity of this bridge type. Generally, rehabilitation treatments are limited to repair of deteriorated material. Similarly, given the design of rigid frame and box bridges, where the abutments and slab are integral, it is difficult to increase the structural capacity of this bridge type. Non-structural solutions, such as load restrictions and making the bridge one lane, should also be considered.

Materials: Concrete and reinforced concrete deterioration may be caused by corrosion of the embedded steel and degradation of the concrete itself. While concrete typically protects the embedded steel, corrosion of the reinforcing members most often occurs when the steel is exposed to water or as a result of chemical corrosion brought on by penetration of deicing salts that reach

steel members. The concrete used in older bridges is more porous than modern concrete, allowing moisture and chlorides to penetrate through the concrete to the reinforcing steel. When this happens, the corroded steel expands, causing the adjacent concrete to crack and spall. Carbonation, a reaction of concrete with the surface, is another problem, especially on older bridges where there is less concrete between the surface and the reinforcing steel. Other causes of damage to concrete can cyclic freezing, shrinkage and creep, and poor workmanship.

When determining whether rehabilitation of a historic concrete bridge is possible, it is necessary to consider the condition of the concrete and reinforcing steel alongside the size and scale of the bridge and significance. For example, it may be more feasible to rehabilitate a deteriorated open spandrel concrete bridge of significant length than a shorter T-beam structure. For certain bridge types, such as box beams, if the corrosion occurs in the steel members, then based on current technologies it is necessary to replace all of the box beams, resulting in a loss of the primary character defining feature of technologically significant box beam bridges.

When repairs of concrete are made, the new material should match the existing concrete as closely as possible, both visually and in terms of its physical properties. It is particularly important that the physical properties of the historic and new materials, including rates of thermal expansion, elasticity, and strength, are compatible so that the old and new material will bond well. The new material should be applied only to a properly prepared substrate where all deteriorated concrete has been removed to expose sound concrete**.** Corroded or lost reinforcing steel should be cleaned or replaced. Removal of concrete will typically extend beyond the level of the reinforcing steel so that the repair encapsulates the steel member and thus provides the necessary mechanical attachment for long-term durability. The use of test panels to determine color and finishing techniques should be prepared and allowed to cure completely before being evaluated. Visually speaking, the new material should match the existing in color, composition, and finish. This may require rubbing, staining, tinting, or pressure wash to achieve the "weathered" appearance.

Workmanship: Repairs should be carried out in a manner that reproduces original detailing like scoring or cornices/string courses or open parapets.

Protective Measures: Similar to stone, among the most important protective measures for concrete bridges is protection from moisture. Appropriate treatments can include keeping the decks, joints, and drains in good condition so that moisture and any deicing or marine salts are not allowed to penetrate the structure and cause corrosion in the internal reinforcing steel. Providing good waterproofing and proper drainage are also important measures for extending the longevity of concrete bridges.

Sources for Additional Information:

Preservation Brief 2: Repointing Mortar Joint in Historic Masonry Buildings, available at: http://www.nps.gov/tps/how-to-preserve/briefs/2-repoint-mortar-joints.htm.

Preservation Briefs 15: Preservation of Historic Concrete: Problems and General Approaches available at: http://www.nps.gov/tps/how-to-preserve/briefs/15-concrete.htmPreservation Brief 15:

Ohio Historic Bridge Preservation Manual, available at:

http://www.dot.state.oh.us/Divisions/Planning/Environment/Cultural_Resources/HISTORIC_BRIDGES/Documents/OhioHistoricBridgePreservationManual910.pdf.