MICHIGAN ANCILLARY STRUCTURE INSPECTION MANUAL (MiASIM)

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MDOT
Michigan Department of Transportation

MIASIM UPDATE – DECEMBER 2024

Updates in this current version are listed and described below. E-mail ancillary structures related questions to mdot-ancillary@michigan.gov

December 2024 Updates

Preface	• Updated Federal and National Manuals for most recent versions/revisions.
Section 1.3.4 Inspection Records	• Added Power Meter Number in Inventory Data Fields sample list. • Added content clarifying asset location description for inspector description consistency. • Added table for cracking widths.
Section 1.4.2.1	• Omitted OSHA 10 hour safety training certification from list of inspector requirements. Added sentence to section that OSHA training is desirable but not required.
Section 1.4 Inspector Qualifications	• Added Action number for Subject Matter Experts and renumbered list in Table 1-4.
Section 2.2 Inventory Record Photographs	• Added two additional photograph names to Table 2-2.
Section 2.4 Routine Inspection	• Added table for cracking widths.
Section 2.4.4.1 Culvert Structure Component Rating	• Modified description of component rating 7 in Table 2-10.
Section 2.4.5 References	• Updated references for culvert inspection manual.
Section 2.5 Work Recommendation Guidance	• Modified material involved for work recommendation 1 and unit of measure for work recommendation 13 in Table 2-18.
Section 2.7 Element Condition States	• Modified 'Good' condition state description for Element 12301 • Modified 'Good' condition state description for Element 12302 • Modified 'Good' condition state description for Element 12404
Section 3.1.2 Elements	• Modified unit of measure in Table 3-1 for Vertical Support/Columns Element
Section 3.4 Routine Inspection	• Added photo to provide clarification for inspection limits for retaining walls. • Added table for cracking widths.

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Section 3.4.1.1 Wall Facing Element Condition States	• Modified unit of measure in Table 3-4. • Modified unit of measure in Table 3-5. • Modified unit of measure in Table 3-6. • Modified unit of measure in Table 3-7. • Modified unit of measure in Table 3-8. • Modified unit of measure in Table 3-9. • Modified unit of measure in Table 3-10. • Added table for cracking widths.
Section 3.4.1.3 Vertical Support Columns Element Condition States	• Modified unit of measure in Table 3-12.
Section 3.7 Element Condition States	• Modified quantity calculation for Element 13101. • Added crack widths for wide cracks in Poor condition state description for concrete cracking for Element 13101. • Added crack widths for wide cracks in Poor condition state description for concrete cracking of reinforced concrete stem (wall facing), MSE panel cracking/spalling, and concrete cracking for anchored (wall facing) for Element 13101. • Added crack widths for wide cracks in Poor condition state description for vertical support/column concrete defects for Element 13103. • Added crack widths for wide cracks in Poor condition state description for MSE reinforced concrete stub cracking for Element 13105.
Section 4.1.3 Components	• Modified unit of measure for arm or truss members in Figure 4-4.
Section 4.4 Routine Inspection	• Added table for cracking widths.
Section 4.4.2 Vertical Structure Routine Inspection	• Added bullet point to sample vertical structure routine inspection including how to measure and record vertical support upright leans (plumb).
Section 5.1 Definitions	• Modified definition of Appurtenance.
Section 5.1.1 Inventory Items	• Modified content. Added clarifying sentences on what embedded poles are appropriate to add to inventory items. • Added example photograph showing embedded poles that should be excluded from inventory. • Added photographs showing two span wires with luminaire.
Section 5.1.2 Elements	• Modified unit of measure for vertical structure element anchor wire in Table 5-1.
Section 5.2 Inventory Record Photographs	• Omitted Miscellaneous bracket and arm photograph naming lines in Table 5-2. • Modified naming convention for photograph name for vertical to horizontal connection.

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Section 5.4.1 Vertical Structure Routine Inspection	• Added bullet point in routine inspection list.
Section 5.4.1.3 Anchor Wire Element Condition States	• Modified unit of measure in Table 5-5.
Section 5.4.2.2 Span Wire Element Condition States	• Modified unit of measure in Table 5-8.
Section 5.4.3 References	• Added Pole Dent & Buckling Calculations.
Section 5.7 Element Condition States	• Added plumb specifications for Good condition state description for misalignment and plumbness for Element 15101. • Modified Good, Fair, Poor, and Severe condition state descriptions for timber checks/shakes for Element 15101. • Modified quantity calculation for Element 15102. • Modified quantity calculation for Element 15201. • Modified quantity calculation for Element 15202. • Modified Fair condition state description for Miscellaneous arm, bracket, and attachment for Element 15204.
Section 6.2 Inventory Record Photographs	• Added an additional photograph name in Table 6-2. • Modified naming convention for photograph name for vertical connection.
Section 6.4 Routine Inspection	• Added bullet point in routine inspection list. • Added table for cracking widths.
Section 6.4.2 References	• Added Pole Dent & Buckling calculations.
Section 6.7 Element Condition States	• Modified quantity calculation for Element 16101.
Section 7.1.2 Elements	• Removed truss or cantilever for vertical structure locations bullet point. • Modified unit of measure for horizontal structure for span wire element in Table 7-1.
Section 7.2 Inventory Record Photographs	• Omitted Miscellaneous bracket and arm photograph naming lines in Table 7-2. • Modified naming convention for photograph name for vertical to horizontal connection.
Section 7.4 Routine Inspection	• Added table for cracking widths.

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Section 7.4.1.3 Anchor Bolts and Leveling Nut Element Condition States	• Modified section including two types of anchor bolts used with steel strain poles – pretensioned and non-pretensioned.
Section 7.4.2 Vertical Structure Routine Inspection	• Added bullet point in routine inspection list.
Section 7.4.3.2 Span Wire Element Condition States	• Modified unit of measure in Table 7-11.
Section 7.4.3.5 Miscellaneous Arm, Bracket, and Attachment Element Condition States	• Updated table caption in Table 7-14.
Section 7.4.4 References	• Added Pole Dent & Buckling calculations.
Section 7.7 Element Condition States	• Modified quantity calculation for Element 17301.
Section 8.4 Routine Inspection	• Added table for cracking widths.
Section 8.4.1.2 Vertical Support Column Element Condition States	• Modified unit of measure in Table 8-10.
Section 8.7 Element Condition States	• Added crack widths for wide cracks in Poor condition state description for concrete cracking for Element 18101. • Added crack widths for wide cracks in Poor condition state description for vertical support/column concrete defects for Element 18102. • Added crack widths for wide cracks in Poor condition state description for horizontal member concrete defects for Element 18103.
Section 9.2 Inventory Record Photographs	• Omitted Miscellaneous bracket and arm photograph naming lines in Table 9-2.
Section 9.4 Routine Inspection	• Added table for cracking widths.
Section 10.1.3 Components	• Modified unit of measure for arm or truss members in Figure 10-2.
Section 10.4 Routine Inspection	• Added table for cracking widths.
Section 11.4 Routine Inspection	• Added table for cracking widths.

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Section 11.4.2.2 Frangible Base Connections Element Condition States	• Modified content regarding purpose of inspection.
Section 11.6 Request for Action Guidance	• Added Priority Level 1 Item (Item e.) and re-lettered list. • Added Priority Level 2 Item (Item i.) and re-lettered list.
Section 11.7 Element Condition States	• Modified Good, Fair, Poor, and Severe condition state descriptions for frangible base connections defects for Element 21201.
Section 12.4 Routine Inspection	• Added table for cracking widths.
Section 12.7 Element Condition States	• Modified Fair, Poor, and Severe condition state descriptions for base plate defects for Element 22201. • Modified Fair, Poor, and Severe condition state descriptions for pole splice connection defects for Element 22203.
Section 13.4 Routine Inspection	• Added table for cracking widths.
Section 13.4.3 References	• Updated web address for Michigan tower safety standard.
Section 14.4 Routine Inspection	• Added table for cracking widths.
Section 14.4.3 References	• Updated ANSI/TIA Reference.

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ENGINEERING MANUAL PREAMBLE

This manual provides guidance to administrative, engineering, and technical staff. Engineering practice requires that professionals use a combination of technical skills and judgment in decision making. Engineering judgment is necessary to allow decisions to account for unique site-specific conditions and considerations to provide high quality products, within budget, and to protect the public health, safety, and welfare. This manual provides the general operational guidelines; however, it is understood that adaptation, adjustments, and deviations are sometimes necessary. Innovation is a key foundational element to advance the state of engineering practice and develop more effective and efficient engineering solutions and materials. As such, it is essential that our engineering manuals provide a vehicle to promote, pilot, or implement technologies or practices that provide efficiencies and quality products, while maintaining the safety, health, and welfare of the public. It is expected when making significant or impactful deviations from the technical information from these guidance materials, that reasonable consultations with experts, technical committees, and/or policy setting bodies occur prior to actions within the timeframes allowed. It is also expected that these consultations will eliminate any potential conflicts of interest, perceived or otherwise. MDOT Leadership is committed to a culture of innovation to optimize engineering solutions.

The National Society of Professional Engineers Code of Ethics for Engineering is founded on six fundamental canons. Those canons are provided below.

Engineers, in the fulfillment of their professional duties, shall:

1. Hold paramount the safety, health, and welfare of the public.
2. Perform Services only in areas of their competence.
3. Issue public statement only in an objective and truthful manner.
4. Act for each employer or client as faithful agents or trustees.
5. Avoid deceptive acts.
6. Conduct themselves honorably, reasonably, ethically, and lawfully so as to enhance the honor, reputation, and usefulness of the profession.

PREFACE

Purpose, Goals, and Objectives

The Michigan Ancillary Structure Inspection Manual (MiASIM) provides guidance to administrative, engineering, and technical staff pertaining to the management of Ancillary Structures assets in the State of Michigan. This manual provides general operational guidelines; however, adjustments may be necessary to account for site-specific and/or other unique conditions.

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Ancillary structures fall under the jurisdiction of the Michigan Department of Transportation (MDOT) Bureau of Bridges and Structures (BOBS). The mission, vision, and values of BOBS are as follows:

- **Mission:** *The Bureau of Bridges and Structures is devoted to the efficient and innovative design, construction, and active preservation of transportation structural assets, inspired by safety, resiliency, and mobility.*
- **Vision:** *To be well-regarded as spanning and connecting lives, safely and efficiently.*
- **Values:** *Proficiency + Supportive + Accountable + Agile + Considerate*

This manual will provide ancillary structure safety inspectors and owners with guidance for meeting the requirements of MDOT's Ancillary Structures Program policies and procedures to ensure statewide consistency with reference to completing and documenting the condition of ancillary structures.

References

The following references have informed the content of this manual:

Federal and National Manuals

National Bridge Inspection Standards Federal Code of Regulations, 23 CFR 650 (NBIS)

Ancillary Structures Inspection Reference Manual, FHWA-NHI-20-999, November 2021

AASHTO Manual for Bridge Evaluation (MBE), 3rd Edition with 2022 revisions

AASHTO Manual for Bridge Element Inspection (MBEI), 2nd Edition 2019

NHI Bridge Inspection Reference Manual (BIRM), 2022

ANSI/TIA Structural Standard for Antenna Supporting Structures, Antennas and Small Wind Turbine Support Structures, TIA-222-H-1, November 2019

MDOT Guides and Manuals

MDOT NBI Rating Guidelines

Michigan Bridge Element Inspection Manual (MiBEIM)

Michigan Structure Inspection Manual (MiSIM)

Michigan SI&A Coding Guide

MDOT Bridge Inspection Frequency Guidelines

MDOT Field Manual for Structural Bolting

MDOT Standard Plans

MDOT Standard Specifications for Construction

MDOT Noise Barrier Wall Design Guidelines

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1 INTRODUCTION AND BACKGROUND

1.1 Program Overview

1.1.1 PURPOSE

The Michigan Department of Transportation (MDOT) has established the Ancillary Structures (AS) Program (“Program”) to develop and maintain a statewide inventory of MDOT-owned AS assets. The Program’s overarching goal is to minimize public safety risks due to deterioration of asset conditions. Other goals are as follows:

- To develop an asset management program for ancillary structures
- To develop and maintain an Ancillary Structures database framework
- To develop and maintain an ancillary structures program which results in consistency in managing the various ancillary structure types deployed by MDOT

1.1.1.1 Ancillary Structure Definition

Ancillary structures serve a secondary purpose to the roads and bridges within a transportation system but play a critical role in roadway network operations and safety. These structures are often significant in size and complexity and provide structural support for the roadway and/or appurtenances. Failure of an ancillary structure could have immediate, severe, and catastrophic impacts to public safety due to the non-redundant structural configuration and proximity to the roadway. Ancillary structures are not governed by the Federal Highway Administration’s (FHWA) National Bridge Inspection System (NBIS) Oversight program and regulations.

The fifteen (15) AS types included in the Program are as follows:

1. Culvert Less than 10-Foot Span
2. Retaining Wall
3. Cantilever Structure
4. Truss Structure
5. Embedded Pole (includes Wood Pole)
6. Spun Concrete Pole
7. Steel Strain Pole
8. Noise Wall
9. Mast Arm
10. Dynamic Message Sign (DMS) Support Structure
11. Frangible Pole Structure
12. Non-Frangible Pole Structure
13. High Mast Lighting Tower (HMLT)
14. Communication Tower
15. Environmental Sensor Station (ESS) Tower

1.1.1.2 Inspection Program Definition

Condition inspection of AS assets is a vital part of the Program's implementation. Accurate, reliable, and current data is necessary to effectively manage infrastructure investments. This manual addresses the following considerations for each AS asset type:

- Inspection types and frequency
- Scope of inspection
- Element and component evaluation
- Inspection team roles and responsibilities
- Inspector qualifications
- Quality management
- Safety issues

In addition to inspection requirements, this manual provides direction on the management of inspection data.

1.1.1.3 Integration with the Asset Management Program

This Program is complementary to existing MDOT asset management programs for bridges and pavement. Bridges and pavement are considered primary structures within the state transportation system; Michigan's Transportation Asset Management Council (TAMC) directs asset management activities for bridge and pavement assets. The asset status and management of bridges and pavement for Michigan are outlined and described in the state's Transportation Asset Management Plan (TAMP), which is submitted on a bi-annual basis to the FHWA. The FHWA requires reporting of status and condition of these assets according to the NBIS and Highway Pavement Monitoring System (HPMS) requirements.

FHWA does not currently require or have a standard for ancillary structures. The FHWA publication FHWA-NHI-20-999 provides general guidance for the inspection of select ancillary structural types.

Inspection findings from this Program shall be communicated to and coordinated with other asset management programs. As ancillary structures are designed, constructed, and maintained in multiple MDOT departments and bureaus, coordination and decision making shall take place with these various stakeholders.

1.1.2 ORGANIZATION AND RESPONSIBILITIES

The AS Program is focused on the various structures that support a wide array of devices that are maintained by various departments. MDOT's Bureau of Bridges and Structures (BOBS) is the owning organization for the Program. The AS Program Manager reports directly to BOBS; MDOT's organization chart is located at the following link: MDOT Bureau of Bridges and Structures.

The Program implementation is supported by additional parties as described in this section, including a Program Management Consultant (PMC). Subsections 1.1.2.1 through 1.1.2.3 provide additional details on select party's responsibilities within the Program.

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1.1.2.1 MDOT Ancillary Structures Program Manager

The MDOT Ancillary Structures Program Manager is responsible for the following major elements of the Program:

- Development of policies and procedures for AS asset management
- Enforcement of policies and procedures
- Develop AS information for statewide planning
- Report AS asset management status to parties of interest
- Coordinate with various MDOT departments and bureaus responsible for design, construction, and operations and maintenance of AS
- Engage MDOT Subject Matter Experts as technical advisors
- Conduct Request For Action (RFA) Committee Meetings
- Scoping and Preliminary Engineering

1.1.2.2 MDOT Ancillary Structures Region Champion

Each MDOT Region has a Region Champion and a Deputy Region Champion. The Region Champion serves as the Region main point of contact for the Bureau of Bridges and Structures (BOBS) and the PMC regarding AS. The Region Champion's responsibilities include the following:

- Disseminate necessary AS information throughout the Region
- Provide Region traffic and lane closure restriction guidance
- Provide direction on use of Region resources to address AS Requests for Action
- Participate in meetings for Program updates and discussions on AS issues

The Deputy Region Champion shall serve as a backup when the AS Region Champion is unavailable.

1.1.2.3 Program Manager Consultant

MDOT may engage a Program Manager Consultant (PMC) to support MDOT Program activities as directed by the MDOT Ancillary Structures Program Manager. The PMC's general responsibilities are generally as follows:

- Asset program development and data collection
- Develop and maintain an AS database framework
- Develop and update an AS inspection manual
- Maintain training and certification program for AS team leaders and inspectors
- Develop and maintain an asset management framework for AS
- Collect and manage AS inventory and inspection rating conditions data
- Collect and manage material testing data
- Collect and manage RFAs and Work Recommendations (Work Recs)
- Stakeholder communication and coordination

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- Provide Subject Matter Experts on various topics
- Ensure compliance with MDOT policies and procedures
- Scoping and Preliminary Engineering for various assets
- Design standards review and validation
- On demand design and maintenance support

1.2 Quality Assurance and Quality Control

Quality Assurance (QA) and Quality Control (QC) procedures are required to maintain accurate and consistent asset information. Asset information is utilized in determining required preservation activities such as maintenance, repairs, prioritizing removal, rehabilitation or replacements, allocating resources, load ratings, and design improvements for new or existing assets.

1.2.1 COMPARISON OF QC AND QA

All parties involved in the Program shall understand the difference between QC and QA. QC is a check to verify that accurate data is collected by qualified individuals and to immediately address any identified safety deficiencies. QA is performed independently to assure QC measures are effective.

The QC system is designed to utilize general methods and standardized procedures to verify accurate and consistent inventory collection, inspection ratings, documentation, and reporting.

1.2.2 RESPONSIBILITIES

Inspection parties are required to develop and implement appropriate QC procedures to assure quality of inspection data. QC procedures include the following:

1. Define and document QC roles and responsibilities
2. Document required qualifications
3. Document special skills, training, and equipment needs for specific types of Program process
4. Document procedures for review and validation of Program reports and data
5. Document procedures for identification and resolution of data errors, omissions, and/or changes.

Regular meetings shall be conducted to review QC procedures, issues, and/or resolutions. Feedback will be provided to all parties on:

- Hardware and software issues for data collection tools
- Digital inspection and reporting platform issues
- Process improvements needed
- Inspection performance and accuracy
- Field inspection scheduling and completion performance

Inspection parties are responsible for ensuring QA activities are completed. Regular meetings shall be conducted to review QA procedures, issues, and/or resolutions. MDOT may hire one or more consultants to perform AS inspections. These consultants will have responsibility for QA and QC of their field inspection crews.

QA/QC requirements specific to field inspection team personnel and their field inspection include:

- Meeting the qualification requirements as specified in Section 1.4 prior to commencement of field inspections. This includes:
    - Document inspection and testing qualifications for each inspector. Consultants are required to provide evidence of individual inspector qualifications when requested by MDOT.
    - Meet current applicable standards for equipment
    - Develop consultant specific safety plan (if applicable)
    - Document and ensure conformance to the safety plan
- Ensure personnel attendance and successful completion of program-specific training on inspection recording process/system and equipment and individual AS modules
- Perform QC reviews of field inspections documentation
- Monitor conformance to the safety plan and safety standards governing AS field inspections

1.2.3 QUALITY CONTROL REQUIREMENTS

Field inspection teams shall complete the following QC activities at a minimum:

- Perform QC reviews of inspection team field inspections documentation
    - Review inspection results using an internally assigned senior level reviewer
    - Complete QC review by a reviewer that did not perform the original inspection being reviewed.
    - Maintain documentation of QC reviews
    - Correct documentation by inspection personnel if needed
    - Turn around for documentation of a maximum 1 week (5 workdays), including review process
    - Review field inspections documentation including:
        - Completed asset inventory of AS features and attributes
        - Asset condition inspection in accordance with the Michigan Ancillary Structures Inspection Manual (MiASIM)
        - Inspector comments to verify the comments support the inspection rating
        - GPS structure location
        - Photo documentation
        - RFA and Work recommendation reasonableness check based on inspection

- Complete final review and re-submittal to database

- Monitor conformance to the safety plan and safety standards that govern AS field inspections

1.2.4 QUALITY ASSURANCE REQUIREMENTS

Programmatic QA activities are as follows:

- Distribute the QA findings regularly to inspection teams.
- Review findings identified in the QA processes
- Analyze declining performance trends that potentially jeopardize program quality and determine root cause
- Work with inspection teams to:
  - Prepare action plans that reduce or eliminate mistakes from occurring during the inventory and inspection process.
  - Determine and implement program or procedure changes that address findings
  - Develop and implement corrective measures and/or program modifications to reverse these trends
  - Implement actions that reduce or eliminate mistakes from occurring during the inventory and inspection process.

QA activities are required for ensuring quality in the field inspection processes. The key QA requirement is to perform post-inspection review of collected data to ensure completeness, accuracy, and compliance with data collection and storage requirements.

This post-inspection review will consist of:

- During field inspection resumption after winter season shut down, verify 100 percent of field inspection start-up reporting of each inspection team for the first five days of inspection to ensure accurate and complete reporting
- Randomly sample and perform desk review of five percent of structures from the field collection system that have passed the QC review. This percentage may increase/decrease as needed based on performance of each inspection team.
- Field verify one percent of the random sample desk reviews with at least one field verification per each inspection team
- Perform targeted desk reviews as needed based on trends identified during performance monitoring and review of inspection teams. The number of target reviews may increase/decrease as needed based on the performance of each inspection team
- Field verify one percent of the targeted desk reviews
- Field inspections data found to be incomplete or substandard shall be rejected and returned to the inspector of record for clarification and updating. The field review will include verifying applicable items are accurately coded. The field review shall confirm any comments provided
- Within two weeks from date of rejection, clarify/update field inspection data, perform internal QC reviews, and resubmit the inspection documentation

- Maintain records of QA review activities
- Initiate QA within 30 days after all final inspections have been performed and data quality checked

The QA process for field inspection is indicated in *Figure 1-1*.

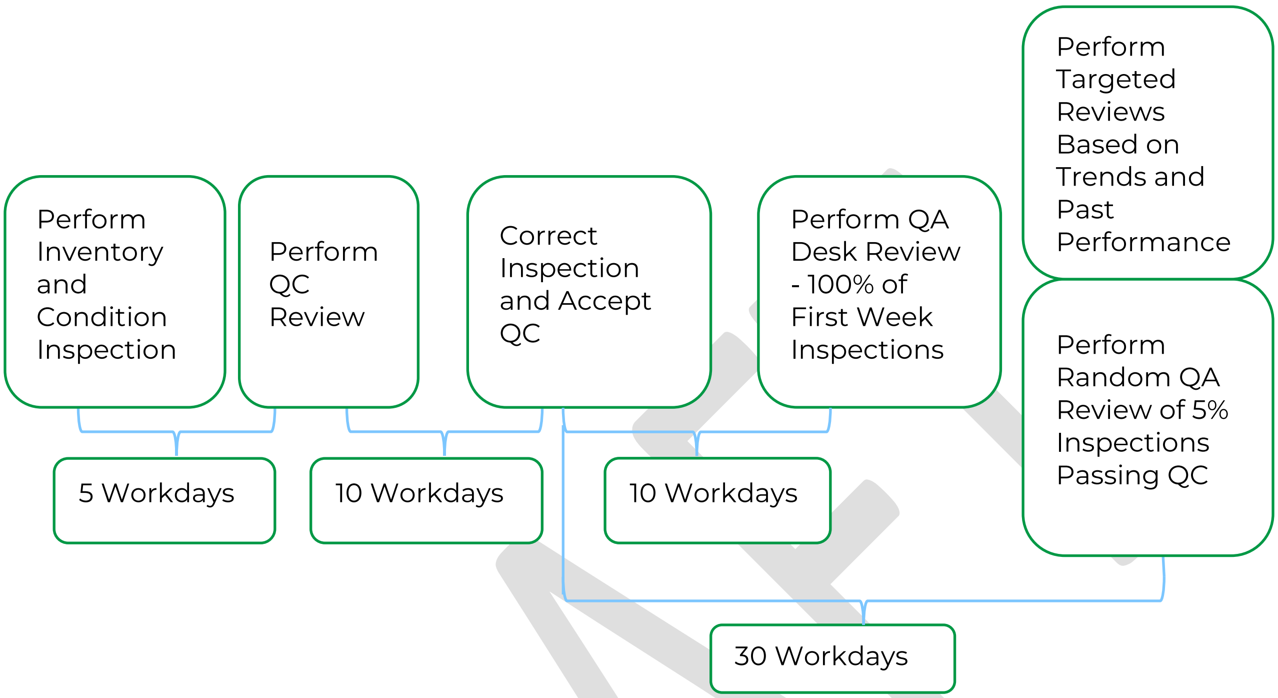

Figure 1-1: Field inspection QC and QA process

1.3 Ancillary Structure Documentation and Records

1.3.1 INVENTORY DATABASE

AS documentation and records data is maintained in a single database; this database is capable of sorting and prioritizing the data sets to maximize its usefulness for all potential users of the data. The plan is to manage the AS assets within the AASHTOWare (BrM) application, alongside MDOT's bridge, tunnel, and large (i.e., over 10 feet span) culvert assets. Prior to migration to BrM, the Program uses a data management platform configured using ArcGIS Online and ArcGIS Enterprise technologies.

The database contains both geospatial location data as well as attribute data. Most of the AS asset types are stored as point locations (e.g., steel strain poles, truss and cantilever structures) and a few of the AS asset types are stored as line locations (e.g., culverts, retaining walls, noise walls). The data dictionary describing the specific attributes associated with each AS asset is provided in their respective sections.

Asset information included in the database is not expected to vary, such as physical location, asset type, design standard, asset material, and installation date. Asset information is stored as one GIS layer for each asset type. Assets are added to the AS database as new assets are designed and constructed.

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1.3.2 NAMING CONVENTION

Each asset is assigned a structure number. The structure number of each ancillary asset type is independent of other types and is identified with a prefix.

Structure Name

A structure name is built from the selected structure prefix, structure name, and structure number. Prefixes are individually determined based on the structure type. The structure number is a combination of prefix and number. The structure name is a concatenation of structure number, type, and location along with a key identifying feature. The structure name formula is provided for each AS type.

Table 1-1: Structure Name

Asset Type	Prefix	Structure Number Example	Structure Name Formula
Culvert Less than 10-Foot Span	CULV	CULV-004801	strc_num + CulverShape + location
Retaining Walls	RW	RW-000025	strc_num + ret_wall_type_cd + location
Cantilever Structure	SS	SS-000001	strc_num + sign_strc_type_cd + location
Truss Structure	SS	SS-000910	strc_num + sign_strc_type_cd + location
Embedded Pole (including wood poles)	EP	EP-004801	strc_num + sppt_matl_type_cd + location
Spun Concrete Pole	SCP	SCP-000001	strc_num + location
Steel Strain Pole	SPP	SSP-000025	strc_num + location
Mast Arm	MA	MA-000001	strc_num + arm_type_cd + location
Noise Wall	NW	NW-000001	strc_num + panel_mat_cd + location
Dynamic Message Sign Support Structure	DSS	DSS-000001	strc_num + location
Frangible Pole Structure	FPS	FPS-004801	strc_num + sppt_matl_type_cd + location
Non-Frangible Pole Structure	NFPS	NFPS -000025	strc_num + sppt_matl_type_cd + location
High Mast Lighting Towers	HMLT	HMLT-000001	strc_num + location
Communication Tower	CT	CT-000021	strc_num + sppt_type_cd + location
Environmental Sensor Station Tower	ESST	ESST-000001	strc_num + location

Structure Name Examples

The Structure Name is a concatenation of structure number, type, and location as noted in the structure name formula. Examples are provided for select AS types:

- CULV–000001 – Concrete – I94W @ Partello Rd
- RW–000025 – Concrete Cantilever Retaining Wall – I496W @ Martin Luther King Jr Blvd
- SS–000910 – Cantilever, Type D – I275N @ US12

1.3.3 DATA MODEL

The data collected for each of the AS asset types is spread across several database tables, each with a specific purpose. A data model diagram shows the type of relationships between the separate tables and the key values that link records from one table to another. MDOT maintains a data model for the Program, including inventory, inspections, RFA, Work Recs, and QA/QC with the ability to maintain multiple inspections with each inventory record.

1.3.4 INSPECTION RECORDS

The inventory attributes collected during inspection include various data fields which involve the physical location of the structure, the personnel involved with the inventory or inspection, specifics about the structure itself, relevant dimensions, and specific attachments. The full list of inventory fields for each AS asset type is provided in the Ancillary Structures Data Dictionary. The list below is a sample of inventory data fields which apply to all AS assets.

- Structure Number
- GPS Coordinates
- County
- Route
- Milepost
- Location Description
- Installation Year
- Last Inspection Date
- Last Inspector Name
- Last Component Rating
- Next Inspection Frequency
- Physical Access Methods
- Traffic Control Requirements

The inspection attributes shall include the broad categories of inspection information, measurements/checks, element ratings, component ratings, and inspection frequency. The inspection frequency is provided for all AS types in the Ancillary Structures Data Dictionary.

All asset location descriptions should be consistently described. If the asset exists in between roadways, for example in a green space between a ramp and the mainline, the mainline should be the reference point to the location of the asset. If another reference point is used other than the mainline, a comment is required to be noted detailing the route chosen in reference to the asset. Additionally, identify left or right in relation to the direction of travel to the nearest lane of the selected route. The asset should be labeled as “protected” if the asset is behind guardrail, barrier wall, bollard, berm, etc. Assets should be labeled as “unprotected” in instances where there are no protected measures adjacent to the asset.

A sample of the inspection fields include:

- Inspector Name
- Inspection Date
- Measurements
- Checks/Tests
- Element Rating
- Component Rating

Work Rec and RFA information will be included, if applicable. Section 1.7, Section 1.8, and each structure-specific section provide additional detail on Work Recs and RFAs.

The following QA/QC attributes are also captured in the inspection record:

- Quality Control Status
- Quality Assurance Status
- Name of QC Reviewers
- Name of QA Reviewers

The following standard cracking widths for reinforced concrete shall apply to all assets except for wood poles and spun concrete poles. Prestressed concrete cracking widths apply only to spun concrete poles.

Table 1-2: 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)

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1.3.5 CONSTRUCTION AND MAINTENANCE DOCUMENTATION

Design and construction plans and maintenance records are maintained outside of the Program database by various MDOT departments and regions and may not be directly accessible through the Program's asset management system, its databases and inventory. The MDOT AS Program Manager will initiate coordination to obtain relevant construction and maintenance information.

1.3.6 SIGNIFICANT CORRESPONDENCE

Significant correspondence pertaining to AS management shall be maintained by MDOT. A document control system such as ProjectWise shall be the repository for significant correspondence. The document control system shall be accessible by Program personnel as appropriate. Required correspondence to be retained is discussed in pertinent sections within this manual.

1.3.7 PHOTO DOCUMENTATION

The Program maintains a repository of photos for AS assets in the database. Each asset type has a standard required list of photos for the inventory listed in their respective section. Inspection photos shall be saved to illustrate poor condition assets or anomalous situations.

During an AS inspection for any AS asset type, inspectors shall capture and save photos for the following conditions:

- Any issues found or unique conditions
- Photo documentation for RFAs and Work Recs
- Photo documentation for components and elements rated poor or severe with accompanying comments

Photographs will follow a standard naming convention, which is provided in each asset type's specific section.

1.3.8 ASSET MANAGEMENT SYSTEM REQUIREMENTS

An Asset Management System (AMS) is a software application or suite of applications used to manage an asset through its lifecycle from design to retirement/replacement. MDOT plans to use the AASHTOWARE BrM application as the basis of its AMS once BrM is deployed. The interim AMS will provide the following functions:

- Support for a geospatial database
- Single point of access for all AS asset types
- Mobile device support for inventory and inspection data editing and viewing
- Real-time inventory and inspection editing and viewing
- Data reporting and dashboarding

The following sections describe more detailed AMS requirements and how the AMS is configured.

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1.3.8.1 Geospatial Database

The geospatial database maintains the following:

- Location for each of the assets, stored as either a point or a line
- Attribute (i.e., tabular data) information for inventory, inspection, Work Recs, and RFAs
- Geotagged photographs

The interim geospatial database has a single point of access for Program users, ArcGIS Online, which provides the following functions:

- Varying levels of access and permissions for asset information security
- Data dictionary alignment
- Device agnostic access, providing for web browser and mobile device access
- Single point to access all relevant Program data sources

1.3.8.2 Inspection Software

The data for the Program is stored within ArcGIS Online and/or ArcGIS Enterprise software. Inspectors interact with the data through either a browser-based web map or a mobile application. Access to the data is provided through role-based user accounts and ArcGIS Online groups.

1.3.8.3 Inspection Documentation

Inspection data is entered in the database using a mobile application. Inspection results are viewable in a browser-based web map or dashboard application.

1.3.9 MONITORING AND REPORTING

The Program requires periodic reports and real-time dashboards to monitor the program status. Data monitoring is developed as required by the AS Program Manager. Minimum reporting requirements include:

- Inspection progress
- QA/QC status reports
- RFAs
- Duplicate photo status reports
- Work Recommendations

1.4 Inspector Qualifications

Inspectors shall be qualified to perform inspections of the AS and perform inspections safely. Inspection findings are communicated and coordinated with multiple stakeholders. Various roles and responsibilities are described in this section. In-service inspections and initial inspections as defined in Section 1.7 may have different inspector qualifications requirements. Where requirements differ, they are noted within this section.

1.4.1 INSPECTION CREW ORGANIZATION

The inspection team, or crew, performs both the inventory and inspection of ancillary structures.

An in-service inspection team is to be comprised of at least two people: an inspection team leader and at least one other inspector (helper). The team leader is to be a fully qualified lead inspector and the helper may possess less technical qualifications. All inspectors must meet the minimum safety requirements. Varying conditions could warrant the need for additional inspectors.

Initial inspections may be composed of a single person, whom should have the qualification of an inspection team leader and is referred to as a team leader.

1.4.1.1 Team Leader

The team leader is responsible for the performance of accurate and complete field inspections of assigned AS assets. The team leader shall meet the technical inspection qualifications required for each AS asset type inspected and shall be qualified to be able to identify critical safety issues. Core responsibilities of the team leader are as follows:

- Perform/confirm asset inventory and geospatial location of assigned AS
- Perform field inspections in compliance with this document
- Identify Work Recs
- Identify RFAs and complete the RFA report form
- Report Priority 1 RFA issues in accordance with Section 1.8
- Monitor and coordinate approved action, when required

The Team Leader shall exercise reasonable judgement based on their knowledge and experience in applying the inspection criteria and rating components and elements of AS inspected. This judgement will require determining whether a Work Rec or RFA is appropriate to address the conditions observed and the priority level of RFA based on safety considerations. The Team Leader is encouraged to seek Subject Matter Expert guidance in making these determinations.

1.4.1.2 Inspector

The member(s) of an inspection crew who shall assist the team leader with inspections as directed. May also be referred to as the helper.

1.4.1.3 Remote Pilot in Command

If an Unmanned Aerial System (UAS) or Unmanned Aerial Vehicle (UAV) is used during the course of an inspection, a person acting as a Remote Pilot in Command (RPIC) of a UAS in the United States National Airspace System (NAS) under part 107 shall hold a current remote pilot certificate with a UAS rating issued by the Federal Aviation Administration (FAA) prior to UAS operation. Though the FAA does provide for a non-FAA certified person to operate the controls under direct, in-person, supervision of a certified pilot, a non-certified person may not operate a UAS for any reason on this Program. Furthermore, the RPIC shall operate under all FAA rules and regulations as well as any additional federal, state, or local laws. Though responsible for the operation of the UAS, the RPIC is a member

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of the inspection crew and reports to the Team Leader. The RPIC is required to hold all minimum safety training requirements.

1.4.2 INSPECTION CREW RESPONSIBILITIES

Inspection crew responsibilities are to perform AS asset inventory and inspections consistently, accurately, and safely by adhering to the inspection procedures described in this manual. Inspection crews will identify safety concerns based on the structure's condition states and recommend appropriate actions to remove or mitigate unsafe conditions.

Based on the processes established for bridge inspections and management as described in the Michigan Structure Inspection Manual (MiSIM), an RFA process will be initiated to address observed safety concerns. RFA guidance is provided in Section 1.8. Work Recs will be initiated to alert MDOT of maintenance and repair needs which are not safety related. Work Rec guidance is provided for each AS in Section 2 through Section 14.

Prior to starting inspections, inspection crews shall be required to attend and satisfactorily pass training. Inspector training includes minimum safety training requirements. Inspection crews shall not provide engineering judgement on structure design.

1.4.2.1 Minimum Safety Training Requirements

These safety procedures will address, but not necessarily be limited to working near traffic and proper use of personal protective equipment (PPE).

All members of the inspection crew shall possess the following training:

- Aerial lift training and certification if performing reviews from aerial lift
- Fall protection when working at heights greater than six feet
- Review Guidance Document 10118 - Personal Protective Equipment (PPE) Policy
- Viewing mandatory MDOT Videos for working near traffic:
  - One Step from Death – Charlie's Story – YouTube (7 minutes)
  - One Step From Death - Mark's Story – YouTube (6.5 minutes)
  - One Step from Death – Scott's Story – YouTube (4.5 minutes)
- Roadway safety training including working near traffic, entering/exiting work zones, and specific training for the applicable responsibilities on the project and tasks being performed
- Proper wearing and maintaining the following minimum PPE items
  - Hard Hat (ANSI Z89.1, Type 1 Class C or E)
  - Safety Glasses (ANSI Z87.1)
  - Safety Vest (ANSI 107 Class 2 or 3)
  - Steel or Composite Toe Boots (ASTM F2413, previously ANSI Z41 Impact Rating I-75)

OSHA 10-hour training certification is desirable but not required. Other specialized safety training may be required for unique site conditions. Examples include, but are not limited to, the following:

- Railroad safety training, various
- ERail safe (if working near rail)
- Confined space training (Culverts Less Than 10-Foot Span)
- Confined space entry training (manhole, inlet, and catch-basin structures)

The AS Program Manager is responsible for coordinating additional identified safety training requirements. Additional safety requirements and protocols are discussed in Section 1.5.

1.4.2.2 Physical Ability

All members of the inspection crew shall meet the following minimal physical job requirements:

- Capable of performing physically strenuous outdoor activities, including lifting 50 pounds
- Comfortable working from an aerial lift at heights of 20-30 feet (when performing inspections with this equipment)
- Working while carrying tools in demanding outdoor conditions such as:
  - Cramped spaces
  - Rugged terrain
  - Steep embankments
  - Elevated surfaces
  - Live traffic in adjacent lanes
  - All seasons and associated weather or environmental conditions
  - In and around water

All team leaders and inspectors shall be capable of using a digital reporting platform to perform field inspections. Team leaders and inspectors shall attend and have successfully completed required training on inspection recording process, system, and equipment. Team leaders shall have appropriate database access for inspection personnel and QC review technicians. Team leaders and inspectors shall attend and successfully complete photo-documentation training for all AS asset inspection elements and components.

Inspection crew technical inspection qualifications for specific structure types are provided in subsections following each AS asset type. A listing of typical tools to be used for structure types is provided in Section 1.6.

1.4.3 CONSULTANT INSPECTION TEAM RESPONSIBILITIES

Consultants hired by MDOT to perform AS field inspection work shall manage their field inspection crew(s). These responsibilities include, but are not limited to:

- Identify team leader and inspection team personnel and provide names to MDOT AS Program Manager
- Ensure team leader and inspector personnel meet inspection qualifications

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- Confirm MDOT permits and advanced notifications are in place and approved prior to performing field inspections
- Assist in obtaining permits or notifications when necessary
- Coordinate traffic control when applicable
- Provide inspection personnel with appropriate (i.e., compliance with MDOT Guidance Document 10118) equipment to safely accomplish each task
- Require inspectors to attend and successfully pass training covering inspection processes and reporting requirements.

1.4.4 INSPECTION SYSTEM TRAINING

All team leaders and inspectors shall be capable of using a digital reporting platform. Team leaders and inspectors shall attend and have successful completion of training on inspection recording process/system and equipment.

1.4.5 MINIMUM TECHNICAL QUALIFICATIONS

The minimum technical inspection qualifications for each AS asset are described in each asset's respective section.

1.5 Safety Requirements

MDOT is committed to ensuring the safety of its employees, partners, and the public through comprehensive measures that foster the prevention of incidents. MDOT occupational safety guidelines are instituted because of the regulations promulgated under Public Act 154 of 1974; the provisions of which are enforced by the Michigan Occupational Safety and Health Administration (MiOSHA). This section describes the minimum safety requirements that shall be adhered to for AS safety inspection. Although consultants performing AS inspections are required to have their own safety plan, they are encouraged to follow MDOT practices to supplement their plans when applicable. An employee concerned for their safety and health on site should contact their supervisor or designated safety person.

Link to MiOSHA:

[Michigan Occupational Safety and Health Administration (MIOSHA)]

The Team Leader shall be familiar with the conditions to be encountered at the inspection site(s) to identify any potential hazards or conditions that need to be accommodated to safely complete the inspections. These should be discussed with the inspection team before inventory and inspection activities begin.

Inspection personnel shall be provided the necessary safety equipment suitable for each type of inspection and properly trained in the use of safety equipment and understand the safety procedures associated with AS inventory and condition inspection activities. Each employee is required to inspect PPE before each use and notify the employer of any defects or damage that may affect the performance of the equipment. Team leaders are responsible for seeing that all on-site inspectors adhere to the PPE requirements.

Inspectors are required to review *Guidance Document 10118 - Personal Protective Equipment Policy* prior to performing any inspections. The guidance document provides

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up-to-date information regarding the minimum requirements for eye, head, and foot protection. The requirement for additional safety equipment shall be assessed according to the specific type of activities to be performed.

Link to MDOT Guidance Document 10118:

MDOT Personal Protective Equipment (PPE) Policy

1.5.1 WORKING NEAR TRAFFIC

Working near traffic is an inherent hazard for all types of AS inspections. While high visibility safety apparel provides attention to motor vehicle operators of a worker's presence near the structure, additional precautions are necessary to limit the risk of an accident. All vehicles used to transport personnel and inspection equipment to the site shall be outfitted with high-visibility lighting and conspicuity tape per MDOT Vehicle Visibility Standard 10196 to provide an additional means for cautioning motorists that work is actively being completed in proximity to the structure. Vehicles shall also be parked in the safest manner possible, where the potential to limit site distance for adjacent intersections is minimized and worker protection is maximized.

Inspectors shall also be cautious of motorist's actions and aware that distracted driving is commonplace. It is never safe to assume that motorists are attentive to the activities being performed even when advanced signing or traffic control devices are in place. It is always preferred to efficiently utilize time for inspections that limit the duration that work occurs nears traffic. When it is possible, inspect ancillary structures from behind the protection of guardrail or have an escape path identified when a barrier does not exist.

1.5.2 CREW SIZE MINIMUM

When feasible, a two-person team performs inspections of an AS. The team is to be comprised of a team leader and an inspector (helper). Two people on-site enable the members to monitor each other's safety and call for assistance if something were to happen to the other crew member. Varying conditions could potentially warrant the need for additional inspectors.

1.5.3 WORKING NEAR POWER LINES

To minimize the risk of injury or death, every inspection shall include a review of the surroundings prior to performing work near power lines. Before using a ladder or entering the platform of a bucket truck or aerial lift, the team leader should review the site for the presence of power lines. Although some overhead wires may be insulated for protection, most are not and rely on adequate clearance to provide shielding. MIOSHA provides minimum recommended distances for working near electrical lines that are dependent on the amount of voltage being transmitted. When work is conducted near the lines, the team leader should contact the utility owner to determine the rating and consult MIOSHA standards for the minimum clearance to determine whether a temporary shutoff during the inspection will be required. Some utility owners may require their own personnel to be on site during inspections; this is not a substitute for complying with required safety procedures.

1.5.4 CONFINED SPACES

A permit-required confined space is defined by MIOSHA as a space having one or more of the following characteristics:

- Contains or has a potential to contain a hazardous atmosphere.
- Contains a material that has a potential for engulfing an entrant.
- Has an internal configuration such that an entrant could be trapped or asphyxiated by inwardly converging walls or by a floor which slopes downward and tapers to a smaller cross-section.
- Contains any other recognized serious safety or health hazard.

Examples of confined spaces that may be encountered by the team leader while performing AS inspections include, but are not limited to, culverts and enclosed drainage structures such as manholes, inlets and catch basins. Specialized equipment is necessary to test the atmospheric conditions inside the space, provide suitable air for inspectors to perform the work, and provide a means for retrieving individuals that cannot exit under their own effort.

AS inspectors shall not enter culverts if it is unsafe to do so, and inspectors shall not enter enclosed drainage structures. Visual inspection of culverts that cannot be entered shall be performed from the end section and enclosed drainage structures shall be performed from the grate or manhole cover at the top of the structure. If the inspector notices a deficient condition that requires further up-close inspection, this should be recommended as a follow-up inspection, such as televising the culvert or enclosed drainage structure inspection by a confined space trained and equipped inspection crew.

1.5.5 ENVIRONMENTAL AND HEALTH HAZARDS

The environmental and health hazards that could be encountered by inspectors inspecting AS can be varied and unpredictable. Often characterized by heavy vegetation growth and wet conditions, culverts and ditches are an attractive habitat for ticks, mosquitos, spiders, snakes, rodents, small wild animals, and noxious plant growth, such as poison ivy and others vegetation. Heavy vegetation could also obscure a slope failure or depression that could trip an inspector and cause a fall resulting in personal injury. These conditions should not be taken lightly and inspectors shall wear appropriate work attire to ensure their safety during culvert inspections and take precautions when approaching a culvert end section and drainage way. AS may have been constructed with materials, such as lead, asbestos, or silica, which may pose long-term exposure hazards. The safety equipment discussed in this section can help mitigate the hazards that may be experienced while performing inspections.

1.5.6 WORKING NEAR TOWERS

Tools and equipment for communication tower inspections shall follow the MiOSHA Communication Towers Standard.

Link to MiOSHA Communication Towers Standard:

MIOSHA-STD-1329 (03/09) - Construction Safety And Health Standard Part 29. Communication Towers

If a communications tower or other tower structure was originally constructed or also functions as an AM Tower, follow safety requirements for radiation and other special considerations prior to inspection. AM towers have high wattage which can cause serious damage or death.

1.5.7 SAFETY EQUIPMENT

Most AS are in close proximity to adjacent roadway driving lanes, and in many cases the inspection vehicle will be located on the shoulder or off the paved surface. Safety of the inspection crew and passing motorists are the highest priority. Inspectors are to use appropriate safety equipment for the specific site characteristics of the AS inspection location. Immediately when exiting the confines of their vehicle, PPE is to be used in accordance with MiOSHA and the employing agency's safety plan. Minimum PPE for all inspectors is as follows:

- Hard Hat (ANSI Standard Z89.1, Type 1 Class C or E)
- Safety Glasses (ANSI Z87.1)
- Safety Vest (ANSI 107 Class 2 or 3)
- Steel or Composite Toe Boots (ASTM F2413, previously ANSI Z41 Impact Rating I-75)

The following list describes typical safety equipment used for the inspection of ancillary structures. Other tools may be used by the inspector at their discretion or as required for a specific job or task:

- **PPE** specific to inspection activities:
  - **Gloves**: Used as hand protection when performing inspections or specific inspection activities such as grinding, clearing brush, digging out foundations, etc.
  - **Waders**: Used as leg protection when performing inspections around culverts.
  - **Long Sleeves**: Used as arm protection when performing inspections around brush or for sun protection
  - **Sunscreen and Bug Spray**: Used as protection from environmental hazards, such as sun exposure and animals, such as ticks or mosquitos
  - **Hearing Protection**: Used when exposed to high decibel noises
  - **Fall Arrest System (body harness and lanyard):** Used for protection against fall from dangerous heights.
- **First Aid Kit**: Used for addressing minor on-site injuries. A kit should always be available in each inspection vehicle.
- **Cellular Phone**: Used for contacting and communicating with various entities for the purpose of coordination or reporting personnel or inspection emergencies or critical conditions.
- **Two Way Radios**: Used for communication between the inspectors during the inspection process, specifically when one inspector is performing inspections from an aerial lift or bucket.
- **Fire Extinguisher:** Required additions to Standard PPE if a UAS is being utilized.
- **Respiratory Protection:** May be needed if confined space entry is undertaken.

1.6 Inspection Tools and Equipment

Different types of ancillary structures require different tools to perform inspection procedures. Access to hand tools and testing equipment during field inspection is vital for proper inspection. The tool lists presented in each subsection are grouped by purpose and are not all inclusive; some situations may require more specialized tools. Tools are listed by name and general purpose for each tool. This list is not exclusive and other tools may be used by the inspector at their discretion.

It is the responsibility of the team leader to determine the necessary tools for each inspection. It is the responsibility of each inspector and their inspection firm to keep the tools the inspector uses in good working condition and properly calibrated when required.

1.6.1 PREPARATION

The lead inspector shall be responsible for determining the appropriate tools necessary to complete the inspection procedures for the ancillary structure(s) being inspected and to confirm the tools are calibrated and are in adequate condition to perform the required inspection. Inspectors should also ensure proper use of any equipment for inspection. When working from an aerial lift to inspect cantilever or truss structures above and adjacent to live traffic lanes, tools used for inspection should be tethered to the inspector or the aerial bucket or platform, to prevent a tool from dropping and potentially striking a ground worker or passing vehicle.

1.6.2 MEASURING DEVICES AND TEST EQUIPMENT

- **4-foot Level**: Used for checking plumbness of non-tapered vertical supports/poles and checking levelness of other components.
- **Plumb Bob**: Used for checking tapered and non-tapered vertical support/pole plumbness and bowing.
- **Nylon string**: Used for determining and measuring sag or any other distortion to a chord or other member.
- **Laser Distance Measuring Tool**: Used to measure clearances and span lengths.
- **25-foot Steel Tape Measure**: Used for measuring sign dimensions, anchor bolt diameters, base plate standoff distances, and deficiency sizes, etc.
- **Folding Ruler**: Used for measuring some sign dimensions, anchor bolt diameters, base plate standoff distances, deficiency sizes, and used as a scale in photographs.
- **Calipers**: Used for measuring diameter or thickness of smaller structure components, such as anchor bolts, and component section losses.
- **Crack Gauge:** Used for measuring width of cracks. For concrete cracks, provide a crack gauge measurement in a photo. For concrete cracks, mark the crack width measurement value on the concrete structure and include the date of the inspection.
- **Feeler or Taper Gauge**: Used for measuring gaps between parts or pieces such as gaps between top nuts and base plates.
- **D-meter**: Used for measuring thickness of components where access to one side is restricted (e.g., pole wall thickness).

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- **8-foot Aluminum Range Pole:** Used in prodding for scour around culvert and for putting in photos to help show depth of scour or embankment erosion.

1.6.3 INSPECTION EQUIPMENT AND TOOLS

- **Angle Grinder**: Used for grinding the tops of anchor bolts to level the surfaces and remove any coating.
- **Cold Galvanizing Compound**: Used for painting the tops of anchor bolts following the grinding and ultrasonic testing to minimize or prevent corrosion.
- **Drill**: Used for drilling grout pads in determining the presence of leveling nuts and assessment of timber vertical supports/poles.
- **Dye Penetrant Testing Kit**: Used for performing non-destructive testing (NDT) on suspected cracks in welds and metal members.
- **Magnet**: Used for determining the material of a structure, securing the end of a string line when measuring sag or distortion of a vertical support/pole or horizontal support/truss, etc.
- **Magnetic Particle Testing Kit**: Used for performing NDT on suspected cracks in welds or steel members.
- **Mason Hammer**: Used for checking tightness of top and leveling nuts, sounding anchor bolts for possible cracks or debonding from the concrete, sounding the concrete pedestals for delamination, removal of rust scale, sounding of wood poles for delamination, and sounding of other structure elements for possible internal corrosion and section loss.
- **Marking Utensils:** Paint sticks (preferred) or lumber crayons used to mark conditions in the structure such as loose bolts, turn of nut measure, etc**.**
- **Number and Letter Stencils**: Used for establishing and applying structure numbers to vertical supports/poles of structures and parapets for bridge parapet-mounted structures.
- **Paint Remover**: Used for removing excess spray paint or overspray created by painting structure numbers on structures.
- **Spray Paint**: Used for painting structure numbers to vertical supports/poles of structures and parapets for bridge parapet-mounted structures.
- **Stencil Template**: Used for aligning, securing, and framing structure numbers and letters (described above) in a vertical or horizontal orientation, and to prevent overspray on the structure during the painting process.
- **Wrenches and Screw Drivers**: Used for removal of anchor bolt covers, hand hole covers, and transformer base access covers.
- **Soil probe:** Used to determine if there is a concrete encasement below grade soil at the base of an embedded pole.

1.6.4 CLEANING TOOLS AND MATERIALS

- **Hand whisk broom:** Used to remove light dirt and debris from foundation anchorage to enable visual inspection of leveling nut and anchor bolts

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- **Shovel**: Used for uncovering pedestals, base plate, etc.
- **Machete/Bush Axe**: Used for removing undergrowth.
- **Rags, Painters Tape, Duct Tape**: Rags are used for various activities, including wiping or cleaning paint, dirt, or grime from areas or elements; painters' tape is used for taping stencils to the stencil template; and duct tape is used for a variety of conditions.
- **Wire Brush:** Used to remove rust and scale from metal to determine the extent of corrosion and metal material loss. Can also be used to remove foreign debris from foundations to provide a clear view or anchor bolt and nut assemblies.

1.6.5 VISUAL AIDS

- **High Powered Binoculars (10x-15x Magnification)**: Used for performing visual inspections of upper portions of offset luminaires when the luminaire distance from the roadway prevents hands-on inspection access using an aerial lift.
- **High Powered Spotting Scope (20x-50x Magnification)**: Used for performing visual inspections of high mast lights, communication towers and for inspecting offset luminaires should access prevent a hands-on inspection.
- **Mechanics Mirror**: Used for inspecting areas that are difficult to access through normal hands-on inspection methods. The mirror affords a visual inspection of the areas. If the mirror is to be used inside hand holes or other potentially electrically active locations, the mirror shall have an electrically insulated handle.
- **Unmanned Aerial System (UAS):** Used for reviewing and documenting vertical structures (High-Mast Lighting, Communication Towers, Environmental Sensor Station Towers) and other ancillary structures as required.

1.6.6 MISCELLANEOUS EQUIPMENT

- **Awl or Ice Pick**: Used for detecting and quantifying the depth of softwood and decay present in timber vertical supports/poles**.**
- **Digital Camera**: Used to take photographs of required items or deficiencies. The inspection tablets used to perform routine inspections should be capable of photos of sufficient quality. However, there may be cases for special inspections where a tablet is not available, and a digital camera is necessary. The camera shall be capable of time and date stamping the photographs with a minimum of 12MP. A camera that can capture voice captions may be beneficial.
- **Electrically Insulated Borescope**: Used for inspecting the interior areas of vertical supports/poles, chords, etc. that cannot be inspected through conventional means due to limited accessibility or live electrical components within the areas.
- **Extension Cord**: Used for powering tools or equipment when accessibility is limited due to structure location or obstructions. Ensure the cord is in good condition and the ground prong is intact.
- **Extension Ladder:** Used for reaching moderate heights when use of a bucket truck is not available.

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- **Generator**: Used for powering various corded power tools or equipment including lights for night inspections, drills for drilling of grout pads, and grinders for ultrasonic testing of anchor bolts.
- **Headlamps and Flashlights**: Used by the inspector when performing an inspection of dark areas or when performing night inspections. Headlamps are particularly useful when mounted to a hardhat as it aids in keeping the inspector's hands free for handling the structure or other tools and equipment. MiOSHA General Rules for Illumination may be referenced for best practices.
- **Manhole Pick:** Used to loosen and remove a manhole cover or drainage casting installed on top of a manhole structure to enable the inspector to visually assess the inside condition of the structure and the connection between the culvert and drainage structure
- **Portable Lighting**: Used to light/illuminate the work zone and structure during nighttime inspection work and able to provide accuracy to within 6 to 10 feet.
- **Resistograph**: Instrument that uses drilling resistance for determining the presence and depth of any softwood, decay, and cavities within timber vertical supports/poles.
- **Timber Coring Kit**: Used for sampling and determining the presence of interior decay and cavities within timber vertical supports/poles.
- **Voltmeter:** Used to determine if a structure that contains internal wiring has become energized due to arcing.

1.7 Inspection Types And Actions

1.7.1 ROUTINE INSPECTION

Ancillary structures typically require acceptance inspection and testing during fabrication and construction for conformance to specifications. After the structures are put into service, they are routinely inspected to evaluate their condition. This section describes the general procedure for inspecting any ancillary structure in the Program as it moves past design and construction and then into its in-service phase. Types of inspection in the Program include initial or acceptance inspection, routine inspection, damage inspection, and in-depth inspection.

The general procedure for completing a routine inspection and guidance for performing Element and Component ratings and evaluating condition states is provided in the following sections.

1.7.1.1 Definitions

Element

Elements are individual pieces of an asset that can be condition assessed on their engineering or maintenance behavior against a consistent set of standards. Element ratings can be used to make decisions on maintenance and funding. The element level inspection is quantity-based, and each quantity is assigned a Condition State to reflect the differing categories of deterioration that often exist on any element. The element rating scale for the Program is in *Table 1-3*.

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Component

A component is a set of related elements that, together, make up a unit that is interrelated for its behavior. Component ratings provide a means to determine the safety of the structure. The component rating scale for the Program is in *Table 1-4*.

Condition State

The combination of defects or distresses results in the element exhibiting behavior at different standards, or condition states. Elements within the AS program have four defined condition states: Good, Fair, Poor, and Severe. During the inspection process, each element shall note the quantity of the element performing at each condition state.

1.7.1.2 Initial Inspection (New Structure or Existing Structure Replacement)

The initial inspection consists of a routine inspection with the addition of confirming or updating the inventory database by entering missing inventory data or comparing the description in the database against the asset in the field so the asset is accurately described. The initial inspection differs from a routine inspection in that previous records are not available to compare inventory items or inspection records.

Initial inspection is considered an acceptance activity that occurs following initial placement of the structure type into the Program, following installation, or initial placement into or back into service. Throughout the life of the structure, it may become necessary to take it out of service temporarily for rehabilitation. Prior to returning it to service, a construction inspection will be necessary to verify the work done was according to MDOT specification.

The initial inspection shall be completed after construction or return to service following notification by the MDOT AS Program Manager. Timelines to complete initial inspection will be determined by the MDOT AS Program Manager as appropriate.

Prior to Mobilization to Site

1. Confirm AS Type
2. Confirm inspectors meet appropriate Inspector Qualification (Section 1.4)
3. Confirm safety requirements are met and appropriate safety equipment is available (Section 1.5)
4. Verify Inspection Tools and Equipment are available and appropriate (Section 1.6)
5. Review Routine Inspection Procedure for Inspection Type (Sections 1.7)
6. Review the structure-specific section in Section 2 through Section 14

Following Site Mobilization

1. Arrive on Site
2. Confirm maintenance of traffic (MOT)
3. Confirm safe work zone
4. Verify device and application access
5. Identify/verify GIS Location
6. Verify/edit prepopulated data
7. Enter field collected inventory data input attribute fields

8. Create inspection record
9. Follow inspection process on tablet for applicable AS type
10. Note if structure is accepted or rejected from construction
11. Follow QC procedures after inspection is submitted

UAS Mobilization Procedure

Prior to Site Mobilization:

- RPIC shall review airspace along with any additional federal, state, or local laws related to UAS missions.
- If in proximity to an airport, an FAA waiver may be required. This waiver could be submitted via the Low Altitude Authorization and Notification Capability (LAANC) or may require a direct submittal to the FAA. Typically, LAANC is an automated system for operations below the denoted elevation deck for the area. Direct submittals to the FAA are generally for flights above the denoted elevation deck and/or complicated airspace.
- Perform equipment check and inventory to support mission
- Review weather forecast for mission location and time to ensure acceptable conditions
- Complete UAS Pre-Mob Documentation

Following Site Mobilization:

- Check for last minute filing of Notice to Airmen (NOTAMs) and Temporary Flight Restrictions (TFRs)
- If a FAA waiver has been acquired, follow all guidance listed
- Secure a Launch and Recovery Zone (LRZ) with cones, flagging, and other required demarcations
- Review weather forecast
- Complete UAS pre-flight and mission documentation
- After ensuring secure LRZ, launch UAS
- Hover at approximately 3 feet, once stability has been confirmed, fly mission
- Provide inspector with visibility to components; capture imagery as requested by inspector
- Land and recover UAS
- Complete post-flight documentation

1.7.1.3 Routine Component and Element Inspection

A routine inspection consists of confirming structure inventory attributes, rating the structural condition states, and rating the structure's overall integrity and safety. The entire structure then receives an overall rating based on the worst component rating identified during the on-site inspection. The overall culvert less than 10-foot span rating is calculated using an alternative method based on a subset of the components (see Section 2.1.3 for more details).

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Inventory items are structure specific attributes. The inventory data are used in conjunction with the inspection data and other documentation in support of the overall AS asset management system. Inventory items are grouped into subheadings for general, location, asset, and QC. For new structures or initial inspections this data needs to be populated; for existing structures, the data may be verified and updated. Inventory tables can be found in the Ancillary Structures Data Dictionary.

Each structure consists of select components. Each component is characterized and rated on its structural condition, ability to perform its function, and possible safety concerns or negative impact to the structure or its foundation. Components may be divided further into elements. The component rating requires an overall assessment and is not directly calculated from the element ratings. However, the condition of the individual elements within the components is likely to affect the component rating.

Report public safety concerns to the appropriate subject matter expert(s) for a more complete evaluation and determination. This may include notifying the appropriate authority, suspending the inspection, directing an RFA, and/or calling for an additional/in-depth inspection. Inspectors do not make engineering judgements or evaluations of public safety independently from trained experienced professionals.

Prior to Mobilization to Site:

1. Confirm AS Type
2. Confirm team meets appropriate Inspector Qualification (Section 1.4)
3. Confirm safety requirements are met and appropriate safety equipment is available (Section 1.5)
4. Verify Inspection Tools and Equipment are available and appropriate (Section 1.6)
5. Review Routine Inspection Procedure for Inspection Type (Section 1.7)
6. Review the structure-specific section in Section 2 through Section 14
7. Review previous inspection records (if available)

Following Site Mobilization:

1. Arrive on Site
2. Confirm maintenance of traffic (MOT) MDOT Work Zone Safety And Mobility Manual
3. Confirm safe work zone
4. Verify device and application access
5. Identify/Verify GIS Location
6. Verify/edit prepopulated data
7. Enter/verify field collected inventory data input attribute fields
8. Create inspection record
9. Follow inspection process on tablet for applicable AS type (refer to Section 2 through Section 14 for details)
10. Perform element(s) rating (see description below)
11. Perform component(s) rating (see description below)
12. Photo-document the conditions (see description below)
13. Record rating comments to support each rating, as required
14. Review for accuracy/completeness before closing the inspection to trigger the QC/QA process (refer to Section 1.2 for details)

15. Create Work Recs if necessary (see Section 2 through Section 14 for structure specific guidance)
16. Initiate the RFA Process if necessary (See Section 1.8); follow QC procedures after inspection is submitted

UAS Mobilization Procedure

Prior to Mobilization:

- RPIC shall review airspace along with any additional federal, state, or local laws related to UAS missions.
- If in proximity to an airport, an FAA waiver may be required. This waiver could be submitted via LAANC or may require a direct submittal to the FAA. Typically, LAANC is an automated system for operations below the denoted elevation deck for the area. Direct submittals to the FAA are generally for flights above the denoted elevation deck and/or complicated airspace.
- Perform equipment check and inventory to support mission
- Review weather forecast for mission location and time to ensure acceptable conditions
- Complete UAS Pre-Mob Documentation

Following Mobilization:

- Check for last minute filing of NOTAMs and TFRs
- If an FAA waiver has been acquired, follow all guidance listed
- Secure an LRZ with cones, flagging, etc.
- Review weather forecast
- Complete UAS pre-flight and mission documentation
- After ensuring secure LRZ, launch UAS
- Hover at approximately 3 feet, once stability has been confirmed, fly mission
- Provide inspector with visibility to components; capture imagery as requested by inspector
- Land and recover UAS
- Complete post-flight documentation

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Element Ratings

Inspectors shall perform element ratings for each element. The condition states for each element are tabulated per the sample shown in *Table 1-3*. Tables specific for each element's condition states are presented in Section 1.10. It is important to note component ratings and element ratings have different scales. These differing scales were developed by the NBIS to require inspectors to evaluate components and elements separately.

Table 1-3: Element Condition State Ratings with Descriptions

Condition State Description					
Condition Rating	**Good**	**Fair**	**Poor**	**Severe**	**Not Rated**
Action Indicated	No action is recommended. Note in inspection report only.	No immediate action is recommended but more frequent inspection may be warranted. Maintenance personnel should be informed.	Inspector evaluates need for corrective action and makes recommendations in inspection report.	Corrective action is required and urgent. Engineering evaluation is required to specify appropriate repair.	No action is required (except when review could not be performed due to conditions.)
Condition Description	Like new with little or no deterioration. Structurally sound and functionally adequate.	Minor to moderate deterioration. Structurally sound with adequate function.	Significant deterioration. May not have adequate function. Maintenance or repair required.	Major deterioration. Failure may have occurred. Requires maintenance, repair, or replacement.	The element was not part of the system design and is not required for functional adequacy. This includes items missing due to vandalism. Also includes inaccessible items that need to be reviewed.

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Component Ratings

Perform component ratings per *Table 1-4* for each component in the structure as itemized. Note that component ratings and element ratings have different scales. These differing scales were developed by the NBIS to require inspectors to evaluate components and elements separately. Component rating guidance is provided for each structure in the applicable subsections of Section 2 through Section 14.

Table 1-4: Component Rating System

Component Rating	Condition	Condition State
9	NEW	Like new, within normal range for a newly installed structure.
8	VERY GOOD	Only minor distress or deterioration
7	GOOD	Some problems noted
6	SATISFACTORY	Some moderate or multiple indications of distress/deterioration
5	FAIR	Moderate or multiple indications of distress/deterioration affecting performance
4	POOR	Significant distress
3	SERIOUS	Significant distress/deterioration with potential for local failure
2	CRITICAL	Advanced deterioration with potential for failure of primary structural elements
1	IMMINENT FAILURE	Imminent failure which could threaten public safety
0	FAILED	Failure has occurred

1.7.1.4 Routine Inspections During and After Existing Structure Rehabilitation

Throughout the life of the structure, it may become necessary to take it out of service temporarily for rehabilitation or replacement. Prior to returning it to service, an installation inspection will be necessary to verify the work done was according to MDOT specifications.

A routine inspection scheduled at the time of a structure rehabilitation may be documented as incomplete with the items which are undergoing rehabilitation left as uninspected.

A routine inspection scheduled after an existing structure is rehabilitated shall complete a full routine inspection, including elements and components which were not rehabilitated. A new inspection cycle is then initiated following the rehabilitation.

Timelines to complete the routine inspection following rehabilitation will be determined by the MDOT AS Program Manager as appropriate at the time of notification of the rehabilitation action completion.

1.7.2 SPECIAL INSPECTIONS

Special inspections are determined on a case-by-case basis and can be triggered by observations from a routine inspection and requested by MDOT or other stakeholders. Special inspections may be necessary due to damage noted by MDOT personnel or the traveling public from a traffic incident, weather event, or other precipitating event not caused by typical deterioration. Special Inspection procedures may be sourced from external references or may be designed for each unique situation. Special Inspections may or may not require a routine inspection as part of the Special Inspection. Identified subject matter experts shall lead the special inspections as approved by MDOT. UAS may be deployed for rapid review, photographic documentation, and additional situational awareness.

1.7.3 WORK RECOMMENDATIONS

The role of the inspector includes recommending work that can be performed by maintenance crews. Work Recs include items such as clearing vegetation and debris or performing other maintenance allowing the asset to function properly and prevent premature deterioration. Inspectors should create separate Work Recs for each type of repair.

1.7.4 RFA PROCESS

The role of the inspector includes initiating the RFA process if a safety issue is observed. The RFA Process is described in greater detail in Section 1.8.

1.8 Request for Action Process

Generate an RFA when a structural- or safety-related deficiency requires immediate follow-up inspection or action. This includes any instance where an entire bridge, roadway, lane, or shoulder is closed to protect public safety due to the condition of an AS component or element.

There may be safety issues identified that result in immediate action but do not affect the structural integrity of the ancillary structure. These situations are addressed using typical emergency or high priority procedures and may require follow-up safety related deficiency documentation. For example, lane or shoulder closures to repair or remove deficient appurtenances shall not be considered a safety issue. Specific examples of safety issues are provided in Section 1.8.4.

1.8.1 PURPOSE OF REQUEST FOR ACTION AND REQUEST FOR ACTION COMMITTEE

The AS RFA Committee is responsible for reviewing, prioritizing, initiating action, monitoring, ensuring resolution and/or following up on all AS RFAs statewide for MDOT-owned AS. The AS RFA Committee will also set goals and timeframes and identify resources for addressing RFAs based on the Priority Levels listed in Section 1.8.4. Committee actions may involve lane or road closure, asset removal, emergency repairs, or contracting of work depending on current maintenance crew backlog and situational urgency.

The inspection teams submit RFAs based on findings from the various field inspection. RFAs are defined by varying degrees of urgency requiring ongoing prioritization and monitoring of implementation. The inspection teams where the RFA originates from will recommend the initial Priority Level to the local Transportation Service Center (TSC) or Region. The TSC and/or Region personnel will confirm the initial Priority Level and actions necessary to ensure public safety.

1.8.2 DOCUMENTING FINDINGS

The procedures herein set forth the minimum requirements for AS Program personnel during critical finding observations and follow-up activities.

The RFA report shall be used for addressing issues with structures that need to be scheduled for repair more urgently than the normal capital work programming process. When the inspector's judgment dictates immediate action is necessary to mitigate a hazard, such action shall be undertaken and reported in the "Immediate Action" section on the RFA report. Immediate action typically requires mitigation of the critical item such as repair or removal of the structure, placement of a barricade, and/or closing a lane or shoulder of adjacent or below a structure because of a safety issue. Documentation of safety issues for MDOT are required to be reported using the RFA report or within the AMS for the RFA process.

1.8.3 RFA PROCEDURES

1.8.3.1 Team Leader Responsibilities

Team leaders are responsible to initiate RFAs as necessary from findings encountered during a special or routine inspection. Team leader and subject matter experts may perform a special inspection during or after action taken by the RFA committee. The team leader shall immediately notify the AS Program Manager or acting responsible authority verbally of any safety issue that is discovered during an inspection. The safety issue shall be documented by entering all known information on the RFA report. The team leader shall also enter data into the fields in the Problems/Comments Explanation and Immediate Action section and submit the form within 24 hours to the AS owner.

The team leader is also responsible for documenting the safety issue on the inspection report. They may also be engaged during or after action taken by the RFA committee to complete a special inspection.

1.8.3.2 MDOT Responsibilities

Upon receiving notification of an RFA, the Program Manager engages subject matter experts as necessary to assist in the evaluation of RFAs. The Program Manager shall ensure that all the processes and procedures to mitigate the deficiency are fulfilled and the safety issue is reported to MDOT.

After the immediate and final actions have been completed to address a safety issue, MDOT will assign a routine inspection be completed of the structure to adjust its rating. If the inspection frequency requires adjustment, the MDOT Program Manager will identify the new inspection frequency.

MDOT shall assemble the RFA Committee and determine methods, such as maintenance or other contracts, necessary to execute actions determined as necessary by the committee.

For non-MDOT-owned assets located in MDOT Right-of-Way, the AS Program Manager shall engage the owner for further action after resolving any immediate safety concerns.

1.8.4 RFA PRIORITIES

RFAs are initiated typically through a routine inspection but may be initiated following a special inspection or notification from MDOT.

Damage inspections are not scheduled and typically initiated by a report from MDOT or the public. MDOT may be the first to be informed and often responds directly. The most common damage inspections performed in Michigan are a result of a vehicle damaging the ancillary structure asset.

The following Priority Levels describe the deficiencies common to each level and the timeframe upon which the deficiency should be addressed, along with any necessary increased inspection frequencies or structural condition monitoring. Deficiencies not addressed within defined timeframes are to be further discussed at AS RFA Committee meetings. Example inspection findings are provided for each Priority Level; however, these lists are not all-inclusive. When assigning Priority Levels, consideration is given to public safety, structural redundancy, resiliency, risk, and consequences of failure including:

- Severe injury or fatality
- Damage to personal or State property
- Partial or total loss of structure
- Long-term impact to the environment
- Intrusion within the clearance of the traveling lanes and shoulders
- Partial or complete closure of traveled roadways

Priority Level 1, Emergency

Repairs, mitigation, or monitoring is typically required as soon as reasonably possible or as determined by engineering judgement and may require on-site presence until the deficiency is addressed. Emergency repairs, closures, or removals are to be completed either by MDOT crews or emergency contract (or combination thereof) to address impacts to public safety. Structural issues resulting in immediate impacts to public safety should be considered for emergency contracting to address and the policy included in the Authority for Bridge Closures memorandum should be followed located at the following link:

MDOT Memo On Authority for Bridge Closures

Priority Level 2, Critical

Repairs, mitigation, or monitoring to be completed within 1 year or as determined by engineering judgement. The deficiency examples below are deemed to pose critical threats to public safety if left unaddressed within the specified timeframe. Emergency contracts shall not be used for this Priority Level.

This Priority Level requires review and assessment of the active RFA list to ensure Priority Level 2 items are addressed within the appropriate timeframe or do not escalate to a Priority Level 1.

Priority Level 3, Primary

Repairs, mitigation, or monitoring to be completed as determined per engineering judgement. The deficiency examples below are not deemed to be critical threats to public safety but could be if left unaddressed within the specified timeframe. Necessary repairs or mitigations for structures in this Priority Level could be programmed through the MDOT Call for Projects process or addressed through maintenance, if possible.

1.8.5 CLOSING REQUEST FOR ACTIONS

The AS RFA Committee meetings are scheduled monthly. The monthly meetings will consist of reviewing and prioritizing the current RFA requests, confirmation of resource availability, and implementation monitoring. The AS RFA Committee Chair will attend AS Steering Committee meetings as necessary to discuss any issues requiring further guidance.

Timeframes for the completion of work for each RFA will be based on the assigned Priority Levels and progress toward reducing the overall number of active RFAs will be tracked. RFAs considered to be Priority Level 1 (Emergency) will be reviewed by the RFA Committee when submitted and are not dependent upon the Committee monthly meeting schedule. The RFA Committee will develop a review system to facilitate tracking and closure of actions. The process actions by responsible parties are shown in *Table 1-5*: Summary of RFA Responsibilities and Actions.

Table 1-5: Summary of RFA Responsibilities and Actions

Responsibility	Action	Action Description
Team Leader/ Region AS Champion	1.	Initiates RFAs through the submission of a RFA form or a telephone call to the local TSC or Region personnel depending on the situational urgency. The local TSC or Region personnel are notified of recommended Priority Level 1 RFAs to be reviewed and addressed immediately. Appropriate MDOT Business Areas are notified per RFA Form guidance. Other asset owners are notified to take actions for the assets not owned by MDOT.
RFA Committee	2.	Review and accept final Priority Levels 2 & 3 RFAs and escalate priority level to 1 if RFA committee assesses the defect as more critical than originally thought. Decide on intermediate and/or final actions to be taken to address identified issues and restore the structure to a state of good repair such that the RFA can be closed out. Initiate final actions in Action 3.
Subject Matter Experts	3.	Perform intermediate action inspections. Recommend Priority Levels, timeframes, and final actions including any increased inspections for review and acceptance by the RFA Committee.
Maintenance/ Other Contract	4.	Execution of final actions necessary.

Responsibility	Action	Action Description
PMC Inspection Team	5.	Monitor maintenance or construction progress. Recommend closing out RFAs following completion or execution of final actions.
Region AS Champion	6.	Review final action recommendations for acceptance and close out RFAs.
RFA Committee Chair	7.	Record progress on addressing RFAs within predefined timeframes and any delays (e.g., funding, local agency coordination, etc.) for reporting. Identify issues that need to be discussed with the Steering Committee for further guidance.

1.9 Special Inspection Procedures

A special inspection may be required to verify findings from the initial or routine inspection, perform additional non-destructive testing, monitor/address conditions, or schedule follow-up site visits. Special inspections may involve enhanced accessibility, special qualifications, and engineered studies or analyses.

Special inspections consist of two major categories: In-depth or Damage Inspections. These Special Inspection types and requirements are discussed.

1.9.1 DAMAGE INSPECTION

Damage inspections are defined as an unscheduled inspection to assess structural damage resulting from environmental factors or human actions. Most damage inspections in Michigan are the result of vehicle or vessel impact to components of an AS. Occasionally the damage causes instability of the AS and reduces the safe function of the AS until repairs are performed. When the damage is substantial it may be a safety issue and the RFA Process shall be initiated. Timely response is required to protect public safety and accurate documentation of the resulting effects shall be accomplished to execute repair or replacement activities. Reporting of the damage is also required for recuperation of costs associated with the inspection, repair, or replacement activities.

Damage Inspection Types I, II, and III follow damage inspection types detailed for bridge inspections in the MiSIM.

Type I Damage Inspection

A Type I inspection shall be completed when minor damage has occurred that was not previously documented or reported. This type of inspection is conducted at distances normally associated with a routine safety inspection where immediate repair work and testing is determined to be unnecessary. Generally, a Type I inspection is satisfactory for unreported vehicle impact damage with the observed defects that include surface damage, such as scrapes to the protective coating, distortion of 2” or less with no bending connections, or shallow spalling that does not exceed 6” in width without cracking.

Documentation shall occur as part of the Work Rec process during a routine inspection or damage inspection report for unscheduled inspections. Photographs with comments describing the damage and associated elements shall be provided. If any concern exists

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following the conclusion of the inspection, an RFA will be submitted. The AS RFA Committee is responsible for reviewing the RFA to determine whether a Type II inspection or other additional action shall be coordinated.

Type II Damage Inspection

A Type II inspection shall be completed whenever damage has occurred that is reported by law enforcement, the degree of damage exceeds the limits specified for the Type I inspection, or when engineering judgment dictates a need for hands-on inspection. Documented damage is provided by law officials through the issuance of a State of Michigan Traffic Crash Report (UD-10) to the agency. MDOT would then request the PMC perform a Type II Damage inspection. This type of inspection is conducted at arms-length to verify the requirements of repair work that may be scheduled or to provide a detailed historical record of any deformations that exist. This inspection shall be performed within 180 days from receipt of the UD-10, but it is recommended to be completed in cases where MDOT personnel arrive at the scene immediately following the incident.

All vessel impact and fire damage inspections should also begin with a Type II damage inspection to accurately assess whether affects to structural capacity occurred. Detailed measurements and photographs of all the affected components and elements shall be documented on the damage inspection report. It is also recommended provide reference for the inspection work or repairs that are installed. If any concern exists following the conclusion of the inspection an RFA shall be submitted. The AS RFA Committee is responsible for reviewing the RFA to determine whether a Type III inspection or other additional action shall be coordinated.

Type III Damage Inspection

A Type III inspection shall be completed when critical damage to the structure causes concern for stability or loss of safe structural capacity. Most of these inspections are initiated from verbal contact from law enforcement, although they may also result following observations during the Type I or II damage inspection. This inspection shall be performed as soon as the scene is safe for individuals and equipment to access the affected ancillary structure. Detailed measurements and photographs of the damaged components and elements shall be documented on the damage inspection report. When immediate repairs are necessary a narrative of the activities completed shall also be provided. Additional actions may be necessary following the inspection which shall be documented on the RFA form. The AS RFA Committee is responsible for reviewing the RFA. The AS Program Manager in coordination with the PMC is responsible for facilitating the necessary actions to resolve the matter and inventory and inspection coding. All damage that results in a safety issue shall be documented on the RFA form or AMS.

Damage Inspection Procedures

Since damage inspections are unscheduled events, extensive resources may not be available to immediately respond. The AS owner is usually the first to be informed of reported damage and often responds directly to the incident. The AS owner may delegate the responsibility of completing the damage inspection to a qualified individual or to the AS Program Manager. Although processes may vary according to agency specific guidelines, the AS owner is ultimately responsible for initiating any required reactions stemming from the reported damage and coordinating the immediate or intermediate actions that shall be undertaken. The course of action taken to ensure public safety will be unique for many incidents and depend upon the extent of damage or the resources available to mitigate public mobility impacts. The procedures that have been developed are guidelines for the AS owner and responding individuals to follow. The assessment of damage should follow established practices, when available, according to the conditions encountered and the degree of damage present. The AS owner or delegated authority responsible for assessing the damage may decide to deviate from established practices according to the damage encountered. However, the AS owner shall ensure that the level of response is appropriate for each reported incident, the damage is well documented, and confirm that follow-up activities to maintain public safety are accomplished. Resulting findings and recommendations shall be documented and submitted to the AS Program Manager and retained as Significant Correspondence as detailed in Section 1.3.

1.9.2 IN-DEPTH INSPECTION

Special inspections may be required to verify findings from the initial or routine inspection, to perform non-destructive testing, or to monitor/address conditions that may impact safety or serviceability. Special inspections not initiated from Damage are termed In-depth inspections. In-depth inspections may be required depending on RFA or Work Rec processes. These in-depth inspection items, which may be conducted as part of a special inspection, are detailed in the following subsections.

RFA-Initiated Special Inspection

Through the RFA process, the RFA committee in collaboration with the PMC may initiate an In-depth inspection. Subject Matter Experts in consultation with the PMC will define the extent of the In-depth inspections.

Work Recommendation-Initiated Special Inspection

Some structures will be encountered during the routine inspection in a state that requires a more detailed inspection than what is feasible during routine inspection but does not warrant an RFA. In this case, an inspector may recommend a Work Rec. The MDOT Program Manager will engage Subject Matter Experts to define the extent of the In-depth inspections.

In-depth Inspection Procedures

Means and methods for the In-depth inspection procedures are anticipated to vary depending upon the type of condition state defects or other structural inadequacies noted in the RFA or Work Rec. Subject Matter Experts should engage to determine the appropriate extent of investigation. The extent of investigations may include, but are not limited to, additional field investigation, testing, and analysis. If available, Subject Matter Experts may request or be provided the plans, specifications, construction documentation, and previous routine inspection results for the Ancillary Structure. Resulting findings and recommendations shall be documented and submitted to the AS Program Manager and retained as Significant Correspondence as detailed in Section 1.3.

1.10 Element Condition States

1.10.1 PURPOSE

The purpose of this section is to provide condition state information for structures inspected within the state of Michigan. This section is to be used by inspectors when collecting element level data.

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The element level inspection method breaks the ancillary structures down into several elements. The element level inspection is a quantity-based inspection, and each quantity is assigned a Condition State to reflect the differing categories of deterioration that often exist on any element.

One of the results of performing element level inspections is the generation of a database for an AMS. By developing a database over time, deterioration rates based upon material, geographic location, age, usage, type of crossing, prior rehabilitation, or preventive actions, etc., can be estimated. The software modeling capabilities allow comparisons between the effectiveness of preventive and corrective actions, predictions of estimated future deterioration, and life cycle costs. Decisions can be made regarding prioritizing funds, when (or when not) to take action, and what type of action to take for the maximum benefit of capital spent.

1.10.2 DETAILED ELEMENT CONDITION STATE DESCRIPTIONS

The condition state tables for each asset are located in their respective section. They contain defect descriptions and severity with guidelines for the inspector on defect severity categorization.

The condition state descriptions are adapted from the standard set of National Bridge Elements (NBE), Bridge Management Elements (BME), or MDOT Agency Developed Elements (ADE). Some elements are unique to ancillary structures and their condition state descriptions were created for the Program.

Structure-specific Section 2 through Section 14 attempt to cover most conditions observed in the field, but the inspector may find conditions that are not described. In these cases, use the general description of the condition states to determine the appropriate condition. Overarching descriptors for the four condition states are as follows:

Condition State 1 (Good) – that portion of the element that has either no deterioration or the deterioration is insignificant to the management of the element, meaning that portion of the element has no condition based preventive maintenance needs or repairs. Areas of an element that have received long lasting structural repairs that restore the full capacity of the element with an expected life expectancy equal to the original element can be recorded as good condition.

Condition State 2 (Fair) – that portion of the element that has minor deficiencies that signifies a progression of the deterioration process. This portion of the element may need condition based preventive maintenance. Areas of the element that have received structural repairs that improve the element, but the repair is not considered equal to the original member recorded as fair.

Condition State 3 (Poor) – that portion of the element that has advanced deterioration requiring repair. The summation of the quantity of the element in poor or worse condition determines the need for repairs, rehabilitation, or replacement activities.

Condition State 4 (Severe) – that portion of the element that warrants a review to determine the effect on strength or serviceability of the element or structure; OR a structural review has been completed and the defects impact strength or serviceability of the element or structure. Elements with a portion or all of the quantity in state 4 may often have load capacity implications warranting a structural review. Within this manual, the term structural review is defined as a review by a person qualified to evaluate the field observed conditions (Subject Matter Expert) and decide the impacts of the conditions on the performance of the element. Structural reviews may include a review of the field inspection notes and photographs, review of as-built plans or analysis as deemed appropriate to evaluate the performance of the element.

Each subsection contains a detailed description for each element and is broken down into the following subsections:

- Structure Type
- Element Number and Name
- Condition State Table to Reference
- Description—Detailed identification and classification of the element.

Unlike the Michigan Bridge Element Inspection Manual (MiBEIM), the MiASIM applies to 15 different Ancillary Structure types instead of a single structure type. Although elements and associated condition states may be similar between ancillary structures, differences in the severity of condition state defects may occur due to different element design considerations. For some ancillary structures, condition state defects are grouped together for each element (e.g., concrete foundation element defects include distresses such as concrete cracking, exposed reinforcement, and erosion). Therefore, rather than referencing Condition States for each element for all ancillary structure types, each structure contains an element subsection arranged as follows:

- Ancillary Structure Type
- Associated Elements – With definition of the element
- Condition States for Each Element – Guidelines for the inspector on defect severity categorization

2 CULVERTS LESS THAN 10-FOOT SPAN

2.1 Definitions

A linear drainage conduit(s) that has a combined span of less than 10 feet as measured along the centerline of the roadway, and the conduit is 12 inches in diameter or greater. Culverts are differentiated from storm sewers in that they are straight-line conduits that are open at each end and typically do not include intermediate drainage structures (manholes, catch basins etc.).

2.1.1 INVENTORY ITEMS

Ditch vegetation is an inventory item of none, partial, or full to note the amount of vegetation blocking the culvert structure opening.

The inventory requires noting the location and type of end treatment: none, headwall, headwall with wingwalls, beveled, mitered, flared, or sloped. If there is an end treatment, the type of material (metal, concrete, clay, or plastic) should also be noted.

The inventory items specific to culvert structures include the material that comprises the culvert barrel. Note the specific type of plastic pipe that is present (if unknown, select Plastic) such as Polyethylene, polypropylene, or PVC, whether the concrete pipe is prestressed or post-tensioned, reinforced, or non-reinforced (if unknown, select Concrete).

Culvert structure inventory also requires confirming the culvert shape: circular, horizontal elliptical, vertical elliptical, arch, box, or 3-sided. For metal barrels, note if the culvert is corrugated or non-corrugated.

If there is a barrel liner, the liner material type will be inventoried.

The culvert height, width, and span should be noted in inches. The water depth at the inlet and outlet should be noted.

The culvert inventory includes culverts under bridge slopes. The inventory identifies such culverts as “beneath” berm. Inspectors should note in the application that the culvert is beneath the paved bridge slope.

Take photos of the required inventory items listed in Section 2.2.2.

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

2.1.2 ELEMENTS

Culverts Less Than 10-Foot Span are divided into four components: Approach Roadway and Embankment, Channel, End Treatments, and Culvert Structure.

End Treatments are further divided into elements: Headwall, Wingwall, and Scour.

The Culvert Structure is further divided into elements: Barrel and Joints.

The approach roadway and embankment and the channel are not divided into elements.

Elements are assigned a condition state described in Section 2.7 based on the distresses identified in each element. The following guidelines for consistent location notation provide the framework to be followed when rating a culvert element in accordance with the condition rating tables.

Consistent Location Notation Examples:

- Culvert Length - Distress locations along the culvert barrel length are referenced by using offsets measured from the outlet end and photographs. The outlet cardinal direction relative to the roadway is referenced also.
- Culvert Radius - The location of points on circular, elliptical, and arch-shaped culvert barrel cross sections is referenced like hours on a clock, with orientation of the clock looking upstream from the outlet. On non-round shaped cross sections, the locations are measured offsets from discrete locations such as corners, longitudinal seams, and foundations. The outlet cardinal direction relative to the roadway is referenced also. This allows for easy record transition for common changes such as culvert barrel length extensions for roadway widening.
- Joints - Identify offsets measured from the outlet end and photographs, rather than counting joint numbers.
- Defects are noted in the inspection report by recording the size of the defect (approximate length by width), distance from outlet, and the clock position or location on the structure wall.

Table 2-1: Culvert Less than 10-Foot Span Components and Elements

Component	Element	Element Code	Unit of Measure
Approach Roadway and Embankment	N/A	N/A	N/A
Channel	N/A	N/A	N/A
End Treatments	Headwall	12301	Each
End Treatments	Wingwall	12302	Each
End Treatments	Scour	12303	Each
Culvert Structure	Barrel	12404	Length, ft
Culvert Structure	Joints	12405	Each

2.1.3 COMPONENTS

Culverts Less Than 10-foot Span are divided into four components: the approach and roadway embankment, the channel, end treatments, and the culvert structure.

Component ratings for Culverts Less Than 10-foot Span are based on the following:

- Approach Roadway and Embankment - Consider the influence of the buried system on the length of roadway and shoulder above the culvert.
- Channel - Consider if the channel, including its watercourse, bed, and adjacent banks, may have anomalies that impact the performance or structural stability of the culvert.
- End Treatments - Consider if the end treatments may have characteristics that impact the structure's performance or if there is scour which impacts the concrete footing performance.
- Culvert Structure - Consider the barrel and joints as critical to the overall culvert structure performance.

A representation of the rating structure for Culverts Less Than 10-foot Span is illustrated in Figure 2-1.

All components are rated based on the guidance provided in Section 2.4 Routine Inspection. The overall culvert rating reflects the minimum of the Approach Roadway and Embankment and Culvert Structure component ratings.

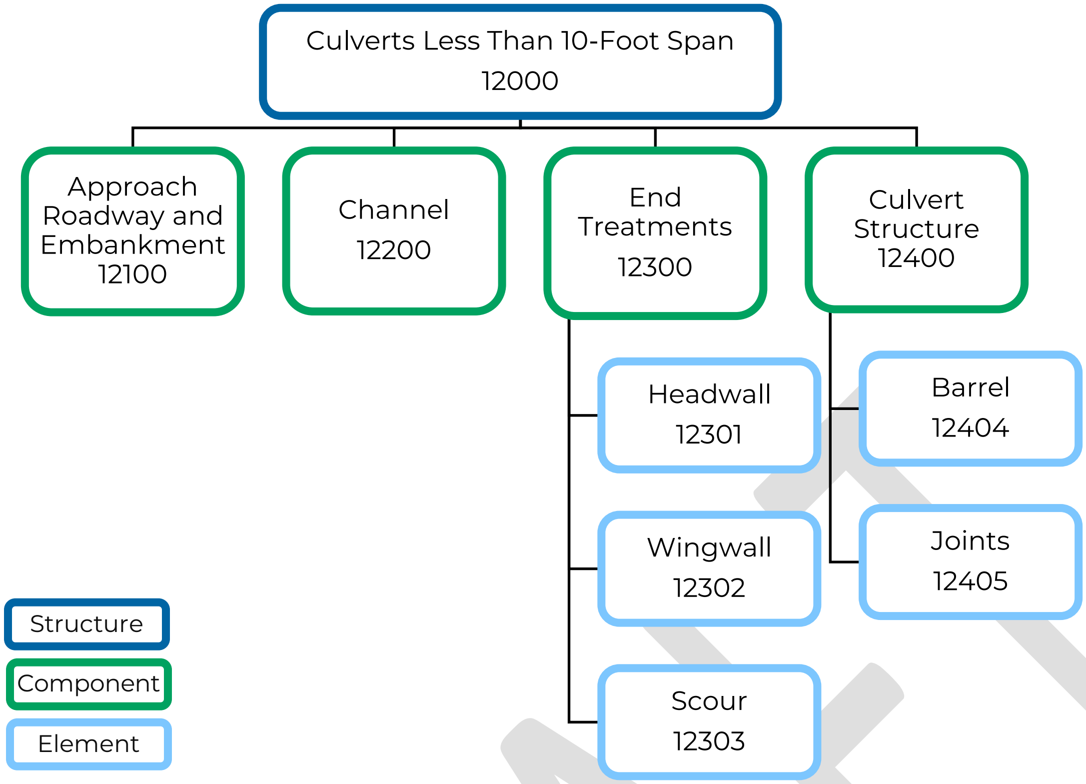

Figure 2-1: Component-element Structure for Culverts Less than 10-Foot Span

Culverts Less Than 10-Foot Span

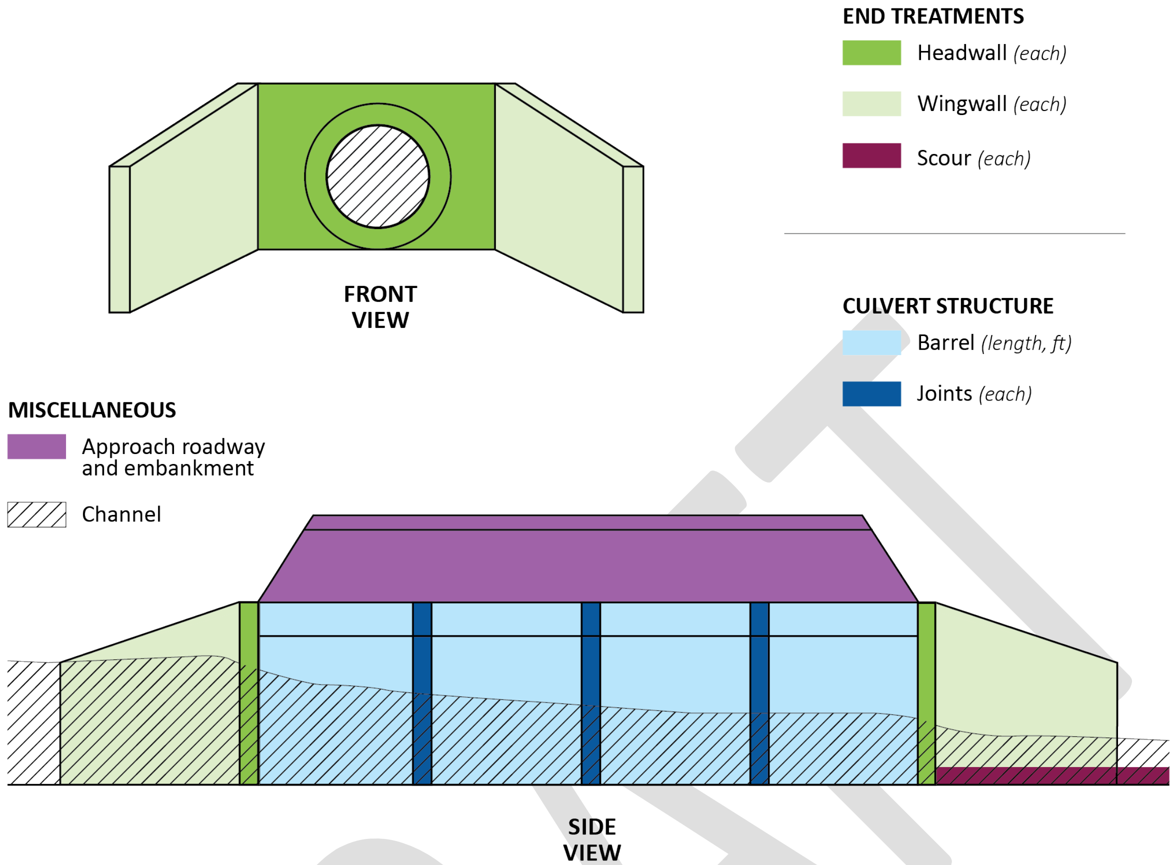

Figure 2-2: Elements and components for Culverts Less Than 10-Foot Span

2.2 Inventory Record Photographs

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

Culvert Less Than 10-Foot Span Required Photos:

- General view of the roadway above culvert
- General view of the channel (upstream and downstream)
- General view of each end section (both sides)
- General view of the culvert barrel

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Table 2-2: Culvert Less Than 10-Foot Span Photograph Naming Convention

Photo Name	Description
Culvert_Inlet	Entire inlet structure and adjacent slope
Culvert_Upstream_Channel	Channel upstream from inlet
Culvert_Barrel_From_Inlet	Barrel from inlet end
Culvert_Outlet	Entire culvert outlet structure and adjacent slope; looking into barrel
Culvert_Downstream_Channel	Channel downstream from outlet in the direction of flow
Culvert_Barrel_From_Outlet	Barrel from outlet end
Culvert_Road_Crossing	Roadway above culvert taken from inlet structure; looking in the direction of flow

Note: If there are two large culverts with a total barrel width exceeding 10', but they are separated from each other by greater than half the width of a single barrel, they are considered two culverts. Separate photos of each barrel and photos combined with all barrels should be taken.

2.3 Inspector Minimum Technical Qualifications

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

- A minimum experience of ten structures combined concrete inspection, steel inspection, or design experience (bridge inspection qualifies). At least three of the ten inspected structures shall be concrete structures.
- Ancillary structures inspection procedures training
- Working knowledge of inspection tools, their use, application, and limitations for the structure type being inspected.
- Inspection experience with anticipated material types, such as concrete, timber, masonry, or steel. Internal training will address inspection procedures for all anticipated material types.

2.4 Routine Inspection

Culvert standard inspection frequency is once every 5 years, unless otherwise identified for more frequent inspection.

Table 2-3 provides guidance for inspecting reinforced and prestressed concrete cracking.

Table 2-3: 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)

2.4.1 APPROACH ROADWAY AND EMBANKMENT ROUTINE INSPECTION

The approach roadway is the length of roadway and shoulder above the culvert that is influenced directly by the performance of the buried culvert system. This includes the pavement (or gravel if not paved), guardrails, and shoulders. The inspection area for the approach roadway includes the culvert span plus a minimum of 20 feet from where each side of the culvert structure ends.

The embankment inspection focuses on the immediate soil slope area. The embankment inspection is conducted visually for slope stability (sloughing or piping) and embankment erosion, which can be interrelated.

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

2.4.1.1 Approach Roadway and Embankment Component Ratings

The purpose of approach roadway inspection is to evaluate the condition and functional adequacy, with a focus on how distress at the pavement, shoulder, and guardrail areas may indicate problems with the culvert below. For example, cracks, sags, or pavement patches may indicate a void around the buried pipe or pipe joint distress. The approach roadway inspection can provide indicators of potential distress in the culvert.

The embankment inspection, like the approach roadway, is to identify distress indicators related to erosion and slope stability that can affect the culvert performance. For example, movement of the embankment soil (sloughing) can open pipe joints, destabilize structures, and ultimately endanger the roadway.

Issues observed in the approach roadway can often be an indicator for culvert performance; however, they can equally be unrelated. Because of this, it is important for inspectors to evaluate the relationship between any identified approach roadway distress and culvert distress whenever possible.

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Figure 2-3: Approach roadway, without observable distress (left), clear distress over culvert (right)

Table 2-4: Component Rating Guidelines for Culvert Less Than 10-Foot Span Approach Roadway and Embankment

Component Rating	Condition	Material	Description
9	**NEW**	All	No noticeable or noteworthy deficiencies which affect the condition of the approach pavement.
8	**VERY GOOD**	All	Minor cracking less than 1/32" wide (0.8mm) with no spalling, scaling, or delamination on the approach pavement.
7	**GOOD**	All	Open cracks less than 1/16" wide (1.6mm) at a spacing of 10 ft or more, light shallow scaling allowed in the surface. Approach pavement will function as designed.

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Component Rating	Condition	Material	Description
6	SATISFACTORY	All	Deterioration of the approach pavement, including repaired areas, is 2% or less of the total area. There may be a considerable number of open cracks greater than 1/16" wide at a spacing of 5 ft or less in the approach pavement. Medium scaling on the surface is 1/4" to 1/2" in depth. Settlement is minor. Approach pavement will function as designed. Embankment may have minor damage.
5	FAIR	All	Deterioration of the approach pavement, including repaired areas, is between 2% and 10% of the surface area. There can be excessive cracking in the surface. Heavy scaling 1/2" to 1" in depth can be present. Settlement is less than 3/4 inches at the culvert centerline. Approach pavement will function as designed. Embankment may have major damage.
4	POOR	All	Deterioration on the approach pavement, including repaired areas, is between 10 - 25%. Settlement is more than 3/4 inches at the culvert centerline. Approach pavement will function as designed. Embankment may have severe damage.
3	SERIOUS	All	Deterioration in the approach pavement, including repaired areas, is more than 25% of the surface area. Urgent surface repairs may be required by the crews.
2	CRITICAL	All	Deterioration has progressed to the point where the approach pavement will not function as designed. Emergency surface repairs may be required by the crews.
1	IMMINENT FAILURE	All	Roadway or roadway shoulder above culvert closed because of approach roadway or embankment failure. Corrective action may put back in service.
0	FAILED	All	Roadway closed above culvert.

2.4.1.2 Pavement and Shoulders

Pavement issues may lead to infiltration, which can cause a loss of backfill around the pipe. The loss of backfill reduces the pipe lateral support and may progress to create voids near and over the pipe. This can result in undermining of pavements that can be observed as cracking, or sags/humps. Pavement types for the purpose of this inspection item may consist of asphaltic concrete, Portland Cement concrete, gravel, or other surface treatments. Field experience has shown that even flexible pavements can bridge relatively large voids, with only a small hole in the pavement hiding large subsurface voids.

When not detected and addressed, the loss of soil support can progress to pavement failure.

Settlement

Pavement or shoulder settlement can be due to many different factors such as:

- Poorly compacted materials
- A significant difference in soils used for roadway embankment compared to those used for pipe embedment
- Piping (washout of fines) along the culvert causing voids or cracks above
- Settlement of backfill material, allowing movement of the structure
- Flexible pipe barrels will deflect at their crown if:
    - Adequate lateral support is not provided by the surrounding embedment soil
    - Pipe is overloaded and deflects
- For rigid culverts, inadequate compaction or low-quality embedment soil can result in settlement on either side of the culvert, usually forming a hump over the buried pipe

Sighting along the edge of pavement or along pavement markings is also important and can reveal settlement indicators including humps, sags, and rutting.

Figure 2-4: Pavement and shoulder issues above culverts

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Sags and Humps

Sags and humps can be indicator of an issue with the culvert below the roadway. They could be from settlement after construction or signs of a much larger issue with the culvert, such as joint infiltration or piping.

Rutting

Rutting is a surface depression in the wheel path that runs parallel to the direction of travel. It is typically from vehicular loads and not related to culvert condition but can sometimes be a sign that is related to a defect and/or deterioration below the surface. Determine if the rutting is repetitive on the roadway or localized to the culvert area. Rutting that appears localized to a culvert may be an indicator for deflection of the pipe or loss of backfill material, like the causes for sags and humps

Cracking

Transverse and longitudinal cracking that occurs over a buried pipe is often a distress indicator for settlement, deflection, or loss of backfill support. All open pavement cracks in the approach roadway inspection length are to be probed for the presence of voids. Record other pavement distress in the approach roadway even if it does not appear to be directly related to the culvert.

Transverse cracks are often related to culvert distress. These cracks run perpendicular to the direction of the road and are of primary interest as a distress indicator in culvert inspection. Regularly spaced transverse cracks along long stretches of roadway are usually caused by temperature-induced expansion and contraction and may not indicate culvert distress. Try to locate any sags or humps that may be associated with transverse cracks over the culvert.

Figure 2-5: Transverse cracking of pavement above culvert

Longitudinal cracks run parallel to the direction of the road. Cracks within 1 foot of the lane edge are typically caused by shoulder settlement, frost action, or poor drainage, and may be unrelated to the presence of buried pipes. Consider these factors when assessing longitudinal cracks as distress indicators for a culvert. Longitudinal cracking that is not a distress indicator for the culvert does not need to be included in the condition rating but shall be noted in the comments.

Figure 2-6: Longitudinal cracking

Alligator cracks are a form of fatigue cracking that forms a pattern of small angular pieces of pavement creating an appearance like alligator skin. This type of cracking is not typically associated with culvert distress. However, it may similarly indicate distress in the culvert if alligator cracking exists locally over the culvert but not in other areas. Note the presence of alligator cracking in the inspection report in the comments.

Figure 2-7: Pavement and shoulder alligator cracking

Slippage cracking is characterized by a generally rounded pattern caused by slippage between an overlay and underlying pavement occurring most commonly at intersections with high volumes of stop/start traffic. As with alligator cracking, slippage cracks do not typically indicate culvert distress. Note the presence of slippage cracks in the inspection report in the comments.

Figure 2-8: Slippage cracking

Other notable approach considerations

Several other factors can cause distress in the approach roadway. If present, they are noted as an important comparison basis for subsequent reviews. If necessary, they can be noted as needing an in-depth inspection. Items that shall be recorded in the notes include:

- Obvious changes in the approach roadway, such as:
    - Grade changes to the roadway, that may reduce the overflow capacity of the culvert system, or

- The addition of a guardrail or barrier that may increase water directed into the channel.
- Pavement patches or crack sealant that have reopened and are determined to indicate:
  - Progressive settlement,
  - Leaking joints, or
  - Other ongoing problems

2.4.1.3 Embankment

The embankment inspection shall focus on the immediate soil slope area. The embankment is visually inspected for slope stability (sloughing) and embankment erosion (piping), which can be interrelated.

This includes burial cover for the pipe from the roadway shoulder, down to the bottom of the slope at the inlet and outlet ends. The inspection width is the same as defined for the approach roadway, a 20 foot minimum on either side of the culvert.

Types of embankment distress are noted below.

Figure 2-9: Example of embankment failure above a culvert

Figure 2-10: Example of embankment issues due to piping (left) or erosion (right)

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Sloughing

Sloughing is the sliding or collapse of a soil slope, caused when the underlying material becomes saturated with water. Sloughing appears as a vertical cut or drop to where the sloughed mass of soil has collapsed downslope.

Tension Cracks

Tension cracks can occur at the top of the embankment slope or adjacent to the top of a retaining wall. Tension cracks are semi-circular in shape to match the slip surface, typically run parallel to the stream, roadway, or retaining wall and can be a precursor to slope failure.

Embankment Erosion

Embankment erosion refers to the loss of the surface materials on the embankment, including vegetation or other protective materials that are used to aid slope stability. Embankment erosion may indicate inadequacy of the roadway and shoulder surface storm water collection system.

There are several types of erosion. It is important to assess the severity of the erosion in relation to the roadway and culvert support. Photo documentation is also vital in determining the progression of any erosion. The following are the main types of erosion related to culverts.

Sheet Erosion

The washing away of slope vegetation and thin layers of soil as runoff water flows in sheets down the slope. Embankment slopes are prone to sheet erosion as water flows off the roadway and down the embankment. Early-stage sheet erosion starts as bare areas, puddling, exposed vegetation roots, and/or exposed subsoils (stony or rocky soils).

Gullying/Rill Erosion

Specific types of surface erosion where runoff carves channels in the soil. This typically occurs with multiple barrel pipes and/or with mitered or projecting ends

Figure 2-11: Culvert erosion—early-stage gully/rill erosion between the culverts

Piping

Erosion of the backfill where water flows along the outside of the pipe. Piping along the outside of the barrel of the culvert can reduce backfill support and can lead to weakened embankment slope stability.

Piping typically presents as one or more of the following:

- Voids or tension cracks in the embankment soil

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- Voids or tensions cracks in the roadway
- Streams of water exiting the embankment in the slope face
- Streams of water around the exterior of the pipe wall during times of high flow

Piping may occur when culvert barrel blockage or upstream embankment conditions cause increased pressure.

2.4.2 CHANNEL ROUTINE INSPECTION

The stream channel is a feature of a culvert system and consists of the watercourse, its bed, and the adjacent banks. Inspection of the channel is performed from the inlet and outlet of the structure. The channel component does not contain any associated elements. Visually observe the channel limits to identify where water typically flows into the culvert, using visual observation such as cut bank, vegetation lines, limits of channel armoring, or limits of the exposed stream bottom.

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

2.4.2.1 Channel Component Rating

The purpose of the channel inspection is to identify channel-related anomalies that may impact the performance or structural stability of the culvert. If a culvert is blocked or the stream capacity is reduced, the waterway adequacy may change significantly. This can result in excessive ponding, flooding of nearby properties, and washouts of the roadway and embankment.

The stream channel leading to the culvert inlet and moving away from the outlet end is inspected to determine whether conditions exist that would cause damage to the culvert system (soil and structure) or adjacent property. Factors to be checked include alignment of the channel relative to the culvert (horizontal and vertical alignment), bank erosion and scour, condition of bank protection, and accumulation of sediment and debris (waterway adequacy). A brief discussion of each of these factors follows.

Poor vertical and horizontal alignment of the culvert relative to the stream channel can result in reduced hydraulic efficiency, increased erosion or sedimentation of the stream channel, damage to the embankment supporting the roadway, and damage to adjacent property. Often, protective measures are required to maintain stability of the channel and hydraulic and structural performance of the culvert.

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Figure 2-12: Stream channel poor vertical alignment (left) and horizontal alignment (right)

Table 2-5: Component Rating Guidelines for Culvert Less Than 10-Foot Span Channel

Component Rating	Condition	Material	Description
9	NEW	All	No noticeable or noteworthy deficiencies affect the condition of the channel
8	VERY GOOD	All	Banks are protected or well vegetated. River control devices such as spur dikes and embankment protection are not required or are in a stable condition.
7	GOOD	All	Bank protection is in need of minor repairs. River control devices and embankment protection have a little minor damage. Banks and/or channel, have minor amounts of drift.
6	SATISFACTORY	All	Bank is beginning to slump. River control devices and embankment protection have widespread minor damage. Minor stream bed movement is evident. Debris is restricting the channel slightly.
5	FAIR	All	Bank protection is being eroded. River control devices and/or embankment have major damage. Trees and brush restrict the channel.
4	POOR	All	Bank and embankment protection is severely undermined. River control devices have severe damage. Large deposits of debris are in the channel.
3	SERIOUS	All	Bank protection has failed. River control devices have been destroyed. Streambed, aggradation, degradation, or lateral movement has changed the channel to threaten the culvert and/or approach roadway now.
2	CRITICAL	All	The channel has changed to the extent the culvert is near a state of collapse.

Component Rating	Condition	Material	Description
1	IMMINENT FAILURE	All	Roadway or roadway shoulder above culvert closed because of channel failure. Corrective action may put back in service.
0	FAILED	All	Roadway above culvert closed because of channel failure. Replacement necessary.

Horizontal Alignment

Check for erosion and indicators of changes in the direction or location of the stream channel. Plan-view sketches and site photographs are used to document the condition and horizontal alignment of the channel relative to the culvert barrel at the time of inspection. The alignment is critical for a three-sided culvert which may be susceptible to failure due to scour. Abrupt changes in stream horizontal alignment (bends) retard flow and cause increased erosion along the outside of the bend, damage to the culvert and end treatments, and increased sedimentation along the inside of the bend. Where sharp channel bends exist at either the inlet or outlet of a culvert, check for sedimentation and erosion.

Figure 2-13: Stream channel poor horizontal alignment

Vertical Alignment

Problems related to vertical alignment are usually indicated by scour or accumulation of sediment. Culverts on grades that differ significantly from the natural gradient (stream channel alignment) may present problems. Culverts on flat grades may have sediment build-up at the entrance or within the barrel. Culverts on moderate and steep grades generally have higher flow velocities than the natural stream and may have problems with outlet scour.

Figure 2-14: Vertical alignment issue leading to foundation undermining

Figure 2-15: Vertical alignment issue leading to stream degradation

Figure 2-16: Vertical alignment distress; may have progressing washout due to high flow

Waterway Adequacy

Determine the ability of the culvert to handle peak flows, changes in the watershed, changes in the stream channel which might affect the hydraulic performance, and, most commonly, levels of sedimentation and debris accumulation. Assessment of waterway adequacy includes inspection of highwater marks and waterway obstructions. Waterway adequacy may not be a large concern for smaller culvert component rating.

Figure 2-17: Blocked inlet

High Water Marks

The high-water marks may not seem important, but they be an indicator for inadequacy of the culvert and shall be investigated. Note any indications of excessive ponding, flooding, or overtopping of the roadway. If the cause is apparent, such as a blocked inlet, note in the inspection comments.

Waterway Obstructions

Accumulation of debris and sediment at the inlet or within the culvert barrel reduces both the size of the opening and the culvert's capacity to handle peak flows and may cause scour of the stream banks and roadway embankment, head cutting, or changes in the channel alignment. Debris and sediment accumulations at the culvert inlets or within the culvert barrel may result in roadway overtopping, excessive ponding, and the potential for damage due to buoyant forces. Note deposits of debris or sediment that could block the culvert or cause local scour in the stream channel. Downstream obstructions which cause water to pond at the culvert's outlet may also reduce the culvert's flow capacity.

Debris collectors are used in some culverts so that the opening is not blocked by floating materials. Identify these devices and note if their condition contributes to debris accumulation or renders them nonfunctional, or if they need repair.

Note some culverts may be designed with fill in the bottom (invert) to create a more natural stream bed for fish. Identify these culverts to distinguish intentional fill from debris accumulation.

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Figure 2-18: Intentional natural streambed

Head Cutting/General Scour

General Scour extends farther along the stream and is not localized around a particular obstruction. General scour involves a gradual, fairly uniform degradation or lowering of the stream channel. It can also result in abrupt drops in the channel that move upstream during peak flows. This type of scour is referred to as head cutting. Head cutting is channel degradation associated with abrupt changes in the bed elevation that migrates in an upstream direction. Head cutting may be a serious problem if it is occurring in the channel downstream from the culvert because it may threaten the culvert outlet as it moves upstream.

Bank Erosion

Bank erosion, in contrast to general scour and head cutting, refers to loss of stream channel (bank) sidewall material and a lateral movement of the channel. Bank erosion includes expansion of the channel at a change in direction of the stream when protection is not provided or provided protection is not adequate. Signs of severe bank erosion include undercutting of bank edge and sod root overhangs.

Figure 2-19: Bank erosion

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Figure 2-20: No scour (left), scour hole (right)

2.4.2.2 Channel Element Condition States

NOT USED.

2.4.3 END TREATMENTS ROUTINE INSPECTION

The end treatments are composed of headwalls and wingwalls, and the concrete footing and inverted slab associated with three-sided structures, such as concrete arches, open-bottom box culverts, and structural plate arches. Joints between the headwall and/or wingwall and the culvert barrel are assessed as part of the end treatment inspection, rather than the barrel as indicated in.

End treatments and appurtenant structures are the inlet/outlet structures and associated elements that are used to reduce erosion, retain fill material, inhibit seepage, improve hydraulic efficiency, provide structural stability to the culvert ends, and improve the appearance of the culvert. Several types of end treatments are commonly used at culvert inlets and outlets ranging from no treatment to a constructed-in-place end structure.

Three-sided structures, such as concrete arches, open-bottom box culverts, and structural plate arches, typically use concrete footings (also called foundations) to transfer vertical loads to the foundation soils. Structural plate arches are usually bolted to a base channel that is secured to the footing. Concrete arches are typically grouted into keyway recesses formed into the top surface of the footings. Invert slabs are paved or cast slabs used in lieu of a natural or open-bottom culvert or used within closed-bottom culverts to provide a widened waterway or as reinforcement for a new or deteriorated culvert.

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

2.4.3.1 End Treatments Component Ratings

Culvert end treatments and appurtenant structures perform a variety of functions and therefore are inspected to assess their structural stability, hydraulic performance, and traffic safety characteristics. Structural stability and hydraulic performance characteristics may differ considerably with different types of end treatments. Typically, assessment of joint between the end section and first pipe segment for evidence of separation is one of the first checks to be conducted. At the upstream end, this is an indicator of a high-water event causing a buoyancy lift. At the downstream end, joint separation can result from a

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scour hole and/or stream degradation. Both distresses often indicate an undersized culvert. The type of end treatment will dictate inspection procedures.

Inspect the concrete footing and invert slab to identify distress and distress indicators, typically due to scour, that may indicate foundation problems.

The flow line condition is also inspected as part of the component rating of the end treatments. Flow line condition is indicated by the amount of sediment or debris accumulation within the pipe. Blockage and ponding due to trees, shrubs, sedimentation, or debris may be noted. In severe conditions, the culvert may be blocked due to mass drift accumulation. There may be high water marks indicating roadway overtopping.

In addition to the foundation (concrete footing and invert slabs), headwalls, and wingwalls, end treatments may also include:

- Projecting ends
- Sloped end sections
- Precast concrete end sections
- Aprons and flumes
- Weep holes

End Treatment Projecting Ends

Projecting ends have no end structure attached to the culvert barrel and the pipe barrel simply projects out of the embankment. Projecting outlets, such as perched outlets, often result from scour holes formed due to impact of high exit velocities and/or stream degradation. They also result from erosion and can be a barrier to fish passage.

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Figure 2-21: Projecting or perched outlet

End Treatment Sloped End Sections

A sloped end section is a culvert end that has been modified to match the embankment slope. They often have safety bars that can trap debris. Culverts with mitered or skewed end treatments are inspected for the same types of problems as culverts with projecting ends. Sloped end sections include prefabricated metal or precast concrete sections that are placed on small diameter pipe.

Metal pipe culverts with a sloped end are inspected for deformation since cutting the ends reduces the structural integrity of the pipe. It is therefore important to check cut ends of culverts for signs of distress including deformation, erosion of the fill slope, and undercutting.

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Figure 2-22: Sloped metal end sections

Precast Concrete End Section

Precast concrete end sections are inspected for deformation and damage similar to sloped ends.

Aprons and Flumes

Aprons may consist of a concrete slab, grouted or un-grouted riprap, or other material. Aprons and flumes are checked for signs of undermining settlement or movement. Dry stone or un-grouted riprap is inspected for displaced or moving stones. A scour hole with a downstream mound will often form in rip-rap aprons and should generally not be disturbed by maintenance activities.

Weep Holes

Weep holes are often provided on the sidewalls and wingwalls to drain water from the backfill and reduce the hydraulic pressure on the concrete surface. Weep holes are inspected to determine if they are functioning properly. Lack of flow during wet conditions or at times when flow has previously been observed may indicate blockage. Fine soils in the flow also indicate improper functioning.

Other items that are used to assess the end treatment component rating are:

- Separation
- Voids
- End Section Drop-Off
- Settlement

Separation

Separation between the barrel and the headwall or wingwalls that exposes fill material can be serious and shall be reported for special attention as part of an RFA or Work Rec. Such separations permit the loss of the supporting soil and could lead to failure anywhere along the length of the culvert.

Voids

Metal headwall and wingwall inspections should include checking for voids behind the walls which may indicate a loss of backfill, toe-out (rotation) of the base which may indicate scour in front of the wall, and outward movement of the wall top which may indicate damage to anchor rods.

End Section Drop-off

Erosion can cause end section displacement and drop-off in rigid pipe culverts, particularly at the outlet ends. End section drop-off is a term used to describe the condition in which the end section of the culvert barrel has separated from the rest of the line. This is usually due to outlet scour, stream degradation, or erosion of the material supporting the pipe section at the outlet end of the culvert barrel.

Settlement

Settlement exerts additional stress on the ends of the culvert and may cause blockage or end failure.

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Table 2-6: Component Rating Guidelines for Culvert Less Than 10-Foot Span End Treatments

Component Rating	Condition	Material	Description
9	NEW	All	No deficiencies in any of the structural components that will affect the 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 coatings and/or dirt contamination on structural components.
7	GOOD	All	All members retain full section properties and function as designed. There may be minor cracking in structural components.
6	SATISFACTORY	All	All members retain full section properties and function as designed. There may be some deterioration affecting structural members such as minor cracking, scaling, small, scattered spalls, or shallow scour. Some protective coating failures.
5	FAIR	All	Moderate deterioration affecting structural members such as cracking, scaling, scattered spalls, minor settlement, or shallow scour. Minor section loss in low or no stress areas. All members continue to function as designed.
4	POOR	All	Considerable deterioration affecting structural members such as cracking, scaling, scattered spalls, partial settlement or, scour. All end treatments continue to function as designed.
3	SERIOUS	All	Considerable deterioration affecting structural members. Structural evaluation, hydraulic, and/or load analysis may be necessary to determine if the structure can continue to function without restricted loading, structurally engineered supports, or immediate repairs. There may be a need to increase the frequency of inspections.
2	CRITICAL	All	Deterioration has progressed to the point where the structure will not support design loads and therefore is posted for reduced loads. Emergency repairs or shoring with structurally engineered temporary supports may be required by the crews. There may be a need to increase the frequency of inspections.
1	IMMINENT FAILURE	All	Roadway or roadway shoulder above culvert closed because of end treatment failure causing embankment and approach failure. Corrective action may put back in service.

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Component Rating	Condition	Material	Description
0	**FAILED**	All	Roadway closed above culvert.

2.4.3.2 *Headwall Element Condition States*

Headwalls and wingwalls are inspected for any signs of undermining and settlement, such as cracking, tipping/rotation, or separation of the culvert barrel from the headwall. If the headwall is comprised of a metal or concrete material will determine the types of condition state distresses which apply. Cracking, surface damage, spalling, delamination, and exposed repair will apply to concrete headwalls. Corrosion, deformation, and damage apply to metal walls. Any visible wall vertical offset is noted in the inspection report.

Figure 2-23: Concrete headwall and wingwall

Figure 2-24: Concrete headwall and metal sheet pile wingwalls

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Table 2-7: Headwall Element Distresses

Element Number	Element Name	Description	Applicable Distresses
12301	Headwall	End Treatment comprising headwall of culvert	End Treatment Cracking (Concrete)
			End Treatment Surface Damage/Spalling/ Delamination (Concrete)
			Exposed Rebar (Concrete)
			End Treatment Deformation and Damage (Metal)
			End Treatment Corrosion (Metal)
Unit of Measure: Length, feet. Distresses are measured as a "slice" of the diameter of the barrel's length.			

Details on the condition state rating schema are in Section 2.7, linked below:

Culvert Less Than 10-Foot Span Condition State Tables

Cracking (Concrete)

Headwall concrete cracking typically consists of longitudinal or transverse cracks.

Hairline cracks less than 0.0625 in. in width are minor and only need to be noted in the inspection notes. Moderate cracks greater than hairline cracks are described in the inspection report and noted as possible candidates for maintenance. Wide cracking may indicate overloading or poor bedding and side support and warrant further evaluation by an engineer. They may also be candidates for remedial action. These larger longitudinal cracks also allow water and oxygen to penetrate to the rebar and initiate corrosion which can lead to concrete spalling, significantly reducing the life of the headwall.

Transverse cracks may be caused by poor bedding. Cracks may occur across headwall when settlement occurs.

Surface Damage, Spalling or Delamination (Concrete)

Deterioration to a concrete headwall is typically due to:

- Surface Damage,
- Spalling, or
- Delamination

Surface Damage

Headwalls are inspected for localized damage. Damage such as dents, bulges, creases, cracks, and tears can be serious if distress is extensive and can impair the integrity of the headwall. Small and localized examples are not ordinarily critical but are noted and photographed. Severe local damage distress will usually display a poorly shaped cross section or through-wall penetration. Document the type, extent, and location of all significant wall damage distress.

Spalling

Spalling is a fracture of the concrete parallel or inclined to the surface of the concrete.

Spalls often occur along the edges of either longitudinal or transverse cracks when the crack is due to overloading or poor support rather than normal temperature or shrinkage cracking. Spalling may also be caused by corrosion of the reinforcing steel bar (rebar) when water is able to reach the rebar through wide cracks or shallow cover. As the rebar corrodes, the oxidized steel expands, causing the concrete covering to spall.

Spalling may be detected by visual examination of the concrete along the edges of cracks. Tapping with a hammer is performed along cracks to check for areas that have fractured but are not visibly debonded, as these areas will produce a hollow sound when tapped.

Figure 2-25: Spalled concrete at headwall

Delamination

Delaminations are separations along a plane parallel to a surface, as in the separation of a coating from a substrate or the layers of a coating from each other. Delaminations are not visible from the surface but can be detected by tapping along the surface with a hammer or dragging a chain to detect hollow-sounding areas. Delaminations are noted in the inspection report by recording the size of the delamination (approximate length by width on the headwall).

Exposed Rebar (Concrete)

Indicate if reinforcement is exposed and the amount of section loss. Larger cracks allow water and oxygen to penetrate to the rebar and initiate corrosion which can lead to concrete spalling, significantly reducing the life of the headwall.

Some red/brown staining emanating from cracks can be caused by iron bacteria in groundwater or other organic staining not related to rusting. Carefully examine the staining and be familiar with the differences. Staining from iron bacteria is not cause for concern and is not a condition defect.

Deformation and Damage (Metal)

Metal headwalls are inspected for localized damage. Damage, such as dents, bulges, creases, cracks, and tears, can be serious if distress is extensive and can impair the integrity of the headwall. Small and localized examples are not ordinarily critical but are noted with size and photographed. Severe local damage distress will usually cause a poorly shaped cross section or through-wall penetration. Document the type, extent, and location of all significant wall damage distress. When examining dents, the opposite side of the plate is checked, when accessible, for cracking.

Corrosion

Corrosion is the deterioration of metal due to electrochemical or chemical reactions. The inspection should include visual observations of metal corrosion. As steel corrodes, it expands considerably. Relatively shallow corrosion can produce thick deposits of scale. A pick hammer is used to scrape off heavy deposits of rust and scale for observation and nondestructive thickness measurement of the metal. A pick hammer is also used to locate unsound areas of exterior corrosion by striking the headwall with the pick end. The pick will deform the wall or break through it at locations of severe exterior corrosion.

Protective coatings are examined for abrasion damage, tearing, cracking, and removal. Document the extent and location of surface deterioration problems. These problems can all contribute to corrosion of the metal headwall.

2.4.3.3 Wingwall Element Condition States

Wingwalls are inspected for any signs of undermining and settlement such as cracking, tipping/rotation, or separation from the culvert barrel. Settlement exerts additional stress on the ends of the culvert and may cause blockage or end failure.

Headwalls and wingwalls share the same condition state distresses. Refer to Sections 2.4.3.2 and 2.4.3.3, respectively, for the discussion of the condition state distresses common to both elements.

Table 2-8: Wingwall Element Distresses

Element Number	Element Name	Description	Applicable Distresses
12302	Wingwall	End Treatment comprising wingwall of culvert	End Treatment Cracking (Concrete)
			End Treatment Surface Damage/Spalling/
			Delamination
			End Treatment Deformation and Damage (Metal)
			End Treatment Corrosion (Metal)
Unit of Measure: Area, feet. Distresses are measured as an area of the wingwall.			

Details on the condition state rating schema are in Section 2.7, linked below:

Culvert Less Than 10-Foot Span Condition State Tables

2.4.3.4 Scour Element Condition States

Concrete footings and inverted slabs are typically installed at a depth below the anticipated scour level to prevent undermining and instability of the foundation. However,

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most older slab culverts are susceptible to scour. The scour element refers to the typical damage that occurs to the concrete footings and inverted slabs due to scour.

Table 2-9: Scour Element Distresses

Element Number	Element Name	Description	Applicable Distresses
12303	Scour	Concrete footing and invert slab damage due to scour	End Treatment Scour and Stability

Unit of Measure: Each. Distresses are measured as each footing or slab.

Details on the condition state rating schema are in Section 2.7, linked below:

Culvert Less Than 10-Foot Span Condition State Tables

Scour and stability are often related as scour can undermine the footing, causing rotation of the foundation and damaging stress to the culvert wall. If allowed to progress, scour can lead to collapse of the culvert. Check for scour and erosion that may cause undermining of the footings and look for any indication of rotation of the footing.

Note the extent and location of any erosion or undercutting around the ends of the culvert barrel or any end treatments. Scour may cause loss of articulated concrete block (ACB), rock, or other measures originally placed to reduce scour.

Culvert scour consists of three types of scours: stream degradation, contraction scour, and local scour. Stream degradation is long term changes in the streambed elevation due to natural or human-induced causes, which can affect the reach of the river near the culvert. Contraction scour is removal of material from the bed and banks across all or most of the channel width, resulting from the contraction of the flow area. Local scour is removal of bed material from around the culvert foundation. Local scour is caused by the acceleration of flow and vortices resulting from flow around an obstruction.

Figure 2-26: Concrete foundation and wingwall damage due to scour

The most common structural distress in concrete footings is differential settlement, typically due to scour undermining the footing. Differential settlement occurs when one section of a footing settles more than the rest of the footing. This can cause cracking in concrete, wrinkling in corrugated metal, distress to joints, or other damage or distortion in the supported culvert structure and in the footing. Flexible corrugated metal culverts can tolerate some differential settlement but will be damaged by excessive differential settlement. The inspection of footings should include a check for differential settlement along the length of a footing. This might be noticed as footing rotation, severe cracking with vertical offset, spalling, or crushing across the footing at the critical spot. If the differential settlement is severe enough, it might be evidenced by a compression or stretching of the corrugations in metal culvert barrels. Differential settlement might be apparent by visual inspection along the length of footings, if present and exposed.

Concrete inverts in arches or three-sided culverts are usually a slab-on-grade used to carry water or traffic. Invert slabs can also provide protection against erosion and undercutting and are also used to improve hydraulic efficiency. Concrete inverts are sometimes used in circular and other closed culvert shapes to protect the metal from severe abrasive or severe corrosive degradation or added as repair for corroded inverts.

Concrete invert slabs are checked for undermining and settlement. Undermining is checked by probing along the edge of the apron. Settlement can be detected by checking for cracks, rotation, and signs of movement at the joint with the headwall. The joints between concrete aprons and headwalls should also be checked for movement (separation) and water tightness. Slabs are checked for damage such as spalls, open cracks, holes, or missing portions. Undermining can lead to a perched condition where piping occurs underneath the barrel. This perched condition can be due to stream degradation, or local scour. In critical conditions, voids around the culvert might appear.

Figure 2-27: Perched outlet with large scour hole

2.4.4 CULVERT STRUCTURE ROUTINE INSPECTION

The culvert structure is composed of the culvert barrels and joints. Barrels could be plastic, concrete, corrugated metal, masonry, and timber. Each are prone to unique sets of potential distresses.

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

2.4.4.1 *Culvert Structure Component Rating*

The purpose of the culvert structure inspection is to identify distress to the barrel or joints that may impact structural stability or functional performance.

Table 2-10. Component Rating Guidelines for Culvert Less Than 10-Foot Span Culvert Structure

Component Rating	Condition	Material	Description
9	NEW	All	No deficiencies in any of the structural components that will affect the long-term performance. No noticeable or noteworthy deficiencies that would affect the operation, movement, or water tightness of the joints.
8	VERY GOOD	All	All structural components are sound and functioning as designed. There may be superficial cracking or weathering of protective coatings and/or dirt contamination on structural components. Possible minor accumulation of noncompressible material and debris in the expansion opening.
7	GOOD	All	All members retain full section properties and function as designed. There may be minor cracking in the barrel. Minor deterioration with shallow hairline cracks less than 1/8" (0.125 inches) within 2 ft. of the joint. No noticeable water leakage.
6	SATISFACTORY	All	All members retain full section properties and function as designed. There may be some deterioration affecting structural members such as minor cracking, scaling, small, scattered spalls, or shallow scour. Some protective coating failures. Device components maybe uneven, misaligned or the joint opening is closed. No noticeable water leakage.
5	FAIR	All	Moderate deterioration affecting barrel such as cracking, scaling, scattered or shallow spalls, minor settlement, or shallow scour. Minor section loss in low or no stress areas. Culvert continues to function as designed. Minor leakage due to adhesion failures of the seal and/or anchorage device (less than 5% of the length).
4	POOR	All	Considerable deterioration affecting barrel and joints such as cracking, scaling, scattered spalls, partial settlement, or scour. Barrel and joints continue to function as designed. Major deterioration of surrounding concrete including cracking and spalling to steel. Leaking along more than 5% of the seal and/or anchorage device.

Component Rating	Condition	Material	Description
3	SERIOUS	All	Considerable deterioration affecting structural members. Possible full-depth failures. Most of barrel and joints are leaking or loose. Ride quality may be impacted. Structural evaluation, hydraulic, and/or load analysis may be necessary to determine if the structure can continue to function without restricted loading, structurally engineered supports, or immediate repairs. There may be a need to increase the frequency of inspections.
2	CRITICAL	All	Deterioration has progressed to the point where the structure will not support design loads and therefore is posted for reduced loads. Emergency repairs or shoring with structurally engineered temporary supports may be required by the crews. There may be a need to increase the frequency of inspections.
1	IMMINENT FAILURE	All	Roadway or roadway shoulder above culvert closed because of barrel and joint failure. Corrective action may put back in service.
0	FAILED	All	Roadway closed above culvert.

2.4.4.2 Barrel Element Condition States

The purpose of the barrel element inspection is to identify distress to the barrel that may impact structural stability or functional performance.

The elements and types of condition deficiencies can vary greatly by barrel type; therefore they are broken into different inspection/rating procedures based on material. Distresses associated with multiple material types are discussed initially, followed by distresses by material type. Distresses associated with each material type are described in detail.

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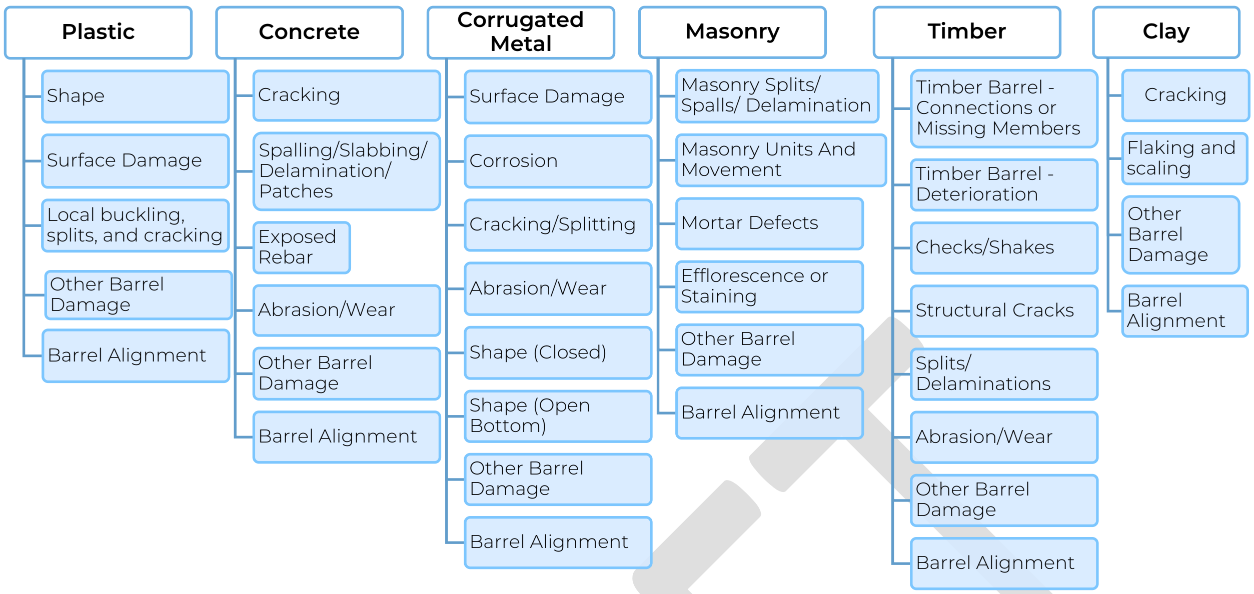

Figure 2-28: Applicable distresses for culvert barrel types

Barrel (Multiple Types)

Barrel Alignment

Barrel alignment is a measure of horizontal and vertical deviation from the design profile. For a pipe with no design curves or bends, the alignment should be straight.

The purpose of inspection of the barrel alignment is to identify distress indicators that result in misalignment of pipe segments. Barrel alignment may be an indicator for barrel structural distress, joint distress, or loss of support through soil piping (water flowing along the barrel exterior). Severe barrel misalignment can lead to reduced hydraulic performance.

Alignment problems may be caused by improper installation, undermining, differential settlement, or overloading. Attempt to identify which of those problems is causing the misalignment in the inspection notes.

Misalignment may be an indicator of problems in the supporting soil. The vertical and horizontal alignment of the culvert barrel is checked by sighting along the crown and sides of the culvert and by checking for differential movement or settlement at joints between pipe sections.

Vertical Alignment

Vertical alignment is checked for distortion, including warping, sagging, local crushing, and heaving. Be aware that pipes are occasionally laid with a camber (concave downward curvature along the pipe length) or a grade change to allow for fill settlement due to differential foundation soils or differential embankment loads.

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Warping is characterized by deviation from flatness as a result of stresses and uneven shrinkage. Sagging is vertical deformation that can be caused by overloading or by creep (permanent deformation due to constant loading over time). Sags impede water flow which may aggravate settlement problems by saturating the supporting soil through leaking joints. Sags may also impede movement of debris and decrease flow capacity. For timber barrels, crushing typically occurs at connections where a member supports a vertical load bearing perpendicular to the direction of the wood grain.

Horizontal Alignment

Horizontal alignment is checked for straightness or as-designed smooth curvature for those culverts constructed with a curved alignment.

Figure 2-29: Loss of vertical alignment in a corrugated metal culvert

Other Barrel Damage – Insect Activity, Fire, etc.

Insect Activity

Insect activity primarily occurs in timber culverts, where insects can bore into wood structures and weaken members. Biotic degradation includes attack of the timber member by bacteria, fungi, insects, and marine borers. Bacteria and fungi degrade wood by breaking down constituents of the material that provide strength, also known as decay. Insects and marine borers degrade the strength of the structure by creating tunnels and cavities in the wood for shelter.

Insect activity is visually indicated by signs of holes in members, or the presence of powder. Typical insects that threaten wood culverts include ants, termites, beetles, worms, and marine borers.

Fire Damage

Note the extent of any charring and fire damage. Large wood members often retain structural strength after fire damage and an in-depth inspection by an Engineer is required to determine the residual capacity or to design for repair or replacement.

Plastic Barrel

Plastic barrels are often used in both culvert and storm drain applications. Plastic barrels are classified as flexible structures because their design and performance rely on soil-structure interaction; plastic barrels depend upon the soil embedment around the full pipe circumference and backfill to provide structural stability and support.

Table 2-11: Barrel Element (Plastic) Distresses

Element Number	Element Name	Description	Applicable Distresses
12404	Barrel	Barrel made out of plastic material.	Plastic Barrel – Shape change
			Plastic Barrel – Surface Damage
			Abrasion/Wear
			Barrel Alignment
			Other Barrel Damage – Insect Activity, Fire, etc.
Unit of Measure: Length, feet. Distresses are measured as a "slice" of the diameter of the barrel's length.			

Details on the condition state rating schema are in Section 2.7, linked below:

Culvert Less Than 10-Foot Span Condition State Tables

Plastic barrel inspection includes evaluation of barrel shape and wall distress. The barrel shape is evaluated relative to its as-designed shape. Wall distress is evaluated as an indicator of structural performance over time.

Typical cross section shapes for plastic barrel include corrugated wall (single-wall, dual-wall with an inner liner, or triple-wall with an inner and outer liner), ribbed profile wall, and solid-wall. The cross section is determined prior to inspection, if possible, or determined during the inspection if not present in the inventory.

Shape Change

Shape change is extremely important to monitor at all stages in the lifecycle plastic barrel but added importance is placed on the initial measurement following construction and annual inspections for the first two years of service, to ensure a good design performance and installation.

Shape change can also be an indicator that the applied loads are greater than the design loads. For condition rating purposes, shape will be quantified as the reduction in vertical diameter, e.g., distance from invert to crown (obvert), as a percent of the pipe nominal diameter.

Bulges in the pipe wall that follow an undulating inward-outward pattern along or around the pipe circumference (rippling) are identified as local buckling. Changes to the circular shape, such as wall-flattening, that increase to reverse curvature would be evaluated in the shape characteristic as global buckling, which is a separate characteristic from the local buckling described here.

Surface Damage

Wall damage, such as impacts, creases, cracks, and tears can be serious if the distress is extensive and can impair either the integrity of the barrel or permit infiltration of groundwater or backfill. Small, localized instances are not ordinarily critical but are noted along with any indications of the cause. Document the type, extent, and location of all wall distress and photograph significant instances.

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Abrasion/Wear

Abrasion is generally most serious in steep areas where high flow rates carry sand and rocks that causes wear of the culvert invert. Plastic barrel materials such as HDPE, PVC, and PP have high resistance to abrasion and are often used as liners to repair other pipes that experienced abrasion-induced distress.

Mild deterioration or abrasion is noted in the inspection report. More severe surface deterioration is reported as a potential candidate for maintenance. In severe cases where the invert is completely deteriorated the RFA process is initiated.

Other types of wear for plastic barrels include buckling, splitting, cracking, and photodegradation.

Buckling, Splitting, Cracking

Buckling occur when the plastic barrel wall folds or bends due to high loads on the pipe.

Splitting can occur along plastic welded seams and/or abrupt changes in geometry in the pipe wall or corrugation, or at the bond between the walls and liners in corrugated wall pipe. Older HDPE pipes can experience cracking in the corrugated wall liner due to stresses that are residual from the manufacturing process and that may also be in locations that are not structurally significant.

Cracking in plastic barrels can occur from multiple types of distress. Plastic degrades with age, it becomes brittle with exposure to cold, and can burst due to ice freezing inside the pipe. Plastic pipe exposed to high levels of chemicals can also degrade the plastic and cause distress.

Photodegradation

Many plastic barrel materials provide resistance to acidity, salt, aggressive soils, fertilizers, pesticides, and other chemicals that can be corrosive to steel and concrete. However, plastic can be susceptible to photodegradation if not adequately designed or treated to be resistant to UV light. Photodegradation is the weakening of the plastic material due to oxidation from absorption of UV radiation when in sunlight for extended time periods. Buried culverts may be at risk for photodegradation at pipe ends where they are exposed to daylight at the inlet and outlet structures. The main visible effects are a mottled, chalky appearance and a color change. If this degradation is suspected, the pipe wall is lightly struck with a hammer and any fracturing or crumbling noted in the inspection report.

Concrete Barrel

Concrete culverts and storm drain barrels may be either precast or cast-in-place. Precast concrete pipe is manufactured in a fabrication facility. The manufacturing process is under controlled conditions enabling uniform quality concrete. Cast-in-place (CIP) concrete is cast at the site in formwork, placing reinforcement bars (rebar), and pouring concrete in its final location. Most CIP concrete culverts are single or multi-cell box culverts constructed using conventional bridge construction techniques. Both CIP and precast concrete culverts are somewhat protected by the soil backfill from rapid fluctuations in surface temperature and direct application chloride (salts) used for deicing. As a result, they are generally more resistant to surface material degradation than conventional concrete bridge elements, such as bridge decks.

Figure 2-30: Concrete barrel culvert

The purpose of the concrete barrel inspection is to identify distress in the pipe wall, other than misalignment, that may affect structural stability or functional performance.

Concrete culvert and storm drain barrels are classified as rigid structures because they do not bend or deflect appreciably under load before cracking or fracturing. As a result, shape evaluations, while very important in flexible structures, are of little value in inspecting concrete pipes. However, adequate stability of the surrounding soil, particularly below the pipe springline, is necessary to prevent excessive stress that can cause cracking of the pipe wall. Therefore, look for any indications of a lack of embedment soil stability as well as signs of structural distress such as cracking. Inspection of concrete barrels concentrates on distress in the walls of the structure.

Table 2-12: Barrel Element (Concrete) Distresses

Element Number	Element Name	Description	Applicable Distresses
12404	Barrel	Barrel made out of concrete material.	Concrete Barrel - Cracking
			Concrete Barrel - Spalling/ Slabbing/Delamination/Patches
			Concrete Barrel – Abrasion/Wear
			Concrete Barrel – Exposed Rebar
			Barrel Alignment
			Other Barrel Damage – Insect Activity, Fire, etc.
Unit of Measure: Length, feet. Distresses are measured as a “slice” of the diameter of the barrel’s length.			

Details on the condition state rating schema are in Section 2.7, linked below:

Culvert Less Than 10-Foot Span Condition State Tables

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Cracking

Cracks typically are classified as either:

- Longitudinal Cracks
- Transverse or Circumferential Cracks

Longitudinal Cracks

Hairline longitudinal cracks in the crown and invert of the pipe usually develop as the rebar picks up the tensile stress due to circumferential bending. Measurements of crack width are taken as an indication of the structural condition of the pipe. Any visible wall vertical offset is noted in the inspection report.

Hairline cracks less than 0.01 in. in width are minor and only need to be noted in the inspection notes. Moderate cracks greater than hairline cracks are described in the inspection report and noted as possible candidates for maintenance. Major longitudinal cracking in equal to or excess of 0.1 inch in width may indicate overloading or poor bedding and side support and warrant further evaluation by an engineer.

Figure 2-31: Longitudinal crack within a concrete barrel

Transverse or Circumferential Cracking

Transverse or circumferential cracks may be caused by poor bedding. Cracks can occur across the bottom of the pipe (broken bell) when the pipe is only supported at the ends of each section. This is generally the result of poor installation practices such as not providing indentions (bell holes) in hard foundation material for the ends of bell-and-spigot-type pipe or not providing a sufficient depth of suitable bedding material. Cracks may occur across the top of pipe (broken back) when settlement occurs and rocks or other areas of hard foundation material near the midpoint of a pipe section are not adequately covered with suitable bedding material.

Spalling, Slabbing, Delamination, and Patches

Deterioration to the concrete face is typically due to:

- Spalling,
- Slabbing,
- Delamination, and
- Patches

Figure 2-32: Spalling within a box culvert

Spalling

Spalling is a fracture of the concrete parallel or inclined to the surface of the concrete.

In precast concrete pipe, spalls often occur along the edges of either longitudinal or transverse cracks when the crack is due to overloading or poor support rather than normal tension or shrinkage cracking. Spalling may also be caused by corrosion of the steel rebar when water is able to reach the rebar through wide cracks or shallow cover. As the rebar corrodes, the oxidized steel expands, causing the concrete covering to spall.

Spalling may be detected by visual examination of the concrete along the edges of cracks. Tapping with a hammer is performed along cracks to check for areas that have fractured but are not visibly debonded, as these areas will produce a hollow sound when tapped. For large arch or box-shaped culverts, this inspection will require a ladder or other safe means to access the culvert wall and top slab.

Slabbing

The terms slabbing, shear slabbing, or slab shear refer to a radial failure of the concrete which occurs from straightening of the curved reinforcement cage due to tension in rebar with inadequate concrete cover. Slabbing is characterized by large slabs of concrete peeling away from the sides of the pipe and a straightening of the reinforcing steel. Slabbing may occur under high fill depths or with severely deteriorated concrete and is accompanied by pipe deformation (deflection). Slabbing is a serious problem that can significantly weaken the structural capacity.

Concrete may experience deterioration for a number of reasons including freeze—thaw, chemical attack, and abrasion. Severe surface deterioration will make the structure a potential candidate for maintenance or repair. In the most advanced distress cases where the invert or any wall section is completely deteriorated, the rating will be severe which will lead to immediate notification through the RFA process.

Delamination

Delaminations are separations along a plane parallel to a surface, as in the separation of a coating from a substrate or the layers of a coating from each other, or, in the case of a concrete slab, a horizontal splitting, cracking, or separation of a slab in a plane roughly parallel to, and generally near, the upper surface. Delaminations are not visible from the surface but can be detected by tapping along the surface with a hammer or dragging a chain to detect hollow-sounding areas.

Figure 2-33: Concrete barrel deterioration

Patches

Visually inspect any patched areas of concrete for cracking and or spalling and sound with a hammer to evaluate the condition of the repair.

Abrasion/Wear

Deterioration, typically due to abrasion distress, is a wearing away of the concrete surface by sediment and debris that is transported by the stream. Abrasion is noted but is not typically considered to reduce the capacity of the pipe. However, the rate of abrasion is monitored by recording the level of abrasion that is present at the time of each inspection.

Mild deterioration or abrasion is noted in the inspection report. More severe surface deterioration is reported as a potential candidate for maintenance. In severe cases where the invert is completely deteriorated, notification is initiated through the RFA process.

Exposed Rebar (Concrete)

Indicate if reinforcement is exposed and the amount of section loss. Larger cracks allow water and oxygen to penetrate to the rebar and initiate corrosion which can lead to concrete spalling, significantly reducing the life of the culvert.

Some red/brown staining emanating from cracks can be caused by iron bacteria in groundwater or other organic staining not related to rusting. Carefully examine the staining and be familiar with the differences. Staining from iron bacteria is not cause for concern and is not a condition defect.

Corrugated Metal Barrel

Corrugated aluminum and corrugated steel culverts and storm drain barrels (pipes and arches) are classified as flexible structures because they respond to and depend upon the soil backfill to provide structural stability and support and are designed using concepts of soil-structure interaction. Inspection should verify both stability and integrity of the barrel. Stability of the structure and soil envelope is evaluated by checking the buried pipe cross section shape along the length. Integrity of the pipe is evaluated by checking for pipe or plate wall distress. An inspection of corrugated metal structures should evaluate shape and barrel distress at locations spaced closely enough to ensure that future deformations can be monitored from one inspection to the next. This manual provides detailed guidance on shape measurement, which is most easily accomplished using a laser profilometer or similar device. However, their inspection occurs concurrently with the corrugated metal barrel inspection, which requires the same access. Descriptions of the types of distress to look for during inspection are provided in the following paragraphs.

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The purpose of the corrugated metal barrel inspection is to identify distress in the pipe wall, other than misalignment, that may affect structural stability or functional performance.

Table 2-13: Barrel Element (Corrugated Metal) Distresses

Element Number	Element Name	Description	Applicable Distresses
12404	Barrel	Barrel made out of corrugated metal, also referred to as corrugated metal pipe.	Corrugated Metal Barrel – Surface damage
			Corrugated Metal Barrel – Corrosion
			Corrugated Metal Barrel – Cracking/ Splitting
			Corrugated Metal Barrel – Abrasion/Wear
			Corrugated Metal Barrel – Shape (Closed Shape)
			Corrugated Metal Barrel – Shape (Open Bottom)
			Barrel Alignment
			Other Barrel Damage - Insect Activity, Fire, etc.
Unit of Measure: Length, feet. Distresses are measured as a "slice" of the diameter of the barrel's length.			

Details on the condition state rating schema are in Section 2.7, linked below:

Culvert Less Than 10-Foot Span Condition State Tables

Surface Damage

All corrugated metal culverts are inspected for localized damage. Pipe damage such as dents, bulges, creases, cracks, and tears can be serious if distress is extensive and can impair the integrity of the barrel and permit infiltration of backfill. Small, localized examples are not ordinarily critical but are noted with size and location and photographed. Severe local damage distress will usually display a poorly shaped cross section or through-wall penetration. Document the type, extent, and location of all significant wall damage distress. When examining dents in corrugated steel culverts, the opposite side of the plate is checked, when accessible, for cracking or debonding of the corrosion-protective coating. If coating is present (such as 6galvanized, plastic, aluminum, or asphalt) note its presence and any distress, if appliable.

Corrosion

Corrosion is the deterioration of metal due to electrochemical or chemical reactions. Metal culverts are subject to corrosion in certain aggressive environments. Steel rapidly corrodes in highly acidic (low pH) conditions in the soil and water. Aluminum is more resistant but will corrode rapidly in highly alkaline (high pH) environments, particularly if metals such as iron or copper and their salts are present. The electrical resistivity of soil and water provide an indication of the likelihood of corrosion. In an aggressive environment, corrosion may result from the resistivity of the soil. Bacterial corrosion may also occur, particularly in the Upper Peninsula.

Figure 2-34: Corrosion of a metal culvert

Durability refers to the ability of a material to resist corrosion and abrasion. Durability problems are one of the most common causes for the repair or rehabilitation of buried metal pipe. The condition of the wall material in corrugated metal culverts and any coatings, if used, is considered when assigning a rating to the culvert barrel.

The inspection should include visual observations of metal corrosion. As steel corrodes, it expands considerably. Relatively shallow corrosion can produce thick deposits of scale. A pick hammer is used to scrape off heavy deposits of rust and scale for observation and nondestructive thickness measurement of the metal. A pick hammer can also be used to locate unsound areas of exterior corrosion by striking the culvert wall with the pick end. The pick will deform the wall or break through it at locations of severe exterior corrosion.

Protective coatings are examined for abrasion damage, tearing, cracking, and removal. Document the condition of coating, if applicable, and the extent and location of surface deterioration problems. These problems can all contribute to corrosion of the metal wall.

Figure 2-35: Loss of protective coatings contributing to corrosion

Abrasion/Wear

Abrasion is the wearing away of culvert materials, typically at the invert, by the erosive action of bedload carried in the stream. Abrasion is generally most serious in steep or mountainous areas where high flow rates carry sand and rocks. Abrasion can accelerate corrosion by wearing away protective coatings and previously corroded surfaces. Abrasion will wear the inside crests of the corrugations first.

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Figure 2-36: Abrasion wearing away corrugated metal pipe corrugations

Shape (Closed Shape)

Cross section shape is an extremely important feature to evaluate when inspecting corrugated metal (flexible) culvert and storm drain barrels. The corrugated metal barrel depends on the backfill or embankment to maintain its shape and its capacity to resist buckling. When the backfill does not provide the required support, the culvert will deflect, settle, or distort. Shape changes in the culvert provide a direct indication of the competency of the supporting soil envelope, or, in some instances, application of excessive loads. Periodic observation and measurement of the culvert's shape change over time are used to verify the adequacy of the soil-structure interaction system.

The design cross section shape of the culvert is the standard against which field measurements and visual observations are compared. If the design cross section is unknown, often a comparison can be made between the unloaded and undamaged culvert ends and the loaded (buried) sections beneath the roadway or deep fills. Symmetrical shape and uniform curvature around the perimeter (circumference) are generally the critical factors. If the curvature around the top or bottom of the structure becomes too flat, the culvert wall may not be able to carry the ring compression without either buckling inward or deflecting excessively to the point of reverse curvature. Either of these distress modes leads to partial or total failure.

Corrugated metal pipes change shape safely within design deflection limits as long as there is adequate exterior soil pressure to balance the ring compression and resist increase of the pipe horizontal diameter; this is the soil-structure interaction system. Shape measurements taken at any one time do not provide conclusive data on backfill instability even when there is significant deviation from the design shape. Backfill stability cannot be reliably determined unless changes in shape are measured over time. It is therefore necessary to measure and document the shape during each inspection. If there is instability of the backfill, the pipe will continue to deflect or deform over time.

In general, the inspection process for checking shape will include visual observations for symmetrical shape and uniform curvature as well as measurements of important dimensions. Static measurements can be collected with conventional tools or with any other devices. The specific measurements to be obtained depend upon factors such as the size, shape, and condition of the structure. If shape changes greater than measurement tolerance are observed, more measurements may be necessary to accurately characterize the distress. For small structures in good condition, one or two representative measurements of the horizontal and vertical diameters from inside crest to inside crest may be sufficient. For structures with shallow cover, observations of the culvert with a few live loads passing over are recommended and deflections may be estimated by use of

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temporary telltales (suspended rulers to directly monitor deflection). Discernible movement in the structure from live loads may indicate possible instability and a need for more in-depth inspection.

The number of measurement locations (stations along the barrel length) depends upon the size and condition of the structure. Measurements may be required at more frequent intervals (closer stations) if significant shape changes are observed. The smaller pipes can usually be measured at longer intervals, unless specific distress is observed. If visual distortion is observed, and if culvert is accessible for entry, no fewer than three measurement locations are taken, including at least one on the culvert interior. Identify and note exact locations of measurement sections and the specific locations on the corrugation that are used to accurately monitor changes.

Closed shape inspection should include evaluation of deflection and flattening. Different closed shapes have different methods of evaluation; details on the shape types are provided for shape types:

- Round
- Ellipses
- Pipe Arches
- Metal Boxes

Round

Round and vertical elongated pipe is expected to deflect vertically during construction resulting in a slightly increased horizontal diameter. Round pipes are sometimes vertically elongated 5 percent to compensate for settlement during construction. Thus, it can be difficult to determine in the field if a pipe was round or elongated when installed if this information was not recorded in an inventory record. Larger diameter round pipe is also susceptible to vertical elongation (peaking) during compaction of backfill at the sides of the pipe.

Round and vertically elongated pipe with Good to Fair shape will generally match the design shape, with smooth, symmetrical curvature and no visible deformations. Pipe with poor to severe shape will appear deformed with shape that does not match the design shape and does not have smooth or symmetrical curvature. In-depth inspections may be necessary to compare the design diameter to the current pipe nominal diameter.

Flattening

Flattening of the pipe wall is a decrease in local curvature that may be caused by unstable backfill. Flattening of the sides may be caused by a deteriorated invert that reduces the pipe's ability to carry ring compression. Flattening of the top arc is an indication of possible distress resulting from insufficient side fill support or from vertical loads greater than the design loads. Flattening of the invert is usually less serious as pipe not installed on shaped bedding will often exhibit minor flattening of the invert arc. Severe flattening of the bottom arc would indicate possible distress in a round pipe.

Note the visual appearance of the culvert's shape and measure the horizontal diameter and vertical diameter.

Flattening of Pipes with Diameters from 4 to 10 feet

When distortion or wall curvature flattening is apparent on pipes with diameter greater than 4 feet, describe the extent of the flattened area, in terms of arc length, length of culvert affected, and the location of the flattened area. Measure and record length of the chord across the flattened area and the middle ordinate of the chord is measured.

Flattening of Pipes with Diameters less than 4 feet

For small diameter pipes, this middle ordinate may be measured by hand or by use of special bars with dial gauges, designed for this purpose. Note the chord length and ordinate measurement with a description of the location and extent of the flattened area. Record any observations for out-of-round shape.

Ellipses

For horizontal ellipses the most important shape factor is adequate curvature in the crown section. The sides and bottom behave like the corners and bottom of relatively minor pressure when compared with the sides, which may have several times the bearing pressure of the invert. As a result, the corners and sides have the tendency to push down into the soil while the bottom does not move. The effect is as if the bottom pushed up. Inspectors should look for indications of bottom flattening and differential settlement between the side and bottom sections.

Record the visual appearance of the shape and measure both the span and the rise. If the span exceeds the design span by more than 3 percent, the span of the top arc, the mid-ordinate of the top arc, and the mid-ordinate of the bottom arc should also be measured.

Figure 2-37: Elliptical concrete barrel

Shape Evaluation

Shape evaluation of an ellipse is essentially the same as the evaluation of a crown section of round pipe (see "Round," previously), except that the curvature of the bottom should also be evaluated. Fair to Poor shape would be indicated when the bottom is flat in the center and corners are beginning to deflect downward or outward. Severe shape conditions would be indicated by reverse curvature in the bottom of arc.

Flattening and Spreading

The bottom arc is inspected for signs of flattening and the bottom corners for signs of spreading. The extent and location of bottom flattening and corner spreading are noted in the inspection report. Complete reversal of the bottom arc can occur without failure if corner movement into the foundation has stabilized. The top arc of the structure is supporting the load above and its curvature is an important factor. However, if the footing corners should fail, the top arc would also fail. The spreading of the corners is very important as it affects the curvature of the top arc.

Pipe Arches

The pipe arch is a completely closed structure that behaves as an arch. The load is transmitted to the foundation principally at the corners, which act like the footings of an arch. There is relatively little force or pressure on the large radius bottom plate. The principal type of distress in a pipe arch is a result of inadequate soil support at the corners where the pressure is relatively high. The corner may push down or out into the soil while the bottom stays in place. The effect will appear as if the bottom pushed up.

Pipe arches in good condition will have a symmetrical appearance, smooth curvature in the top of the pipe, and span within 5 percent of the as-designed span. The bottom may be flattened but should still have curvature. Pipe arches in fair condition will have minor distorted shape appearance in the top half of the pipe, no reverse curvature in bottom of the pipe, and a horizontal span 5 percent to 7 percent greater than theoretical. Pipe in Poor to Severe condition will have characteristics such as a poor shape appearance, severe deflection or distortion in the top half of the pipe, reverse curvature in the bottom of the pipe, flattening of one side, flattening of the crown, or a span more than 7 percent greater than theoretical.

Metal Boxes

Metal box culverts support loads by a combination of ring compression and conventional structure bending. The sides (legs) are straight, and the large radius top plates are heavily reinforced and have moment or bending strength that is quite significant in relation to the loads carried. The key shape factor in a box culvert is the top arc. The design geometry is very flat (large radius) and therefore cannot be allowed to deflect much without risk of buckling instability or bending distress. The span at the top is also important and cannot be allowed to increase much, due to inward or outward deflection or rotation of the side plates. Generally, an inward deflection would be more critical as an outward movement would be restrained by soil.

Shape factors to be checked visually include flattening of the top arc, outward movement of the sides, or inward deflection of the sides. Note the visual appearance of the shape and should measure and record the rise from the crown to the bottom of the base channel, and the span at the top of the straight legs.

The radius points (changes in radius from legs to haunches to top arc) are not necessarily located at the longitudinal seams. Many box culverts use double radius plates and the points where the radius changes shall be estimated. These selected measurement points are referenced to the bolt pattern to describe exactly where they are. Since these are all low-height structures, the measurement points are marked and painted for convenient repeat inspection.

Shape (Open Bottom)

Arches, unlike closed-shape pipe, have open bottoms and are typically founded on concrete spread footings or concrete caps on deep foundations. This difference between pipes and arches means that arches deflect differently during backfill. Backfill forces flatten the arch sides when they peak (raise) its top because the bottom of the arch, if well supported, cannot move inward like the wall of a round pipe.

An important shape factor in arches is symmetry. A non-symmetric arch will have racking; a racked cross section is one that is not symmetrical about the centerline of the culvert and

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can be. If the arch was erected with the base channels (footing connection to arch) not square to the centerline, it can cause racking of the cross section. One side tends to flatten, while the other side tends to curve more, and the crown moves laterally and possibly upward. If these distortions are not corrected before backfilling the arch, they usually get worse during backfill. Improper backfill, such as differential height on one side or excessive compaction, can also cause racking.

Visually observe if flattening of the sides, peaking or flattening of the crown, or racking to one side is present. Measure the vertical distance from the crown to the bottom of the base channels or top of footings (rise) and the horizontal distances from each of the base channels to a vertical line from the highest point on the crown (combined, these give the span). Record the curvature on the flatter side of the arch by noting chord and mid-ordinate measurements. In-depth inspections may be required to survey the culvert if major distortion, flattening, peaking, or racking is observed.

Arches in Fair to Good condition will have a good shape appearance with smooth and symmetrical curvature. Poor condition would be indicated when the arch is significantly nonsymmetrical, or when major side or top plate flattening has occurred. Arches in Poor to Severe condition will have a poor shape appearance including major distortion and deflection, extremely nonsymmetrical shape, severe flattening, or a major rise.

Masonry Barrel

Masonry barrels refer to structures constructed of individual masonry units made of stone, brick, or concrete block. Brick and concrete block structures are typically constructed with a layer of mortar placed between units. Masonry units are placed in wythes and courses. Course refers to the layer of units running horizontally. The number of courses determines the height of the wall. Wythes are the continuous vertical sections of the wall. The number of wythes determines the wall thickness. Stone masonry may be dry (no mortar), pointed (stones set in mortar), or cemented (stones set in concrete).

While new culverts are rarely constructed from masonry, a wide variety of masonry culverts are still in service.

Table 2-14: Barrel Element (Masonry) Distresses

Element Number	Element Name	Description	Applicable Distresses
12404	Barrel	Barrel made out of masonry material.	Masonry Barrel – Masonry Units and Movement
			Masonry Barrel – Mortar Defects
			Masonry Barrel – Efflorescence or Staining
			Barrel Alignment
			Other Barrel Damage – Insect Activity, Fire, etc.

Unit of Measure: Length, feet. Distresses are measured as a “slice” of the diameter of the barrel’s length.

Details on the condition state rating schema are in Section 2.7, linked below:

Culvert Less Than 10-Foot Span Condition State Tables

The purpose of inspection of the masonry barrel is to identify distress or potential distress using common and distress indicators in the masonry units and mortar. Barrel shape can also be an indicator of structural distress, joint/mortar distress, or loss of backfill support.

Masonry culverts are generally arch shaped, pipe arch shaped, or box shaped. These structures may be supported on footings, or with closed bottoms. The walls, floors, and top of masonry culverts are carefully inspected both visually and by tapping stones, bricks, or blocks and mortar with a geologist's rock hammer. Note any apparent signs of distress.

Many masonry culverts are very old and local development and changes in the surrounding land use may have increased the volume of storm water runoff that flows to the culvert. Hence, some may now be undersized for hydraulic capacity. When flow exceeds the culvert capacity, the culvert may overtop and suffer erosion and damage at the outlets. In addition, these historic structures may now carry heavier vehicle loads than existed at the time of their construction.

Typical items to inspect include the condition of the masonry units and mortar, movement or distortion, and weathering of the masonry. The individual stones, bricks, or blocks are checked for displaced, cracked, broken, crushed, or missing units. For some types of masonry, surface deterioration or weathering can also be a problem and can cause spalling.

Masonry Units and Movement

Identify deteriorated, loose, or dislodged units. Movement or damage of individual or grouped masonry units may occur due to:

- Acid weathering,
- Cracking and splitting,
- Freeze—thaw,
- Mortar deterioration (discussed under mortar defects),
- Shape changes, and
- Vegetation growth.

Acid Weathering

Acidic rainwater and storm water runoff can dissolve the surface of the units. Weathering typically appears as roughened surface with discoloration when compared with unweathered counterparts. Sandstone, limestone, and marble are susceptible to acid attack.

Cracking and Splitting

Cracking and splitting in masonry units are generally caused by tensile stress in the units. Cracking may be due to differential settlement or expansion of foundation soils, increased lateral earth pressure, shifting of units due to mortar deterioration, or impact damage. Note the presence and location of cracked masonry units.

Freeze-Thaw Action

Expansion of frozen water trapped behind or within a masonry unit can cause movement of the unit or internal distress. Under repeated cycling, and sometimes combined with other deterioration and erosion, units can become damaged, loose, and dislodged.

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Shape Changes

Masonry arches act primarily in compression. Racking, flattened curvature, bulges in walls, or other shape deformations may indicate unstable soil conditions. The vertical and horizontal alignment is checked visually.

Vegetation

Lichen and mosses growing on the face of units can create a moist environment which accelerates chemical weathering. Higher order vegetation and trees can also plant roots between units and dislodge masonry units.

Mortar Defects

In most masonry arch culverts, mortar is used to bond the masonry units together. The condition of the mortar is checked to ensure that it is still holding strongly. It is particularly important to note cracked, deteriorated, or missing mortar especially if other deterioration is present such as loose or missing masonry units. The presence of dirt or vegetation between masonry units is noted as these can be indicators of loss of backfill or erosion behind the structure.

Efflorescence or Staining

Water infiltration can also contribute to mortar distress in cold climates as freeze—thaw cycles break the mortar apart. Water infiltration through walls or joints may be indicated by deposits caused by efflorescence (leaching of salts or chlorides) leaking through the mortar joints.

Efflorescence and staining on its own are primarily cosmetic issues due to capillary action in porous materials; therefore, its presence alone cannot cause a severe rating. However, it can sometimes lead to spalling and deterioration and is recorded and tracked during inspection.

Clay Barrel

Clay barrels are usually vitrified products made by blending clay and shale at high temperature. The vitrification process is used to develop the strength and load bearing capacities of the product, turning it into an inert ceramic pipe. Clay pipes are sometimes glazed to ensure that they will be watertight. Clay pipes are generally resistant to chemicals but are brittle and difficult to install and repair.

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Table 2-15: Barrel Element (Clay) Distresses

Element Number	Element Name	Description	Applicable Distresses
12404	Barrel	Barrel made out of clay material.	Clay Barrel – Cracking
			Flaking and Scaling
			Barrel Alignment
			Other Barrel Damage – Insect Activity, Fire, etc.
Unit of Measure: Length, feet. Distresses are measured as a "slice" of the diameter of the barrel's length.			

Details on the condition state rating schema are in Section 2.7, linked below:

Culvert Less Than 10-Foot Span Condition State Tables

Cracking

In comparison to other barrel materials, clay barrels are more susceptible to cracking if they experience differential settlement or blunt impacts because of weak tensile strength. Cracked clay barrels could eventually cause the culvert system to collapse. Note the presence, location, and extent of cracks on the clay barrel.

Flaking and Scaling

Over time, clay barrels develop scale which causes the barrel to flake. This flaking traps debris within the walls of the barrel. Eventually increase in trapped debris may cause blockage. Note the presence and extent of scaling and flaking within the barrel. Also note if debris is trapped within the walls of the barrel.

Timber Barrel

Timber culverts are primarily inspected for material deterioration, called biotic degradation, and mechanical damage. Biotic degradation includes attack of the timber member by bacteria, fungi, insects, and marine borers. Bacteria and fungi degrade wood by breaking down constituents of the material that provide strength, also known as decay. Insects and marine borers degrade the strength of the structure by creating tunnels and cavities in the wood for shelter. Mechanical damage may be caused by abrasion, creating marred or worn surfaces (from traffic, stream flow, or ice), impact damage (from vehicles, debris, or ice floes), long-term exposure to overload stresses, or fire.

The purpose of the timber barrel inspection is to identify distressed connections, decay, structural overload distress, or other material deterioration to allow assignment of a condition rating.

Table 2-16: Barrel Element (Timber) Distresses

Element Number	Element Name	Description	Applicable Distresses
12404	Barrel	Barrel made out of timber material.	Timber Barrel – Connections or Missing Members
			Timber Barrel – Deterioration
			Timber Barrel – Checks/Shakes
			Timber Barrel – Structural Cracks
			Timber Barrel – Splits/ Delaminations
			Timber Barrel – Abrasion/Wear
			Barrel Alignment
			Other Barrel Damage – Insect Activity, Fire, etc.
Unit of Measure: Length, feet. Distresses are measured as a “slice” of the diameter of the barrel’s length.			

Details on the condition state rating schema are in Section 2.7, linked below:

Culvert Less Than 10-Foot Span Condition State Tables

Visual inspection is a cursory means to assess the structure for signs of actual or potential deterioration, noting areas for further investigation. Inspection of timber culverts should also check for signs of material deterioration at the surface (exterior) and interior of wood members. Material deterioration is inspected by sounding the wood, probing, and possibly by pick testing.

Sounding the wood surface by striking it with a hammer or other object is used to detect interior deterioration based on the tonal quality of the strike sounds. A trained and experienced Inspector can typically interpret dull or hollow sounds that may indicate the presence of large interior voids or decay. Although sounding is widely used, it is often difficult to interpret because factors other than decay can contribute to variations in sound quality. In addition, sounding provides only a partial picture of the extent of decay present and will not detect wood in the incipient or intermediate stages of decay. Nevertheless, sounding still has its place in inspection and can quickly identify seriously decayed structures. When suspected advanced decay is encountered, it shall be verified by other methods such as boring or coring. Boring involves drilling into the member with an electric drill. Inspection during boring includes noting depths where drilling becomes easier and inspecting shavings for signs of decay. Coring is the removal of a solid small diameter core to evaluate for decay.

Probing is conducted with a pointed tool, such as an awl, screwdriver, pick, or knife, to identify decay near the wood surface. Degradation is indicated by excessive softness and reduced resistance to probe penetration. Although probing is a simple inspection method, experience is required to interpret results. Care shall be taken to differentiate between decay and water-softened wood that may be sound but somewhat softer than dry wood.

Connections or Missing Members

Check connections for signs of potential capacity loss. Common issues with joints include deteriorated or missing bolts/fasteners, and local defects in the wood material at load transfer zones. Timber connections made with steel plates shall also be checked for degradation. This includes surface rust and pack rust. Pack rust is a form of corrosion that occurs in metallic crevices and joints between the plate and the connected element. Pack rust can cause bulging and deterioration of the connection plate which can significantly reduce its structural capacity.

Missing members may be due to structural failure of the member or its connection, or impact from stream or ice flows. Other activities such as installation of utilities or structure modifications may remove a member in whole or part (e.g., notched or cored beam for utility conduit).

Deterioration

Visual inspection for deterioration and decay requires good lighting and is suitable for detecting intermediate or advanced surface decay. It may not detect decay in the early stages, when control is most effective, nor will a visual inspection reveal internal decay. Consequently, visual inspection should never be the sole method employed. Decay indicators are sounded and probed to assess the extent of decay. Some common decay indicators include fruiting bodies, sunken faces, staining or discoloration, insect activity, and fire damage.

Other deterioration that can occur to timber consists of:

- Fruiting bodies
- Staining or discoloration
- Sunken faces

Fruiting Bodies

Fruiting bodies are the reproductive spores of fungi that form on the surface of wood. Fruiting bodies are found in a variety of shapes such as cap-and-stem mushrooms or shelf-like, antler-like, coral-like, cage-like, trumpet-shaped, or club-shaped fungi. Fruiting bodies provide positive indication of advanced fungal attack, but do not indicate the amount or extent of decay. Some species of fungi produce fruiting bodies after small amounts of internal decay have occurred, while others develop only after decay is extensive. Fruiting bodies almost certainly indicate serious decay problems when they are present.

Staining or Discoloration

Staining and discoloration are indicators of potential decay. Members with staining have been subjected to water and potentially high moisture contents and stained areas may mean conditions are suitable for decay. Rust stains on a member face may indicate wetting-induced deterioration of the connection hardware. These areas are noted for future monitoring.

Sunken Faces

Sunken faces or localized surface depressions can indicate underlying decay. Sunken faces occur when a thin layer of intact or partially intact wood forms a depression over voids or pockets near the surface of the member.

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Checks/Shakes

Checks are shrinkage cracks that occur along the radius of solid sawn timber, usually perpendicular through the growth rings. Checks can be seen along the face of members and are typically not a structural problem as they are accounted for in the engineering design values for strength. Severe checking at connections can weaken the ability of fasteners to carry load and shall be noted during inspections.

Shakes are separations between growth rings in the grain of the wood and can extend for some distance longitudinally into the member. Shakes are often identified by inspecting the end grain of a timber member. In contrast to checks, shakes can reduce the bending strength of a member and are noted and tracked during inspections.

Structural Cracks

Structural cracks, unlike checks and shakes, occur from an overload condition indicating the strength of a member and/or its connections has been exceeded due to service loads. Structural cracks may originate at knots on the tension face of bending members. The presence of any structural cracks that have not already been repaired will warrant a Poor or Severe rating.

Splits/Delaminations

Laminated structural timbers, called glulams, are members constructed by gluing and laminating thinner members to form a thicker (composite) section. Delaminations are separations within laminated members. Glulam beams rely on composite action to provide full strength and therefore shall remain fully laminated to function as designed. Delaminations near connections can be more important than delaminations elsewhere as they may reduce the capacity of the fasteners.

Abrasion/Wear

Abrasion and impact damage may occur due to stream flow, debris, or ice. Note section loss due to abrasion.

2.4.4.3 Joint Element Condition States

The purpose of the joint inspection is to identify distressed joints within the barrel that could affect the performance of the culvert structure. Joints are the transverse transitions between barrel sections; seams are longitudinal or helical transitions between barrel sections. Joints between the barrel and end treatments are assessed as part of the end treatment inspection. Joints may be present where the culvert barrel is extended as part of a roadway widening. Some joint movement may be a part of the manufacturing or construction tolerance. Joint failure is more common with concrete pipe. Joints are critical to the overall function of the culvert.

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Table 2-17: Joints Element Distresses

Element Number	Element Name	Description	Applicable Distresses
12405	Joints	Joints present within the culvert barrel	Joint Separation, Offset, and Rotation Joint Infiltration/Exfiltration Joint Cracking (Concrete)
Unit of Measure: Each. Record quantity of each joint.			

Details on the condition state rating schema are in Section 2.7, linked below:

Culvert Less Than 10-Foot Span Condition State Tables

Joint Separation, Offset, and Rotation

Vertical movement can occur in the forms of uniform settlement or differential settlement. Depending on the magnitude of the settlement realized, uniform settlement will have limited impact on the structural stability of the culvert. Differential settlements, on the other hand, may lead to serious problems in the culvert. Differential settlements may cause the opening of joints or cause culvert cracking or transverse tipping. The most common causes of vertical movement consist of soil bearing failure, soil consolidation, erosion, and material deterioration.

Inspect the culvert for evidence of vertical differential settlement, offset, or rotation as evidenced in joints. Gaskets may be exposed or missing. Backfill material may be exposed in severe cases.

Joint Infiltration/Exfiltration

Joint distresses may be identified by infiltration of soil or water through joints which are intended to be tight. In severe cases, distresses to the barrel, end treatments, and roadway embankment will result from the soil and/or water infiltration.

Exfiltration refers to water leaking from the culvert into the underlying soil. It is also an indication of distress.

Joint Cracking (Concrete)

Longitudinal cracking in concrete joints is also an indication of distress. Spalling, exposed reinforcing or exposed joint sealing would all be indications of poor joint condition. Large spalls along the spigot end would be present in severe distress cases.

2.4.5 REFERENCES

Timber Bridge Design, Construction, Inspection and Maintenance Report

FHWA-IP-86-2 Culvert Inspection Manual

FHWA NHI 12-049 Bridge Inspector's Reference Manual Chapter 14

MDOT Drainage Manual

2.5 Work Recommendation Guidance

Culvert less than 10 feet span Work Recs are recorded to initiate preventive maintenance actions. Preventive maintenance needs are determined for each ancillary structure and the corresponding actions are identified on the Work Recs documentation. The following Work Recs are not meant to be all-inclusive and other work recommendations may be added to supplement those noted in *Table 2-18*.

Approach roadway and embankment Work Recs include repair of guardrail and approach pavement. Brush cutting or slope embankment repairs may be recommended. Heavy slope riprap may be recommended.

Channels suspected of being inadequate may be due to blocked inlets. Possible maintenance includes cleaning of the channel adjacent to culvert, removal of debris inflow or outflow, addition of riprap, or channel repairs. Scour countermeasures and/or scour monitoring systems may need to be installed or repaired.

Aprons and flumes may require additional rock if the scour has penetrated through the riprap.

Blocked weep holes are cleaned. Headwalls, wingwalls, or the foundation may need repair. Washout or erosion due to scour around the foundation may be recommended.

Culvert structure Work Recs typically consist of removal of debris, sediment, or vegetation from the barrel. Vegetation is removed from the barrels as part of regular maintenance. Culvert barrel Work Recs consist of barrel repair, sealing the barrel and cracks, installing culvert liner, and cleaning/painting/re-sealing the culvert for graffiti removal. Work Recs may be created for other items, which could include noting if a safety grate is missing or another item not otherwise specifically listed in *Table 2-18*.

Photographs should include sufficient information to determine the relationship of the defect to the element or component or entire structure. Close-up photos of each defect with deficiencies marked on the photo should be provided.

Table 2-18: Culvert Less than 10-Foot Span Work Recommendations

Number	Description of Work Recommendation	Material involved	Quantity/Unit of Measure
1	Channel – Install/Repair Scour Countermeasures	Rock or Articulated Concrete Block (ACB)	Cubic Foot
2	Channel - Monitor Scour	N/A	N/A
3	Substructure - Repair Abutment/Wings/ Headwall	Concrete	Cubic Foot
4	Repair/Replace Treatment	End Treatment Material, as needed	Each
5	Repair washouts/erosion	Stone or Other, As Needed	Cubic Foot
6	Approach Pavement Repair	Asphalt	Square Foot

Number	Description of Work Recommendation	Material involved	Quantity/Unit of Measure
7	Brush Cut	Brush	Cubic Yard
8	Culvert Cleanout	Sediment	Cubic Foot
9	Clean and/or paint/re-seal concrete for graffiti removal	Concrete	Square Foot
10	Seal Barrel	Joint Sealer	Lineal Foot
11	Seal cracks	Crack Sealer	Lineal Foot
12	Barrel repair	Barrel Material, As needed	Square Foot
13	Install Culvert Liner	Liner	Lineal Foot
14	Replace Culvert	Culvert	Lineal Foot
99	Other		

2.6 Request for Action Guidance

The culvert examples for Priority Level 1 are deemed to have caused failure or are progressing toward an impending failure of the roadway or embankment within a 1:1 slope influence of the roadbed. The culvert examples below for Priority Level 2 are deemed to threaten the roadway or embankment within a 1:1 slope influence of the roadbed. The culvert examples for Priority 3 are not deemed to threaten the roadway or embankment within a 1:1 slope influence of the roadbed but could if not addressed within the specified timeframe.

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

Priority 1 Level Items

a. Major tears, splits, shape deformation or bulges resulting in major infiltration of soil, voids, and piping with accompanying settlement or sinkholes within the roadway limits

b. Holes or major section loss resulting in voids beneath invert with evidence of piping and accompanying settlement or sinkholes within the roadway limits

c. Open or displaced joints (misaligned) with evidence of soil infiltration or piping causing settlement or sinkholes in the roadway limits

d. *Concrete* – Large cracks with widespread exposed reinforcement exhibiting major corrosion and soil infiltration through cracks with settlement or sinkholes in the roadway limits

e. *Metal* – Connection hardware has many loose or missing bolts in any seam with major yielding of steel or cracking/splitting local to bolt holes reducing seam capacity and/or evidence of major soil infiltration or piping that has caused settlement or sinkholes within the roadway limits

f. *Plastic* – Barrel conditions with major wall flattening with the reversal of curvature (global buckling) or kinks

g. Severe erosion of embankment material or major soil tension cracks perpendicular to slope indicating shifting or settlement within a 1:1 slope influence of the roadbed
h. End treatment (along with any apron) is crushed or separated from the barrel and scour protection is missing with evidence of major erosion or undermining progressing toward an impending failure of the embankment within a 1:1 slope influence of the roadbed
i. Footings are severely undermined due to scour, which could progress toward an impending failure of the roadway or embankment within a 1:1 slope influence of the roadbed

Priority 2 Level Items

a. Open or displaced joints (misaligned) with significant infiltration or exfiltration of water or soil, but no settlement or sinkholes within the roadway limits
b. Holes or significant section loss resulting in voids beneath invert with evidence of piping, but no settlement or sinkholes exist in the roadway limits, however a threat is posed to the roadway or embankment within a 1:1 slope influence of the roadbed
c. *Concrete* – Cracks with widespread exposed reinforcement with significant corrosion, evidence of soil infiltration or piping, but no settlement or sinkholes in the roadway limits exists
d. *Metal* – Perforations visible or easily made, connection hardware has loose or missing bolts in any seam, corrosion with significant section loss around bolt holes or on bolts with significant yielding of steel or cracking/splitting local to bolt holes and/or evidence of soil infiltration or piping, but no settlement or sinkholes in the roadway limits exists
e. *Plastic* – Barrel conditions with significant wall flattening or reversal of curvature (global buckling) or kinks, UV degradation (barrel ends) has resulted in cracks or broken culvert walls
f. Soil tension cracks perpendicular to slope indicating shifting or settlement and/or sloughing of embankment threatens the roadway or embankment within a 1:1 slope influence of the roadbed
g. End treatment (along with any apron) is crushed or separated from the barrel, scour protection has been significantly displaced and scour has caused significant undermining causing loss of support threatening the roadway or embankment within a 1:1 slope influence of the roadbed
h. Longitudinal cracks in crown, invert, or haunches with perceptible cross-section deformation
i. Significant reconfiguration of inner liner
j. Mass drift or sediment is reducing the capacity of the culvert greater than 50% (*some culverts are intentionally recessed. Check historical plans to verify culvert invert and stream flowlines*).

Priority 3 Level Items

a. Open or displaced joints (misaligned) with moderate water infiltration through leak-resistant seams with possible evidence of repeated patching or cracking transverse or longitudinally in pavement over the culvert alignment

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b. *Concrete* – Cracks present with no perceptible cross-section deformation, heavy abrasion, and scaling with exposed steel reinforcement
c. *Metal* – Moderate wall buckling, deformation at worst section or local bulging, surface corrosion with minor section loss and moderate yielding of steel, or cracking/splitting local to bolt holes
d. *Plastic* – Moderate wall buckling, deformation at worst section or local bulging
e. Localized displacement of scour protection with scour exposing the vertical face of a footing or progressing toward a threat to the embankment within a 1:1 slope influence of the roadbed; however, no undermining or rotation of footing exists
f. Moderate reconfiguration of inner liner
g. Mass drift or sediment is reducing the capacity of the culvert from 33% to less than 50%. (*Some culverts are intentionally recessed. Check historical plans to verify culvert invert and stream flowlines.*)

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2.7 Element Condition States

Element Number	Element	Condition States Defects Note	Link to Discussion in Section 2
12301	Headwall	Use the appropriate condition state table based on material (Concrete or Metal).	Headwall Element Condition States
12302	Wingwall	Use the appropriate condition state table based on material (Concrete or Metal).	Wingwall Element Condition States
12303	Scour	Use the appropriate condition state table.	Scour Element Condition States
12304	Barrel	Use the appropriate condition state table based on material (Plastic, Concrete, Corrugated Metal, Masonry, Clay, or Timber).	Barrel Element Condition States
12305	Joint	Use the appropriate condition state table.	Joint Element Condition States

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Element 12301 (Headwall) – Concrete

Description	This element is for headwalls attached to the end of the culvert.			
Quantity Calculation	The quantity for this element is measured as “each.”			
	Condition State Descriptions			
Defect Type	**Good**	**Fair**	**Poor**	**Severe**
End Treatment Cracking (Concrete)	No measurable crack width greater than hairline (maximum 0.0625 inches).	Minor cracks with no infiltration. No increase in cracking from previous inspection (if applicable).	Cracks 0.05 in. to 0.1 inches wide. Minor water infiltration through cracks.	Cracks greater than 0.1 inches wide. Water and soil infiltration through cracks.
End Treatment Surface Damage Spalling or Delamination (Concrete)	No scaling, abrasion, or other surface damage. No spalling. No hollow sounds (delaminations). Patched areas that are sound.	Light or moderate scaling (less than 0.25 in. exposed aggregate). Abrasion less than 0.25 in. deep over less than 20% of surface. Localized minor impact damage (less than 0.25 inches deep). Localized spalls less than 6 inches diameter. No exposed rebar. Small hollow sounding areas. Patch edges tightly bonded.	Moderate to severe scaling (aggregate clearly exposed). Abrasion between 0.25 and 0.5 inches deep over more than 30% of surface. Impact damage. Multiple plugged weep holes. Spalling and/or hollow sounding areas larger than 6inches diameter, rebar exposed, rust staining from spalled areas. Patch delamination.	Extensive surface damage. Includes significant exposed and/or corroded rebar. Widespread spalling or delamination with exposed and corroded rebar. Structure may be unstable.
Exposed Rebar	No Exposed rebar.	Moderate efflorescence and no rust staining emanating from cracks.	Local areas of exposed rebar. Efflorescence and/or rust staining emanating from cracks.	Widespread exposed rebar with significant corrosion. Widespread rust staining emanating from cracks

Element 12301 (Headwall) – Metal

Description	This element is for headwalls attached to the end of the culvert.			
Quantity Calculation	The quantity for this element is measured as "each."			
	Condition State Descriptions			
Distresses	**Good**	**Fair**	**Poor**	**Severe**
End Treatment Deformation and Damage (Metal)	No dents, impact damage, or abrasion.	Small dents or impact damage. Abrasion of wall or coating with no breaches in the coating exposing structural wall	Large dents/ deformation or impact damage. Abrasion of protective coating with breaches exposing the base material.	Deformation that restricts flow capacity or is resulting in scour or erosion of embankment
End Treatment Corrosion (Metal)	No corrosion.	Freckled rust or other sign of corrosion of material. No loss of section or pitting.	Corrosion of material and section loss less than 10% of thickness. Deep pitting pronounced thinning. Several holes less than 1inch diameter. Penetration possible with hammer Scour exposing vertical face of previously buried structure or footing. No undermining or rotation of footing.	Widespread corrosion, local through thickness penetrations. Holes greater than 1 in. diameter or many smaller grouped holes allowing soil migration.

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Element 12302 (Wingwall) – Concrete

Description	This element is for headwalls attached to the end of the culvert.			
Quantity Calculation	The quantity for this element is measured as "each."			
	Condition State Descriptions			
Defect Type	**Good**	**Fair**	**Poor**	**Severe**
End Treatment Cracking (Concrete)	No measurable crack width greater than hairline (maximum 0.0625 inches).	Minor cracks with no infiltration. No increase in cracking from previous inspection (if applicable).	Cracks 0.05 in. to 0.1 inches wide. Minor water infiltration through cracks.	Cracks greater than 0.1 inches wide. Water and soil infiltration through cracks.
End Treatment Surface Damage Spalling or Delamination (Concrete)	No scaling, abrasion, or other surface damage. No spalling. No hollow sounds (delaminations). Patched areas that are sound.	Light or moderate scaling (less than 0.25 in. exposed aggregate). Abrasion less than 0.25 in. deep over less than 20% of surface. Localized minor impact damage (less than 0.25 inches deep). Localized spalls less than 6 inches diameter. No exposed rebar. Small hollow sounding areas. Patch edges tightly bonded.	Moderate to severe scaling (aggregate clearly exposed). Abrasion between 0.25 and 0.5 inches deep over more than 30% of surface. Impact damage. Multiple plugged weep holes. Spalling and/or hollow sounding areas larger than 6inches diameter, rebar exposed, rust staining from spalled areas. Patch delamination.	Extensive surface damage. Includes significant exposed and/or corroded rebar. Widespread spalling or delamination with exposed and corroded rebar. Structure may be unstable.
Exposed Rebar	No Exposed rebar.	Moderate efflorescence and no rust staining emanating from cracks.	Local areas of exposed rebar. Efflorescence and/or rust staining emanating from cracks.	Widespread exposed rebar with significant corrosion. Widespread rust staining emanating from cracks

Element 12302 (Wingwall) – Metal

Description	This element is for headwalls attached to the end of the culvert.			
Quantity Calculation	The quantity for this element is measured as "each."			
	Condition State Descriptions			
Defect Type	**Good**	**Fair**	**Poor**	**Severe**
End Treatment Deformation and Damage (Metal)	No dents, impact damage, or abrasion.	Small dents or impact damage. Abrasion of wall or coating with no breaches in the coating exposing structural wall	Large dents/ deformation or impact damage. Abrasion of protective coating with breaches exposing the base material.	Deformation that restricts flow capacity or is resulting in scour or erosion of embankment
End Treatment Corrosion (Metal)	No corrosion.	Freckled rust or other sign of corrosion of material. No loss of section or pitting.	Corrosion of material and section loss less than 10% of thickness. Deep pitting pronounced thinning. Several holes less than 1 inch diameter. Penetration possible with hammer Scour exposing vertical face of previously buried structure or footing. No undermining or rotation of footing.	Widespread corrosion, local through thickness penetrations. Holes greater than 1 in. diameter or many smaller grouped holes allowing soil migration.

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Element 12303 (Scour)

Description	This element is to be used for culverts that are constructed with a footing or other end treatment. Distress due to scour is typically only encountered on 3-Sided Box or Arch Culverts.			
Quantity Calculation	The quantity for this element is measured as each footing or slab.			
	Condition State Descriptions			
Defect Type	**Good**	**Fair**	**Poor**	**Severe**
End Treatment Scour and Stability	No exposure of previously buried sections of footing. No rotation from installed condition.	Scour exposing any surface of previously buried structure but no exposure of the vertical face of the footing. No undermining. No rotation from installed condition.	Scour exposing vertical face of previously buried structure or footing. No undermining or rotation of footing.	Scour with significant undermining of footing. Severe rotation leading to structure distress (kinking of metal culvert; cracking of concrete culvert, cracking of mortar, displacement of masonry units).

Element 12404 (Barrel) – Plastic

Description	This element is for culvert barrel, regardless of culvert shape or culvert material type.			
Quantity Calculation	The quantity is collected in length of feet unless otherwise noted. The barrel element is measured along the flow line of the barrel times the number of barrels. Distresses are measured as a "slice" of the diameter of the barrel's length.			
	Condition State Descriptions			
Defect Type	**Good**	**Fair**	**Poor**	**Severe**
Plastic Barrel – Shape Change	Barrel maintains round shape with no local wall flattening. Vertical deformation less than 5% of nominal diameter.	Minor wall flattening. Vertical deformation 5% to 7.5% of original inside diameter.	Significant wall flattening or increased wall curvature. Vertical deformation 7.5% to 10% of nominal diameter. Visual out-of-roundness.	Major wall flattening with reversal of curvature (global buckling) and/or kinks. Vertical deformation greater than 10% of nominal diameter. Significant visual out-of-roundness.
Plastic Barrel – Surface Damage	No indication of wear, abrasion, impact damage or UV degradation.	Minor wear and abrasion with less than 10% of wall thickness impacted. Minor staining or UV degradation. Blistering over less than 25% of pipe inner surface.	Wear and abrasion that exceeds 10% of wall thickness. UV degradation causing discoloration. Blistering over greater than 25% of pipe inner surface.	Wear and abrasion that exceeds 25% of wall thickness. UV degradation resulting in cracked or broken pipe wall.
Plastic Barrel – Abrasion/ Wear	Smooth interior wall. No splits in welded seams or cracking in wall.	Initiation of local buckling indicated by rippling in wall. Wall cracking or splits, less than ¼ of circumference. No infiltration. No longitudinal cracking.	Advanced and widespread local wall buckling indicated by extensive interior surface rippling. Wall cracking or splits up to ½ of circumference. Minor water infiltration with no soil infiltration. Longitudinal cracking less than 12 inches in length.	Kinks present through the full wall thickness. Pipe wall shows local inward buckling. Wall cracking or splits greater than ½ of circumference. Cracks with indication of soil infiltration. Longitudinal cracking more than 12 inches in length.
Other Barrel Damage – Insect Activity, Fire, etc.	No issues present.	Minor damage to barrel.	Moderate to significant deterioration of barrel.	Major structural defects. Barrel may have failed.

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Description	This element is for culvert barrel, regardless of culvert shape or culvert material type.			
Quantity Calculation	The quantity is collected in length of feet unless otherwise noted. The barrel element is measured along the flow line of the barrel times the number of barrels. Distresses are measured as a "slice" of the diameter of the barrel's length.			
	Condition State Descriptions			
Defect Type	**Good**	**Fair**	**Poor**	**Severe**
Barrel Alignment	Horizontal alignment shows no signs of movement from installed condition (straight or smooth bends). Vertical alignment shows no sagging or heaving.	Horizontal alignment shows small visible deviations from installed condition that does not affect joints or barrel. Vertical alignment has minor sagging or heaving.	Horizontal alignment with deviations from installed condition that may affect joints or barrel (refer to joint inspection). Vertical misalignment causing ponding/sediment accumulation at sags between 10% and 30% of diameter.	Distress at joints or in barrel due to vertical or horizontal misalignment with pipe section offsets. Vertical misalignment has caused ponding/sediment accumulation of more than 30% of diameter. Indication of significant flow restriction

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Element 12404 (Barrel) – Concrete

Description	This element is for culvert barrel, regardless of culvert shape or culvert material type.			
Quantity Calculation	The quantity is collected in length of feet unless otherwise noted. The barrel element is measured along the flow line of the barrel times the number of barrels. Distresses are measured as a “slice” of the diameter of the barrel’s length.			
	Condition State Descriptions			
Defect Type	**Good**	**Fair**	**Poor**	**Severe**
Concrete Barrel – Cracking	No measurable crack width. Hairline cracks (less than 0.0625-inch width) may be present.	Longitudinal cracks 0.01 to 0.05 inches wide with spacing of 3 feet or more. Some circumferential cracks with no water or soil infiltration.	Longitudinal cracks between 0.05 and 0.1 inches wide, with spacing of 1 to 3 feet. Circumferential cracks may have water infiltration. No cracks with vertical offset. No increase in cracking from previous inspection (if applicable).	Longitudinal cracks greater than 0.1 inches wide, and significant water infiltration with soil migration may be present. Cracks with vertical offset.
Concrete Barrel – Spalling/ Slabbing/ Delamination/Patches	No visual spalling, slabbing or delamination as indicated by wall visual appearance. Any patches are sound.	Localized spalls less than 0.5-inch depth and 6-inch diameter. No slabbing. Patches stable but may have small delaminations (as indicated by hollow sounds).	Spalling and/or delaminations from 0.5 to 0.75-inch depth and larger than 6-inch diameter. Deterioration from slabbing with exposed aggregate and loss of up to ½inch of surface mortar.	Widespread spalling greater than 0.75-inch depth or delamination. Slabbing of concrete with complete loss of invert or other wall section. Structure may be unstable.
Concrete Barrel – Exposed Rebar	No Exposed rebar.	Moderate efflorescence and no rust staining emanating from cracks. No exposed rebar.	Local areas of exposed rebar. Efflorescence and/or rust staining emanating from cracks.	Widespread exposed rebar with significant corrosion. Widespread rust staining emanating from cracks

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Description	This element is for culvert barrel, regardless of culvert shape or culvert material type.			
Quantity Calculation	The quantity is collected in length of feet unless otherwise noted. The barrel element is measured along the flow line of the barrel times the number of barrels. Distresses are measured as a "slice" of the diameter of the barrel's length.			
	Condition State Descriptions			
Defect Type	**Good**	**Fair**	**Poor**	**Severe**
Concrete Barrel – Abrasion/ Wear	No scaling, abrasion, or other surface damage.	Minor scaling with less than 0.25-inch exposed aggregate. Abrasion less than 0.25 inches deep over less than 20% of pipe surface. Minor and localized (less than 0.25-inch depth) impact damage. May have multiple plugged weep holes.	Significant to major scaling with aggregate clearly exposed. Abrasion between 0.25 and 0.5-inch-deep over more than 30% of pipe surface. Impact damage present. May have multiple plugged weep holes. May have through wall perforation at the invert.	Major surface damage and aggregate pop-out. Complete invert deterioration and loss of pipe wall section.
Other Barrel Damage – Insect Activity, Fire, etc.	No issues present.	Minor damage to barrel.	Moderate to significant deterioration of barrel.	Major structural defects. Barrel may have failed.
Barrel Alignment	Horizontal alignment shows no signs of movement from installed condition (straight or smooth bends). Vertical alignment shows no sagging or heaving.	Horizontal alignment shows small visible deviations from installed condition that does not affect joints or barrel. Vertical alignment has minor sagging or heaving.	Horizontal alignment with deviations from installed condition that may affect joints or barrel (refer to joint inspection). Vertical misalignment causing ponding/sediment accumulation at sags between 10% and 30% of diameter.	Distress at joints or in barrel due to vertical or horizontal misalignment with pipe section offsets. Vertical misalignment has caused ponding/sediment accumulation of more than 30% of diameter. Indication of significant flow restriction

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Element 12404 (Barrel) – Corrugated Metal

Description	This element is for culvert barrel, regardless of culvert shape or culvert material type.			
Quantity Calculation	The quantity is collected in length of feet unless otherwise noted. The barrel element is measured along the flow line of the barrel times the number of barrels. Distresses are measured as a “slice” of the diameter of the barrel’s length.			
	Condition State Descriptions			
Defect Type	**Good**	**Fair**	**Poor**	**Severe**
Corrugated Metal Barrel – Surface Damage	No dents or other localized damage.	Minor dents or impact damage to pipe wall or end section with no wall breaches.	Large dents or impact damage to pipe wall or end section with localized wall breaches. Breaches no more than one corrugation over circumferential length of inches.	Dents or damage that warrant engineering evaluation. Through-wall holes greater than one corrugation over a length more than 6 inches which allow unimpeded soil infiltration.
Corrugated Metal Barrel – Corrosion	Isolated areas of freckled rust may be present.	Freckled rust or corrosion of pipe wall material. No loss of section and no through wall penetration from corrosion.	Corrosion of pipe material and widespread section loss less than 10% of wall thickness. Localized deep pitting. Several holes less than 1 inch diameter. Penetration possible with hammer pick strike.	Widespread through-wall penetration. Invert missing in localized sections. Through-wall penetrations present. Holes greater than 1 inch diameter or many smaller holes closely grouped.
Corrugated Metal Barrel – Cracking/ Splitting	None present.	Steel cracking is self-arrested or arrested with holes, doubling plates, or similar. Minor yielding of steel and/or cracking/splitting less than 1 inch long local to bolt holes. Minor corrosion developing around bolt holes or on bolts.	Steel cracking is progressing. Yielding of steel and/or cracking/ splitting 1 inch to 3 inches long local to bolt holes. Corrosion with section loss around bolt holes or on bolts.	Major deterioration due to cracking impacting strength of barrel. Significant yielding of steel at bolt holes. Cracking/ splitting 3 inches or more local to bolt holes.

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Description	This element is for culvert barrel, regardless of culvert shape or culvert material type.			
Quantity Calculation	The quantity is collected in length of feet unless otherwise noted. The barrel element is measured along the flow line of the barrel times the number of barrels. Distresses are measured as a "slice" of the diameter of the barrel's length.			
	Condition State Descriptions			
Defect Type	**Good**	**Fair**	**Poor**	**Severe**
Corrugated Metal Barrel – Abrasion/ Wear	No damage due to abrasion.	Small or local abrasion of wall or coating. No breaches in the coating exposing structural wall or signs of corrosion.	Widespread abrasion of protective coating. Probing with a pick may show breaches by exposing wall material and allowing through wall penetration with a pick.	Abrasion has worn large holes through the metal pipe greater than one corrugation in length for more than 6 inches around the circumference.
Corrugated Metal Barrel – Shape (Closed Shape)	Smooth curvature of barrel with deformation less than 5% of nominal diameter.	Top half is smooth. Minor bulges or flattening of the bottom. Deformation 5%-10% of nominal diameter.	Significant distortions or flattening. Lower third may be kinked. Deformation 10% to 15% of nominal diameter. Visible out-of-roundness.	Major distortion throughout pipe. Local areas of reverse curvature and kinks. Deformation greater than 15% of nominal diameter. Significant out-of-roundness.
Corrugated Metal Barrel – Shape (Open Bottom)	Smooth curvature, rise and span measurements within tolerance. The mid-ordinate of the top arc half should be within 10 percent of design.	May have slight asymmetry with smooth curvature. Span may differ more than 5 percent from the design span. The mid-ordinate of the top arc half should be within 15 percent of design.	Noticeable distortion, deflection, or non-symmetrical curvature. The mid-ordinate of the top may be up to 50 percent less than design.	Major visual distortion and deflection. Curvature. Span should be within 5 percent of the design span. Mid-ordinate of the top arc half may be greater than 50 percent less than design.
Other Barrel Damage – Insect Activity, Fire, etc.	No issues present.	Minor damage to barrel.	Moderate to significant deterioration of barrel.	Major structural defects. Barrel may have failed.

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Description	This element is for culvert barrel, regardless of culvert shape or culvert material type.			
Quantity Calculation	The quantity is collected in length of feet unless otherwise noted. The barrel element is measured along the flow line of the barrel times the number of barrels. Distresses are measured as a "slice" of the diameter of the barrel's length.			
	Condition State Descriptions			
Defect Type	**Good**	**Fair**	**Poor**	**Severe**
Barrel Alignment	Horizontal alignment shows no signs of movement from installed condition (straight or smooth bends). Vertical alignment shows no sagging or heaving.	Horizontal alignment shows small visible deviations from installed condition that does not affect joints or barrel. Vertical alignment has minor sagging or heaving.	Horizontal alignment with deviations from installed condition that may affect joints or barrel (refer to joint inspection). Vertical misalignment causing ponding/sediment accumulation at sags between 10% and 30% of diameter.	Distress at joints or in barrel due to vertical or horizontal misalignment with pipe section offsets. Vertical misalignment has caused ponding/sediment accumulation of more than 30% of diameter. Indication of significant flow restriction

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Element 12404 (Barrel) – Masonry

Description	This element is for culvert barrel, regardless of culvert shape or culvert material type.			
Quantity Calculation	The quantity is collected in length of feet unless otherwise noted. The barrel element is measured along the flow line of the barrel times the number of barrels. Distresses are measured as a "slice" of the diameter of the barrel's length.			
	Condition State Descriptions			
Defect Type	**Good**	**Fair**	**Poor**	**Severe**
Masonry Barrel – Masonry Units and Movement	No cracking, split or missing masonry units. No displaced masonry units. No surface deterioration. No measurable cross-sectional distortion.	Cracking of isolated individual units. Surface weathering or spalling. No movement of masonry units.	Split or cracked masonry units. Large areas with significant spalling, scaling, or weathering. Pronounced movement or dislocation of masonry units.	Widespread cracking, splitting, or cracking of masonry units. Missing masonry units. Large areas of major spalling, scaling, or weathering. Holes through structure wall. Significant movement of individual units. Visible movement or distortion of cross-sectional shape. Structure may appear unstable.
Masonry Barrel – Mortar	Mortar is intact with no deterioration.	Localized cracked or missing mortar. Widespread areas of shallow mortar deterioration, possible minor water infiltration (with no active flow) or exfiltration through joints.	Significant missing mortar and mortar deterioration. Minor water flow but no soil infiltration or exfiltration through joints. Vegetation sprouting from between units.	Missing mortar with backfill infiltration. Possible voids in roadway.
Masonry Barrel – Efflorescence or Staining	Minor areas of efflorescence less than 2 inches square.	Widespread areas of efflorescence without rust staining.	Heavy buildup of efflorescence with rust staining.	Critical rating not applicable to this element.
Other Barrel Damage – Insect Activity, Fire, etc.	No issues present.	Minor damage to barrel.	Moderate to significant deterioration of barrel.	Major structural defects. Barrel may have failed.

Description	This element is for culvert barrel, regardless of culvert shape or culvert material type.			
Quantity Calculation	The quantity is collected in length of feet unless otherwise noted. The barrel element is measured along the flow line of the barrel times the number of barrels. Distresses are measured as a "slice" of the diameter of the barrel's length.			
	Condition State Descriptions			
Defect Type	**Good**	**Fair**	**Poor**	**Severe**
Barrel Alignment	Horizontal alignment shows no signs of movement from installed condition (straight or smooth bends). Vertical alignment shows no sagging or heaving.	Horizontal alignment shows small visible deviations from installed condition that does not affect joints or barrel. Vertical alignment has minor sagging or heaving.	Horizontal alignment with deviations from installed condition that may affect joints or barrel (refer to joint inspection). Vertical misalignment causing ponding/sediment accumulation at sags between 10% and 30% of diameter.	Distress at joints or in barrel due to vertical or horizontal misalignment with pipe section offsets. Vertical misalignment has caused ponding/sediment accumulation of more than 30% of diameter. Indication of significant flow restriction

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Element 12404 (Barrel) – Clay

Description	This element is for culvert barrel, regardless of culvert shape or culvert material type.			
Quantity Calculation	The quantity is collected in length of feet unless otherwise noted. The barrel element is measured along the flow line of the barrel times the number of barrels. Distresses are measured as a "slice" of the diameter of the barrel's length.			
	Condition State Descriptions			
Defect Type	**Good**	**Fair**	**Poor**	**Severe**
Clay Barrel – Cracking	No cracking in wall.	Wall cracking less than ¼ of circumference. No longitudinal cracking.	Wall cracking up to ½ of circumference. Longitudinal cracking less than 12 inches in length.	Wall cracking greater than ½ of circumference. Longitudinal cracking more than 12 inches in length.
Clay Barrel - Flaking and Scaling	No indication of flaking and scaling	Minor flaking and scaling with no indication of trapped debris	Moderate flaking and scaling with trapped debris that minimally affects flow.	Major flaking and scaling. Trapped debris significantly obstructs flow.
Other Barrel Damage – Insect Activity, Fire, etc.	No issues present.	Minor damage to barrel.	Moderate to significant deterioration of barrel.	Major structural defects. Barrel may have failed.
Barrel Alignment	Horizontal alignment shows no signs of movement from installed condition (straight or smooth bends). Vertical alignment shows no sagging or heaving.	Horizontal alignment shows small visible deviations from installed condition that does not affect joints or barrel. Vertical alignment has minor sagging or heaving.	Horizontal alignment with deviations from installed condition that may affect joints or barrel (refer to joint inspection). Vertical misalignment causing ponding/sediment accumulation at sags between 10% and 30% of diameter.	Distress at joints or in barrel due to vertical or horizontal misalignment with pipe section offsets. Vertical misalignment has caused ponding/sediment accumulation of more than 30% of diameter. Indication of significant flow restriction

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Element 12404 (Barrel) – Timber

Description	This element is for culvert barrel, regardless of culvert shape or culvert material type.			
Quantity Calculation	The quantity is collected in length of feet unless otherwise noted. The barrel element is measured along the flow line of the barrel times the number of barrels. Distresses are measured as a “slice” of the diameter of the barrel’s length.			
	Condition State Descriptions			
Defect Type	**Good**	**Fair**	**Poor**	**Severe**
Timber Barrel – Connections or Missing Members	No loose bolts, broken welds, missing rivets, or missing fasteners. No surface rust.	Loose bolts or fasteners. Freckled rust (no pitting or section loss), rust staining on face of members but connection is functioning as designed.	Missing bolts, rivets, or fasteners, broken welds, surface rusting with some pitting, pack rust without distortion, but connection is functioning as designed.	Connection integrity is in question. Missing bolts, rivets, or fasteners, broken welds causing movement in connected elements. Heavy rusting with section loss, and/or pack rust causing distortion. Imminent collapse.
Timber Barrel – Deterioration	No sunken faces, staining, or discoloration of member surfaces. No signs of fruiting bodies.	Decay allowing probe penetration up to 10% of the member cross section. Localized hollow sounds.	Decay allowing probe penetration 10% to 20% of the member cross section but is away from connections and tension zone of bending member.	Probe penetrates more than 20% of member cross section or more than 10% near connections or in a tension zone of bending member. Fruiting bodies.
Timber Barrel – Checks/Shakes	Checks or shakes penetrating less than 5% of member thickness	Checks or shakes penetrating 5% to 50% of member cross section, but away from connections and tension zones of bending members.	Checks or shakes penetrating more than 50% of member cross section or up to 10% near connections or in a tension zone of bending member.	Checks or shakes penetrating more than 10% near connections or in a tension zone of bending member.
Timber Barrel – Structural Cracks	No structural cracking.	Structural cracking that has been arrested.	Structural cracking exists, but projects less than 5% into the member cross section.	Structural cracking exists with differential movement across crack.

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Description	This element is for culvert barrel, regardless of culvert shape or culvert material type.			
Quantity Calculation	The quantity is collected in length of feet unless otherwise noted. The barrel element is measured along the flow line of the barrel times the number of barrels. Distresses are measured as a "slice" of the diameter of the barrel's length.			
	Condition State Descriptions			
Defect Type	Good	Fair	Poor	Severe
Timber Barrel – Delamination	No separation between laminations.	Delamination length less than the total member depth and away from connections or has been arrested.	Delamination length equal to or greater than the total member depth, but only present away from connections.	Delamination near connections; imminent collapse of member or structure.
Timber Barrel – Abrasion	No section loss due to abrasion.	Section loss of less than 10% of the member cross section.	Section loss of 10% to 20% of the member cross section.	Section loss of more than 20% of the member cross section.
Timber Barrel – Distortion	No change in structure cross section. No warping, crushing, or sagging of individual members.	Warping or sagging of single or few members not requiring mitigation or has been previously mitigated.	Warping, sagging causing distortion of cross-sectional shape. Crushing of member(s).	Significant distortion of cross-sectional shape or widespread warping, crushing, or sagging.
Other Barrel Damage – Insect Activity, Fire, etc.	No issues present.	Minor damage to barrel.	Moderate to significant deterioration of barrel.	Major structural defects. Barrel may have failed.
Barrel Alignment	Horizontal alignment shows no signs of movement from installed condition (straight or smooth bends). Vertical alignment shows no sagging or heaving.	Horizontal alignment shows small visible deviations from installed condition that does not affect joints or barrel. Vertical alignment has minor sagging or heaving.	Horizontal alignment with deviations from installed condition that may affect joints or barrel (refer to joint inspection). Vertical misalignment causing ponding/sediment accumulation at sags between 10% and 30% of diameter.	Distress at joints or in barrel due to vertical or horizontal misalignment with pipe section offsets. Vertical misalignment has caused ponding/sediment accumulation of more than 30% of diameter. Indication of significant flow restriction

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Element 12405 (Joint)

Description	This element is for joints which define sections between lengths of culvert barrels.			
Quantity Calculation	The quantity for this element is measured as "each."			
	Condition State Descriptions			
Defect Type	**Good**	**Fair**	**Poor**	**Severe**
Joint Separation, Offset, and Rotation	Joints are tightly installed with proper alignment and are functioning well.	Joint separation, offset, or rotation with no indication of distress. Gasket not exposed.	Joint separation, offset, or rotation in one or more joints, with exposed or missing gasket materials.	Joint separation, offset, or rotation with exposed backfill material. Multiple locations of exposed or missing gaskets.
Joint Infiltration/ Exfiltration	Joints are performing as intended with respect to infiltration and exfiltration.	Not applicable. Joint shall meet performance requirement specified in design or will rate as poor.	Joint distress identified by coarse grained soil infiltration through soil-tight joints. Fines infiltration through silt-tight joints. Any water infiltration/exfiltration through leak resistant or watertight joint.	Joint distress directly causes distress to barrel/end section, roadway/shoulder, or embankment.
Joint Cracking (Concrete)	No joint cracking.	Longitudinal cracks of 0.01 in.to 0.05 in. wide (thickness of dime) emanating from joint. No spalling. Small spalls along edge of spigot end that do not expose reinforcing or joint sealant.	Between 0.05 in. and 0.1 in. wide longitudinal cracks emanating from joint. Moderate spalls along edge of spigot end, possible exposed reinforcing or joint sealant.	Greater than 0.1 in. longitudinal cracks emanating from joint. Large spalls along edge of spigot end with associated structural cracking.

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3 RETAINING WALL

3.1 Definitions

An earth retaining structure that retains and stabilizes an unstable soil mass by means of lateral support or reinforcement, with a height of 4 feet or greater and the angle of face inclination greater than 70 degrees from horizontal. Retaining walls join end to a soil and the other end to either soil, a bridge abutment, or other structure(s).

Other common terms which may be used when discussing retaining walls include:

Gravity Walls: A structure that provides lateral support for a mass of soil and owes its stability primarily to its own weight and to the weight of any soil located directly above its base. Examples are mass gravity, reinforced (such as Mechanically Stabilized Earth [MSE]) or modular block.

Semi-Gravity Walls: Somewhat more slender than a gravity wall and requires reinforcement consisting of vertical bars along the inner face and dowels continuing into the footings.

Non-Gravity Walls: A soil-retaining system that derives lateral resistance through embedment of vertical wall elements and supports retained soil with facing elements. Examples are walls with tangent or non-tangent walls with structural facing, such as soldier pile and lagging, shotcrete, and sheet pile walls.

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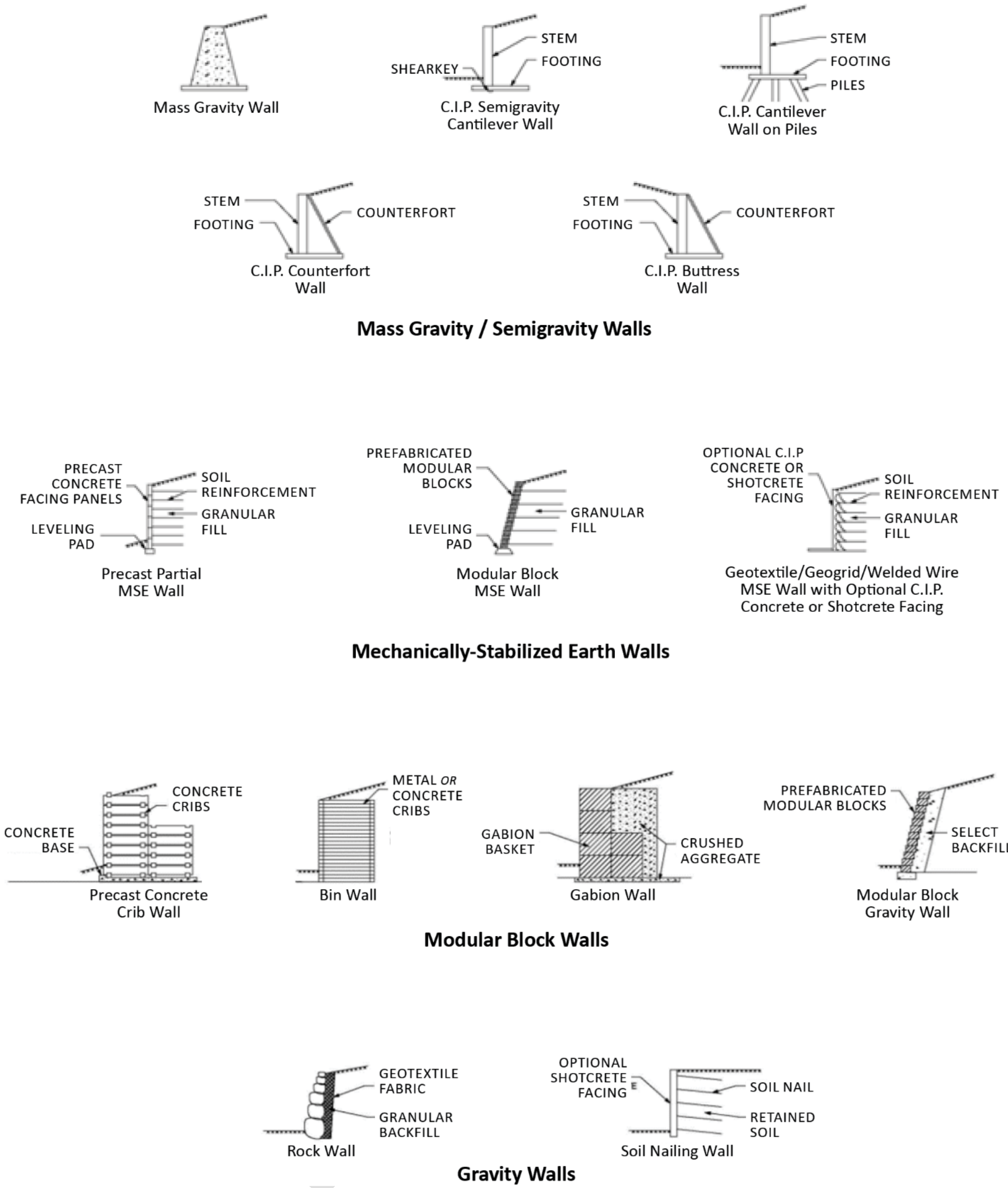

Figure 3-1: Gravity Walls

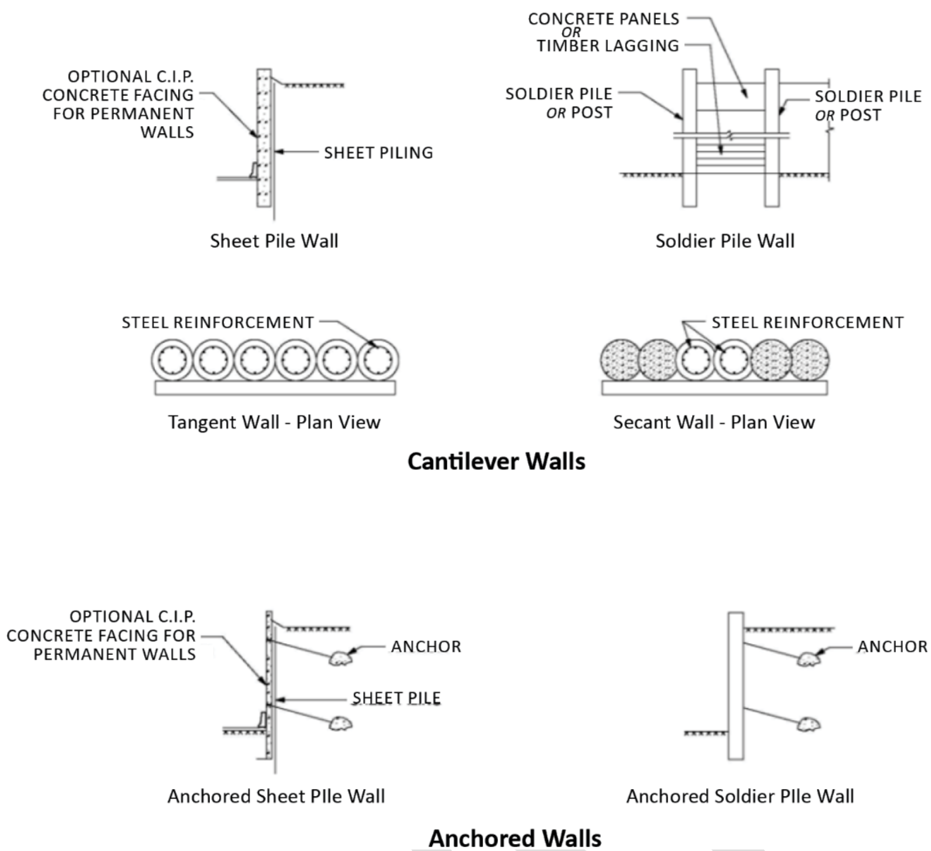

Figure 3-2: Non-Gravity Walls

3.1.1 INVENTORY ITEMS

The inspector shall identify the wall type. The different wall types are Reinforced Concrete Stem, Mechanically Stabilized Wall (MSE), Timber, Masonry, Block, Metal, Anchored, Reinforced, (such as a soil nail wall), Gabion, Plastic/Vinyl Lumber, or Other. Sheet pile walls and sea walls may also be present. The inspector shall also identify the architectural wall facing type, foundation type, and features supported or protected by the wall, and confirm the wall's maximum height, minimum height, length, and batter. The slope of backfill behind and in front of the wall should also be identified. Structures attached to the wall and instrumentation placed on the wall should also be noted. Appurtenances and attachments, such as signs or electrical boxes, should be observed and work recommendations or requests for action should be created to address issues, failure, or safety concerns. Appurtenances and attachments are not rated as part of the retaining wall.

Take photos of the required inventory items listed in Section 3.2.2.

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

3.1.2 ELEMENTS

Retaining walls are divided into six elements. Elements are assigned a condition state based on the distresses identified in each element.

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

Consistent Location Notation Examples:

- ***Wall Facing Area*** – The wall facing area should be calculated by measuring the maximum and minimum height of the wall. The difference in height between maximum and minimum should be multiplied by the wall length to obtain an approximate area.
- ***Wall Length***- In many cases, a retaining wall joins to a bridge. Where a bridge wingwall extends past the nearest expansion or construction joint beyond the abutment and is no longer considered integral with the abutment, the wingwall is then defined as an “independent wingwall”, i.e., a retaining wall. Otherwise, a retaining wall is measured from the location where it joins to soil. The location of points on walls, if measured and noted, are from the south or east end of the wall, not along the direction of vehicle travel. The distress(es) observed, if applicable, is assumed to be at any location within the wall height at that lateral point.
- ***Anchors/Connections –*** The total number of anchors may be counted individually or obtained from plan drawings, if available. Alternatively, the number may be estimated by determining the number of anchors per a ten-foot square area. The wall facing area may then be divided by ten and then multiplied by the number of anchors per a ten-foot square area to obtain an estimated number of anchors.
- ***Vertical Support/Columns*** – The total length of vertical support and columns can be obtained by measuring the average height of post multiplied by the number of vertical supports present.
- ***Wall Stability***- Distress locations along the wall length may be referenced by using photographs. If wall stability distress is noted, the length of distress shall be measured along the length of the wall.
- ***Foundation*** – If the foundation is visible, measure distresses along the total wall length.
- ***Drainage*** – The total amount of drainage can be measured as the length of the wall drainage visible. This is likely equivalent to the wall length plus the distance of drainage extending laterally from the wall.

Table 3-1: Retaining Wall Elements and Unit of Measure

Component	Element	Element Code	Unit of Measure
Retaining Wall Conditions	Wall Facing	13101	Area, square feet
Retaining Wall Conditions	Anchors/Connections	13102	Each
Retaining Wall Conditions	Vertical Support/Columns	13103	Each
Retaining Wall Conditions	Wall Stability	13104	Length, ft
Retaining Wall Conditions	Foundation	13105	Length, ft
Retaining Wall Conditions	Drainage Approach	13106	Length, ft

3.1.3 COMPONENTS

Retaining walls are defined by a single component: the retaining wall structure.

The component rating for a retaining wall is based on the following:

- Retaining Wall Structure - The wall's overall rating is based on its structural condition, ability to perform its function, and possible negative impact to the roadway above or below. The wall facing, buried conditions, and overland conditions are all considered.

See Section 1.7 for discussion on component ratings, element ratings, and condition states.

A representation of the rating structure for retaining walls is provided in Figure 3-3.

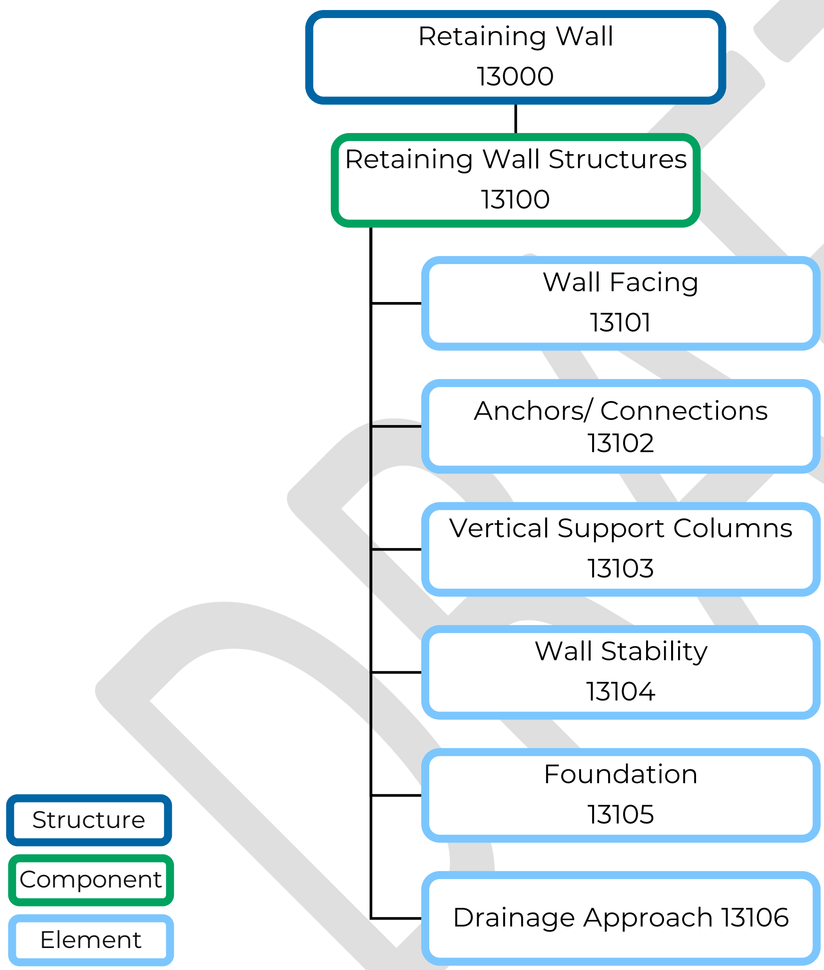

Figure 3-3: Component-element diagram for Retaining Wall Structures

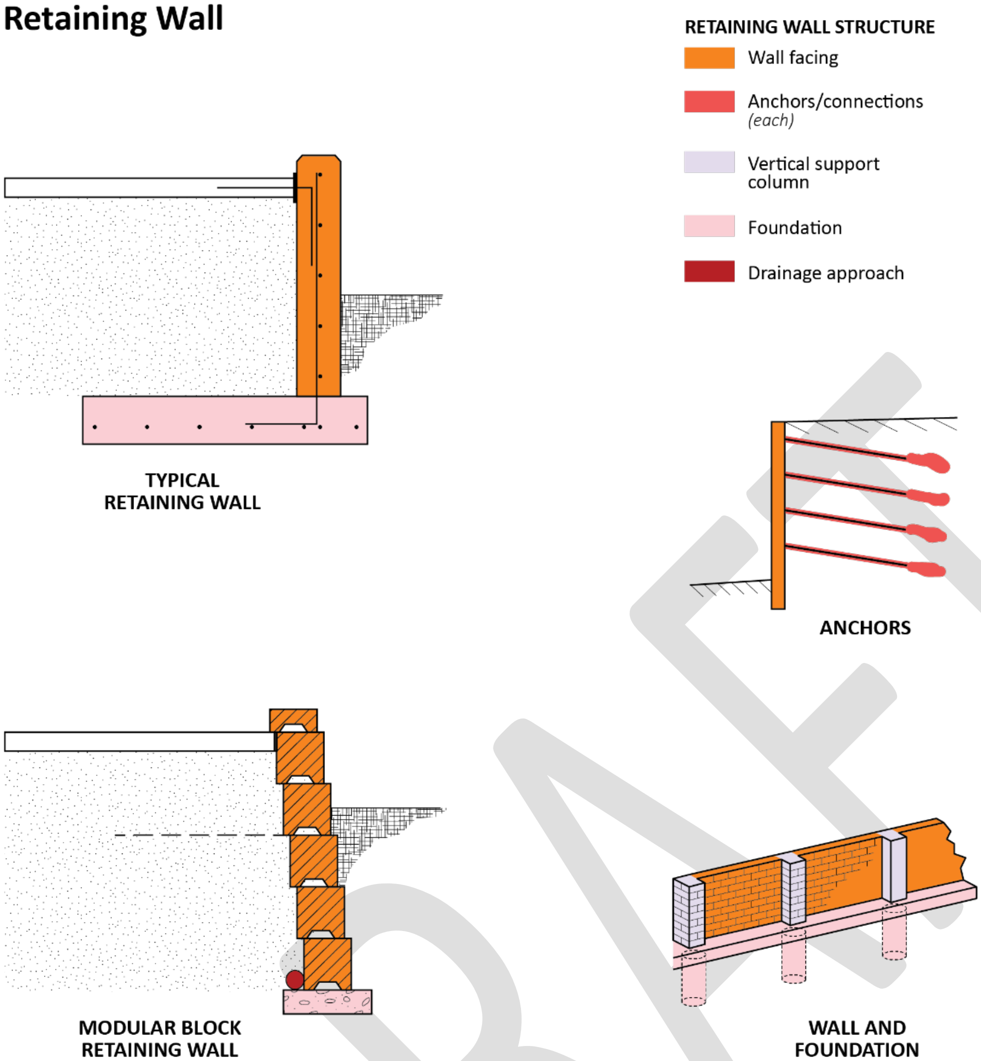

Figure 3-4: Elements and components for Retaining Walls

Note: Wall stability is not represented in the figure. The drainage approach is not fully illustrated. Buried portions of the element(s) will not be inspected.

3.2 Inventory Record Photographs

Inventory photos are captured during a routine inspection, saved as part of the inventory database, and follow the naming convention in *Table 3-2*.

Retaining Wall Required Photos:

- General view of the full wall (may require several sequential photos)
- General view at the top of wall (may require several sequential photos)
- Typical joint photo

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Table 3-2: Retaining Wall Photograph Naming Convention

Photo Name	Description
Wall_Entire_Front	General view of entire wall
Wall_Top	General view of top of wall
Wall_Joint	Typical joint photo
Wall_Attachment	Typical attachment

Note: Photo sequence should coincide with inspection direction for the walls.

3.3 Inspector Minimum Technical Qualifications

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

- A minimum experience of ten structures combined concrete inspection, steel inspection, or design experience (bridge inspection qualifies). At least three of the ten inspected structures shall be concrete structures.
- Ancillary structures inspection procedures training
- Working knowledge of inspection tools, their use, application, and limitations for the structure type being inspected.
- Inspection Experience with anticipated material types, such as concrete, timber, masonry, or steel. Internal training will address inspection procedures for all anticipated material types.

3.4 Routine Inspection

These inspections should assess highway earth retaining structures with heights of greater than 4 feet and the angle of face inclination greater than 70 degrees from horizontal. Walls that retain earth are assessed separately from noise walls, which are not designed to retain soil. Retaining walls should join one end to soil and the other end to either soil, a bridge abutment, or other structure.

Where a bridge wingwall extends past the nearest expansion or construction joint beyond the abutment and is no longer considered integral with the abutment, the wingwall is then defined as an “independent wingwall,” (i.e., a retaining wall). Where a wingwall walls adjoin to a bridge abutment and is considered integral to that abutment, the wall along the abutment is part of the National Bridge Inspection process and is considered part of the bridge. Therefore, a wall which visually appears to be a single length would be defined as ancillary structure retaining wall, bridge abutment wall, ancillary structure retaining wall, similarly to the below sketch. Typically, the expansion or construction joint is within 40 feet of the abutment face and is easily visually observed.

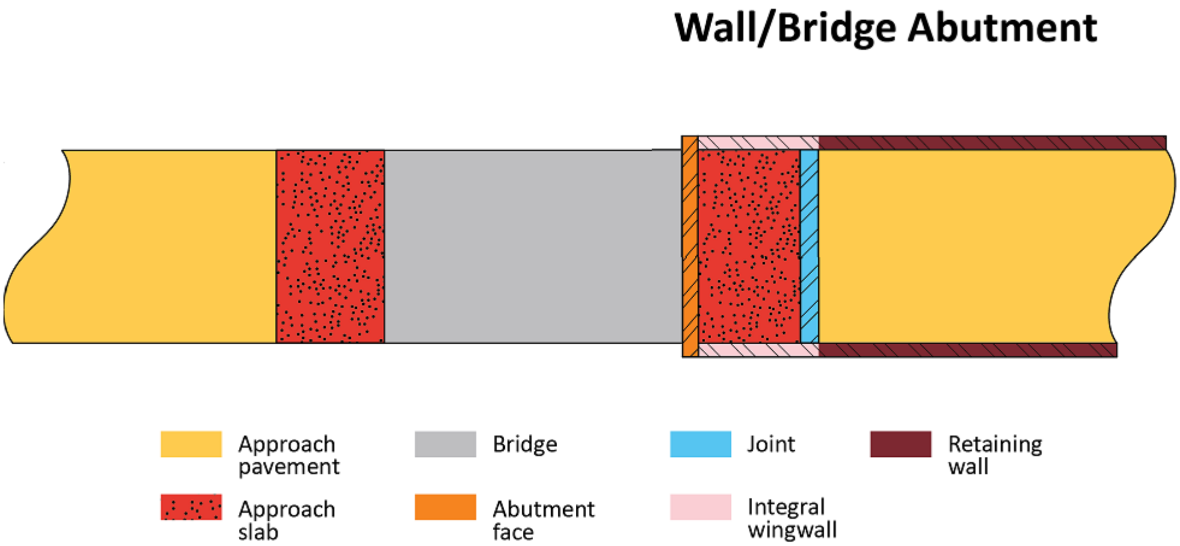

Figure 3-5: Diagram indicating where retaining walls differ from bridge abutments and wingwalls

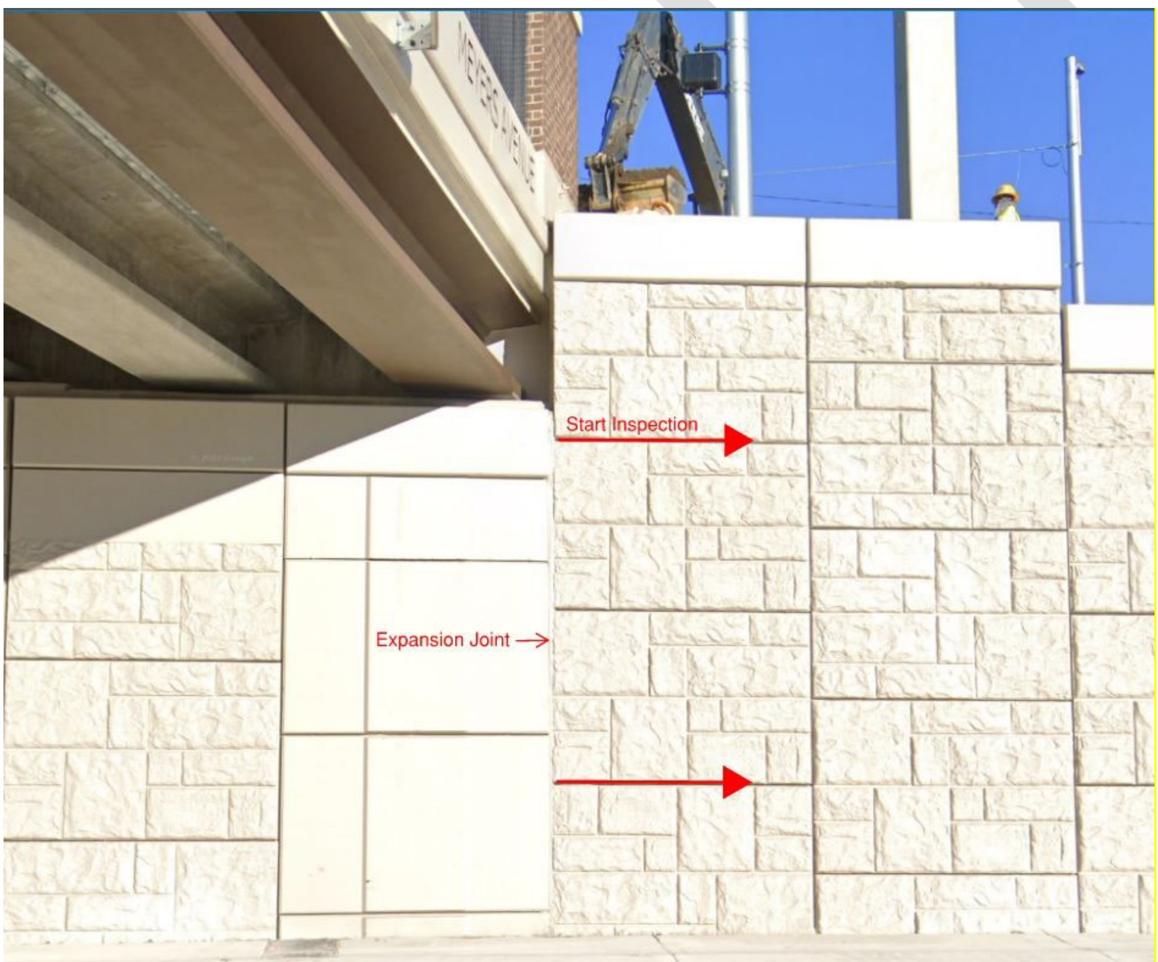

Figure 3-6 Inspection Limits for Retaining Walls

Retaining wall standard inspection frequency is once every 2 years, unless otherwise identified for more frequent inspection.

The routine inspection assesses the retaining wall's ability to safely perform, transfer all loads to the surrounding soil or subsurface material, and assess signs of stability. The inspection of walls for signs of instability (sliding, overturning etc.) is of utmost importance. If safety concerns such as significant erosion, settlement, lateral displacement, etc. are noted, initiate an RFA.

The routine inspection is performed on a regularly scheduled basis, with frequency determined by AS type, and includes the element condition ratings of the wall facing (including joints), vertical support columns, wall stability, foundation, and drainage approach. Walls are typically inspected either from south to north or west to east, similar to bridge inspection procedures.

The purpose of retaining wall inspection is to identify distress indicators related to wall condition and wall stability. It consists of observations and measurements needed to determine the physical and functional condition of the retaining wall. For example, concrete materials might exhibit spalling or cracking, and reinforcing may exhibit corrosion and section loss.

The inspection should identify any changes from initial or previously recorded conditions, and to ensure that the retaining wall continues to satisfy present service requirements. All elements and the component shall be visually inspected at a distance that is close enough to determine the overall condition and to detect deficiencies.

A sample retaining wall routine inspection would consist of:

- Verify set elevations along the face of the wall for signs of settlement.
- Inspect the vertical alignment of the wall with a plumb-bob. Most retaining walls should be vertical (verify with plans or inventory); however, some retaining walls are built at an angle.
- Examine the opening of the construction joints between sections of the wall.
- Inspect joints for any fill material washing out from between or below the panels.
- Inspect panel joints for differential movement or rotation. Sight down panel face to note individual rotation or tipping out of plane.
- If applicable, inspect for erosion or heaving of the embankment material in front and in back of the wall.
- If applicable, inspect for cracking of pavement or sidewalk materials in front and in back of the wall.
- Inspect sidewalk or roadway along the wall for signs of joint separation, potholes and areas of settlement which may indicate a more global impact on the retaining wall system.
- Inspect for settlement of the fill material behind the wall.
- Examine site grading for any locations that may prohibit proper drainage along the wall.
- Examine and probe drains within the vicinity of the wall for signs of clogging.
- Examine the wall for deterioration of the material, such as cracking, spalling, corrosion, discoloration, etc. noting the width, length, depth, and/or orientation of the deterioration.
- Check wall for evidence of efflorescence or rust staining.

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- Examine Panel connections & frame, if applicable.
- Examine post base and anchorage systems if present. Fasteners and connections should be checked for tightness and distress.
- Examine vegetation growth along the wall. Root infiltration may create undesirable stresses on the wall and may induce cracking or failure if left untreated.
- If foundation is visible, note length of foundation exposed and distresses associated with visible foundation.
- Rate Component.
- Rate Elements.
- Provide photographs for all Poor or Severe condition state defects and submit the applicable Work Recs or RFAs.

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

Table 3-3: 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”)

Note: Cracking width guidelines taken from FHWA Bridge Inspector’s Reference Manual (Publication No. FHWA NHI 03-001, October 2002)

3.4.1 STRUCTURE COMPONENT RATING

The retaining wall’s overall characteristics are rated on its structural condition, ability to perform its function, and possible negative impact to the entire wall or the roadway above or below. The wall facing, buried conditions, and overland conditions are all considered as part of the component rating. The component rating includes consideration of critical items pertaining to the structural condition of the wall face including anchors or connections. When evaluating cracking or other wall face distresses consider that different distresses are not of equal importance to the wall function. The failure of an anchored wall system may result in serious consequences such as partial or full collapse of retaining wall and surrounding assets, loss of life and significant financial loss. Wall failure may also impact nearby structures behind the wall, including other roadways, bridges, or buildings.

Distresses due to water pressure effects are highly important when rating the overall structure.

The predominant characteristic determining overall condition is stability. Consider if the wall is unstable due to soil movement or foundation issues. Also consider if scour or erosion

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has created wall instability. Wall backfill or drainage system issues may occur in conjunction with the unstable wall condition.

Table 3-4: Component Rating Guidelines for Retaining Walls

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 elements are sound and functioning as designed. There may be superficial cracking or weathering and/or dirt contamination of structural elements.
7	GOOD	All	All elements retain full section properties and function as designed. Minor cracks or moderate cracks that are sealed.
6	SATISFACTORY	Concrete	Unsealed moderate-width or map cracks. Minor delamination, spalling, or efflorescence without build-up or rust staining.
		Timber	Decay or section loss affecting less than 5% of the member section. Splits arrested and concerns mitigated.
		Steel	Protective coating failures is limited to less than 2% of the surface area with no loss of section.
		Masonry	Moderate weathering or cracking (joints may have minor deterioration). Evidence of slight freeze-thaw.
		All	Minor deterioration affecting structural elements. Scour effects have been arrested with countermeasures.
5	FAIR	Concrete	Moderate delamination, spalling, or efflorescence. Reinforcement exposure without section loss.
		Timber	Decay or section loss affecting 5% to 10% of the member section. Checks, shakes, and splits have no effect on capacity.
		Steel	Protective coating failure is limited to less than 5% of the surface area with minor loss of section. Loose fasteners or broken welds present but the connection is in place and functioning as intended.
		Masonry	Extensive weathering or cracking (joints may have slight separation or offset). Evidence of minor freeze-thaw.
		All	Moderate deterioration affecting structural elements including minor settlement, shallow scour, or impact damage. Structure continues to function as designed.
4	POOR	Concrete	Considerable cracking, spalling, and efflorescence with heavy build-up or rust staining.
		Timber	Extensive decay, section loss, checks, shakes, or splits that do not warrant structural review.

Component Rating	Condition	Material	Description
3	SERIOUS	Steel	Protective coating failure affecting between 5% and 10% of the surface area with some loss of section. Cracks that have not been arrested but do not require structural review.
		Masonry	Advanced weathering or cracking (joints may have separation or offset). Evidence of moderate freeze-thaw.
		Concrete	Considerable areas of spalling, exposed reinforcement with section loss, or heavy rust staining.
		Timber	Decay or section loss that affects more than 10% of the member section. Checks, shakes, splits warrant action.
		Steel	Protective coating failure affecting more than 10% of the surface area with measurable loss of section. Missing fasteners or adjacent broken welds present.
		Masonry	Severe cracking, offset or misalignment. Evidence of severe freeze-thaw.
		All	Considerable deterioration or damage affecting structural elements. Structural evaluation, hydraulic, and/or load analysis may be necessary to determine if the structure can continue to function without restrictions or immediate repairs.
2	CRITICAL	All	Deterioration has progressed to the point where the structure is not stable and emergency repairs or shoring with structurally engineered temporary supports is required. Inspection frequency may need to be increased.
1	IMMINENT FAILURE	All	Road is closed to traffic due to retaining wall failure, but corrective action may put the noise wall back in service.
0	FAILED	All	Road is closed due to retaining wall condition.

3.4.1.1 Wall Facing Element Condition States

Start by identifying the wall type: Reinforced Concrete, MSE, Timber, Masonry or Block, Metal, Anchored (such as a soil nail wall), Gabion, or Plastic/ Vinyl Lumber, such as described in section 3.1. Wall type identification is used to identify the distresses applicable to that wall facing type. Where walls are composed of multiple facing types, a separate inspection is performed for each wall face type. *Figure 3-7* provides the wall facing distresses that might be determined for select wall facing types. Other wall types should consider the materials present at the facing and use the distresses typical for those materials.

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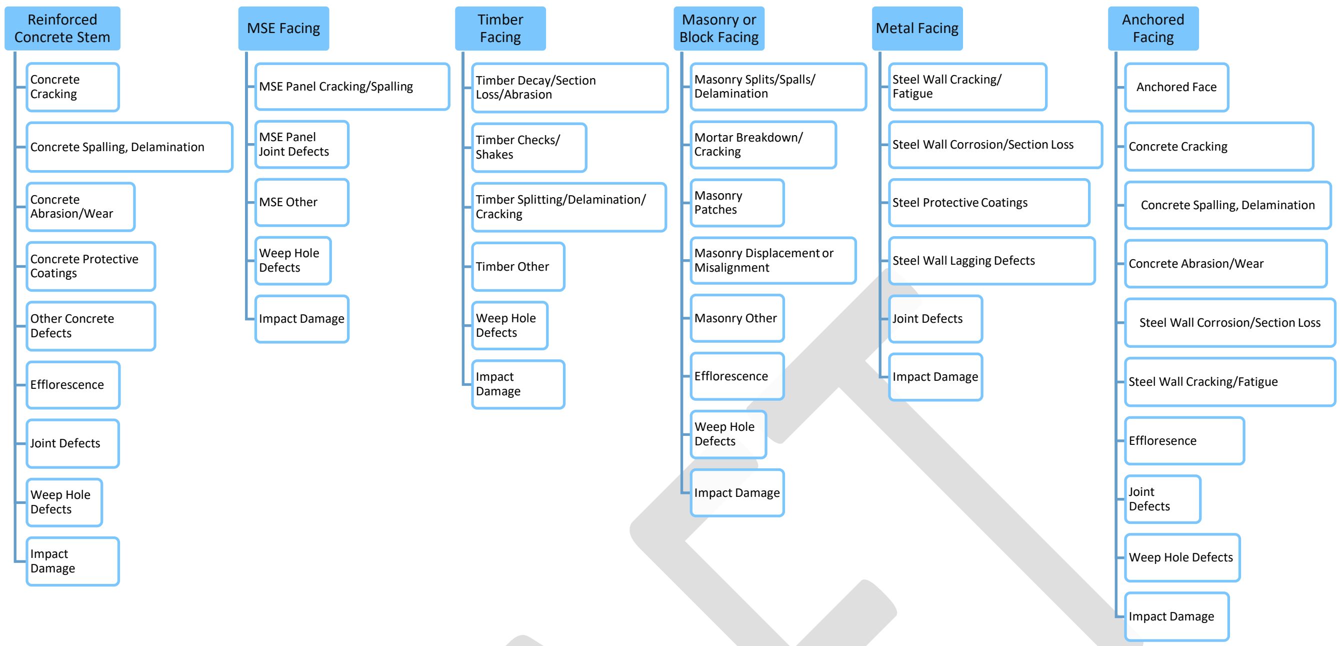

Figure 3-7: Wall facing distresses

The wall facing element provides the primary restraint to the slope behind the wall by adequately resisting the lateral forces generated by the slope. The wall facing is the exposed portion of the retaining wall. Wall facings can be metal, precast, or reinforced concrete, timber, masonry, or other types of material. This includes modular units such as MSE panels and concrete panels/blocks or masonry blocks. Barriers and coping at the top of the wall, however, do not count as part of the wall face area.

Some wall facing types have multiple condition states associated with the facing, such as reinforced concrete walls which require assessment for the concrete cracking, spalling, delamination, and efflorescence. Wall facings have elements closely associated with the facing such as joints and weep holes. For ease of inspection, these joints and weep hole distresses are inspected as part of the wall facing element inspection.

The wall facing inspection shall identify the facing type of material and the associated distresses with the facing type. Inspect the wall facing from the top of the wall (below any copings) to the top of the foundation or to the top of finished grade. Embedded and buried portions of walls are not subject to condition inspection since they are not visible.

Figure 3-8: Typical wall facing inspection limits

Reinforced Concrete Stem

The reinforced concrete wall face includes all types and shapes of reinforced concrete. Reinforced concrete exhibits several different types of deterioration and defects, including, reinforcing bar corrosion, concrete cracking, spalling, and delamination, and other deterioration as described in this subsection.

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Table 3-5: Reinforced Concrete Stem Element Distresses

Element Number	Element Name	Description	Applicable Distresses
13101	Reinforced Concrete Stem	Concrete wall stem exposed above ground.	Concrete Cracking
			Concrete Spalling, Delamination
			Concrete Abrasion/Wear
			Concrete Protective Coatings
			Other Concrete Defects
			Efflorescence*
			Joint Defects**
			Weep Hole Defects*
			Impact Damage*

Unit of Measure: Area, square feet measured or estimated using average height of facing multiplied by length.

***Applies to all facing types**

****Applies to all facing types except MSE wall facings**

Details on the condition state rating schema are in Section 3.7, linked below:

[Retaining Wall Condition State Tables]

Concrete Cracking

Concrete cracking can be either nonstructural or structural and can be caused by many 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. Nonstructural cracking is typically less than 1/8 inch wide. 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.

Figure 3-9: Horizontal structural cracking

Inspect the wall face for cracking and investigate whether any observed cracking is non-structural or structural in nature. Document the approximate location, orientation, width, and spacing of the cracking.

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Inspect and document the extent and location of exposed reinforcing bar corrosion. Estimate the extent of any section loss.

Figure 3-10: Corroded wall reinforcing

Concrete Spalling and Delamination

Concrete spalling is a surface failure in which concrete breaks off from the underlying concrete substrate. Like cracking, the spalling typically occurs when the steel reinforcing embedded within the concrete member undergoes corrosion. Spalling can also occur at expansion and contraction joints, at rustication and other ornamental non-structural features. It can also occur at cracks that have propagated due to wall deflection or impact damage.

Figure 3-11: Concrete spall with corroded reinforcing

Figure 3-12: Spalled and delaminated concrete

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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 wall for delamination and spalling. With a sounding hammer or other device, sound any areas that are exhibiting signs of distress to determine the limits of deterioration. Document the approximate location of delamination or spalling while indicating if reinforcement is exposed.

Abrasion/Wear

Damage occurs when the surface of concrete is unable to resist wear caused by rubbing and friction. As the outer paste of concrete wears on wall face, the fine and coarse aggregate are exposed, and abrasion and impact will cause additional degradation that is related to aggregate-to-paste bond strength and hardness of the aggregate. Abrasion of retaining wall faces is most often the result of wind or water-borne particles along the face of the wall.

Inspect the wall for signs of concrete abrasion, including the loss of cement paste and the exposure of the underlying aggregate. Document on the location and extent of any abrasion on the surface of the wall face.

Figure 3-13: Retaining wall concrete abrasion

Concrete Protective Coatings

Inspect concrete surfaces for protective coating failure. Document the approximate location and extent of coating failure. Inspect concrete coating systems for wear due to UV exposure and other deterioration. Some failures are specific to the coating system, (i.e., epoxy systems) are subject to chalking, cracking, and flaking. Note the degree of effectiveness to which the concrete protection system is functioning.

Figure 3-14: Semi-protective concrete protective coating

Other Concrete Defects

Includes distresses otherwise not noted, which may indicate that the wall facing is not functioning as intended or designed. Identify, inspect, and document the type and extent of any problematic deterioration or conditions.

Efflorescence

Efflorescence is caused when soluble salts and other dispersible water materials come to the surface of concrete and mortars. Efflorescence can be identified by the presence of a white powdery solid which appears on the surface of the concrete.

Inspect the wall for the presence of efflorescence, including surface white with built up or heavy build up with rust staining.

Figure 3-15: Efflorescence accumulation

Joint Defects

Wall joints are horizontal or vertical discontinuities in the wall facing, created intentionally to relieve differential movement, as a result of constructure procedures such as concrete pours, or as a characteristic of the wall facing material.

Inspect the wall joints for displacement, evidence of joint material damage or missing material, and seepage of moisture or backfill through the joint. Document any noted problem areas.

Weep Holes Defect

Inspect weep holes in the wall (if applicable) to determine if they are functioning adequately. Document the approximate location of clogged or ineffective drain systems.

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Figure 3-16: Weep holes/wall drainage

Impact Damage

Inspect the wall system for vehicular impact damage. Document the location and degree of damage.

Figure 3-17: Impact damage

MSE Wall Facing (Precast Facing Panels)

MSE walls consist of a reinforced soil mass and a concrete facing which is vertical or near vertical. The facing is often precast panels which are used to hold the soil in position at the face of the wall. The reinforced soil mass consists of select granular backfill. The soil reinforcements and their connections may be proprietary, and may utilize either metallic (e.g., strip- or grid-type) or polymeric (e.g., sheet-, strip-, or grid-type) reinforcement. The soil reinforcing strips hold the wall facing panels in position and provide reinforcement for the soil. Geotextiles are used to cover the joint between the panels and are placed behind the precast panels to keep the soil from spilling through the joints and to allow excess water to flow out.

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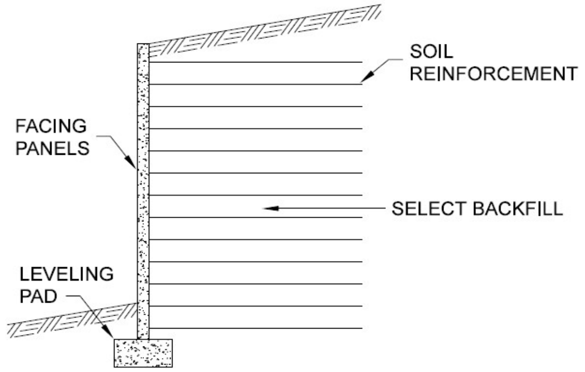

Figure 3-18: Typical MSE Wall configuration

MSE Walls are inspected for evidence of wall movement, as well as for evidence of bulging, bowing or panel offset. It is noted that MSE walls are intended to accommodate movement within tolerable limits. It is at the discretion/interpretation of the inspector to document and understand the extents of those movements. MSE walls are also inspected for poor or uncontrolled drainage, and for other evidence of damage. Inspect the MSE Wall for the following distresses.

Table 3-6: MSE Wall Facing Element Distresses

Element Number	Element Name	Description	Applicable Distresses
13101	MSE Wall Facing	MSE wall exposed above ground.	MSE Panel Cracking/ Spalling
			MSE Panel Joints
			MSE Other
			Impact Damage***
Unit of Measure: Area, square feet measured or estimated using average height of facing multiplied by length. ******See the descriptions and discussions under the Reinforced Concrete Wall subsection.***			

Details on the condition state rating schema are in Section 3.7, linked below:

Retaining Wall Condition State Tables

MSE Panel Cracking/Spalling

Check the wall panels for evidence of horizontal or vertical cracking and staining caused by moisture. Structural cracking may be characterized by a separation which penetrates through the full depth of the panel. Wall panels shall also be checked for spalling and other forms of deterioration. Document the location of cracking and other signs of deterioration and the quantity of panels affected.

MSE Panel Joints

The joints between panels of MSE Walls are to be inspected and examined for loss of backfill, change in spacing, and indications of settlement. Check joints for exposure of geotextile fabric, lack of seal adhesion, loss of joint filler material, and leakage through the

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joints. Check for evidence of backfill seeping through the joints, including backfill piles at the base of the wall. Document the location where fabric is exposed, lack of seal adhesion, loss of joint filler and or loss of fill is occurring. Inspect the wall system for vegetation growth between the panels. Document locations where vegetation is growing.

MSE Other

Drainage systems through or along MSE walls is inspected to verify water is free flowing into and out of the appropriate facility. Ensure that weep holes are free draining. Additionally, associated patterned vertical cracks that propagate at the weep hole and up along the wall facing are often visual indications of excessive hydrostatic pressure or inadequate drainage flow.

Timber Wall Facing

Timber wall facing includes many types and shapes, including timber lagging, slats, and stacked beams.

Wood is a natural engineering material that is prone to deterioration caused by decay, fungi, and insect attack, and through mechanical damage. Typically, areas of high moisture content in timber elements create conditions suitable for biological damage. Mechanical damage might include damaged members or mechanical fasteners.

Walls composed solely or primarily of timber require inspection for insect damage, decay, splitting, and other defects. Since decay often occurs from the inside-out it is important to perform additional investigation when rotting is suspected. Timber walls located in water or saturated soil are also susceptible to advanced loss near the waterline.

Timber members are also susceptible to drying and weathering, which often results in surface and through splits. Checks and splits in members can indicate a weakened member and create an entry for moisture to enter the element.

Table 3-7: Timber Wall Facing Element Distresses

Element Number	Element Name	Description	Applicable Distresses
13101	Timber Wall Facing	Timber wall facing exposed above ground.	Timber Decay/Section Loss/ Abrasion
			Timber Checks/Shakes
			Timber Splitting/ Delamination/ Cracking
			Timber Other
			Impact Damage***

Unit of Measure: Area, square feet measured or estimated using average height of facing multiplied by length.

*****See the descriptions and discussions under Reinforced Concrete Wall subsection.**

Details on the condition state rating schema are in Section 3.7, linked below:

Retaining Wall Condition State Tables

Decay/Section Loss/Abrasion

Inspect the wall for insect damage, decay, and section loss or abrasion. Surfaces exposed to drainage and other moisture is also documented. Use an awl or sharp knife to penetrate suspected areas to check for decay. When section loss or abrasion is measurable, evaluate the area to determine if an in-depth inspection and subsequent load analysis is warranted. Document the approximate location and estimated amount of section loss, and the location, type of defects, and other deterioration.

Figure 3-19: Section loss at top of wall

Figure 3-20: Timber lagging splitting

Checks/Shakes

Checks and Shakes are natural and are present in most timber members. Inspect the wall for check or shakes. Document the approximate location and the length in respect to member depth.

Splits/Delaminations/Cracking

Inspect the wall for splits and delaminations. Document the approximate location and length in respect to the member depth.

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Figure 3-21: Timber lagging is split along top

Timber Other

Inspect the timber walls for loose or failed connections, and other problem areas not noted above. Document the location, and extent of deterioration or damage if present.

Masonry Walls Facing

Stone masonry is seldomly used in new construction today except as facing or ornamentation. However, many old stone walls are still in use and require inspection. Granite, limestone, and sandstone are the most common types of stone that were used and are still seen today. There are three general types of stone masonry construction:

- **Rubble Masonry** consists of rough stones that are un-squared and used as they come from the quarry. They can be constructed to approximate regular rows or courses (coursed rubble) or could be uncoursed (random rubble).
- **Squared-Stone Masonry** consists of stones, that are squared and dressed roughly. They can be laid randomly or in courses.
- **Ashlar Masonry** consists of stones, that are precisely squared and finely dressed. Like square-stone masonry, they can be laid randomly or in courses.

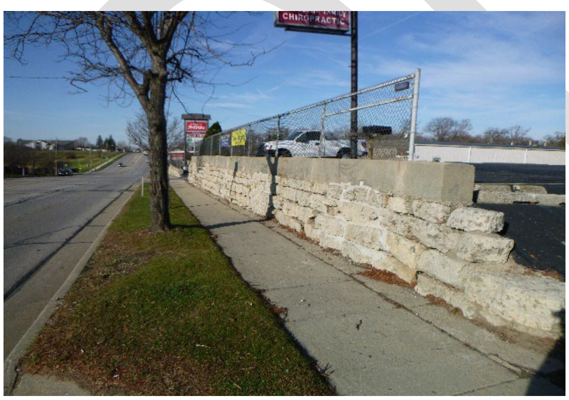

Figure 3-22: Typical square-stone masonry wall

Table 3-8: Masonry Wall Element Distresses

Element No.	Element Name	Description	Applicable Distresses

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13101	Masonry Wall Facing	Masonry wall facing exposed above ground.	Masonry Wall Splits/Spalls/ Delamination
			Masonry exposed reinforcement
			Mortar Breakdown/Cracking
			Masonry Patches
			Masonry Displacement/ Misalignment
			Masonry Other
			Efflorescence***
			Weep Hole Defects***
			Impact Damage***

Unit of Measure: Area, square feet measured or estimated using average height of facing multiplied by length.

*****See the descriptions and discussions under the Reinforced Concrete Wall subsection.**

Details on the condition state rating schema are in Section 3.7, linked below:

Retaining Wall Condition State Tables

Masonry Splits/Spalls/Delaminations

Inspect the wall face for evidence of splitting, spalling and delaminated areas. Document the extent and location of any noted deterioration.

Figure 3-23: Vertical split in modular block

Masonry Exposed Reinforcement

Inspect the wall face for evidence exposed steel reinforcement. Note any section loss or corrosion on exposed steel.

Mortar Breakdown/Cracking

Inspect the masonry joints for cracks, loose or missing mortar, vegetation, and water seepage.

Figure 3-24: Masonry breakdown

Masonry Patches

Inspect any patched areas of masonry for cracking and or spalling. Sound previous patches with a hammer to evaluate the condition of the repair.

Masonry Displacement or Misalignment

Check overall configuration of the wall for vertical or horizontal misalignment, signs of settlement, and bulging or warping of the wall.

Figure 3-25: Wall misalignment

Metal Facing

The Metal Facing element includes steel sheet piling, bin wall construction, corrugated metal panels and other constructions.

Sheeting piling walls are structural units which, that when connected to one another, will form a continuous wall. Sheeting is driven to a depth sufficient for the passive pressure exerted on the embedded portion to resist the lateral active earth pressures acting on the cantilevered section. This type of facing system is not typically constructed with weep holes.

Metal bin walls are a system of adjoining closed-faced bins, approximately 10 ft. wide, comprised of sturdy, lightweight steel members. The overlapping steel members are bolted together to form an integral structure. The closed bins are then backfilled with granular material. Together, the backfill and the closed-faced bins form a composite gravity wall.

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Figure 3-26: Typical sheet pile wall

Figure 3-27: Typical metal bin wall

Table 3-9: Metal Wall Element Distresses

Element Number	Element Name	Description	Applicable Distresses
13101	Metal Wall Facing	Metal or steel wall facing exposed above ground.	Steel Wall Cracking/Fatigue
			Steel Wall Corrosion/Section Loss
			Steel Protective Coatings
			Steel Other
			Joint Defects***
			Impact Damage***

Unit of Measure: Area, square feet measured or estimated using average height of facing multiplied by length.

*****See the descriptions and discussions under the Reinforced Concrete Wall subsection.**

Details on the condition state rating schema are in Section 3.7, linked below:

Retaining Wall Condition State Tables

Steel walls shall be inspected for corrosion, cracking, collision, coating failures, and other defects. Steel walls located in water or saturated soils are also susceptible to advanced section loss near the waterline.

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Sheet pile walls, typical composed of steel, which are located along shorelines are not required to have inspection performed from the water. Water-side inspection would necessitate the use of boat, kayak, or other conveyance. Visual inspection for distresses and the associated condition state defects from the shoreline shall be conducted. Steel sheet piling not visible below the waterline will not be assessed.

Steel Wall Cracking/Fatigue

Inspect the wall for cracking. When cracking has been previously arrested or repairs have been installed observe the surrounding surface area to verify that further propagation is not occurring. Document the approximate location and estimated length of the cracking.

Steel Wall Corrosion/Section Loss

Inspect the wall for corrosion and section loss. Inspect surfaces that are exposed to drainage or other moisture for additional corrosion and section loss. Document the approximate location, type of defect, and cause of the damage and estimate the extent of any section loss.

Figure 3-28: Steel corrosion and section loss

Steel Protective Coatings

Inspect steel surfaces for protective coating failure. Note whether the failure is limited to the top application coat or to bare steel. Create Work Rec and document the approximate location, percentage, and extent of coating failure. Coating failure may be indicated by surface dulling, loss of pigment, exposure of bare metal, oxidation indicated by darkening of the coating, or peeling and curling of the protective coating.

Steel protective coatings are for steel elements that have a protective coating such as paint, galvanization, or other top-coat steel corrosion inhibitor. This element describes all coating systems, including but not limited to paint systems, oxide on weathering steel, metallizing, and galvanization.

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Figure 3-29: Steel protective coating missing

Inspect steel coating systems for chalking, peeling, curling, and oxide color. Document on the location and extent of any observed deterioration to coating systems present.

Steel Other

Inspect the wall for defects such as distortion or buckling of the wall or lagging. Check for horizontal or vertical misalignment between sheeting or other panels. Document the location, length of area affected, and estimated extent of damage.

Anchored Wall Facing

Anchored walls generally consist of vertical structural elements, such as soldier piles, sheet pile, caissons or drilled shafts, combined with lateral anchorage elements placed beside or through the vertical structural elements. Anchorage types include ground anchors, soil nails, dead man anchorage, and post tensioned caissons. The anchor typically includes the anchorage visible in front of the wall face and the anchor length installed behind the wall face. In some walls, for aesthetic reasons, the anchorage is covered by lagging.

Anchored walls offer several advantages over more conventional gravity type wall systems. One of the biggest benefits of these types is the wall's ability to withstand relatively large horizontal wall pressures without requiring a significant increase in the wall cross-section area. Additional benefits include the elimination of the need for deep foundation support, and reduced right-of-way (ROW) acquisition. Anchor failures may be the result of excessive loading of an anchor (e.g., surcharge by construction materials or equipment), failure of the soil mass behind the wall, or anchorage material failure.

Distresses applicable to various wall types and materials could all apply to the anchored wall types, depending on the type of exposed face. The anchored wall face element applies to distresses observed on the face of the anchored wall. The anchors themselves are discussed as a separate element in Section 3.4.1.2.

Table 3-10: Anchored Wall Facing Element Distresses

Element Number	Element Name	Description	Applicable Distresses
13101	Anchored Wall Facing	Anchored wall including ground anchors, soil nails, dead man walls, and post-tensioned caissons.	Anchored Face
			Concrete Cracking***
			Concrete Spalling, Delamination***
			Concrete Abrasion/Wear***
			Steel Wall Corrosion/Section Loss***
			Steel Wall Cracking/Fatigue***
			Joint Defects***
			Efflorescence***
			Weep Hole Defects
			Impact Damage***

Unit of Measure: Area, square feet measured or estimated using average height of facing multiplied by length.

*****See the descriptions and discussions under Reinforced Concrete Wall subsection.**

Details on the condition state rating schema are in Section 3.7, linked below:

Retaining Wall Condition State Tables

Types of anchored wall systems are presented below.

Soldier Pile and Lagging Wall

Soldier pile and lagging walls are a common type of anchored wall system. This wall system uses discrete vertical wall elements spanned by lagging which is typically timber, but which may also be precast panels or reinforced shotcrete.

Figure 3-30: Soldier pile wall with precast lagging (note: anchors not shown)

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Continuous Walls

Ground anchors are also used in continuous wall systems, such as sheet-pile walls, tangent or secant pile walls, slurry walls, or soil mixed walls. Unlike soldier pile and lagging walls, continuous walls act as both vertical and horizontal wall elements. Because of the relative continuity of these wall systems, the design also takes the water pressure behind continuous walls into account.

Figure 3-31: Typical continuous wall

Soil Nail Walls

Soil nails are reinforcing, passive elements that are drilled and grouted horizontally in the ground to support excavations in soil or in soft and weathered rock. Unlike ground anchors that are post-tensioned, soil nails contribute to the stability of the earth-resisting systems mainly through tension as a result of the deformation of the retained soil or weathered soil mass. Soil nails also transfer loads to the surrounding ground through shear stresses (i.e., bond stresses) along the grout-ground interface. As with any passive system, some movement of the wall is expected to engage the nails.

Figure 3-32: Typical soil nail wall

Post Tensioned Caissons

Post tensioned caissons are a method used to provide anchorage for retaining walls to resist overturning and other wall forces. An example of the details used for this design is shown in *Figure 3-33*. Like other anchorage systems, the caissons and connections on the

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fill side of the wall are not directly visible for inspection; however, it is very important to recognize the external indications of potentially serious problems with anchorage systems.

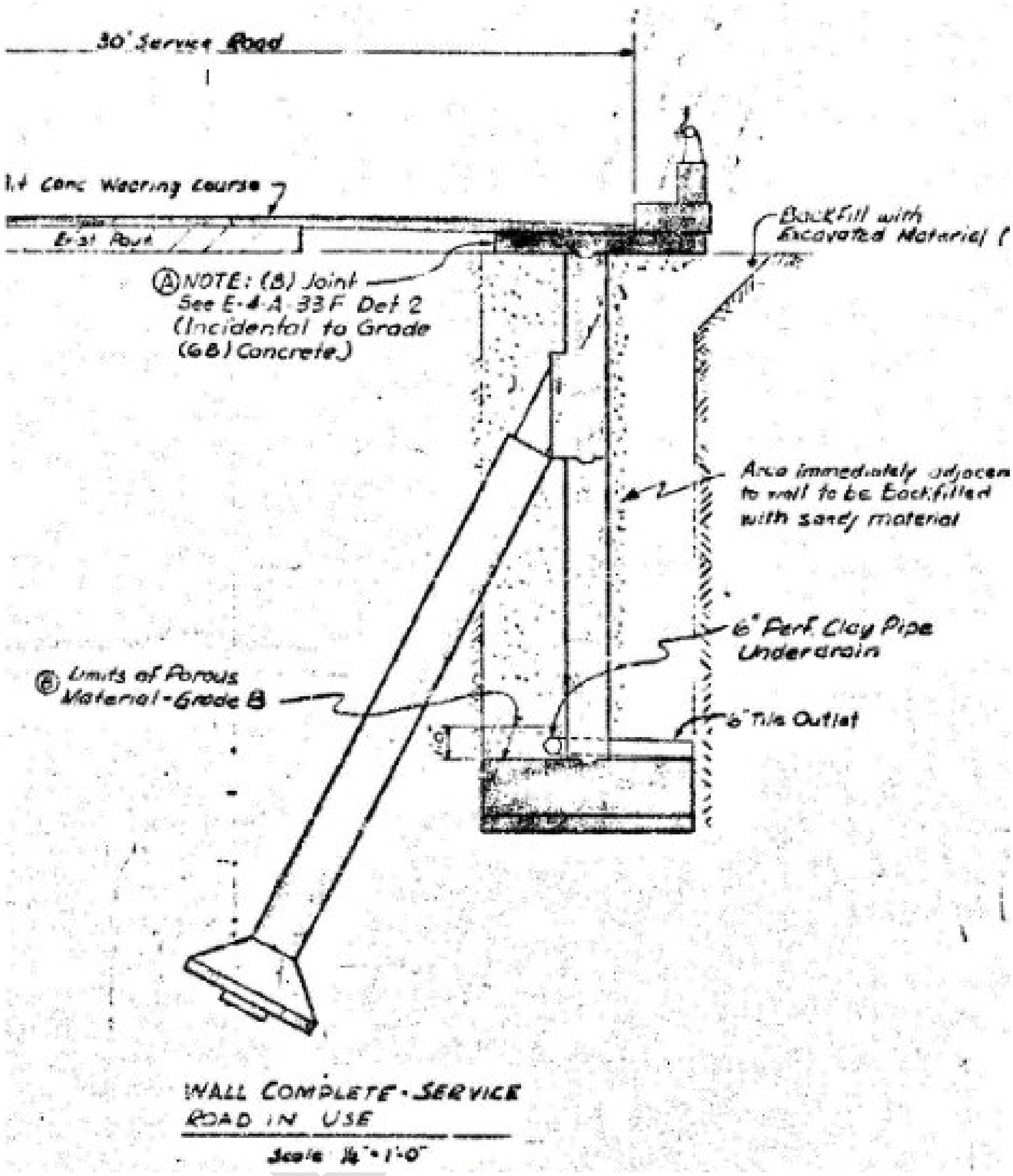

Figure 3-33: Caisson wall detail

Other Wall Types (Gabion, Plastic/Vinyl Lumber, etc.)

Other materials have recently been introduced for use in the construction of retaining walls. These include gabion walls, as well as plastic and vinyl lumber, and other materials.

Table 3-11: Other Wall Type Element Distresses

Element Number	Element Name	Description	Applicable Distresses
13101	Gabions	Basket or compartmented rectangular containers made of wire mesh filled with rock which comprise a wall.	Gabion Wall Defect Impact Damage***
13101	Plastic/Vinyl Lumber Wall	Wall made of composite materials, typically plastic lumber.	Plastic/Vinyl Lumber Defect Joint Defects*** Impact Damage***

Unit of Measure: Area, square feet measured or estimated using average height of facing multiplied by length.

*****See the descriptions and discussions under the Reinforced Concrete Wall subsection.**

Details on the condition state rating schema are in Section 3.7, linked below:

Retaining Wall Condition State Tables

Gabion Walls

Gabion walls are constructed from rock-filled wire mesh baskets. The gabions typically have a heavy wire mesh with a nominal opening and are formed into rectangular baskets. Individual baskets are placed on the prepared earthen surface, reinforced with internal tie wires, and filled with a select stone.

Succeeding rows of gabions are placed and filled in the same manner. Geotextile fabric is placed behind the baskets to keep the backfill soil from entering the rock filled gabions.

Gabion walls are inspected for the loss of the welded wire section due to corrosion, and loss of stone fill. Additionally, inspect the wall for misalignment including vertical overturning or leaning, settlement and bulging of baskets.

Figure 3-34: Gabion wall

Plastic/Vinyl Lumber

Composites come in a variety of forms including plastic lumber, which is typically formed from recycled high-density polyethylene (HDPE) plastic, vinyl sheet piling, and integrated hybrid composites of plastic and steel. Plastics can exhibit ultraviolet deterioration, material incompatibility, corrosion damage, and overstress damage. Plastics will typically exhibit discoloration when undergoing ultraviolet deterioration. The material may also begin to fray when under constant sunlight.

Connections for securing, supporting, or bracing other material components are inspected for corrosion or other similar material deficiencies. For instance, the tie rod or nuts anchoring a whaler to the outer face of a vinyl sheet piling wall are inspected to ensure they are properly tightened with no signs of corrosion.

Figure 3-35: Plastic/vinyl lumber wall

3.4.1.2 Anchors/Connections Element Condition States

Anchors or connections are used to connect buried structure elements to the wall face.

An inspector will not typically be able to inspect tie-backs or other types of anchorage that are embedded behind a wall for stabilization. Only the visible features of the anchor, anchor head, walers, and bearing plate are typically inspected during a normal routine inspection. The wall facing element and/or discrete vertical elements are reported with their corresponding element and not with the anchor element. Typical tieback spacing ranges along the length of the wall from 5 ft to 15 ft and depends on the height of the wall, retained soil properties, the type of anchorage system and other factors. Vertical anchors may be installed in single or multiple rows depending on the height of the wall and the loads being retained.

It is important to identify the potential issues that may otherwise indicate distress in an anchorage system. These indications might include visual signs of wall movements, panel deflections, differential displacements, rust staining through panel joints (possible indication of anchorage section loss) material distress and other factors.

Inspect grout pockets, such as those located on tiebacks installed on reinforced concrete stem walls or other walls for stabilization post-construction. Grout pockets shall be inspected for cracking, delamination, or spalling of the grout as well as for separation at the grout and concrete interface. For grout pockets, note if corrosion of conventional steel reinforcement or prestressing steel is present, indicated by corrosion byproduct bleeding through the grout. Note if there is inadequate clear cover.

Visual signs of wall movement and/or deformations and evidence of differential displacement (in plane and out of plane) between wall panels are good indicators for the distress. Additional evidence may include displaced railing and/or distress of overlying fill or pavement. This may be caused by several factors including structural failure of the wall itself, the wale system if present, or the anchor. Additional evidence includes soil failure at the toe or backfill slope, horizontal sliding, or seepage.

Figure 3-36: Wall displacement

Examine anchorage systems, including anchor seals or other fasteners, at connection to the wall for material distress. Signs of distress may include distortion, areas of cracking, spalling, leakage stains, and loss of seal adhesion. Note any corrosion of bars or other anchorage hardware. Identify any damage, looseness or excessive projection of bars or anchorage hardware such as nuts, wedges, collars, or plates. Rotations of anchored retaining walls are often preceded by punching shear or cracking around the area of the anchor attachment to the stem.

Corrosion protection for ground anchor tendons includes either one or more physical barrier layers which protect the tendon from the corrosive environment. The barrier layers include anchorage covers, corrosion inhibiting compounds, sheaths, encapsulations, epoxy coatings, galvanization, and grouts. Inspect the visible portions of the anchors, including tie rods, bolts, or nuts for signs of corrosion and section loss. Document the location and extent of corrosion and section loss in the inspection report.

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Table 3-12: Anchor/Connection Element Distresses

Element Number	Element Name	Description	Applicable Distresses
13102	Anchors/ Connections	Anchors or connections, when present, which are used to connect buried structure elements to the wall face.	Anchor/Connection Defects
Unit of Measure: Each. Total number of anchors to be counted or estimated where visible.			

Details on the condition state rating schema are in Section 3.7, linked below:

Retaining Wall Condition State Tables

Figure 3-37: Wall anchor

MSE Wall Anchorage

MSE wall panels resist shear loads through the inclusion of attached horizontal reinforcement or anchorage that is distributed throughout the compacted backfill. The anchorage may consist of plastic reinforcement or steel reinforcement such as metallic strips. The MSE wall anchorage will typically not be exposed except in the case of wall failure.

Deadman Anchorage

Deadman anchors are used to anchor a retaining wall in place. Walls using this type of construction include cast-in-place concrete, steel sheeting, timber and other wall construction types. The anchors typically include a steel tie rod attached to the front face of the wall and extending behind the wall to attach to a mass of concrete, and a steel plate, sheeting or other material to provide resistance to lateral wall movement. Deadman anchors could also be used to connect the back face to the wall face.

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3.4.1.3 Vertical Support Columns Element Condition States

The Vertical Support/Columns element includes metal, prestressed or reinforced concrete, timber, masonry or other columns or posts that provide structural support to the wall facing element. This also includes any connection hardware present between the vertical supports and adjacent elements. The Vertical Support/Column elements transfer loads from the wall facing elements to the ground or to connected foundation elements. The Vertical Support/Column elements shall be inspected for material specific deterioration and other defects. This element can occur with any wall facing type.

Inspect each of the vertical supports or columns based on the typical defects for the material they are constructed from. In addition, document the location and extent of any misalignment or displacement of the elements, broken connections, damage, erosion or scour at the base of the support, and other defects.

Table 3-13: Vertical Support/Column Element Distresses

Element Number	Element Name	Description	Applicable Distresses
13103	Vertical Support/ Columns	Vertical Support/Columns provides structural support to the wall facing and includes any connection hardware present between the vertical supports and adjacent elements.	Vertical Support/Column Steel Defects Vertical Support/Column Concrete Defects Vertical Support/Column Timber Defects Vertical Support/Column Masonry Defects Vertical Support/Column Other Defects
Unit of Measure: Each support.			

Details on the condition state rating schema are in Section 3.7, linked below:

Retaining Wall Condition State Tables

Vertical Support/Column Steel

Vertical Support/Column Steel includes all steel columns or vertical supports regardless of size, shape, or protective system. The H-Pile is the most common column type used in retaining wall construction and is commonly used with timber or concrete lagging spanning between the vertical elements. Inspect steel elements for evidence of corrosion and section loss, fatigue cracking, distortion or buckling and misalignment including but not limited to rotation.

Figure 3-38: Vertical support steel

Vertical Support/Column Concrete

Vertical Support/Column Concrete includes all prestressed and reinforced concrete columns/posts regardless of size, shape, or protective system. Inspect concrete elements for delamination, spalling, cracking, efflorescence, exposed reinforcing or prestressing strands and other deterioration. Additionally, inspect the element for evidence of distortion or buckling and misalignment including but not limited to rotation.

Figure 3-39: Vertical support concrete

Vertical Support/Column Timber

Vertical Support/Column Timber includes all timber columns/posts regardless of size, shape or protective system. Inspect timber element for evidence of decay and section loss, checks and shakes, splits and delamination, and other types of deterioration. Additionally, inspect the element for evidence of distortion or buckling and misalignment including but not limited to rotation.

Vertical Support/Column Masonry

Vertical Support/Column Masonry includes all masonry and stone columns/posts regardless of size, shape or protective system. The block or stone may be placed with or without mortar. Inspect the masonry/ stone elements for delaminations, spalling, cracking, efflorescence, exposed reinforcing, mortar deterioration, masonry displacement and other deterioration. Note exposed reinforcing steel as CMU block walls contain vertical steel reinforcement bars. Additionally, inspect the element for evidence of distortion or buckling and misalignment including but not limited to rotation.

Vertical Support/Column Other

Vertical Support/Column Other includes all other material columns/posts regardless of size, shape, or protective system. Inspect other vertical support or column elements for deterioration related to the specific materials used. Additionally, inspect the element for evidence of distortion or buckling and misalignment including but not limited to rotation.

3.4.1.4 Wall Stability Element Condition States

The wall buried conditions elements include the wall foundation element and portions of the wall structure which are not typically visible. These elements also include any evidence (wall sliding, overturning etc.) which may indicate that the underlying foundation element is not functioning as intended or designed.

Table 3-14: Wall Stability Element Distresses

Element Number	Element Name	Description	Applicable Distresses
13104	Wall Stability	Retaining wall subsurface conditions which contribute to the overall wall stability.	Stability- Sliding Stability- Overturning, Tilting, Misalignment Stability- Settlement Other Wall Buried Defects
Unit of Measure: Length, ft measured along the wall face, extending behind or below wall for visually observed location of element.			

Details on the condition state rating schema are in Section 3.7, linked below:

Retaining Wall Condition State Tables

Sliding

Earth retention structures are susceptible to lateral movements or sliding. Lateral movement may occur when the lateral soil pressures exceed the resisting soil frictional and shearing forces, wall anchorage capacities or the capacities of other wall components. In determining condition rating and severity, consider the most common causes of lateral movement which are slope failures (deep shear failures), seepage, changes in soil and water characteristics (e.g., poor drainage, frost action and ice), and settlement of the original soil. Deep shear failures occur along a cylindrical surface when there is a weak layer of soil under the wall at a depth of approximately 1.5 times the width of the base of the wall. A sliding failure is a failure at the soil and wall interface at the base of the wall (e.g., at the base of a reinforced concrete spread footing).

Inspect the wall for visual evidence of a sliding failure including buckling of soil in front of the wall, and in some cases separation of soil at the top of the wall. Document on the location and extent of soil buckling in front of the wall or soil separation on the back face of the wall.

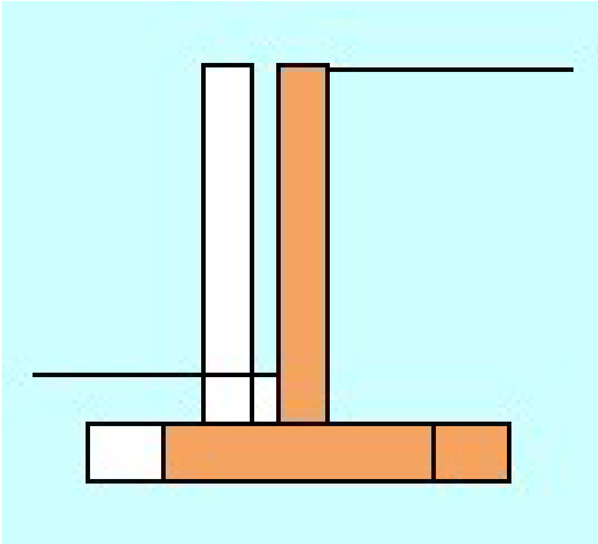

Figure 3-40: Wall sliding

Overturning, Tilting, Misalignment

Wall stability issues may be indicated from rotational movement also referred to as overturning. Overturning is generally the result of asymmetrical settlements or lateral movements; however, it may result from increased soil pressure behind the wall. The most common causes of rotational movement are saturation of backfill due to clogged drains, embankment erosion along the front of the wall, or in some cases improper design. The rotation of retaining walls can occur either inward or outward depending on whether it is overcome by passive or active earth pressures. Outward wall rotations are often preceded and accompanied by sinkholes and/or tension cracks at the top of the wall. Inward wall rotation might also be accompanied by the swelling of the backfill soil at the top of the wall. Alternatively, soil may slope downward towards the wall near its base.

Overturning may be indicated by tilt of the wall above the ground level. A small amount of tilt is typical of most retaining walls over time and is not necessarily a cause for concern. This tilt from vertical can be measured with a 4-foot level.

Wall misalignment may also indicate a stability issue. Prior to checking alignment and if construction plans or shop drawings are available, review the plans or drawings review the to determine if the wall was built vertical or has a setback. Inspect the vertical alignment of the wall with a plumb bob. Examine panel joints for differential movement or rotations might indicate rotation between adjacent wall segments. Inspect for heaving of embankment material in front of the wall which would indicate inward rotation of the wall.

Inspect the wall for evidence of excessive deflections. Deflection is considered excessive if it could allow the fill behind the wall to spill or wash out, causing settlement of the retained material above. Document the location of excessive deflections and evidence of fill loss if any.

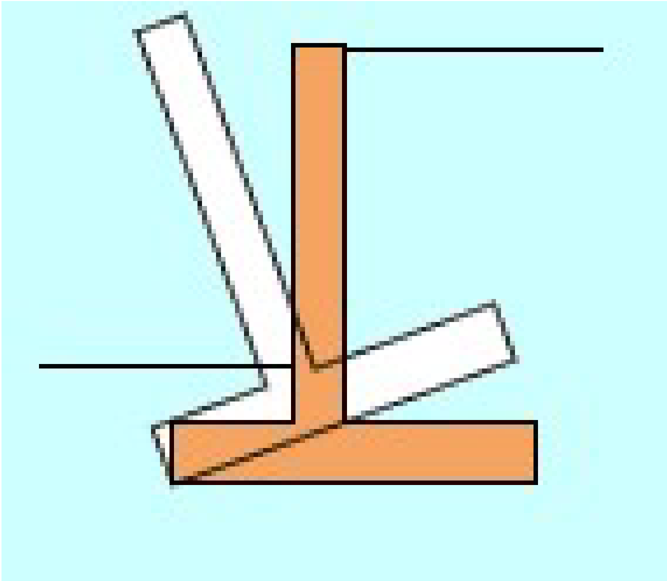

Figure 3-41: Wall overturning

Settlement

Vertical movement can occur in the forms of uniform settlement or differential settlement. Depending on the magnitude of the settlement realized, uniform settlement will have limited impact on the structural stability of the wall; however, overtopping of the wall may occur if the settlement is significant. Differential settlements, on the other hand, may lead to serious problems in the wall. Differential settlements may cause the opening of joints or cause wall cracking or transverse tipping. The most common causes of vertical movement consist of soil bearing failure; soil consolidation; erosion; and foundation material deterioration.

Inspect the wall for evidence of vertical differential settlement. Settlement issues within the retained fill and backfill are also captured within this defect. Inspect sidewalks or roadway components above the wall for signs of joint separation, potholes, and areas of settlement. It is recommended that the roadway and other elements above the wall be inspected within an area of 1.5 times the height of the wall (the surcharge influence loading zone) for any signs of settlement or other distress.

Figure 3-42: Wall settlement

3.4.1.5 *Foundation Element Condition States*

Retaining wall foundations may fail when the bearing capacity of the soil supporting the foundation is exceeded. The bearing capacity of soil depends upon the type and consistency of soil.

Foundations are critical to maintain the stability of the wall since the foundation ultimately supports the entire structure. The foundation component provides load bearing capacity to the base of the retaining wall by transferring vertical and lateral forces from the wall to soil below. The foundation component can be comprised of varying foundation elements including footings, piles, and caissons of various construction materials. The foundation elements provide support to the wall facing components and any secondary elements.

The wall foundation includes all the wall elements below the bottom of the wall stem. The wall foundation elements are most often not visible. Often the retaining wall foundations are exposed when undermining or erosion of the foundation occurs. Rate only the visible portions of the foundation. Often the foundations are only visible when distresses are present. Consider the external evidence of the foundation's adequacy to support the wall.

Table 3-15: Wall Foundation Element Distresses

Element Number	Element Name	Description	Applicable Distresses
13105	Foundation	Retaining wall foundation conditions	Foundation Defects MSE Reinforced Concrete Stub Cracking
Unit of Measure: Length, ft measured along the wall face			

Details on the condition state rating schema are in Section 3.7, linked below:

[Retaining Wall Condition State Tables](#)

Various retaining wall foundation types may be encountered and are briefly described in the following sections.

Deep Foundations

Piles can be partially exposed and are made of steel, concrete (cast-in-place or precast), or timber. Caisson, drilled shafts, and piles are other types of deep foundation used when the soil is not competent to support a spread footing.

Shallow Foundations

Shallow foundations are the most common foundation type to experience bearing failure since the foundations are directly supported by the underlying soil. Visual evidence of soil bearing failure may include heaving of the soil at the base of the wall or vertical settlement of the wall. Inspect the wall for signs of vertical settlement and heaving of the soil at the base of the wall. Evaluate the base of the wall perimeter to determine if the foundation is exposed or undermining has occurred due to erosion or other cause. Document the location of foundation exposure.

MSE Reinforced Concrete Stub

MSE walls typically are built on a non-reinforced concrete pad used to provide a level, consistent surface at the proper grade to place the first row of MSE panels. This consistent surface is typically referred to as a "leveling pad." If visible, inspect the leveling pad for signs of concrete deterioration including, cracking, spalling and delaminations. Additionally, check the leveling pad for erosion or undermining. Significant undermining or loss of soil bearing support could have a serious impact on the wall function, including footing failure, loss of retained backfill, and other distress.

3.4.1.6 Drainage Approach Element Condition States

This element defines the drainage along the backside of the retaining wall, as well as drainage through the wall. This element includes area drainage, such as underdrains, which convey water from the backfill to an outfall such as drainage swales, weep holes in the wall facing as well as storm sewer pipes, drainage flumes and other behind the wall drainage features. All drainage elements associated with the wall should adequately divert water from the structure. Internal elements such as subsurface pipes and sheet drains connected to weep holes should prevent water accumulation within the slope behind the wall. It is noted that a weep hole's condition state is rated as part of the Wall Facing element and not with the Drainage Approach element.

Table 3-16: Drainage Approach Element Distresses

Element Number	Element Name	Description	Applicable Distresses
13106	Drainage Approach	Drainage approach for retaining wall both behind and in in front of wall	Drainage Approach Defects
			Streambank Defects
			Vegetation Defects
Unit of Measure: Length, ft			

Details on the condition state rating schema are in Section 3.7, linked below:

Retaining Wall Condition State Tables

Drainage Approach

Inspect the backside of the retaining wall for evidence of erosion along the embankment directly above or below the wall or in the drainage ditches or flumes. Note whether run off is able to properly drain away or through the wall. Also note any erosion or loss of fill due to drainage at the ends of the walls.

Inspect all inlets to verify water is draining into the inlet and flowing freely to the inlet and out of the outlet. Inspect swales above the wall. Verify rock fall or other materials (trees, etc.) are not blocking, redirecting, or restricting the flow of water through any drainage ditch above wall to the appropriate receptacle.

Storm sewer pipes, including inlets or field inlets, along the wall are inspected and noted if clogged. Flow from seepage sources, including weep holes and horizontal drains etc., is examined for signs of migration of solid particles or fines to check whether there is any internal erosion of the fill behind the wall. Document any signs of abnormal seepage observed on the wall face and any clogs in the drainage system. If applicable compare in-

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field drainage structures to available design plans to ensure proper drainage systems have been installed.

Figure 3-43: Drainage outlet is partially clogged with leaves and debris

Streambank

In some cases, water features such as lakes, rivers, or streams may be at the base of the wall. Inspection of the wall from a conveyance such as kayak or boat is not required as part of the AS program. Scour countermeasures or channel protection devices are typical at the base of the wall to protect the wall from undermining or damage due to causes such as erosion, channel widening, local scour and downstream scour. Scour countermeasures may include items such as riprap placed at the base of the wall. Probe with a rod to determine loss of riprap or other protection.

Vegetation

The presence of plant foliage and other vegetation may be interfering with the function of the wall. The penetration of plant roots behind the wall or into wall facing elements may accelerate the deterioration of the wall. The lack of vegetation may also indicate other element defects, such as lack of drainage or wall movement.

Inspect the wall for evidence of vegetation or root growth on the back and front sides of the wall. Document the location and extent of any roots that are penetrating the structure through cracks or other means.

3.4.2 REFERENCES

Michigan Earth Retaining Structure Element Inspection Manual (2020 Draft, unpublished)

AASHTO LRFD Bridge Design Specifications (2020, 9th edition)

3.5 Work Recommendation Guidance

Retaining wall Work Recs are recorded to initiate preventive maintenance actions. Preventive maintenance needs are determined for each ancillary structure and the corresponding actions are identified on the Work Recs documentation.

Work Recs include maintenance, such as cleaning, painting, or re-sealing with protective coatings or paint due to condition defects in efflorescence, corrosion rust staining, or other causes. Repair procedures include patching of concrete or repair of concrete coping or pilasters. Drainage recommendations may consist of filling of erosion and scour holes, or drainage installed around the wall. Other Work Recs may consist of tightening of facing or expansion joints. Repair of facing (including joint repair), foundation, vertical supports, anchors, or drainage may also be Work Recs.

The following work recommendations are not meant to be all-inclusive and other work recommendations may be added to supplement those noted below.

Photographs should include sufficient information to determine the relationship of the defect to the element or component or entire structure. Close-up photos of each defect with deficiencies marked on the photo should be provided.

Table 3-17: Retaining Wall Work Recommendations

Number	Description of Work Recommendation	Material Involved	Quantity/Unit of Measure
1	Clean and/or paint/re-seal wall	Concrete	Square Foot
2	Tighten/repair timber wall facing	Wood	Square Foot
3	Patch Spalls: Patch delaminations or spalls on concrete or masonry wall facing	Concrete	Square Foot
4	Repair damaged wall facing	Concrete	Square Foot
5	Metal/Corrosion: Remove corrosion and overlay protective coating on metal wall facing	Metal Coating System	Square Foot
6	Fill erosion/scour holes around wall	Stone	Cubic Foot
7	Repair concrete foundation	Concrete	Cubic Foot
8	Clean and/or paint vertical support members	Paint	Square Foot
9	Repair vertical support member	Concrete	Lineal Foot
10	Stabilize vertical supports re-stabilize vertical support member (insert grout plugs, anchors, etc.)	Vertical Support	Each
11	Repair/replace anchors	Steel/Concrete Anchor	Each
12	Repair Wall Railing	Steel	Lineal Foot
13	Paint Coping: Clean and/or paint coping/pilaster	Paint	Square Foot
14	Replace coping/pilaster	Concrete	Square Foot
15	Repair concrete coping/pilaster	Concrete	Square Foot
16	Backfill Erosion: Fill erosion/voids/scour holes in backfill	Earth/Stone	Cubic Yard
17	Re-stabilize Slope	Earth/Stone/Other	Cubic Yard
18	Seal Open Joint (non-expansion)	Joint Filler	Lineal Foot

Number	Description of Work Recommendation	Material Involved	Quantity/Unit of Measure
19	Repair Barrel (non-expansion) e.g., "D" cracking.	Concrete	Square Foot
20	Repair/replace expansion Barrel and seals	Sealant, variable types	Lineal Foot
21	Tighten Expansion Joint	N/A	Lineal Foot
22	Repair/replace Weep Holes	Concrete	Each
23	Repair/replace drain swales/area drains/other drains	N/A	Lineal Foot
24	Install weep holes (for walls with no prior drainage)	N/A	Each
25	Install drainage swales/area drains/other drains	N/A	Lineal Foot
26	In-Depth Inspection	N/A	N/A
99	Other		

3.6 Request for Action Guidance

Priority 1 Level items for Retaining Walls consist of a condition that is compromising the wall's structural capacity and is progressing toward an impending wall failure. Priority 2 Level items for retaining wall consist of a condition that threatens wall functionality and structural capacity.

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

Priority 1 Level Items

a. Undermining of the foundation or MSE wall leveling pad through erosion, scour, or other ground loss that threatens the integrity of the retaining wall

b. Joints with differential deflection that exhibit major active movement

c. Major wall or panel movement evident, whether rotational or horizontal, such as tilting, sliding, buckling, or heaving of soil at the base of retaining wall, or other evidence of misalignment which indicates a loss of wall stability

d. Retained materials showing major settlement, distortion, rotation, or erosion, potentially occurring in conjunction with a major amount of water or backfill leaking through the wall or wall joints

e. Wall materials showing deterioration that would impact the strength of the structure causing failure of the wall, which could consist of concrete fractures, reinforcement loss, MSE panel cracking, timber cracking, or metal corrosion or deflection

f. Wall constructed with tiebacks that have failed anchor components or distortion impacting strength or function of the structure

g. Multiple loose, missing, or damaged parts, or major deterioration, related to attachments or appurtenances that results in major impact to capacity or durability

Priority 2 Level Items

a. Significant corrosion or section loss at the base of a steel cantilever wall (e.g., sheet pile walls, soldier pile walls, etc.)
b. Concrete wall with significant cracking or spalling resulting in exposed reinforcement with significant section loss
c. Concrete walls with active structural cracking
d. Differential joint deflection where movement is not active but affects stability
e. Masonry with significant shifting out of alignment that impacts stability of the structure, typically indicated by cracking or block misalignment
f. MSE walls showing significant deterioration such as wall misalignment, panel bowing, or cracking that impacts stability of the structure
g. Timber walls showing loss from decay or abrasion, shakes, active cracks, splitting, or delamination
h. Incident resulting in significant structural damage
i. Walls constructed with tiebacks that contain compromised anchor components showing significant deterioration impacting structural functionality
j. Significant water leakage through the wall at locations other than weep holes containing soil particles indicating significant piping is occurring in conjunction with improper drainage
k. Significantly loose parts, or significant deterioration or wear, related to attachments or appurtenances that results in significant impact to capacity or durability

Priority 3 Level Items

a. Concrete exhibiting moderate cracking, spalling, or delamination resulting in exposed reinforcement with moderate section loss
b. Concrete reinforcement exposure with moderate section loss or major staining
c. Masonry showing moderate cracking, spalling, delamination, splitting, or shifting
d. MSE walls with connections visible at isolated locations where panels show bowing or with moderate structural cracking of panels
e. Steel walls with protective coating failure with moderate section loss
f. Timber walls exhibiting moderate decay, cracks, or abrasion
g. Settlement with moderate impact to wall stability
h. Loose or misaligned parts, or moderate deterioration or wear, related to attachments or appurtenances that results in moderate impact to capacity or durability

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3.7 Element Condition States

Element Number	Element	Condition States Defects Note	Link to Discussion in Section 3
13101	Wall Facing	Use the appropriate condition state table based on material (Reinforced Concrete, MSE, Timber, Masonry, Metal/Steel, or Other).	Wall Facing Element Condition States
13102	Anchors/Connections	Use the appropriate condition state table	Anchors/Connections Element Condition States
13103	Vertical Supports/Columns	Use the appropriate condition state based on material (Reinforced Concrete, Timber, Masonry, Metal/Steel, or Other).	Vertical Support Columns Element Condition States
13104	Wall Stability	Use the appropriate condition state table	Wall Stability Element Condition States
13105	Foundation	Use the appropriate condition state based on foundation type.	Foundation Element Condition States
13106	Drainage	Use the appropriate condition state table	Drainage Approach Element Condition States

Element 13101 (Wall Facing) – Reinforced Concrete Stem

Description	This element defines wall facing, regardless of facing material type.
Quantity Calculation	Area, square feet measured or estimated using average height of facing multiplied by length. Retaining walls adjacent to bridge abutments are measured beginning from the nearest expansion or construction joint between the abutment and the start of the retaining wall.

Defect Type	Condition State Descriptions			
	Good	**Fair**	**Poor**	**Severe**
Concrete Cracking	Insignificant cracks or moderate-width cracks that have been sealed. No exposed reinforcing.	Unsealed moderate-width cracks or unsealed moderate pattern (map) cracking. No exposed reinforcing.	Wide cracks (>3/16” or 0.1875 inches) or heavy pattern (map) cracking. Some reinforcing may be exposed. Incidental loss of section of reinforcing may be present but does not affect the function.	Major deterioration due to cracking impacting strength of wall. Substantial amounts of water or backfill may be leaking through cracks or joints. Major corrosion of exposed reinforcing.
Concrete Spalling, Delamination, Patching	None present.	Delaminations or spalls ≤ 1 inch in depth and ≤ 6 inches in diameter. Patch present and functioning.	Delaminations or spalls > 1 inch in depth or > 6 inches in diameter. Patches partially functioning or showing distress. Cracks ≤1/2-inch width may be present. Patches partially functioning or showing distress.	Major deterioration due to spalling, or delamination impacting strength of wall. Failed patches.
Concrete Abrasion/Wear	None present	Abrasion or wearing has exposed coarse aggregate.	Abrasion or wearing has caused coarse aggregate to be loose and/or lost from the concrete matrix.	Major deterioration of concrete due to abrasion or wear. Wall strength may be impacted.
Other Concrete Defects	Other Concrete is present and does not exhibit deterioration or distress.	Minor deterioration or distress of Other Concrete.	Moderate deterioration or distress of Other Concrete.	Major deterioration or distress of Other Concrete.

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Description	This element defines wall facing, regardless of facing material type.			
Quantity Calculation	Area, square feet measured or estimated using average height of facing multiplied by length. Retaining walls adjacent to bridge abutments are measured beginning from the nearest expansion or construction joint between the abutment and the start of the retaining wall.			
	Condition State Descriptions			
Defect Type	**Good**	**Fair**	**Poor**	**Severe**
Concrete Protective Coatings	Protective coatings functioning.	Minor peeling/ bubbling/ cracking present.	Protective coatings partially effective. Major peeling, bubbling, or cracking is present.	Does not create a critical condition.
Efflorescence	None	Surface white without build-up or leaching without rust staining.	Heavy build-up with rust staining present.	Does not create a critical condition.
Joint Defects	No damage present	Joints are slightly misaligned between units. Joints may have irregular spacing and be too wide or narrow. Joint with seals showing minor damage, cracking, or loss of seal adhesion. Debris is impacted into joints.	Joints are moderately misaligned between units. Joints may have irregular spacing and be too wide or narrow. Debris is impacted into joints. Joints allowing water leakage or backfill migration. Joints with seals showing moderate damage, cracking, or loss of seal adhesion.	Joints allowing major water leakage or backfill migration. Joints with seals are non-functioning.
Weep Hole Defects	No issues present.	Minor amount of debris build up in weep holes. Wall surface in weep hole vicinity have none to minor cracking or mortar deterioration.	Major accumulation of debris in weep holes. Moderate amounts of cracking extending through weep hole vicinity. Minor spalls adjacent to weep holes. Vegetation may impact wall drainage functions.	Drainage functions plugged and have major deterioration. Extensive cracking extending through weep holes. Major spalling adjacent to weep holes.
Impact Damage	Not applicable.	The element has minor damage caused by vehicular impact.	The element has moderate damage caused by vehicular impact.	Major impact damage from vehicular or vessel collision.

Element 13101 (Wall Facing) – MSE

Description	This element defines wall facing, regardless of facing material type.			
Quantity Calculation	Area, square feet measured or estimated using average height of facing multiplied by length. Retaining walls adjacent to bridge abutments are measured beginning from the nearest expansion or construction joint between the abutment and the start of the retaining wall.			
	Condition State Descriptions			
Defect Type	**Good**	**Fair**	**Poor**	**Severe**
MSE Panel Cracking/Spalling	Like new condition	Minor non-structural cracks without surface staining. Hairline cracks (less than 1/16 inch) or moderate-width cracks that have been sealed.	Structural cracks or cracking with surface staining. Unsealed moderate-width cracks or unsealed moderate pattern map) cracking. Wide cracks (>3/16" or 0.1875 inches) or heavy pattern (map) cracking. Moderate amounts of water or small amounts of backfill may be leaking through cracks or joints	Cracks greater than ½ inch wide. Major amounts of water or moderate/major amounts of backfill may be leaking through cracks or joints.
MSE Panel Joint Defects	Wall panel joint spacing is substantially uniform.	Wall panel joint width exceeds as-built spacing without geotextile fabric exposure.	Wall panel joint width exceeds as-built spacing or is irregular with exposed geotextile fabric.	Wall panel joints showing differential deflection and major active movement.
MSE Other Defects	Other MSE is present and does not exhibit deterioration or distress.	Minor deterioration or distress of Other MSE.	Moderate deterioration or distress of Other MSE.	Major deterioration or distress of Other MSE.
Impact Damage	Not applicable.	The element has minor damage caused by vehicular impact.	The element has moderate damage caused by vehicular impact.	Major impact damage from vehicular or vessel collision.

Element 13101 (Wall Facing) – Timber

Description	This element defines wall facing, regardless of facing material type.			
Quantity Calculation	Area, square feet measured or estimated using average height facing multiplied by length. Retaining walls adjacent to bridge abutments are measured beginning from the nearest expansion or construction joint between the abutment and the start of the retaining wall.			
	Condition State Descriptions			
Defect Type	**Good**	**Fair**	**Poor**	**Severe**
Timber Decay/ Section Loss/ Abrasion	None present.	Decay or section loss affects less than 10% of the member. Abrasion affects less than 10% of the member thickness.	Decay or section loss affects more than 10% of the member. Abrasion affects more than 10% of the member thickness.	Major decay, section loss, or abrasion of wall. Wall strength may be impacted.
Timber Checks/ Shakes	None present.	Checks affect less than 5% of the member thickness.	Checks/shakes affect 5% to 50% of the member thickness. Larger checks/shakes have been repaired.	Checks and shakes of timber affect more than 50% of member thickness. Wall strength and stability may be impacted.
Timber Splitting/ Delamination/ Cracking	No splitting or delamination present. Sealed cracks may exist.	Cracking affects less than 5% of the member thickness.	Delamination or splitting length equal to or greater than the total member depth, but only present away from connections. Cracking penetrates 5% to 50% of the member thickness. Larger cracks have been repaired.	Delamination or splitting near connections; imminent collapse of member or structure. Severe deterioration due to cracking impacting strength of wall.
Timber Other	Other Timber is present and does not exhibit deterioration or distress.	Minor deterioration or distress of Other Timber.	Moderate deterioration or distress of Other Timber.	Major deterioration or distress of Other Timber.
Impact Damage	Not applicable.	The element has minor damage caused by vehicular impact.	The element has moderate damage caused by vehicular impact.	Major impact damage from vehicular or vessel collision.

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Element 13101 (Wall Facing) – Masonry

Description	This element defines wall facing, regardless of facing material type.			
Quantity Calculation	Area, square feet measured or estimated using average height of facing multiplied by length. Retaining walls adjacent to bridge abutments are measured beginning from the nearest expansion or construction joint between the abutment and the start of the retaining wall.			
	Condition State Descriptions			
Defect Type	**Good**	**Fair**	**Poor**	**Severe**
Masonry Splits/Spalls/ Delamination	None present.	Delaminations or spalls ≤ 1 inch in depth and ≤ 6 inches in diameter. Hairline cracks may be present. Block or stone has split or spalled with no shifting.	Delaminations or spalls > 1 inch in depth or > 6 inches in diameter. Cracks ≤1/2-inch width may be present. Block or stone has split or spalled with shifting.	Major deterioration such as spalling/delamination or splitting. May affect structure strength or performance.
Masonry Exposed Reinforcement	No exposed reinforcing.	Reinforcement may be exposed with no measurable section loss.	Incidental loss of section of reinforcing may be present but does not affect the function.	Major corrosion of exposed reinforcing.
Mortar Breakdown/ Cracking	No mortar breakdown.	Cracking or voids in less than 10% of the mortar joints.	Cracking or voids in greater than 10% or more of the mortar joints.	Mortar joints with cracks or voids in more than 50% of the mortar joints. Substantial amounts of water or backfill may be leaking or migrating through cracks. May affect structure strength or performance.
Masonry Patches	Not applicable.	Patch is present and functioning as intended to arrest original deterioration.	Unsound patches or patches showing distress.	Patch has failed.
Masonry Displacement/ Misalignment	None present.	Block or stone has shifted slightly out of alignment.	Block or stone has shifted moderately out of alignment or is missing.	Major displacement of block or stone with missing blocks and stones. May affect structure strength or performance.

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Description	This element defines wall facing, regardless of facing material type.			
Quantity Calculation	Area, square feet measured or estimated using average height of facing multiplied by length. Retaining walls adjacent to bridge abutments are measured beginning from the nearest expansion or construction joint between the abutment and the start of the retaining wall.			
	Condition State Descriptions			
Defect Type	**Good**	**Fair**	**Poor**	**Severe**
Masonry Other	Other Masonry is present and does not exhibit deterioration or distress.	Minor deterioration or distress of Other Masonry.	Moderate deterioration or distress of Other Masonry.	Major deterioration or distress of Other Masonry.
Efflorescence	None	Surface white without build-up or leaching without rust staining.	Heavy build-up with rust staining present.	Does not create a severe condition.
Weep Hole Defects	No issues present.	Minor amount of debris build up in weep holes. Wall surface in weep hole vicinity have none to minor cracking or mortar deterioration.	Moderate accumulation of debris in weep holes. Moderate amounts of cracking extending through weep hole vicinity. Minor spalls adjacent to weep holes. Vegetation may impact wall drainage functions.	Drainage functions plugged and have major deterioration. Extensive cracking extending through weep holes. Major spalling adjacent to weep holes.
Impact Damage	Not applicable.	The element has minor damage caused by vehicular impact.	The element has moderate damage caused by vehicular impact.	Major impact damage from vehicular or vessel collision.

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Element 13101 (Wall Facing) – Metal/Steel

Description	This element defines wall facing, regardless of facing material type.			
Quantity Calculation	Area, square feet measured or estimated using average height of facing multiplied by length. Retaining walls adjacent to bridge abutments are measured beginning from the nearest expansion or construction joint between the abutment and the start of the retaining wall.			
	Condition State Descriptions			
Defect Type	**Good**	**Fair**	**Poor**	**Severe**
Steel Wall Cracking/ Fatigue	None present.	Steel cracking is self-arrested or arrested with holes, doubling plates, or similar. Fasteners are performing as intended.	Steel cracking is progressing.	Major deterioration due to cracking impacting strength of wall. Substantial amounts of water or backfill may be leaking through cracks or joints.
Steel Wall Corrosion/ Section Loss	None present.	Freckle rust on steel and minor corrosion.	Moderate section loss due to corrosion.	Major wall section loss due to corrosion. Wall strength may be impacted.
Steel Wall Lagging Defects	No issues present.	Minor splitting of lagging.	Moderate splitting or deterioration of lagging. Some lagging may be non-functional.	Lagging missing or non-functioning.
Steel Wall Protective Coatings	Protective coatings functioning.	Minor peeling/bubbling/cracking present.	Protective coatings on steel partially effective. Major peeling, bubbling, or cracking is present. Chalking or oxide films may be present.	Does not create a critical condition.
Impact Damage	Not applicable.	The element has minor damage caused by vehicular impact.	The element has moderate damage caused by vehicular impact.	Major impact damage from vehicular or vessel collision.
Joint Defects	No damage present	Joints are slightly misaligned between units. Joints may have irregular spacing and be too wide or narrow. Joint with seals showing minor damage, cracking, or loss of seal adhesion. Debris is impacted into joints.	Joints are moderately misaligned between units. Joints may have irregular spacing and be too wide or narrow. Debris is impacted into joints. Joints allowing water leakage or backfill migration. Joints with seals showing moderate damage, cracking, or loss of seal adhesion.	Joints allowing major water leakage or backfill migration. Joints with seals are non-functioning.

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Element 13101 (Wall Facing) – Anchored

Description	This element defines wall facing, regardless of facing material type.			
Quantity Calculation	Area, square feet measured or estimated using average height of facing multiplied by length. Retaining walls adjacent to bridge abutments are measured beginning from the nearest expansion or construction joint between the abutment and the start of the retaining wall.			
	Condition State Descriptions			
Defect Type	**Good**	**Fair**	**Poor**	**Severe**
Anchored Wall Face	Anchored wall such as soil nail wall is present and does not exhibit deterioration or distress.	Minor deterioration or distress of Anchored Wall.	Moderate deterioration or distress of Anchored Wall.	Severe deterioration or distress of Anchored Wall.
Concrete Cracking	Minor or moderate-width cracks that have been sealed. No exposed reinforcing.	Unsealed moderate-width cracks or unsealed moderate pattern (map) cracking. No exposed reinforcing.	Wide cracks (>3/16” or 0.1875 inches) or heavy pattern (map) cracking. Some reinforcing may be exposed. Incidental loss of section of reinforcing may be present but does not affect the function.	Major deterioration due to cracking impacting strength of wall. Significant amounts of water or backfill may be leaking through cracks or joints. Severe corrosion of exposed reinforcing.
Concrete Spalling, Delamination, Patching	None present.	Delaminations or spalls ≤ 1 inch in depth and ≤ 6 inches in diameter. Patch present and functioning.	Delaminations or spalls > 1 inch in depth or > 6 inches in diameter. Patches partially functioning or showing distress. Cracks ≤1/2-inch width may be present. Patches partially functioning or showing distress.	Major deterioration due to spalling, or delamination impacting strength of wall. Failed patches.
Concrete Abrasion/Wear	None present	Abrasion or wearing has exposed coarse aggregate.	Abrasion or wearing has caused coarse aggregate to be loose and/or lost from the concrete matrix.	Major deterioration of concrete due to abrasion or wear. Wall strength may be impacted.

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Description	This element defines wall facing, regardless of facing material type.			
Quantity Calculation	Area, square feet measured or estimated using average height of facing multiplied by length. Retaining walls adjacent to bridge abutments are measured beginning from the nearest expansion or construction joint between the abutment and the start of the retaining wall.			
	Condition State Descriptions			
Defect Type	**Good**	**Fair**	**Poor**	**Severe**
Steel Wall Cracking/ Fatigue	None present.	Steel cracking is self-arrested or arrested with holes, doubling plates, or similar. Fasteners are performing as intended.	Steel cracking is progressing.	Major deterioration due to cracking impacting strength of wall. Substantial amounts of water or backfill may be leaking through cracks or joints.
Steel Wall Corrosion/ Section Loss	None present.	Freckle rust on steel and minor corrosion.	Moderate section loss due to corrosion.	Major wall section loss due to corrosion. Wall strength may be impacted.
Joint Defects	No damage present	Joints are slightly misaligned between units. Joints may have irregular spacing and be too wide or narrow. Joint with seals showing minor damage, cracking, or loss of seal adhesion. Debris is impacted into joints.	Joints are moderately misaligned between units. Joints may have irregular spacing and be too wide or narrow. Debris is impacted into joints. Joints allowing water leakage or backfill migration. Joints with seals showing moderate damage, cracking, or loss of seal adhesion.	Joints allowing major water leakage or backfill migration. Joints with seals are non-functioning.
Efflorescence	None	Surface white without build-up or leaching without rust staining.	Heavy build-up with rust staining present.	Does not create a critical condition.
Weep Hole Defects	No issues present.	Minor amount of debris build up in weep holes. Wall surface in weep hole vicinity have none to minor cracking or mortar deterioration.	Moderate accumulation of debris in weep holes. Moderate amounts of cracking extending through weep hole vicinity. Minor spalls adjacent to weep holes. Vegetation may impact wall drainage functions.	Drainage functions plugged and have major deterioration. Extensive cracking extending through weep holes. Moderate spalling adjacent to weep holes.

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Description	This element defines wall facing, regardless of facing material type.			
Quantity Calculation	Area, square feet measured or estimated using average height of facing multiplied by length. Retaining walls adjacent to bridge abutments are measured beginning from the nearest expansion or construction joint between the abutment and the start of the retaining wall.			
	Condition State Descriptions			
Defect Type	Good	Fair	Poor	Severe
Impact Damage	Not applicable.	The element has minor damage caused by vehicular impact.	The element has moderate damage caused by vehicular impact.	Major impact damage from vehicular or vessel collision.

Element 13101 (Wall Facing) – Other – Reinforced Face, Gabion, Plastic/Vinyl, Lumber, etc.

Description	This element defines wall facing, regardless of facing material type.			
Quantity Calculation	Area, square feet measured or estimated using average height of facing multiplied by length. Retaining walls adjacent to bridge abutments are measured beginning from the nearest expansion or construction joint between the abutment and the start of the retaining wall.			
	Condition State Descriptions			
Defect Type	Good	Fair	Poor	Severe
Gabion Wall Defect	Gabion wall is present and does not exhibit deterioration or distress.	Minor deterioration or distress of Gabion Wall.	Moderate deterioration or distress of Gabion Wall.	Severe deterioration or distress of Gabion Wall.
Plastic/Vinyl Lumber Wall Defect	Plastic or Vinyl Lumber Wall is present and does not exhibit deterioration or distress.	Minor deterioration or distress of Plastic or Vinyl Lumber Wall.	Moderate deterioration or distress of Plastic or Vinyl Lumber Wall.	Major deterioration or distress of Plastic or Vinyl Lumber Wall.

Description	This element defines wall facing, regardless of facing material type.			
Quantity Calculation	Area, square feet measured or estimated using average height of facing multiplied by length. Retaining walls adjacent to bridge abutments are measured beginning from the nearest expansion or construction joint between the abutment and the start of the retaining wall.			
	Condition State Descriptions			
Defect Type	**Good**	**Fair**	**Poor**	**Severe**
Joint Defects	No damage present	Joints are slightly misaligned between units. Joints may have irregular spacing and be too wide or narrow. Joint with seals showing minor damage, cracking, or loss of seal adhesion. Debris is impacted into joints.	Joints are moderately misaligned between units. Joints may have irregular spacing and be too wide or narrow. Debris is impacted into joints. Joints allowing water leakage or backfill migration. Joints with seals showing moderate damage, cracking, or loss of seal adhesion.	Joints allowing major water leakage or backfill migration. Joints with seals are non-functioning.
Impact Damage	Not applicable.	The element has minor damage caused by vehicular impact.	The element has moderate damage caused by vehicular impact.	Major impact damage from vehicular or vessel collision.
Anchors/ Connections Defects	No damage present	Anchor heads may show minor displacement. Anchors show minor rust spots or corrosion. Tie rods or nuts should be snug tight with no signs of corrosion. Debris may be impacted into connections. Anchor seals or other fasteners showing minor damage, cracking, or loss of seal adhesion.	Anchor heads may show moderate displacement with exposure past the anchor head. Tie rods, bolts, or nuts may be loose or show corrosion. Anchor seals or other fasteners showing moderate damage, cracking, or loss of seal adhesion.	Wall connections showing failure. Missing tie rods, bolts, or nuts. Wall strength or stability may be impacted.

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Element 13102 (Anchors/Connections)

Description	This element includes anchors or connections which are used to connect buried structure elements to the retaining wall face.			
Quantity Calculation	The quantity for this element is collected as each anchor or connection unit. Anchors and connections are frequently covered by the wall facing element and are not visible.			
Defect Type	**Condition State Descriptions**			
	Good	**Fair**	**Poor**	**Severe**
Anchors/ Connections Defects	No damage present	Anchor heads may show minor displacement. Anchors show minor rust spots or corrosion. Tie rods or nuts should be snug tight with no signs of corrosion. Debris may be impacted into connections. Anchor seals or other fasteners showing minor damage, cracking, or loss of seal adhesion.	Anchor heads may show moderate displacement with exposure past the anchor head. Tie rods, bolts, or nuts may be loose or show corrosion. Anchor seals or other fasteners showing moderate damage, cracking, or loss of seal adhesion.	Wall connections showing failure. Missing tie rods, bolts, or nuts. Wall strength or stability may be impacted.

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Element 13103 (Vertical Support/Columns)

Description	This element is defined by vertical supports and connection hardware which provide structural support to the wall facing and adjacent elements.			
Quantity Calculation	The quantity is collected as each.			
	Condition State Descriptions			
Defect Type	**Good**	**Fair**	**Poor**	**Severe**
Vertical Support/ Column Steel Defects	No deterioration present	Steel cracking is self-arrested or arrested with holes, doubling plates, or similar. Fasteners are performing as intended. Freckle rust on steel and minor corrosion. Wall movement is occurring with signs of bulging, bending, misalignment, distortion, or deflection of vertical support.	Steel cracking is progressing. Moderate loss due to corrosion.	Major deterioration due to cracking, corrosion, section loss, or misalignment impacting strength of wall. Wall movement is active with sloughing behind and major wall misalignment.
Vertical Support/ Column Concrete Defects	Hairline cracks may be present. Minor cracks or moderate-width cracks that have been sealed. No exposed reinforcement.	Unsealed moderate-width cracks or unsealed moderate pattern (map) cracking. Delaminations or spalls ≤ 1 inch in depth and ≤ 6 inches in diameter. Reinforcement exposed without measurable section loss. Freckled rust may be present. Corrosion has initiated.	Wide cracks (>3/16” or 0.1875 inches) or heavy pattern (map) cracking. Delaminations or spalls > 1 inch in depth or > 6 inches in diameter. Cracks ≤1/2-inch width may be present. Exposed reinforcement with measurable section loss. Pack rust may be present.	Major deterioration due to cracking, spalling, reinforcement corrosion, section loss or other deterioration impacting strength of wall.

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Description	This element is defined by vertical supports and connection hardware which provide structural support to the wall facing and adjacent elements.
Quantity Calculation	The quantity is collected as each.

Defect Type	**Condition State Descriptions**			
	Good	**Fair**	**Poor**	**Severe**
Vertical Support/ Column Timber Defects	No deterioration present	Decay or section loss affects less than 10% of the member. Abrasion affects less than 10% of the member thickness. Checks affect less than 5% of the member thickness. Cracking affects less than 5% of the member thickness. Wall has shifted slightly out of alignment.	Decay or section loss affects more than 10% of the member. Abrasion affects more than 10% of the member thickness. Checks/ shakes/cracks affect 5% to 50% of the member thickness. Larger checks/ shakes/cracks have been repaired. Delamination or splitting length equal to or greater than the total member depth. Wall has shifted moderately out of alignment.	Severe decay, section loss, or abrasion of wall. Checks and shakes of timber affect more than 50% of member thickness. Delamination or splitting near connections. Severe shift in alignment. Wall strength may be impacted.
Vertical Support/ Column Masonry Defects	No splits or spalls, mortar breakdown present. No displacement or misalignment of stones present. No exposed reinforcing.	Delaminations or spalls ≤ 1 inch in depth and ≤ 6 inches in diameter. Hairline cracks in stones may be present. Cracking or voids in less than 10% of the mortar joints. Block or stone has shifted slightly out of alignment. Reinforcement may be exposed with no measurable section loss.	Delaminations or spalls > 1 inch in depth or > 6 inches in diameter. Cracks ≤1/2-inch width may be present. Cracking or voids in greater than 10% or more of the mortar joints. Block or stone has shifted moderately out of alignment or is missing. Incidental loss of section of reinforcing may be present but does not affect the function.	Major spalling, delamination cracking or splitting of masonry. Mortar joints with cracks or voids in more than 50% of the mortar joints. Major displacement of block or stone with missing blocks and stones. May effect structure strength or performance. Major corrosion of exposed reinforcing.
Vertical Support/ Column Other Defects	Vertical Support /Column Other is present and does not exhibit deterioration or distress.	Minor deterioration or distress of Vertical Support/Column Other.	Moderate deterioration or distress of Vertical Support/ Column Other.	Major deterioration or distress of Vertical Support/Column Other.

Element 13104 (Wall Stability)

Description	This element defines the adjacent soil movement caused by vertical or lateral pressures such as settlement, global stability, wall tilt, which affects the wall stability. The wall buried conditions elements include the wall foundation element and portions of the wall structure which are not typically visible. These elements also include any evidence (wall sliding, overturning etc.) which may indicate that the underlying foundation element is not functioning as intended or designed.			
Quantity Calculation	The quantity is collected in length of feet measured along the wall face.			
	Condition State Descriptions			
Defect Type	**Good**	**Fair**	**Poor**	**Severe**
Stability – Sliding	Wall shows no signs of movement.	Wall movement has occurred. Signs of bulging, bending, heaving, misalignment, distortion, deflection, or displacement are present. Wall may have had preventative or countermeasures installed such as straps or anchors.	Sloughing of retained material behind wall is evident. Previous stabilization measures, if present, are failed.	Major wall sliding either along the base of a wall or a slip surface cutting through the wall. Wall movement is active and extensive. Wall considered failed. Threat to wall structural capacity and overall stability. The condition warrants a structural review to determine the effect on strength or functionality of the element or wall.
Stability – Overturning, Tilting, or Misalignment	Wall shows no signs of movement.	Wall movement has occurred. Signs of bulging, bending, heaving, misalignment, distortion, deflection, or displacement are present. Wall may have had preventative or countermeasures installed such as straps or anchors.	Moderate rotation, misalignment, tilting, or vertical or horizontal movement has occurred. Previous stabilization measures, if present, are failed.	Major wall rotation, misalignment, or tilting. MSE wall geotextile (if applicable) may be exposed. Wall considered failed. Threat to wall structural capacity and overall stability. The condition warrants a structural review to determine the effect on strength or functionality of the element or wall.

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Description	This element defines the adjacent soil movement caused by vertical or lateral pressures such as settlement, global stability, wall tilt, which affects the wall stability. The wall buried conditions elements include the wall foundation element and portions of the wall structure which are not typically visible. These elements also include any evidence (wall sliding, overturning etc.) which may indicate that the underlying foundation element is not functioning as intended or designed.			
Quantity Calculation	The quantity is collected in length of feet measured along the wall face.			
	Condition State Descriptions			
Defect Type	**Good**	**Fair**	**Poor**	**Severe**
Stability – Settlement	Facilities behind wall, such as pavement, are smooth and show no signs of settlement. No indications of retained material/ backfill loss.	Facilities behind wall, such as pavement, may have minor settlement, cracking, or deterioration. If settlement is present the structure has no other associated distress.	Facilities behind wall, such as pavement, may have moderate settlement, cracking, or deterioration. Structural distress due to settlement is present.	Facilities behind wall, such as pavement, may have moderate settlement, cracking, or deterioration. Retained materials showing major settlement, distortion, or erosion. Substantial amounts of water or backfill may be leaking through joints.
Other Wall Buried Defects	Other Wall Buried is present and does not exhibit deterioration or distress.	Minor deterioration or distress of Other Wall Buried.	Moderate deterioration or distress of Other Wall Buried.	Major deterioration or distress of Other Wall Buried.

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Element 13105 (Foundation)

Description	This element defines a foundation, regardless of foundation type			
Quantity Calculation	The quantity is collected in length of feet measured along the wall face.			
	Condition State Descriptions			
Defect Type	**Good**	**Fair**	**Poor**	**Severe**
Foundation Defects	Wall shows no signs of movement. Wall foundation elements are in place.	Wall movement has occurred. Signs of settlement, deflection, or displacement are present. Foundation may be exposed. Wall is still attached to foundation.	Moderate wall settlement, rotation, or movement indicating possible foundation damage. Wall may be partially disconnected from its foundation.	Major loss of wall bearing capacity which is a threat to wall structural capacity and stability. Wall may not be attached to foundation elements.
MSE Reinforced Concrete Stub Cracking	No damage present	Unsealed moderate-width cracks or unsealed moderate pattern (map) cracking. Stub exposed due to erosion.	Stub highly exposed and undermined. Wide cracks (>3/16" or 0.1875 inches) or heavy pattern (map) cracking.	Cracks greater than ½-inch wide.

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Element 13106 (Drainage Elements)

Description	This element defines the drainage along the backside of the retaining wall, as well as drainage through the wall.			
Quantity Calculation	The quantity is collected in length of feet measured along the wall face.			
	Condition State Descriptions			
Defect Type	**Good**	**Fair**	**Poor**	**Severe**
Drainage Approach Defects	Wall flume end and associated ditches in good condition.	Minor rill erosion of slope below wall. Minor sheet erosion (up to 10% bare ground), indications of storm water runoff down embankment below wall.	Evidence of piping. Moderate sheet erosion of slopes below retaining wall requiring protection and investigation. Drainage functions plugged or with moderate deterioration.	Major erosion of slopes at ends of retaining wall. Drainage functions plugged and have major deterioration. Soil tension cracks perpendicular/semi-circular to slope indicating shifting or settlement. Sloughing of embankment causing loss of support to wall above. Slope stability failure likely.
Streambank Defects	No indications of bank erosion or scour.	Wall remains stable but has intermittent bank erosion or local scour that does not expose or undermine wall. Countermeasures are substantially effective. Extensive minor to isolated advanced defects present.	General bank erosion leading to channel widening, local scour or head cutting or signs of downstream scour. Trees and brush may restrict stream channel. Extensive advanced to major defects.	Countermeasures or channel protection devices are unstable, missing, or no longer effective. Bank, wall, and/or roadway weakened by scour. Foundation has lost support and is undermined sufficiently to threaten the wall integrity. Danger of collapse with next flood event.
Vegetation Defects	Minor vegetation growth through or around elements. No evidence of damage from growth.	Moderate vegetation growth through or around element and/or evidence of minor to moderate damage to the element caused by the growth. Structural elements are still sound.	Heavy vegetation growth through or around elements and/or severe damage or deterioration of the element due to growth.	Not applicable.

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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.

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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.

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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.

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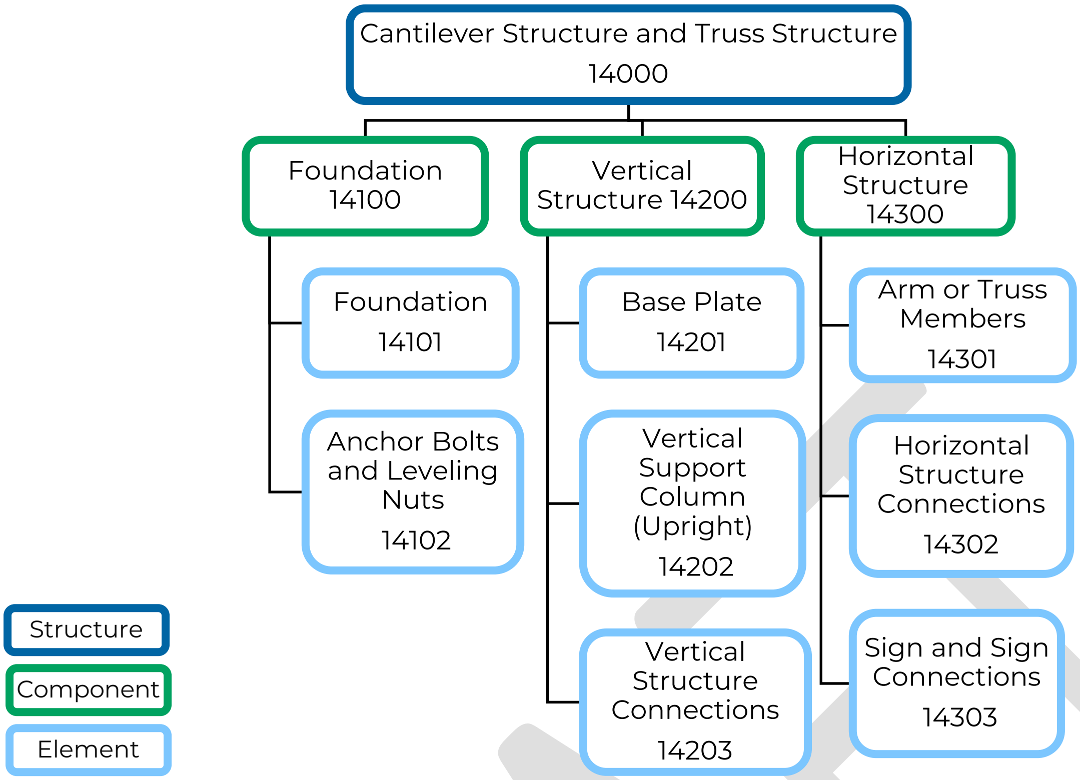

Figure 4-3: Rating structure for Cantilever Structures and Truss Structures

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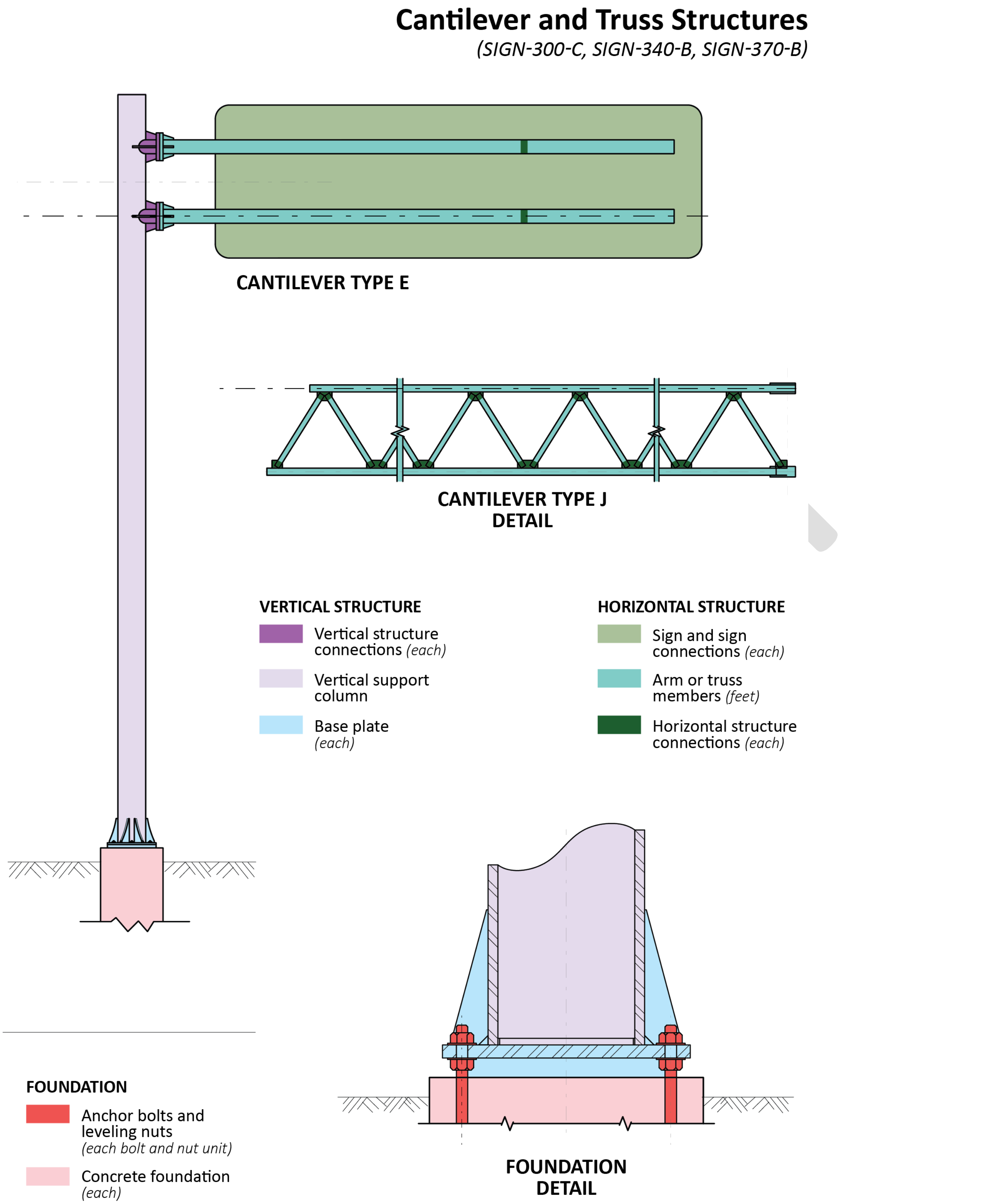

Figure 4-4: Elements and components for Cantilever Structures and Truss Structures (adapted from MDOT Standards SIGN-300-C, SIGN-340-B, SIGN-370B)

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

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

*** 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.**

4.3 Inspector Minimum Technical Qualifications

At least <u>one</u> 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 2 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. Cantilever structure frequency inspection is more often than truss structures due to the non-redundant vertical structure.

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 rod diameter and length, then scan for defects.
- Examine anchor rods for tightness and embedment using a standard inspection hammer. Inspect visually for corrosion, section loss, and plumbness.
- Examine anchor rods for any eccentricity. Note any noticeable eccentricity measurements.
- Perform ultrasonic testing of anchor rods 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.

Component Rating	Condition	Material	Description
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.
		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.

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Component Rating	Condition	Material	Description
		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

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

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.

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

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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)

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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 references, Section 4.7, linked below:

Cantilever Structure and Truss Structure Condition State Tables

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. Any distance greater than one inch does not meet specifications and may be cause for concern.

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

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

Examples of common distresses associated with anchor bolts and leveling nuts are shown in Figure 4-7 *through 4.9*.

Figure 4-7: Cantilever or truss structure anchor bolts and leveling nuts, corrosion in anchor bolt below upright base with section loss

Figure 4-8: Cantilever or truss structure anchor bolts and leveling nuts, anchor nut without fully engaged threads

Figure 4-9: 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.

Component Rating	Condition	Material	Description
		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.
		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.
3	SERIOUS	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	Base Plate for Cantilever or Truss Structure	Weld defect or crack Base plate warping

Unit of Measure: Each, percentage of base plate within 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

Figure 4-10: 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

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
Unit of Measure: Length, inch of vertical support within 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

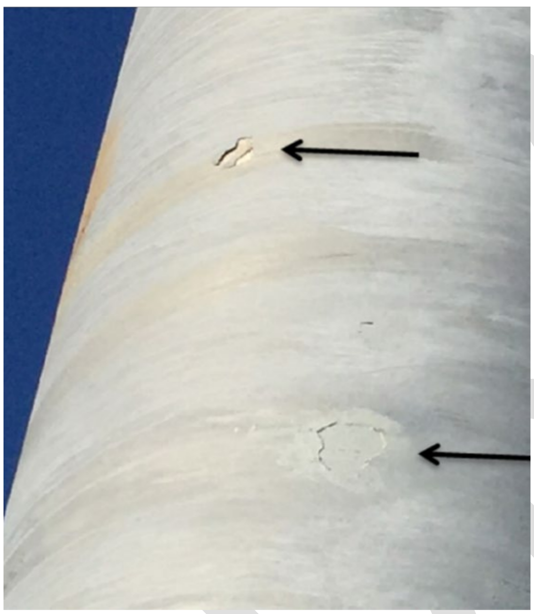

Figure 4-11: Cantilever or truss structure vertical supports, galvanizing damage

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

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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

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
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

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 4-12: Vertical structure connection, missing flat washer on head side of bolt

Figure 4-13: 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.

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Figure 4-14: 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.
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

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Component Rating	Condition	Material	Description
			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	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	Cracking 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.

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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

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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 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'

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

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

No.	Description of Work Recommendation	Material Involved	Quantity/ Unit of Measure
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
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

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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

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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 inch but less than twice the anchor bolt diameter 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

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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

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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.

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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. No evidence of impact damage.	Minor corrosion of the elements may be present. The elements are fully engaged and functioning as intended. 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. 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. Multiple nuts are loose/missing. Anchor bolt standoff distance is greater than two times the bolt diameter. UT testing indicates major cracks or breaks in bolts. The element conditions have majorly affected the serviceability or integrity of the structure.

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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. 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.

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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. 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.

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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.

5 EMBEDDED POLE

5.1 Definitions

Embedded poles are used to support span wires, signals, lighting, cameras, or other appurtenances. They are constructed in a box span, diagonal span, or other type of configuration. Embedded poles may be constructed of round or multi-sided steel cross-sections, or timber. The poles are directly embedded in soil or cast in place concrete. The embedment material may be covered with concrete, bituminous, or masonry materials.

Other common terms which may be used when discussing Embedded Pole or other AS include:

- **Anchor Wires:** A tensioned cable designed to add stability to a free-standing structure. Often used for embedded poles to support unbalanced lateral loads. Embedded poles typically have a strain insulator near the top of the guy wire to mitigate voltage.
- **Camera:** A camera is a device that captures images or videos. A device that is both camera and sensor would classify as a camera (i.e., video detection).
- **Sensor:** A sensor is a device that detects and measures changes in traffic or environment. (e.g., atmospheric sensors).
- **Appurtenance:** An appurtenance is an attachment connected to the structure that does not constitute a rated element and is neither a camera nor a sensor (e.g., roadside unit, cell modem, antenna, radio antenna, signs, pedestrian signals, electrical utilities, etc.).

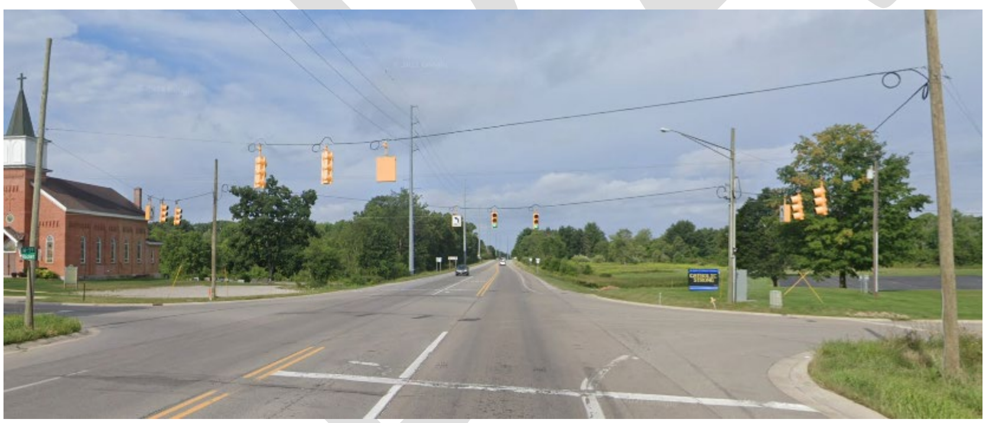

Figure 5-1: Embedded wood poles with box span configuration

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Figure 5-2: Embedded steel poles with single span configuration

Figure 5-3: Embedded wood pole supporting ITS infrastructure

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5.1.1 INVENTORY ITEMS

The inspector shall identify the pole and embedment material types. The pole may be constructed of timber or steel, and the latter may have a round cross-section or may be multi-sided. Embedded poles with round or multi-sided steel cross-sections are no longer being installed.

If the pole is steel, determine the type of coating – paint, galvanizing, or uncoated. The embedment material should be soil or concrete, although it may sometimes be covered by concrete sidewalk, masonry or pavers, or bituminous paving. Identify whether the pole is part of a configuration of poles and span wires such as a box span, if it is a single span between two poles, or if it is a single stand-alone pole. When a span wire is present, half of the span wire and whatever is attached to that half is assigned to each pole. The pole may support a variety of attachments, both directly and indirectly, including span wires, luminaires and luminaire arms, signs, signals, cameras, and other ITS infrastructure or power supply infrastructure. The quantity and type of these attachments and their connections to the structure should be noted. The types of connections may include direct bolting, bands, clamps, or brackets. Non-structural attachments such as signs, signals, and cameras receive ratings under Miscellaneous Arm, Bracket, and Attachment, and should be reported appropriately if they pose a safety risk. Length and type of bracket arm should be recorded when applicable. The connections of these attachments to the structure are to be rated.

The inspector shall note and record the presence of any secondary support elements of the pole such as anchor wires, and also note and record the presence of any non-typical attachments that may not have been approved or been part of the original purpose or function of the pole.

Some embedded poles should not be included as inventory items as they are not under MDOT ownership. If there are two wood poles that only support a suspended luminaire, it is considered to be owned and operated by the power company, not part of the AS program.

Figure 5-4 Example of Excluded Embedded Poles as Inventory Items

If there are signals on a span wire and if there is a second span wire with luminaire above the signals, the presence of the suspended luminaire should be noted in the inventory.

Figure 5-5 Example of Second Span Wire with Luminaire

The inspector shall confirm any pre-populated inventory data while recording information that is not already documented. It may not be possible to record or verify all measurements exactly due to access limitations; estimate and use experience and best judgement to record data to the most accurate extent possible. Take photos of the required inventory items listed in Section 5.2.2. A complete list of inventory items is provided in the Ancillary Structures Data Dictionary.

5.1.2 ELEMENTS

Embedded poles (steel and wood) are divided into two components: Vertical Structure and Horizontal Structure.

Vertical Structure is further divided into elements: Pole and Embedment, Anchor Wire, and Vertical Structure Connections.

Horizontal Structure is further divided into elements: Span Wire, Span Wire Attachment Connections, Luminaire and Luminaire Arm, and Miscellaneous Arm, Bracket, and Attachment.

Elements are assigned a condition state described in Section 5.7 based on the distresses identified in each element.

The following guidelines for consistent location notation provide the framework for rating an embedded pole element in accordance with the condition rating tables:

- Vertical Structure Locations - Distress locations along the embedded vertical support are referenced by using offsets measured from the grade as measured in feet and prominent features (e.g., span wire connection).
- Horizontal Element Locations - Distress locations along the span wire or arm length are referenced by using offsets measured from the vertical support end. For span wires, half of the span wire length is assigned to each vertical support, along with any attachments along that length.
- Attachments on Span Wires or Arm Members - Attachments are identified in relationship to directionality (e.g., North/South, East/West, Right End/Left End looking at front of signal or 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. Annotate drawings and photos, as necessary.

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Table 5-1: Embedded Pole Components and Elements

Component	Element	Element Code	Unit of Measure
Vertical Structure	Pole and Embedment	15101	Length, feet
Vertical Structure	Anchor Wire	15102	Each
Vertical Structure	Vertical Structure Connections	15103	Each
Horizontal Structure	Span Wire	15201	Each
Horizontal Structure	Span Wire Attachment Connections	15202	Each
Horizontal Structure	Luminaire and Luminaire Arm	15203	Each
Horizontal Structure	Miscellaneous Arm, Bracket, and Attachment	15204	Each

5.1.3 COMPONENTS

Embedded Poles are divided into two main components: Vertical Structure and Horizontal Structure. Component ratings for embedded poles are based on the following:

- ***Vertical Structure*** - Consider if the vertical structure may have damage that compromises the structural capacity such as cracking, fractured welds or base metal, deformation, corrosion, section loss, lack of embedment support, or fraying/damaged anchor wires.
- ***Horizontal Structure*** - Consider fractures in welds or base metal, corrosion, section loss, vertical clearance, fraying of wires, or advanced deterioration as critical to the overall horizontal structure.

A representation of the rating structure for embedded poles is provided in Figure 5-6. A graphic indicating components and elements is in Figure 5-7 and Figure 5-8 for wood and steel embedded poles, respectively.

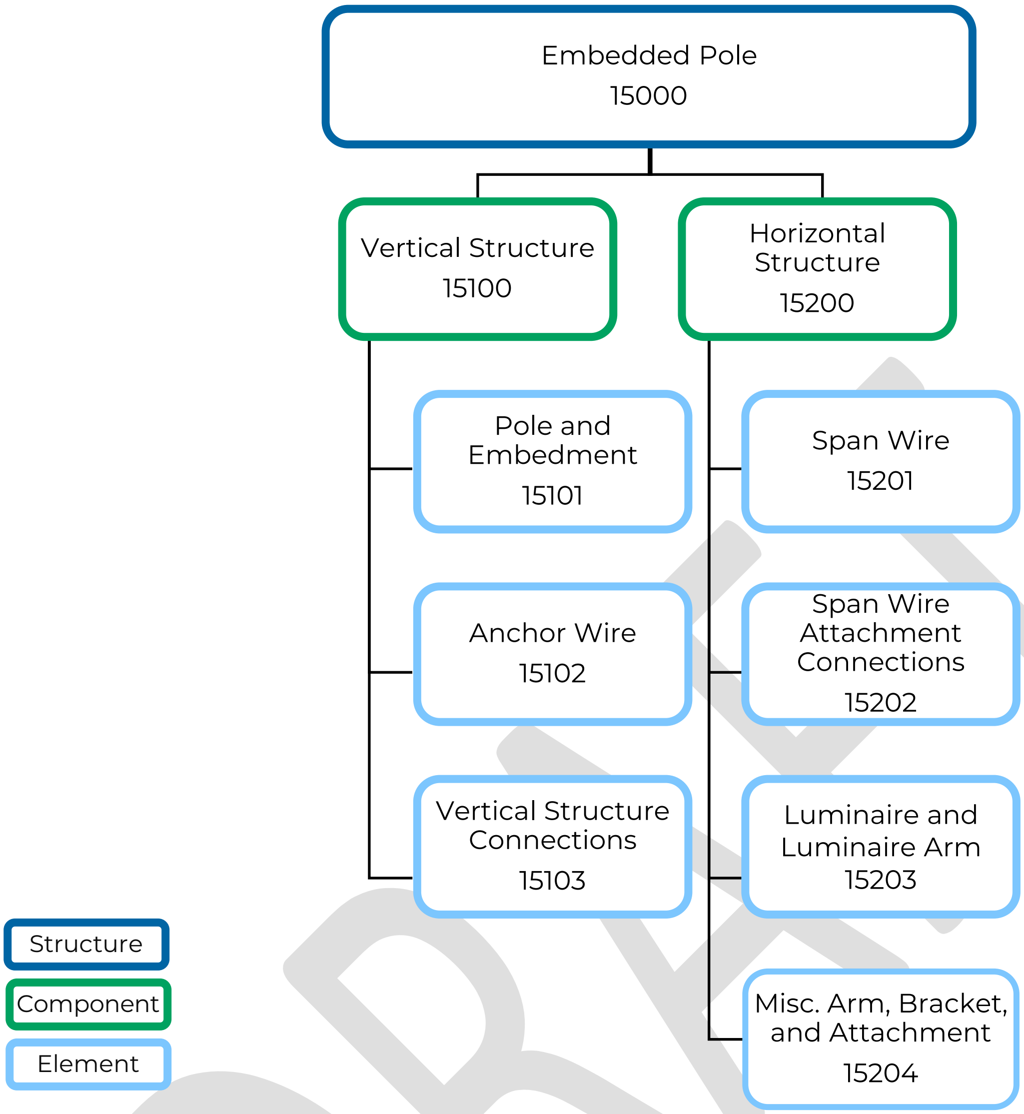

Figure 5-6: Rating structure for Embedded Poles

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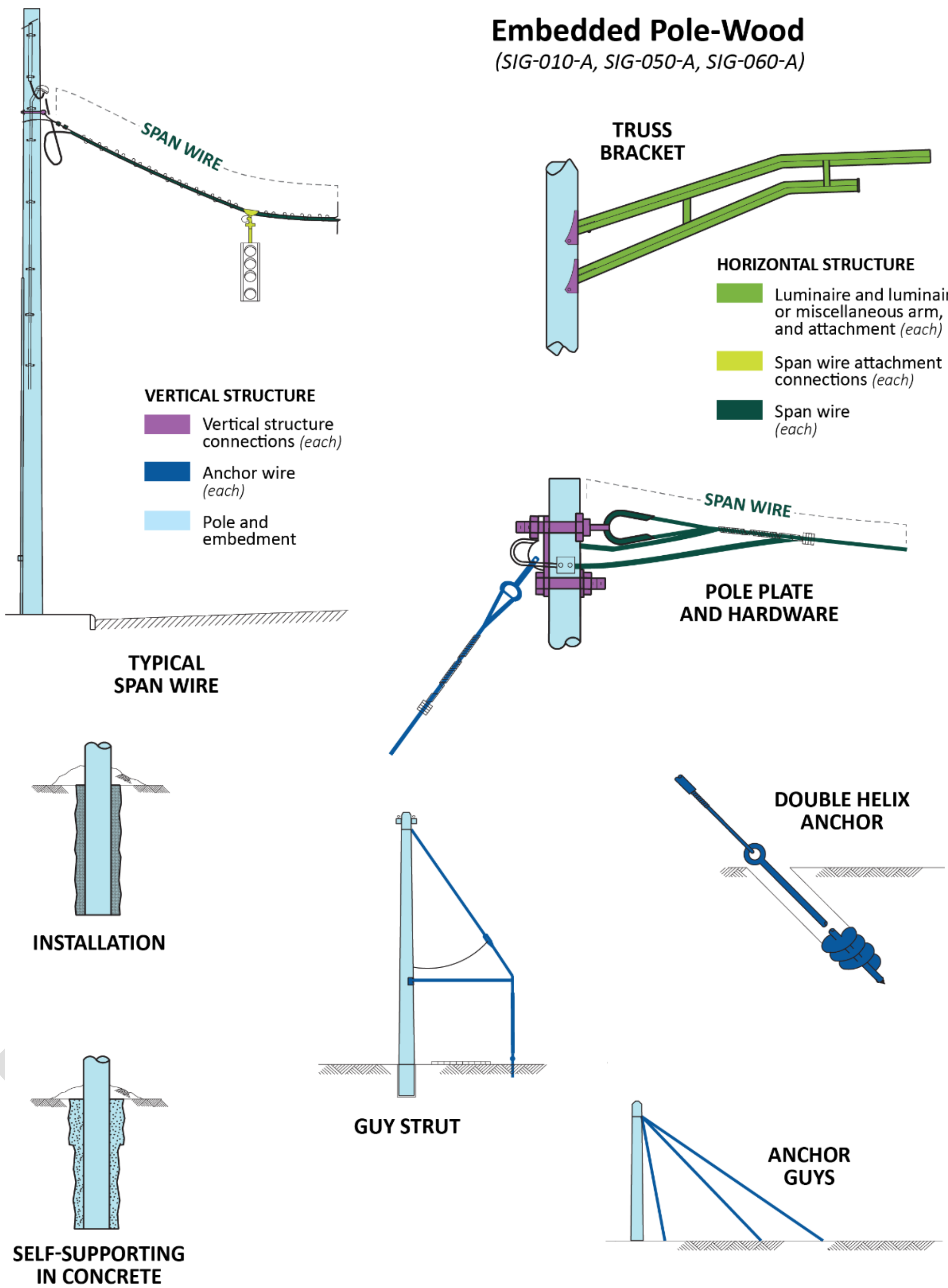

Figure 5-7: Elements and components for Embedded Pole, Wood Pole material (adapted from MDOT Standards SIG-010A, SIG-050A, SIG-060A, SIG-061A)

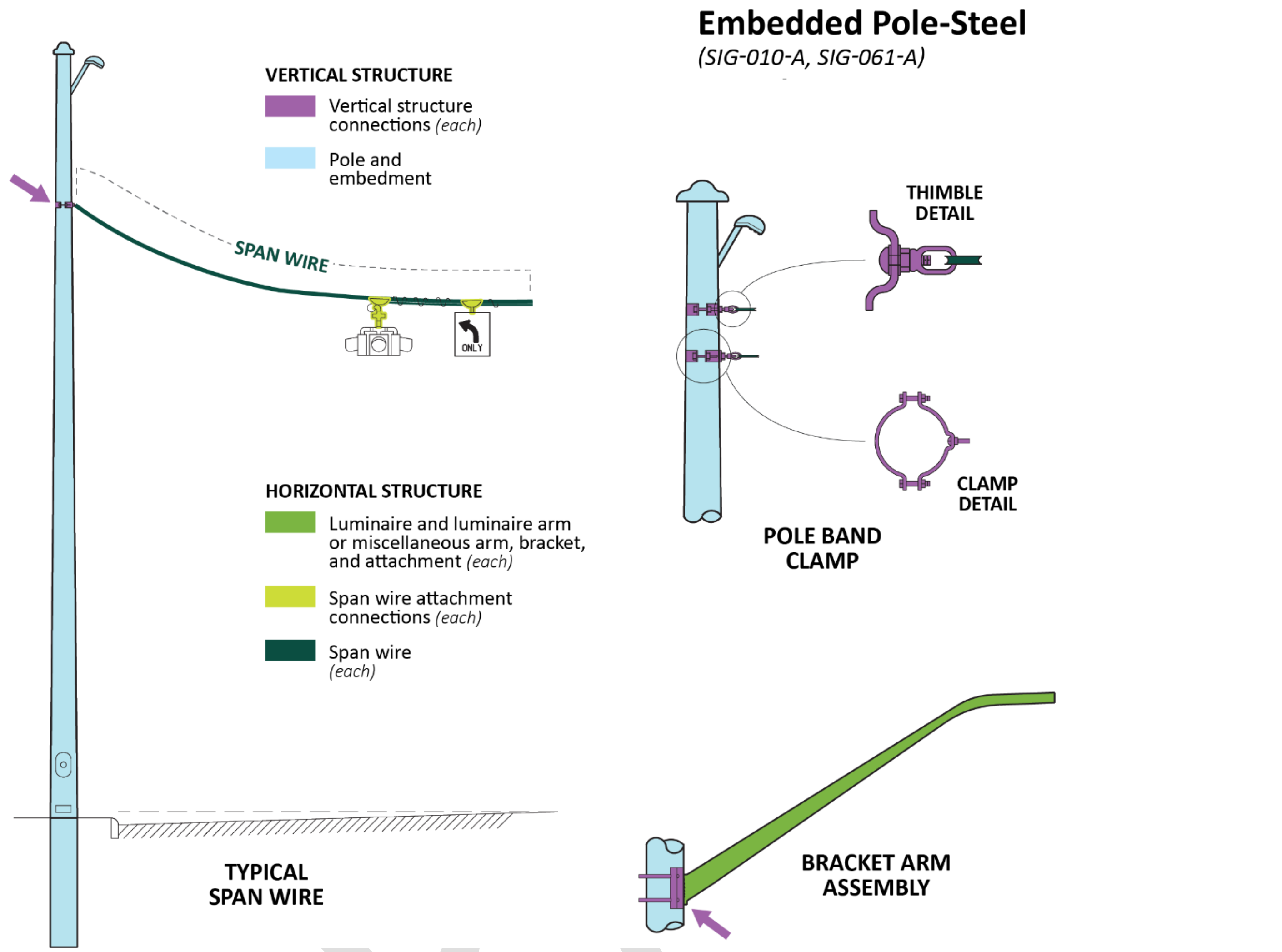

Figure 5-8: Elements and components for Embedded Pole, Steel Pole material (adapted from MDOT Standards SIG-010A, SIG-060A, SIG-061A)

5.2 Inventory Record Photographs

Inventory photos are captured during a routine inspection, saved as part of the inventory database, and follow the naming convention in *Table 5-2*.

Embedded Pole Required Photos:

- General view of the entire pole
- Each foundation (if applicable)
- General view of guy wires (if applicable)
- Structure number stenciled on support
- Manufacturer plate (if applicable)

Table 5-2: Embedded Pole Photograph Naming Convention

Photo Name	Description
EmbPole_Entire	Entire embedded pole
EmbPole_VH#*_Connection	Vertical to horizontal connection
EmbPole_Lum	Luminaire and luminaire arm
EmbPole_ID	Old ID and new structure number
EmbPole_Attachment Name	Replace “Attachment Name” with attachment or appurtenance (e.g. sensor, camera, etc.)
***The # in photo naming convention should reflect the sequential number ranging from 1-x. One image is acceptable 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, multiple photos are necessary to provide required level of visibility.**	

5.3 Inspector Minimum Technical Qualifications

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

- Ancillary structures inspection procedures training
- Working knowledge of inspection tools, their use, application, and limitations for the structure type being inspected.
- Experience with anticipated material types such as wood, concrete, or steel. Internal training will address inspection procedures for all anticipated material types.

5.4 Routine Inspection

These inspections should assess embedded pole structures. Embedded poles are used to support signs, signals, and other appurtenances, most commonly on non-freeway routes. Damage or deterioration of embedded pole structures may impact function or safety.

In many cases, embedded poles are installed at intersections, where they comprise a box span or other geometric configuration. Embedded poles are distinguished from steel strain poles in that they do not have a concrete foundation to support the pole structure, they are embedded directly in the soil, with either soil or concrete filling the space between the edge of the drilled hole and the pole. As such, the interaction between the pole structure and adjacent soil plays a key role in assessing the overall condition of the asset.

Embedded pole standard inspection frequency is once every 4 years for wood poles, and once every 2 years for steel poles, unless otherwise identified for more frequent inspection.

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Figure 5-9: Embedded wood pole (left) and embedded steel pole (right)

5.4.1 VERTICAL STRUCTURE ROUTINE INSPECTION

Routine inspection of the vertical structure is conducted from the ground. Binoculars should be used as a visual aid for inspecting the top of the pole and connections.

- Inspect the general site conditions and assess the global stability of the structure and its operational function.
- Check around the base of the pole for erosion or soil displacement. If the pole is embedded in concrete inspect the concrete for deficiencies such as cracks and spalls, and for any voids between concrete and soil or between the pole and the soil/concrete.
- 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.
- If sidewalk or other material covers the embedment material check for signs of separation, settlement, or cracking at the surface.
- Inspect the vertical alignment of the pole with a 4 ft level or similar. Note that some poles 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.
- For steel poles: inspect the protective coating – galvanizing and/or paint and note any corrosion or section loss. The base of embedded poles is especially prone to corrosion and should be checked carefully. An ultrasonic testing device or thickness gauge should be used to verify the wall thickness when signs of corrosion are present.
- Check for any cracks or deformations in the steel noting the size of deficiencies.
- For wood poles: inspect the timber for signs of deterioration such as cracking, splitting, or section loss noting the size or extent of deficiencies. Perform sounding of

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cracked areas to determine extent of delamination. Photograph the depth of decay measurement.

- Check for signs of vehicle damage noting that impact in one location may affect the structure in other locations as well.
- Inspect any secondary support of the pole such as anchor wires, guy struts, etc. Check for any corrosion and section loss, looseness or deterioration of connections, and anchorage condition.
- Inspect the connection to the pole of the horizontal structure – span wires and arms. This includes band clamps, brackets, and other bolted assemblies. Check for connections that are loose, missing, deteriorated or otherwise deficient.
- Review welds for signs of cracking.
- Check the base for signs of damage from maintenance equipment.
- Check for pole dents and buckling (refer to pole dents & buckling calculations).
- Provide photographs for all Poor or Severe condition state defects and submit the applicable Work Recs or RFAs.

5.4.1.1 Vertical Structure Component Ratings

The embedded pole's vertical structure overall characteristics are rated on its structural condition, ability to support the horizontal structure, and possible negative impact to the entire structure, its operation, or the adjacent roadway. The pole embedment, pole structure, and connections to the pole are all considered as part of the component rating. When evaluating distresses consider that different distresses and the location on the structure at which they occur are not of equal importance to the pole's function. The predominant characteristics determining overall condition are stability and resiliency. Consider if the pole has stable support in the embedment material, a robust and consistent pole cross-section, and the horizontal structure is securely fastened.

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Table 5-3: Component Rating Guidelines for Embedded Pole Vertical 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.
		Steel	Protective coating failure and less than 25% loss of section. Cracks may be present. Fasteners may be considerably deteriorated. Considerable impact damage.
		All	Considerable deterioration or misalignment affecting structural members. Structural review may be warranted.

Component Rating	Condition	Material	Description
3	SERIOUS	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.
		Timber	Extensive decay, section loss, checks, shakes, or splits.
		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.

5.4.1.2 Pole and Embedment Element Condition States

Start by inspecting the condition of pole embedment material around the base of the pole. Identify whether the pole is embedded directly into the soil or has cast in place concrete around it. The concrete may be below the soil surface and a soil probe may be necessary. Signs of soil erosion, soil that has been displaced, or settlement are conditions that could impact the support of the pole. A gap between the pole and adjacent soil may also indicated that the pole has moved. If the embedment soil is covered by bituminous paving, concrete sidewalk, or masonry pavers look for signs of settlement, cracking, or other distress at the surface which may indicate issues below.

If the pole is wood, inspect the timber for the various types of deterioration such and splits, checks, shakes, decay, etc. Check for misalignment or crooks or sweep in the pole and note if pole is out of plumb. Pay close attention to the timber at the soil surface and slightly below as it may be more deteriorated. Note the quantity or extent of the deterioration and its location on the structure. Check for signs of impact damage. If the pole has a handhole, the handhole should be free from excess moisture and debris. The handhole cover should be securely fastened, and the hand hole frame should be inspected for any crack in the welds or base metal, along with any other welded components.

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Figure 5-10: Minor crook in wood pole

Figure 5-11: Wood pole embedment (left), steel pole embedment (right)

Figure 5-12: Measuring pole misalignment with a 4 ft. level

Figure 5-13: Measuring impact damage

If the pole is steel, check for the associated steel deterioration types and note the quantities and locations. Check for misalignment and note if pole is out of plumb. Also check for impact damage. For corrosion, pay special attention to the condition of the pole at the ground surface as corrosion tends to accelerate in that location. When corrosion is present at the base of the pole and section loss is suspected, use a thickness gauge or ultrasonic testing device to check the pole wall thickness close to the groundline at four locations equally spaced around the perimeter. Do the same at an elevation four feet above ground level to check the consistency of the pole wall thickness. Verify pole cap is in place.

Figure 5-14: Embedded Pole with heavy corrosion, concrete sidewalk covering embedment material

Table 5-4: Embedded Pole, Pole and Embedment Element Distresses

Element Number	Element	Description	Associated Distresses
15101	Pole and Embedment	Steel poles and wood poles embedded in soil or concrete	Misalignment or out of plumbness
			Embedment distress, erosion, or settlement
			Concrete cracking or spalling
			Corrosion and Cracking
			Timber decay/section loss/abrasion
			Timber checks/shakes
			Timber splitting/delamination/ cracking
			Other Timber Defects
			Impact damage
			Handhole Defects
Unit of Measure: Length, feet along member which apply to each condition state			

Details on the condition state rating schema are in Section 5.7, linked below:

Embedded Pole Condition State Tables

5.4.1.3 Anchor Wire Element Condition States

For the anchor wire condition states inspect any wires, struts, anchors, dead ends, and connections that comprise the element, which provides additional support to the pole structure. Any wires should be tensioned and free from corrosion and fraying. Connections at the pole and between portions of the element should be securely fastened and free of corrosion, cracks, wear, and deterioration. The soil anchorage should be fully embedded and the surrounding soil free of distress.

Table 5-5: Embedded Pole Anchor Wire Element Distresses

Element Number	Element	Description	Associated Distresses
15102	Anchor Wire	Anchor and guy wires, guy struts, preformed dead ends, thimbles, guy guards, and soil anchor rods	Corrosion, section loss, or cracks
			Under tensioned or frayed wires
			Missing guy guard
			Worn or deteriorated assemblies
			Anchorage displacement
Unit of Measure: Each member which apply to each condition state			

Details on the condition state rating schema are in Section 5.7, linked below:

Embedded Pole Condition State Tables

5.4.1.4 Vertical Structure Connections Element Condition States

For the vertical structure connections element consider all connections to the pole structure. There are several different types of connections that may be present. In general, any steel portions of a connection should be securely in place, and free of corrosion, wear, missing pieces, cracks, or other deterioration.

If the pole is wood, span wires and anchor wires are usually connected to the pole with a through bolt assembly. The bolting assembly should be tight to the pole and pass through the center of the cross-section. If the pole is steel, span wires and anchor wires are usually connected to the pole with band clamps. The two halves of the clamps are tightened against the pole with bolting assemblies on either side. Consider the typical steel deterioration types and inspect the band clamps for any distortion or cracking which may precede a failure. Luminaire arms or other arms used to connect attachments to the bolt may use brackets or other types of steel connections. Consider the typical steel and fastener deterioration modes for these connections. If miscellaneous arms, brackets, and attachments are failing or in some way pose a safety risk they should be noted in a Work Rec or RFA.

Table 5-6: Embedded Pole Vertical Structure Connections Element Distresses

Element Number	Element	Description	Associated Distresses
15103	Vertical Structure Connections	Bracket assemblies, pole band clamps, stainless steel straps, through bolts, or other connections to poles	Weld defects or cracks
			Corrosion or coating damage
			Loose, missing, or failing hardware
Unit of Measure: Each connection quantity within the condition state			

Details on the condition state rating schema are in Section 5.7, linked below:

Embedded Pole Condition State Tables

5.4.2 HORIZONTAL STRUCTURE ROUTINE INSPECTION

Routine inspection of the horizontal structure is conducted from the ground, and binoculars should be used as a visual aid.

- Inspect the vertical clearance of the horizontal structure and its attachments, the alignment, and the operational function.
- Check for corrosion or section loss on the horizontal structure.
- Check the span wire for signs of fraying, corrosion, or broken strands.
- Inspect the luminaire and luminaire arm, and other miscellaneous arms or brackets, for any cracked welds, damage or deterioration, or loose and deficient connections.
- Inspect signals and other 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.

5.4.2.1 Horizontal Structure Component Ratings

The embedded pole's horizontal structure overall characteristics are rated on its structural condition, ability to support the connected attachments, and possible negative impact to the structure's operation and the roadway below. The span wire, arms, and the attachment connections to them are all considered as part of the component rating. When evaluating distresses, consider that different distresses and the location on the structure at which they occur are not of equal importance to the horizontal structure's function. The predominant characteristic determining overall condition is resiliency. Consider if the span wire and arms have a robust and consistent cross-section, and the attachments are securely connected.

Table 5-7: Component Rating Guidelines for Embedded Pole 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**	Steel	Protective coating failure in very small and scattered locations.
		All	All components retain full section properties and function as designed.
6	**SATISFACTORY**	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**	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.

Component Rating	Condition	Material	Description
4	POOR	Steel	Up to 25% loss of section. Span wire may have minor fraying or attachments may have less than 17 ft of vertical clearance. Fasteners may be considerably deteriorated.
3	SERIOUS	All	Considerable deterioration affecting structural members. Structural review may be warranted.
		Steel	Section loss in excess of 25%. Missing or broken fasteners or excess sagging of the span wire.
		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.

5.4.2.2 Span Wire Element Condition States

For the span wire element condition consider the connection of the span wire to the pole connection – which includes the span wire, thimble, and dead end. Consider wear, deterioration and portions that may be loose, distorted, or otherwise exhibiting distress. For the length of the span wire, half of each wire is assigned to each supporting pole. The wire should be inspected for corrosion, fraying, or any broken wires. Any attachment connected to the span wire should have a minimum vertical clearance to the top of pavement of 17 feet. Inspectors should rate the Span Wire element as severe for both poles if the clearance is less than 17 feet. While this may not be able to be measured, note report any vertical clearance that looks out of the ordinary.

Table 5-8: Embedded Pole Span Wire Element Distresses

Element Number	Element	Description	Associated Distresses
15201	Span Wire	Span wires, thimbles, preformed dead ends	Insufficient under clearance Corrosion or section loss, frayed wires Worn or deteriorated dead ends
Unit of Measure: Each member which apply to each condition state			

Details on the condition state rating schema are in Section 5.7, linked below:

[Embedded Pole Condition State Tables]

5.4.2.3 *Span Wire Attachment Connections Element Condition States*

Attachments connected to the span wire include signals and case signs. Typically, the signals and signs are connected using span wire hangers and suspension clamps. Consider the typical steel and fastener deterioration modes for these connections: loose connections, wear, corrosion, cracking, and deformation. The signals and signs themselves are not rated but if there is noticeable deterioration that could impact safety it should be reported.

Table 5-9: Embedded Pole Span Wire Attachment Connections

Element Number	Element	Description	Associated Distresses
15202	Span Wire Attachment Connections	Span wire hangers, lashing rods, armor rods, suspension clamps	Corrosion or section loss Loose, missing, or cracked hardware Deformed or worn parts
Unit of Measure: Each connection quantity within the condition state			

Details on the condition state rating schema are in Section 5.7, linked below:

[Embedded Pole Condition State Tables]

5.4.2.4 *Luminaire and Luminaire Arm Element Condition States*

Luminaires are usually mounted on a luminaire arm but may also be mounted directly on the pole, on a tenon, or using some other pole mounting device. The arms may be a single member type or truss type. Note that the bracket assembly or other method of attaching the luminaire arm to the pole is considered part of the vertical structure connections element. The arms should be inspected for steel condition and the condition of any welds. The condition of the luminaire connection to the arm or tenon should be inspected for material defects and connection type defects such as looseness and wear. The luminaire itself includes the light source, any fixtures or assemblies, and the housing. Note any visibly broken portions of the luminaire.

Table 5-10: Embedded Pole Luminaire and Luminaire Arm Element Distresses

Element Number	Element	Description	Associated Distresses
15203	Luminaire and Luminaire Arm	Lighting sources, fixtures and assemblies, bracket arms, truss arms, tenon mounts, shepherds crooks, or other pole mounting devices	Broken lighting source or assembly
			Damaged or cracked housing, cover
			Corrosion or section loss
			Weld cracks/defects
			Deteriorated gasket/seal
Unit of Measure: Each luminaire and luminaire arm within the condition state			

Details on the condition state rating schema are in Section 5.7, linked below:

[Embedded Pole Condition State Tables]

5.4.2.5 Miscellaneous Arm, Bracket, and Attachment Element Condition States

Attachments or appurtenances may be mounted on a bracket or arm but may also be mounted directly on the pole, on a tenon, or using some other pole mounting device. The arms may be a single member type or truss type. Note that the bracket assembly or other method of attaching the miscellaneous bracket or arm to the pole is considered part of the vertical structure connections element. The miscellaneous arms, brackets, and attachments should be inspected for steel condition and the condition of any welds. The condition of the attachment connection to the bracket, arm, or tenon should be inspected for material defects and connection type defects such as looseness and wear.

Table 5-11. Embedded Pole Miscellaneous Arm, Bracket, and Attachment Element Distresses

Element Number	Element	Description	Associated Distresses
15204	Miscellaneous Arm, Bracket, and Attachment	Power sources, fixtures and assemblies, bracket arms, truss arms, tenon mounts, shepherds crooks, or other pole mounting devices	Broken power source or assembly
			Damaged or cracked housing, cover
			Corrosion or section loss
			Weld cracks/defects
			Deteriorated gasket/seal
Unit of Measure: Each miscellaneous arm, bracket, and attachment within the condition state			

Details on the condition state rating schema are in Section 5.7, linked below:

Embedded Pole Condition State Tables

5.4.3 REFERENCES

MDOT Traffic and Safety Standards and Special Details

SIG-010-series All Span Wire T.S. on Steel and Wood Poles

SIG-050-series Wood Pole Guys and Setting Depth

SIG-060-series Steel Truss Brackets

SIG-061-series Clamp on Bracket Arm Assembly (Street Light)

Pole Dent & Buckling Calculations

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5.5 Work Recommendation Guidance

The Work Recs are not meant to be all-inclusive and other Work Recs may be added to supplement those noted.

Inspectors should create Work Recs to address span wires with less than 17 ft clearance. Half of the span of the wire is attributed to each pole. Inspectors should generate a single Work Rec to correct the wire tension. Inspectors should assign it to one of the poles and note the Work Rec in the other pole's inspection. Photographs should include sufficient information to determine the relationship of the defect to the element or component or entire structure. Close-up photos of each defect with deficiencies marked on the photo should be provided.

Table 5-12: Embedded Pole Work Recommendations

Number	Description of Work Recommendation	Material involved	Quantity/Unit of Measure
1	Repair guardrail (protecting pole)	Galvanized Steel	Linear feet
2	Correct erosion	Stone/Soil	Cubic feet
3	Repair/monitor foundation	Concrete	Cubic foot
4	Repair/replace handhole cover	Galvanized Steel	Each cover
5	Remove non-MDOT or unauthorized attachments to structures	Various	Each item
6	Remove graffiti	n/a	Square foot
7	Repair galvanizing	Galvanic Paint	Square inch
8	Repair protective coatings system	Metal Coatings System	Square foot
9	Tighten leveling nut	Galvanized Steel Clamp	Each
10	Address loose bolts	Galvanized Steel	Each bolt
11	Weld repair	Steel	Each weld
12	Replace pole band clamps	Galvanized Steel	Each clamp
13	Replace through bolt assembly	Galvanized Steel	Each assembly
14	Tension anchor wire	Steel Strand	Each
15	Replace anchor wire	Steel Strand	Linear feet
16	Replace anchor	Galvanized Steel	Each anchor
17	Replace arm guy/pole guy/guy strut/ guy guard	Various	Each
18	Tension span wire	Steel Strand	Each
19	Replace span wire	Steel Strand	Linear feet

Number	Description of Work Recommendation	Material involved	Quantity/Unit of Measure
20	Replace span wire hanger	Galvanized Steel	Each
21	Replace pole cap	Galvanized Steel	Each cap
22	Replace pole cap bolt	Galvanized Steel	Each bolt
23	Replace preformed dead-end	Preformed Dead-end	Each preformed dead-end
24	Replace connectors	Galvanized Steel	Each connector
25	Replace service cap, PVC	PVC	Each cap
26	Replace service cap, metal	Galvanized Steel	Each cap
27	Replace Luminaire	Various	Each luminaire
28	Replace Luminaire arm	Galvanized Steel	Each arm
29	Replace luminaire arm clamp	Galvanized Steel	Each clamp
30	Replace bracket assembly	Galvanized Steel	Each assembly
31	Replace signal head	Various	Each signal head
32	Replace case sign	Various	Each sign
33	Replace misc. attachment	Various	Each attachment
34	Replace miscellaneous arm or bracket	Various	Each arm or bracket

5.6 Request for Action Guidance

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

Priority 1 Level Items

a. Major soil erosion or undermining of the pole evidenced by pole lateral displacement and/or pole out of plumb/rotated
b. Major corrosion or section loss of pole adjacent to the groundline, which impacts the capacity or short-term resiliency of the structure
c. Pole vehicle impact damage resulting in major cracks and pole deformation
d. Major vertical misalignment of the pole
e. Steel poles with major cracking in a weld or base metal
f. Wood poles with major splitting/cracking/decay and/or major crooks/sweep
g. Multiple loose, missing, or damaged parts, or major deterioration, in a connection assembly for signs, signals, miscellaneous attachments, or luminaires
h. Major span wire corrosion and section loss, including fractured individual wires of the span wire strand

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Priority 2 Level Items

a. Significant soil erosion or undermining of the pole and embedment
b. Corrosion or section loss at or near the groundline of the pole causing significant impact to capacity, stability, or durability
c. Pole impact damage resulting in significant pole deformation and cracking
d. Pole is significantly out of vertical alignment
e. 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
f. Wood poles with significant splitting/cracking/decay or significant crooks/sweep
g. Significantly loose parts or significant deterioration or wear in a connection assembly for signs, signals, miscellaneous attachments, or luminaires over traffic where there is significant impact to capacity or durability
h. Significant span wire corrosion and section loss

Priority 3 Level Items

a. Localized moderate soil erosion or undermining of the pole and embedment
b. Corrosion or section loss at or near the groundline of the pole causing moderate impact to capacity or durability
c. Pole impact damage resulting in moderate pole deformation
d. Moderate weld deficiencies, which do not meet code but do not impact function where significant redundancy is also present
e. Pole is moderately out of vertical alignment
f. Wood poles with moderate splitting/cracking/decay or moderate crooks/sweep
g. Loose or misaligned parts or moderate deterioration or wear in a connection assembly for signs, signals, miscellaneous attachments, or luminaires over traffic where capacity or durability is moderately affected
h. Moderate span wire corrosion and section loss

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5.7 Element Condition States

Element Number	Element	Condition States Defects Note	Link to Discussion in Section 5
15101	Pole Embedment	Use the appropriate condition state table.	Pole and Embedment Element Condition States
15102	Anchor Wire	Use the appropriate condition state table.	Anchor Wire Element Condition States
15103	Vertical Structure Connections	Use the appropriate condition state table.	Vertical Structure Connections Element Condition States
15201	Span Wire	Use the appropriate condition state table.	Span Wire Element Condition States
15202	Span Wire Attachment Connections	Use the appropriate condition state table.	Span Wire Attachment Connections Element Condition States
15203	Luminaire and Luminaire Arm	Use the appropriate condition state table.	Luminaire and Luminaire Arm Element Condition States
15204	Miscellaneous Arm, Bracket, and Attachment	Use the appropriate condition state table.	Miscellaneous Arm, Bracket, and Attachment Element Condition States

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Element 15101 (Pole and Embedment) – Metal

Description	This element defines the vertical pole included in installing an embedded pole, regardless of steel or metal material type.			
Quantity Calculation	Quantity measured in length in feet along pole which is exposed above ground.			
	Condition State Descriptions			
Defect Type	**Good**	**Fair**	**Poor**	**Severe**
Misalignment and Plumbness	Pole is plumb, no evidence of misalignment.	Pole may be slightly out of plumb, but serviceability and function are unaffected.	Pole may be moderately out of plumb. The condition does not significantly affect serviceability and/or function.	Pole is majorly out of plumb. The condition has affected the serviceability or integrity of the structure.
Embedment distress, erosion, or settlement	Embedment material is compact, well graded, and provides adequate pole support.	Any surface paving may have minor cracks or settlement. Minor erosion of the embedment material may be present at the groundline.	Any surface paving may have moderate to major cracks or pieces missing. Moderate embedment erosion is present, or embedment material is loose. The conditions do not significantly affect serviceability and/or function.	Major embedment erosion is present. The element conditions have majorly affected the serviceability or integrity of the structure.
Corrosion and Cracking	No evidence of active corrosion. Surface coating is sound and functioning as intended.	Minor corrosion may be present. Minor superficial damage to the component parts. Pole caps may be missing.	Moderate corrosion/pitting/ section loss may be present. Protective coatings are failing. Element welds have no evidence of defects and/or cracking.	Major corrosion/pitting/ section loss is present. Protective coatings are significantly failing. Element welds may have cracks/ defects.
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.

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Description	This element defines the vertical pole included in installing an embedded pole, regardless of steel or metal material type.			
Quantity Calculation	Quantity measured in length in feet along pole which is exposed above ground.			
	Condition State Descriptions			
Defect Type	**Good**	**Fair**	**Poor**	**Severe**
Handhole Defects	Cover is securely fastened. No handhole or reinforcing frame weld defects are evident. The inside of the pole is free of excess moisture, debris, and corrosion.	Handhole cover is in place, but fastener is loose, minimally damaged or missing. No handhole or reinforcing frame weld defects are evident. The inside of the pole may contain minor moisture and debris.	Handhole cover is moderately damaged. No handhole or reinforcing frame weld defects are evident. 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 or reinforcing frame welds have defects. Moisture or debris inside the pole is creating major corrosion and/or section loss of material.

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Element 15101 (Pole and Embedment) – Wood

Description	This element defines the vertical pole included in installing an embedded pole, regardless of steel or metal material type.			
Quantity Calculation	Quantity measured in length in feet along pole which is exposed above ground.			
	Condition State Descriptions			
Defect Type	**Good**	**Fair**	**Poor**	**Severe**
Misalignment and Plumbness	Pole is plumb– i.e. within 3/16 inch of plumb over 3 feet or ~0.5%, no evidence of misalignment.	Pole may be slightly out of plumb or have minor crooks or sweep.	Pole may be moderately out of plumb. The condition does not significantly affect serviceability and/or function.	Pole is majorly out of plumb. The condition has affected the serviceability or integrity of the structure.
Embedment Distress, Erosion, or Settlement	Embedment material is compact, well graded, and provides adequate pole support.	Any surface paving may have minor cracks or settlement. Minor erosion of the embedment material may be present at the groundline.	Any surface paving may have moderate to major cracks or pieces missing. Moderate embedment erosion is present, or embedment material is loose. The conditions do not significantly affect serviceability and/or function.	Major embedment erosion is present. The element conditions have majorly affected the serviceability or integrity of the structure.
Timber Decay/ Section Loss/ Abrasion	No indication of decay, section loss or abrasion	Minor decay, section loss or abrasion.	Moderate decay, section loss or abrasion	Major decay, section loss, or abrasion.
Timber Checks/ Shakes	Checks and shakes affect less than 5% of the member thickness.	Checks and shakes affect 5% to 50% of the member thickness. Larger checks/shakes have been repaired.	Checks and shakes of timber affect more than 50% of member thickness.	The condition warrants a structural review to determine the effect on strength or serviceability of the element OR structural review has been completed and defects impact strength or serviceability of the element.

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Description	This element defines the vertical pole included in installing an embedded pole, regardless of steel or metal material type.			
Quantity Calculation	Quantity measured in length in feet along pole which is exposed above ground.			
	Condition State Descriptions			
Defect Type	**Good**	**Fair**	**Poor**	**Severe**
Timber Splitting/ Delamination/ Cracking	No splitting or delamination present. Sealed cracks may exist.	Minor delamination or cracking is present.	Delamination or splitting length equal to or greater than the total member depth, but only present away from connections. Evidence of moderate cracking of the member thickness. Larger cracks have been repaired.	Delamination or splitting near connections; Severe deterioration due to cracking.
Other Timber Defects	Other timber defects are present and do not exhibit deterioration or distress.	Minor deterioration or distress of other timber defects.	Moderate deterioration or distress of other timber defects.	Major deterioration or distress of other timber defects.
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.

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Element 15102 (Anchor Wire)

Description	This element defines the anchor and guy wires, guy struts, preformed dead ends, thimbles, guy guards, and soil anchor rods associated with an embedded pole which extend to terminate at the ground level.			
Quantity Calculation	The quantity is collected as each anchor wire.			
	Condition State Descriptions			
Defect Type	**Good**	**Fair**	**Poor**	**Severe**
Anchor Wire	No evidence of active corrosion. Anchor wire, dead ends, guy strut, and anchorage are functioning as intended with no evident wear.	Minor surface corrosion or wear may be present. Minor wear of anchor wire, dead ends, guy strut, and anchorage may be present, but members are functioning as intended.	Moderate corrosion/section loss or wear is present. Safety guy guard may be missing. Wire may not be fully tensioned.	Major corrosion/section loss is present. Protective coatings or dead ends are significantly failing. Elements may have cracks/ defects or major wear. Major ground displacement may be present at the anchorage. Anchor wire is not tensioned or is not functioning as intended.

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Element 15103 (Vertical Structure Connections)

Description	This element consists of the connections along the embedded pole for various attachments. Connections may include bracket assemblies, pole band clamps, stainless steel straps, through bolts, or other connections to poles.			
Quantity Calculation	The quantity to be collected includes each connection location.			
	Condition State Descriptions			
Defect Type	**Good**	**Fair**	**Poor**	**Severe**
Vertical Structure Connections	Pole band clamps, bracket assemblies, and other connection hardware are functioning as intended with no evidence of wear or corrosion.	Minor surface corrosion or wear may be present.	Moderate corrosion/ section loss or wear is present. U-bolts, band clamps, or lag bolts may be loose, but the conditions do not significantly affect serviceability and/or function.	Major corrosion/section loss is present. Protective coatings are significantly failing. Members may have cracks/defects or major wear. U-bolts, band clamps, or lag bolts are loose or missing. Element is not functioning as intended.
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.

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Element 15201 (Span Wire)

Description	This element defines the span wires, thimbles, preformed dead ends which extend to terminate at another vertical structure.			
Quantity Calculation	The quantity is collected as each span wire.			
	Condition State Descriptions			
Defect Type	**Good**	**Fair**	**Poor**	**Severe**
Span Wire Defects	Span wire, preformed dead end, and thimble have no evidence of corrosion or wear and minimum clearance is 17 ft from roadway to bottom of any signal/sign.	Minor surface corrosion or wear may be present. Minimum clearance is 17 ft from roadway to bottom of any signal/sign.	Moderate corrosion/ section loss or wear is present. Minimum clearance is 17 ft from roadway to bottom of any signal/sign.	Minimum clearance is less than 17 ft from roadway to bottom of a signal/sign. Major corrosion/pitting/ section loss is present. Protective coatings are failing. Members may have cracks/defects or major wear.

Element 15202 (Span Wire Attachment Connections)

Description	This element defines the span wires hangers, lashing rods, armor rods, and suspension clamps.			
Quantity Calculation	The quantity is collected as each connection.			
	Condition State Descriptions			
Defect Type	**Good**	**Fair**	**Poor**	**Severe**
Span Wire Attachment Connection Defects	Span wire hangers, preformed lashing rods and armor rods, and other connection hardware have no evidence of wear or corrosion.	Minor surface corrosion or wear may be present. Hardware is fully engaged, and no gap is present.	Moderate corrosion/ section loss or wear is present. Hardware is fully engaged but gaps may be present	Major corrosion/pitting/section loss is present. Protective coatings are failing. Members may have cracks/defects or major wear. Gaps are present and hardware is loose or missing.

Element 15203 (Luminaire and Luminaire Arm)

Description	This element consists of lighting sources, fixtures and assemblies, bracket arms, truss arms, tenon mounts, shepherds' crooks, or other pole mounting devices.			
Quantity Calculation	The quantity is collected as each luminaire and luminaire arm unit.			
	Condition State Descriptions			
Defect Type	**Good**	**Fair**	**Poor**	**Severe**
Luminaire and Luminaire Arm	Lighting source, housing/cover, waterproofing-gasket/seal, and arm do not have evident wear or corrosion.	Gasket/seal may have minor deterioration. Lighting source, housing/cover, or arm may have minor wear or corrosion.	Gasket/seal may be moderately deteriorated. Lighting source, housing/cover, or arm have moderate wear or corrosion, but the conditions do not significantly affect serviceability and/or function.	Major deterioration of gasket/seal is present. Lighting assembly or hardware is broken or missing. Major failure of protective coatings or corrosion/pitting/section loss is present. Welds have cracks/defects.

Element 15204 (Miscellaneous Arm, Bracket, and Attachment)

Description	This element consists of power sources, fixtures and assemblies, bracket arms, truss arms, tenon mounts, shepherds' crooks, or other pole mounting devices.			
Quantity Calculation	The quantity is collected as each miscellaneous arm, bracket, and attachment unit.			
	Condition State Descriptions			
Defect Type	**Good**	**Fair**	**Poor**	**Severe**
Miscellaneous Arm, Bracket, and Attachment	Power source, housing/cover, waterproofing-gasket/seal, and arm do not have evident wear or corrosion.	Gasket/seal may have minor deterioration. Power source, housing/cover, or arm may have minor wear or corrosion. Arm, bracket, and attachment have	Gasket/seal may be moderately deteriorated. Power source, housing/cover, or arm have moderate wear or corrosion, but the conditions do not significantly affect serviceability and/or function.	Major deterioration of gasket/seal is present. Assembly or hardware is broken or missing. Major failure of protective coatings or corrosion/pitting/section loss is present. Welds have cracks/defects.

Description	This element consists of power sources, fixtures and assemblies, bracket arms, truss arms, tenon mounts, shepherds' crooks, or other pole mounting devices.			
Quantity Calculation	The quantity is collected as each miscellaneous arm, bracket, and attachment unit.			
	Condition State Descriptions			
Defect Type	**Good**	**Fair**	**Poor**	**Severe**
		minor deterioration. Bracket arm & fixture has minor wear or corrosion but does not impact serviceability and/or function.		

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6 SPUN CONCRETE POLE

6.1 Definitions

Spun concrete poles are high mast prestressed precast concrete poles used to support ITS infrastructure such as cameras and radar detectors. They do not have standard concrete foundations and are embedded in soil and sometimes with the addition of a cast in place concrete skirt.

Other common terms which may be used when discussing a spun concrete pole include:

- **Arm:** A cantilevered support, either horizontal or sloped.
- **Tenon:** A pole adapter projecting from top of the pole and used for fitting accessories such as cameras or lighting units.

6.1.1 INVENTORY ITEMS

The inspector shall confirm the height of the vertical structure measuring from the base of the structure and identify the number of cameras and other appurtenances attached to the pole. The inspector shall note if a camera lowering device is attached. Also, connectors used to attach appurtenances to the pole should be identified.

Take photos of the required inventory items listed in Section 6.2.2.

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

6.1.2 ELEMENTS

Spun Concrete Poles have one component: Vertical Structure.

The Vertical Structure is divided into elements: Pole and Foundation, Vertical Structure Connections, and Camera and Camera Arm.

Elements are assigned a condition state described in Section 6.7 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 vertical support are referenced by using offsets measured from top of foundation (if exposed) or grade as measured in feet or inches from prominent features (e.g., vertical structure connections).

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Table 6-1: Spun Concrete Pole Components and Elements

Component	Element	Element Code	Unit of Measure
Vertical Structure	Pole and Foundation	16101	Length, feet
Vertical Structure	Vertical Structure Connections	16102	Each
Vertical Structure	Camera and Camera Arm	16103	Each

6.1.3 COMPONENTS

Spun Concrete Poles have one component: Vertical Structure.

Component rating for spun concrete pole is based on:

- ***Vertical Structure*** – Consider if the vertical structure may have damage that compromises the structural capacity such as cracking, spalls, abrasion, or lack of foundation support.

A representation of the rating structure for spun concrete poles is provided in Figure 6-1. A graphic indicating the components and elements is shown in Figure 6-2.

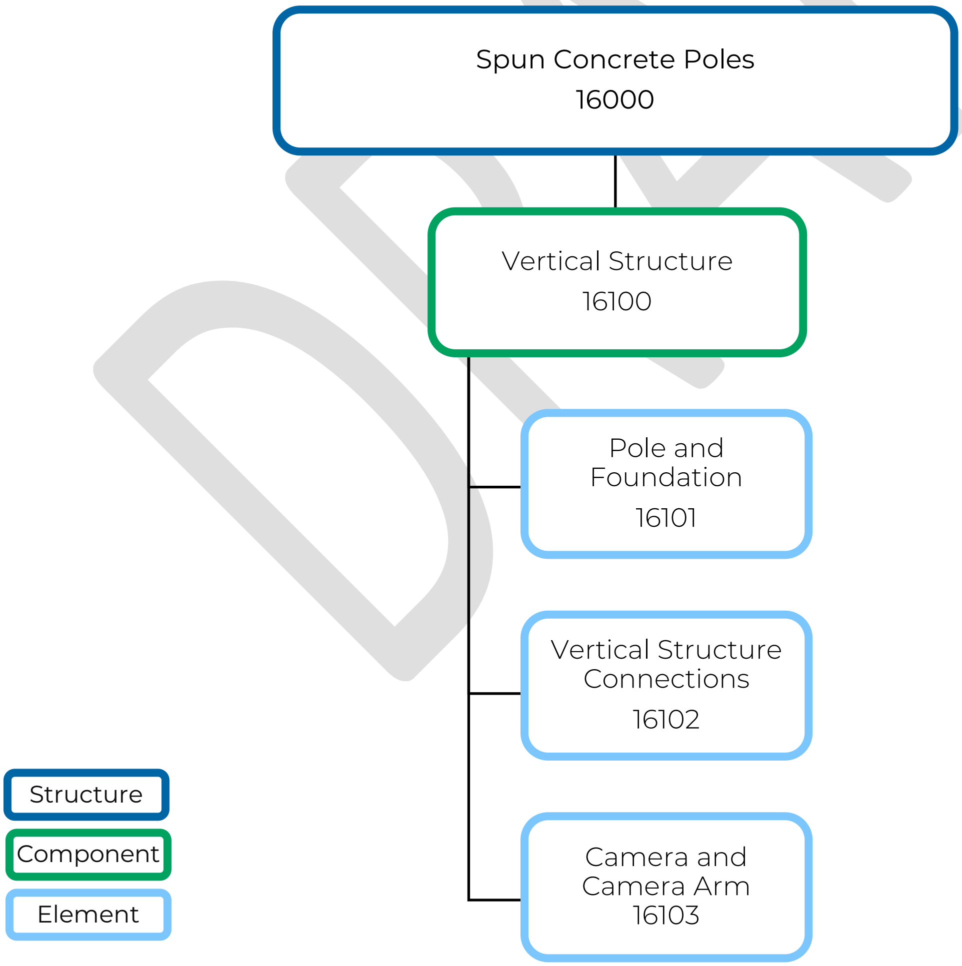

Figure 6-1: Rating structure for Spun Concrete Poles

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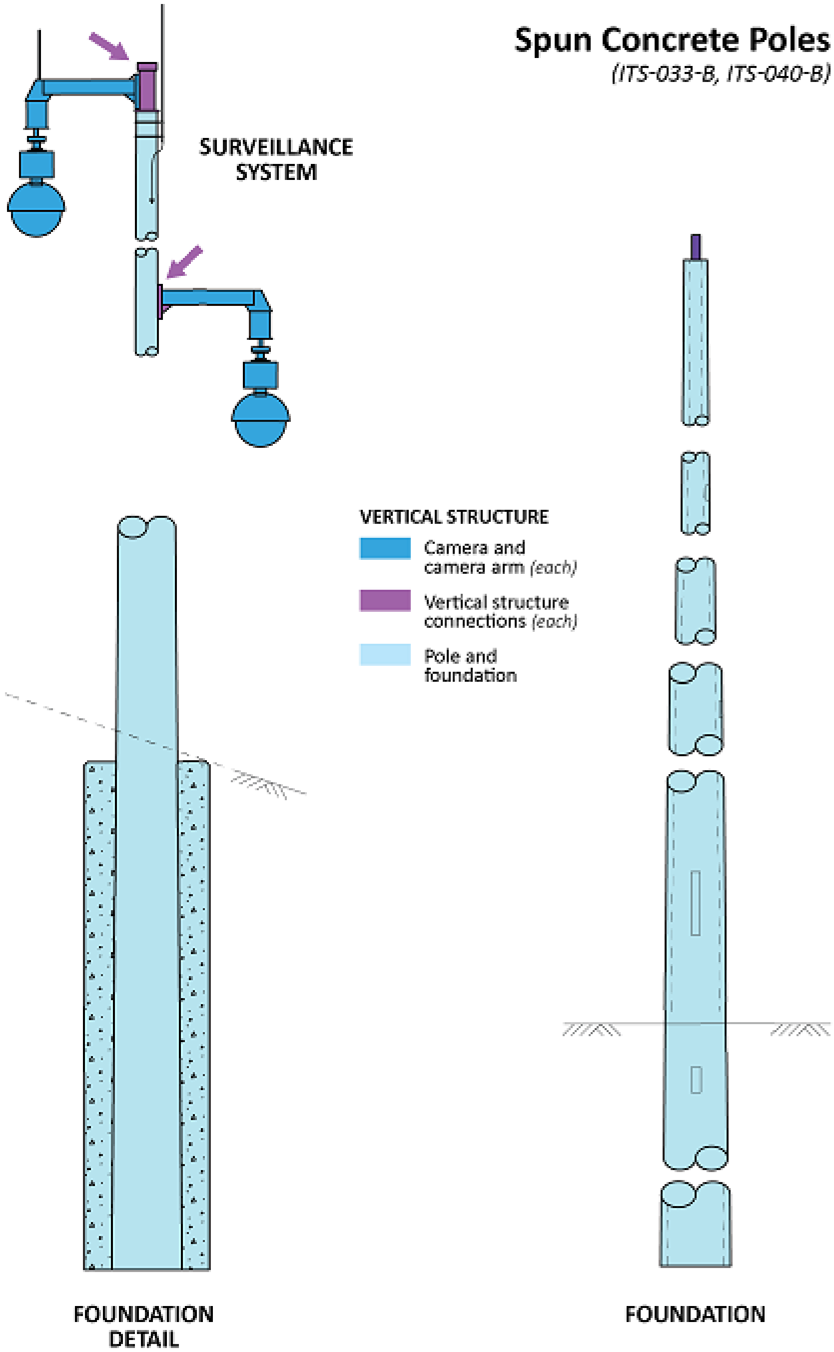

Figure 6-2: Elements and component for Spun Concrete Poles (adapted from MDOT Standard ITS-033-B, ITS-040-B)

6.2 Inventory Record Photographs

Inventory photos are captured during a routine inspection, saved as part of the inventory database, and follow the naming convention in *Table 6-2*.

Spun Concrete Poles Required Photos:

- General view of the entire pole

- Each foundation (if applicable)
- General view of guy wires (if applicable)
- Structure number stenciled on support
- Manufacturer plate (if applicable)

Table 6-2: Spun Concrete Pole Photograph Naming Convention

Photo Name	Description
SCPole_Entire	Entire spun concrete pole
SCPole_V#*_Connection	Vertical connection
SCPole_Foundation	Foundation
SCPole_Att	Camera and camera arm
SCPole_ID	Old ID and New ID
SCPole_Mfr_Plate	Manufacturer Plate

***The # in photo naming convention should reflect the sequential number ranging from 1-x. One image is acceptable 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, multiple photos are necessary to provide required level of visibility.**

6.3 Inspector Minimum Technical Qualifications

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

- Ancillary structures inspection procedures training.
- Working knowledge of inspection tools, their use, application, and limitations for the structure type being inspected.
- Inspection experience with anticipated material types such as concrete or steel. Internal training will address inspection procedures for all anticipated material types.
- Inspection and activities for prestressed structures will require minimum experience of ten structures combined concrete inspection, steel inspection, or design experience (bridge inspection qualifies). At least three of the ten inspected structures shall be concrete structures.

6.4 Routine Inspection

Spun concrete poles are used to support cameras and radar detectors. Damage or deterioration of the structures may impact safety of road users and function of the structure and appurtenances being supported. Similar to embedded poles, they are embedded directly in the soil. The interaction between the pole structure and adjacent soil plays a key role in assessing the overall condition of the asset.

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Spun concrete pole standard inspection frequency is once every 4 years, unless otherwise identified for more frequent inspection.

Figure 6-3: Spun Concrete Pole

The uprights support the camera and camera arm, or other attachments. The routine inspection assesses the vertical structure's ability to safely support the attachments and transfer all loads to the foundation. The routine inspection is performed on a regularly scheduled basis, with frequency determined by the structure inspection needs, and includes the vertical structure component rating as determined by the pole and foundation, vertical structure connections, and camera and camera arm 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 a distance that is close enough to determine the overall condition and to detect deficiencies. Binoculars are used as a visual aid if closer access with equipment or climbing is not available.

A sample routine inspection of the vertical structure would consist of:

- Inspect the general site conditions and assess the global stability of the structure and its operational function.
- Check around the base of the pole for erosion or soil displacement. Check for grading issues that could result in drainage toward the pole. If the pole is embedded in concrete inspect the concrete for deficiencies such as cracks and spalls, and for any voids between concrete and soil.
- Inspect the weep holes to ensure that they are clear of debris that could prevent the pole from draining.

- If sidewalk or other material covers the embedment material check for signs of separation, settlement, or cracking at the surface.
- 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.
- Inspect the vertical alignment of the pole with a 4 ft level or similar. Note that some poles 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.
- Check for cracks, spalls, or any other deterioration, noting the size of deficiencies.
- Check for signs of vehicle 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 – span wires and arms. This includes band clamps, brackets, and other bolted assemblies. Check 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.

Table 6-3 provides guidance for inspecting reinforced and prestressed concrete cracking.

Table 6-3: 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)

6.4.1 VERTICAL STRUCTURE COMPONENT RATING

The component rating for the vertical structure depends on the condition of the pole and foundation, vertical structure connections, and the camera and camera arm connection. Assessing these factors with respect to the overall ability of the vertical structure to safely support all attachments and transfer loads to the foundation provides the appropriate component rating.

Table 6-4: Component Rating Guidelines for Spun Concrete Pole Vertical 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.
		Concrete	Unsealed moderate-width or map cracks. Minor delamination or spalling.
		Soil	Minor displacement or erosion of soil.
6	SATISFACTORY	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.
		Steel	Protective coating failure and less than 25% loss of section. Cracks may be present. Fasteners may be considerably deteriorated. Considerable impact damage.

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Component Rating	Condition	Material	Description
3	**SERIOUS**	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.

6.4.1.1 Pole and Foundation Element Condition States

Verify that the structure number label is affixed on the front of the pole (facing approaching traffic) and is still legible. If necessary, create and install a new inventory label on the pole. Note any cracking, spalling or other defect on the pole and the degree if any. Inspect the handhole for missing or loosely fastened cover, cracks in the welds or base materials, and for excess moisture and debris. Unless a mechanical lift or climbing or other means of working at heights (i.e., UAS) are utilized, binoculars are used as a visual aid to inspect the tops of pole. If any type of impact damage is present (gouges, dents) clean the area and visually inspect for any cracks. Using a 4-ft level, check the plumbness of the pole 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). Inspect the condition of the soil foundation, noting any gap between pole and soil, erosion, settlement, grading issues, or other defect around the foundation/footing. Check the weep holes to ensure that they are clear of debris that could prevent the pole from draining.

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Figure 6-4: Sound patch area

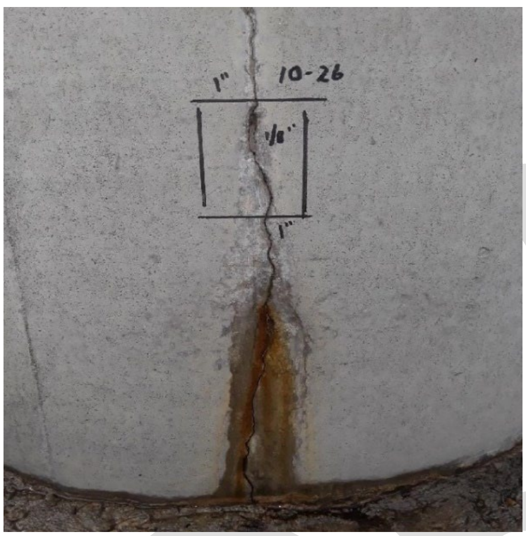

Figure 6-5: Crack with rusted rebar water leakage

Figure 6-6: Spalls (left), major cracking and spalls (right)

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Table 6-5: Spun Concrete Pole, Pole and Foundation Element Distresses

Element Number	Element	Description	Associated Distresses
16101	Pole and Foundation	Concrete pole in soil foundation	Misalignment or out of plumbness
			Erosion or settlement
			Concrete cracking, delamination, spalling or abrasion
			Handhole Defects
			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 6.7, linked below:

[Spun Concrete Pole Condition State Tables]

6.4.1.2 *Vertical Structure Connections Element Condition States*

Most connections are either made using tenons, band clamps, or bolts. Tenons are mostly used for camera arm attachments. Visually inspect the attachment and identify any corrosion or section loss. Note tenon misalignment and check for loose, missing, or broken tenon or tenon cap. Band clamps are used to support metal enclosures and other appurtenances.

Visually inspect any band clamp connection and identify any loose, cracked, or broken band clamp. Check clamping long bolt, washer, and nut for breaks, misalignment, looseness, or gap. Also identify any corrosion or section loss on band clamp or the clamping bolt and nut. For bolted connections, visually inspect the 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.

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Figure 6-7: Band clamp connection to metal enclosure

Table 6-6: Spun Concrete Pole Vertical Structure Connections Element Distresses

Element Number	Element	Description	Associated Distresses
16102	Vertical Structure Connections	Bracket assemblies, tenon mounts, pole band clamps, stainless steel straps, through bolts, or other connections to poles	Weld defects or cracks Corrosion or coating damage Loose, missing, or failing hardware
Unit of Measure: Each connection quantity within the condition state			

Details on the condition state rating schema are in Section 6.7, linked below:

Spun Concrete Pole Condition State Tables

6.4.1.3 Spun Concrete Pole Camera and Camera Arm Element Condition States

Visually inspect the camera and camera arm for any loose, missing, cracked, ruptured or broken arm or camera head. Check for loose or missing end cap and identify any danger of falling camera. Check for corrosion and peeling. Note any galvanizing damage and the degree, if any, of corrosion on the base metal. If nothing of note was found, spray "cold galvanizing" compound or zinc-rich paint on any area where galvanizing was removed. Binoculars are used as a visual aid to inspect arms or truss members when closer access with equipment or climbing is not possible.

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Table 6-7: Spun Concrete Pole Camera and Camera Arm Element Distresses

Element Number	Element	Description	Associated Distresses
16103	Camera and Camera Arm	Camera, fixtures and assemblies, and camera arms	Broken camera, arm, or assembly
			Damaged or cracked housing, cover
			Corrosion or section loss
			Weld cracks/defects
			Deteriorated gasket/seal
Unit of Measure: Each camera and camera arm within the condition state			

Details on the condition state rating schema are in Section 6.7, linked below:

Spun Concrete Pole Condition State Tables

6.4.2 REFERENCES

MDOT Traffic and Safety Standards and Special Details

ITS-033-series Spun Concrete Pole

Pole Dent & Buckling Calculations

6.5 Work Recommendation Guidance

Spun concrete pole Work Recs are recorded to initiate preventive maintenance actions. Preventive maintenance needs are determined for each ancillary structure and the corresponding actions are identified on the Work Recs documentation.

Work Recs include maintenance such as patching delamination or spalls, repairing or monitoring foundation and erosion, repairing, or replacing the handhole cover, epoxy crack injection, tightening loose bolts, and replacing pole band. Other Work Recs may not affect the stability of the structure such as repairing protecting guardrail or removing graffiti.

The Work Recs are not meant to be all-inclusive and other Work Recs may be added to supplement those noted.

Photographs should include sufficient information to determine the relationship of the defect to the element or component or entire structure. Close -up photos of each defect with connection deficiencies marked on the photo should be provided.

Table 6-8: Spun Concrete Pole Work Recommendations

Code	Description of Work Recommendation	Material involved	Quantity/Unit of Measure
1	Repair guardrail (protecting pole)	Galvanized Steel	Linear Feet
2	Repair/monitor foundation	Concrete	Cubic Feet
3	Correct erosion or grading	Stone/Soil	Cubic Feet
4	Repair/replace handhole cover	Galvanized Steel	Each Cover
5	Epoxy crack injection	Epoxy	Lineal Foot
6	Patch delamination or spalls	Concrete	Square foot
7	Address loose connections	N/A	Each Connection
8	Remove graffiti	N/A	Square Foot
9	Replace pole band	Stainless Steel	Each Band
10	Replace misc. attachment	Various	Each
11	Clear out weep holes	N/A	N/A
12	Remove debris from inside of pole	N/A	N/A
13	Remove non-MDOT or unauthorized attachments to structures	Various	Each item

6.6 Request for Action Guidance

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

Priority 1 Level Items

a. Major cracking/spalling/delamination of the pole embedment concrete, which impacts the capacity or short-term resiliency of the structure

b. Major soil erosion or undermining of the pole evidenced by lateral displacement and/or out of plumbness

c. Major vertical misalignment and/or sweep of the pole

d. Major concrete cracking/spalling/delamination present in the pole wall, which impacts the capacity or short-term resiliency of the structure

e. Exposed prestressing strand(s) with major corrosion and section loss

Priority 2 Level Items

a. Significant cracking/spalling/delamination of the pole embedment concrete causing significant impact to capacity or durability

b. Significant soil erosion or undermining of the pole and embedment

c. Pole is significantly out of vertical alignment or has significant sweep
d. Significant concrete cracking/spalling/delamination present in the pole wall causing significant impact to capacity or durability
e. Isolated exposed prestressing strand with significant corrosion and section loss

Priority 3 Level Items

a. Moderate cracking/spalling/delamination of the pole embedment concrete causing moderate impact to capacity or durability
b. Moderate soil erosion or undermining of the pole and embedment
c. Pole is moderately out of vertical alignment or has moderate sweep
d. Moderate concrete cracking/spalling/delamination present in the pole wall causing moderate impact to capacity or durability
e. Isolated exposed prestressing strand(s) with surface corrosion
f. 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
g. Major soil erosion or undermining of the foundation element evidenced by lateral displacement or vertical out of plumbness
h. Major corrosion, section loss or failure of high strength bolts where load-path redundancy is minimal
i. Major base plate distortion or section loss around anchor bolts
j. Multiple loose or missing bolts in a high strength bolted connection, anchor bolt connection, or sign connection
k. Multiple loose or missing bolts where connections do not have load-path redundancy and bolt tensioning is not possible
l. Standoff distance more than twice the bolt diameter, where bending of anchor bolts is evident
m. Major cracks 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 arm connection
n. 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
o. Major section loss due to corrosion of a main element which impacts the capacity or short-term resiliency of the element or structure

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6.7 Element Condition States

Element Number	Element	Condition States Defects Note	Link to Discussion in Section 6
16101	Pole Embedment	Use the appropriate condition state table	Pole and Foundation Element Condition States
16102	Vertical Structure Connections	Use the appropriate condition state table. Use UT testing result to assist in the condition assessment	Vertical Structure Connections Element Condition States
16103	Camera and Camera Arm	Use the appropriate condition state table	Spun Concrete Pole Camera and Camera Arm Element Condition States

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Element 16101 – Pole and Foundation

Description	This element is defined as the concrete pole above the soil and embedded below the soil surface			
Quantity Calculation	The quantity is collected in length in feet along member.			
	Condition State Descriptions			
Defect Type	**Good**	**Fair**	**Poor**	**Severe**
Pole Embedment	Embedment material is compact, well graded, and provides adequate pole support.	Minor erosion of the embedment soil may be present at the groundline. Minor cracks and spalls may be present in the embedment concrete.	Moderate embedment erosion is present, or embedment soil is loose. Moderate cracks and/or spalls may be present in the embedment concrete. The conditions do not significantly affect serviceability and/or function.	Major embedment erosion is present. Major spalling, cracking, deterioration of the embedment concrete. The element conditions have majorly affected the serviceability or integrity of the structure.
Misalignment and Plumbness	Pole is plumb, no evidence of misalignment.	Pole may be slightly out of plumb, but serviceability and function are unaffected.	Pole may be moderately out of plumb. The condition does not significantly affect serviceability and/or function.	Pole is majorly out of plumb. The condition has affected the serviceability or integrity of the structure.
Concrete Cracking	Insignificant cracks or moderate-width cracks that have been sealed. No exposed steel reinforcing or prestressing strand.	Unsealed moderate-width cracks or unsealed moderate pattern (map) cracking. Steel reinforcement may be exposed without measurable section loss present.	Wide cracks or heavy pattern (map) cracking. Steel reinforcement is exposed with section loss present. Prestressing strand may be exposed.	Major deterioration due to extensive cracking. Major corrosion of exposed reinforcing and/or prestressing strand.
Concrete Spalling, Delamination, Patching	No evidence of concrete spalling, delamination, or patching.	Minor delamination is present. Patched areas are sound.	Moderate delamination is present. Patches partially functioning or showing distress.	Major deterioration due to spalling, or delamination. Failed patches.

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Description	This element is defined as the concrete pole above the soil and embedded below the soil surface			
Quantity Calculation	The quantity is collected in length in feet along member.			
	Condition State Descriptions			
Defect Type	**Good**	**Fair**	**Poor**	**Severe**
Concrete Abrasion/Wear	No evidence of concrete abrasion or wear.	Abrasion or wearing has exposed coarse aggregate.	Abrasion or wearing has caused coarse aggregate to be loose and/or lost from the concrete matrix.	Major deterioration of concrete due to abrasion or wear.
Other Concrete Defects	Other concrete defects are present and do not exhibit deterioration or distress.	Minor deterioration or distress of other concrete defects.	Moderate deterioration or distress of other concrete defects.	Major deterioration or distress of other concrete defects.
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. Moderate amounts of moisture and debris may be present inside the pole	Handhole cover is missing or majorly damaged. Handhole attachment to pole is failing. Major amounts of moisture and debris are present inside the pole.

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Element 16102 – Vertical Structure Connections

Description	This element consists of the connections along the spun concrete pole for various attachments. Connections may include bracket assemblies, tenon mounts, pole band clamps, stainless steel straps, through bolts, or other connections to poles.			
Quantity Calculation	The quantity to be collected includes each connection location.			
	Condition State Descriptions			
Defect Type	**Good**	**Fair**	**Poor**	**Severe**
Vertical Structure Connection Defects	Connection hardware is functioning as intended with no evidence of wear or corrosion.	Minor surface corrosion, wear, or superficial damage may be present. Connection hardware is functioning as intended.	Moderate corrosion/ section loss or wear is present. Hardware may be present. Hardware may be loose, but the conditions do not significantly affect serviceability and/or function.	Major corrosion/section loss is present. Protective coatings are significantly failing. Members may have cracks/defects or major wear. Hardware is loose or missing. Element is not functioning as intended.

Element 16103 – Camera and Camera Arm

Description	This element is defined as the camera, fixtures and assemblies, and camera arms			
Quantity Calculation	Quantity is collected as each camera arm and its associated devices.			
	Condition State Descriptions			
Defect Type	**Good**	**Fair**	**Poor**	**Severe**
Camera and Camera Arm Defects	Camera and camera arm, or mounting device do not have evident wear or corrosion and are functioning as intended.	Minor wear or corrosion of the elements may be present. The elements are functioning as intended.	Element may have moderate deterioration, cracks, or corrosion. End cap may be loose and camera head may be loosely connected to the arm but not in danger of falling.	Element has major deterioration, corrosion, or cracks. Camera head or arm is ruptured or broken. Hardware is loose or missing. Camera head may be in danger of falling.

7 STEEL STRAIN POLE

7.1 Definitions

Steel strain poles are span wire structures supporting signals, lighting, cameras, or other appurtenances. They may be constructed in a box span, diagonal span, or other type of configuration. The poles may be round or multi-sided and are supported on a drilled shaft concrete foundation. Steel strain poles are distinguished from embedded steel poles by use of anchor bolts to transfer load from the pole to the concrete foundation.

7.1.1 INVENTORY ITEMS

The inspector shall identify the foundation and pole type. All strain poles should be constructed of steel but may be round or multi-sided. The steel strain poles are typically galvanized but are sometimes painted over the galvanizing. All steel strain poles should be constructed on a concrete drilled shaft foundation with an elevated base plate connected to the concrete foundation with four or six anchor bolts (some in service strain poles may have four anchor bolts while the current MDOT standards specify the use of six anchor bolts). Identify whether the pole is part of a configuration of poles and span wires such as a box span, if it is a single span between two poles, or if it is a single stand-alone pole. When a span wire is present, half of the span wire and whatever is attached to that half is assigned to each pole. The pole may support a variety of attachments, both directly and indirectly, including span wires, luminaires and luminaire arms, signs, signals, cameras, and other ITS infrastructure. The quantity and type of these attachments and their connections to the structure should be noted. The types of connections may include bands, clamps, or brackets. Non-structural attachments such as signs, signals, and cameras receive ratings under Miscellaneous Arm, Bracket, and Attachment, and should be reported appropriately if they pose a safety risk. The connections of these attachments to the structure are to be rated.

The inspector shall note the presence of any non-typical attachments that may not have been approved or been part of the original purpose or function of the pole and confirm any pre-populated inventory data while recording information that is not already documented. It may not be possible to record or verify all measurements exactly due to access limitations; estimate and use experience and best judgement to record data to the most accurate extent possible.

Take photos of the required inventory items listed in Section 7.2.2. A complete list of inventory items is provided in the Ancillary Structures Data Dictionary.

7.1.2 ELEMENTS

Steel strain poles are divided into three components: Foundation, Vertical Structure, and Horizontal Structure.

Foundation is further divided into elements: Concrete Foundation and Anchor Bolts and Leveling Nuts.

Vertical Structure is further divided into elements: Base Plate, Vertical Support Column (Upright), and Vertical Structure Connections.

Horizontal Structure is further divided into elements: Span Wire, Span Wire Attachment Connections, Luminaire and Luminaire Arm, and Miscellaneous Arm, Bracket, and Attachment.

Elements are assigned a condition state described in Section 7.7 based on the distresses identified in each element.

The following guidelines for consistent location notation provide the framework for rating a strain pole element in accordance with the condition rating tables:

- **Vertical Structure Locations** – Distress locations along the vertical support are referenced by using offsets measured from the base plate as measured in feet and prominent features (e.g., span wire connection).
- **Horizontal Element Locations** – Distress locations along the span wire, luminaire arm, or miscellaneous arm or bracket length are referenced by using offsets measured from the vertical support end. For span wires, half of the total span wire length is assigned to each vertical support, along with any attachments along that length.
- **Attachments on Span Wires or Arm Members** – Attachments are identified in relationship to directionality (e.g., North/South, East/West, Right End/Left End looking at front of signal or 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. Annotate drawings and photos, as necessary.

Table 7-1: Steel Strain Pole Components and Elements

Component	Element	Element Code	Unit of Measure
Foundation	Concrete Foundation	17101	Each
Foundation	Anchor Bolts and Leveling Nuts	17102	Each bolt and nut unit
Vertical Structure	Base Plate	17201	Each
Vertical Structure	Vertical Support Column (Upright)	17202	Length, feet
Vertical Structure	Vertical Structure Connections	17203	Each
Horizontal Structure	Span Wire	17301	Each
Horizontal Structure	Span Wire Attachment Connections	17302	Each
Horizontal Structure	Luminaire and Luminaire Arm	17303	Each
Horizontal Structure	Miscellaneous Arm, Bracket, and Attachment	17304	Each

7.1.3 COMPONENTS

Steel strain poles are divided into three main components: Foundation, Vertical Structure, and Horizontal Structure.

Component ratings for steel strain poles are based on the following:

- ***Foundation*** – Consider the structure's foundation effect on overall stability of the steel strain pole structure. Include concrete condition, soil erosion, and anchor bolt/nuts condition and tightness.
- ***Vertical Structure*** – Consider if the vertical structure may have damage that compromises the structural capacity such as fractures, significant twisting or kinking, impact damage, corrosion, section loss, cracked welds, or stress cracks in the metal.
- ***Horizontal Structure*** – Consider fractures in welds or base metal, corrosion, section loss, vertical clearance, or advanced deterioration as critical to the overall horizontal structure.

A representation of the rating structure for steel strain poles is provided in Figure 7-1. A graphic indicating components and elements is in Figure 7-2.

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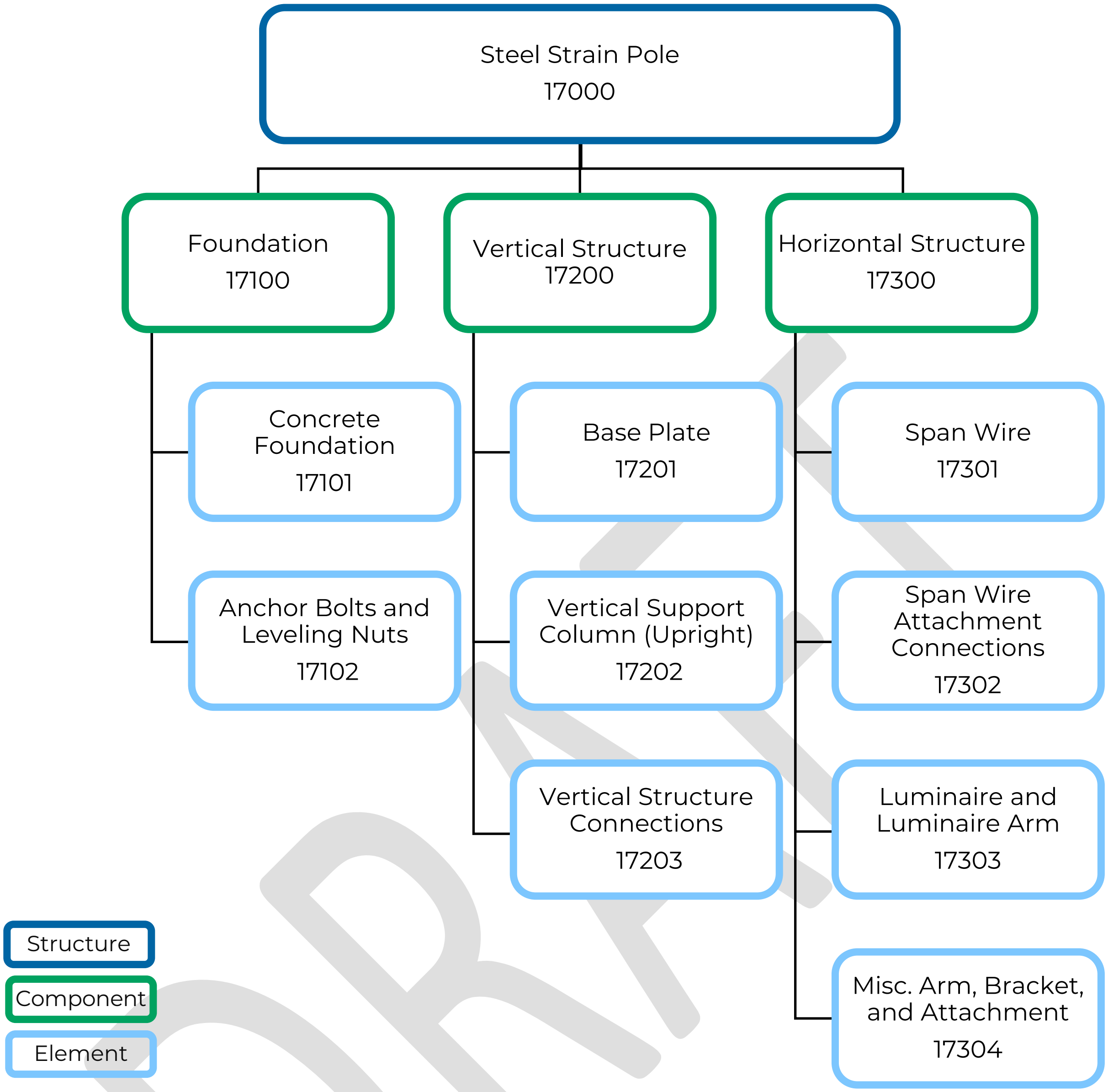

Figure 7-1: Rating structure for Steel Strain Poles

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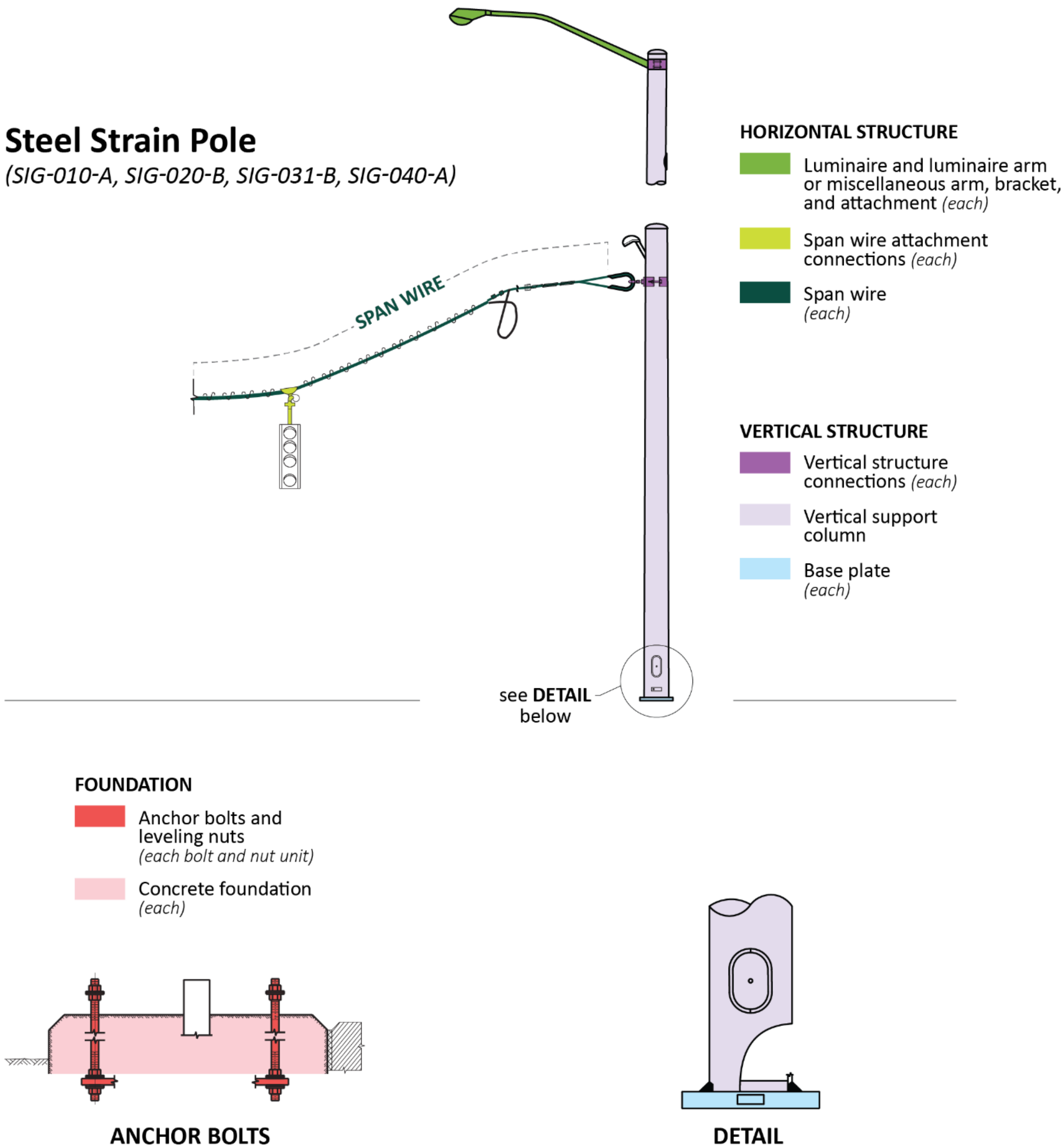

Figure 7-2: Elements and components for Steel Strain Pole (adapted from MDOT Standards SIG-010A, SIG-020-B, SIG-031-B, SIG-040-A)

7.2 Inventory Record Photographs

Inventory photos are captured during a routine inspection, saved as part of the inventory database, and follow the naming convention in *Table 7-2*.

Steel Strain Pole Required Photos:

- General view of the entire pole
- Each foundation (if applicable)

- General view of guy wires (if applicable)
- Structure number stenciled on support
- Manufacturer plate (if applicable)

Table 7-2: Steel Strain Pole Photograph Naming Convention

Photo Name	Description
SSPole_Entire	Entire steel strain pole
SSPole_Foundation	Foundation
SSPole_VH#*_Connection	Vertical to horizontal connection
SSPole_Lum	Luminaire and luminaire arm
SSPole_ID	Old ID and new structure number
SSPole_Attachment Name	Replace “Attachment Name” with attachment or appurtenance (e.g., sensor, camera, etc.)

***The # in photo naming convention should reflect the sequential number ranging from 1-x. One image is acceptable 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, multiple photos are necessary to provide required level of visibility.**

7.3 Inspector Minimum Technical Qualifications

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

- A minimum experience of two projects with a minimum of 10 structures total inspecting pole structures. Bolt inspection experience on cantilever or truss structures, or other ancillary structure type. Multiple structure types shall have been inspected as part of the total project experience.
- Ancillary structures inspection procedures training.
- Working knowledge of inspection tools, their use, application, and limitations for the structure type being inspected.
- Experience with anticipated material types such as concrete or steel. Internal training will address inspection procedures for all anticipated material types.
- Ultrasound qualification – Current training in straight beam ultrasonic testing.
- 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.
- If a follow up UT inspection is needed for the weld, ASNT Level II (ASNT or per ASNT TC-1A guidelines) is required.

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7.4 Routine Inspection

Steel strain poles are used to support signs, signals, and other appurtenances, most commonly on non-freeway routes. Damage or deterioration of steel strain pole structures may impact function or safety.

In many cases, steel strain poles are installed at intersections, where they comprise a cable box span or other geometric configuration. They are supported on drilled shaft foundations and connected to the foundations with either four or six anchor bolts.

Steel strain pole standard inspection frequency is once every 4 years, unless otherwise identified for more frequent inspection.

Figure 7-3: Steel strain poles with box span configuration

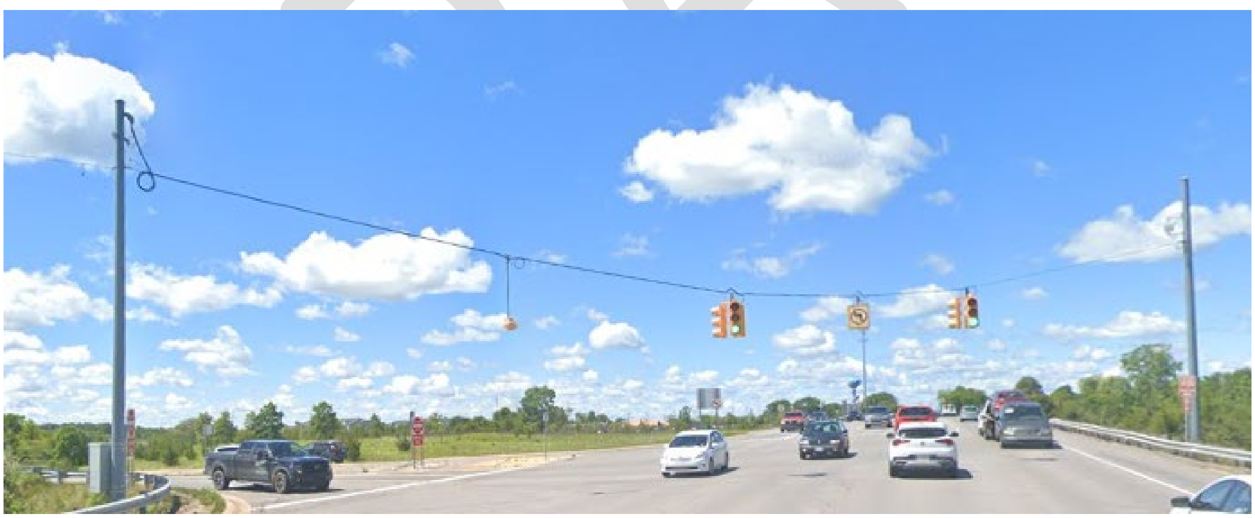

Figure 7-4: Steel strain poles with single diagonal span configuration

Figure 7-5: Steel strain pole with suspended/hanging box span configuration (suspension circled)

Figure 7-6: Steel strain pole (multi-sided) structure with four anchor bolts (left) and six anchor bolts (right)

Table 7-3 provides guidance for inspecting reinforced and prestressed concrete cracking.

Table 7-3: 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)

7.4.1 FOUNDATION ROUTINE INSPECTION

Inspect the general site conditions and assess the global stability of the structure.

- Check around the foundation for erosion or soil displacement, and for any voids between concrete and soil.
- If sidewalk or other material covers the material surrounding the foundation check for signs of separation, settlement, or cracking at the surface.
- Check for signs of vehicle impact that may have damaged the foundation concrete or the anchor bolts.
- Inspect the foundation concrete for cracking, spalling, delamination, or other defects measuring sizes or quantities. Pay particular attention to the condition of the concrete immediately around the anchor bolts.
- Inspect the anchor bolt connections to the base plate. Measure the anchor bolt standoff distance and check for any damage or corrosion of the bolts and nuts.
- Note if any of the anchor bolts are out of vertical alignment and if any of the nuts have anything less than full bearing.
- Sound the anchor bolts and nuts to check for looseness. Note if any washers are missing, incorrectly sized, or if the lock washers are not fully compressed.
- Provide photographs for all Poor or Severe condition state defects and submit the applicable Work Rec or RFA.

7.4.1.1 Foundation Component Ratings

The steel strain pole’s foundation overall characteristics are rated on its structural condition, ability to support the vertical structure, and possible negative impact to the entire structure, its operation, or the adjacent roadway. The foundation concrete, anchor bolts, and anchor bolt connection to the pole base plate are all considered as part of the component rating. When evaluating distresses consider that different distresses and the location on the foundation at which they occur are not of equal importance to the pole’s

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function. The predominant characteristic determining overall condition is stability. Consider if the foundation has stable support from the soil, solid and durable concrete, and securely fastened anchor bolt connections.

Table 7-4: Component Rating Guidelines for Steel Strain Pole Foundation

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	Minor damage or worn galvanizing of anchor bolt connections.
		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.
		Steel	Less than 25% loss of section. Fasteners may be considerably deteriorated.

Component Rating	Condition	Material	Description
3	SERIOUS	All	Considerable deterioration or misalignment affecting structural members. Considerable impact damage. 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, cracked, or broken fasteners.
		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.

7.4.1.2 Concrete Foundation Element Condition States

Start by inspecting the condition of the soil around the foundation noting any erosion or settlement that could impact the foundation. A gap between the foundation and adjacent soil may indicate foundation movement. Inspect the concrete for cracking, spalling, and delamination noting the quantities and locations. Check for exposed or corroded reinforcing steel. Pay special attention to the concrete immediately surrounding the anchor bolts. Older foundations may be square in shape while current standards specify a circular drilled shaft. Look for signs of impact damage.

Figure 7-7: Steel strain pole square foundation with four anchor bolts (left, note misalignment), newer style drilled shaft foundation with six anchor bolts (right)

Table 7-5: Steel Strain Pole Concrete Foundation Element Distresses

Element Number	Element	Description	Associated Distresses
17101	Concrete Foundation	Steel strain pole foundations	Cracking
			Spalling, delamination, and patching
			Exposed rebar
			Embedment erosion
			Impact damage
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.			

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Details on the condition state rating schema are in Section 7.7, linked below:

[Steel Strain Pole Condition State Tables]

7.4.1.3 Anchor Bolts and Leveling Nuts Element Condition States

The anchor bolt connection is a key element of the steel strain pole structure and frequent location of deficiencies. The anchor bolts should be plumb with all nuts tightly affixed to the base plate and the center of the connection should be centered on the foundation. The standoff distance – the distance from the top of the concrete foundation to the bottom of the leveling nut should not exceed one inch for each anchor bolt.

There are two types of anchor bolts used with steel strain poles – pretensioned and non-pretensioned. For pretensioned anchor bolts, flat washers should be placed between each nut and the base plate and completely cover the holes in the base plate. All washers and nuts should bear fully on the base plate around their perimeter. These anchor bolts are pretensioned using the turn of the nut method and ultrasonic testing and sounding of the anchor bolts is required.

For non-pretensioned anchor bolts, flat washers should be placed between each nut and the base plate, with an additional lock washer placed between the top nut and the flat washer. The flat washers and nuts should bear fully around their perimeter and the flat washers should completely cover the holes in the base plate. The lock washers should be fully compressed, which means there is no gap anywhere between the top nut and lock washer. Because these anchor bolts are not pre-tensioned, the lock washers prevent the nuts from relaxing. Ultrasonic testing and sounding of the anchor bolts are not required when lock washers are present. The top nuts shall be fully engaged on the anchor rod, which means the top of the anchor rod is flush or higher than the top of the nut. Inspect the connection for any signs of impact damage, including bent anchor bolts or damaged threads. Inspect the galvanizing of all components and note corrosion. Nut covers may be present covering the top nuts of the connection. These were used to protect the connection but are a detriment as they retain moisture and debris and can accelerate corrosion; they are no longer permitted.

Figure 7-8: Excess anchor bolt standoff distance (left), fully compressed lock washer (right)

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Figure 7-9: Anchor bolt negative projection – the top of the anchor bolt is not flush or higher than the top of the nut

Figure 7-10: Steel strain pole foundation with excess standoff distance and nut covers

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Table 7-6: Steel Strain Pole Anchor Bolt and Leveling Nuts Element Distresses

Element Number	Element	Description	Associated Distresses
17102	Anchor Bolts and Leveling Nuts	Anchor bolts and leveling nuts	Corrosion or coating damage
			Loose or missing anchor nut
			Cracked bolt
			Standoff distance
			Impact damage
Unit of Measure: Each, note quantity of anchor bolt and nut units within each condition state			

Details on the condition state rating schema are in Section 7.7, linked below:

Steel Strain Pole Condition State Tables

7.4.2 VERTICAL STRUCTURE ROUTINE INSPECTION

Routine inspection of the vertical structure is conducted from the ground. Binoculars should be used as a visual aid for inspecting the top of the pole and connections.

- Inspect the general site conditions and assess the global stability of the structure and its operational function.
- Inspect the vertical alignment of the pole with a 4 ft level or similar. Note that some poles 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, powder-coated, and/or paint and note any corrosion or section loss.
- 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.
- Check for any cracks or deformations in the steel noting the size of deficiencies.
- Check for signs of impact damage noting that impact in one location may affect the structure in other locations as well.
- Inspect any secondary support of the pole such as guy wires, guy struts, etc. Check for any corrosion and section loss, looseness or deterioration of connections, and anchorage condition.
- Inspect the connection to the pole of the horizontal structure – span wires and arms. This includes band clamps, brackets, and other bolted assemblies. Check for connections that are loose, missing, deteriorated or otherwise deficient.
- Check the welds for signs of cracking.
- Check for pole dents and buckling (refer to pole dents & buckling calculations).
- Provide photographs for all Poor or Severe condition state defects and submit the applicable Work Recs or RFAs.

7.4.2.1 Vertical Structure Component Ratings

The steel strain pole's vertical structure overall characteristics are rated on its structural condition, ability to support the horizontal structure, and possible negative impact to the entire structure, its operation, or the adjacent roadway. The base plate and base plate to pole connection, pole structure, and connections to the pole are all considered as part of the component rating. When evaluating distresses consider that different distresses and the location on the structure at which they occur are not of equal importance to the pole's function. The predominant characteristics determining overall condition are stability and resiliency. Consider if the pole has stable support in the embedment material, a robust and consistent pole cross-section, and the horizontal structure is securely fastened.

Table 7-7: Component Rating Guidelines for Steel Strain Pole Vertical Structure

Component Rating	Condition	Material	Description
9	**NEW**	All	No deficiencies in any of the structural components that will affect long term performance.

Component Rating	Condition	Material	Description
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.
		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.
3	SERIOUS	Concrete	Extensive cracking and spalling.
		Soil	Extensive displacement or erosion of soil. Large gaps may be present between pole and embedment material.

Component Rating	Condition	Material	Description
		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.

7.4.2.2 Base Plate Element Condition States

The base plate is part of the anchor bolt connection but is connected to the pole with a full penetration weld and considered part of the vertical structure along with the pole and its vertical structure connections. The base plate should be checked for warping that may have occurred during fabrication or construction, and corrosion. Pay particular attention to the weld between the base plate and pole and look for any cracks or weld deficiencies. A crack will typically appear in the galvanizing and may or may not extend into the weld metal. Additional non-destructive testing may be required to determine the extent of any cracks.

Figure 7-11: Steel strain pole base plate with six anchor bolts

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Table 7-8: Steel Strain Pole Base Plate Element Distresses

Element Number	Element	Description	Associated Distresses
17201	Base Plate	Base plate for strain pole	Corrosion or coating damage
			Weld defect or crack
Unit of Measure: Each, percentage of base plate within each condition state			

Details on the condition state rating schema are in Section 7.7, linked below:

Steel Strain Pole Condition State Tables

7.4.2.3 Vertical Support Column (Upright) Element Condition States

Steel strain poles are typically 30-40 ft in length and may be round or multi-sided. The poles should be checked for any vertical misalignment with a 4 ft level or similar, keeping in mind that steel strain poles may be tapered and multiple checks around the perimeter of the pole may be necessary. A hand hole is located near the base of the pole to allow for access to electrical components and there are typically additional electrical entry and exit ports higher on the pole. The handhole should be free from excess moisture and debris. The handhole cover should be securely fastened, and the hand hole frame inspected for any cracks in the welds or base metal, along with any other welded components. The poles are hot dip galvanized and may have a single or multi-coat paint system on top of the galvanizing for aesthetic treatment. Any corrosion should be noted and if there is significant corrosion, the pole wall thickness should be checked for section loss with a thickness gauge or ultrasonic testing device. Inspect the length of the pole for impact damage and cracks and note that multi-sided poles have a longitudinal weld the length of the pole.

Newly installed strain poles have fabrication tolerances for deviation from vertical, sweep, camber, and twist; initial installation inspection should take these tolerances into account for out of plumb condition state distresses.

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Figure 7-12: Impact damage and missing hand hole cover (left) and graffiti/coatings repair (right)

Table 7-9: Steel Strain Pole Vertical Support Column (Upright) Element Distresses

Element Number	Element	Description	Associated Distresses
17202	Vertical Support Column (Upright)	Vertical Support (Upright) for strain pole	Corrosion or coating damage
			Weld defect or crack
			Out of plumb
			Impact damage
			Handhole defects
Unit of Measure: Length, feet of vertical support within each condition state			

Details on the condition state rating schema are in Section 7.7, linked below:

Steel Strain Pole Condition State Tables

7.4.2.4 Vertical Structure Connections Element Condition States

For the vertical structure connections, element consider all connections to the pole structure. There are several different types of connections that may be present. In general, any steel portions of a connection should be securely in place, and free of corrosion, excess wear, missing pieces, cracks, or other deterioration. For attachments like cabinets and sensors the steel straps connecting the attachments are rated, and if they are failing or in some way pose a safety risk they should be noted.

Span wires are usually connected to the pole with band clamps. The two halves of the clamps are tightened against the pole with bolting assemblies on either side. Consider the typical steel deterioration modes and inspect the band clamps for any distortion or cracking which may precede a failure. Luminaire arms or other arms (for cameras or other sensors) used to connect attachments to the pole may use bracket assemblies or other types of steel connections. Consider the typical steel and fastener deterioration modes for these connections.

Figure 7-13: Steel strain pole band clamp connections for span wires

Figure 7-14: Steel strain pole bracket assembly connections for luminaire arms

Table 7-10: Steel Strain Pole Vertical Structure Connections Element Distresses

Element Number	Element	Description	Associated Distresses
17203	Vertical Structure Connection	Bracket assemblies, pole band clamps, stainless steel straps, or other connections to strain poles	Weld defects or cracks Corrosion or coating damage Loose, missing, or failing hardware
Unit of Measure: Each connection quantity within the condition state			

Details on the condition state rating schema are in Section 7.7, linked below:

Steel Strain Pole Condition State Tables

7.4.3 HORIZONTAL STRUCTURE ROUTINE INSPECTION

Routine inspection of the horizontal structure is conducted from the ground. Binoculars should be used as a visual aid.

- Inspect the vertical clearance of the horizontal structure and its attachments, the alignment, and the operational function.
- Check span wires for signs of fraying or broken strands.
- Check for corrosion or section loss on the horizontal structure.
- Inspect luminaires and luminaire arms or other miscellaneous arms or brackets for any cracked welds, or other deterioration.
- Check signals and other miscellaneous 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.

7.4.3.1 Horizontal Structure Component Ratings

The steel strain pole's horizontal structure overall characteristics are rated on its structural condition, ability to support the connected attachments, and possible negative impact to the structure's operation and the roadway below. The span wire, arms, and the attachment connections to them are all considered as part of the component rating. When evaluating distresses consider that different distresses and the location on the structure at which they occur are not of equal importance to the horizontal structure's function. The predominant characteristic determining overall condition is resiliency. Consider if the span wire and arms have a robust and consistent cross-section, and the attachments are securely connected.

Table 7-11: Component Rating Guidelines for Steel Strain Pole 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.
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. Span wire may have minor fraying 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 sagging of the span wire.

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Component Rating	Condition	Material	Description
		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.

7.4.3.2 Span Wire Element Condition States

For the span wire element condition consider the connection of the span wire to the pole connection – which includes the span wire, thimble, dead end, or any other portion leading to the pole band clamp. Consider wear, deterioration and portions that may be loose, distorted, or otherwise exhibiting distress. For the length of the span wire, half of each wire is assigned to each supporting pole. The wire should be inspected for corrosion, fraying, or any broken wires. Any attachment connected to the span wire should have a minimum vertical clearance to the top of pavement of 17 ft. While this may not be able to be measured, note report any vertical clearance that looks out of the ordinary.

Figure 7-15: Steel strain pole span wire supporting signals and sign

Figure 7-16: Span wire assemblies attached to steel strain pole band clamps

Table 7-12: Steel Strain Pole Span Wire Element Distresses

Element Number	Element	Description	Associated Distresses
17301	Span Wire	Span wires, thimbles, preformed dead ends	Insufficient under clearance
			Corrosion or section loss, frayed wires
			Worn or deteriorated dead ends
Unit of Measure: Each member which apply to each condition state			

Details on the condition state rating schema are in Section 7.7, linked below:

[Steel Strain Pole Condition State Tables]

7.4.3.3 Span Wire Attachment Connections Element Condition States

Attachments connected to the span wire include signals and case signs. Typically, the signals and signs are connected using span wire hangers and suspension clamps. Consider the typical steel and fastener deterioration modes for these connections: loose connections, wear, corrosion, cracking, and deformation. The signals and signs themselves are not rated but if there is noticeable deterioration that could impact safety it should be reported.

Figure 7-17: Span wire supporting signals and sign (left), span wires supporting signs (right)

Figure 7-18: Span wire hanger

Table 7-13: Steel Strain Pole Span Wire Attachment Connections Element Distresses

Element Number	Element	Description	Associated Distresses
17302	Span Wire Attachment Connections	Span wire hangers, lashing rods, armor rods, suspension clamps	Corrosion or section loss
			Loose, missing, or cracked hardware
			Deformed or worn parts
Unit of Measure: Each connection quantity within the condition state			

Details on the condition state rating schema are in Section 7.7, linked below:

Steel Strain Pole Condition State Tables

7.4.3.4 Luminaire and Luminaire Arm Element Condition States

Luminaires are usually mounted on a luminaire arm but may also be mounted directly on the pole, on a tenon, or using some other pole mounting device. The arms may be a single member type or truss type. Note that the bracket assembly or other method of attaching the luminaire arm to the pole is considered part of the vertical structure connections element. The arms should be inspected for steel condition and the condition of any welds. The condition of the luminaire connection to the arm or tenon should be inspected for material defects and connection type defects such as looseness and wear. The luminaire itself includes the light source, any fixtures or assemblies, and the housing. Note any visibly broken portions of the luminaire.

Figure 7-19: Luminaire and luminaire truss arm

Table 7-14: Luminaire and Luminaire Arm Element Distresses

Element Number	Element	Description	Associated Distresses
17303	Luminaire and Luminaire Arm	Lighting sources, fixtures and assemblies, bracket arms, truss arms, tenon mounts, shepherds crooks, or other pole mounting devices	Broken lighting source or assembly
			Damaged or cracked housing, cover
			Corrosion or section loss
			Weld cracks/defects
			Deteriorated gasket/seal
Unit of Measure: Each luminaire and luminaire arm within the condition state			

Details on the condition state rating schema are in Section 7.7, linked below:

Steel Strain Pole Condition State Tables

7.4.3.5 Miscellaneous Arm, Bracket, and Attachment Element Condition States

Attachments or appurtenances may be mounted on a bracket or arm but may also be mounted directly on the pole, on a tenon, or using some other pole mounting device. The arms may be a single member type or truss type. Note that the bracket assembly or other method of attaching the miscellaneous bracket or arm to the pole is considered part of the vertical structure connections element. The miscellaneous arms, brackets, and attachments should be inspected for steel condition and the condition of any welds. The condition of the attachment connection to the bracket, arm, or tenon should be inspected for material defects and connection type defects such as looseness and wear. Cameras and other sensors may also be attached to the pole using the same types of arms and connections as luminaires.

Figure 7-20: Cameras mounted on luminaire truss arms

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Table 7-15: Steel Strain Pole Miscellaneous Arm, Bracket, and Attachment Element Distresses

Element Number	Element	Description	Associated Distresses
17304	Miscellaneous Arm, Bracket, and Attachment	Power sources, fixtures and assemblies, bracket arms, truss arms, tenon mounts, shepherds crooks, or other pole mounting devices	Broken power source or assembly
			Damaged or cracked housing, cover
			Corrosion or section loss
			Weld cracks/defects
			Deteriorated gasket/seal
Unit of Measure: Each miscellaneous arm, bracket, and attachment within the condition state			

Details on the condition state rating schema are in Section 7.7, linked below:

Steel Strain Pole Condition State Tables

7.4.4 REFERENCES

MDOT Traffic and Safety Standards and Special Details

SIG-010-series All Span Wire T.S. on Steel and Wood Poles

SIG-020-series 6 Anchor Bolt Strain Pole and Foundation

FUSP-820A Tolerances for alignment, sweep, camber, and twist

Pole Dent & Buckling Calculations

7.5 Work Recommendation Guidance

The Work Recs are not meant to be all-inclusive and other Work Recs may be added to supplement those noted.

Inspectors should create Work Recs to address span wires with less than 17 ft clearance. Half of the span of the wire is attributed to each pole. Inspectors should rate the Span Wire element as severe for both poles but generate a single Work Rec to correct the wire tension. Inspectors should assign it to one of the poles and note the Work Rec in the other pole's inspection.

Photographs should include sufficient information to determine the relationship of the defect to the element or component or entire structure. Close-up photos of each defect with deficiencies marked on the photo should be provided.

Table 7-16: Work Recommendations for Steel Strain Pole

Number	Description of Work Recommendation	Material Involved	Quantity/Unit of Measure
1	Repair guardrail (protecting pole)	Galvanized Steel	Linear feet
2	Correct erosion at foundation (prevent undermining)	Stone/Soil	Cubic feet
3	Repair/monitor foundation	Concrete	Cubic feet
4	Repair/replace handhole cover	Galvanized Steel	Each cover
5	Remove non-MDOT or unauthorized attachments to structures	Various	Each item
6	Remove graffiti	n/a	Square foot
7	Repair galvanizing	Galvanic Paint	Square inch
8	Repair protective coatings system	Metal Coatings System	Square foot
9	Tighten leveling nut	Galvanized Steel	Each nut
10	Address loose bolts	Galvanized Steel	Each bolt
11	Weld repair	Steel	Each weld
12	Replace pole band clamps	Galvanized Steel	Each clamp
13	Tension span wire	Steel Strand	Each
14	Replace span wire	Steel Strand	Linear feet
15	Replace span wire hanger	Galvanized Steel	Each
16	Replace pole cap	Galvanized Steel	Each cap
17	Replace pole cap bolt	Galvanized Steel	Each bolt
18	Replace preformed dead-end	Preformed Dead-end	Each preformed dead-end
19	Replace connectors	Galvanized Steel	Each connector
20	Replace service cap, PVC	PVC	Each cap
21	Replace service cap, metal	Galvanized Steel	Each cap

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Number	Description of Work Recommendation	Material Involved	Quantity/Unit of Measure
22	Replace luminaire	Various	Each luminaire
23	Replace luminaire arm	Galvanized Steel	Each arm
24	Replace luminaire arm clamp	Galvanized Steel	Each clamp
25	Replace bracket assembly	Galvanized Steel	Each assembly
26	Replace signal head	Various	Each signal head
27	Replace case sign	Various	Each sign
28	Replace misc. attachment	Various	Each attachment
29	Replace miscellaneous arm or bracket	Various	Each arm or bracket

7.6 Request for Action Guidance

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 lateral displacement or pole out of plumb/rotated

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

d. Standoff distance more than twice the bolt diameter, where bending of anchor bolts is evident

e. Major cracks present in the base metal or weld(s)

f. Major section loss due to corrosion which impacts the capacity or short-term resiliency of the structure

g. Multiple loose or missing bolts in a high strength bolted connection, anchor bolt connection, or in attachment connection assemblies

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

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

j. Cracked or failing tenon/bracket assembly/luminaire or miscellaneous attachment mounting device

k. Band clamps with major cracks or bolts failures which impact the traffic lighting cable attachment

l. Major span wire corrosion and section loss, including fractured individual wires of the span wire strand

m. 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 soil erosion or undermining of the foundation

c. Pole is significantly out of vertical alignment

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

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

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

g. Loose bolts in a high strength bolted connection, anchor bolt connection, or in attachment connection assemblies where there is acceptable load-path redundancy, but moderate impact to capacity or durability

h. Significantly loose or misaligned tenon/bracket assembly/luminaire or miscellaneous attachment mounting device

i. Band clamps with significant cracks or loose bolts which impact the traffic lighting cable attachment

j. 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

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

l. Significant corrosion of primary elements or connections is present

m. Significant span wire corrosion and section loss

n. Significant structural damage to foundation, anchor bolts, upright, or other elements, which moderately impacts capacity or function, clearance, safety, or durability of the structure

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

c. Pole is moderately out of vertical alignment

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

e. Standoff distance more than one inch but less than twice the bolt diameter with no bending of anchor bolts

f. Moderate corrosion of primary elements or connections is present

g. Loose connections where there is adequate redundancy and moderate impact to structural capacity or durability

h. Moderate weld deficiencies, which do not meet code but do not impact function where significant redundancy is also present

i. Misaligned tenon/bracket assembly/luminaire mounting device

j. Surface corrosion on span wire

k. Moderate structural damage to foundation, anchor bolts, upright, or other elements, which moderately impacts capacity or function, clearance, safety, or durability of the structure

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7.7 Element Condition States

Element Number	Element	Condition States Defects Note	Link to Discussion in Section 7
17101	Concrete Foundation	Use the appropriate condition state table.	Concrete Foundation Element Condition States
17102	Anchor Bolts and Leveling Nuts	Use the appropriate condition state table. Use UT testing result to assist in the condition assessment.	Anchor Bolts and Leveling Nuts Element Condition States
17201	Base Plate	Use the appropriate condition state table.	Base Plate Element Condition States
17202	Vertical Support Column	Use the appropriate condition state table.	Vertical Support Column (Upright) Element Condition States
17203	Vertical Structure Connections	Use the appropriate condition state table.	Vertical Structure Connections Element Condition States
17301	Span Wire	Use the appropriate condition state table.	Span Wire Element Condition States
17302	Span Wire Attachment Connections	Use the appropriate condition state table.	Span Wire Attachment Connections Element Condition States
17303	Luminaire and Luminaire Arm Connections	Use the appropriate condition state table.	Luminaire and Luminaire Arm Connections Element Condition States
17304	Miscellaneous Arm, Bracket, and Attachment	Use the appropriate condition state table.	Miscellaneous Arm, Bracket, and Attachment Element Condition States

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Element 17101 – Concrete Foundation

Description	This element defines a concrete foundation for a steel strain pole, 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	The concrete shows no deterioration. Superficial cracking, discoloration, or efflorescence or damage may be present. No exposed reinforcing.	Minor cracks and/or spalls may be present in the concrete. No exposed reinforcing or embedment erosion.	Moderate cracks and/or spalls may be present. Some reinforcing may be exposed. Incidental loss of section or surface pitting of reinforcing may be present. Element may show evidence of some impact damage or embedment erosion.	Major cracks and/or spalls are present. Major corrosion of exposed reinforcing. Extensive steel and/or concrete loss, impact damage or embedment erosion is present.

Element 17102 – 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	There is no deterioration or damage. The elements are fully engaged. Anchor bolt standoff distance is less than 1".	Minor damage or corrosion of the elements may be present. The elements are fully engaged and functioning as intended. Anchor bolt standoff distance is less than 1".	Moderate damage or corrosion/section loss of the elements may be present. Anchor nuts may not be fully tightened. Anchor bolt standoff distance is greater than 1" but less than two times the bolt diameter.	Major impact damage may be present. Major corrosion/section loss of the elements may be present. Multiple nuts are loose/missing. Anchor bolt standoff distance is greater than two times the bolt diameter. UT testing indicates cracks or breaks in bolts.

Element 17201 – 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 or weld defect. Surface coating is sound.	Minor surface corrosion or superficial damage may be present. Base element welds have no evidence of defects.	Moderate corrosion/ 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.	Major corrosion/section loss is present. Base element welds may have cracks/defects. Base plate has moderate to major warping.

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Element 17202 – Vertical Support Column (Upright)

Description	This element is defined by all upright supporting a steel strain pole, 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.	Moderate corrosion/ section loss may be present. Protective coatings are failing. Element welds have no evidence of defects and/or cracking. Support may be out moderately 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.

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Element 17203 – Vertical Structure Connections

Description	This element consists of the connections along the steel strain pole for various attachments. Connections may include bracket assemblies, pole band clamps, stainless steel straps, through bolts, or other connections to poles.			
Quantity Calculation	The quantity to be collected includes each connection location.			
	Condition State Descriptions			
Defect Type	**Good**	**Fair**	**Poor**	**Severe**
Vertical Structure Connection Defects	Pole band clamps, bracket assemblies, and other connection hardware are functioning as intended with no evidence of wear or corrosion.	Minor surface corrosion, wear, or superficial damage may be present. Pole band clamps, bracket assemblies, and other connection hardware are functioning as intended.	Moderate corrosion/ section loss or wear is present. U-bolts, band clamps, or lag bolts may be loose, but the conditions do not significantly affect serviceability and/or function.	Major corrosion/section loss is present. Protective coatings are significantly failing. Members may have cracks/defects or major wear. U-bolts, band clamps, or lag bolts are loose or missing. Element is not functioning as intended.

Element 17301 – Span Wire

Description	This element defines the span wires, thimbles, preformed dead ends which extend to terminate at another vertical structure.			
Quantity Calculation	The quantity is measured in length in each span wire."			
	Condition State Descriptions			
Defect Type	**Good**	**Fair**	**Poor**	**Severe**
Span Wire Defects	Span wire, preformed dead end, and thimble have no evidence of corrosion or wear and minimum clearance is 17 ft from roadway to bottom of any signal/sign.	Minor surface corrosion or wear may be present. Minimum clearance is 17 ft from roadway to bottom of any signal/sign.	Moderate corrosion/section loss or wear is present. Minimum clearance is 17 ft from roadway to bottom of any signal/sign.	Minimum clearance is less than 17 ft from roadway to bottom of any signal/sign. Major corrosion/pitting/ section loss is present. Protective coatings are significantly failing. Members may have cracks/defects or major wear.

Element 17302 – Span Wire Attachment Connections

Description	This element is defined by the span wire hangers, lashing rods, armor rods, suspension clamps.			
Quantity Calculation	The quantity to be collected is the number of connections for span wires.			
	Condition State Descriptions			
Defect Type	**Good**	**Fair**	**Poor**	**Severe**
Span Wire Attachment Connections	Span wire hangers, preformed lashing rods and armor rods, and other connection hardware have no evidence of wear or corrosion.	Minor surface corrosion or wear may be present.	Moderate corrosion/section loss or wear is present.	Major corrosion/pitting/section loss is present. Protective coatings are significantly failing. Members may have cracks/defects or major wear.

Element 17303 – Luminaire and Luminaire Arm

Description	This element consists of lighting sources, fixtures and assemblies, bracket arms, truss arms, tenon mounts, shepherds crooks, or other pole mounting devices			
Quantity Calculation	The quantity is collected as each luminaire and luminaire arm unit.			
	Condition State Descriptions			
Defect Type	**Good**	**Fair**	**Poor**	**Severe**
Luminaire and Luminaire Arm	Lighting source, housing/cover, waterproofing-gasket/seal, and arm or mounting device do not have evident wear or corrosion and are functioning as intended.	Gasket/seal may have minor deterioration. Lighting source, housing/cover, arm, and connections may have minor wear or corrosion.	Gasket/seal may be moderately deteriorated. Lighting source, housing/cover, arm, and connections may have moderate wear or corrosion, but the conditions do not significantly affect serviceability and/or function.	Major deterioration of gasket/seal is present. Lighting assembly or hardware is broken or missing. Major failure of protective coatings or corrosion/pitting/section loss is present. Welds have cracks/defects. Element is not functioning as intended.

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Element 17304 – Miscellaneous Arm, Bracket, and Attachment

Description	This element consists of power sources, fixtures and assemblies, bracket arms, truss arms, tenon mounts, shepherds' crooks, or other pole mounting devices.			
Quantity Calculation	The quantity is collected as each miscellaneous arm, bracket, and attachment unit.			
	Condition State Descriptions			
Defect Type	**Good**	**Fair**	**Poor**	**Severe**
Miscellaneous Arm, Bracket, and Attachment	Power source, housing/cover, waterproofing-gasket/seal, and arm do not have evident wear or corrosion.	Gasket/seal may have minor deterioration. Power source, housing/cover, or arm may have minor wear or corrosion.	Gasket/seal may be moderately deteriorated. Power source, housing/cover, or arm have moderate wear or corrosion, but the conditions do not significantly affect serviceability and/or function.	Major deterioration of gasket/seal is present. Assembly or hardware is broken or missing. Major failure of protective coatings or corrosion/pitting/section loss is present. Welds have cracks/defects.

8 NOISE WALL

8.1 Definitions

A noise wall is constructed of steel, concrete, and other materials to provide traffic noise abatement to property near or adjacent to the road right-of-way.

Exclusions

Noise walls measuring less than 4 feet from grade at the highest point shall not be inspected and inventoried as part of the Program. Noise barriers which are constructed as earthen berms shall not be inventoried or inspected as part of the Program, as they do not fit the definition of a Noise Wall. Jersey barriers, Jersey walls, or other types of barriers under 4 feet in height are not considered noise walls.

Noise wall structures owned by agencies other than MDOT (private, local cities, etc.) that meet the definition of a noise wall are not included in the Program unless included at the determination of the Program Manager.

8.1.1 INVENTORY ITEMS

The inspector shall identify the noise wall facing type. A variety of noise wall types are present in Michigan, including post and panel, brick and masonry, concrete masonry unit (CMU), cantilevered free-standing, and cast-in-place concrete. Other material types may be present such as concrete fiberglass, plastics, or other composites. It is recommended the noise wall be inspected as two separate walls if there is a change in type such as a different wall face type.

The inspector shall confirm the noise wall maximum height as measured from the maximum wall height to the ground elevation or supporting structure such as a bridge. The wall shall be greater than 4 feet at its highest point to be considered a noise wall. The noise wall total height includes the coping, wall facing and a horizontal member, if present.

The inspector shall record the noise wall length to the nearest tenth of a foot, excluding features such as concrete barriers. If the wall curves or bends, the wall should be considered as one wall.

The inspector shall also identify the wall batter (typically vertical for noise walls). Identify the slope in front of the wall. Note if the noise wall is attached to a retaining wall or bridge. Note noise walls which have bench or crash barrier attachments. It is recommended the noise wall be inspected as two separate walls if there is a change in support structure type such as transitioning from foundation supported to retaining wall supported.

Appurtenances and attachments, such as signs or electrical boxes, should be observed and work recommendations or requests for action should be created to address issues, failure, or safety concerns. Appurtenances and attachments are not rated as part of the noise wall.

Take photos of the required inventory items listed in Section 8.2.2. A complete list of inventory items is provided in the Ancillary Structures Data Dictionary.

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8.1.2 ELEMENTS

The Noise Wall is evaluated using six elements: Wall Facing, Vertical Support Column, Horizontal Member, Joints, Foundation, and Bridge or Structure Attachment. All six elements may be considered to compose the Noise Wall Structure component.

As the noise wall facing elements are similar to retaining wall facings elements with the same materials similar condition states and defects should be expected to those noted in Section 3 for retaining walls. Vertical support columns and foundations should all have similar condition states to those noted for retaining walls in Section 3.

Units measured in linear feet includes the length along the top of the exposed height of the noise wall element. The exposed area should be inspected and evaluated for distress and the element quantified under the appropriate noise wall defects. The wall facing quantity is only calculated for a single wall side. Wall facing or wall panel area excludes the horizontal members if present.

Table 8-1: Noise Wall Components and Elements

Component	Element	Element Code	Unit of Measure
Noise Wall Structure	Wall Facing	18101	Area, Square Feet
Noise Wall Structure	Vertical Support Column	18102	Each
Noise Wall Structure	Horizontal Member	18103	Length, feet
Noise Wall Structure	Joints	18104	Each
Noise Wall Structure	Foundation	18105	Each
Noise Wall Structure	Bridge or Structure Attachment	18106	Each
Noise Wall Structure	Wall Cap	18107	Length, feet

8.1.3 COMPONENTS

The noise wall shall be evaluated with a single component rating which describes the overall rating of the structure: Noise Wall Structure. The Noise Wall Structure component rating is based on the following:

- Noise Wall Structure – The wall's overall rating is based on its structural condition, ability to perform its function, and possible negative impact to the roadway or structures on either side or below the wall. The noise wall facing, vertical columns, horizontal members, joints, foundation and/or attachment of the wall to a support structure may all affect the component rating.

A representation of the rating structure for Noise Walls is provided in Figure 8-1. A graphic indicating component and elements is in Figure 8-2.

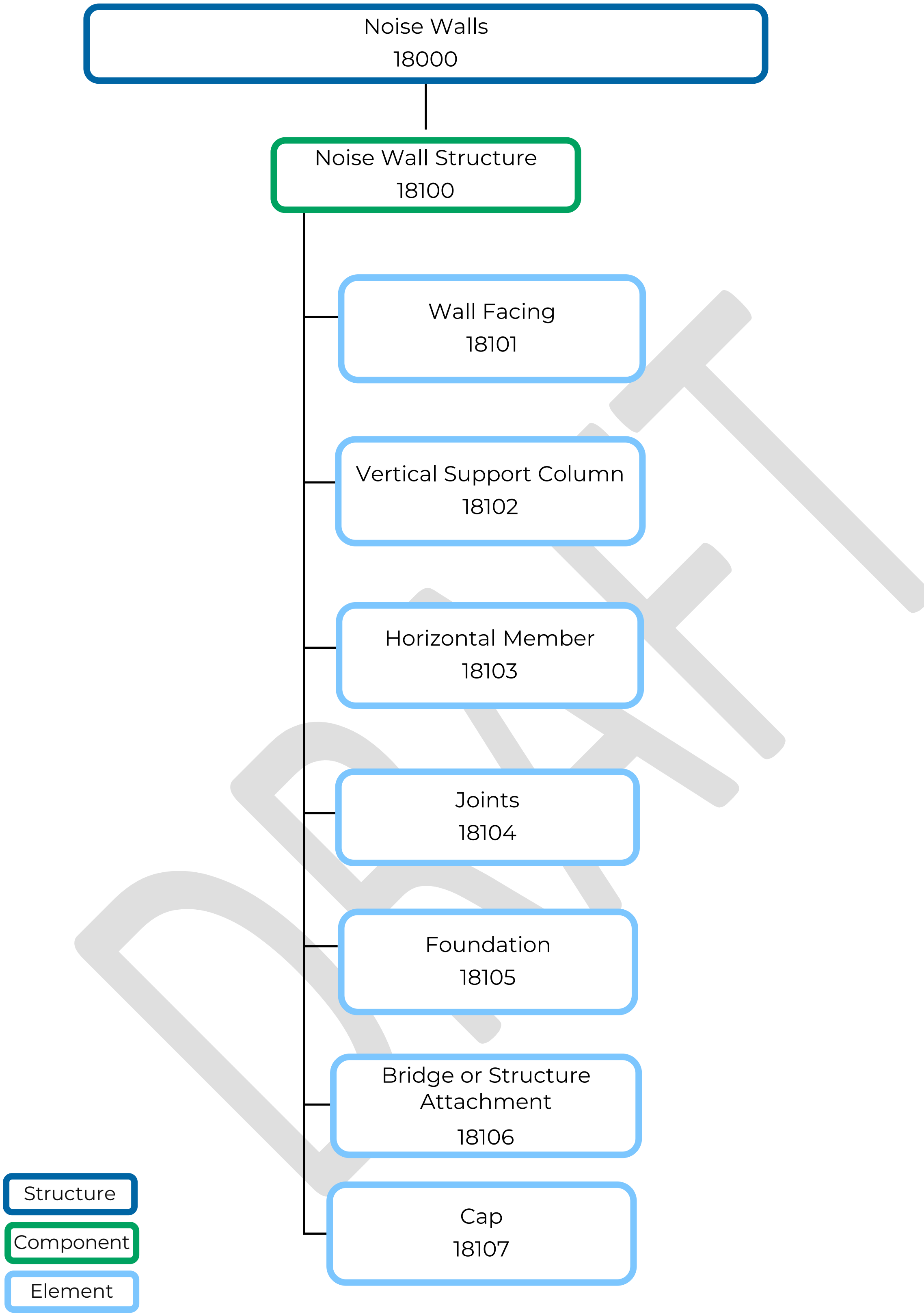

Figure 8-1: Rating structure for Noise Wall

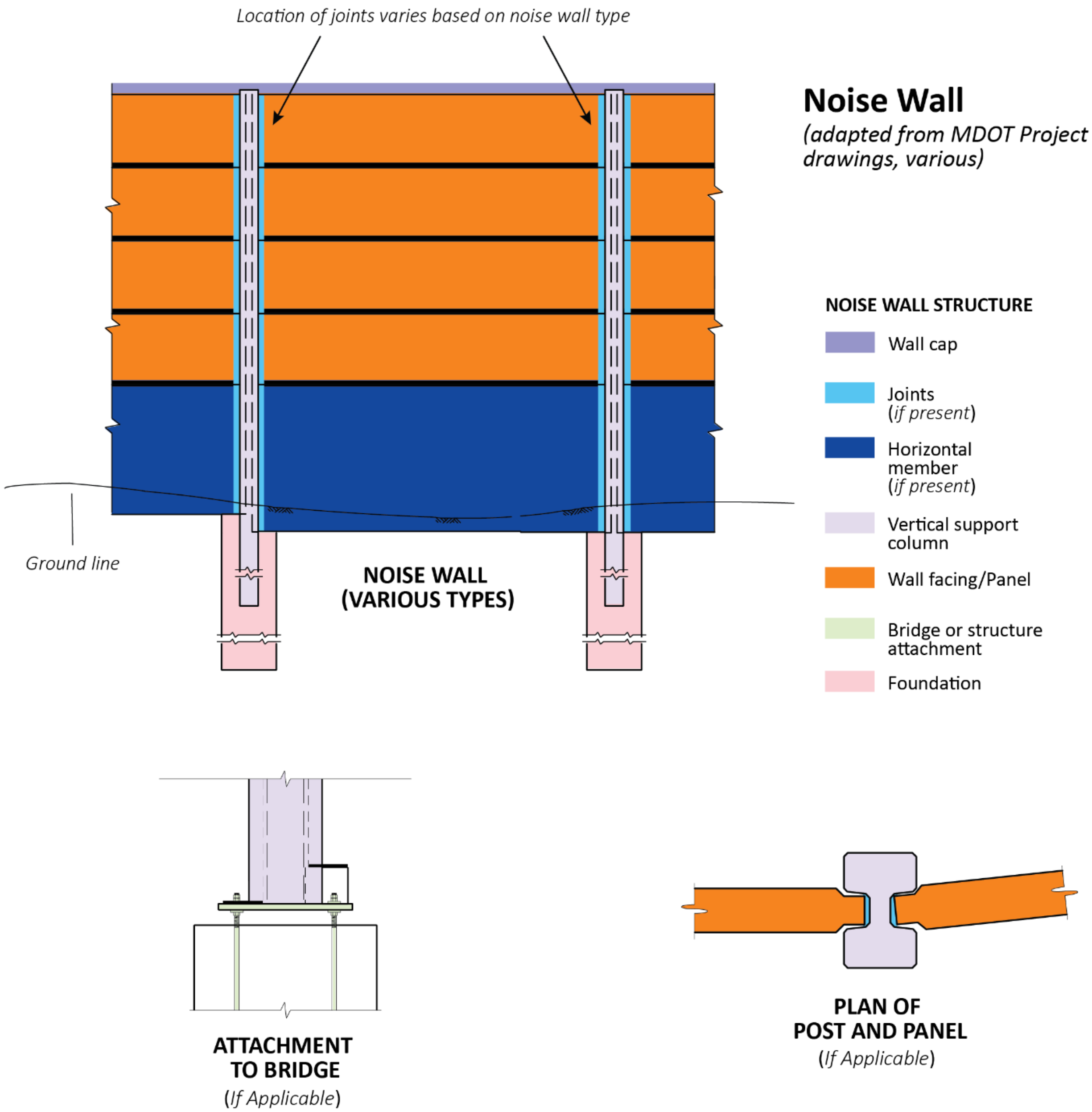

Figure 8-2: Elements and component for post and panel Noise Wall (adapted from MDOT Project drawings, various)

8.2 Inventory Record Photographs

Inventory photos are captured during a routine inspection, saved as part of the inventory database, and follow the naming convention in Table 8-2.

Noise Wall Required Photos:

- General view of the full noise wall (may require several sequential photos)

- General view at the top of noise wall (may require several sequential photos)
- Typical joint photo
- Photo of attachment to bridge or retaining wall (if applicable)

Table 8-2: Noise Wall Photograph Naming Convention

Photo Name	Description
Wall_Entire_Front	General View of entire wall
Wall_Entire_Back	General View of entire wall
Wall_Top	General view of top of wall
Wall_Joint	Typical joint photo
Wall_Attachment	Typical attachment

Note: Photo sequence should coincide with inspection direction for the walls.

8.3 Inspector Minimum Technical Qualifications

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

- A minimum experience of ten structures combined concrete inspection, steel inspection, or design experience (bridge inspection qualifies). At least three of the ten inspected structures shall be concrete structures.
- Ancillary structures inspection procedures training.
- Working knowledge of inspection tools, their use, application, and limitations for the structure type being inspected.
- Experience with anticipated material types such as concrete, timber, masonry, or steel. Internal training will address inspection procedures for all anticipated material types.
- In-depth inspection and activities for prestressed structures may require PCI Certification.

8.4 Routine Inspection

These inspections shall include the assessment of noise wall structures. Noise walls are also referred to as sound walls, noise abatement walls, or noise barrier walls. The purpose of a noise wall is to alter the noise travel along a corridor. Noise walls may be designed to either absorb or reflect noise. Minor damage to the wall may decrease its effectiveness in reducing traffic noise.

In many cases, noise walls or portions of a noise wall are installed on other structure types, such as bridge railings or retaining walls. Structure-Mounted noise walls may be attached to that structure or integral to that structure. When a noise wall is installed in either manner, the inspector of the bridge or retaining wall may conduct a cursory inspection of the noise wall as part of that inspection; this inspection is not considered a Noise Wall Inspection.

Noise wall standard inspection frequency is once every 6 years, unless otherwise identified for more frequent inspection.

Figure 8-3: Noise wall mounted on soil

Figure 8-4: Noise wall mounted on crash barrier

Figure 8-5: Noise wall attached to retaining wall

The routine inspection assesses the noise wall's ability to safely perform, transfer of all loads to the surrounding soil or subsurface material, or through attachments to a structure such as a bridge or retaining wall. 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 element condition ratings of the foundation, attachment to bridge or structure (if applicable), joints, horizontal and vertical members, and wall facing. Walls are typically inspected either from south to north or west to east, similar to bridge inspection procedures.

It consists of observations and measurements needed to determine the physical and functional condition of the noise wall, to identify any changes from initial or previously recorded conditions, and to ensure that the noise wall continues to satisfy present service requirements. All elements of the component shall be visually inspected to determine the overall condition and to detect deficiencies.

A sample noise wall routine inspection shall consist of:

- Verify set elevations along the face of the wall for signs of settlement.
- Inspect the vertical alignment (batter) of the wall with a plumb-bob. Most noise barrier walls are vertical (verify with plans or inventory).
- Examine the opening of the construction joints between sections of the wall.
- Inspect joints near ground line for any fill material washing out from between or below the panels.
- Inspect panel joints for differential movement or rotation. Sight down panel face to note individual rotation or tipping out of plane.
- Inspect for erosion of the embankment material in front and behind the wall (if ground mounted).
- Inspect for heaving of the embankment material in front and behind the wall.
- Inspect for settlement of the fill material along the wall.
- Examine site grading for any locations that may prohibit proper drainage along the wall. Note the slope in front or behind the wall, for example if 3 horizontal to 1 vertical (3H:1V).
- Examine and probe drains within the vicinity of the wall for signs of clogging.

- Examine the wall for deterioration of the material, such as cracking, spalling, corrosion, discoloration, etc. noting the width, length, depth, and/or orientation of the deterioration.
- Check wall for evidence of efflorescence or rust staining.
- Examine panel connections & frame, if applicable.
- Examine post base and anchorage systems if present. Fasteners and connections should be checked for tightness and distress.
- Note any holes around foundation or footing base which are the result of animal activity.
- Note condition of fire hydrant holes or access holes, if applicable.
- Inspect sidewalk or roadway along the wall for signs of joint separation, potholes and areas of settlement which may indicate a more global impact on the noise wall system.
- Examine vegetation growth along the wall. Root infiltration may create undesirable stresses on the wall and may induce cracking or failure if left untreated.
- Rate Component.
- Rate Elements.
- Provide photographs for all Poor or Severe condition state defects and submit the applicable Work Recs or RFAs.

Table 8-3 provides guidance for inspecting reinforced and prestressed concrete cracking.

Table 8-3: 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)

8.4.1 NOISE WALL STRUCTURE COMPONENT RATING

The noise wall’s overall characteristics are rated on its structural condition, ability to perform its function, and possible negative impact to the entire wall or nearby roadway. The wall facing, joints, vertical supports and horizontal members, foundation, or attachment, are all considered as part of the component rating. When evaluating facing distresses consider that different distresses are not of equal importance to the wall function.

The predominant characteristic determining overall condition is stability. Consider if the wall is unstable due to soil movement, foundation, or attachment issues. Also consider if scour or erosion has created wall instability. A guideline for component rating for noise walls is provided in the following table.

Table 8-4: Component Rating Guidelines for Noise Walls

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 elements are sound and functioning as designed. There may be superficial cracking or weathering and/or dirt contamination of structural elements.
7	**GOOD**	Concrete	Insignificant cracks or moderate cracks that are sealed.
		Timber	Checks or shakes penetrate less than 5% of the member thickness.
		Steel	Protective coating failure in very small and scattered locations.
		Masonry	Minor weathering or cracking (joints have little or no deterioration)
		All	All elements retain full section properties and function as designed.
6	**SATISFACTORY**	Concrete	Unsealed moderate-width or map cracks. Minor delamination, spalling, or efflorescence without build-up or rust staining.
		Timber	Decay or section loss affecting less than 5% of the member section. Splits arrested and concerns mitigated.
5	**FAIR**	Steel	Protective coating failures is limited to less than 2% of the surface area with no loss of section.
		Masonry	Moderate weathering or cracking (joints may have minor deterioration). Evidence of slight freeze-thaw.
		All	Minor deterioration affecting structural elements. Scour effects have been arrested with countermeasures.
		Concrete	Moderate delamination, spalling, or efflorescence. Reinforcement exposure without section loss.
		Timber	Decay or section loss affecting 5% to 10% of the member section. Checks, shakes, and splits have no effect on capacity.
		Steel	Protective coating failure is limited to less than 5% of the surface area with minor loss of section. Loose

Component Rating	Condition	Material	Description
			fasteners or broken welds present but the connection is in place and functioning as intended.
		Masonry	Extensive weathering or cracking (joints may have slight separation or offset). Evidence of minor freeze-thaw. Exposed steel reinforcement.
		All	Moderate deterioration affecting structural elements including minor settlement, shallow scour, or impact damage. Structure continues to function as designed.
4	POOR	Concrete	Considerable cracking, spalling, and efflorescence with heavy build-up or rust staining.
		Timber	Extensive decay, section loss, checks, shakes, or splits that do not warrant structural review.
		Steel	Protective coating failure affecting between 5% and 10% of the surface area with some loss of section. Cracks that have not been arrested but do not require structural review.
		Masonry	Advanced weathering or cracking (joints may have separation or offset). Evidence of moderate freeze-thaw. Exposed steel reinforcement.
		All	Considerable deterioration affecting structural elements including partial settlement or scour. Structure continues to function as designed.
3	SERIOUS	Concrete	Considerable areas of spalling, exposed reinforcement with section loss, or heavy rust staining.
		Timber	Decay or section loss that affects more than 10% of the member section. Checks, shakes, splits warrant action.
		Steel	Protective coating failure affecting more than 10% of the surface area with measurable loss of section. Missing fasteners or adjacent broken welds may be present.
		Masonry	Severe cracking, offset or misalignment. Evidence of severe freeze-thaw. Exposed steel reinforcement with section loss, or heavy rust staining.
		All	Considerable deterioration or damage affecting structural elements. Structural evaluation, hydraulic, and/or load analysis may be necessary to determine if the structure can continue to function without restrictions or immediate repairs.
2	CRITICAL	All	Deterioration has progressed to the point where the structure is not stable and emergency repairs or shoring with structurally engineered temporary supports is required.

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Component Rating	Condition	Material	Description
1	**IMMINENT FAILURE**	All	Road is closed to traffic due to noise wall failure, but corrective action may put the noise wall back in service.
0	**FAILED**	All	Road is closed due to noise wall condition.

8.4.1.1 Wall Facing Element Condition States

Start by identifying the noise wall facing type, as the noise wall type identification is used to identify the applicable condition states distresses.

The noise wall facing is exposed on both sides. Noise wall facings can be reinforced concrete, timber, masonry, metal, plastic, fiberglass, or other types of composite material. Noise walls may be precast or composed of modular units such as concrete panels/blocks or masonry blocks. The facing may be referred to as wall panel or panel for post and panel noise walls.

Some noise wall types have multiple defects associated with the facing material, such as reinforced concrete walls require assessment for the concrete cracking, spalling, delamination, and efflorescence. All noise wall types may have distresses associated with impact damage, typically from vehicles.

The noise wall facing inspection shall identify the facing type of material and the associated distresses with the facing type. Inspect the wall facing from the top of the wall (below any copings) to the top of the horizontal member, foundation, or to the top of finished grade, as applicable. Both sides of the wall should be inspected, if accessible. Embedded and buried portions of walls are not subject to condition inspection since they are not visible.

Reinforced Concrete Facing

The reinforced concrete wall face includes all types and shapes of reinforced concrete. Reinforced concrete exhibits several different types of deterioration and defects including concrete cracking, spalling and delamination, concrete abrasion and wear, protective coating loss, and efflorescence.

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Table 8-5: Noise Wall Facing Element, Reinforced Concrete Distresses

Element No.	Element Name	Description	Applicable Distresses
18101	Wall Facing	Noise wall facing exposed above ground.	Concrete Cracking
			Concrete Spalling, Delamination
			Concrete Abrasion/Wear
			Concrete Protective Coatings
			Other Concrete Defects
			Efflorescence
			Impact Damage
Unit of Measure: Area, square feet measured or estimated using average facing height (excluding horizontal members) multiplied by length.			

Details on the condition state rating schema are in Section 8.7, linked below:

Noise Wall Condition State Tables

Concrete Cracking

Concrete cracking can be either nonstructural or structural and can be caused by many 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. Nonstructural cracking is typically less than 1/8 inch wide. 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 wall face for cracking and investigate whether any observed cracking is non-structural or structural in nature. Document the approximate location, orientation, width, and spacing of the cracking.

Inspect and document the extent and location of exposed reinforcing bar corrosion. Estimate the extent of any section loss.

Concrete Spalling and Delamination

Concrete spalling is a surface failure in which concrete breaks off from the underlying concrete substrate. Like cracking, the spalling typically occurs when the steel reinforcing embedded within the concrete member undergoes corrosion. Spalling can also occur at expansion and contraction joints, at rustication and other ornamental non-structural features. It can also occur at cracks that have propagated due to wall deflection or impact damage.

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 wall for delamination and spalling. With a sounding hammer or other device, sound any areas that are exhibiting signs of distress to determine the limits of deterioration. Document the approximate location of delamination or spalling while indicating if reinforcement is exposed.

Abrasion/Wear

Damage occurs when the surface of concrete is unable to resist wear caused by rubbing and friction. As the outer paste of concrete wears on wall face, the fine and coarse aggregate are exposed, and abrasion and impact will cause additional degradation that is related to aggregate-to-paste bond strength and hardness of the aggregate. Abrasion of noise wall faces is most often the result of wind or water-borne particles along the face of the wall.

Inspect the wall for signs of concrete abrasion, including the loss of cement paste and the exposure of the underlying aggregate. Document on the location and extent of any abrasion on the surface of the wall face.

Concrete Protective Coatings

Inspect concrete surfaces for protective coating failure. Document the approximate location and extent of coating failure. Inspect concrete coating systems for wear due to UV exposure and other deterioration. Some failures are specific to the coating system, i.e., epoxy systems are subject to chalking, cracking, and flaking. Note the degree of effectiveness to which the concrete protection system is functioning.

Other Concrete Defects

Includes distresses otherwise not noted, and which may indicate that the wall facing is not functioning as intended or designed. Identify, inspect, and document the type and extent of any problematic deterioration or conditions.

Efflorescence

Efflorescence is caused when soluble salts and other dispersible water materials come to the surface of concrete and mortars. Efflorescence can be identified by the presence of a white powdery solid which appears on the surface of the concrete.

Inspect the wall for the presence of efflorescence, including surface white with built up or heavy build up with rust staining.

Impact Damage

Inspect the wall system for vehicular impact damage. Document the location and degree of damage.

Timber Facing

Timber noise walls include many types and shapes, including timber lagging, slats, stacked beams, and plywood.

Wood is a natural engineering material that is prone to deterioration caused by decay, fungi, and insect attack, and through mechanical damage. Typically, areas of high moisture content in timber elements create conditions suitable for biological damage.

Timber members are also susceptible to distresses such as checks/shakes and splitting/delamination/cracking.

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Table 8-6: Wall Facing Element, Timber Distresses

Element No.	Element Name	Description	Applicable Distresses
18101	Wall Facing	Noise wall facing exposed above ground.	Timber Decay/Section Loss/ Abrasion
			Timber Checks/Shakes
			Timber Splitting/ Delamination/Cracking
			Timber Other
			Impact Damage
Unit of Measure: Area, square feet measured or estimated using average facing height (excluding horizontal members) multiplied by length.			

Details on the condition state rating schema are in Section 8.7, linked below:

Noise Wall Condition State Tables

Decay/Section Loss/Abrasion

Inspect the wall for insect damage, decay, and section loss or abrasion. Surfaces exposed to drainage and other moisture is also documented. Use an awl or sharp knife to penetrate suspected areas to check for decay. When section loss or abrasion is measurable, evaluate the area to determine if an in-depth inspection and subsequent load analysis is warranted. Document the approximate location and estimated amount of section loss, and the location, type of defects, and other deterioration.

Checks/Shakes

Checks and Shakes are natural and are present in most timber members. Inspect the wall for check or shakes. Document the approximate location and the length in respect to member depth.

Splits/Delaminations/Cracking

Inspect the wall for splits and delaminations. Document the approximate location and length in respect to the member depth.

Timber Other

Inspect the timber walls for loose or failed connections, and other problem areas not noted above. Document the location, and extent of deterioration or damage if present.

Masonry Facing

Masonry noise walls are typically brick masonry or concrete masonry units (CMU). Stone masonry is seldomly used in new construction today except as facing or ornamentation.

Condition state distresses such as splits/spalls/delamination and exposed reinforcement in the masonry, breakdown and cracking of mortar, patches in the masonry, displacement or misalignment of the masonry, or efflorescence are anticipated for noise walls with masonry facing. In some cases, a simulated stone masonry coating may be applied to the facing of the noise wall; the simulated stone masonry coating should not be inspected for masonry distresses.

Table 8-7: Noise Wall Facing Element, Masonry Distresses

Element No.	Element Name	Description	Applicable Distresses
18101	Wall Facing	Noise wall facing exposed above ground.	Masonry Wall Splits/Spalls/ Delamination
			Masonry exposed reinforcement
			Mortar Breakdown/Cracking
			Masonry Patches
			Masonry Displacement/ Misalignment
			Masonry Other
			Efflorescence
			Impact Damage
Unit of Measure: Area, square feet measured or estimated using average facing height (excluding horizontal members) multiplied by length.			

Details on the condition state rating schema are in Section 8.7, linked below:

[Noise Wall Condition State Tables]

Masonry Splits/Spalls/Delaminations

Inspect the wall face for evidence of splitting, spalling and delaminated areas. Document the extent and location of any noted deterioration.

Masonry Exposed Reinforcement

Inspect the wall face for evidence exposed steel reinforcement. Note any section loss or corrosion on exposed steel.

Mortar Breakdown/Cracking

Inspect the masonry mortar for cracks, loose, or missing mortar, vegetation, and water seepage. Mortar between masonry blocks is assessed as part of the facing and not as a joint element, however the contact between blocks is often referred to as a joint.

Masonry Patches

Inspect any patched areas of masonry for cracking and or spalling. Sound previous patches with a hammer to evaluate the condition of the repair.

Masonry Displacement or Misalignment

Check overall configuration of the wall for vertical or horizontal misalignment, signs of settlement, and bulging or warping of the wall.

Metal Facing

The Metal Facing element includes steel sheet piling, corrugated metal panels, and other constructions.

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Sheeting piling noise walls are structural units which, that when connected to one another, will form a continuous wall.

Steel facing shall be inspected for cracking and fatigue, corrosion, coating failures, and other defects. Steel noise walls located in saturated soils are also susceptible to advanced section loss near the groundline.

Table 8-8: Noise Wall Facing Element, Metal/Steel Distresses

Element No.	Element Name	Description	Applicable Distresses
18101	Wall Facing	Noise wall facing exposed above ground.	Steel Wall Cracking/Fatigue
			Steel Wall Corrosion/Section Loss
			Steel Protective Coatings
			Steel Other
			Impact Damage
Unit of Measure: Area, square feet measured or estimated using average facing height (excluding horizontal members) multiplied by length.			

Details on the condition state rating schema are in Section 8.7, linked below:

Noise Wall Condition State Tables

Steel walls shall be inspected for corrosion, cracking, collision, coating failures, and other defects. Steel walls located in water or saturated soils are also susceptible to advanced section loss near the waterline.

Sheet pile walls, typical composed of steel, which are located along shorelines are not required to have inspection performed from the water. Water-side inspection would necessitate the use of boat, kayak, or other conveyance. Visual inspection for distresses and the associated condition state defects from the shoreline shall be conducted. Steel sheet piling not visible below the waterline will not be assessed.

Steel Wall Cracking/Fatigue

Inspect the wall for cracking. When cracking has been previously arrested or repairs have been installed observe the surrounding surface area to verify that further propagation is not occurring. Document the approximate location and estimated length of the cracking.

Steel Wall Corrosion/Section Loss

Inspect the wall for corrosion and section loss. Inspect surfaces that are exposed to drainage or other moisture for additional corrosion and section loss. Document the approximate location, type of defect, and cause of the damage and estimate the extent of any section loss.

Steel Protective Coatings

Inspect steel surfaces for protective coating failure. Note whether the failure is limited to the top application coat or to bare steel. Create Work Rec and document the approximate location, percentage, and extent of coating failure. Coating failure may be indicated by surface dulling, loss of pigment, exposure of bare metal, oxidation indicated by darkening of the coating, or peeling and curling of the protective coating.

Steel protective coatings are for steel elements that have a protective coating such as paint, galvanization, or other top-coat steel corrosion inhibitor. This element describes all coating systems, including but not limited to paint systems, oxide on weathering steel, metallizing, and galvanization.

Inspect steel coating systems for chalking, peeling, curling, and oxide color. Document on the location and extent of any observed deterioration to coating systems present.

Steel Other

Inspect the wall for defects such as distortion or buckling of the wall or lagging. Check for horizontal or vertical misalignment between sheeting or other panels. Document the location, length of area affected, and estimated extent of damage.

Other Facing Types

Other materials may be introduced for use in the construction of noise walls. These include plastic, fiberglass, and other composite materials.

Table 8-9: Noise Wall Facing Element, Plastic, Fiberglass, or other Composites Distresses

Element No.	Element Name	Description	Applicable Distresses
18101	Wall Facing	Noise wall facing exposed above ground.	Other Defect Impact Damage
Unit of Measure: Area, square feet measured or estimated using average facing height (excluding horizontal members) multiplied by length.			

Details on the condition state rating schema are in Section 8.7, linked below:

Noise Wall Condition State Tables

Plastic/Vinyl Lumber

Composites come in a variety of forms including plastic lumber, which is typically formed from recycled high-density polyethylene (HDPE) plastic, vinyl sheet piling, and integrated hybrid composites of plastic and steel. Plastics can exhibit ultraviolet deterioration, material incompatibility, corrosion damage, and overstress damage. Plastics will typically exhibit discoloration when undergoing ultraviolet deterioration. The material may also begin to fray when under constant sunlight.

Connections for securing, supporting, or bracing other material components are inspected for corrosion or other similar material deficiencies. For instance, the tie rod or nuts anchoring a whaler to the outer face of a vinyl sheet piling wall are inspected to ensure they are properly tightened with no signs of corrosion.

8.4.1.2 Vertical Support Column Element Condition States

The Vertical Support/Columns element includes metal, prestressed or reinforced concrete, timber, masonry or other columns or posts that provide structural support to the cantilevered noise wall facing element.

The Vertical Support/Columns transfer loads from the wall facing elements to the ground, to connected foundation elements, or through attachments to a bridge or other structure. The Vertical Support/Column elements shall be inspected for material specific deterioration and other defects. This element can occur with any noise wall facing type. This element is like the Vertical Support/Column element for the Retaining Wall ancillary structure.

Inspect each of the vertical supports or columns based on the typical defects for the material they are constructed from. In addition, document the location and extent of any misalignment or displacement of the elements, broken connections, erosion at the base of the support, impact damage, and other defects.

Table 8-10: Noise Wall Vertical Support/Column Element Distresses

Element No.	Element Name	Description	Applicable Distresses
18102	Vertical Support/ Columns	Vertical Support/Columns provides structural support to the wall facing and includes any connection hardware present between the vertical supports and adjacent elements.	Vertical Support/Column Steel Defects
			Vertical Support/Column Concrete Defects
			Vertical Support/ Column Timber Defects
			Vertical Support/Column Masonry Defects
			Vertical Support/Column Other Defects
Unit of Measure: Each support			

Details on the condition state rating schema are in Section 8.7, linked below:

Noise Wall Condition State Tables

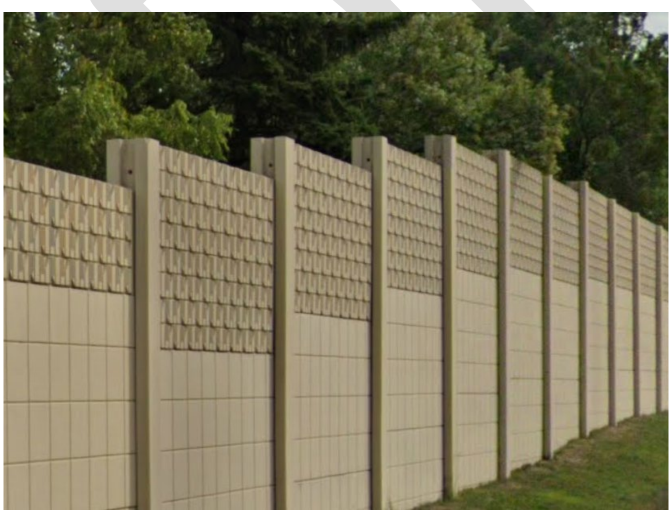

Figure 8-6: Noise wall with vertical support columns

Vertical Support/Column Steel

Vertical Support/Column Steel includes all steel columns or vertical supports regardless of size, shape, or protective system. Inspect steel elements for evidence of corrosion and section loss, fatigue cracking, distortion or buckling and misalignment including but not limited to rotation.

Vertical Support/Column Concrete

Vertical Support/Column Concrete includes all prestressed and reinforced concrete columns/posts regardless of size, shape, or protective system. Inspect concrete elements for delamination, spalling, cracking, efflorescence, exposed reinforcing or prestressing strands and other deterioration. Additionally, inspect the element for evidence of distortion or buckling and misalignment including but not limited to rotation.

Vertical Support/Column Timber

Vertical Support/Column Timber includes all timber columns/posts regardless of size, shape, or protective system. Inspect timber element for evidence of decay and section loss, checks and shakes, splits and delamination, and other types of deterioration. Additionally, inspect the element for evidence of distortion or buckling and misalignment including but not limited to rotation.

Vertical Support/Column Masonry

Vertical Support/Column Masonry includes all masonry and stone columns/posts regardless of size, shape, or protective system. The block or stone may be placed with or without mortar. Inspect the masonry/ stone elements for delamination, spalling, cracking, efflorescence, exposed reinforcing, mortar deterioration, masonry displacement and other deterioration. Note exposed reinforcing steel as CMU block walls contain vertical steel reinforcement bars. Additionally, inspect the element for evidence of distortion or buckling and misalignment including but not limited to rotation.

Vertical Support/Column Other

Vertical Support/Column Other includes all other material columns/posts regardless of size, shape, or protective system. Inspect other vertical support or column elements for deterioration related to the specific materials used. Additionally, inspect the element for evidence of distortion or buckling and misalignment including but not limited to rotation.

8.4.1.3 Horizontal Member Element Condition States

The Horizontal Member element includes metal, prestressed or reinforced concrete, timber, masonry, or other horizontal supports that provide structural support to the cantilevered noise wall facing element. Where noise walls are constructed above a concrete stem extending into a foundation, the concrete stem portion of a noise wall is rated as a horizontal member.

The Horizontal Members transfer loads from the wall facing elements to the ground or to connected foundation elements. The Horizontal Member elements shall be inspected for material specific deterioration and other defects. This element can occur with any noise wall facing type.

Inspect each of the horizontal supports based on the typical defects for the material they are constructed from. In addition, document the location and extent of any misalignment or displacement of the elements, broken connections, impact damage, and other defects.

Joint material, if present, between horizontal members shall be rated as part of the horizontal member element. Contacts between panels within post and panel walls are not considered joints.

Condition state distresses for horizontal members are like those for vertical support columns of the same material type. Descriptions of the condition state distresses are detailed above for Vertical Support Column Element Condition States.

Table 8-11: Noise Wall Horizontal Member Element Distresses

Element No.	Element Name	Description	Applicable Distresses
18103	Horizontal Member	Horizontal Member provides structural support to the wall facing and includes any connection hardware present between the horizontal supports and adjacent elements.	Horizontal Member Steel Defects Horizontal Member Concrete Defects Horizontal Member Timber Defects Horizontal Member Masonry Defects Horizontal Member Other Defects
Unit of Measure: Length, ft of all horizontal members. Measure total or estimate using average horizontal length of members multiplied by number of horizontal members.			

Details on the condition state rating schema are in Section 8.7, linked below:

Noise Wall Condition State Tables

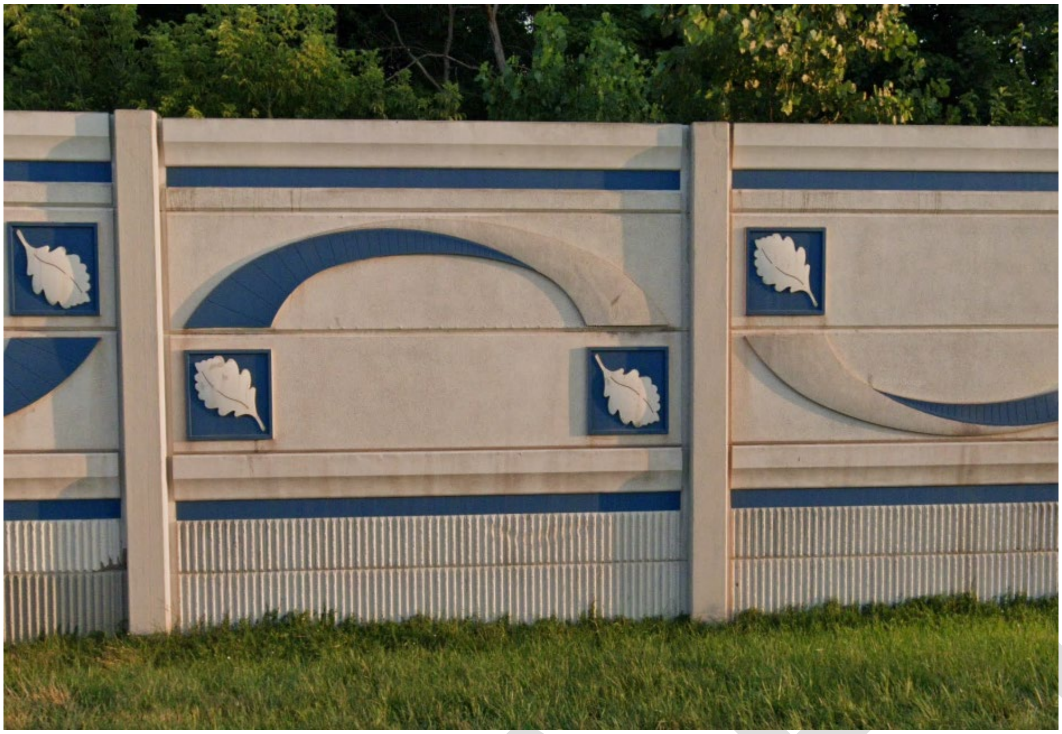

Figure 8-7: Noise wall with architectural features with vertical supports and horizontal members

8.4.1.4 Joint Element Condition States

The purpose of the joint inspection is to identify distressed joints between noise wall panels that could affect the performance of the noise wall. Joints may be sealed and distresses to seals should also be captured. Joints may be expansion joints, compression joints, strip seal expansion joints which use a waterproof gland, or some other joint type. Noise walls with expansion joints in the center of masonry panels are considered "T-types" and those with expansion joints in columns are considered "H-types." Joints present at post and panel noise walls are typically not exposed to view and are interior to the post. The horizontal contact between panels of a noise wall is not considered a joint as there is no material present to define the element such as joint compound or filler.

Table 8-12: Noise Wall Joint Element Distresses

Element No.	Element Name	Description	Applicable Distresses
18104	Joints	Joints present along a noise wall	Joint Separation, Offset, and Rotation
			Joint Infiltration
			Joint Cracking (Concrete)
			Joint closed/crushing
Unit of Measure: Each. Record quantity of each joint.			

Details on the condition state rating schema are in Section 8.7, linked below:

Noise Wall Condition State Tables

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Figure 8-8: Noise wall with vertical joints at posts and horizontal contacts between panels

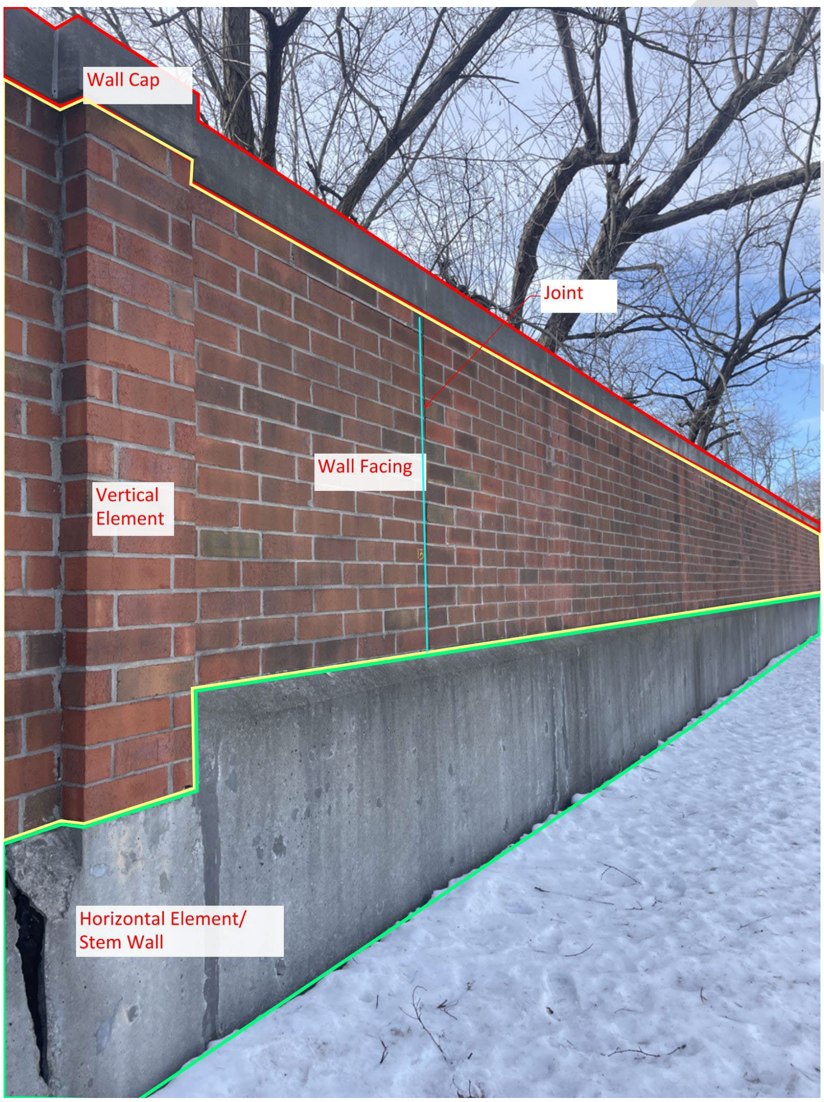

Figure 8-9: Noise Wall with masonry block indicating T-wall joint element

Joint Separation, Offset, and Rotation

Vertical movement can occur in the forms of uniform settlement or differential settlement. Depending on the magnitude of the settlement realized, uniform settlement will have limited impact on the structural stability of the noise wall. Differential settlements, on the other hand, may lead to serious problems in the noise wall. Differential settlements may cause the opening of joints or cause noise wall cracking or transverse tipping. The most common causes of vertical movement consist of soil bearing failure; soil consolidation; erosion; and material deterioration.

Inspect the noise wall for evidence of vertical differential settlement, offset, or rotation as evidenced in joints.

Joint Infiltration

Joint distresses may be identified by infiltration of soil or water through joints which are intended to be tight. This infiltration will usually only occur near the transition between the noise wall facing to the foundation or structure attachment. In severe cases, distresses to the noise wall facing, foundation, or bridge or structure attachment will result from the soil and/or water infiltration.

Joint Cracking (Concrete)

Longitudinal cracking in concrete joints is also an indication of distress. Spalling, exposed reinforcing or exposed joint sealing would all be indications of poor joint condition.

Joint Closed/Crushing

Horizontal forces such as wind, vertical movements such as differential settlement or material issues may also cause the joints to close with or without crushing. Depending on the magnitude of forces or movement experienced by the walls, noise walls such as masonry and concrete are more likely to experience crushing when joints are closed.

8.4.1.5 Foundation Element Condition States

Noise walls are either founded on soil or attached to a bridge or other structure. This subsection discusses noise walls founded on and in soil.

Noise wall foundations may fail when the bearing capacity of the soil supporting the foundation is exceeded. The bearing capacity of soil depends upon the type and consistency of soil. Soft soils comprised of clay or silt, or loose sands are the most prone to bearing capacity failure.

Foundations are critical to maintain the stability of the noise wall since the foundation supports the entire structure. The foundation component provides load bearing capacity to the base of the noise wall by transferring vertical and lateral forces from the wall to soil below. The foundation element can be comprised of shallow or deep foundations including spread footings, piles, and drilled shafts or caissons. Shallow and deep foundations are described in Section 3.4.1.6. The foundation element supports the vertical support column element and the attached facing and horizontal members.

The noise wall foundation includes all the wall elements below the bottom of the facing or horizontal member element if present. The wall foundation element is most often not visible. Rate only the visible portions of the foundation. Often the foundations are only visible when distresses are present. In some cases, a base plate may be present between the vertical support column and the foundation. The base plate and anchor bolts should be assessed as part of the Bridge or Structure Attachment element.

Evaluate the base of the noise wall perimeter to determine if the foundation is exposed or undermining has occurred due to erosion or other cause. Document the location of foundation exposure. Visual evidence of foundation defects such as bearing failure may include heaving of the soil at the base of the wall or vertical settlement of the wall or tilting of the wall originating from the foundation.

Consider the external evidence of the foundation's adequacy to support the noise wall. This may include vegetation growth along the wall, as root infiltration may create undesirable stresses on the wall and may induce cracking or failure if left untreated. Identify if holes created as the result of animal activity may impact the foundation element.

Table 8-13: Noise Wall Foundation Element Distresses

Element No.	Element Name	Description	Applicable Distresses
18105	Foundation	Noise wall foundation conditions	Foundation Defects
Unit of Measure: Length, ft measured along the noise wall face			

Details on the condition state rating schema are in Section 8.7, linked below:

Noise Wall Condition State Tables

8.4.1.6 Bridge or Structure Element Condition States

The support for the noise wall may be a foundation, bridge, or other structure. The bridge or other structure such as a retaining wall are assessed as part of the NBIS or the Retaining Wall ancillary structure.

Attachments such as anchors or other connections are used to connect the noise wall to a structure which in turn supports the noise wall. This subsection discusses the attachment joining the noise wall to a foundation, bridge, retaining wall, concrete barrier, or other structure.

Figure 8-10: Noise wall attachment to concrete barrier

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The support for the noise wall may be a foundation, bridge, or other structure. The bridge or other structure (such as a retaining wall) are inspected as described in the MiSIM for bridges or Section 3 for retaining walls. The noise wall is typically attached to a foundation or retaining wall. A noise wall may wrap around a bridge and have both foundation and bridge support. In these cases, rate both elements of foundation and bridge or structure attachment element.

Figure 8-11: Noise wall attached to retaining wall

Inspectors shall record any hardware that is missing, damaged, or not in its proper location. Examine anchorage systems, including anchor seals or other fasteners, at connection to the wall for material distress. Signs of distress may include distortion, areas of cracking, spalling, leakage stains, and loss of seal adhesion. Rotations of anchored noise walls are often preceded by punching shear or cracking around the area of the anchor attachment to the structure.

Corrosion protection for attachments includes either one or more physical barrier layers which protect the anchor and bolts from the corrosive environment. The barrier layers include anchorage covers, corrosion inhibiting compounds, sheaths, encapsulations, epoxy coatings, galvanization, and grouts. Inspect the visible portions of the anchors, including tie rods, bolts, or nuts for signs of corrosion and section loss and document the location and extent of corrosion and section loss.

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Table 8-14: Noise Wall Bridge or Structure Attachment Element Distresses

Element No.	Element Name	Description	Applicable Distresses
18106	Bridge or Structure Attachment	Attachment such as anchors or other connections, when present, which are used to connect the noise wall to a bridge, retaining wall, concrete barrier, foundation, or other structure.	Anchor/Connection Defects
Unit of Measure: Each, Total number of attachments			

Details on the condition state rating schema are in Section 8.7, linked below:

Noise Wall Condition State Tables

8.4.1.7 Wall Cap Element Condition States

Some noise walls have caps fixed to the top of the wall to protect the top of the wall from damages. The cap could be made of concrete, timber, masonry, metal (steel), plastic, sheetrock, or other components. Inspect wall caps based on the typical defects for the material they are constructed from. The material defects are similar to the same material defects of wall facing element. The wall cap inspection shall identify the cap material and the associated distresses with the cap type. Use binoculars are used as a visual aid if arm's length access from a ladder is not available. Post and panel walls may not have wall caps present or the top- most panel may be architecturally different in order to give the appearance of a wall cap.

Table 8-15: Noise Wall Cap Element Distresses

Element No.	Element Name	Description	Applicable Distresses
18107	Wall Cap	Noise wall cap conditions	Wall Cap Concrete Defects
			Wall Cap Timber Defects
			Wall Cap Masonry Defects
			Wall Cap Metal Defects
			Wall Cap Plastic, Sheetrock, Other Defects
Unit of Measure: Length, feet measured along the wall facing			

Details on the condition state rating schema are in Section 8.7, linked below:

Noise Wall Condition State Tables

Wall Cap Concrete

Members are susceptible to distresses such as delamination, spalling, abrasion, efflorescence, and cracking. They also experience misalignment.

Wall Cap Timber

Members are susceptible to distresses such as splitting, delamination, abrasion, and cracking. They also experience misalignment.

Wall Cap Masonry

Masonry noise caps are typically brick masonry or concrete masonry units (CMU). Stone masonry is seldomly used in new wall cap construction. Like wall facing element, condition state distresses such as splits/spalls/and delamination in the masonry, breakdown and cracking of mortar, patches in the masonry, displacement or misalignment of the masonry, or efflorescence are anticipated for masonry cap.

Wall Cap Metal

The metal cap element should be inspected for cracking and fatigue, corrosion, coating failures, and cap misalignment.

Wall Cap Plastic, Sheetrock, Other Composite

Plastic, sheetrock, and other materials may be introduced for use in the construction of wall caps. The cap should be inspected for distress including cracking, peeling, and cap misalignment.

8.4.2 REFERENCES

- None Noted

8.5 Work Recommendation Guidance

Noise wall Work Recs are recorded to initiate preventive maintenance actions. Preventive maintenance needs are determined for each ancillary structure and the corresponding actions are identified on the Work Recs documentation.

Work Recs include maintenance to facing such as cleaning off graffiti, painting, or re-sealing with protective coatings or paint. Tree or brush removal may be a Work Rec. Removal of drainage blockages may be a Work Rec; ponding or indications of water movement towards the wall do not require a work recommendation unless it is creating a condition state distress. Recommendations may consist of filling erosion or scour holes around the base of wall, foundation, or vertical supports. Repair procedures include patching of concrete or repair of concrete coping or pilasters. Work Recs for joints may consist of tightening of expansion joints, replacing expansion joints and seals, or sealing open joints (which are non-expansion joints). Other repairs of facing, joints, foundation(s), vertical supports, horizontal members, or attachments may be recommended.

The Work Recs are not meant to be all-inclusive and other Work Recs may be added to supplement those noted.

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Photographs should include sufficient information to determine the relationship of the defect to the element or component or entire structure. Close-up photos of each defect with deficiencies marked on the photo should be provided.

Table 8-16: Work Recommendations for Noise Wall

Number	Description of Work Recommendation	Material involved	Quantity/Unit of Measure
1	Clean and/or paint re-seal wall, remove graffiti	Concrete	Square Foot
2	Tighten/repair timber wall facing	Wood	Square Foot
3	Repair/monitor foundation	Concrete	Cubic Feet
4	Remove vegetation growth	N/A	N/A
5	Patch Spalls: Patch delamination or spalls on concrete or masonry	Concrete	Square Foot
6	Repair damaged wall facing	Concrete	Square Foot
7	Remove corrosion and overlay protective coating for steel facing or vertical supports or horizontal members	Metal Coating system	Square Foot
8	Fill erosion/scour holes around wall	Earth/stone fill	Cubic Feet
9	Repair concrete foundation	Concrete	Cubic Feet
10	Paint Vertical Supports clean and/or paint vertical support members	Paint	Square Foot
11	Repair Vertical Support member	Concrete/Steel	Lineal Foot
12	Paint coping clean and/or paint coping/pilaster	Paint	Square Foot
13	Replace coping/pilaster	Concrete	Square Foot
14	Repair concrete coping/pilaster	Concrete	Square Foot
15	Repair and monitor the berms	Soil	Cubic Feet
16	Masonry Noise Wall Joint Repair – T Type with expansion joint in middle of panel	Joint Seal	Lineal Foot
17	Masonry Noise Wall Joint Repair – H type with expansion joint in the column	Joint Seal	Lineal Foot

8.6 Request for Action Guidance

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

Priority 1 Level Items

a. Undermining of the foundation through major erosion or other severe ground loss that threatens the integrity of the noise wall

b. Wall connection to a bridge, retaining wall or other structure type with multiple loose, missing, or failing hardware, major deterioration, or damage which impacts the capacity or short-term resiliency of the element or structure
c. Major wall movement evident, whether vertical, rotational, or horizontal, observed in joints, panels, or vertical connections
d. Wall materials showing deterioration that would impact the strength of the structure causing failure of the wall, which may be observed as concrete fractures, reinforcement loss, timber cracking, or metal corrosion or deflection
e. Major structural damage to foundation, panels, or posts, which impacts safety or short-term resiliency of the structure
f. Loose/shifted cap(s) with fall potential in close proximity to public or private land-use
g. Multiple loose, missing, or damaged parts, or major deterioration, related to attachments or appurtenances that results in major impact to capacity or durability

Priority 2 Level Items

a. Undermining of the foundation through significant erosion or other significant ground loss
b. Wall connection to a bridge, retaining wall or other structure, with loose, missing, or failing hardware, significant deterioration, or damage which significantly impacts the capacity or short-term resiliency of the element or structure
c. Significant wall movement evident, whether rotational or horizontal, whether in joints, panels, or vertical connections
d. Wall materials showing significant deterioration that impacts the capacity or durability of the structure leading to failure of the wall, which could consist of concrete fractures, reinforcement loss, timber cracking, or metal corrosion or deflection
e. Structural damage to foundation, panels, or posts, which significantly impacts capacity or function, clearance, safety, or durability of the structure
f. Loose/shifted cap(s) with fall potential remote from public or private land-use, yet hazardous to anyone in close proximity
g. Significantly loose parts, or significant deterioration or wear, related to attachments or appurtenances that results in significant impact to capacity or durability

Priority 3 Level Items

a. Undermining of the foundation through moderate erosion or other ground loss
b. Wall connection to a bridge, retaining wall or other structure, with loose, missing, or failing hardware, moderate deterioration, or damage, with adequate redundancy and moderate impact to structural capacity or durability
c. Wall materials showing moderate deterioration that impacts the capacity or durability of the structure leading to failure of the wall, which could consist of concrete fractures, reinforcement loss, timber cracking, or metal corrosion or deflection

d. Loose or misaligned parts, or moderate deterioration or wear, related to attachments or appurtenances that results in moderate impact to capacity or durability

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8.7 Element Condition States

Element Number	Element	Condition States Defects Note	Link to Discussion in Section 8
18101	Noise Wall Facing	Use the appropriate condition state table based on material (Reinforced Concrete, MSE, Timber, Masonry, Metal/Steel, or Other).	Wall Facing Element Condition States
18102	Vertical Supports/Columns	Use the appropriate condition state based on material (Reinforced Concrete, Timber, Masonry, Metal/Steel, or Other).	Vertical Support Columns Element Condition States
18103	Horizontal Member	Use the appropriate condition state based on material (Reinforced Concrete, Timber, Masonry, Metal/Steel, or Other).	Horizontal Member Element Condition States
18104	Joints	Use the appropriate condition state table.	Joint Element Condition States
18105	Foundation	Use the appropriate condition state based on foundation type.	Foundation Element Condition States
18106	Bridge or Structure Attachment	Use the appropriate condition state table.	Bridge or Structure Element Condition States
18107	Noise Wall Cap	Use the appropriate condition state table.	Wall Cap Element Condition States

Element 18101 (Noise Wall Facing, Reinforced Concrete)

Description	This element defines noise wall facing, regardless of facing material type.			
Quantity Calculation	Area, square feet measured or estimated using maximum height minus minimum height multiplied by length. Noise walls which are supported by both foundations and by bridge or structure attachments should be considered two separate structures, with the separation at the nearest joint where the support type changes.			
	Condition State Descriptions			
Defect Type	**Good**	**Fair**	**Poor**	**Severe**
Concrete Cracking	Insignificant cracks or moderate-width cracks that have been sealed. No exposed reinforcing.	Unsealed moderate-width cracks or unsealed moderate pattern (map) cracking. Reinforcement may be exposed with no measurable section loss.	Wide cracks (>3/16" or 0.1875 inches) or heavy pattern (map) cracking. Some reinforcing may be exposed. Incidental loss of section of reinforcing may be present but does not affect the function.	Major deterioration due to extensive cracking. Substantial amounts of water or backfill may be leaking through cracks or joints. Major corrosion of exposed reinforcing.
Concrete Spalling, Delamination, Patching	No evidence of concrete spalling, delamination, or patching.	Minor delamination is present. Patched areas are sound.	Moderate delamination and spalling is present. Patches are partially functioning or showing distress. Moderate cracks may be present.	Major deterioration due to spalling, or delamination impacting function of wall. Failed patches.
Concrete Abrasion/Wear	No evidence of concrete abrasion or wear.	Abrasion or wearing has exposed coarse aggregate.	Abrasion or wearing has caused coarse aggregate to be loose and/or lost from the concrete matrix.	Major deterioration of concrete due to abrasion or wear.
Other Concrete Defects	Other Concrete is present and does not exhibit deterioration or distress.	Minor deterioration or distress of Other Concrete.	Moderate deterioration or distress of Other Concrete.	Major deterioration or distress of Other Concrete.
Concrete Protective Coatings	Protective coatings functioning.	Minor peeling/ bubbling/cracking present.	Protective coatings partially effective. Major peeling, bubbling, or cracking is present.	Does not create a severe condition.

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Description	This element defines noise wall facing, regardless of facing material type.			
Quantity Calculation	Area, square feet measured or estimated using maximum height minus minimum height multiplied by length. Noise walls which are supported by both foundations and by bridge or structure attachments should be considered two separate structures, with the separation at the nearest joint where the support type changes.			
	Condition State Descriptions			
Defect Type	**Good**	**Fair**	**Poor**	**Severe**
Efflorescence	Free of efflorescence.	Surface white without build-up or leaching without rust staining.	Heavy build-up with rust staining present.	Does not create a severe condition.
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.	Major impact damage from vehicular or vessel collision.

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Element 18101 (Noise Wall Facing, Timber)

Description	This element defines noise wall facing, regardless of facing material type.			
Quantity Calculation	Area, square feet measured or estimated using maximum height minus min height multiplied by length. Noise walls which are supported by both foundations and by bridge or structure attachments should be considered two separate structures, with the separation at the nearest joint where the support type changes.			
	Condition State Descriptions			
Defect Type	**Good**	**Fair**	**Poor**	**Severe**
Timber Decay/ Section Loss/ Abrasion	No indication of decay, section loss or abrasion	Minor decay, section loss or abrasion.	Moderate decay, section loss or abrasion	Major decay, section loss, or abrasion of wall.
Timber Checks/ Shakes	Checks and Shakes are not present.	Checks and shakes affect less than 5% of the member thickness.	Checks and shakes affect 5% to 50% of the member thickness. Larger checks/shakes have been repaired.	Checks and shakes of timber affect more than 50% of member thickness.
Timber Splitting/ Delamination/ Cracking	No splitting or delamination present. Sealed cracks may exist.	Minor delamination or cracking is present.	Delamination or splitting length equal to or greater than the total member depth, but only present away from connections. Evidence of moderate cracking. Larger cracks have been repaired.	Delamination or splitting near connections. Severe deterioration due to cracking.
Other Timber Defects	None present.	Minor deterioration or distress of other timber defects.	Moderate deterioration or distress of other timber defects.	Major deterioration or distress of other timber defects.
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.	Major damage from vehicular impact.

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Element 18101 (Noise Wall Facing, Masonry)

Description	This element defines noise wall facing, regardless of facing material type.			
Quantity Calculation	Area, square feet measured or estimated using maximum height minus min height multiplied by length. Noise walls which are supported by both foundations and by bridge or structure attachments should be considered two separate structures, with the separation at the nearest joint where the support type changes.			
	Condition State Descriptions			
Defect Type	**Good**	**Fair**	**Poor**	**Severe**
Masonry Splits/Spalls/ Delamination	No splits, spalls, or delamination.	Minor delamination or spalls is present. Hairline cracks may be present. Block or stone has split or spalled with no shifting.	Moderate delamination or spalls is present. Minor cracks may be present. Block or stone has split or spalled with shifting.	Major deterioration such as spalling/delamination or splitting.
Masonry Exposed Reinforcement	No exposed reinforcing.	Reinforcement may be exposed with no measurable section loss.	Incidental loss of section of reinforcing may be present but does not affect the function.	Major corrosion of exposed reinforcing.
Mortar Breakdown/ Cracking	No mortar breakdown.	Cracking or voids in less than 10% of the mortar joints.	Cracking or voids in 10% to 50% of the mortar joints.	Mortar joints with cracks or voids in more than 50% of the mortar joints. Substantial amounts of water or backfill may be leaking or migrating through cracks.
Masonry Patches	Free of patches.	Patch is present and functioning as intended to arrest original deterioration.	Unsound patches or patch showing distress.	Patch has failed.
Masonry Displacement/ Misalignment	None present. No displacement or misalignment	Block or stone has shifted slightly out of alignment.	Block or stone has shifted moderately out of alignment or is missing.	Major displacement of block or stone with missing blocks and stones.
Other Masonry Defects	None present.	Minor deterioration or distress of Other Masonry Defects.	Moderate deterioration or distress of Other Masonry Defects.	Major deterioration or distress of Other Masonry Defects.

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Description	This element defines noise wall facing, regardless of facing material type.			
Quantity Calculation	Area, square feet measured or estimated using maximum height minus min height multiplied by length. Noise walls which are supported by both foundations and by bridge or structure attachments should be considered two separate structures, with the separation at the nearest joint where the support type changes.			
	Condition State Descriptions			
Defect Type	**Good**	**Fair**	**Poor**	**Severe**
Efflorescence	Free of efflorescence.	Surface white without build-up or leaching without rust staining.	Heavy build-up with rust staining present.	Does not create a severe condition.
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.	Major impact damage from vehicular or vessel collision.

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Element 18101 (Noise Wall Facing, Metal/Steel)

Description	This element defines noise wall facing, regardless of facing material type.			
Quantity Calculation	Area, square feet measured or estimated using maximum height minus min height multiplied by length. Noise walls which are supported by both foundations and by bridge or structure attachments should be considered two separate structures, with the separation at the nearest joint where the support type changes.			
	Condition State Descriptions			
Defect Type	**Good**	**Fair**	**Poor**	**Severe**
Steel Wall Cracking/ Fatigue	No evidence of wall cracking/fatigue.	Steel cracking is self-arrested or arrested with holes, doubling plates, or similar. Fasteners are performing as intended.	Steel cracking is progressing.	Major deterioration due to extensive. Substantial amounts of water or backfill may be leaking through cracks or joints.
Steel Wall Corrosion/ Section Loss	Free of corrosion/section loss	Minor surface corrosion.	Moderate section loss due to corrosion.	Major wall section loss due to excessive corrosion.
Steel Wall Protective Coatings	Protective coatings functioning.	Minor peeling/bubbling/ cracking present.	Protective coatings on steel partially effective. Major peeling, bubbling, or cracking is present. Chalking or oxide films may be present.	Does not create a severe condition.
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.	Major damage from vehicular impact.

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Element 18101 (Noise Wall Facing – Plastic, Sheetrock, Other Composite)

Description	This element defines noise wall facing, regardless of facing material type.			
Quantity Calculation	Area, square feet measured or estimated using maximum height minus min height multiplied by length. Noise walls which are supported by both foundations and by bridge or structure attachments should be considered two separate structures, with the separation at the nearest joint where the support type changes.			
	Condition State Descriptions			
Defect Type	**Good**	**Fair**	**Poor**	**Severe**
Plastic, Vinyl, Composite, Other Wall Defect	Plastic, Vinyl, Composite, or Other Wall does not exhibit deterioration or distress.	Minor deterioration or distress of Plastic, Vinyl, Composite, or Other Wall.	Moderate deterioration or distress of Plastic, Vinyl, Composite, or Other Wall.	Major deterioration or distress of Plastic, Sheetrock, or Other Composite material.
Plastic, Vinyl, Composite, Other Protective Coatings	Protective coatings functioning.	Minor peeling/bubbling/ cracking present.	Protective coatings partially effective. Major peeling, bubbling, or cracking is present.	Does not create a severe condition.
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.	Major damage from vehicular impact.

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Element 18102 (Vertical Support/Column)

Description	This element is defined by vertical supports and connection hardware which provide structural support to the wall facing and adjacent elements such as horizontal members. It includes base plates present at the connection of the vertical column and the attachment element.			
Quantity Calculation	The quantity is measured in each.			
	Condition State Descriptions			
Defect Type	**Good**	**Fair**	**Poor**	**Severe**
Vertical Support/ Column Steel Defects	No deterioration present.	Steel cracking is self-arrested or arrested with holes, doubling plates, or similar. Fasteners are performing as intended. Minor surface corrosion. Minor wall movement may be occurring with signs of bending, misalignment, distortion, or deflection of vertical support.	Steel cracking is progressing. Moderate section loss due to corrosion. Moderate wall movement may be occurring with signs of bending, misalignment, distortion, or deflection of vertical support.	Major deterioration due to cracking, corrosion, section loss or misalignment. Wall movement may be active with major wall bending, misalignment, distortion, or deflection of vertical support.
Vertical Support/ Column Concrete Defects	Hairline cracks may be present. Minor cracks or moderate-width cracks that have been sealed. No exposed reinforcement.	Unsealed moderate-width cracks or unsealed moderate pattern (map) cracking. Minor delamination or spalls is present. Reinforcement exposed without measurable section loss. Minor wall movement may be occurring with deflection of vertical support.	Wide cracks (>3/16" or 0.1875 inches) or heavy pattern (map) cracking. Moderate delamination or spall is present. Exposed reinforcement with measurable section loss. Moderate wall movement may be occurring with deflection of vertical support. Exposed prestressing strand without section loss.	Major deterioration due to cracking, spalling, reinforcement corrosion, section loss or other deterioration impacting strength of wall. Exposed prestressing strand with section loss. Wall movement may be active with major deflection of vertical support.

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Description	This element is defined by vertical supports and connection hardware which provide structural support to the wall facing and adjacent elements such as horizontal members. It includes base plates present at the connection of the vertical column and the attachment element.
Quantity Calculation	The quantity is measured in each.

Defect Type	**Condition State Descriptions**			
	Good	**Fair**	**Poor**	**Severe**
Vertical Support/ Column Timber Defects	No deterioration present	Minor decay, section loss, abrasion, or cracking. Checks affect less than 5% of the member thickness. Minor wall movement may be occurring with deflection of vertical support.	Moderate decay, section loss, abrasion, or cracking. Checks/ shakes/ cracks affect 5% to 50% of the member thickness. Larger checks/shakes/cracks have been repaired. Delamination or splitting length equal to or greater than the total member depth. Moderate wall movement may be occurring with deflection of vertical support.	Major decay, section loss, or abrasion of wall. Checks and shakes of timber affect more than 50% of member thickness. Delamination or splitting near connections. Wall movement may be active with major deflection of vertical support.
Vertical Support/ Column Masonry Defects	No splits or spalls, mortar breakdown present. No displacement or misalignment of stones present. No exposed reinforcing.	Minor delamination or spalls. Hairline cracks in stones may be present. Cracking or voids in less than 10% of the mortar joints. Block or stone has shifted slightly out of alignment. Reinforcement may be exposed with no measurable section loss.	Moderate delamination or spalls. Minor cracks may be present. Cracking or voids in greater than 10% or more of the mortar joints. Block or stone has shifted moderately out of alignment or is missing. Incidental loss of section of reinforcing may be present but does not affect the function.	Major spalling, delamination cracking or splitting of masonry. Mortar joints with cracks or voids in more than 50% of the mortar joints. Major displacement of block or stone with missing blocks and stones. May effect structure strength or performance. Major corrosion of exposed reinforcing.

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Description	This element is defined by vertical supports and connection hardware which provide structural support to the wall facing and adjacent elements such as horizontal members. It includes base plates present at the connection of the vertical column and the attachment element.			
Quantity Calculation	The quantity is measured in each.			
	Condition State Descriptions			
Defect Type	**Good**	**Fair**	**Poor**	**Severe**
Vertical Support/ Column Plastic, Other Composite, Defects	Plastic or Other Composite material does not exhibit deterioration or distress.	Minor deterioration or distress of Plastic or Other Composite material. Minor wall movement may be occurring with deflection of vertical support.	Moderate deterioration or distress of Plastic, or Other Composite material. Moderate wall movement may be occurring with deflection of vertical support.	Major deterioration or distress of Plastic, or Other Composite material. Wall movement may be active with major deflection of vertical support.

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Element 18103 (Horizontal Member)

Description	This element is defined as a horizontal member provides structural support to the wall facing and includes any connection hardware present between the horizontal supports and adjacent elements.			
Quantity Calculation	This quantity is measured in length in feet of all horizontal members.			
	Condition State Descriptions			
Defect Type	**Good**	**Fair**	**Poor**	**Severe**
Horizontal Member Steel Defects	No deterioration present	Steel cracking is self-arrested or arrested with holes, doubling plates, or similar. Fasteners are performing as intended. Minor surface corrosion. Wall movement may be occurring with signs of deflection of Horizontal Member.	Steel cracking is progressing. Moderate section loss due to corrosion. Moderate wall movement may be occurring with signs of bending, misalignment, distortion, or deflection of Horizontal Member.	Major deterioration due to cracking, corrosion, section loss or misalignment impacting strength of wall. Wall movement may be active.
Horizontal Member Concrete Defects	Hairline cracks may be present. Minor cracks or moderate-width cracks that have been sealed. No exposed reinforcement.	Unsealed moderate-width cracks or unsealed moderate pattern (map) cracking. Minor delamination or spalls. Reinforcement exposed without measurable section loss. Minor wall movement may be occurring with deflection of Horizontal Member.	Wide cracks (>3/16" or 0.1875 inches) or heavy pattern (map) cracking. Moderate delamination or spalls. Exposed reinforcement with measurable section loss. Moderate wall movement may be occurring with deflection of Horizontal Member.	Major deterioration due to cracking, spalling, reinforcement corrosion, section loss or other deterioration impacting strength of wall. Exposed prestressing strand with corrosion. Wall movement may be active with major deflection of Horizontal Member.

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Description	This element is defined as a horizontal member provides structural support to the wall facing and includes any connection hardware present between the horizontal supports and adjacent elements.			
Quantity Calculation	This quantity is measured in length in feet of all horizontal members.			
	Condition State Descriptions			
Defect Type	**Good**	**Fair**	**Poor**	**Severe**
Horizontal Member Timber Defects	No deterioration present	Minor decay, section loss, abrasion, or cracking. Checks affect less than 5% of the member thickness. Minor wall movement may be occurring with deflection of Horizontal Member.	Moderate decay, section loss, abrasion, or cracking. Checks/ shakes/cracks affect 5% to 50% of the member thickness. Larger checks/shakes/cracks have been repaired. Delamination or splitting length equal to or greater than the total member depth. Moderate wall movement may be occurring with deflection of Horizontal Member.	Severe decay, section loss, or abrasion of wall. Checks and shakes of timber affect more than 50% of member thickness. Delamination or splitting near connections; Wall movement may be active with major deflection of Horizontal Member.
Horizontal Member Masonry Defects	No splits or spalls, mortar breakdown present. No displacement or misalignment of stones present.	Minor Delamination or spalls. Hairline cracks in stones may be present. Cracking or voids in less than 10% of the mortar joints. Block or stone has shifted slightly out of alignment.	Moderate delamination or spalls. Minor cracks may be present. Cracking or voids in 10% to 50% of the mortar joints. Block or stone has shifted moderately out of alignment or is missing.	Major spalling, delamination cracking or splitting of masonry. Mortar joints with cracks or voids in more than 50% of the mortar joints. Major displacement of block or stone with missing blocks and stones. May effect structure strength or performance.
Horizontal Member (Plastic, Composite, Other) Defects	Plastic, or Other Composite material does not exhibit deterioration or distress.	Minor deterioration or distress of Plastic or Other Composite material. Minor wall movement may be occurring with deflection of Horizontal Member.	Moderate deterioration or distress of Plastic, or Other Composite material. Moderate wall movement may be occurring with deflection of Horizontal Member.	Major deterioration or distress of Plastic, or Other Composite material. Wall movement may be active with major deflection of Horizontal Member.

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Element 18104 (Joints)

Description	This element is for joints which define sections between noise wall facing panels.			
Quantity Calculation	The quantity for this element is measured as "each."			
Defect Type	**Condition State Descriptions**			
	Good	**Fair**	**Poor**	**Severe**
Separation, Offset, Rotation, and Cracking	No damage present.	Joints are slightly misaligned and may have irregular spacing between units. Joints with seals show minor damage, cracking, or loss of seal adhesion.	Joints are moderately misaligned and may have irregular spacing between units. Joints with seals show moderate damage, cracking, or loss of seal adhesion.	Joints are extensively misaligned with irregular spacing. Joints with seals are not functioning.
Joint Infiltration	None.	Partially filled, but still allowing free movement.	Completely filled and impacts joint movement.	Completely filled and prevents joint movement.
Joint closed/crushing	No damage present.	Localized closure or crushing of the joints but still allowing movement.	Joints are closed and moderate crushing has occurred impacting joint movement.	Joints are closed with significant joint crushing.

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Element 18105 (Foundation)

Description	This element defines a foundation, regardless of foundation type.			
Quantity Calculation	The quantity is collected in length of feet measured along the wall face.			
	Condition State Descriptions			
Defect Type	**Good**	**Fair**	**Poor**	**Severe**
Foundation Defects	Wall shows no signs of movement. Wall foundation elements are in place.	Minor wall movement has occurred. Signs of settlement, deflection, or displacement are present. Foundation may be exposed. Wall is still attached to foundation.	Moderate wall settlement, rotation, or movement indicating possible foundation damage. Wall may be partially disconnected from its foundation.	Major loss of wall bearing capacity which is a threat to wall structural capacity and stability. Wall may not be attached to foundation elements.

Element 18106 (Bridge or Structure Attachments)

Description	This element defines an attachment such as anchors or other connections (when present), which are used to connect the noise wall to a bridge, retaining wall, concrete barrier, foundation, or other structure.			
Quantity Calculation	The quantity is measured in each.			
	Condition State Descriptions			
Defect Type	**Good**	**Fair**	**Poor**	**Severe**
Anchor/ Connection Defects	No evidence of damage, wear, or corrosion. Anchor/Connections are fully engaged.	Hairline cracks, minor spall, and minimal corrosion or coating damage may be present. Connection is free of distortion and hardware is engaged with no evidence of loss of seal adhesion or loosing fasteners	Moderate damages including cracks and spalls, or corrosion/coating damage may be present. Signs of distortion and loosening fastener is present.	Major corrosion/section loss is present. Protective coatings are significantly failing. Members may have major cracks or wear. Significant distortion of connections, loss of seal adhesion or loosening of fasteners may be present.

Element 18107 (Noise Wall Cap)

Description	This element is defined by the condition of the wall cap which could be made of timber, masonry, metal (steel), plastic, sheetrock, or other components.			
Quantity Calculation	The quantity is collected in feet along the noise wall facing.			
	Condition State Descriptions			
Defect Type	**Good**	**Fair**	**Poor**	**Severe**
Timber Defects	No indication of decay, splitting, delamination, section loss, abrasion, or unsealed cracks. No evidence of cap misalignment.	Minor evidence of decay, splitting, delamination, section loss, abrasion, or unsealed cracks. Cap may be slightly out of alignment.	Moderate evidence of decay, splitting, delamination, section loss, abrasion, or cracks. Evidence of moderate misalignment may be present.	Evidence of major deterioration due to extensive splitting, delamination, section loss, abrasion, or cracks is present. Major displacement or failure of cap may be present.
Masonry Defects	No split, spall, delamination, crack, or other distress is present. Free of patches. No evidence of cap misalignment.	Minor splits, spalls, delamination, cracks, or other distress is present. Minor patches may be present but are adequately functioning to arrest original deterioration. Cap may be slightly out of alignment.	Moderate splits, spalls, delamination, cracks, or other distress is present. Patches are not adequately functioning. Cap may be loosely fixed.	Major deterioration due to extensive splits, spalls, delamination, cracks, or other distress. Patch has failed. Major displacement of cap may be evident.
Metal/Steel Defects	No evidence of corrosion, coating wear or cap misalignment.	Minor evidence of surface corrosion, coating wear, or crack is present. Cap may be slightly out of alignment.	Moderate evidence of surface corrosion, coating wear, or crack is present. Cap may be loosely aligned.	Extensive surface corrosion, coating wear, or crack is present. Extensive misalignment of cap may be present.
Plastic, Sheetrock, Other Composite Defects	No evidence of deterioration or misalignment.	Minor peelings, cracking or another surface distress may be present. Minor cap misalignment may be present without loss of function.	Moderate peelings, cracking or other distress is present. Evidence of moderate misalignment may be present.	Evidence of major deterioration is present. Major displacement of cap may be present.

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9 MAST ARM

9.1 Definitions

Mast Arms are steel pole structures with one or more horizontal mast arm(s) used to support signals, luminaries, signs, cameras, and other appurtenances. The steel pole is supported on a drilled shaft concrete foundation with anchor bolts.

Other common terms which may be used when discussing Mast Arms include:

- *Mast:* The steel pole, or mast, is supported on a drilled shaft concrete foundation with either four or six anchor bolts, with six anchor bolts specified in the current MDOT standards. Beside mast arms supporting signals and signs, these structures may also have cantilevered arms supporting luminaires, cameras, or other appurtenances. Mast arms are designed with varying levels of resistance to fatigue, and as such may be labeled either Category I, II, or III.
- *Category I mast arms:* Largest Mast Arm structures designed for an “infinite” fatigue life. This means the structures’ details are subjected to stress ranges below which a particular fatigue detail can withstand an infinite number of repetitions without fatigue failure.
- *Category II and III mast arms*: Mast arm structures which may have finite fatigue lives.

Figure 9-1: MDOT Category I Mast Arm, note previous design in background before removal

Figure 9-2: MDOT Category II Mast Arm

Figure 9-3: MDOT Category III Mast Arm

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9.1.1 INVENTORY ITEMS

Inspectors shall identify the pole and foundation material types. A mast arm is typically constructed of steel and may have a round cross-section or multi-sided. If the pole is steel, determine the type of coating – paint, galvanizing, or uncoated. All mast arms should be constructed on a concrete drilled shaft foundation with an elevated base plate connected to the concrete foundation with four or six anchor bolts. The mast arm may support a variety of attachments, both directly and indirectly, including luminaires and luminaire arms, signs, signals, cameras, and other miscellaneous attachments. The quantity and type of connections of these attachments to the structure should be noted. The types of connections may include direct bolting, bands, clamps, or brackets. Non-structural attachments, such as signs, signals, and cameras, receive ratings under Miscellaneous Arm, Bracket, and Attachment and should be reported appropriately if they pose a safety risk. The connections of these attachments to the structure are rated. Also, note the presence of any secondary support elements of the pole.

The inspector shall note the presence of any non-typical attachments that may not have been approved or been part of the original purpose or function of the pole.

Inspector shall confirm any pre-populated inventory data while recording information that is not already documented. It may not be possible to record or verify all measurements exactly due to access limitations; estimate and use experience and best judgement to record data to the most accurate extent possible. Take photos of the required inventory items listed in Section 9.2.2.

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

9.1.2 ELEMENTS

Mast Arms are divided into three components: Foundation, Vertical Structure, and Horizontal Structure.

Foundation is further divided into elements: Concrete Foundation and Anchor Bolts and Leveling Nuts.

Vertical Structure is further divided into elements: Base Plate, Vertical Support Column (Upright), and Vertical Structure Connections.

Horizontal Structure is further divided into elements: Mast Arm Member, Mast Arm Splice Connection, Mast Arm Attachment Connections, Luminaire and Luminaire Arm, and Miscellaneous Arm, Bracket, and Attachment.

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 cantilevered vertical support are referenced by using offsets measured from the base plate as measured in feet and prominent features (e.g., pole mounted cabinet).
- Horizontal Element Locations – Distress locations along the mast arm length are referenced by using offsets measured from the vertical support end.
- Attachments on Mast Arm Members – Attachments are identified in relationship to directionality (e.g., North/South, East/West, Right End/Left End looking at front of signal or 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. Annotate drawings and photos as necessary.

Table 9-1: Mast Arm Components and Elements

Component	Element	Element Code	Unit of Measure
Foundation	Concrete Foundation	19101	Each
Foundation	Anchor Bolts and Leveling Nuts	19102	Each bolt and nut unit
Vertical Structure	Base Plate	19201	Each
Vertical Structure	Vertical Support Column (Upright)	19202	Length, feet
Vertical Structure	Vertical Structure Connections	19203	Each
Horizontal Structure	Mast Arm Member	19301	Length, feet
Horizontal Structure	Mast Arm Splice Connection	19302	Each
Horizontal Structure	Mast Arm Attachment Connections	19303	Each
Horizontal Structure	Luminaire and Luminaire Arm	19304	Each
Horizontal Structure	Miscellaneous Arm, Bracket, and Attachment	19305	Each

9.1.3 COMPONENTS

Mast Arms are divided into three main components: Foundation, Vertical Structure, and Horizontal Structure.

Component ratings for mast arms are based on the following:

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

A representation of the rating structure for Mast Arms is provided in Figure 9-4.

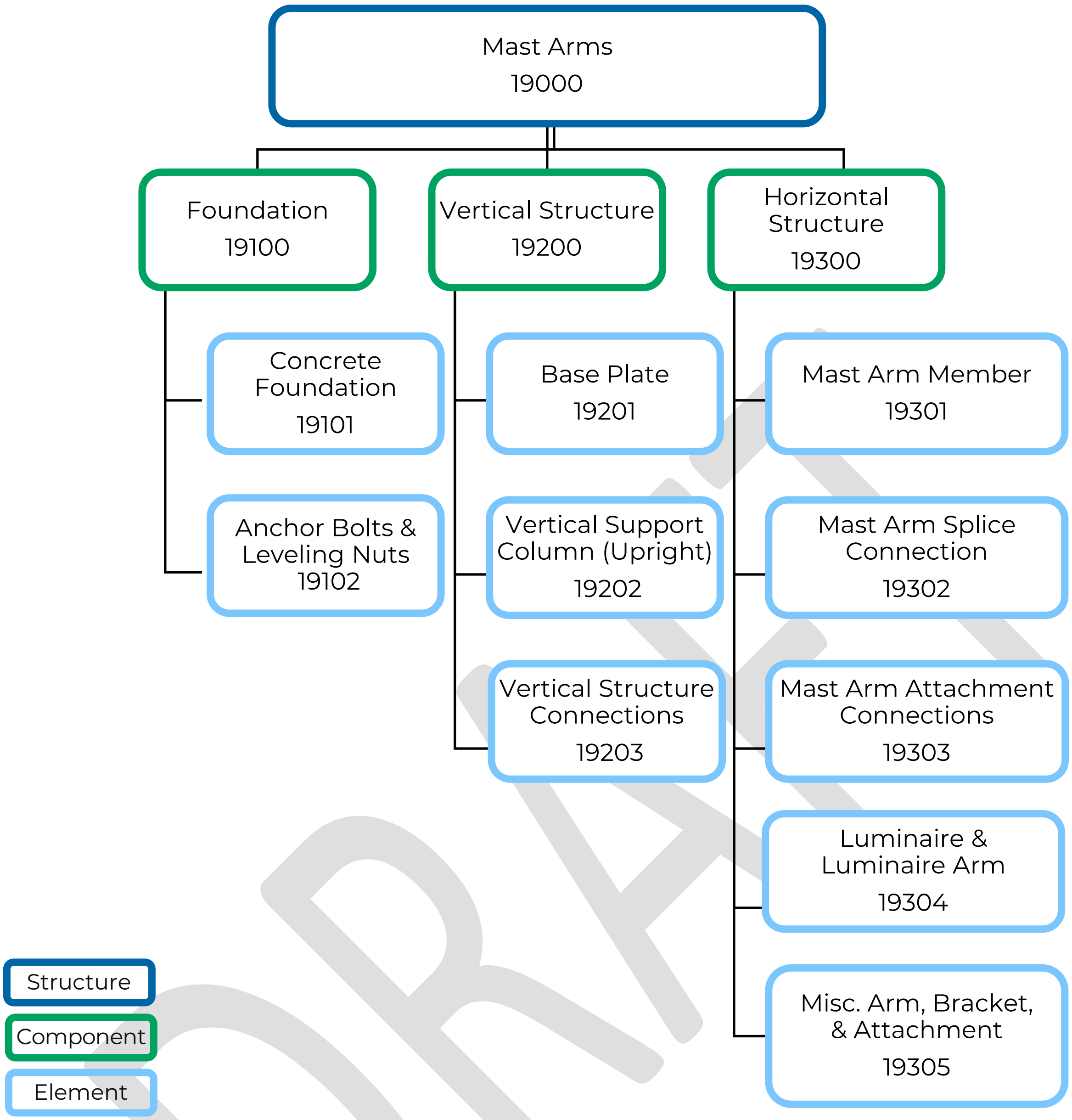

Figure 9-4: Rating structure for Mast Arms

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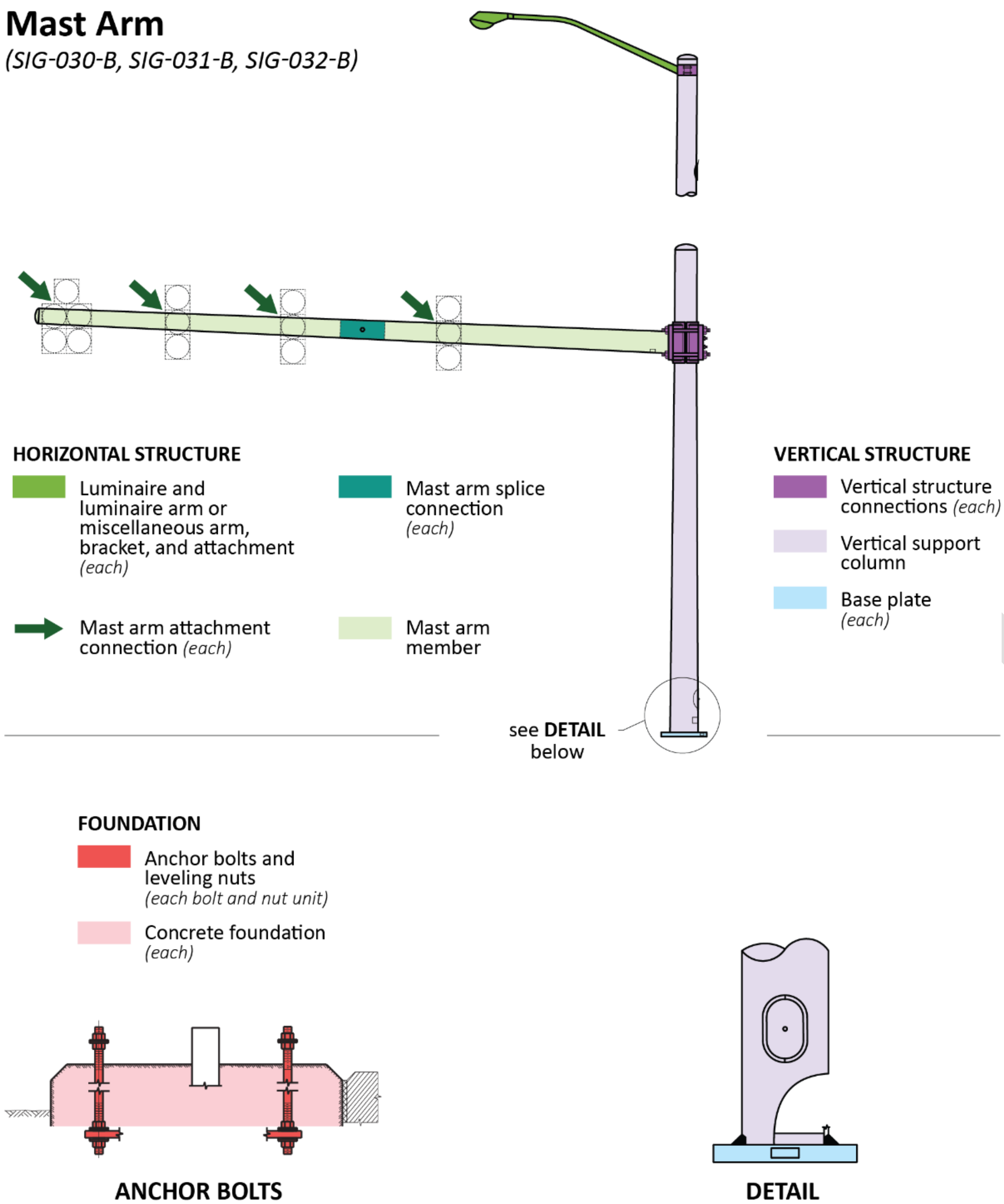

Figure 9-5: Elements and components for Mast Arm

9.2 Inventory Record Photographs

Inventory photos are captured during a routine inspection, saved as part of the inventory database, and follow the naming convention in *Table 9-2*.

Mast Arm Required Photos:

- General view of the entire structure
- Each foundation
- Each vertical-to-horizontal connection
- Structure number stenciled on support

Table 9-2: Mast Arm Photograph Naming Convention

Photo Name	Description
MastArm_Entire	Entire Mast Arm structure
MastArm_Foundation	Foundation
MastArm_VH_Connection	Vert-Horiz Connection
MastArm_Lum	Luminaire and Luminaire Arm
MastArm_ID	Old ID and New ID
MastArm_Attachment Name	Replace "Attachment Name" with attachment or appurtenance (e.g., sensor, camera, etc.)

9.3 Inspector Minimum Technical Qualifications

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

- A minimum experience of two projects with a minimum of 20 structures total inspecting Mast Arms or other truss structures. Multiple structure types shall have been inspected as part of the total project experience. Bolt inspection on cantilever or truss structures or other ancillary structure types is required as part of the total project experience.
- Ancillary structures inspection procedures training.
- Working knowledge of inspection tools, their use, application, and limitations for the structure type being inspected
- 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
- MDOT structural bolting workshop for initial field installation verification
- 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

9.4 Routine Inspection

Mast Arms are also referred to as traffic signal mast arms. They serve a similar role to steel strain poles, supporting traffic signals along with signs, luminaires, and other appurtenances. Damage or deterioration of mast arm structures may impact function or safety.

In most cases, mast arms are placed at intersections. They are supported on drilled shaft foundations and connected to the foundations with either four or six anchor bolts.

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Mast Arm standard inspection frequency is once every 4 years, unless otherwise identified for more frequent inspection.

Table 9-3 provides guidance for inspecting reinforced and prestressed concrete cracking.

Table 9-3: 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)

9.4.1 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:

- Check around the foundation for erosion or soil displacement, and for any voids between concrete and soil.
- If sidewalk or other material covers the material surrounding the foundation check for signs of separation, settlement, or cracking at the surface.
- Check for signs of vehicle impact that may have damaged the foundation concrete or the anchor bolts.
- Inspect the foundation concrete for cracking, spalling, delamination, or other defects measuring sizes or quantities. Pay particular attention to the condition of the concrete immediately around the anchor bolts.
- Measure the anchor bolt standoff distance and check for any damage or corrosion of the bolts and nuts.

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- Inspect the anchor bolt connections to the base plate. Note if any of the anchor bolts are out of vertical alignment and if any of the nuts have anything less than full bearing.
- Sound the anchor bolts and nuts to check for looseness. Note if any washers are missing or incorrectly sized.
- Perform ultrasonic testing of the anchor bolts to note any breaks, verify lengths, and repair galvanizing afterwards.
- Rate Component.
- Rate Elements.
- Provide photographs for all Poor or Severe condition state defects and submit the applicable Work Recs or RFAs.

9.4.1.1 Foundation Component Ratings

The mast arm's foundation overall characteristics are rated on its structural condition, ability to support the vertical structure, and possible negative impact to the entire structure, its operation, or the adjacent roadway. The foundation concrete, anchor bolts, and anchor bolt connection to the pole base plate are all considered as part of the component rating. When evaluating distresses consider that different distresses and the location on the foundation at which they occur are not of equal importance to the pole's function. The predominant characteristic determining overall condition is stability. Consider if the foundation has stable support from the soil, solid and durable concrete, and securely fastened anchor bolt connections.

Table 9-4: Component Rating Guidelines for Mast Arm Foundations

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.

Component Rating	Condition	Material	Description
		Steel	Minor damage or worn galvanizing of anchor bolt connections.
5	FAIR	All	Minor deterioration affecting structural components. Minor misalignment.
		Concrete	Moderate delamination or spalling.
		Soil	Moderate displacement or erosion of soil. Minor gaps may be present between pole and embedment material.
4	POOR	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.
		Concrete	Considerable cracking and spalling.
		Soil	Considerable displacement or erosion of soil.
		Steel	Less than 25% loss of section. Fasteners may be considerably deteriorated.
		All	Considerable deterioration or misalignment affecting structural members. Considerable impact damage. 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 pole and embedment material.
		Steel	Protective coating failure affecting more than 10% of the surface area with Measurable loss of section in excess of 25%. Missing, cracked, or broken fasteners that do not warrant a structural review.
		All	Considerable deterioration or damage affecting structural members. Structural evaluation, hydraulic, and/or load analysis may be 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.

Component Rating	Condition	Material	Description
0	FAILED	All	Road is closed due to condition. Notify Region and the Bureau of Bridges and Structures.

9.4.1.2 Concrete Foundation Element Condition States

Inspectors shall start by inspecting the condition of the soil around the foundation noting any erosion or settlement that could impact the foundation. A gap between the foundation and adjacent soil may indicate foundation movement. Inspect the concrete for cracking, spalling, and delamination noting the quantities and locations. Check for exposed or corroded reinforcing steel. Pay special attention to the concrete immediately surrounding the anchor bolts. Older foundations may be square in shape while current standards specify a circular drilled shaft. Look for signs of impact damage.

Figure 9-6: Six anchor bolt concrete foundation

Table 9-5: Mast Arm Concrete Foundations Element Distresses

Element Number	Element	Description	Associated Distresses
19101	Concrete Foundation	Mast arm pole foundations	Cracking
			Spalling, delamination, and patching
			Exposed rebar
			Embedment erosion
			Impact damage
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.			

Details on the condition state rating schema are in Section 9.7, linked below:

Mast Arm Condition State Tables

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9.4.1.3 Anchor Bolts and Leveling Nuts Element Condition States

The anchor bolt connection is a key element of the mast arm structure and frequent location of deficiencies. The anchor bolts should be plumb with all nuts tightly affixed to the base plate and the center of the connection should be centered on the foundation. The standoff distance – the distance from the top of the concrete foundation to the bottom of the leveling nut should not exceed one inch for each anchor bolt. Flat washers should be placed between each nut and the base plate and completely cover the holes in the base plate. All washers and nuts should bear fully around their perimeter. Anchor bolts for a mast arm are pre-tensioned, meaning the nuts are tightened to produce a prescribed tension between the top nut and leveling nut at installation. This tension exceeds the stress that they would see under in-service loads and therefore prevents loosening and improves fatigue performance. Ultrasonic testing and sounding of the anchor bolts are required for all mast arm anchor bolts. The procedure is referenced in Section 4.4.5.

The top nuts shall be fully engaged on the anchor rod, which means the top of the anchor rod is flush or higher than the top of the nut. Inspect the connection for any signs of impact damage, including bent anchor bolts or damaged threads. Inspect the galvanizing of all components and note corrosion. Nut covers may be present covering the top nuts of the connection. These were used to protect the connection but are a detriment as they retain moisture and debris and can accelerate corrosion; they are no longer permitted.

Table 9-6: Mast Arm Anchor Bolt and Leveling Nuts Element Distresses

Element Number	Element	Description	Associated Distresses
19102	Anchor Bolts and Leveling Nuts	Anchor bolts and leveling nuts	Corrosion or coating damage
			Loose or missing anchor nut
			Cracked bolt
			Standoff distance
			Impact damage
Unit of Measure: Each, note quantity of anchor bolt and nut units within each condition state			

Details on the condition state rating schema are in Section 9.7, linked below:

Mast Arm Condition State Tables

Figure 9-7: Four anchor bolt foundation with excessive standoff distance and corrosion

9.4.2 VERTICAL STRUCTURE ROUTINE INSPECTION

Routine inspection of the vertical structure is conducted from the ground and a bucket truck as needed to inspect the pole and pole connections. All elements of the component shall be visually inspected at an arm's length distance to determine the overall condition and detect deficiencies.

- 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 pole with a 4 ft level or similar. Note that some poles 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, powder coated, and/or paint and note any corrosion or section loss.
- An ultrasonic testing device or thickness gauge should be used to verify the wall thickness when significant corrosion is present.
- Check for any cracks or deformations in the steel noting the size of deficiencies.
- Verify the handhole cover is securely fastened in place and check for cracks around the frame of the handhole.
- 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 – mast arms, luminaire arms, and other arms. This includes band clamps, brackets, and other bolted

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assemblies. Check for connections that are loose, missing, deteriorated or otherwise deficient.

- Pay particular attention to the mast arm connections to the pole: 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.
- Provide photographs for all Poor or Severe condition state defects and submit the applicable Work Recs or RFAs.

9.4.2.1 Vertical Structure Component Ratings

The mast arm's vertical structure overall characteristics are rated on its structural condition, ability to support the horizontal structure, and possible negative impact to the entire structure, its operation, or the adjacent roadway. The base plate and base plate to pole connection, pole structure, and connections to the pole are all considered as part of the component rating. When evaluating distresses consider that different distresses and the location on the structure at which they occur are not of equal importance to the pole's function. The predominant characteristics determining overall condition are stability and resiliency. Consider if the pole has stable support in the embedment material, a robust and consistent pole cross-section, and the horizontal structure is securely fastened.

Table 9-7: Component Rating Guidelines for Mast Arm Vertical 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.

Component Rating	Condition	Material	Description
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.
		Steel	Protective coating failure and less than 25% loss of section. Cracks may be present. Welded connection deficiencies 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.
3	SERIOUS	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%. Extensive welded connection deficiencies may be present. 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 condition. Notify Region and the Bureau of Bridges and Structures.

9.4.2.2 Base Plate Element Condition States

The base plate is part of the anchor bolt connection but is connected to the pole with a full penetration weld and considered part of the vertical structure along with the pole and its vertical structure connections. The base plate should be checked for warping, and corrosion. Pay particular attention to the weld between the base plate and pole and look for any cracks or weld deficiencies. A crack will typically appear in the galvanizing and may or may not extend into the weld metal. Additional non-destructive testing may be required to determine the extent of any cracks.

Figure 9-8: Mast arm base plate with four anchor bolts

Table 9-8: Mast Arm Base Plate Element Distresses

Element Number	Element	Description	Associated Distresses
19201	Base Plate	Base plate for mast arm	Corrosion or coating damage
			Weld defect or crack
Unit of Measure: Each, percentage of base plate within each condition state			

Details on the condition state rating schema are in Section 9.7, linked below:

Mast Arm Condition State Tables

9.4.2.3 Vertical Support Column (Upright) Element Condition States

Mast arm poles are typically 30 ft in length and may be round or multi-sided. The poles should be checked for any vertical misalignment with a 4 ft level or similar, keeping in mind that poles may be tapered and multiple checks around the perimeter of the pole may be necessary. A hand hole is located near the base of the pole to allow for access to electrical components and there are typically additional electrical entry and exit ports higher on the pole. The handhole should be free from excess moisture and debris. The handhole cover should be securely fastened, and the hand hole frame inspected for any cracks in the welds or base metal, along with any other welded components. The poles are hot dip galvanized and may have a single or multi-coat paint system on top of the galvanizing for aesthetic treatment. Any corrosion should be noted and if there is significant corrosion, the pole wall thickness should be checked for section loss with a thickness gauge or ultrasonic testing device. Inspect the length of the pole for impact damage and cracks and note that multi-sided poles have a longitudinal weld the length of the pole.

Figure 9-9: Mast arm impact damage and coatings repair

Table 9-9: Mast Arm Vertical Support Column (Upright) Element Distresses

Element Number	Element	Description	Associated Distresses
19202	Vertical Support Column (Upright)	Vertical Support (Upright) for mast arm	Corrosion or coating damage
			Weld defect or crack
			Out of plumb
			Impact damage
			Handhole defects
Unit of Measure: Length, feet of vertical support within each condition state			

Details on the condition state rating schema are in Section 9.7, linked below:

[Mast Arm Condition State Tables]

9.4.2.4 Vertical Structure Connections Element Condition States

For the vertical structure connections element consider all connections to the pole structure. There are several different types of connections that may be present. The primary connections to inspect are the mast arm member to pole connections. There may also be connections for luminaire arms or other arms supporting cameras or other miscellaneous

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attachments or appurtenances. In general, any steel portions of a connection should be securely in place, and free of corrosion, excess wear, missing pieces, cracks, or other deterioration. For attachments like cabinets and sensors the steel straps connecting the attachments directly to the pole are rated, and if they are failing or in some way pose a safety risk they should be noted.

Mast arm members are usually connected to the pole with saddle clamps. The two halves of the clamps are tightened against the pole with bolting assemblies on either side. Additional bolts connect the back of the clamp through the pole wall. The saddle clamp connections are reinforced with several gusset plates and associated welds Consider the typical steel deterioration modes and inspect the clamps for any distortion, cracks, or weld deficiencies. Luminaire arms or other miscellaneous arms (for cameras or other sensors) used to connect attachments to the pole may use bracket assemblies or other types of steel connections. Consider the typical steel and fastener deterioration modes for these connections.

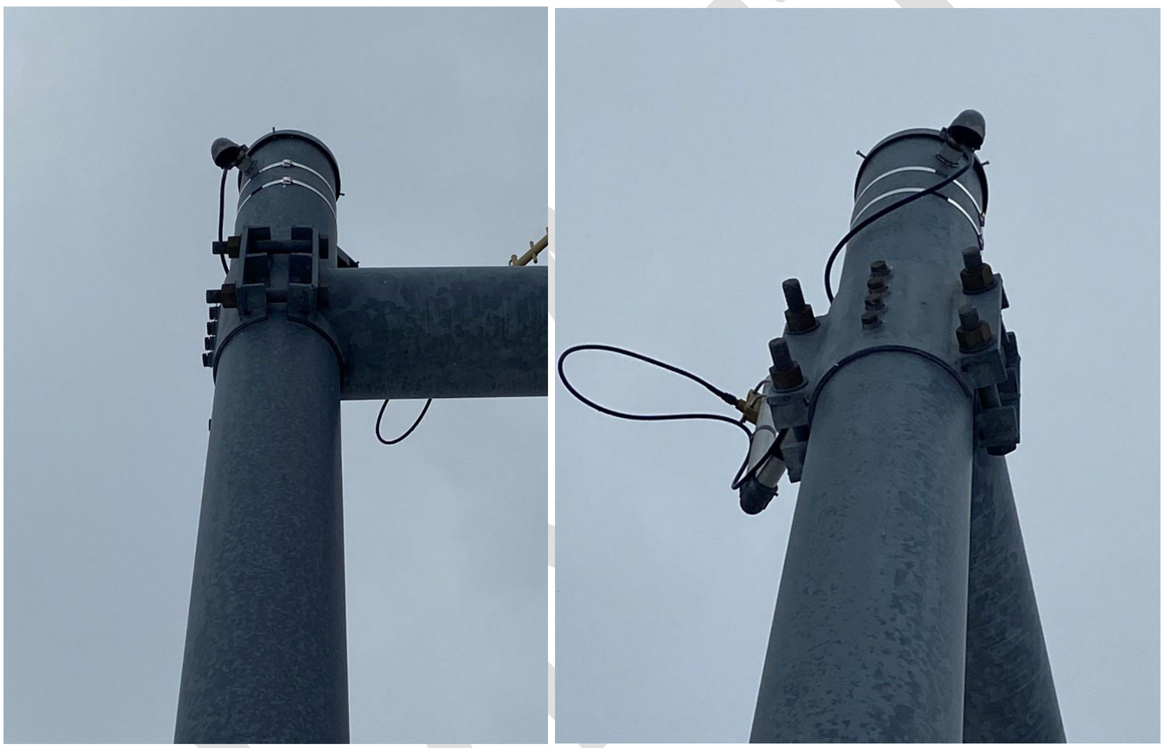

Figure 9-10: Mast arm to pole vertical structure connection, saddle clamp type

Figure 9-11: Mast arm to pole vertical structure connection, welded box type

Figure 9-12: Mast arm vertical structure connection, note missing vertical weld on gusset plate

Table 9-10: Mast Arm Vertical Structure Connection Element Distresses

Element Number	Element	Description	Associated Distresses
19203	Vertical Structure Connection	Bracket assemblies, pole band clamps, stainless steel straps, through bolts, or other connections to mast arms	Weld defects or cracks Corrosion or coating damage Loose, missing, or failing hardware
Unit of Measure: Each connection quantity within the condition state			

Details on the condition state rating schema are in Section 9.7, linked below:

Mast Arm Condition State Tables

9.4.3 HORIZONTAL STRUCTURE ROUTINE INSPECTION

Routine inspection of the horizontal structure is conducted from the ground or using a bucket truck. Inspectors shall:

- Inspect the vertical clearance of the horizontal structure and its attachments, the alignment, and the operational function.
- Check for corrosion or section loss on the mast arms or any other portions of the horizontal structure.
- Inspect arms for any cracked welds or other deterioration.
- Inspect mast arm splices for any signs of displacement or deterioration. Verify splice connections are securely fastened. Verify slip connections are secure and do not have any cracks.
- Check signals and other 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.

9.4.3.1 Horizontal Structure Component Ratings

The mast arm's horizontal structure overall characteristics are rated on its structural condition, ability to support the connected attachments, and possible negative impact to the structure's operation and the roadway below. The mast arm members, other arms, and the attachment connections to them, in addition to the internal arm splice connections are all considered as part of the component rating. When evaluating distresses consider that different distresses and the location on the structure at which they occur are not of equal importance to the horizontal structure's function. The predominant characteristic determining overall condition is resiliency. Consider if the mast arm members have a robust and consistent cross-section, the internal connections are secure, and the attachments are securely connected.

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Table 9-11: Component Rating Guidelines for Mast Arm 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.
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 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. Welded connection deficiencies may be present. 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%. Extensive welded connection deficiencies may be present.

Component Rating	Condition	Material	Description
			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 to condition. Notify Region and the Bureau of Bridges and Structures.

9.4.3.2 Mast Arm Member Element Condition States

Mast arm members are typically 20-50 ft in length and may be constructed of several sections spliced together. Some mast arm structures may have multiple arms. For the mast arm member element condition consider the alignment of the arms and their structural and material conditions. Alignment is checked visually and any excess deflection, or rotation of the arm should be noted. Check for excess movement under wind loading. The alignment can be deceptive so make sure to check from multiple angles. Check the arm for missing arm cap, any impact damage or other deformation and cracking. Inspect the coating, which may be hot dip galvanizing or hot dip galvanizing covered in paint for deterioration and corrosion. Any attachment connected to the mast arm member should have a minimum vertical clearance to the top of pavement of 17 ft. While this may not be able to be measured, note and report any vertical clearance that looks out of the ordinary.

Figure 9-13: Mast arm structure with single arm

Table 9-12: Mast Arm Member Element Distresses

Element Number	Element	Description	Associated Distresses
19301	Mast Arm Member	Inboard and outboard arm sections of a traffic signal mast arm	Corrosion or coating damage
			Weld defect or crack
			Impact damage
			Misalignment
			Missing arm cap
Unit of Measure: Each mast arm within the condition state			

Details on the condition state rating schema are in Section 9.7, linked below:

Mast Arm Condition State Tables

9.4.3.3 Mast Arm Splice Connection Element Condition States

Many mast arm members contain a telescopic field splice, which may be located at any point along the arm. When referring to the two sections being spliced, the larger diameter arm is called the outboard arm, while the smaller diameter arm being seated inside the outboard arm is called the inboard arm. The field splices should have a horizontally mounted connection bolt securing the two arms together. Inspect the splice for any wear, corrosion, cracking, or damage and make sure the connection bolt is securely in place.

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Figure 9-14: Mast arm member splice with connection bolt

Table 9-13: Mast Arm Splice Connection Element Distresses

Element Number	Element	Description	Associated Distresses
19302	Mast Arm Splice Connection	Field splices, splice bolts	Corrosion or coating damage
			Cracking
			Impact damage
			Missing or loose bolt

Unit of Measure: Each connection within the condition state

Details on the condition state rating schema are in Section 9.7, linked below:

[Mast Arm Condition State Tables](#)

9.4.3.4 Mast Arm Attachment Connections Element Condition States

Attachments connected to the mast arm member include signals, signs, cameras, sensors, or other appurtenances. The attachments may be connected using various brackets and fixtures which may be welded or bolted. Consider the typical steel and fastener deterioration modes for these connections: loose connections, wear, corrosion, cracking, and deformation. The signals, signs, and appurtenances themselves are rated and if there is noticeable deterioration that could impact safety, it should be reported.

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Figure 9-15: Mast arm signal and sign attachment connections

Table 9-14: Mast Arm Attachment Connections Element Distresses

Element Number	Element	Description	Associated Distresses
19303	Mast Arm Attachment Connections	Signal head hangers, case sign attachments, camera or other ITS attachment connections	Corrosion or section loss Loose, missing, or cracked hardware Deformed or worn parts
Unit of Measure: Each connection quantity within the condition state			

Details on the condition state rating schema are in Section 9.7, linked below:

Mast Arm Condition State Tables

9.4.3.5 Luminaire and Luminaire Arm Connections Element Condition States

Luminaires are usually mounted on a luminaire arm but may also be mounted directly on the pole or using some other pole mounting device. The arms are typically the single member type. Note that the bracket assembly or band clamps or other method of attaching the luminaire arm to the pole is considered part of the vertical structure connections element. The arms should be inspected for steel condition and the condition of any welds. The condition of the luminaire connection to the arm mounting device should be inspected for material defects and connection type defects such as looseness and wear. The luminaire itself includes the light source, any fixtures or assemblies, and the housing. Note any visibly broken portions of the luminaire.

Figure 9-16: Mast arm structure supporting signals, sign, luminaire, camera, and sensor

Table 9-15: Mast Arm Luminaire and Luminaire Arm Element Distresses

Element Number	Element	Description	Associated Distresses
19304	Luminaire and Luminaire Arm	Lighting sources, fixtures and assemblies, bracket arms, truss arms, tenon mounts, shepherds crooks, or other pole mounting devices	Broken lighting source or assembly
			Damaged or cracked housing, cover
			Corrosion or section loss
			Weld cracks/defects
			Deteriorated gasket/seal
Unit of Measure: Each luminaire and luminaire arm within the condition state			

Details on the condition state rating schema are in Section 9.7, linked below:

Mast Arm Condition State Tables

9.4.3.6 Miscellaneous Arm, Bracket, and Attachment Element Condition States

Attachments or appurtenances may be mounted on a bracket or arm but may also be mounted directly on the pole, the mast arm, on a tenon, or using some other pole mounting device. The arms may be a single member type or truss type. Note that the bracket assembly or other method of attaching the miscellaneous bracket or arm to the pole is considered part of the vertical structure connections element. The miscellaneous arms, brackets, and attachments should be inspected for steel condition and the condition of any welds. The condition of the attachment connection to the bracket, arm, or tenon should be inspected for material defects and connection type defects such as looseness

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and wear. Cameras and other sensors may also be attached to the pole using the same types of arms and connections as luminaires.

Table 9-16: Embedded Pole Miscellaneous Arm, Bracket, and Attachment Element Distresses

Element Number	Element	Description	Associated Distresses
19305	Miscellaneous Arm, Bracket, and Attachment	Power sources, fixtures and assemblies, bracket arms, truss arms, tenon mounts, shepherds crooks, or other pole mounting devices	Broken power source or assembly
			Damaged or cracked housing, cover
			Corrosion or section loss
			Weld cracks/defects
			Deteriorated gasket/seal
Unit of Measure: Each miscellaneous arm, bracket, and attachment within the condition state			

Details on the condition state rating schema are in Section 9.7, linked below:

Mast Arm Condition State Tables

9.4.4 REFERENCES

MDOT Traffic and Safety Standards and Special Details

SIG-030-series Traffic Signal Mast Arm Pole and Mast Arm Details – Category I

SIG-031-series Traffic Signal Mast Arm Pole and Mast Arm Details – Category II

SIG-032-series Traffic Signal Mast Arm Pole and Mast Arm Details – Category III

SIG-040-series Traffic Signal Mast Arm Standard Foundations

SIG-301-series Mast Arm Mounted T.S. Bracket Assembly

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9.5 Work Recommendation Guidance

The Work Recs are not meant to be all-inclusive and other Work Recs may be added to supplement those noted.

Photographs should include sufficient information to determine the relationship of the defect to the element or component or entire structure. Close-up photos of each defect with connection deficiencies marked on the photo should be provided.

Table 9-17: Work Recommendations for Mast Arms

Number	Description of Work Recommendation	Material involved	Quantity/Unit of Measure
1	Repair guardrail (protecting pole)	Galvanized Steel	Linear feet
2	Correct erosion at foundation (prevent undermining)	Stone/Soil	Cubic feet
3	Repair/monitor foundation	Concrete	Cubic feet
4	Repair/replace handhole cover	Galvanized Steel	Each cover
5	Remove non-MDOT or unauthorized attachments to structures	Various	Each item
6	Remove graffiti	n/a	Square foot
7	Repair galvanizing	Galvanic Paint	Square inch
8	Repair protective coatings system	Metal Coatings System	Square foot
9	Tighten leveling nut	Galvanized Steel	Each nut
10	Address loose bolts	Galvanized Steel	Each bolt
11	Weld repair	Steel	Each weld
12	Replace mast arm	Galvanized Steel	Each mast arm
13	Replace mast arm splice bolt	Galvanized Steel	Each bolt
14	Replace mast arm attachment connection	Galvanized Steel	Each attachment connection
15	Replace end cap	Galvanized Steel	Each cap
16	Replace end cap bolt	Galvanized Steel	Each bolt
17	Replace connectors such as clevis pins or other	Galvanized Steel	Each connector
18	Replace luminaire	Various	Each luminaire
19	Replace luminaire arm	Galvanized Steel	Each attachment
20	Replace luminaire arm clamp	Galvanized Steel	Each clamp
21	Replace bracket assembly	Galvanized Steel	Each assembly
22	Replace signal head	Various	Each signal head

Number	Description of Work Recommendation	Material involved	Quantity/Unit of Measure
23	Replace case sign	Various	Each sign
24	Replace misc. attachment	Various	Each attachment
25	Replace miscellaneous arm or bracket	Various	Each arm or bracket
26	Replace fatigue mitigation device	Various	Each device
99	Other		

9.6 Request for Action Guidance

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, 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 lateral displacement or vertical out of plumb alignment
c. Major section loss due to corrosion which impacts the capacity or short-term resiliency of the structure
d. Major base plate distortion or section loss around anchor bolts
e. Standoff distance more than twice the bolt diameter, where bending of anchor bolts is evident
f. Multiple loose or missing bolts in a high strength bolted connection, anchor bolt connection, or in attachment connection assemblies
g. Multiple loose or missing bolts where connections do not have load-path redundancy and bolt tensioning is not possible
h. Major cracks present in the base metal or weld(s) on the base plate to column connection or for single column supports or the column to mast arm connection
i. Cracked or failing tenon/bracket assembly/luminaire or miscellaneous attachment mounting device
j. 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 as opposed to a heavily corroded-cracked surfaces which have been present for some time
k. Major cracking or failing splice connection in a mast arm
l. 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

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Priority 2 Level Items

a. Significant foundation deterioration including concrete cracking/spalling/delamination, steel reinforcement corrosion and section loss
b. Significant soil erosion or undermining of the foundation
c. Pole is significantly out of vertical alignment
d. Significant base plate distortion or section loss around anchor bolts
e. Standoff distance more than twice the bolt diameter where no bending of anchor bolts is evident
f. Anchor nuts are engaged with some gaps and/or bolts are misaligned
g. Loose bolts in a high strength bolted connection, anchor bolt connection, or in attachment connection assemblies where there is acceptable load-path redundancy, but significant impact to capacity or durability
h. Loose or missing hardware or miscellaneous attachment, significant section loss, or displacement of a mast arm field splice
i. Significant corrosion of primary elements or connections is present
j. 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
k. Structural cracks in secondary members that could potentially propagate through welded connections into main members
l. Significantly loose or misaligned tenon/bracket assembly/luminaire mounting device
m. 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
c. Pole is moderately out of vertical alignment
d. Moderate corrosion of primary elements or connections is present
e. Moderate base plate distortion or section loss around anchor bolts
f. Standoff distance more than one inch but less than twice the bolt diameter where no bending of anchor bolts is evident
g. Misaligned tenon/bracket assembly/luminaire mounting device
h. Moderate weld deficiencies, which do not meet code but do not impact function where significant redundancy is also present
i. Loose connections where there is adequate redundancy and moderate impact to structural capacity or durability
j. Moderate structural damage to foundation, anchor bolts, upright, or other elements, which moderately impacts capacity or function, clearance, safety, or durability of the structure

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9.7 Element Condition States

Element Number	Element	Condition States Defects Note	Link to Discussion in Section 9
19101	Concrete Foundation	Use the appropriate condition state table	Concrete Foundation Element Condition States
19102	Anchor Bolts and Leveling Nuts	Use the appropriate condition state table. Use UT testing result to assist in the condition assessment	Anchor Bolts and Leveling Nuts Element Condition States
19201	Base Plate	Use the appropriate condition state table	Base Plate Element Condition States
19202	Vertical Support Column	Use the appropriate condition state table	Vertical Support Column (Upright) Element Condition States
19203	Vertical Structure Connections	Use the appropriate condition state table	Vertical Structure Connections Element Condition States
19301	Mast Arm Member	Use the appropriate condition state table	Mast Arm Member Element Condition States
19302	Mast Arm Splice Connection	Use the appropriate condition state table	Mast Arm Splice Connection Element Condition States
19303	Mast Arm Attachment Connections	Use the appropriate condition state table	Mast Arm Attachment Connections Element Condition States
19304	Luminaire and Luminaire Arm Connections	Use the appropriate condition state table	Luminaire and Luminaire Arm Connections Element Condition States
19305	Miscellaneous Arm, Bracket, and Attachment	Use the appropriate condition state table	Miscellaneous Arm, Bracket, and Attachment Element Condition States

Element 19101 – Concrete Foundation

Description	This element defines a concrete foundation for a mast arm pole, 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 or damage. Superficial cracking, discoloration, or efflorescence may be present. No exposed reinforcing.	Minor cracks and/or spalls may be present in the concrete. No exposed reinforcing, embedment erosion, or impact damage.	Moderate cracks and/or spalls may be present. Some reinforcing may be exposed. Incidental loss of section or surface pitting of reinforcing may be present. Element shows evidence of some embedment erosion or impact damage.	Major cracks and/or spalls are present. Major corrosion of exposed reinforcing. Extensive steel and/or concrete loss of section. Embedment erosion or major impact damage is present.

Element 19102 – 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 or damage. The elements are fully engaged. Anchor bolt standoff distance is less than 1".	Minor corrosion of the elements may be present. The elements are fully engaged and functioning as intended. 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 may not be fully tightened. Anchor bolt standoff distance is greater than 1" but less than two times the bolt diameter. Evidence of minor impact damage may be present	Severe corrosion/section loss of the elements may be present. Multiple nuts are loose/missing. Anchor bolt standoff distance is greater than two times the bolt diameter. UT testing indicates major cracks or breaks in bolts. Evidence of major impact damage may be present.

Element 19201 – 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 measured as "each."			
	Condition State Descriptions			
Defect Type	**Good**	**Fair**	**Poor**	**Severe**
Base Plate Defects	No evidence of active corrosion or weld defect. Surface coating is sound.	Minor surface corrosion may be present. Base element welds have no evidence of defects.	Moderate corrosion/ 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.	Major corrosion/section loss is present. Base element welds may have cracks/defects. Base plate has moderate to major warping.

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Element 19202 – Vertical Support Column (Upright)

Description	This element is defined by all upright supporting mast arms, 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. 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.

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Element 19203 – Vertical Structure Connections

Description	This element consists of the connections along the mast arm for various attachments. Connections may include bracket assemblies, pole band clamps, stainless steel straps, through bolts, or other connections.			
Quantity Calculation	The quantity to be collected includes each connection location.			
	Condition State Descriptions			
Defect Type	**Good**	**Fair**	**Poor**	**Severe**
Vertical Structure Connection Defects	Pole clamps, saddles, bracket assemblies, and other connection hardware are functioning as intended with no evidence of wear or corrosion.	Minor surface corrosion or wear may be present. Pole clamps, saddles, bracket assemblies, and other connection hardware are functioning as intended.	Moderate corrosion/section loss or wear is present. Pole clamps, saddles, bracket assemblies or other connection hardware may be loose, but the conditions do not significantly affect serviceability and/or function.	Major corrosion/section loss is present. Protective coatings are significantly failing. Members may have cracks/defects or major wear. Pole clamps, saddles, bracket assemblies or other connection hardware are loose or failing.

Element 19301 – Mast Arm Member

Description	This element consists of the inboard and outboard arm sections of a traffic signal mast arm.			
Quantity Calculation	The quantity for this element is measured as "each."			
	Condition State Descriptions			
Defect Type	**Good**	**Fair**	**Poor**	**Severe**
Mast Arm Member Defects	New or like-new condition with no deficiencies. Arm cap is not missing.	Minor corrosion or superficial damage may be present. Arm cap may be missing. No weld defects or cracks.	Moderate corrosion and section loss or damage is present. Arm cap may be missing. No weld defects or cracks. Arm may be misaligned.	Multiple or major element defects or section loss is present. Arm is excessively misaligned. Major impact damage may be present.

Element 19302 – Mast Arm Splice Connection

Description	This element is defined field splices and splice bolts connecting mast arms.			
Quantity Calculation	The quantity to be collected is the number of spliced connections.			
	Condition State Descriptions			
Defect Type	**Good**	**Fair**	**Poor**	**Severe**
Mast Arm Splice Connection	New or like-new condition with no deficiencies	Minor surface corrosion or superficial damage may be present.	Moderate corrosion/ section loss or wear is present. Bolt and splice may be loose or damaged but are functioning as intended.	Major corrosion/section loss is present. Protective coatings are failing. Members may have cracks/defects or major wear. Splice bolt may be missing.

Element 19303 – Mast Arm Attachment Connections

Description	This element is defined by the Signal head hangers, case sign attachments, camera or other ITS attachment connections to the mast arm.			
Quantity Calculation	The quantity to be collected is the number of connections for span wires.			
	Condition State Descriptions			
Defect Type	**Good**	**Fair**	**Poor**	**Severe**
Mast Arm Attachment Connection	New or like-new condition with no deficiencies	Minor corrosion or wear of the elements or superficial damage to the component parts may be present. Hardware is fully engaged. No gaps are present.	Moderate corrosion and section loss or wear/damage is present to one or more component parts. Hardware is fully engaged but gaps may be present. The conditions do not significantly affect serviceability and/or function.	Multiple or major element defects, wear or section loss is present. Gaps are present. Hardware is loose or missing. Major impact damage may be present. Connection is not functioning as intended.

Element 19304 – Luminaire and Luminaire Arm

Description	This element consists of lighting sources, fixtures and assemblies, bracket arms, truss arms, tenon mounts, shepherds crooks, or other pole mounting devices.			
Quantity Calculation	The quantity is collected as each luminaire and luminaire arm unit.			
	Condition State Descriptions			
Defect Type	**Good**	**Fair**	**Poor**	**Severe**
Luminaire and Luminaire Arm	Lighting source, housing/cover, waterproofing-gasket/seal, arm, and connections to pole do not have evident wear or corrosion and are functioning as intended.	Gasket/seal may have minor deterioration. Lighting source, housing/cover, arm, and connections may have minor wear or corrosion.	Gasket/seal may be moderately deteriorated. Lighting source, housing/cover, arm, and connections may have moderate wear or corrosion, but the conditions do not significantly affect serviceability and/or function.	Major deterioration of gasket/seal is present. Lighting assembly or hardware is broken or missing. Major failure of protective coatings or corrosion/pitting/section loss is present. Welds have cracks/defects.

Element 19305 – Miscellaneous Arm, Bracket, and Attachment

Description	This element consists of power sources, fixtures and assemblies, bracket arms, truss arms, tenon mounts, shepherds crooks, or other pole mounting devices.			
Quantity Calculation	The quantity is collected as each miscellaneous arm, bracket, and attachment unit.			
	Condition State Descriptions			
Defect Type	**Good**	**Fair**	**Poor**	**Severe**
Miscellaneous Arm, Bracket, and Attachment	Power source, housing/cover, waterproofing-gasket/seal, and arm do not have evident wear or corrosion.	Gasket/seal may have minor deterioration. Power source, housing/cover, or arm may have minor wear or corrosion.	Gasket/seal may be moderately deteriorated. Power source, housing/cover, or arm have moderate wear or corrosion, but the conditions do not significantly affect serviceability and/or function.	Major deterioration of gasket/seal is present. Assembly or hardware is broken or missing. Major failure of protective coatings or corrosion/pitting/section loss is present. Welds have cracks/defects.

10 DYNAMIC MESSAGE SIGNS (DMS) SUPPORT STRUCTURE

10.1 Definitions

DMS support structures consist of a single vertical support with horizontal arms supporting electronic signs and access walkways. They are galvanized steel structures mounted on a concrete foundation with anchor bolts.

Other common terms which may be used when discussing DMS support structures include:

- **Dynamic Message Sign:** Programmable electronic signs that are located along highways and provide real-time information to drivers.
- **Walkway:** Horizontal steel structures with grating and supporting frame that provide walkable access to the DMS and supporting structure. Walkways may have moveable railings that enable their positioning as needed for inspection and maintenance.

10.1.1 INVENTORY ITEMS

The inspector shall record the height of the vertical support column from the base and the length of the truss arm, both in feet. The inspector shall also identify the type of foundation, e.g., six anchor bolts, twelve anchor bolts, and note the presence of the cabinet and handhole. Take photos of the required inventory items listed in Section 10.2.2.

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

10.1.2 ELEMENTS

DMS support structures are divided into three components: foundation, vertical structure, and the horizontal structure.

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

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

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

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

- Vertical Structure Locations – Distress locations along the DMS structure 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 horizontal arm length are referenced by using offsets measured from the vertical support. Facing the front of the DMS structure, indicate the side of the distress (i.e., left or right) in reference to the vertical support.

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- 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. Identify nodes by number and relative location to front of truss arm, e.g., "UF@N3" for upper front at node 3.

Table 10-1: DMS Support Structure Components and Elements

Component	Element	Element Code	Unit of Measure
Foundation	Concrete Foundation	20101	Each
Foundation	Anchor Bolts and Leveling Nuts	20102	Each bolt and nut unit
Vertical Structure	Base Plate	20201	Each
Vertical Structure	Vertical Support Column (Upright)	20202	Length, feet
Vertical Structure	Vertical Structure Connections	20203	Each
Horizontal Structure	Arm or Truss Members	20301	Each
Horizontal Structure	Horizontal Structure Connections	20302	Each
Horizontal Structure	Sign and Sign Connections	20303	Each
Horizontal Structure	Walkway and Walkway Connections	20304	Each

10.1.3 COMPONENTS

DMS Support Structures are divided into three main components: the foundation, the vertical structure, and the horizontal structure.

Component ratings for DMS Support Structures are based on the following:

- ***Foundation*** – Consider the structure's foundation effect on overall stability of the DMS Support 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, impact damage, corrosion, section loss, or buckling of truss compression members as critical to the overall horizontal structure.

See Section 1.7 for discussion on component ratings, element ratings, and condition states. A representation of the rating structure for DMS support structure is provided in Figure 10-1.

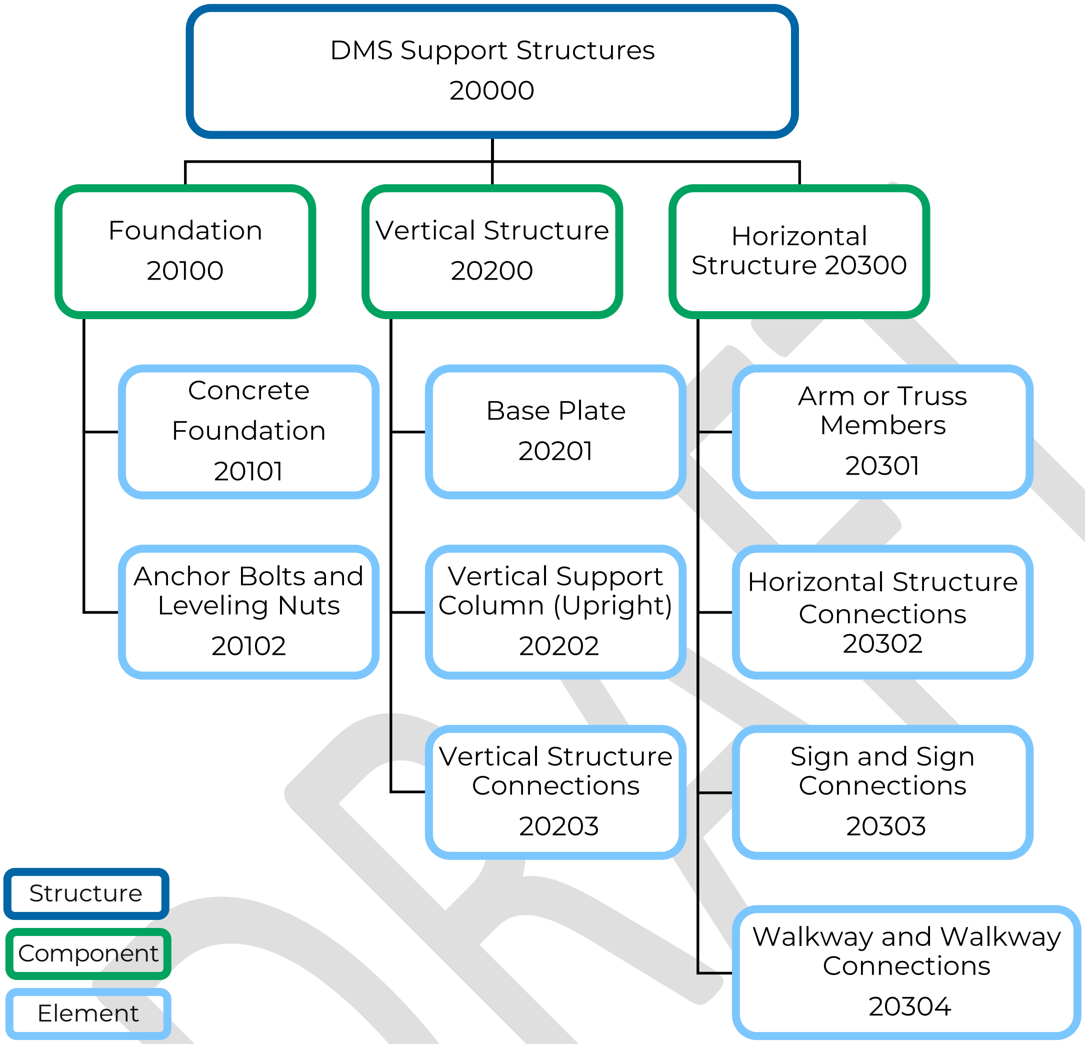

Figure 10-1: Rating structure for DMS Support Structures

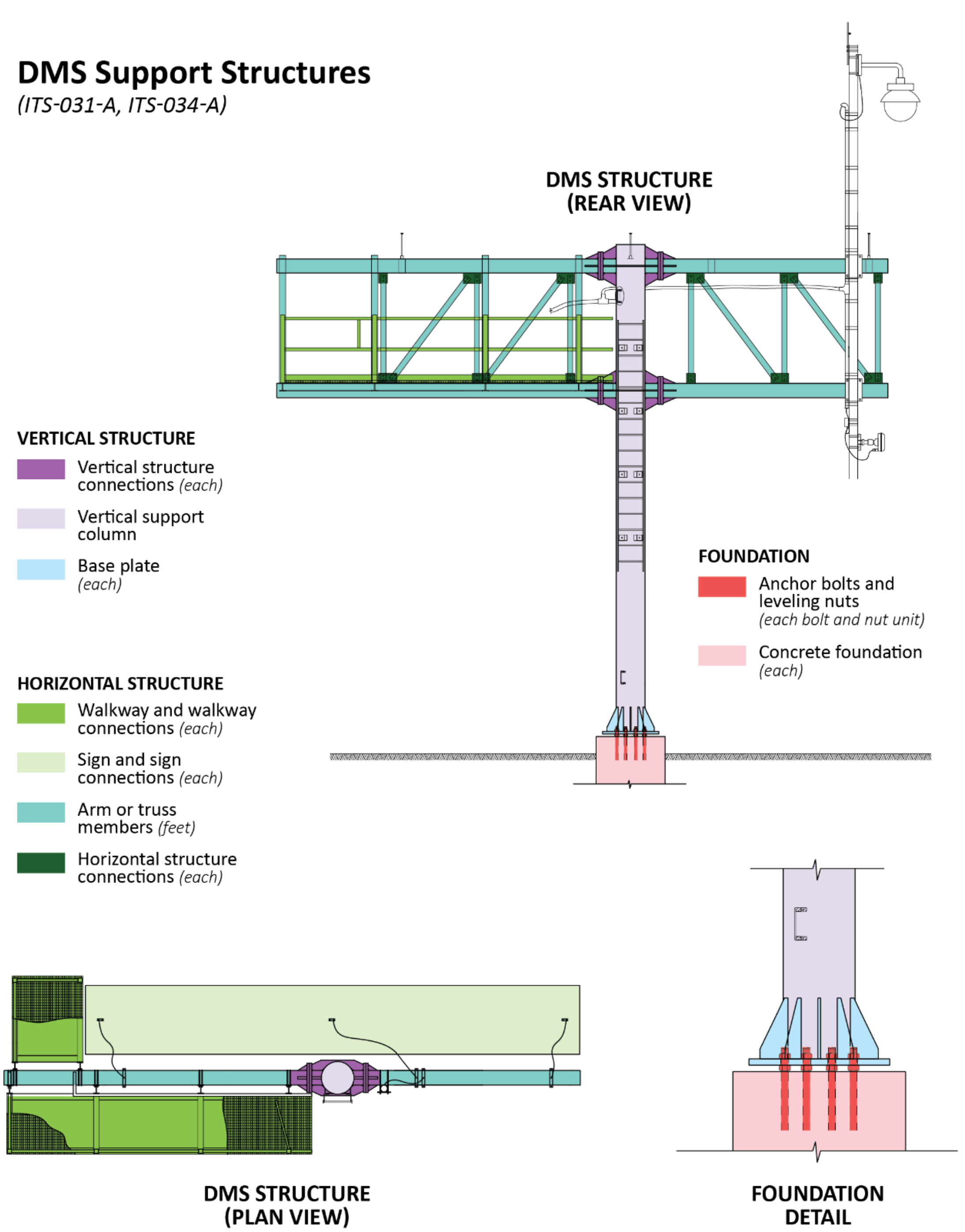

Figure 10-2: Components and elements for DMS Support Structure

10.2 Inventory Record Photographs

Inventory photos are captured during a routine inspection, saved as part of the inventory database, and follow the naming convention in *Table 10-2*.

Dynamic Message Sign Support Structure Required Photos:

- General view of the entire structure

- Each foundation
- Each vertical-to-horizontal connection
- Structure number stenciled on support

Table 10-2: Dynamic Message Sign Support Structure Photograph Naming Convention

Photo Name	Description
DMS_Entire_Front	Entire DMS and Structure from Front
DMS_Entire_Back	Entire DMS and Structure from Back
DMS_Foundation	Foundation
DMS_VH#_Connection*	Vertical to horizontal connection
DMS_ID	Old ID and new structure number
*** 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 photos needed to provide this level of visibility.**	

10.3 Inspector Minimum Technical Qualifications

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

- A minimum experience of two projects with a minimum of 20 structures total inspecting DMS support structures or other cantilevered structures. Multiple structure types shall have been inspected as part of the total project experience. Bolt inspection on cantilever or truss structures, or other ancillary structure types is required as part of the total projectexperience.
- Ancillary structures inspection procedures training
- Working knowledge of inspection tools, their use, application, and limitations for the structure type being inspected
- 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
- MDOT structural bolting workshop for initial field installation verification
- 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

10.4 Routine Inspection

DMS support structure consist of a single vertical support with horizontal truss arms on either/both side of the vertical structure supporting electronic signs and access walkways. They are galvanized steel structures mounted on concrete foundations with anchor bolts. The truss arms are comprised of two or more chords supporting all diagonal and vertical members within the two-dimensional horizontal plane. Loading is transferred from the horizontal members to vertical members through welded and bolted connections.

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

Figure 8.10.1: Dynamic Message Sign Support Structure

Table 10-3 provides guidance for inspecting reinforced and prestressed concrete cracking.

Table 10-3: 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)

10.4.1 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 rod diameter and length, then scan for defects.
- Examine anchor rods for tightness and embedment using a standard inspection hammer. Inspect visually for corrosion, section loss, and plumbness.
- Examine anchor rods for any eccentricity. Note any noticeable eccentricity measurements.
- Perform ultrasonic testing of anchor rods 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.

10.4.1.1 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 10-4: Foundation Component Rating Guidelines for DMS Support 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

Component Rating	Condition	Material	Description
			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 to condition. Notify Region and the Bureau of Bridges and Structures.

10.4.1.2 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 10-5: DMS Support Structure Concrete Foundation Element Distresses

Element Number	Element	Description	Associated Distresses
20101	Concrete Foundation	DMS support structure foundations	Cracking
			Spalling, delamination, and patching
			Exposed rebar
			Embedment erosion
			Impact damage
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.			

Details on the condition state rating schema are in Section 10.7, linked below:

DMS Support 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.

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Figure 10-3: DMS support structure foundation, minor spalling

Embedment Erosion

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

Impact Damage

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

10.4.1.3 Anchor Bolt and Leveling Nuts Foundation Element Condition States

The anchor bolts transfer load from the structure into the foundation. The purpose of 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 references found 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. Any distance greater than one inch does not meet specifications and may be cause for concern.

Table 10-6: DMS Support Structure Anchor Bolt and Leveling Nuts Element Distresses

Element Number	Element	Description	Associated Distresses
20102	Anchor Bolts and Leveling Nuts	Anchor bolts and leveling nuts	Corrosion or coating damage
			Loose or missing anchor nut
			Cracked bolt
			Standoff distance
			Impact damage
Unit of Measure: Each, note quantity of anchor bolt and nut units within each condition state			

Details on the condition state rating schema are in Section 10.7, linked below:

[DMS Support Structure Condition State Tables]

Examples of common distresses associated with anchor bolts and leveling nuts are shown in *Figure 10-4* through *Figure 10-6*.

Figure 10-4: Anchor bolts and leveling nuts, corrosion in anchor bolt below upright base with section loss

Figure 10-5: Anchor bolts and leveling nuts, anchor nut without fully engaged threads

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Figure 10-6: Leveling nut and anchor bolt corrosion with section loss

10.4.2 VERTICAL STRUCTURE ROUTINE INSPECTION

The uprights support the horizontal elements that directly support the DMS, walkways, 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 a distance that is close enough to determine the overall condition and to detect deficiencies. A bucket truck is required for inspection when closer access from the ground is not possible.

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 pole with a 4 ft level or similar. Note that some poles 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 for any cracks or deformations in the steel noting the size of deficiencies.
- Verify the handhole cover is securely fastened in place and check for cracks around the frame of the handhole.
- 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 – mast arms, luminaire arms, and other arms. This includes band clamps, brackets, and other bolted assemblies. Check for connections that are loose, missing, deteriorated or otherwise deficient.
- Pay particular attention to the mast arm connections to the pole: 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.

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

10.4.2.1 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 10-7: Component Rating Guidelines for DMS Support Structure Vertical 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.

Component Rating	Condition	Material	Description
		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. 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.
3	SERIOUS	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 repair 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.

10.4.2.2 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 10-8: DMS Support Structure Base Plate Element Distresses

Element Number	Element	Description	Associated Distresses
20201	Base Plate	Base plate for DMS support structure	Corrosion or coating damage
			Weld defect or crack
Unit of Measure: Each, percentage of base plate within each condition state			

Details on the condition state rating schema are in Section 10.7, linked below:

DMS Support Structure Condition State Tables

An example of base plate distress is shown *Figure 10-7*.

Figure 10-7: Vertical supports, rust underneath galvanizing repair

Figure 10-8: Corrosion in bonding clamp along bolt of base plate stiffener

10.4.2.3 Vertical Support Column (Upright) Element Condition States

Verify that the inventory number label is securely affixed on the front of the upright (facing traffic) and is still legible. If no label is present, install an inventory label on the vertical support (upright). If the existing label is in poor condition the label should be replaced. The upright should also be inspected for any vertical misalignment. A mechanical lift such as bucket trucks, climbing or other means of working at heights (i.e., UAS) are utilized for inspecting the tops of vertical supports. Note any galvanizing damage on the upright, including the ladder. Also record the degree of damage, including any corrosion on the base metal. A hand hole is located near the base of the pole to allow for access to electrical components and there are typically additional electrical entry and exit ports higher on the pole. The handhole should be free from excess moisture and debris. The handhole cover should be securely fastened and the hand hole frame inspected for any cracks in the welds, along with any other welded components. 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.

Table 10-9: DMS Support Structure Vertical Support Column (Upright) Element Distresses

Element Number	Element	Description	Associated Distresses
20202	Vertical Support Column (Upright)	Vertical Support (Upright) for DMS support structure	Corrosion or coating damage
			Weld defect or crack
			Out of plumb
			Impact damage
			Handhole defects
Unit of Measure: Length, inch of vertical support within each condition state			

Details on the condition state rating schema are in Section 10.7, linked below:

DMS Support Structure Condition State Tables

An example of vertical support distress is shown in *Figure 10-9*.

Figure 10-9: Vertical structure column (upright) with minor coating damage

10.4.2.4 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 trucks are required for inspecting the connections of vertical supports when closer access from the ground is not possible. 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.

Table 10-10: DMS Support Structure Vertical Structure Connection Element Distresses

Element Number	Element	Description	Associated Distresses
20203	Vertical Structure Connection	Connections to support column	Weld defects or cracks
			Corrosion or coating damage
			Loose, missing, or failing hardware
			Impact damage
Unit of Measure: Each connection quantity within the condition state			

Details on the condition state rating schema are in Section 10.7, linked below:

[DMS Support Structure Condition State Tables]

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

Bolted Connections

Visually inspect the horizontal 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 10-10: Vertical structure connection, missing flat washer on head side of bolt

Figure 10-11: 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

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bleeding through the galvanizing, chip off the galvanizing (wire brush and 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 10-12: Vertical structure connection, rust bleeding through galvanizing at welded gusset plate arm to vertical structure upright

10.4.3 HORIZONTAL STRUCTURE ROUTINE INSPECTION

The horizontal elements directly support the signs, walkways, 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 a distance that is close enough to determine the overall condition and to detect deficiencies. A mechanical lift such as bucket truck or climbing or other means of working at heights (i.e., UAS) are utilized for inspecting 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.

10.4.3.1 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. Assessing 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 provides the appropriate component rating.

Table 10-11: Component Rating Guidelines for DMS Support Structure 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	Steel	Protective coating failure in very small and scattered locations.
		All	All components retain full section properties and function as designed.
6	SATISFACTORY	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	Steel	Up to 25% loss of section. DMS support structure may be mis-aligned 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	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

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Component Rating	Condition	Material	Description
			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 to condition. Notify Region and the Bureau of Bridges and Structures.

10.4.3.2 Arm or Truss Members Element Condition States

DMS Support Structure horizontal members directly support the signage. Horizontal members comprise of the horizontal arm, and the two chords with all truss members within the plane.

Visually inspect all the truss chords or arm members for corrosion, cracking, 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 arms or truss members when closer access from the ground is not possible.

Table 10-12: DMS Support Structure Arm or Truss Members Element Distresses

Element Number	Element	Description	Associated Distresses
20301	Arm or Truss Members	Arm members and truss chords and bracing for DMS Support Structures	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 10.7, linked below:

[DMS Support Structure Condition State Tables]

10.4.3.3 Horizontal Structure Connections Element Condition States

Truss chord splice connections stabilize and secure the truss sections to each other longitudinally. Truss bracing connections stabilize and secure the truss chord sections to each other transversely. Bucket trucks are used to inspect horizontal structure connections when closer access from the ground is not possible.

Truss chord splice and bracing connection bolts require a flat washer and lock washer on the nut end. Visually inspect the chord splice and bracing (horizontal, vertical, and diagonal) connections. Note any lock washers that are not fully compressed. Record any loose, missing, or broken hardware, missing caps, cracked welds and cracks at the ends of gusset plates. Gaps may be present within connections due to fabrication tolerances and bolts will not squeeze plates together at every location. Use wrench to inspect bolt connection to ensure gaps in connections are not due to loose bolts. Record any signs of corrosion.

Table 10-13: DMS Support Structure Horizontal Structure Connection Element Distresses

Element Number	Element	Description	Associated Distresses
20302	Horizontal Structure Connections	Connections of the horizontal structure for all DMS Support Structures. Connections may include splices, chord splices. Or bracing.	Cracking 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 10.7, linked below:

[DMS Support Structure Condition State Tables]

Figure 10-13: Horizontal structure connection, gap between arm connection flanges

10.4.3.4 *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 sign panels are secured in place and do not fall onto the roadway. Sign connections inspected on DMS signs include I-Beam connections to the sign panels, and U-bolt connections of the I-beams to the horizontal chords of the DMS Support 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 used to inspect the signs and sign connections.

Inspect the general appearance of the sign panel and record any deterioration, 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. Also verify that the rubber pads have been placed between the steel mounting supports and the aluminum sign cabinet to prevent reactions between dissimilar metals. Record any deficiencies.

Inspect the sign panel mounting bolts connecting the aluminum I-beam to the sign panel. 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 truss chords, and the U-bolts.

Table 10-14: DMS Support Structure Sign and Sign Connections Element Distresses

Element Number	Element	Description	Associated Distresses
20303	Sign and Sign Connections	Sign and Sign Connections for DMS Support Structure	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: Length, feet along arm or truss which can be rated at each condition state

Details on the condition state rating schema are in Section 10.7, linked below:

DMS Support Structure Condition State Tables

Details on the connection types are noted in the following sections.

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. 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 DMS Support 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 dynamic message sign 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 DMS Support Structure. Inspectors should consider if the sign vibrates or separates from the chord connection when traffic passes below or in windy conditions.

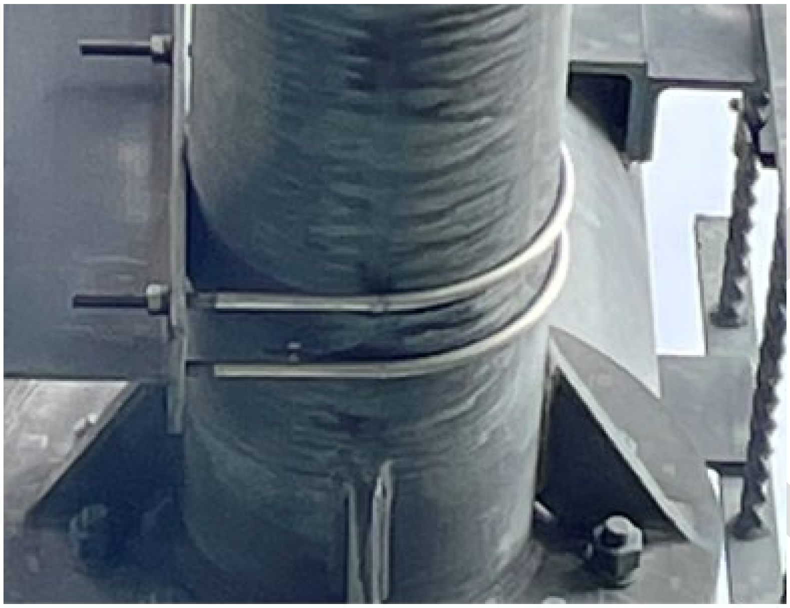

Figure 10-14: Horizontal structure connection, broken U-bolt connection at the nut end

10.4.3.5 Walkway and Walkway Connections Element Condition States

The walkway system comprises of the metal grating platform which is the walking surface, and the railing which protects against fall accidents. Walkway connections stabilize and secure walkways to the structure. The purpose of inspection of the walkway connections is to ensure the walkways are secured in place and are safe for personnel use. The connections consist of the grating welded connections to the arm or truss members and connections to the horizontal structure with galvanized fasteners. Walkway brace connections also uses spacer bar tack welded to walkway grating.

Bucket trucks should be used as needed to inspect the walkway and walkway connections when closer access with equipment or climbing is not possible. Inspect the walkway for deterioration of any member, and vehicular impact that may have affected the structure and its connections. Inspect the grating for irregular surfaces, tripping hazard, or misaligned members. Also record any damage or misalignment of the railings.

Inspect structure for loose, missing, deformed or misaligned connection with horizontal arm or truss members. Visually check snug tightness of fasteners used for attaching walkway grating to flange members and note any looseness observed in bolts or nuts. Inspect the grating weld connections to bracing and vertical flanges. The welded connections should be free of cracking, incomplete or excessively ground, or poor welds that can contribute to stress in the weld. Document damages to the weld connections and

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any corrosion or coating damage of any part of the walkway. The extent of section loss should also be determined and documented.

Table 10-15: Walkway and Walkway Connections Element Distresses

Element Number	Element	Description	Associated Distresses
20304	Walkway and Walkway Connections	Metal grating platform, railing, and connections which secure the walkway to the DMS Support Structure.	Corrosion or coating damage
			Loose, missing, or failing hardware
			Walkway collapse or separation
			Impact Damage
Unit of Measure: Length, feet along arm or truss which can be rated at each condition state			

Details on the condition state rating schema are in Section 10.7, linked below:

DMS Support Structure Condition State Tables

10.4.4 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 panel 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.

10.4.5 REFERENCES

MDOT Traffic and Safety Standards and Special Details

ITS-030-series	LH Master DMS Structure
ITS-031-series	RH Master DMS Structure
ITS-032-series	DMS Sign Support Foundation
ITS-034-series	DMS Structure Mount CCTV MVDS

10.5 Work Recommendation Guidance

DMS support structure Work Recs 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 Recs. 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 recommendation. 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.

I-beam Connections to the Walkway

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.

U-bolt Connections of the I-beams to the Horizontal Chords of the DMS Support Structure

Isolated loose bolts would typically be a work recommendation. If multiple U-bolts need tightening or replacement, and the walkway 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 walkway vibrates or separates from the chord connection when traffic passes below or in windy conditions.

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 Rec. 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 Rec may be to tighten items such as U-bolts, leveling nuts, or DMS panel bolts. Installation of elastomeric pads may be a Work Rec. 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, DMS 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.

The Work Recs are not meant to be all-inclusive and other Work Recs may be added to supplement those noted.

Photographs should include sufficient information to determine the relationship of the defect to the element or component or entire structure. Close-up photos of each defect with connection deficiencies marked on the photo should be provided.

Table 10-16: DMS Support Structure Work Recommendations

Code	Name	Material involved	Quantity/Unit of Measure
1	Repair Guardrail (protecting foundation and pole)	Galvanized Steel	Linear Feet
2	Correct erosion at foundation (prevent undermining)	Stone/Soil	Cubic Feet
3	Repair/Monitor foundation	Concrete	Cubic Feet
4	Tighten leveling nut	Galvanized Steel	Each nut

Code	Name	Material involved	Quantity/Unit of Measure
5	Install/replace U-bolt	Galvanized Steel	Each assembly
6	Tighten U-bolt	Galvanized Steel	Each
7	Secure U-bolt spacer	Galvanized Steel	Each
8	Replace sign connection assembly	Galvanized Steel	Each assembly
9	Repair web member angle supports	Galvanized Steel	Each angle
10	Repair vertical sign support	Galvanized Steel	Linear Feet of Upright
11	Repair galvanizing	Galvanic Paint	Square inch
12	Repair chord	Galvanized Steel	Linear Foot
13	Replace end cap	Galvanized Steel	Each cap
14	Replace end cap bolt	Galvanized Steel	Each bolt
15	Tighten leveling nut	Galvanized Steel	Each nut
16	Address loose bolts	Galvanized Steel	Each bolt
17	Weld repair	Steel	Each weld
18	Replace arm/chord to upright bolted connection bolts	Galvanized Steel	Each bolt
19	Replace bolted connection bolts for internal truss connections (vertical or horizontal)	Galvanized Steel	Each bolt
20	Replace sign panel bolts	Galvanized Steel	Each bolt
21	Tighten sign panel bolts	Galvanized Steel	Each bolt
22	Remove graffiti from steel structural element	N/A	Square Foot
23	Remove graffiti from sign	N/A	Square Foot
24	Repair/replace ID stencil on upright	Paint	Each stencil
25	Replace elastomeric pads between dissimilar metals	Elastomeric Pad	Each pad
26	Repair railing/walkway	Galvanized Steel	Pound (lb)

10.6 Request for Action Guidance

Guidance for creating an RFA pertaining to DMS Support Structure defects is provided below for specific situations which may occur.

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.

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 evidenced by lateral displacement or vertical 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. Multiple loose or missing bolts in a high strength bolted connection, anchor bolt connection, or sign connection
f. Multiple loose or missing bolts where connections do not have load-path redundancy and bolt tensioning is not possible
g. Standoff distance more than twice the bolt diameter, where bending of anchor bolts is evident
h. Major cracks 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 arm connection
i. 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
j. Major section loss due to corrosion of a main element which impacts the capacity or short-term resiliency of the element or structure
k. 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 heavily corroded and/or cracked surfaces which have been present for some time
l. 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 soil erosion or undermining of the foundation
c. Pole is significantly out of vertical alignment

d. Significant base plate distortion or section loss around anchor bolts
e. Standoff distance more than twice the bolt diameter where no bending of anchor bolts is evident
f. Anchor nuts are engaged with some gaps and/or bolts are misaligned
g. Multiple loose or missing bolts in a high strength bolted connection, anchor bolt connection, or sign connection where there is acceptable load-path redundancy, but significant 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 corrosion of primary elements or connections is present
j. Significant misalignment of elements at the column to chord connection where significant corrosion or damage is also present to one or more elements
k. Structural cracks in secondary members that could potentially propagate through welded connections into main members
l. 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
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. Pole is moderately out of vertical alignment
f. Moderate weld deficiencies, which do not meet code but do not impact function where significant redundancy is also present
g. Missing nuts or other elements of a bolted connection where there is adequate redundancy and moderate impact to structural capacity or durability
h. Anchor bolt standoff distance more than one inch but less than twice the anchor bolt diameter with no anchor bolt bending present
i. Missing elastomeric pads between dissimilar metals where moderate corrosion is present

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10.7 Element Condition States

Element Number	Element	Condition States Defects Note	Link to Discussion in Section 10
20101	Concrete Foundation	Use the appropriate condition state table	Foundation Element Condition States
20102	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
20201	Base Plate	Use the appropriate condition state table	Base Plate Element Condition States
20202	Vertical Support Column	Use the appropriate condition state table	Vertical Support Column (Upright) Element Condition States
20203	Vertical Structure Connections	Use the appropriate condition state table	Vertical Structure Connections Element Condition States
20301	Arm or Truss Members	Use the appropriate condition state table	Arm or Truss Members Element Condition States
20302	Horizontal Structure Connections	Use the appropriate condition state table	Horizontal Structure Connections Element Condition States
20303	Sign and Sign Connections	Use the appropriate condition state table	Sign and Sign Connections Element Condition States
20304	Walkway and Walkway Connections	Use the appropriate condition state table. Inspectors are not required to access walkway.	Walkway and Walkway Connections Element Condition States

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Element 20101 – Concrete Foundation

Description	This element defines a concrete foundation for a mast arm pole, 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, or efflorescence may be present. No exposed reinforcing, and free from impact damage.	Minor cracks and/or spalls may be present in the concrete. No exposed reinforcing or embedment erosion, and free from impact damage.	Moderate cracks and/or spalls may be present. Some reinforcing may be exposed. Incidental loss of section or surface pitting of reinforcing may be present. Element shows evidence of some embedment erosion or impact damage.	Major cracks and/or spalls are present. Major corrosion of exposed reinforcing. Extensive steel and/or concrete loss of section. Embedment erosion or impact damage is present.

Element 20102 – 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. Anchor bolt standoff distance is less than 1". No evidence of impact damage.	Minor corrosion of the elements may be present. The elements are fully engaged and functioning as intended. 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 may not be fully tightened. Anchor bolt standoff distance is greater than 1" but less than two times the bolt diameter. Minor evidence of impact damage may be present.	Severe corrosion/section loss of the elements may be present. Multiple nuts are loose/missing. Anchor bolt standoff distance is greater than two times the bolt diameter. UT testing indicates major cracks or breaks in bolts. Major evidence of impact damage may be present.

Element 20201 – 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	No evidence of active corrosion. Surface coating is sound.	Minor surface corrosion may be present. Base element welds have no evidence of defects.	Moderate corrosion/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.	Major corrosion/section loss is present. Base element welds may have cracks/defects. Base plate has moderate to major warping.

Element 20202 – Vertical Support Column (Upright)

Description	This element is defined by uprights supporting dynamic message signs, 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.	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.

Description	This element is defined by uprights supporting dynamic message signs, 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**
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 20203 – Vertical Structure Connections

Description	This element consists of the connections along the DMS support structure for various attachments.			
Quantity Calculation	The quantity to be collected includes each connection location.			
	Condition State Descriptions			
Defect Type	**Good**	**Fair**	**Poor**	**Severe**
Vertical Structure Connection Defects	Pole clamps, saddles, bracket assemblies, and other connection hardware are functioning as intended with no evidence of wear or corrosion.	Minor surface corrosion or wear may be present. Pole clamps, saddles, bracket assemblies, and other connection hardware are functioning as intended.	Moderate corrosion/section loss or wear is present. Pole clamps, saddles, bracket assemblies or other connection hardware may be loose, but the conditions do not significantly affect serviceability and/or function.	Major corrosion/section loss is present. Protective coatings are significantly failing. Members may have cracks/defects or major wear. Hardware is loose or missing. Connection is not functioning as intended.

Element 20301 – Arm or Truss Members

Description	This element defines all arm members, truss chords and bracing for DMS Support 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 Member 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/section loss or damage is present. Arm cap may be missing. No weld defects or cracks.	Multiple or major element defects or section loss are present. Arm or Truss Members have propagating cracks. Loose or missing hardware. Major impact damage may be present.

Element 20302 – Horizontal Structure Connection

Description	This element consists of the connections of the horizontal structure for all DMS Support Structures. Connections may include splices, chord 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 Connection Defects	New or like-new condition with no deficiencies	Minor surface corrosion, wear, or superficial damage may be present. The connection is functioning as intended. Hardware is fully engaged. No gaps are present.	Moderate corrosion/section loss or wear is present. Hardware is fully engaged. The conditions do not significantly affect serviceability and/or function.	Major corrosion/section loss is present. Protective coatings are significantly failing. Members may have cracks/defects or major wear. Hardware is loose or missing. Connection is not functioning as intended.

Element 20303 – Sign and Sign Connections

Description	This element consists of the sign and sign connections for all DMS Support Structures.			
Quantity Calculation	The quantity to be collected includes each connection location, which may contain one or more anchored connections, bracing, or bolts. It includes general structural condition of the dynamic message sign.			
	Condition State Descriptions			
Defect Type	**Good**	**Fair**	**Poor**	**Severe**
Sign and Sign Connections Defects	New or like-new condition with no deficiencies	Minor surface corrosion, wear, or superficial damage may be present. Hardware is fully engaged. No gaps are present.	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. Missing elastomeric pads between dissimilar metals.	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.

Element 20304 – Walkway and Walkway Connections

Description	This element consists of the metal grating platform, railing, and connections which secure the walkway to the DMS Support Structure.			
Quantity Calculation	The quantity is measured in length in feet along arm or truss.			
	Condition State Descriptions			
Defect Type	**Good**	**Fair**	**Poor**	**Severe**
Walkway and Walkway Connection Deficiencies	New or like-new condition with no deficiencies.	Minor surface corrosion, wear, or superficial damage may be present. Hardware is fully engaged.	Moderate corrosion/section loss, wear or damage is present. Evidence of multiple loose or improperly assembled connection hardware and minimal impact damage may be present but the conditions do not significantly affect serviceability and/or function.	Major corrosion/section loss is present. Protective coatings are significantly failing. Members may have cracks/defects or major wear and damage. Loose, missing or failing hardware. Gaps are present. Connections are not functioning as intended.

11 FRANGIBLE AND NON-FRANGIBLE POLE STRUCTURE

11.1 Definitions

The frangible pole structure is a steel or aluminum pole mounted onto a cast aluminum transformer base, which is mounted to a concrete foundation. The frangible transformer base is designed to break away at impact for safety of motorists. Due to the breakaway performance frangible pole structures may be used within the roadway clear zone. The non-frangible type is a steel or aluminum pole mounted directly on a concrete foundation with anchor bolts. Since non-frangible light poles are not considered breakaway structures, they are used outside of roadway clear zones or are shielded; shielding typically means the pole is protected by guardrail.

Other common terms which may be used when discussing frangible and non-frangible pole structures include:

- **Breakaway:** A design feature that allows a sign, luminaire, or pole top-mounted traffic signal support to yield, fracture, or separate near ground level on impact.
- **Clear zone:** The roadside border area, starting at the edge of the traveled way, available for unobstructed use by errant vehicles.
- **Frangible:** A component readily or easily broken on impact.
- **Frangible Transformer Base:** A base constructed of a brittle material and designed for breakaway performance, used to support a pole structure.
- **Luminaire:** A complete lighting unit consisting of a lamp or lamps together with the parts designed to distribute the light, to position and protect the lamps, and to connect the lamps to the electric power supply.
- **Screw-in Helix:** Galvanized steel foundation installed by rotary equipment.

11.1.1 INVENTORY ITEMS

The inspector shall identify and record the type of base (i.e., Frangible or Non-Frangible base) and the number of arms and type of arm (i.e., single, davit, or truss bracket). The inspector shall also note the lengths of the arms and the mounting height of the structure. The inspector shall note the power source such as direct wire or solar. The inspector shall provide the Power Meter number. Take photos of the required inventory items listed in Section 11.2.2. A complete list of inventory items is provided in the Ancillary Structures Data Dictionary.

Figure 11-1: Pole structure arm types (numbering from left), single member (1), Davit member (2), single truss arm (3), double truss arm member (4)

11.1.2 ELEMENTS

Frangible and Non-Frangible Pole Structures are divided into three components: Foundation, Vertical Structure, and Horizontal Structure.

Foundation is further divided into elements: Concrete Foundation, Anchor Bolts, and Frangible Transformer Base.

Vertical Structure is further divided into elements: Base Plate, Frangible Base Connections, Vertical Support Column (Upright), and Vertical Structure Connections.

Horizontal Structure consists of one element: Luminaire and Luminaire Arm.

Table 11-1: Frangible and Non-Frangible Pole Structure Components and Elements

Component	Element	Element Code	Unit of Measure
Foundation	Concrete Foundation	21101	Each
Foundation	Anchor Bolts and Nuts	21102	Each bolt and nut unit
Foundation	Frangible Base	21201	Each
Vertical Structure	Base Plate	21202	Each
Vertical Structure	Frangible Base Connections	21203	Each bolt and nut unit
Vertical Structure	Vertical Support Column (Upright)	21204	Length, feet
Vertical Structure	Vertical Structure Connections	21205	Each
Horizontal Structure	Luminaire and Luminaire Arm	21301	Each

11.1.3 COMPONENTS

Frangible and non-frangible pole structures are divided into three main components: the foundation, the vertical structure, and the horizontal structure.

Component ratings for pole structures are based on the following:

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- ***Foundation*** – Consider the structure's foundation effect on overall stability of the pole 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 rating, element rating, and condition states. A representation of the rating structure for frangible and non-frangible pole structures is provided in Figure 11-2.

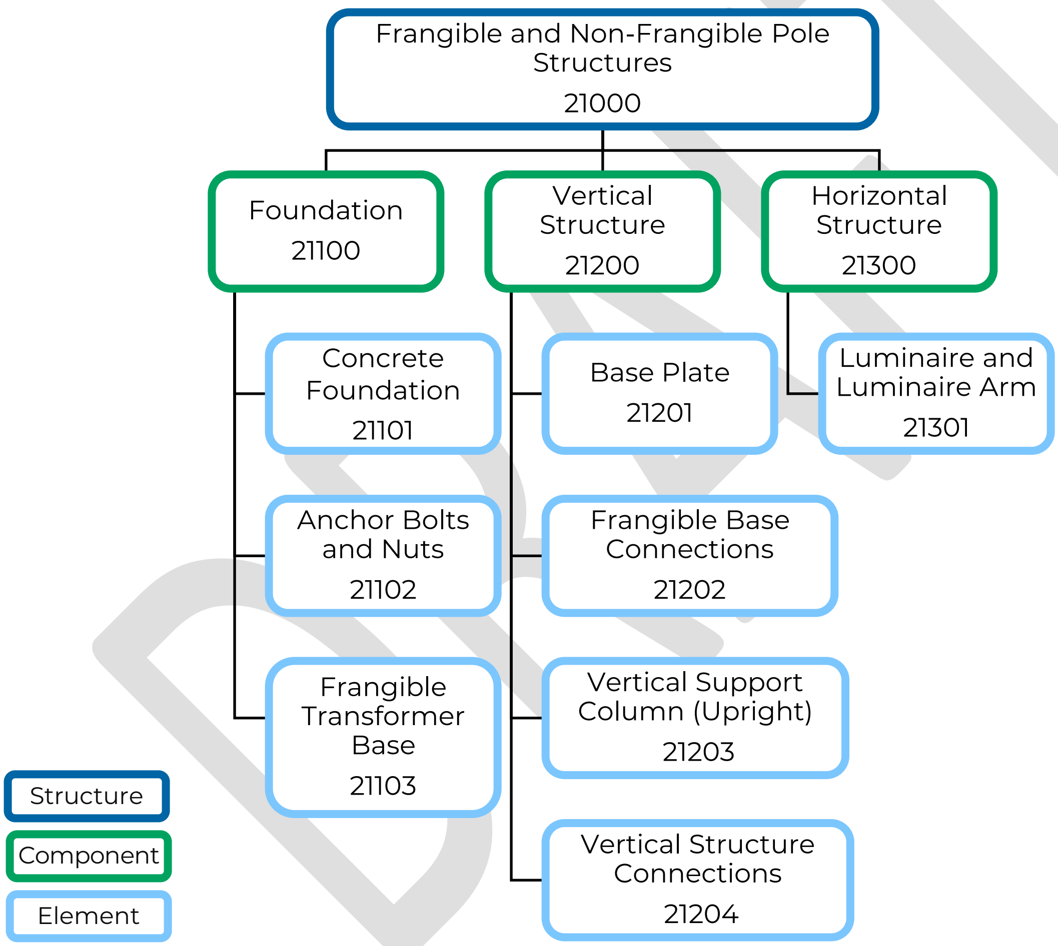

Figure 11-2: Rating structure for Frangible and Non-Frangible Pole Structures

Frangible Pole Structure

(adapted from SIG-061-A)

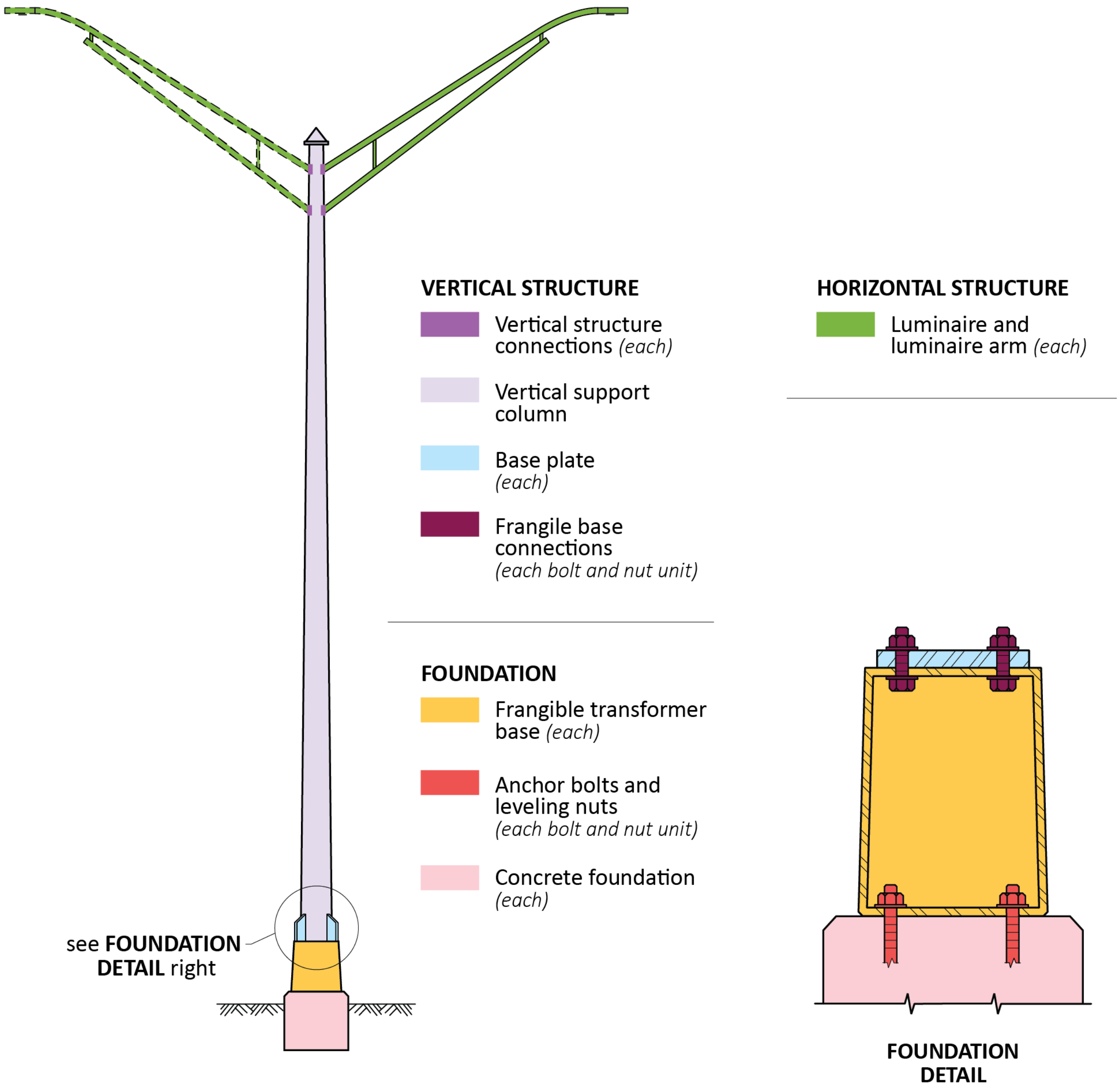

Figure 11-3: Component and elements on a Frangible Pole Structure (adapted from MDOT Detail SIG-061-A)

Non-Frangible Pole Structure

(adapted from SIG-061-A)

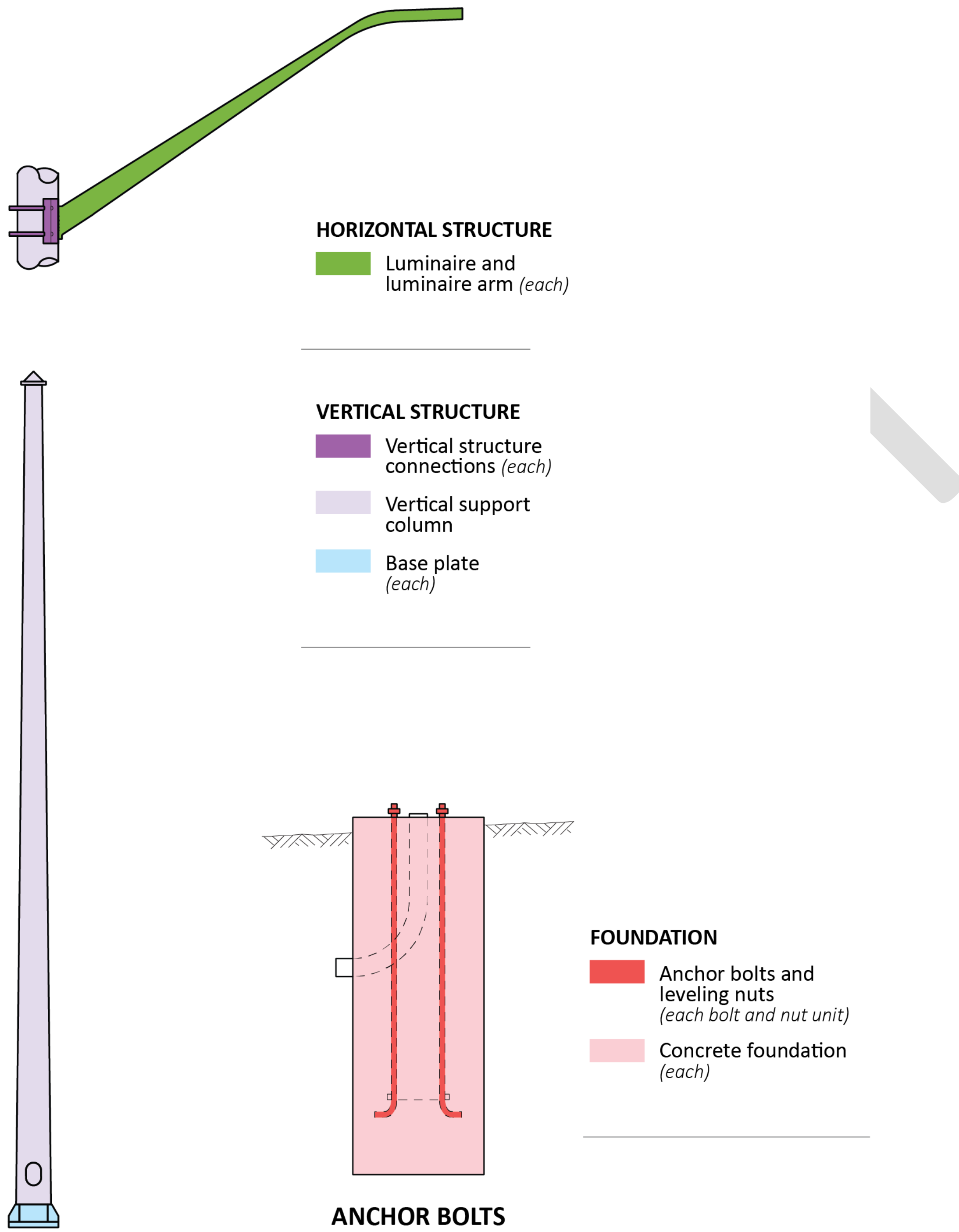

Figure 11-4: Components and elements on a Non-Frangible Pole Structure

11.2 Inventory Record Photographs

Inventory photos are captured during a routine inspection, saved as part of the inventory database, and follow the naming convention in *Table 11-2.*

Frangible Pole Structure and Non-Frangible Pole Structure Required Photos:

- General view of the entire structure
- Each foundation
- Structure number stenciled on support

Table 11-2: Frangible and Non-Frangible Pole Structures Photograph Naming Convention

Photo Name	Description
PS_Entire	Entire frangible or non-frangible pole structure
PS_Foundation	Foundation
PS_VH_Connection	Vertical to horizontal connection
PS_Lum	Luminaire and luminaire arm
PS_ID	Old ID and new structure number

11.3 Inspector Minimum Technical Qualifications

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

- A minimum experience of two projects with a minimum of 10 structures total inspecting pole structures. Bolt inspection experience on cantilever or truss structures, or other ancillary structure type. Multiple structure types shall have been inspected as part of the total project experience.
- Ancillary structures inspection procedures training
- Working knowledge of inspection tools, their use, application, and limitations for the structure type being inspected
- MDOT structural bolting workshop for Non-Frangible Pole Structure initial field installation verification.
- Certified Welding Inspector – American Welding Society, Certified Welding Inspector (CWI) (Current)
- Ultrasound qualification for Non-Frangible Pole Structure – 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.

11.4 Routine Inspection

Pole structures may be categorized as either frangible or non-frangible types. The frangible type is a steel or aluminum pole mounted onto a cast aluminum transformer base, which is mounted to the concrete foundation. The frangible transformer base is designed to break away at impact to protect the safety of motorists. Due to the breakaway performance frangible pole structures may be used within the roadway clear zones. The non-frangible type is a steel or aluminum pole mounted directly on a concrete foundation with anchor bolts. Since non-frangible light poles are not considered breakaway structures, they are used outside of roadway clear zones or are shielded; shielding typically means the pole is protected by guardrail.

Both frangible and non-frangible pole structures may support a variety of luminaires and different types of pole attachments and connections.

Frangible and non-frangible pole structure standard inspection frequency is once every 4 years for steel poles and once every 2 years for aluminum poles, unless otherwise identified for more frequent inspection.

Table 11-3 provides guidance for inspecting reinforced and prestressed concrete cracking.

Table 11-3: 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)

11.4.1 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. Visually inspect all elements of the component at a distance close enough to determine the overall condition and to detect deficiencies.

A sample foundation routine inspection would consist of:

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- 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 rod diameter and length, then scan for defects.
- Examine anchor rods for tightness and embedment using a standard inspection hammer. Inspect visually for corrosion, section loss, and plumbness.
- Examine anchor rods for any eccentricity. Note any noticeable eccentricity measurements.
- On Non-Frangible pole structures, perform ultrasonic testing of anchor rods to note any breaks and verify lengths.
- Provide photographs for all Poor or Severe condition state defects and submit the applicable Work Recs or RFAs.

11.4.1.1 Foundation Component Ratings

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 11-4: Component Rating Guidelines for Frangible and Non-Frangible Pole Structure Foundation

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.

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Component Rating	Condition	Material	Description
		Steel	Minor damage or worn galvanizing of anchor bolt connections.
		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.
		Steel	Less than 25% loss of section. Fasteners may be considerably deteriorated.
		All	Considerable deterioration or misalignment affecting structural members. Considerable impact damage. 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 pole and embedment material.
		Steel	Measurable loss of section in excess of 25%. Missing, cracked, or broken fasteners.
		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.

11.4.1.2 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 11-5: Frangible and Non-Frangible Pole Structure Concrete Foundations Element Distresses

Element Number	Element	Description	Associated Distresses
21101	Concrete Foundation	Frangible and non-Frangible pole structure foundations	Cracking Spalling, delamination, and patching Exposed rebar Embedment erosion Impact damage
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.			

Details on the condition state rating schema are in Section 11.7, linked below:

Frangible and Non-Frangible Pole 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.

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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.

Figure 11-5: Non-frangible concrete foundation deterioration

Exposed Rebar or Anchor Bolt Thread

Indicate if reinforcement is exposed.

Figure 11-6: Concrete foundation, exposed anchor bolt in damaged foundation

Embedment Erosion

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

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Impact Damage

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

11.4.1.3 Anchor Bolt and Leveling Nuts Foundation Element Condition States

The anchor bolts transfer load from the structure into the foundation. For frangible bases, this element does not address the bolts and nuts connecting the base plate and the frangible base. It addresses the bolts in connection with the concrete foundation only. The bolts and nuts connecting the base plate and the frangible base are addressed in frangible base connection element.

The purpose of the anchor bolt inspection is to identify any degradation of the nuts, flat washers, leveling nuts, and anchor bolts connecting the frangible transformer base to the concrete foundation. Typical issues include corrosion, damaged threads, loose connections, missing or damaged anchor bolts 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, and a determination of the tightness of the bolts and nuts. For non-frangible bases, a sounding test, and a straight beam ultrasound scan (UT test) of 10 inches into the anchor bolts are required. Published procedures for the sounding and UT test are provided in references found in Section 4.3.7. Testing frangible bases may require appropriate PPE and insulated tools, recognizing the potential of electrical hazard. Panel doors may also be present and need to be opened to inspect the bolts and nuts.

For either frangible or non-frangible base, visually inspect the base looking for missing or damaged anchor bolts or nuts connected to the foundation. Note any damage or corrosion and any bolt that shows signs of bending. 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. Any distance greater than one inch does not meet specifications and may be cause for concern.

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Table 11-6: Frangible and Non-Frangible Pole Structure Anchor Bolt and Leveling Nuts Element Distresses

Element Number	Element	Description	Associated Distresses
21102	Anchor Bolts and Leveling Nuts	Anchor bolts and leveling nuts	Corrosion or coating damage
			Loose or missing anchor nut
			Cracked bolt
			Standoff distance
			Impact damage
Unit of Measure: Each, note quantity of anchor bolt and nut units within each condition state			

Details on the condition state rating schema are in Section 11.7, linked below:

[Frangible and Non-Frangible Pole Structure Condition State Tables]

Examples of common distresses associated with anchor bolts and leveling nuts are shown in *Figure 11-7* through *Figure 11-11*.

Figure 11-7: Anchor bolt and leveling nuts foundation, severed anchor bolt and nut of non-frangible base

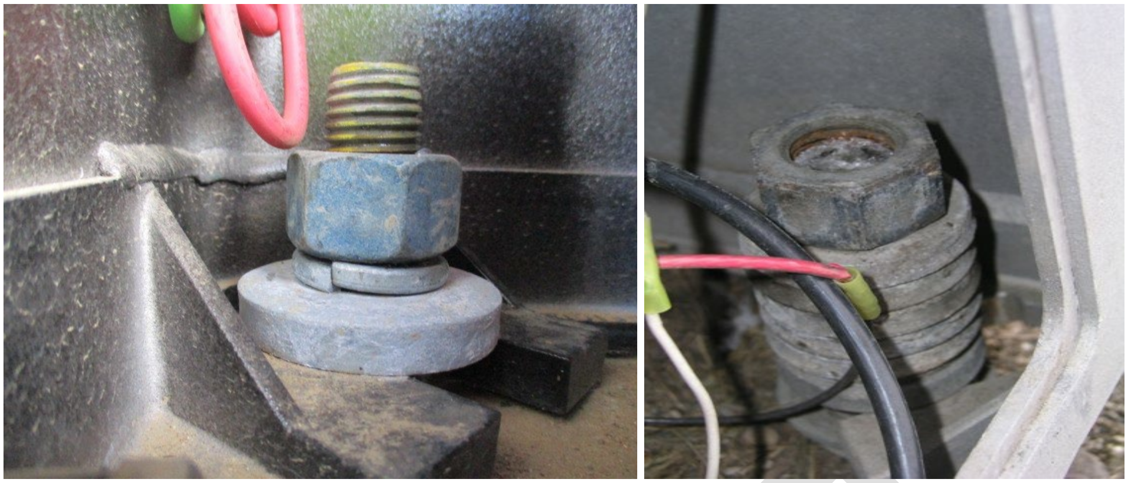

Figure 11-8: Frangible pole structure anchor bolts and leveling nuts foundation, loose anchor bolt (left), anchor nut without fully engaged thread (right)

Figure 11-9: Anchor bolt and leveling nuts foundation, non-frangible base anchor bolt corrosion

Figure 11-10: Anchor bolt and leveling nut foundation, gap between anchor nut and washer in corroding base unit (left), gap between anchor nut and washer with bolt out of plumb and debris between upright base and concrete foundation (right)

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Figure 11-11: Anchor bolt and leveling nuts foundation, nut tack welded to washer (left), incorrect washer type – plate washers intended to cover slotted holes (right)

11.4.1.4 Frangible Base Element Condition States

Inspectors shall visually inspect for any damage to the frangible base 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.

With appropriate PPE and insulated tools, recognizing the potential of electrical hazard, open access panel of the frangible base and conduct a visual inspection of the interior for damages such as corrosion and section loss. Inspect the interior anchor bolts, flash washer, lock washer and nuts, and document loose connections and lock washers not fully compressed. Note any damage such corrosion, or bolt misalignment. Debris and moisture aid damages such as corrosion and section loss. Document any debris and water within the frangible base access panel, and any loose, missing or unopenable access panel.

Figure 11-12: Frangible transformer base, panel door present (left), corrosion and debris in transformer base interior with missing panel door, and exposed wires (right)

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Table 11-7: Frangible Pole Structure Frangible Base Element Distresses

Element Number	Element	Description	Associated Distresses
21103	Frangible Base	Base connecting the foundation to an upright designed to break away or yield when a vehicle impact occurs.	Corrosion or coating damage
			Loose or missing anchor nut
			Cracked bolt
			Impact damage
Unit of Measure: Each, note quantity of anchor bolt and nut units within each condition state			

Details on the condition state rating schema are in Section 11.7, linked below:

Frangible and Non-Frangible Pole Structure Condition State Tables

11.4.2 VERTICAL STRUCTURE ROUTINE INSPECTION

The uprights support the horizontal elements that directly support the luminaire arm. 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 frangible base connections, 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. Visually inspect all elements of the component at a distance close enough to determine the overall condition and to detect deficiencies. Binoculars are used as a visual aid if closer access with equipment or climbing is not available.

A sample routine inspection would consist of:

- Inspect the general site conditions and assess the global stability of the structure and its operational function.
- Inspect the vertical alignment of the pole with a 4 ft level or similar. Note that some poles 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, powder coated, and/or paint and note any corrosion or section loss.
- 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.
- Check for pole dents and buckling (refer to pole dents & buckling calculations).
- Check for any cracks or deformations in the steel or aluminum noting the size of deficiencies.

- Check for signs of 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. This includes band clamps, brackets, and other bolted assemblies. Check 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.

11.4.2.1 Vertical Structure Component Ratings

The component rating for the vertical structure depends on the condition of the Frangible base connections, 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 11-8: Component Rating Guidelines for Frangible and Non-Frangible Pole Vertical 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/ Aluminum	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/ Aluminum	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.

Component Rating	Condition	Material	Description
		Soil	Moderate displacement or erosion of soil. Minor gaps may be present between pole and embedment material.
		Steel/ Aluminum	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/ Aluminum	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.
3	SERIOUS	Concrete	Extensive cracking and spalling.
		Soil	Extensive displacement or erosion of soil. Large gaps may be present between pole and embedment material.
		Steel/ Aluminum	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.

11.4.2.2 *Frangible Base Connections Element Condition States*

Frangible base connections require extra attention because the connections are locations of high stresses. The purpose of inspection of the frangible base connections is to identify any degradation of the nuts, washers, and bolts above and below the vertical support (upright) base plate throughout the lifespan of the structure. Typical issues include loose, missing, corroded, or damaged bolting assemblies. All nuts should be tight and fully bear on connected surfaces. Inspection may require appropriate PPE and insulated tools, recognizing the potential of electrical hazard. Panel doors may also be present and need to be opened to inspect the interior washers and nuts. Loose nuts, nuts that don't fully bear on adjacent steel, nuts not fully engaged, or damaged or cracked bolts can lead to connection movement, load redistribution, and ultimately failure. Check the bolts and nuts to ensure they are fully tightened. Note any damage or corrosion and any bolt that shows signs of bending.

Figure 11-13: Frangible base connections, exposed bolt hole

Table 11-9: Frangible Pole Structure Frangible Base Connections Element Distresses

Element Number	Element	Description	Associated Distresses
21202	Frangible Base Connections	Connections connecting the upright to the frangible base.	Corrosion or coating damage
			Loose or missing anchor nut
			Cracked bolt
Unit of Measure: Each, note quantity of anchor bolt and nut units within each condition state			

Details on the condition state rating schema are in Section 11.7, linked below:

Frangible and Non-Frangible Pole Structure Condition State Tables

11.4.2.3 Frangible and Non-Frangible Pole Structure 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.

Figure 11-14: Non-frangible pole structure base plate crack

Figure 11-15: Non-frangible pole structure base plate, corrosion of base plate, anchor bolts, and nuts and inadequate bolt projection

Figure 11-16: Base plate, pole corrosion and section loss at base weld

Table 11-10: Frangible and Non-Frangible Pole Structure Base Plate Element Distresses

Element Number	Element	Description	Associated Distresses
21202	Base Plate	Base plate for Frangible and non-frangible pole structure	Corrosion or coating damage Weld defect or crack
Unit of Measure: Each, percentage of base plate within each condition state			

Details on the condition state rating schema are in Section 11.7, linked below:

[Frangible and Non-Frangible Pole Structure Condition State Tables]

11.4.2.4 Frangible and Non-Frangible Pole Structure Vertical Support Column (Upright) Condition States

Verify that the structure number is stenciled on the front of the upright (facing traffic) and is still legible. If necessary, use black paint to stencil the number on the vertical support (upright). Note any galvanizing damage on the upright and the degree, if any, of corrosion on the base metal. Unless a mechanical lift or climbing or other means of working at heights (i.e., UAS) are utilized, binoculars are used as a visual aid 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. 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). Also record any case of missing or loosely covered handhole.

Table 11-11: Frangible and Non-Frangible Pole Structure Vertical Support Column (Upright) Element Distresses

Element Number	Element	Description	Associated Distresses
21203	Vertical Support Column (Upright)	Vertical Support (Upright) for frangible and non-Frangible pole structure	Corrosion or coating damage
			Weld defect or crack
			Impact damage
			Out of plumb
			Missing handhole cover or post cap
Unit of Measure: Length, inch of vertical support within each condition state			

Details on the condition state rating schema are in Section 11.7, linked below:

Frangible and Non-Frangible Pole Structure Condition State Tables

Figure 11-17: Non-frangible pole structure vertical support column (upright), coating system failure and corrosion in upright at base weld (left), corrosion inside column (right)

Figure 11-18: Non-frangible pole structure vertical support column (upright), dent

Figure 11-19: Non-frangible pole structure vertical support column (upright), loosely covered handhole

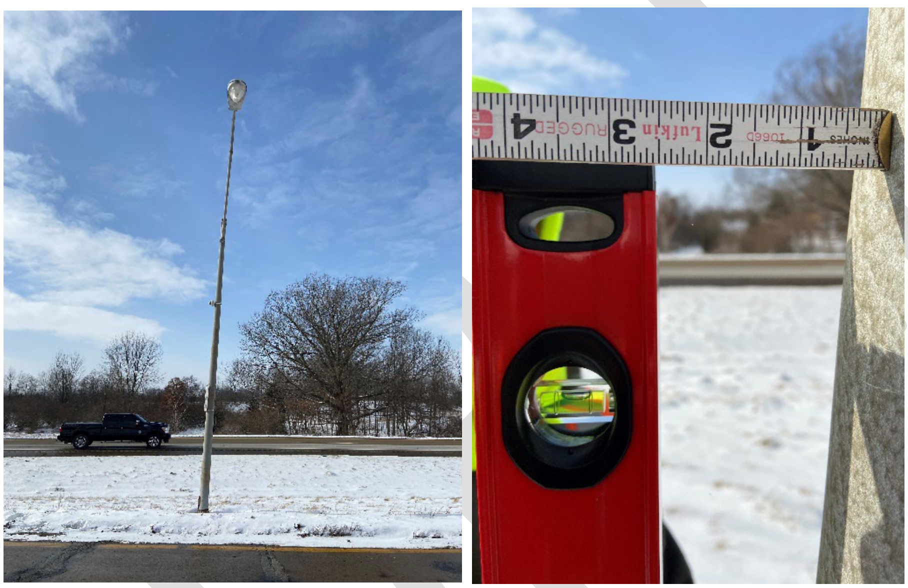

Figure 11-20: Non-frangible pole structure vertical support column (upright), visual identification of out of plumb pole (left), measurement of pole plumbness (right)

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11.4.2.5 Frangible and Non-Frangible Pole Structure Vertical Structure Connections Condition States

Most connections are either bolted or welded. Stainless steel arm connection bolts require a flat washer and a lock washer on the nut end. Typical issues include loose bolts and nuts, weld discontinuities, galvanizing damage, flange connection gaps, missing washers, and missing end caps. Binoculars are used as a visual aid to inspect the connections of vertical supports when closer access through equipment or climbing is not possible. 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.

Table 11-12: Frangible and Non-Frangible Pole Structure Vertical Structure Connections Element Distresses

Element Number	Element	Description	Associated Distresses
21204	Vertical Structure Connection	Bracket assemblies, pole band clamps, stainless steel straps, through bolts, or other connections to frangible and non-frangible pole structure	Weld defects or cracks Corrosion or coating damage Loose, missing, or failing hardware
Unit of Measure: Each connection quantity within the condition state			

Details on the condition state rating schema are in Section 11.7, linked below:

Frangible and Non-Frangible Pole Structure Condition State Tables

Figure 11-21: Frangible and non-frangible pole structure vertical structure connections, gap at arm flange (left), loose arm connection bolt (right)

11.4.3 HORIZONTAL STRUCTURE ROUTINE INSPECTION

The horizontal elements directly support the luminaire and other attachments. The routine inspection assesses the horizontal structure's ability to safely support 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. Visually inspect all elements of the component at a distance close enough to determine the overall condition and to detect deficiencies. Unless a mechanical lift or climbing or other means of working at heights (i.e., UAS) are utilized, binoculars are used as a visual aid to inspect the horizontal structures.

A sample routine inspection would consist of:

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- Inspect the vertical clearance of the horizontal structure and its attachments, the alignment, and the operational function.
- Inspect luminaires and luminaire arms or other 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.

11.4.3.1 Horizontal Structure Component Ratings

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. Assessing 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 provides the appropriate component rating.

Table 11-13: Component Rating Guidelines for Frangible and Non-Frangible Pole Structure 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/Aluminum	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.
		Steel/Aluminum	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.
5	**FAIR**	All	Minor deterioration affecting structural components.
		Concrete	Moderate delamination or spalling.

Component Rating	Condition	Material	Description
		Steel/Aluminum	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/Aluminum	Up to 25% loss of section. Span wire may have minor fraying 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/Aluminum	Section loss in excess of 25%. Missing or broken fasteners or excess sagging of the span wire.
		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.

11.4.3.2 Luminaire and Luminaire Arm Element Condition States

Inspectors shall visually inspect the luminaire and luminaire arm for any loose, missing, cracked, ruptured or broken arm or luminaire head. Check for loose or missing end cap and identify any danger of falling luminaire. Check for corrosion and peeling. Note any galvanizing damage and the degree, if any, of corrosion on the base metal. If nothing of note is found, spray "cold galvanizing" compound or zinc-rich paint on any area where galvanizing was removed. Use binoculars as a visual aid to inspect arms or truss members when closer access with equipment or climbing is not possible.

Table 11-14: Frangible and Non-Frangible Pole Structure Luminaire and Luminaire Arm Element Distresses

Element Number	Element	Description	Associated Distresses
21301	Luminaire and Luminaire Arm	Lighting sources, fixtures and assemblies, bracket arms, truss arms, tenon mounts, shepherds crooks, or other pole mounting devices	Broken lighting source or assembly Damaged or cracked housing, cover Corrosion or section loss Weld cracks/defects Deteriorated gasket/seal
Unit of Measure: Each luminaire and luminaire arm within the condition state			

Details on the condition state rating schema are in Section 11.7, linked below:

Frangible and Non-Frangible Pole Structure Condition State Tables

Figure 11-22: Luminaire and luminaire arm element, evidence of galvanizing damage

Figure 11-23: Luminaire and luminaire arm element, missing luminaire head

11.4.4 REFERENCES

***Light Standard Details are currently unpublished

MDOT Frangible Light Standard Installation Inspection Procedure

MDOT Non-Frangible Light Standard Installation Inspection Procedure

Pole Dent & Buckling Calculations

11.5 Work Recommendation Guidance

Frangible and Non-Frangible Structure Work Recs 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 Recs. 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 Work Recs include repairing or monitoring foundation, replacing base cover or transformer base, repairing galvanizing or paint, and replacing luminaire, luminaire arm or luminaire arm connections.

Lighting support structures are not designed to have attachments other than the luminaire itself. Record and document any attachments to the vertical member and create a Work Rec to remove unauthorized attachments. Solar panels that power the lights are excluded from this as they are designed to be part of the structure.

The Work Recs are not meant to be all-inclusive and other Work Recs may be added to supplement those noted.

Photographs should include sufficient information to determine the relationship of the defect to the element or component or entire structure. Close-up photos of each defect with connection deficiencies marked on the photo should be provided.

Table 11-15: Frangible and Non-Frangible Pole Structure Work Recommendations

Code	Name	Material Involved	Quantity/Unit of Measure
1	Repair guardrail (protecting pole)	Galvanized Steel	Linear Feet
2	Correct erosion at foundation (prevent undermining)	Stone/Soil	Cubic Feet
3	Repair/monitor foundation	Concrete	Cubic Feet
4	Tighten leveling nut	Galvanized Steel	Each nut
5	Replace transformer base cover	Aluminum	Each cover
6	Address loose transformer base nuts	Galvanized Steel	Each nut
7	Replace transformer base	Aluminum	Each base
8	Replace baseplate to transformer base bolts	Galvanized Steel	Each bolt
9	Repair/replace handhole cover	Galvanized Steel	Each cover
10	Remove non-MDOT or unauthorized attachments to structures	Various	Each item
11	Remove graffiti	N/A	Square Foot
12	Repair galvanizing	Galvanic Paint	Square Inch
13	Repair paint	Metal Coating System	Square Foot
14	Address loose bolts	Galvanized Steel	Each bolt
15	Weld repair	Steel	Each weld
16	Replace pole cap	Galvanized Steel	Each cap
17	Replace pole cap bolt	Galvanized Steel	Each bolt
18	Replace luminaire	Various	Each luminaire
19	Replace luminaire arm/tenon	Steel or aluminum	Each arm/tenon
20	Replace arm/tenon connection	Steel or aluminum	Each connection
21	Replace bracket assembly	Galvanized Steel	Each assembly
22	Replace misc. attachment connecting appurtenance	Various	Each attachment
23	Permanently remove cap	Steel or aluminum	Each cap

11.6 Request for Action Guidance

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 lateral displacement or vertical out of plumbness

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

d. Frangible transformer base with broken tabs or tabs not engaged by anchor nuts (Frangible pole structures only)

e. Frangible base connections with broken or missing bolts, or bolts with less than 50% of nut engagement.

f. Standoff distance more than twice the bolt diameter, where bending of anchor bolts is evident (non-frangible pole structures only)

g. Multiple loose or missing bolts in a high strength bolted connection, anchor bolt connection, or luminaire arm connection

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

i. Major cracks present in the base metal or weld(s) on the base plate to column connection or for single column supports or the column to luminaire arm connection

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

k. Cracked or failing tenon/bracket assembly/luminaire mounting device

l. 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

m. Major structural damage to foundation, anchor bolts, transformer base, upright, or other elements, which impacts capacity and/or function, clearance, safety, and/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 soil erosion or undermining of the foundation

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

d. Pole is significantly out of vertical alignment

e. Significant corrosion of primary elements or connections is present
f. Standoff distance more than twice the bolt diameter where no bending of anchor bolts is evident (non-frangible pole structures only)
g. Frangible transformer base with tabs partially engaged by anchor nuts and/or bolts are misaligned (frangible pole structures only)
h. Loose bolts in a high strength bolted connection, anchor bolt connection, or luminaire arm connection where there is acceptable load-path redundancy, but significant impact to capacity or durability
i. Frangible base connection bolts with 50% to 100% nut engagement.
j. Significantly loose or misaligned tenon/bracket assembly/luminaire mounting device
k. 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
l. Structural cracks in secondary members that could potentially propagate through welded connections into main members
m. 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
c. Moderate corrosion of the base plate, which includes moderate section loss
d. Moderate corrosion of the anchor bolt connections or high strength bolted connections
e. Pole is moderately out of vertical alignment
f. Standoff distance more than one inch but less than twice the bolt diameter where no bending of anchor bolts is evident (non-frangible pole structures only)
g. Moderate weld deficiencies, which do not meet code but do not impact function where significant redundancy is also present
h. Misaligned tenon/bracket assembly/luminaire mounting device
i. Loose or missing nuts or other elements of a bolted connection assembly where there is adequate redundancy and moderate impact to structural capacity or durability
j. Transformer base with tabs not fully engaged by anchor nuts (Frangible pole structures only)

11.7 Element Condition States

21101	Concrete Foundation	Use the appropriate condition state table.	Concrete Foundation Element Condition States
21102	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
21103	Frangible Base	Use the appropriate condition state table. Use for Frangible pole structures only.	Frangible Transformer Base Element Condition States
21201	Frangible Base Connections	Use the appropriate condition state table. Use for Frangible pole structures only.	Frangible Base Connections Element Condition States
21202	Base Plate	Use the appropriate condition state table.	Frangible and Non-Frangible Pole Structure Base Plate Element Condition States
21203	Vertical Support Column	Use the appropriate condition state table.	Frangible and Non-Frangible Pole Structure Vertical Support Column (Upright) Condition States
21204	Vertical Structure Connections	Use the appropriate condition state table.	Frangible and Non-Frangible Pole Structure Vertical Structure Connections Condition States
21301	Luminaire and Luminaire Arm Connections	Use the appropriate condition state table.	Luminaire and Luminaire Arm Element Condition States

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Elements 21101 – Concrete Foundation

Description	This element defines a concrete foundation for a steel strain pole, regardless of foundation type such as drilled shaft or reinforced concrete pile.			
Quantity Calculation	The quantity is collected in each.			
	Condition State Descriptions			
Defect Type	**Good**	**Fair**	**Poor**	**Severe**
Concrete Foundation Defects	The concrete shows no deterioration. Superficial cracking, discoloration, or efflorescence may be present. No exposed reinforcing or impact damage.	Minor cracks and/or spalls may be present in the concrete. No exposed reinforcing or embedment erosion or impact damage.	Moderate cracks and/or spalls may be present. Some reinforcing may be exposed. Incidental loss of section or surface pitting of reinforcing may be present. Element may show evidence of some embedment erosion or impact damage.	Major cracks and/or spalls are present. Major corrosion of exposed reinforcing. Extensive steel and/or concrete loss or embedment erosion is present. Major impact damage may be present.

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Elements 21102 – 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 Bolt and Leveling Nut Defects	There is no deterioration. The elements are fully engaged. For non-frangible pole structures, the anchor bolt standoff distance is less than 1". For frangible pole structures lock washers are fully compressed. No evidence of impact damage	Minor corrosion of the elements may be present. The elements are fully engaged and functioning as intended. For non-frangible pole structures, the anchor bolt standoff distance is less than 1". For frangible pole structures lock washers are fully compressed. No evidence of impact damage.	Moderate corrosion/section loss of the elements may be present. Anchor nuts may not be fully tightened. For non-frangible pole structures, anchor bolt standoff distance is greater than 1" but less than two times the bolt diameter. For frangible pole structures a lock washer may be missing or not fully compressed. A nut may not fully engage the frangible transformer base. Some evidence of impact damage may be present.	Severe corrosion/section loss of the elements may be present. Multiple nuts or washers are loose/missing. For non-frangible pole structures, anchor bolt standoff distance is greater than two times the bolt diameter. UT testing indicates cracks or breaks in bolts. For frangible pole structures multiple nuts may not fully engage the base. Major evidence of impact damage may be present.

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Elements 21103 – Frangible Base

Description	Frangible base which connects the upright element to the foundation which is designed to break away or yield when a vehicle impact occurs to a frangible pole structure.			
Quantity Calculation	The quantity is collected in each.			
	Condition State Descriptions			
Defect Type	**Good**	**Fair**	**Poor**	**Severe**
Frangible Base Defects	New or like-new condition with no deficiencies. The inside of the base is free of excess moisture, debris, and corrosion.	Minor corrosion or superficial damage may be present. The inside of the base may contain minor moisture and debris. Minor gaps may be present between the base and foundation.	Moderate corrosion/section loss, wear or damage is present. Moisture and debris may be present inside the base creating moderate corrosion and/or section loss. Moderate gaps may be present between the base and the foundation.	Major corrosion/section loss or damage is present. Major debris and moisture present inside the base. Cracks are present in the base or base tabs. Major gaps may be present between the base and foundation.

Elements 21201 – Frangible Base Connections

Description	This element defines the connections connecting the upright to the frangible base for a frangible pole structure.			
Quantity Calculation	The quantity for this element is measured as "each."			
	Condition State Descriptions			
Defect Type	**Good**	**Fair**	**Poor**	**Severe**
Frangible Base Connections Defects	New or like-new condition with no deficiencies. Lock washers are fully compressed. Ends of bolts are at least flush with top surface of nuts.	Minor corrosion or superficial damage may be present. Lock washers are fully compressed. Ends of bolts are at least flush with top surface of nuts.	Moderate corrosion/section loss, wear or damage is present. A lock washer may be missing, or not fully compressed. The flat washer may be deformed or not fully cover the bolt hole. The end of a bolt may not be at least flush with the top surface of the nut, but at least 75% of the threads are engaged.	Major corrosion/section loss or damage is present. Nuts or bolts are broken or missing. Bolt engages less than 75% of the threads of the nut.

Elements 21202 – 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.	Minor surface corrosion or superficial damage may be present. Base element welds have no evidence of defects.	Moderate corrosion/ 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.	Major corrosion/section loss is present. Base element welds may have cracks/defects. Base plate has moderate to major warping.

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Elements 21203 – Vertical Support Column (Upright)

Description	This element is defined by all upright supporting a frangible or non-frangible pole structure.			
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.	Moderate corrosion/ section loss may be present. Protective coatings are failing. Element welds have no evidence of defects and/or cracking. Support may be out moderately 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.

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Elements 21204 – Vertical Structure Connections

Description	This element consists of the connections along the upright for various attachments.			
Quantity Calculation	The quantity to be collected includes each connection location.			
	Condition State Descriptions			
Defect Type	**Good**	**Fair**	**Poor**	**Severe**
Vertical Structure Connection Defects	New or like-new condition with no deficiencies.	Minor surface corrosion, wear, or superficial damage may be present. The connection is functioning as intended. Hardware is fully engaged. No gaps are present.	Moderate corrosion/section loss or wear is present. Hardware is fully engaged. Gap may be present at bolted connection, but bolts are tight. The conditions do not significantly affect serviceability and/or function.	Major corrosion/section loss is present. Protective coatings are significantly failing. Members may have cracks/defects or major wear. Hardware is loose or missing. Connection is not functioning as intended.

Elements 21301 – Luminaire and Luminaire Arm

Description	This element consists of lighting sources, fixtures and assemblies, bracket arms, truss arms, tenon mounts, shepherds crooks, or other pole mounting devices.			
Quantity Calculation	The quantity is collected as each luminaire and luminaire arm unit.			
	Condition State Descriptions			
Defect Type	**Good**	**Fair**	**Poor**	**Severe**
Luminaire and Luminaire Arm	Lighting source, housing/cover, waterproofing-gasket/seal, and arm or mounting device do not have evident wear or corrosion and are functioning as intended.	Gasket/seal may have minor deterioration. Lighting source, housing/cover, arm, and connections may have minor wear or corrosion.	Gasket/seal may be moderately deteriorated. Lighting source, housing/cover, arm, and connections may have moderate wear or corrosion, but the conditions do not significantly affect serviceability and/or function.	Major deterioration of gasket/seal is present. Lighting assembly or hardware is broken or missing. Major failure of protective coatings or corrosion/pitting/section loss is present. Welds have cracks/defects. Element is not functioning as intended.

12 HIGH MAST LIGHTING TOWER (HMLT)

12.1 Definitions

HMLT are light poles mounted on a concrete foundation with anchor bolts and a lighting array containing multiple luminaires. The poles may be constructed of galvanized or weathering steel and may be round or multi-sided. The poles are typically constructed from multiple pieces joined together with slip joints. The lighting array is mounted with a lowering device contained within the pole to allow for the array to be lowered for luminaire maintenance.

12.1.1 INVENTORY ITEMS

The inspector shall identify the number of anchor bolts on the foundation and shall determine the type of coating – paint, galvanizing, powder coated, or uncoated.

The tower may support a variety of attachments, both directly and indirectly. The quantity and type of these appurtenances and their attachments or connections to the structure should be noted. The types of connections may include direct bolting, bands, clamps, or brackets. Although the non-structural appurtenances such as luminaires do not receive ratings themselves, the general conditions should be noted and reported appropriately if they pose a safety risk.

The inspector shall provide a Work Rec if the mounts and attachments for the luminaires appear to be damaged or need the luminaires need replacement. The inspector shall also note the presence of any non-typical attachments that may not have been approved or been part of the original purpose or function of the HMLT. The inspector shall provide the Power Meter number.

The inspector shall confirm any pre-populated inventory data while recording information that is not already documented. It may not be possible to record or verify all measurements exactly due to access or other limitations; estimate and use experience and best judgement to record data to the most accurate extent possible. Take photos of the required inventory items listed in Section 12.2.2.

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

12.1.2 ELEMENTS

HMLT are divided into two components: Foundation and Vertical Structure.

Foundation is further divided into elements: Concrete Foundation, Anchor Bolts.

Vertical Structure is further divided into elements: Base Plate, Vertical Support Column (Upright), Pole Splice Connections, and Lighting Array.

Table 12-1: High-Mast Lighting Tower Components and Elements

Component	Element	Element Code	Unit of Measure
Foundation	Concrete Foundation	22101	Each
Foundation	Anchor Bolts and Leveling Nuts	22102	Each bolt and nut unit
Vertical Structure	Base Plate	22201	Each
Vertical Structure	Vertical Support Column (Upright)	22202	Length, feet
Vertical Structure	Pole Splice Connections	22203	Each
Vertical Structure	Lighting Array	22204	Each

12.1.3 COMPONENTS

HMLT are divided into two main components: the foundation and the vertical structure.

Component ratings for HMLT are based on the following:

- ***Foundation*** – Consider the structure's foundation effect on overall stability of the HMLT.
- ***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.

See Section 1.7 for discussion on component ratings, element ratings, and condition states. A representation of the rating structure is provided in Figure 12-1. A sketch of a typical HMLT with components and elements is shown in Figure 12-2.

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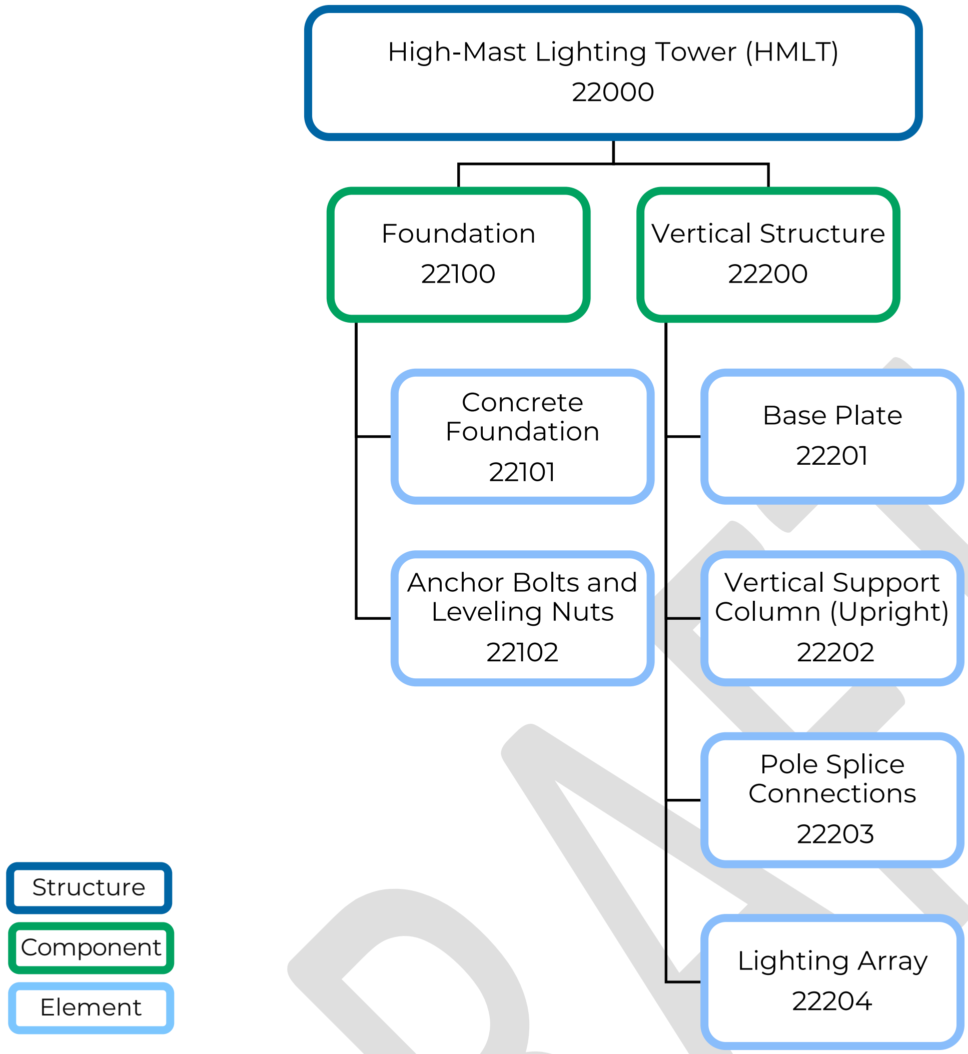

Figure 12-1: Rating structure for High-Mast Lighting Tower

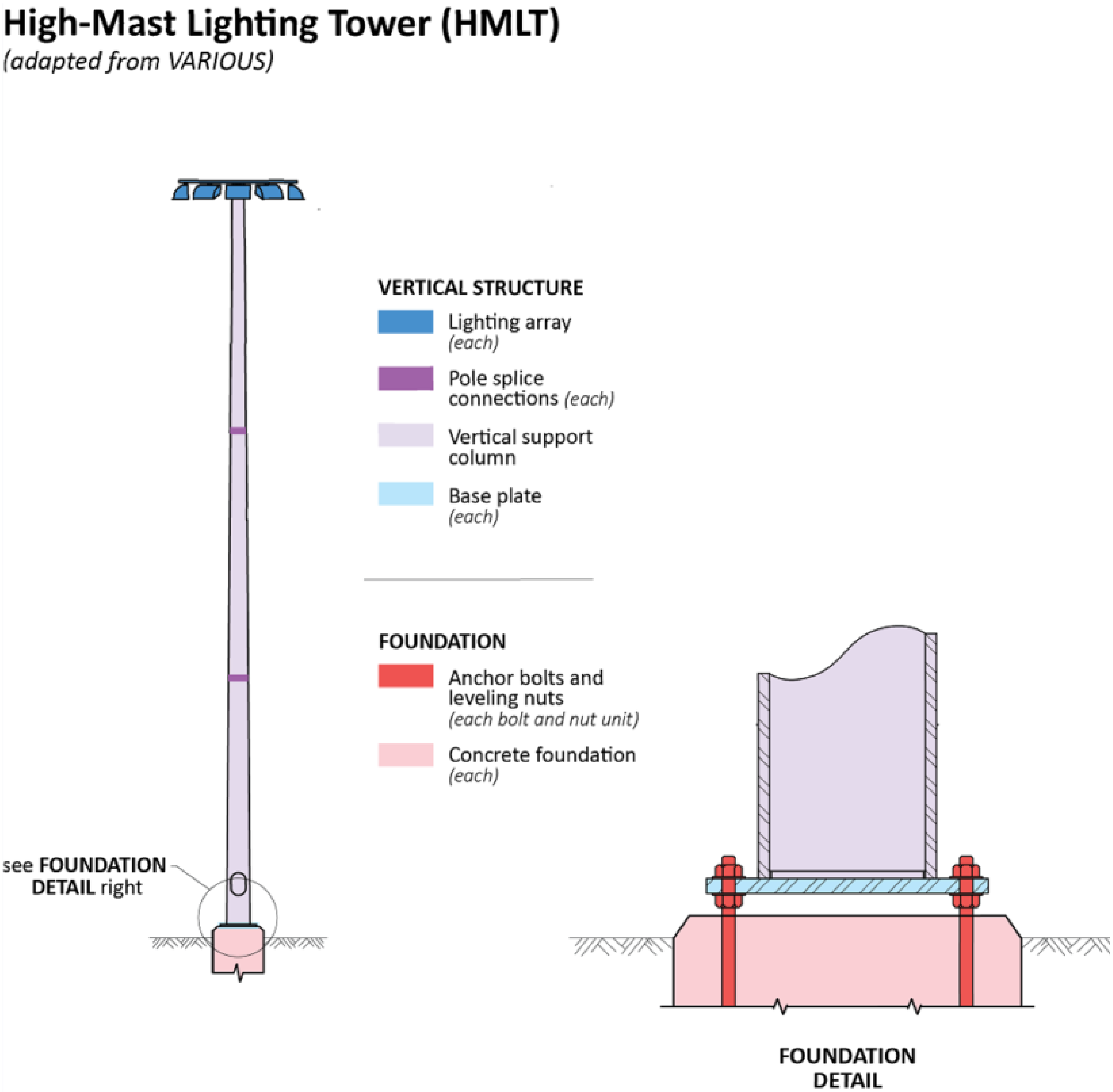

Figure 12-2: Elements and components for HMLT (adapted from MDOT Project Drawings, various)

12.2 Inventory Record Photographs

Inventory photos are captured during a routine inspection, saved as part of the inventory database, and follow the naming convention in *Table 12-2*.

High Mast Lighting Tower Required Photos:

- General view of the entire structure
- General view of the entire foundation

- General view of the top of the tower showing attachments, such as luminaires, communication equipment, cameras, or sensors

Table 12-2: High Mast Lighting Tower Photograph Naming Convention

Photo Name	Description
HMLT_Entire	Entire high mast lighting tower
HMLT_Foundation	Foundation
HMLT_Splice_Connection	Splice Connection, typical
HMLT_Lum	Lighting array
HMLT_ID	Old ID and new structure number
HMLT_UAS_#	Still photographs extracted from UAS video of the high mast lighting tower, numbered sequentially, if applicable

*** Where # is a sequential number ranging from 1-X. One image will be accepted if all items can be captured in a single image that provides enough detail. If this level of detail cannot be obtained in a single image, then take photos needed to provide this level of visibility.**

12.3 Inspector Minimum Technical Qualifications

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

- A minimum experience of two projects with a minimum of 10 structures total inspecting towers (High Mast, ESS, or Communication). Bolt inspection experience on towers, cantilever or truss structures, or other ancillary structure type. Multiple structure types shall have been inspected as part of the total project experience
- Ancillary structures inspection procedures training
- 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
- 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
- Visual Testing (VT) – Current ASNT or CWI qualifications

12.4 Routine Inspection

High-mast lighting typically consists of a tall pole with lighting attached at the top pointing to the ground. High Mast Lighting Tower (HMLT) ancillary structures are constructed and designed to support lighting arrays along roadways. They are rigidly anchored to their foundations, with heights ranging from 60 to 200 feet. They are typically freestanding

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structures and include a self-supporting tower. Splices between support column sections may be butt welded or have overlap slip joints. Poles are typically tapered and are connected to the concrete foundation with anchor bolts.

HMLT standard inspection frequency is once every 2 years, unless otherwise identified for more frequent inspection.

Figure 12-3: High-Mast Lighting Tower, aerial view of tower and lighting array from UAS

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Table 12-3 provides guidance for inspecting reinforced and prestressed concrete cracking.

Table 12-3: 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)

12.4.1 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. The routine inspection is performed on a regularly scheduled basis and includes the foundation component rating as determined by the element condition ratings of the concrete foundation and steel anchor bolts and nuts. Steel anchor bolt and nut connections may have lock washers or use turn-of-nut method. The inspection should cover these features as applicable. Routine inspection 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 rod diameter and length, then scan for defects.
- Examine anchor rods for tightness and embedment using a standard inspection hammer. Inspect visually for corrosion, section loss, and plumbness.
- Examine anchor rods for any eccentricity. Note any noticeable eccentricity measurements.
- Perform ultrasonic testing of anchor rods to note any breaks and verify lengths.
- Provide photographs for all Poor or Severe condition state defects and submit the applicable Work Recs or RFAs.

12.4.1.1 *Foundation Component Ratings*

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, not the foundation component.

Table 12-4: Component Rating Guidelines for HMLT Foundation

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 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.
		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 repair 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 of structure. Notify Region and the Bureau of Bridges and Structures.

12.4.1.2 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, impact damage, 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 12-5: HMLT Concrete Foundation Element Distresses

Element Number	Element	Description	Associated Distresses
22101	Concrete Foundation	Frangible and non-Frangible pole structure foundations	Cracking
			Spalling, delamination, and patching
			Exposed rebar
			Embedment erosion
			Impact damage
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.			

Details on the condition state rating schema are in Section 12.7, linked below:

HMLT Condition State Tables

Figure 12-4: HMLT concrete foundation, spalling deterioration

12.4.1.3 Anchor Bolts and Leveling Nuts Element Condition States

The anchor bolts transfer load from the structure into the foundation. For HMLT, this element addresses the bolts in connection with the concrete foundation only.

The purpose of the anchor bolt inspection is to identify any degradation of the nuts, flat washers, leveling nuts, and anchor bolts connecting the tower base to the concrete foundation. Typical issues include corrosion, damaged threads, loose connections, missing or damaged anchor bolts 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, and a determination of the tightness of the bolts and nuts. A sounding test, and a straight beam ultrasound scan (UT test) of 10 inches into the anchor bolts are recommended. Published procedures for the sounding and UT test are provided in references found in Section 4.3.7.

Visually inspect the base looking for missing or damaged anchor bolts or nuts connected to the foundation. Note any damage or corrosion and any bolt that shows signs of bending. 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. Any distance greater than one inch does not meet specifications and may be cause for concern.

Table 12-6: HMLT Anchor Bolt and Leveling Nuts Element Distresses

Element Number	Element	Description	Associated Distresses
22102	Anchor Bolts and Leveling Nuts	Anchor bolts and leveling nuts at HMLT foundation	Corrosion or coating damage
			Loose or missing anchor nut
			Cracked bolt
			Standoff distance
			Impact damage
Unit of Measure: Each, note quantity of anchor bolt and nut units within each condition state			

Details on the condition state rating schema are in Section 12.7, linked below:

HMLT Condition State Tables

12.4.2 VERTICAL STRUCTURE ROUTINE INSPECTION

The uprights directly support the lighting arrays. The routine inspection assesses the vertical structure's ability to safely support the lighting array and transfer all loads to the foundation. As the high mast tower is a single tower, it is non-redundant and can be considered fracture critical. The structures are susceptible to effects of solar heating from the sun, with the side exposed to sunlight typically exhibiting tensile stress cracks. The lighting array is typically comprised of a ring with multiple luminaires mounted to it, which lights a large area. Towers have winches that can be used to raise or lower the lighting array for routine maintenance.

The routine inspection is performed on a regularly scheduled basis and includes the vertical structure component rating as well as the condition state element ratings of the baseplate, vertical support column (upright), pole splice connections, and lighting array. It consists of observations and measurements needed to determine the physical and functional condition of the vertical structure, to identify any changes from initial or previously recorded conditions, and to ensure that the vertical structure continues to satisfy present service requirements. Routine inspection does not include raising and lowering the lighting array to check for mechanical or moving functionality.

Visually inspect all elements of the component at a distance close enough to determine the overall condition and to detect deficiencies. Historically, binoculars have been used as a visual aid while closer review has been accomplished with mechanical lift equipment or climbing. Recently, the employment of UAS equipment has been accepted given the ability to provide close-up, high-resolution imagery from many different angles around a tower. UASs have been shown to reduce risk to the inspection team and public as generally no lane closures or large equipment in the right-of-way are required.

An example of a typical vertical structure routine inspection would be:

- Note condition of base plate above top of foundation.
- Examine rodent screen (if present) visually for holes, connection, and corrosion. Note vegetation growth impeding access to the structure.
- Inspect the welds around hatches and handholes and all transverse welds near the base of the high mast pole for potential cracking.
- Examine the pole using visual methods outlined above. Note deterioration of the material, such as cracking, corrosion, and/or pack rust, noting the width, length, depth, and/or orientation of the deterioration.
- Pay specific attention to splice connections and distresses at those locations.
- Examine light ring for loose hardware or cords not properly secured, cracked lenses, damaged housing, and levelness of ring.
- Provide photographs for all Poor or Severe condition state defects and submit the applicable Work Recs or RFAs.

12.4.2.1 Vertical Structure Component Ratings

The component rating for the vertical structure depends on the condition of the baseplate, vertical upright(s), vertical support column, pole splice connections, and the lighting array. Assessing these factors with respect to the overall ability of the vertical structure to safely support the lighting, other attached appurtenances, and transfer loads to the foundation provides the appropriate component rating.

Examination of the inside of the pole Examine inside of pole for corrosion, section loss, cracking, water accumulation, and/or pack rust by removing handhole cover is not part of the Routine Inspection Procedure. If the handhole cover is missing, consider the condition of the interior of the visible portion of the pole as part of the component rating.

Table 12-7: Component Rating Guidelines for HMLT Vertical 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.
7	**GOOD**	All	Protective coating failure in very small and scattered locations on the tower steel. All components retain full section properties and function as designed.
6	**SATISFACTORY**	Steel	Protective coating failures is limited to less than 10% of the surface area with no loss of section.

Component Rating	Condition	Material	Description
		All	Minor deterioration affecting structural components. Minor misalignment.
5	FAIR	Steel	Minor loss of section. Loose connections and splice deterioration may be present, but the connections and splicing are in place and functioning as intended.
		All	Moderate deterioration affecting structural components including impact damage. Moderate misalignment. All members continue to function as designed.
4	POOR	Steel	Protective coating failure and less than 25% loss of section. Cracks may be present. Fasteners, bracing, connections, and splices may be considerably deteriorated. Considerable damage from impact or attachments.
		All	Considerable deterioration or misalignment affecting structural members. Structural review may be warranted.
3	SERIOUS	Steel	Measurable loss of section in excess of 25%. Missing or broken fasteners or extensive cracking in tower.
		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.

12.4.2.2 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 12-8: HMLT Base Plate Element Distresses

Element Number	Element	Description	Associated Distresses
22201	Base Plate	Base plate for High-Mast Lighting Tower	Corrosion or coating damage
			Weld defect or crack
Unit of Measure: Each, percentage of base plate within each condition state			

Details on the condition state rating schema are in Section 12.7, linked below:

HMLT Condition State Tables

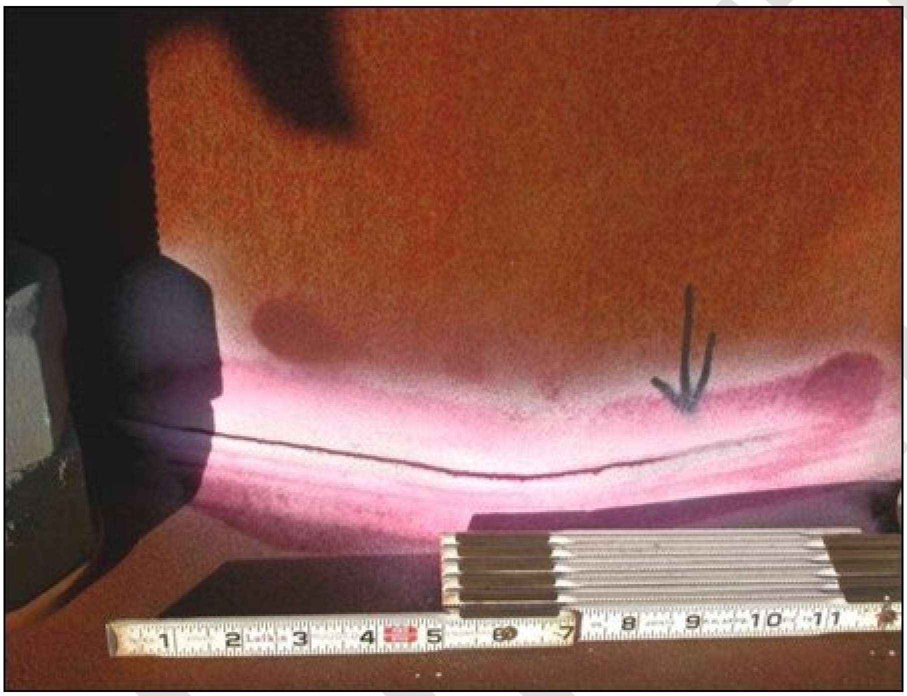

Figure 12-5: Crack at connection of HMLT vertical support column to base plate

12.4.2.3 Vertical Support Column (Upright) Element Condition States

Verify that the structure number is stenciled on the front of the upright (facing traffic) and is still legible. If necessary, use black paint to stencil the number on the vertical support (upright). Unless a mechanical lift or other means of working at heights (i.e., UAS) are utilized, binoculars are used as a visual aid to inspect the tops of vertical supports.

Note any galvanizing damage on the upright. 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.

The uprights should be checked for any vertical misalignment with a 4 ft level or similar, keeping in mind that HMLT uprights may be tapered and multiple checks around the perimeter may be necessary. A hand hole may be located near the base of the upright to allow for access to electrical systems. The hand hole cover should be securely fastened, and the hand hole frame inspected for any cracks in the welds or base metal, along with any other welded components. The uprights are typically galvanized and may have a single or multi-coat paint system on top of the galvanizing for FAA compliance or other reasons such as aesthetics. Any corrosion should be noted and if there is significant corrosion, the upright wall thickness should be checked for section loss with a thickness gauge or ultrasonic testing device.

Inspect the length of the upright for impact damage and cracks. If any type of impact damage is present (gouges, dents), clean the area (if accessible) and visually inspect for any cracks. Damage may also be caused by attachments to the vertical support column.

Table 12-9: HMLT Vertical Support Column (Upright) Element Distresses

Element Number	Element	Description	Associated Distresses
22202	Vertical Support Column (Upright)	Vertical Support (Upright) for HMLT	Corrosion or coating damage
			Weld defect or crack
			Out of plumb
			Impact damage
			Handhole defects
Unit of Measure: Length, feet of vertical support within each condition state			

Details on the condition state rating schema are in Section 12.7, linked below:

HMLT Condition State Tables

12.4.2.4 Pole Splice Connections Element Condition States

Spliced connections are present at the connection between sections of vertical support column. Pole splice connections include slip joints and circumferential welds for the column support of the structure. Poles greater than 50 feet in length are typically spliced together as separate pieces. Splices are often slip joints, with an upper section fitting over the top of the section below it. The splice transfers the load between sections. Occasionally, pole sections are connected with welds instead of the more typical splices.

Typical issues include weld discontinuities, galvanizing damage, or flange connection gaps. Note any gaps between steel in the spliced connections or cracked welds. Gusset, lacing, or stiffener plates may be present; note any cracks or corrosion in these plates. If plates are present at the connections, record any bolting components that are missing, deteriorated, or damaged. Record any signs of corrosion.

Table 12-10: HMLT Pole Splice Connections Element Distresses

Element Number	Element	Description	Associated Distresses
22203	Pole Splice Connections	Splices to support sections of vertical support columns on HMLT	Weld defects or cracks
			Corrosion or coating damage
			Loose, missing, or failing hardware
Unit of Measure: Each connection quantity within the condition state			

Details on the condition state rating schema are in Section 12.7, linked below:

HMLT Condition State Tables

Figure 12-6: HMLT pole splice

12.4.2.5 Lighting Array Element Condition States

Lighting arrays are comprised of many different parts including structural framing, brackets, luminaires, wiring and electrical connections/hardware. The arrays should be visually inspected for weld defects or cracks, corrosion, coating damage, hardware issues, etc.

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Figure 12-7: HMLT lighting array, as seen from a UAS

Table 12-11: HMLT Lighting Array Element Distresses

Element Number	Element	Description	Associated Distresses
22204	Lighting Array	Lighting array which supports luminaires on High-Mast Lighting Tower	Weld defects or cracks
			Corrosion or coating damage
			Loose, missing, or failing hardware
Unit of Measure: Each connection quantity within the condition state			

Details on the condition state rating schema are in Section 12.7 linked below:

HMLT Condition State Tables

12.4.3 REFERENCES

MDOT Tower Lighting Unit Installation Inspection Procedure

12.5 Work Recommendation Guidance

HMLT Work Recs are recorded to initiate preventive maintenance actions. These Work Recs are presented on the Ancillary Structures (AS) Inspection Report Form. Loose bolts are

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frequently the cause of Work Recs. 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.

The Work Recs are not meant to be all-inclusive and other Work Recs may be added to supplement those noted.

Photographs should include sufficient information to determine the relationship of the defect to the element or component or entire structure. Close-up photos of each defect with connection deficiencies marked on the photo should be provided.

Table 12-12: High-Mast Lighting Tower Work Recommendations

Code	Name	Material Involved	Quantity/Unit of Measure
1	Correct erosion at foundation (prevent undermining)	Stone/Soil	Cubic Feet
2	Repair/monitor foundation	Concrete	Cubic Feet
3	Address loose or damaged grounding wire/ground rod	Steel	Each
4	Address loose or damaged lightning rod	N/A	Each
5	Tighten leveling nut	Galvanized Steel	Each Nut
6	Repair/replace handhole cover	Galvanized Steel	Each Covert
7	Remove graffiti	N/A	Square Foot
8	Repair galvanizing	Galvanic Paint	Square Inch
9	Repair painting	Paint	Square Inch
10	Weld repair at upright to base plate connection	Steel	Each Weld
11	Weld repair at splice connections	Steel	Each Weld
12	Replace luminaire	Various	Each Light
13	Replace lighting array	Steel	Each Array
14	Repair/service lowering device	Various	Each Device
15	Repair/replace ID stencil on upright	Paint	Each Stencil

12.6 Request for Action Guidance

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 lateral displacement or vertical out of plumbness
c. Major base plate distortion or section loss around anchor bolts
d. Standoff distance more than twice the bolt diameter, where bending of anchor bolts is evident
e. Multiple loose bolts in an anchor bolt connection
f. Major cracks present in the base metal or weld(s) on the base plate to column connection
g. Major section loss due to corrosion of a main element which impacts the capacity or short-term resiliency of the element or structure
h. Presence of major cracks or active corrosion on main members (base metal) or connections (welded or slip) 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
i. 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 soil erosion or undermining of the foundation
c. Significant base plate distortion or section loss around anchor bolts
d. Standoff distance more than twice the bolt diameter where no bending of anchor bolts is evident
e. Pole is significantly out of vertical alignment
f. Anchor nuts are engaged with some gaps and/or bolts are misaligned
g. 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
h. Structural cracks in secondary members that could potentially propagate through welded connections into main members
i. Significant corrosion of primary elements or connections is present
j. Significant section loss or weld deficiencies at a field splice
k. Loose lighting connection assemblies where there is acceptable load-path redundancy, but significant impact to capacity or durability
l. 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)

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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. Anchor bolt standoff distance more than one inch but less than twice the anchor bolt diameter with no anchor bolt bending present
f. Pole is moderately out of vertical alignment
g. Moderate weld deficiencies, which do not meet code but do not impact function where significant redundancy is also present
h. Missing or loose nuts or other elements of a lighting connection assembly where there is adequate redundancy and moderate impact to structural capacity or durability
i. Moderate section loss at a field splice

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12.7 Element Condition States

Element Number	Element	Condition States Defects Note	Link to Discussion in Section 8
22101	Concrete Foundation	Use the appropriate condition state table	Concrete Foundation Element Condition States
22102	Anchor Bolts and Leveling Nuts	Use the appropriate condition state table. Use UT testing result to assist in the condition assessment.	Anchor Bolts and Leveling Nuts Element Condition States
22201	Base Plate	Use the appropriate condition state table.	Base Plate Element Condition States
22202	Vertical Support Column	Use the appropriate condition state table.	Vertical Support Column (Upright) Element Condition States
22203	Pole Splice Connections	Use the appropriate condition state table.	Pole Splice Connections Element Condition States
22204	Lighting Array and Lowering Device	Use the appropriate condition state table.	Lighting Array Element Condition States

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Elements 22101 – Concrete Foundation

Description	This element defines a concrete foundation for an HMLT, regardless of foundation type such as drilled shaft or reinforced concrete pile.			
Quantity Calculation	The quantity is collected in each.			
	Condition State Descriptions			
Defect Type	**Good**	**Fair**	**Poor**	**Severe**
Concrete Foundation Defects	The concrete shows no deterioration. Superficial cracking, discoloration, or efflorescence may be present. No exposed reinforcing.	Minor cracks and/or spalls may be present in the concrete. No exposed reinforcing, embedment erosion, or impact damage.	Moderate cracks and/or spalls may be present. Some reinforcing may be exposed. Incidental loss of section or surface pitting of reinforcing may be present. Element may show evidence of some embedment erosion or impact damage.	Major cracks and/or spalls are present. Major corrosion of exposed reinforcing. Extensive steel and/or concrete loss or embedment erosion is present. Major impact damage may be present.

Elements 22102 – Anchor Bolts and Leveling Nuts

Description	Anchor bolts and leveling nuts attaching the upright to the foundation for HMLT.			
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. Anchor bolt standoff distance meets standard. No evidence of impact damage. The elements are fully engaged.	Minor corrosion of the elements may be present. Anchor bolt standard off distance meets standard. No evidence of impact damage. The elements are fully engaged and functioning as intended.	Moderate corrosion/ section loss of the elements may be present. Anchor bolt standoff distance is not excessive. Anchor nuts may not be fully tightened. Anchor bolts may have some evidence of impact damage and slight bending.	Major corrosion/section loss of the elements may be present. Multiple nuts are loose/missing. Excessive anchor bolt standoff distance. Major evidence of impact damage and anchor bolt bending or out of plumbness. UT testing indicates cracks or breaks in bolts.

Elements 22201 – Base Plate

Description	Base plate which connects the upright element to the anchor bolt and leveling nut element for the HMLT.			
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.	Minor surface corrosion or superficial damage may be present. Base element welds have no evidence of defects.	Moderate corrosion/section loss or damage may be present. Protective coatings are failing. Base element welds have no evidence of defects and/or cracking. Base plate may exhibit minor warping.	Major corrosion/section loss is present. Base element welds may have cracks/defects. Base plate has moderate to major warping.

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Elements 22202 – Vertical Support Column (Upright)

Description	This element is defined by all uprights supporting an HMLT.			
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 and functioning as intended.	Minor corrosion or superficial damage of the elements may be present. No element weld defects or cracking are evident. Minor superficial impact damage may be present.	Moderate corrosion/ pitting/section loss may be present. Protective coatings are failing. Element welds have no evidence of defects and/or cracking. Support may be out moderately 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.
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.
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.

Elements 22203 – Pole Splice Connections

Description	This element consists of the splices to support sections of vertical support columns on an HMLT.			
Quantity Calculation	The quantity is collected as each splice.			
	Condition State Descriptions			
Defect Type	**Good**	**Fair**	**Poor**	**Severe**
Pole Splice connection defects	New or like-new condition with no deficiencies.	Minor surface corrosion or superficial damage may be present.	Moderate corrosion/ section loss or wear is present but splice is functioning as intended.	Major corrosion/section loss is present. Protective coatings are failing. Members may have weld cracks ordefects.

Elements 22204 – Lighting Array and Lowering Device

Description	This element consists of the lighting array and associated lowering device which supports luminaires on HMLT.			
Quantity Calculation	The quantity is collected as each array. A single rating is anticipated.			
	Condition State Descriptions			
Defect Type	**Good**	**Fair**	**Poor**	**Severe**
Lighting Array and Lowering Device Defects	No evidence of corrosion, loose, or damaged component. No imbalance or misalignment of structure. Hardware components are sound and function as intended.	Minor corrosion, coating loss, loose, or damaged component may be present. Minor element imbalance or misalignment may be visible. Any minor defect present does not affect serviceability and/or function of structure.	Moderate corrosion, loose, or damaged component may be present. Major element imbalance or misalignment may be visible. Any defect present does not significantly affect serviceability and/or function of structure.	Major corrosion, loose, missing, or damaged component may be present. Major element imbalance or misalignment may be visible. Element conditions have majorly affected the serviceability or integrity of the structure.

13 COMMUNICATION TOWER

13.1 Definitions

Communication towers support ITS infrastructure and communication antennae and consist of three main vertical supports (legs), each mounted on a separate concrete foundation with anchor bolts. The vertical supports have lattice members connected to each other with diagonal bracing at lower elevations and combining into a single vertical lattice member at higher elevations.

13.1.1 INVENTORY ITEMS

The inspector shall identify the number of anchor bolts per foundation. The inspector shall also identify if the tower is triangular or square shaped (3 or four vertical supports) with triangular or square shaped bracing. The inspector shall determine the type of coating – paint, galvanizing, or uncoated and note if there is a secured fence around the tower, preventing casual access to the tower. Note the accessibility and safety of the climbing apparatus attached to the tower for inspection.

The tower may support a variety of attachments, both directly and indirectly. The quantity and type of these appurtenances and their attachments or connections to the structure should be noted. The types of connections may include direct bolting, bands, clamps, or brackets. Although the non-structural appurtenances such as signals, sensors, dishes, cabinets, other ITS devices do not receive ratings themselves, the general conditions should be noted and reported appropriately if they pose a safety risk.

The inspector shall provide a Work Rec if the mounts and attachments for the appurtenances appear to be damaged. The inspector shall note and record the presence of any non-typical attachments that may not have been approved or been part of the original purpose or function of the tower and confirm any pre-populated inventory data while recording information that is not already documented. It may not be possible to record or verify all measurements exactly due to access or other limitations; estimate and use experience and best judgement to record data to the most accurate extent possible. Take photos of the required inventory items listed in Section 13.2.2.

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

13.1.2 ELEMENTS

Communication Towers are divided into two components: Foundation and Vertical Structure.

Foundation is further divided into elements: Concrete Foundation, Anchor Bolts.

Vertical Structure is further divided into elements: Base Plate, Vertical Support Column (Upright), Bracing, Vertical Structure Connections, and Vertical Structure Splices.

Table 13-1: Communication Tower Components and Elements

Component	Element	Element Code	Unit of Measure
Foundation	Concrete Foundation	23101	Each
Foundation	Anchor Bolts and Leveling Nuts	23102	Each bolt and nut unit
Vertical Structure	Base Plate	23201	Each
Vertical Structure	Vertical Support Column (Upright)	23202	Length, feet
Vertical Structure	Bracing	23203	Each
Vertical Structure	Vertical Structure Connections	23204	Each
Vertical Structure	Vertical Structure Splices	23205	Each

13.1.3 COMPONENTS

Communication Towers are divided into two main components: the foundation and the vertical structure.

Component ratings for Communication Towers are based on the following:

- ***Foundation*** – Consider the structure's foundation effect on overall stability of the communication tower 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.

See Section 1.7 for discussion on the component rating and element condition states rating process. A representation of the rating structure is provided in Figure 13-1. A sketch of a typical Communication Tower with components and elements is shown in Figure 13-2.

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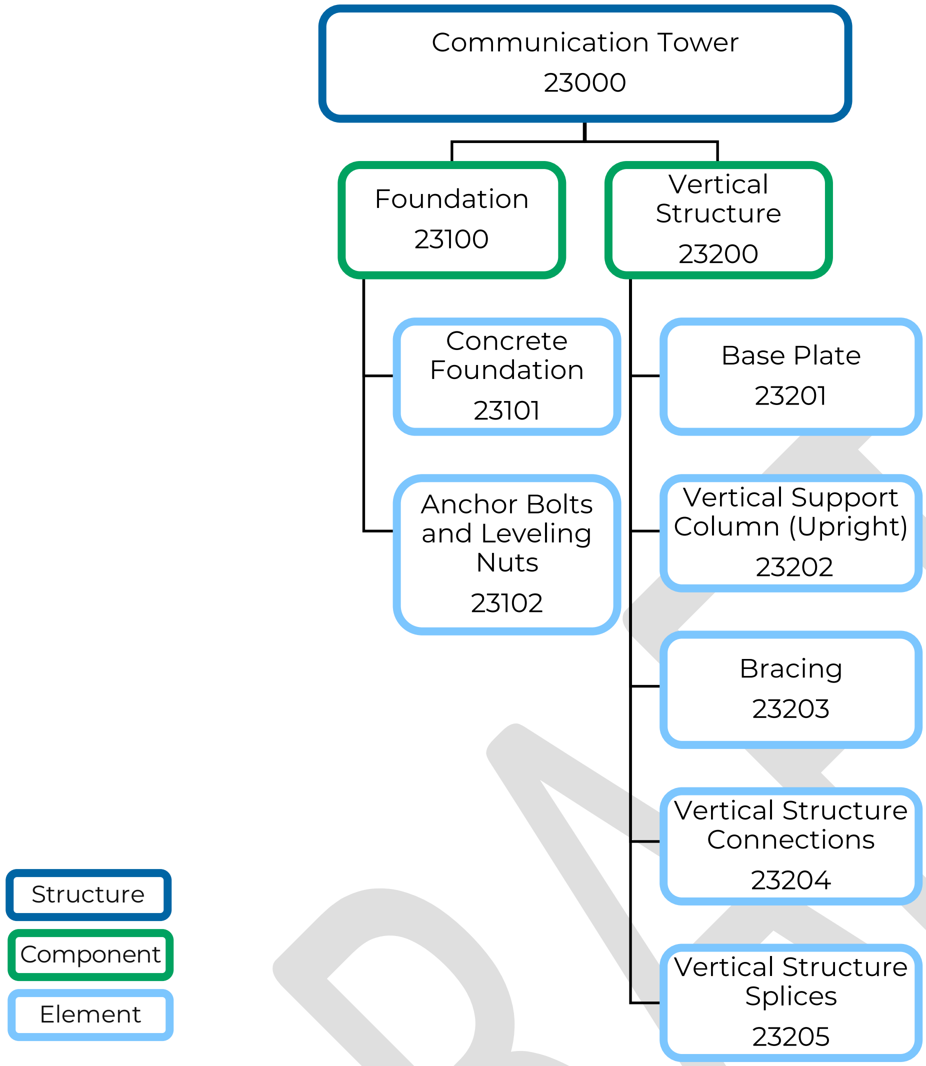

Figure 13-1: Rating structure for Communication Tower

Communication Tower

(adapted from MDOT Project drawings, various)

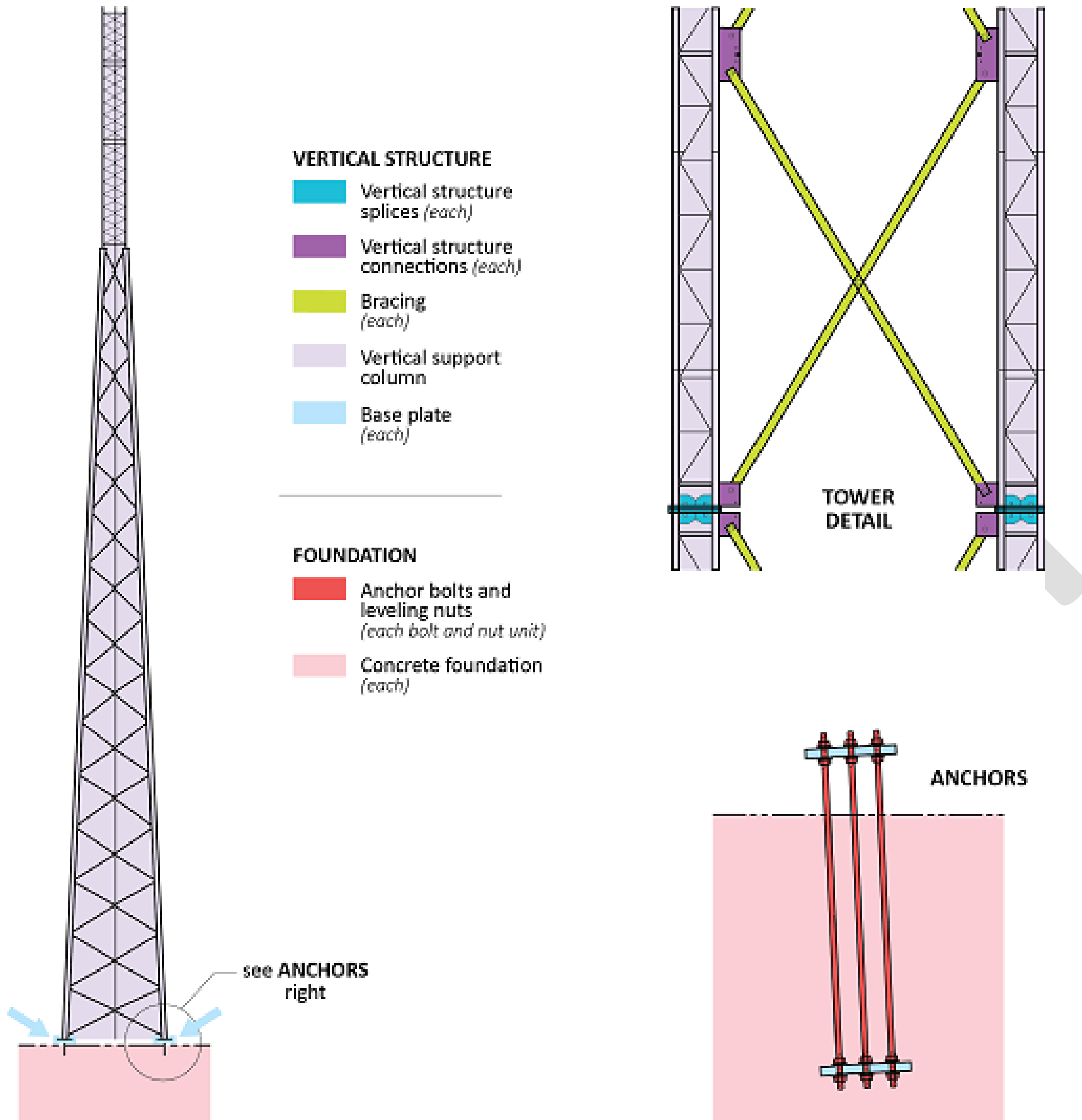

Figure 13-2: Elements and components for Communication Tower (adapted from MDOT Project drawings, various)

13.2 Inventory Record Photographs

Inventory photos are captured during a routine inspection, saved as part of the inventory database, and follow the naming convention in *Table 13-2*.

Communication Tower Required Photos:

- General view of the entire structure
- General view of the entire foundation
- General view of the top of the tower showing attachments. such as luminaires, communication equipment, cameras, or sensors

Table 13-2: Communication Tower Photograph Naming Convention

Photo Name	Description
Comm_Entire	Entire communication tower
Comm_Foundation#	Foundation
Comm_Climb#	Communication tower climbing apparatus
Comm_ID	Old ID and new structure number
Comm_UAS_#	Still photographs extracted from UAS video of the communication tower, numbered sequentially, if applicable
*** Where # is a sequential number ranging from 1-X. One image will be accepted if all items can be captured in a single image that provides enough detail. If this level of detail cannot be obtained in a single image, then take photos needed to provide this level of visibility.**	

13.3 Inspector Minimum Technical Qualifications

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

- A minimum experience of two projects with a minimum of 10 structures total inspecting towers (High Mast, ESS or Communication). Bolt inspection experience on towers, cantilever or truss structures, or other ancillary structure type. Multiple structure types shall have been inspected as part of the total project experience.
- Certified climber (steeplejack) if arm's length inspection is conducted
- Ancillary structures inspection procedures training
- 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
- 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
- Visual Testing (VT) – Current ASNT or CWI qualifications

13.4 Routine Inspection

Communication Towers are constructed and designed to support antennas for telecommunications and broadcasting. They may support the broadcast of various signals, including television, cellular phone, wireless internet, or radio. They may gather sensor data and camera images, which are then distributed over cellular communications to servers hosted by MDOT. They are typically freestanding structures and include a self-supporting (lattice) tower; communication towers are alternatively designed with guyed towers (guyed towers are not within the Program). In Michigan, these structures are typically designed and constructed through design-build contracting mechanisms.

Communication Tower standard inspection frequency is once every 10 years for arm's length inspection and once every 5 years for visual inspection, unless otherwise identified for more frequent inspection. A visual inspection may consist of use of binoculars to inspect the structure portions that cannot be reasonably observed within "arm's length" (approximately 2 feet) distance.

Figure 8.13.1: Communication Tower, aerial view from UAS

Table 13-3 provides guidance for inspecting reinforced and prestressed concrete cracking.

Table 13-3: 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)

13.4.1 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. The routine inspection is performed on a regularly scheduled basis and includes the foundation component rating, and element condition state 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. Some amplitude modulation (AM) towers have been repurposed for communications towers. If the tower is an AM Tower, follow safety requirements for radiation and other special considerations prior to inspection. AM towers have high wattage which can cause serious damage or death.

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 rod diameter and length, then scan for defects.
- Examine anchor rods for tightness and embedment using a standard inspection hammer. Inspect visually for corrosion, section loss, and plumbness.
- Examine anchor rods for any eccentricity. Note any noticeable eccentricity measurements.
- Perform ultrasonic testing of anchor rods to note any breaks and verify lengths.
- Provide photographs for all Poor or Severe condition state defects and submit the applicable Work Recs or RFAs.

13.4.1.1 Foundation Component Ratings

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.

Confirm that the tower base ground is connected to the steel and terminated to the ground ring or ground rod, and that ground leads are not broken and torn. If the tower is an AM tower, thoroughly inspect the insulator for any cracks in the porcelain or ceramics, which would weaken its integrity.

Table 13-4: Component Rating Guidelines for Communication Tower Foundation

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

Component Rating	Condition	Material	Description
			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.
3	**SERIOUS**	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 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 to condition. Notify Region and the Bureau of Bridges and Structures.

13.4.1.2 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, impact damage, 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 13-5: Communication Tower Concrete Foundations Element Distresses

Element Number	Element	Description	Associated Distresses
23101	Concrete Foundation	Communication Tower concrete foundations	Cracking
			Spalling, delamination, and patching
			Exposed rebar
			Embedment erosion
			Impact damage
Unit of Measure: Each foundation, note number of foundations within each condition state			

Details on the condition state rating schema are in Section 13.7, linked below:

Communication Tower Condition State Tables

13.4.1.3 Anchor Bolts and Leveling Nuts Element Condition States

The anchor bolts transfer load from the structure into the foundation. For Communication Towers, this element addresses the bolts in connection with the concrete foundation only.

The purpose of the anchor bolt inspection is to identify any degradation of the nuts, flat washers, leveling nuts, and anchor bolts connecting the tower base to the concrete foundation. Typical issues include corrosion, damaged threads, loose connections, missing or damaged anchor bolts 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, and a determination of the tightness of the bolts and nuts. A sounding test, and a straight beam ultrasound scan (UT test) of 10 inches into the anchor bolts are recommended. Published procedures for the sounding and UT test are provided in references found in Section 4.3.7.

Visually inspect the base looking for missing or damaged anchor bolts or nuts connected to the foundation. Note any damage or corrosion and any bolt that shows signs of bending. 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. Any distance greater than one inch does not meet specifications and may be cause for concern.

Table 13-6: Communication Tower Anchor Bolt and Leveling Nuts Element Distresses

Element Number	Element	Description	Associated Distresses
23102	Anchor Bolts and Leveling Nuts	Anchor bolts and leveling nuts	Corrosion or coating damage
			Loose or missing anchor nut
			Cracked bolt
			Standoff distance
			Impact damage
Unit of Measure: Each, note quantity of anchor bolt and nut units within each condition state			

Details on the condition state rating schema are in Section 13.7, linked below:

Communication Tower Condition State Tables

13.4.2 VERTICAL STRUCTURE ROUTINE INSPECTION

The uprights and connected bracing elements directly support the communication dishes and arrays, as well as other attachments. The routine inspection assesses the vertical structure's ability to safely support the attachments and transfer all loads to the foundation. The routine inspection is performed on a regularly scheduled basis and includes the vertical structure component rating as well as the condition state element ratings of the baseplate, vertical support column (upright), bracing, vertical structure connections, and vertical structure splice conditions. It consists of observations and measurements needed to determine the physical and functional condition of the vertical structure, to identify any changes from initial or previously recorded conditions, and to ensure that the vertical structure 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. Historically, binoculars have been used as a visual aid while closer review has been accomplished with mechanical lift equipment or climbing. Recently, the employment of UAS equipment has been accepted given the ability to provide close-up, hi-res imagery from many different angles around a tower. UASs have been shown to reduce risk to the inspection team and public as generally no lane closures or large equipment in the right-of-way are required.

- Assess foundation and baseplate, performing bolt tests, as necessary.
- Examine the tower using visual methods outlined above. Identify and log any locations, if any, that require an arm's length inspection by an inspector.
- Prior to climbing, the inspector shall verify the safety climb is properly tensioned and visually inspect that it is properly secured to the cable throughout the length of the tower. The UAS may be used to assist with the review of the safety climb.
- Verify feed cords and SOOW cords are properly secured.
- Observe and measure vertical structure column, bracing, connections, and splices.

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

13.4.2.1 Vertical Structure Component Rating

The component rating for the vertical structure depends on the condition of the baseplate, vertical upright(s), vertical support column, bracing, the vertical connection(s) to the horizontal structures, and the vertical structure splices. Assessing these factors with respect to the overall ability of the vertical structure to safely support the attached appurtenances and transfer loads to the foundation provides the appropriate component rating.

Table 13-7: Component Rating Guidelines for Communication Tower Vertical 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.
7	GOOD	All	Protective coating failure in very small and scattered locations on the tower steel. All components retain full section properties and function as designed.
6	SATISFACTORY	Steel	Protective coating failure is limited to less than 10% of the surface area with no loss of section.
6	SATISFACTORY	All	Minor deterioration affecting structural components. Minor misalignment.
5	FAIR	Steel	Minor loss of section. Loose connections and splice deterioration may be present, but the connections and splicing are in place and functioning as intended.
5	FAIR	All	Moderate deterioration affecting structural components including impact damage. Moderate misalignment. All members continue to function as designed.
4	POOR	Steel	Protective coating failure and less than 25% loss of section. Cracks may be present. Fasteners, bracing, connections, and splices may be considerably deteriorated. Considerable damage from impact or attachments.
4	POOR	All	Considerable deterioration or misalignment affecting structural members. Structural review may be warranted.
3	SERIOUS	Steel	Measurable loss of section in excess of 25%. Missing or broken fasteners or extensive cracking in tower.

Component Rating	Condition	Material	Description
		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.

13.4.2.2 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 13-8: Communication Tower Base Plate Element Distresses

Element Number	Element	Description	Associated Distresses
23201	Base Plate	Base plate for Communication Tower	Corrosion or coating damage
			Weld defect or crack
Unit of Measure: Each, percentage of base plate within each condition state			

Details on the condition state rating schema are in Section 13.7, linked below:
[Communication Tower Condition State Tables]

13.4.2.3 Vertical Support Column (Upright) Element Condition States

Verify that the structure number is stenciled on the upright and is legible. If necessary, use black paint to stencil the number on the vertical support (upright). Unless a mechanical lift, climbing, or other means of working at heights (i.e., UAS) are utilized, binoculars are used as a visual aid to inspect the tops of vertical supports. Note any galvanizing damage on the upright, including the climbing ladder. Also record the degree of damage, including any corrosion on the base metal. If any type of impact damage is present (gouges, dents), clean

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the area and visually inspect for any cracks. Damage may be caused by attachments to the vertical support column.

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.

Table 13-9: Communication Tower Vertical Support Column (Upright) Element Distresses

Element Number	Element	Description	Associated Distresses
23202	Vertical Support Column (Upright)	Vertical Support (Upright) for Communication Tower	Corrosion or coating damage Weld defect or crack Impact damage
Unit of Measure: Length, feet of vertical support within each condition state.			

Details on the condition state rating schema are in Section 13.7, linked below:

Communication Tower Condition State Tables

Figure 13-3: Communication tower with vertical supports and diagonal and horizontal bracing

13.4.2.4 Bracing Element Condition States

Bracing may be in both diagonal and horizontal directions connecting the vertical supports, with bolts and splices securing bracing to the vertical supports. Note any galvanizing damage on the bracing. Also record the degree of damage, including any corrosion on the base metal. If any type of damage is present (gouges, dents, or deformation), clean the area and visually inspect for any cracks. Damage may be caused by attachments to the vertical support column. Record any signs of corrosion. Record if bracing appears to be out of plumb or alignment.

Table 13-10: Communication Tower Bracing Element Distresses

Element Number	Element	Description	Associated Distresses
23203	Bracing	Bracings, either diagonal or horizontal, used for Communication Towers	Corrosion or coating damage
			Weld defects or cracks
			Out of Plumb
Unit of Measure: Each bracing quantity within the condition state			

Details on the condition state rating schema are in Section 13.7, linked below:

[Communication Tower Condition State Tables]

Figure 13-4: Bracing showing vertical structure bolted connection to vertical support

13.4.2.5 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. 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.

Table 13-11: Communication Tower Vertical Structure Connections Element Distresses

Element Number	Element	Description	Associated Distresses
23204	Vertical Structure Connection	Connections to support vertical column and bracing between columns for Communication Towers	Weld defects or cracks Corrosion or coating damage Loose, missing, or failing hardware
Unit of Measure: Each connection quantity within the condition state			

Details on the condition state rating schema are in Section 13.7, linked below:

[Communication Tower Condition State Tables]

Connection types are described in the following sections.

Bolted Connections

Visually inspect the horizontal 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 compressed, tight, and secure. Check for misalignment of the bolts. UAS may be implemented to assist with the visual inspection of these items and identification of distresses that require hands-on measurements or testing with a hammer.

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.

Welded Connections

In some cases, towers may have welded stiffener plates to additional support leg support. Visually inspect the welds for any indication of weld defects such as cracking, undercut, overlap, porosity, and proper weld size.

In many cases, the galvanizing above the weld, if present, may 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 a visual indication of deterioration in the weld has appeared, note the area and type of indication.

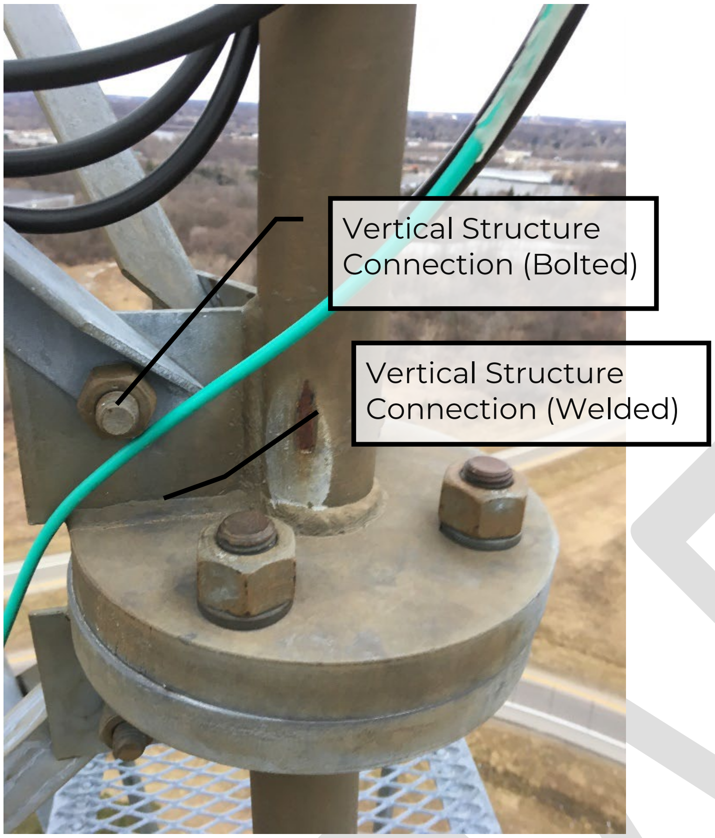

Figure 13-5: Welded and bolted vertical structure connections

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13.4.2.6 Vertical Structure Splices Element Condition States

Spliced connections are present at the connection of bracing to the vertical support columns. Typical issues include loose bolts and nuts, weld discontinuities, galvanizing damage, flange connection gaps, missing washers, and missing end caps. Note any gaps between steel in the bolted connections or cracked welds. Gusset, lacing, or stiffener plates may be present; note any cracks or corrosion in these plates. Record any bolting components that are missing, deteriorated, or damaged. Record any signs of corrosion.

Table 13-12: Communication Tower Vertical Structure Splices Element Distresses

Element Number	Element	Description	Associated Distresses
23205	Vertical Structure Splices	Splices to support vertical column and bracing for a Communication Tower	Weld defects or cracks Corrosion or coating damage Loose, missing, or failing hardware
Unit of Measure: Each connection quantity within the condition state			

Details on the condition state rating schema are in Section 13.7, linked below:

[Communication Tower Condition State Tables](#)

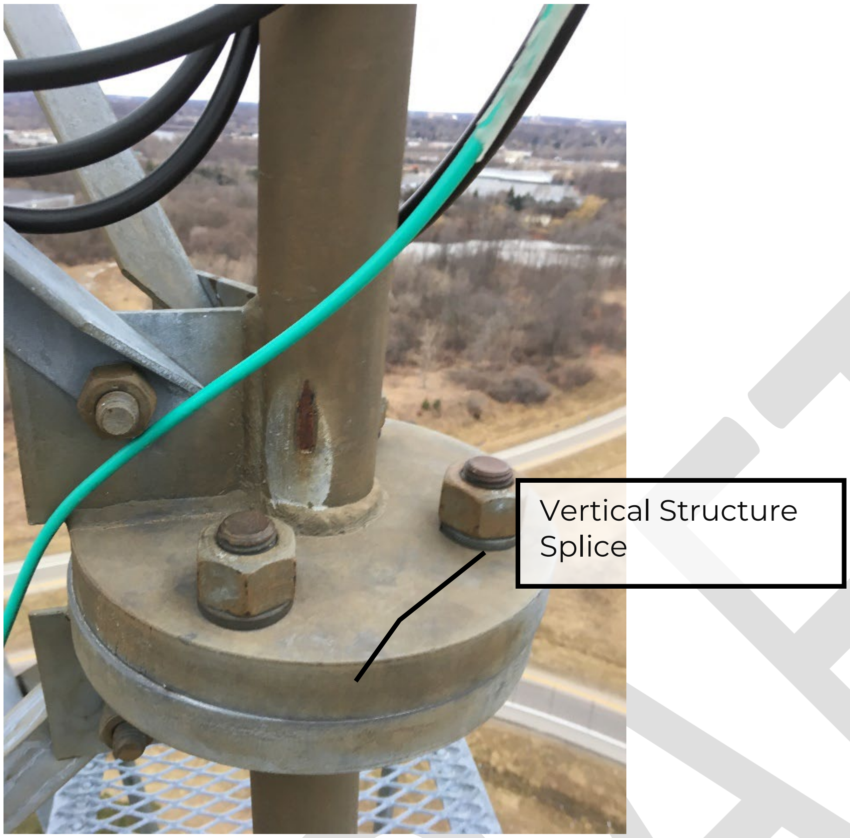

Figure 13-6: Vertical structure splice

13.4.3 REFERENCES

National Association of Tower Erectors (NATE)

ANSI/ASSP 10.48 Standard – Criteria for Safety Practices with the Construction, Demolition, Modification and Maintenance of Communications Structures

Michigan Tower Safety Standard: MIOSHA STD 1329 (03/09) Construction Safety And Health Standard Part 29. Communication Towers

13.5 Work Recommendation Guidance

Communication Tower Work Recs 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 Recs. 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.

Ladders, decks, and walkways of steel towers and similar structures do not need to be painted if a smooth surface presents a potential hazard to maintenance personnel. Painting may also be omitted from precision or critical surfaces if the paint would have an adverse effect on the transmission or radiation characteristics of a signal. However, the structure's overall marking effect should not be reduced. Note if painting appears to be missing; painting patterns may be required for various regulations such as solid, checkerboard, or alternating bands.

The Work Recs are not meant to be all-inclusive and other Work Recs may be added to supplement those noted.

Photographs should include sufficient information to determine the relationship of the defect to the element or component or entire structure. Close-up photos of each defect with connection deficiencies marked on the photo should be provided.

Table 13-13: Communication Tower Work Recommendations

Number	Description of Work Recommendation	Material involved	Quantity/Unit of Measure
1	Correct erosion at foundation (prevent undermining)	Stone/Soil	Cubic Foot
2	Repair/monitor foundation	Concrete	Cubic Foot
3	Address Grounding Wire	Steel	Each
4	Tighten leveling nut	Galvanized Steel Bolt	Each
5	Repair galvanizing	Galvanic Paint	Square Inch
6	Repair Painting	Paint	Square Inch
7	Repair grout pad	Cementitious Grout	Cubic Foot
8	Address loose bolts	Galvanized Steel	Each
9	Address loose connectors	Galvanized Steel	Each
10	Repair bracing	Steel	Each
11	Replace bracing	Steel	Each
12	Weld repair	Steel	Each Weld
13	Replace Misc. attachment	Various	Each
14	Repair or replace jacketing on coaxial	Various	Each
15	Repair leaks into conduit	Repair materials	Each
16	Add supports for waveguides	Galvanized Steel	Each

Number	Description of Work Recommendation	Material involved	Quantity/Unit of Measure
17	Add or replace guy wires	Guy Wires	Each
16	Remove empty dish mounts	Dish Mounts	Each
19	Remove cables extending to empty dish mounts	Cables	Each

13.6 Request for Action Guidance

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 lateral displacement or out of plumbness
c. Major base plate distortion or section loss around anchor bolts
d. Major corrosion, section loss or failure of high strength bolts where load-path redundancy is minimal
e. Multiple loose or missing bolts in a high strength bolted connection or appurtenance connection which impacts capacity or function, clearance, safety, or short-term resiliency of the element or structure
f. Major cracks present in the base metal or weld(s) on the base plate to column connection
g. Major section loss due to corrosion of a main element which impacts the capacity or short-term resiliency of the element or structure
h. Presence of major cracks or active corrosion on main members (base metal) or connections (welded or slip) 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
i. Buckling of primary members such as the uprights and bracing which carry vertical and shear loads.
j. 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)

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c. Significant base plate distortion or significant section loss, especially around anchor bolts
d. Significant deterioration of base plate grout pads with or without anchor bolt misalignment or bending
e. Anchor nuts are engaged with some gaps and/or bolts are misaligned
f. Significant corrosion of primary elements or connections is present
g. 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
h. Column supports are significantly out of vertical alignment
i. 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
j. Significant misalignment of elements at the chord splice connection where significant corrosion or damage is also present in one or more elements
k. Significant damage or corrosion of the column support elements are present
l. Structural cracks in bracing that could potentially propagate through welded connections into uprights.
m. Buckling of secondary members such as redundant bracing.
n. 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 deterioration of the base plate grout pads with no anchor bolt bending
f. Moderate weld deficiencies, which do not meet code but do not impact function where significant redundancy is also present
g. Missing nuts or other elements of a bolted connection where there is adequate redundancy and moderate impact to structural capacity or durability

13.7 Element Condition States

Element Number	Element	Condition States Defects Note	Link to Discussion in Section 13
23101	Concrete Foundation	Use the appropriate condition state table.	Concrete Foundation Element Condition States
23102	Anchor Bolts and Leveling Nuts	Use the appropriate condition state table. Use UT testing result to assist in the condition assessment.	Anchor Bolts and Leveling Nuts Element Condition States
23201	Base Plate	Use the appropriate condition state table.	Base Plate Element Condition States
23202	Vertical Support Column	Use the appropriate condition state table.	Vertical Support Column (Upright) Element Condition States
23203	Bracing	Use the appropriate condition state table.	Bracing Element Condition States
23204	Vertical Structure Connections	Use the appropriate condition state table.	Vertical Structure Connections Element Condition States
23205	Vertical Structure Splices	Use the appropriate condition state table.	Vertical Structure Splices Element Condition States

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Elements 23101 – Concrete Foundation

Description	This element defines a concrete foundation for a communication tower, regardless of foundation type such as drilled shaft or reinforced concrete pile.			
Quantity Calculation	The quantity is collected in each.			
	Condition State Descriptions			
Defect Type	**Good**	**Fair**	**Poor**	**Severe**
Concrete Foundation Defects	The concrete shows no deterioration. Superficial cracking, discoloration, or efflorescence may be present. No exposed reinforcing or erosion.	Minor cracks and/or spalls may be present in the concrete. No exposed reinforcing, embedment erosion or impact damage.	Moderate cracks and/or spalls may be present. Some reinforcing may be exposed. Incidental loss of section or surface pitting of reinforcing may be present. Element may show evidence of some embedment erosion or impact damage	Major cracks and/or spalls are present. Major corrosion of exposed reinforcing. Extensive steel and/or concrete loss or embedment erosion is present. Major impact damage may be present.

Elements 23102 – Anchor Bolts and Leveling Nuts

Description	Anchor bolts and leveling nuts attaching the upright to the foundation for communication towers.			
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. Anchor bolt standoff distance meets standard. No evidence of impact damage. The elements are fully engaged.	Minor corrosion of the elements may be present. Anchor bolt standard off distance meets standard. No evidence of impact damage. The elements are fully engaged and functioning as intended.	Moderate corrosion/section loss of the elements may be present. Anchor bolt standoff distance is not excessive. Anchor nuts may not be fully tightened. Anchor bolts may have some evidence of impact damage and slight bending.	Major corrosion/section loss of the elements may be present. Multiple nuts are loose/missing. Excessive anchor bolt standoff distance. Major evidence of impact damage and anchor bolt bending or out of plumbness. UT testing indicates cracks or breaks in bolts.

Elements 23201 – Base Plate

Description	Base plate which connects the upright element to the anchor bolt and leveling nut element for the communications tower.			
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.	Minor surface corrosion or superficial damage may be present. Base element welds have no evidence of defects. Grout may have minor cracking.	Moderate corrosion/section loss or damage may be present. Protective coatings are failing. Base element welds have no evidence of defects and/or cracking. Base plate may exhibit minor warping. Grout may have moderate cracking and spalling.	Major corrosion/section loss is present. Base element welds may have cracks/defects. Base plate has moderate to major warping. Sections of grout are missing.

Elements 23202 – Vertical Support Column (Upright)

Description	This element is defined by all uprights supporting a communication tower.			
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 and functioning as intended.	Minor corrosion or superficial damage of the elements may be present. No element weld defects or cracking are evident. Minor superficial impact damage may be present.	Moderate corrosion/pitting/section loss may be present. Protective coatings are failing. Element welds have no evidence of defects and/or cracking. Support may be out moderately 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.

Elements 23203 – Bracing

Description	This element consists of the boom which allows the tower to be lowered for maintenance.			
Quantity Calculation	The quantity is collected as each boom.			
	Condition State Descriptions			
Defect Type	**Good**	**Fair**	**Poor**	**Severe**
Bracing 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. Evidence of slight misalignment of bracing may be present.	Multiple or major element defects or section loss that may significantly affect the serviceability or integrity of the structure. Propagating cracks. Major misalignment of bracing may be present

Elements 23204 – Vertical Structure Connections

Description	This element consists of the connections to support vertical column and bracing between columns for communication towers			
Quantity Calculation	The quantity is collected as each connection.			
	Condition State Descriptions			
Defect Type	**Good**	**Fair**	**Poor**	**Severe**
Vertical Structure Connection 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.	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. 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. Hardware is loose or missing.

Elements 23205 – Vertical Structure Splices

Description	This element consists of the splices to support vertical column and bracing for a communication tower.			
Quantity Calculation	The quantity is collected as each splice.			
	Condition State Descriptions			
Defect Type	**Good**	**Fair**	**Poor**	**Severe**
Vertical Structure Splice Defects	New or like-new condition with no deficiencies	Minor surface corrosion or superficial damage may be present.	Moderate corrosion/ section loss or wear is present. Splice bolts or welds may be loose or damaged but are functioning as intended.	Major corrosion/section loss is present. Protective coatings are failing. Cracks/defects or major wear may be present. Splice bolt may be missing.

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14 ENVIRONMENTAL SENSOR STATION (ESS) TOWER

14.1 Definitions

ESS Towers refer to single vertical supports of built-up steel or aluminum members supported on a concrete foundation with anchor bolts. Some towers are combination of steel and aluminum members. They are three or four leg lattice structures and jointed to allow the structure to be lowered for maintenance. They are used to support a variety of sensory attachments.

14.1.1 INVENTORY ITEMS

The inspector shall identify the number of anchor bolts per foundation. The inspector shall also identify if the tower is triangular or square shaped and determine the type of coating – paint, galvanizing, powder coated, or uncoated.

The tower may support a variety of attachments, both directly and indirectly. The quantity and type of these appurtenances and their attachments or connections to the structure should be noted. The types of connections may include direct bolting, bands, clamps, brackets, or antennae mounts. Although the non-structural appurtenances such as signals, sensors, dishes, cabinets, other ITS devices do not receive ratings themselves, the general conditions should be noted and reported appropriately if they pose a safety risk. Provide a Work Rec if the mounts and attachments for the sensors and appurtenances appear to be damaged. Note and record the presence of any non-typical attachments that may not have been approved or been part of the original purpose or function of the ESS tower.

The inspector shall confirm any pre-populated inventory data while recording information that is not already documented. It may not be possible to record or verify all measurements exactly due to access or other limitations; estimate and use experience and best judgement to record data to the most accurate extent possible. Take photos of the required inventory items listed in Section 14.2.2.

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

14.1.2 ELEMENTS

ESS Towers are divided into two components: Foundation and Vertical Structure.

Foundation is further divided into elements: Concrete Foundation, Anchor Bolts.

Vertical Structure is further divided into elements: Base Plate, Vertical Support Column (Upright), and Tower Lowering Boom.

Table 14-1: ESS Tower Components and Elements

Component	Element	Element Code	Unit of Measure
Foundation	Concrete Foundation	24101	Each
Foundation	Anchor Bolts and Leveling Nuts	24102	Each bolt and nut unit
Vertical Structure	Base Plate	24201	Each
Vertical Structure	Vertical Support Column (Upright)	24202	Length, feet
Vertical Structure	Tower Lowering Boom	24203	Each

14.1.3 COMPONENTS

ESS Towers are composed of two components: the foundation and the vertical structure.

Component ratings for ESS Towers are based on the following:

- ***Foundation*** – Consider the structure's foundation effect on overall stability of the ESS Tower.
- ***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.

See Section 1.7 for discussion on the component rating and element condition states rating process. A representation of the rating structure is provided in Figure 14-1. A sketch of a typical ESS Tower with components and elements is shown in Figure 14-2.

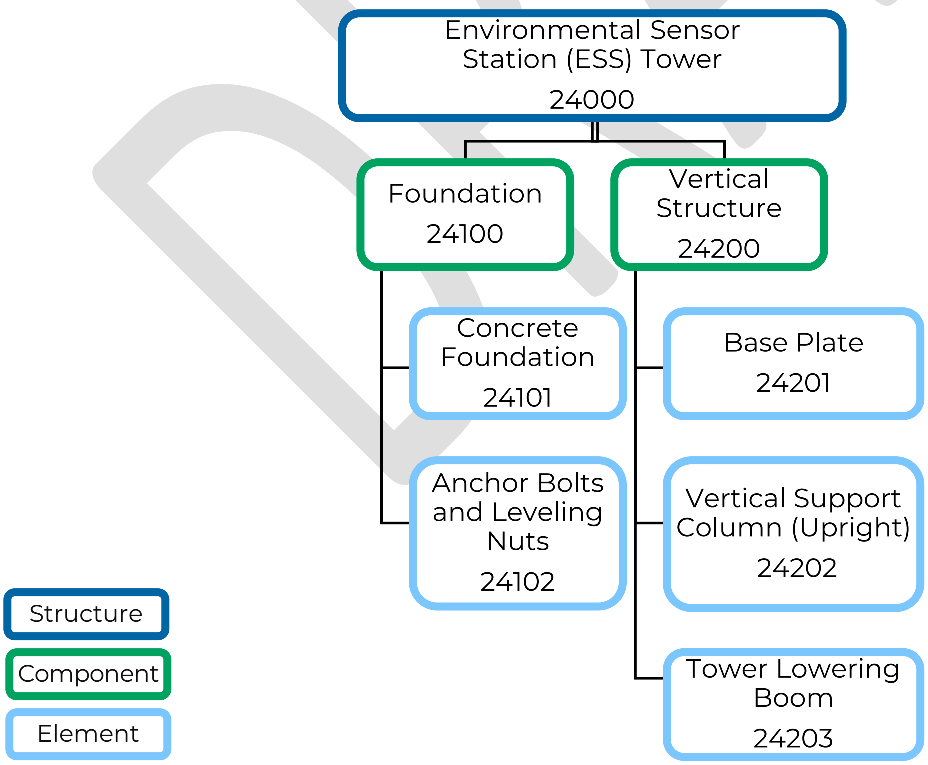

Figure 14-1: Rating structure for ESS Tower

Environmental Sensor Station (ESS) Tower

(ITS-052-B, ITS-053-A)

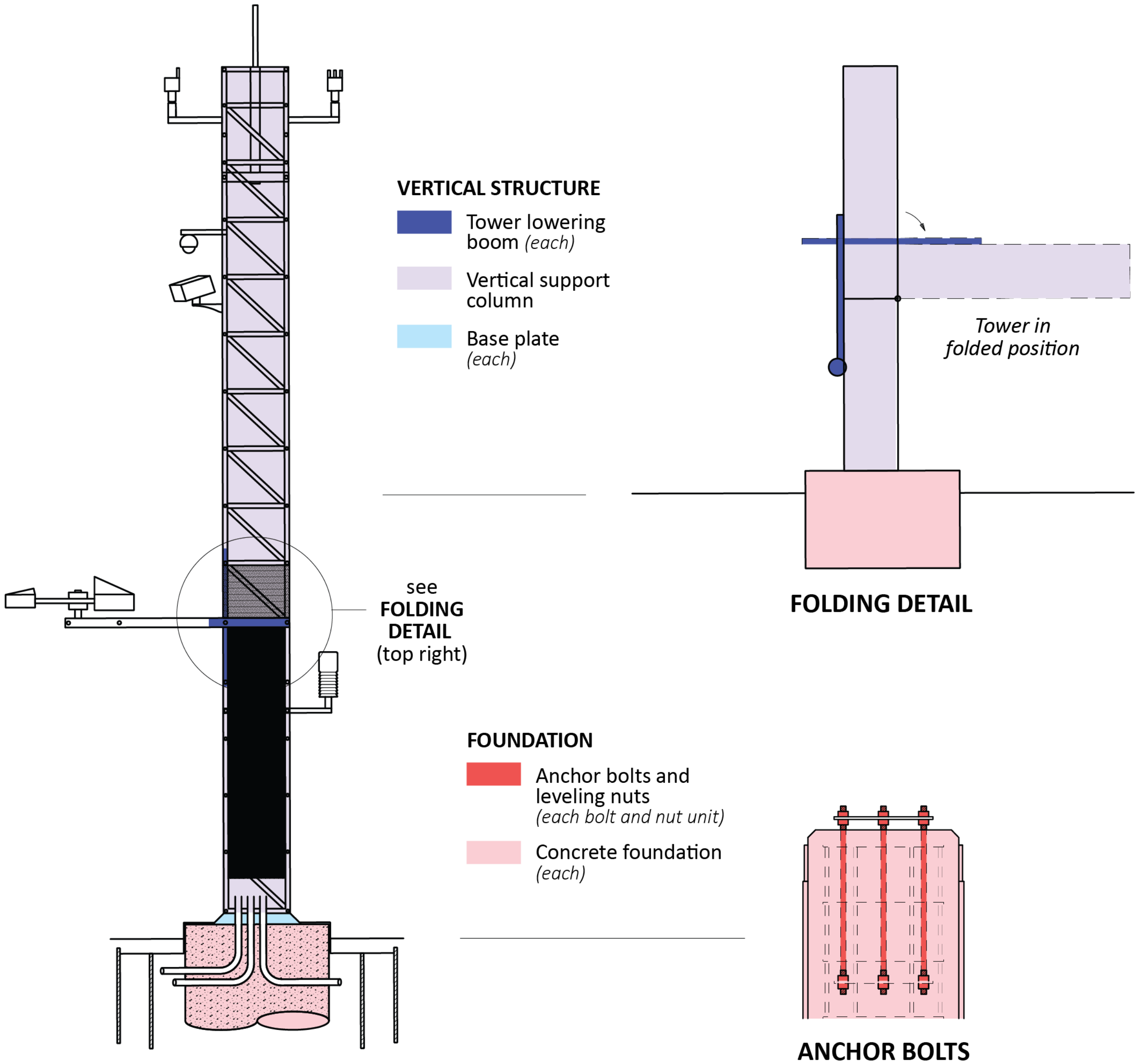

Figure 14-2: Elements and components for ESS Tower (adapted from MDOT Standards ITS-052-B, ITS-053-A)

14.2 Inventory Record Photographs

Inventory photos are captured during a routine inspection, saved as part of the inventory database, and follow the naming convention in *Table 14-2.*

Environmental Sensor Station Tower Required Photos:

- General view of the entire structure
- General view of the entire foundation
- General view of the top of the tower showing attachments such as luminaires, communication equipment, cameras, or sensors

Table 14-2: Environmental Sensor Station Tower Photograph Naming Convention

Photo Name	Description
ESS_Entire	Entire ESS tower
ESS_Foundation	Foundation
ESS_Boom	ESS tower lowering boom
ESS_ID	Old ID and new structure number

14.3 Inspector Minimum Technical Qualifications

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

- A minimum experience of two projects with a minimum of 10 structures total inspecting towers (HMLT, ESS or Communication). Bolt inspection experience on towers, cantilever or truss structures, or other ancillary structure type. Multiple structure types shall have been inspected as part of the total project experience.
- Ancillary structures inspection procedures training
- 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
- 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
- Visual Testing (VT) – Current ASNT or CWI qualifications

14.4 Routine Inspection

Environmental Sensor Station (ESS) Towers are constructed and maintained to gather sensor data and camera images which are then distributed over cellular communications to servers hosted by MDOT. To gather this data, most ESS Towers contain a power supply (housed in a cabinet), and sensors capable of acting as atmospheric sensors, precipitation sensors, and/or weather stations. Sensors are typically comprised of two-part housing designs that allow the combined sensors and electronics to be removed for maintenance or calibration. The ESS camera and sensors should be installed as to not interfere with the tower lowering boom.

ESS Towers are sometimes referred as a Road Weather Information System (RWIS). ESS Towers are often sited to sit between 30 to 50 feet from the roadway. ESS Towers are typically fenced to prevent vandalism.

ESS Tower standard inspection frequency is once every 4 years for arm’s length inspection and once every 2 years for visual inspections, unless otherwise identified for more frequent inspection. A visual inspection may consist of use of binoculars to inspect the structure portions that cannot be reasonably observed within “arm’s length” (approximately 2 feet) distance.

Figure 14-3: ESS Tower

Table 14-3 provides guidance for inspecting reinforced and prestressed concrete cracking.

Table 14-3: 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)

14.4.1 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. The routine inspection is performed on a regularly scheduled basis 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.

14.4.1.1 Foundation Component Ratings

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. Confirm that the tower base ground is connected to the steel or aluminum and terminated to the ground ring or ground rod, and that ground leads are not broken and torn.

Table 14-4: Component Rating Guidelines for ESS Tower Foundation

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

Component Rating	Condition	Material	Description
			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/Aluminum	Protective coating failure or corrosion in very small and scattered locations. No deformation.
		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/Aluminum	Protective coating failures or corrosion is limited to less than 10% of the surface area with no loss of section. No deformation
		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/Aluminum	Minor loss of section or corrosion. Loose fasteners may be present, but the connection is in place and functioning as intended. Minor deformation may also be present.
		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/Aluminum	Protective coating failure or corrosion 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

Component Rating	Condition	Material	Description
			functioning as intended. Considerable deformation.
3	SERIOUS	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 tower and embedment material.
		Steel/Aluminum	Measurable loss of section or corrosion in excess of 25%. Missing or broken anchor bolts and leveling nuts. Extensive deformation.
		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.

14.4.1.2 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, impact damage, and general deterioration. Typical issues include cracking throughout the foundation, shifting, spalling, chipping, delaminated or broken sections of the foundation, exposed aggregate and rebar, and soil erosion around the foundation. The foundation and anchor points should be free of outside obstructions as well. Verify no water is collecting around the foundation. The foundation may have flange or base welds.

Table 14-5: ESS Tower Concrete Foundations Element Defects

Element Number	Element	Description	Associated Distresses
23101	Concrete Foundation	ESS Tower foundations	Cracking
			Spalling, delamination, and patching
			Exposed rebar
			Embedment erosion
			Impact damage
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.			

Details on the condition state rating schema are in Section 14.7, linked below:

ESS Tower Condition State Tables

Figure 14-4: ESS tower foundation with triangular anchor bolt pattern

14.4.1.3 Anchor Bolts and Leveling Nuts Element Condition States

The anchor bolts transfer load from the structure into the foundation. For ESS Towers, this element addresses the bolts in connection with the concrete foundation only.

The purpose of the anchor bolt inspection is to identify any degradation of the nuts, flat washers, leveling nuts, and anchor bolts connecting the tower base to the concrete foundation. Typical issues include corrosion, damaged threads, loose connections, missing or damaged anchor bolts 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, and a determination of the tightness of the bolts and nuts. A sounding test, and a straight beam ultrasound scan (UT test) of 10 inches into the anchor bolts are recommended. Published procedures for the sounding and UT test are provided in references found in Section 4.4.5.

Visually inspect the base looking for missing or damaged anchor bolts or nuts connected to the foundation. Note any damage or corrosion and any bolt that shows signs of bending. 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. Any distance greater than one inch does not meet specifications and may be cause for concern.

Table 14-6: ESS Tower Anchor Bolt and Leveling Nuts Element Distresses

Element Number	Element	Description	Associated Distresses
24102	Anchor Bolts and Leveling Nuts	Anchor bolts and leveling nuts	Corrosion or coating damage
			Loose or missing anchor nut
			Cracked bolt
			Standoff distance
			Impact damage
Unit of Measure: Each, note quantity of anchor bolt and nut units within each condition state			

Details on the condition state rating schema are in Section 14.7, linked below:

ESS Tower Condition State Tables

14.4.2 VERTICAL STRUCTURE ROUTINE INSPECTION

The uprights support directly support the sensors and other attachments. The routine inspection assesses the vertical structure's ability to safely support the environmental sensors and attachments and transfer all loads to the foundation. The routine inspection is performed on a regularly scheduled basis and includes the vertical structure component rating as determined by the baseplate, vertical support column (upright), and tower lowering boom 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.

The tower should be lowered for inspection and 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.

- Observe and measure base plate.
- Operate the boom to ensure it is working and note if any malfunction is experienced.

- Observe upright and lowering boom.
- Note number of sensors and attachments and types of sensors and attachments in the inventory.
- Note locations of condition state distresses.
- Note locations and number of hinges.
- Pay special attention to bolts at hinges and observe for wear/rubbing which would indicate loose connections.
- Note evidence of wear on metal due to oscillation along with loose connections. UT testing shall be conducted on the anchor bolts and close attention should be given for fatigue cracks in the anchor bolts.
- Note any missing lock washer and location of the missing lock washer (i.e., at the base hinges or lowering boom hinge).
- Provide photographs for all Poor or Severe condition state defects and submit the applicable Work Recs or RFAs.

14.4.2.1 Vertical Structure Component Rating

The component rating for the vertical structure depends on the condition of the baseplate, vertical upright(s), and the tower lowering boom. 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 14-7: Component Rating Guidelines for ESS Tower Vertical 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.
7	**GOOD**	All	Protective coating failure or corrosion in very small and scattered locations on the tower steel. All components retain full section properties and function as designed.
6	**SATISFACTORY**	Steel/ Aluminum	Protective coating failures or corrosion is limited to less than 10% of the surface area with no loss of section. No deformation.
		All	Minor deterioration affecting structural components. Minor misalignment.
5	**FAIR**	Steel/ Aluminum	Minor loss of section. Loose connections and splice deterioration may be present, but the connections and splicing are in place and functioning as intended. Minor deformation may also be present.

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Component Rating	Condition	Material	Description
		All	Moderate deterioration affecting structural components including impact damage. Moderate misalignment. All members continue to function as designed.
4	POOR	Steel/ Aluminum	Protective coating failure or corrosion and less than 25% loss of section. Cracks may be present. Fasteners, bracing, connections, and splices may be considerably deteriorated. Considerable damage from impact or attachments. Considerable deformation.
		All	Considerable deterioration or misalignment affecting structural members. Structural review may be warranted.
3	SERIOUS	Steel/ Aluminum	Measurable loss of section or corrosion in excess of 25%. Missing or broken fasteners or extensive cracking in tower. Extensive deformation.
		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.

14.4.2.2 Base Plate Element Condition States

Visually inspect for any damage to the base plate welds and gusset plates, such as gouges, distortion, impact damage, deformation, 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.

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Table 14-8: ESS Tower Base Plate Element Distresses

Element Number	Element	Description	Associated Distresses
24201	Base Plate	Base plate for Environmental Service Station Tower	Corrosion or coating damage
			Weld defect or crack
			Deformation
Unit of Measure: Each, percentage of base plate within each condition state			

Details on the condition state rating schema are provided in Section 14.7, linked below:

[ESS Tower Condition State Tables]

Figure 14-5: ESS tower base plate

14.4.2.3 Vertical Support Column (Upright) Element Condition States

Verify that the structure number is stenciled on the front of the upright (facing traffic) and is still legible. If necessary, use black paint to stencil the number on the vertical support (upright). Note any galvanizing damage on the upright, including the ladder. Also record the degree of damage, including any corrosion on the base metal. If any type of impact damage is present (gouges, dents), clean the area and visually inspect for any cracks. 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. Also note if any part of the upright is deformed and the extent of deformation.

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Appurtenances and their attachments to the structure (such as mounting brackets or straps) are not rated as part of this inspection. If the appurtenances and or their attachments appear to be missing or damaged in any way, provide a Work Rec. If the attachment appears to have damaged the structure, note the condition state distress to the vertical support column.

Table 14-9: ESS Tower Vertical Support Column (Upright) Element Distresses

Element Number	Element	Description	Associated Distresses
24202	Vertical Support Column (Upright)	Vertical Support (Upright) for ESS Tower	Corrosion or coating damage
			Weld defect or crack
			Out of plumb
			Impact damage
			Deformation
Unit of Measure: Length, feet of vertical support within each condition state			

Details on the condition state rating schema are provided in Section 14.7, linked below:

ESS Tower Condition State Tables

Figure 14-6: ESS tower vertical support column with ITS attachments

14.4.2.4 *Tower Lowering Boom Element Condition States*

Maintenance of sensors and appurtenances require maintenance performed at regular intervals for ESS Towers. Many ESS towers are therefore constructed with fold-over towers to allow for easier maintenance. This fold-over capability is accomplished using a tower lowering boom which may also have telescoping capabilities.

Most connections of the boom to the tower 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. Note any gaps between steel in the bolted connections, cracked welds, and other steel cracking. Record any bolting components that are missing, deteriorated, or damaged. Record any signs of corrosion or deformation. As part of an arm's length inspection, the tower lowering boom is lowered and inspected. Note any damage from operations that is visible.

Table 14-10: ESS Tower, Tower Lowering Boom Element Distresses

Element Number	Element	Description	Associated Distresses
24203	Tower Lowering Boom	Boom and device for Environmental Service Station Tower	Weld defects or cracks
			Corrosion or coating damage
			Loose, missing, or failing hardware
			Operations damage
			Deformation

Unit of Measure: Each tower lowering boom quantity within the condition state, anticipated to have a single condition state

Details on the condition state rating schema are in Section 14.7, linked below:

ESS Tower Condition State Tables

Figure 14-7: ESS tower lowering boom element

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14.4.3 REFERENCES

ESS Tower Detail Standard
https://www.michigan.gov/documents/mdot/ESS_Tower_Detail_2017_01_12_548624_7

ANSI/TIA Structural Standard for Antenna Supporting Structures, Antennas and Small Wind Turbine Support Structures, TIA-222-H-1, November 2019

14.5 Work Recommendation Guidance

ESS Tower Work Recs 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 Recs. 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.

The Work Recs are not meant to be all-inclusive and other Work Recs may be added to supplement those noted. Photographs should include sufficient information to determine the relationship of the defect to the element or component or entire structure. Close-up photos of each defect with connection deficiencies marked on the photo should be provided.

Table 14-11: ESS Tower Work Recommendations

Code	Name	Material Involved	Quantity/Unit of Measure
1	Correct erosion at foundation (prevent undermining)	Stone/Soil	Cubic Feet
2	Repair/monitor foundation	Concrete	Cubic Feet
3	Address loose or damaged grounding wire/ground rod	Steel	Each
4	Address damaged or missing lightning rod	N/A	Each
5	Address loose or damaged anti-climb panels	Aluminum	Each
6	Tighten leveling nut	Galvanized Steel	Each Nut
7	Repair galvanizing	Galvanized Steel	Square Inch
8	Repair grout pad	Cementitious Grout	Cubic Feet
9	Address loose bolts	Steel	Each Bolt
10	Address loose connectors	Steel	Each Connector
11	Repair hinge connection	Galvanized Steel or Aluminum	Pound
12	Repair/service lowering device (Boom or other, each)	Boom or Other	Each
13	Repair or replace misc. attachment connecting appurtenances	Various	Each Attachment

Code	Name	Material Involved	Quantity/Unit of Measure
14	Replace or remove misc. appurtenances	Various	Each Appurtenance

14.6 Request for Action Guidance

Guidance for creating an RFA pertaining to structure defects is provided below for specific situations which may occur.

When a combination of evidence of oscillation is noted along with loose connections, conduct UT testing on the anchor bolts and provide close attention to any fatigue cracks in the anchor bolts.

Figure 14-8: Evidence of wear on metal due to oscillation along with loose connection

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 evidenced by lateral displacement or vertical out of plumbness
c. Major corrosion, section loss or failure of high strength bolts where load-path redundancy is minimal
d. Major distortion at the tower foundation connection or section loss around anchor bolts
e. Where bending of anchor bolts is evident
f. Loose or missing bolt in a high strength bolted connection, anchor bolt connection, or appurtenance connection
g. Multiple loose or missing bolts where connections do not have load-path redundancy

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h. Major crack(s) present in the base metal or weld(s) at the base to column connection
i. Major section loss due to corrosion of a main element which impacts the capacity or short-term resiliency of the element or structure
j. 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
k. 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
l. Presence of evidence of wear/rubbing at the hinge(s) indicating oscillation
m. Loose connections such as fasteners or hinges particularly of aluminum structures.

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 distortion or section loss of the tower foundation connection or the anchor bolts
d. Anchor nuts are engaged with some gaps and/or bolts are misaligned
e. Significant corrosion of primary elements or connections is present
f. 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
g. Column support is significantly out of vertical alignment
h. Anchor bolt standoff distance more than twice the anchor bolt diameter with no bending of the anchor bolts
i. Missing or loose nuts or other elements of a bolted connection where there is acceptable load-path redundancy, but significant impact to capacity or durability
j. Structural cracks in secondary members that could potentially propagate through welded connections into primary members such as the upright
k. 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
c. Moderate corrosion of the anchor bolt connections or high strength bolted connections
d. Anchor bolt standoff distance more than one inch but less than twice the anchor bolt diameter with no anchor bolt bending present

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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

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14.7 Element Condition States

Element Number	Element	Condition States Defects Note	Link to Discussion in Section 8
24101	Concrete Foundation	Use the appropriate condition state table.	Concrete Foundation Element Condition States
24102	Anchor Bolts and Leveling Nuts	Use the appropriate condition state table. Use UT testing result to assist in the condition assessment.	Anchor Bolts and Leveling Nuts Element Condition States
24201	Base Plate	Use the appropriate condition state table.	Base Plate Element Condition States
24202	Vertical Support Column	Use the appropriate condition state table.	Vertical Support Column (Upright) Element Condition States
24203	Tower Lowering Boom	Use the appropriate condition state table.	Tower Lowering Boom Element Condition States

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Elements 24101 – Concrete Foundation

Description	This element defines a concrete foundation for an ESS tower, regardless of foundation type such as drilled shaft or reinforced concrete pile.			
Quantity Calculation	The quantity is collected in each.			
	Condition State Descriptions			
Defect Type	**Good**	**Fair**	**Poor**	**Severe**
Concrete Foundation Defects	The concrete shows no deterioration. Superficial cracking, discoloration, or efflorescence may be present. No exposed reinforcing, or erosion.	Minor cracks and/or spalls may be present in the concrete. No exposed reinforcing or embedment erosion, or impact damage.	Moderate cracks and/or spalls may be present. Some reinforcing may be exposed. Incidental loss of section or surface pitting of reinforcing may be present. Element may show evidence of some embedment erosion, or impact damage	Major cracks and/or spalls are present. Major corrosion of exposed reinforcing. Extensive steel and/or concrete loss or embedment erosion is present. Major impact damage may be present.

Elements 24102 – Anchor Bolts and Leveling Nuts

Description	Anchor bolts and leveling nuts attaching the upright to the foundation for ESS towers.			
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. Anchor bolt standoff distance meets standard. No evidence of impact damage or deformation. The elements are fully engaged.	Minor corrosion of the elements may be present. Anchor bolt standard off distance meets standard. No evidence of impact damage or deformation. The elements are fully engaged and functioning as intended.	Moderate corrosion/ section loss of the elements may be present. Anchor bolt standoff distance is not excessive. Anchor nuts may not be fully tightened. Anchor bolts may have some evidence of impact damage and slight bending or deformation.	Major corrosion/section loss of the elements may be present. Multiple nuts are loose/missing. Excessive anchor bolt standoff distance. Major evidence of impact damage and anchor bolt bending, deformation or out of plumbness. UT testing indicates cracks or breaks in bolts. Fatigue cracking of bolts due to structure oscillation is considered a major defect.

Elements 24201 – 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 or deformation. Surface coating is sound.	Minor surface corrosion or superficial damage may be present. Base element welds have no evidence of defects.	Moderate corrosion/ 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 or deformation.	Major corrosion/section loss is present. Base element welds may have cracks/defects. Base plate has moderate to major warping or deformation.

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Elements 24202 – Vertical Support Column (Upright)

Description	This element is defined by all uprights supporting an ESS tower.			
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 and functioning as intended.	Minor corrosion or superficial damage of the elements may be present. No element weld defects or cracking are evident. Minor superficial impact damage may be present.	Moderate corrosion/ pitting/section loss may be present. Protective coatings are failing. Element welds have no evidence of defects and/or cracking. Support may be out moderately 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.
Deformation/ Impact Damage	No deformation or damage caused by vehicular impact.	The element has minor deformation or damage caused by vehicular impact.	The element has moderate deformation or damage caused by vehicular impact.	Deformation or 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.

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Elements 24203 – Tower Lowering Boom

Description	This element consists of the boom which allows the tower to be lowered for maintenance.			
Quantity Calculation	The quantity is collected as each boom.			
	Condition State Descriptions			
Defect Type	**Good**	**Fair**	**Poor**	**Severe**
Tower Lowering Boom Defects	Elements are free of corrosion or deterioration. No evidence of loose, damaged, deformed, or misaligned component.	Minor corrosion or superficial damage of the elements may be present. No weld defects or cracking are evident. Elements are fully engaged. Minor deformation, misalignment may be present but components and connections function as intended.	Moderate corrosion or damage may be present. Element welds have no evidence of defects and/or cracking. Elements may not be fully engaged. Moderate element deformation, or misalignment may be visible.	Major corrosion or damage is present and may have evidence of weld defects. Elements may be partially engaged. Major element deformation, or misalignment may be visible. Major damage due to operations is visible. Loose fasteners lead to structure oscillation and is considered a major defect.

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