

APPENDIX O

Appendix/Attachment Title

Example Critical Findings and Repair Recommendations

Appendix/Attachment Revision and Year:

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Appendix/Attachment Introduction and Discussion

Critical findings and repair recommendations shall be reported by inspectors according to Chapter 8.

Appendix/Attachment Description

Appendix O includes common examples both for critical findings (Urgent, Restrictive and Serious) and Repair Recommendations (Priority A, Priority B and Priority C) on bridges in South Carolina. The lists are not all-inclusive; final evaluation as to how to determine status of the deficiency is the responsibility of the BITL. The list on Page O-2 is not all-inclusive as a critical findings list. Special consideration shall be made by the BITL if the bridge involves the Interstate or NHS, for a bridge with ADT greater than 10,000 or for a bridge with recommendations for immediate work needed to prevent a substantial load reduction for safety of the traveling public.

Critical Finding Examples

Examples of a critical finding are listed below. Material specific critical findings are included on the following page.

Given the severity of a discovered deficiency, all of the items listed below may warrant bridge closure (urgent – red), bridge restriction (orange) or immediate maintenance work because of a safety related item (serious – yellow).

- A partial or complete collapse of a bridge,
- Bridges which are given a structural condition evaluation rating code of 3 or less; this includes:
 - NBI Item 58 (Deck)
 - NBI Item 59 (Superstructure)
 - NBI Item 60 (Substructure)
 - NBI Item 62 (Culvert)
- Bridges which are given any waterway rating of 3 or less; this includes:
 - NBI Item 61 (Channel and Channel Protection)
 - NBI Item 71 (Waterway Adequacy)
- Bridges which are given a current vulnerability status rating (NBI 113) of 2 or less,
- Bridges with a recommended inventory load rating of 6 tons or less,
- Any quantity of a non-redundant bridge element (including FCMs) placed in Condition State 4,
- Critical damage or a defect to main structural members which poses imminent danger to the structure and/or to public safety,
- Immediate work needed to prevent substantial reduction in safe load capacity,
- Loose, deteriorated or damaged expansion joints which may damage passing vehicles,
- Bridge railing is missing, damaged, deteriorated or no longer can contain and/or redirect vehicles,
- Pedestrian railing is missing or detached, potentially allowing a pedestrian to fall off the structure,
- Sidewalk walking surface with damage or deterioration presenting a hazardous condition to pedestrians,
- Serious mechanical, electrical, or hydraulic problems which have stopped or may stop the operation of a movable span or safety equipment,
- Loose or spalling deck material (such as concrete or timber) in imminent danger of falling onto traffic or pedestrians which could cause extensive damage or injury,
- Bridges which are damaged either by collision, natural event, fire or chemicals and the damage poses an imminent danger to the structure and/or to public safety,
- Bridges which are or may be prone to severe scour before, during or after a scour or hydraulic event, and the scour event may lead to bridge failure or partial bridge failure, or
- Drastic/excessive movement or vertical/horizontal displacement (e.g. sliding or deflection) in a major structural component or to the structure as a whole, including unstable foundations, which poses an imminent danger to the structure and/or to public safety.

Critical Finding Examples – Steel

- Significant damage, failure, unmitigated cracks or significant section loss of FCM such as severe corrosion in girder flanges, webs, in truss members, in gusset plates, and connections or a fatigue-prone detail such as certain welds,
- Members with deteriorated areas that have failed in buckling, crippling, etc., or make failure likely in the near future,
- Pin and hanger systems with severe deterioration or severe accumulation of debris or rust packing,
- Rocker bearings that are excessively tilted, exceeding the acceptable amount or bearing on the outer 1/4 width of the rocker.
- Primary structural member with completely fractured tension element due to fatigue, or
- Bottom flange cover plates with cracked welds at the end of a partial length welded cover plate for a steel girder or steel floorbeam.

Critical Finding Examples – Concrete

- Prestressed girder with broken strands or 100 percent section loss at high tension area,
- Non-composite prestressed adjacent box beams with cracking and rust-staining, strand loss, loss of camber, or torsional cracking,
- Severe loss of girder bearing area, where remaining area may no longer have capacity to support the girder under legal load,
- Reinforced concrete girder with damaged or deteriorated primary rebar with 100 percent section loss, with more bars affected at the same location,
- Reinforced concrete bent cap with broken primary rebar or 100 percent section loss, with more bars affected at the same location, or
- Concrete column or cap with significant structural cracking that is supporting a span with a fracture critical member.

Critical Finding Examples – Timber

- Bents with a majority of timber piles where the timber piles are mushroomed piles, piles hollowed with less than only decayed shell remaining, or with less than 1” of heartwood remaining,
- Through-loss in deck planks or broken planks in danger of breaking through,
- Primary structural member with multiple open cracks (splits) in high stress region, or crushing/decay leading to superstructure settlement, or
- Bents which have a loss of bearing capacity or soil retention with crushing, decay, or insect damage which may lead to failure.

General Bridge – Repair Recommendation Examples

Repair Recommendation – Priority A – “A Flags”

- Missing, incorrect or illegible weight limit signs,
- Missing, incorrect or illegible vertical clearance signs (when the field measured vertical clearance is 14’-6 or less),
- Missing or illegible narrow bridge or one lane bridge signs,
- Severe loss of bearing,
- Scouring of a foundation (generally greater than 30% of bearing area),
- Navigational lighting systems on the structure with failure (significant threat to structure given boat traffic),
- Lighting fixtures, signs, traffic signals, or utility poles with damaged, split or buckled sections, missing connections or with cracked welds at connections, or base plate connections with loose nuts,
- Significant scour damage, bank erosion or slope erosion which endanger the stability of substructure elements, or
- Hole in the deck (no immediate damage to traffic below).

Repair Recommendation – Priority B – “B Flags”

- Missing, incorrect or illegible vertical clearance signs (when the field measured vertical clearance is more than 14’-6),
- Loss of bearing,
- Scouring of a foundation (generally less than 30% of bearing area),
- Wearing surface failures which cannot wait for general maintenance, i.e. large pot holes,
- Leveling of approach slabs or excessive settlement to approach slabs or approach roadway to reduce impact loading on the structure,
- Mechanical, electrical, hydraulic problems which will affect the operation of a movable span or safety equipment if allowed to continue to deteriorate, or
- Navigational lighting systems on the structure with failure (some threat to structure given boat traffic),
- Regulatory or warning signs which are missing or worn, including delineators.

Repair Recommendation – Priority C – “C Flags”

- Other missing or worn signs, which are not regulatory or warning, such as informational signs,
- Damage to handrail, guardrail, attenuators, or parapets,
- Large spalls with exposed rebar,
- Slight substructure settlement,
- Frozen or rusted bearings,
- Channel maintenance required before significant scour may occur,
- Leaking or damaged expansion joints,

- Heavy dirt and debris around bridge bearings,
- Exposed coarse aggregate and/or exposed rebar due to abrasion in concrete deck,
- Clogged deck drains,
- Extensive dirt and debris on bridge deck,
- Navigational lighting systems on the structure with failure (no threat to structure given boat traffic),
- Highway lighting systems on the structure with lighting outages,
- Excess vegetation around bridge area limiting bridge inspection access,
- Heavy debris on caps, bridge seats or bents,
- Primary masonry members out of alignment,
- Primary masonry members with unsound patching, or
- Drift causing excess substructure pressure/scour.

Timber Bridge Components

Below are potential repair recommendations for bridge components which are timber.

Timber Repair Recommendation – Priority A – “A Flags”

- Deck boards with hole completely through, broken deck boards in traffic areas, (no immediate damage to traffic below),
- Cracked or broken timber stringers,
- Bearing loss/undermining due to scour on timber mud-sill footing (>30% loss of footing bearing area),
- Broken or severely decayed timber joists, or
- Mushroomed piles, piles hollowed with less than ½” shell remaining, or with less than 3” of heartwood remaining.

Timber Repair Recommendation – Priority B – “B Flags”

- Bearing loss/undermining due to scour on timber mud-sill footing (<30% loss of footing bearing area),
- Mushroomed piles, piles hollowed with less than 1½” shell remaining, or with less than 6” of heartwood remaining,
- Failed deck plank boards,
- Extensively decayed and crushed caps, crown strips, or sills,
- Missing/broken/damaged/loose/badly decayed rail posts, rail boards, and blockouts, or
- Loose deck boards.

Timber Repair Recommendation – Priority C – “C Flags”

- Split/decayed nailers,
- Decayed or unusual/excessive splits in timber joists,

- Decayed or unusual/excessive splits in caps and sills, but still intact and not subject to extensive crushing,
- Decayed/split piles but not in imminent danger of failure,
- Decayed timber wingwall system.
- Decayed or missing bulkhead boards with loss of fill,
- Bearing loss/undermining due to scour on timber mud-sill footing (<30% loss of footing bearing area),
- Excessive drift causing excess pressure/scour on bridge substructure, or
- Bracing boards for piles missing or not functioning on bents $\geq 12'$ high.

Concrete Bridge Components

Below are potential repair recommendations for bridge components which are concrete.

Concrete Repair Recommendation – Priority A – “A Flags”

- Deep and wide cracks ($\frac{1}{2}$ ” wide) in areas which compromise the structural integrity of the member,
- Severely deteriorated concrete sections, especially spalled concrete caps at girder bearing area which do not present an imminent safety concern,
- Severely sheared tee-beam ends which may be compromising the structural integrity of the beam,
- Severely deteriorated concrete sections which may be compromising the structural integrity of the beam, or
- Deck spalls below the top mat of reinforcing steel, which do not pose a hazard to traffic, or in danger of punching through.

Concrete Repair Recommendation – Priority B – “B Flags”

- Severely deteriorated concrete sections,
- Severely sheared tee-beam ends, or
- Deep and wide cracks ($\frac{1}{2}$ ” wide) in areas which may lead to a condition that could compromise the structural integrity of the member.

Concrete Repair Recommendation – Priority C – “C Flags”

- Spalled prestressed girder with exposed/deteriorating strands,
- Unsound patches with rust staining in prestressed concrete members,
- Previous unsatisfactory repairs (i.e. mortar or patches) of delaminated, spalled, or cracked concrete to prevent additional deterioration especially in the bearing areas,
- Slightly sheared tee-beam ends,
- Spalled reinforced concrete girder with exposed/deteriorating main rebar with section loss and more than one bar affected at same location on girder,
- Spalled/cracked columns with extensive spalls and areas of exposed rebar,
- Bearing loss/undermining due to scour on concrete spread footing (<30% bearing area), or

- Deep and wide cracks (½” wide) in areas which are not applicable to the condition listed under the Priority B – “B Flags” section.

Steel Bridge Components

Below are potential repair recommendations for bridge components which are steel.

Steel Repair Recommendation – Priority A – “A Flags”

- Beams, girders, or piles with deteriorated areas which are likely to cause localized failure, or have localized failure in buckling, crippling, etc. (redundant structures only with no safety risk),
- Impact damage to steel members which are likely to cause failure, or have failed in buckling, crippling, etc. (redundant structures only with no safety risk),
- Active measurable section loss in the tension zone on FCMs, or
- Primary structural members (beams/girders/steel piles) with active corrosion and over 75% section loss, (redundant structures only with no safety risk).

Steel Repair Recommendation – Priority B – “B Flags”

- Primary structural members (beams/girders/steel piles) with active corrosion and over 50% section loss, or
- Active minor (non-measurable or negligent) section loss in the tension zone on FCMs.

Steel Repair Recommendation – Priority C – “C Flags”

- Cracks or deterioration in secondary steel members,
- Spot painting primary structural steel members in need,
- Primary structural members (beams/girders/steel piles) with active corrosion and under 50% section loss,
- Secondary members (diaphragms, bracing, etc.) with 25% or more section loss,
- Bolted Field Splice: Missing bolts, active corrosion and 10% section loss,
- Dormant measurable section loss in the tension zone on FCMs,
- Unmitigated crack in a secondary steel member, or
- Cracked welds on steel grid deck.

Barrier Rail or Guardrail

Barrier Rail or Guardrail Repair Recommendation – Priority A – “A Flags”

- Serious damage to guardrail which may lead to issues with future public safety, or
- Guardrail connections to bridge railing, concrete barrier rebar, or guardrail that is detached.

Barrier Rail or Guardrail Repair Recommendation – Priority B – “B Flags”

- Impacted approach guardrail or end terminal/treatment within 75 feet of the bridge.

Barrier Rail or Guardrail Repair Recommendation – Priority C – “C Flags”

- Minor damage to guardrail,
- Failed paint system,

- Decayed or damaged wheel guard not presenting danger to vehicles, or
- Loose or missing connection shoe.