4 CANTILEVER AND TRUSS STRUCTURES

4.1 Definitions

A cantilever structure consists of a rigid structural element extending above the roadway and is supported at only one end. Cantilever structures are structural supports for traffic signs including static signs, dynamic message signs (i.e., DMS), lighting, signals, and other traffic-related appurtenances. This element consists of cantilever structures used to support static signs only. Cantilever structures are comprised of steel horizontal members which support the appurtenance noted above, steel vertical members which support the horizontal members from the foundations and the concrete foundation.

A truss structure consists of a rigid structural element spanning across the roadway with supporting columns at both ends. Truss structures are structural supports for traffic signs including static signs, small dynamic message signs (i.e., DMS), lighting, signals, and other traffic-related appurtenances. This element consists of truss structures used to support static signs only. Truss structures are comprised of steel horizontal members which support the appurtenances noted above, steel vertical members which support the horizontal members from the foundations, and the concrete foundations.

Other common terms which may be used when discussing Cantilever Structures:

- *Cantilever Structure (Types C, D, and E):* Cantilever structure with two horizontal arms
- *Cantilever Structure (Type J):* Cantilever structure with a horizontal truss arm comprised of three chords (, also known as a tri-chord cantilever. Where horizontal truss arms are present, the three or four horizontal chord members are connected by vertical, horizontal, and diagonal bracing.

Figure 4-1: Cantilever structure, two-arm (left) and tri-chord style (right)

Other common terms that may be used when discussing Truss Structures:

- *Box trusses (Types C and D):* Most trusses are supported on dedicated concrete foundations, though some may be supported at one or both ends by reinforced concrete barrier, retaining wall, or bridge girders. Depending on the truss type, the dedicated foundation may be a spread footing or drilled shaft.
- *Tri-chord trusses (Type E):* A tri-chord truss is identified by the use of three chords to connect the truss; a top truss, back truss, and bottom truss chord.

Figure 4-2: Truss structures, box truss (left), tri-chord truss (right)

4.1.1 INVENTORY ITEMS

A complete list of inventory items is provided in the Ancillary Structures Data Dictionary.

4.1.2 ELEMENTS

Cantilever Structures and Truss Structures are divided into three components: the foundation, the vertical structure, and the horizontal structure.

The foundation is divided into two elements: the concrete foundation and anchor bolts and leveling nuts.

The vertical structure is divided into three elements: the base plate, the vertical support column (upright), and the vertical structure connections.

The horizontal structure is divided into two elements: the arm or truss members, and the horizontal structure connections.

Elements are assigned a condition state described in Section 4.7 based on the distresses identified in each element.

The following guidelines for consistent location notation provide the framework for rating a sign element in accordance with the condition rating tables.

- Vertical Structure Locations - Distress locations along the truss or cantilever vertical support are referenced by using offsets measured from the base plate as measured in inches and prominent features (e.g., top chord connection).
- Horizontal Element Locations - Distress locations along the truss or cantilever length are referenced by using offsets measured from the vertical support end. For trusses, Indicate the referenced support and any locations beyond the referenced support are recorded as negative.
- Vertical Supports on Arm or Truss Members - Vertical supports are identified in relationship to directionality (e.g., North/South, East/West, Right End/Left End looking at front of sign, or Right/Left looking upstation or downstation).
- Other – When possible, identify other elements in relation to the defined elements above. Otherwise, photograph location and document distress. A combination of both the entire element or structure and a close-up view would be best practice. Comments to support each photo should be provided.
- Create maps for nodes when necessary, especially for trusses. Identify nodes by number and relative location to front of truss, e.g., “UF@N3” for upper front at node 3.

Table 4-1: Cantilever Structure and Truss Structure Components and Elements

Component	Element	Element Code	Unit of Measure
Foundation	Concrete Foundation	14101	Each foundation
Foundation	Anchor Bolts and Leveling Nuts	14102	Each bolt and nut unit
Vertical Structure	Base Plate	14201	Each base plate
Vertical Structure	Vertical Support Column (Upright)	14202	Length, feet
Vertical Structure	Vertical Structure Connections	14203	Each
Horizontal Structure	Arm or Truss Members	14301	Length, feet
Horizontal Structure	Horizontal Structure Connections	14302	Each
Horizontal Structure	Sign and Sign Connections	14303	Each sign

4.1.3 COMPONENTS

Cantilever structures and truss structures are divided into three main components: the foundation, the vertical structure, and the horizontal structure.

Component ratings for cantilever structures and truss structures are based on the following:

- ***Foundation*** – Consider the structure's foundation effect on overall stability of the cantilever or truss structure.
- ***Vertical Structure*** - Consider if the vertical structure may have damage that compromises the structural capacity such as fractures, significant twisting or kinking, corrosion, section loss, or stress cracks in the metal.
- ***Horizontal Structure*** - Consider fractures in welds or base metal, corrosion, section loss, or buckling of truss compression members as critical to the overall horizontal structure.

See Section 1.7 for the discussion on component ratings and condition state tables.

A representation of the rating structure for cantilever structures and truss structures is provided in Figure 4-3. A depiction of the elements and components on standard details is provided in Figure 4-4.

Figure 4-3: Rating structure for Cantilever Structures and Truss Structures

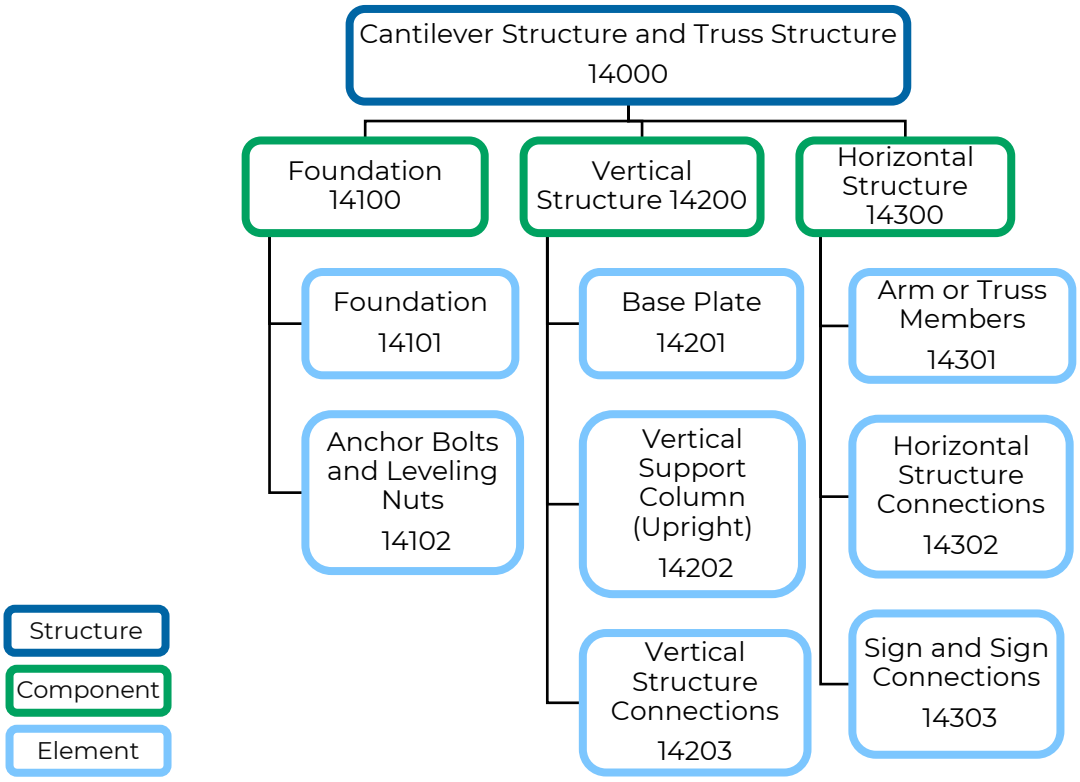
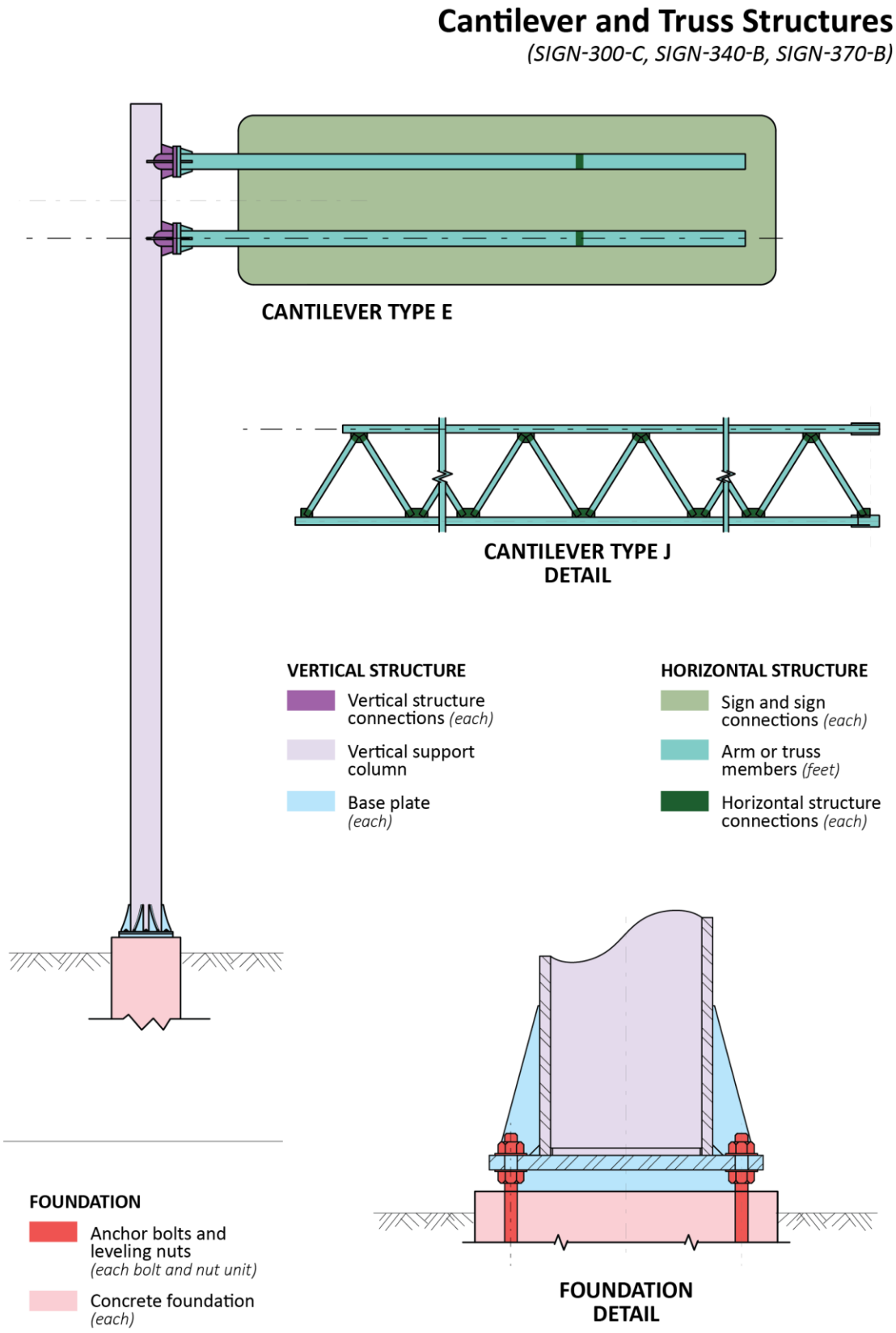


Figure 4-4: Elements and components for Cantilever Structures and Truss Structures (adapted from MDOT Standards SIGN-300-C, SIGN-340-B, SIGN-370B)



4.2 Inventory Record Photographs

Inventory photos are captured during a routine inspection, saved as part of the inventory database, and follow the naming convention in in *Table 4-2*.

Cantilever Structure and Truss Structure Required Photos:

- Elevation view of the roadway under the sign
- Each foundation
- Each vertical-to-horizontal connection
- Structure number stenciled on support

Table 4-2: Cantilever Structure and Truss Structure Photograph Naming Convention

* Where # is a sequential number ranging from 1-X. One image will be accepted if all connections can be captured in a single image that provides enough detail to determine connection type and bolts/nuts. If this level of detail cannot be obtained in a single image, then take multiple photos to provide the required level of visibility.

Photo Name	Description
Sign_Entire_Front	Entire sign and structure from front
Sign_Entire_Back	Entire sign and structure from back
Sign_Right_Foundation	Right foundation
Sign_Left_Foundation	Left foundation
Sign_VH#_Connection*	Vertical to horizontal connection
Sign_ID	Old ID and new structure number

4.3 Inspector Minimum Technical Qualifications

At least one member of the field inspection crew shall possess the following certifications and training:

- Certified Welding Inspector – American Welding Society, Certified Welding Inspector (CWI) (Current)
- Ultrasound qualification – Current ASNT Level II (ASNT or per ASNT TC-1A guidelines) qualification in straight beam ultrasonic testing. In conditions where a weld needs ultrasonic testing (UT) then Level II in shear wave is required
- A minimum experience of two projects with a minimum of 20 structures total inspecting cantilever structures or truss structures, including bolts. Multiple structure types shall have been inspected as part of the total project experience.
- Working knowledge of inspection tools, their use, application, and limitations for the structure type being inspected.
- MDOT structural bolting workshop for initial field installation verification
- Ancillary structures inspection procedures training

- Magnetic Particle Test (MT) – If a follow-up MT inspection is required for verification, then ASNT Level II (or per TC-1A) MT certified Level II is required
- Dye Penetrant Test (PT) – If a follow-up PT inspection is required for verification, then ASNT Level II (or per TC-1A) PT certified Level II is required

4.4 Routine Inspection

Overhead sign structures are structural supports for traffic signs including static signs, small dynamic message signs (i.e., DMS), and electronic lane control signs. They may also support lighting, signals, and other traffic-related appurtenances. This section discusses both truss and cantilever types of structures that support static signs. Both types are comprised of steel horizontal members which support the sign(s), steel vertical members which support the horizontal members from the foundations, and the concrete foundations. Loading is transferred from the horizontal members to vertical members through welded and bolted connections, and from the vertical members to foundations with anchor bolts. Most cantilevers are supported on concrete drilled shaft foundations, though some may be mounted to retaining walls or bridge girders.

Cantilever structure standard inspection frequency is once every 4 years, unless otherwise identified for more frequent inspection. Truss structure standard inspection frequency is once every 4 years, unless otherwise identified for more frequent inspection.

The acceptable tolerance for intervals of less than 24 months for the next inspection is up to two (2) months after the month in which the inspection was due. The acceptable tolerance for intervals of 24 months or greater for the next inspection is up to three (3) months after the month in which the inspection was due. Exceptions to the inspection interval tolerance due to rare and unusual circumstances should be approved by MDOT's Ancillary Structures Program Manager in advance of the inspection due date plus the above tolerances.

It is recognized that severe weather, inspector safety, inspection quality, resource optimization, technological difficulties, or other unique situations may be a reason to adjust the scheduled inspection date. In these situations, the adjusted inspection date should not extend more than two (2) months after the month the inspection was due for any inspection interval less than 24 months and not extend more than three (3) months after the month the inspection was due for any inspection interval 24 months or greater. Inspection interval tolerances are intended to provide some flexibility. When tolerances are applied, the longest time period prescribed between inspections is the applicable interval plus the prescribed tolerance. For example, a routine inspection on a 12-month interval could be performed during the 14th month if the tolerance is applied. Repeatedly applying the tolerance to the next inspection will create inspection date creep and may impact an owner's ability to perform future inspections in a timely manner due to other limitations (e.g. available resources, inspection workload, schedule, seasonal weather conditions, technological difficulties, etc.). Exceptions to inspection interval tolerances due to rare and unusual circumstances should be approved by MDOT's Ancillary Structures Program Manager in advance of the inspection due date, plus the tolerance. For example, if an inspection with an interval of 24 months is due on June 17, an exception request should be approved by MDOT's Ancillary Structures Program Manager before the end of the 3-month tolerance (i.e. September 30). However, a request for exception should be made when the potential for not meeting the tolerance becomes known to provide MDOT's Ancillary Structures Program Manager with adequate time for review and approval.

Table 4-3 provides guidance for inspecting reinforced and prestressed concrete cracking.

Table 4-3: Standard Cracking Widths

Description	Reinforced Concrete	Prestressed Concrete
Hairline (HL)	<1/16” (0.0625”)	< (0.004”)
Narrow (N)	1/16” to 1/8” (0.0625” to 0.125”)	(0” to 0.009”)
Medium (M)	1/8” to 3/16” (0.125” to 0.1875”)	(0.010” to 0.030”)
Wide (W)	>3/16” > (0.1875”)	> (0.03”)

Source: FHWA Bridge Inspector’s Reference Manual (Publication No. FHWA NHI 03-001, October 2002)

4.4.1 FOUNDATION ROUTINE INSPECTION

The routine inspection assesses the foundation’s ability to safely support the structure and transfer all loads to the surrounding soil or subsurface materials. If safety concerns, such as significant erosion, settlement, or lateral displacement, are noted, initiate an RFA. The routine inspection is performed on a regularly scheduled basis, with frequency determined by AS type, and includes the foundation component rating as determined by the element condition ratings of the concrete foundation and steel anchor bolts and nuts. It consists of observations and measurements needed to determine the physical and functional condition of the foundation, to identify any changes from initial or previously recorded conditions, and to ensure that the foundation continues to satisfy present service requirements. All elements of the component shall be visually inspected at a distance that is close enough to determine the overall condition and to detect deficiencies.

A sample foundation routine inspection would consist of:

- Note vegetation growth impeding access to the structure.
- Inspect ground line for any material washing out around foundation.
- Examine the foundation visually and by sounding with a standard inspection hammer.
- Verify anchor bolt diameter and length, then scan for defects.
- Examine anchor bolts for tightness and embedment using a standard inspection hammer. Inspect visually for corrosion, section loss, and plumbness.
- Examine anchor bolts for any eccentricity. Note any noticeable eccentricity measurements.
- Perform ultrasonic testing of anchor bolts to note any breaks and verify lengths.
- Rate Component.

- Rate Elements.
- Provide photographs for all Poor or Severe condition state defects and submit the applicable Work Recs or RFAs.

4.4.1.1 Cantilever Structure and Truss Structure Foundation Component Rating

The component rating for the foundation depends on the condition of the foundation concrete and surrounding soil, and the anchor bolts and nuts that connect the structure to the foundation. Assessing these factors with respect to the overall ability of the foundation to safely support the structure, along with the element condition ratings, provides the appropriate component rating. Note that the base plate is considered as part of the vertical structure component.

Table 4-4: Foundation Component Rating Guidelines for Cantilever Structure and Truss Structure

Component Rating	Condition	Material	Description
9	**NEW**	All	No deficiencies in any of the structural components that will affect long-term performance.
8	**VERY GOOD**	All	All structural components are sound and functioning as designed. There may be superficial cracking or weathering of protective components and/or dirt contamination of structural components.
7	**GOOD**	Concrete	Insignificant cracks or moderate cracks that are sealed.
		Soil	Insignificant displacement or erosion of soil.
		Steel	Protective coating failure in very small and scattered locations.
		All	All components retain full section properties and function as designed.
6	**SATISFACTORY**	Concrete	Unsealed moderate-width or map cracks. Minor delamination or spalling.
		Soil	Minor displacement or erosion of soil.
		Steel	Protective coating failures is limited to less than 10% of the surface area with no loss of section.
		All	Minor deterioration affecting structural components. Minor misalignment.
5	**FAIR**	Concrete	Moderate delamination or spalling.
		Soil	Moderate displacement or erosion of soil. Minor gaps may be present between pole and embedment material.

Component Rating	Condition	Material	Description
		Steel	Minor loss of section. Loose fasteners may be present but the connection is in place and functioning as intended.
		All	Moderate deterioration affecting structural components including minor settlement, or impact damage. Moderate misalignment. All members continue to function as designed.
4	POOR	Concrete	Considerable cracking and spalling.
		Soil	Considerable displacement or erosion of soil.
		Steel	Protective coating failure and less than 25% loss of section of anchor bolts and leveling nuts. Loose anchor bolts or leveling nuts may be present but are in place and functioning as intended.
		All	Considerable deterioration or misalignment affecting structural members. Structural review may be warranted.
3	SERIOUS	Concrete	Extensive cracking and spalling.
		Soil	Extensive displacement or erosion of soil. Large gaps may be present between tower and embedment material.
		Steel	Measurable loss of section in excess of 25%. Missing or broken anchor bolts and leveling nuts.
		All	Considerable deterioration or damage affecting structural members. Structural evaluation, is necessary to determine if the structure can continue to function without repairs.
2	CRITICAL	All	Deterioration has progressed to the point where the structure will not support design loads and emergency repairs, or removal is required.
1	IMMINENT FAILURE	All	Road is closed to traffic due to imminent failure, but corrective action may put it back in service.
0	FAILED	All	Road is closed due condition. Notify Region and the Bureau of Bridges and Structures.

4.4.1.2 Concrete Foundation Element Condition States

The foundation stabilizes and secures the entire structure. The purpose of inspection is to identify and record any minor to severe deficiencies throughout the lifespan of the foundations. Inspect the condition of the concrete foundation, noting any cracking, spalling, voids, and general deterioration. Typical issues include cracking throughout the foundation, spalling, chipping, delaminated or broken sections of the foundation, exposed aggregate and rebar, and soil erosion around the foundation.

Table 4-5: Cantilever and Truss Structure Concrete Foundation Element Distresses

Unit of Measure: Each foundation, note number of foundations within each condition state. Typically a single foundation which will then be rated as a single condition state.

Element Number	Element	Description	Associated Distresses
14101	Concrete Foundation	Sign Truss and Cantilever Structure Foundations	Cracking
			Spalling, Delamination, and Patching
			Exposed rebar
			Embedment erosion
			Impact Damage

Details on the condition state rating schema are in Section 4.7, linked below:

Cantilever Structure and Truss Structure Condition State Tables

Cracking

Concrete cracking can be either nonstructural or structural and can be caused by different factors. Nonstructural cracking is most often related to volumetric changes in concrete caused by fluctuations in moisture content and/or temperature during curing or while in service. Structural related cracking is often related to loading on the concrete being beyond its tensile capacity. Concrete can also crack if the embedded reinforcing bars are corroding. Inspect the foundation for cracking and investigate whether any observed cracking appears non-structural or structural in nature. Document the approximate location, orientation, width, and spacing of the cracking.

Spalling, Delamination, and Patching

Concrete spalling is a surface failure in which concrete breaks off from the underlying concrete substrate. Like cracking, spalling may occur when the steel reinforcing embedded within the concrete member undergoes corrosion. Inspect and document the extent and location of spalling and reinforcing bar corrosion. Estimate the extent of any section loss.

Concrete delamination can be identified as a thin layer of concrete separation from its substrate. Unlike spalling, delaminated concrete does not break away but remains attached to the structure.

Inspect the foundation for delamination by sounding areas that are exhibiting signs of distress to determine the limits of deterioration. Document the approximate location of delamination or spalling.

Exposed Rebar

Indicate if reinforcement is exposed.

Figure 4-5: Truss or cantilever structure foundation, minor cracking measured with a crack comparator (left), significant cracking (right)

Embedment Erosion

Soil erosion may cause instability of the foundation. Document the extent of erosion, including the depth.

Figure 4-6: Erosion of soil around a truss or cantilever structure foundation

Impact Damage

Inspect the concrete foundation for vehicular damage. Document the location and degree of damage.

4.4.1.3 Anchor Bolt and Leveling Nuts Foundation Element Condition States

The anchor bolts transfer load from the structure into the foundation. The purpose of inspection of the anchor bolt inspection is to identify any degradation of the nuts, flat washers, leveling nuts, and anchor bolts above and below the vertical support (upright) base throughout the lifespan of the structure. Typical issues include corrosion, damaged threads, loose connections, missing or damaged anchor nuts and leveling nuts, soil or debris between the upright base and concrete foundation, ultrasound indications, excessive leveling nut to foundation standoff distance, bent or warped base plates, and bent or warped anchor bolts. All nuts should be tight and fully bear on connected surfaces. Loose nuts, nuts that don't fully bear on adjacent steel, nuts not fully engaged, or damaged

or cracked anchor bolts can lead to connection movement, load redistribution, and ultimately failure.

Inspection of the anchor bolts includes a visual inspection of the anchor bolts, anchor nuts, and leveling nuts, a sounding test,, and a straight beam ultrasound scan (UT test) of 10 inches into the anchor bolts. Published procedures for the sounding and UT test are provided in Section 4.4.4.

Visually inspect the structure base looking for missing or damaged anchor bolts or nuts. Note any damage or corrosion and any bolts that show signs of bending. Inspect the anchor bolts for corrosion. Check for any gaps between the nuts, washers, and base plate. Check for excessive standoff distance between the underside of the leveling nut and the top of the foundation (or the top of sound concrete in cases of foundation deterioration).

The standoff distance is an indication of whether or not the anchor bolts are subjected to bending moment stress. For double-nut connections, if the clearance between the bottom of the leveling nuts and the top of the concrete foundation is less than or equal to one bolt diameter, bending stress in the anchor bolts can be disregarded (AASHTO LRFD Specifications for Structural Supports, sec. 5.16.3.1). Any distance greater than one bolt diameter may be cause for concern.

Figure 4-7: Standoff measurement for a sound foundation (left) and standoff measurement with foundation concrete deterioration (right)

Table 4-6: Cantilever or Truss Structure Anchor Bolt and Leveling Nut Element Distresses

Unit of Measure: Each, note quantity of anchor bolt and nut units within each condition state

Element Number	Element	Description	Associated Distresses
14102	Anchor Bolt and Leveling Nut	Anchor Bolts and Leveling Nuts	Corrosion or coating damage
			Loose or missing anchor nut
			Cracked bolt

Standoff distance

Impact damage

Details on the condition state rating schema are in Section 4.7, linked below:

Cantilever Structure and Truss Structure Condition State Tables

Examples of common distresses associated with anchor bolts and leveling nuts are shown in Figure 4-8 *through 4-10.*

Figure 4-8: Cantilever or truss structure anchor bolts and leveling nuts, corrosion in anchor bolt below upright base with section loss

Figure 4-9: Cantilever or truss structure anchor bolts and leveling nuts, anchor nut without fully engaged threads

Figure 4-10: Leveling nut and anchor bolt corrosion with section loss

4.4.2 VERTICAL STRUCTURE ROUTINE INSPECTION

The uprights support the horizontal elements that directly support the signs, lights, or other attachments. The routine inspection assesses the vertical structure's ability to safely support the horizontal structure and transfer all loads to the foundation. The routine inspection is performed on a regularly scheduled basis, with frequency determined by AS

type, and includes the vertical structure component rating as determined by the baseplate, vertical support column (upright), and vertical structure connections element condition ratings. It consists of observations and measurements needed to determine the physical and functional condition of the vertical structure and connections, to identify any changes from initial or previously recorded conditions, and to ensure that the vertical structure and connections continue to satisfy present service requirements. All elements of the component shall be visually inspected at an arm's length distance to determine the overall condition and detect deficiencies.

A sample vertical structure routine inspection would consist of:

- Inspect the base plate and welds for cracks, deficiencies, and corrosion. Note and measure any warping or deformations of the base plate.
- Inspect the vertical alignment of the structure with a 4 ft level or similar. Note that some structures may be tapered and checking at several points around the perimeter at the same elevation may be necessary to obtain the complete picture of any misalignment.
- Inspect the protective coating – galvanizing and/or paint and note any corrosion or section loss of the steel. An ultrasonic testing device or thickness gauge should be used to verify the wall thickness when significant corrosion is present.
- Check the inventory label affixed to the pole facing approaching traffic for legibility. Install a new inventory number label if no label exists or the label is in poor condition (replaces painted inventory number).
- Check for any cracks or deformations in the steel noting the size of deficiencies.
- Check for signs of vehicle impact damage noting that impact in one location may affect the structure in other locations as well.
- Inspect the connection to the pole of the horizontal structure – arm or truss members.
- Check for connections that are loose, missing, deteriorated or otherwise deficient.
- Pay particular attention to the arm connections to the vertical: Inspect the tightness of bolts and look for gaps. Check welds in the connections for any cracks or deficiencies. Check for any signs of slippage in the connections which may be evidenced by damage to the protective coating.
- Measure and record the distance the vertical support upright leans in relation to the roadway. This must be measured using a 4-foot level and recorded as inches per 4 feet and direction related to the roadway (i.e. upright leans ¼" in 4 feet away from traffic, towards traffic, with traffic, or against traffic).
- Provide photographs for all Poor or Severe condition state defects and submit the applicable Work Recs or RFAs.

4.4.2.1 Cantilever Structure and Truss Vertical Structure Component Rating

The component rating for the vertical structure depends on the condition of the baseplate, vertical upright(s), and the connection(s) to the horizontal structures. Assessing these factors with respect to the overall ability of the vertical structure to safely support the

horizontal structure and transfer loads to the foundation provides the appropriate component rating.

Table 4-7: Component Rating Guidelines for Cantilever Structure and Truss Structure

Component Rating	Condition	Material	Description
9	NEW	All	No deficiencies in any of the structural components that will affect long term performance.
8	VERY GOOD	All	All structural components are sound and functioning as designed. There may be superficial cracking or weathering of protective components and/or dirt contamination of structural components.
7	GOOD	Concrete	Insignificant cracks or moderate cracks that are sealed.
		Soil	Insignificant displacement or erosion of soil.
		Steel	Protective coating failure in very small and scattered locations.
		All	All components retain full section properties and function as designed.
6	SATISFACTORY	Concrete	Unsealed moderate-width or map cracks. Minor delamination or spalling.
		Soil	Minor displacement or erosion of soil.
		Steel	Protective coating failures is limited to less than 10% of the surface area with no loss of section.
		All	Minor deterioration affecting structural components. Minor misalignment.
5	FAIR	Concrete	Moderate delamination or spalling.
		Soil	Moderate displacement or erosion of soil. Minor gaps may be present between pole and embedment material.
		Steel	Minor loss of section. Loose fasteners may be present, but the connection is in place and functioning as intended.
		All	Moderate deterioration affecting structural components, including minor settlement or impact damage. Moderate misalignment. All members continue to function as designed.
4	POOR	Concrete	Considerable cracking and spalling.
		Soil	Considerable displacement or erosion of soil.

Component Rating	Condition	Material	Description
3	SERIOUS	Steel	Protective coating failure and less than 25% loss of section. Cracks may be present. Fasteners may be loose, missing, or considerably deteriorated. Considerable impact damage.
		All	Considerable deterioration or misalignment affecting structural members. Structural review may be warranted.
		Concrete	Extensive cracking and spalling.
		Soil	Extensive displacement or erosion of soil. Large gaps may be present between pole and embedment material.
		Steel	Measurable loss of section in excess of 25%. Missing or broken fasteners or extensive cracking in pole.
		All	Considerable deterioration or damage affecting structural members. Structural evaluation, is necessary to determine if the structure can continue to function without repairs.
2	CRITICAL	All	Deterioration has progressed to the point where the structure will not support design loads and emergency repairs, or removal is required.
1	IMMINENT FAILURE	All	Road is closed to traffic due to imminent failure, but corrective action may put it back in service.
0	FAILED	All	Road is closed due to condition. Notify Region and the Bureau of Bridges and Structures.

4.4.2.2 Base Plate Element Condition States

Visually inspect for any damage to the base plate welds and gusset plates, such as gouges, distortion, impact damage, or warping. Note galvanizing damage and the degree of corrosion present. Areas of galvanizing that appear to have been repaired are monitored closely throughout the lifespan of the structure. If that area was not thoroughly cleaned prior to repair, corrosion might not show through the repair immediately but could appear in later years.

Perform a visual inspection of the gusset welds and base weld looking for cracks or other weld defects. Document questionable fillet or groove weld discontinuities. The base weld is a full-penetration weld and any crack identified in the toe or throat of the weld is considered as severe, and the appropriate procedure such as an RFA or Work Rec initiated.

Table 4-8: Cantilever Structure and Truss Structure Base Plate Element Distresses

Element No.	Element	Description	Associated Distresses
14201	Base Plate		Weld defect or crack

	Base Plate for Cantilever or Truss Structure	Base plate warping

Details on the condition state rating schema are in Section 4.7, linked below:

Cantilever Structure and Truss Structure Condition State Tables

Figure 4-11: Cantilever or truss structure base plate and vertical support, rust underneath galvanizing repair

4.4.2.3 Vertical Support Column (Upright) Element Condition States

Verify that the structure number label on the front of the upright (facing traffic) and is still legible. If no label is present, create and install inventory number label on the vertical support (upright). Note any galvanizing damage on the upright and the degree, if any, of corrosion on the base metal. A mechanical lift such as bucket truck, or climbing or other means of working at heights, such as Unmanned Aerial Systems (UAS), are utilized for inspection as needed to inspect the tops of vertical supports. If any type of impact damage is present (gouges, dents) clean the area and visually inspect for any cracks. An in-depth inspection may be needed to explore suspect visual indications by performing a magnetic particle inspection, liquid penetrant test or other appropriate non-destructive examination methods. Additional measures may be needed if the corrosion protection included painting over galvanizing. If nothing of note was found, spray “cold galvanizing” compound or zinc rich paint, after properly cleaning or preparing the surface, on any area where galvanizing was removed. For cantilevers, using a 4-ft level, check the plumbness of the upright in every direction and note any lean in the structure (e.g., “1/4 in 4ft away from traffic, towards traffic, with or against traffic).

Table 4-9: Cantilever Structure and Truss Structure Vertical Supports (Upright) Element Distresses

Unit of Measure: Length, inch of vertical support within each condition state

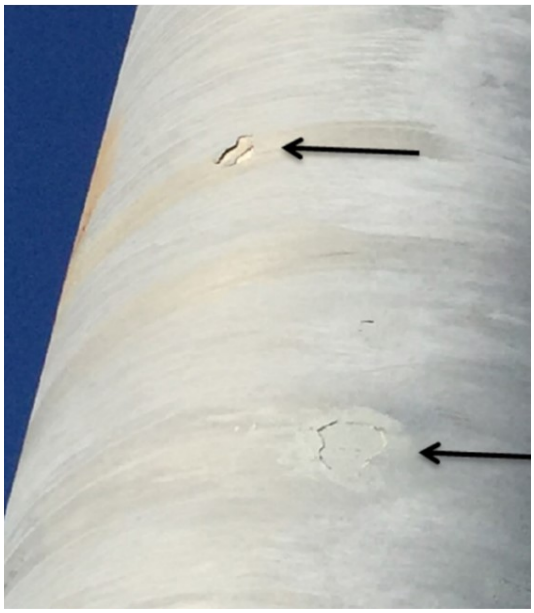
Element Number	Element	Description	Associated Distresses
14202	Vertical Support Column (Upright)	Vertical Support (Upright) for cantilever and truss structures	Corrosion or coating damage
			Weld defect or crack
			Impact damage
			Out of plumb

Missing handhole cover or post cap

Details on the condition state rating schema are in Section 4.7, linked below:

Cantilever Structure and Truss Structure Condition State Tables

Figure 4-12: Cantilever or truss structure vertical supports, galvanizing damage



4.4.2.4 Vertical Structure Connections Element Condition States

Most connections are either bolted or welded. Typical issues include loose bolts and nuts, weld discontinuities, galvanizing damage, flange connection gaps, missing washers, and missing end caps. Bucket truck is used as needed to inspect the connections of vertical supports. Check the bolts with a wrench. Note any gaps between steel in the bolted connections, cracked welds, and cracks at the ends of gusset plates. Record any bolting components that are missing, deteriorated, or damaged. Record any signs of corrosion.

Truss chord or bracing connections between the vertical and horizontal components are applicable to box and tri-chord truss structures and tri-chord cantilevers.

Cantilever arm connections utilizing bolted flange connections are used between the vertical and horizontal components on Type C, D, and E cantilevers. The flange and gusset plates welded to the vertical structure during fabrication, along with the bolting assemblies, are considered part of the element. Lock washers may or may not be present as part of the high strength bolting assemblies; the standards recently changed to omit lock washers at the upright to arm connections.

Typical issues include loose bolts and nuts, weld discontinuities, galvanizing damage, flange connection gaps, missing washers, and missing end caps. Bucket trucks are required for inspecting the connections of vertical supports.

Table 4-10: Cantilever Structure and Truss Structure Vertical Structure Connection Element Distresses

Unit of Measure: Each connection quantity within the condition state

Element Number	Element	Description	Associated Distresses
14203	Vertical Structure Connection	Box Truss Upright Bracing Connections; Type C or D for Truss Sign structures; Chord Connections for Type C, D, and E Truss Sign structures; or Cantilever Chord Connections for Type J Cantilever Sign Structures, Cantilever Arm connections for Type C, D, and E Cantilever Sign Structures	Weld defects and Cracking Corrosion or coating damage Loose, missing, or failing hardware; gap at connection Impact damage

Details on the condition state rating schema are in Section 4.7, linked below:

Cantilever Structure and Truss Structure Condition State Tables

Connection types are described below. The bolted and welded connection inspection guidance below applies to both truss connections and cantilever connections, as applicable.

Bolted Connections

Visually inspect the cantilever arm connection to the vertical support. Identify any missing flat washers. Look for fully compressed lock washers, when present, and note any that are not. Check for misalignment of the bolts. Identify and measure any gaps between the nut or the head of the bolt and the washer. Note any gaps between the bolted flanges, loose, or missing hardware, missing caps, and cracks at the ends of gusset plates. Using a 16- to 24-oz hammer, hit the nuts on the flat portion, in multiple directions if possible, listening for a dull sound or a sharp ringing sound. A dull sound may indicate that the nuts are not properly tightened or that the bolt is cracked or broken. While sounding, look for any shift of the bolt within the bolt hole or movement of the nut. Note any signs of corrosion.

Figure 4-13: Vertical structure connection, missing flat washer on head side of bolt

Figure 4-14: Vertical structure connection, loose bolt/lock washer not fully compressed

Welded Connections

Visually inspect the welds through the galvanizing for any indication of weld defects. In many cases, the galvanizing will be too thick to accurately see the surface of the weld. In this case, there may be indications in the galvanizing itself that are a sign of weld discontinuities or cracks, such as areas along the toe of the weld where the galvanizing did not bond properly to the base metal, which can give the impression of a crack. If rust is bleeding through the galvanizing, chip off the galvanizing (the ball peen side of a hammer works well) for a better visual inspection of the weld. If the weld looks acceptable, use “cold galvanizing” compound or zinc-rich paint to repair the area where the galvanizing was removed. If a visual indication in the weld has appeared, note the area and type of indication.

Figure 4-15: Vertical structure connection, rust bleeding through galvanizing at welded gusset plate arm to vertical structure upright

4.4.3 HORIZONTAL STRUCTURE ROUTINE INSPECTION

The horizontal elements directly support the signs, lights, or other attachments. The routine inspection assesses the horizontal structure’s ability to safely support the all the

attachments and transfer loads to the vertical support structures. The routine inspection is performed on a regularly scheduled basis, with frequency determined by AS type, and includes the horizontal structure component rating as determined by the element condition ratings. It consists of observations and measurements needed to determine the physical and functional condition of the horizontal structure, to identify any changes from initial or previously recorded conditions, and to ensure that the horizontal structure continues to satisfy present service requirements. All elements of the component shall be visually inspected at an arm's length distance to determine the overall condition and detect deficiencies. A mechanical lift such as bucket truck, climbing or other means of working at heights (i.e., UAS) are utilized for inspection as needed to inspect the horizontal structures.

A sample horizontal structure routine inspection would consist of:

- Inspect the vertical clearance of the horizontal structure, the alignment, and the operational function.
- Check for corrosion or section loss on the arms or any other portions of the horizontal structure.
- Inspect arms for any cracked welds, or other deterioration.
- Check attachments to the horizontal structure for connections that are loose, missing, deteriorated or otherwise deficient.
- Provide photographs for all Poor or Severe condition state defects and submit the applicable Work Recs or RFAs.

4.4.3.1 Horizontal Structure Component Rating

The component rating for the horizontal structure depends on the condition of the horizontal members, their internal connections, the attachments, and connections to the attachments. Assess these factors with respect to the overall ability of the horizontal structure to safely support the attachments and transfer loads to the rest of the structure to provide the appropriate component rating.

Table 4-11: Component Rating Guidelines for Horizontal Structure

Component Rating	Condition	Material	Description
9	**NEW**	All	No deficiencies in any of the structural components that will affect long term performance.
8	**VERY GOOD**	All	All structural components are sound and functioning as designed. There may be superficial cracking or weathering of protective components and/or dirt contamination of structural components.
7	**GOOD**	Concrete	Insignificant cracks or moderate cracks that are sealed.
		Steel	Protective coating failure in very small and scattered locations.
		All	All components retain full section properties and function as designed.

Component Rating	Condition	Material	Description
6	SATISFACTORY	Concrete	Unsealed moderate-width or map cracks. Minor delamination or spalling.
		Steel	Pole protective coating failures is limited to less than 10% of the surface area with no loss of section. Surface corrosion with no section loss of span wire or attachment connections.
		All	Minor deterioration affecting structural components.
5	FAIR	Concrete	Moderate delamination or spalling.
		Steel	Minor loss of section. Loose fasteners may be present, but the connection is in place and functioning as intended.
		All	Moderate deterioration affecting structural components including minor settlement, or impact damage. Moderate misalignment. All members continue to function as designed.
4	POOR	Concrete	Considerable cracking and spalling.
		Steel	Up to 25% loss of section. Mast arm may be misaligned, or attachments may have less than 17 ft of vertical clearance. Fasteners may be considerably deteriorated.
		All	Considerable deterioration affecting structural members. Structural review may be warranted.
3	SERIOUS	Concrete	Extensive cracking and spalling.
		Steel	Section loss in excess of 25%. Missing or broken fasteners or excess displacement of mast arm.
		All	Considerable deterioration or damage affecting structural members. Structural evaluation, is necessary to determine if the structure can continue to function without immediate repairs.
2	CRITICAL	All	Deterioration has progressed to the point where the structure will not support design loads and emergency repairs, or removal is required.
1	IMMINENT FAILURE	All	Road is closed to traffic due to imminent failure, but corrective action may put it back in service.
0	FAILED	All	Road is closed due condition. Notify Region and the Bureau of Bridges and Structures.

4.4.3.2 Arm or Truss Members Element Condition States

Truss and Cantilever Structure horizontal members directly support the signage. Horizontal members are comprised of box trusses on Type C and D Trusses, Tri-Chord trusses on Type E Trusses and Type J Cantilevers, and two horizontal tubular members on Type C, D, and E Cantilevers. The flange and gusset plates welded to the tubular members during fabrication are considered part of the element.

Visually inspect all the truss chords or arm members for corrosion and impact damage. Note any galvanizing damage and the degree, if any, of corrosion on the base metal. If any type of impact damage is present (gouges, dents), clean the area and visually inspect for any type of deficiency. If nothing of note was found, spray “cold galvanizing” compound or zinc-rich paint on any area where galvanizing was removed. Bucket trucks are required for inspecting the arms or truss members.

Table 4-12: Cantilever Structure and Truss Structure Arm or Truss Member Element Distresses

Element Number	Element	Description	Associated Distresses
14301	Arm or Truss Members	Truss Chord Members for Type C, D, and E Truss and Type J Cantilevers and Arms for Type C, D, and E Cantilevers	Cracking Corrosion or coating damage Impact damage
Unit of Measure: Length, feet along member which apply to each condition state			

Details on the condition state rating schema are in Section 4.7, linked below:

Cantilever Structure and Truss Structure Condition State Tables

4.4.3.3 Horizontal Structure Connections Element Condition States

Box truss chord splice connections (Type C and D trusses) and Tri-chord splice connections (Type E trusses and Type J cantilevers) stabilize and secure the truss sections to each other longitudinally. Truss bracing connections stabilize and secure the truss chord sections to each other transversely. They can be found in truss structures and in Type J cantilevers. Cantilever arm horizontal members directly support the signage on Type C, D, and E cantilevers. Bucket trucks are required for inspecting horizontal structure connections.

Box truss chord splice connection bolts should have been fully tensioned at installation. Record any hardware that is missing, damaged, or not in its proper location. Record any signs of corrosion.

Tri-chord splice connection bolts require a flat washer and lock washer on the nut end. Visually inspect the splice connection. Note any lock washers that are not fully compressed. Record any hardware that is missing, damaged, or not in its proper location. Record any signs of corrosion.

Visually inspect the truss bracing connections (horizontal, vertical, and diagonal). Truss bracing connection bolts require a flat washer on the nut end. Record any hardware that is loose, missing, damaged, or not in its proper location. Record any signs of corrosion.

Table 4-13: Cantilever Structure and Truss Structure Horizontal Structure Connections Element Distresses

Element Number	Element	Description	Associated Distresses
14302			Cracking

Horizontal Structure Connections	Box Truss Chord Splice Connection for Type C, and D Truss Sign structures, Tri-Chord Splice connection for Type E truss sign structures, Truss bracing connection for Type E Truss sign structures, and cantilever Truss splice connection for Type J cantilever Sign structures, Truss bracing connection for Type J cantilever sign structures, Cantilever arm members for type C, D, and E Cantilever sign structures	Corrosion or coating damage Loose, missing, or failing hardware; gap at connection Impact damage

Unit of Measure: Each connection quantity within the condition state

Details on the condition state rating schema are in Section 4.7, linked below:

Cantilever Structure and Truss Structure Condition State Tables

4.4.3.4 Sign and Sign Connections Element Condition States

Sign connections stabilize and secure signs to the structure. The purpose of inspection of the sign connections is to ensure the signs are secured in place and do not fall onto the roadway. Four different types of sign connections inspected on cantilevers and truss structures are present: sign panel connections, angle bracing, I-Beam connections to the sign panels, and U-bolt connections of the I-beams to the horizontal chords of the cantilever or truss structure.

Typical issues include sign deterioration or failure, impact damage, corrosion or coating damage, missing elastomeric pads, and loose, missing, or failing hardware. Bucket trucks are required for inspecting the signs and sign connections.

Inspect the general appearance of the sign panel and record any deterioration such as fading of paint, loss of reflectivity, or physical damage due to vehicular impact. Vehicular impact may also affect the connections of the sign to the horizontal structure. Document any corrosion or coating damage of any of the sign or hardware elements. Elastomeric or rubber pads are used between dissimilar metals, usually steel and aluminum, to prevent a corrosion cell from forming.

Verify that rubber pads separating dissimilar metals have been placed between the steel truss chords and the aluminum mounting supports and that the U-bolts project through the holes in the pads. For trusses with electronic sign panels, the mounting supports are steel, and rubber pads are placed between the steel mounting supports and the aluminum sign cabinet to prevent reactions between dissimilar metals. Record any deficiencies.

Inspect the sign bolts connecting the aluminum sign planks to each other. If there are gaps between the planks, note the gap and visually check the bolt to verify the nut is snug-tight. Inspect the sign panel mounting bolts connecting the aluminum I-beam to the sign planks. Visually check snug-tightness and note nuts that are not fully engaged. Visually check snug-tightness and note any loose bolts or nuts that are not fully engaged. Check for

gaps between the vertical I-beam mounting supports, the steel arm or truss chords, and the U-bolts. Details on the various connection types are noted below:

Sign Panel Connections

Horizontal bolted connections of sign panels/planks (extrusions) to fabricate the sign connect the individual planks or extrusions to each other. Connection holes exist on 12-inch center-to-center to connect panels. The bolts spacing for these bolts shall be 24 inches. These connections appear to be least critical from load-path and safety perspectives. There are redundant connections with the angle braces and to a lesser extent with the I-Beam connections to the extrusion panels.

Angle Bracing

Vertical angle braces found across the back of signs are connected to extrusion panels to provide stability and support to the sign. These braces can extend to top and bottom sign extensions such as “Exit XXX,” that are typically comprised of shorter panels. Angle braces installed to support only a main sign are part of the secondary load path of the sign installation. Isolated missing or loose bolt(s) should not be cause for major concern in this application. Loose or missing bolts on braces that support sign panel extensions and missing bolts that connect the extension panels to the main sign, could increase the risk that the sign extension could detach from the sign and fall on traffic.

I-beam Connections to the Sign Panels

I-Beams are fastened to the sign panels by four bolts at the top and bottom of the I-beam and alternating bolts on either side the length of the beam fastened to the extrusion panels. I-Beams are part of the critical load path, so several missing or loose bolt connections to the sign panels could impact the functionality of the cantilever or truss structure and public safety.

U-bolt Connection of the I-beams to the Horizontal Chords

Inspect the U-bolts connecting the sign I-beams to the horizontal members. The sign panel is attached to the horizontal chords through U-bolt pairs. These are the most critical connection on a sign installation as they involve the primary load path to attach the sign to the sign structure. Inspectors should consider if the sign panel vibrates or separates from the chord connection when traffic passes below or in windy conditions.

Table 4-14: Cantilever Structure and Truss Structure Sign and Sign Connection Element Distresses

Element Number	Element	Description	Associated Distresses
14303	Sign and Sign Connections	Sign and Sign Connections for all cantilever and truss structure types	Corrosion or coating damage
			Loose, missing, or failing hardware
			Sign collapse or separation

Deterioration of legibility or reflectivity
Missing elastomeric pads between dissimilar metals
Impact Damage

Unit of Measure: Each, signs which can be rated at each condition state. If a cantilever or truss structure has two signs they shall be referred to as 'Left' and 'Right' when facing the front of the signs. If cantilever or truss structure has three signs they shall be referred to as 'Left,' 'Center,' and 'Right' when facing the front of the signs. If a cantilever or truss structure has four signs they shall be referred to as 'Left,' 'Left Center,' 'Right Center,' and 'Right' when facing the front of the signs and so forth.

Details on the condition state rating schema are in Section 4.7, linked below:

Cantilever Structure and Truss Structure Condition State Tables

4.4.4 REFERENCES

MDOT Traffic and Safety Sign Standards

MDOT Truss Installation Inspection Procedure, describing UT and Sounding Testing

MDOT Truss, Type E Installation Inspection Procedure

MDOT Cantilever Installation Inspection Procedure, describing UT Testing

MDOT Cantilever-Type-E Installation Inspection Procedure

MDOT Traffic Signing Details

SIGN-300-C Type E Cantilever

SIGN-330-B Type E Spread Cantilever Foundation

SIGN-340-B Type E Cantilever Drilled Shaft Foundation

SIGN-350-B Type J Cantilever Drilled Shaft Foundation

SIGN-370-B Type J Cantilever 20'-40'

SIGN-375-A Type J Cantilever Spread Footing Foundation Details

SIGN-360-B Type E Truss 50'-140'

SIGN-365-A Type E Truss Spread Footing Foundation Details

SIGN-380-A Bridge Support Bracket for Steel Truss, Type E and Steel Cantilever Truss, Type J

SIGN-500-B Steel Truss Type D 105'-125' (Special Details for Maintenance Use Only)

SIGN-520-B Type C Truss 75'-100' (Special Details for Maintenance Use Only)

SIGN-540-B Type C Truss 50'-70' (Special Details for Maintenance Use Only)

SIGN-600-B Truss Foundation Type C (Special Details for Maintenance Use Only)

SIGN-610-B Truss Foundation Type D (Special Details for Maintenance Use Only)

SIGN-700-E Truss, Cantilever, Column and Exit Number Connections

AASHTO LRFD Specifications for Structural Supports for Highway Signs, Luminaires, and Traffic Signals, 2015 (AASHTO Signs)

4.5 Work Recommendation Guidance

Cantilever Structure and Truss Structure work recommendations are recorded to initiate preventive maintenance actions. These Work Recs are presented on the Ancillary Structures (AS) Inspection Report Form. Loose bolts are frequently the cause of work recommendations. Loose or missing extrusion panel connecting bolts are considered work recommendations. Typically, isolated or limited loose or missing bolts would qualify as a Work Rec but could increase to an RFA if bolt conditions worsened with time.

Additional guidance for creating Work Recs pertaining to sign connection defects is provided below for specific connection types. Sign plumb/out of plumb and whether loose bolts are equally loose should be noted on a Work Rec. Note dimensions if possible. Photographs should include the entire rear of the sign with loose, missing, or broken bolts marked on the photo. Close-up photos of each loose connection to support the full view of the sign connections with connection deficiencies marked on the photo should be provided.

Sign Panel Connections

Loose or missing extrusion panel connecting bolts should typically be considered a Work Rec.

Angle Bracing

Isolated or limited loose or missing bolts would qualify as Work Recs, if not jeopardizing the safe performance of the sign.

I-beam Connections to the Sign Panels

Connections between the I-Beam(s) and sign panels is critical to the safe performance of the sign. If several bolts are loose or missing, causing the sign panels to vibrate against the I-Beam, these defects would not be considered Work Recs and would instead require an RFA.

For U-bolt Connections of the I-beams to the Horizontal Chords

Isolated loose bolts would typically be a Work Rec. If multiple U-bolts need tightening or replacement, and the sign panel is not firmly secured to the chord, these deficiencies would not be considered Work Recs and would instead require an RFA. Inspectors should consider if the sign vibrates or separates from the chord connection when traffic passes below or in windy conditions.

Other

Work Recs are identified, but not limited to, actions such as repairs to guardrail, web member angle supports, vertical supports, splice connection bolts, or truss chords. Repairs to galvanizing are also a work recommendation. Work Recs may also consist of correcting the erosion at the foundation to prevent undermining or to otherwise repair or monitor the foundation. A work recommendation may be to tighten items such as U-bolts, splice

connection bolts for tri-chords, leveling nuts, or sign panel bolts. Installation of elastomeric pads may be a work recommendation. Removal of graffiti or removal of non-MDOT attachments to structures may be recommended. Work Recs can also consist of recommendations to replace various types of bolts, end caps, clamps, connections, spacers, sign panels, or connection assemblies. Weld repairs may be a Work Rec. Repair or replacement of the ID stencil on the upright is a Work Rec.

Table 4-15: Cantilever and Truss Structure Work Recommendations

No.	Description of Work Recommendation	Material Involved	Quantity/ Unit of Measure
1	Repair Guardrail (protecting foundation and pole)	Galvanized Steel	Lineal Foot
2	Correct erosion at foundation (prevent undermining)	Stone/Soil	Cubic Foot
3	Install/replace U-bolt	U-Bolt Assembly	Each
4	Repair web member angle supports	Angle Support	Each
5	Repair vertical sign support	Galvanized Steel	Lineal Foot
6	Repair galvanizing	Galvanic Paint	Square Inch
7	Replace splice connection bolt	Bolt	Each
8	Tighten splice connection bolt (tri-chords only)	Bolt	Each
9	Repair truss chord	Galvanized Steel	Lineal Foot
10	Replace end cap	End Cap	Each
11	Replace end cap bolt	Galvanized Steel Bolt	Each
12	Replace sign mount connection bolt	Galvanized Steel Bolt	Each
13	Tighten leveling nut	Galvanized Steel Bolt	Each
14	Address loose bolts	Galvanized Steel Bolt	Each
15	Weld repair	Steel	Each Weld
16	Replace arm/chord to upright bolted connection bolts	Galvanized Steel Bolt	Each
17	Replace bolted connection bolts for internal truss connections (vertical or horizontal)	Galvanized Steel Bolt	Each
18	Replace sign panel bolts	Galvanized Steel Bolt	Each
19	Tighten sign panel bolts	Galvanized Steel Bolt	Each

No.	Description of Work Recommendation	Material Involved	Quantity/ Unit of Measure
20	Replace/repair sign panels	Aluminum Sign	Each
21	Remove graffiti from steel structural element	N/A	Square Foot
22	Remove graffiti from sign face	N/A	Square Foot
23	Remove non-MDOT attachments to structures	Attachment	Each
24	Repair/replace ID stencil on upright	Paint	Each Stencil
25	Replace sign connection assembly	Galvanized Steel Assembly	Each
26	Replace sign connection clamp	Galvanized Steel Clamp	Each
27	Replace sign panel connector	Galvanized Steel	Each
28	Secure U-bolt spacer	Galvanized Steel	Each
29	Install elastomeric pad	Elastomeric Pad	Each
30	Tighten U-bolt	Galvanized Steel	Each
31	Repair/monitor foundation	Concrete	Cubic Foot
99	Other		

4.6 Request for Action Guidance

The RFA Process provides guidance on the processes to identify and report "Critical deterioration/damage to ancillary structure identified during a routine inspection or site visit, which is a concern to public safety." Follow the guidelines noted in Section 1.8.

Additional guidance for creating an RFA pertaining to sign connections defects is provided below for specific connection types. Sign plumb/out of plumb and whether loose bolts are equally loose should be noted for an RFA. Note dimensions if possible. Photographs should include the entire rear of the sign with loose, missing, or broken bolts marked on the photo. Close-up photos of each loose connection to support the full view of the sign connections with connection deficiencies marked on the photo should be provided.

Sign Panel Connections

Loose or missing extrusion panel connecting bolts should typically be considered a Work Rec and not an RFA.

Angle Bracing

Isolated or a limited number of loose or missing bolts will not jeopardize the safe performance of the sign, but the risk would increase as the number of loose or missing bolts increases. Isolated or limited loose or missing bolts would qualify as a Work Rec but

could increase to an RFA if bolt conditions worsened with time, particularly if the braces were the primary support for the sign extensions.

I-beam connections to the sign panels

Connections between the I-Beam(s) and sign panels is critical to the safe performance of the sign and could be considered an RFA if several bolts were loose or missing, causing the sign panels to vibrate against the I-Beam.

For U-bolt connections of the I-beams to the horizontal chords

Loose, missing, or broken U-bolts may require an RFA if multiple U-bolts need tightening or replacement, and the sign is not firmly secured to the chord. Inspectors should consider if the sign vibrates or separates from the chord connection when traffic passes below or in windy conditions. Isolated loose bolts would typically be a Work Rec.

Examples of applicable priority level items include, but are not limited to:

Priority 1 Level Items

a. Major foundation deterioration including concrete cracking/spalling/delamination, thread damage, steel reinforcement corrosion, anchor bolt corrosion, ultrasonic test failure, failure of anchor bolts, and significant section loss of steel reinforcement or anchor bolts

b. Major soil erosion or undermining of the foundation element(s) evidenced by structure displacement or out of plumbness

c. Major corrosion, section loss or failure of high strength bolts where load-path redundancy is minimal

d. Major base plate distortion or section loss around anchor bolts

e. Standoff distance in excess of twice the bolt diameter where bending of anchor bolts is evident

f. Major cracking present in the base metal or weld(s) on the base plate to column connection or for single column supports or the column to cantilever to arm connection

g. Cracking in single column supports at gusset plate welds where the cracking is major, or when minor cracking at gusset plate welds is present at two or more gusset plates in a connection

h. Major section loss due to corrosion of a main element which impacts the capacity or short-term resiliency of the element or structure

i. Presence of major cracks or active corrosion on main members (base metal) or connections (bolted or welded) where presence of new or recent cracking shows non-corroded, minimally corroded, or progressively corroded cracked steel surfaces is observed as opposed to a heavily corroded cracked surfaces which have been present for some time

j. Multiple loose or missing bolts in a high strength bolted connection, anchor bolt connection, or sign connection

k. Multiple U-bolts are loose, broken, or missing and the sign is not firmly secured to the chords resulting in major sign vibration/separation

l. Multiple bolts connecting the sign to the I-beams are loose, broken, or missing and the sign is not firmly secured to the I-beams resulting in major sign vibration/separation

m. Multiple loose or missing bolts where connections do not have load-path redundancy and bolt tensioning is not possible

n. Major structural damage to foundation, anchor bolts, upright, or other elements, which impacts capacity or function, clearance, safety, or short-term resiliency of the structure

Priority 2 Level Items

a. Significant foundation deterioration including concrete cracking/spalling/delamination, steel reinforcement corrosion and section loss

b. Significant erosion or undermining of the foundation element(s)

c. Significant base plate distortion or significant section loss, especially around anchor bolts

d. Anchor bolt standoff distance more than twice the anchor bolt diameter with no bending of the anchor bolts

e. Significant corrosion of primary elements or connections is present

f. Anchor nuts are engaged with some gaps and/or bolts are misaligned

g. Missing or loose nuts or other elements of a bolted connection where there is acceptable load-path redundancy, but moderate impact to capacity or durability

h. Significant weld deficiencies that have not initiated cracking but do not meet current code or will lead to Priority Level 1, but acceptable redundancy and/or resiliency is present

i. Significant damage or corrosion of the column support elements are present

j. Column supports are out of vertical alignment

k. Significant misalignment of elements at the column to chord connection where significant corrosion or damage is also present to one or more elements

l. Significant misalignment of elements at the chord splice connection where significant corrosion or damage is also present in one or more elements

m. Significant corrosion or impact damage is present in one or more elements of span truss members

n. Significant deterioration or impact damage to the sign frame is present where multiple panel points may not be engaged, and multiple loose/missing backing strip nuts significantly affect the strength or function of either the element or sign frame

o. Multiple U-bolts are loose, broken, or missing and the sign is firmly secured to the chords

p. Multiple bolts connecting the sign to the I-beams are loose, broken, or missing and the sign is firmly secured to the I-beams

q. Structural cracks in secondary members that could potentially propagate through welded connections into main members

r. Strengthening is required based upon an unsatisfactory load carrying capacity evaluation

s. Incident resulting in significant structural damage

Priority 3 Level Items

a. Localized moderate foundation deterioration including concrete cracking/spalling/delamination, or exposed steel reinforcement, but section loss is negligible
b. Moderate erosion around the foundation element(s)
c. Moderate corrosion of the anchor bolt connections or high strength bolted connections
d. Moderate corrosion of the base plate, which includes moderate section loss
e. Moderate weld deficiencies, which do not meet code but do not impact function where significant redundancy is also present
f. Missing nuts or other elements of a bolted connection where there is adequate redundancy and moderate impact to structural capacity or durability
g. Anchor bolt standoff distance in excess of one bolt diameter but less than two bolt diameters with no anchor bolt bending present
h. Missing elastomeric pads between dissimilar metals where moderate corrosion is present
i. Isolated U-bolts are loose, broken, or missing and the sign is firmly secured to the chords

4.7 Element Condition States

Element Number	Element	Condition States Defects Note	Link to Discussion in Section 4
14101	Concrete Foundation	Use the appropriate condition state table	Concrete Foundation Element Condition States
14102	Anchor Bolts and Leveling Nuts	Use the appropriate condition state table. Use UT testing result to assist in the condition assessment	Anchor Bolt and Leveling Nuts Foundation Element Condition States
14201	Base Plate	Use the appropriate condition state table	Base Plate Element Condition States
14202	Vertical Support Column	Use the appropriate condition state table	Vertical Support Column (Upright) Element Condition States
14203	Vertical Structure Connections	Use the appropriate condition state table	Vertical Structure Connections Element Condition States
14301	Arm or Truss Member	Use the appropriate condition state table	Arm or Truss Members Element Condition States
14302	Horizontal Structure Connection	Use the appropriate condition state table	Horizontal Structure Connections Element Condition States
14303	Sign and Sign Connections	Use the appropriate condition state table	Sign and Sign Connections Element Condition States

Element 14101 (Concrete Foundation)

Description	This element defines a concrete foundation, regardless of foundation type such as drilled shaft or reinforced concrete pile			
Quantity Calculation	The quantity for this element is measured as “each.”			
	Condition State Descriptions			
Defect Type	**Good**	**Fair**	**Poor**	**Severe**
Concrete Foundation Defects	The concrete shows no deterioration. Superficial cracking, discoloration, efflorescence may be present. Foundation is functioning as intended. No exposed reinforcing, and free from impact damage.	Minor cracks and spalls may be present in the concrete, no exposed reinforcing, and free from impact damage.	Moderate cracks and/or spalls may be present. Some reinforcing may be exposed. Incidental loss of section of reinforcing or evidence of impact damage may be present but does not affect the function. Surface pitting of reinforcing may be present.	Major corrosion of exposed reinforcing. Steel and/or concrete loss of section is present that has majorly affected the serviceability or integrity of the structure. Major spalling, cracking, embedment erosion or impact damage may be present.

Element 14102 (Anchor Bolts and Leveling Nuts)

Description	Anchor bolts and leveling nuts attaching the upright to the foundation.			
Quantity Calculation	The quantity for this element is each anchor bolt and nut unit.			
	Condition State Descriptions			
Defect Type	**Good**	**Fair**	**Poor**	**Severe**
Anchor Bolts and Leveling Nuts Defects	There is no deterioration. The elements are fully engaged and the sounding test produces a sharp ringing sound. No evidence of impact damage.	Minor corrosion of the elements may be present. The elements are fully engaged and functioning as intended. The sounding test produces a sharp ringing sound. Anchor bolt standoff distance is less than 1". No evidence of impact damage.	Moderate corrosion/ section loss of the elements may be present. Anchor nuts are not fully engaged. The sounding test produces a dull sound. One or two loose nuts may be observed, but do not significantly affect serviceability and/or function. Anchor bolt standoff distance is greater than 1" but less than two times the bolt diameter. No evidence of impact damage.	Severe corrosion/section loss of the elements may be present. Nuts are loose/missing. The sounding test produces a dull sound. Anchor bolt standoff distance is greater than two times the bolt diameter. UT testing indicates cracks or breaks in bolts. The element conditions have majorly affected the serviceability or integrity of the structure.

Element 14201 (Base Plate)

Description	Base plate which connects the upright element to the anchor bolt and leveling nut element.			
Quantity Calculation	The quantity for this element is each base plate.			
	Condition State Descriptions			
Defect Type	**Good**	**Fair**	**Poor**	**Severe**
Base Plate Defects	No evidence of active corrosion. Surface coating is sound and functioning as intended.	Minor surface corrosion may be present. Base element welds have no evidence of defects. Protective coating failure with no section loss. The elements function as intended.	Moderate corrosion/ pitting/section loss may be present. Protective coatings are failing. Base element welds have no evidence of defects and/or cracking. Base plate may exhibit minor warping. The conditions do not significantly affect serviceability and/or function.	Major corrosion/pitting/ section loss is present. Base element welds may have cracks/defects. Base plate has moderate to major warping. The element conditions have majorly affected the serviceability or integrity of the structure.

Element 14202 (Vertical Support Column (Upright))

Description	This element is defined by all uprights supporting cantilevers or truss structures, regardless of material type or protective coating.			
Quantity Calculation	The quantity is collected in length in feet of vertical support.			
	Condition State Descriptions			
Defect Type	**Good**	**Fair**	**Poor**	**Severe**
Vertical Support Column (Upright) Defects	No evidence of active corrosion. Surface coating is sound.	Minor corrosion or superficial damage of the elements may be present. No element weld defects, or cracking are evident. Protective coating failure with no section loss. The inside of the pole may contain minor moisture and debris.	Moderate corrosion/ section loss may be present. Protective coatings are failing. Element welds have no evidence of defects and/or cracking. Support may be moderately out of plumb.	Major corrosion/section loss is present. Protective coatings are significantly failing. Element welds may have cracks/defects. Support may be majorly out of plumb.
Impact Damage	No damage caused by vehicular impact.	The element has minor damage caused by vehicular impact.	The element has moderate damage caused by vehicular impact.	Impact damage is major and affects the integrity of the structure.
Handhole Defects	Handhole cover and attachment to pole is securely fastened. The inside of the pole is free of excess moisture, and debris.	Handhole cover is in place but loosely fastened or minimally damaged. Handhole attachment to pole may have minor deficiencies. The inside of the pole may contain minor moisture and debris.	Handhole cover is moderately damaged or missing fasteners. Handhole attachment to pole may have moderate deficiencies. Moisture and debris may be present inside the pole creating moderate corrosion and/or section loss of material.	Handhole cover is missing or majorly damaged. Handhole attachment to pole is failing. Moisture or debris inside the pole is creating major corrosion and/or section loss of material.

Element 14203 (Vertical Structure Connections)

Description	This element consists of the connections of the vertical structure for all cantilever or truss structures. Connections may include bolts or welds. Includes the connection of the upright element to the arm or truss member element.			
Quantity Calculation	The quantity to be collected includes each connection location.			
	Condition State Descriptions			
Defect Type	**Good**	**Fair**	**Poor**	**Severe**
Vertical Structure Connections Defects	New or like-new condition with no deficiencies.	Minor corrosion of the elements or cracking may be present. Superficial damage to the component parts. The connection is functioning as intended. Hardware is fully engaged.	Moderate corrosion and section loss, cracking or other or damage is present to one or more component parts. The connection is functioning as intended. Hardware is fully engaged. Gap may be present at bolted connection, but bolts are tight.	Multiple or major element defects or section loss that may significantly affect the serviceability or integrity of the structure. Propagating cracks. Connection is not functioning as intended. Major impact damage may be present. Hardware is loose or missing.

Element 14301 (Arm or Truss Members)

Description	This element defines all arms or trusses for cantilever and truss structures. It may include tension and compression members and includes all protective coating types.			
Quantity Calculation	The quantity is collected in length in feet of horizontal member.			
	Condition State Descriptions			
Defect Type	**Good**	**Fair**	**Poor**	**Severe**
Arm or Truss Members Defects	New or like-new condition with no deficiencies.	Minor corrosion of the elements may be present. Superficial damage to the component parts.	Moderate corrosion and section loss or damage is present to one or more component parts.	Multiple or major element defects or section loss that may significantly affect the serviceability or integrity of the structure. Chord has propagating cracks. Major impact damage.

Element 14302 (Horizontal Structure Connections)

Description	This element consists of the connections of the horizontal structure for all cantilever or truss structures. Connections may include splices or bracing			
Quantity Calculation	The quantity to be collected includes each connection location.			
	Condition State Descriptions			
Defect Type	**Good**	**Fair**	**Poor**	**Severe**
Horizontal Structure Connections Defects	New or like-new condition with no deficiencies	Minor corrosion of the elements may be present. Superficial damage to the component parts. The connection is functioning as intended. Hardware is fully engaged. No gaps are present.	Moderate corrosion and section loss or damage is present to one or more component parts. The connection is functioning as intended. Hardware is fully engaged. No gaps are present.	Multiple or major element defects or section loss that may significantly affect the serviceability or integrity of the structure. Propagating cracks. Connection is not functioning as intended. Gaps are present. Hardware is loose or missing. Major impact damage may be present.

Element 14303 (Sign and Sign Connections)

Description	This element consists of the sign and sign connections for all cantilever or truss structures			
Quantity Calculation	The quantity to be collected includes each connection location, which may contain one or more adhesively anchored connections, bracing, or bolts. It includes general structural condition of the sign.			
	Condition State Descriptions			
Defect Type	**Good**	**Fair**	**Poor**	**Severe**
Sign and Sign Connections Defects	New or like-new condition with no deficiencies.	Minor deficiencies, dulled paint or reflection, occasional loose connection hardware. Missing elastomeric pads between dissimilar metals.	Moderate deficiencies, deterioration/legibility or impact damage to panels or connecting parts and hardware. Multiple loose or improperly assembled connection hardware and/or corrosion is present.	Multiple or major element defects that may significantly affect the serviceability or integrity of the structure. Major impact damage, loose, missing or failing hardware, corrosion, collapse, or separation is present.