National Park Service
U.S. Department of the Interior

1201 Eye Street, NW, 10th Floor
Washington, DC 20005

Inspection Guidance: 2200 Trail Bridges

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INTRODUCTION

This document contains the inspection guidance for major trail bridges. The components associated with trail bridges should be inspected using the guidelines in this document.

Trails have many different bridge types ranging from footbridges and footlogs to sophisticated, engineered bridges. As a general rule, any "major" trail bridge should be classified as a separate trail bridge location record (2200 asset category) from the trail location record (2100 asset category) in the Facility Management Software System (FMSS). A trail bridge should be considered a location record (2200 asset category) in the FMSS if: (a) it has a span greater than 20 feet or a vertical distance greater than 5 feet in height (excluding footlogs, boardwalks, and similar trail structures); or (b) it is determined to have user safety concerns. Otherwise, a trail bridge should be classified as an asset record of the trail location record (2100 asset category). Trail bridge location assets should be inspected and assessed using the guidelines in this document. Trail bridges that do not fall into these categories should be considered "components" of a trail and should be inspected using "Inspection Guidance – Trails."

Any trail bridge condition inspection should include a complete visual inspection of all constructed architectural, civil/structural, and mechanical components. A field inspection should be performed using both a system and component inspection method to identify all maintenance and repair deficiencies that need correction. The inspector should determine if there is sufficient evidence to warrant complete replacement of a system versus repair of only specific components of that system (e.g., repairing damaged decking as opposed to replacing a large section of a deck).

A systematic approach to visual inspections must be employed to document all problems with a given trail bridge. Some deficiencies announce themselves, such as damaged rails or a failing deck. However, many deficiencies are more subtle and may require further examination. During an inspection, the inspector should thoroughly document the information that will be needed in the preparation of cost estimates and inspection reports. At a minimum, the following should be recorded for each deficiency:

- The trail bridge deficiency should be defined (e.g., rotted decking, damaged railing).
- The corrective action should be specified with the appropriate verb (e.g., build/add, repair, replace, realign, adjust, relocate, remove, reopen, maintain, monitor).
- Geographic data should be provided with global positioning system (GPS) reading coordinates and/or a wheeled distance from a recognizable trail bridge component, and, if possible, the geographical location should be marked on a map (e.g., 300 feet north, east, south, or west of a sign or crossing).

- Data should be quantified in sufficient detail to permit later development of budget level cost estimates using the appropriate unit of measure (e.g., 200 square feet of Type A bridge decking material, 100 square feet of sand blasting, or 7 each). It may also be useful to note whether on-site or imported materials will be used.
- The relative priority of the deficiency should be noted as high, medium, or low.
- Additional comments or notes should be included that will help to define the project needs or special circumstances to consider.

While this document lays out universal inspection guidance, it does not establish one standard for all major trail bridges. Trail bridges are constructed and maintained to different standards as defined by a park unit's management plan. These park-level standards must be considered when completing trail bridge assessments and should guide the corrective action (and costs) to address identified deficiencies.

When creating work orders based on the output of an assessment, please refer to the *Life-Cycle Business Practices, Volume 3* for lumping and splitting guidance.

Common Components and Critical Systems

Table 1 lists typical classifications used for the trail bridge asset category. Any classification in the FMSS can be used to categorize components of a trail bridge, but the table contains those most likely to be used.

Table 1. Trail Bridge Component List

Top-Level Classification	Classification	Critical System
Barrier/	Fence/Gate	No
Barrier/	Railing	No
Electrical/	Lighting	No
Furnishing/	Exterior Furnishing	No
Marking/	Sign	No
Structure/	Abutment	Yes
Structure/	Deck Structure	No
Structure/	Piling	Yes
Structure/	Platform	No
Structure/	Superstructure	Yes
Structure/	Walkable Structure	No
Structure/Access/	Stairs	No
Surface/	Land Surface	No
Surface/	Traffic Surface	Yes
Structure/	Wall	Yes
Water Control/	Culvert	Yes
Water Control/	Drain	Yes

COMPREHENSIVE CONDITION ASSESSMENTS

TIPS FOR INSPECTIONS

Parks should determine whether they have the expertise to conduct trail bridge inspections. Some bridges may be particularly complex or unique and may require a high level of knowledge to complete an adequate inspection. In contrast, other trail bridges can be inspected by park staff with in-house knowledge of bridge design, construction, and maintenance. If a bridge is beyond the capability or comfort level of a park to inspect, assistance should be sought. The Federal Highway Administration (FHWA) may be available to assist or contracted condition assessments may also be appropriate. Because the failure of a trail bridge could be catastrophic, it is important to ensure that inspections are being conducted by a qualified inspector.

If a park is conducting its own trail bridge inspection, it is recommended that the park package the trail bridge inspection with the inspection of the trail of which the trail bridge is a part.

Below is a short list of items that may be useful during a field inspection:

- Fully charged GPS unit for collecting point and line data
- Digital camera with a fully charged battery and spares
- Sufficient storage space on the GPS unit and camera memory cards
- Paper maps, paper, and a pencil/pen for field notes
- Compass and measuring tape and/or measuring wheel
- Previous inspection information or a list of current work orders for that section of trail
- Necessary hiking gear.

COMPONENT INSPECTION GUIDANCE

Barrier & Fencing

Railing

Bridge Railings and Parapets

The bridge railing or parapet is a fence-like construction built at the outer most edge of the bridge. The primary function of the bridge railing or parapet is safety: to keep errant vehicles from driving off the edge of the bridge and to guard and guide the movement of pedestrian traffic. Bridge railing must also smoothly redirect the vehicle in such a manner that the vehicle does not overturn and the railing does not fail.

Older steel or timber bridge railings consisted of timber planks nailed together in a picket fence-like arrangement. More recently, railings are made of steel angles, welded steel tubing, or "W" shape rails supported by a wide flange post, replacing the timber

railing. Solid concrete parapets with steel or aluminum railings attached to the top are also commonly used today.

Checks to be made:

1. Timber railing and post:
   - Weathering:
     - Surface of wood is rough and corrugated and member may be warped
     - Surface of wood is rough and corrugated with cracks partially through the wood member, may have minor section loss
     - Warped member, large cracks extend deeply or completely through the wood, wood is crumbly and seriously deteriorated
   - Decay (decay from rot/fungus is most likely to occur at connections, splices, support points or around bolt holes – this may be due either to the tendency of such areas to collect and retain moisture or to bolt holes or cuts being made in the surface after the preservative treatment has been applied):
     - Moist and stained or discolored area, signs of fungi, surface is solid
     - Surface spongy, member may show signs of crushing
     - Brown and white discolored area, member may show section loss and crushing
   - Parasites (termites, carpenter ants, powder post beetles):
     - Pinholes with dark stain area around the holes
     - Holes, surface sag, and sawdust observed
     - Surface channels and crushing of the member
   - Post connections:
     - Loose fasteners
     - Broken, split, or damaged
     - Missing fasteners or anchorage
   - Corrosion at post anchors:
     - Surface rust, no pitting evident
     - Corrosion evident, pitting and blistering of base material
     - Corrosion evident with loss to base section
   - Vehicular damage:
     - Railing out of alignment
     - Post out of alignment
     - Railing shattered or damaged
     - Post shattered or damaged member
   - Vertical joint displacement due to substructure or bearing settlement
   - Horizontal joint misalignment due to substructure or bearing settlement
2. Concrete parapets:
   - Cracks and spalling:
     - Cracks

  - Staining of concrete surface with signs of efflorescence deposit and spalling of cracks
  - Reinforcing bars exposed
- Scaling and popouts:
  - Loss of mortar
  - Exposed aggregate
  - Reinforcing bars exposed
- Vehicular damage:
  - Member out of alignment
  - Shattered or major damage to member
- Vertical joint displacement due to substructure or bearing settlement
- Horizontal joint misalignment due to substructure or bearing settlement

3. Steel railing and post:

- Corrosion railing or post:
  - Surface rust, no pitting evident
  - Corrosion evident, pitting and blistering of base material
  - Corrosion evident with loss to base section
- Post connections:
  - Loose bolts or fasteners
  - Broken or missing bolts
- Rail connections:
  - Loose bolts or fasteners
  - Broken or missing bolts
- Corrosion at post anchors:
  - Surface rust, no pitting evident
  - Corrosion evident, pitting and blistering of base material
  - Corrosion evident with loss to base section
- Vehicular damage:
  - Railing out of alignment
  - Post out of alignment
  - Post broken or missing
  - Railing broken or missing
- Vertical joint displacement due to substructure or bearing settlement
- Horizontal joint misalignment due to substructure or bearing settlement.

Signage & Marking

Sign

Signs are displayed to convey information. Four basic types of signs are common to NPS trails and trail bridges: identification signs, directional signs, information/education signs, and regulatory signs. Signs differ in purpose and size (e.g., small directional metal sign versus kiosk/bulletin board with a roof), and signs may be made of acrylic, aluminum, concrete, fiberglass embedment, fiberglass, glass, high-

pressure laminate, laminate, masonry/stone, metal, plastic, recycled plastic, steel, timber, and/or wood.

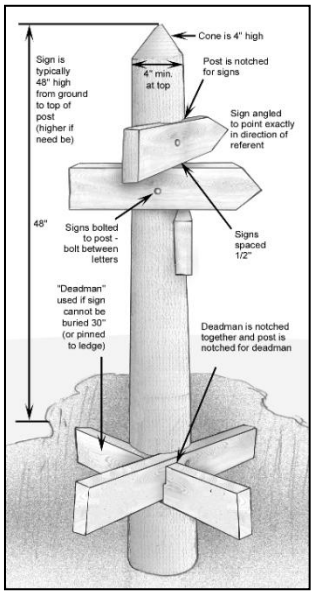

Figure 1. Timber Sign (© Acadia National Park)

Checks to be made:

1. Signage:
   - Missing sign resulting in noticeable damage, such as inappropriate social trails or resource damage
   - Signs contain incorrect information
2. Kiosk/bulletin boards:
   - Warped, rotting, or loose shingles on kiosk roof
   - Ultraviolet damage to Lexan/plexiglass case, cracked or checked
   - Kiosk/bulletin board contains incorrect information
3. Signage (wood):
   - Loose, damaged, illegible, or missing sign face:
     - Loose sign face
     - Damaged sign face
     - Illegible sign face
     - Missing sign face
   - Splits/cracks/broken posts:
     - Surface fibers separated, less than 25 percent of thickness affected
     - Surface fibers separated, greater than 25 percent of thickness affected
     - Physically damaged and broken
   - Rot, fungus or decay of posts:
     - Moist stained area
     - Discolored, soft or crushed area

- Parasite damage of posts:
  - Holes less than ⅛ inch, surface, sag, and frays observed
  - Large holes greater than ⅛ inch , surface channels, punctures, and crushing
- Out of level:
  - Less than or equal to 3 inches in 4 feet
  - More than 3 inches in 4 feet
- Out of plumb:
  - Less than or equal to 3 inches in 8 feet
  - More than 3 inches in 8 feet
- Erosion/vegetation:
  - Soil erosion around posts
  - Vines, trees, or shrubs climbing over or obscuring sign
- Decaying or leaning trees (if sign is mounted to tree)

4. Signage (metal):

- Loose, damaged, illegible, or missing sign face:
  - Loose sign face
  - Damaged sign face
  - Illegible sign face
  - Missing sign face
- Out of level:
  - Less than or equal to 3 inches in 4 feet
  - More than 3 inches in 4 feet
- Out of plumb:
  - Less than or equal to 3 inches in 8 feet
  - More than 3 inches in 8 feet
- Corrosion of posts:
  - Surface corrosion, no pitting evident
  - Corrosion evidenced by pitting or blistering
  - Rust/corrosion evidenced loss of base metal
- Erosion/vegetation:
  - Soil erosion around posts
  - Vines, trees, or shrubs climbing over or obscuring sign

5. Signage (concrete):

- Loose, damaged, illegible, or missing sign face:
  - Loose sign face
  - Damaged sign face
  - Illegible sign face
  - Missing sign face
- Cracking:
  - Hairline crack
  - Medium cracks $^{1}/_{16}$ inch wide

  - Wide cracks more than $^{1}/_{16}$ inch wide
  - Disintegration of concrete surfaces, with loss of surface exceeding depth of 2 inches
- Spalling:
  - Less than 1 inch deep or 6 inches in diameter
  - More than 1 inch in depth or greater than 6 inches in diameter, or loss of more than 10 percent of surface area of a member
  - Disintegration of surface area, with corrosion of exposed reinforcing steel
- Scaling:
  - Loss of surface up to ½ inch deep, with exposure of coarse aggregates
  - Loss of surface from ½ inch to 1 inch deep with coarse aggregates clearly exposed
  - Loss of surface exceeds 1 inch, reinforcing steel usually exposed
- Reinforcing steel corrosion: rusting/discoloration evident, cracks occurring parallel to reinforcement
- Out of level:
  - Less than or equal to 3 inches in 4 feet
  - More than 3 inches in 4 feet
- Out of plumb:
  - Less than or equal to 3 inches in 8 feet
  - More than 3 inches in 8 feet
- Erosion/vegetation:
  - Soil erosion around posts
  - Vines, trees, or shrubs climbing over or obscuring sign

6. Signage (masonry/stone):

- Loose, damaged, illegible, or missing sign face:
  - Loose sign face
  - Damaged sign face
  - Illegible sign face
  - Missing sign face
- Deteriorated mortar joint material:
  - Cracked mortar joint material
  - Loose/missing mortar joint material
- Out of level:
  - Less than or equal to 2 inches in 8 feet
  - More than 2 inches in 8 feet
- Out of plumb:
  - Less than or equal to 3 inches in 8 feet
  - More than 3 inches in 8 feet
- Damage bricks, stones, or concrete masonry unit (CMU):
  - Cracked, split, damaged
  - Loose, missing

- Erosion/vegetation:
  - Soil erosion around sign footing
  - Vines, trees, or shrubs climbing over or obscuring sign

Structure

Abutment

Bridge Abutment

An abutment is a substructure unit located at the end of a bridge. Its function is to provide end support for the bridge and to retain the approach embankment. Abutments are classified according to their location with respect to the approach embankment. The most common abutment types are the full height/closed type and open/spill-through type. The primary material used in the construction are plain cement concrete, reinforced concrete, stone masonry, timber, or a combination of these materials. Plain concrete and stone masonry abutments are usually gravity structures while reinforced concrete abutments are mostly cantilever or counter fort types.

Checks to be made:

1. Concrete:

- Drains or weep holes:
  - Drains and weep hole clogged
  - Signs of water stain on the face of abutment around cracks
  - Visible signs of water seeping through cracks or joints in the abutment
- Erosion or scouring at abutment or wingwalls:
  - Voids
  - Undermining of abutment
- Cracks and spalling:
  - Cracks
  - Staining of concrete surface with signs of efflorescence deposit and spalling of cracks
  - Reinforcing bars exposed
- Scaling and popouts:
  - Loss of mortar
  - Exposed aggregate
  - Reinforcing bars exposed
- Backwall and wingwall joints: Joint separation or movement
- Rotational movement (some abutments are constructed with battered or slope front face):
  - Abutment walls rotated inward or outward

    - Wingwalls rotated inward or outward
- Breast wall bearing seat (critical where beam bears directly on the abutment wall):
    - Light spalling and chipping of concrete
    - Dirt and debris accumulated on bearing seat
    - Spalling or cracking of concrete at edge of seat
    - Severe spalling and cracking with crushing of concrete and exposed reinforcing bars
- Collision damage:
    - Member out of alignment
    - Member cracked, crushed, or missing

2. Masonry:

- Drains or weep holes:
    - Drains and weep hole clogged
    - Signs of water stain on the face of abutment around cracks
    - Visible signs of water seeping through cracks or joints in the abutment
- Erosion or scouring at abutment or wingwalls:
    - Voids
    - Undermining of abutment
- Mortar joint:
    - Mortar joint cracked with no voids and masonry stone sound
    - Mortar joint deteriorated with voids with vegetation growing from joint and/or stone loose
    - Mortar joint totally deteriorated and/or masonry stone missing
- Masonry stone deterioration:
    - Masonry stone has minor spalling and hairline cracks
    - Masonry stone has spalling with cracks and chipping and/or stone loose
    - Masonry stone has spalling with large cracks and chipping and section loss greater than 15 percent
- Backwall and wingwall joints: joint separation or movement
- Rotational movement (some abutments are constructed with battered or slope front face):
    - Abutment walls rotated inward or outward
    - Wingwalls rotated inward or outward with visible slumping or bulging of wall face
- Breast wall bearing seat (critical where beam bears directly on the abutment wall):
    - Light spalling and chipping of concrete
    - Dirt and debris accumulated on bearing seat
    - Spalling or cracking of concrete at edge of seat

    - Severe spalling and cracking with crushing of concrete and exposed reinforcing bars
- Collision damage:
    - Member out of alignment
    - Member cracked, crushed, or missing

3. Timber:

- Erosion or scouring at abutment or wingwalls:
    - Voids
    - Undermining of abutment
- Decay at breast/wingwalls (decay from rot/fungus is most likely to occur at connections, splices, support points, or around bolt holes – this may be due either to the tendency of such area to collect and retain moisture or to bolt holes or cuts being made in the surface after the preservative treatment has been applied):
    - Moist and stain on discolored area with signs of fungi and surface is solid
    - Surface spongy and member may shown signs of crushing
    - Brown and white in discolored area and member may show section loss and crushing
- Parasites at breast/wingwalls and pile lagging (termites, carpenter ants, powder post beetles):
    - Pinholes with dark stain area around the holes
    - Holes with surface sag and sawdust observed
    - Surface channels and crushing of the member
- Weathering:
    - Surface of wood is rough and corrugated and member may be warped
    - Surface of wood is rough and corrugated with cracks partially through the wood member and may have minor section loss
    - Member may be warped, large cracks extend deeply or completely through the wood, wood is crumbly and seriously deteriorated
- Rotational movement (some abutments are constructed with battered or slope front face):
    - Abutment walls rotated inward or outward
    - Wingwalls rotated inward or outward
- Bearing seat:
    - Moist and stained area, surface solid
    - Dirt and debris accumulated on bearing seat
    - Moist and stained area, surface soft with slight crushing
    - Area soft and crumbly and seriously deteriorated
- Collision damage:
    - Member out of alignment
    - Member cracked, crushed, or missing

Piling

Bridge Piles

Piles are substructure elements of a bridge that transmit the loads from the superstructure and/or footing to the underlying soil or rock. Piles are generally completely buried, and therefore cannot be visually inspected. Piles that are exposed are used as intermediate supports for a bridge when multiple spans are required and are referred to as pile bents. Pile bents are transverse structural frames composed of piles and a pile cap. Piles are constructed of reinforced concrete or timber and steel.

Checks to be made:

1. Concrete:
   - Concrete disintegration (inspect waterline, splash zone, and ground line areas):
     - Hollow spaces or voids present
     - Concrete aggregate exposed or missing
     - Exposed reinforcing bars
   - Cracks and spalling:
     - Cracks
     - Staining of concrete surface with signs of efflorescence deposit and spalling of cracks
     - Reinforcing bars exposed
   - Scaling and popouts:
     - Loss of mortar
     - Exposed aggregate
     - Reinforcing bars exposed
   - Bearing seat:
     - Light spalling and chipping of concrete
     - Dirt and debris accumulated on bearing seat
     - Spalling, cracking of concrete at edge of seat
     - Severe spalling and cracking with crushing of concrete and exposed reinforcing bars
   - Collision damage:
     - Member out of alignment
     - Member cracked, crushed, or missing
2. Timber:
   - Deep abrasions or excessive wear:
     - Inspect waterline, splash zone, and ground line areas
     - Measure diameter loss
   - Splits in piles, pile cap:
     - Partial split in member
     - Split completely through member

    - Member split and failed
- Decay (decay from rot/fungus is most likely to occur at connections, splices, support points, or around bolt holes – this may be due either to the tendency of such areas to collect and retain moisture or to bolt holes or cuts being made in the surface after the preservative treatment has been applied):
    - Moist and stained or discolored area, signs of fungi, surface is solid
    - Surface spongy, member may shown signs of crushing
    - Brown and white discolored area, member may show section loss and crushing
- Parasites:
    - Pinholes with dark stain area around the holes
    - Holes, surface sag, and sawdust observed
    - Surface channels and crushing of the member
- Pile cap bearing seat:
    - Moist and stained, surface solid
    - Dirt and debris accumulated on bearing seat
    - Moist and stained, surface soft, slight crushing
    - Area soft and crumbly and seriously deteriorated
- Connections:
    - Loose fasteners
    - member broken, split or damaged
    - Missing fastener or anchors
- Collision damage:
    - Member out-of-alignment
    - Member cracked, crushed, or missing

3. Steel:

- Piles and pile cap corrosion:
    - Surface rust, no pitting evident
    - Corrosion evident pitting and blistering of base material
    - Corrosion evident with loss to base section
- Straightness or buckling in the pile:
    - Sign of wrinkles in pile web or flanges
    - Pile buckling
- Fungi damage or marine growth:
    - Inspect waterline, splash zone, and ground line areas
    - Measure diameter loss
- Cracks in the pile cap, piles, and bracing:
    - Hairline or greater crack, fillet of flanges
    - Hairline or greater crack, fillet of web
- Connectors or fasteners:
    - Loose bolts or fasteners
    - Missing fasteners or connectors

  - Crack in weld
  - Crack in connection plate
- Collision damage:
  - Pile out of alignment
  - Pile missing

Superstructure

The superstructure is designed to carry dead and live loads associated with the structural deck to the substructure (abutments or piers). The superstructure includes as primary members a floor system with two or more main supporting members, secondary members (bracing diaphragms or cross frames), connections, and bearings.

The floor system supports the deck or wear surface, and may consist of either closely spaced transverse floor beams or several longitudinal stringers carried by transverse floor beams. In floor systems of the latter type, stringers are usually wide flange beams, and the floor beams may be plate girders, wide flange beams, or trusses. When floor beams only are used, they may be rolled or plate girders.

The main supporting members may be steel, timber or concrete beams; steel plate girders, steel or timber trusses; steel or concrete rigid frames. Beams and girders are considered single elements while trusses have several identifiable parts: the chords, which are generally longitudinal members at the top and bottom of a truss, and the verticals and diagonals which are called web members.

Secondary members for beams and girder structures are bracing which include diaphragms and cross frames. Trusses are braced with portal cross frames, and sway bracing. Diaphragms and cross frames stabilize the beams or trusses and distribute loads between them. A diaphragm is usually a solid web member, either a rolled shape or built-up member, while a cross frame is a truss panel or frame.

The beams, girders, stringers, trusses and other members which form a complete bridge superstructure are designed to support certain loads. Each of these members must transmit its load through connections to supporting members. As a means to transmit this load, fasteners such as bolts or welds are used with connection material, made of angles, plates, or pieces of rolled sections.

Bearings transmit and distribute the superstructure loads to the substructure, and they permit the superstructure to undergo necessary movement without developing harmful overstresses.

Checks to be made:

1. Timber primary and secondary members:
   - Beam end at supports:

    - Moist and stained, surface solid
    - Moist and stained, surface soft, beam has slight crushing
    - Area soft and crumbly and seriously deteriorated
- Decay (decay from rot/fungus is most likely to occur at connections, splices, support points, or around bolt holes - this may be due either to the tendency of such areas to collect and retain moisture, or to bolt holes or cuts being made in the surface after the preservative treatment has been applied):
    - Moist and stained or discolored area, signs of fungi, surface is solid
    - Surface spongy, member may shown signs of crushing
    - Brown and white discolored area, member may show section loss and crushing
- Parasites (termites, carpenter ants, powder post beetles):
    - Pinholes with dark stain area around the holes
    - Holes, surface sag, and sawdust observed
    - Surface channels, and crushing of the member
- Horizontal splits:
    - Partial splits in member
    - Split completely through member
    - Member split and completely failed
- Vehicular damage of primary and secondary members:
    - Member out of alignment
    - Member split or broken at cracks
- Deflection (observed deflection of members with passing traffic):
    - Slight deflection in member
    - Noticeable deflection in member
    - Permanent sagging or deflection in member
- Straightness:
    - Slight bowing in member
    - Noticeable bowing in member
    - Excessive bowing in member

2. Concrete primary and secondary members:

- Beam end at supports:
    - Light spalling and chipping of concrete
    - Spalling and cracks of beam
    - Spalling, cracks and crushing at end of beam
- Honeycombing:
    - Hollow spaces or voids present within concrete, aggregate partially exposed, concrete is sound around damaged area
    - Hollow spaces or voids present with concrete with exposed aggregate, concrete is sound around defected area
    - Hollow spaces or voids present within concrete with exposed reinforcing bars

- Cracks and spalling:
  - Cracks
  - Staining of concrete surface with signs of efflorescence deposit and spalling of cracks
  - Reinforcing bars exposed
- Scaling and popouts:
  - Loss of mortar
  - Exposed aggregate
  - Reinforcing bars exposed
- Vehicular damage:
  - Member out-of-alignment
  - Member cracked with section loss
- Deflection:
  - Slight deflection in member
  - Noticeable deflection in member
  - Permanent sagging or deflection in member

3. Steel primary and secondary members:

- Corrosion of top and bottom flange:
  - Surface rust no pitting evident
  - Corrosion evident pitting and blistering of base material
  - Corrosion evident with loss to base section
- Corrosion of web plate:
  - Surface rust no pitting evident
  - Corrosion evident pitting and blistering of base material
  - Corrosion evident with loss to base section
- Cracks:
  - Hairline or greater crack, fillet of top flange
  - Hairline or greater crack, fillet of bottom flange
  - Hairline or greater vertical crack, in web of beam
- Cracks in attachment welds (check all vertical and longitudinal stiffener welds or cracks): hairline or greater crack at toe of weld or adjacent metal
- Straightness or buckling:
  - Sign of wrinkles in web and or stiffener plate at support
  - Sign of wrinkles in flange
  - Sign of buckling in web and or stiffener plate at support
  - Sign of buckling in flange
- Support ends:
  - Slight wrinkles in web or flanges
  - Sign of buckling in web or flanges
- Vehicular damage:
  - Primary member out of alignment
  - Secondary member out-of-alignment

4. Connections:
- Corrosion of gussets or connection plates:
  - Surface rust, no pitting evident
  - Corrosion evident, pitting and blistering of base material
  - Corrosion evident with loss to base section
- Corrosion of bolts or welds:
  - Surface rust, no pitting evident
  - Corrosion evident, pitting and blistering of base material
  - Corrosion evident with loss to base section
- Connectors or fasteners:
  - Loose bolts or fasteners
  - Missing fasteners or connectors
  - Crack in weld
  - Crack in connection plate

5. Bearings:
- Metal bearing (expansion or fixed bearing):
  - Surface rust no evidence of pitting, expansion bearing free to rotate
  - Dirt and debris accumulated around base of bearing
  - corrosion pitting and blistering of base metal, expansion bearing free to rotate
  - Corrosion with loss to base section, expansion bearing frozen
  - Excess rotation of expansion bearing
  - Loss of bearing area due to lateral or longitudinal movement
- Elastomeric bearing:
  - Bulging of the bearing
  - Splitting or tearing of the bearing, including interior steel shims bond
  - Bond to the sole and or masonry plate failed
  - Excess longitudinal movement
- Excess rotation movement: loss of bearing area due to lateral or longitudinal movement
- Pin and link bearing:
  - Surface rust no pitting evident, joint free to rotate
  - Corrosion evident pitting and blistering of base material
  - Corrosion evident with loss to base section, joint frozen
- Corrosion of sole and masonry plates:
  - Surface rust no pitting evident
  - Corrosion evident pitting and blistering of base material
  - Corrosion evident with loss to base section
- Anchor bolts:
  - Surface rust no pitting evident
  - Loose anchor bolts, nuts or bearing
  - Corrosion evident pitting and blistering of base material

- Corrosion evident with loss to base section
- Missing or broken anchor bolts

Deck Structure

Decking

The primary function of a bridge deck is to provide a walkway over or through the superstructure which traffic can move and distribute the live and dead loads to the superstructure. There are three common materials used: timber, concrete, and steel. The specific structural function of a deck is determined by whether the deck is composite or non-composite.

A composite deck is designed to join together the deck and supporting members such that they structurally behave as one member. A composite deck spans between its supports but also functions to increase the superstructure strength and allowable span length. Composite decks are often used in bridge designs, the most common application being the attachment of a deck to steel beams or girders.

A non-composite deck does not contribute to the structural capacity of the supporting members. A non-composite deck only functions to span between supporting members and to provide a wearing surface for traffic.

Curb barriers which parallel the side limits of the bridge deck guide the movement of vehicle wheels and safeguard bridge trusses, railing or other construction existing outside the roadway limit. For trail bridges these are often call bulrails or kickrails. These often protect handroal posts and help to direct horses across the bridge.Pedestrian traffic on sidewalks are also protected from collision with vehicular traffic.

Some bridge decks provide deck area to serve pedestrian traffic only and, for safety and convenience to its users, these walkways are commonly elevated above the deck portion used by vehicles. In these cases, the bridge should be classified as a road bridge (1700) as the primary asset type.

Checks to be made:

General note: when two or three levels of severity exist within one distressed area and can be easily distinguished from each other, they should be measured and recorded separately. However, if the different levels of severity cannot be easily divided, the entire area should be rated at the highest severity level present.

1. Asphaltic wearing surface:
   - Alligator or fatigue cracking:

  - Longitudinal disconnected hairline cracks running parallel to each other, but the cracks are not spalled. Initially there may only be a single crack in the wheel or traffic path.
  - Further development of low severity alligator cracking into a pattern of pieces formed by cracks that may be lightly surface-spalled.
  - Medium alligator cracking has progressed so that pieces are more severely spalled at the edges and loosened until the cells rock under traffic. Pumping may also exist.
- Asphalt bleeding:
  - Bleeding has only occurred to a very slight degree and it is noticeable only during a few days a year. Asphalt does not stick to shoes or vehicles.
  - Bleeding has occurred to the extent that asphalt sticks to shoes and vehicles during only a few weeks of the year.
  - Bleeding has occurred extensively and considerable asphalt sticks to shoes and vehicles during at least several weeks of the year.
- Block cracking:
  - Blocks are defined by non-sealed cracks that are non-spalled (sides of the crack are vertical) or only minor spalling with a ¼-inch or less mean width.
  - Blocks are defined by sealed cracks that have a sealant in satisfactory condition to prevent moisture infiltration.
  - Blocks are defined by sealed or non-sealed cracks that are moderately spalled.
  - Blocks are defined by non-sealed cracks that are not spalled or have only minor spalling, but have a mean width greater than approximately 1/4-inch.
  - Blocks are defined by sealed cracks that are not spalled or have only minor spalling, but have sealant in unsatisfactory condition to prevent moisture infiltration.
  - Blocks are well defined by cracks that are severely spalled.
- Edge cracking:
  - Low or medium severity cracking with no breakup or raveling
  - Medium severity cracks with some breakup or raveling
  - Considerable breakup or raveling along the edge, broken pieces may be removable
- Longitudinal and transverse cracking:
  - Non-sealed cracks have either minor spalling or no spalling, and the cracks have a mean width of ¼-inch or less.
  - Sealed cracks have either minor spalling or no spalling. Cracks are of any width, but their sealant material is in satisfactory condition to substantially prevent water infiltration.
  - No significant bump occurs when traffic crosses the crack.

  - Cracks are moderately spalled and can be either sealed or non-sealed of any width.
  - Sealed cracks are not spalled or have only minor spalling, but the sealant is in a condition so that water can freely infiltrate.
  - Non-sealed cracks are not spalled or are only lightly spalled, but the mean crack width is greater than 1/4-inch.
  - Low-severity random cracking exists near the crack or at the corners of intersecting cracks.
  - The crack causes a significant bump to traffic.
  - Cracks are severely spalled and/or there exists medium or high random cracking near the crack or at the corners of intersecting cracks.
  - The crack causes a severe bump to traffic.
- Patch deterioration:
  - Patch is in very good condition and is performing satisfactorily.
  - Patch is somewhat deteriorated, having low to medium levels of any types of distress.
  - The patch causes a significant bump to traffic.
  - Patch is badly deteriorated and needs replacement soon.
  - The patch causes a severe bump to traffic.
- Polished aggregate:
  - The existence of polishing can be detected by both visually observing and running the fingers over the surface.
  - Aggregate extending above the pavement is negligible, and the surface aggregate is smooth to the touch.
  - Pavement surface is smooth and has a distinctive dull finish.
  - Pavement surface appears highly smooth and the aggregate is highly polished.
- Damaged decking:
  - Damaged decking area up to 3 square feet and depth less than 1 inch.
  - Damaged decking area up to 3 square feet and depth between 1 and 2 inches.
  - Damaged decking area more than 3 square feet and depth less than 1 inch.
  - Damaged decking area less than 1 square feet and depth more than 2 inches.
  - Damaged decking area between 1 and 3 square feet and depth more than 2 inches.
- Reflection cracking:
  - Cracks have either minor spalling or no spalling. Non-sealed cracks have a mean width of ¼-inch or less.
  - Cracks have either minor spalling or no spalling. Cracks are sealed and of any width, and their sealant material is in satisfactory condition to substantially prevent water infiltration.
  - No significant bump occurs when traffic crosses the crack.

  - Cracks are moderately spalled and can be either sealed or non-sealed of any width.
  - Sealed cracks are not spalled or have only minor spalling, but the sealant is in a condition so that water can freely infiltrate.
  - Non-sealed cracks are not spalled or are only lightly spalled, but the mean crack width is greater than ¼-inch.
  - Low-severity random cracking exists near the crack or at the corners of intersecting cracks.
  - The crack causes a significant bump to traffic.
  - Cracks are severely spalled and/or there exists medium or high random cracking near the crack or at the corners of intersecting cracks.
  - The crack causes a severe bump to traffic.
- Rutting (rutting severity is determined by the mean depth of the rut. To determine the mean depth, a 4-foot straight edge should be laid across the rut and the maximum depth measured. The mean depth should be computed from measurements taken every 20 feet along the length of the rut):
  - Mean rut depth criteria:
    - ¼ - ½ inch
    - Between ½ - 1 inch
    - Greater than 1 inch

2. Timber:

- Weathering and wear:
  - Surface of wood is rough and corrugated and member may be warped
  - Surface of wood is rough and corrugated with cracks partially through the wood member, may have minor section loss to the top surface
  - Warped members, large cracks extend deeply or completely through the wood, wood is crumbly and seriously deteriorated
- Deflection:
  - Slight deflection of member when traffic passes
  - Noticeable deflection of member when traffic passes
  - Large deflection of member when traffic passes
  - Permanent deformation of member
- Vibration per span:
  - Slight vibration in deck when traffic passes
  - Noticeable vibration in deck when traffic passes
  - Excessive vibration in deck when traffic passes
- Vehicular damage:
  - Member out of alignment
  - Shattered or injured timber member
- Decay (decay from rot/fungus is most likely to occur at connections, splices, support points or around bolt holes - this may be due either to the tendency of such areas to collect and retain moisture, or to bolt holes or cuts being made in the surface after the preservative treatment has been applied):

    - Moist and stain or discolored area signs of fungi, surface is solid
    - Surface spongy, member may show signs of crushing
    - Brown and white discolored area, member may show section loss and crushing
- Connections:
    - Loose fasteners
    - Member broken, split or damaged
    - Missing fasteners or anchorage
- Parasites (termites, carpenter ants, powder post beetles):
    - Pinholes with dark stain area around the holes
    - Holes, surface sag, and sawdust observed
    - Surface channels, and crushing of the member
- Deck missing: hole in deck

3. Concrete:

- Wear and abrasion (top surface):
    - Slight or noticeable dull finish to concrete surface
    - Distinctive dull finish to concrete surface
    - Glossy mirror finished to concrete surface
- Cracks (top surface):
    - Hairline cracks less than 1/16" wide
    - Medium cracks greater than 1/16", less than 1/8" wide with spalling of cracks
    - Wide cracks greater than 1/8" wide with spalling of cracks and reinforcing bars exposed
- Cracks (underside):
    - Hairline cracks less than 1/16" wide, slight staining of concrete surface
    - Medium cracks greater than 1/16" less than 1/8" wide
    - Staining of concrete surface with sign of efflorescence deposits and spalling of crack
    - Wide cracks greater than 1/8" wide
    - Staining of concrete surface with efflorescence deposits, spalling of crack and reinforcing bars exposed
- Scaling, spalling and popouts:
    - Loss of mortar; exposed aggregate
    - Reinforcing bars exposed
- Honeycombing:
    - Hollow spaces or voids present within concrete, aggregate partially exposed, concrete is sound around damaged area
    - Hollow spaces or voids present with concrete with exposed aggregate, concrete is sound around defected area
    - Hollow spaces or voids present within concrete with exposed reinforcing bars

- Vibration - per span:
  - Slight vibration in deck when traffic passes
  - Noticeable vibration in deck when traffic passes
  - Excessive vibration in deck when traffic passes
- Deck missing: hole in deck

4. Steel:
- Wear (no wearing surface):
  - Minor wear to the serrated bars or steel plate
  - Noticeable wear to the serrated bars or plate, surface slippery
- Connections:
  - Loose bolts or fasteners
  - Broken or missing bolts, rivets
  - Broken welds
- Corrosion on grid rails or corrugated steel flooring:
  - Surface rust, no pitting evident
  - Corrosion evident, pitting and blistering of base material
  - Corrosion evident with loss to base section
- Damage grid rail and/or transverse bars:
  - Out of alignment or damaged member; grid rail cracked
  - Broken or missing member
- Vibration per span:
  - Slight vibration in deck when traffic passes
  - Noticeable vibration in deck when traffic passes
  - Excessive vibration in deck when traffic passes

5. Expansion joints:
- Joint displacement: measure joint displacement
- Joint horizontal clearance (the proper joint opening size depends on the season, the type of expansion joint, the temperature range, and the length of the slab whose expansion the joint must accommodate):
  - Joint opening less than 3"
  - Joint completely closed
  - Joint opening greater than 4"
- Finger plate:
  - Loose finger plate
  - Jammed fingers
  - Fingers do not lap
  - Broken or cracked joint finger
  - Broken fasteners or welds
- Corrosion, expansion or armor plates:
  - Surface rust, no pitting evident
  - Corrosion evident, pitting and blistering of base material
  - Corrosion evident with loss to base section

- Joint seal damage:
  - Examine joint sealant condition
  - Water and/or incompressible material infiltrate through the joint
- Sliding plate:
  - Loose sliding plates or anchor
  - Jammed slide plate
  - Bent or cracked sliding plate
  - Broken fasteners or welds
- Indiscriminate overlay: new pavement or wearing surface over existing deck joint

Piers

A pier is an intermediate substructure unit located between the ends of a bridge. Its function is to support the superstructure at intermediate intervals with minimal obstruction to the flow of traffic or water. The most common pier types are solid shaft, columns, columns with web wall, and cantilever. The primary material used in pier constructions are plain cement concrete, reinforced concrete, stone masonry, timber, steel, or a combination of these materials.

Checks to be made:

1. Timber:

- Pier cap bearing seat:
  - Moist and stained, surface solid
  - Dirt and debris accumulated on bearing seat
  - Moist and stained, surface soft, slight crushing
  - Area soft and crumbly and seriously deteriorated
- Splits in the cap, columns, and bracing:
  - Partial split in member
  - Split completely through member
  - Member split and failed
- Decay in the pier cap, columns and joints (decay from rot/fungus is most likely to occur at connections, splices, and support points, or around bolt holes – this may be due either to the tendency of such areas to collect and retain moisture or to bolt holes or cuts being made in the surface after the preservative treatment has been applied):
  - Moist and stained or discolored area, signs of fungi, surface is solid
  - Surface spongy, member may shown signs of crushing
  - Brown and white discolored area, member may show section loss and crushing
- Weathering of cap, columns, and bracing:
  - Surface of wood is rough and corrugated and member may be warped

    - Surface of wood is rough and corrugated with cracks partially through the wood member, may have minor section loss
    - Warped member
    - Large cracks extend deeply or completely through the wood
    - Wood is crumbly and seriously deteriorated
- Parasites in pier cap, columns and bracing (termites, carpenter ants, powder post beetles):
    - Pinholes with dark stain area around the holes
    - Holes, surface sag, and sawdust observed
    - Surface channels and crushing of the member
- Connections:
    - Loose fasteners
    - Member broken, split, or damaged
    - Missing fastener or anchors
- Collision damage:
    - Member out of alignment
    - Member cracked, crushed, or missing
- Scouring or erosion at base of footing:
    - Voids
    - Undermining of footing
- Deflection of pier cap:
    - Slight deflection of member when traffic passes
    - Noticeable deflection of member when traffic passes
    - Large deflection of member when traffic passes
    - Permanent deformation in member
- Rotational movement: pier rotated or tipping

2. Concrete:

- Concrete disintegration (inspect waterline, splash zone, and ground line areas):
    - Hollow spaces or voids present
    - Concrete aggregate exposed or missing
    - Exposed reinforcing bars
- Erosion or scouring at base of pier:
    - Voids
    - Undermining of base
- Honeycombing:
    - Hollow spaces or voids present within concrete, aggregate partially exposed, concrete is sound around damaged area
    - Hollow spaces or voids present with concrete with exposed aggregate, concrete is sound around affected area
    - Hollow spaces or voids present within concrete with exposed reinforcing bars
- Cracks and spalling:

    - Cracks
    - Staining of concrete surface with signs of efflorescence deposit and spalling of cracks
    - Reinforcing bars exposed
- Scaling and popouts:
    - Loss of mortar
    - Exposed aggregate
    - Reinforcing bars exposed
- Rotational movement: pier rotated or tipping
- Bearing seat or pedestal:
    - Light spalling and chipping of concrete
    - Dirt and debris accumulated on bearing seat
    - Spalling, cracking of concrete at edge of seat
    - Severe spalling and cracking with crushing of concrete and exposed reinforcing bars
- Collision damage:
    - Member out of alignment
    - Member cracked, crushed, or missing
- Construction joints: joint separation or movement

3. Masonry:

- Erosion or scouring at base of pier:
    - Voids
    - Undermining of base
- Bearing seat:
    - Light spalling and chipping of masonry
    - Dirt and debris accumulated on bearing seat
    - Spalling, cracking of masonry at edge of seat
    - Severe spalling and cracking with crushing of masonry
- Mortar joint:
    - Mortar joint cracked with no voids, masonry stone sound
    - Mortar joint deteriorated with voids, vegetation growing from joint, masonry stone loose
    - Mortar joint totally deteriorated, masonry stone missing
- Masonry stone deterioration:
    - Masonry stone, minor spalling and hairline cracks
    - Masonry stone, spalling with cracks and chipping, stone loose
    - Masonry stone, spalling with large cracks and chipping, section loss greater than 15 percent
- Rotational movement: pier rotated or tipping
- Collision damage:
    - Member out of alignment
    - Member cracked, crushed, or missing

4. Steel:

- Corrosion of pier cap, columns, and bracings:
  - Surface rust, no pitting evident
  - Corrosion evident, pitting and blistering of base material
  - Corrosion evident with loss to base section metal
- Cracks in pier cap, columns, and bracing:
  - Hairline or greater crack, fillet of flanges
  - Hairline or greater crack, fillet of web
- Cracks in attachment welds (check all vertical and longitudinal stiffener welds for cracks): hairline or greater crack at toe of weld or adjacent metal
- Straightness or buckling of member:
  - Sign of wrinkles in web and/or stiffener plate at support
  - Sign of wrinkles in flanges
  - Sign of buckling in web and/or stiffener plate at support
  - Sign of buckling in flanges
- Deflection of pier cap:
  - Slight deflection of member when traffic passes
  - Noticeable deflection of member when traffic passes
  - Large deflection of member when traffic passes
  - Permanent deformation of member
- Corrosion of gussets or connection plates:
  - Surface rust, no pitting evident
  - Corrosion evident, pitting and blistering of base material
  - Corrosion evident with loss to base section
- Corrosion of bolts or fasteners:
  - Surface rust, no pitting evident
  - Corrosion evident, pitting and blistering of base material
  - Corrosion evident with loss to base section
- Connectors or fasteners:
  - Loose bolts or fasteners
  - Missing fasteners or connectors
  - Crack in weld
  - Crack in connection plate
- Rotational movement: pier rotated or tipping
- Vehicular damage:
  - Pier column out of alignment
  - Bracing member out of alignment

RESOURCES

Name	Work Group/Company Name	E-mail Address	Date Resource

			Added
Keith Johnston	Servicewide Trails Advisory Group	keith_johnston@nps.gov	4/12/2012
David Reus	Servicewide Trails Advisory Group	david_reus@nps.gov	4/12/2012
Shawn Wignall	Servicewide Trails Advisory Group	shawn_wignall@nps.gov	4/12/2012

REFERENCES

The following is a list of suggested references that parks may wish to use in developing their own trail bridge standards:

Birchard, Jr., William and Robert Proudman. *Appalachian Trail Design Construction and Maintenance*. Appalachian Trail Conservancy, 2000.

Trail Construction and Maintenance Notebook (USDA FS, 9623-2833-MTDC).

Demrow, Carl and David Salisbury. *The Complete Guide to Trail Building and Maintenance*. Appalachian Mountain Club, 1998.

RELATED DOCUMENTS

The following documents provide additional information on the asset category discussed in this business practice:

- Trail Bridges Asset Business Practice
- Trails Bridges Asset Best Management Practice
- Critical Systems List
- Life-Cycle Estimates
- Trails Toolbox on InsideNPS.