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

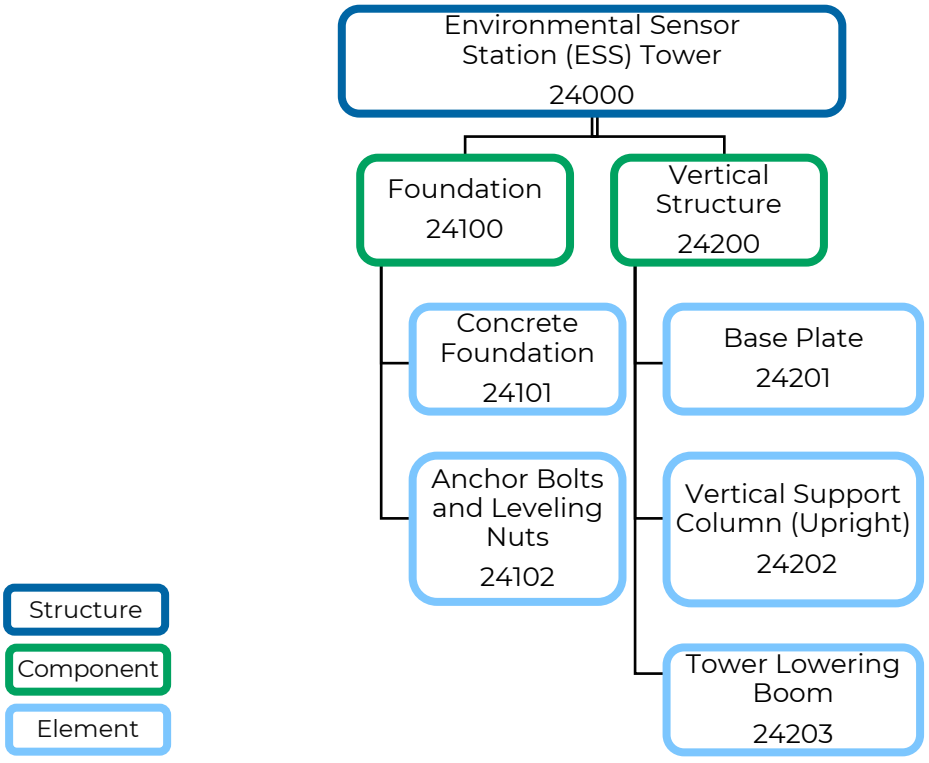
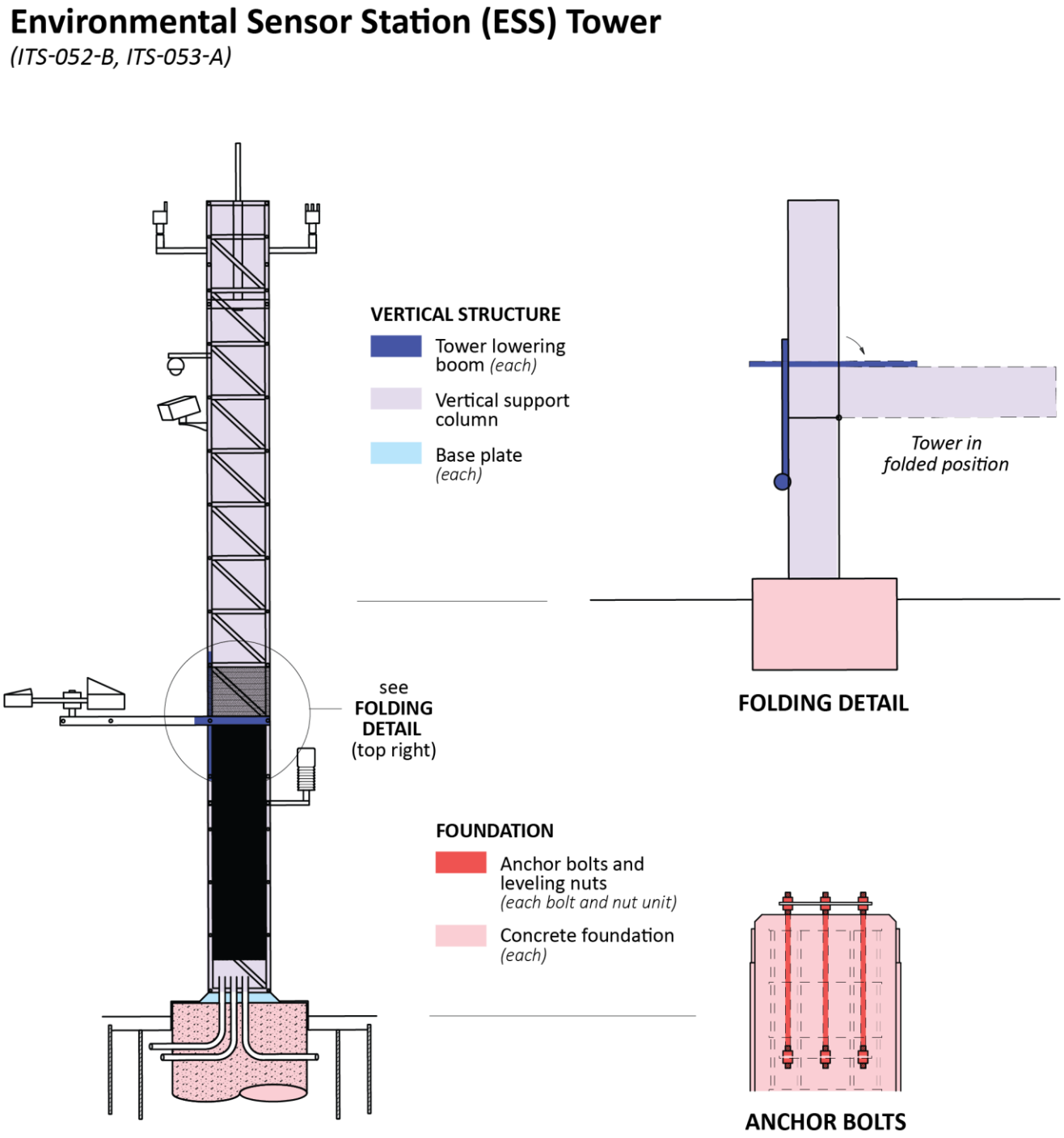


Figure 14-2: Elements and components for ESS Tower (adapted from MDOT Standards ITS-052-B, ITS-053-A)



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.

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

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

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.
		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/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 14.4.3.

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 (or the top of sound concrete in cases of foundation deterioration).

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

Figure 14-5: Standoff measurement for a sound foundation

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.
		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.

Component Rating	Condition	Material	Description
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.

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 14-6: 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.

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 14-7: 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 14-8: ESS tower lowering boom element

14.4.3 REFERENCES

MDOT ESS Tower Installation Inspection Procedure, describing UT and Sounding Testing

ESS Tower Detail Standard

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

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

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
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 14-9: 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

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 bolt diameter but less than two bolt diameters with no anchor bolt bending present
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

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

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 and the sounding test	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. The sounding test	Moderate corrosion/ section loss of the elements may be present. Anchor bolt standoff distance is not excessive. Anchor nuts may not be fully tightened. The sounding test produces a dull sound. Anchor bolts may have some evidence of impact damage and	Major corrosion/section loss of the elements may be present. Nuts are loose/missing. The sounding test produces a dull sound. 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

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**
	produces a sharp ringing sound.	produces a sharp ringing sound.	slight bending or deformation.	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. Protective coating failure with no section loss. 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.

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. Protective coating failure with no section loss. 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.

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.