Bridge Inspection Field Manual

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Chapter B of the Bridge and Structure Inspection Program Manual

DEPARTMENT OF TRANSPORTATION

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B.1 OVERVIEW

This manual is intended to serve as a field guide for the inspection and condition rating of bridges and culverts on roadways in Minnesota. A bridge inspection includes examining the structure, evaluating the physical condition of the structure, and reporting the observations and evaluations on the bridge inspection report. MnDOT currently uses two separate bridge condition rating systems - the NBI condition ratings and the structural element condition ratings:

- The NBI condition ratings describe the general overall condition of a bridge, culvert, or tunnel. This 0-9 rating system was developed by the Federal Highway Administration (FHWA) in 1971, and is outlined in the "FHWA Recording and Coding Guide for the Structure Inventory and Appraisal of the Nation's Bridges". The NBI condition ratings are used to determine inspection frequency and deficient status, and are a key component of the Bridge Sufficiency Rating.

- Structural element condition ratings divide a bridge into separate components which are then rated individually based upon the severity and extent of deterioration. This 1-4 rating system was developed by the American Association of State Highway and Transportation Officials (AASHTO), and is outlined in the "AASHTO Manual for Bridge Element Inspection". Minnesota has been collecting element level bridge condition data since 1994. The FHWA began mandating (and collecting) element level data in October of 2014. Structural element condition ratings provide input data for a Bridge Management System (BMS) which can be used to identify present maintenance needs, and is intended to provide cost-effective options for long-range bridge maintenance and improvement programs (using computer projections of future deterioration).

Bridge inspection reports (along with the NBI & structural element condition ratings), are entered into SIMS (Structure Information Management System). Access to this system is typically restricted to MnDOT certified Bridge Inspection Team Leaders or Bridge Inspection Program Administrators appointed by those agencies with bridge inspection responsibility. A username and password are required. For more information, contact simshelp.dot@state.mn.us.

Bridge inspection reports and structure inventory reports for any bridge on the MnDOT inventory can be printed at the link below (no password required):
http://dotapp7.dot.state.mn.us/bridgereports/Logon.aspx

B.2 NBI CONDITION AND APPRAISAL RATINGS

The NBI bridge condition and appraisal ratings were introduced in 1971 with the National Bridge Inspection Standards (NBIS). These ratings are outlined in the FHWA Recording & Coding Guide. Minnesota has added some guidance in an effort to improve consistency.

B.2.1 NBI BRIDGE CONDITION RATINGS

The NBI condition ratings describe the general overall condition of a bridge or culvert. These must be reviewed during each inspection.

B.2.1.1 NBI Condition Ratings – General Guidelines

There are five NBI condition ratings. They are rated on a numerical scale of 1 to 9 (with 9 being a “new” condition).

- Deck Condition Rating (NBI Item 58)
- Superstructure Condition Rating (NBI Item 59)
- Substructure Condition Rating (NBI Item 60)
- Channel & Channel Protection Condition Rating (NBI Item 61)
- Culvert Condition Rating (NBI Item 62)

Bridges are typically rated in three components – deck, superstructure, and substructure. If a bridge spans over a waterway, the channel (NBI Item 61) must also be rated.

- For filled spandrel arch bridges (or rigid frame structures with fill), the NBI superstructure and substructure items should be rated, but the NBI deck rating may be entered as “N”.
- For concrete slab span structures with concrete wearing surfaces, the NBI deck and superstructure ratings will typically be the same. The NBI deck and superstructure ratings may differ when the wearing surface material is different than the structural slab material (such as a timber slab with a bituminous overlay).

Culverts are rated as a single component (NBI Item 62). NBI Item 62 describes the general overall condition of the culvert. This rating should consider the condition of the culvert barrel, joints and seams, as well as any deflection, distortion, misalignment, settlement, scour, or voiding of backfill. Headwalls, wingwalls or aprons (up to the first construction joint) should be included in this rating. If water flows through a culvert, the channel (NBI Item 61) must also be rated.

The following general guidelines apply to the NBI Condition Ratings:

- New bridges and culverts are initially assigned NBI ratings of “9” (excellent condition).
- Repaired components should typically not be rated higher than “7” (good condition).
- An NBI rating of “5” (fair condition) or less generally implies that repairs are recommended. NBI ratings of “5” or less will also reduce the bridge sufficiency rating.
- An NBI rating of “4” (poor condition) or less may impact the inspection frequency.
- An NBI rating of “3” (serious condition) or less generally implies that immediate repairs, structural analysis, or a new load rating is necessary.
- An NBI rating of “2” (critical condition) indicates a critical finding. Specific reporting and follow-up procedures are required for critical findings. NBI ratings of “2” should be adjusted immediately after the critical finding is addressed.
- Temporary supports (shoring, bracing, or underpinning) should generally not improve the NBI rating. One exception would be if a critical condition was corrected with temporary shoring (the NBI rating should be raised from condition 2 after the temporary repairs have been performed).
- The load carrying capacity should not be considered when determining the NBI condition ratings.

B.2.1.2 Deck Condition Rating (NBI Item 58)

Deck Condition Rating (NBI Item 58)	
Code	This rating should reflect the overall general condition of the deck (or slab). This includes the underside of the deck and the wearing surface. The condition of railings, sidewalks, curbs, expansion joints, and deck drains are not considered in this rating.
N	**Not Applicable:** Use for culverts, roadway tunnels, or filled spandrel arch bridges.
9	**Excellent Condition:** Deck is in new condition (recently constructed).
8	**Very Good Condition:** Deck has very minor (and isolated) deterioration. • Concrete: minor cracking, leaching, scale, or wear (no delamination or spalling) • Timber: minor weathering and/or isolated (minor) splitting • Steel: no corrosion (paint/protection system remains sound)
7	**Good Condition:** Deck has minor (or isolated) deterioration. • Concrete: minor cracking, leaching, scale, or wear (isolated spalling/delamination) • Timber: minor splitting (no decay or crushing) – planks are secure • Steel: minor paint failure or corrosion (no section loss) – connections are secure
6	**Satisfactory Condition:** Deck has minor (or isolated) deterioration. • Concrete: moderate cracking, leaching, scale, or wear (minor spalling and/or delamination) • Timber: moderate splitting (isolated decay or crushing) – some planks may be slightly loose • Steel: moderate paint failure and/or surface corrosion (minor section loss) – some connections may have worked loose
5	**Fair Condition:** Deck has moderate deterioration (repairs may be necessary). • Concrete: extensive cracking, leaching, scale, or wear (moderate delamination or spalling) • Timber: extensive splitting (moderate decay or crushing) – some planks may be loose, broken, or require replacement • Steel: extensive paint failure and/or surface corrosion (moderate section loss) – several connectors may be loose or missing (primary components remain secure)
4	**Poor Condition:** Deck has advanced deterioration (replacement or overlay should be planned). • Concrete: advanced cracking, leaching, scale, or wear (extensive delamination or spalling) – isolated full-depth failures may be imminent • Timber: advanced splitting or decay - numerous planks may be loose, broken, or require replacement • Steel: advanced corrosion (significant section loss) – deck components may be loose or slightly out of alignment
3	Deck has severe deterioration. Immediate repairs may be necessary. • Concrete: severe cracking, leaching, delamination, or spalling – full-depth failures may be present • Timber: severe splitting, crushing or decay – majority of planks need replacement • Steel: severe and section loss – deck components may be severely misaligned
2	**Critical Condition:** Deck has failed. Emergency repairs are required.
1	**"Imminent" Failure Condition:** Bridge is closed. Corrective action is required to open to restricted service.
0	**Failed Condition:** Bridge is closed. Deck replacement is necessary.

B.2.1.3 Superstructure Condition Rating (NBI Item 59)

Superstructure Condition Rating (NBI Item 59)	
Code	This rating should reflect the overall general condition of the superstructure – this includes all primary structural components located above (and including) the bearings.
N	**Not Applicable:** Use for culverts.
9	**Excellent Condition:** Superstructure is in new condition (recently constructed).
8	**Very Good Condition:** Superstructure has very minor (and isolated) deterioration.
7	**Good Condition:** Superstructure has minor (or isolated) deterioration. • Steel: minor corrosion, little or no section loss • Concrete: minor scale or non-structural cracking (isolated spalling/delamination) • Timber: minor splitting (no decay or crushing) • Masonry: minor scaling or cracking (joints have little or no deterioration)
6	**Satisfactory Condition:** Superstructure has minor to moderate deterioration. Members may be slightly bent or misaligned – connections may have minor distress. • Steel: moderate corrosion (section loss or cracks in non-critical areas) • Concrete: moderate scale or cracking (minor spalling/delamination) • Timber: moderate splitting (minor decay or crushing) • Masonry: moderate scaling or cracking (joints may have minor deterioration)
5	**Fair Condition:** Superstructure has moderate deterioration. Members may be bent, bowed, or misaligned. Bolts/rivets may be loose/missing, but connections remain intact. • Steel: extensive corrosion (initial section loss in critical stress areas); cracks have been arrested or are not likely to propagate into critical stress areas • Concrete: extensive scaling or cracking (structural cracks may be present), moderate spalling or delamination (reinforcement may have some section loss) • Timber: extensive splitting (moderate decay or crushing) • Masonry: extensive scaling or cracking (slight joint separation or offset)
4	**Poor Condition:** Superstructure has advanced deterioration. Members significantly bent or misaligned. Connection failure may be imminent. Bearings severely restricted. • Steel: significant section loss in critical stress areas; un-arrested cracks exist that may likely propagate into critical stress areas • Concrete: advanced scaling, cracking, or spalling (significant structural cracks may be present – exposed reinforcement may have significant section loss) • Timber: advanced splitting (extensive decay or significant crushing) • Masonry: advanced scaling, spalling or cracking (joint separation or offset)
3	**Serious Condition:** Superstructure has severe deterioration – immediate repairs or structural evaluation may be required. Members may be severely bent or misaligned - connections or bearings may have failed. • Steel: severe section loss or cracks in critical stress areas • Concrete: severe structural cracking or spalling • Timber: severe splitting, decay, or crushing • Masonry: severe cracking, offset or misalignment
2	**Critical Condition:** Superstructure has critical damage or deterioration. Primary structural elements may have failed (severed, detached or critically misaligned). Immediate repairs may be required to prevent collapse or closure.
1	**"Imminent" Failure Condition:** Bridge is closed. Superstructure is no longer stable (corrective action might return the structure to restricted service).
0	**Failed Condition:** Bridge is closed due to superstructure failure and is beyond corrective action (replacement required).

B.2.1.4 Substructure Condition Rating (NBI Item 60)

Substructure Condition Rating (NBI Item 60)	
Code	This rating should reflect the overall general condition of the substructure – this includes all structural components located below the bearings. Integral wingwalls or retaining walls (up to the first expansion or construction joint) may be considered in this rating.
N	**Not Applicable:** Use for culverts.
9	**Excellent Condition:** Substructure is in new condition (recently constructed).
8	**Very Good Condition:** Substructure has very minor (and isolated) deterioration.
7	**Good Condition:** Substructure has minor (or isolated) deterioration. • Concrete: minor cracking, leaching, or scale (isolated delaminations or spalls) • Steel: minor paint failure and/or surface corrosion (little or no section loss) • Timber: minor splitting (no decay or crushing) • Masonry: minor scaling or cracking (joints have little or no deterioration)
6	**Satisfactory Condition:** Substructure has minor to moderate deterioration. Scour or erosion is minor and isolated (there may be slight movement or misalignment). • Concrete: moderate scaling, cracking, or leaching (minor spalling/delamination) • Steel: moderate paint failure and/or surface corrosion (minor section loss) • Timber: moderate splitting (minor decay or crushing) • Masonry: moderate scaling or cracking (joints may have minor deterioration)
5	**Fair Condition:** Substructure has moderate deterioration. Repairs may be necessary. There may be moderate scour, erosion, or undermining. There may be minor settlement, movement, misalignment, or loss of bearing area. • Concrete: extensive scaling, cracking or leaching (isolated structural cracks may be present) – there may be moderate delamination or spalling • Steel: extensive paint failure and/or surface corrosion (moderate section loss) • Timber: extensive splitting (moderate decay or crushing) • Masonry: extensive scaling or cracking (slight joint separation or offset)
4	**Poor Condition:** Substructure has advanced deterioration. Repairs may be necessary to maintain stability. There may be extensive scour, erosion, or undermining. There may be significant settlement, movement, misalignment, or loss of bearing area. • Concrete: advanced scaling, cracking, or leaching (significant structural cracks may be present) – there may be extensive delamination or spalling • Steel: advanced corrosion (significant section loss) • Timber: advanced splitting (significant decay or crushing) • Masonry: advanced scaling, spalling, or cracking (joints separation or offset)
3	**Serious Condition:** Substructure has severe deterioration. Immediate corrective action may be required. Scour, erosion, or undermining may have resulted in severe settlement, movement, misalignment, or loss of bearing area. • Concrete: severe spalling or structural cracking • Steel: severe section loss • Timber: severe decay or crushing • Masonry: severe cracking, offset or misalignment
2	**Critical Condition:** Substructure has critical damage or deterioration (near the point of collapse). It may be necessary to close the bridge until corrective action is completed. Scour may have removed substructure support.
1	**Imminent Failure Condition:** Bridge is closed. Substructure is no longer stable (corrective action might return the structure to restricted service).
0	**Failed Condition:** Bridge is closed due to substructure failure and is beyond corrective action (replacement required).

B.2.1.5 Channel and Channel Protection Condition Rating (NBI Item 61)

Channel and Channel Protection Condition Rating (NBI Item 61)	
Code	This rating should reflect the overall general condition of the waterway under the bridge (or running through the culvert), even if the channel is occasionally dry. This rating can be based upon findings from routine inspections, soundings, or underwater inspections. This rating includes the channel and banks below the bridge, as well as immediately upstream and downstream of the bridge (typically those areas visible from the bridge). Changes in the channel – such as aggradation, degradation, or lateral stream migration – that might adversely affect the bridge should be considered in this rating. The presence drift in the channel, debris lodged against the bridge, or sediment inside culvert barrels should also be considered in this rating. *Note: For bridges over a navigable waterway (NBI Item 38 coded as '1') the condition and adequacy of substructure protection devices (such as dolphins, fenders, and shear walls) must be rated using NBI Item 111.*
N	**Not Applicable:** Bridge is not over a waterway.
9	**Excellent Condition:** There are no noticeable or noteworthy deficiencies.
8	**Very Good Condition:** Channel banks are protected (or well vegetated) – there is little or no erosion. Control structures and protection devices (if present) have little or no deterioration. Drift or debris in the channel is incidental. Culvert has little or no sediment.
7	**Good Condition:** Channel has no notable aggradation, degradation, or lateral movement. There is no notable scour around the bridge substructure. The banks may have minor erosion – bank protection (if any) may have minor deterioration. Control structures and/or protection devices may have minor deterioration. There may be minor drift or debris in the channel. Culvert barrel may have minor sediment.
6	**Satisfactory Condition:** Channel may have minor aggradation, degradation, or lateral movement. The channel banks may have moderate erosion or slumping. Bank protection may have moderate deterioration. Control structures and/or protection devices may have moderate deterioration. Drift or debris in the channel may be slightly restricting the channel. Culvert barrel may have moderate sediment.
5	**Fair Condition:** Channel may have moderate aggradation, degradation, or lateral movement, but the bridge and approaches have not yet been adversely affected. The channel banks may have extensive erosion – the bank protection may have extensive deterioration. Control structures and/or protection devices may have extensive deterioration, but are functioning as intended. Debris in the channel (or sediment in the culvert barrel) is restricting the channel and should be removed.
4	**Poor Condition:** Aggradation, degradation, or lateral movement of the channel may be adversely affecting the structure or approaches. Channel banks may have severe erosion. The bank protection may have severe deterioration. Control structures and/or protection devices may be deteriorated to the extent that they are no longer functioning as intended. Large accumulations of debris or sediment are severely restricting the channel, and should be removed immediately.
3	**Serious Condition:** Aggradation, degradation, or lateral movement has altered the channel to the extent that the structure (or approach roadway) is threatened. Bank protection has failed. Control structures and/or protection devices have been destroyed. Channel is blocked by debris or sediment.
2	**Critical Condition:** Aggradation, degradation, or lateral movement has altered the channel to the extent that the bridge (or culvert) is near a state of collapse. It may be necessary to close the bridge (or culvert) until corrective action is completed.
1	**Bridge closed due to channel failure:** Corrective action may restore bridge to light service.
0	**Bridge closed due to channel failure:** Replacement necessary.

B.2.1.6 Culvert Condition Rating (NBI Item 62)

Culvert Condition Rating (NBI Item 62)	
Code	This rating should reflect the overall general condition of the culvert. If this item is rated, the NBI deck, superstructure, and substructure ratings must all be "N".
N	**Not Applicable:** Structure is not a culvert.
9	**Excellent Condition:** Culvert is new condition (recently constructed).
8	**Very Good Condition:** Culvert has very minor (and isolated) deterioration.
7	**Good Condition:** Culvert has minor (or isolated) deterioration. Joints are sound and properly aligned (no backfill infiltration). Footings have no undermining. • Concrete/Masonry: minor scaling, cracking, or leaching (isolated spalling) • Steel: minor corrosion (little or no section loss) - barrel has no distortion • Timber: minor splitting (no decay, crushing, or sagging)
6	**Satisfactory Condition:** Culvert has minor to moderate deterioration. Joints may have minor separation or misalignment (slight backfill infiltration). • Concrete/Masonry: moderate scaling, cracking, or leaching (minor spalling) • Steel: moderate corrosion (minor section loss) – barrel may have minor distortion (seams may have minor distress, but no cracking) • Timber: moderate splitting (minor decay, crushing, or sagging)
5	**Fair Condition:** Culvert has moderate deterioration – repairs may be required, but the culvert is structurally sound and functioning as intended. Joints may have separation or misalignment (moderate backfill infiltration). Footings may be partially undermined (minor settlement). • Concrete/Masonry: extensive scaling, cracking, or leaching (moderate spalling) • Steel: extensive corrosion (any significant section loss is isolated) – barrel may have moderate distortion (seams may have missing bolts or isolated cracking) • Timber: extensive splitting (moderate decay, crushing, or sagging)
4	**Poor Condition:** Culvert has advanced deterioration – structural evaluation or repairs may be necessary (structural integrity or functional capacity of the culvert may be slightly reduced). Footings may have significant undermining or settlement. • Concrete/Masonry: advanced cracking, leaching, or scaling (significant spalling). Joints may have significant separation or misalignment. • Steel: advanced corrosion (significant section loss) – barrel may have significant distortion (seams may have extensive cracking or isolated failures) • Timber: advanced splitting (significant decay, crushing, or sagging)
3	**Serious Condition:** Culvert has serious deterioration – immediate repairs or corrective action may be required (structural integrity or functional capacity of the culvert has been significantly reduced). Joints may have severe deterioration, misalignment, offset, or separation. Loss of backfill may have resulted in significant settlement or undermining of the roadway or embankment. Severe undermining or settlement. • Concrete/Masonry: severe scaling, cracking, or spalling • Steel: severe section loss or severe barrel distortion (seams may have failed) • Timber: severe decay, crushing, or sagging
2	**Critical Condition:** Culvert has critically advanced deterioration (near collapse) – it may be necessary to close the roadway until corrective action is completed.
1	**"Imminent" Failure Condition:** Culvert is closed – corrective action may restore to light service.
0	**Failed Condition:** Culvert is closed – replacement is necessary.

B.2.2 NBI BRIDGE APPRAISAL RATINGS

The FHWA has five appraisal ratings that are used to evaluate a bridge in regards to the current standards for the particular highway system it is located on.

- Deck Geometry Appraisal Rating (NBI Item 68)
- Vertical and Horizontal Under Clearance Appraisal Rating (NBI Item 69)
- Bridge Posting Appraisal Rating (NBI Item 70)
- Waterway Adequacy Appraisal Rating (NBI Item 71)
- Approach Roadway Alignment Appraisal Rating (NBI Item 72)

NBI Items 68 (Deck Geometry), 69 (Under Clearance), and 70 (Bridge Posting) are automatically calculated based upon other structure inventory items. These ratings are displayed on the Minnesota Structure Inventory Report. They are not displayed on the Minnesota Bridge Inspection Report.

NBI Items 71 (Waterway Adequacy) and 72 (Approach Roadway Alignment) are displayed on the header of the Minnesota Bridge Inspection Report, and on the Minnesota Structure Inventory Report. The coding for these two items must be determined by the inspector, and entered in SIMS, according to the guidance below.

B.2.2.1 Approach Roadway Alignment Appraisal Rating (NBI Item 72)

NBI Item 72 is a general assessment that identifies bridges or culverts that do not function properly or adequately due to the approach roadway alignment. For new bridges or culverts, this item will initially be rated as "9" – an appropriate rating must be determined during the initial inspection. This item should also be reviewed if the bridge approaches have been reconstructed or reconfigured. This rating only applies to the roadway passing over the bridge (not the roadway passing below the bridge). For railroad or pedestrian bridges crossing over a roadway, this item should be coded as "N".

This rating is based upon the speed reduction required (due to the vertical or horizontal approach alignment) by a typical vehicle using the roadway. If an advisory speed limit is posted, the reduction from the base speed limit should be used to determine this rating. Note: Speed reductions necessary due to structure width shall not be considered when evaluating this item.

Approach Roadway Alignment Appraisal Rating (NBI Item 72)	
Code	**Description**
N	Not Applicable (use for railroad or pedestrian bridges).
9	***New Structure – an appropriate rating code should be determined.***
8	No speed reduction required.
7	Minor sight distance problems with no speed reduction required.
6	Very minor speed reduction required (less than 5 MPH for a typical vehicle using the roadway).
5	Minor speed reduction required (5 MPH for a typical vehicle using the roadway).
4	Significant speed reduction required (6-10 MPH for a typical vehicle using the roadway).
3	Intolerable alignment requiring a substantial reduction in the operating speed (11-20 MPH for a typical vehicle using the roadway).
2	Severe vertical or horizontal alignment problems, such as a sharp vertical or horizontal curve immediately adjacent to the bridge (speed reduction greater than 20 MPH for a typical vehicle using the roadway).
1	***This rating code should not be used.***
0	Bridge Closed.

B.2.2.2 Waterway Adequacy Appraisal Rating (NBI Item 71)

This rating is a general assessment of the waterway opening with respect to the passage of flow through the bridge. This rating is based upon the frequency of "overtopping" of the bridge and approach (and the resultant traffic delays). The functional class of the roadway is also taken into consideration. Site conditions may warrant somewhat higher or lower ratings than indicated by the table (e.g. flooding of an urban area due to a restricted bridge opening). Note: When a new bridge or culvert is added to the MnDOT bridge database, this item will initially be coded as "9" – as this coding may not be appropriate, this item should always be reviewed for new bridges.

The descriptions given in the bottom table mean the following:

Chances of Overtopping			Traffic Delays	
Remote	Greater than 100 years		**Insignificant**	Minor inconvenience (impassable for a few hours)
Slight	11 to 100 years			
Occasional	3 to 10 years		**Significant**	Traffic delays of up to several days
Frequent	Less than 3 years			
"Freeboard" is defined as the distance from the bottom of the superstructure to the water surface (at the water level of the 50-year frequency design storm)				

Waterway Adequacy Appraisal Rating (NBI Item 71)			
Functional Classification			Description
Interstates, Freeways, or Expressways	Other Principal and Minor Arterial and Major Collectors	Minor Collectors and Local Roads	
N	**N**	**N**	Bridge not over a waterway.
9	**9**	**9**	Bridge deck and roadway approaches above floodwater elevations (high water). Chance of overtopping is remote.
8	**8**	**8**	Bridge deck above roadway approaches. Slight chance of overtopping roadway approaches. Greater than 3 ft. of freeboard.
6	**6**	**7**	Bridge deck above roadway approaches. Slight chance of overtopping bridge deck and roadway approaches. 2 to 3 ft. of freeboard.
4	**4**	**6**	Bridge deck above roadway approaches. Occasional overtopping of roadway approaches with insignificant traffic delays. 1 to 2 ft. of freeboard.
3	**4**	**5**	Bridge deck above roadway approaches. Occasional overtopping of roadway approaches with significant traffic delays. Less than 1 ft. of freeboard.
2	**3**	**4**	Occasional overtopping of bridge deck and roadway approaches with significant traffic delays.
2	**2**	**3**	Frequent overtopping of bridge deck and roadway approaches with significant traffic delays.
2	**2**	**2**	Occasional or frequent overtopping of bridge deck and roadway approaches with severe traffic delays.
0	**0**	**0**	Bridge closed.

B.3 STRUCTURAL ELEMENT CONDITION RATINGS

Structural element condition ratings provide a detailed condition evaluation of the bridge by dividing the bridge into separate elements, which are then rated individually based upon the severity and extent of any deterioration. This rating system was developed by the American Association of State Highway and Transportation Officials (AASHTO), and is outlined in the "AASHTO Manual for Bridge Element Inspection".

B.3.1 INTRODUCTION TO STRUCTURAL ELEMENT CONDITION RATINGS

Structural element condition ratings provide input data for a Bridge Management System (BMS), which allows computer projections of deterioration rates, providing cost-effective options for bridge maintenance, rehabilitation, or replacement. Bridge Management Systems are intended to be a source of information (and qualitative backing) for engineers and managers responsible for long-range bridge improvement programs. MnDOT adopted an element based bridge inspection format in 1994 to comply with the 1991 Inter-Modal Surface Transportation Efficiency Act (ISTEA), which mandated that all states develop and implement a Bridge Management System (BMS) by October of 1998. In 2014, the FHWA mandated that element level condition ratings (based upon the AASHTO Manual for Bridge Element Inspection) be submitted for all bridges on the National Highway System (NHS).

An "element" refers to structural members (beams, pier columns, decks, etc.), or any other components (railings, expansion joints, approach panels, etc.) commonly found on a bridge.

B.3.1.1 Structural Element Types

AASHTO defines three basic element types:

- **National Bridge Elements (NBEs)** represent the primary structural components of a bridge or culvert (bearings and railings are also included). The condition rating language for NBE's cannot be altered, as these are intended to remain consistent across the country.
- **Bridge Maintenance Elements (BME's)** include components of the bridge such as joints, wearing surfaces, and protective coating systems that might be managed by agencies using Bridge Management Systems. The condition rating language for BME's can be altered by states to best suit their bridge management practices.
- **Agency-Developed Elements (ADEs)** are custom elements defined by an agency. They may be sub-elements of NBE's or BME's, or may have no ties to the AASHTO elements. ADE's provide some flexibility for agencies to rate specific bridge components not addressed by the NBE's or BME's.

Structural elements are also classified into five groups, depending upon structural function:

- **Deck Elements** (decks, slabs, wearing surface, deck joints, railings, and approaches)
- **Superstructure Elements** (girders, beams, arches, trusses, and bearings)
- **Substructure Elements** (abutments, piles, columns, pier caps, pier walls, and footings)
- **Culvert Elements** (culvert barrels, culvert end treatments, and roadway above culvert)
- **Miscellaneous Elements** (bridge components that do not fall under the other groups)

Structural elements are also divided into six material groups:

- **Steel Elements**
- **Reinforced Concrete Elements**
- **Pre-stressed (and Post-Tensioned) Concrete Elements**
- **Timber Elements**
- **Masonry Elements**
- **Other Material Elements** (Aluminum, Plastic, Composite, Etc.)

B.3.1.2 Structural Element Quantities

Structural element quantities may be expressed in three ways:

- **Square Feet (SF):** elements such as decks, slabs, wearing surfaces, and coatings are expressed in square feet (SF) quantities. *Example, a deck with a length of 100 ft. and a width of 24 ft. would have an element quantity of 2,400 SF.*
- **Linear Feet (LF):** elements such as girders, beams, box girders, culvert barrels, deck joints, and railings are expressed in linear feet (LF) quantities. *Example, on a 100 ft. long bridge with five beam lines, the beam quantity would be 500 LF.*
- **Each (EA):** elements such as columns, pilings, and bearings are expressed as each (EA) quantities. *Example, on a bridge with three piers, and three columns at each pier, the column quantity would be 9 EA.*

B.3.1.3 Structural Element Ratings

Structural elements are all rated on a scale of 1-4. Condition state 1 is the best condition, with condition state 4 being the worst condition (this is the reverse of the NBI condition ratings).

If the severity of deterioration varies within a particular element, the element should be rated using more than one condition state. Example, on a bridge with 500 LF of beams, 250 LF could be rated as condition state 1, 150 LF could be rated as condition state 2, and 100 LF could be rated as condition state 3, and condition state 4 would be 0 LF.

Elements expressed as an “Each” (EA) quantity can also be rated using more than one condition state (but only if the total quantity is greater than one). Example, on a bridge with 9 columns, five could be rated as condition state 1, three could be rated as condition state 2, and one could be rated as condition state 3, and condition state 4 would be 0.

B.3.1.4 Structural Element Display (Bridge Inspection Report)

Only structural elements that have been entered for a bridge will be displayed on the Minnesota Bridge Inspection Report. The element condition ratings from the most recent inspection, as well as those from the previous inspection, are displayed on the inspection report in “SF”, “LF”, or “Each” quantities. Inspection notes pertaining to each element are displayed directly below the element. It is the Team Leaders responsibility to verify that the elements and quantities displayed on the inspection report are correct.

B.3.1.5 MnDOT Structural Element List

This list displays the 112 structural elements currently being used by MnDOT. This includes 82 of the 103 AASHTO elements, and 30 elements developed by MnDOT. AASHTO elements that do not apply to bridges in Minnesota are not included in this manual.

This element list is arranged in groups based upon the structural function and material type, in the same order that they are arranged in this manual. The AASHTO element numbering systems is used for National Bridge Elements (NBE’s) and Bridge Management Elements (BME’s). Agency-Developed Elements (ADE’s) created by MnDOT are numbered starting with 800.

MnDOT Structural Element List					
#	Element Description	Type	Component	Units	Page
	Critical Findings				
800	Critical Findings or Safety Hazards	ADE	Miscellaneous	Each	19
	Deck & Slab Elements				
12	Reinforced Concrete Deck	NBE	Deck	SF	21
16	Reinforced Concrete Top Flange	NBE	Deck	SF	21
38	Reinforced Concrete Slab	NBE	Deck	SF	21
13	Prestressed Concrete Deck	NBE	Deck	SF	25
15	Prestressed Concrete Top Flange	NBE	Deck	SF	25
805	Prestressed Concrete Slab	ADE	Deck	SF	25
31	Timber Deck	NBE	Deck	SF	27
54	Timber Slab	NBE	Deck	SF	27
28	Steel Grid Deck - Open	NBE	Deck	SF	30
29	Steel Grid Deck - Concrete Filled	NBE	Deck	SF	30
30	Other Steel Deck	NBE	Deck	SF	30
	Wearing Surface Elements				
510	Wearing Surface	BME	Deck	SF	33
810	Concrete Wearing Surface - Cracking & Sealing	ADE	Deck	LF	43
521	Concrete Protective Coating	BME	Deck	SF	43
	Deck Joint Elements				
300	Strip Seal Deck Joint	BME	Deck	LF	45
815	Plow Fingers	ADE	Deck	Each	47
301	Poured Seal Joint	BME	Deck	LF	48
302	Compression Deck Joint	BME	Deck	LF	50
303	Modular Deck Joint	BME	Deck	LF	52
304	Open Deck Joint	BME	Deck	LF	54
305	Assembly Deck Joint	BME	Deck	LF	56
816	Approach Relief Joint	ADE	Deck	LF	58
	Bridge Railing Elements				
330	Metal Bridge Railing	NBE	Deck	LF	61
331	Reinforced Concrete Bridge Railing	NBE	Deck	LF	63
332	Timber Bridge Railing	NBE	Deck	LF	67
333	Other Material Bridge Railing	NBE	Deck	LF	69
334	Masonry Bridge Railing	NBE	Deck	LF	71
	Bridge Approach Roadway Elements				
321	Concrete Approach Slab	BME	Deck	SF	73
822	Bituminous Approach Roadway	ADE	Deck	Each	75
823	Gravel Approach Roadway	ADE	Deck	Each	75
	Steel Superstructure Elements				
102	Steel Box Girder	NBE	Superstructure	LF	77
107	Steel Girder or Beam	NBE	Superstructure	LF	77
113	Steel Stringer	NBE	Superstructure	LF	77
120	Steel Truss	NBE	Superstructure	LF	77
141	Steel Arch	NBE	Superstructure	LF	77
152	Steel Floorbeam	NBE	Superstructure	LF	77
162	Steel Gusset Plate	NBE	Superstructure	Each	77
	Steel Substructure Elements				
202	Steel Column	NBE	Substructure	Each	80
207	Steel Column Tower (Trestle)	NBE	Substructure	LF	80
219	Steel Abutment	NBE	Substructure	LF	80
225	Steel or CIP Piling	NBE	Substructure	Each	80
231	Steel Pier/Bearing Cap	NBE	Substructure	LF	80
	Steel Protective Coating				
515	Steel Protective Coating	BME	Miscellaneous	SF	85

MnDOT Structural Element List					
#	Element Description	Type	Component	Units	Page
	Reinforced Concrete Superstructure Elements				
105	Reinforced Concrete Box Girder	NBE	Superstructure	LF	89
110	Reinforced Concrete Girder or Beam	NBE	Superstructure	LF	89
116	Reinforced Concrete Stringer	NBE	Superstructure	LF	89
144	Reinforced Concrete Arch	NBE	Superstructure	LF	89
155	Reinforced Concrete Floorbeam	NBE	Superstructure	LF	89
	Reinforced Concrete Substructure Elements				
205	Reinforced Concrete Column	NBE	Substructure	Each	92
210	Reinforced Concrete Pier Wall	NBE	Substructure	LF	92
215	Reinforced Concrete Abutment	NBE	Substructure	LF	92
220	Reinforced Concrete Footing	NBE	Substructure	LF	92
227	Reinforced Concrete Piling	NBE	Substructure	Each	92
234	Reinforced Concrete Pier/Bearing Cap	NBE	Substructure	LF	92
	Prestressed Concrete Superstructure Elements				
104	Prestressed Concrete Box Girder	NBE	Superstructure	LF	98
109	Prestressed Concrete Girder or Beam	NBE	Superstructure	LF	98
115	Prestressed Concrete Stringer	NBE	Superstructure	LF	98
154	Prestressed Concrete Floorbeam	NBE	Superstructure	LF	98
	Prestressed Concrete Substructure Elements				
204	Prestressed Concrete Column	NBE	Substructure	Each	101
226	Prestressed Concrete Piling	NBE	Substructure	Each	101
233	Prestressed Concrete Pier/Bearing Cap	NBE	Substructure	LF	101
	Timber Superstructure Elements				
111	Timber Girder or Beam	NBE	Superstructure	LF	103
117	Timber Stringer	NBE	Superstructure	LF	103
135	Timber Truss	NBE	Superstructure	LF	103
146	Timber Arch	NBE	Superstructure	LF	103
156	Timber Floorbeam	NBE	Superstructure	LF	103
	Timber Substructure Elements				
206	Timber Column	NBE	Substructure	Each	106
208	Timber Column Tower (Trestle)	NBE	Substructure	LF	106
216	Timber Abutment	NBE	Substructure	LF	106
228	Timber Piling	NBE	Substructure	Each	106
235	Timber Pier/Bearing Cap	NBE	Substructure	LF	106
	Masonry Superstructure & Substructure Elements				
145	Masonry Arch	NBE	Superstructure	LF	109
213	Masonry Pier Wall	NBE	Substructure	LF	109
217	Masonry Abutment	NBE	Substructure	LF	109
	Bearings & Special Feature Elements				
310	Elastomeric Expansion Bearing	NBE	Superstructure	Each	115
311	Expansion Bearing	NBE	Superstructure	Each	118
313	Fixed Bearing	NBE	Superstructure	Each	121
314	Pot Bearing	NBE	Superstructure	Each	123
315	Disk Bearing	NBE	Superstructure	Each	123
161	Pin & Hanger Assembly or Pinned Connection	NBE	Superstructure	Each	126
850	Steel Hinge Assembly	ADE	Superstructure	Each	129
851	Concrete Hinge Assembly	ADE	Superstructure	Each	129
147	Steel Main Cable	NBE	Superstructure	LF	135
148	Steel Secondary Cable	NBE	Superstructure	Each	135
855	Secondary Members (Superstructure)	ADE	Superstructure	Each	138
856	Secondary Members (Substructure)	ADE	Substructure	Each	138
861	Non-Integral Retaining Wall	ADE	Substructure	Each	142
862	Tiled Surface	ADE	Miscellaneous	SF	143
863	Decorative Facade	ADE	Superstructure	LF	144

MnDOT Structural Element List					
#	Element Description	Type	Component	Units	Page
	Culvert Elements				
240	Steel Culvert	NBE	Culvert	LF	148
241	Concrete Culvert	NBE	Culvert	LF	152
242	Timber Culvert	NBE	Culvert	LF	156
243	Other Material Culvert	NBE	Culvert	LF	158
244	Masonry Culvert	NBE	Culvert	LF	160
870	Culvert End Treatment	ADE	Culvert	Each	162
871	Roadway Over Culvert	ADE	Culvert	Each	164
	Defect Elements				
880	Impact Damage	ADE	Miscellaneous	Each	166
881	Steel Section Loss	ADE	Miscellaneous	Each	168
882	Steel Cracking	ADE	Miscellaneous	Each	170
883	Concrete Shear Cracking	ADE	Miscellaneous	Each	172
884	Substructure Settlement & Movement	ADE	Miscellaneous	Each	173
885	Scour	ADE	Miscellaneous	Each	176
	Other Elements				
890	Load Posting and Vertical Clearance Signing	ADE	Miscellaneous	Each	178
891	Other Bridge Signing	ADE	Miscellaneous	Each	179
892	Slopes & Slope Protection	ADE	Miscellaneous	Each	180
893	Guardrail	ADE	Miscellaneous	Each	181
894	Deck & Approach Drainage	ADE	Miscellaneous	Each	182
895	Sidewalk, Curb, & Median	ADE	Miscellaneous	Each	183
899	Miscellaneous Items	ADE	Miscellaneous	Each	183
900	Protected Species	ADE	Miscellaneous	Each	184

B.3.2 CRITICAL FINDINGS AND SAFETY HAZARDS

B.3.2.1 Critical Findings or Safety Hazards (Element #800)

#800: Critical Findings or Safety Hazards (Each)

This element indicates if a critical structural deficiency or a serious safety hazard is present. *Note: This element must be rated for all structures on the MnDOT bridge inventory (vehicular bridges, culverts, railroad bridges, and pedestrian bridges).*

A critical finding is any structural condition that, if not promptly corrected, could result in collapse (or partial failure) of a bridge or culvert. This is not limited to findings observed during a scheduled inspection, and can include traffic impact damage or flood damage. It may be necessary to restrict traffic until further evaluation can be made or until the situation is corrected. A critical finding should be thoroughly documented, and the Engineer (and Bridge Owner) must be notified immediately. Critical findings must also be reported to the MnDOT Bridge Office (a report must be entered and submitted in SIMS). Refer to the reporting procedures outlined in Section A.6.2 of the Minnesota Bridge and Structure Inspection Program Manual (BSIPM). *Note: A critical structural deficiency should correlate with an NBI condition rating of 2 (critical condition) for the deck, superstructure, substructure, channel, or culvert.*

A serious safety hazard refers to a non-structural condition that poses a significant safety hazard and must be addressed immediately. Examples include severely damaged railings or guardrails, or loose concrete above traffic or a pedestrian walkway. Serious safety hazards should be immediately reported to the Inspection Program Administrator and Bridge Owner, but do not need to be reported to the MnDOT Bridge Office (a separate report in SIMS is not required).

If a critical finding (or serious safety hazard) is present on a bridge or culvert, refer to the reporting procedures outlined in Section A.6.2 of the Minnesota Bridge and Structure Inspection Program Manual (BSIPM).

Defect or Item	Condition States			
	1	2	3	4
	Good	Fair	Poor	Severe
Critical Finding	None	* Previously reported critical finding has been addressed.	NA	A critical finding is present.
Serious Safety Hazard	None	NA	A serious safety hazard is present.	NA

*After a critical finding has been addressed, the condition state rating should be changed from condition state 4 to condition state 2. The element notes should briefly describe the critical finding, note when it occurred, and explain how it was resolved.

B.3.3 DECK AND SLAB ELEMENTS

B.3.3.1 Rating Procedures for Decks and Slabs

A typical deck or slab will be rated using two structural elements. The underside is rated using one of the deck or slab elements, and the top is rated using Element #510 (Wearing Surface).

MnDOT uses 11 deck and slab elements. The square feet (SF) quantity should include the full width of the deck (out-to-out dimension) over the length of the bridge. If segments of a bridge deck are comprised of different material types, more than one deck (or slab) element should be used. If the roadway and sidewalk decks are comprised of different materials, they should be rated under separate deck (or slab) elements.

The SF quantities may be broken up into multiple conditions states. In most situations, the deck (or slab) element rating will be based upon the underside condition. In this manual, the condition rating descriptions for deck and slab elements are divided into four material groups:

- **Concrete Decks & Slabs** (Elements #12, #16 and #38)
- **Prestressed Concrete Decks & Slabs** (Elements #13, #15, and #805)
- **Timber Decks & Slabs** (Elements #31 and #54)
- **Steel Decks** (Elements #28, #29, and #30)

Most bridge decks in Minnesota are reinforced concrete. Virtually all concrete bridge decks constructed in Minnesota since 1980 have epoxy coated reinforcement; however, decks designed prior to 1986 often had epoxy coated reinforcement on the top mat only (uncoated reinforcement was used on the lower mat). These decks tend to have increased deterioration (rust staining and delamination) on the underside.

Element #510 (Wearing Surface) is used to rate the top surface on bridge decks or slabs – this element includes any wearing surface type or material. The wearing surface type, depth, and year of installation are displayed on the Minnesota Structure Inventory Report. The inspector should note any changes in the type or depth of the wearing surface. Any significant increase in dead load will require a new load rating. On decks with bituminous or gravel wearing surfaces, it is common for the wearing surface depth to increase over the years.

- On roadway bridges, the SF wearing surface quantity includes only the roadway surface area (curb to curb). Sidewalks, curbs, and raised medians are excluded.
- On pedestrian bridges, the SF wearing surface quantity includes the entire top deck surface area (curb-to-curb or rail-to-rail).
- For bridge decks that carry only rail traffic, Element #510 does not have to be rated. There is no need for a roadway agency to inspect the top of the deck on an active railroad. An appropriate deck element should be selected and rated (based upon the underside condition). The inspection report notes should indicate if the railroad is active and how many tracks are present.
- Element #510 does not need to be rated for bare timber decks (such as a timber plank deck without wearing planks), or bare steel decks (such as an open grid steel deck).

Element #810 (Concrete Wearing Surface – Cracking & Sealing) must be rated for all MnDOT bridges with a concrete wearing surface. This element is optional for other agencies. It tracks the total length of cracks in the deck wearing surface and indicates if they are sealed.

Element #521 (Concrete Protective Coating) is intended only for concrete bridge decks that have been “flood sealed” with a waterproof sealant.

B.3.3.2 Reinforced Concrete Decks & Slabs (Elements #12, #16 and #38)

Reinforced Concrete Deck & Slab Elements				
#12: Reinforced Concrete Deck (SF) **#16: Reinforced Concrete Top Flange (SF)**			**#38: Reinforced Concrete Slab (SF)**	
These elements describe the underside condition of reinforced concrete decks or slabs. The deck overhangs and vertical fascia edges should also be considered in this rating. The top surface of the deck or slab is rated using Element #510 (Wearing Surface). • Element #16 (Reinforced Concrete Top Flange) refers to the upper horizontal "flange" of box girders, cast-in-place concrete T-girders, or precast concrete channel beams. • If shear cracking is present on concrete slabs, Element #883 (Shear Cracking) must be added and rated.				
Item or Defect	**Condition States**			
	1	**2**	**3**	**4**
	Good	**Fair**	**Poor**	**Severe**
Structural Review, Repairs, or Underpinning	No deck repairs present.	Repaired area that is sound.	Repaired area that is unsound or distressed. Structural underpinning present.	Immediate repairs or structural review required. Full-depth failures present or imminent.
Delamination, Spall, or Exposed Reinforcement	None	Delamination (not yet loose). Spall 1" or less deep **and** 6" or less in diameter.	Loose delamination. Spall more than 1" deep **or** more than 6" diameter. Exposed rebar with corrosion or section loss.	Loose delamination (safety hazard). Spalling greater than 3" deep. Rebar has severe section loss.
Efflorescence (Leaching)	None	Light leaching (little or no build-up).	Heavy leaching (significant build-up or stalactites).	Severe leaching (deck failure imminent).
Water/Salt Saturation, or Rust Staining	None	Light water saturation. Minor rust stains.	Significant water/salt saturation. Rust stains indicating rebar corrosion.	Severe salt/water saturation (deck failure imminent).
Cracking and Map (Pattern) Cracking	Minor cracks or map cracking.	Moderate width cracks. Map cracking with light leaching or minor water saturation.	Wide cracks. Map cracking with heavy leaching, significant water saturation, or rust staining.	Severe cracks or full depth fractures. Deck failure may be imminent.
Stay-in-Place Steel Forms	No corrosion	Surface corrosion. Minor sagging.	Flaking rust or through corrosion. Significant bulging or sagging.	Steel forms loose (safety hazard).
Cracks less than 0.012" wide can be considered "minor", cracks from 0.012" to 0.05" wide are "moderate", cracks wider than 0.05" are "wide", and cracks 1/8" (0.125") or wider are "severe". Cracks are typically documented as a linear feet (LF) quantity. To determine condition states for square feet (SF) elements, multiply the LF crack quantity by the width of the affected area (a minimum crack width of 0.1 ft. should be assumed). Example, on a concrete deck with 200 LF of light transverse leaching cracks, multiply the 200 LF crack quantity by 0.1 ft., and rate 20 SF as condition state 2. Interconnecting transverse and longitudinal cracks are often described as pattern or map cracking. As a general rule, when the spacing between cracks is 2 ft. or less, map cracked areas or areas with concentrated cracking can be documented and rated as a SF area. Rate the SF area based upon the crack width and/or any associated defects.				

Reinforced Concrete Deck & Slab Elements

Condition Rating Examples (Reinforced Concrete Decks & Slabs)

Condition State 2
Transverse crack on the underside of a concrete deck with light leaching (efflorescence)

Condition State 2
Diagonal crack on the underside of a concrete deck with light leaching (efflorescence)

Condition State 2
Map cracking (moderate width) on the underside of a deck with no leaching or water saturation

Condition State 2
Light water saturation on the underside of a concrete deck

Reinforced Concrete Deck & Slab Elements

Condition Rating Examples (Reinforced Concrete Decks & Slabs)

Condition State 3
Map cracking with heavy leaching on the underside of a concrete deck

Condition State 3
Leaching, rust stains, and delamination on the underside of a deck (not over traffic)

Condition State 3
Significant water saturation and rust staining on the underside of a concrete deck

Condition State 3
Spalling (deeper than 1") with exposed and corroded rebar on the underside of a concrete deck

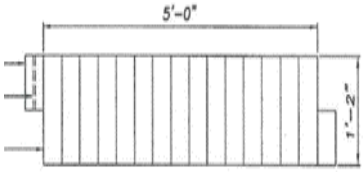
Reinforced Concrete Deck & Slab Elements	
Condition Rating Examples (Reinforced Concrete Decks & Slabs)	
 **Condition State 3** **Steel stay-in-place forms on underside of concrete deck rusted through**	 **Condition State 4** **Delaminated and loose concrete on the underside of a concrete deck (over traffic - safety hazard)**
 **Condition State 4** **Severe spalling (more than 3" deep) on the underside of a concrete deck**	 **Condition State 4** **Severe spalling (more than 3" deep) on the underside of a concrete deck**

B.3.3.3 Prestressed Concrete Decks and Slabs (Elements #13, #15, and #805)

Prestressed Concrete Deck & Slab Elements				
#13: Prestressed Concrete Deck (SF) #15: Prestressed Concrete Top Flange (SF)			**#805: Prestressed Concrete Slab (SF)**	
These elements describe the underside condition of prestressed (or post-tensioned) concrete decks or slabs. The deck overhangs and vertical fascia edges should also be considered in this rating. The top surface of the deck or slab is rated using Element #510 (Wearing Surface). • Element #15 (Prestressed Concrete Top Flange) refers to the upper horizontal "flange" of prestressed box girders or prestressed Bulb, Double, or Quad Tees. • If shear cracking is present on prestressed concrete slabs, Element #883 (Shear Cracking) must be added and rated.				
Defects	**Condition States**			
	1	**2**	**3**	**4**
	Good	**Fair**	**Poor**	**Severe**
Structural Review, Repairs, or Underpinning	No deck repairs present.	Repaired area that is sound.	Repaired area that is unsound or showing distress. Structural underpinning in good condition.	Immediate repairs or structural review required. Full-depth failures present or imminent.
Delamination, Spall, or Exposed Reinforcement	None	Delamination (not yet loose). Spalling 1" or less deep **and** 6" or less in diameter.	Loose delamination. Spalling greater than 1" deep **or** greater than 6" diameter. Exposed or corroded rebar.	Loose delamination (safety hazard). Spalling deeper than 3" or rebar with severe section loss.
Exposed Prestressing Strands	None	None	Exposed with corrosion or section loss (not severed).	Exposed with severe section loss (or severed).
Cracking and Map (Pattern) Cracking	Minor cracks or map cracking.	Moderate width cracks. Map cracking with light leaching or minor water saturation.	Wide cracks. Map cracking with heavy leaching, significant water saturation, or rust staining.	Severe cracks or full depth fractures. Deck failure may be imminent.
Efflorescence (Leaching)	None	Light leaching (little or no build-up).	Heavy leaching (significant build-up or stalactites).	Severe leaching (deck failure imminent).
Water/Salt Saturation, and Rust Staining	None	Water saturation. Minor rust stains.	Significant water/salt saturation. Rust stains indicate rebar corrosion.	Severe salt/water saturation (deck failure imminent).
Cracks less than 0.004" can be considered "minor", cracks from 0.004" to 0.009" wide can be considered "moderate", and cracks wider than 0.009" can be considered "wide". Transverse or longitudinal cracks on the underside of concrete decks (or slabs) are typically documented as a linear feet (LF) quantity. When determining condition states for square feet (SF) deck elements, the LF crack quantity should be multiplied by the estimated width of the affected concrete adjacent to the crack (a minimum crack width of 0.1 ft. should be assumed). Example, on a concrete deck with 200 LF of light transverse leaching cracks, the 200 LF crack quantity is multiplied by 0.1 ft., and 20 SF of the deck element is rated condition state 2. Interconnecting transverse and longitudinal cracks are often described as pattern or map cracking. As a general rule, when the spacing between cracks is 2 ft. or less, map cracked areas or areas with concentrated cracking can be documented and rated as a SF area. Rate the SF area based upon the crack width and/or any associated defects.				

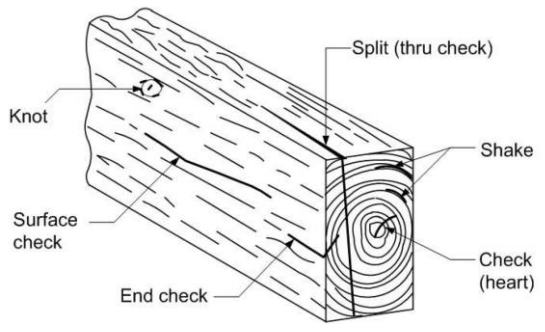
Prestressed Concrete Deck & Slab Elements	
#13: Prestressed Concrete Deck (SF) **#15: Prestressed Concrete Top Flange (SF)**	**#805: Prestressed Concrete Slab (SF)**
Condition Rating Examples (Prestressed Concrete Decks & Slabs)	
 **Condition State 2** **Light leaching along joint between prestressed voided slab panels**	 **Condition State 2** **Minor spalling (no exposed steel) along the edge of a prestressed voided slab panel**
 **Condition State 3** **Cracking with heavy leaching on the underside of a prestressed voided slab panel**	 **Condition State 4** **Loose delamination (over traffic) on the underside of prestressed voided slab panel**

B.3.3.4 Timber Decks and Slabs (Elements #31 and #54)

Timber Deck & Slab Elements	
#31: Timber Deck (SF) **#54: Timber Slab (SF)**	
These elements describe the condition of timber decks (or slabs). This includes timber plank decks, glue-lam timber deck panels, and nail laminated timber decks or slabs. The rating will typically reflect the underside condition, but should also consider the top condition on bare timber decks or slabs. If a wearing surface (bituminous overlay, gravel, timber wearing planks, or other material) is present, Element #510 (Wearing Surface) must also be rated.	
	**Timber Plank Decks** Plank decks are comprised of transverse timber planks (wide dimension in the horizontal plane). The planks are typically clipped to the top flange of steel beams, and nailed (or bolted) to timber beams. Timber plank decks are found primarily on low-volume roads or pedestrian bridges. Timber plank decks are typically bare (no overlay), but longitudinal wearing planks are sometimes present along the wheel tracks.
	**Nail-Laminated Timber Decks** Nailed-laminated timber decks consist of transverse timbers (wide dimension in the vertical position) that are nailed to the adjacent timbers. These are often installed in pre-nailed sections, with overlap joints between adjacent sections. Nailed-laminated decks may have a bituminous overlay, longitudinal timber wearing planks, or a gravel wearing surface.
	**Glulam Timber Decks** Glulam decks are similar to nail-laminated decks, except the individual timbers are bonded together with waterproof structural adhesive. The panels are typically around 4 ft. wide, and are installed transversely across the deck. Glulam timber decks are often used on temporary bridges (with a bituminous overlay). When used in new construction, they may have timber wearing planks.
  **Timber Slab Panel Cross Section**	**Timber Slabs** Timber slabs are comprised of adjacent timber planks set vertically – the timbers run longitudinally, and serve as the primary superstructure element (as well as the deck). Most timber slabs are nail-laminated, newer timber slabs may be glulam or stress-laminated. Timber slabs are typically comprised of prefabricated panels – there will often be a transverse beam running below the slab at the center of each span – these help to tie the panels together and distribute load and deflection across the width of the slab. Transverse beams below timber slabs should be rated using Element #156 (Timber Floorbeam). Timber slabs often have a bituminous or gravel wearing surface.

Timber Deck & Slab Elements #31: Timber Deck (SF) #54: Timber Slab (SF)				
Defects	**Condition States**			
	1 **Good**	**2** **Fair**	**3** **Poor**	**4** **Severe**
Structural Review	Structural review is not required.	Structural review is not required.	Structural review is not required **or** structural review has determined that strength or serviceability has not been impacted.	Condition warrants structural review **or** structural review has determined that the defects impact strength or serviceability.
Repairs	No repairs are present.	Existing repair in sound condition.	Repairs are recommended **or** existing repair is deteriorated.	Immediate repairs are required (failures present or imminent).
Section Loss	None	Less than 10% of the deck or slab thickness.	10% - 40% of the deck or slab thickness.	40% of the deck or slab thickness.
Decay	No evidence of decay.	Staining. No crushing or sagging.	Minor crushing or sagging.	Significant crushing or sagging.
Fire Damage	None	Soot or superficial charring.	Significant charring.	Severe charring.
Delamination (Glulam)	None	Minor	Significant	Severe
Weathering, Abrasion, or Section Loss	Minor surface deterioration (no section loss).	Section loss less than 10% of the member thickness.	Section loss 10% - 40% of the member thickness.	Section loss more than 40% of the member thickness.
Connection or Misalignment	Components are properly aligned and securely connected.	Loose fasteners or slight misalignment of components.	Fasteners broken or missing. Components loose or misaligned.	Components severely misaligned or missing.
Shakes, Checks, or Splits	Less than 5% of the member thickness.	5% to 50% of the member thickness and not in a tension zone.	More than 50% of the thickness (or more than 5% of the member thickness in a tension zone).	Split through entire member (or more than 25% of the member thickness in a tension zone).

- **Shake:** A separation along the grain (between the growth rings). Usually forms within a standing tree or during felling.
- **Check:** A separation perpendicular to the grain (across the growth rings). Usually results from stress due to drying shrinkage.
- **Split (or Thru Check):** A check extending further through the timber member due to tearing apart of wood cells.



Timber Deck & Slab Elements

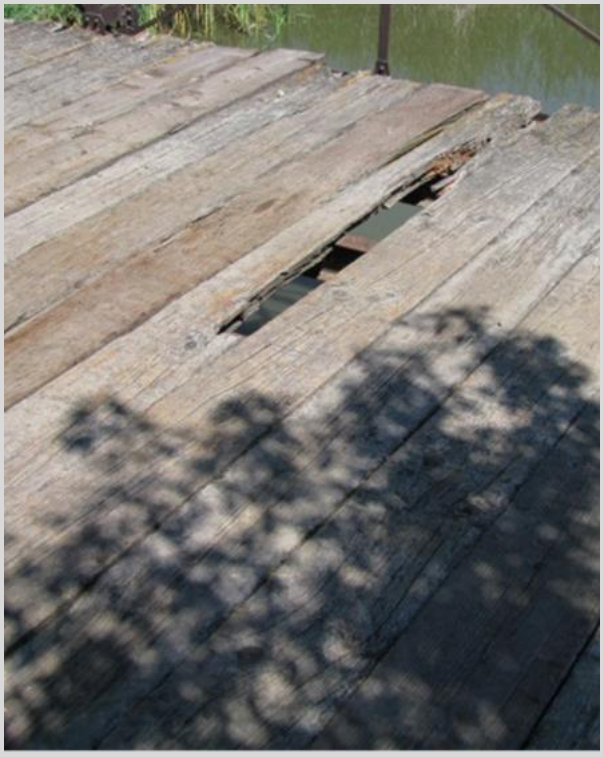
#31: Timber Deck (SF)
#54: Timber Slab (SF)

Condition Rating Examples (Timber Decks & Slabs)

Condition State 2
Weathering (minor section loss) on a timber plank

Condition State 2
Staining on the underside of a timber slab

Condition State 3
Fire damage (significant charring) on a timber slab



Condition State 4
Hole in a timber plank deck

B.3.3.5 Steel Decks (Elements #28, #29, and #30)

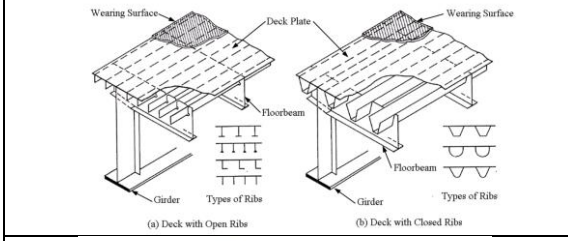
Steel Grid Deck Elements				
#28:Steel Grid Deck – Open (SF) **#29: Steel Grid Deck – Concrete Filled (SF)**				
These elements describe the condition of steel grid decks. Note: The rating should consider any deck support components that are not addressed by other structural elements.				
	**Open Grid Steel Decks (Element #28)** Open grid steel grid panels may be welded, riveted, or bolted. Note: Element 510 (Wearing Surface) does not need to be rated for open grid decks.			
	**Concrete-Filled Steel Grid Decks (Element #29)** Use this element for steel grid decks that are fully or partially filled with concrete. Note: Element 510 (Wearing Surface) would only apply to the filled section of the deck.			
Defects	**Condition States**			
	1 **Good**	**2** **Fair**	**3** **Poor**	**4** **Severe**
Structural Review or Repairs	No deck repairs present.	Repaired area that is sound.	Repaired area that is showing distress. Repairs may be recommended (structural review is not required) **or** structural review has determined that the strength of the deck has not been impacted.	Immediate repairs or structural review are required. Full-depth failures may be present or imminent **or** structural review has determined that the defects impact the strength of the deck.
Corrosion (Steel)	None	Surface corrosion (freckled rust).	Section loss or pack rust is present.	Severe section loss (holes rusted through).
Cracking (Steel)	None	Crack has self-arrested or has been arrested or repaired.	Crack that has not been arrested, but is unlikely to propagate.	Crack through deck panel (or support beam) that warrants immediate repair.
Connection or Misalignment	Deck panels are properly aligned and securely connected.	Loose fasteners or slightly misaligned deck panels.	Broken or missing fasteners. Deck panels loose or misaligned.	Steel grid deck panels severely misaligned or missing.
Impact Damage or Distortion (Steel)	Superficial damage (minor scrapes).	Deck components slightly bent, or bowed.	Deck components bent, bowed, loosened, or misaligned.	Severely bent, bowed, torn loose or missing.

Other Steel Decks

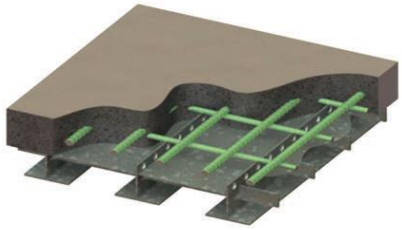
#30: Other Steel Deck (SF)

This element should be used to describe the underside condition of corrugated steel decks, orthotropic steel plate decks, exodermic decks, steel ballast plate decks, or any type of steel deck that cannot be adequately described using elements #28 or #29.
The top surface will typically be rated using Element #510 (Wearing Surface).
Note: The rating should take into consideration any deck support components that are not addressed by other structural elements.

Corrugated Steel Decks
Corrugated decks are comprised of corrugated steel forms (with concrete or bituminous fill). The steel forms provide the primary structural support for the completed deck.



Orthotropic Steel Plate Decks
An orthotropic deck consists of a steel plate that has been stiffened by closely spaced ribs. An orthotropic deck typically acts integrally with the superstructure.
None are known to currently exist in Minnesota.



Exodermic Decks
An Exodermic deck is a recently developed composite design that combines a steel grid deck with a reinforced concrete deck (advantages include light weight and rapid construction).

Steel Ballast Plate Decks
These decks are common on railroad bridges in Minnesota – they typically consist of a solid steel plate, covered with a waterproof membrane, rock ballast, and railroad ties and tracks.
Steel ballast plates are typically connected to the top flange of the supporting beams with small clips - these clips sometimes have a small chain to prevent them from falling onto traffic if they come loose.

For decks carrying a railroad tracks only, Element #510 (Wearing Surface) does not need to be rated. The inspector should note if the railroad tracks are active or if the tracks have been removed.
Railroad bridges converted to trail use may have a concrete, bituminous, or gravel wearing surface – Element #510 (Wearing Surface) should be rated.

Other Steel Decks				
#30: Other Steel Deck (SF)				
Defects	**Condition States**			
	1	**2**	**3**	**4**
	Good	**Fair**	**Poor**	**Severe**
Structural Review or Repairs	No deck repairs present.	Repaired area that is sound.	Repaired area that is showing distress. Repairs may be recommended (structural review is not required) **or** structural review has determined that the strength of the deck has not been impacted.	Immediate repairs or structural review are required. Full-depth failures may be present or imminent **or** structural review has determined that the defects impact the strength of the deck.
Corrosion (Steel)	None	Surface corrosion (freckled rust).	Section loss or pack rust is present.	Severe section loss (holes rusted through).
Cracking (Steel)	None	Crack has self-arrested or has been arrested or repaired.	Crack that has not been arrested, but is unlikely to propagate.	Crack through deck panel (or support beam) that warrants immediate repair.
Connection or Misalignment	Primary deck components are properly aligned and securely connected.	Some loose fasteners, but primary deck components are still secure.	Some fasteners broken or missing. Primary deck components may be loose or misaligned.	Primary deck components may be severely misaligned or missing.
Impact Damage or Distortion (Steel)	Superficial damage (minor scrapes).	Deck components slightly bent, bowed, or misaligned.	Deck components significantly bent, bowed, or misaligned.	Deck components severely damaged (bent, bowed, or missing).

Condition Rating Examples (Other Steel Decks)

Condition State 2
Paint failure and surface corrosion on the underside of a wrought iron ballast plate deck

Condition State 4
Hole rusted through a steel ballast plate deck (crack extending out of rust hole)

B.3.4 WEARING SURFACE ELEMENTS

#510: Deck Wearing Surface (SF)				
For bridges with a deck or slab element, this element is typically used to rate the condition of the top (wearing) surface. This table includes specific condition rating criteria for low slump concrete, plain concrete (bare decks), bituminous, epoxy chip seal, bituminous, timber plank, or gravel wearing surfaces. For other deck wearing surfaces, use the "General" condition guidelines. This element does not need to be rated for bare timber decks, open grid steel decks, or decks carrying only rail traffic.				
General Guidelines (All Wearing Surface Types)				
Item or Defect	**Structural Element Condition States**			
	1	**2**	**3**	**4**
	Good	**Fair**	**Poor**	**Severe**
General Condition	Little or no deterioration.	Minor to moderate deterioration (no repairs needed).	Significant deterioration (repairs recommended).	Severe deterioration (repairs required).

B.3.4.1 Deck Wearing Surface (Element #510)

#510: Deck Wearing Surface – Low Slump Overlay (SF)				
Low slump concrete overlays are the most common wearing surface on concrete bridge decks in Minnesota (approximately 66% of the concrete bridge deck area). Low slump overlays are intended to provide a high-density surface to protect the underlying deck from chlorides. This is typically a 2" layer of concrete with a high cement content, small course aggregate, and a ¾" slump (such as MnDOT mix #3U17A). Low slump concrete is mixed at the bridge site, and is bonded to the deck with a grout layer.				
Item or Defect	**Structural Element Condition States**			
	1	**2**	**3**	**4**
	Good	**Fair**	**Poor**	**Severe**
Delamination or Spalling	None	Spalls less than ½" deep. No delamination.	Spalls from ½" to 1½" deep. Delamination.	Spalls 1½" deep or greater. Loose overlay sections.
Scale, Wear, or Abrasion	Less than ¼" deep.	From ¼" up to ½" deep.	From ½" up to 1½" deep.	1½" deep or greater.
Patching or Repairs	None	Permanent patches (concrete or other high quality repair) that remain sound.	Bituminous or other temporary patches. Deteriorated repairs.	Repair patches that have failed.
Cracking and Map (Pattern) Cracking	Unsealed minor cracks less than 0.012″ wide.	Unsealed moderate width cracks (from 0.012″ up to 0.05″). Sealed cracks less than 1/8″ wide.	Unsealed wide cracks (from 0.05″ up to 1/8″).	Severe cracks (1/8″ or wider).
• Transverse or longitudinal cracking in a low slump overlay is typically documented as a linear feet (LF) quantity. When determining condition ratings for Element #510, cracks must be converted to a square feet (SF) quantity by multiplying by the width of the affected concrete adjacent to the crack (a minimum width of 0.1 ft. should be assumed). Example, on a low slump concrete overlay with 1,000 LF of unsealed transverse cracks (with a typical crack width 1/16″), the 1,000 LF crack quantity is multiplied by 0.1 ft.), and 100 SF of Element #510 would be rated as condition state 3. • Interconnecting transverse and longitudinal cracks are often described as pattern or map cracking. As a general rule, when the spacing between cracks is 2 ft. or less, map cracked areas or areas with concentrated cracking can be documented and rated as a SF area. Rate the SF area based upon the crack width and/or any associated defects.				

#510: Deck Wearing Surface – Low Slump Overlay (SF) Condition Rating Examples (Low Slump Concrete Overlay)	
 **Condition State 2** **Map cracking (1/32″ or 0.03″ wide) on a low slump concrete overlay**	 **Condition State 2** **Sealed transverse cracks (medium width) on a low concrete slump overlay**
 **Condition State 2** **Sound concrete patch on a low slump overlay**	 **Condition State 2** **Scaling (1/4″ deep) on a low slump overlay**
 **Condition State 3** **Map cracking (1/16″ or 0.06″ wide) with failed sealant on a low slump overlay**	 **Condition State 3** **Bituminous patch on a low slump concrete overlay**

Condition State 3
Delamination on a low slump concrete overlay

Condition State 3
Crack ($^{1}/_{16}$″ or 0.06″ wide) in a low slump overlay

Condition State 4
Failed bituminous patch on a low slump overlay

Condition State 4
Failed patch on low slump concrete overlay

#510: Deck Wearing Surface – Plain Concrete (SF)				
This element should be used for concrete wearing surfaces that are not low slump concrete. This may include concrete decks without an overlay, monolithic decks that include a wearing surface layer (poured with the underlying deck), or plain concrete wearing surfaces added to the deck. Bridge decks (or slabs) are constructed without a low slump overlay when there are construction time constraints or on bridges with a low traffic volume. Concrete bridge decks (or slabs) constructed prior to the 1970's are often bare.				
Item or Defect	**Structural Element Condition States**			
	1	**2**	**3**	**4**
	Good	**Fair**	**Poor**	**Severe**
Delamination or Spalling	None	Spalling less than ½″ deep. No delamination.	From ½″ up to 2″ deep (no exposed reinforcement). Delamination. Rust stains due to rebar corrosion.	2″ deep or greater **or** with exposed reinforcement
Scale, Wear, or Abrasion	Less than ¼″ deep.	From ¼″ up to ½″ deep.	From ½″ up to 2″ deep (no exposed reinforcement).	2″ deep or greater **or** with exposed reinforcement
Patching or Repairs	None	Concrete (or other high quality) patches that. remain sound	Temporary patches (such as bituminous) **or** Deteriorated repairs.	Repair patches that have failed.
Cracking or Map (Pattern) Cracking	Unsealed minor cracks less than 0.012″ wide.	Unsealed moderate width cracks (from 0.012″ up to 0.05″). Sealed cracks less than 1/8″ wide.	Unsealed wide cracks (from 0.05″ up to 1/8″).	Severe cracks (1/8″ or wider).
• Transverse or longitudinal cracking in a concrete wearing surface is typically documented as a linear feet (LF) quantity. When determining condition ratings for Element #510, cracks must be converted to a square feet (SF) quantity by multiplying by the estimated width of the affected concrete adjacent to the crack (a minimum crack width of 0.1 ft. should be assumed). Example, on a concrete wearing surface with 1,000 LF of unsealed transverse cracks (with a typical crack width 1/16"), the 1,000 LF crack quantity is multiplied by 0.1 ft.), and 100 SF of Element #510 would be rated as condition state 3. • Interconnecting transverse and longitudinal cracks are often described as pattern or map cracking. As a general rule, when the spacing between cracks is 2 ft. or less, map cracked areas or areas with concentrated cracking can be documented and rated as a SF area. Rate the SF area based upon the crack width and/or any associated defects.				

#510: Deck Wearing Surface – Plain Concrete (SF)

Condition Rating Examples (Plain Concrete Wearing Surface)

Condition State 2
Map cracking (1/32″ or 0.03″ wide) on a bare concrete deck

Condition State 2
Sealed cracks (moderate width) on a bare concrete deck

Condition State 2
Sound concrete patches on a bare concrete deck

Condition State 3
Bituminous patch on a bare concrete deck

Condition State 3
Transverse crack ($^{1}/_{16}$″ or 0.06″ wide) in a bare concrete deck

Condition State 3
Map cracked area with rust staining on a bare concrete deck

#510: Deck Wearing Surface – Plain Concrete (SF)	
Condition Rating Examples (Plain Concrete Wearing Surface)	
 **Condition State 3** **Shallow spall (1″ deep with no exposed reinforcement) on a bare concrete deck**	 **Condition State 3** **Deteriorated (map cracked) patch on a bare concrete deck**
 **Condition State 4** **Failed patch (exposed reinforcement) on a bare concrete deck**	 **Condition State 4** **Spalling 2″ or deeper on a bare concrete deck**

#510: Deck Wearing Surface – Bituminous (SF)				
Bituminous wearing surfaces are mainly found on older (pre-1970's) concrete bridge decks, laminated timber bridge decks, or timber slab span bridges.				
Item or Defect	**Structural Element Condition States**			
	1	**2**	**3**	**4**
	Good	**Fair**	**Poor**	**Severe**
Potholes	No potholes.		Less than 2" deep (underlying deck is not exposed).	2" or deeper (or underlying deck is exposed).
Wear or Rutting	Minor wearing, no rutting.	Moderate wearing or minor rutting.	Significant wearing or rutting.	Severe wearing or rutting.
Patching or Repairs	None	Patches that remain sound.	Deteriorated patches or repairs.	Repair patches that have failed.
Cracking	Minor cracks	Moderate unsealed cracks. Sealed cracks.	Significant unsealed cracks.	Severe unsealed cracks.

Condition Rating Examples (Bituminous Wearing Surface)

Condition State 2
Sealed crack on a bituminous overlay

Condition State 2
Sound patches on a bituminous overlay

Condition State 3
Significant cracking on a bituminous overlay

Condition State 4
Pothole (2" deep) in bituminous overlay

#510: Deck Wearing Surface – Epoxy Chip Seal Overlay (SF)

Minnesota starting using epoxy chip seal overlays on concrete decks around 2012. While they have only been used on a handful of bridge decks, many of those are large major river crossings. Epoxy chip seal overlays are comprised of a thin epoxy layer covered with small course aggregate. They have been used on new and existing concrete decks, they have been used on bare decks as well as decks that already had a low slump overlay.

Item or Defect	Structural Element Condition States			
	1 Good	2 Fair	3 Poor	4 Severe
Delamination, Bubbling, or Adhesion Failure	No delamination or bubbling of the epoxy layer.		Delamination or bubbling of epoxy layer.	Epoxy layer loose or missing.
Scale, Wear, or Abrasion	None	Minor to moderate aggregate loss or polishing of surface (no significant friction loss).	Significant loss of aggregate or polishing of surface (noticeable loss of friction).	Severe wear – loss of friction could pose a hazard in adverse weather conditions.
Patching or Repairs	None	Permanent patches that remain sound.	Temporary patches **or** deteriorated repairs.	Repair patches that have failed.
Cracking	None	Minor to moderate. Sealed cracks.	Significant	Severe

Condition Rating Examples (Chip Seal Overlay)

Condition State 2
Repair patch on a chip seal overlay

Condition State 3
Significant cracking on a chip seal overlay

Condition State 4
Chip seal overlay peeling off (loose)

Condition State 4
Chip seal overlay missing

#510: Deck Wearing Surface – Timber Planks (SF)

The wearing surface element is not used for bare timber decks. This element is intended only for timber decks that have an additional layer of timber wearing planks (typically orientated parallel to traffic). Wearing planks may be present over the entire deck, or only along the wheel tracks.

Item or Defect	Structural Element Condition States			
	1 Good	2 Fair	3 Poor	4 Severe
Connections	Timber wearing planks are properly aligned and solidly attached.		Timber planks are slightly loose or misaligned.	Timber planks are loose or missing.
Timber Deterioration	Minor weathering or splitting.	Moderate weathering or splitting. Minor decay.	Significant splitting, decay, or section loss (no crushing or sagging).	Severe splitting, decay, or section loss (crushing or sagging).

Condition Rating Examples (Timber Wearing Planks)

Condition State 1
Minor weathering on timber wearing planks

Condition State 2
Moderate weathering on a timber wearing plank

Condition State 3
Significant decay on timber wearing planks

Condition State 4
Section of timber wearing plank missing

#510: Deck Wearing Surface – Gravel (SF)

A gravel (or dirt) wearing surface may be present on concrete or timber bridge decks. As gravel roads are periodically graded, the gravel depth on the bridge deck may vary. The inspector should attempt to determine the depth of gravel present on a bridge deck, as it may be a significant dead load on the bridge.

Item or Defect	Structural Element Condition States			
	1	2	3	4
	Good	Fair	Poor	Severe
General Deterioration	Gravel is evenly graded and flat.	Minor to moderate rutting or ponding.	Significant rutting or ponding.	Severe rutting.

Condition Rating Examples (Gravel Wearing Surface)

Condition State 1
Gravel evenly graded and smooth

Condition State 2
Moderate ponding on a gravel wearing surface

Condition State 3
Significant rutting on a gravel wearing surface

Condition State 3
Significant rutting on shoulder

B.3.4.2 Concrete Wearing Surface – Cracking and Sealing (Element #810)

#810: Concrete Wearing Surface – Cracking & Sealing (LF)

This element is intended to describe the quantity (and severity) of cracking on concrete wearing surfaces, approach slabs, sidewalks, or medians, and to identify if crack sealing is required. If the deck or approach slab has a bituminous or gravel wearing surface, there is no need to use this element. Cracking of the top surface will eventually result in chloride contamination of the underlying concrete deck or approach slab, and corrosion of the reinforcing steel – sealing these cracks can extend the service life of the deck.

Note: This element is required for MnDOT bridges with concrete deck wearing surfaces; it is optional for other agencies.

The inspector should first determine the total linear feet (LF) of sealed and unsealed cracks on the concrete wearing surface, concrete sidewalks, and concrete medians. This should include all transverse, longitudinal, diagonal, or random cracks that can be quantified in linear feet (LF). The cracks should then be rated using the following criteria.

Defect or Item	Condition States			
	1	2	3	4
	Good	Fair	Poor	Severe
Unsealed Cracks	Unsealed cracks less than 0.012" wide.	Unsealed cracks from 0.012" wide up to 0.05" wide.	Unsealed cracks from 0.05" wide up to 1/8" wide.	Unsealed cracks 1/8" or wider.
Sealed Cracks	NA	Crack is effectively sealed.	NA	NA

B.3.4.3 Concrete Protective Coating (Element #521)

#521: Concrete Protective Coating (SF)

This element is primarily intended for concrete bridge decks that have been flood sealed with High Molecular Weight Methacrylate (HMWM) sealants. It could also be used for decks coated with Silane or Siloxane water-proofers, or similar products. These coatings will generally be effective at sealing cracks for about 5-6 years. These coatings are difficult to see or inspect. The inspector should look for obvious unsealed cracks on the wearing surface or obvious leakage through cracks on the underside of the deck. **Note: This element does not apply to epoxy chip seal overlays – they should be rated using Element #510.**

Defect or Item	Condition States			
	1	2	3	4
	Good	Fair	Poor	Severe
Unsealed Cracks	Unsealed cracks less than 0.012" wide.	Unsealed cracks from 0.012" wide up to 0.05" wide.	Unsealed cracks from 0.05" wide up to 1/8" wide.	Unsealed cracks 1/8" or wider.

Transverse or longitudinal cracking in a concrete wearing surface is typically documented as a linear feet (LF) quantity. When determining condition ratings for Element #521, cracks must be converted to a square feet (SF) quantity by multiplying by the estimated width of the affected concrete adjacent to the crack (a minimum crack width of 0.1 ft. should be assumed). Example, on a flood sealed deck wearing surface with 100 LF of unsealed transverse cracks (with a typical crack width 1/16"), the 100 LF crack quantity is multiplied by 0.1 ft., and 10 SF of the Element #521 would be rated as condition state 3.

B.3.5 DECK JOINT ELEMENTS

Deck Joint Elements

MnDOT has eight structural elements to rate the condition of bridge deck joints:

- #300 – Strip Seal Deck Joint (LF)
- #815 – Plow Fingers (Each)
- #301 – Poured Deck Joint (LF)
- #302 – Compression Seal Deck Joint (LF)
- #303 – Modular Deck Joint (LF)
- #304 – Open Deck Joint (LF)
- #305 – Assembly Deck Joint (LF)
- #816 – Approach Relief Joint (LF)

Deck Joint Element Quantities

For most deck joints, the plan quantity (LF) will be entered as the element quantity. This will typically include the roadway portion of the joint, but may also include portions of the joint that extend through railings or under sidewalks and medians.

On bridge deck joints, steel cover plates are often present at the curbs, medians, sidewalks, and railings. These cover plates are a component of the deck joint, and should be rated as part of the deck joint element. If a sealed joint (such as a strip seal or modular joint) extends below a sidewalk or median, that section should be rated under the strip seal or modular joint element. If the seal does not extend below the sidewalk or median, that portion of the joint should be rated under a separate deck joint element (typically Element #305 – Assembly Joint).

Inspection of Deck Joints

Deck joints should be inspected for leakage, as well as for proper function. Deck joint leakage is a significant concern in Minnesota due to de-icing salt applied to roadways and sidewalks. Deck joint leakage that results in damage to the superstructure or substructure below the joint should result in a lowered condition rating, even if the joint is not designed or intended to be sealed.

Deck joints should be examined for skew, offset, or any evidence that the joint is restricted or is beyond the limits of expansion or contraction. Deck expansion joints that are closed tightly, offset vertically or horizontally, or have large gaps may indicate severe structural problems (such as substructure movement).

Deck Joint Measurements

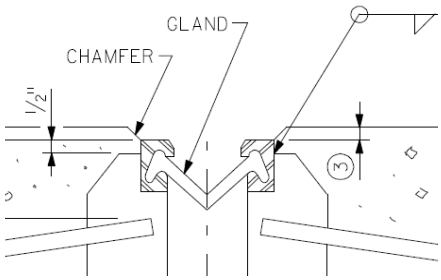
In order to confirm that deck expansion joints are properly functioning, periodic joint measurements are recommended. Joint measurements should be taken at the same location, in a consistent manner, and ideally under a wide range of temperatures.

A common place to take deck joint gap measurements is at the shoulder stripes. The gap between the inside vertical faces of the joint is typically measured. Measurements can also be taken at railing gaps or at sidewalk or curb cover plates. Recent scrape marks along the edges of cover plates are a good indication that the joint is expanding and contracting.

B.3.5.1 Strip Seal Deck Joint (Element #300)

#300: Strip Seal Deck Joint (LF)

This element applies to deck joints that utilize a single line "V" shaped neoprene gland, typically held in place by a steel extrusion.



Strip seal deck joints came into use in Minnesota around 1974, and are now the most common type of bridge deck expansion joint used in the state.

- Type 4 joints are designed to accommodate 4" of movement (they are typically installed with a 2" gap).
- Type 5 joints are designed to accommodate 5" of movement. They are often used on skewed joints.

The condition state language for Element #300 (Strip Seal Deck Joint) is configured with the intent that joints requiring replacement (or concrete/steel extrusion repairs) are rated as condition state 4, and that joints requiring gland repair or replacement are rated as condition state 3.

Item or Defect	Structural Element Condition States			
	1	2	3	4
	Good	Fair	Poor	Severe
General Joint Condition	Little or no deterioration.	Minor to moderate deterioration (no repairs needed).	Strip seal gland repair or replacement is required.	Joint reconstruction or concrete repair work is required.
Joint Function and Alignment	Joint is functioning as intended (movement is not restricted).		Slight restriction of joint movement.	Joint is restricted (not functioning as intended).
	Horizontal joint gap is within design limits.		Joint gap is at or near design limits.	Joint is closed to less than ½" or has opened beyond design limits.
	No vertical offset.	Vertical offset of ¼" or less.	Vertical offset of ½" or less.	Vertical offset greater than ½".
Leakage	None	Minimal leakage (slight dripping).	Significant leakage.	NA
Strip Seal Gland	Securely anchored and properly positioned.	Strip seal gland is partially pulled out of the extrusion.	Strip seal gland is torn, punctured, or pulled out from the extrusion.	NA
Steel Extrusions, Anchorages, or Cover Plates	Minor surface corrosion or superficial scrapes.	Corrosion (or damage), that does not affect joint function.	NA	Damage or section loss that prevents proper joint function or presents a safety hazard.
Adjacent Deck or Header	Sound.	Deterioration that does not affect joint function.	NA	Significant deterioration that affects joint function.

#300 : Strip Seal Deck Joint (LF)

Condition Rating Examples (Strip Seal Deck Joints)

Condition State 2
Strip seal gland partially pulled out

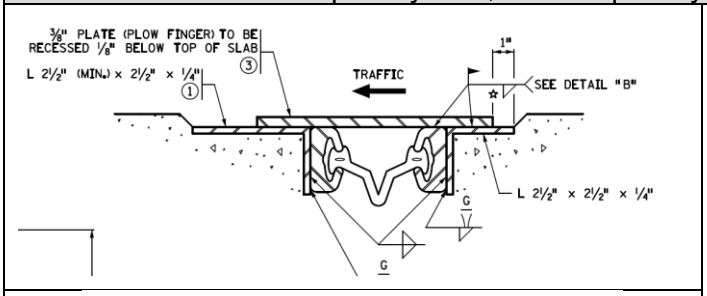
Condition State 3
Hole in strip seal gland

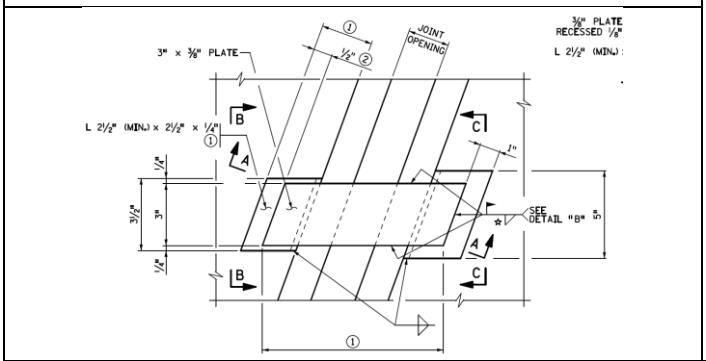
Condition State 4
Strip seal deck joint closed to less than a ½" gap

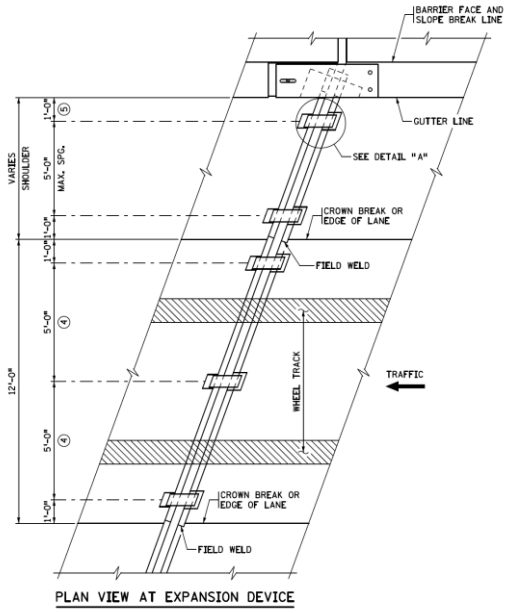
Condition State 4
Joint open beyond design limits (5" gap) – the gland has pulled out of the steel extrusion

B.3.5.2 Plow Fingers (Element #815)

#815: Plow Fingers (1 Each)
Plow fingers are small steel plates welded to bridge deck expansion joints to prevent a snow plow blade from falling into the joint. They are typically installed on strip seal expansion joints that are skewed to an angle that approximates the angle of a snow plow (skews between 15° and 50°). The current design standard (MnDOT Standard Detail 5-397.628) is a 3/8" thick steel plate (3" wide – length varies) that is welded to one side of the joint and can slide freely on the other side. Plow fingers are spaced at 5 ft. intervals, with 3 plow fingers in each traffic lane (a typical MnDOT snowplow blade is 11 to 12 ft. wide). Note: This is an "each" quantity item, but the quantity should be left as "1".







Item or Defect	Structural Element Condition States			
	1	2	3	4
	Good	Fair	Poor	Severe
Plow Fingers Missing (Individual Joint)	All plow fingers are present.	No adjacent plow fingers missing on any particular joint.	Two adjacent plow fingers missing on any particular joint.	3 or more adjacent plow fingers missing on a particular joint.
Plow Fingers Missing (Entire Bridge)		3 or less plow fingers missing on the entire bridge.	4 to 7 plow fingers missing on the entire bridge.	More than 7 plow fingers missing on the entire bridge.
Plow Fingers Missing (Entire Bridge)		Less than 10% of plow fingers missing on the entire bridge.	11% to 25% of plow fingers missing on the entire bridge.	More than 25% of plow fingers missing on the entire bridge.



B.3.5.3 Poured Seal Joint (Element #301)

#301: Poured Seal Joint (LF)				
This element applies to joints filled with a poured or extruded sealant – this typically refers to transverse saw and seal joints (above piers or along end blocks), but can include any poured joint on the bridge deck or on a concrete bridge approach panel. The condition state language for Element #301 (Poured Seal Joint) is configured with the intent that joints requiring reconstruction (or concrete repairs) are rated as condition state 4, and that joints that need to be resealed are rated as condition state 3.				
Item or Defect	**Structural Element Condition States**			
	1	**2**	**3**	**4**
	Good	**Fair**	**Poor**	**Severe**
General Joint Condition	Little or no deterioration	Minor to moderate deterioration (no repairs needed).	Joint resealing is required.	Joint reconstruction or concrete repair work is required.
Joint Alignment	No vertical offset.	Slight vertical offset (1/4” or less).	Vertical offset (1/2” or less).	Vertical offset greater than ½”.
Leakage	None	Minimal. Minor dripping through the joint.	Significant leakage is present on the underside of the joint.	NA
Joint Adhesion	Joint sealant is properly adhered.	Minor adhesion failure or seal deterioration.	Complete adhesion failure. Seal has severe deterioration or is missing.	NA
Adjacent Deck, End Block, or Concrete Approach Panel	Sound and intact.	Spalling or deterioration that does not affect joint function.	NA	Spalling or deterioration that prevents proper joint function or presents a safety hazard.

#301: Poured Seal Joint (LF)

Condition Rating Examples (Poured Deck Joints)

Condition State 3
Section of poured seal missing

Condition State 4
Cracking and delamination adjacent to a transverse poured deck joint

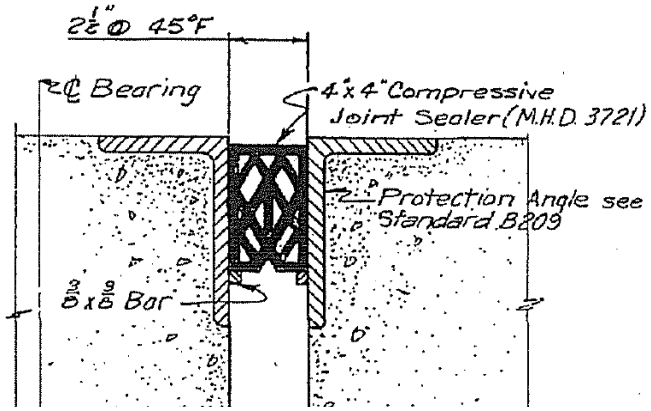
Condition State 4
Extensive deck deterioration (bituminous patching) along transverse poured deck joints

Condition State 4
Severe spalling along a longitudinal poured joint

B.3.5.4 Compression Seal Deck Joint (Element #302)

#302: Compression Seal Deck Joint (LF)

This element applies to deck joints consisting of a pre-formed elastic compression seal.
Note: This element should not be used for approach relief joints (use Element #816 instead).



Compression seal deck joints were phased out in favor of strip seal joints around 1975 (only a few remain on Minnesota bridges).

Compression seals may have a solid or hollow cross-section. The joint may or may not include steel protection angles along the deck edges.

A cross-section plan diagram of typical compression seal deck joint (with steel protection angles) is shown at left.

The condition state language for Element #302 (Compression Seal Deck Joint) is configured with the intent that joints requiring replacement (or concrete/steel protection angle repairs) are rated as condition state 4, and that joints requiring seal repair or replacement are rated as condition state 3.

Item or Defect	Structural Element Condition States			
	1	2	3	4
	Good	Fair	Poor	Severe
General Joint Condition	Little or no deterioration	Minor to moderate deterioration (no repairs needed).	Compression seal gland repair or replacement is required.	Joint reconstruction or concrete repair work is required.
Joint Function and Alignment	Joint is functioning as intended (movement is not restricted).		Slight restriction of joint movement.	Joint is restricted (not functioning as intended).
	Horizontal joint gap is within design limits.		Joint gap width is at or near the design limits.	Joint is closed tightly or gap has opened beyond design limits.
	No vertical offset.	Vertical offset of ¼" or less.	Vertical offset of ½" or less.	Vertical offset greater than ½".
Leakage	None	Minimal leakage (slight dripping).	Significant leakage.	NA
Compression Seal Gland	Securely anchored.	Gland partially pulled out, pushed up, or dropped slightly.	Compression seal gland is torn, punctured, pulled out, or fallen out.	NA
Steel Protection Angles, Anchors, or Cover Plates	Minor surface corrosion or superficial scrapes.	Corrosion (or damage), that does not affect joint function,	NA	Damage or section loss that prevents proper joint function or presents a safety hazard.
Adjacent Deck or Header	Sound	Spalling that does not affect joint function.	NA	Significant spalling that affects joint function.

#302: Compression Seal Deck Joint (LF)

Condition Rating Examples (Compression Seal Deck Joint)

Condition State 2
Plow damage on steel protection angle along compression joint

Condition State 3
Compression seal gland has dropped out of joint

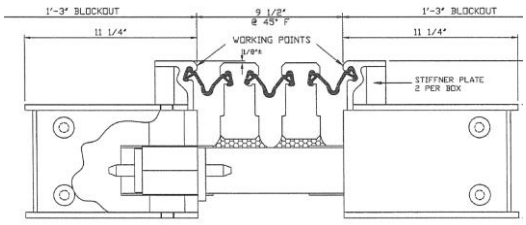
Condition State 4
Steel protection angle on a compression seal joint fractured and separated

Condition State 4
Severe spalling (temporary patch) along a compression seal joint

B.3.5.5 Modular Deck Joint (Element #303)

#303: Modular Deck Joint (LF)

This element only applies to modular deck joints comprised of two or more adjacent waterproof seals ("V" strip or compression seal).



Modular deck joints came into use in Minnesota in the 1980's, and are now the standard deck joint used if more than 4" of expansion must be accommodated. A cross-section diagram of a 3-gland modular deck joint is shown at left.

The seals are anchored by steel extrusions cast into the deck, and are typically supported from below by small beams (with an independent expansion bearing system). Modular joints typically incorporate equalizer springs and guide systems to keep the seals equally spaced and properly aligned. The underside support beams and equalizer system on a 7-gland modular joint are shown at left.

The condition state language for Element #303 (Modular Deck Joint) is configured with the intent that joints requiring replacement (or concrete/steel extrusion repairs) are rated as condition state 4, and that joints requiring seal repair/replacement are rated as condition state 3.

Item or Defect	Structural Element Condition States			
	1 Good	2 Fair	3 Poor	4 Severe
Joint Function and Alignment	Joint is functioning as intended (movement is not restricted).		Slight restriction of joint movement.	Joint is restricted (not functioning as intended).
	Overall joint gap is within design limits. Individual joint gaps are relatively equal.		Individual (or overall) joint gaps are at or near the design limits.	Individual (or overall) joint gaps are beyond design limits.
	No vertical offset.	Vertical offset of ¼" or less.	Vertical offset of ½" or less.	Vertical offset greater than ½".
Leakage	None	Minimal	Significant	NA
Seals (Glands)	Secure and properly positioned.	Seal partially pulled out of extrusion.	Seal torn, punctured, or pulled out of extrusion.	NA
Support Beams and Equalizer System	Little or no deterioration	Minor to moderate deterioration (no repairs needed).	Equalizer/guide components loose, missing, or malfunctioning. Joint support loose or misaligned.	Joint support is dislodged, jammed, detached, or missing.
Steel Extrusions or Cover Plates	Minor surface corrosion or superficial scrapes.	Corrosion (or damage), that does not affect joint function.	NA	Damage or section loss that prevents proper joint function or presents a safety hazard.
Adjacent Deck or Header	Sound	Minor spalling (doesn't affect joint function).	NA	Significant spalling that affects joint function.

#303: Modular Deck Joint (LF)

Condition Rating Examples (Modular Deck Joints)

Condition State 1

Minor surface corrosion on steel extrusions (debris is not affecting the joint function)

Condition State 2

Minor leakage (with surface corrosion) on underside of a modular joint

Condition State 3

Modular joint gaps are uneven (equalizer system is not functioning properly) - one gland is pulled out.

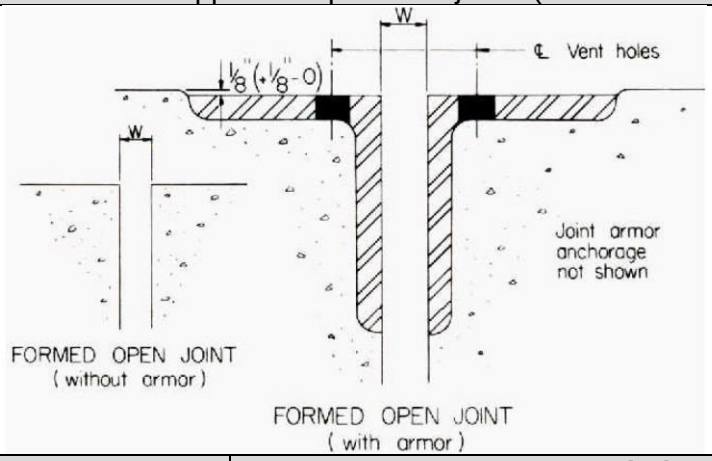
Condition State 4

Support missing from underside of modular joint - gland has fallen out and is hanging down

B.3.5.6 Open Deck Joint (Element #304)

#304: Open Deck Joint (LF)

This element applies to open deck joints (with or without steel protection angles).



Due to the heavy use of chlorides on roadways during the winter months, open joints are rarely used on bridge decks in Minnesota.

Leakage through an open deck joint should be considered in the condition rating if it is contributing to deterioration of superstructure or substructure elements located below the joint.

Item or Defect	Structural Element Condition States			
	1	2	3	4
	Good	Fair	Poor	Severe
Joint Function and Alignment	Joint is functioning as intended (movement is not restricted).		Slight restriction of joint movement.	Joint is completely restricted (no longer functioning as intended).
	Horizontal joint gap is within design limits.		Joint gap width is at or near the design limits.	Joint is closed tightly or gap has opened beyond design limits.
	No vertical offset.	Vertical offset of ¼" or less.	Vertical offset of ½" or less.	Vertical offset greater than ½".
Leakage	Leakage is effectively directed away from structure below.	Leakage through joint is causing minor damage to structure below.	Leakage through joint is causing significant damage to structure below.	NA
Steel Extrusions or Cover Plates	Minor surface corrosion.	Minor section loss or traffic damage.	Section loss or traffic damage that does not affect joint function.	Severe section loss or traffic damage that prevents proper joint function or presents a safety hazard.
Adjacent Deck or Header	Sound	Minor spalling.	Moderate spalling that does not affect joint function.	Significant spalling that affects joint function.

#304: Open Deck Joint (LF)

Condition Rating Examples (Open Deck Joints)

Condition State 2
Minor spalling along an open deck joint

Condition State 3
Leakage through and open deck joint resulting in severe corrosion of superstructure below

Condition State 3
Moderate spalling along an open deck joint (does not impact function or present a safety hazard)

Condition State 4
Open joint contacting at curb (no further expansion is permitted) – deck is offset laterally

B.3.5.7 Assembly Deck Joint (Element #305)

#305: Assembly Deck Joint (LF)				
This element applies to finger plate deck joints, sliding plate deck joints, or any other joint that cannot be adequately defined by the other joint elements. Note: This element includes joints with or without seals or drainage systems. Joint leakage should be considered in the condition rating, particularly if it is contributing to deterioration of superstructure or substructure elements located below the joint.				
Item or Defect	**Structural Element Condition States**			
	1	**2**	**3**	**4**
	Good	**Fair**	**Poor**	**Severe**
Joint Function and Alignment	Joint is functioning as intended (movement is not restricted).		Slight restriction of joint movement.	Joint is completely restricted (not functioning).
	Horizontal joint gap is within design limits.		Joint gap width is at or near the design limits.	Joint is closed tightly or gap has opened beyond design limits.
	No vertical offset.	Vertical offset of ¼" or less.	Vertical offset of ½" or less.	Vertical offset greater than ½".
Leakage (Sealed Joints)	None	Minimal	Significant leakage is present.	NA
Leakage (Joints without Seals)	Leakage is effectively directed away from structure below.	Leakage through joint is causing minor damage to the structure below.	Leakage through joint is causing significant damage to the structure below.	NA
Seal Torn, Punctured, or Pulled Out of Extrusion	None	Seal gland is partially pulled out.	Seal is torn, punctured, or pulled out completely.	NA
Steel Plate Corrosion or Damage	Minor surface corrosion.	Minor section loss or traffic damage.	Section loss or traffic damage that does not affect joint function.	Severe section loss or traffic damage (affects joint function).
Steel Plate Anchorage	Steel plates are properly anchored (no noise under traffic) – all anchor bolts are intact.		Plate may be slightly loose (noise under traffic) – anchor bolts loose or missing.	Plate is loose or missing.
Adjacent Deck or Header	Sound	Minor spalling.	Moderate spalling that does not affect joint function.	Significant spalling that affects joint function.

#305: Assembly Deck Joint (LF)

Condition Rating Examples (Assembly Deck Joints)

Condition State 2
Anchor bolt covers missing from a "Wabo®Flex" deck expansion joint

Condition State 3
Spalling and temporary patching along a sliding plate deck joint (does not impact joint function)

Condition State 3
Finger joint laterally misaligned (fingers contacting)

Condition State 4
Finger joint is opened beyond design limits (gap between the two finger plates)

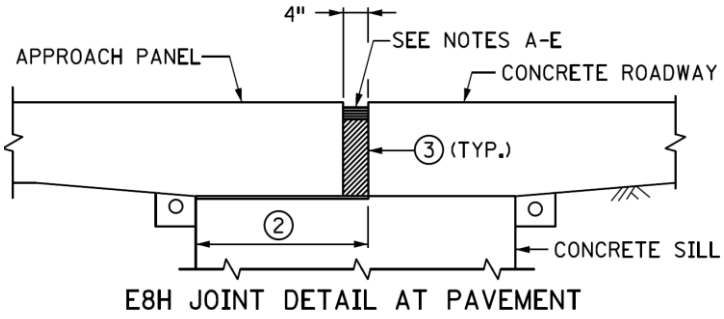
B.3.5.8 Approach Relief Joint (Element #816)

#816: Approach Relief Joint (LF)

This element applies to approach relief joints. A typical "E-8" approach relief joint is 4" wide (some are 2" wide), and consists of a preformed polystyrene filler (MnDOT Spec. #3702) with a hot poured seal (MnDOT Spec. #3725). Approach relief joints are typically located at the roadway end of the approach panel adjacent to the approach roadway.

Note: As bridges with "Integral" or "Semi-Integral" abutments typically do not have expansion joints on the bridge deck, the approach relief joint must accommodate expansion/contraction of the bridge deck as well as the approach roadway. If approach relief joints are present on such bridges, it is particularly important that they be functioning properly.

Periodic relief joint gap measurements at different temperatures are recommended – particularly on bridges with "Integral" or "Semi-Integral" abutments that have no deck expansion joints.



E8H JOINT DETAIL AT PAVEMENT

A cross-section of a typical "E8H" Approach Relief Joint (note 3) is shown at left.

Concrete approach slabs are typically supported by a concrete sill. A plastic sheet on top of the sill (note 2) breaks the bond, allowing the approach slab to expand and contract.

The condition state language for Element #816 (Approach Relief Joint) is configured with the intent that joints requiring reconstruction (or concrete repairs) are rated as condition state 4, and that joints that need to be resealed are rated as condition state 3.

Item or Defect	Structural Element Condition States			
	1 Good	2 Fair	3 Poor	4 Severe
Joint Function and Alignment	Joint is functioning as intended (movement is not restricted).		Slight restriction of joint movement.	Joint is completely restricted (no longer functioning).
Joint Gap (for a 4" Relief Joint)	Joint gap is between 3" and 5".		Closed to less than 3" or opened to more than 5".	Closed to less than 2" or opened to more than 6".
Joint Seal & Filler	Little or no deterioration	Minor to moderate deterioration of seal (foam filler still in place).	Poured seal has failed - foam filler may be missing.	NA
Adjacent Deck or Header	Sound	Minor spalling.	Moderate spalling that does not affect joint function.	Significant spalling that affects joint function.

#816: Approach Relief Joint (LF)

Condition Rating Examples (Approach Relief Joints)

Condition State 2
Minor spalling along an approach relief joint

Condition State 2
Partial failure of poured seal on an approach relief joint

Condition State 3
Poured seal and foam filler missing from an approach relief joint

Condition State 4
Severe spalling (temporary patch) along approach relief joint

B.3.6 BRIDGE RAILING ELEMENTS

Bridge railing elements apply to railing mounted on bridge decks, approaches, or wingwalls. This includes vehicular barriers, ornamental railing, pedestrian fencing, and handrails. Railing elements can also be used for railings directly connected to culvert structures. Note: Guardrail that is not directly attached to the structure should be rated using Element #982 (Guardrail).

MnDOT uses five bridge railing elements:

- **#330: Metal Bridge Railing (LF)**
- **#331: Reinforced Concrete Bridge Railing (LF)**
- **#332: Timber Bridge Railing (LF)**
- **#333: Other Material Bridge Railing (LF)**
- **#334: Masonry Bridge Railing (LF)**

Railing element quantities are expressed in linear feet (LF). The quantity is measured along the length of the railing (for each railing line). Most bridges will have two railing lines (one on each side), but there may be additional rail lines if there is a median barrier or a protected bicycle or pedestrian lane. Solid median barriers are counted as one line – split median barriers are counted as two lines. The railing quantity may include approach railing (generally up to the first construction joint beyond the approach panel), but could include railing extending beyond that point if those railing sections are included in the plan quantity for the bridge.

<table>
<tr><th colspan="3">Railing Element Selection Examples for Combination Railings</th></tr>
<tr><td colspan="3">Railings comprised of more than one material should be broken up into separate elements to best represent the materials present. Some examples for common railing types are shown below.</td></tr>
<tr><td>For concrete parapets with metal railing mounted on top, the railing must be spilt into two elements.
The lower parapet is rated using Element #331 (Concrete Railing) and the upper rail is rated using Element #330 (Steel Railing) – the element quantities would be the same.</td><td>  </td><td>  </td></tr>
<tr><td>If the railing can be logically divided into separate material segments, those segments should be rated under separate elements.
The steel segments are rated using Element #330 (Steel Railing) and the concrete posts are rated using Element #331 (Concrete Railing). Quantities should reflect the total length of the segments.</td><td>  </td><td>  </td></tr>
<tr><td>For masonry railings with a concrete top cap, the railing is split into two elements.
The lower parapet is rated using Element #334 (Masonry Railing) and the top cap is rated using Element #331 (Concrete Railing).</td><td colspan="2">  </td></tr>
<tr><td>For steel plate beam railing with timber posts & curbs, the railing should be split into two elements.
The steel plate beam is rated using Element #330 (Steel Railing). The timber posts and curb are rated using Element #332 (Timber Railing).</td><td colspan="2">  </td></tr>
<tr><td colspan="3">Steel railings (Element #330) are typically painted, galvanized, or both (galvanized then painted). If a protective coating is present, Element #515 (Steel Protective Coating) must also be rated as a sub-element. The SF quantity may be estimated by multiplying the railing length by the railing height.</td></tr>
</table>

B.3.6.1 Metal Bridge Railing (Element #330)

#330: Metal Bridge Railing (LF)				
This element applies to railings comprised of steel, stainless steel, aluminum, or any other metal. This includes tubes, pipes, cables, beams, or other rolled, cast, or built-up shapes. This includes vehicular railings, pedestrian railings, and chain link fence. This element includes railings constructed entirely of metal, as well as the metal portions of combination railings. The other components of a combination railing should be rated separately using the appropriate railing element (concrete, timber, or masonry). Steel railings typically have a protective coating – they may be painted, galvanized, or both (galvanized then painted). Chain link fence is typically galvanized or vinyl-coated. Aluminum or stainless steel railings typically have no protective coating. If a protective coating is present, Element #515 (Steel Protective Coating) must also be rated as a sub-element. The SF quantity may be estimated by multiplying the railing length by the railing height.				
Item or Defect	**Structural Element Condition States**			
	1	**2**	**3**	**4**
	Good	**Fair**	**Poor**	**Severe**
Structural Review	Structural review is not required.	Structural review is not required.	Structural review is not required **or** review of existing defects has determined that strength or serviceability has not been impacted.	Condition warrants structural review **or** review has determined that defects impact strength or serviceability.
Repairs	No repairs are present.	Existing repairs are in sound condition.	Repairs are recommended **or** existing repair is unsound.	Immediate repairs are required.
Corrosion	None	Surface corrosion.	Flaking rust (section loss) or pack rust with distortion.	Post, rail beam, or anchorage rusted through.
Cracking	None	Crack is arrested and/or reinforced.	Un-arrested crack that is unlikely to propagate through member.	Post, rail beam, or anchorage cracked through.
Connection or Anchorage	In-place and functioning.	Loose fasteners, but functioning as intended.	Missing fasteners or broken welds.	Connection has failed (or failure is eminent).
Distortion	None	Mitigated distortion or mitigation not required.	Distortion that requires mitigation that has not been addressed.	Severely bent or bowed.
Alignment	Proper alignment.	Slightly misaligned.	Significantly misaligned.	Severely misaligned.
Impact Damage	Superficial damage.	Railing slightly gouged, torn or bent.	Railing significantly gouged, torn or bent.	Railing severely bent, torn, or missing.

#330: Metal Bridge Railing (LF)

Condition Rating Examples (Metal Bridge Railing)

Condition State 2
Surface corrosion on steel rail beams

Condition State 3
Steel angle railing bent significantly

Condition State 4
Horizontal steel rail pipe rusted through at connection to a concrete post

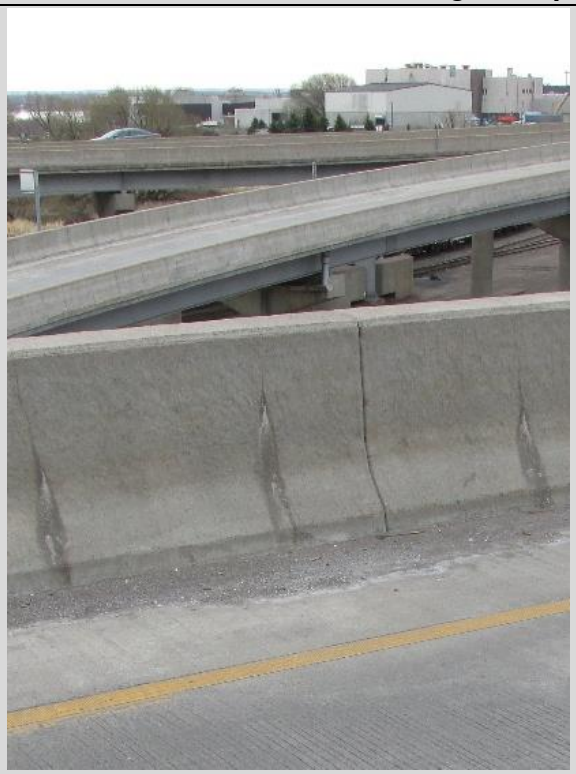
Condition State 4
Aluminum rail post severely damaged

B.3.6.2 Reinforced Concrete Bridge Railing (Element #331)

#331: Reinforced Concrete Bridge Railing (LF)				
This element applies to all types and shapes of reinforced concrete bridge railings or barriers. This includes railings constructed entirely of reinforced concrete, as well as the reinforced concrete base (or "parapet") portions of combination railings. The other components of a combination railing should be rated separately using the appropriate railing element (metal, timber, or masonry).				
Item or Defect	**Structural Element Condition States**			
	1	**2**	**3**	**4**
	Good	**Fair**	**Poor**	**Severe**
Structural Review	Structural review is not required.	Structural review is not required.	Structural review is not required **or** structural review of has determined that strength or serviceability has not been impacted.	Condition warrants structural review **or** structural review has determined that the defects impact strength or serviceability.
Repairs	No repairs are present.	Existing repairs are in sound condition.	Repairs are recommended **or** existing repair is unsound.	Immediate repairs are required.
Delamination, Spall, or Patched Area	None	Delamination. Spall 1" or less deep **and** 6" or less in diameter.	Spall greater than 1" deep **or** greater than 6" diameter. Exposed rebar with section loss.	Spalling deeper than 4" or exposed rebar with severe section loss.
Scale, Abrasion, or Wear	Superficial	Course aggregate is exposed but remains secure.	Course aggregate is loose or popped out.	Severe voiding (concrete unsound).
Efflorescence or Rust Staining	None	Leaching without build-up or rust staining.	Leaching with heavy build-up or rust staining.	Severe leaching (concrete unsound).
Impact Damage	Superficial scrapes.	Minor to moderate impact damage.	Significant impact damage.	Severe impact damage.
Cracking	Minor cracks or map cracks.	Moderate width cracks. Map cracking with light staining or leaching. Sealed cracks.	Wide cracks. Map cracking with heavy staining or leaching.	Severe structural cracking.
When determining condition states for the cracking defect, the inspector should consider width, spacing, location, orientation, and structural (or non-structural) nature of the cracking. Cracks less than 0.012" can be considered "minor", cracks from 0.012" to 0.05" wide can be considered "moderate", and cracks wider than 0.05" can be considered "wide". Map cracking on railings often occurs at light post or overhead sign support anchorages. Map cracking on concrete railings will typically have a relatively dense spacing (less than 1 ft.). The condition rating of map cracked areas should be based upon the severity of any associated leaching or staining, the crack severity, and the soundness of the concrete.				

#331: Reinforced Concrete Bridge Railing (LF)

Condition Rating Examples (Concrete Bridge Railing)



Condition State 2
Vertical cracks with light leaching in a concrete J-barrier

Condition State 2
Repair patch on a concrete parapet of a combination railing

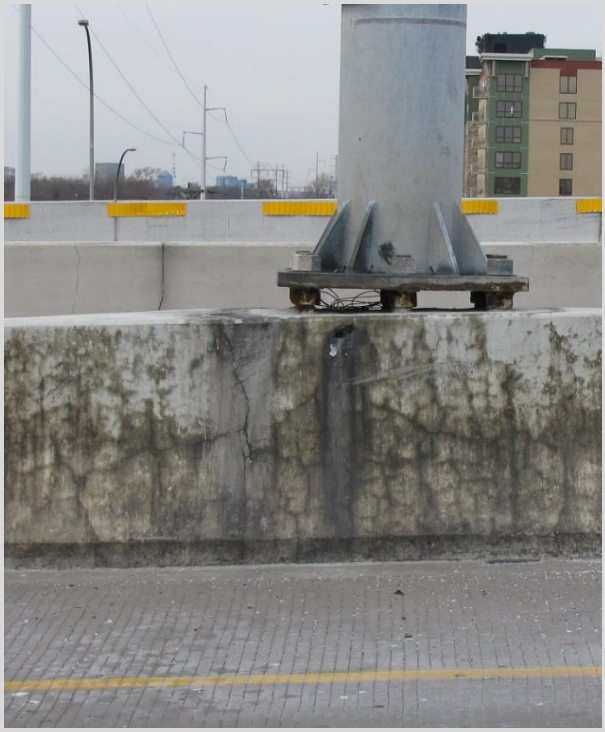
Condition State 2
Scale on a concrete J-barrier

Condition State 2
Scale and pot-outs on a concrete parapet railing

#331: Reinforced Concrete Bridge Railing (LF)

Condition Rating Examples (Concrete Bridge Railing)

Condition State 2
Map cracking on a concrete post & beam railing



Condition State 3
Map cracking and staining on concrete J-barrier below an overhead sign support

Condition State 3
Spalling/scaling along the top of a concrete J-barrier

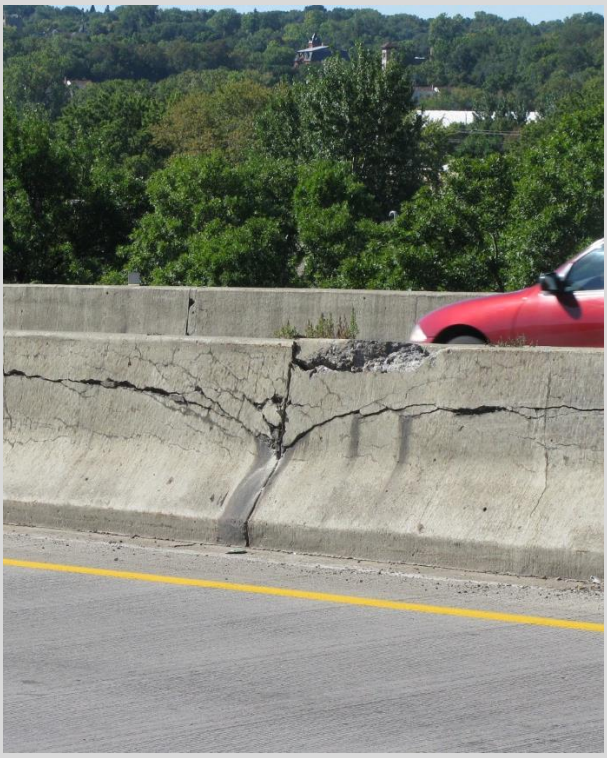
Condition State 3
Spalling (exposed rebar) on the concrete parapet of a combination railing

#331: Reinforced Concrete Bridge Railing (LF)

Condition Rating Examples (Concrete Bridge Railing)

Condition State 3
Scale/spall on a concrete end post

Condition State 4
Severe spall and fracture on a concrete end post



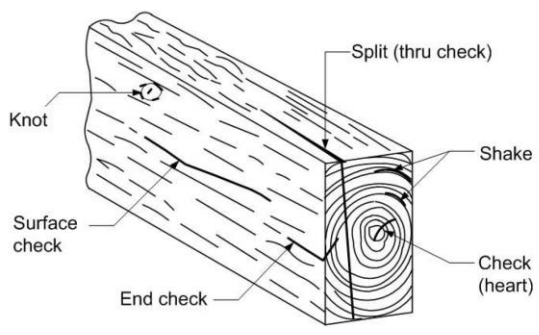
Condition State 4
Severe fracture and cracking in a concrete median J-barrier

Condition State 4
Severe spalling on the concrete rail base of a combination railing

B.3.6.3 Timber Bridge Railing (Element #332)

#332: Timber Bridge Railing (LF)				
This element applies all types and shapes of timber railing. This includes railings constructed primarily of timber (the connections are typically steel), as well as the timber portions of combination railings. The other components of a combination railing should be rated separately using the appropriate railing element (metal, concrete, or masonry).				
Item or Defect	**Structural Element Condition States**			
	1	**2**	**3**	**4**
	Good	**Fair**	**Poor**	**Severe**
Structural Review	Structural review is not required.	Structural review is not required.	Structural review is not required **or** review of existing defects has determined that strength or serviceability has not been impacted.	Condition warrants structural review **or** review has determined that the defects impact strength or serviceability.
Repairs	No repairs are present.	Existing repairs in sound condition.	Repairs recommended **or** existing repair is unsound.	Immediate repairs are required.
Section Loss from Decay, Abrasion, or Fire Damage	Minor deterioration (no section loss).	Less than 10% section loss. No crushing or sagging.	10% to 40% section loss. Some crushing or sagging.	More than 40% section loss. Severe crushing or sagging.
Connection (Steel)	Connection in-place and functioning.	Loose fasteners, but connection is functioning.	Missing fasteners; broken welds; or pack rust with distortion.	Connection has failed (or failure is eminent).
Misalignment	None	Slightly misaligned.	Significantly misaligned.	Severely misaligned.
Impact Damage	Superficial damage.	Minor to moderate impact damage.	Significant impact damage.	Members severely damaged, detached, or missing.
Shakes, Checks, or Splits	Penetrating less than 5% of the member thickness.	Penetrates 5% to 50% of the member thickness (not in a tension zone).	Penetrates more than 50% of the member thickness or more than 5% of member thickness in a tension zone.	Penetrates through entire member or more than 25% of member thickness in a tension zone.

- **Shake:** A separation along the grain (between the growth rings). Usually forms within a standing tree or during felling.
- **Check:** A separation perpendicular to the grain (across the growth rings). Usually results from stress due to drying shrinkage.
- **Split (or Thru Check):** A check extending further through the timber member due to tearing apart of wood cells.



#332: Timber Bridge Railing (LF)

Condition Rating Examples (Timber Bridge Railing)

Condition State 2
Checks in a timber rail post

Condition State 3
Significant decay on a timber rail beam

Condition State 4
Timber rail post missing (adjacent post is severely damaged)

Condition State 4
Timber rail beam detached from posts

B.3.6.4 Other Material Bridge Railing (Element #333)

#333: Other Material Bridge Railing (LF)				
This element applies to bridge railings where the primary material is something other than metal, concrete, timber, or masonry. This includes railings comprised of glass, acrylic, or other transparent materials. This could include the enclosure on pedestrian skyways (if not adequately described by the other railing element). Note: The other components of a combination railing should be rated separately using the appropriate railing element (metal, concrete, masonry, or timber).				
Item or Defect	**Structural Element Condition States**			
	1	**2**	**3**	**4**
	Good	**Fair**	**Poor**	**Severe**
Structural Review	Structural review is not required.	Structural review is not required.	Structural review is not required **or** structural review of has determined that strength or serviceability has not been impacted.	Condition warrants structural review **or** structural review has determined that the defects impact strength or serviceability.
Repairs	No repairs are present.	Existing repairs are in sound condition.	Repairs are recommended **or** existing repair is unsound.	Immediate repairs are required.
General Deterioration	Superficial deterioration.	Minor to moderate deterioration.	Significant deterioration.	Severe deterioration.
Transparent Materials (Glass, Acrylic, Etc.)	May be dirty, but with no permanent loss of transparency	Abrasion, staining, or discoloration (some permanent loss of transparency)	Cracking or pitting. Severe loss of transparency.	Fractured, loose or missing sections.
Connections	Connection in-place and functioning.	Loose fasteners, but connection is functioning.	Missing fasteners; broken welds; or pack rust with distortion.	Connection has failed (or failure is eminent).
Sealant (Enclosed Skyways)	Functioning properly	Deterioration with no leakage	Leakage	Severe leakage
Misalignment	None	Slightly misaligned.	Significantly misaligned.	Severely misaligned.
Impact Damage	Superficial damage.	Minor to moderate impact damage.	Significant impact damage.	Members severely damaged, detached, or missing.

#333: Other Material Bridge Railing (LF)

Condition Rating Examples (Other Material Bridge Railing)

Condition State 1
Transparent Noise Barrier is dirty (no permanent loss of transparency)

Condition State 2
Transparent Noise Barrier scratched by vandal.

Condition State 2
Loose seal (no leakage) on an enclosed pedestrain skyway

Condition State 3
Cracks in a transparent panel

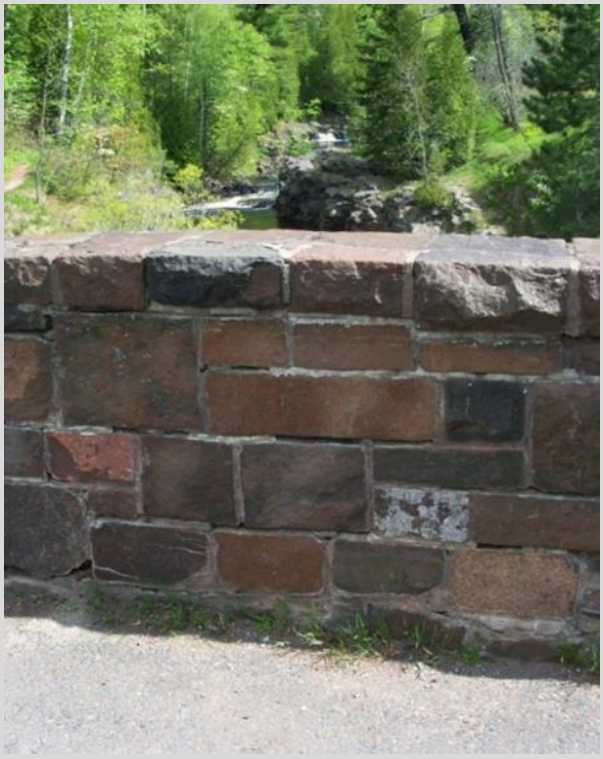
B.3.6.5 Masonry Bridge Railing (Element #334)

#334: Masonry Bridge Railing (LF)				
This element applies all shapes or types of masonry bridge railing (block, brick, or stone). This includes railings constructed entirely of masonry, as well as the masonry portions of combination railings. The other components of a combination railing should be rated separately using the appropriate railing element (metal, concrete, or timber).				
Item or Defect	**Structural Element Condition States**			
	1	**2**	**3**	**4**
	Good	**Fair**	**Poor**	**Severe**
Structural Review	Structural review is not required.	Structural review is not required.	Structural review is not required **or** review of defects has determined that strength or serviceability has not been impacted.	Condition warrants structural review **or** review has determined that the defects impact strength or serviceability.
Repairs	No repairs are present.	Existing repairs are in sound condition.	Repairs are recommended **or** existing repair is unsound.	Immediate repairs are required.
Mortar Breakdown (Masonry)	None	Cracks or voids in less than 10% of the joints.	Cracks or voids in 10% or more of the joints.	NA
Delamination or Spall (Masonry)	None	Delamination. Spalling less than 10% loss of block thickness.	Spalling with 10% to 25% loss of block thickness.	Spalling with more than 25% loss of block thickness.
Spilt or Fracture (Masonry)	None	Block split (no continuation into adjacent courses).	Fractured through adjacent courses or block split with significant offset.	Fracture or split reduces stability of structure.
Scaling or Abrasion (Masonry)	Minor surface deterioration.	Less than 10% loss of block thickness.	10% to 25% loss of block thickness.	More than 25% loss of block thickness.
Masonry Displacement	None	Block or stone slightly misaligned.	Block or stone significantly misaligned.	Block or stone is severely misaligned (or detached).
Impact Damage	Superficial damage.	Minor to moderate impact damage.	Significant impact damage.	Block or stone severely damaged, displaced, or missing.

#334: Masonry Bridge Railing (LF)

Condition Rating Examples (Masonry Bridge Railing)

Condition State 2
Minor mortar breakdown on a masonry bridge railing



Condition State 3
Extensive mortar breakdown on a masonry bridge railing

Condition State 3
Block split on a masonry parapet

Condition State 4
Severe impact damage on a masonry railing

B.3.7 BRIDGE APPROACH ELEMENTS

MnDOT has three bridge roadway approach elements. The approach should provide a smooth transition for vehicles travelling on and off of the bridge deck. In addition to material defects, bridge approaches should be inspected for settlement or undermining. Approach alignment and geometric issues should be addressed using the Approach Roadway Alignment Appraisal Rating (NBI Item 72).

- **#321: Concrete Approach Slab (SF)**
- **#822: Bituminous Approach Roadway (Each)**
- **#823: Gravel Approach Roadway (Each)**

Note: these elements are intended for vehicular bridges, and should not be used for culverts, pedestrian bridges, or railroad bridges. Approaches on pedestrian bridges should be rated using Element #895 (Sidewalk, Curb, or Median).

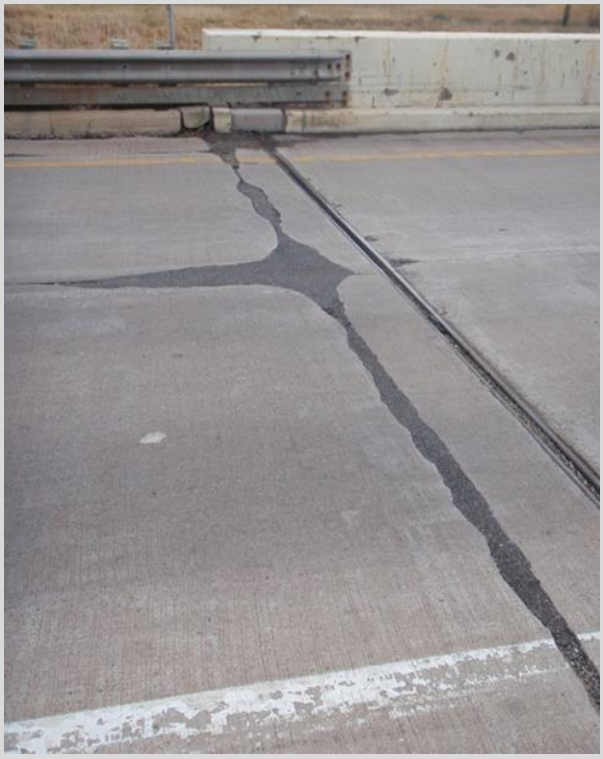
B.3.7.1 Concrete Approach Slab (Element #321)

#321: Concrete Approach Slab (SF)				
This element applies to reinforced concrete bridge approach slabs, regardless of wearing surface type. A bridge approach slab is a short (about 20 ft. long) reinforced concrete roadway paving segment adjacent to the bridge. The SF quantity typically includes the approach roadway width (cub-to-curb) from the abutment end block joint to the approach relief joint. If no relief joint is present, the quantity should include the area extending to the end of the approach slab, or to a construction joint that provides a logical termination point.				
Item or Defect	**Structural Element Condition States**			
	1	**2**	**3**	**4**
	Good	**Fair**	**Poor**	**Severe**
Wearing Surface	Little or no deterioration	Minor to moderate deterioration.	Significant deterioration (repairs recommended).	Severe deterioration (repairs required).
Delamination or Spalling	None	Spalling less than ½″ deep. No delamination.	Delamination or spalling from ½″ up to 2″ deep (no exposed reinforcement).	2″ deep or greater **or** with exposed reinforcement.
Scale, Wear, or Abrasion	Less than ¼″ deep.	From ¼″ up to ½″ deep.	From ½″ up to 2″ deep (no exposed reinforcement).	2″ deep or greater **or** with exposed reinforcement.
Patching or Repairs	None	Permanent patches that remain sound.	Temporary patches or deteriorated repairs.	Repair patches that have failed.
Settlement or Undermining	None	Slight undermining or settlement.	Significant undermining or settlement (traffic impact on bridge).	Severe undermining or severe settlement (possible traffic hazard).
Cracking and Map (Pattern) Cracking	Minor cracks.	Moderate width cracks or map cracking. Sealed cracks.	Wide cracks or wide map cracking.	Severe width cracks or full depth slab fracture.
Cracks less than 0.012" wide can be considered “minor”, cracks from 0.012" to 0.05" wide are “moderate”, cracks wider than 0.05" are “wide”, and cracks 1/8" (0.125") or wider could be considered to be “severe”. Interconnecting transverse and longitudinal cracks are often described as pattern or map cracking. As a general rule, when the spacing between cracks is 2 ft. or less, map cracked areas or areas with concentrated cracking can be documented and rated as a SF area. Rate the SF area based upon the crack width and/or any associated defects.				

#321: Concrete Approach Slab (SF)

Condition Rating Examples (Concrete Approach Slab)

Condition State 2
Concrete patch on a concrete approach panel (along the end block joint)



Condition State 3
Temporary bituminous patch on a concrete approach panel (along the end block joint and centerline)

Condition State 4
Severe spall along centerline of a concrete approach panel

Condition State 4
Concrete approach panel fractured at the corner

B.3.7.2 Bituminous and Gravel Approach Roadway (Elements #822 and #823)

Element #822: Bituminous Approach Roadway (Each) Element #823: Gravel Approach Roadway (Each)				
These elements apply to roadways that terminate at the bridge abutments (with no underlying concrete slab). These are "each" items – the quantity is typically "2 "(one for each end of the bridge). If the bridge has a divided median or ramp, the quantity can be increased to rate each approach roadway segment separately. The area considered in the rating typically includes the approach roadway extending out about 20 ft. from the end of the bridge deck.				
Item or Defect	**Structural Element Condition States**			
	1	**2**	**3**	**4**
	Good	**Fair**	**Poor**	**Severe**
General Condition	Little or no deterioration.	Minor to moderate deterioration.	Extensive or significant deterioration – repairs may be required.	Severe deterioration – immediate repairs are required.
Bituminous Roadway	Smooth and even (no potholes).	Moderate cracking or slight rutting (potholes may be present).	Significant rutting or uneven surface. Extensive cracking or potholes.	Severe deterioration of the bituminous roadway (possible traffic hazard).
Gravel Roadway	Evenly graded.	Moderately rutted or eroded.	Extensive rutting or erosion.	Severe deterioration of the gravel roadway (possible traffic hazard).
Settlement or Undermining	No settlement or undermining – smooth transition on and off the bridge deck.	Slight settlement or undermining (traffic impact on the bridge has not been significantly increased).	Settlement has significantly increased traffic impact on the bridge. Significant undermining.	Settlement has severely increased traffic impact on the bridge. Severe undermining.

#822: Bituminous Approach Roadway (Each)
#823: Gravel Approach Roadway (Each)

Condition Rating Examples (Bituminous or Gravel Approach Roadways)

Condition State 2
Moderate deterioration on a bituminous approach roadway (cracking and patching)

Condition State 3
Extensive deterioration on a bituminous approach roadway (settlement, cracking, and patching)

Condition State 3
Significant settlement on a bituminous approach roadway (along the bridge deck)

Condition State 4
Severe washouts on a gravel approach roadway (traffic hazard)

B.3.8 SUPERSTRUCTURE AND SUBSTRUCTURE ELEMENTS

B.3.8.1 Steel Superstructure Elements

Steel Superstructure Elements				
#102: Steel Box Girder (LF) #107: Steel Girder or Beam (LF) #113: Steel Stringer (LF) #120: Steel Truss (LF)			**#141: Steel Arch (LF) #152: Steel Floorbeam (LF) #162: Steel Gusset Plate (Each)**	
These elements apply to steel components of the bridge superstructure. This includes any steel type (weathering or non-weathering steel), and also includes wrought iron. • Element #515 (Steel Protective Coating) must be rated as a separate sub-element for each of these steel elements. • If impact damage is present, Element #880 (Impact Damage) must be added and rated. • If section loss is present, Element #881 (Section Loss) must be added and rated. • If cracking is present, Element #882 (Steel Cracking) must be added and rated.				
Item or Defect	**Condition States**			
	1	**2**	**3**	**4**
	Good	**Fair**	**Poor**	**Severe**
Structural Review	Structural review is not required.	Structural review is not required.	Structural review is not required **or** structural review has determined that the strength of the element has not been impacted.	Condition warrants structural review **or** structural review has determined that the strength of the element has been reduced.
Repairs	No repairs are present.	Existing repair in sound condition.	Repair recommended **or** existing repair is unsound.	Immediate repairs are required.
Corrosion	None	Surface corrosion (freckled rust).	Section loss, flaking rust, or pack rust is present.	Section loss exceeds 10% of the member cross section (or effective section).
Corrosion (Weathering Steel)	Initial layer of protective oxide coating.	Corrosion beyond the initial layer of protective oxide coating.		
Cracking	None	Crack has self-arrested or has been arrested.	Un-arrested crack that is unlikely to propagate into a critical stress area.	Crack in a critical stress area (or may propagate into a critical stress area).
Connection	Connection in-place and functioning as intended.	Loose fasteners, but the connection is functioning as intended.	Missing bolts or rivets; broken welds; or pack rust with distortion.	Connection has failed (or failure is eminent).
Distortion	None	Mitigated distortion (or mitigation is not required).	Distortion requires mitigation and has not been addressed.	Severely bent or bowed.
Misalignment	None	Slightly out of position or alignment.	Significantly out of proper position or alignment.	Severely out of proper position or alignment.

Steel Superstructure Elements

Condition Rating Examples (Steel Superstructure Elements)

Condition State 1
Unpainted weathering steel (initial protective layer of surface corrosion)

Condition State 2
Paint failure and surface corrosion on the bottom flange of a steel beam

Condition State 2
Extensive paint failure and surface corrosion on a steel girder

Condition State 2
Truss diagonal member reinforced with a bolted channel plate

Steel Superstructure Elements

Condition Rating Examples (Steel Superstructure Elements)

Condition State 3
Flaking rust (and pitting) in girder web at splice

Condition State 3
Pitting in girder web at splice (painted over)

Condition State 3
Pack rust along truss connection

Condition State 4
Large hole rusted through the web of a steel floorbeam

B.3.8.2 Steel Substructure Elements (LF)

Steel Substructure Elements (LF)				
#207: Steel Tower Trestle (LF) **#219: Steel Abutment (LF)**			**#231: Steel Pier/Bearing Cap (LF)**	
These elements apply to steel components of the bridge substructure – this includes any steel type (weathering or non-weathering steel), and includes wrought iron. • If a steel substructure element is present on a bridge, Element #515 (Steel Protective Coating) must be rated specifically for that element. • If impact damage is present, Element #880 (Impact Damage) must be added and rated. • If section loss is present, Element #881 (Section Loss) must be added and rated. • If settlement is evident, Element #884 (Settlement) must be added and rated. • If scour is present, Element #885 (Scour) must be added and rated.				
Item or Defect	**Condition States**			
	1	**2**	**3**	**4**
	Good	**Fair**	**Poor**	**Severe**
Structural Review	Structural review is not required.	Structural review is not required.	Structural review is not required **or** structural review has determined that the strength of the element has not been impacted.	Condition warrants structural review **or** structural review has determined that the strength of the element has been reduced.
Repairs	No repairs are present.	Existing repairs are in sound condition.	Repairs are recommended **or** existing repair is unsound.	Immediate repairs are required.
Corrosion	None	Surface corrosion (freckled rust).	Section loss or pack rust is present.	Section loss exceeds 10% of the cross-section.
Cracking	None	Crack has self-arrested or has been arrested with holes, plates, or similar.	Un-arrested crack that is unlikely to propagate into a critical stress area.	Crack in a critical stress area (or may propagate into a critical stress area).
Connection	None	Loose fasteners, but functioning as intended.	Missing fasteners, broken welds, or pack rust.	Connection has failed (or failure is eminent).
Distortion	None	Distortion not requiring mitigation or mitigated distortion.	Distortion requiring mitigation that has not been addressed.	Severely bent or bowed.
Misalignment	None	Slightly out of position or alignment.	Significantly out of position or alignment.	Severely misaligned.
Settlement	None	Within tolerable limits or arrested (no structural distress).	Exceeds tolerable limits.	Stability of element has been reduced.
Scour	None	Within tolerable limits (or counter-measures installed).	Exceeds tolerable limits but is less than the critical scour limits.	Exceeds the critical scour limits.

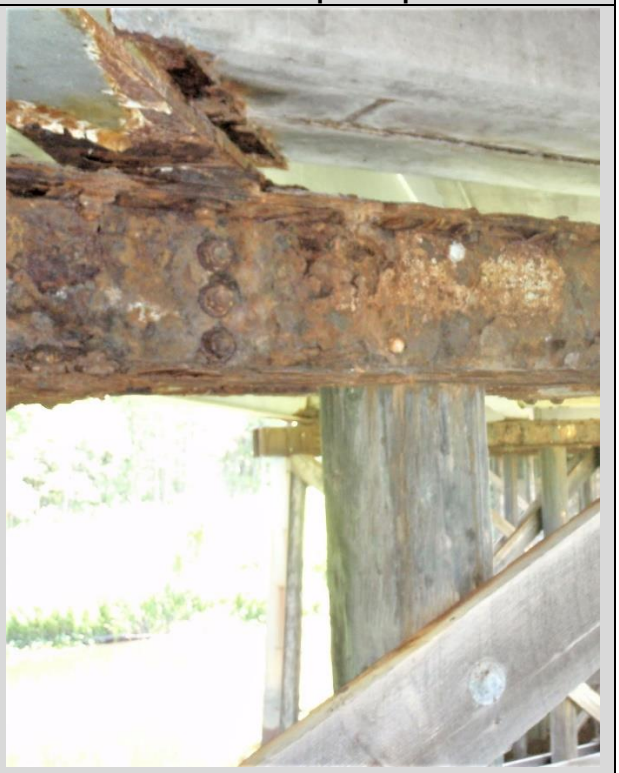
Steel Substructure Elements (LF)

Condition Rating Examples (Steel Substructure Elements)

Condition State 2
Paint failure and surface corrosion on a steel bearing cap

Condition State 2
Extensive paint failure and surface corrosion on a steel pier cap

Condition State 3
Flaking rust and pack rust on a steel pier cap



Condition State 4
Severe section loss (more than 10% of cross-section) on a steel pier cap

B.3.8.3 Steel Columns and Pilings

Steel Columns and Pilings				
#202: Steel Column (Each)			**#225: Steel or CIP Piling (Each)**	
These elements apply to steel columns or pilings of any steel type. These are "Each" quantities, so an overall condition state rating must be determined for each column or piling. Element #202 typically refers to vertical supports bearing on a concrete footing, but could include the inclined legs on a steel K-frame. Element #225 refers specifically to piling that are driven into the ground. • If a steel column or piling element is present on a bridge, Element #515 (Steel Protective Coating) must be rated specifically for that element. • If impact damage is present, Element #880 (Impact Damage) must be added and rated. • If section loss is present, Element #881 (Section Loss) must be added and rated. • If settlement is evident, Element #884 (Settlement) must be added and rated. • If scour is present, Element #885 (Scour) must be added and rated.				
Item or Defect	**Condition States**			
	1	**2**	**3**	**4**
	Good	**Fair**	**Poor**	**Severe**
Structural Review	Structural review is not required.	Structural review is not required.	Structural review is not required **or** structural review has determined that the strength of the element has not been impacted.	Condition warrants structural review **or** structural review has determined that the strength of the element has been reduced.
Repairs	No repairs are present.	Existing repairs are in sound condition.	Repairs are recommended **or** existing repair is unsound.	Immediate repairs are required.
Corrosion and Section Loss	None	Surface corrosion or isolated flaking rust. Section loss less than 1% of the total cross-section.	Significant flaking rust. Section loss less between 1% and 10% of the total cross-section.	Section loss exceeds 10% of the total cross-section.
Cracking	None	Crack has self-arrested or has been arrested.	Un-arrested crack that is unlikely to propagate into a critical stress area.	Crack in a critical stress area (or may propagate into a critical stress area).
Connection	None	Loose fasteners or minor pack rust, but functioning as intended.	Missing fasteners, cracked welds, or significant pack rust distortion.	Connection has failed (or failure is eminent).
Distortion	None	Distortion not requiring mitigation (or mitigated).	Distortion requiring mitigation that has not been addressed.	Severely bent or bowed.
Misalignment	None	Slightly misaligned.	Significantly misaligned.	Severely misaligned.
Settlement	None	Within tolerable limits or arrested (no structural distress).	Exceeds tolerable limits.	Stability of element has been reduced.
Scour	None	Within tolerable limits or counter-measures installed.	Exceeds tolerable limits but is less than the critical scour limits.	Exceeds the critical scour limits.

Steel Columns and Pilings

Condition Rating Examples (Steel Columns and Pilings)

Condition State 2
Paint failure and surface corrosion on a CIP Pile

Condition State 2
Paint failure and surface corrosion on a steel column

Condition State 2
Impact damage (bent flange) on a steel H-pile

Condition State 2
Paint failure and surface corrosion on a pinned steel column

Steel Columns and Pilings

Condition Rating Examples (Steel Columns and Pilings)

Condition State 3
Flaking rust (section loss) on a CIP Pile

Condition State 3
Flaking rust (section loss) on a steel H-Pile

Condition State 4
Severe corrosion and section loss on a steel h-pile

Condition State 4
Fracture in steel shell of a CIP Piling

B.3.8.4 Steel Protective Coating (Element #515)

#515: Steel Protective Coating (SF)

If an NBE steel element (deck, railing, superstructure, substructure, or culvert) is present on a bridge, Element #515 (Steel Protective Coating) must be rated as a sub-element for that particular steel element. Element #515 is entered in SIMS (and displayed on the inspection report) directly below each steel element.

The total surface area (in square feet) of each steel element must be determined. Portions of a steel element that are encased in concrete (such as the top surface of the top flange of a beam), should not be included in this quantity. For steel box members, this quantity will include the exterior and interior surfaces. This SF quantity may initially be entered as a rough estimate, but a more accurate quantity should eventually be calculated.

Item or Defect	Condition States			
	1	2	3	4
	Good	Fair	Poor	Severe
Painted Steel Surfaces	Little or no paint deterioration.	Minor paint deterioration. Chalking and fading of finish coat.	Moderate paint deterioration. Finish coat failure (cracking, bubbling, or peeling) – prime coat remains mostly intact.	Paint system failure. Prime coat cracked, bubbling or peeling (steel exposed).
Rusting Steel Percentage (1 SF Coated Segment)	0.3% or less*	0.3% to 3%*	3% to 16%*	More than 16%*
	*Percentages are based upon The Society for Protective Coatings SSPC-VIS 2 (Standard Method of Evaluating Degree of Rusting on Painted Steel Surfaces)			
Galvanized Steel Surfaces	Little or no deterioration of galvanized coating.	Minor coating deterioration. Light chalking or fading of galvanized surface.	Moderate coating deterioration (coating remains mostly intact). Heavy chalking.	Galvanized coating system failure.
Duplex Coated (Galvanized and Painted) Steel Surfaces	Little or no deterioration.	Minor coating deterioration. Chalking or fading of finish coat – any exposed steel is very isolated.	Moderate coating deterioration. Finish coat failure (cracking, bubbling, or peeling) – galvanized coating remains mostly intact.	Extensive duplex coating system failure.
Unpainted Weathering Steel Surfaces (Protective Oxide Coating)	Protective oxide coating is uniform and tightly adhered (yellow, orange, or brown color)	Protective oxide coating is uneven or has minor deterioration. Dark brown color – the surface may be dusty or granular.	Protective oxide coating has moderate failure (small flakes, less than ½" diameter). Black color.	Protective oxide coating has failed. Large areas of the surface layer are flaking off.

#515: Steel Protective Coating – Paint (SF)

Condition Rating Examples (Protective Coatings – Paint)

Condition State 2
Chalking paint on steel arch bracing members

Condition State 2
Minor paint failure (Isolated – less than 3%)

Condition State 3
Paint finish coat failure (primer coat remains intact)

Condition State 4
Paint system failure (exposed steel)

#515: Steel Protective Coating – Weathering Steel (SF)

Condition Rating Examples (Protective Coatings – Weathering Steel)

Condition State 1
Weathering steel patina is uniform and tightly adhered to the steel beam

Condition State 2
Weathering steel patina is slightly uneven – surface is granular and dusty

Condition State 3
Weathering steel patina has flaking (less than ½" diameter) along the bottom flange

Condition State 4
Weathering steel patina has failed – large areas of surface layer flaking off

#515: Steel Protective Coating – Galvanized or Duplex (SF)

Condition Rating Examples (Protective Coatings – Glanvanized or Duplex)

Condition State 2
Galvanized coating on bridge rail is faded

Condition State 3
Finish paint coat (Duplex system) has been scraped off, the galvanized layer below remains intact

Condition State 3
Finish paint coat (Duplex system) has extensive failure, the galvanized layer below remains intact

Condition State 4
Complete failure of a Duplex system on a steel railing (isolated locations)

B.3.8.5 Reinforced Concrete Superstructure Elements

Reinforced Concrete Superstructure Elements				
#105: Reinforced Concrete Box Girder (LF) #110: Reinforced Concrete Girder/Beam (LF) #116: Reinforced Concrete Stringer (LF)			**#144: Reinforced Concrete Arch (LF) #155: Reinforced Concrete Floorbeam (LF)**	
These elements apply to structural members constructed of reinforced concrete (cast-in-place or pre-cast). These elements should not be used for prestressed or post-tensioned concrete. • If impact damage is present, Element #880 (Impact Damage) must be added and rated. • If shear cracking is present, Element #883 (Shear Cracking) must be added and rated.				
Item or Defect	**Condition States**			
	1	**2**	**3**	**4**
	Good	**Fair**	**Poor**	**Severe**
Structural Review	Structural review is not required.	Structural review is not required.	Structural review is not required **or** structural review has determined that the strength of the element has not been impacted.	Condition warrants structural review **or** structural review has determined that the strength of the element has been reduced.
Repairs	No repairs are present.	Existing repair in sound condition.	Repairs are recommended **or** existing repair is unsound.	Immediate repairs are required.
Delamination, Spall, or Exposed Rebar	None	Delamination. Spall 1” or less deep **and** 6” or less in diameter.	Spall greater than 1” deep **or** greater than 6” diameter. Exposed rebar with corrosion or section loss.	Spalling deeper than 4” or exposed rebar with severe section loss.
Efflorescence Rust Staining	None	Leaching without build-up (stalactites). Minor rust stains (rebar chairs).	Leaching with heavy build-up (stalactites).Rust stains indicating rebar corrosion.	Severe leaching (concrete unsound).
Scale, Abrasion, or Wear	Superficial	Course aggregate is exposed but remains secure.	Course aggregate is loose or has popped out.	Severe voiding (concrete unsound).
Misalignment	None	Slightly out of position or alignment.	Significantly out of position or alignment.	Severely misaligned.
Cracking or Map (Pattern) Cracking	Minor cracks.	Moderate cracks or moderate map cracking. Sealed cracks.	Wide cracks or heavy map cracking. Minor or moderate shear/flexure cracks	Severe cracks or fractures. Wide shear or flexure cracks.
When determining condition states for the cracking defect, the inspector should consider width, spacing, location, orientation, and structural (or non-structural) nature of the cracking. Cracks less than 0.012" can be considered “minor”, cracks from 0.012" to 0.05" wide can be considered “moderate”, and cracks wider than 0.05" can be considered “wide”.				

Reinforced Concrete Superstructure Elements

Condition Rating Examples (Reinforced Concrete Superstructure Elements)

Condition State 2
Cracking on precast concrete channel beams

Condition State 2
Patching on a concrete arch spandrel cap

Condition State 3
Water saturation, rust staining, and spalling on a cast-in-place concrete T-girder

Condition State 3
Cracking, delamination, and rust staining a precast concrete channel beam

Reinforced Concrete Superstructure Elements

Condition Rating Examples (Reinforced Concrete Superstructure Elements)

Condition State 3
Spalling on a precast concrete channel beam

Condition State 3
Spalling on a reinforced concrete arch

Condition State 4
Severe spalling (and fracture) on a concrete arch spandrel wall

Condition State 4
Severe impact damage (exposed and bent reinforcement) on a cast-in-place concrete T-girder

B.3.8.6 Reinforced Concrete Substructure Elements (LF)

Reinforced Concrete Substructure Elements (LF)				
#210: Reinforced Concrete Pier Wall (LF) **#220: Reinforced Concrete Footing (LF)** **#215: Reinforced Concrete Abutment (LF)** **#234: Reinforced Concrete Pier/Bearing Cap (LF)**				
These elements apply to substructure members constructed of cast-in-place or pre-cast concrete. • If impact damage is present, Element #880 (Impact Damage) must be added and rated. • If shear cracks are present on a pier cap, Element #883 (Shear Cracking) must be rated. • If settlement is evident, Element #884 (Settlement) must be added and rated. • If scour is present, Element #885 (Scour) must be added and rated.				
Item or Defect	**Condition States**			
	1	**2**	**3**	**4**
	Good	**Fair**	**Poor**	**Severe**
Structural Review	Structural review is not required.	Structural review is not required.	Structural review is not required **or** structural review has determined that the strength of the element has not been impacted.	Condition warrants structural review **or** structural review has determined that the strength of the element has been reduced.
Repairs	No repairs are present.	Existing repair in sound condition.	Repair recommended **or** existing repair is unsound.	Immediate repairs are required.
Delamination, Spall, or Exposed Rebar	None	Delaminated. Spall 1” or less deep **and** 6” or less in diameter.	Spall deeper than 1” **or** greater than 6” in diameter. Exposed rebar with section loss.	Severe spall (deeper than 4” or rebar rusted through).
Efflorescence Rust Staining	None	Leaching without build-up (stalactites). Minor rust stains (rebar chairs).	Leaching with heavy build-up (stalactites).Rust stains indicating rebar corrosion.	Severe leaching (concrete unsound).
Scale or Abrasion	None	Aggregate exposed but remains secure	Aggregate is loose or popped out	Severe voiding (unsound).
Misalignment	None	Slightly misaligned.	Significantly misaligned.	Severely misaligned.
Decorative Veneers	Superficial deterioration	Delaminated or deteriorated.	Missing or severely deteriorated.	Loose veneer poses a safety hazard.
Settlement	None	Within tolerable limits or arrested.	Exceeds tolerable limits.	Stability of element has been reduced.
Scour	None	Within tolerable limits or counter-measures installed.	Exceeds tolerable limits but less than critical scour limits.	Exceeds the critical scour limits.
Cracking or Map (Pattern) Cracking	Minor cracks.	Moderate cracks or moderate map cracking. Sealed cracks.	Wide cracks or heavy map cracking. Minor or moderate shear/flexure cracks	Severe cracks or fractures. Wide shear or flexure cracks.
When determining condition states for the cracking defect, the inspector should consider width, spacing, location, orientation, and structural (or non-structural) nature of the cracking. Cracks less than 0.012" can be considered “minor”, cracks from 0.012" to 0.05" wide can be considered “moderate”, and cracks wider than 0.05" can be considered “wide”.				

Reinforced Concrete Substructure Elements (LF)	
Condition Rating Examples (Reinforced Concrete Substructure Elements)	
 **Condition State 2** **Leaching crack in the parapet (back wall) on a reinforced concrete abutment**	 **Condition State 3** **Shear crack (1/16″ or 0.06″ wide) in a reinforced concrete pier cap**
 **Condition State 3** **Cracks with heavy leaching on a reinforced concrete abutment**	 **Condition State 3** **Wide horizontal cracking with rust stains on the face of a reinforced concrete abutment**
 **Condition State 3** **Spalling with exposed reinforcement and rust stains on a reinforced concrete pier cap**	 **Condition State 4** **Severe spalling on a reinforced concrete pier cap**

B.3.8.7 Reinforced Concrete Columns and Pilings

Reinforced Concrete Columns and Pilings

#205: Reinforced Concrete Column (Each) #227: Reinforced Concrete Piling (Each)

These elements apply to columns or pilings constructed of cast-in-place or pre-cast concrete. These are "Each" quantities, so an overall condition state rating must be determined for each column or piling present on the bridge. Element #227 (Concrete Piling) refers specifically to piling that are driven into the ground. Drilled shafts or caissons should be rated using Element 205 (Concrete Column)

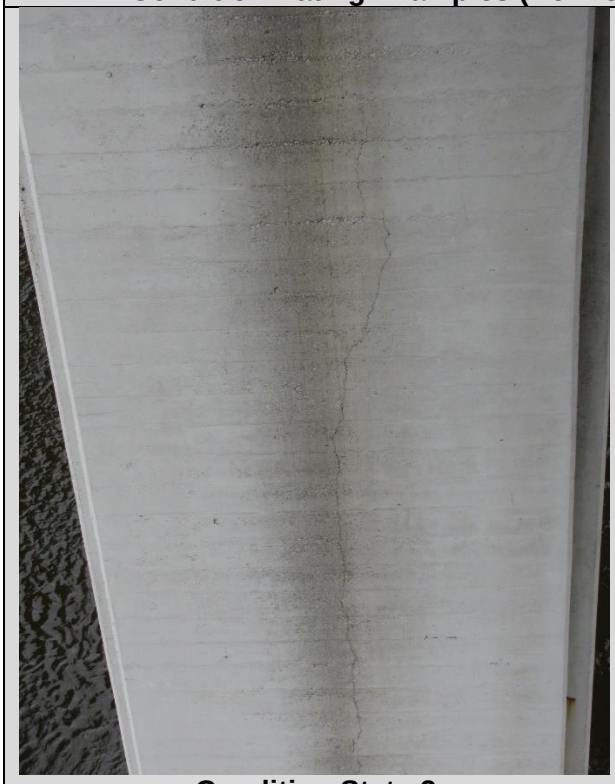
- If impact damage is present, Element #880 (Impact Damage) must be added and rated.
- If settlement is evident, Element #884 (Settlement) must be added and rated.
- If scour is present, Element #885 (Scour) must be added and rated.

Item or Defect	Condition States			
	1	2	3	4
	Good	Fair	Poor	Severe
Structural Review	Structural review is not required.	Structural review is not required.	Structural review is not required **or** structural review has determined that the strength of the element has not been impacted.	Condition warrants structural review **or** structural review has determined that the strength of the element has been reduced.
Repairs	No repairs are present.	Existing repair in sound condition.	Repair recommended **or** existing repair is unsound.	Immediate repairs are required.
Loss of Cross-Section	None	Insignificant (less than 1%)	Moderate (from 1% to 10%)	Severe (more than 10%)
Delamination, Spall, or Exposed Rebar	None	Isolated delamination or spalling (any exposure of rebar is extremely isolated)	Significant delamination or spalling. Exposed rebar with corrosion and/or section loss.	Extensive spalling. Severe spalls (deeper than 4″). Exposed reinforcement with severe section loss.
Efflorescence Rust Staining	Little or none	Minor leaching or rust stains.	Extensive leaching or rust stains.	Severe leaching (concrete unsound).
Scale or Abrasion	Little or none	Isolated and/or moderate scale or abrasion	Extensive and/or significant scale or abrasion.	Severe scale or abrasion (significant loss of cross-section).
Decorative Veneers	Superficial deterioration	Delaminated or deteriorated.	Missing or severely deteriorated.	Loose veneer poses a safety hazard.
Settlement	None	Within tolerable limits or arrested.	Exceeds tolerable limits.	Stability of element has been reduced.
Scour	None	Within tolerable limits or counter-measures installed.	Exceeds tolerable limits but less than critical scour limits.	Exceeds the critical scour limits.
Cracking or Map (Pattern) Cracking	Minor cracks.	Moderate cracks or moderate map cracking. Sealed cracks.	Wide cracks or heavy map cracking. Minor or moderate shear/flexure cracks	Severe cracks or fractures. Wide shear or flexure cracks.

When determining condition states for the cracking defect, the inspector should consider width, spacing, location, orientation, and structural nature of the cracking. Cracks less than 0.012" can be considered "minor", cracks from 0.012" to 0.05" wide can be considered "moderate", and cracks wider than 0.05" can be considered "wide".

Reinforced Concrete Columns and Pilings

Condition Rating Examples (Reinforced Concrete Columns and Pilings)



Condition State 2
Moderate width vertical crack on a reinforced concrete column

Condition State 2
Moderate map cracking on a reinforced concrete column

Condition State 2
Isolated spall with exposed reinforcement on a reinforced concrete column

Condition State 2
Isolated impact spall on a reinforced concrete column

Reinforced Concrete Columns and Pilings

Condition Rating Examples (Reinforced Concrete Columns and Pilings)

Condition State 2
Isolated loose and missing stone veneer.

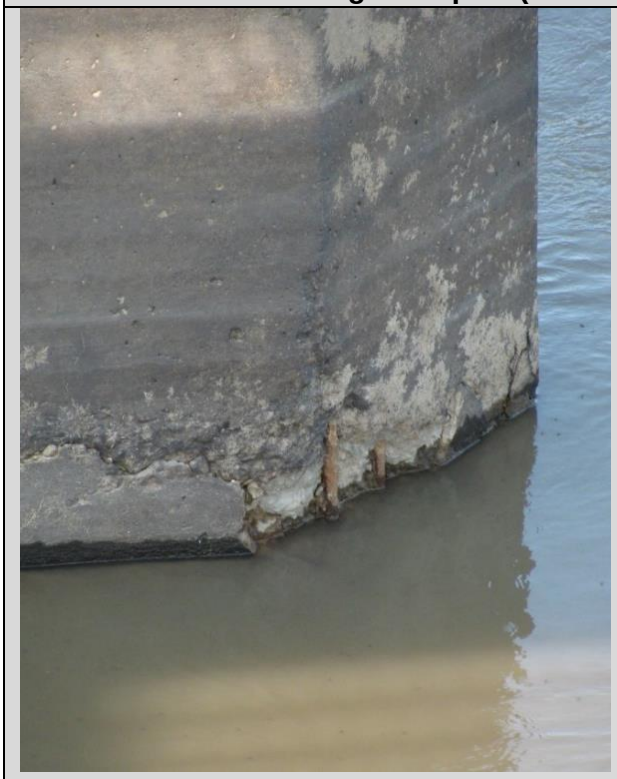
Condition State 2
Repair on a reinforced concrete column

Condition State 3
Significant spall on a precast concrete pile

Condition State 3
Spalling (exposed and corroded reinforcement) at the base of a reinforced concrete column

Reinforced Concrete Columns and Pilings

Condition Rating Examples (Reinforced Concrete Columns and Pilings)



Condition State 3
Significant scale/abrasion along the waterline on a reinforced concrete column

Condition State 4
Extensive spalling ((exposed and corroded reinforcement) on a reinforced concrete column

Condition State 4
Severe scale/spall on a reinforced concrete pile

Condition State 4
Severe spall on a reinforced concrete column

B.3.8.8 Prestressed Concrete Superstructure Elements

Prestressed Concrete Superstructure Elements				
#104: Prestressed Concrete Box Girder (LF) #109: Prestressed Concrete Girder or Beam (LF) #115: Prestressed Concrete Stringer (LF) #154: Prestressed Concrete Floorbeam (LF)				
These elements apply to superstructure members constructed of either prestressed or post-tensioned concrete. • If impact damage is present, Element #880 (Impact Damage) must be added and rated. • If shear cracking is present, Element #883 (Shear Cracking) must be added and rated.				
• Element #104 (Prestressed Concrete Box Girder) includes the bottom flange and web walls of post-tensioned box girders. The top flange is rated separately using Element #15 (Prestressed Concrete Top Flange). • Element #109 (Prestressed Concrete Girder or Beam) includes the vertical portions of prestressed Bulb Tees, Double Tees, or Quad Tees. The horizontal portions are rated separately using Element #15 (Prestressed Concrete Top Flange).				
Item or Defect	**Condition States**			
	1 Good	**2 Fair**	**3 Poor**	**4 Severe**
Structural Review	Structural review is not required.	Structural review is not required.	Structural review is not required **or** structural review has determined that the strength of the element has not been impacted.	Condition warrants structural review **or** structural review has determined that the strength of the element has been reduced.
Repairs	No repairs are present.	Existing repair in sound condition.	Repairs are recommended **or** existing repair is unsound.	Immediate repairs are required.
Delamination, Scale, Spall, and Exposed Rebar or Prestressing	None	Delaminated. Spall 1” or less deep **and** 6” or less in diameter.	Spall deeper than 1” **or** greater than 6” in diameter. Exposed rebar or prestressing with section loss.	Severe spall (deeper than 4”), rebar rusted through, or prestressing stands severed.
Efflorescence Rust Staining	None	Leaching without build-up (stalactites). Minor rust stains.	Leaching with heavy build-up (stalactites). Rust stains indicating rebar corrosion.	Severe leaching (concrete unsound).
Misalignment	None	Slightly misaligned.	Significantly misaligned.	Severely misaligned.
Cracking	Minor cracks.	Moderate cracks or moderate map cracking. Sealed cracks.	Wide cracks or heavy map cracking. Minor or moderate shear/flexure cracks	Severe cracks or fractures. Wide shear or flexure cracks.
When determining condition states for the cracking defect, the inspector should consider width, spacing, location, orientation, and structural (or non-structural) nature of the cracking. Cracks less than 0.004" can be considered “minor”, cracks from 0.004" to 0.009" wide can be considered “moderate”, and cracks wider than 0.009" can be considered “wide”.				

Prestressed Concrete Superstructure Elements

Condition Rating Examples (Prestressed Concrete Superstructure Elements)

Condition State 2
Impact damage (minor spall) on a prestressed concrete beam

Condition State 2
Draped strand cracking in the end a prestressed concrete beam

Condition State 3
Spalling on the web of a prestressed concrete beam

Condition State 3
Spalling on a bottom flange of a prestressed concrete beam

Prestressed Concrete Superstructure Elements	
Condition Rating Examples (Prestressed Concrete Superstructure Elements)	
 **Condition State 3** **Scale/spall on the fascia of a prestressed concrete box beam**	 **Condition State 3** **Impact damage (spalling) on a post-tensioned concrete beam**
 **Condition State 4** **Severe spall and strand corrosion on a post-tensioned box girder**	 **Condition State 4** **Severe impact damage on a prestressed concrete beam**

B.3.8.9 Prestressed Concrete Substructure Elements

Prestressed Concrete Substructure Elements				
#204: Prestressed Concrete Column (Each) #226: Prestressed Concrete Piling (Each) #233: Prestressed Concrete Pier/Bearing Cap (LF)				
These elements apply to substructure members comprised of prestressed or post-tensioned concrete. • If impact damage is present, Element #880 (Impact Damage) must be added and rated. • If shear cracks are present on a post-tensioned pier cap, Element #883 (Shear Cracking) must be added and rated. • If settlement is evident, Element #884 (Settlement) must be added and rated. • If scour is present, Element #885 (Scour) must be added and rated.				
Item or Defect	**Condition States**			
	1	**2**	**3**	**4**
	Good	**Fair**	**Poor**	**Severe**
Structural Review	Structural review is not required.	Structural review is not required.	Structural review is not required **or** structural review has determined that the strength of the element has not been impacted.	Condition warrants structural review **or** structural review has determined that the strength of the element has been reduced.
Repairs	No repairs are present.	Existing repair in sound condition.	Repairs recommended **or** existing repair is unsound.	Immediate repairs are required.
Delamination, Spall, or Exposed Rebar/Strands	None	Delaminated. Spall 1” or less deep **and** 6” or less in diameter.	Spall deeper than 1” **or** greater than 6” in diameter. Exposed rebar or strand with section loss.	Spall deeper than 4”, rebar rusted through, or severed prestressing strands.
Efflorescence Rust Staining	None	Leaching without build-up (stalactites). Minor rust stains.	Leaching with heavy build-up (stalactites).Rust stains indicating rebar corrosion.	Severe leaching (concrete unsound).
Misalignment	None	Slightly misaligned.	Significantly misaligned.	Severely misaligned.
Settlement	None	Within tolerable limits or arrested (no distress).	Exceeds tolerable limits.	Stability of element has been reduced.
Scour	None	Within tolerable limits or counter-measures installed.	Exceeds tolerable limits but less than critical scour limits.	Exceeds the critical scour limits.
Cracking	Minor cracks.	Moderate cracks or moderate map cracking. Sealed cracks.	Wide cracks or heavy map cracking. Minor or moderate shear/flexure cracks	Severe cracks or fractures. Wide shear or flexure cracks.
When determining condition states for the cracking defect, the inspector should consider width, spacing, location, orientation, and structural (or non-structural) nature of the cracking. Cracks less than 0.004" can be considered “minor”, cracks from 0.004" to 0.009" wide can be considered “moderate”, and cracks wider than 0.009" can be considered “wide”.				

Prestressed Concrete Substructure Elements

Condition Rating Examples (Prestressed Concrete Substructure Elements)

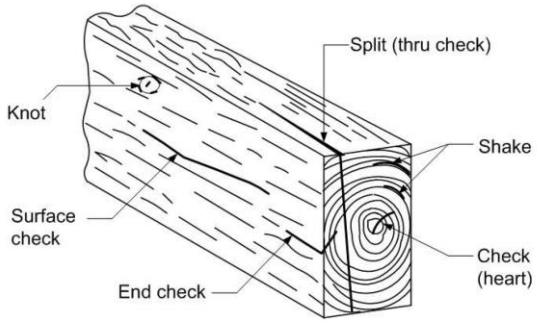
Condition State 1
Post-tensioned pier cap with no defects

Condition State 2
Cracking on the face of a post-tensioned pier cap

Condition State 3
Spalled end cap on a post-tensioned concrete pier cap

Condition State 4
Severe spalling on a prestressed concrete pile

B.3.8.10 Timber Superstructure Elements

Timber Superstructure Elements				
#111: Timber Girder or Beam (LF) #117: Timber Stringer (LF) #135: Timber Truss (LF)			**#146: Timber Arch (LF) #156: Timber Floorbeam (LF)**	
These elements apply to timber superstructure members of any type or shape. This includes sawn or glue-lam timber members. Connections on timber elements will typically include steel components (bolts, nuts, washers, connection plates, Etc.). • If impact damage is present, Element #880 (Impact Damage) must be added and rated.				
Item or Defect	**Condition States**			
	1 Good	**2 Fair**	**3 Poor**	**4 Severe**
Structural Review	Structural review is not required.	Structural review is not required.	Structural review is not required **or** structural review has determined that the strength of the element has not been impacted.	Condition warrants structural review **or** structural review has determined that the strength of the element has been reduced.
Repairs	No repairs are present.	Existing repair in sound condition.	Repairs are recommended **or** existing repair is unsound.	Immediate repairs are required.
Decay, Abrasion, or Fire Damage	Minor deterioration (no section loss).	Less than 10% section loss. No crushing or sagging.	10% to 40% section loss. Some crushing or sagging.	More than 40% section loss. Severe crushing or sagging.
Delamination (Glulam)	None	Minor	Significant	Severe
Connection (Steel)	Connection in-place and functioning as intended.	Loose fasteners, but connection is functioning as intended.	Missing bolts, rivets, or fasteners; broken welds; or pack rust with distortion.	Connection has failed (or failure is eminent).
Misalignment	None	Slightly misaligned.	Significantly misaligned.	Severely misaligned.
Shakes, Checks, or Splits	Penetrating less than 5% of the member thickness.	Penetrates 5% to 50% of the member thickness (not in a tension zone).	Penetrates more than 50% of the member thickness or more than 5% of the member thickness in a tension zone.	Penetrates through entire member or more than 25% of the member thickness in a tension zone.
• **Shake:** A separation along the grain (between the growth rings). Usually forms within a standing tree or during felling. • **Check:** A separation perpendicular to the grain (across the growth rings). Usually results from stress due to drying shrinkage. • **Split (or Thru Check):** A check extending further through the timber member due to tearing apart of wood cells.				

Timber Superstructure Elements

Condition Rating Examples (Timber Superstructure Elements)

Condition State 2
Moderate horizontal splitting on a sawn timber beam

Condition State 2
Minor impact damage on a Glulam timber beam

Condition State 3
Significant horizontal splitting on a sawn timber beam

Condition State 3
Horizontal splitting with internal decay (plant growth) on a sawn timber beam

Timber Superstructure Elements

Condition Rating Examples (Timber Superstructure Elements)

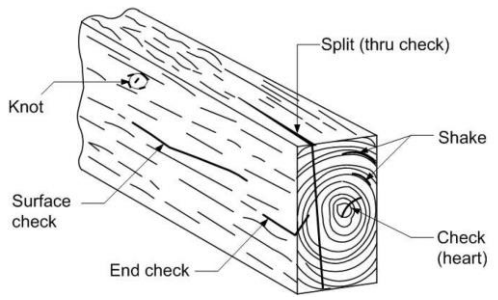
Condition State 3
Fire damage on a sawn timber beam

Condition State 3
Sawn timber beam fractured at pier bearing

Condition State 4
Severe internal decay on a sawn timber beam

Condition State 4
Severe crushing (failure) of a sawn timber beam

B.3.8.11 Timber Substructure Elements

Timber Substructure Elements				
#206: Timber Columns (Each) #208: Timber Trestle Tower (LF) #216: Timber Abutment (LF)			**#228: Timber Pile (Each) #235: Timber Pier/Bearing Cap (LF)**	
These elements apply to timber substructure members of any type or shape. • If impact damage is present, Element #880 (Impact Damage) must be added and rated. • If settlement is evident, Element #884 (Settlement) must be added and rated. • If scour is present, Element #885 (Scour) must be added and rated.				
Item or Defect	**Condition States**			
	1	**2**	**3**	**4**
	Good	**Fair**	**Poor**	**Severe**
Structural Review	Structural review is not required.	Structural review is not required.	Structural review is not required **or** structural review has determined that the strength of the element has not been impacted.	Condition warrants structural review **or** structural review has determined that the strength of the element has been reduced.
Repairs	No repairs are present.	Existing repair in sound condition.	Repairs are recommended **or** existing repair is unsound.	Immediate repairs are required.
Decay, Abrasion, or Fire Damage	Minor deterioration (no section loss).	Less than 10% section loss. No crushing or sagging.	10% to 40% section loss. Some crushing or sagging.	More than 40% section loss. Severe crushing or sagging.
Connection (Steel)	In-place and functioning as intended.	Loose fasteners, but functioning as intended.	Missing fasteners, connection is distressed.	Connection has failed (or failure is eminent).
Misalignment	None	Slightly misaligned.	Significantly misaligned.	Severely misaligned.
Settlement	None	Within tolerable limits or arrested.	Exceeds tolerable limits.	Stability of element has been reduced.
Scour	None	Within tolerable limits or counter-measures installed.	Exceeds tolerable limits but less than critical scour limits.	Exceeds the critical scour limits.
Shakes, Checks, or Splits	Penetrates less than 5% of member thickness.	Penetrates 5% to 50% of member thickness and not in a tension zone.	Penetrates more than 50% of member thickness (or more than 5% in a tension zone).	Penetrates through entire member (or more than 25% in a tension zone).
• **Shake:** A separation along the grain (between the growth rings). Usually forms within a standing tree or during felling. • **Check:** A separation perpendicular to the grain (across the growth rings). Usually results from stress due to drying shrinkage. • **Split (or Thru Check):** A check extending further through the timber member due to tearing apart of wood cells.				

Timber Substructure Elements

Condition Rating Examples (Timber Substructure Elements)

Condition State 2
Checking on the end of a timber pier cap

Condition State 2
Timber piling with decay at waterline (less than 10% section loss)

Condition State 3
Shell damage on a timber piling (section loss between 10% and 40%)

Condition State 3
Fire damage on a timber piling (section loss between 10% and 40%)

Timber Substructure Elements	
Condition Rating Examples (Timber Substructure Elements)	
	
Condition State 3 **Timber pile with splitting and decay at a bracing connection**	**Condition State 3** **Timber cap with significant misalignment (tipped) – not bearing fully on the steel piling**
	
Condition State 4 **Failure of abutment backing planks**	**Condition State 4** **Timer pile with severe decay and crushing**

B.3.8.12 Masonry Superstructure and Substructure Elements

Masonry Superstructure and Substructure Elements				
#145: Masonry Arch (LF) #213: Masonry Pier Wall (LF) #217: Masonry Abutment (LF)				
These elements apply to structural bridge components comprised primarily of masonry. Masonry structures that have reinforced concrete components (that cannot be conveniently broken into separate elements) may be rated using masonry elements – use the reinforced concrete defect language to rate those areas. ***Note: These elements should not be used for masonry arch structures that are classified as "culverts" – use Element #244 (Masonry Culvert) instead.*** • If impact damage is present, Element #880 (Impact Damage) must be added and rated. • If settlement is evident, Element #884 (Settlement) must be added and rated. • If scour is present, Element #885 (Scour) must be added and rated.				
Defects	**Condition States**			
	1	**2**	**3**	**4**
	Good	**Fair**	**Poor**	**Severe**
Structural Review	Structural review is not required.	Structural review is not required.	Structural review is not required **or** structural review has determined that the strength of the element has not been impacted.	Condition warrants structural review **or** structural review has determined that the strength of the element has been reduced.
Repairs	No repairs are present.	Existing repair in sound condition.	Repairs are recommended **or** existing repair is unsound.	Immediate repairs are required.
Mortar Breakdown (Masonry)	None	Cracking or voids in less than 10% of the joints.	Cracking or voids in 10% or more of the joints.	NA
Delamination or Spall (Masonry)	None	Delamination. Spalling less than 10% loss of block thickness.	Spalling with 10% to 25% loss of block thickness.	Spalling with more than 25% loss of block thickness.
Spilt or Fracture (Masonry)	None	Block split without continuation into adjacent courses.	Fractured through adjacent courses or block split with significant offset.	Fracture or split reduces stability of structure.
Weathering, Scale or Abrasion (Masonry)	Minor surface deterioration (no section loss).	Less than 10% loss of block thickness.	10% to 25% loss of block thickness.	More than 25% loss of block thickness.
Masonry Displacement	None	Block or stone is slightly misaligned.	Block or stone is significantly misaligned.	Block or stone is severely misaligned (or detached from structure).
Settlement	None	Within tolerable limits or arrested.	Exceeds tolerable limits.	Stability of element has been reduced.
Scour	None	Within tolerable limits or counter-measures installed.	Exceeds tolerable limits but less than critical scour limits.	Exceeds the critical scour limits.

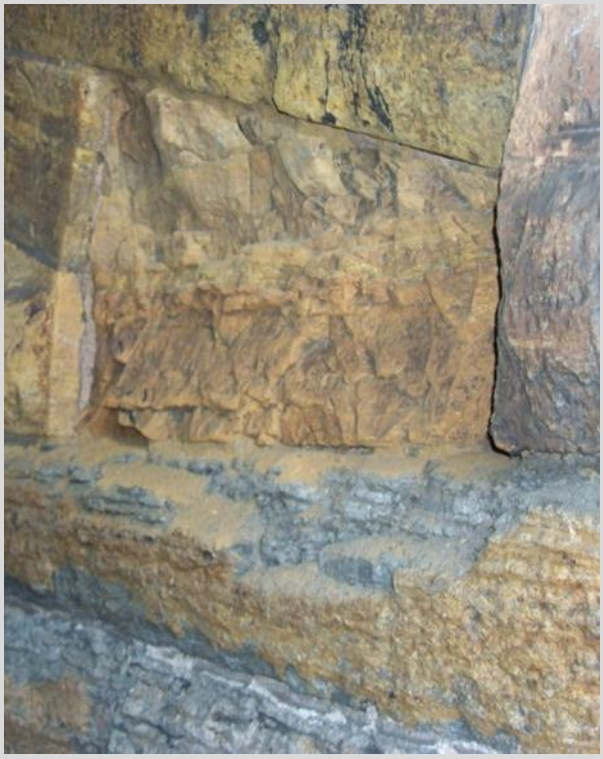
Masonry Superstructure and Substructure Elements

Condition Rating Examples (Masonry Superstructure and Substructure Elements)

Condition State 2
Staining and scaling (minor section loss) on a masonry arch

Condition State 2
Concrete repairs on a masonry arch

Condition State 3
Fracture in a masonry block continuing into adjacent courses



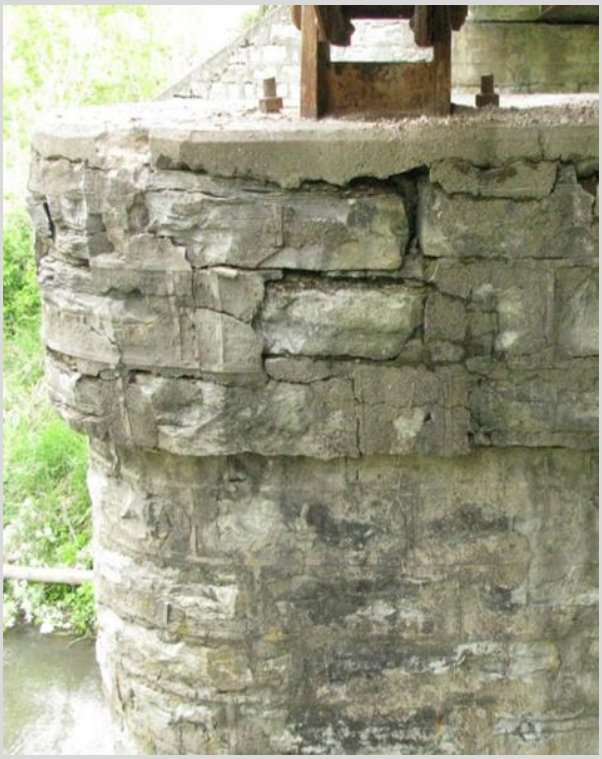
Condition State 3
Spalling on a masonry arch block (10% to 25% of block thickness)

Masonry Superstructure and Substructure Elements

Condition Rating Examples (Masonry Superstructure and Substructure Elements)

Condition State 3
Extensive mortar loss on a masonry arch

Condition State 3
Leaching through joints on a masonry arch



Condition State 4
Masonry pier wall severely deteriorated below a truss bearing

Condition State 4
Masonry pier wall severely damaged by scour

B.3.9 BEARINGS & SPECIAL FEATURE ELEMENTS

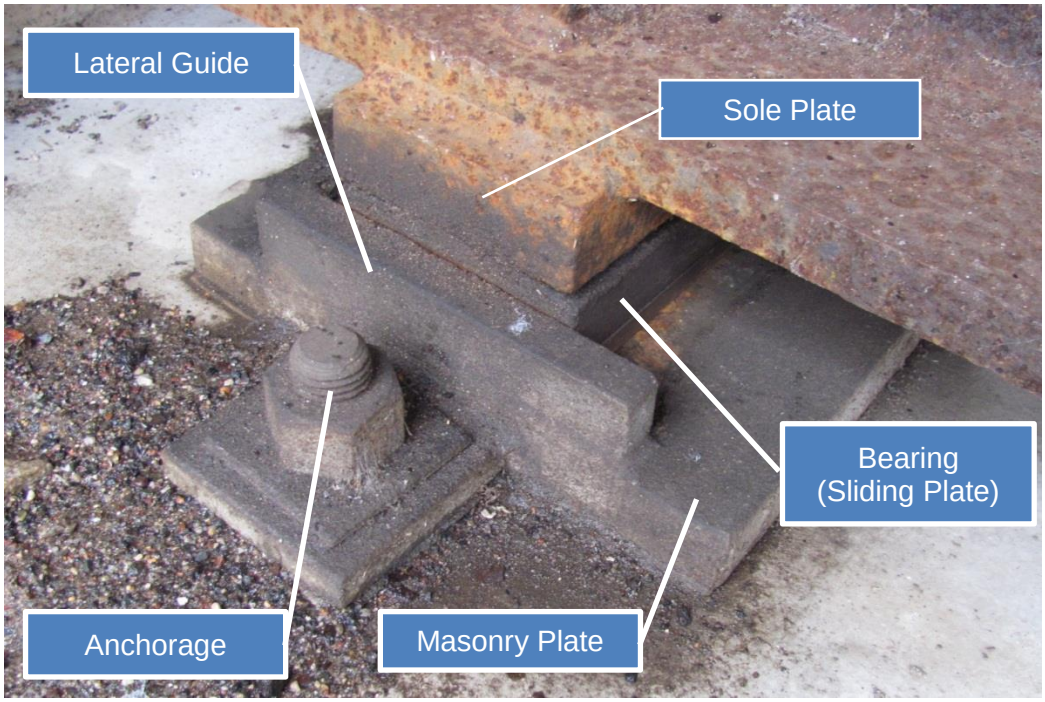
B.3.9.1 Bearing Components and Inspection Procedures

The primary function of a bearing is to transmit loads from the superstructure to the substructure. There are two basic types of bearings, expansion and fixed.

- Expansion bearings permit longitudinal movement of the superstructure due to thermal expansion and contraction. Most expansion bearings allow for rotation of the superstructure due to live load deflection. Some expansion bearings are designed to restrict lateral movement or to prevent uplift of the superstructure.
- Fixed bearings resist longitudinal movement of the superstructure due to thermal expansion and contraction. Most fixed bearings allow for rotation of the superstructure due to live load deflection, and to resist lateral movement of the superstructure.

A typical bearing assembly consists of the following components.

- **Sole Plate:** The sole plate protects the superstructure member, and transfers load from the superstructure to the bearing.
- **Bearing Device:** The bearing transfers load from the sole plate to the masonry plate. Bearings may incorporate sliding plates, rollers, rockers, pins, or elastomeric pads to allow for longitudinal or rotational movement of the superstructure.
- **Masonry Plate:** The masonry plate distributes load from the bearing to the supporting substructure unit (abutment, pier, or footing). Some bearings bear directly upon the bearing seat.
- **Anchorage:** Bearings that resist longitudinal or lateral movement (or uplift forces) require an anchorage system. This typically consists of threaded steel rods drilled (or cast) into the substructure unit.
- **Lateral Guide System:** Some expansion bearing assemblies include guides to prevent lateral movement while still allowing longitudinal expansion or contraction.



Inspection and Condition Rating of Bridge Bearings

Bearings should be examined for deterioration, function, alignment, as well as the soundness of the anchorage and substructure support. All of these factors should be taken into consideration when rating a bearing element. MnDOT uses five bearing elements, the bridge design plans may need to be referenced to verify the type and quantity of bearing elements.

- **#310 - Elastomeric Bearing (Each)**
- **#311 - Expansion Bearing (Each)**
- **#313 - Fixed Bearing (Each)**
- **#314 - Pot Bearing (Each)**
- **#315 - Disk Bearing (Each)**

The importance of inspecting and maintaining bridge bearings should not be underestimated. If ignored, seemingly minor bearing problems could result in serious structural issues.

- Bearing malfunction can damage adjacent structural elements.
- Severe bearing misalignment often indicates significant problems elsewhere on the bridge (such as substructure settlement, shifting, or tipping).
- Loss of bearing area could result in collapse of a bridge span.

The 2005 collapse of the Dunn Bridge in Albany, New York was attributed to the malfunction of the rocker bearings, combined with horizontal deflection of the supporting pier. The rocker bearings had been misaligned for a number of years prior to the collapse.

Bearing Malfunction: A common problem with expansion bearings is seizing due to corrosion or debris. Bearings are typically located below deck joints, a highly corrosive environment. Debris (such as sand, dirt, and flaking rust) can restrict expansion, accelerate corrosion, increase wear, and prevent adequate inspection. Sliding plate, roller, and rocker bearings provide numerous locations for debris and moisture to collect. Expansion bearings should be examined for obvious evidence of recent movement (such as scraped paint, wear, or fretting rust). If no movement is evident, the inspector should take bearing measurements, and examine adjacent components (such as deck joints, railings, or curb plates) for evidence of recent expansion or contraction. Bearing malfunction can also result from bearing components that are worn, misaligned, broken, loose, or missing. Contact surfaces (plates, rollers, rockers, and pins) should be examined for wear and freedom of movement. Loose bearing components may be identified by noise (or movement) when the bridge is subjected to live loads.

Severe malfunction of an elastomeric bearing

Fixed pin truss bearing with severe loss of bearing area

Corroded (possibly frozen) sliding plate bearing

Bearings – Thermal Expansion and Contraction: The magnitude of the longitudinal movement of a bridge is dependent upon three factors – the coefficient of thermal expansion (steel and concrete are similar), the temperature range, and the structure length. As temperatures in Minnesota range from -30° F up to 110° F, a bridge bearing must be able to accommodate about 1-1/8" of longitudinal movement for every 100 ft. of structure length. In Minnesota, expansion bearings are typically designed to be in the neutral (centered) position at 40° F (nationally, the neutral temperature is assumed to be 68° F).

Expansion bearings should be periodically measured to ensure that they are functioning as intended. The horizontal (longitudinal) distance from the neutral alignment should be recorded. Bearing measurements should be taken to the nearest 1/8", and the temperature at the time of the measurement should be recorded. Thermal expansion or contraction which exceeds the bearing design limits can result in bearing failure – sliding plates may tip and lock, or rocker bearings may bind. The adjacent deck, superstructure, and substructure should be examined for contacting surfaces that might be preventing proper expansion.

Bearings - Lateral Movement and Uplift: Expansion bearings are often restrained from lateral movement by guide tabs, keeper bars, pintles, pin caps, or other mechanisms. Lateral guides should be examined for binding, particularly on skewed or curved bridges. Keeper bars on roller bearings can seize due to corrosion or debris – keeper bar failure could result in misalignment of rollers. Pintles that are exposed or sheared off may indicate excessive longitudinal movement.

Lateral restraint is sometimes provided by shear keys, shear lugs, or other devices that are incorporated into end diaphragms or floorbeams. Lateral restraint systems separate from the bridge bearings may be rated using Element #855 (Secondary Members – Superstructure).

Some bearings are also designed to resist uplift of the bridge superstructure – uplift forces may be present on curved bridges, anchor spans, steel pier caps, steel arch bridges, or on short end spans of continuous bridges. An uplift restraint system may consist of tension members such as anchor bolts or eyebars, or may incorporate a counterweight. Uplift restraints should be examined for section loss, cracking, binding, or connection failure. Anchor bolts may require periodic ultrasonic examination.

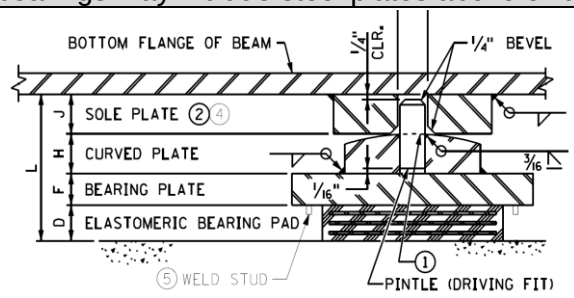
Sliding plate bearing near the design limits of expansion

Uplift (gap) on a curved plate fixed bearing

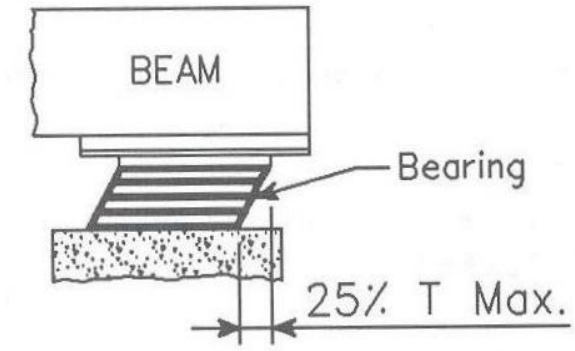
Anchor bolt failure on a fixed bearing

Bearings - Seats and Anchor Bolts: The bearing seats and anchor bolts should be examined for any evidence of deterioration or distress. Cracking or spalling of the bearing seat may indicate bearing anchorage failure – deterioration of the bearing seat can eventually result in loss of bearing area. Anchor bolts that are bent (or contacting the ends of slotted plates) may indicate excessive expansion or substructure movement. The position of bearing masonry plates should be measured and compared to the original plans, as they are sometimes reset due to substructure movement. Look for any evidence that the anchor bolts were not properly installed, such as bolts extending up too high or nuts not properly tightened.

B.3.9.2 Elastomeric Expansion Bearing (Element #310)

<table>
<tr><th colspan="2">#310: Elastomeric Expansion Bearing (Each)</th></tr>
<tr><td colspan="2">This element applies to elastomeric bearing pads that facilitate expansion by deformation. These bearings may include steel plates above or below the elastomeric pads.</td></tr>
<tr><td> 
</td><td>MnDOT Spec. #3741 covers elastomeric bearing pads. The pads are comprised of alternating layers of elastomer (100% virgin chloroprene) and 1/8” thick steel plates, which are bonded together and covered.

Older elastomeric bearing pads may have fiberglass plates, or may be solid neoprene (with no internal reinforcement).</td></tr>
<tr><td>  </td><td>A curved steel pintle plate is usually placed on top of elastomeric pads to allow rotation due to deflection. The pintles fit into a sole plate attached to the bottom flange of the beam.

The pintle plate at left has small weldments on the underside to keep the pad from “walking”. Older elastomeric bearings may not have a pintle plate. Some elastomeric expansion bearings are restrained against lateral movement or uplift forces.</td></tr>
<tr><td> 
</td><td>Elastomeric bearings can accommodate longitudinal movement up to approximately 25% of the pad thickness – the longer the span, the thicker the pad required.

While the pad deformation and orientation should correspond with the current temperature, the actual “neutral” position is the temperature when the bearing was installed. Example, a pad installed on a very hot day may always appear to be tipped in contraction.</td></tr>
<tr><td>  </td><td>Elastomeric bearings generally require less maintenance than mechanical expansion bearings, as they are less susceptible to debris and corrosion.

Elastomeric pads should be examined for excessive bulging, as well as splitting or tearing that expose the internal reinforcement plates.</td></tr>
<tr><td>  </td><td>Elastomeric pads have a tendency to “walk” out from beneath the upper plate. Any significant misalignment should be measured, noted, and monitored during future inspections.

Newer elastomeric bearings incorporate welded guides on the underside of the sole plate to keep them in position.</td></tr>
</table>

#310: Elastomeric Expansion Bearing (Each)				
Item or Defect	**Structural Element Condition States**			
	1	**2**	**3**	**4**
	Good	**Fair**	**Poor**	**Severe**
Bearing Movement & Structural Review	Free to move.	Minor restriction.	Restricted but not warranting structural review (no immediate structural concern).	Severe restriction - structural review is warranted. **or** resetting, repair, or replacement required.
Alignment (Deformation)	Alignment is appropriate for the current temperature.	Alignment is inconsistent for the current temperature.	Deformation is near design limits (25% of pad thickness).	Deformation is beyond design limits (25% of pad thickness).
Bearing Pad Position	Pad is properly positioned.	Pad has moved slightly (less than ½" beyond sole plate).	Pad has moved ½" to 2" beyond sole plate – resetting recommended.	Pad has moved more than 2" beyond sole plate – resetting required.
Bulging, Splitting or Tearing	None	Bulging less than 15% of pad thickness. Minor rolling along pad edges.	Bulging more than 15% of pad thickness. Splitting or tearing (internal plates exposed). Significant rolling along pad edges. Pad surfaces are not be parallel.	Splitting, bulging, de-bonding, or pad damage that severely impacts bearing function or capacity
Corrosion	None	Freckled rust (corrosion has initiated).	Section loss or pack rust is present.	Section loss severely impacts bearing function or capacity.
Plates, Restraints, or Anchor Bolts	Plates, restraints, or anchor bolts are sound, properly positioned, and functioning.	Anchor nuts loose or missing (bolts remain intact). Plates slightly misaligned. Restraint system is functioning.	Anchor bolts loose, bent or at expansion limits. Plates significantly misaligned. Welds broken. Restraints not functioning.	Anchorage or restraint failure has severely impacted bearing function or capacity. Plates severely misaligned.
Loss of Bearing Area	None	Less than 10%	10% to 25%	More than 25%

#310: Elastomeric Expansion Bearing (Each)

Condition Rating Examples (Elastomeric Expansion Bearings)

Condition State 2
Elastomeric pads tipped in opposite directions

Condition State 2
Pad rolled up slightly on the bottom edge and moved from beneath sole plate (less than ½")

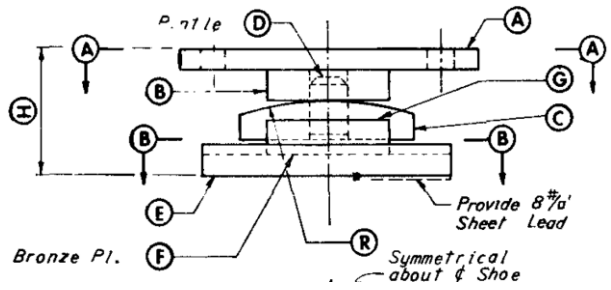
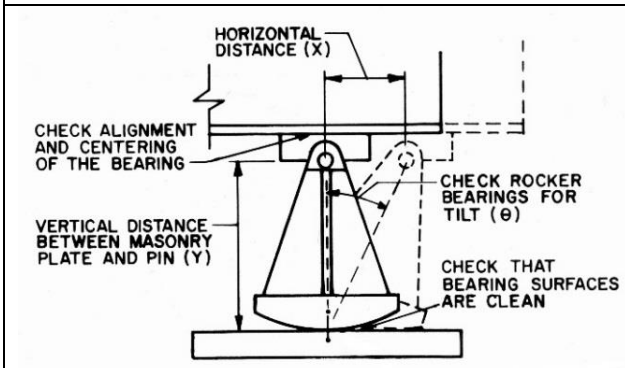
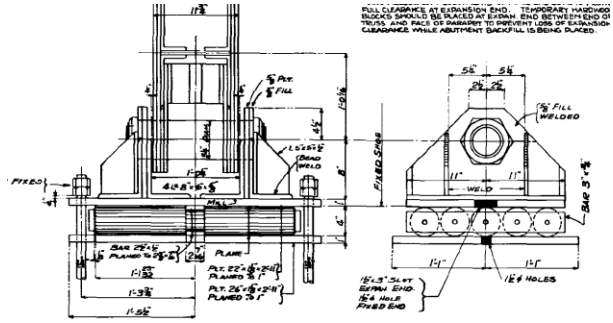
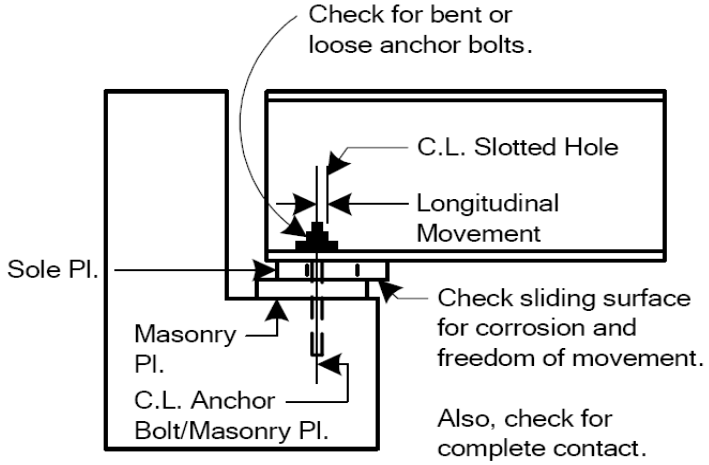
Condition State 3
Pad has moved out from beneath the sole plate (more than ½" but less than 2")

Condition State 3
Pad covering torn, internal plates rusting

Condition State 4
Pad has moved from beneath the curved pintle plate (nearly fallen off)

Condition State 4
Pad has moved from beneath the curved pintle plate (nearly fallen off)

B.3.9.3 Expansion Bearing (Element #311)

#311: Expansion Bearing (Each)	
This element applies to mechanical expansion bearings of any type – such as sliding plate bearings, roller bearings, or rocker bearings. Expansion bearings allow for longitudinal movement of the superstructure due to thermal expansion and contraction. Most expansion bearings allow rotation of the superstructure due to live load deflection – some may be designed to restrict lateral movement or uplift forces.	
	Sliding plate bearings allow longitudinal movement by one steel plate sliding upon another (a curved pintle plate is sometimes included to allow for rotation). Sliding plate bearings often incorporate bronze plates or lubricants to facilitate movement. Lateral restraint may be provided by guide tabs, or by anchor bolts extending up through slots in the sole plate.
	Rocker bearings are typically comprised of a curved rocker plate (bearing on the masonry plate), that is connected to the sole plate with an upper pin. The bearing may have a single rocker or multiple rockers (“rockernest bearings”). Lateral restraint may be provided by pintles (attached to the masonry plate), pin caps, or anchor bolts extending up through slotted plates.
	A roller bearing consists of a horizontal steel cylinder that “rolls” between the sole plate and masonry plate as the superstructure expands and contracts. The bearing may have a single roller or multiple rollers (“rollernest bearing”). Lateral restraint may be provided by pintles (on the top and bottom of the roller), or keeper bars attached the ends of the rollers.
	

#311: Expansion Bearing (Each)				
Item or Defect	**Structural Element Condition States**			
	1	**2**	**3**	**4**
	Good	**Fair**	**Poor**	**Severe**
Movement & Structural Review	No restriction of movement – bearing is functioning as intended.	Minor restriction (cleaning and/or lubrication recommended).	Restricted but not warranting structural review (no immediate structural concern). Cleaning and/or lubricating are required. Resetting or repairs recommended.	Severe restriction – structural review is warranted. **or** resetting, repairs, or bearing replacement are required.
Alignment	Alignment is appropriate for the current temperature.	Alignment is tolerable but is inconsistent for the current temperature	Alignment is near the design limits for expansion or contraction.	Alignment is beyond the design limits for expansion or contraction.
Primary Bearing Components	Primary bearing components are intact and properly positioned.	Primary bearing components are moderately worn or slightly misaligned.	Primary bearing components are significantly worn, damaged, or misaligned.	Primary bearing components are severely misaligned, jammed or detached.
Corrosion	None	Freckled rust (corrosion has initiated).	Section loss or pack rust is present.	Severe section loss impacts bearing function or capacity.
Connections	In place and functioning as intended.	Loose fasteners, but connection still functioning.	Missing fasteners (bolts, rivets, etc.) or broken welds.	Connection failure impacts bearing function or capacity.
Lateral Guide System, Uplift Restraints, or Anchor Bolts	Guides, restraints, or anchor bolts (if present) are sound, properly positioned, and functioning properly.	Anchor bolt nuts loose or missing (bolts remain intact). Guide or restraint system has minor deterioration but is functioning properly.	Anchor bolts loose, bent or at expansion limits. Lateral guide system moderately worn or misaligned. Uplift restraint has moderate deterioration, but is functioning properly.	Failure of anchor bolts or lateral guide system has severely impacted bearing function or capacity. Uplift restraint system has failed.
Loss of Bearing Area	None	Less than 10%	10% to 25%	More than 25%

#311: Expansion Bearing (Each)

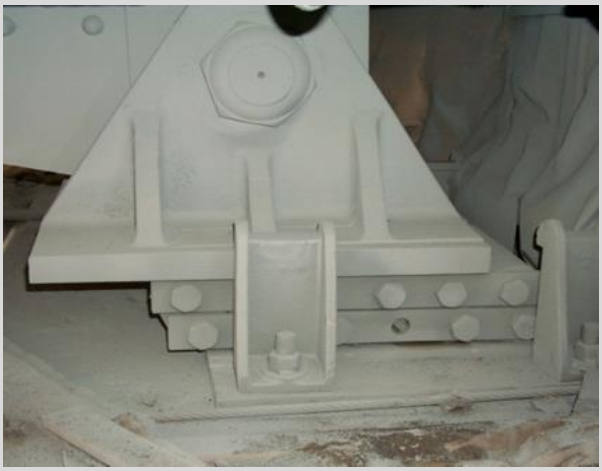
Condition Rating Examples (Expansion Bearings)

Condition State 2
Debris and surface corrosion on sliding plate bearing

Condition State 2
Surface corrosion on a rocker expansion bearing

Condition State 3
Sliding plate bearing near expansion limits (slide plate extends well beyond the masonry plate)

Condition State 3
Flaking rust and debris below rocker bearing (restriction of movement)



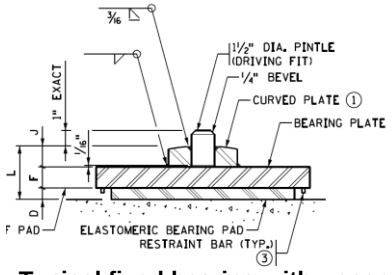
Condition State 4
Severe misalignment of rockernest bearing due to substructure movement

Condition State 4
Rocker bearing locked and sliding on the masonry plate

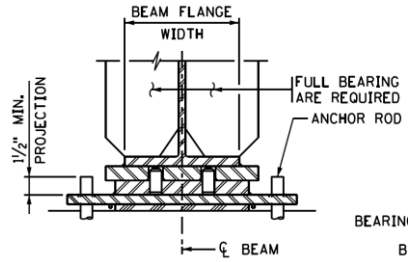
B.3.9.4 Fixed Bearing (Element #313)

#313: Fixed Bearing (Each)

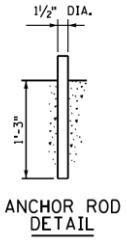
This element applies to bearings that are fixed against longitudinal movement of the superstructure. Fixed bearings may incorporate a pin, curved steel plate, or thin elastomeric pad to allow rotational movement (from live load deflection of the superstructure). Fixed bearings are typically designed to resist transverse movement, and may be designed to resist uplift forces.



Typical fixed bearing with upper curved plate and elastomeric pad.

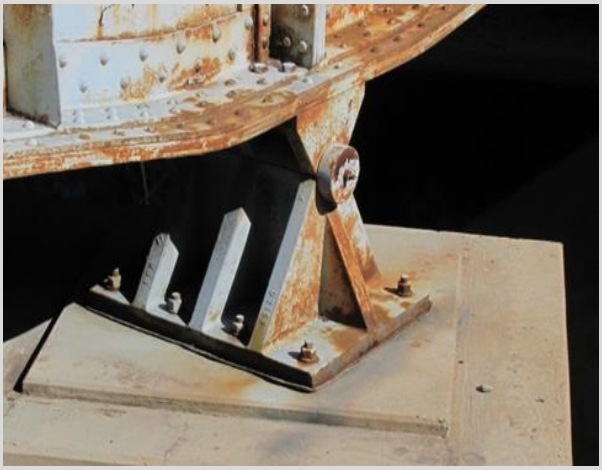


Typical fixed bearing with two anchor rods (1-1/2″ minimum projection).



Standard anchor rods are 18″ long (1-1/2″ dia.) with a 15″ embedment depth.

Item or Defect	Structural Element Condition States			
	1	2	3	4
	Good	Fair	Poor	Severe
Structural Review & Rotational Movement (If Allowed by Design)	Bearing is functioning as intended.	Minor rotational restriction (cleaning and/or lubrication recommended).	Rotational restriction not warranting structural review. Cleaning or lubricating required.	Severe rotational restriction. Structural review, repair, or replacement is required.
Primary Bearing Components	All components are intact and properly positioned.	Primary bearing components have moderate deterioration or slight misalignment.	Primary bearing components have significant deterioration or misalignment.	Primary bearing components have severe deterioration or misalignment (or have failed).
Elastomeric Pads or Lead Leveling Sheets	In place and functioning as intended.	Misaligned or extruded along the bearing plate.	Severely misaligned, deformed or extruded.	NA
Corrosion	None	Freckled rust (corrosion has initiated).	Section loss or pack rust is present.	Section loss severely impacts bearing function or capacity.
Connections	In place and functioning as intended.	Loose fasteners, but connection still functioning as intended.	Missing fasteners (bolts, rivets, etc.) or broken welds.	Connection failure severely impacts bearing function or capacity.
Anchor Bolts, Anchor Rods and Uplift Restraints	Anchor bolts and uplift restraints (if present) are properly installed.	Anchor bolts slightly misaligned. Anchor rod projects 3” to 6” above bearing.	Anchor bolts loose or bent. Anchor rod projects 6” to 10” above bearing. Uplift restraint is still functioning.	Failure of anchor bolt (or uplift restraint). Anchor rod projects more than 10” above bearing.
Loss of Bearing Area	None	Less than 10%	10% to 25%	More than 25%

#313: Fixed Bearing (Each)	
Condition Rating Examples (Fixed Bearings)	
	
Condition State 2 **Surface corrosion on a fixed pin bearing**	**Condition State 2** **Elastomeric pad is extruding and anchor bolt projects 4” above bearing**
	
Condition State 3 **Improperly installed anchor bolt extends 8” above bearing**	**Condition State 3** **Flaking rust (section loss) and debris on two fixed pin bearings**
	
Condition State 4 **Masonry plate cracked (and supporting pier fractured) on a fixed pin bearing**	**Condition State 4** **Anchor bolt failure on a fixed pin bearing (masonry plate has slid back to the parapet)**

B.3.9.5 Pot and Disk Bearings (Elements #314 and #315)

#314: Pot Bearing (Each)
#315: Disk Bearing (Each)

Pot and Disk bearings allow for multi-dimensional rotational movement. These are specialized bearings used for high loads (long spans, steel pier caps, or railroad bridges). It is difficult to distinguish pot bearings from disc bearings without referencing plans or shop drawings.

- Pot bearings consist of a shallow steel piston resting within a steel cylinder, which contains a confined elastomer. Typically, only the perimeter edge of the elastomer is visible for inspection. Pot bearings are not recommended for use on railroad bridges.
- Disk bearings consist of a shallow steel piston resting within a steel cylinder, which contains a semi-spherical disc (hard plastic or steel). The "disc" is enclosed within the assembly and is typically not visible for inspection. Disk bearings are most common on railroad bridges.

Pot/Disk bearings may be "fixed" against horizontal movement (but allowing rotation), "guided expansion" (allowing horizontal expansion/contraction but lateral movement is restricted), or "non-guided expansion" (free to move in any direction).

The photo on the left shows a fixed pot bearing with uplift restraint pins.

On a typical expansion pot bearing, the upper plate has a "mirror finish stainless steel plate welded to the underside, and the lower plate has polytetrafluoroethylene (PFTE) bonded to the top surface. This combination provides an extremely low friction sliding surface (lubrication is not required).

The photo on the left shows an expansion pot bearing with a center guide key. The stainless steel plate should be examined evidence of separation (or pack rust). Look for evidence of movement, such as wear near the guide or on the stainless steel plate.

On guided expansion pot bearings, look for evidence of wear, binding, or deterioration of the guide system. The upper piston plate should be properly seated (and positioned) within the lower cylinder plate. Visible portions of the elastomer should be examined for splitting, tearing, or extrusion.

The photo on the left shows an expansion pot bearing with a guide bars on both edges. The lower plate should be examined for any wear or de-bonding of the PTFE. The presence of shavings in the photo at left indicates wear on the PTFE slide surface.

The photo on the left shows an unguided expansion pot bearing. While these bearings are designed to allow free movement in any direction, any measurable lateral movement should be noted.

Longitudinal movement can be measured by the offset between the centerline of the upper and lower plates.

#314: Pot Bearing (Each) #315: Disk Bearing (Each)				
Item or Defect	**Structural Element Condition States**			
	1	**2**	**3**	**4**
	Good	**Fair**	**Poor**	**Severe**
Movement and Structural Review	No restriction of movement – bearing is functioning as intended.	Minor restriction (cleaning and/or lubrication recommended).	Restricted but not warranting structural review (no immediate structural concern). Cleaning and/or lubricating required. Resetting or repairs recommended.	Severe restriction – structural review is warranted. **or** resetting, repairs, or bearing replacement are required.
Alignment	Alignment is appropriate for the current temperature	Alignment is tolerable but is inconsistent for the current temperature.	Alignment is near the design limits for expansion or contraction.	Alignment is beyond the design limits for expansion or contraction.
Primary Bearing Components	Primary components are intact and properly positioned.	Primary bearing components are slightly worn or misaligned.	Primary bearing components are significantly worn or misaligned.	Primary bearing components are severely deteriorated, misaligned, jammed or detached.
Corrosion	None	Freckled rust (corrosion has initiated).	Section loss or pack rust is present.	Section loss severely impacts bearing function or capacity.
Connections	In place and functioning as intended.	Loose fasteners, but connection still functioning as intended.	Missing fasteners (bolts, rivets, etc.) or broken welds.	Connection failure severely impacts bearing function or capacity.
Lateral Guide System, Uplift Restraints, or Anchor Bolts	Guides, restraints, or anchor bolts (if present) are sound, and functioning properly.	Anchor bolt nuts loose or missing (bolts remain intact). Guide or restraint system has minor deterioration but is still functioning properly.	Anchor bolts loose or bent. Lateral guide system moderately worn or misaligned. Uplift restraint system has moderate deterioration, but is still functioning.	Failure of anchor bolts, lateral guide system, or uplift restraint system has severely impacted bearing function or capacity.
Loss of Bearing Area	None	Less than 10%	10% to 25%	More than 25%

#314: Pot Bearing (Each)
#315: Disk Bearing (Each)

Condition Rating Examples (Pot and Disk Bearings)

Condition State 2
Loose sole plate bolts on a fixed pot bearing

Condition State 2
Teflon strop peeling off from the guide bar on a guided expansion pot bearing

Condition State 2
Paint/galvanizing failure and surface corrosion on a fixed pot bearing

Condition State 3
Pack rust on the sliding plate on a free expansion pot bearing

Condition State 3
Teflon shavings due to wear on the sliding surface of a free expansion pot bearing

Condition State 3
Flaking rust on a free expansion pot bearing

B.3.9.6 Pin and Hanger Assembly/Pinned Connection (Element #161)

This element applies to pin and hanger assemblies and fixed pin assemblies. This element should also be used for pin-connected trusses, arches, columns, or any pinned connection on a primary bridge structural element that is not rated under a bearing element.

Pin and Hanger Assembly on a Riveted Steel Girder Bridge

Fixed Pin Assembly on a Riveted Steel Girder Bridge

Ultrasonic Examination of a Pinned Truss Connection

On continuous steel bridges with cantilever or suspended spans (where the end of one span is supported by an adjacent span), the connection detail may consist of a pinned assembly. Pin and hanger (or fixed pin) assemblies are relatively rare in Minnesota. They are mostly present on steel multiple girder/beam bridges constructed from 1935 to 1975. A pin and hanger assembly typically consists of two vertical hanger plates with pinned connections at the top and bottom. This allows both rotation and longitudinal movement of the superstructure. Pin and hanger assemblies may incorporate a guide/restraint system to prevent lateral movement. A fixed pin assembly has only one pin. This allows rotation, but restricts longitudinal movement of the superstructure. Some bridges in Minnesota have “swivel hinges” – the center girder will have a fixed pin assembly, while the other girders will have pin and hanger assemblies.

Pinned assemblies on bridges that carry highway traffic require periodic ultrasonic examination. Pinned assemblies should be examined for deterioration, function, alignment, as well as the soundness of the adjacent superstructure support. All of these factors should be taken into consideration when rating a pinned assembly. All components of a pinned assembly (pins, plates, pin caps, nuts, washers, spacers, etc.) should be examined for wear, corrosion, defects, cracks, bending, loosening or misalignment. Note: Severe pack rust can deform hanger plates or result in failure of pinned connections.

Periodic measurements should be taken to verify the proper function of pin and hanger assemblies (be sure to record the temperature at the time of inspection). As a frozen pin will transfer additional bending stresses to the hanger plates, any significant restriction of a pin and hanger assembly should be identified and analyzed immediately. Note: While the presence of fretting rust (a red-colored dust resulting from the wearing of steel surfaces) indicates that recent movement has occurred, it may also indicate inadequate lubrication.

Pin-connected steel truss bridges are extremely rare in Minnesota – these were generally constructed prior to 1920. Steel pier columns with pinned connections (that allow the pier to tip) are sometimes found on bridges in areas with unstable soil conditions. Pinned connections are sometimes present on newer bridges, such as hanger cable connections on a suspension bridge.

#161: Pin and Hanger Assembly or Pinned Connection (Each)				
This element applies to steel pin and hanger assemblies or fixed pin connections. This element should also be used for pin-connected trusses, arches, columns, or any pinned connection on a primary bridge structural element that is not rated under a bearing element. • A pin and hanger assembly can be grouped as "1" when determining the element quantity. • As this is an NBE steel element, the coating system must be rated as a separate sub-element using Element #515 (Steel Protective Coating).				
Item or Defect	**Condition States**			
	1	**2**	**3**	**4**
	Good	**Fair**	**Poor**	**Severe**
Movement and Structural Review	No restriction. Pinned connection is functioning as intended.	Minor restriction (cleaning and/or lubrication recommended).	Restricted but not warranting structural review. Cleaning or lubricating required. Repairs recommended.	Severe restriction – structural review is warranted. Repair or replacement is required.
Longitudinal Alignment (Pin & Hangers)	Alignment is appropriate for the current temperature.	Alignment is tolerable but is inconsistent for the current temperature.	Expansion or contraction is near the design limits.	Expansion or contraction is beyond the design limits.
Misalignment	None	Slightly out of position or alignment.	Significantly out of proper position or alignment.	Severely out of proper position or alignment.
Pinned Connection or Pinned Assembly Components	All components are intact and properly positioned.	Plates or pins have minor wear. Cotter pins missing.	Plates or pins are significantly worn. Cap nuts are loose.	Connection has failed (or failure is eminent). Pins or plates have severe wear. Cap nuts missing.
Corrosion	None	Surface corrosion (freckled rust).	Section loss, flaking rust, or pack rust is present.	Section loss exceeds 10% of cross section.
Cracking	None	Crack has self-arrested or has been arrested.	Crack that is unlikely to propagate into a critical stress area.	Crack that has propagated into a critical stress area.
Distortion	None	Mitigated distortion.	Significant distortion.	Severe distortion

#161: Pin and Hanger Assembly or Pinned Connection

Condition Rating Examples (Pinned Connections)

Condition State 2
Paint failure and surface corrosion on a pin and hanger assembly

Condition State 3
Pin and hanger near limits of expansion, fretting rust on top pin and section loss on hanger plate

Condition State 3
Pack rust distortion on the hanger plate on a pin and hanger connection

Condition State 4
Severe pack rust and section loss on a pinned truss connection

B.3.9.7 Hinge Bearing Assemblies (Elements #850 and #851)

Hinge bearing assemblies are the connection detail on continuous bridges with cantilever joints or suspended spans (where the end of one span is supported by an adjacent span). Hinge bearings are often "cantilevered" (offset from the piers), to reduce deterioration of the substructure from leaking deck joints. In Minnesota, cantilever hinge bearings were relatively common on continuous steel multi-beam bridges constructed in the 1960's and 1970's – they are seldom used on newer bridges. Hinge bearings are sometimes used on continuous concrete box girder bridges.

Hinge bearings may be expansion (permitting longitudinal movement of the superstructure) or fixed (resisting longitudinal movement of the superstructure). Most hinge bearings are designed to allow rotation of the superstructure due to live load deflection – some are designed to restrict lateral movement of the superstructure. Hinge bearings can include a variety of bearing assembly types (rocker, roller, sliding plate, elastomeric pad, or pot bearings).

Hinge Bearing Assembly Types

Rocker (Expansion) Hinge Bearing

Roller (Expansion) Hinge Bearing

Sliding Plate (Expansion) Hinge Bearing

Curved Plate (Fixed) Hinge Bearing

As there are no AASHTO elements for hinge bearing assemblies; MnDOT created two agency defined elements (ADEs).

- **#850: Steel Hinge Assembly:** applies to hinge bearings on steel superstructures (typically girders or beams).
- **#851: Concrete Hinge Assembly:** applies to hinge bearings on concrete superstructures (typically box girders).

Hinge bearing assemblies should be examined for deterioration, function, alignment, as well as the soundness of the superstructure support. All of these factors should be taken into consideration when rating a hinge bearing element. The following items should be emphasized when inspecting a hinge bearing assembly.

- Hinge bearing assemblies should be examined for corrosion or debris. Adjacent deck joints and deck drainage systems should be examined for leakage, clogging, or other malfunction that might be exposing the hinge bearing to water, salt, or debris.
- Hinge bearing components (rockers, rollers, sliding plates, elastomeric pads, pins, nuts, washers, cotter pins, spacers and guide tabs) should be examined for wear, corrosion, defects, cracks, bending, loosening or misalignment. Excessive movement (or noise) at the hinge bearing under live loads may indicate bearing malfunction.
- Proper function of expansion hinge bearings is a primary concern. A malfunctioning expansion hinge could damage adjacent deck, superstructure, or substructure elements. The inspector should verify that longitudinal movement is not restricted (any significant restriction should be identified and analyzed immediately). Obvious visual evidence of recent movement (such as scrape marks on contact surfaces) should be noted. The adjacent superstructure and deck should be examined for any evidence of contact that could restrict expansion. To verify proper function, periodic measurements should be taken (preferably at a clean, easily identifiable location) – be sure to record the temperature when the measurements were taken. If the hinge bearings cannot be accessed up-close, measurements can be taken at adjacent deck joints, curb plates, or railings.
- The longitudinal, lateral, and vertical alignment of the hinge bearing should be observed and noted. Misalignment of a hinge bearing may indicate significant problems elsewhere on the bridge (such as substructure settlement or tipping). On expansion hinge bearings, the longitudinal alignment should be appropriate for the current temperature, and the alignment of adjacent hinge bearings should be similar.
- The superstructure adjacent to the hinge bearing assembly should be examined for deterioration (or evidence of structural distress). On steel beams, the webs, flanges, and bearing stiffeners should be examined for corrosion, section loss, buckling, or cracking. On concrete box girders, the concrete surfaces should be examined for structural cracking, leaching, rust staining, delamination, or spalling (internal inspection of the hinge area is recommended).

Scrape marks on a sliding plate hinge bearing indicate recent movement

Misaligned hinge bearing

Hinge bearing in full expansion (beam ends contacting)

#850: Steel Hinge Bearing Assembly (Each)				
This element applies to hinge bearings on steel girders, beams, or other steel superstructure members. This includes expansion or fixed hinge bearings of any type (rocker, roller, sliding plate, or elastomeric pad). This element may also be used for any bearing assembly where a steel superstructure element bears upon another steel superstructure element. This is an "each" item, a condition state must be determined for each hinge assembly.				
Item or Defect	**Structural Element Condition States**			
	1	**2**	**3**	**4**
	Good	**Fair**	**Poor**	**Severe**
Movement and Structural Review	No restriction. Hinge is functioning as intended.	Minor restriction (cleaning and/or lubrication recommended).	Restricted but not warranting structural review. Cleaning or lubricating required. Repairs recommended.	Severe restriction – structural review is warranted. Resetting, repairs, or replacement are required.
Longitudinal Alignment	Alignment is appropriate for the current temperature.	Alignment is tolerable but is inconsistent for the current temperature.	Expansion or contraction is near the design limits.	Expansion or contraction is beyond the design limits.
Misalignment (Lateral)	None	Slight	Significant	Excessive
Hinge Components	All components are intact and properly positioned.	Hinge components have moderate deterioration or are slightly misaligned.	Hinge components are significantly deteriorated or misaligned.	Hinge components have severe deterioration or misalignment (jammed, detached, or otherwise failed).
Corrosion	None	Surface corrosion (freckled rust).	Section loss, flaking rust, or pack rust is present.	Section loss that severely impacts function or capacity.
Guide, Restraint, or Anchorage System	Guides, restraints, and anchorages are sound and functioning properly.	Anchor nuts loose or missing (bolts remain intact). Plates slightly misaligned. Restraint system is still functioning properly.	Anchor bolts loose, bent or at expansion limits. Plates significantly out of position. Broken welds. Restraints are not functioning properly.	Failure of anchor bolts or restraint system has severely impacted bearing function or capacity. Pintle or bearing plates severely out of position.
Loss of Bearing Area	None	Less than 10%	10% to 25%	More than 25%
Adjacent Members	Little or no deterioration.	Minor to moderate deterioration.	Extensive deterioration.	Severe or critical deterioration.

#850: Steel Hinge Bearing Assembly (Each)	
Condition Rating Examples (Steel Hinge Bearing Assembly)	
 **Condition State 2** **Minor corrosion on a sliding plate hinge**	 **Condition State 2** **Minor corrosion on a sliding plate hinge**
 **Condition State 3** **Lateral guide below hinge bearing is severely corroded (possibly restricting movement)**	 **Condition State 3** **Pack rust under a rocker expansion hinge**
 **Condition State 4** **Severe corrosion on a sliding plate hinge (severe section loss in beam web above hinge)**	 **Condition State 4** **Sliding plate hinge locked in expansion (curved slide plate tipped)**

#851: Concrete Hinge Bearing Assembly (Each)				
This element applies to hinge bearings on concrete bridges (where a concrete superstructure element bears upon another concrete superstructure element). This includes expansion or fixed hinge bearings of any type (rocker, roller, sliding plate, pot, or elastomeric pad). This is an "each" item – a condition state may be determined for each individual hinge assembly or the entire hinge joint may be rated as a unit.				
Item or Defect	**Structural Element Condition States**			
	1	**2**	**3**	**4**
	Good	**Fair**	**Poor**	**Severe**
Movement and Structural Review	No restriction. Hinge is functioning as intended.	Minor restriction (cleaning and/or lubrication recommended).	Restricted but not warranting structural review. Cleaning or lubricating required. Repairs recommended.	Severe restriction – structural review is warranted. Resetting, repairs, or replacement are required.
Longitudinal Alignment	Alignment is appropriate for the current temperature.	Alignment is tolerable but is inconsistent for the current temperature.	Expansion or contraction is near the design limits.	Expansion or contraction is beyond the design limits.
Lateral Misalignment	None	Slight	Significant	Excessive
Hinge Components	All components are intact and properly positioned.	Hinge components have moderate deterioration or slight misalignment.	Hinge components are significantly deteriorated or misaligned.	Hinge components have severe deterioration or misalignment (jammed, detached, or otherwise failed).
Corrosion	None	Freckled rust (corrosion has initiated).	Section loss or pack rust is present.	Section loss that severely impacts function or capacity.
Guide, Restraint, or Anchorage System	Guides, restraints, and anchorages are sound and functioning properly.	Anchor nuts loose or missing (bolts remain intact). Plates slightly misaligned. Restraint system is still functioning properly.	Anchor bolts loose, bent or at expansion limits. Plates significantly out of position. Broken welds. Restraints are not functioning properly.	Failure of anchor bolts or restraint system has severely impacted bearing function or capacity. Pintle or masonry plates severely out of position.
Loss of Bearing Area	None	Less than 10%	10% to 25%	More than 25%
Adjacent Members	Little or no deterioration.	Minor to moderate deterioration.	Extensive deterioration.	Severe or critical deterioration.

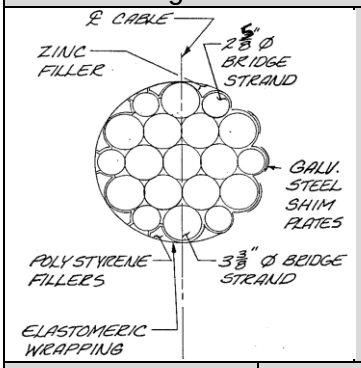
#851: Concrete Hinge Bearing Assembly (Each)	
Condition Rating Examples (Concrete Hinge Bearing Assembly)	
 **Condition State 2** Cracking on concrete adjacent to hinge adjacent concrete	 **Condition State 2** Structural retrofit at a hinge joint in a concrete box girder
 **Condition State 3** Spalling on concrete box girder adjacent to hinge	 **Condition State 3** Rust staining and cracking in concrete box girder at hinge joint
 **Condition State 4** Extensive (and severe) spalling on concrete box girder adjacent to hinge	 This bridge near Montreal (Canada) collapsed in 2006 due to failure of a concrete hinge, resulting in five fatalities

B.3.9.8 Steel Cables (Elements #147 and #148)

#147: Steel Main Cable (LF)

This element applies only to the primary steel support cables on suspension or cable-stayed bridges. The quantity is the total length of all main cables on the bridge, measured along the length of each main cable from anchorage to anchorage. Anchorages should be considered in the condition rating.

- Steel main cables are typically galvanized, and often have an additional protective wrapping and/or coating. The steel protective coating should be rated as a sub-element using Element #515.



A cross-section of the main suspension cables on the Hennepin Ave. bridge is shown at left. Each cable is comprised of 19 steel bridge strands. The bridge strands (3-3/8" or 2-5/8" diameter) are comprised of helically-wound galvanized wires. Except inside the underground chambers (where the strands splay out to individual anchorages), only the outer elastomeric wrapping is visible for inspection (photo on right).

Item or Defect	Structural Element Condition States			
	1 Good	2 Fair	3 Poor	4 Severe
Structural Review	Structural review is not required.	Structural review is not required.	Structural review is not required **or** structural review of existing defects has determined that strength or serviceability has not been impacted.	Condition warrants structural review **or** structural review has determined that the defects impact strength or serviceability.
Corrosion	None	Surface corrosion.	Section loss or pack rust.	Section loss exceeds 5% of the cross-section.
Frayed, Worn, or Damaged Cables	None	Minor wear or abrasion that has been mitigated. Minor strand or wire separation.	Active wear or abrasion at contact points. Isolated fraying or severing of individual wires. Significant strand or wire separation.	Severe wear or abrasion. Multiple wires frayed, severed or loose.
Cable Banding	Banding is intact.	Banding is loose.	Banding has failed.	NA
Vibration	Little or no vibration.	Slight (or mitigated) vibration.	Moderate vibration.	Significant vibration.
Cable Anchorage	Minor deterioration.	Moderate deterioration.	Significant deterioration. Evidence of slight cable loosening or slippage.	Severe deterioration or anchorage failure.

#148: Secondary Steel Cable (Each)				
This element applies to steel cables that transfer loads from the bridge superstructure to the main cable (or arch). Examples include vertical hanger cables on suspension or tied arch bridges. The quantity may be the total number of secondary cables or the number of secondary cable "groups" (groups of cables at one location). The cable anchorages should be included in the condition rating. Secondary cables are typically steel structural strands or wire ropes comprised of galvanized wires. • The steel protective coating should be rated as a sub-element using Element #515.				
Item or Defect	**Structural Element Condition States**			
	1	**2**	**3**	**4**
	Good	**Fair**	**Poor**	**Severe**
Structural Review	Structural review is not required.	Structural review is not required.	Structural review is not required **or** structural review of existing defects has determined that strength or serviceability has not been impacted.	Condition warrants structural review **or** structural review has determined that the defects impact strength or serviceability.
Corrosion	None	Surface corrosion.	Section loss or pack rust.	Section loss exceeds 5% of the cross-section.
Frayed, Worn, or Broken Strands	None	Minor wear or abrasion that has been mitigated. Minor strand or wire separation.	Active abrasion or wear at contact points. Isolated fraying of individual wires. Significant strand or wire separation.	Severe abrasion or wear. Multiple wires frayed, severed or loose.
Cable Banding	Banding is intact.	Banding is loose.	Banding has failed.	NA
Vibration	Little or no vibration.	Slight (or mitigated) vibration.	Moderate vibration.	Significant vibration.
Cable Anchorage	Minor deterioration	Moderate deterioration (no evidence of distress).	Significant deterioration. There may be evidence of loosening or slight slippage.	Severe deterioration or anchorage failure. There may be significant slippage.

#148: Secondary Steel Cable (Each)

Condition Rating Examples (Secondary Steel Cables)

Condition State 2
Minor wear on steel strand hanger cable

Condition State 3
Active abrasion at contact point (steel wire rope hanger cable wearing against a steel batten plate)

Condition State 3
Corrosion on steel strand hanger cable just above the anchorage socket

Condition State 4
Cable failure due to fractured anchorage plate

B.3.9.9 Secondary Members (Elements #855 and #856)

#855: Secondary Members – Superstructure (1 Each)

This element applies to secondary members that are part of the bridge superstructure (such as diaphragms, bracing, or struts). This element includes any material – steel, concrete, timber, or masonry. This element may also be used for moveable bridge components (such as sheaves, trunnions, turntables, or counterweights). This element should not be used for culvert structures.

The quantity is typically listed as "1", and should reflect the condition of the most deteriorated secondary member. The element notes should describe the secondary superstructure members present on the bridge.

- Element #515 Steel Protective Coating is not rated as a specific sub-element for secondary members. The paint condition for steel secondary elements should be included in the painted area for the most appropriate steel element.

Item or Defect	Structural Element Condition States			
	1	2	3	4
	Good	Fair	Poor	Severe
Structural Review and Repairs	Little or no deterioration	Minor to moderate deterioration. Any repaired or reinforced areas are sound.	Extensive deterioration, but secondary member is still functioning as intended. Repairs are deteriorated.	Severe damage or deterioration. Secondary member is not functioning as intended – structural analysis or immediate repairs are required.
Steel	No corrosion.	Surface corrosion (freckled rust).	Section loss or pack rust. Minor cracks.	Advanced corrosion (severe section loss). Significant cracks.
Concrete	Minor cracking.	Moderate cracking, scale, or leaching. Minor spalls or delaminations.	Extensive cracking, scale, or leaching. Significant spalling or delamination or (exposed rebar).	Severe structural cracking or extensive spalling (exposed rebar may have severe section loss).
Timber	Minor cracking or splitting.	Moderate splits, decay, or fire damage.	Extensive splits, decay, or fire damage (minor sagging or crushing).	Advanced decay. Severe structural cracking, sagging, or crushing.
Connections	Connections are sound.	Connections have minor distress.	Connections are loosening.	Connections have failed.
Impact Damage	None	Minor dents, gouges, spalls, or scrapes.	Moderate impact damage – members bent out of plane.	Severe impact damage – members severed or severely bent.

#855: Secondary Members – Superstructure (1 Each)

Condition Rating Examples (Secondary Members – Superstructure)

Condition State 2
Surface corrosion (freckled rust) on a steel diaphragm

Condition State 2
Delamination and spall on a concrete end diaphragm (adjacent to a prestressed beam)

Condition State 3
Flaking rust (section loss) on a steel diaphragm

Condition State 3
Loose bolts on a steel diaphragm connection

Condition State 4
Truss portal brace fractured

Condition State 4
Truss portal brace severely damaged

#856: Secondary Members – Substructure (1 Each)

This element applies to secondary members that are part of the bridge substructure (such as pier bracing, crash struts, or buttresses). This element should not be used for culvert structures. This includes any material – steel, concrete, timber, or masonry.

The quantity is typically listed as "1", and should reflect the condition of the most deteriorated secondary member. The element notes should describe the secondary substructure members present on the bridge.

- Element #515 Steel Protective Coating is not rated as a specific sub-element for secondary members. The paint condition for steel secondary elements should be included in the painted area for the most appropriate steel element.

Item or Defect	Structural Element Condition States			
	1	2	3	4
	Good	Fair	Poor	Severe
Structural Review and Repairs	Little or no deterioration	Minor to moderate deterioration. Any repaired or reinforced areas are sound.	Extensive deterioration, but the secondary member is still functioning as intended. Repaired or reinforced areas may be unsound.	Severe damage or deterioration. Secondary member is no longer functioning as intended – structural analysis or immediate repairs are required.
Steel	No corrosion.	Surface corrosion (freckled rust).	Section loss or pack rust. Minor cracks.	Advanced corrosion (severe section loss). Significant cracks.
Concrete	Minor cracking.	Moderate cracking, scale, or leaching. Minor spalls or delaminations.	Extensive cracking, scale, or leaching. Significant spalling or delamination or (exposed rebar).	Severe structural cracking or extensive spalling (exposed rebar may have severe section loss).
Timber	Minor cracking or splitting.	Moderate splits, decay, or fire damage.	Extensive splits, decay, or fire damage (minor sagging or crushing).	Advanced decay. Severe structural cracking, sagging, or crushing.
Connections	Connections are sound.	Connections have minor distress.	Connections are loosening.	Connections have failed.
Impact Damage	None	Minor dents, gouges, spalls, or scrapes.	Moderate impact damage – members bent out of plane.	Severe impact damage – members severed or severely bent.

#856: Secondary Members – Substructure (1 Each)

Condition Rating Examples (Secondary Members – Substructure)

Condition State 1
Concrete wall protecting a steel pier column adjacent to a railroad track

Condition State 2
Minor Ice abrasion on a timber pier bracing plank

Condition State 3
Spalling on a concrete pier strut

Condition State 3
Steel pier brace bent (batten plate detached)

Condition State 3
Fractured shear key on a concrete pier cap

Condition State 4
Severe ice damage to timber pier bracing planks

B.3.9.10 Non-Integral Retaining Wall (Element #861)

#861: Non-Integral Retaining Wall (Each)				
This element is primarily intended for retaining walls (of any material) that are adjacent to the abutment (or wingwall), but are separated by a construction joint. This will generally include retaining walls extending from the abutment/wingwall up to the approach relief joint (or end of the roadway approach). This element could be used for any other retaining walls that are important to the function or safety of the bridge. This is an "Each" quantity (one for each retaining wall present).				
Item or Defect	**Structural Element Condition States**			
	1	**2**	**3**	**4**
	Good	**Fair**	**Poor**	**Severe**
Structural Review or Repairs	Structural review or repairs are not required. No previous structural repairs are present.	Structural review or repairs are not required. Any existing structural repairs are in sound condition.	Repairs may be recommended (structural review is not required) **or** Structural review has determined that strength or serviceability has not been impacted.	Condition warrants a structural review **or** Structural review has determined that the defects impact strength or serviceability.
Tipping or Settlement	None	Within tolerable limits or arrested (no structural distress).	Exceeds tolerable limits.	Stability or function has been reduced.
Concrete	Minor cracking, scaling, or leaching (no delaminations or spalls).	Moderate cracking, scaling, or leaching. Minor delamination or spalling – any exposure of reinforcement is minimal.	Extensive cracking, scaling, or leaching. Significant structural cracking. Delamination or spalling is prevalent. Exposed rebar has measurable section loss.	Severe scaling or spalling. Exposed reinforcement has severe section loss. Severe structural cracking.
Steel	Little or no corrosion.	Moderate surface corrosion. Minor flaking rust or pack rust (minimal section loss).	Extensive corrosion (measurable section loss). Minor cracks are present.	Advanced corrosion (severe section loss). Significant cracks or fractures.
Timber	Minor cracking or splitting.	Moderate splits, decay, or fire damage.	Extensive splits, decay, or fire damage – there may be some sagging or crushing.	Advanced decay. Severe structural cracking, sagging, or crushing.
Masonry	Minor weathering.	Mortar deterioration. Moderate spalling, splitting, or displacement.	Extensive mortar deterioration. Extensive spalling, splitting, or displacement.	Severe spalling, splitting, or displacement.

B.3.9.11 Tiled Surface (Element #862)

#862: Tiled Surface (SF)				
This element applies to ceramic tiled surfaces on concrete structures. This typically includes concrete rigid frame structures or NTIS tunnels, but may apply to tiled surfaces on any concrete element. The SF quantity should correspond with the total area of tiled surfaces on the structure.				
Item or Defect	**Structural Element Condition States**			
	1	**2**	**3**	**4**
	Good	**Fair**	**Poor**	**Severe**
Tiled Surfaces	Tiles are in good condition and securely attached.	Tile cracked but still secure. Tiles scraped, gouged or stained.	Tiles broken, delaminated or loose.	Tiles missing. Loose tiles that pose a significant safety concern.

Condition Rating Examples (Tiled Surfaces)

Condition State 2
Tile cracked (still secure)

Condition State 2
Tile Stained

Condition State 3
Delaminated Tiles (Marked with "X")

Condition State 4
Tiles missing

B.3.9.12 Decorative Facade (Element #863)

#863: Decorative Facade (LF)

This element is intended for decorative facades along the fascia of bridge structures. These facades are typically not part of the primary load path, but must support their own weight and would be subjected to wind loads and vibration. These are most commonly precast concrete panels, but could be cast-in-place concrete or comprised or other materials. This is an "LF" quantity (measured along the length of the decorative facade.

Precast concrete façade with faux masonry surface

Precast concrete façade (detail at abutment)

Fiberglass panels mounted on bridge fascia

Item or Defect	Structural Element Condition States			
	1	2	3	4
	Good	Fair	Poor	Severe
Structural Review and Repairs	Little or no deterioration (no repairs present)	Minor to moderate deterioration. Any repaired or reinforced areas are sound.	Extensive deterioration. Repairs may be recommended.	Severe damage or deterioration. Structural analysis or immediate repairs are required.
Concrete	Minor cracking, scaling, or leaching (no delaminations or spalls).	Moderate cracking, scaling, or leaching. Minor delamination or spalling.	Extensive cracking, scaling, or leaching. Significant cracking. Spalling with exposed reinforcement. Significant delamination.	Severe scaling or spalling. Exposed reinforcement has severe section loss. Severe cracking.
Other Material Deterioration	None	Initiated breakdown or deterioration.	Significant deterioration.	Severe or critical deterioration.
Connections	Connections are sound.	Connections have minor corrosion or distress.	Connections have extensive corrosion. Connections are loosening.	Connections have failed.

Condition Rating Examples (Decorative Façade)

Condition State 2
Leaching crack on precast concrete panel

Condition State 3
Significant cracking and spalling on façade due to impact damage

B.3.10 CULVERT ELEMENTS

B.3.10.1 Inspection Procedures for Culverts

While the FHWA requires inspection of any structure with a total length of 20 ft. or greater, Minnesota State law requires inspection of any structure with a total length of 10 ft. or greater – thus, the MnDOT structure inventory includes many small (10 ft. to 20 ft.) culverts.

While culverts are typically designed to allow drainage below a roadway embankment, they may also serve as underpasses for vehicles, pedestrians, or livestock. Culverts are designed to support the dead load of the embankment material as well as live loads from traffic. If the embankment fill is more than 3 ft. deep, the fill is likely the primary load.

Culverts are constructed of a variety of materials, including concrete (cast-in-place or precast), corrugated steel plate, stone masonry, timber, or aluminum. The size and shape of a culvert is usually determined by the hydraulic requirements (the opening must be large enough to carry the design discharge). Culvert shapes include arch culverts, box culverts, round pipe culverts, pipe-arch culverts, or elliptical culverts. A culvert may consist of a single barrel or multiple barrels.

Culverts can be structurally classified as either “flexible” or “rigid”. Steel culverts are typically considered to be flexible – a flexible culvert derives a significant amount of structural strength from the surrounding soil (the lateral soil pressure helps to resist vertical loads). Concrete culverts are typically considered to be rigid – a rigid culvert provides its own structural strength, and does not necessarily require embankment fill.

A complete culvert inspection should include examining the culvert barrel, end treatments, waterway, embankment slopes, and the roadway. Ideally, a walk-through inspection of the entire the culvert barrel should be conducted during low water conditions (high water or ice can prevent inspection of critical areas). If an adequate walk-through inspection cannot be performed, it should be noted in the inspection report, and a complete inspection should be performed when conditions allow. If necessary, an underwater inspection may need to be performed.

During culvert inspection, two main items need to be determined - the hydraulic performance and the structural condition.

Hydraulic Performance: Poor hydraulic performance can result in excessive ponding, flooding of adjacent properties, or washouts of the embankment and roadway. The inspector should note any conditions that might reduce the hydraulic performance of the culvert. A reduction of the hydraulic performance that is not related to the structural condition of the culvert (such as sediment) would only impact the NBI channel rating.

- Poor horizontal or vertical channel alignment can reduce hydraulic efficiency, increase sedimentation, or accelerate embankment erosion. Culverts on flat grades may have excessive sediment, culverts on steep grades may have outlet scour.
- Accumulation of debris at the inlet (or excessive sedimentation within the barrel) can reduce the culvert's hydraulic capacity, accelerate embankment erosion, or alter the channel alignment. While some sedimentation is inevitable, any excessive sedimentation should be noted.
- Changes in land use such as wetland drainage, deforestation, or increased development can significantly increase the runoff (and resultant discharge) that a culvert must carry. Channel changes upstream (or immediately downstream) of the culvert can result in overtopping of the roadway. The inspector should note the high water elevation (or freeboard), as well as any evidence of overtopping.

Structural Condition: Although culverts generally deteriorate at a slower rate than bridges, poor structural condition can eventually result in load restrictions or failure. The inspector should note any evidence of structural deterioration or distress. This includes material deterioration, barrel shape, and joint misalignment/separation. Photographs are useful for comparison to previous (or future) inspections.

Material Deterioration: The inspector should inspect all visible surfaces of the culvert, and note both the extent and severity of any significant material deterioration.

- Concrete culverts should be examined for scaling, cracking, leaching, rust stains, delaminations, or spalls. Severe cracking may indicate uneven settlement or structural overloading (from traffic or excessive earth pressure). Any significant spalling (with exposed reinforcing steel) should be documented. Connection bolts on pre-cast concrete culverts should be examined for corrosion.
- Steel culverts should be examined for corrosion (particularly along the waterline). Bolted seams should be examined for cusping, loose or missing bolts, and cracking around bolt holes.
- Timber culverts should be examined for weathering, splitting, warping, decay, fire damage, insect damage, or loose connections. Defects or connections can provide openings for moisture (and eventually decay) – any evidence of decay (such as fruiting bodies, staining, or surface depressions) should be noted.
- Masonry culverts should be examined for weathering, scaling, cracks, spalls, crushing, or misalignment of the masonry blocks. The mortar joints should be examined for any deterioration.
- Aluminum culverts are relatively resistant to corrosion, but will corrode rapidly in highly alkaline environments.

Barrel Shape: As flexible culverts (steel, aluminum, or timber) rely upon the surrounding soil to provide lateral support, embankment stability is essential. Deflection or distortion of the barrel may indicate instability of the supporting soil, and may reduce the load-carrying capacity of the culvert. Significant changes in the barrel shape should be noted (and verified with field measurements).

- Deflection is caused by long-term settlement over the length of the culvert (from embankment pressure). As the center of the embankment will settle more than the side slopes, culverts often end up with a low spot below the center of the roadway (steel culverts are often designed with a camber to compensate for this).
- Distortion is any deviation from the design cross-section of the culvert barrel, which should be symmetrical, with even curvature. Barrel distortion may be caused by uneven settlement, overloading, or from damage during the initial backfilling. Distortion is more common on culverts with less than 3 ft. of embankment fill.

Joint Misalignment and Separation: Joint misalignment or separation may be caused by improper installation, undermining, uneven settlement, or embankment failure. Exfiltration or infiltration can eventually result in severe undermining or even culvert failure.

- Exfiltration is water leaking out of the culvert barrel – this can lead to “piping” (water flowing along the outside of the culvert barrel), which can eventually erode the supporting soil. The inspector should look for separated or misaligned joints and observe the culvert ends for evidence of piping.
- Infiltration is water leaking into the culvert – this can also erode the supporting soil. Infiltration can be difficult to detect, as the backfill deposits are often washed away. The inspector should look for staining at the joints on the sides and top of the culvert, or depressions above the culvert.

Like bridges, culverts must be rated using both the NBI and structural element condition ratings.

NBI Condition and Appraisal Ratings:

The overall structural condition of a culvert will be rated using the Culvert Rating (NBI Item 62). The deck, superstructure, and substructure condition ratings (NBI Items 58, 59, and 60) should all be listed as "N".

If the culvert is designed to carry water (even if the culvert barrel is normally dry) the channel should be rated using Channel and Channel Protection Condition Rating (NBI Item 61). This rating should reflect the channel alignment, as well as the presence of any sedimentation or debris. If NBI Item 61 is rated, the Waterway Adequacy Appraisal Rating (NBI Item 71) must also be rated. This item is rated primarily on the frequency of overtopping of the roadway during high water events.

Structural Element Condition Ratings: MnDOT uses seven elements specifically for culvert structures.

- **#240 – Steel Culvert (LF)**
- **#241 – Concrete Culvert (LF)**
- **#242 – Timber Culvert (LF)**
- **#243 – Other Material Culvert (LF) – Use for Aluminum or Plastic Culverts**
- **#244 – Masonry Culvert (LF)**
- **#870 – Culvert End Treatment (Each)**
- **#871 – Roadway Over Culvert (Each)**

The condition of the culvert barrel must be rated using one of the five AASHTO NBE Elements (depending upon the material type). The quantity is expressed in linear feet, as measured along the length of the barrel (multiplied by the number of barrels). If the condition varies along the length of the culvert barrel, more than one condition state may be used.

- If an arch culvert has concrete footings that are visible for inspection, they may be rated separately from the arch barrel using Element #220 (Reinforced Concrete Footing).
- MnDOT added Element #870 to rate the condition of the headwalls, wingwalls, and aprons (or any other type of culvert end treatment).
- MnDOT added Element #871 to rate the condition of the roadway above the culvert. The inspector should note any settlement or cracking of the roadway, as this may indicate culvert distortion (or voiding of backfill). On flexible (steel) culverts; look for settlement above the centerline of the culvert. On rigid (concrete) culverts, look for settlement along the edges of the culvert.
- Element #892 (Slopes and Slope Protection) should be used to rate the condition of the embankment above the culvert. Embankment erosion may be the result of channel scour or roadway drainage.
- Element #894 (Deck and Approach Drainage) should be rated for a culvert structure, even if no drainage issues are currently present.
- If applicable, the inspector should also rate Element 890 (Load Posting/Clearance Signing, Element #891 (Other Signing) and Element #893 (Guardrail).
- The MnDOT "Defect" Elements (#880: Impact Damage, #881: Steel Section Loss, #882: Steel Cracking, #883: Concrete Shear Cracking, #884: Substructure Settlement, and #885: Scour) should not be rated for culvert structures. However, the presence of these defects should be rated (and noted) under the appropriate culvert element.

B.3.10.2 Steel Culvert (Element #240)

<table>
<tr><th colspan="2">#240: Steel Culvert (LF)</th></tr>
<tr><td colspan="2">This element applies to steel culverts of any type or shape. The MnDOT coding system describes four types of steel culverts – pipe-arch, round pipe, arch, or long span/elliptical. The LF quantity is measured along the length of the culvert barrel.</td></tr>
<tr><td>  </td><td>Steel Pipe-Arch Culverts (MnDOT Code 315)

The most common steel culvert shape in Minnesota (around 1,000 on the bridge inventory), they were introduced around 1930.

The low-profile design requires less fill than a round pipe, and provides a wider channel during low flow.
MnDOT Standard Plates 3050B and 3051B show standard dimensions for spans from 6’-1” up to 20’-7”.</td></tr>
<tr><td>  </td><td>Steel Round Pipe Culverts (MnDOT Code 314)

The second most common steel culvert shape in Minnesota (around 250 on the bridge inventory), they were introduced around 1930.

MnDOT Standard Plates 3040F and 3041D show standard dimensions for diameters up to 10 ft. (largest in Minnesota is 19 ft. diameter).</td></tr>
<tr><td>  </td><td>Steel Arch Culverts (MnDOT Code 312)

About 65 remain on the Minnesota bridge inventory – most constructed from 1930-1960 (none have been constructed since 1980).

Spans typically range from 10 ft. to 24 ft. Footings are typically reinforced concrete. Some steel arch culverts have masonry headwalls.</td></tr>
<tr><td>  </td><td>Steel “Long Span” or Elliptical Culverts (MnDOT Code 316)

This category includes elliptical culverts, as well as various culverts shapes with spans longer than 20 ft. (such low profile arch, high profile arch, underpass, or pear shape).

There are about 50 “long span” steel culverts on the Minnesota bridge inventory – the most common shape is elliptical. Most were constructed from 1965 to 1985 (none have been constructed since 1987). Span lengths range from 20 ft. to 33 ft.</td></tr>
</table>

#240: Steel Culvert (LF)				
As with all other steel elements, the protective coating (typically galvanized or bituminous) should be rated using Element #515 Steel Protective Coating.				
Item or Defect	**Structural Element Condition States**			
	1	**2**	**3**	**4**
	Good	**Fair**	**Poor**	**Severe**
Structural Review or Repairs	No structural repairs are present.	Structural review or repairs are not required. Existing structural repairs are in sound condition.	Repairs may be recommended (structural review is not required) **or** structural review has determined that strength or serviceability has not been impacted.	Condition warrants structural review **or** structural review has determined that the defects impact strength or serviceability.
Corrosion	None	Surface corrosion.	Flaking rust or section loss.	Severe section loss (holes or significant loss of thickness).
Cracking	None	Crack has been arrested or reinforced.	Crack has not been arrested, reinforced, or mitigated.	Severe crack or fracture.
Connections (Bolted Seams)	Bolted seams are tight and functioning as intended.	Bolted seams have minor openings or distress.	Bolted seams or joints have significant distress (cusped or cocked) or significant openings. Bolts may be tipped, loose, or missing.	Bolted seams have failed or buckled.
Joint Separation or Backfill Infiltration	None	Minor joint separation or backfill infiltration.	Moderate joint separation or backfill infiltration.	Severe joint separation or backfill infiltration.
Barrel Distortion	None	Slight distortion (less than 5% change from design dimensions). Barrel shape remains mostly symmetrical.	Significant distortion (5% to 10% change from design dimensions). Barrel may have notable asymmetry.	Severe distortion – more than 10% change from design dimensions. Severe buckling of corrugations.
Settlement (Longitudinal Deflection)	None or within design limits.	Slight longitudinal deflection (within tolerable limits). No structural distress.	Significant longitudinal deflection (exceeds tolerable limits).	Severe deflection – stability or function of culvert has been reduced.
Scour	None	Within tolerable limits (or counter-measures installed).	Exceeds tolerable limits but less than critical scour limits.	Exceeds the critical scour limits.

#240: Steel Culvert (LF)

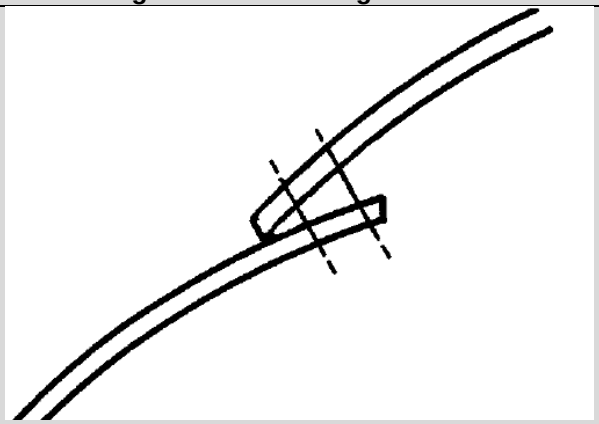
Condition Rating Examples (Steel Culverts)

Condition State 2
Surface corrosion along the waterline

Condition State 3
Flaking rust along the waterline

Condition State 4
Through corrosion along the waterline

Condition State 3
Cracking along a bolted seam



Condition State 3
Diagram showing a "cusped" bolted seam

Condition State 4
Failed seam along the bottom of a culvert

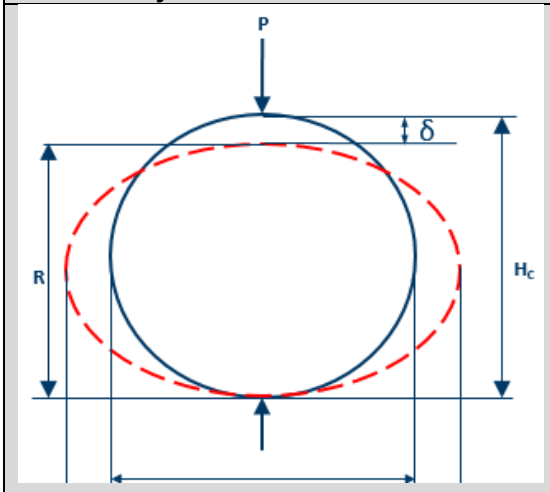
#240: Steel Culvert (LF)

Condition State 3
Significant longitudinal deflection

Condition State 4
Severe buckling of corrugations in sidewall

Condition State 3
Asymmetrical barrel distortion

Condition State 4
Severe barrel distortion



Hc =Culvert height specified in original design
R = measured rise
δ = Hc-R (vertical culvert deflection at crown)

Deflection ratio = δ/Hc

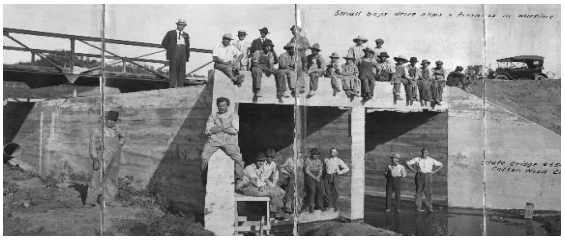
Note, if the deflection ratio is higher than 10%, the culvert may need to be closed, repaired, or replaced.

Symmetrical Culvert Barrel Distortion Measurement Diagram

B.3.10.3 Concrete Culvert (Element #241)

#241: Concrete Culvert (LF)

This element applies to concrete culverts of any type or shape. The MnDOT coding system describes five concrete culvert shapes (box, pipe-arch, round pipe, arch, or rigid frame/3-sided), and also identifies precast and cast-in-place concrete culverts. The LF quantity is measured along the length of the culvert barrel.



Cast-in-Place Concrete Box Culverts (MnDOT Code 113)

CIP box culverts were used extensively in Minnesota from the early 1900's until the 1970's. There are over 2,900 on the bridge inventory. Typical spans range from 4 ft. up to 20 ft.

- Type "W" CIP box culverts were constructed prior to 1945, and have a single layer of reinforcement in the walls and ceiling.
- Type "C" CIP box culverts boxes were constructed after 1945, and have two layers of steel reinforcing, with more substantial reinforcement at the corners.

Precast Concrete Box Culverts (MnDOT Code 513)

The most common culvert type in Minnesota (around 3,500 on the bridge inventory), they were introduced in 1974.

MnDOT Standard Plans 5.395.100a-e show standard dimensions for span lengths from 6 ft. to 16 ft. and barrel heights from 4 ft. to 12 ft.

Precast box culvert sections are typically 6 ft. long, but 4 ft. sections are used on larger boxes to reduce weight. The precast sections are connected with steel tie bolts.

Precast Concrete Pipe-Arch (RCPA) Culverts (MnDOT Code 515)

Introduced in Minnesota in the 1950's, there are approximately 3,200 on the bridge inventory.

MnDOT Standard Plate 3014J shows the standards dimensions for spans ranging from 51" up to 169" (14 ft. - 1 in.). The precast sections are typically 6 ft. long and connected with steel tie rods.

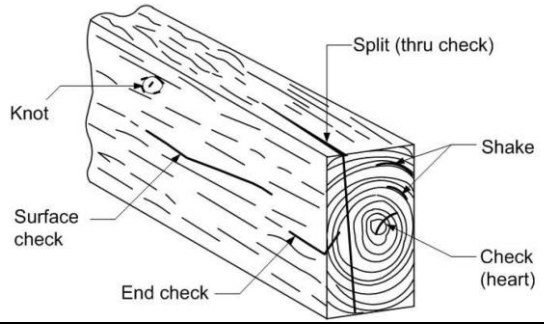
Smaller RCPA culverts have a one piece end treatment (MnDOT Plate 3100G). Larger spans have a 3-section end treatment (MnDOT Plate 3114H).

#241: Concrete Culvert (LF)	
	**Precast Concrete Round Pipe (RCP) Culverts (MnDOT Code 514)** Precast concrete round pipe (RCP) culverts came into use in the 1920's – these are the oldest precast concrete structures in Minnesota. While RCP culverts are still commonly used in Minnesota, most of them are too small to meet the legal bridge definition (about 75 are on the bridge inventory). MnDOT Standard Plate 3000L has standard pipe diameters from 4 ft. to 11 ft. (the segments are typically 6 ft. long). MnDOT Standard Plate 3100G shows the flared end treatments for RCP culverts.
	**Precast Concrete Arch Culverts (MnDOT Code 512)** Precast concrete arch culverts were introduced in Minnesota in 1981 – there are now around 70 on the bridge inventory. The footings are typically cast-in-place, while the headwalls and wingwalls are typically precast. The MnDOT LRFD Bridge Design Manual (section 12.3.2) shows details for the "MnDOT Precast Arch" – there are 6 standard spans ranging from 24 ft. to 44 ft. (the precast sections are 6-8 ft. wide). A variety of shapes and larger span lengths are also available from several manufacturers.
	**Cast-in-Place Concrete Arch Culverts (MnDOT Code 112)** Cast-in-place concrete arch culverts require extensive formwork, and are no longer being constructed in Minnesota – about 40 remain on the bridge inventory (constructed from 1900 to 1960). Typical spans range from 10 ft. to 30 ft. – the longest span is 46 ft.
 	**Concrete Rigid Frame (3-Sided) Culverts (MnDOT Codes 108 and 508)** 3-sided culverts are supported by footings (and/or pilings), and have a natural streambed. They may be pre-cast or cast-in-place. They may have a flat or arched top. These are a relatively new structure type in Minnesota (there are only about 25 on the bridge inventory). Flat-top shapes are generally limited to spans up to 30 ft. Arch top designs are available in spans up to 48 ft.

#241: Concrete Culvert (LF)				
Item or Defect	**Structural Element Condition States**			
	1	**2**	**3**	**4**
	Good	**Fair**	**Poor**	**Severe**
Structural Review or Repairs	No structural repairs are present.	Structural review or repairs are not required. Existing structural repairs are in sound condition.	Repairs may be recommended (structural review is not required) **or** structural review has determined that strength or serviceability has not been impacted.	Condition warrants structural review **or** structural review has determined that the defects impact strength or serviceability.
Efflorescence or Rust Staining	None	Leaching without build-up or rust staining.	Leaching with heavy build-up (stalactites) or rust staining.	Severe leaching (unsound concrete).
Delamination, Spall, or Exposed Rebar	None	Delamination. Spall 1” or less deep **and** 6” or less in diameter. Exposed rebar without measurable section loss.	Spall greater than 1” deep **or** greater than 6” diameter. Exposed rebar with measurable section loss.	Spalling deeper than 4” or exposed rebar with severe section loss.
Scale, Abrasion, or Wear	Superficial	Course aggregate is exposed but remains secure.	Course aggregate is loose or has popped out.	Severe voiding (concrete unsound).
Connections	Connections are in-place and functioning as intended.	Connection rods have minor distress. Bolts or connectors misaligned – nuts loose or missing.	Connection rods have significant distress (bolts or connectors have significant section loss).	Connection rods have failed or are missing.
Joint Misalignment or Backfill Infiltration	None	Minor joint separation, misalignment or backfill infiltration.	Moderate joint separation, misalignment or backfill infiltration.	Severe joint separation, misalignment or backfill infiltration.
Settlement	None	Within tolerable limits or arrested (no structural distress).	Exceeds tolerable limits.	Stability or function of culvert has been reduced.
Scour	None	Within tolerable limits (or counter-measures installed).	Exceeds tolerable limits but less than critical scour limits.	Exceeds the critical scour limits.
Cracking	Minor cracks.	Moderate cracks or moderate map cracking. Sealed cracks.	Wide cracks or heavy map cracking.	Severe structural cracking.
When determining condition states for the cracking defect, the inspector should consider width, spacing, location, orientation, and structural (or non-structural) nature of the cracking. Cracks less than 0.012" can be considered “minor”, cracks from 0.012" to 0.05" wide can be considered “moderate”, and cracks wider than 0.05" can be considered “wide”.				

#241: Concrete Culvert (LF)	
Condition Rating Examples (Concrete Culverts)	
	
Condition State 2 **Minor joint separation/backfill infiltration between the segments of a precast box culvert**	**Condition State 2** **Leaching cracks on a cast-in-place (CIP) concrete box culvert**
	
Condition State 3 **Heavy leaching on a cast-in-place (CIP) concrete box culvert**	**Condition State 3** **Spalling (exposed rebar) on a cast-in-place (CIP) concrete box culvert**
	
Condition State 4 **Severe separation and deterioration at a construction on a cast-in-place (CIP) concrete box culvert**	**Condition State 4** **Severe spalling on a precast concrete elliptical culvert**

B.3.10.4 Timber Culvert (Element #242)

#242: Timber Culvert (LF)				
This element applies to timber box culverts. There are about 75 timber box culverts on the Minnesota bridge inventory, constructed from 1936 to 1987. The longest span is 10 ft. (most have multiple barrels). The LF quantity is measured along the length of the culvert barrel (and multiplied by the number of barrels).				
Item or Defect	**Structural Element Condition States**			
	1	**2**	**3**	**4**
	Good	**Fair**	**Poor**	**Severe**
Structural Review or Repairs	No structural repairs are present.	Structural review or repairs are not required. Existing repairs are in sound condition.	Repairs recommended (structural review not required) **or** structural review has determined that strength/serviceability hasn't been impacted.	Condition warrants structural review **or** structural review has determined that the defects impact strength or serviceability.
Decay, Abrasion, or Fire Damage	Minor deterioration (no section loss).	Less than 10% section loss. No crushing or sagging.	10% to 40% section loss. Some crushing or sagging.	More than 40% section loss. Severe crushing or sagging.
Connection (Steel)	In-place and functioning as intended.	Loose fasteners, but functioning as intended.	Missing fasteners; broken welds; or pack rust.	Connection has failed (or failure is eminent).
Joint Misalignment or Backfill Infiltration	None	Minor joint separation, misalignment or backfill infiltration.	Moderate joint separation, misalignment or backfill infiltration.	Severe joint separation, misalignment or backfill infiltration.
Settlement (Longitudinal Deflection)	None	Slight deflection (within tolerable limits). No structural distress.	Significant longitudinal deflection (exceeds tolerable limits).	Severe deflection. Stability or function of culvert has been reduced.
Scour	None	Within tolerable limits or counter-measures installed.	Exceeds tolerable limits but less than critical scour limits.	Exceeds the critical scour limits.
Shakes, Checks, or Splits	Less than 5% of the member thickness.	5% to 50% of the member thickness (not in a tension zone).	More than 50% of member thickness (or more than 5% in a tension zone).	Through entire member (or more than 25% in a tension zone).
• **Shake:** A separation along the grain (between the growth rings). Usually forms within a standing tree or during felling. • **Check:** A separation perpendicular to the grain (across the growth rings). Usually results from stress due to drying shrinkage. • **Split (or Thru Check):** A check extending further through the timber member due to tearing apart of wood cells.				

#242: Timber Culvert (LF)

Condition Rating Examples (Timber Culverts)

Condition State 2
Separation between timber members on a timber box culvert (no backfill infiltration)

Condition State 2
Evidence of decay along the waterline of a timber box culvert

Condition State 3
Wall section misaligned on a timber box culvert

Condition State 4
Separation (connection failure) between wall and ceiling on a timber box culvert

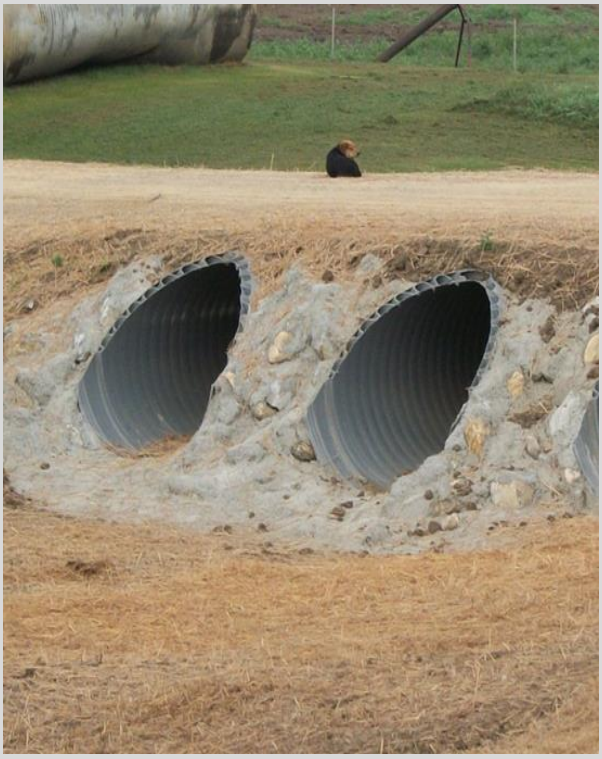
B.3.10.5 Other Material Culvert (Element #243)

#243: Other Material Culvert (LF)	
This element applies to culverts constructed of materials other than steel, concrete, timber, or masonry. Examples include aluminum box culverts or plastic culverts. The LF quantity is measured along the length of the culvert barrel.	
Aluminum Box Culverts (MnDOT Code A13) There are 14 aluminum box culverts on the Minnesota bridge inventory, constructed from 1980 to 2012. Spans range from 10 ft. to 23 ft.	**Plastic Culverts (MnDOT Code 014)** There is one plastic (Double Wall Polyethylene) pipe culvert on the Minnesota bridge inventory, constructed in 2004 (5 ft. diameter).

Item or Defect	Structural Element Condition States			
	1 Good	2 Fair	3 Poor	4 Severe
Structural Review	Structural review is not required.	Structural review is not required.	Structural review is not required **or** Structural review has determined that strength or serviceability has not been impacted.	Condition warrants structural review **or** Structural review has determined that the defects impact strength or serviceability.
Repairs	No repairs are present.	Existing repair in sound condition.	Repairs are recommended **or** existing repair is unsound.	Immediate repairs are required.
Other Deterioration	None	Initiated breakdown or deterioration.	Significant deterioration.	Severe or critical deterioration.
Corrosion	None	Surface corrosion.	Section loss.	Severe section loss (holes).
Cracking	None	Crack has been arrested or mitigated.	Crack has not been arrested or mitigated.	Crack has reduced the strength or stability.
Connections (Bolted Seams)	Connections functioning as intended.	Minor seam distress – some bolts may be loose.	Significant seam distress – bolts may be missing.	Seams have failed.
Barrel Distortion	None	Slight distortion (less than 5% change from design dimensions).	Significant distortion (5% to 15% change from design dimensions).	Severe distortion – more than 15% change from design dimensions.
Settlement (Longitudinal Deflection)	None	Slight deflection. Within tolerable limits or arrested (no distress).	Significant deflection. Exceeds tolerable limits.	Severe deflection. Stability or function has been reduced.
Joint Misalignment or Backfill Infiltration	None	Minor joint separation, misalignment or backfill infiltration.	Moderate joint separation, misalignment or backfill infiltration.	Severe joint separation, misalignment or backfill infiltration.
Scour	None	Within tolerable limits (or counter-measures installed).	Exceeds tolerable limits but less than critical scour limits.	Exceeds critical scour limits.

#243: Other Material Culvert (LF)

Condition Rating Examples (Other Material Culverts)



Condition State 1
Plastic pipe culvert (DWPE – Double Wall Polyethylene)

Condition State 1
Aluminum Box Culvert

Condition State 3
Torn edge on an aluminum box culvert

Condition State 4
Failed seam on an aluminum box culvert

B.3.10.6 Masonry Culvert (Element #244)

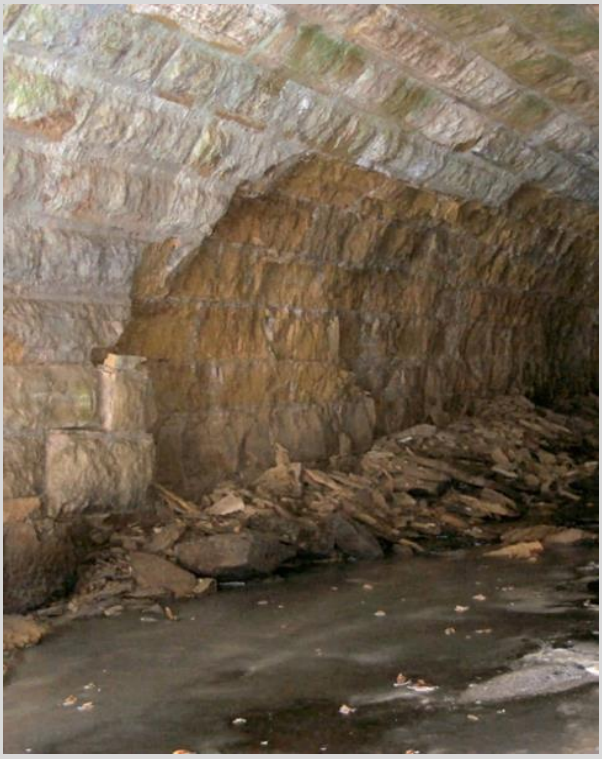
#244: Masonry Culvert (LF)				
This element applies to arch culverts with arch barrels comprised primary of masonry (MnDOT Code 812). There are about 37 masonry arch culverts on the Minnesota bridge inventory, constructed from 1880 to 1940. Spans range from 10 ft. to 22 ft. The LF quantity is measured along the length of the culvert barrel.				
Item or Defect	**Structural Element Condition States**			
	1	**2**	**3**	**4**
	Good	**Fair**	**Poor**	**Severe**
Structural Review	Structural review is not required.	Structural review is not required.	Structural review is not required **or** structural review has determined that strength or serviceability has not been impacted.	Condition warrants structural review **or** structural review has determined that the defects impact strength or serviceability.
Repairs	No repairs are present.	Existing repair in sound condition.	Repairs are recommended **or** existing repair is unsound.	Immediate repairs are required.
Mortar Breakdown (Masonry)	None	Cracking or voids in less than 10% of the joints.	Cracking or voids in 10% or more of the joints.	NA
Delamination or Spall (Masonry)	None	Delamination. Spalling less than 10% loss of block thickness.	Spalling with 10% to 25% loss of block thickness.	Spalling with more than 25% loss of block thickness.
Spilt or Fracture (Masonry)	None	Block split without continuation into adjacent courses.	Fractured through adjacent courses or block split with significant offset.	Fracture or split reduces stability of structure.
Weathering, Scale or Abrasion (Masonry)	Minor surface deterioration (no section loss).	Less than 10% loss of block thickness.	10% to 25% loss of block thickness.	More than 25% loss of block thickness.
Masonry Displacement	None	Block or stone is slightly misaligned.	Block or stone is significantly misaligned.	Block or stone is severely misaligned (or detached from structure).
Settlement	None	Within tolerable limits or arrested.	Exceeds tolerable limits.	Stability of element has been reduced.
Joint Misalignment or Backfill Infiltration	None	Minor joint separation, misalignment or backfill infiltration.	Moderate joint separation, misalignment or backfill infiltration.	Severe joint separation, misalignment or backfill infiltration.
Scour	None	Within tolerable limits (or counter-measures installed).	Exceeds tolerable limits but less than critical scour limits.	Exceeds critical scour limits.

#244: Masonry Culvert (LF)

Condition Rating Examples (Masonry Culverts)

Condition State 2
Weathering (section loss less than 10%) of fascia blocks on a masonry arch culvert

Condition State 3
Scour (mortar missing) along the waterline on a masonry arch culvert



Condition State 4
Severe (and extensive) spalling on a masonry arch culvert

Condition State 4
Severe vertical fracture (with blocks misaligned and loose) on a masonry arch culvert

B.3.10.7 Culvert End Treatment (Element #870)

#870: Culvert End Treatment (Each)				
This element applies to culvert end treatments of any type or material. This is an "each" item, and includes headwalls, wingwalls, aprons or other end treatment components. • On single barrel culverts, the quantity will typically be 2 (one for each end). • For multiple barrel culverts with separate end treatments, the quantity will typically be twice the number of barrels (same as the plan quantity for new culverts). • Monolithic end treatments on multiple barrel culverts may be considered to be "1". • If no end treatments are present, this element does not need to be used.				
Item or Defect	**Structural Element Condition States**			
	1	**2**	**3**	**4**
	Good	**Fair**	**Poor**	**Severe**
Structural Review	Structural review is not required.	Structural review is not required.	Structural review is not required **or** structural review has determined that capacity or function has not been impacted.	Condition warrants structural review **or** structural review has determined that capacity or function has been reduced.
Repairs	No repairs are present.	Existing repair in sound condition.	Repairs are recommended **or** existing repair is unsound.	Immediate repairs are required.
Steel	Minor surface corrosion.	Moderate surface corrosion (minor section loss).	Extensive corrosion (measurable section loss).	Advanced corrosion (severe section loss).
Concrete	Superficial scaling.	Moderate scaling (minor spalling).	Significant spalling or extensive scaling.	Severe spalling or scale.
	Minor cracking.	Moderate cracking or light leaching.	Extensive cracking or moderate leaching.	Severe cracking or deterioration.
Timber	Minor splitting.	Moderate splitting or decay.	Extensive splitting or significant decay.	Severe splitting or advanced decay.
Masonry	Minor weathering or mortar deterioration.	Moderate weathering, scaling, spalling, or mortar deterioration.	Extensive scaling, spalling, cracking, or mortar deterioration.	Severe scaling, cracking, or spalling.
Aluminum or Plastic	Superficial deterioration.	Moderate deterioration.	Significant deterioration.	Severe deterioration.
Connections	In-place and functioning as intended.	Connectors loose or missing (major components are secure).	Some connections have failed (major components may be loose).	Connection failure has significantly reduced structural integrity.
Joint Misalignment or Backfill Infiltration	None	Minor joint separation, misalignment or backfill infiltration.	Moderate joint separation, misalignment or backfill infiltration.	Severe joint separation, misalignment or backfill infiltration.
Settlement or Scour	None	Within tolerable limits or arrested.	Exceeds tolerable limits.	Stability of element has been reduced.

#870: Culvert End Treatment (Each)

Condition Rating Examples (Culvert End Treatments)

Condition State 2
Cracking and scale on a concrete headwall (three barrel steel pipe culvert)

Condition State 3
Precast headwall separated due to tree growth

Condition State 3
Extensive leaching cracks on the headwall of a cast-in-place (CIP) concrete box culvert

Condition State 3
Fractured wingwall on a cast-in-place (CIP) concrete box culvert

Condition State 4
Failed wingwall on a precast concrete box culvert

Condition State 4
Wingwall failure on a masonry arch culvert

B.3.10.8 Roadway over Culvert (Element #871

#871: Roadway over Culvert (1 Each)				
This element rates the condition of the roadway running above a culvert structure. It must be rated for all culvert structures that carry vehicular traffic. This includes paved or unpaved (gravel) roadways. • The type of wearing surface and number of traffic lanes should be noted. If possible, the year of pavement installation (or overlay) should be noted.				
Cracking or settlement of the roadway may be the result of culvert settlement, barrel distortion, or voiding of backfill. On flexible (steel) culverts; look for cracking and settlement above the centerline of the culvert. On rigid (concrete) culverts, look for cracking and settlement along the edges of the culvert.				
Item or Defect	**Structural Element Condition States**			
	1	**2**	**3**	**4**
	Good	**Fair**	**Poor**	**Severe**
Roadway Condition (General)	Little or no deterioration. No patches.	Minor to moderate deterioration. Permanent patches that remain sound.	Extensive deterioration (repairs recommended). Temporary patches or deteriorated repairs.	Severe deterioration (possible safety hazard – immediate repairs required). Repair patches that have failed.
Concrete Paving	Minor cracking (no significant spalling).	Moderate cracking. Minor spalling	Significant cracking or spalling.	Severe/extensive cracking or spalling.
Bituminous Paving	Smooth and even (minor cracking – no potholes).	Moderate cracking or slight rutting (some potholes present).	Significant cracking, rutting, or uneven surface. Extensive potholes.	Severe rutting, fractures, or potholes.
Gravel Roadway	Evenly graded.	Moderately rutted or eroded.	Extensive rutting or erosion.	Severe rutting or washouts.
Roadway Settlement or Undermining	None	Slight settlement or minor undermining.	Significant settlement or undermining.	Severe settlement or undermining.

#871: Roadway over Culvert (1 Each)

Condition Rating Examples (Roadway over Culvert)

Condition State 1
Minor cracking in a bituminous roadway above a masonry arch culvert

Condition State 2
Bituminous patches (due to settlement) along both sides of a concrete box culvert

Condition State 3
Temporary patch due to settlement (loss of backfill above a severely corroded steel culvert)

Condition State 3
Temporary patch due to settlement (loss of backfill above a severely corroded steel culvert)

Condition State 4
Severe settlement of a bituminous roadway above a collapsed steel culvert

Condition State 4
Roadway closed due to culvert failure

B.3.11 DEFECT ELEMENTS

Defect elements are intended to identify specific structural problems present on a bridge. These elements are not intended for structures classified as culverts. These elements are all "Each" items – the quantity should be left as "1". These MnDOT elements are not associated with the AASHTO elements or defects – they are not reported to the FHWA.

B.3.11.1 Impact Damage (Element #880)

#880: Impact Damage (1 Each)				
This element applies to primary structural bridge elements (superstructure or substructure) with impact damage. This may include bracing members on steel truss bridges. This includes any type of impact damage – such as traffic impact, flood debris, or ice dams. • This element should remain after repairs to provide a history of impact damage to the bridge. • This element should <u>not</u> be used for culvert structures, bridge railings, or guardrail.				
Defect or Item	**Defect Element Condition States**			
	1	**2**	**3**	**4**
	Good	**Fair**	**Poor**	**Severe**
Impact Damage (General)	Minor (superficial) impact damage.	Moderate impact damage, any significant impact damage has been analyzed and repaired.	Damage may be significant (repair may be warranted), but is not severe enough to warrant immediate structural analysis.	Immediate structural analysis is warranted.
Steel Members	Minor scrapes or dents. No heat-straightened or reinforced members.	Significant gouges. Members bent or dented, but are still functioning as intended. Members have been heat-straightened or reinforced.	Members bent out of plane but remain intact. Members have been heat-straightened more than once in the same location. Reinforced areas have significant impact damage.	Members severely damaged (bent, torn or fractured).
Concrete Members	Minor scrapes or gouges (no exposed reinforcement or tensioning cables). No patches. No significant cracking.	Significant gouges (no exposed reinforcement or tensioning cables). Patches (underlying damage has been analyzed or reinforced). Cracking has been analyzed or repaired.	Spalling with exposed reinforcement or tensioning cables (moderate damage to reinforcement or tensioning cables). Patched areas where the extent of underlying damage is unknown. Structural cracking.	Severe spalling or structural cracking. Reinforcement or tensioning cables are severely damaged.

#880: Impact Damage (1 Each)

Condition Rating Examples (Impact Damage)

Condition State 2
Heat-straightened truss vertical member

Condition State 2
High load gouges on a prestressed concrete beam

Condition State 3
Steel H-piling bent due to rock impact

Condition State 3
Ice or flood damage to a truss bottom chord

Condition State 4
Steel beam severely bent due to high load impact

Condition State 4
Prestressed beam severely damaged by high load impact

B.3.11.2 Steel Section Loss (Element #881)

#881: Steel Section Loss (1 Each)				
This element applies to bridges with primary steel members with section loss due to corrosion. This typically refers to steel superstructure members, but could also apply to steel substructure members (such as pilings) that serve as primary supports. Section loss is typically expressed as a percentage of the total cross-section area of the member (the percentages listed below are intended to be general guidelines). • The presence of flaking rust or pack rust indicates that at least some section loss is present. • This element should not be used for culvert structures.				
Structural Member	**Defect Element Condition States**			
	1	**2**	**3**	**4**
	Good	**Fair**	**Poor**	**Severe**
Flanges or tension members	Less than 2% section loss of the flange cross-section area.	2% to 5% section loss of the flange cross-section area.	5% to 10% section loss of the flange cross-section area.	More than 10% section loss of the effective flange cross-section.
Webs or compression members	Less than 2% section loss (average over the full height of the web). No through corrosion.	2% to 5% section loss (average over the full height of the web). No through corrosion.	5% to 10% section loss (average over the full height of the web). Isolated through corrosion.	More than 10% section loss (average over full height of the web). Significant through corrosion.
Stiffeners, Lacing, or Batten Plates	Moderate section loss.	Extensive section loss. Isolated through corrosion.	Severe section loss. Significant through corrosion.	NA

#881: Steel Section Loss (1 Each)

Condition Rating Examples (Steel Section Loss)

Condition State 1
Pitting on girder web (less than 2% section loss averaged over full height of web plate)

Condition State 2
Pitting on girder bottom flange (2% to 5% section loss on the bottom flange)

Condition State 2
Isolated through corrosion on girder web stiffener

Condition State 3
Pitting on the top flange of a cantilever floorbeam extension (5% to 10% section loss)

Condition State 3
Pitting on girder bottom flange (5% to 10% section loss on the bottom flange)

Condition State 4
Extensive pitting and significant through corrosion in girder web

B.3.11.3 Steel Cracking (Element #882)

#882: Steel Cracking (1 Each)

This element applies only to primary steel structural members (typically superstructure). This element is intended to track the presence (and severity) of cracks due to fatigue or other causes. This element should not be used for culvert structures.

- This element should be rated for any bridge with a steel superstructure that has fatigue prone details of AASHTO category "C" or higher, even if no cracks are present.
- Reference the Minnesota Bridge & Structure Inspection Program Manual (BSIPM - Section D.7.10) for descriptions and photos of common fatigue prone details. Fatigue prone details present on a bridge should be noted in the inspection report under this element.
- For MnDOT (trunk highway) bridges, fatigue prone details identified by plan review are listed in SIMS under the SIA - One Column (Steel Fatigue Data) item.

Defect or Item	Defect Element Condition States			
	1	2	3	4
	Good	Fair	Poor	Severe
Cracking (Base metal on Primary Steel Structural Members)	Fatigue prone details are present on primary steel superstructure elements (no cracks are present).	Cracking has been arrested (drilled or ground out). Any resultant damage to the steel element has been repaired.	Cracking exists and has not been arrested. Note: This condition state is normally used when cracking is initially observed, or if additional cracking is observed after repairs.	Cracking has seriously damaged a primary steel superstructure element. Immediate repairs or structural analysis are required.
Tack Welds (on Primary Steel Structural Members)	No cracked tack welds are present.	Cracked tack weld is present, but has not yet propagated into the base metal of the primary member.	Cracked tack weld has propagated into the base metal of a primary structural member.	

#882: Steel Cracking (1 Each)

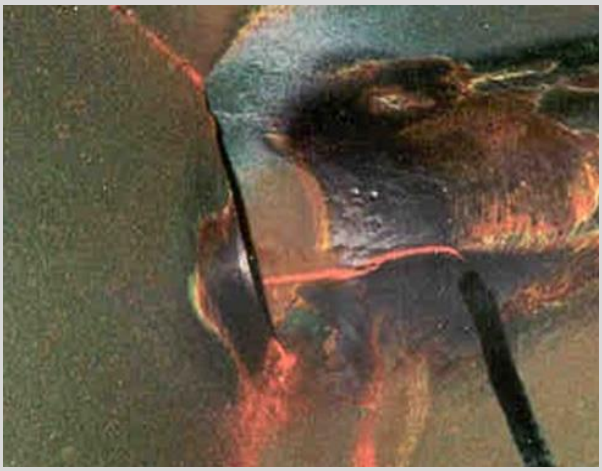
Condition Rating Examples (Steel Cracking)

Condition State 1
Welded cover plate on the bottom flange of a rolled steel beam (fatigue prone detail)

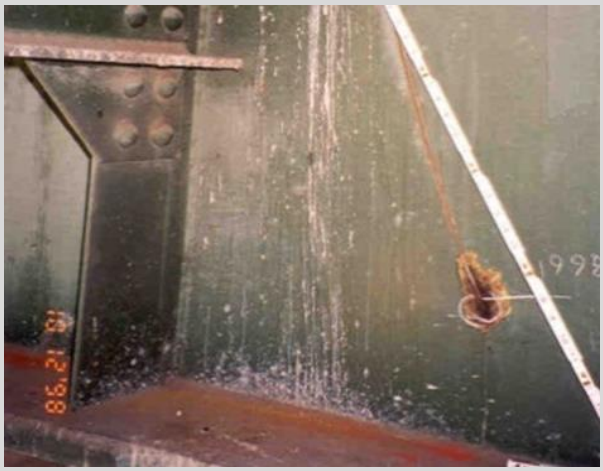
Condition State 2
Fractured beam web reinforced with bolted plates

Condition State 2
Crack in girder web has arrested with a drilled hole

Condition State 2
Partially cracked tack weld along connection plate (could propagate into base metal)



Condition State 3
Fatigue crack in web to flange weld at diaphragm connection (due to out-of-plane bending)



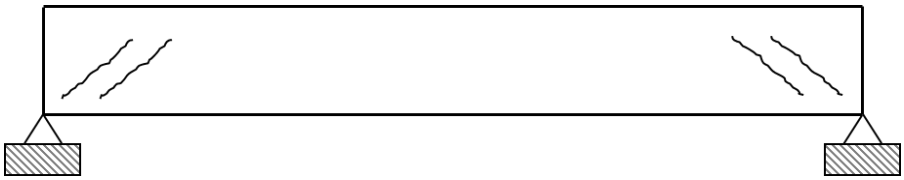
Condition State 4
Fatigue crack has propagated through beam web

B.3.11.4 Concrete Shear Cracking (Element #883)

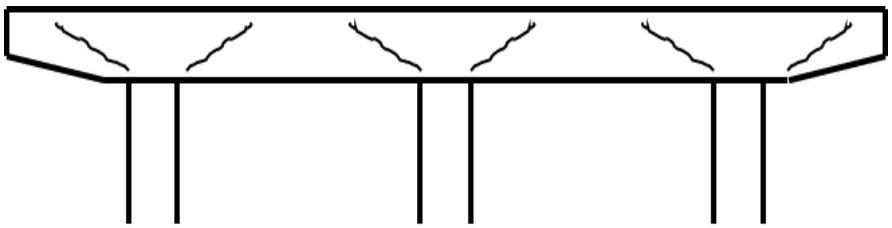
#883: Concrete Shear Cracking (1 Each)

This element tracks the presence and severity of shear cracking on reinforced, prestressed, or post-tensioned concrete primary structural elements. Shear cracks in concrete result when equal but opposite transverse forces create an internal diagonal tension force. Shear cracks are typically diagonal (approximately 45° angle) and located near bearings or supports. Shear cracks will initiate at the front edge of the bearing or support, and are inclined towards the center of the span.

- If shear cracking is present on any reinforced, prestressed or post-tensioned concrete superstructure element (box girder, girder, beam, T-beam, floorbeam, stringer, or slab), or on a reinforced or post-tensioned concrete pier cap, Element #883 must be added and rated.
- This element should not be used for culverts.



Expected shear crack location & orientation on a simple span concrete beam.



Expected shear crack location & orientation on a concrete pier cap.

Shear cracking is of particular concern on prestressed concrete beams designed prior to 2007 and reinforced concrete pier caps designed prior to 1984. Element #883 must be rated for these bridges. Shear cracks can result from inadequate shear reinforcement. However, shear cracks may also appear in properly designed elements, as the concrete may need to crack to engage the steel reinforcement.

The presence of shear cracking in a reinforced or prestressed member is not necessarily critical, but becomes more of a concern if the shear cracks grow or if additional parallel shear cracks develop. Shear cracks should be measured and documented so that changes in size (width or length) can be determined during subsequent inspections. When shear cracking is observed, examine both faces to determine if the crack is full-depth (extending through the thickness of the beam web or cap).

Shear crack in a reinforced concrete pier cap

Multiple parallel shear crack in a prestressed concrete beam being loaded to failure

#883: Concrete Shear Cracking (1 Each)				
Defect or Item	**Defect Element Condition States**			
	1	**2**	**3**	**4**
	Good	**Fair**	**Poor**	**Severe**
Shear Cracking (General)	No shear cracks.	Minor shear cracks.	Moderate shear cracks. Severe shear cracks that have been repaired or reinforced.	Shear cracks that reduce the structural integrity of the concrete member or the bridge.
Prestressed or Post-tensioned Concrete	No shear cracks.	Shear crack width is less than 0.004".	Shear crack width is between 0.004" and 0.009".	Shear crack width exceeds 0.009".
Reinforced Concrete	No shear cracks.	Shear crack width is less than 0.012".	Shear crack width is between 0.012" and 0.05".	Shear crack width exceeds 0.05".

Draped strand cracks in prestressed beams are not shear cracks!

Draped strand cracks develop in the ends of prestressed concrete beams when they are released from the casting bed at the fabrication plant. As the cables are released, asymmetrical loading can result in cracking. Draped strand cracks typically run to the end of the prestressed beam and can vary in orientation.

Some draped strand cracks may appear to be inclined in the direction of shear cracks, but unlike shear cracks, “draped strand” cracks typically run to the vertical end of the beam.

If draped strand cracking is present in a prestressed beam, it should be rated and documented using Element 109 (Prestressed Beam). Draped strand cracks are a concern as beam ends are typically located below deck joints, increasing the chance of chloride exposure.

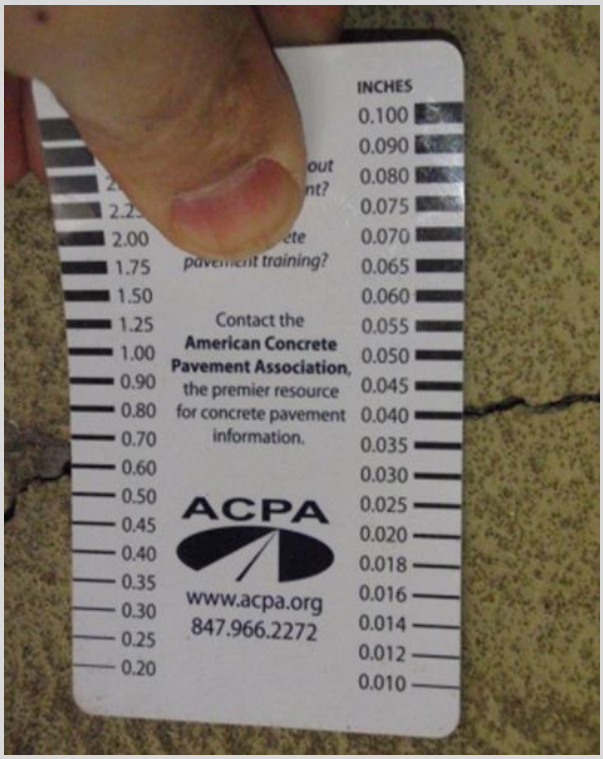
#883: Concrete Shear Cracking (1 Each)

Condition Rating Examples (Concrete Shear Cracking)

Condition State 2
Shear crack less than 0.012″ wide in a reinforced concrete pier cap

Condition State 3
Shear cracks between 0.004″ and 0.009″ wide in a prestressed concrete beam

Condition State 4
Shear crack greater than 0.05″ wide in a reinforced concrete pier cap



Condition State 4
Shear crack wider than 0.025″ in a prestressed concrete beam

B.3.11.5 Substructure Settlement (Element #884)

#884: Substructure Settlement (1 Each)

This element applies to bridge substructure elements (piers, abutments, or wingwalls) that show evidence of settlement, movement, or rotation. It is intended to identify bridges that are experiencing settlement and to provide some measure of the magnitude of that settlement. This element should not be used for culvert structures.

Substructure movement is not always obvious. Inspectors should look for clues that may indicate substructure movement or tipping, such as bearing misalignment or deck expansion joints that are tighty closed (or have large gaps). Check the abutment corners for evidence of the deck, superstructure, or railing contacting (preventing further expansion).

Bearing misalignment due to substructure movement (the rockers should be tipped in opposite directions at the same angle)

Finger joint open beyond design limits due to substructure movement

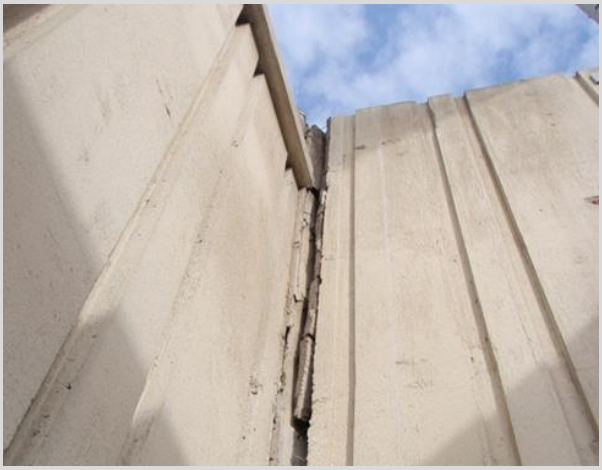
Concrete diaphragm offset excessively at shear key due to pier movement

Deck corner contacting the abutment end post due to abutment movement

Defect or Item	Defect Element Condition States			
	1	2	3	4
	Good	Fair	Poor	Severe
Settlement, Movement, or Rotation	Minor substructure settlement, movement, or rotation.	Moderate substructure settlement, movement, or rotation (no impact to the structural integrity of the bridge). Any significant settlement has been arrested or has stabilized.	Significant substructure settlement, movement, or rotation. If not arrested, this could adversely impact the structural integrity of the bridge.	Severe substructure settlement, movement, or rotation – structural analysis is warranted.

#884: Substructure Settlement (1 Each)

Condition Rating Examples (Substructure Settlement, Movement, or Rotation)



Condition State 2
Wingwall separation due to abutment movement

Condition State 2
Abutment end diaphragm offset and fractured due to abutment movement

Condition State 3
Significant settlement of a concrete approach pier

Condition State 3
End post fractured due to contact with deck and railing (abutment movement)

Condition State 4
Steel tube pier column severely tipped

Condition State 4
Abutment severely tipped

B.3.11.6 Scour (Element #885)

#885: Scour (1 Each)

This element is intended to identify bridges that are experiencing scour (or have a history of scour problems) and to provide some measure of the magnitude of scour. This element also identifies scour critical bridges (and bridges requiring scour monitoring during high water events). If the MnDOT Scour Code is D, G, K, O, P, R or U, this element must be added and rated, even if no scour is currently present at the bridge.
Scour is the most common cause of bridge failure. During routine inspections, submerged substructure components should be investigated for scour by wading and probing. If the channel is too deep for inspection by wading, the bridge should be included in the state-wide underwater bridge inspection contract. This element should not be used for culvert structures.

Defect or Item	Defect Element Condition States			
	1 Good	2 Fair	3 Poor	4 Severe
Scour	No scour is evident. Bridges with a MnDOT Scour Code of D, G, K, O, P, R or U should be rated as condition 1 if no scour is currently present.	Scour exists, but is of little concern to the structural integrity of the bridge.	Scour exists that, if left unchecked, could adversely impact the structural integrity of the bridge.	Scour is significant enough to warrant analysis of the structure.
Scour Counter-measures (If Present)	Counter-measures are in good condition and are functioning as intended.	Counter-measures have minor to moderate deterioration, but are still functioning.	Counter-measures have significant damage or deterioration.	Counter-measures have failed.

Condition Rating Examples (Scour)

Condition State 2
Scour hole at abutment

Condition State 3
Pier column footing exposed due to scour

Condition State 3
Scour behind abutment (significant streambed degradation)

Condition State 4
Scour has undermined the abutment cap (further scour could wash out the approach roadway)

B.3.12 OTHER BRIDGE ELEMENTS

The elements in this section are intended to rate bridge (or culvert) components not addressed by the AASHTO NBE or BME elements. These elements are "Each" items, the quantity should be left as "1". These are MnDOT elements, they are not reported to the FHWA.

- #890: Load Posting or Vertical Clearance Signing
- #891: Other Signing
- #892: Slopes and Slope Protection
- #893: Guardrail
- #894: Deck & Approach Drainage
- #895: Sidewalk, Curb, & Median
- #899: Miscellaneous Items
- #900: Protected Species

B.3.12.1 Load Posting or Vertical Clearance Signing (Element #890)

#890: Load Posting or Vertical Clearance Signing (1 Each)

This element applies only to Load Posting signs or Vertical Clearance signs mounted on or in advance of a bridge (or culvert). If load posting and vertical clearance signing is not required, this element should not be rated.

- The actual load posted weight limits and/or posted vertical clearances present at the bridge should be documented in the element notes (and confirmed with the structure inventory).

Defect or Item	Condition States			
	1	2	3	4
	Good	Fair	Poor	Severe
Signage Present and/or Correct	Required load posting or vertical clearance signing is properly installed.	All required signing is present. Placement may not be ideal.	Vertical clearance signing (at or in advance of bridge) is absent or incorrect.	Load posting signing (at or in advance of bridge) is absent or incorrect.
Damage or Deterioration	Load posting or vertical clearance signs are in good condition (superficial any damage or deterioration).	Load posting or vertical clearance signs have moderate damage or deterioration, but are still readable.	Vertical clearance signing (at or in advance of bridge) is severely damaged or unreadable. Repair or replacement is required.	Load posting signing (at or in advance of bridge) is severely damaged or unreadable. Repair or replacement is required.

Condition Rating Examples (Load Posting or Vertical Clearance Signing)

Condition State 2
Vertical Clearance sign is bent but is still readable

Condition State 4
Load posting sign is severely bent

Condition State 4
Load posting sign is not readable

B.3.12.2 Other Bridge Signing (Element #891)

#891: Other Bridge Signing (1 Each)

This element applies to all signage (except load posting or vertical clearance) mounted on the bridge or pertaining to the bridge. This includes Traffic Control Signage, Horizontal Control Signage, plow markers, or delineators. This also includes signs mounted on the bridge fascia or bridge railings. Note: While some agencies may choose to inventory and inspect bridge mounted signs separately from the bridge, the condition of bridge mounted signs should be reflected in this element rating.

Overhead sign structure mounted on bridge railing

Signs mounted on bridge fascia

Dynamic Message Sign (DMS) mounted on bridge fascia

Defect or Item	Condition States			
	1 Good	2 Fair	3 Poor	4 Severe
Bridge Closed, Narrow Bridge, One Lane Bridge, Bridge Speed Limit, or "Trucks/Vehicles Must Not Meet on Bridge" Signs	Required signing is properly installed (minor damage or deterioration).	Required signing is present (placement may not be ideal). Moderate damage or deterioration.	All required signing is present. Sign is significantly damaged or deteriorated, but is still readable.	Sign is severely damaged, unreadable, or missing. Closed bridge is not properly barricaded.
Type III Object Markers, Plow Markers, or Delineators	Required signing is properly installed (minor damage or deterioration).	Required signing is present (placement may not be ideal). Moderate damage or deterioration.	Sign is severely damaged, severely deteriorated, knocked down, or missing.	NA
Bridge Mounted Signs, Dynamic Message Signs, or Other Bridge-Related Signage	Minor damage or deterioration.	Moderate damage or deterioration.	Sign is significantly damaged, deteriorated, or is missing. DMS inoperable.	Damage or deterioration to sign, DMS, or support presents a safety hazard.

Condition Rating Examples (Other Bridge Signing)

Condition State 2
One Lane Bridge sign with several bullet holes

Condition State 3
Type III Object Marker lying on the ground

Condition State 4
Closed bridge not properly barricaded

B.3.12.3 Slopes and Slope Protection (Element #892)

#892: Slopes and Slope Protection (1 Each)				
This element rates the condition of slopes and slope protection. This includes unprotected (bare dirt) slopes. This includes the slopes in front of abutments, abutment side slopes, slopes around piers, and culvert embankments. Slope protection may consist of concrete, bituminous-coated aggregate, loose riprap, grouted riprap, grout-injected fabric, gabions, or any material intended to protect slopes from erosion. Note: The inspector should attempt to determine the cause of any slope erosion (such as deck drainage or channel scour).				
Defect or Item	**Element Condition States**			
	1	**2**	**3**	**4**
	Good	**Fair**	**Poor**	**Severe**
Deterioration or Loss of Slope Protection	Minor deterioration.	Minor to moderate deterioration or loss of protection (slight undermining).	Significant deterioration or loss of protection (significant undermining).	Severe deterioration, loss of protection, or undermining.
Erosion or Settlement	None	Minor to moderate erosion or settlement.	Significant erosion or settlement.	Severe erosion or settlement.
Exposure of Footings or Pilings	None	Minor to moderate footing exposure (no undermining of footings or piling exposure).	Significant footing exposure (slight undermining of footings or isolated piling exposure).	Severe undermining of footings and/or significant piling exposure.
Loss of Abutment or Approach Backfill	None	Isolated loss of abutment or approach backfill.	Moderate loss of abutment or approach backfill.	Significant loss of abutment or approach backfill.

Condition Rating Examples (Slopes and Slope Protection)

Condition State 2
Moderate footing exposure due to slope settlement

Condition State 3
Significant slope erosion due to approach runoff

Condition State 3
Significant undermining of concrete slope paving

Condition State 4
Footing undermined (timber piling exposed) due to slope failure

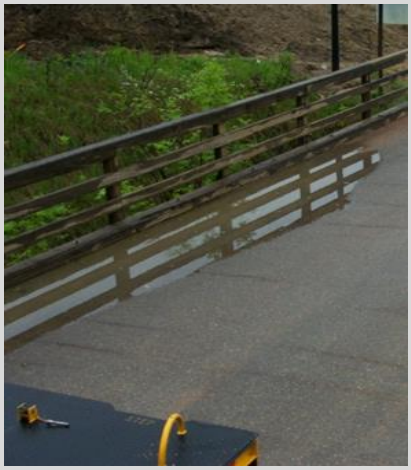
B.3.12.4 Guardrail (Element #893)

<table>
<tr><th colspan="5">#893: Guardrail (1 Each)</th></tr>
<tr><td colspan="5">This element rates the condition of guardrail above or below a bridge (or above a culvert). This includes all guardrail types (plate beam or cable), as well as guardrail end treatments or crash cushions/crash attenuators. If guardrail is required, but is not present, there is no need to rate this item; however NBI items 36B, 36C & 36D must be coded appropriately.</td></tr>
<tr><th rowspan="2">Defect or Item</th><th colspan="4">Condition States</th></tr>
<tr><th>1
Good</th><th>2
Fair</th><th>3
Poor</th><th>4
Severe</th></tr>
<tr><td>Guardrail Condition</td><td>Guardrail is in good condition – no notable damage or deterioration</td><td>Guardrail has minor to moderate damage or deterioration, but is still functioning as intended to protect vehicles from impacting the bridge.</td><td>Guardrail has significant damage or deterioration. While repairs may be necessary, the conditions do not pose an immediate traffic safety hazard.</td><td>Guardrail has severe damage or deterioration (traffic safety hazard) – repair or replacement is required.</td></tr>
<tr><th colspan="5">Condition Rating Examples (Guardrail)</th></tr>
<tr><td colspan="2"> 
Condition State 2
Plate beam guardrail scraped and bent</td><td colspan="3"> 
Condition State 2
Splitting and decay on timber guardrail post</td></tr>
<tr><td colspan="2"> 
Condition State 3
Plate beam guardrail torn</td><td colspan="3"> 
Condition State 4
Severe damage to guardrail end</td></tr>
</table>

B.3.12.5 Deck and Approach Drainage (Element #894)

#894: Deck and Approach Drainage (1 Each)				
This element rates the condition, function, and adequacy of the drainage system. This element should be rated for all bridge or culvert structures. This includes drainage of the deck, approaches, and areas adjacent to (or below) the bridge and drainage of the roadway travelling over a culvert structure. This includes items such as deck drains, inlets, scuppers, grates, drain troughs, downspouts, catch basins, spillways, splash aprons, ditches, or holding ponds. Note: Deck drain downspouts should extend down far enough to prevent runoff from falling onto the superstructure.				
Defect or Item	**Condition States**			
	1	**2**	**3**	**4**
	Good	**Fair**	**Poor**	**Severe**
Drainage System (Condition and Function)	Drainage system is in good condition and functioning as intended.	Drainage system has minor damage or deterioration, but is still functioning adequately.	Drainage system has moderate damage or deterioration. Drainage system is not functioning properly. Drainage system may be clogged with debris. Drainage issues are contributing to the deterioration of bridge elements.	Drainage system has severe damage or deterioration – repairs are required. Failure of drainage system has resulted in significant deterioration of bridge elements.
Erosion	None	Minor erosion due to deck, roadway, or approach drainage.	Drainage issues have resulted in significant slope erosion.	Failure of drainage system has resulted in severe slope erosion.
Ponding	None	Minor to moderate ponding on deck, approaches, or roadway.	Significant ponding on deck, approaches, or roadway.	Severe ponding (possible safety hazard).

Condition Rating Examples (Deck and Approach Drainage)



Condition State 2
Moderate ponding on deck

Condition State 3
Drain clogged at elbow

Condition State 4
Downspout split due to freezing

B.3.12.6 Sidewalk, Curb, and Median (Element #895)

#895: Sidewalk, Curb, and Median (1 Each)				
This element applies to sidewalks, curbs, and median paving on the bridge deck and approaches. This element is primarily intended to rate the top surface of sidewalks on vehicular bridge decks. The supporting deck, slab or superstructure should be rated under the appropriate structural element. • This element does not apply to sidewalks or trails running below a bridge (that should be addressed using Element #899 - Miscellaneous). • Concrete sidewalks with a width of 18” or less, that are integral with the concrete bridge railing, should be rated using Element #331 (Concrete Railing) instead of this element. • This element should be used to rate the approaches to pedestrian bridges (instead of approach Elements #321, #822, or #823).				
Defect or Item	**Condition States**			
	1	**2**	**3**	**4**
	Good	**Fair**	**Poor**	**Severe**
General	Sidewalks, curbs, and medians are in good condition.	Sidewalks, curbs, or medians have moderate damage or deterioration (repairs are not yet required).	Sidewalks, curbs, or medians have extensive (or significant) damage or deterioration. Repairs may be required.	Sidewalks, curbs, or medians have severe damage or deterioration (immediate repairs are required).
Concrete	Minor cracking, superficial damage or deterioration.	Moderate cracking, scale, or abrasion. Isolated spalling.	Extensive (and significant) cracking, scale, or abrasion. Moderate spalling.	Severe cracking or extensive spalling.
Timber	Superficial damage or deterioration.	Moderate splitting, damage or deterioration. Any decay is isolated.	Extensive (and significant) splitting, decay, damage or other deterioration. Sections may be loose.	Severe decay, damage, or other deterioration. Sections may be missing.
Sidewalk Approach Settlement	No significant settlement.	Minor settlement (less than 1”).	Moderate settlement (1” to 2”).	Severe settlement (more than 2”).

B.3.12.7 Miscellaneous Items (Element #899)

#899: Miscellaneous Items (1 Each)				
This element can be used to rate the condition of any bridge (or culvert) feature not adequately described by the other elements (such as lighting or utilities). This element can also be used to address general maintenance issues (such as flushing, tree trimming or graffiti).				
Defect or Item	**Condition States**			
	1	**2**	**3**	**4**
	Good	**Fair**	**Poor**	**Severe**
Condition	Minor damage or deterioration.	Moderate damage or deterioration.	Significant damage or deterioration.	Severe damage or deterioration.
Maintenance or Repairs	No maintenance necessary.	Preventive maintenance may be recommended.	Repairs are recommended.	Immediate repairs are required.

B.3.12.8 Protected Species (Element #900)

#900: Protected Species (1 or Possibly 2 Each)

This element was added in 2016 for all bridges and culverts in Minnesota. It is intended to track structures with protected species nesting or roosting on them.

Birds

Most birds are protected under the federal Migratory Bird Treaty Act (MBTA), which means that they cannot be harmed during their nesting season. Swallows are the most common protected bird to nest on bridges. Several species of swallows are found in Minnesota. Cliff swallows commonly nest in large colonies on the underside of bridges located over or near water. Cliff swallow nests are made from mud pellets and are shaped like a gourd, with an elongated entrance tube. Barn swallows nest almost exclusively on man-made structures (such as bridges). Barn swallow nests are shaped like an open-top cup, and are made from mud mixed with grass (typically with a grass or feather lining).

Other protected bird species known to nest on bridges in Minnesota include: American robins; eastern phoebes; peregrine falcons; great horned owls; and long-eared owls. Any small, round, neatly constructed bird nest (or large stick nest) observed on a bridge likely indicates the presence of a protected bird species.

Note: Pigeons, house sparrows, and starlings are not protected bird species.

Bats

The northern long-eared bat was designated as a threatened species under the federal Endangered Species Act on May 4, 2015. This was primarily due to the threat posed by white-nose syndrome, a fungal disease that has devastated many bat populations in the U.S., including Minnesota.

Many species of bats, including the northern long-eared bat, will roost on bridges. They tend to prefer bridges located over or near water. Bats typically roost in any cave-like cavity on a bridge structure, often located at least 4 feet above the ground. A common roosting spot for bats is within bridge deck expansion joints (typically located at abutments or piers), or below median joints. The underside of bridge deck joints should be inspected up close with a flashlight. Other potential roosting spots include gaps between timbers deck planks, between timber beams, or inside cracks or voids in concrete or masonry bridge structures. Bats can also hang from small cracks or surface irregularities on concrete structures, including box culverts, or from connections on steel bridges.

Bridge inspectors are not expected to identify the exact bat species present on a bridge, but should determine if bats are roosting on the bridge. Aside from seeing bats directly, bridge inspectors should look for other evidence of bats, such as high-pitched squeaking or chirping coming from joints. Inspectors should also look for bat droppings (similar to mouse droppings, but less regularly-shaped) or dark urine stains on pier caps or abutment bearing seals below deck joints. Bat droppings may also be present on the slopes below median joints. Another bat clue is the strong ammonia-like smell associated with their droppings.

This element will initially be entered with a quantity of 1. If protected birds and bats are both present on a bridge, the quantity should be increased to 2, with a "1" rated under both condition state 3 and condition state 4.

Defect or Item	Condition States			
	1	2	3	4
Protected Species	New structure (not yet inspected), or structure has not been fully inspected (due to access limitations, etc.)	No evidence of protected species nesting or roosting on the structure (currently or in the recent past)	Protected bird species and/or nests (swallows, falcons, etc.) are present on the structure.	Bats or evidence of bats is present on the structure (add notes on location)

#900: Protected Species (Each)

Condition Rating Examples (Protected Species)

Condition State 3
Cliff swallow nests on the underside of a bridge

Condition State 3
Barn swallow nest on the underside of a bridge

Condition State 3
Robbin's nest on a bridge beam

Condition State 3
Great horned owl in a large stick nest on a bridge

Condition State 4
Bats roosting on the underside of a deck joint

Condition State 4
Bats droppings on an abutment bearing seat

B.4 BRIDGE INSPECTION DOCUMENTATION

B.4.1 INSPECTION NOTES

Inspection notes are a key component of a bridge inspection report. The inspection notes should provide a clear narrative of the structural condition of the bridge, and must appropriately justify the NBI and structural element condition ratings. Thorough inspection notes will allow the Engineer/Program Administrator reviewing the report to better understand the current condition of the bridge, and determine if repairs or further structural analysis are required. If the bridge condition is accurately described, it is much easier to identify any change in condition in subsequent inspections. The quality of bridge inspection notes will generally reflect the quality of the bridge inspection, and the quality of the agency's bridge inspection program. Bridge inspection reports are legal, public documents – inspectors should keep that in mind when taking field notes and entering then in SIMS.

Notes should be taken and entered in SIMS for each bridge inspection. The extent of notes taken during an inspection will vary depending upon the size and structural complexity of the bridge, the condition of the bridge, and the change in condition since the last inspection. When creating a new inspection report in SIMS, notes may be entered in several locations.

NBI Condition Rating Notes: When a new bridge is entered into the database, the NBI Condition Ratings (Deck, Superstructure, Substructure, Channel, and Culvert) will initially be entered as "9" or "N". SIMS includes an inspection note section for each of these five condition ratings.

- Inspection notes should be entered whenever an NBI Condition Rating is changed (up or down). If no notes are present for an NBI condition rating, the inspection history should be reviewed to determine when and why the current condition rating was assigned.
- As the NBI condition ratings describe the general overall condition of a structure, the NBI notes do not need to be specific or lengthy. They should briefly explain why (and when) the NBI condition rating was changed. For example: "NBI deck rating lowered from 6 to 5 in 2016 due to delamination and spalling on underside of deck".
- Inspection notes are mandatory if an NBI condition rating (Deck, Superstructure, Substructure, Channel, Culvert, Approach Alignment, Waterway Adequacy) is "5" (fair condition) or lower.

NBI Appraisal Ratings and NBI Item 36 Notes: Notes may be entered in SIMS for the Approach Roadway Alignment Rating, the Waterway Adequacy Rating, and for NBI Items 36A, B, C & D (Safety Features).

- If the coding for the Approach Roadway Alignment or Waterway Adequacy Appraisal Ratings is changed, the notes should explain when and why this was done.
- Notes should be added for NBI Items 36A-D if the safety features are updated. If any Safety Feature is coded as "substandard", the notes should briefly describe why.

Structural Element Notes: Every structural element has a dedicated section in SIMS for entering inspection notes. It is recommend that the structural element notes include a brief description of the structural element being rated - this is particularly helpful on large or complex bridges.

- Inspection notes are mandatory for any structural element rated lower than condition state 1.
- The structural element notes should clearly describe the extent, severity, and location of any defects present on that element. As MnDOT does not track defects as separate

sub-elements, it is essential that defects be described in a consistent and quantifiable manner.

When entering an inspection report in SIMS, notes are carried over from previous inspections. Thus, it is essential that inspection notes are dated. Dated inspection notes allow the reviewer to determine changes in condition, and to identify when structural modifications were performed (or when dead loads were added to the structure).

- While the exact manner of dating inspection notes will vary, it is recommended that the year the condition was observed precede the inspection note. Example, "[2012] South fascia girder has 10 LF of surface corrosion on the exterior bottom flange, extending out from the west abutment".
- When the condition changes during a subsequent inspection, the year the condition was first observed, as well as the year the condition last changed, should precede the inspection note. Example, "[2012/2014] South fascia girder has 15 LF of surface corrosion on the exterior bottom flange, extending out from the west abutment."
- Old structural element notes that no longer apply to the bridge should be deleted. Example, if a deck expansion joint is replaced, notes describing the previous expansion joint should be deleted.

General Inspection Notes: Notes that do not apply to a specific structural element (or NBI item) may be placed in the "General Notes" area.

- On larger multi-span structures, the general layout of the bridge from the original construction plans should be described. Example, "Bridge runs from the south to the north, with piers and spans numbered from the south."
- It is also helpful to describe the beam numbering system used on the bridge framing plan. Example, "Beams are numbered 1-6 starting from the west."
- If a structure has had significant structural modifications (such as bridge widening, bridge re-decking, or a culvert extension), a brief note should describe the modifications and when they were performed.
- If high water (or snow), prevents a full inspection, it should be noted here so that a follow-up inspection can be performed.
- If a bridge carries railroad traffic (or crosses over a railroad), emergency contact information for the railroad should be provided. If possible, the railroad mile point should be noted to assist in identifying the structure to the railroad.

B.4.2 INSPECTION PHOTOGRAPHS

A digital camera is basic bridge inspection equipment. Photographs should be taken (and entered in SIMS) during each routine bridge inspection. Photos can provide an excellent illustration of changes in the condition of a bridge (or culvert) over time. Note: Photographs should not be used as a replacement for inspection notes, but rather as a way to complement the inspection notes.

Section 2.2.1 of the AASHTO Manual for Bridge Evaluation requires that these three general photographs must be included in the file for each bridge. Taking these three photographs during each routine inspection will ensure that each bridge file will have up-to-date photographs to meet this requirement.

1. Top view of the roadway across the bridge (or culvert)
2. A side elevation view of the bridge (or culvert)
3. An underside view of the main span (or a typical span)

1. Roadway across Bridge

2. Side Elevation View

3. Underside View

The MnDOT Bridge Office requires photos for the following situations.

- Critical findings must always be documented with photographs.
- If a primary structural element is rated as condition state 4, at least one photograph of the element is required during each routine inspection.

Other recommended photographs to take during a routine bridge inspection (or have in the bridge file) include the following.

- Significant damage or deterioration (primary elements rated as condition state 3)
- Serious safety hazards
- General and/or close-up views of primary structural elements (even if there is little or no deterioration) to provide a baseline of the general structural condition
- Structural repairs or modifications
- Load posting signing (if present)
- Height restriction signing (if present)
- Significant or unusual bridge features
- Upstream and downstream views of the channel or waterway below the bridge
- Deck expansion joint gaps
- Bearing orientation
- Safety features (railings and guardrail)
- Utilities or other ancillary items that have been added to the bridge

B.4.3 MEASURING & DOCUMENTING SECTION LOSS ON STEEL MEMBERS

Corrosion is the most common defect found on steel bridges. Any measureable loss of the original steel member cross-section due to corrosion referred to as "section loss". Accurately measuring and documenting the extent and location of section loss is one of the primary responsibilities of the bridge inspector, and is essential in evaluating the load-carrying capacity of a steel bridge.

The bridge inspection report should accurately describe the location and extent of any significant section loss. Section loss is typically expressed as a percentage of the original cross-sectional area.

- On members subjected to axial loading (such as truss members), section loss is typically expressed as percentage of the entire member cross-section. *Example: "Truss bottom chord member L2-L3 has 15% section loss at the L2 connection."*

- On members subjected to bending moment (such as girders or beams), section loss is typically expressed as percentage of the bottom flange, top flange, or the web cross-section. *Example: "The bottom flange of the west girder has 10% section loss at the 1st deck drain east of Pier #2."*

When describing section loss in an inspection report, it is important that the extent of section loss not be misrepresented. For example, the bottom flange of a steel beam has a 1" diameter hole rusted through, which constitutes 15% of the total bottom flange cross-section at that location. This should not be described as "*the bottom flange has 100% section loss*", but rather as "*the bottom flange has 15% section loss*" (or "*the bottom flange has a 1" diameter hole*").

If the original cross-section has not yet been determined, it may be better to describe the location and dimensions of the area with section loss. *For example: "Girder #3 has 4" wide by 2" high area of pitting (up to 1/8" deep) at the west abutment bearing".*

When should section loss measurements be performed? As a general rule, section loss measurements should be taken if the approximate section loss on a primary structural steel member exceeds 5% of the total member cross-section (or 5% of the flange or web cross-section). As it is not generally practical to accurately measure and document every area of section loss on a bridge, some judgment must be used by the inspector in prioritizing the locations where section loss measurements are taken. Highly stressed portions of the structure (such as the bottom flange near the center of a span) should be prioritized for section loss measurements. If section loss is present at similar details throughout a bridge, measurements should be taken at locations that appear to have the most severe and/or extensive section loss.

Locations where section loss is likely on bridges: The locations where corrosion (and section loss) will occur on a bridge are typically predictable – steel members exposed to salt spray or covered by debris will typically have section loss. The exact locations will vary depending upon the structural configuration and features present on the bridge – locations where corrosion (and section loss) is likely to occur include the following.

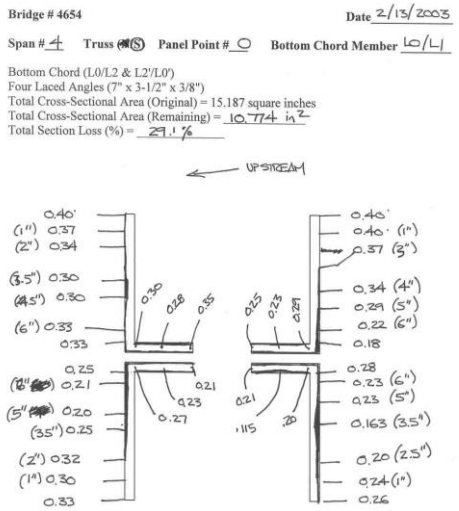
- Structural members located below deck joints
- Bearing areas
- Areas below deck drains or adjacent to downspouts
- Areas located directly above traffic (exposed to salt spray)
- Horizontal surfaces, field splices, or other details that tend to accumulate debris
- Fascia girders, beams, or stringers will typically have more corrosion and section loss than interior members – particularly along the exterior bottom flange
- On bridges with concrete decks, corrosion will tend to be localized (below deck joints or leaching cracks) – on bridges with timber decks, corrosion may be widespread

- Through truss and pony truss bridges will typically have section loss along the bottom chord, particularly at the panel point connections – section loss may be present on the truss members or gusset plates. Truss diagonal and vertical members will typically have corrosion at the railing connections, at the curb level, and at the bottom chord connections.
- Steel box girders (or other box sections) will develop internal corrosion if moisture accumulates within the box section
- Steel piling will typically have corrosion at the waterline and/or ground line

Cleaning prior to inspection: In order to properly inspect a steel member (and to determine the extent of section loss) – the steel must first be cleaned of any dirt, debris, or excess flaking rust. A large build-up of debris on a steel member indicates not only inadequate maintenance, but also indicates inadequate inspection. A bridge inspector should have ready access to cleaning tools such as a shovel, spade, whisk broom, wire brush, pick hammer, or scraper. Inspection during (or immediately after) re-painting contracts will often allow for more precise section loss measurements.

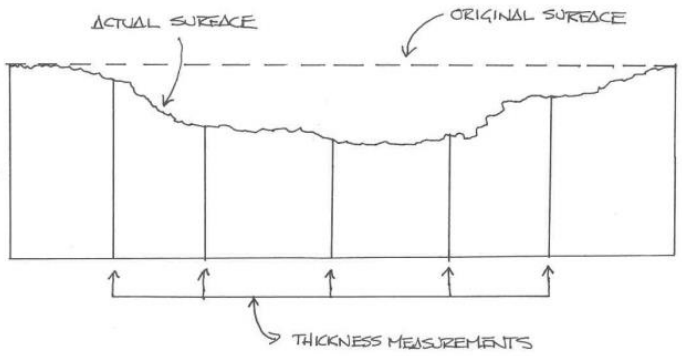
Methods of measurement: During a bridge inspection, initial section loss is often estimated (often aided by a straight edge or ruler) – as section loss advances, more precise measurements may be necessary. Calipers are a simple and inexpensive method of measuring the thickness of the remaining steel, but they may not be able to reach some locations (such as a girder web). An ultrasonic thickness gauge is the most precise and effective method of obtaining thickness measurements – this can be used in confined areas or locations where only one side of the member is accessible.

Field notes and cross-section diagrams: Field notes should be thorough, concise, and readable – they should include not only the thickness measurements, but the exact location where those measurements were taken. To determine the extent of section loss on a structural member, the original cross section area must be known. If no plans are available, measurements and thickness readings should be taken in areas without section loss to establish a basis for the section loss calculations. Plan dimensions and thicknesses should be verified. Cross-section diagrams are helpful in documenting field measurements and performing section loss calculations. If possible, blank forms (with cross section diagrams) should be prepared prior to taking field measurements. To facilitate section loss calculations, the exact location of all thickness readings should be recorded – areas with section loss should be clearly indicated.

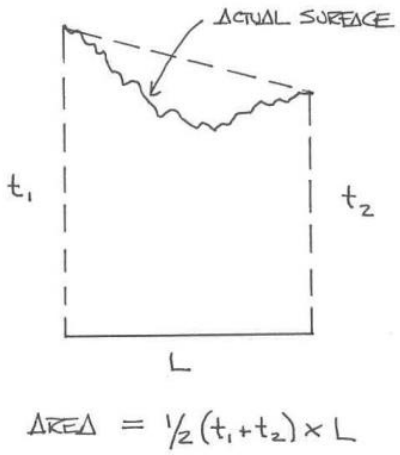


Example of cross section diagram with section loss field measurements

Section loss calculations: When performing section loss calculations, the level of accuracy will generally depend on how many thickness measurements are taken – the more measurements are taken, the greater the accuracy. One common method of calculating section loss is to simply take the average of several thickness measurements over a portion of the member cross-section. A slightly more accurate method is to divide the cross-section into trapezoidal sub-areas, based upon the exact locations of the thickness measurements – these areas are then calculated separately and added up. Whatever method is used, it should be done clearly and consistently, so the calculations can be easily checked and verified.



Cross-section showing location of thickness measurements



Trapezoidal sub-area

B.5 BRIDGE STRUCTURE TYPES AND COMPONENTS

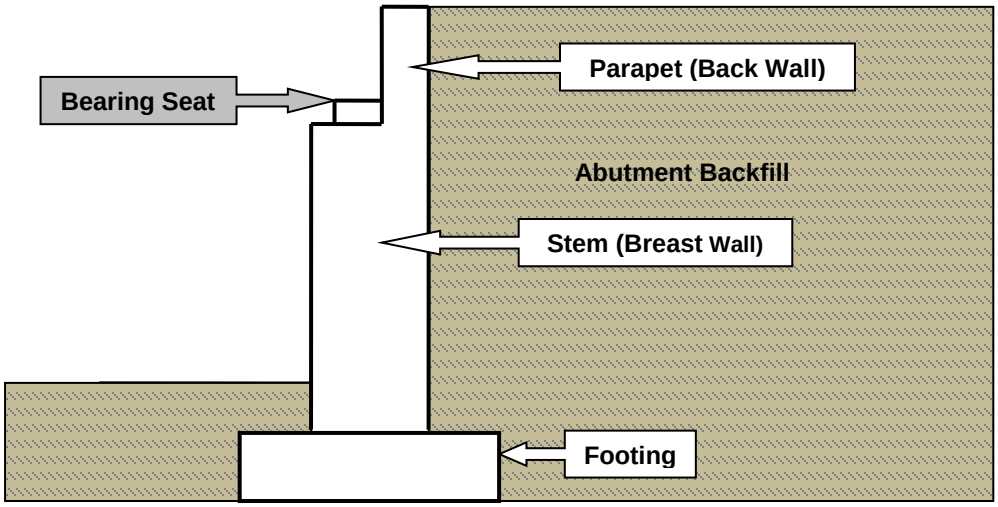
Note: This section is incomplete – it will eventually include general inspection procedures and condition rating guidelines for common bridge deck, superstructure, and substructure types. This is intended to be a condensed version of the guidelines in the Bridge Inspector's Reference Manual (BIRM).

B.5.1 SUBSTRUCTURE COMPONENTS

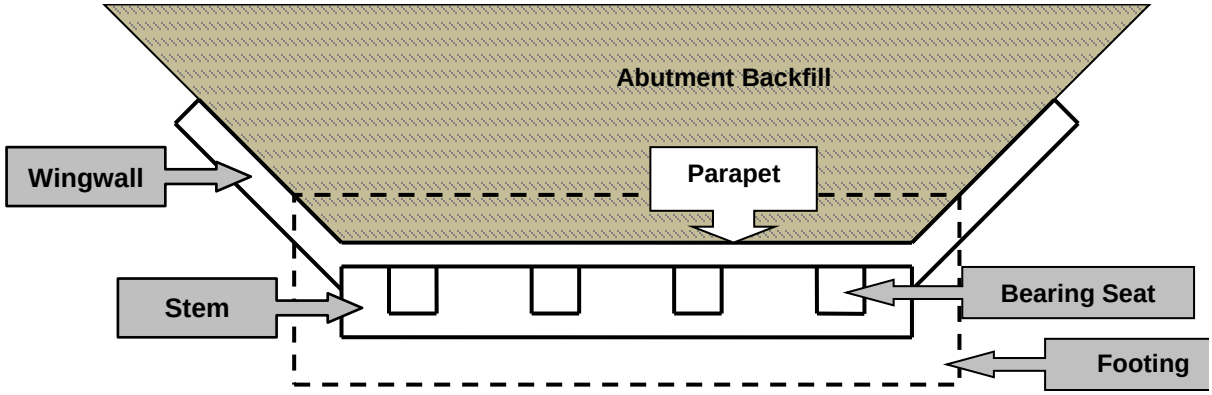
This section includes general inspection procedures and condition rating guidelines for substructure components (abutments and piers). This includes general descriptions and terminology, as well as guidelines for the proper selection of structural elements (and determining element quantities).

B.5.1.1 Concrete Abutments

Most abutments are constructed of reinforced concrete, while the overall configuration will vary, most concrete abutments share the following typical components.



Cross-section of a Typical Concrete Abutment



Plan View of a Typical Concrete Abutment

- **Stem:** The abutment stem (or breast wall) is the primary component of the abutment – it transmits the load of the bridge superstructure to the footing, and retains the abutment backfill. Only the front face is typically visible for inspection.
- **Bearing Seat:** The bearing seat provides a horizontal bearing area for the superstructure.
- **Parapet:** The parapet (or back wall) prevents backfill soil from sliding onto the bearing seat, and provides support for the deck expansion joint (or approach slab).
- **Footing:** The footing transmits the weight of the abutment, the soil loads, and the load of the bridge superstructure to the supporting soil. A footing may be supported by piling, or may transfer these loads directly to the supporting soil or rock (spread footing).
- **Wingwall:** A wingwall is a short retaining wall extending from each end of the abutment that serves to retain the side slope. The wingwall configuration (height, length, and angle from the abutment face) will vary depending upon the abutment geometry and site conditions.

General inspection procedures for concrete abutments:

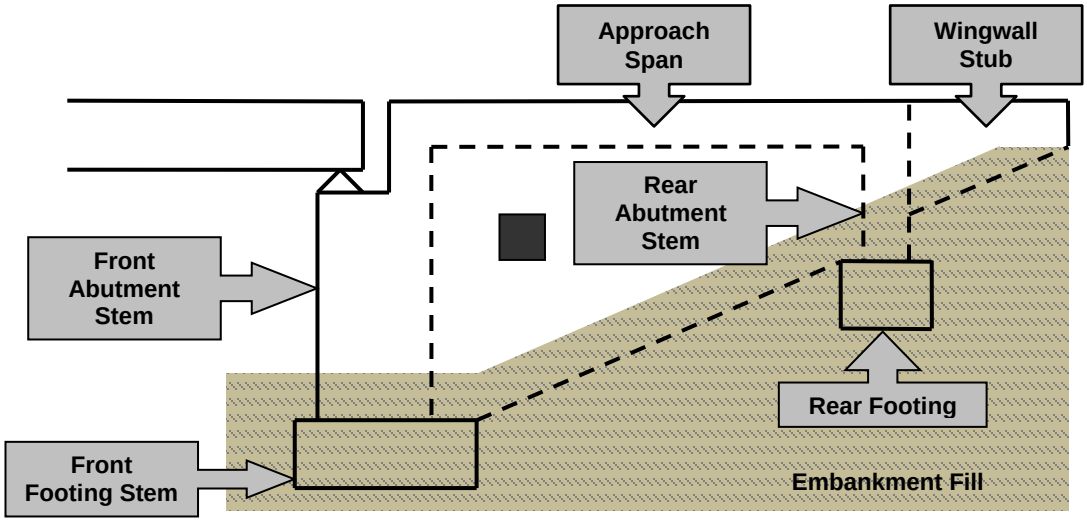
- Note any concrete deterioration (cracking, leaching, rust staining, delamination or spalling).
- Note any evidence of deck joint leakage (such as staining on the abutment face or debris on the bearing seat).
- Weep holes (typically located near the base of the stem) should be examined for proper function.
- Note any distress on the parapet (cracking, spalling or tipping) resulting from the superstructure contacting the parapet or from approach pavement thrust.
- Note any evidence of settlement, rotation, or other movement.
- Note any deterioration of the slope protection, slope erosion, undermining, or footing/piling exposure.
- If the abutment is submerged in water, probe along the front face for any evidence of scour (review the underwater inspection report, if applicable).

Condition ratings for concrete abutments: An abutment has two basic functions – to support for the bridge superstructure, and to retain the abutment backfill. The condition ratings should reflect not only the condition of the visible concrete surfaces, but also the ability of the abutment to perform these two basic functions.

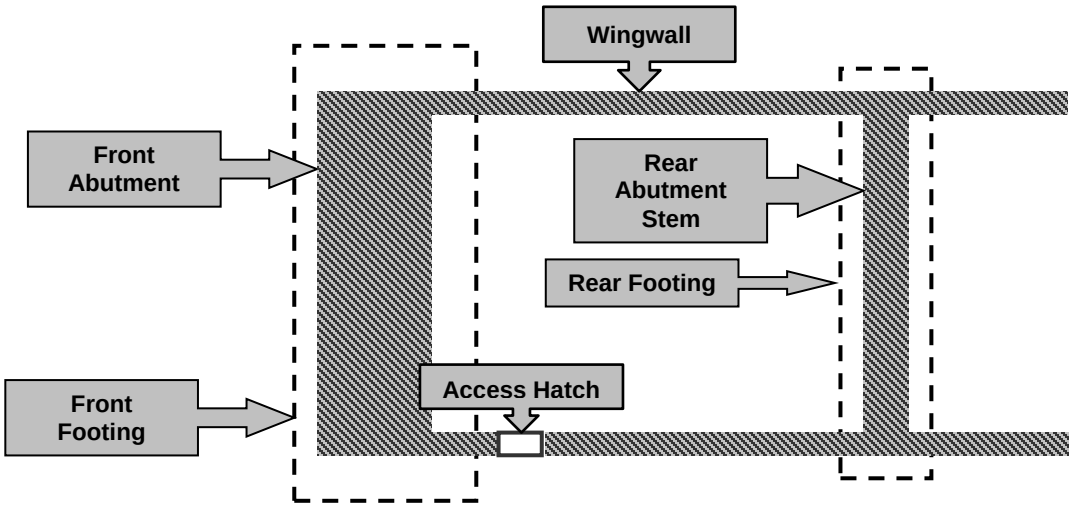
- Element #215 (Reinforced Concrete Abutment) should be used to rate the abutment stem, seat, parapet, and integral wingwalls. This is a linear foot (LF) item – the quantity is determined by measuring horizontally across the front face of the abutment and along the length of any integral wingwalls.
- As the footings (and pilings) supporting a concrete abutment are typically not visible for inspection, they are typically not rated. If the abutment footing is visible for inspection, it can be rated using Element #220 (Reinforced Concrete Footing). This is a LF item.
- If settlement, rotation, or other movement of the abutment is evident, Element #883 (Substructure Settlement and Movement) must be rated accordingly.
- If scour is present, Element #884 (Scour) must be rated accordingly.
- Element #890 (Slopes and Slope Protection) should be used to rate the condition of the abutment slopes and slope protection.

B.5.1.2 Hollow ("U-Type") Concrete Abutments

Hollow or "U-Type" reinforced concrete abutments are actually an enclosed approach span, typically a cast-in-place concrete slab or T-girder span. The wingwalls enclose the sides of the span, creating a "hollow" abutment that appears to be solid. Access hatches are typically located on the wingwalls or parapets. Hollow abutments are intended to reduce the dead load (compared to a solid abutment) and subsequent settlement of the abutment. Note: Periodic internal inspections should be performed to assess the condition of the interior elements – confined space entry procedures are typically required.



Elevation View of a Hollow Concrete Abutment



Section View (Looking Down) of a Hollow Concrete Abutment

Element #215 (Reinforced Concrete Abutment) should be used to rate hollow "U-Type" abutments. The LF quantity is measured around the exterior perimeter (front face and side walls, including any integral wingwall extensions). An element or elements must also be selected to rate the enclosed approach span – this may include beam, deck, or slab elements.

B.5.1.3 Integral and Semi-Integral Concrete Abutments

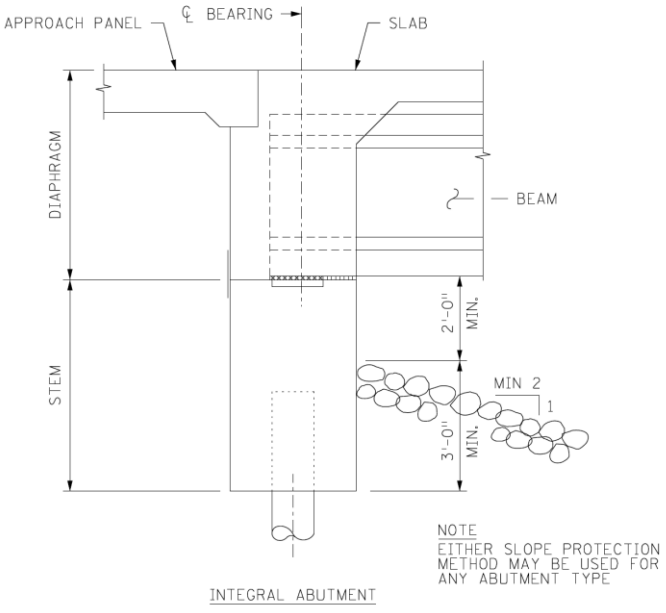
Integral and semi-integral abutments are now the preferred design for new bridges in Minnesota, as they eliminate the need for a deck expansion joint above. Traditional concrete parapet abutments are now only used when the design criteria for integral or semi-integral abutments cannot be met (see Section 11.1 in the MnDOT LRFD Bridge Design Manual).

An integral abutment consists of a concrete abutment stem supported by a single line of piles. The beams, girders, or slabs bear upon the abutment stem. A concrete diaphragm, poured with the deck, encases the beam ends, making the superstructure, deck, and often the approach panel integral with the abutment.

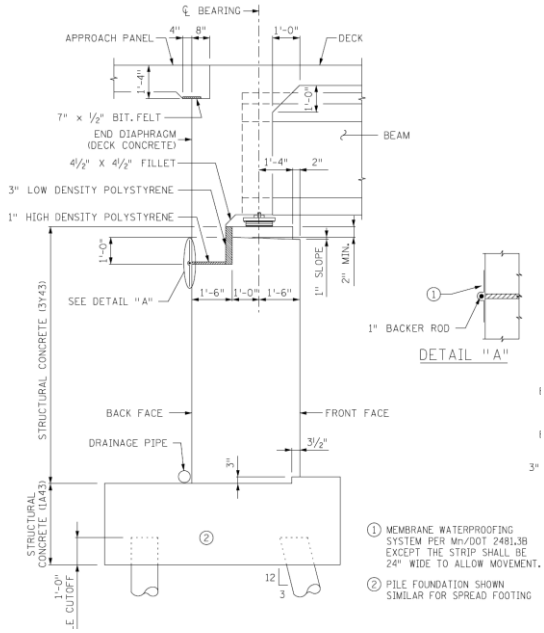
A semi-integral abutment is similar to an integral abutment in that the superstructure, deck, and approach panel are integral and expand and contract as a single unit. The primary difference is that the superstructure is supported on bearings, allowing the superstructure to move independently form the abutment stem. Another difference is that the stem footing is typically supported by multiple rows of piles.

Use the criteria below when rating the condition of an integral or semi-integral abutment.

- The abutment stem should be rated using Element #215 (Concrete Abutment) and should be considered to be part of the substructure.
- The concrete diaphragm should be rated using Element #855 (Secondary Members – Superstructure) and should be considered to be part of the superstructure.
- Bearing elements will typically be used only if bearing assemblies are present on the abutment stem and are visible for inspection.
- If integral concrete approach panels are present, Element #321 (Concrete Approach Slab) will typically be used.
- If approach relief joints are present on a bridge with integral or semi-integral abutments, it is important that Element #816 (Approach Relief Joint) be added and rated. On these bridges, the approach relief joints often must accommodate thermal expansion of the bridge as well as the adjacent roadway.



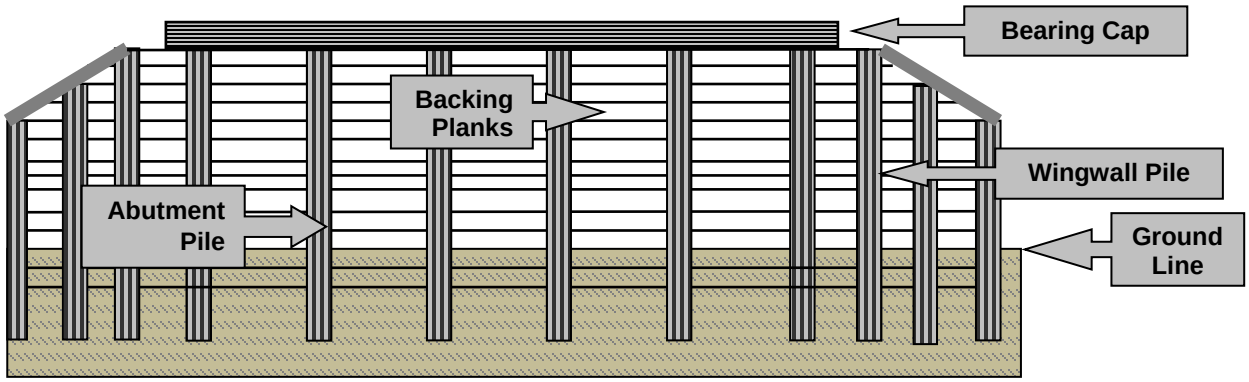
Integral Abutment (Cross Section)



Semi-Integral Abutment (Cross Section)

B.5.1.4 Timber Abutments

Timber abutments are typically comprised of three main components (backfill planks, bearing cap, and piling), which are rated using three separate structural elements. These components may be connected with bolts, straps, lag screws, nails, spikes, or drift pins. The inspector should determine the condition of each timber element, as well as the overall orientation and stability of the abutment. The presence of failed connections or misaligned members should be reflected in the element ratings. Note: If the abutment has tipped, rotated, or settled, Element #883 (Substructure Settlement and Movement) must be rated accordingly.



Front View of a Typical Timber Abutment

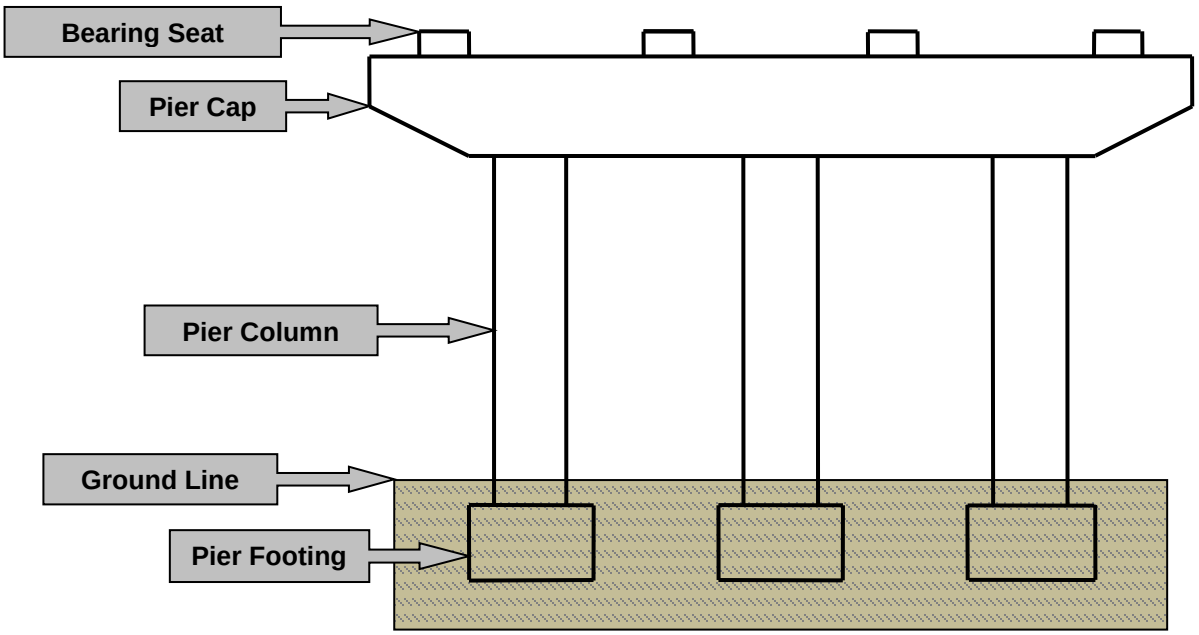
- **Backfill planks (abutment face and wingwalls**): The backfill planks retain the abutment backfill and transfer earth pressure forces to the piling. Element #216 (Timber Abutment) should primarily reflect the condition of the backfill planks, but should also reflect the overall structural condition of the abutment. This is a linear feet (LF) item, measured across the front face of the abutment, including the length of any timber wingwalls. Backfill planks should be inspected for bulging, gaps, or voided backfill. There should be some backing planks below the ground line. If the bottom backing plank is exposed (due to erosion of stream degradation), the abutment backfill cannot be properly retained.

- **Bearing cap:** The bearing cap provides a bearing seat for the superstructure and transfers superstructure loads to the piling. Element #235 (Timber Pier Cap) should be used to rate the condition of the abutment bearing cap. This is a linear feet (LF) item, measured along the length of the cap. The total element quantity should include the abutment caps as well the pier caps (if there are any). Note: If the cap is comprised of another material (such as steel or concrete), the appropriate structural element should be selected. If the cap is not bearing properly on the pilings (twisted, offset, or gap), this should be reflected in the cap element rating.

- **Pile:** Pilings transmit superstructure loads from the bearing cap into the surrounding soil. Most timber abutments are supported by timber pile. A timber pile is a cylindrical shaft (typically 12” to 16” in diameter) driven into the ground using a pile hammer. Some timber abutment piling incorporate steel cable tie-back systems to resist the horizontal force resulting from earth pressure. Element #228 (Timber Pile) should be used to rate the condition of the abutment (and wingwall) piling. This is an “each” item – the total element quantity includes all timber piling on the bridge (abutment, wingwall, and piers). Note: If the abutment piling are comprised of another material (such as steel or concrete), the appropriate piling element should be selected. Free-standing vertical supports (not driven in the ground with a hammer) should be rated using a column element. Timber columns (Element #206) typically have a square cross-section.

B.5.1.5 Concrete Column Piers

The most common pier configuration is a reinforced concrete column pier, which is comprised of two or more columns (bearing on footings), which support a bearing cap. These piers are typically cast-in-place, and are tied together with steel reinforcement to create a rigid frame.



Typical Concrete "Column Pier" Configuration

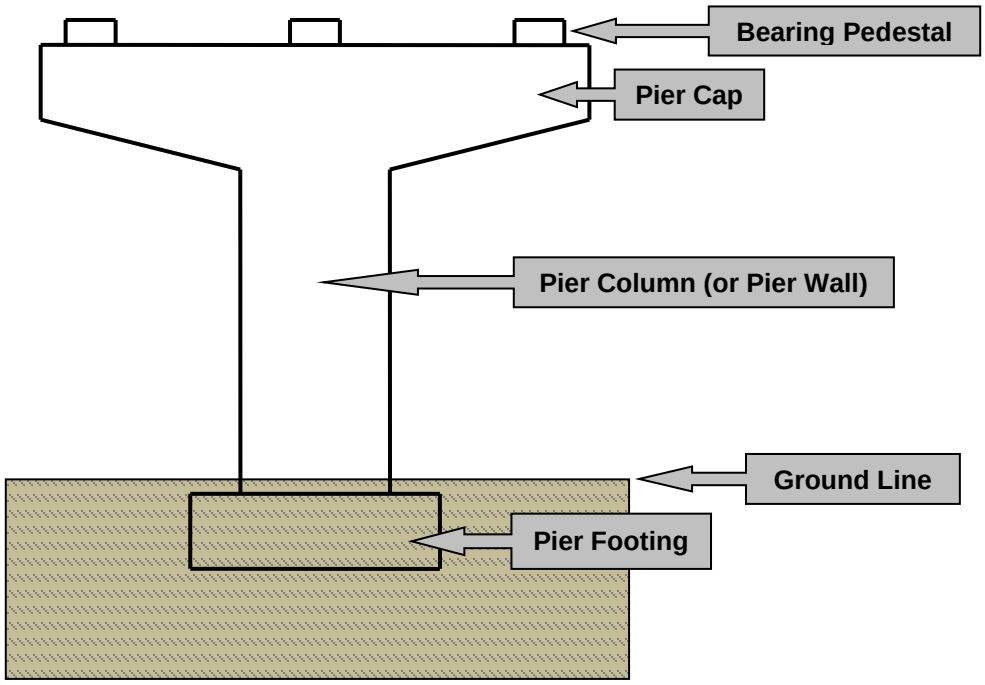
- **Pier cap:** The pier cap is the upper horizontal portion of the pier that supports the superstructure. Pier caps are subjected to bending and shear forces. The pier cap (including the bearing seats) is rated using Element #234 (Reinforced Concrete Cap). This is a "linear foot" quantity, measured along the length of the cap. If shear cracking is present, Element #883 must be added to the report and rated.
- **Pier columns:** The vertical pier columns transfer the superstructure load from the pier cap to the pier footing – they are primarily subjected to compression forces. Pier columns are rated using Element #205 (Reinforced Concrete Column). This is an "each" item, a condition rating must be determined for each specific column. Crash struts (or barriers) between the pier columns should be rated using Element #856 (Secondary Members – Substructure). This is an "each" item, the quantity can simply be left as "1".
- **Pier footings:** As most pier footings are designed to be located below grade (not visible for inspection), they are typically not rated. If footings are exposed by scour or streambed degradation, it should be brought to the attention of the agency Program Administrator (and bridge owner). Concrete footings that are visible for inspection should be rated using Element #220 (Reinforced Concrete Footing).

General inspection procedures for concrete piers:

- Note concrete deterioration (cracking, leaching, rust staining, delamination or spalling).
- Note evidence of deck joint leakage (staining on the cap or debris on the bearing seat).
- Note any evidence of settlement, tipping, rotation, or other movement.
- If the pier is submerged in water, the perimeter should be probed for evidence of scour, undermining, or footing/piling exposure (refer to the underwater inspection report, if applicable).
- Note the presence and condition of any pier protection components (such as dolphins, fenders, or crash struts).

B.5.1.6 Concrete Hammerhead Piers

A reinforced concrete hammerhead pier consists of a single column with a relatively wide cantilevered pier cap (the cap is typically tapered in depth).



Typical "Hammerhead" Pier Configuration

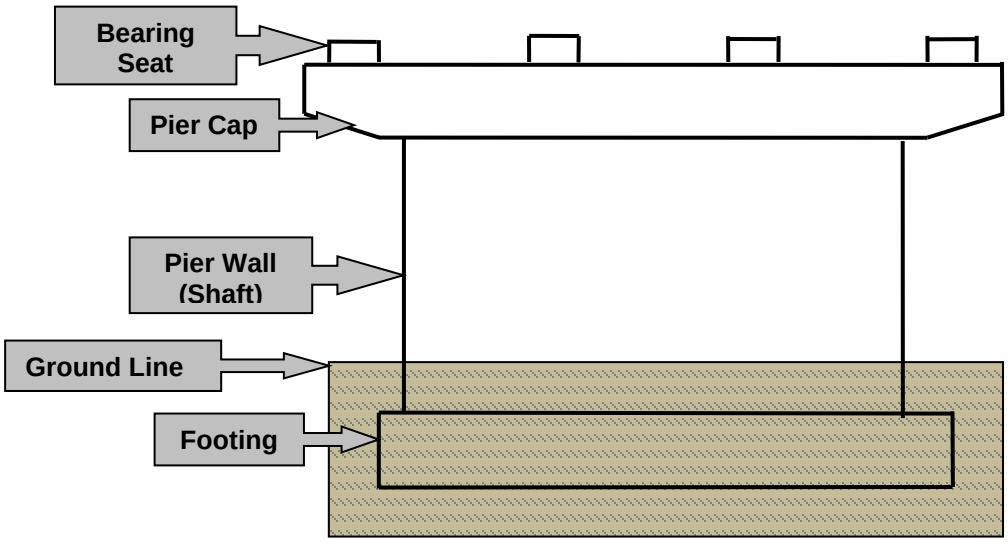
- **Pier cap:** Element #234 (Reinforced Concrete Cap) should be used to rate the cap and bearing pedestals – this is a linear foot (LF) quantity (measured along the length of the cap). The cantilever portion of the cap should be examined for any evidence of structural distress (such as shear cracking). If shear cracking is present, Element #883 (Substructure Settlement and Movement) must be added to the report and rated.

- **Pier column or Pier Walls:** The vertical portion of a hammerhead pier could consist of a column or pier wall. Element #205 (Reinforced Concrete Column) will typically be used to rate columns – this is an "each" item. If the vertical support is 10 ft. or greater in width (and wider than it is deep), it should be rated using Element #210 (Reinforced Concrete Pier Wall) – this is a LF item.

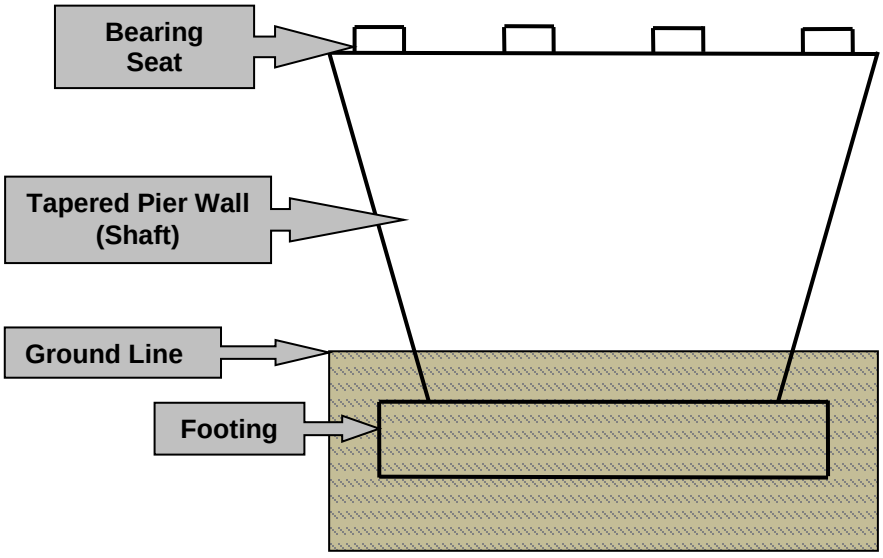
- **Pier footing:** As the pier footing (and pilings) are typically located below grade and not visible for inspection, they are not rated as a structural element.

B.5.1.7 Concrete Pier Walls

A reinforced concrete pier wall is comprised of a solid shaft (as opposed to separate columns). The shaft may be straight (vertical) or tapered. There may or may not be a pier cap.



Concrete Pier Wall – Straight (Vertical) Shaft with Pier Cap

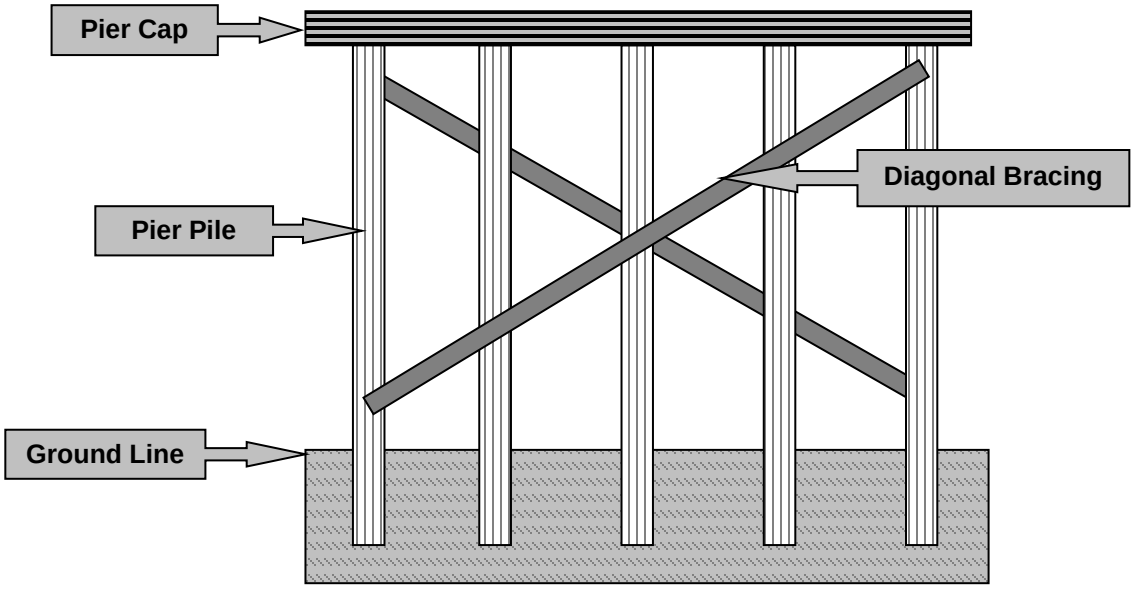


Concrete Pier Wall – Tapered Shaft without Pier Cap

- Element #210 (Reinforced Concrete Pier Wall) should be used to rate the pier wall shaft. This is a linear feet (LF) quantity (measured horizontally along the face of the pier wall (on tapered pier walls, use the widest dimension). As a general rule, pier shafts less than 10 ft. long should be rated using Element #205 (Concrete Column).
- If a pier cap is present, Element #234 (Reinforced Concrete Cap) should be used to rate the cap and bearing seats. If no cap is present, the bearing seats can be included with Element #210 (Reinforced Concrete Pier Wall). As pier footings are typically below grade and not visible for inspection, they are not rated.

B.5.1.8 Pile Bent Piers (Timber, Steel, or Concrete)

Piers comprised of two or more piling supporting a cap are known as pile bents. While typically comprised of timber, they may include steel or concrete members. The inspector should determine the condition of each element, as well as the overall orientation and stability of the pier. The presence of failed connections or misaligned members should be reflected in the element ratings. Note: If the pier has tipped, settled, or moved, Element #883 (Substructure Settlement and Movement) must be rated accordingly.



Pile Bent Pier

- **Piling:** Pier piling transmit the superstructure load from the pier cap to the supporting soil (they are mainly subjected to compression forces). Piling should be examined for impact damage or deterioration, particularly along the waterline or ground line. MnDOT has four piling elements – they are all "each" items, a single condition rating must be determined for each pile.
    - **#225: Steel Piling (Includes H-pile and CIP Piling)**
    - **#226: Prestressed Concrete Piling**
    - **#227: Reinforced Concrete Piling**
    - **#228: Timber Piling**

- **Pier Cap:** The pier cap provides a bearing seat for the superstructure, and transfers the superstructure loads to the piling. The connections between the cap and piling should be examined for any deterioration or distress. The cap material on pile bent piers may differ from the piling material. Pier cap elements are all "LF" items, measured along the length of the cap.
    - **#231: Steel Pier Cap**
    - **#234: Reinforced Concrete Pier Cap**
    - **#235: Timber Pier Cap**

- **Pier Bracing:** To prevent pile buckling, pile bent piers are often reinforced with diagonal bracing. The bracing members should be examined for deterioration, impact damage, or connection failure. Bracing members can be rated using Element #856 (Secondary Members – Substructure). This is an "each" item, the quantity can simply be left as "1".