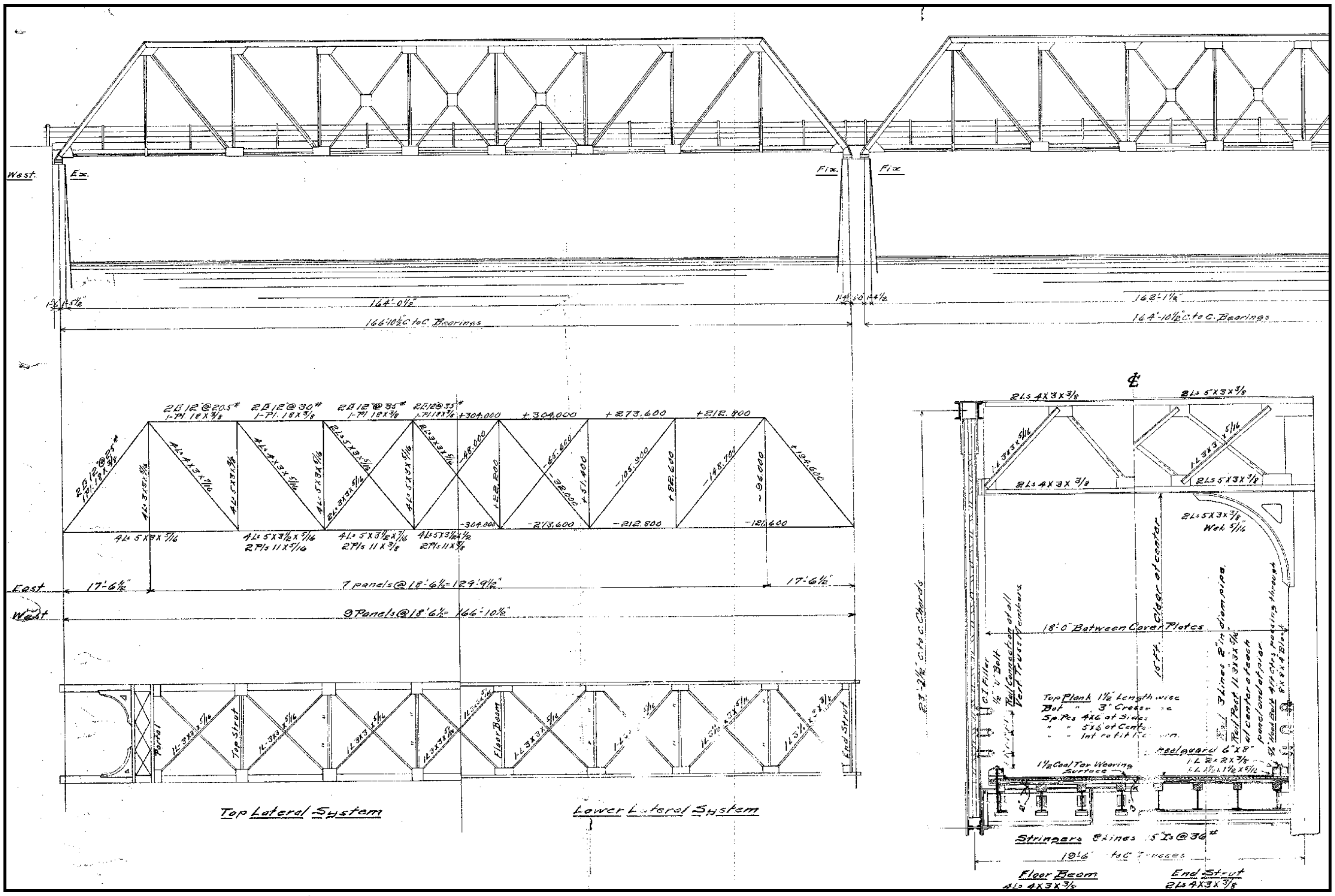
Sewells (or Sewalls) Falls Bridge
Concord, New Hampshire

Effects of Proposed Rehabilitation Alternatives on Historic Characteristics of Bridge



Portion of Original Bridge Drawing by Storrs & Storrs, Bridge Engineers, Concord, NH, 1915.

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1.0 INTRODUCTION

The purpose of this report is to review two recent reports, *Sewalls Falls Bridge 2012 In-Depth Inspection* and *Sewalls Falls Bridge 2012 Load Rating,*[1] and provide an assessment of the findings and recommendations of those reports as they pertain to the potential treatment and historic integrity of the historic Sewalls Fall Bridge (Bridge). The general finding of both engineering reports is that the Bridge is in worse physical and structural condition than previously estimated, raising two issues: certain aspects of the *Preferred Alternative Plan* for the Sewalls Falls Bridge Replacement Project, adopted and approved by the Concord City Council in 2010, may no longer be feasible, and repairs to the trusses may be so extensive or intrusive that the historic integrity of the bridge is lost. The Preferred Alternative Plan calls for the rehabilitation of the existing truss bridge as a one-lane eastbound bridge with a new sidewalk added and extended off the downstream side. A new one-lane bridge for westbound traffic will be constructed upstream and alongside the existing truss.

Because the Sewalls Falls Bridge is a historic structure that has been determined eligible for listing in the National Register of Historic Places,[2] the truss must be rehabilitated in accordance with the Secretary of the Interior's Standards for the Treatment of Historic Properties (SOI Standards)[3] if federal funding is to be used for the project. The SOI Standards for Rehabilitation projects, while intentionally general in nature to enable broad interpretation to fit the particular circumstances of each historic property, were conceived with buildings in mind, not bridges. The result has been wide variations in historic bridge rehabilitation practice among different states and a lack of clear consensus on the limits to which specific bridge features can be repaired and replaced without destroying the historic integrity of the bridge, and hence, its eligibility for the National Register. In 2001, the Virginia Transportation Research Council studied the problem and published *The Secretary's Standards Interpreted for Bridge Repair, Rehabilitation, and Replacement Situations* (see Appendix A). The VTRC standards serve as perhaps the best available guidelines for engineers to follow, however, they have not been officially adopted or codified by the regulating agencies.

The actual determination of the effects of a rehabilitation design on the integrity and eligibility of the Bridge will be arrived at thru consultation meetings of the NHDOT Cultural Resource Committee between representatives of NHDOT, FHWA, NHSHPO, the City and its engineering consultant, CHA. Typically, the preparation of relatively specific bridge rehabilitation plans or intentions must be provided in order for the Committee to best appraise the effects of each type of repair. Before the City expends further monies to prepare detailed rehabilitation plans, it seeks to gauge the feasibility of making the necessary repairs without destroying the integrity of the Bridge, and thus loosing the source of federal funding.

[1] Reports prepared by Clough Harbour & Associates (CHA), Keene, NH for the City of Concord Engineering Services Division, March 2012, and June 2012, respectively.
[2] *New Hampshire Division of Historical Resources Determination of Eligibility (DOE), Sewells Falls Bridge over Merrimack River, Inventory Number CON0278, July 6, 2008.* On file at NHDHR, Concord. The DOE determined the bridge to be eligible for the National Register under Criterion A - History, and Criterion C - Engineering.
[3] The Secretary of the Interior's Standards for the Treatment of Historic Properties – Rehabilitation (1995). Cited as Rehabilitation Standards. See: http://www.cr.nps.gov/local-law/arch_stnds_8_2.htmGuidelines.

2.0 CHARACTER DEFINING FEATURES

Character defining features are those physical components and elements of the resource, which are special or unique to the particular resource in design, materials or construction. The character defining features must be present and retain a reasonable degree or level of physical integrity for the resource to be eligible for listing in the National and /or State Register of Historic Places. The character defining features of High Pratt Truss Bridges have been identified in a previous study[4] from which the following table is taken:

Elements of the High Pratt Truss

Component/Feature	**Character Defining Feature (CDF)? Yes/No. Why**
Panel point connections	Yes. The type of panel connection, pin or riveted, have evolved in design and reflect the technological development and evolution of the truss type.
Configuration of truss design	Yes. The layout of the truss members define the truss type and subtypes.
Upper chord	Yes. Upper (top) Chord design has evolved and reflects engineering development of the truss type. Earlier truss upper chords were built-up members with channels, cover plates, tie-plates and/or lattice bars; later trusses may have single rolled member top chord.
Lower chord	Yes. Lower (bottom) Chord design has evolved and reflects engineering development of the truss type. Earlier truss lower chords were eyebars; later trusses generally have built-up members with channels or angles and tie plates.
Vertical members	Yes. Design of verticals has evolved and reflects engineering development of the truss type. Earlier trusses have built-up members; later trusses use single rolled wide-flange members.
Diagonal members	Yes. Design of diagonals has evolved the same as the vertical members and reflects engineering development of the truss type.
Floor beams and stringers	Yes and No. Floor beams and stringers from earlier pin-connected bridges typically have important design, material and connection details related to the truss design. Later riveted trusses are generally not defined in any important way by their floor beams and stringers. Riveted floorbeam-to-post connections are a defining feature and considered above under panel point connections.
Lateral top bracing	Yes. Top bracing methods have evolved and reflects engineering development of the truss type.
Portal	Yes. Portal design has evolved & reflects engineering development of the truss type.
Bearings	Yes. Bearing types have evolved and contribute to then understanding of the bridge type.
Sway bracing	Yes. Sway bracing has evolved in different forms depending on the designer and fabricator.
Lower lateral bracing	Yes and No. Lower lateral bracing on the early pin-connected bridges is often wrought iron with varying section shapes and end attachment fittings and are a CDF. Nearly all riveted bridges utilize steel angle lateral braces that do not possess design features other than section size and are not a CDF.

4 *New Hampshire Historic Bridge Management Plan for High Pratt Truss Bridges.* Prepared by Historic Documentation Company, Inc., Portsmouth, Rhode Island for New Hampshire Department of Transportation Bureau of the Environment, Concord, New Hampshire, June 2011.

Elements of the High Pratt Truss

Component/Feature	**Character Defining Feature (CDF)? Yes/No. Why**
Deck	Yes and No. Deck systems such as concrete slab are typical of many bridge types and are generally unrelated to truss design and not considered a CDF. Lightweight floors such as timber, open steel grid, solid bridge plank with wearing-course overlay can typically be related to design variations in the truss for economy such as lighter structural members and may be considered a CDF.
Sidewalk supports	Yes and No. Early bridges may have unique built-up, shaped, fabricator-specific or decorative sidewalk supports that can be considered a CDF. Later bridges typically all have simple angle or T-section braces of utilitarian design and are not a CDF.
Railings	Yes and No. Early bridges may have unique built-up, shaped, fabricator-specific or decorative railings that can be considered a CDF. Later bridges typically all have simple horizontal runs of pipe, angle or channel that are not a CDF.
Substructure	Yes and No. Generally the substructure is not directly related in any important way to the particular features of the Pratt Truss type. However early bridges may have a stone masonry or an early concrete substructure (before 1910) that possesses engineering significance in its own right; in which case may be considered as contributing to the overall significance of the resource. Unusual substructure elements such as riveted pipe piers, early pre-cast concrete pilings, open or decorative concrete piers or abutments can also be significant. Later bridges with simple standard-design concrete abutments and piers should be considered as non-CDFs.
Rivets and Bolts	Yes and No. Rivets as a whole define the engineering of individual riveted members of pin-connected trusses, and the members as well as the joint connections of all riveted trusses. The use of bolted connections for field splices was also typical. The significance of riveted vs. bolted connections in a particular truss design should be evaluated in each case for any relative importance to the overall truss design.
Composition / Dimension / Strength of structural members	Yes. Early bridges built before 1910 may use wrought iron tension members with specialized end connections and adjusting nuts. Specialized high-strength steel alloy may be used for long spans and reflect special engineering design practice. New structural member shapes such as wide-flange beams used for columns and braces reflect the design evolution of the type.

3.0 REHABILITATION FEASIBILITY

3.1 CHA Load Rating Report Findings

The Load Rating Report states: "The results of the analysis indicate the bridge is understrength for current legal highway loads with all diagonals and most gussets having insufficient capacity. CHA believes the bridge can be rehabilitated and strengthened to support legal highway loads (HL93). The gusset plates control the capacity at about 50% of the legal load. CHA believes these members can be strengthened to achieve the full legal highway capacity by replacing rivets with high strength bolts and lengthening the connection. The previous engineering report included the addition of a sidewalk cantilevered outside of the truss. This can be done but will require additional strengthening of the top and bottom chords. Rehabilitating the truss to support a sidewalk requires the strengthening of every member of the truss. CHA believes this exceeds the practical limits of rehabilitation."

CHA estimates the work to rehabilitate the trusses to full legal capacity without a sidewalk will consist of the following repairs:

Description	Number Repaired	Total Number In Bridge	Percent Replaced
1. Replace diagonals bent from vehicular impact	7	40	17.5%
2. Strengthen tension diagonals	25	40	62.3%
3. Strengthen lower chord members	17	36	47.2%
4. Strengthen verticals	7	32	21.9%
5. Strengthen gussets	40	72	55.6%
6. Replace Floorbeams	20	20	100%
7. Replace Stringers	144	144	100%
8. Replace bottom lateral Bracing	36	36	100%

The Load Rating Report notes that the information above was based on the following:

> "The inspection was limited to the two truss spans superstructure elements only. The substructure and existing bridge flooring members are contemplated for complete replacement in the various bridge rehab/replacement schemes under consideration. The main members and gusset plates were analyzed. The floor beams and stringers were assumed to be replaced in kind and were not analyzed."

Section 4.0 below examines the effect of eliminating the added sidewalk from the plan, the complete replacement of the floor system, and the selective repair and/or replacement of each truss member type listed in the table above.

2.2 Integrity Considerations for Rehabilitation[5]

High Pratt truss bridges like Sewells Falls that are eligible for the National Register under Criterion C for engineering significance, "should always possess several, and usually most, of the [seven] aspects of integrity: location, design, setting, materials, workmanship, feeling and association.[6] Bridges should be intact, with an identifiable truss system, the majority of which should be original members or members replaced in-kind. The truss system should be capable of functioning, with or without structural reinforcement, but need not be in use for carrying traffic. Additions such as sidewalks, guide rails, replaced flooring and decking, and new abutments are acceptable as long as the truss system is in place.

According to the American Society of Civil Engineers (ASCE), engineers have a duty to seek cost effective methods to rehabilitate historic bridges so they remain on line. "Vehicular use is the best

5 From: *New Hampshire Historic Bridge Management Plan for High Pratt Truss Bridges.*

6 "How to Evaluate the Integrity of a Property" [Section VIII] *National Register Bulletin 15, How to Apply the National Register Criteria for Evaluation.* Washington, DC: US Department of the Interior, 1997, p. 44.

preservation because it keeps the bridge in highway maintenance, inspection and funding programs" (see Appendix C for the complete ASCE policy statement on historic bridges).

4.0 PROPOSED REHABILITATION TREATMENTS & EFFECTS

4.1 Elimination of Proposed Sidewalk

Description: According to CHA, "rehabilitating the truss to support a sidewalk requires the strengthening of every member of the truss… [and] that would exceed the practical limits of rehabilitation." [7]

Proposed Treatment: Do not add the cantilevered sidewalk to truss bridge.

Effect of Treatment: Since the sidewalk is not an original feature of the bridge, its elimination from the rehabilitation plan removes an alteration that would have diminished the integrity of the original design.

4.2 Replacement of Floor System.

Description: According to CHA, "The Stringers are rolled beams; their date of origin was not determined, but they have the same staggered holes in the top flanges (for fastening timber nailers), as shown in the 1915 shop drawings. Floorbeams are built-up riveted sections with separate web plates and flange angles. Both the stringers and the floorbeams have been extensively modified; they have welded flange cover plates and web repair plates, possibly from multiple generations of rehabs and retrofit construction."

Proposed Treatment: Floor beams and stringers are assumed to be 100% replaced in kind.

Effect of Treatment: As noted in Section 2.1 above, the floor systems of *riveted* Pratt truss bridges such as Sewells Falls, including the floor beams, stringers and lateral bracing, do not typically contribute significantly to the technology of the truss design. Riveted floorbeam-to-post connections can be a defining feature and are considered under panel point connections. The term "replacement in-kind" can be open to interpretation. Since the new replacement floor beams and stringers must "fit" the existing truss connections, it is assumed for the purposes of this report that they will be of very similar overall dimensions to the existing members, but varying in section as required to meet load requirements. The new floor beams will likely be rolled or welded instead of built-up riveted.

Evidence in the form of the old bolt holes and the repair work suggests that the existing floor beams and stringers are probably original. Their complete removal would be considered an adverse effect under S106 Standards but their advanced deterioration and numerous ad-hoc repairs has rendered them unsuitable for further repairs. If repairs to existing members can be

[7] "Practical limits" is not defined in the Load Rating report but presumably means that the cost of strengthening every member of the truss would grossly exceed the cost of a new bridge and therefore fail to meet the eligibility requirement of "reasonable costs" under the Federal Highways Historic Bridge Program (see Appendix B).

shown to be not feasible, then the Rehabilitation Standards allows full replacement of members in-kind as the "least degree of intervention."

4.3 Top Chords

Description: The top chords are built-up member consisting of two 12" channels with their legs turned out, joined with 18"x3/8" cover plates on top and double lacing bars on bottom. The channels are in four weights: 20.5, 25, 30 and 35 p.l.f.

According to the CHA Inspection Report: "top chords of the truss exhibit minor deterioration in their top plates due to crevice corrosion ("pack rust")…typically present between the horizontal bracing gusset plates and the top plates of the upper chords at each panel point…a conservative estimate of 33% section loss in the top plates of the upper chords is recommended for load rating purposes. Because this loss typically occurs over very short lengths along the member (<1"), it applies only to local bearing/compression stress, and not to slenderness or buckling modes of analysis. No losses were evident in the channel components of the chords, so the resulting weighted maximum effect of the top plate losses on the gross section is 12% for the section with the lightest channels."

Top chords are essentially in good serviceable condition with minor areas of corrosion. Providing that the cantilevered sidewalk is not added to the truss, the upper chords meet intended design loads (as a single lane bridge) as originally designed without repair or strengthening.

Proposed Treatment: No treatment other than blasting and painting and perhaps small localized weld fills in areas of deep corrosion pitting.

Effect of Treatment: The proposed treatment is regular maintenance and complies with the Rehabilitation Standards as and the least degree of intervention. Maintenance that can be considered typical for a particular resource or feature does not constitute an adverse effect by S106 standards.

4.4 Bottom Chords

Description: Built-up member consisting of four angles joined with tie plates to form an I-section member, installed with the web axis oriented horizontal. Angles are 5x3" or 5x3-1/2", in thicknesses of 5/16, 7/16, or 1/2". Web tie plates are 11" wide by 5/16 or 3/8" thick. Bottom chords are joined with gusset plates at the panel points to vertical and diagonal members.

According to CHA Inspection and LR reports, the lower chords as originally designed are of adequate capacity for the intended loading. Where vertical and diagonal truss members intersect gusset plates at the lower-chord panel points, there is minor to moderate crevice corrosion and localized section loss, typically greater at the inside gusset plates. A total of 17 of the 36 lower chord members were determined to exhibit enough potential section loss (up to 27%) to require repair.

Proposed Treatment: Strengthen 17 of the 36 lower chord members. Since all loss of section in the lower chords is localized at the gusset plates, repair can be made by increasing the size of the gusset plates to obtain several new bolt connections points beyond the areas of section loss. This could be done with new larger plates, or by adding cover and filler plates over the existing plates. Alternatively, strengthening plates the size of the chord angle legs could be welded or bolted directly to the chord members. The advantage of the gusset plate repair is that at many panel point locations the plates can also be designed with longer connections to the deficient vertical and/or diagonal members at that node, thereby accomplishing multiple repairs with one design and construction action.

Effect of Treatment: Either new larger plates or added cover plates will alter the appearance of the panel point connection – a character defining feature of riveted truss bridges – to some degree. An increase in connection length using cover plates sized to the width of the members to be strengthened would be the least noticeable, retain the original gussets, and would meet the SOI Standards. As long at the altered gusset plates do not significantly alter the overall appearance of the truss or disguise the intended purpose or function of its character defining features, the alteration would not constitute an adverse effect under S106 Standards. Gusset plates are further discussed in section 4.7 below.

4.5 Verticals

Description: Built-up member consisting of four angles joined with single lacing bars to form an I-section member. Angles are 5x3" or 3x3", in thicknesses of 5/16 or 5/8".

According to CHA Inspection report, where vertical and diagonal truss members intersect gusset plates at the lower-chord panel points, there is minor to moderate crevice corrosion and localized section loss, typically greater at the inside gusset plates. The greatest section losses found among all truss verticals was 15% on Span 1 Right Truss member U3L3.

Proposed Treatment: Strengthen 7 of the 32 verticals. Again, the most practical repair methods in terms of engineering, constructability and cost will be determined during the rehabilitation design. The needed repairs for the verticals can be accomplished in the same manner as for the lower chords by altering the connection length of the gusset plates. The alternative is to repair members by welding or bolting-on additional steel (sistering), and this is a suitable option as well. In the design phase it may be determined that a combination of sistering and gusset plate modification may be most cost-effective at certain panel points.

Effect of Treatment: The effects of repairs to the diagonals will be essentially the same as those discussed above for the lower chords. Special effort should be made by the engineer to design the least visually intrusive repairs as possible in order to meet the Rehabilitation Standards of least intervention.

4.6 Diagonals

Description: Built-up member consisting of either two angles joined with tie plates or four angles joined with lacing bars. Angles are 3x3, 4x3, or 5x3", in thicknesses of 5/16, 3/8 or 1/2". According to the CHA Inspection Report, deterioration of the diagonals is found at the lower-chord panel points where they are riveted to the gusset plates. As with the verticals, there is "minor to moderate crevice corrosion and localized loss of cross-sectional area…the greatest section losses found among all truss diagonals was 9% on Span 2 Left Truss member U1L2." There are also seven diagonals that have been damaged in some way by impacts of vehicles or snow plow blades.

Proposed Treatment:
Replace the 7 diagonals damaged from vehicular impact and strengthen 25 tension diagonals to meet loading requirements. The diagonals are the controlling member in achieving the required design load, with seven out of the ten in each truss falling below the required strength as originally designed, and 25 showing some loss of section. Several options are available for repair and/or replacement of both the impact-damaged and the under-rated diagonal members that can be designed to meet SOI Standards:

- Sister partial or full-length strengthening plates onto existing angle members by welding or bolting.
- Fabricate entire new built-up welded member of similar and compatible design, with greater section if needed. Tie plates could be substituted for lacing bars to reduce cost provided some original lacing bar diagonals are retained on the bridge.
- Increase gusset plate connection length as previously described.

Effect of Treatment: The use of bolts or welding is an obvious visual difference from riveting, but there is no reason to assume that such repairs would fail to meet the SOI Standards. Large wood beams in historic buildings are routinely reinforced with columns or through-bolted steel sister plates in SOI–approved historic tax credit rehabilitation projects as the repair method constituting the least degree of intervention. Similar repairs can be allowed on bridges. The use of tie plates instead of lacing bars on the tension diagonals can be justified by their original use on the counter diagonals and vertical members. It can be assumed that cost effective repairs to the diagonals can be designed the meet the SOI Standards with minor adverse effect.

4.7 Gusset Plates (Panel Point Connections)

Description: Structural members of riveted trusses are joined together where they intersect at the panel points with steel plates of varying size, shape and thickness called gusset plates. The plates extend out from the center of the intersection point a calculated distance to provide the connection length and number of rivets structurally required. The dimensions and shape of the plates is dictated in part by the connection length, and for purposes of material savings the plates are multi-angled polygons that roughly conform to the loading stresses they bear. As discussed in the Inspection Report, corrosion typically occurs at gusset plates where water and other corrosion facilitators penetrate between the layers of steel in spite of their tight riveted bond.

Proposed Treatment:
The gussets are also controlling members in the load rating analysis and over half, 40 out of 72, will require strengthening or replacement to meet design loads. As previously noted, the strengthening of the gusset plates and lengthening of the connections the plates make with the members they are joining, also remedies most of the structural deficiencies in those members as well. Because the section losses are relatively small in all but a few of the gusset plates and the members they join, nearly all truss members are good candidates for repair and strengthening.

Effect of Treatment:

The impact of new oversized gusset plates, should that be the preferred engineering design, would need to be evaluated with a scale elevation drawing of the truss with the new plates superimposed over the old plates. New plates cut to the same polygonal shape of the old plates, with connection length extensions cut to the width of the member they were strengthening, might be considered less visually incongruent with the original design. The application of cover plates, bolted through existing gusset plate rivet holes, and extended up the diagonal members and attached with bolts thru new holes, would not be a significance adverse effect if shown to offer the least degree of intervention.

4.8 BRACING SYSTEMS

Description: Upper and lower bracing systems form rigid connection between the two trusses above the roadway and below the floor. Lower lateral bracing consists of 3x3" or 3x3-1/2" angles, two per panel crossing in an X to join diagonally opposite panel connections at gusset plates riveted to the floorbeams. Upper laterals are crossed 3x3" angles, diagonally joining the upper panel points at gusset plates riveted to the top chord cover plates. Sway bracing consist of light triangular trusses built entirely of angles. According to the CHA Inspection Report: "the upper lateral (horizontal-plane) and sway (vertical-plane) bracing exhibit only minor pack rust and no significant distortions…at the intermediate sway bracing, several low chords exhibit minor to moderate bends, with little effect on other components…"

Proposed Treatment: Lower laterals will be replaced in-kind along with the other components of the floor system. The portal bracing and upper sway bracing will require alteration in order to meet vertical clearance requirements. This work will require disassembly of portions of the portal and sway bracing in order to shorten the diagonal members of the bracing and raise the bottom bracing members by roughly 18 inches. Because the overall depth of the bracing assembly will be decreased, heavier members and connections will likely be required.

Effect of Treatment: Laterals are all angle members without any significant historic design or material characteristics for their time. Laterals can be replaced entirely in-kind without any effect on the character defining features of the bridge. Alteration of the portal and sway bracing assemblies to meet clearance requirements will require their reconstruction with stronger members. If reconstruction of the portal bracing follows the same original member layout and resembles the original design as closely as possible, adverse effects can be minimized or eliminated.

5.0 CONCLUSIONS

The CHA Load Rating Report finds rehabilitation of the Sewells Falls Bridge practical, and based on the information presented in the Inspection and Load Rating Reports, there is nothing to suggest that the rehabilitation can't be done in accordance with the Secretary of the Interior's Standards for Rehabilitation. Compliance with those standards, as elaborated in Virginia's *Secretary's Standards Interpreted for Bridge Repair, Rehabilitation, and Replacement Situations*, will insure that the bridge retains the necessary integrity of its historic design and materials required for listing in the National Register of Historic Places.

Three types of repairs require strengthening roughly half of the total number of members in the type group: diagonals, 62.3%, lower chords, 47.2%, and gusset plates, 55.6%. These percentages suggest that roughly 50 percent of the members require replacement, which is not necessarily a correct assumption. The members in question are in most cases in good condition with relatively small section losses making them good candidates for cost-effective repair and strengthening to meet the intended loading.

The high percentage of certain members needing repair or replacement raises a question regarding the amount of historic integrity that would be left after the rehabilitation of the bridge. There is no rule or standard of practice that establishes 50%, or any other percentage of materials or members repaired or replaced, as a historic integrity cutoff point. Integrity is a measure of multiple factors with varying weights of importance depending on the resource and the nature of the repairs.

Conversion of the bridge to carry a single lane of traffic has made the job of rehabilitating the bridge to carry modern loads feasible from the standpoint of maintaining the historic integrity of the bridge.

The use of high strength bolts in place of rivets, modified gusset plates, "in kind" replacement members, sistering plates, and welding, can all be used to rehabilitate historic bridges. Although some member repairs or replacement alternatives may by necessity stray from the original design, the effects will be considered acceptable under the Rehabilitation Standards providing the designing engineer can show the chosen alternative will have the least degree of intervention.

APPENDIX A

THE SECRETARY'S STANDARDS INTERPRETED FOR BRIDGE REPAIR, REHABILITATION, AND REPLACEMENT SITUATIONS

[Adapted from Miller, A.B., K.M. Clark, and M.C. Grimes. 2001. A Management Plan for Historic Bridges in Virginia. VTRC 01-R11. Virginia Transportation Research Council, Charlottesville]

The Secretary of the Interior's Standards for Treatment of Historic Properties (Weeks and Grimmer, 1995) were first codified in 1979 in response to a federal mandate requiring the establishment of policies for all programs under the authority of the Department of the Interior. The Secretary's Standards are used in review of all federal projects involving historic properties listed on or eligible for listing on the National Register of Historic Places. Compliance with the Secretary's Standards provides for the preservation of the historic and architectural integrity of properties being rehabilitated. The Secretary's Standards were most recently revised in 1992. The Department of the Interior regulations (36 C.F.R. 67.7(b)) states that the Secretary's Standards are to be applied in a reasonable manner, taking into consideration economic and technical feasibility.

Since their identification, the Secretary's Standards have been interpreted and applied in response overwhelmingly to one type of historic resource: buildings. Although the philosophy of the Secretary's Standards can be applied to bridges, the fundamental differences between buildings and structures must be considered. Newlon (1985) argued that the purpose of buildings is the organization and control of space, providing for a wide and flexible range of functions. Engineering structures such as bridges are designed primarily to control loads and forces to accomplish more limited functions such as the transport of people and goods on roads and bridges, retention of water by dams, or support of cables by towers. The more restrictive function of engineering structures is reflected in their design and construction, and this imposes limitations on continued or alternative uses that do not apply in the same degree to buildings.

The following wording of the Secretary's Standards addresses the unique requirements of historic bridges. This text closely follows the similar section that appeared in A Management Plan for Historic Bridges in Virginia (Miller et al., 2001).

1. Every reasonable effort shall be made to continue a historic bridge in useful transportation service. Primary consideration shall be given to rehabilitation of the bridge on site. Only when this option has been considered shall other alternatives be explored.

Bridges are designed to carry roadways over obstructing conditions: ravines, waterways, and other roadways. Bridges are best suited for this type of use. The first priority should always be retention of a bridge in its existing location and in its existing function. In many instances, contemporary vehicular traffic demands may exceed the capacity of an old bridge, and programmatic modifications, such as reduced transportation service, should be considered. Limiting the loads and types of vehicles that may use a bridge will require minimal change to the defining characteristics of the bridge. Under some circumstances, bridges may be suitable for adaptive re-use. Zuk, Newlon, and McKeel (1980) described some approaches for adapting metal truss bridges for alternative uses, including housing, commerce, etc. Alternative uses may be considered for bridges left in their original locations and for bridges that are re-located. Some metal truss bridge types were designed so that relocation would be readily achievable, and many smaller trusses have served at several locations in Virginia. One example is a Fink Truss located in Lynchburg. This bridge, when taken out of service, was relocated to a park, where it is visible, accessible, and presented in context with a locomotive and other transportation resources.

2. The original character-defining qualities or elements of a bridge, its site, and its environment should be respected. The removal, concealment, or alteration of any historic material or distinctive engineering or architectural features shall be avoided.

The character-defining features of a historic bridge must be identified so that these physical features can be retained and preserved. The bridge surveys completed by the Virginia Transportation Research Council (see, for example, Miller and Clark, 1997) are the primary means of identifying important bridges and their character-defining features.

1 All bridges shall be recognized as products of their own time. Alterations that have no historical basis and that seek to create a false historical appearance shall not be undertaken.

2 Most properties change over time; those changes that have acquired historic significance in their own right

shall be retained and preserved.

3 Distinctive engineering and stylistic features, finishes, and construction techniques or examples of craftsmanship that characterize a historic property shall be preserved.

Characteristic features, finishes, and construction techniques must be identified so that they can be preserved. In most bridges, the most important character-defining features will be the primary structural components: trusses, girders, T-beams, slabs, concrete arches, etc. Operating mechanisms for moveable spans should also be considered primary character-defining features. Secondary characteristic features may include Phoenix columns, pinned truss connections, lattice beams, cork rails, and curbs. Abutments, piers, approaches, and other features of the crossing may be identified as primary or secondary character-defining features. In many cases, decking and roadbeds will not be considered significant character-defining features.

6. Deteriorated structural members and architectural features shall be retained and repaired, rather than replaced. Where the severity of deterioration requires replacement of a distinctive element, the new element should match the old in design, texture, and other visual qualities and, where possible, materials. Replacement of missing features shall be substantiated by documentary, physical, or pictorial evidence.

The Secretary's Standards recommend retention and repair of existing historic features, rather than replacement. They also acknowledge the limited life-span of most building materials. When bridge components are deteriorated beyond a reasonable prospect of retention and repair, replacement can be considered. Although replacement in kind is generally recommended, alternative materials can be considered.

Modern metals with superior resistance to deterioration (stainless steel, for example) may be used to replace missing or severely deteriorated historic members provided they are galvanically compatible with the surviving original members.

7. Chemical or physical treatments 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.

Materials typically used in bridge construction are generally selected for their ability to resist harsh conditions. Aggressive chemical or physical treatments may be appropriate for cleaning of some common bridge materials and components. In Metals in America's Historic Buildings, Gayle, Look, and Waite (1992) describe appropriate measures for proper surface preparation of iron and iron alloys, including flame cleaning, pickling, sandblasting, and other abrasive processes. Dismantling of truss bridges and galvanizing or metallizing the component chords is suggested as a sound means of preserving the historic features and configuration without damage.

8. Significant archaeological and cultural resources affected by a project shall be protected and preserved. If such resources must be disturbed, mitigation measures shall be undertaken.

Associated resources may include fords, abutments, piers, and other features associated with earlier crossings. They may also include structures that are adjacent to, but not culturally related to the bridge: canals, sluices, mills, raceways, shipwrecks, fish-traps, and power plants.

9. New additions, exterior alterations, structural reinforcements, 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.

Structural reinforcement may be necessary to allow a historic bridge to continue in service. In extreme cases, new structural components that supersede the historic components may be necessary. Priority must be given, in all such cases, to retaining significant historic structural components, even if their load-carrying function is reduced or eliminated. New structural elements should be designed so that the historic components remain visible and so that the historic structural configuration remains evident. A valid approach is the method of superimposing structural steel arches in truss bridges, which relieves the critical historical connections and members of much of the stresses imposed by modern traffic (Kim and Kim, 1988).

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.

APPENDIX B

TITLE 23 – UNITED STATES CODE – HIGHWAYS
[As Amended Through P.L. 106-347, October 13, 2000]

CHAPTER 1, FEDERAL-AID HIGHWAYS
SECTION 144: Highway Bridge Replacement and Rehabilitation Program

(o) **Historic Bridge Program.**

(1) **Coordination.—** The Secretary shall, in cooperation with the States, implement the programs described in this section in a manner that encourages the inventory, retention, rehabilitation, adaptive reuse, and future study of historic bridges.

(2) **State inventory.—** The Secretary shall require each State to complete an inventory of all bridges on and off Federal-aid highways to determine their historic significance.

(3) **Eligibility.—** Reasonable costs associated with actions to preserve, or reduce the impact of a project under this chapter on, the historic integrity of historic bridges shall be eligible as reimbursable project costs under this title (including this section) if the load capacity and safety features of the bridge are adequate to serve the intended use for the life of the bridge; except that in the case of a bridge which is no longer used for motorized vehicular traffic, the costs eligible as reimbursable project costs pursuant to this subsection shall not exceed the estimated cost of demolition of such bridge.

(4) **Preservation.—** Any State which proposes to demolish a historic bridge for a replacement project with funds made available to carry out this section shall first make the bridge available for donation to a State, locality, or responsible private entity if such State, locality, or responsible entity enters into an agreement to—

(A) maintain the bridge and the features that give it its historic significance; and

(B) assume all future legal and financial responsibility for the bridge, which may include an agreement to hold the State transportation department harmless in any liability action.

Costs incurred by the State to preserve the historic bridge, including funds made available to the State, locality, or private entity to enable it to accept the bridge, shall be eligible as reimbursable project costs under this chapter up to an amount not to exceed the cost of demolition. Any bridge preserved pursuant to this paragraph shall thereafter not be eligible for any other funds authorized pursuant to this title.

(5) **Historic bridge defined.—** As used in this subsection, “historic bridge” means any bridge that is listed on, or eligible for listing on, the National Register of Historic Places.

APPENDIX C

Policy Statement of the American Society of Civil Engineers for the

REHABILITATION OF HISTORIC BRIDGES

Policy:

The American Society of Civil Engineers (ASCE) supports the maintenance, repair and rehabilitation of historic bridges preferably in continued vehicular use, and when that is not possible, some alternative transportation means such as a pedestrian or bike bridge.

Rationale:

Historic bridges are important links to our past, serve as safe and vital transportation routes in the present, and can represent significant resources for the future. Rehabilitation maintains these important engineering structures in service and can represent significant cost savings. Bridges are the single most visible icons of the civil engineer's art. By demonstrating interest in the rehabilitation and reuse of historic bridges, the civil engineering profession acknowledges concern with these resources and an awareness of the historic built environment.

Justification:

Many historic bridges can still serve the nation's transportation needs given appropriate repair, maintenance and flexibility in interpreting transportation standards as suggested by national transportation policy. Due to perceived functional obsolescence, lack of cyclical maintenance, and any funding priority, historic bridges are a heritage at risk. Over half the historic bridges of the United States have been destroyed during the last twenty years - a startling and alarming statistic. Certainly no one can argue that outstanding and representative examples of the nation's historic bridges shouldn't be preserved.

Vehicular use is the best preservation because it keeps the bridge in highway maintenance, inspection and funding programs. W hen not possible to continue in vehicular use on primary roads, consideration must be given to relocating historic bridges to roads receiving lighter volumes of traffic or alternative means of transportation such as hiking trails and bikeways. America is developing a comprehensive network of scenic highways and byways. Tandem to this is a network of hiking trails and bikeways. Maintaining and relocating historic bridges to these systems sustains the scale, character and feeling of these historic, recreational and scenic corridors.

There is growing public interest in historic bridges. Citizens groups throughout the country are working to save historic bridges. We, as civil engineers, need to help lead and support these efforts. Bridges are engineered resources thus requiring the skills of engineers. There is little chance that the historic bridges of the United States can be saved without the interest and skills of engineers, until they become part of everyday transportation policy, receive the support of transportation officials at all levels, and the continued interests of citizen groups.

Source: Eric DeLony and Terry Klein, *Historic Bridges: A Heritage at Risk. A Report on a Workshop on the Preservation and Management of Historic Bridges, Washington, D.C., 2003.* Find at: http://www.srifoundation.org/pdf/bridge_report.pdf