Historic Bridge Inspection and Assessment

Presented By: Nathan Holth

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Historic Bridge Inspection and Assessment

Part 1:
Historic Bridge Inspection: Purpose and Need

Working With Historic Bridges

Visiting historic bridges can be an enjoyable experience, however historic bridge enthusiasts often like to work to preserve these bridges, by trying to get a bridge restored/rehabilitated and/or by photographing the bridge to record it.

Working With Historic Bridges

A photo-documentation and an inspection of a historic bridge can be done quickly and is an effective way to record a bridge, learn about its history, and identify preservation solutions.

Certified Bridge Inspectors

Certified bridge inspectors examine bridges routinely to ensure they are safe, and to identify and potential problems on bridge and determine if bridges need repair or replacement.

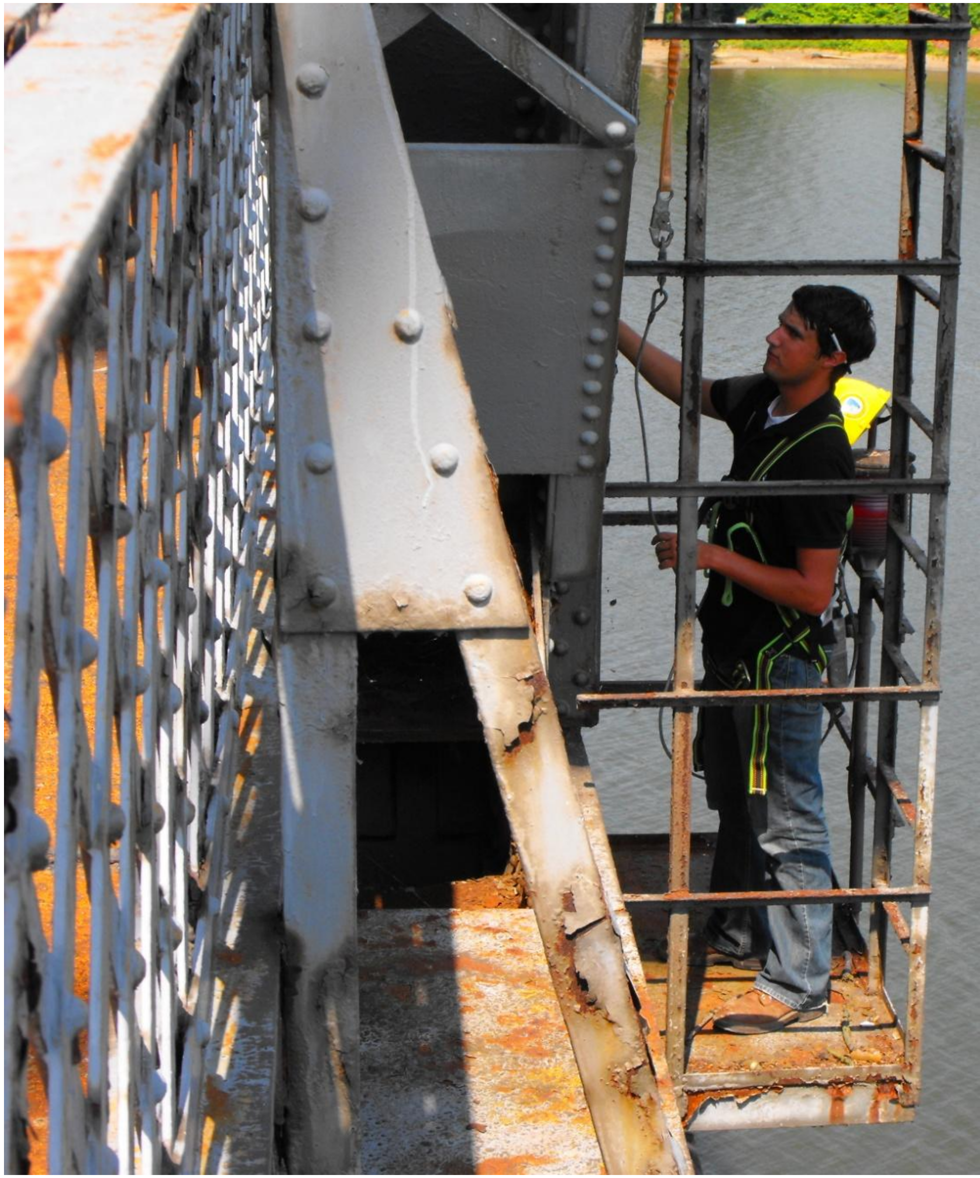
Often their findings are seemingly used against preservationists by agencies who cite problems in historic bridges as reasons for demolition.

Bridge Inspection

However, the job of a bridge inspector is important and is generally not biased. Their focus is finding facts about a bridge. What may be biased is how agencies (or preservationists) interpret these findings and how they decide to act upon them.

Bridge Inspection

As preservationists, we also can inspect bridges to see and better understand what the bridge inspectors are seeing, and can then work more effectively to develop appropriate preservation solutions that are based on facts, not speculation.



Bridge Inspection

This presentation is not meant to be an exhaustive training manual, but is instead designed to provide a surface introduction to the subject, technique, and philosophy of a historic bridge inspection.

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Historic Bridge Inspection and Assessment

Part 2:
Historic Bridge Inspection Preparations

Questions Preservationists Answer When Inspecting

What is the structural condition of the bridge?

Is the bridge's current use appropriate?

Is the bridge protected from possible damage sources?

Inspection Questions

Questions Preservationists Answer When Inspecting

What is the history of this bridge?

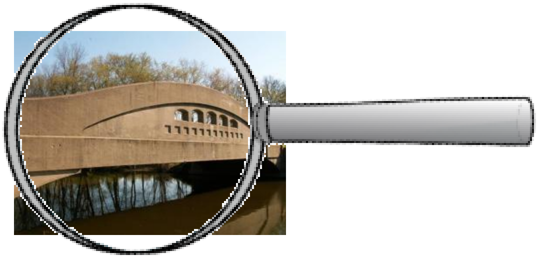
How historically significant is the bridge?

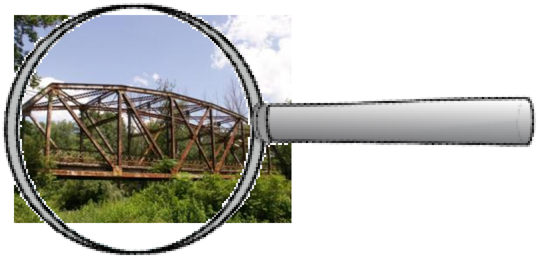
What preservation solutions are appropriate?

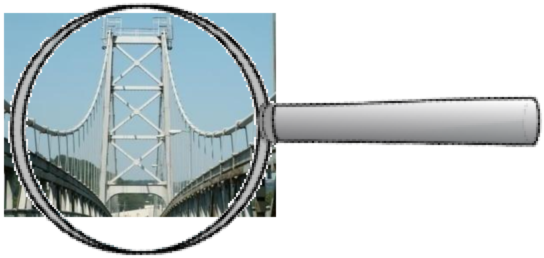
What arguments might be made against preservation?

Inspection Parts

3 Parts To Historic Bridge Inspection







•Structural Inspection – Examine the physical condition of the bridge.

•History Inspection – Identify key events and facts about the history of the bridge.

•Preservation Inspection – Assess the bridge's current use and identify the best preservation solutions.

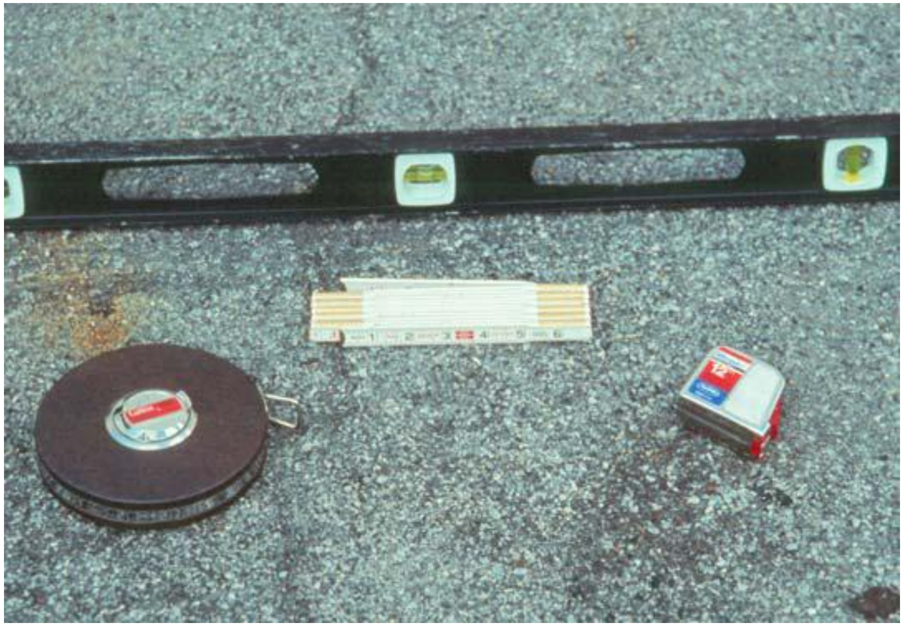
Bridge Inspection

Suggested Tools

- Digital camera – The most important thing to bring!
- Flat head screwdriver – probing, cleaning
- Wire brush – remove loose paint and corrosion
- Wisk broom – remove loose dirt and debris
- Chipping hammer – sounding concrete, cleaning.

Bridge Inspection

Suggested Tools



- Measurement tools – tape, calipers, etc.
- Flashlight – Illuminate connections, under-deck items.
- Branch clippers – clear brush for photography
- Reflective vest / hard hat – protection from traffic
- Chalk, marker, lumber crayon – mark areas of interest

Bridge Inspection

Tool Belt To Hold It All Together!

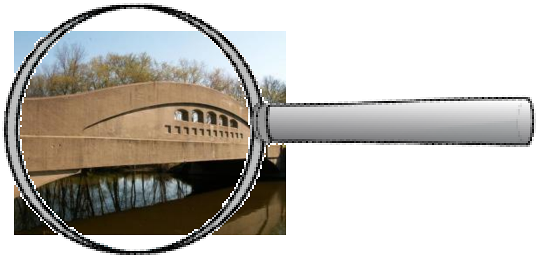
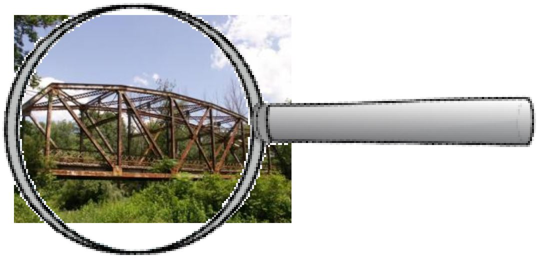
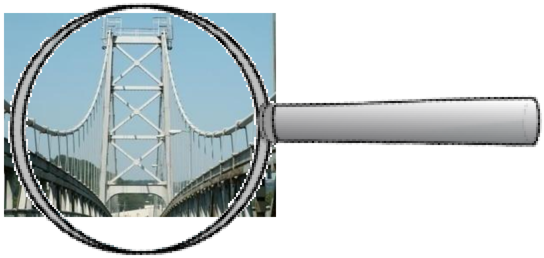
Photo-Documentation

Be sure to photograph not only all possible overview angles (elevation/side, portal/roadway) but also all visible details of the bridge structure. Photo-documenting bridge details can occur simultaneously with your structural inspection.

Historic Bridge Inspection and Assessment

Part 3: Structural Inspection

Structural Inspection/Assessment

Questions To Answer During This Process

- What parts need repair?
- What parts are beyond repair?
- What parts are in good condition?
- Has the bridge been maintained or neglected?
- How soon should corrective action be taken?

As You Inspect The Structural Condition:

Never focus only on problems: Be sure to also note areas in good condition. This creates an unbiased inspection and will not mislead anyone into thinking problem areas represent the overall structure's condition.

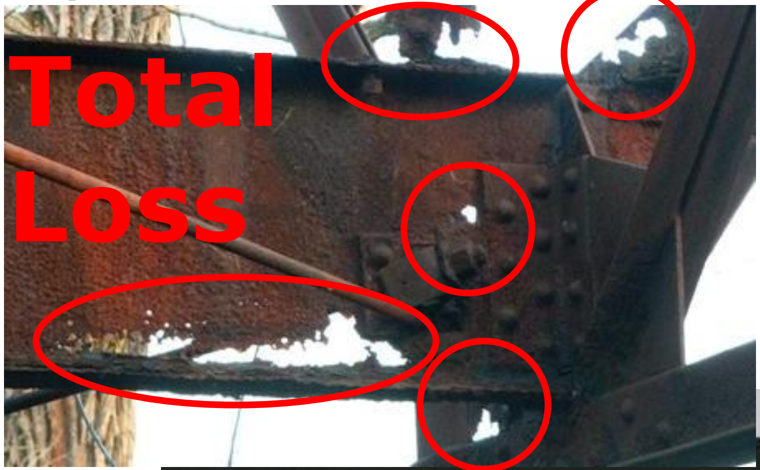
Historic Bridge Inspection and Assessment

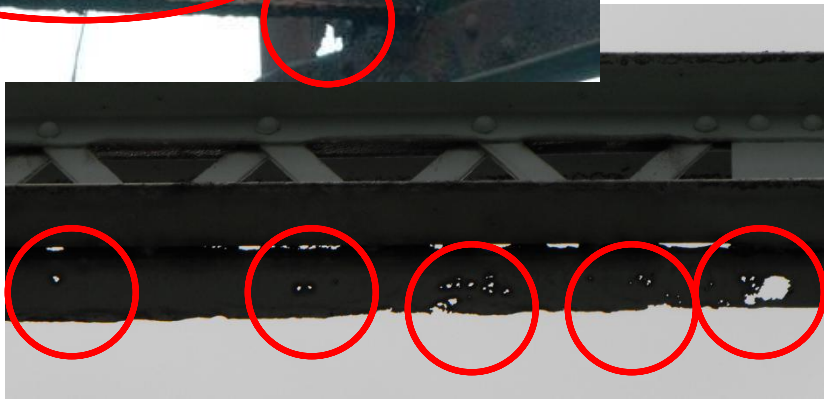
Part 3a: Structural Inspection: Metal

Examine Metal For Section Loss

Section loss is where rust and deterioration has resulted in the thickness of the metal being reduced, or even completely gone. Section loss often occurs in isolated parts of a metal part, such as at connection points, the web portion of a rolled i-beam, or under the deck.

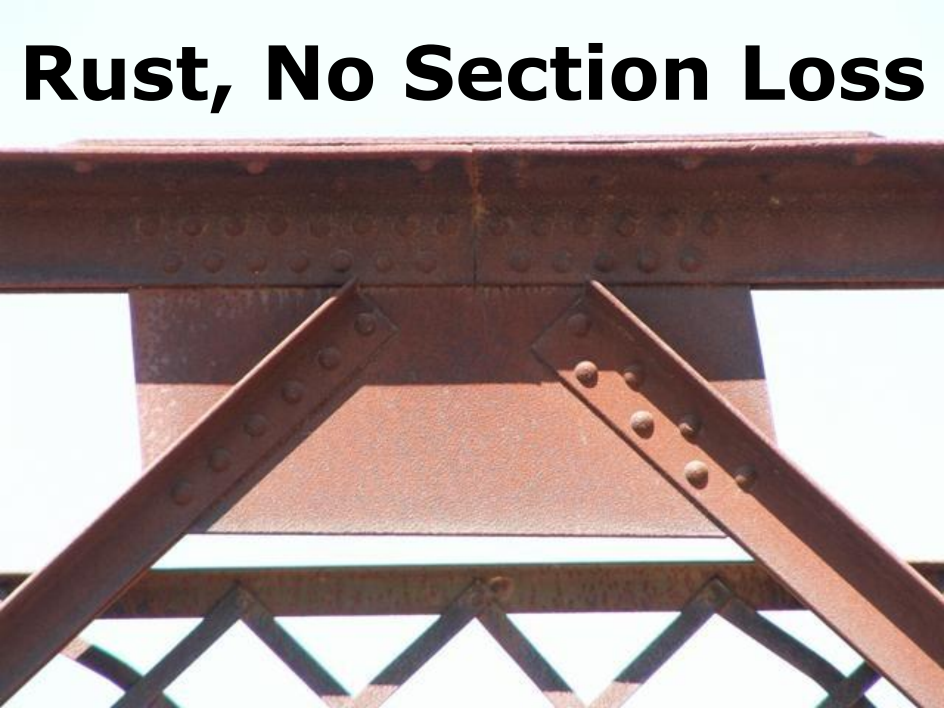
Metal: Identifying Section Loss





Partial section loss can be identified by comparing the beam to the surrounding area and nothing if it is thinner. Total (100%) section loss means there is a hole, and is easy to identify.

Metal: Identifying Section Loss



Rust, No Section Loss

Paint, With Section Loss (Shaded Areas)

Rust alone does not mean that there is section loss. Also, recent paint may cover past section loss. Look for depressions with a rough texture.

Metal: Section Loss: Implications

Section loss is a severe problem that reduces the structural integrity of the bridge. It is largely prevented by the maintenance of paint on the metal. In contrast, section loss on unprotected metal is drastically accelerated by deicing salt.

Metal: Section Loss: Implications

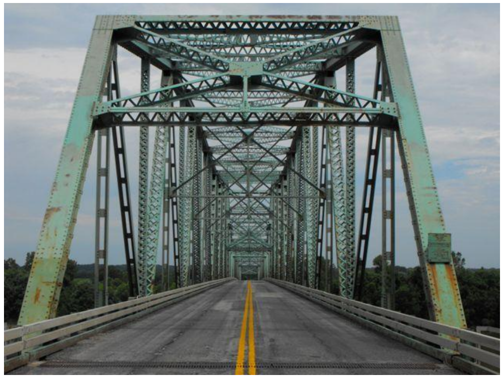
Partial section loss may be repairable. Severe to total section loss on a part of a historic bridge often indicates that the part will have to be removed and replaced with a replica.

Section Loss: Note On Metal Trusses

Often the bottom chord of a through or pony truss will have far worse section loss than the rest of the truss due to de-icing salt and moisture. Don’t forget to also document parts without loss!

Structural Inspection

Section Loss: Note On Metal Trusses


Severe section loss on only the bottom chord and flooring systems of through/pony truss bridges should not be used to justify demolition of these bridges, when the rest of the truss web (a far greater percentage of the truss) is in much better condition.

Examine Metal For Pack Rust

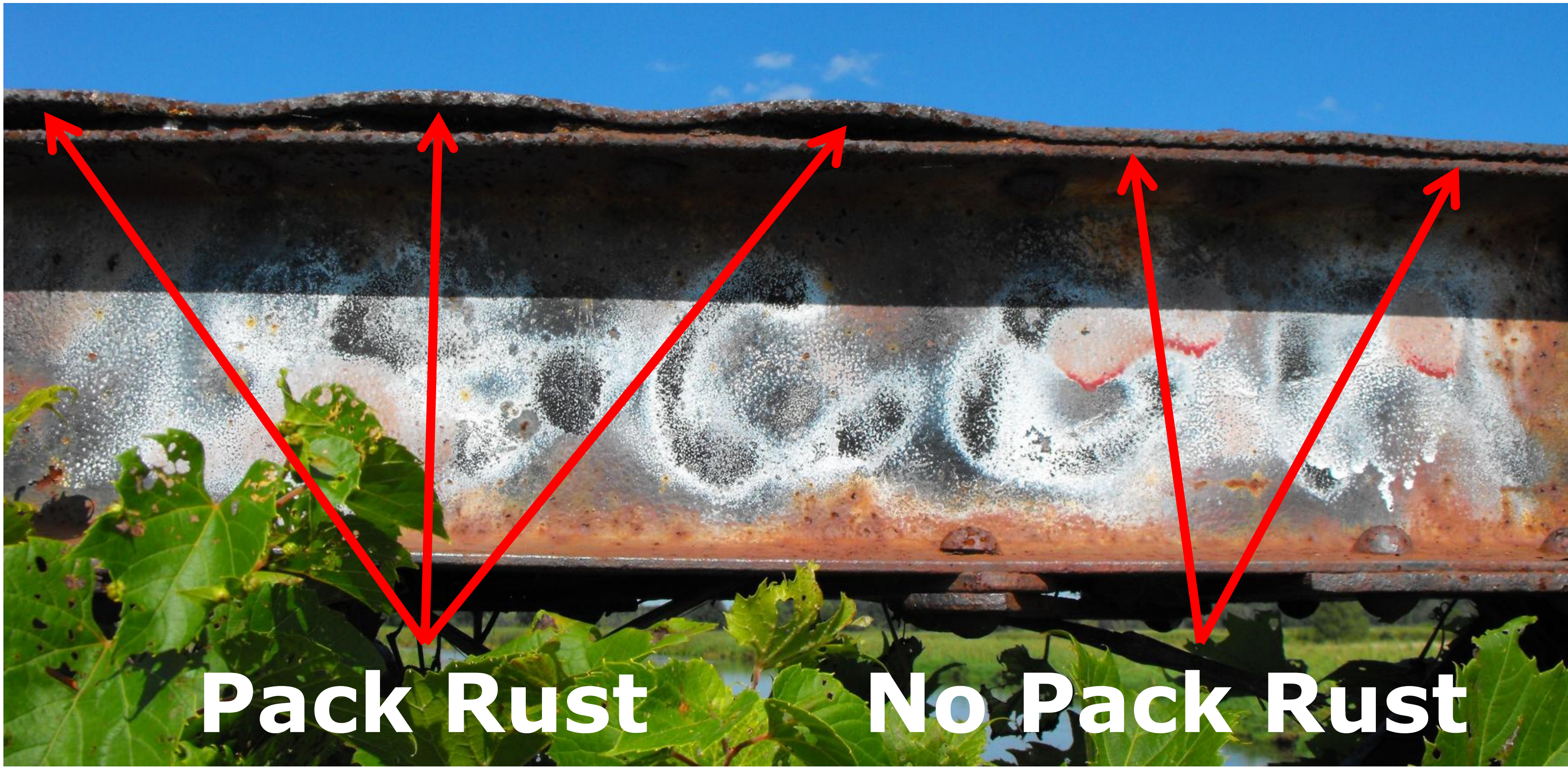
Plate With Section Loss

Pack Rust

Top Chord Plate With Section Loss

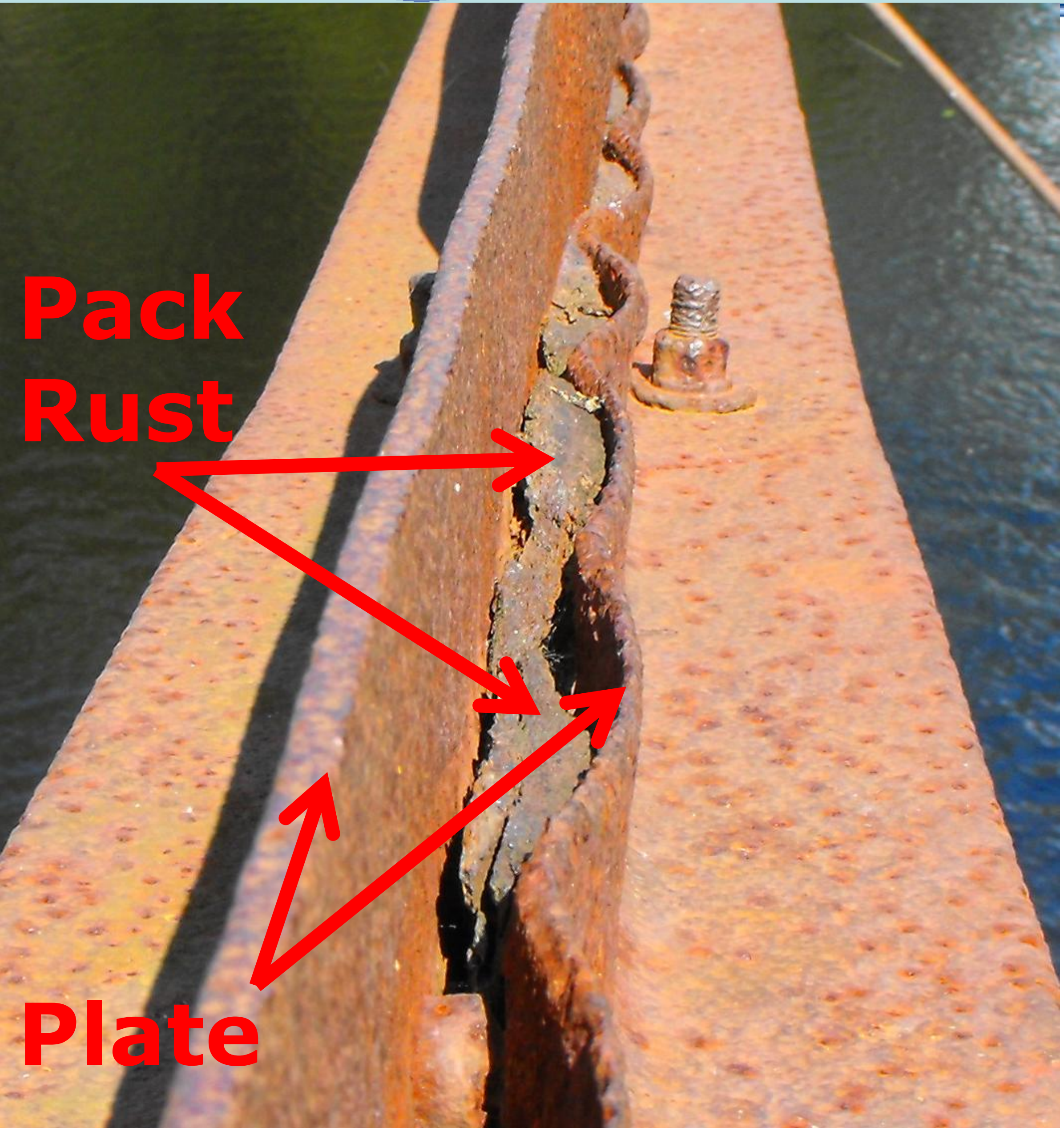
Pack rust occurs when two metals flush with each other produce rust between each other, creating pressure which expands and damages the metal. There may be section loss at the affected area.

Metal: Pack Rust



Top chord/end post cover plates are a common location for pack rust on truss bridges.

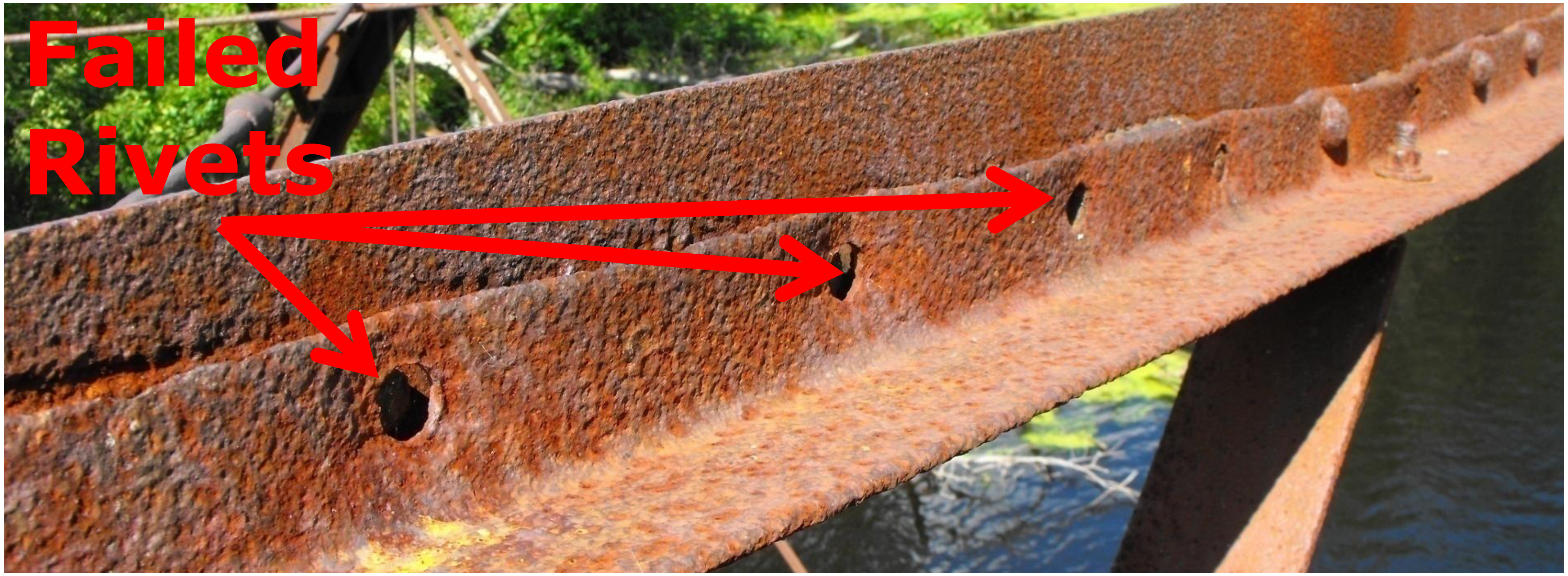
Structural Inspection



Metal: Pack Rust

Severe pack rust has separated these metal plates. The separation is worse in between rivets where there is less resistance to the pressure.

Metal: Failed Rivets



Pack rust is a common source of failed (broken) rivets. In this case, the rivets were completely missing. Hammers can be used to sound rivets and check for weakening or failure, indicating a need to place new rivets.

Metal: Pack Rust

Inspect the bridge to check for pack rust, and note whether the pack rust has mainly bent the metal, or if it is cracked, broken and/or has significant section loss.

Metal: Pack Rust: Implications

Pack rust can be removed. Bent metal from pack rust can often be straightened, while broken and cracked metal may require replication.

This Top Chord Cover Plate Had Pack Rust and Bending Which Was Removed

Historic Bridge Inspection and Assessment

Part 3b: Structural Inspection: Concrete

Examine Concrete For Cracking

Examine the bridge for cracks in the concrete. For cracks larger than a hairline crack, it is important to determine whether the crack extends through the entire member/part of the bridge.

Concrete: Cracking: Efflorescence

Efflorescence is white material that may outline cracks on a bridge or form stalactites under the deck of a bridge. It consists of minerals and salts from both the concrete and outside sources that are left behind when the moisture evaporates.

Concrete: Cracking: Efflorescence

Efflorescence indicates potential problems, since it is evidence that moisture can travel through concrete in a bridge, often aided by cracks.

Concrete: Cracking: Implications

Hairline cracks are generally not a major problem. For larger cracks, especially those which extend through entire members or parts of a bridge, cracks are an area of concern for preservation that would need to be addressed.

Examine Concrete For Scaling

Scaling is when thin, flat sheets of concrete peel or fall away. It is caused by chemical breakdowns in the concrete bond. Scaling is generally very thin, between .25 and 1 inch.

Examine Concrete For Delamination

Delamination is when concrete separates or peels away from the outermost layer of reinforcing. It is often caused by moisture and deicing salt.

Concrete: Delamination

Delaminated concrete may not have fallen away from the bridge. Partly uplifted areas may also exist. Tap it with a hammer and listen for a hollow clacking sound to indicate delamination.

Examine Concrete For Spalling

Spalling is when concrete has fallen away from the bridge often caused by corrosion of the reinforcing within. It can range from potholes in the deck to loss of concrete on a concrete railing or girder.

Concrete: Scaling, Delamination, and Spalling: Implications

Concrete can be a challenging material to repair, and the worse and more widespread the deterioration is the more difficult preservation will be. Also deterioration tends to accelerate once it gets started.

Concrete: Scaling, Delamination, and Spalling: Implications

Widespread deterioration is extremely serious:

•Destroys architectural features

•Exposes structural elements such as reinforcing and inner portions of concrete, which results in more deterioration.

Concrete: Scaling, Delamination, and Spalling: Implications

Repair of minor to moderate concrete deterioration is possible however, and ongoing research may yield new techniques.

Concrete: Scaling, Delamination, and Spalling: Implications

Preventative maintenance is recommended for historic concrete bridges to ensure they do not deteriorate to an irreparable condition.

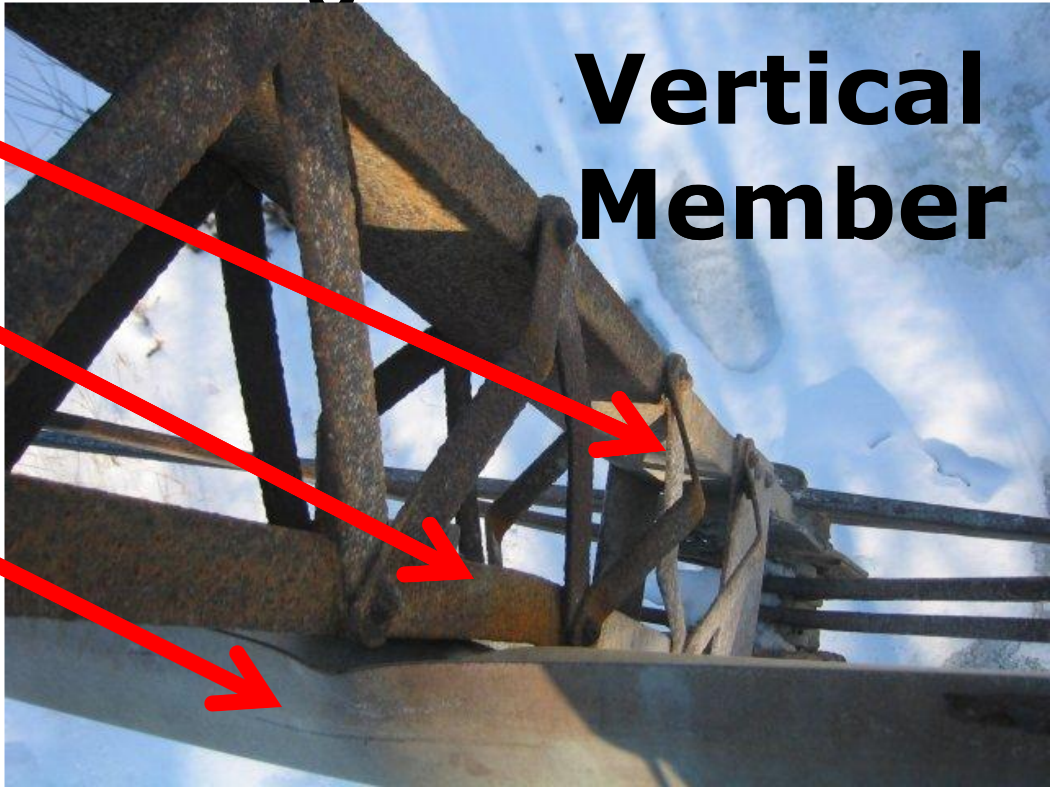
Historic Bridge Inspection and Assessment

Part 3c:
Structural Inspection: All Bridges and Materials

Identify Impact Damage and Risk

Buckled V-lacing
Bent channel

Vertical-mounted guardrail transferred impact directly to bridge



Inspect the bridge for damage from vehicular use and flooding. Look for bent metal members or missing/broken sections of concrete.

Identify Impact Damage and Risk

For “through” bridges, do the guardrails on the bridge protect the superstructure, or do they transfer impact forces directly to the superstructure?

Structural Priorities

Finally, Look At The Entire Bridge

As site conditions and time allows, examine as much of the bridge as possible. Do not forget to look under the bridge if possible. This is easy to forget with through truss and arch bridges, etc.

Historic Bridge Inspection and Assessment

Part 4: History Inspection

Inspection: Historic Record

The bridge is a historic record, just like a history book. Learning to “read the bridge” is a skill that comes with time and visiting many bridges. A detailed guide to this skill is beyond the scope of this presentation, however a series of tips follow.

History Inspection

Who fabricated and built the bridge, and when?

Look for builder plaques. They may be located on the portal, endpost, or with pony trusses also on the top chord. If they are missing see if you can find where they were. Note the shape of any plaque scar if visible.

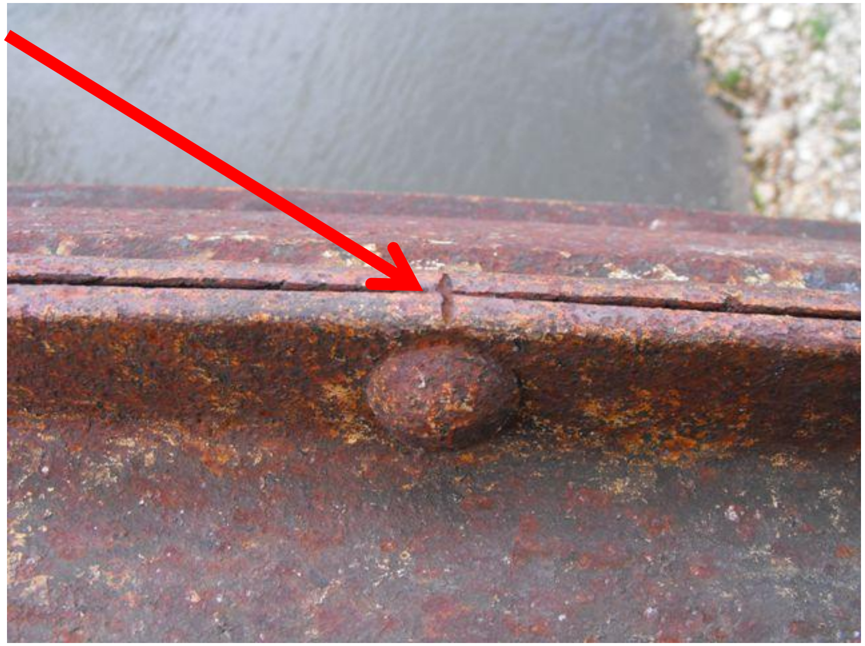
History Inspection

Who fabricated and built the bridge, and when?

Look for the marks of the metal fabricator. Names often appear on the beams. Badly rusted bridges or those with many coats of thick paint may make this difficult.

History Inspection

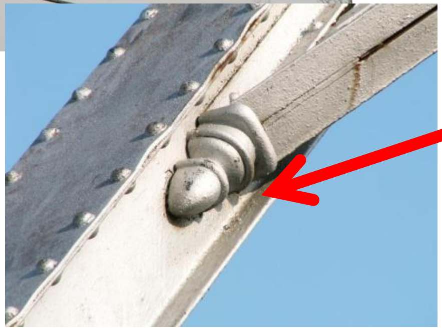
How was the bridge fabricated?



The craftsmen who fabricated bridges may have left evidence of their techniques and processes on the bridge itself. Look for marks, etches, forge welds on metal bridges. Concrete bridges may retain imprints of the forms in which the concrete was poured.

History Inspection

What unique design details are present on this bridge?



Distinctive Details of Smith Bridge Company Trusses

Different builders had different styles. Architectural treatment on bridges, connection design on truss bridges, and even structure type (truss configuration, spandrel configuration) may be a characteristic of a builder or engineer.

History Inspection

Is the bridge in its original location, and/or has its function changed over time?

Clues like a substructure that appears newer than the superstructure might suggest the bridge has been relocated. A highway bridge that has design details of a railroad bridge may have once been a railroad bridge, etc.

1889 Truss On 1946 Concrete Pier

Identify Alterations

Rivets Replaced With Bolts

Bracing and connection replaced

Plate welded onto bridge.

Diagonals replaced

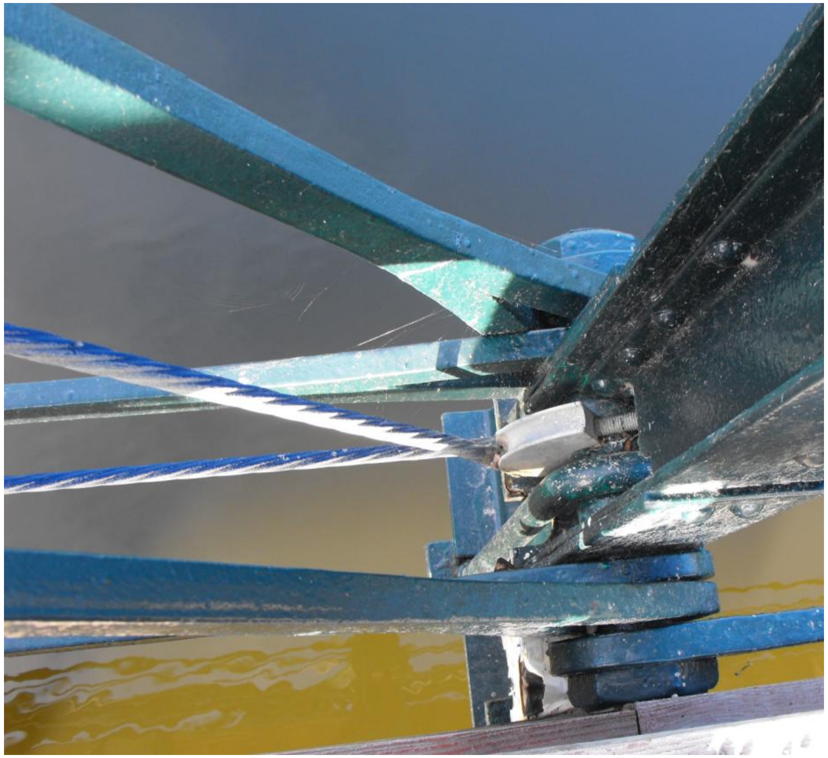
What original materials and designs on the bridge have been altered? When? Why?

Identify Alterations

Insensitive: One of the unique trussed floor beams was replaced with a rolled beam.

Are any alterations insensitive, reducing the historic integrity of the bridge?

Identify Alterations



Sensitive: Cable added to truss diagonal adds strength, but does not remove, alter, or obstruct the view of the original eye bars.

Are any alterations insensitive, reducing the historic integrity of the bridge?

Identify Alterations

Irreversible: The floorbeams have been replaced and the bottom chord has been welded to the verticals. The original connection assembly design and its materials has been lost and cannot be returned to its original design.

Are any insensitive alterations reversible, able to be removed as part of a restoration?

Identify Alterations

Are any insensitive alterations reversible, able to be removed as part of a restoration?

Reversible: The load-bearing stringers added under this bridge could be removed to return the bridge to its original appearance and design, because the original flooring system remains in place and was not removed.

History Inspection

Do any alterations to the bridge tell a story?

Addition of bracing outside truss lines

+

Removal of original knee bracing

=

Increased truck presence on route.

Look for welds, high-strength bolts etc. on old metal bridges (also cables on truss bridges), beams that do not match the rest of the bridge, patched concrete, etc. Try to deduce if these repairs were due to deterioration, change of function, flood damage, collision damage, etc.

History Inspection

Does the surrounding area (land, buildings, etc) tell us something about the bridge?

This bridge passes over a deep, fast-flowing hydroelectric canal, which accounts for why this unusual single span bridge was built instead of a multi-span bridge with a pier in the water.

Try to see if the geography influenced the bridge location and structure type. Ruins and/or extant structures near the bridge (mills, factories, etc) may also help determine the original purpose of the bridge.

History Inspection

Is this the first bridge at this location?

Current Bridge

Former Bridge Pier

It is not unusual to find ruins of a former substructure next to the bridge. Similarly, if a bridge's substructure appears older than the superstructure, it may have been reused for the current bridge, also indicating a previous bridge. In rare cases, remnants of a previous superstructure may have been left in the water or shore.

Historic Bridge Inspection and Assessment

Part 5: Preservation Inspection

Historic Bridge Inspection and Assessment

Part 5a:
Assess Current Use of Bridge

Preservation Inspection

Identify Current Bridge Users

- Is the bridge rural or urban?
- How much traffic does it carry?
- Does it carry truck traffic?
- Does it cross a navigable waterway or railroad, and if so, what type of traffic passes under the bridge?

Identify Current Bridge Restrictions

- If present, what is the posted weight limit and how many current and potential bridge users does this limit appear to affect?
- Is the width/lanes of the bridge appropriate given the current and potential bridge users?

Identify Current Bridge Clearance

- Overhead clearance on roadway.
- Vertical and horizontal clearance for boats on navigable waterways.

Are any a problem for current or potential bridge users? Look for impact damage on the bridge which may help to answer this question.

Identify Current Bridge Alignment


•Identify horizontal alignment issues (sharp curve in road to meet ends of bridge). Are they severe or minor?

•Identify vertical alignment issues (steep grade on or before bridge limiting view of oncoming traffic). Are they severe or minor?

Preservation Inspection

Identify Current Bridge Alternatives

Identify how far restricted traffic must detour to find an unrestricted bridge that they can cross to reach the same destination. Is the detour lengthy? Does it appear to affect a significant amount of traffic?

Identify Feasible Preservation Options

Based On Current Bridge Use

What preservation solutions are most feasible and appropriate for this bridge?

Is its current use acceptable?

What risks does the bridge face?

Historic Bridge Inspection and Assessment

Part 5b: Determine Feasible Preservation Alternatives

Identify Potential For Continued Use

Using all the data you compiled from the previous section along with logic and common sense, develop a sound argument for whether or not the bridge is feasible to preserve for continued current use.

Continued Use or Alternative Reuse?

If continued current use of the bridge appears impossible, or that drastic alterations to the original design of the bridges would be needed, then feasible alternative “reuse” preservation solutions should be chosen. Try to identify as many feasible alternatives as possible.

Common Continued Use Solutions

School Street Bridge, Hunterdon County, NJ was built in 1870 and has been well-maintained ever since.

Maintenance

There is no better cost-effective and user-convenient approach than by engaging in routine preventative maintenance and repairs as needed. Bridges should not be neglected until they deteriorate to the point where more drastic action is needed.

Common Continued Use Solutions

Rehabilitation

Bridges which have either had their routine maintenance deferred or have otherwise deteriorated should be designated for a comprehensive rehabilitation.

Common Alternative Reuse Solutions

Bypass and Preserve

Build a new bridge next to the existing bridge and preserve the existing bridge for non-motorized use. Effective for crossings for which the new bridge can be built on a new alignment with equal or improved alignment quality.

Common Alternative Reuse Solutions

One-Way Couplet

Build a new one-lane bridge next to the existing bridge and form a couplet of one-way bridges. Effective for situations where the primary concern is the one-lane (or narrow multi-lane) width of a historic bridge.

Preservation Inspection

Common Alternative Reuse Solutions

Relocate And Preserve For Use

Move the bridge to a new location such as a park or non-motorized trail for preservation. Effective for bridges that are in the way at their current location. Metal truss bridges, particularly those with pinned connections are easy to relocate.

Preservation Inspection

Common Alternative Reuse Solutions

Relocate For Exhibit

Relocate the bridge onto the ground, such as in a park, where it stands as a non-functional historic structure. Effective for situations where money, bridge condition, or location does not allow for relocating the bridge for a functional use.

Common Alternative Reuse Solutions

Build Another Bridge Someplace Else

Build a second bridge at an entirely new location to serve as the primary bridge and maintain the historic bridge for local/light traffic. Effective when space and money allows, and when a large percentage of traffic would favor the new bridge location.

Common Alternative Reuse Solutions

Abandon

Abandon the bridge and leave standing as a historic relic/ruin. Appropriate for situations where money is short. Bridge remains present for preservation if funds become available in the future.

Historic Bridge Inspection and Assessment

Part 6: Conclusions

Knowledge Is Power

In addition to identifying preservation solutions, the data gathered through this inspection enables preservationists to have an educated discussion/argument with the agencies who own the bridges on an equal footing of knowledge.

Knowledge Is Power

Preservationists are often cast aside by engineers since they often have a reputation for not understanding the problems a historic bridge has that may be barriers to preservation.

Knowledge Is Power

Engineers and highway agencies in contrast often are unaware of preservation alternatives and they also tend to focus on isolated bridge problems and ignore any evidence that the overall bridge is in good condition and functional.

Inspection Results

Knowledge Is Power

By conducting a Historic Bridge Inspection, preservationists come to the table with a more complete knowledge of both the positive and negative aspects of a historic bridge and can have well-formed and prepared arguments with solid evidence to back it up.