# 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.

**Figure 13-1: Rating structure for Communication Tower**

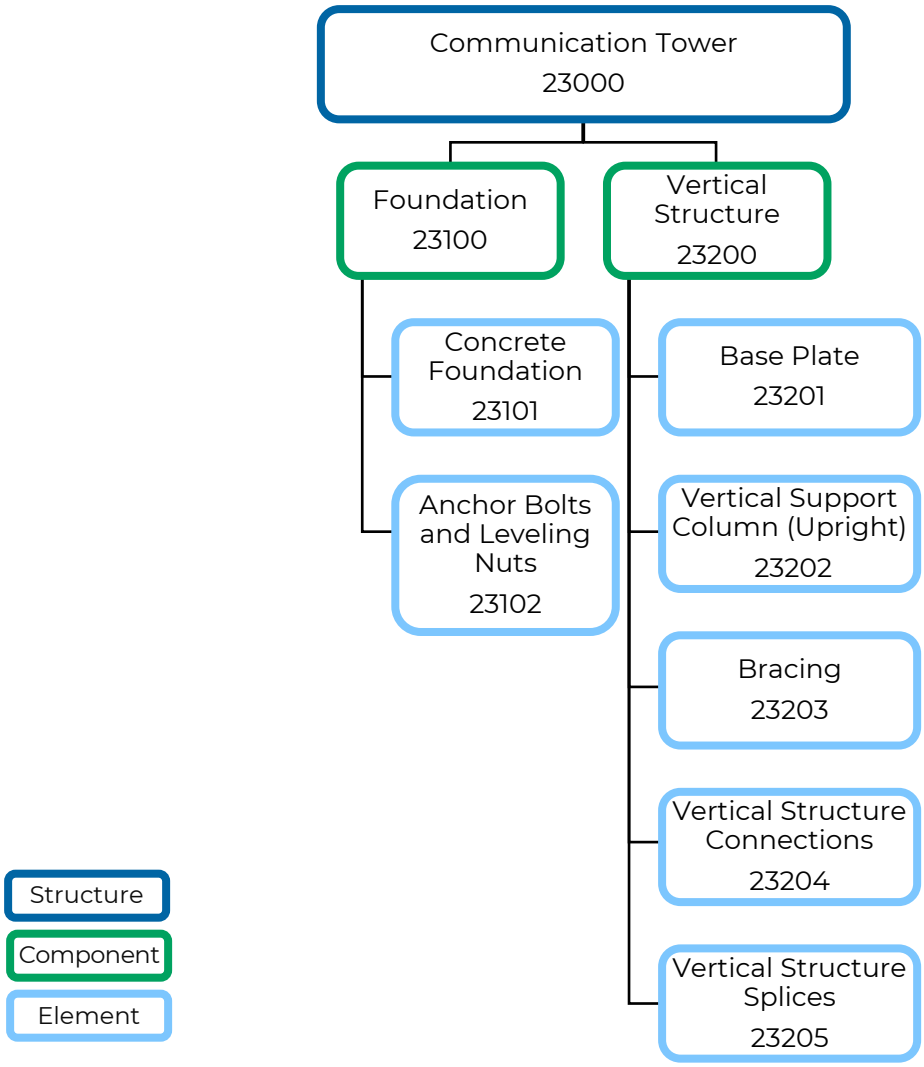
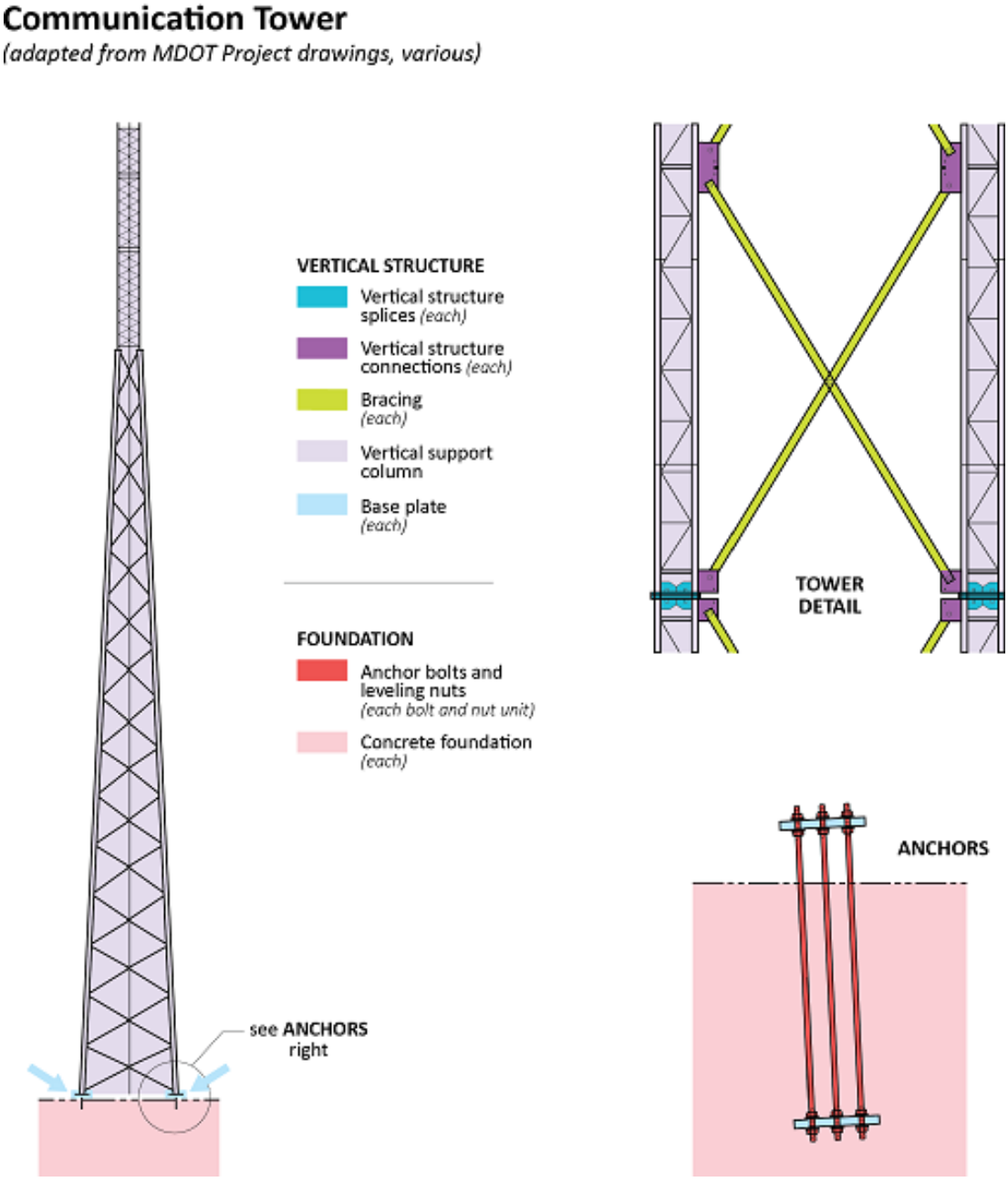


**Figure 13-2: Elements and components for Communication Tower (adapted from MDOT Project drawings, various)**



## 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 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 (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.

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 13-3: 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”<br>> (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 bolt diameter and length, then scan for defects.
- Examine anchor bolts for tightness and embedment using a standard inspection hammer. Inspect visually for corrosion, section loss, and plumbness.
- Examine anchor bolts for any eccentricity. Note any noticeable eccentricity measurements.
- Perform ultrasonic testing of anchor bolts to note any breaks and verify lengths.
- 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. |

| Component Rating | Condition | Material | Description |
|---|---|---|---|
| | | 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. |
| | | All | Considerable deterioration or damage affecting structural members. Structural evaluation, is necessary to determine if the structure can continue to function without repairs. |

| Component Rating | Condition | Material | Description |
|---|---|---|---|
| 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 4.4.4.

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 13-4: Standoff measurement for a sound foundation (left) and standoff measurement with foundation concrete deterioration (right)**

**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. |
| 5 | FAIR | All | Minor deterioration affecting structural components. Minor misalignment. |
| | | 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. |

| 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

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 13-5: 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 13-6: 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.

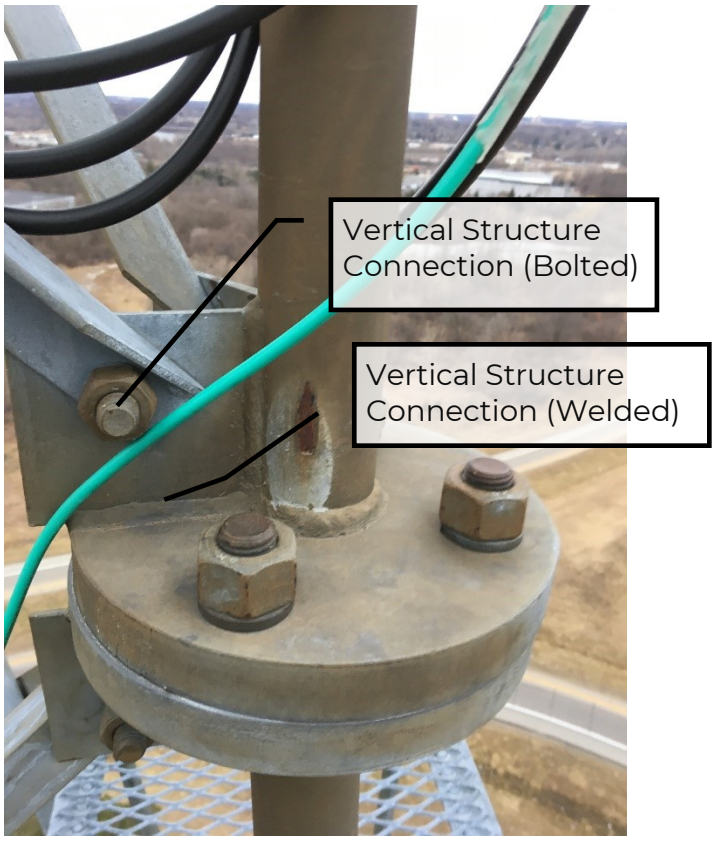
#### Welded Connections

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 13-7: Welded and bolted vertical structure connections**




### *13.4.2.6 Vertical Structure Splices Element Condition States*

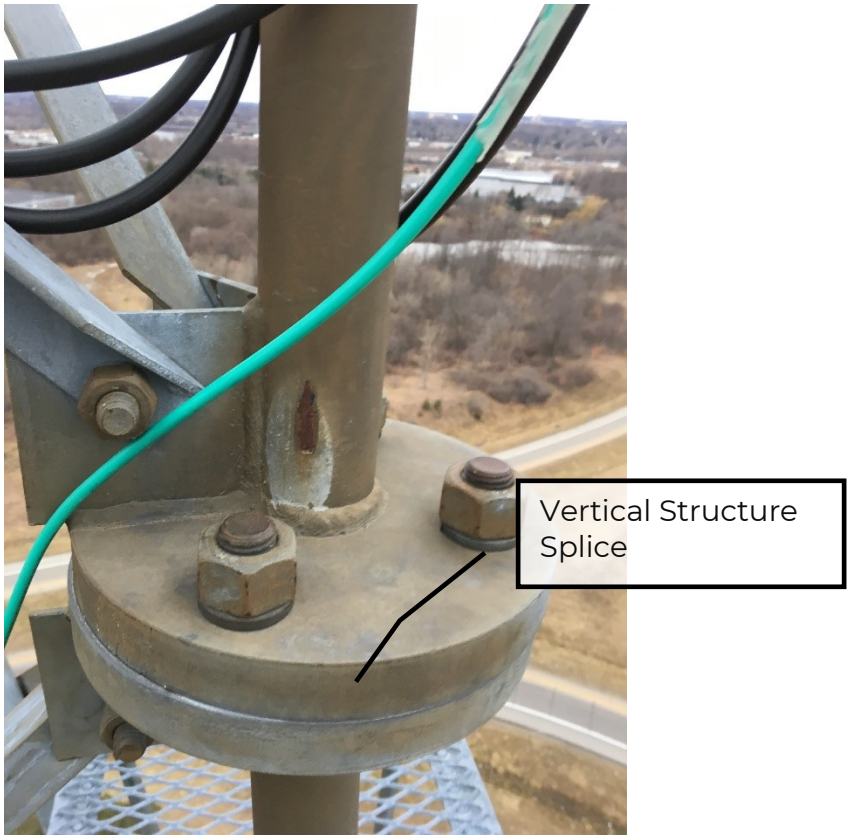
Spliced connections are present at the connection of bracing to the vertical support columns. Typical issues include loose bolts and nuts, weld discontinuities, galvanizing damage, flange connection gaps, missing washers, and missing end caps. Note any gaps between steel in the bolted connections or 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:

**Figure 13-8: 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

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

## 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)

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
h. Standoff distance more than one bolt diameter but less than two bolt diameters with no bending of anchor bolts

## 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 |

## 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 and the sounding test | 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. 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 slight bending. | 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 or out of plumbness. UT testing |

| | | | | |
|---|---|---|---|---|
| **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** |
| | produces a sharp ringing sound. | produces a sharp ringing sound. | | 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. Protective coating failure with no section loss. 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. 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. |
| **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. |

| | | | | |
|---|---|---|---|---|
| **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** |
| | | | | 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. |