OVERHEAD SIGN STRUCTURES

INSPECTION AND INVENTORY MANUAL

South Carolina Department of Transportation

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Abstract

The South Carolina Department of Transportation (SCDOT) Overhead Sign Structures Inspection and Inventory Manual provides standardized procedures and guidance for the inspection, evaluation, and inventory documentation of ancillary structures within the state's highway system. This manual ensures consistency, accuracy, and accountability in the structural assessment and reporting processes performed by inspection personnel.

This updated edition incorporates revisions to inspection classifications, frequency requirements, documentation protocols, and condition rating procedures. It emphasizes the use of both qualitative and quantitative assessment techniques, including hands-on, visual, and non-destructive evaluations. The manual also outlines the training and qualification standards required for inspection team leaders and program managers, ensuring that inspections are conducted by certified and competent personnel.

Designed to support the SCDOT's mission of providing a safe and efficient transportation network, this manual serves as a foundational resource for engineers, inspectors, consultants, and maintenance personnel. It promotes a proactive, data-driven approach to infrastructure stewardship, aiding in prioritization of repairs, mitigation of risks, and long-term asset preservation. By formalizing these practices, the manual supports the continuous improvement of SCDOT's sign structure management program, fostering both public safety and fiscal responsibility.

Chapter 1 INTRODUCTION

The purpose of this manual is to guide the in-service inspections of overhead sign structures and high mast light poles for the South Carolina Department of Transportation (SCDOT). The intent of this manual is not to rewrite procedures described in other overhead sign and bridge inspection manuals but rather to highlight specific items and details of the SCDOT inspection and data management program. This manual should be used with Federal Highway Administration (FHWA) Publication No. FHWA NHI 05-036, "Guidelines for the Installation, Inspection, Maintenance, and Repair of Structural Supports for Highway Signs, Luminaires, and Traffic Signals," dated March 2005. The FHWA document will be referenced throughout this manual as the *Guidelines*. The Traffic Section of the SCDOT manages the inspection and database work for the structures. The inspection project that contributed to the development of the manual consisted of a complete inventory of all qualifying sign structures and high mast light structures located on or near roadways maintained by the SCDOT. Qualifying ancillary structures included:

- Bridge-Mounted Sign
- Fullspan Sign Structures
- Cantilever Sign Structures
- Butterfly Sign Structures
- Mast Arm Sign Structures
- Monotube Sign Structures
- High Mast Light Poles (>80 ft tall)

Structures used to support traffic signals (mast arm or cable) were not included in the inventory and thus not inspected or included as part of this manual.

1.1 INSPECTION TYPES

Initial Inspection

An initial inspection is the first inspection of a structure to establish baseline inventory and conditions of the structure for future comparisons. This inspection should take place shortly after the structure is completed. The initial inspection should be a fully documented investigation by inspectors meeting the qualifications for inspecting personnel. The initial inspection purpose is two-fold:

- Gather all structure inventory data to add the structure into the asset management database.
- Determine baseline conditions and identify existing problems or locations of potential issues.

Routine Inspection

Routine inspections are scheduled on a recurring basis and include observations, measurements, or both needed to determine the physical and functional condition of the structure. Changes from initial or previously recorded conditions shall be identified to ensure that the structure continues to satisfy present service requirements.

A routine inspection is a close-up or hands-on examination of the entire structure to identify any deficiencies. When appropriate or necessary to fully ascertain any defects' existence or extent, nondestructive testing, other material tests, or both may be appropriate.

Inspection findings should be carefully documented with photographs and a written report that includes recommendations for maintenance or repair and scheduling the follow-up routine or special inspections, if necessary.

Access for routine inspections may require aerial lifts, structure climbing, lane or shoulder closures, and/or unmanned aerial systems (UAS).

Damage Inspection

A damage inspection is unscheduled and used to assess structural damage resulting from environmental factors or human actions. The scope should be sufficient to determine the need for structure repair or removal. The intensity may vary significantly depending on the extent of the damage.

Interim Inspection

The team leader should recommend an interim inspection if a structure has deficiencies or other problems requiring more frequent examinations than the typical inspection frequency. An interim inspection might also be necessary after temporary repairs.

1.2 INSPECTION FREQUENCY

Determining the inspection frequency for ancillary structures may depends on several factors, such as material type, structural redundancy, and age. For example, aluminum span structures have shown increased fatigue deficiencies. Signs with less structural redundancy, such as cantilever sign structure supports, that only have one primary support instead of two or more, may be recommended for more frequent inspections.

It is recommended that all overhead sign and HML structures be inspected on a 48-month inspection cycle; however, the SCDOT Program Manager has the discretion to increase or decrease inspection frequencies.

1.3 INSPECTOR QUALIFICATIONS

Introduction

Inspecting ancillary structures is similar to inspecting highway bridges, though there are special considerations. Due to the large number of welded members used in most ancillary structures, at least one team member should have experience with visual weld inspection and training in locating and recognizing fatigue cracks.

Program Manager

The inspection program manager is in charge of the program and is assigned or delegated the duties and responsibilities for ancillary structure inspection, reporting, and inventory. The program manager provides overall leadership and is available to inspection team leaders to provide guidance. The inspection program manager should have the following qualifications:

- Registered as a Professional Engineer in the State of South Carolina or have at least ten (10) years of experience in highway structure inspections in a responsible capacity.
- Successfully completed FHWA NHI Course 130055: Safety Inspection of In-Service Bridges or FHWA NHI Course 130056: Safety Inspection of In-Service Bridges for Professional Engineers.
- Successfully completed FHWA NHI Course 130087: Inspection and Maintenance of Ancillary Highway Structures.

Inspection Team Leader

A qualified team leader oversees an inspection team and is responsible for planning, preparing, and performing field inspections of the ancillary structures. A qualified team leader shall be on-site during each initial, routine, interim, and damage inspection. The qualified team leader shall meet the following qualifications:

- Have a minimum of ten (10) years of inspection experience on similar overhead sign and ancillary structure inspection projects.
- Successfully completed FHWA NHI Course 130087: Inspection and Maintenance of Ancillary Highway Structures.

Inspection Team Member

A team member assists the Inspection Team Leader onsite during each inspection. A team member shall meet the following qualification:

- Successfully completed FHWA NHI Course 130087: Inspection and Maintenance of Ancillary Highway Structures.

Inspection Team

At minimum a two-person inspection team shall perform on-site inspections with at least one member qualified as an Inspection Team Leader.

1.4 INSPECTOR SAFETY

Introduction

Ensuring the safety of inspection personnel is a fundamental priority for SCDOT. Ancillary structure inspections often require work in challenging environments, including work at height and in close proximity to active traffic. These conditions present unique hazards that demand thorough planning, situational awareness, and strict adherence to established safety procedures.

All inspection team members are responsible for recognizing potential hazards and taking appropriate measures to mitigate risks. This includes wearing appropriate personal protective equipment (PPE), following safe access procedures, using proper fall protection systems, and complying with traffic control standards. No task is so urgent that it cannot be performed safely. Safety planning must begin prior to arriving at the job site. Pre-inspection meetings and job hazard analyses are required to identify risks, assign responsibilities, and review emergency procedures. Inspectors must be trained in the use of safety equipment and be familiar with protocols specific to the type of inspection being performed.

SCDOT mandates that safety guidelines be followed without exception. The continued well-being of inspection personnel depends on a culture of safety where every team member is empowered to speak up, stop work if conditions are unsafe, and collaborate to prevent accidents.

General Safety

The following general safety policies are provided to assist inspection personnel in mitigating risk during the inspections:

- Inspectors and other personnel working within a work zone shall wear, at a minimum, a hard hat, safety shoes, and high-visibility safety apparel that meet the requirements of SCDOT. Safety equipment such as safety glasses and gloves should be used as required.
- When in/on an aerial lift, the inspector shall wear an OSHA-approved fall protection harness attached to a secure tie-off point with an OSHA-approved lanyard.
- Maintenance of Traffic (MOT) procedures shall be in accordance with the latest edition of the SCDOT *Traffic Control for Maintenance Operations*.
- Inspection vehicles shall be as far from the travel lane(s) as possible when performing shoulder or median work.
- Inspection vehicles shall be equipped with high-intensity rotating, oscillating, or flashing strobe lights.
- Inspectors shall assume all wires are energized and shall not come in contact with any wiring on or inside a structure.
- Inspectors shall use caution and follow SCDOT and OSHA guidance when operating an aerial lift around power lines. The inspector shall maintain a minimum safe distance from any overhead utility wires located on or in close proximity to the structure within the work zone of 10 ft. or as required by OSHA 1926.1408, which provides minimum safe distances based on a known line voltage.

PHOTOGRAPH 1-01: INSPECTOR CLIMBING STRUCTURE

- Inspection operations shall not be conducted in inclement weather unless deemed necessary due to an observable emergency. Should inspection operations be underway on a specific structure during inclement weather, the operations may continue until the inspection is completed or roadway conditions become hazardous to the inspection team.

Climbing and Aerial Lift Safety

All inspection personnel shall have completed an OSHA-approved “Fall Protection” course/class, which fulfills the requirements of OSHA 1926.503. In addition, the following climbing safety policies are provided to assist inspection personnel in mitigating risks associated with climbing:

- Climbing shall be restricted to only those areas where access by aerial lift is not possible, does not provide adequate inspection, or where a critical deficiency is suspected, and a more detailed or special inspection (non-destructive testing) is necessary to investigate the suspected critical deficiency.
- Climbing over live traffic is permissible when access from an aerial platform is not possible. All climbing activities must follow the guidelines outlined below.
- The inspector shall wear an OSHA-approved fall protection harness attached securely to a primary load-carrying member (e.g., chord) with an OSHA-approved lanyard. One hundred percent (100%) tie-off shall be maintained at all times, using two lanyards.
- The inspector should always have three positive points of contact when moving through the structure (both hands and one foot or both feet and one hand in contact with the members).
- Climbing shall not be performed if the inspector is fatigued or mentally distracted.
- Boots, ladders, bucket lifts, and scaffolding should be free of oil and grease.
- Lifting equipment, whether ladders, bucket lifts, or scaffolding, should be properly secured to the ground with brakes, blocks, outriggers, etc., before climbing.
- All inspectors shall be properly trained in the inspection process, fall protection, climbing techniques, and the use of all climbing equipment in accordance with OSHA 1926 Subpart M.
- Climbing activities shall not be conducted in inclement weather or wind speeds of 30 miles per hour (mph) or greater. Should inclement weather or wind speeds develop during climbing activities, as mentioned earlier, the activities shall be halted until the inclement weather passes or the wind speeds drop below 30 mph.

PHOTOGRAPH 1-02: INSPECTORS WORKING AT NIGHT

Night Work Safety

When night inspections are required, the inspectors must ensure adequate illumination of the inspection surfaces and visibility of the inspection personnel. The inspectors may wear lights mounted on the inspection bucket or ground-mounted. The team leader must determine which method(s) of illumination will provide the best view of the inspection surfaces. Consideration shall be given to the placement and movement of the lights to properly illuminate all areas of the structure being inspected to eliminate shadows and provide the best possible visual inspection conditions. Lights must be positioned to not distract or impair on-coming motorists or pedestrians. Extreme caution should be used during night operations due to the reduced visibility of the inspection personnel to on-coming traffic.

Traffic Control

Shoulder Closures

Shoulder closures, both static and mobile (short duration), may be acceptable for ancillary structure inspection work when standard-width shoulders that can safely accommodate traffic and inspection equipment while not impacting a travel lane are present. Should the possibility exist that any equipment could encroach upon or impact a travel lane, a standard lane closure shall be used. Shoulder closure operations shall be in accordance and compliance with the latest edition of the SCDOT Traffic Control for Maintenance Operation Manual.

PHOTOGRAPH 1-03: SHOULDER CLOSURE

PHOTOGRAPH 1-04: SHORT DURATION SHOULDER CLOSURE

Lane Closures

Lane closures are required when inspection procedures have the potential to impact a travel lane. The two basic lane closures used for ancillary traffic inspections include static and mobile (short duration). The static and short-duration closure operations may be applied to a single or double-lane road. Short-duration closures may be used for most of the inspection work; however, static closures may be necessary for inspecting four-chord or tri-chord-truss sign structures due to the time required to inspect the truss members and panel points thoroughly.

When planning the inspection, the number of lanes to be closed must be determined and coordinated with the SCDOT's lane closure restrictions for the roadway along which the inspections are to be performed. The type of lane closure required will depend on each lane's anticipated inspection duration. Interstates and limited access highways with more than four lanes may require special closures for which the Department needs special planning, preparation, and approval before implementation.

PHOTOGRAPH 1-05: STATIC LANE CLOSURE

PHOTOGRAPH 1-06: MOBILE LANE CLOSURE

All lane closure operations shall comply with the latest edition of the SC*DOT Traffic Control for Maintenance Operations Manual*.

Closure Restrictions

Before planning inspection work that requires lane closures, the team leaders should determine which lane closure restrictions apply to the roadways along which the work will be performed. Lane closures along high-traffic roadways (such as interstates, US highways, and some State routes) may only be conducted during nighttime hours. Typically, night lane closure hours are between 9 P.M. and 5 A.M; however, these hours may vary depending on the roadway and the maximum number of lanes that can be closed at specific times. For example, a roadway with four lanes of travel in one direction might allow for a single lane closure between 9 P.M and 5 A.M., but double lane closures may only be allowed between 11 P.M. and 2 A.M due to the low volume or traffic flow during that time. **Before the inspection, team leaders must check with the local SCDOT District at least 7 days prior to inspections to determine any closure restrictions that apply to specific roadways where ancillary inspections are required.**

1.5 INSPECTION PROCEDURES

Typical inspection procedures have been developed in detail and documented in the *FHWA Guidelines for the Inspection of Highway Sign Structures* and not rewritten in this document. For further information, please refer to Sections 8 through 15 in the *FHWA Guidelines for the Inspection of Highway Sign Structures*. The remainder of this section shall cover the descriptions of the components to be inspected at each structure and a listing of the components considered part of each specific element that shall be rated within.

Arrival on Site

Upon arriving on-site, the inspection team should verify that the structure number, location description, and GPS coordinates are correct. Potential discrepancies may result from newly installed structures, incorrectly marked structures, structures removed from the field and not from the database, or arrival at an incorrect location.

Field Inspection

The field inspection of a sign structure consists of inventorying and inspecting the structure. The inventory component requires verification of basic structure information such as structure type, Route ID, GPS coordinates, and other fields in the SCDOT database. For a routine inspection, the inspection component requires a comprehensive, detailed inspection of the entire sign structure that includes a 100% hands-on examination of each component, member, fastener, and weld on the structure. The inspections should document any defects or deficiencies, including dents, damage, corrosion, material section loss, loose and missing fasteners, broken or cracked welds, and any other condition that may impact the structure's functionality or integrity in the near or long term. In addition to the hands-on examination, the inspector(s) should conduct non-destructive testing (NDT) during the inspection to verify any suspected structural deficiencies. The following are types of NDT that may be performed:

- Dye Penetrant or Magnetic Particle Testing at locations of suspected surface cracks.
- Ultrasonic testing to detect internal defects in anchor bolts.
- Ultrasonic thickness measurements (D-meter) determines the thickness of structural members whose thickness cannot be readily verified by other means or where visible corrosion exists.

Typical Field Inspection Operations

A consistent methodology for field inspection of a sign structure must be developed to properly organize the inventory and inspection process, to ensure that all elements are inspected, and to record all inspection findings accurately. The recommended sequence for typical field inspection and specific items to be inventoried and inspected follows.

Inventory

Inventory information related to the as-built configuration of the structure should only vary between inspection cycles if corrective maintenance or retrofit work has been completed. The basic inventory information listed in Chapter 2 should be gathered at the initial inspection, verified at each subsequent inspection, and updated as necessary at each subsequent inspection.

Inspection

The sign structure should be inspected to determine its overall condition and the condition of the individual components. All deficiencies should be fully quantified by describing the defect type (i.e., corrosion, section loss, spall, crack, etc.), location, and size (i.e., length, width, depth, etc.). For example, the location of exposed reinforcing steel and the severity of any corrosion that has taken place should be recorded. If the corrosion has caused section loss, the section loss should be quantified. Before leaving the site, all inspection notes should be reviewed for accuracy and completeness.

Documentation

Documentation of field observations should be as specific, clear, and concise as possible without unnecessary details. Documentation shall include a location description, defect description (i.e., type and severity of a deficiency) and size/area of defect. Dimensions that may be required to document a given deficiency may include, length by width by height or, if more applicable, surface area, depth, remaining section measurements where there is section loss and distance from a specific reference point. The following are examples of deficiency documentation:

- The south face of the east foundation exhibited a 6 in. wide by 8 in. high by 2 in. deep spall with no exposed reinforcing steel.
- 2 of 6 anchor rod nuts were loose on the east foundation.
- Diagonal member UF8-LF8 exhibited a 1/8 in. wide by 2 in. long crack in the weld at LF8.
- 4 of 24 sign clips were missing on sign hanger 2 of sign panel 1.

Photographs

Photographs shall be taken to provide a visual representation of the structure’s overall condition. As such, several basic photographs shall be taken at the start of the inspection, with each view maximized within the photograph’s frame. These photographs include:

- Front view of the structure
- Rear view of the structure
- View of foundation(s).
- View of chord splice(s)

Photographs of all deficiencies or conditions resulting in an element rating of poor or critical must be taken. When placed in the report, each photograph shall be captioned with appropriate verbiage that describes the deficiency or condition. A scale such as a ruler or measuring tape should be included in the photograph whenever possible. All photographs should be reviewed in the field to ensure that each view and/or deficiency is depicted.

The photographs on the next page, represent the basic inventory photographs that shall be taken with the inspection.

PHOTOGRAPH 1-07: OVERALL FRONT PHOTOGRAPH

PHOTOGRAPH 1-08: OVERALL REAR PHOTOGRAPH

PHOTOGRAPH 1-09: FOUNDATION PHOTOGRAPH (MULTIPLE FOUNDATIONS)

PHOTOGRAPH 1-10: FOUNDATION (SINGLE POST)

PHOTOGRAPH 1-11: FOUNDATION (SET IN SIDEWALK)

PHOTOGRAPH 1-12: TYPICAL SPLICE

1.6 INSPECTION EQUIPMENT/TOOLS

The following equipment/tools are needed to perform the inspection after access to the structure has been obtained. The type of access equipment needed for each sign structure is dependent on the structure location. For the various types of access equipment which may be needed for a given inspection type.

- **Standard Personal Protective Equipment** (hard hat, steel toe boots, safety vests/pants, safety glasses, etc.)
- **Gloves**
- **Headlamps and Flashlights**: used by the inspector when performing inspection of dark areas or when performing night inspections. A headlamp is particularly useful when mounted to a hardhat as it aids in keeping the inspectors hands free for handling the structure or other tools and equipment.
- **Portable Lighting**: used to illuminate the work zone and structure during nighttime inspection work.
- **Hand-held GPS**: used to obtain and verify the GPS coordinates of the structure in the field. The unit is to be WAAS-capable and able to provide accuracy to within 6-to-10 ft.
- **Digital Camera**
- **Laser Distance Measuring Tool**: used to measure clearances and span lengths.
- **Shovel**: used for uncovering pedestals, base plate, etc.
- **Machete/Bush Ax**: used to remove undergrowth.
- **Mason Hammer:** used to check the tightness of top and leveling nuts, sound anchor bolts for possible cracks or debonding from concrete, sounding the concrete pedestals for delamination, and possible sounding of other structure elements for possible internal corrosion and section loss.
- **4 ft. Level**: used to check plumbness of non-tapered vertical supports/poles and levelness of other components.
- **Plumb Bob:** used to check tapered and non-tapered vertical support/pole plumbness and bowing.
- **Nylon string**: used to determine and measure sag or any other distortion of a chord or other member.
- **25 ft. Tape Measure:** used to measure sign dimensions, anchor bolt diameters, base plate standoff distances, and deficiency sizes, etc.
- **Folding Ruler**: used to measure sign dimensions, anchor bolt diameters, base plate standoff distances and deficiency sizes, and used for scale in photographs.
- **Angle Grinder**: used to grind the tops of anchor bolt to level the surfaces and remove any coating.
- **Spray Paint**: used to paint structure numbers to vertical supports/poles of structures and parapets for bridge parapet-mounted structures.

- **Paint Remover:** used to remove excess spray paint or overspray from painting numbers on structure.
- **Number and Letter Stencils**: used to establish and apply structure numbers to vertical supports/poles of structures and parapets for bridge parapet-mounted structures.
- **Stencil Template**: used to align, secure, and frame structure numbers and letters (described above) in a vertical or horizontal orientation, and to prevent overspray on the on the structure during the painting process.
- **Cold Galvanizing Compound**: used to paint the tops of anchor bolts following grinding and ultrasonic testing to minimize or prevent corrosion.
- **Mechanics Mirror**: used to inspect areas which are difficult to access through normal hands-on inspection methods; the mirror affords a visual inspection of the areas. If the mirror is to be used inside hand holes or other potentially electrically active locations, the mirror shall have an electrically insulated handle.
- **Electrically Insulated Boroscope:** used to inspect the interior areas of vertical supports/poles, chords, etc. which cannot be inspected through conventional means due to limited accessibility or live electrical components within the areas. This scope is not required at all inspections.
- **Calipers**: used to measure component section loss and the diameter or thickness of smaller components such as anchor bolts.
- **Feeler Gauge**: used to measure gaps between parts or pieces, such as a gap between the top nuts and base plates.
- **Magnet**: used to determine the material of a structure and secure the end of a string line when measuring sag or distortion of a vertical support/pole or horizontal support/truss, etc.
- **Ultrasonic Thickness Gauge**– used to measure the thickness of components where access to one side is restricted (e.g. pole wall thickness).
- **Wrenches and Screw Drivers**– used to remove anchor bolt covers, hand hole covers, and transformer base access covers.
- **Generator**: used to provide power for various corded tools or equipment, including lights for night inspections, drills for drilling of grout pads, and grinders for ultrasonic testing of anchor bolts.
- **Extension Cord**: used to power tools or equipment when accessibility is limited due to structure location or obstructions.
- **First Aid Kit**: used to address minor on-site injuries. A kit shall be available in each inspection vehicle at all times**.**
- **Rags, Painters Tape, Duct Tape**: rags are used for various activities including wiping or cleaning paint, dirt, or grime from areas or elements. Painters tape is used to tape stencils to the stencil template and duct tape is used for a variety of conditions, as necessary.

- **Dye Penetrant Testing Kit**: used to perform NDT on suspected cracks in welds or metal members.
- **Magnetic Particle Testing Kit**: used to perform NDT on suspected cracks in welds or steel members.
- **Cellular Phone**: used to contact and communicate with various entities to coordinate or report personnel or inspection emergencies or critical conditions.
- **Two-Way Radios**: used for communication between the inspectors during the inspection process, specifically when one inspector is performing inspections from an aerial lift or bucket.

1.7 ACCESS

When planning the inspection of ancillary structures, the team leader should review previous inspection reports and the location of each structure to determine if special access requirements exist. This section addresses typical conditions or locations which may require special access methods and equipment.

Access Equipment

Special equipment may be necessary to perform and/or complete the inspection of certain ancillary traffic structures. This equipment is based on the location of the structure and may include:

- Bucket Truck: Truck-mounted aerial lifts will be used to perform majority of inspections.
- Underbridge Inspection Unit (Snooper): May be required for structures located where a conventional bucket truck cannot be used to access the foundation structure, such as a sign bracket structure with pedestrian walkways and fencing with no roadway. A snooper would be required to access the structure's bridge beam/ girder connection.
- Manlift/Scissor Lift: May be required to access and inspect structures which cannot be adequately accessed using a bucket truck.

Special Access Requirements

Special Access Requirements will be necessary for the inspection of certain ancillary structures. Examples of some typical structures include:

- Structures behind a sound wall: Structures located behind sound walls may be difficult to access and may often have access doors which require a key to unlock. Coordination with the local SCDOT District may be required to attain access through doors in a sound wall.

- Structures in railroad right-of-ways: Access to a structure located within railroad right-of-ways may require permits and special access training from the owner of the right-of-way. Coordination with the owner may define the requirements of access to the structure.
- Structures on movable bridges: Structures located on the swing or lift span of a bridge require coordination with the bridge operator to ensure that the inspection work does not interfere with bridge operations.
- Poles and foundations within a median barrier: Structure foundations located within the median of a roadway may be enclosed within a steel plate that must be removed to provide access for inspection. These plates may require specific removal equipment which should be present on site at the time of inspection.
- Structures behind pedestrian fencing: Structures may be located behind fencing that prohibits access. Special lift equipment or pre-inspection planning to approach the structure from behind the fencing may be required.

Additional scenarios may also present themselves in the field which require alternative or modified methods of access to all or part of a structure. If a structure cannot safely be inspected with the equipment and traffic control that is available on-site, the inspection should be terminated until a plan to safely access and inspect the structure is developed.

1.8 NONDESTRUCTIVE TESTING

Introduction

Structures of all types are susceptible to a range of defects. Some defects are unknowingly built into a structure, while others develop over time due to natural or manmade events. While some of these defects may be detected by visual or tactile means, others may be hidden within the structure's members or components. In some cases, an indication of a defect may be readily observed, but the true extent or cause of the defect is not evident. For cases such as these, the use of nondestructive evaluation (NDE) methods can be used to more thoroughly investigate a structure's condition without inflicting damage.

This section presents an overview of NDE techniques as they apply to overhead sign structures. Although NDE is often performed by specialists, all structure inspectors should be familiar with available NDE techniques so they can recommend appropriate testing procedures and recognize the limitations of the testing data.

Liquid Penetrant

Liquid Penetrant Testing (LPT) is used to confirm the presence of a crack or flaw. It relies on the ability of a liquid to enter a discontinuity. Therefore, it can only find discontinuities which are open to the surface of the material. The penetrant can be applied to any non-porous material that is not adversely affected by the penetrant material.

PHOTOGRAPH 1-13: INSPECTOR PERFORMING LIQUID PENETRANT TESTING

The basic LPT procedure requires that the material be pre-cleaned to remove all surface contaminants and the liquid (penetrating oil) be applied to the surface being tested; the penetrant will then enter small surface openings. Penetrant is then removed from the test surface by wiping or rinsing with water. A drying developer is next applied. The penetrant remaining in the discontinuity bleeds out, forming a highly visible, contrasting indication on the test surface.

The characteristics of a good penetrant relate to the ability of the fluid to be drawn into small openings, even against gravity. This penetrating ability is affected by many variables including surface tension of the liquid, wetting ability, surface condition, surface contamination, and temperature.

There are two major types of penetrants used: (1) visible dye penetrants, and (2) fluorescent-visible penetrants. Visible dye penetrants are normally red, providing contrast with the applied white developer. Fluorescent penetrants contain dyes, which fluoresce brilliantly when viewed under black light in a darkened area. The ability to see penetrant indications on the test surface relates to the contrast provided between the penetrant and the test surface. Fluorescent penetrants provide better contrast than visible dye penetrants and therefore are more accurate than visible dye penetrants.

Interpretation of the liquid penetrant indication involves determining what condition caused the indication, evaluating the condition for its effect and severity regarding the usability of the part, and reporting inspection results accurately and clearly.

Proper interpretation and evaluation of liquid penetrant indications requires knowledge of the types, causes, and appearance of indications, knowledge of the test method and material fabrication process, adequate illumination, good eyesight, and experience.

The LPT method is documented in American Society for Testing and Materials (ASTM) E165 95 “Standard Test Method for Liquid Penetrant Examination” and ASTM E1417-99 “Standard Practice for Liquid Penetrant Examination.”

Applications

LPT can be conducted on a wide variety of non-porous materials, including metallic and non-metallic, magnetic and non-magnetic, and conductive and non-conductive materials. The method is highly sensitive to small surface discontinuities and produces indications directly on the surface of the component to provide a visual representation of the flaw.

The penetrant materials are typically supplied in aerosol form, which makes them portable and well adapted to field use, and also allows large areas of a component to be tested rapidly even if the component has a complex geometric shape. Powder penetrant materials are also available, but are typically cumbersome to use in the field.

Finally, the penetrant materials and associated equipment are relatively inexpensive, especially when compared to most other nondestructive evaluation (NDE) methods. See Photograph 1-13 for a view of an inspector performing a LPT in the field.

Limitations

Liquid penetrant testing does have several limitations, as the method only works on non-porous materials and the surface finish and roughness of the tested component can affect the sensitivity of the test.

Additionally, LPT can only detect discontinuities which are open to the surface. Discontinuities filled with contaminants, paint, rust, oxidation, or corrosion products may not be detected; therefore, pre-cleaning of any tested component is critical. The process also requires multiple steps, including cleaning the component, applying the dye/fluorescent, cleaning off the dye/fluorescent, applying the developer, and cleaning off the developer after the test is completed. The method also requires the safe handling of chemicals and the proper disposal of saturated cleaning rags and empty aerosol cans.

Finally, the sensitivity of LPT decreases at reduced temperatures since crack widths are typically reduced and the test medium is less fluid.

Ultrasonic Testing

Ultrasonic Testing (UT) is used to evaluate the internal condition of materials. Specifically, it is used to confirm suspected discontinuities or cracks and identify material thicknesses or lengths. Typical discontinuities which are detectable by use of UT include laminations, internal cracks, and many surface and subsurface weld-related discontinuities, such as lack of fusion, porosity, etc.

In UT, a transducer directs a wave of high frequency vibrations that are inaudible to the human ear into the test specimen and then receives the returning echoes. The ultrasonic instrument contains the necessary electronics to produce these waves and display the returning echoes for interpretation.

PHOTOGRAPH 1-14:4 INSPECTOR PERFORMING ULTRASONIC TEST

A transducer is a device that is capable of converting energy from one form to another. In the case of UT, electrical energy is changed to mechanical energy and vice versa, as UT transducers convert electrical energy into mechanical vibrations produce high frequency sound waves. Upon receipt of the return echo, they also convert high frequency sound back into electrical energy.

The most common ultrasonic technique currently used in the United States is the pulse echo method. This method employs short bursts, or pulses, of waves, which are transmitted into the specimen by the transducer which must be in integral contact with the specimen. This is typically accomplished through the use of a coupling gel. Any returning unexpected echo from these pulses is evaluated for the reflector location and size.

The signal height (amplitude) of the return echo is related to the amount of reflected sound energy. Large reflectors, which cause total reflection of sound, produce signal responses of higher amplitude than smaller reflectors, which only reflect a portion of sound energy. Larger return echo amplitudes typically indicate larger sized flaws. Areas with indications of flaws should be retested from another position to confirm flaw size and location.

Applications

Perhaps the biggest advantage of UT is its ability to examine the internal structure of a material when accessibility is limited to one side of the component. It is an ideal method to detect flaws which are generally not readily apparent by visual means. UT is used to inspect a variety of both metallic and nonmetallic members, such as welds, forgings, castings, plastics, ceramics, concrete, steel sheeting, aluminum tubing, fiberglass, and timber. Since UT is capable of economically revealing subsurface discontinuities (variations in material composition) in a variety of dissimilar materials, it is an extremely effective and useful tool. UT is most successful for detecting discontinuities which are oriented perpendicular to the direction of the propagating stress beam.

UT is readily adaptable to field testing, as the equipment comes in portable lightweight units that contain a rechargeable battery with an 8-hour battery life. Refer to Photograph 1-14 for a view of an inspector conducting UT in the field.

Limitations

UT should not be performed on rough surfaces, parts with complicated geometries, highly attenuated materials, or components where the expected discontinuity size is smaller than one half of the wavelength. Additionally, rough surfaces may require grinding during surface preparation.

Magnetic Particle

The magnetic particle test (MT) is used for testing ferromagnetic materials (steel, wrought iron, cast iron, etc.). MT is used to confirm suspected cracks or test fracture critical details. The primary advantage of MT is high sensitivity for detection of tight surface cracks and other small discontinuities. Typical detectable discontinuities include cracks, lack of fusion, and other weld-related surface discontinuities. Base metal discontinuities such as seams, laps, and "stringers" are also readily detected by MT.

PHOTOGRAPH 1-15: INSPECTOR PERFORMING MAGNETIC PARTICLE TEST

As defined by the American National Standards Institute (ANSI), MT utilizes the principle that magnetic lines of force, when present in a ferromagnetic material, will be distorted by a change in material continuity, such as a sharp dimensional change or a discontinuity. If the discontinuity is open to, or close to, the surface of a magnetized material, flux lines will be distorted at the surface; this condition is termed flux leakage. When fine magnetic particles are distributed over the area of the discontinuity with flux leakage, the fillings will converge at the discontinuity and the accumulation of particles will be visible for the inspector.

The objective of MT is to cause a magnetic field of sufficient strength and in a predetermined direction to leak if discontinuities are present. The inspector detects these leaks by sprinkling the test area with iron filings, blowing away the excess, and then looking for areas where the filings have accumulated. These areas of accumulation indicate a surface or a subsurface discontinuity.

Applications

MT is a sensitive means of locating small and shallow surface cracks and has the ability to locate near-surface discontinuities with direct current. Unlike LPT, cracks filled with foreign material can be detected by MT and no elaborate pre-cleaning is necessary. This test is also effective on painted surfaces.

MT is reasonably fast and inexpensive, especially when compared to some other nondestructive evaluation (NDE) methods, and the testing equipment is portable. There is also little or no limitation of MT's effectiveness due to size or shape of the part being inspected. Refer to Photograph 1-15 for view of an inspector conducting MT in the field.

Limitations

MT is only effective on ferromagnetic materials and the induced magnetic field must be perpendicular to the principal plane of the discontinuity for best detection. Additionally, MT will not disclose fine porosity; the deeper the discontinuity below the test surface, the larger the discontinuity must be to provide a readable indication.

To conduct MT, AC electricity is required on-site, as DC prods should not be used on fracture critical members. Test surfaces must be clean and paint should be removed for highest sensitivity. Also, residual magnetism may need to be removed prior to testing. Although the method appears simple, the need for experienced and knowledgeable operators is required.

Chapter 2 INVENTORY

This chapter will cover description of the types of sign structures, identification of structures and their geometry, and photographs for structure inventory.

2.1 STRUCTURES INCLUDED IN INVENTORY

General

Sign structures typically consist of four components: the sign panel that displays the message, the horizontal portion of the structure that carries the sign panels and is located over traffic lanes, the vertical supports adjacent to the roadway that carry the horizontal component of the structure, and the foundation that anchors the vertical supports.

Sign panels may consist of rigid panels on which a message is placed using reflective material or are variable message signs (VMS), which can vary light-emitting elements to display various messages. The reflective material and lights are arranged and displayed in accordance with the message they are intended to communicate to traffic.

The horizontal component of the structure provides structural support for the sign over the roadway. The main horizontal component types are full span, cantilever, and butterfly structures. The type of horizontal support typically determines the nomenclature of the structure. These configurations usually involve one or more horizontal members called chords. In the case of multiple chords, the chords are connected by intermediate bracing members, forming a truss.

The vertical supports, also known as columns, frames, or towers, provide structural support for the horizontal components of the sign structure. The vertical supports also set the elevation of the sign to provide clearance between traffic on the roadway and the bottom of the sign structure. These columns are typically constructed with individual poles or vertical plane trusses with two main vertical members.

The foundation provides structural support for the columns. The majority of the foundation is below ground. The foundation transfers the loads that act on the structure to the ground.

Full Span Sign Structures

These structures span over a roadway, with vertical supports constructed at each end of the structure. They may span over the entire roadway across both directions of traffic, with columns on the outside edges of the roadway, or over a single direction of traffic, with one column in the median and one column on the outside edge of the roadway. Depending on the structure's requirements and design, the horizontal supports typically are constructed with one of four standard configurations. The configurations are classified by the number of chords comprising the structure's horizontal portion spanning the roadway. The four bridge span structure configuration types are Single Chord, Two Chord Truss, Tri-Chord Truss, and Four Chord Truss.

PHOTOGRAPH 2-01: FULLSPAN SIGN STRUCTURE

Cantilever Sign Structures

These structures are constructed with arms that overhang part of the roadway in a single direction of traffic, with vertical supports constructed at one end of the structure. Depending on the structure's requirements and design, the horizontal supports typically are constructed with one of three standard configurations. The configurations are classified by the number of chords comprising the structure's horizontal portion spanning the roadway. The four types of cantilever span structures are Single Chord, Two Chord, Tri-Chord, and Four Chord.

PHOTOGRAPH 2-01: CANTILEVER SIGN STRUCTURE

Butterfly Sign Structures

The butterfly structure shares some characteristics with the cantilever but is constructed with arms on both sides of the vertical support. The arms may be of different sizes and lengths. Depending on the structure's requirements and design, the horizontal supports typically are constructed with one of three standard configurations. The configurations are classified by the number of chords comprising the structure's horizontal portion spanning the roadway. The three types of

PHOTOGRAPH 2-02: BUTTERFLY SIGN STRUCTURE

cantilever span structures are Single Chord, Two Chord, Tri-Chord, and Four Chord.

Bridge Mounted Sign Structures

Bridge Mounted structures consist of a sign panel and framing constructed with tubular shapes, angles, I-beams, or T-sections. The sign structure is typically attached to the bridge beams/girders and parapet via bolted or clamped connections. Connections to steel bridges should never be made by field welding.

PHOTOGRAPH 2-03: BRIDGE MOUNTED SIGN STRUCTURE

Mast-arm Sign Structures

A mast-arm sign structure consists of a single horizontal member (the chord), typically a tubular shape, that spans the roadway and supports the sign panels. The horizontal portion of the structure is supported at one end by a vertical support consisting of a single pole.

PHOTOGRAPH 2-04: MAST ARM SIGN STRUCTURE

Monotube Sign Structures

A monotube sign structure consists of a single horizontal tubular shape (the chord) that bends at each end so that the chord transitions into the vertical supports, thereby creating a continuous structure with integrated poles.

2.2 STRUCTURE IDENTIFICATION AND LOCATION

Each structure shall receive an identification number. This number is a 5-digit number comprised of a 2-digit county code and a 3-digit consecutive number. For example, the 4th inventoried sign in Anderson County is labeled 04004. The county code number corresponds to the county the structure is located in. A list of county codes can be found on the next page:

1	Abbeville	13	Chesterfield	25	Hampton	37	Oconee
2	Aiken	14	Clarendon	26	Horry	38	Orangeburg
3	Allendale	15	Colleton	27	Jasper	39	Pickens
4	Anderson	16	Darlington	28	Kershaw	40	Richland
5	Bamburg	17	Dillon	29	Lancaster	41	Saluda
6	Barnwell	18	Dorchester	30	Laurens	42	Spartanburg
7	Beaufort	19	Edgefield	31	Lee	43	Sumter
8	Berkeley	20	Fairfield	32	Lexington	44	Union
9	Calhoun	21	Florence	33	McCormick	45	Williamsburg
10	Charleston	22	Georgetown	34	Marion	46	York
11	Cherokee	23	Greenville	35	Marlboro		
12	Chester	24	Greenwood	36	Newberry		

2.2.1 GPS AND STRUCTURE NUMBERS

GPS Coordinates

For single support structures, coordinates shall be obtained at the foundation.

For structures with multiple supports, coordinates shall be obtained at the rightmost foundation when facing the front of the sign.

For sign structures that cross multiple directions of traffic and have sign panels on both faces, the northbound and eastbound lanes are to be considered the front face of the structure.

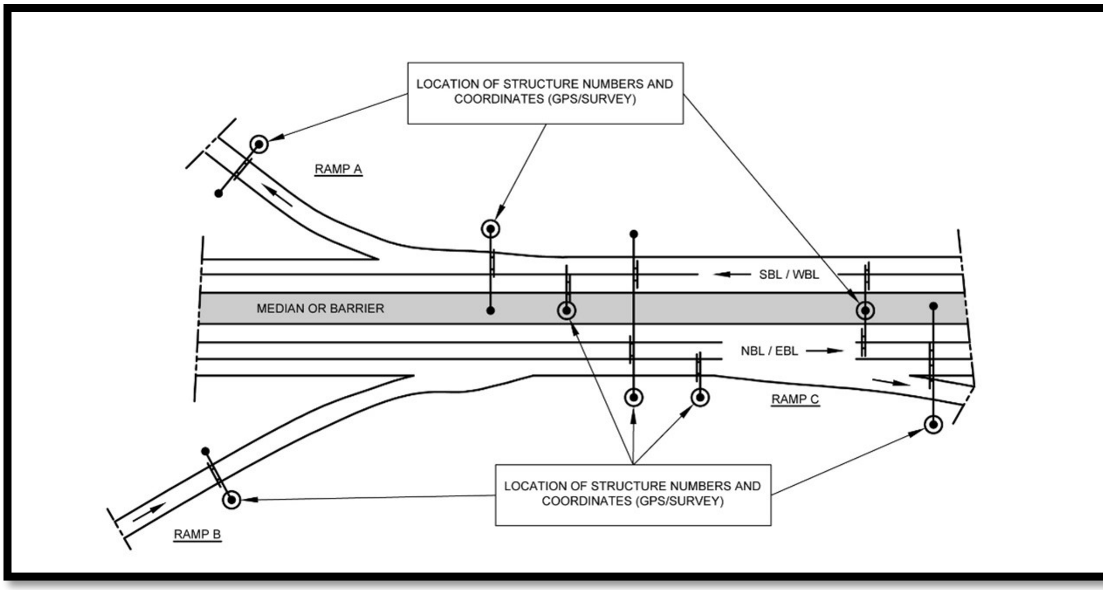


FIGURE 2-01: GPS LOCATIONS

Structure Numbers

The structure identification number will consist of 5 numbers preceded by a three-letter designation for the type of structure.

- OSS – Overhead Sign Structure
- HML – High Mast Light
- GMS – Ground Mounted Sign

Painting/stenciling of structure numbers is outlined below.

a. Height of numbering: The stenciled numbers shall be 3" high and have a 1" space between the numbers.
b. Stenciling paint shall be highly durable and weatherproof with UV inhibitor. The color of the paint shall be black or deep brown. For poles painted with a dark color, light grey paint may be used. Yellow paint may be used for timber poles. As an alternative to painting the number, adhesive reflective panels or numbers may be applied to structure. The numbers on the reflective panel shall have the same height, spacing, and location requirements as stenciling paint.
c. Location of structure number:

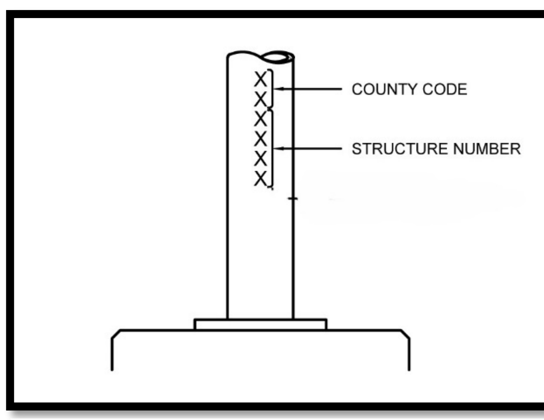


FIGURE 2-02: STENCILING

i. Bridge mounted sign structures: Number shall be placed horizontally, approximately 2" below the top of the parapet on the face of the parapet. If no parapet is present, the number shall be placed on the top rail. The identification number shall be centered along the sign panel(s). The number shall not be placed on the sign. Structure numbers are required for each individual structure. For bridge mounted sign structures that support multiple signs, a single structure number is required. If each sign is supported by its own structure, a structure number is required for each sign mount.

PHOTOGRAPH 2-06: STENCILING ON COLUMN

ii. All other structures: The number shall be placed at an elevation such that the bottom number is a minimum of 6" above the top of the adjacent guardrail/barrier. When no guardrail/barrier is present, the number shall be placed approximately 36" above the top of the anchorage. Lettering shall be placed vertically on the pole and must be visible to oncoming traffic.

d. Numbers marked horizontally shall read from left-to-right. Numbers marked vertically shall read from top-to-bottom.

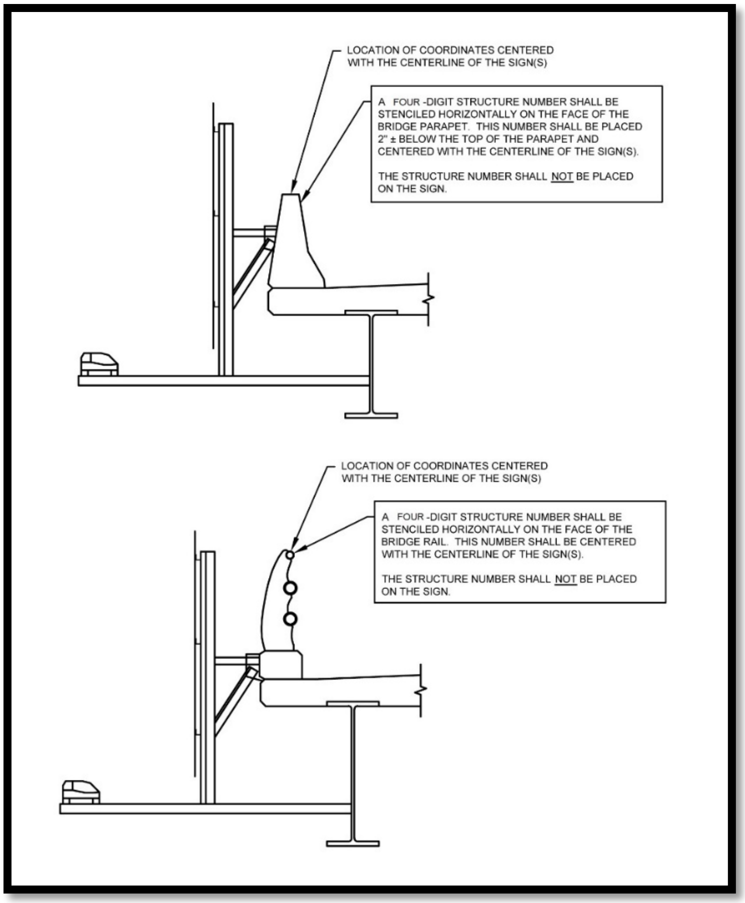


FIGURE 2-03: STENCILING LOCATION FOR BRIDGE MOUNTED STRUCTURES

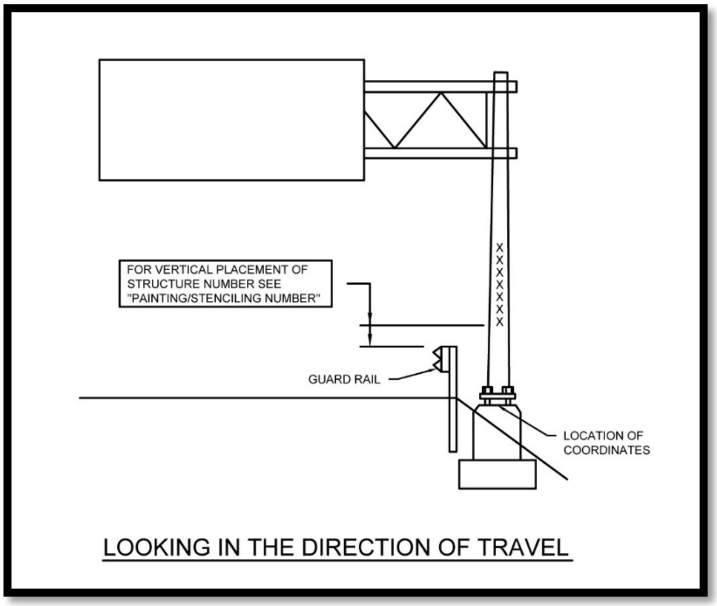


FIGURE 2-04: STENCILING FOR CANTILEVER STRUCTURES

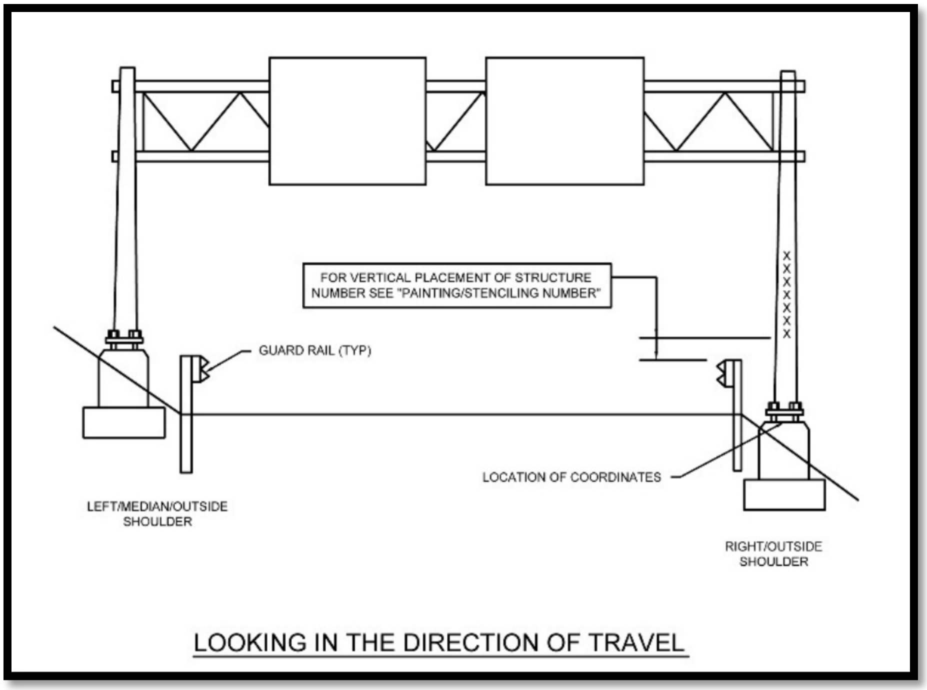


FIGURE 2-05: STENCILING FOR FULLSPAN STRUCTURES

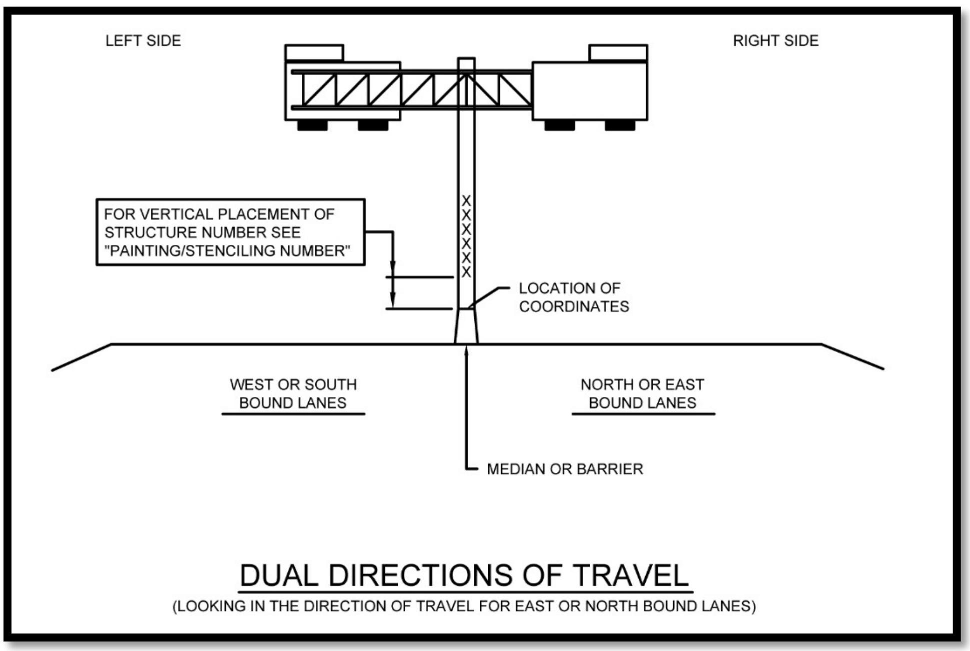


FIGURE 2-06: STENCILING FOR BUTTERFLY STRUCTURES

Chapter 3 STRUCTURE INFORMATION

This chapter covers the basic inventory structure information to be collected or reviewed for accuracy during each inspection. The database's structure information field describes the ancillary structure and its location. This includes all basic inventory data for the structure.

Overall Structure Rating (See Section 5.1 for ratings):

- Good
- Fair
- Poor
- Critical

Status:

- In-Service – This designation is for structures that are currently being used on the roadway or will be when the roadway is under construction.
- Removed – This deisgnation is for structures that have been taken down. There may be a foundation and/or anchor rods left at the site.

Structure Type:

- 2- Chord Mast Arm
- 3 – Chord Cantilever Truss
- 4 – Chord Cantilever Truss
- 2 – Chord Fullspan
- 3 – Chord Fullspan
- 4 – Chord Fullspan
- 4 - Chord Fullspan with Cantilever
- Butterfly
- Bridge Mounted
- Mast Arm
- Monotube Fullspan
- High Mast Light Pole
- Other

PHOTOGRAPH 3-01: 2-CHORD MAST ARM (FRONT)

PHOTOGRAPH 3-02: 2-CHORD MAST ARM (REAR)

PHOTOGRAPH 3-03: 3-CHORD CANTILEVER (FRONT)

PHOTOGRAPH 3-04: 3-CHORD CANTILEVER (REAR)

PHOTOGRAPH 3-05: 4-CHORD CANTILEVER (FRONT)

PHOTOGRAPH 3-06: 4-CHORD CANTILEVER (REAR)

PHOTOGRAPH 3-07: 2-CHORD FULLSPAN (FRONT)

PHOTOGRAPH 3-08: 2-CHORD FULLSPAN (REAR)

PHOTOGRAPH 3-09: 3-CHORD FULLSPAN (FRONT)

PHOTOGRAPH 3-10: 3-CHORD FULLSPAN (REAR)

PHOTOGRAPH 3-11: 4-CHORD FULLSPAN (FRONT)

PHOTOGRAPH 3-12: 4-CHORD FULLSPAN (REAR)

PHOTOGRAPH 3-13: 4-CHORD FULLSPAN WITH CANTILEVER (FRONT)

PHOTOGRAPH 3-14: 4-CHORD FULLSPAN WITH CANTILEVER (REAR)

PHOTOGRAPH 3-15: BUTTERFLY

PHOTOGRAPH 3-16: BUTTERFLY (VMS)

PHOTOGRAPH 3-17: BRIDGE MOUNTED (FRONT)

PHOTOGRAPH 3-18: BRIDGE MOUNTED (REAR)

PHOTOGRAPH 3-19: MAST ARM (FRONT)

PHOTOGRAPH 3-20: MAST ARM (REAR)

PHOTOGRAPH 3-21: MONOTUBE (FRONT)

PHOTOGRAPH 3-22: MONOTUBE (REAR)

PHOTOGRAPH 3-23: HIGH MAST LIGHT POLE

PHOTOGRAPH 3-24: HIGH MAST LIGHT POLE (CONCRETE)

PHOTOGRAPH 3-25: SINGLE POST

PHOTOGRAPH 3-26: SINGLE POST

PHOTOGRAPH 3-27: TWO POST FRAME

PHOTOGRAPH 3-28: FOUR POST FRAME

Truss/Arm Material:

- Galvanized Steel
- Painted Steel
- Weathering Steel
- Aluminum

End Support Type:

- Single Post – See Photographs 3-25 and 3-26.
- Two Post Frame – See Phtograph 3-27.
- Four Post Frame – See Photograph 3-28.
- N/A – This applies to bridge mounted sign structures.

End Support Material

- Galvanized Steel
- Painted Steel
- Weathering Steel
- Aluminum

Installation Type:

- **Ground Mounted** – A ground mounted structure is any ancillary structure that has a foundation that is on the ground. The exception being a sign structure that is mounted on a concrete barrier. The foundation can be a single concrete pedestal or multiple individual pedestals for each support. See Photographs 3-29 and 3-30 for examples.
- **Bridge Mounted** – A bridge mounted structure is has a foundation that is part of a bridge. It can either be mounted directly to the bridge with no end support, or the end supports could be founded on the bridge deck or bent cap. See Photographs 3-31 and 3-32.
- **Wall Mounted** – A wall mounted structure has no end supports and the truss is connected directly to a wall.

PHOTOGRAPH 3-29: GROUND MOUNTED

PHOTOGRAPH 3-30: GROUND MOUNTED (BARRIER FOUNDATION LISTED AS GROUND MOUNTED)

PHOTOGRAPH 3-31: BRIDGE MOUNTED

PHOTOGRAPH 3-32: BRIDGE MOUNTED

Truss/Arm Length (FT):

- Structure length is measured in feet. For Overhead span structures, measurement is taken from the right most to the left most vertical support. For cantilever structures, the measurement is taken from the vertical support to the end of the truss. For butterfly structures, the measurement is taken from end to end of the truss. For bridge mounted sign structures, the measurement is taken from end to end of the sign frame.

Number of Splices:

- A splice is a mechanical connection in the truss of the sign structure. At each splice location, there will be a connection on every chord member. This location counts as one splice. See Photographs 3-33 and 3-34 for typical splices.

PHOTOGRAPH 3-33: ROUND CHORD SPLICE

PHOTOGRAPH 3-34: BOX CHORD SPLICE

Number of Sign Panels:

- The number of sign panels includes all signs attached to the truss or mast arm of the structure. This total does not include exit signs, supplemental signs, or any signs attached to the end supports.

VMS Structure:

- A variable message sign is an electronic traffic sign often to give travelers information about special events. Such signs warn of traffic congestion, accidents, or roadwork zones.

PHOTOGRAPH 3-35: BUTTEFLY VMS

PHOTOGRAPH 3-36: FULLSPAN VMS

Total Travel Lanes Under:

- The total lanes under the structure include any travel lane that is under any portion of the structure. This number does not include shoulder lanes.

Minimum Vertical Clearance:

- The minimum vertical clearance shall be taken at the most restrictive clearance to any point on the sign(s) or structure to the travel lanes below.

Distance to Edge of Lane Line:

- Measurements to the nearest tenth of a foot shall be taken from the edge of the travel lane to the base of the nearest column on both the left and right sides of the road where applicable.

Base Plate Thickness (IN):

- The base plate thickness is the measurement of the thickness of the plate that is welded to the column, measured in inches to the nearest 1/8 inch. This measurement does not include any anchor rod templates remaining in-place.

Number of Anchor Rods:

- Enter the total number of anchor rods on the structure in this field. Anchor bolt numbering is necessary to accurately locate the various defects and deficiencies encountered during the inspection or ultrasonic testing of the base plate and anchor bolts. The numbering is established by standing beside the structure looking at the roadway for the primary direction of travel. The first bolt to the right of the base plate/column centerline is labeled as Bolt No.1, subsequent bolts are numbered consecutively in the clockwise direction from Bolt No. 1. Figure 3-01 depicts the anchor rod numbering system.

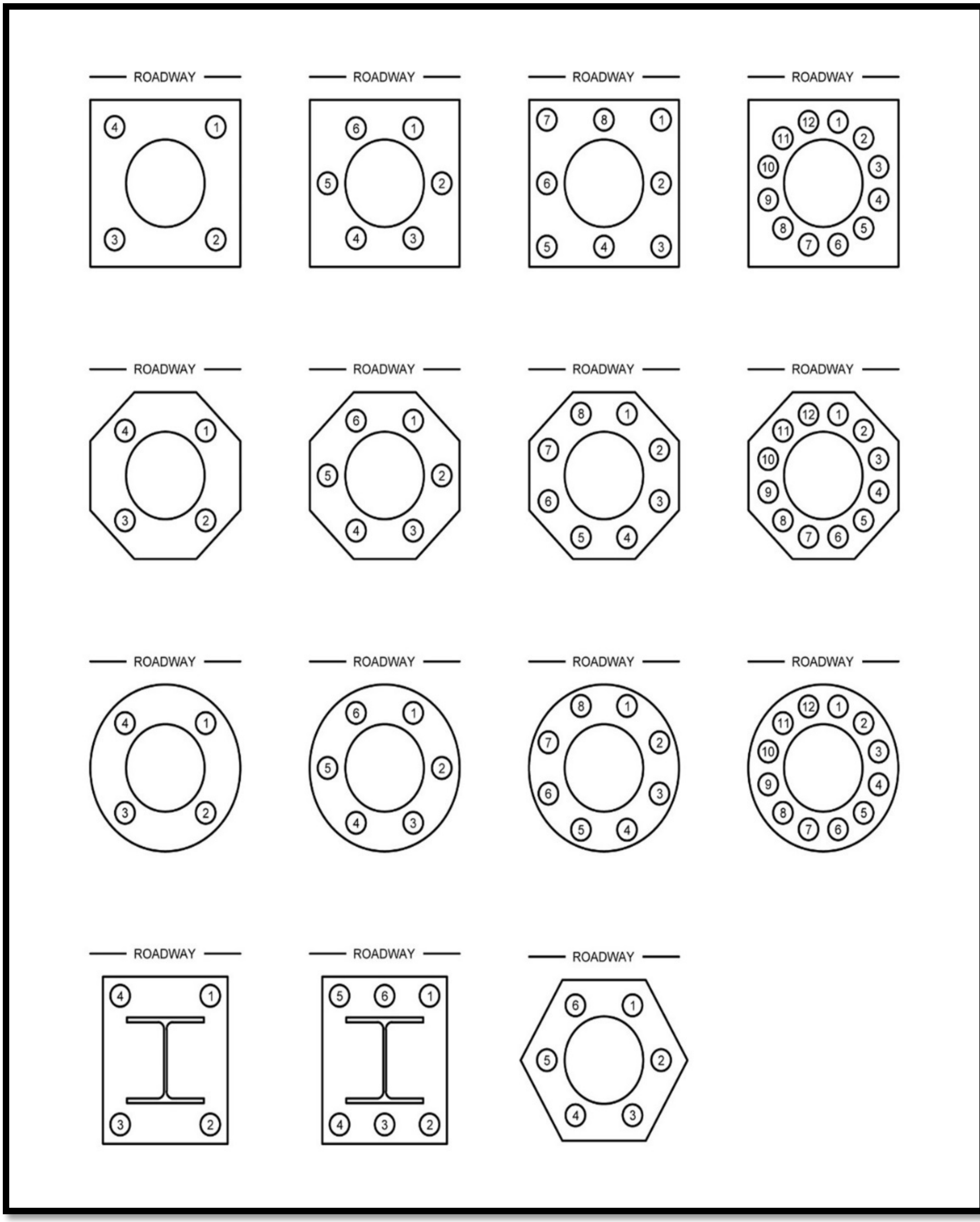


FIGURE 3-01: ANCHOR ROD NUMBERING

Anchor Rod Diameter (IN):

- The anchor rod diameter is measured in inches. See Photograph 3-37 for the technique used to measure the anchor rods.

PHOTOGRAPH 3-37: ANCHOR ROD MEASUREMENT WITH CALIPERS

Anchor Rod Maximum Standoff (IN):

- The distance between the bottom of the base plate and the top of the pedestal, denoted as H, as shown in Figure 3-02. Base plates which exceed a clear height above the pedestal of two bolt diameters induce stress on the anchor bolts which were not accounted for during design and can reduce the load capacity and fatigue life. The maximum measured distance between the bottom of the base plate and the top of the pedestal should be documented for each base plate of a structure, as differing heights may impact any recommendations for lowering of the structure.

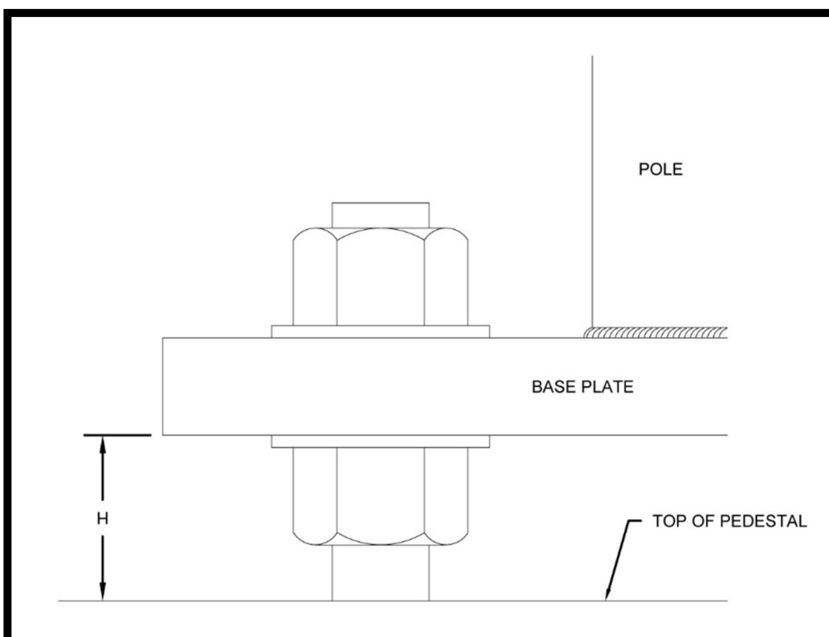


FIGURE 3-02: STAND OFF DISTANCE MEASUREMENT

Grout Pad:

- This field is to record the presence of a grout pad. A grout pad is formed around the opening between the foundation and base plate. It is not necessary to remove the grout pad but should be documented if it is deteriorated.

Handhole:

- This is an opening in the column near the base that can be opended for electrical work or interior inspection. It is typically elliptical in shape, is surrounded by a reinforcing ring, and has a cover that is fastened in place with ascrews or a locking clamp assembly.

Catwalk:

- This field is to record the presence of a catwalk. Catwalks consist of members that form a frame for grating to rest on, providing walkable access to the structure.

Luminaires:

- This field is to record the presence of luminaires on the sign structure. The luminaire sytem illuminates the sign and extends from the bottom of the hangers, out beyond the front of the sign.

Chapter 4 STRUCTURAL ELEMENTS

This chapter will cover the elements and components to be inspected at each structure.

4.1 GENERAL

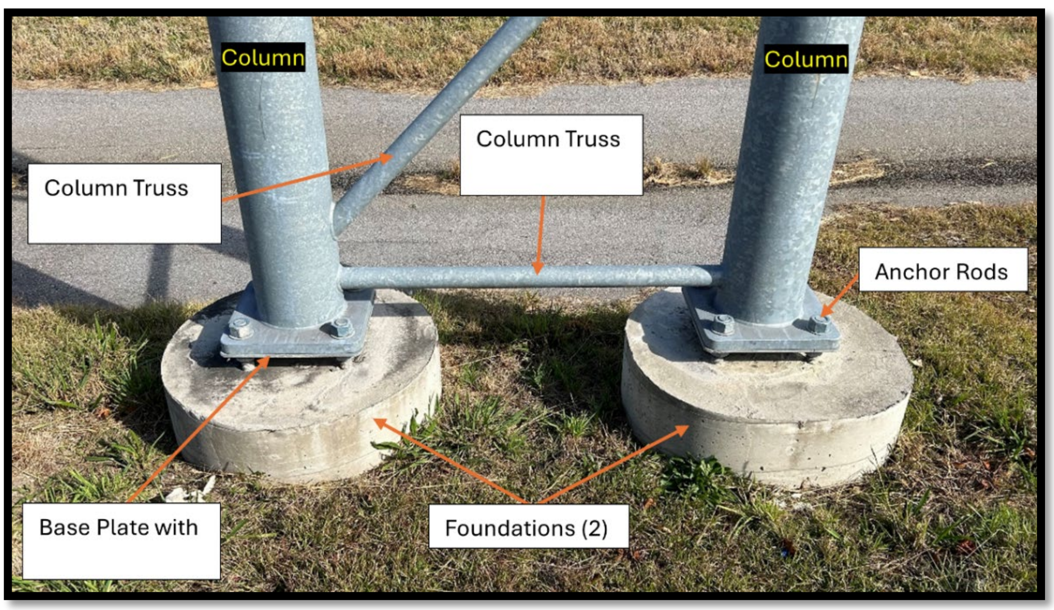
The inspection of overhead sign structures shall be in-depth using a "hands-on" approach. This typically involves climbing and being within an arm's reach of the components for visual examination. The inspection is element-based, but does not include element quantities.

The typical inspection approach and procedures has been developed and are provided in the *Guidelines* so they will not be rewritten in this document. Please

to Sections 8 through 15 in the *Guidelines* for further information. The remainder of this section shall cover the descriptions of the elements to be inspected at each structure and a listing of the components that are considered part of each specific element that shall be rated within.

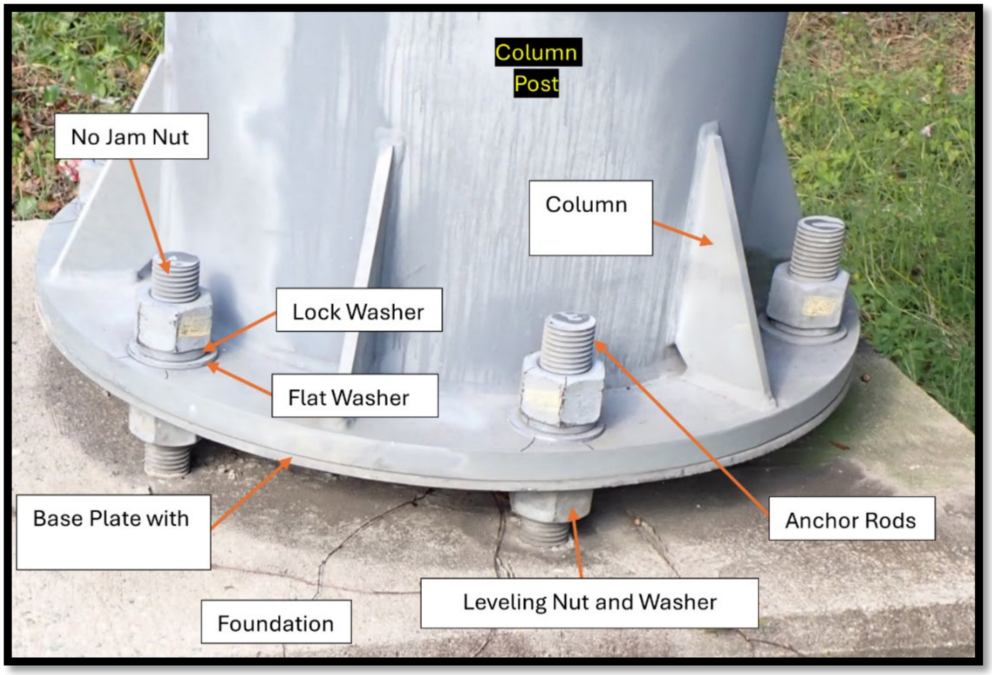
4.2 ELEMENTS AND COMPONENTS

S.01 Foundation – This element shall include the concrete foundation and grout pad. In addition to these components, any erosion of the surrounding grade shall be evaluated. Refer to Photograph 4-01 for components of this element.



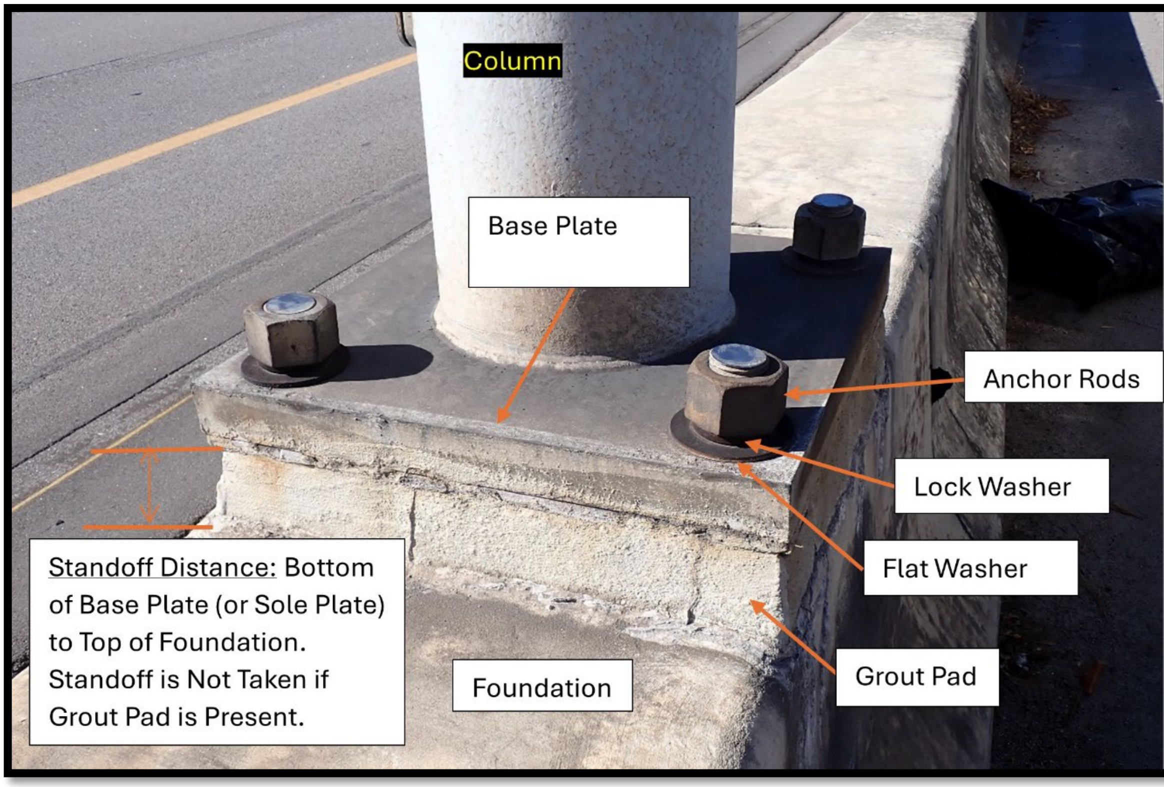
PHOTOGRAPH 4-01: FOUNDATION NOMENCLATURE (TWO POST FRAME)

S.02 Anchor Rod – This element shall include the anchor rods and all associated washers and nuts. The nuts and washers located on the underside of the base plate shall be labeled as leveling nuts and washers. The washers and nuts located on the top side of the base plate shall be labeled anchor nuts and washers. If a second nut is placed on top of the anchor nut, it shall be labeled jam nut. Refer to Photograph 4-02 for components of this element.



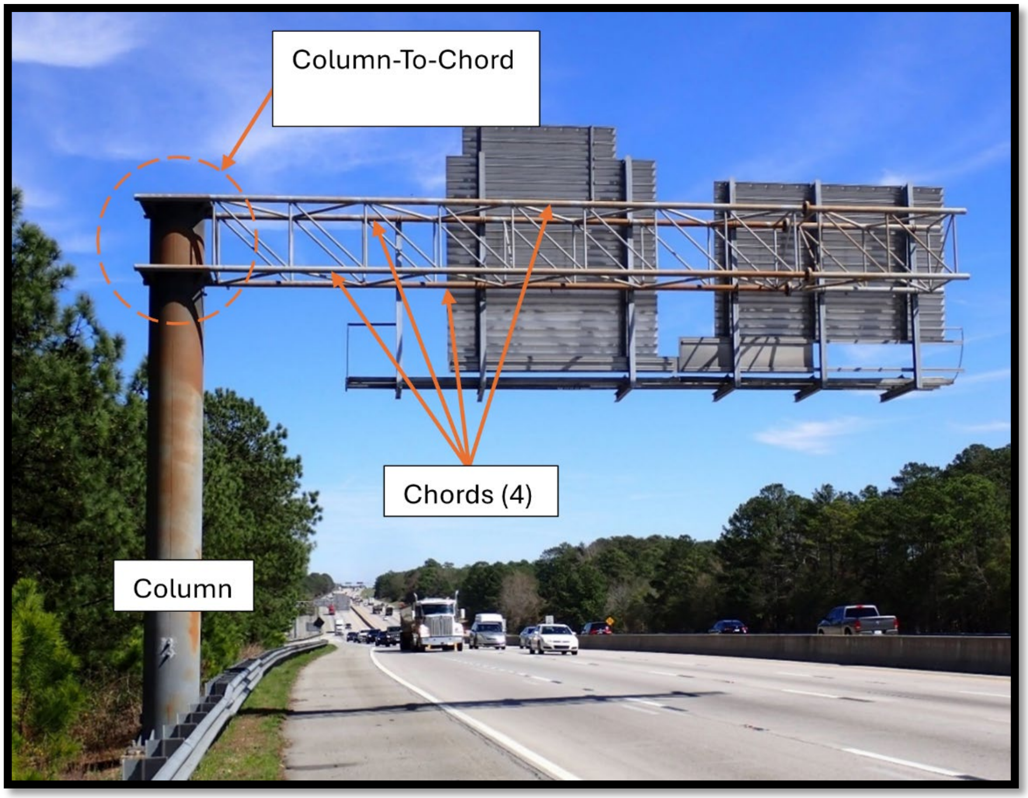
PHOTOGRAPH 4-02: FOUNDATION NOMENCLATURE (SINGLE POST)

S.03 Base Plate – This element shall include the base and stiffener plates (if present). Refer to Photograph 4-03 for components of this element.



PHOTOGRAPH 4-03: BASE PLATE NOMENCLATURE

S.04 Column(s)/Support Frame(s) – This element shall include the vertical support, column cap and associated stiffener plates and welds at the base plate connection. This element is used for columns composed of a single support as well as multiple columns in a vertical frame. Cap plates, stiffener plates and welds connected to the columns for span connections are included in this element. The plates welded to the span chords and the connection bolts are not included in this element. Refer to Photograph 4-04 for components of this element. See Figure 4-01 for nomenclature to call out defects.



PHOTOGRAPH 4-04: COLUMN SUPPORT/FRAME (SINGLE POST)

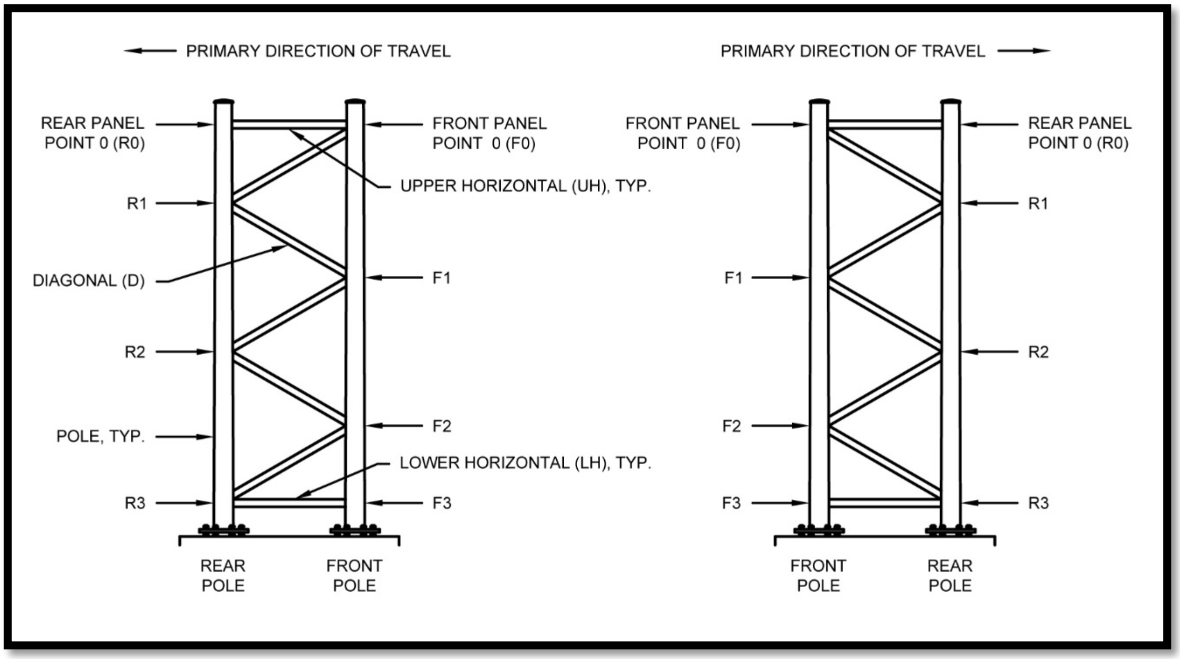
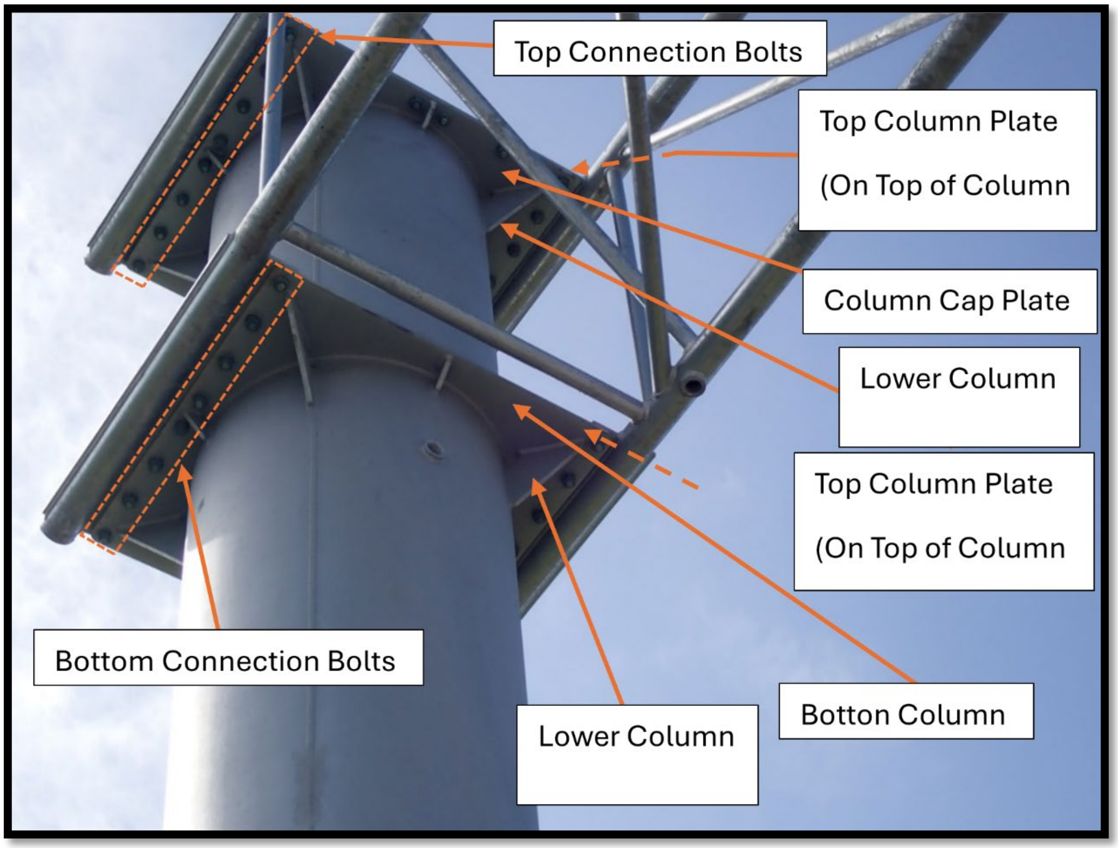


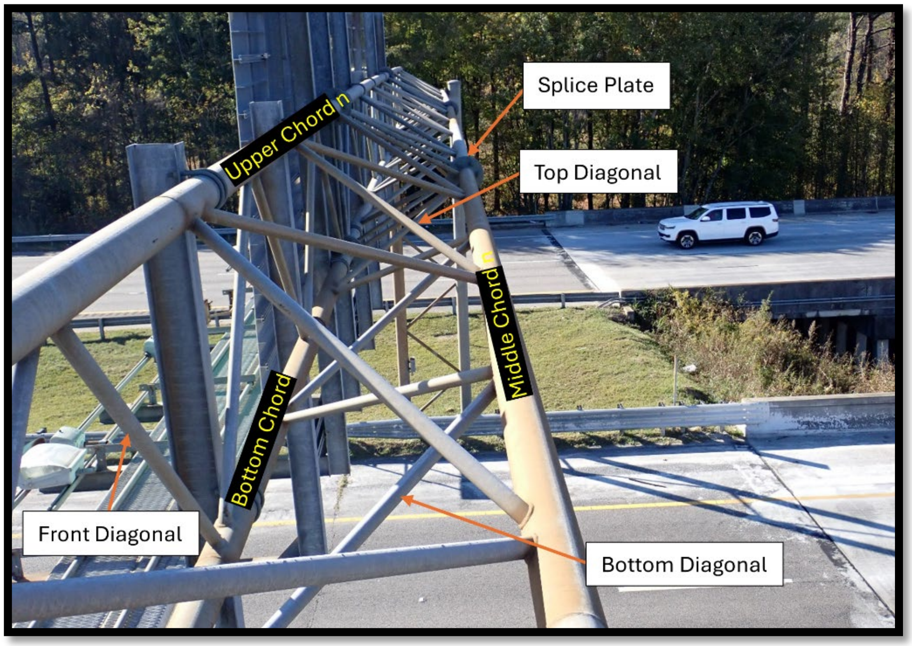
FIGURE 4-01: DIAGRAM OF COLUMN FRAME NOMENCLATURE

S.05 End Support-to-Chord Connection – This element shall include all connection plates, gusset plates, stiffener plates, saddles, u-bolts and associated welds and bolts that connect the span member(s) to the upright(s). Refer to Photograph 4-05 for components of this element.

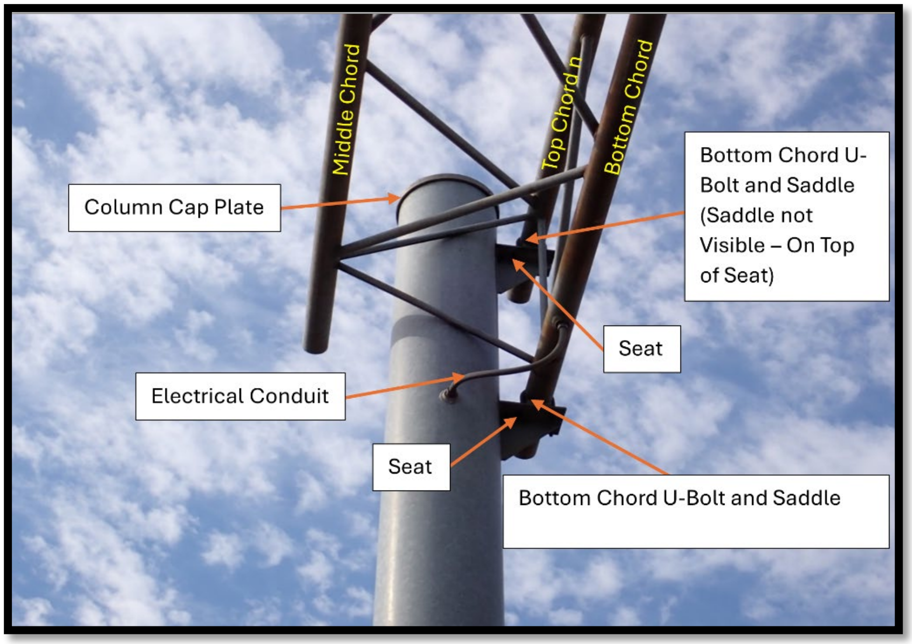


PHOTOGRAPH 4-05: END SUPPORT TO CHORD CONNECTION NOMENCLATURE

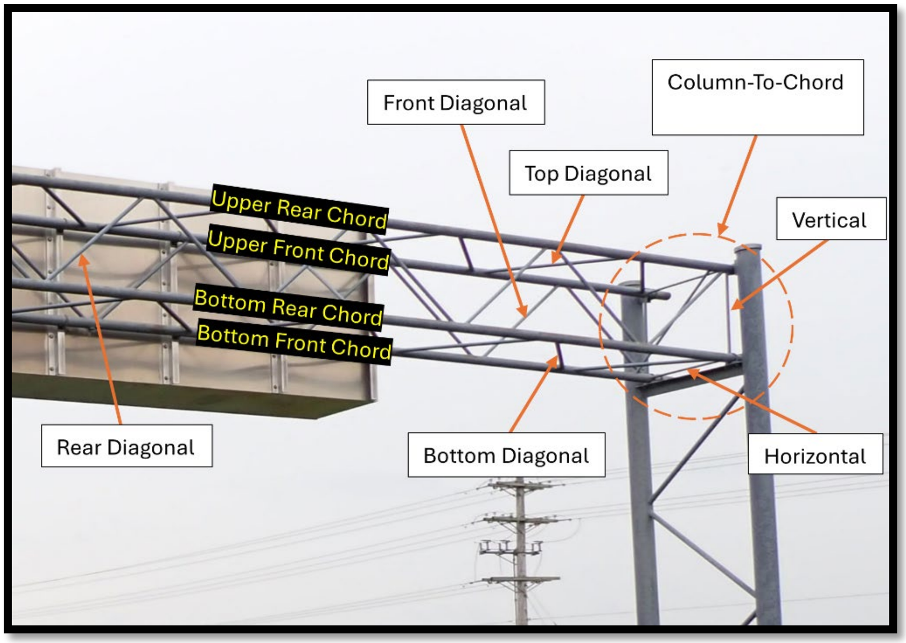
S.06 Truss Chord(s)/Mast Arm(s) – This element shall include the horizontal support member, and the chord base plate and weld if present. Secondary members, welds for secondary members (for truss spans), and bolts connecting the span to the support(s) are not included in this member. See Photographs 4-06 thru 4-09 for nomenclature. Refer to Figures 4-02 thru 4-04 for components of this element.



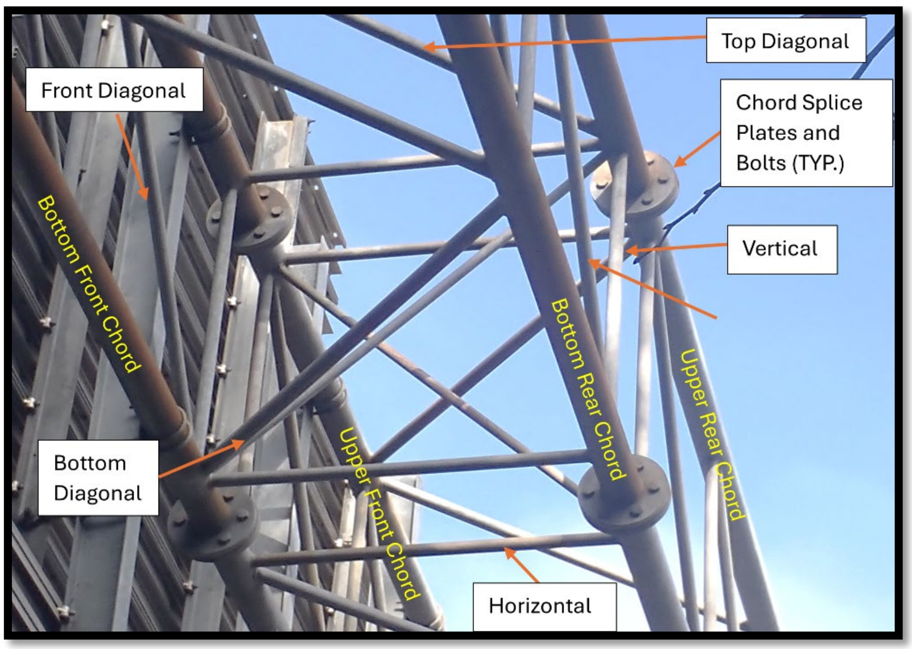
PHOTOGRPAH 4-06: 3-CHORD TRUSS NOMENCLATURE



PHOTOGRPAH 4-07: 3-CHORD TRUSS NOMENCLATURE



PHOTOGRAPH 4-08: 3-CHORD TRUSS NOMENCLATURE



PHOTOGRAPH 4-09: 4-CHORD TRUSS NOMENCLATURE

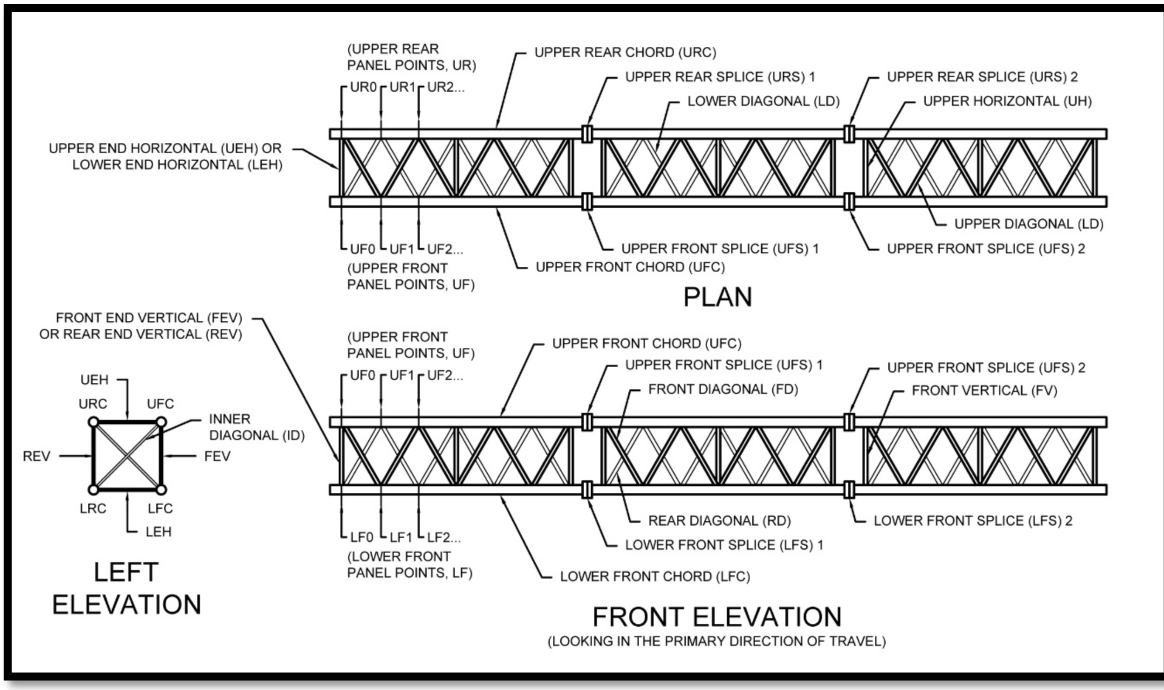


FIGURE 4-02: DIAGRAM 4-CHORD TRUSS DIAGRAM

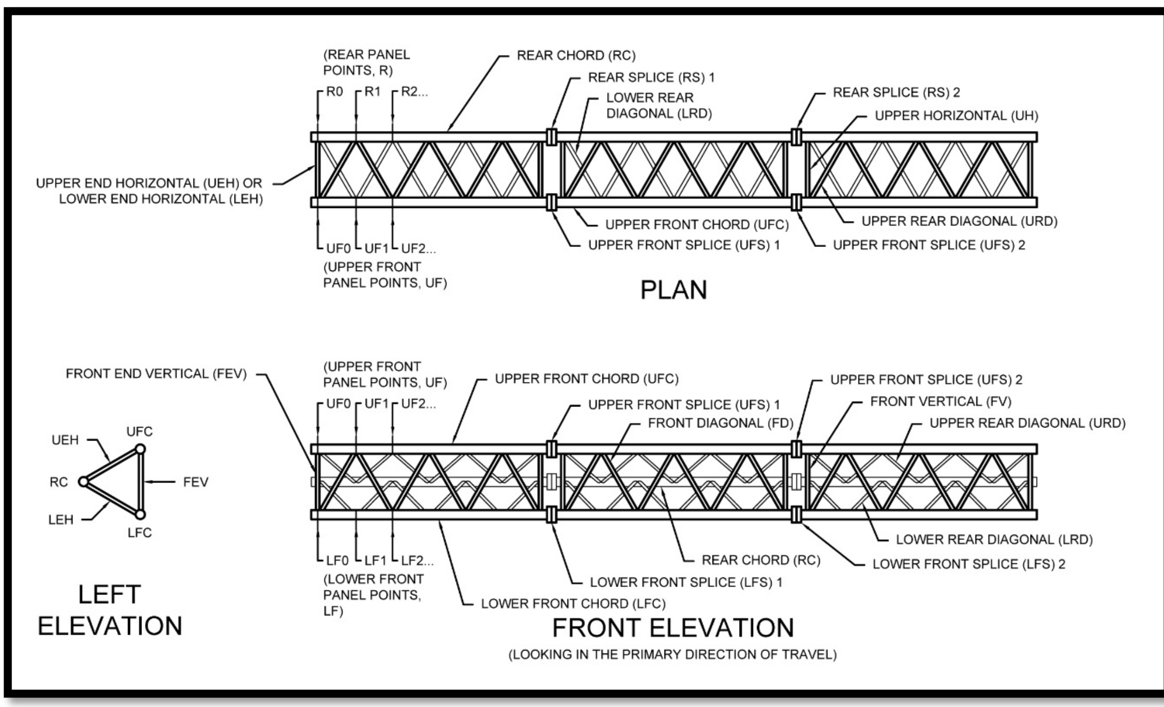


FIGURE 4-03: DIAGRAM 3-CHORD TRUSS DIAGRAM

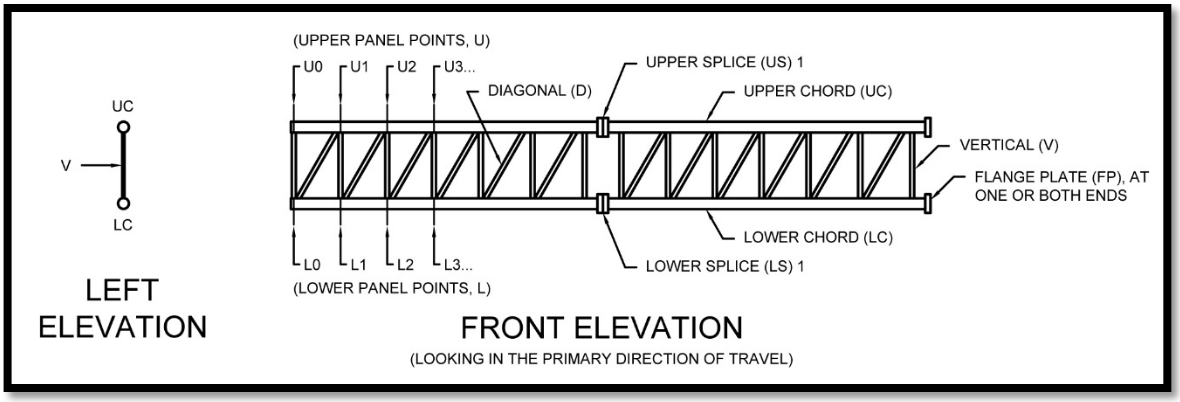
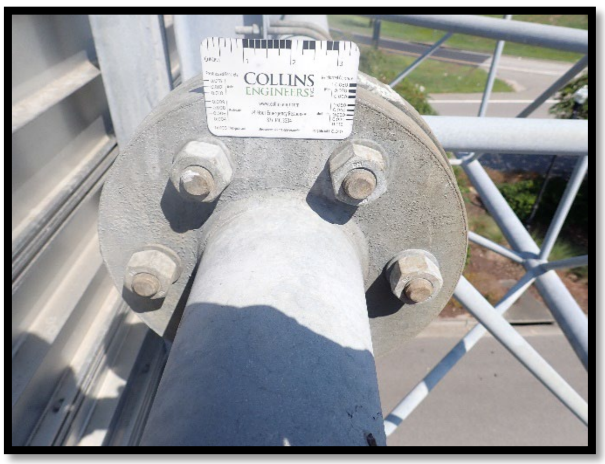


FIGURE 4-04: DIAGRAM 2-CHORD TRUSS DIAGRAM

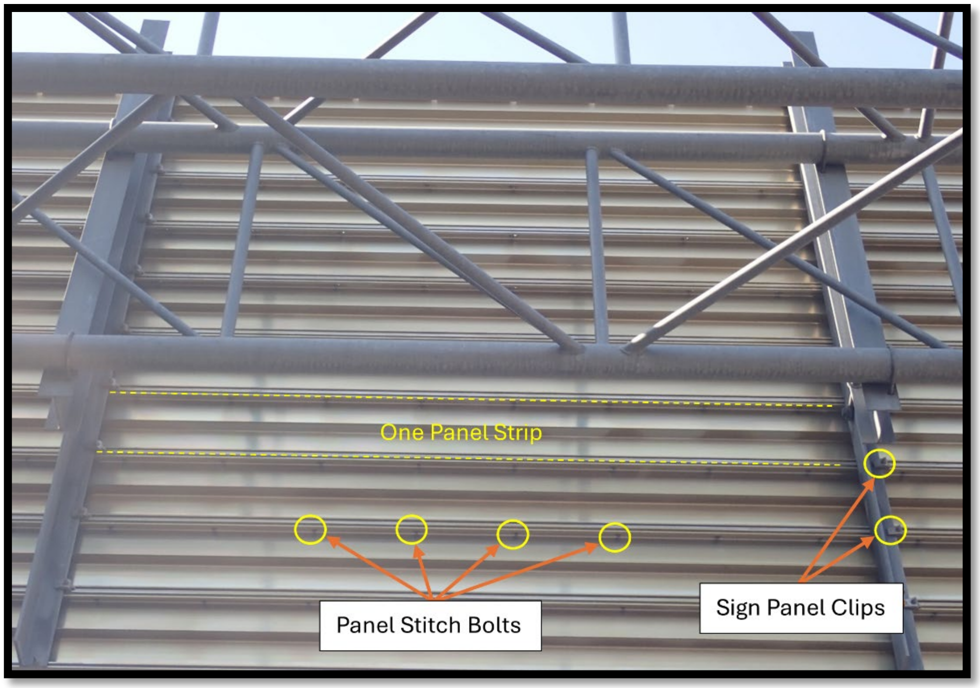
S.07 Splice – This element shall include the flange plates, bolts, welds, and stiffener plates for the chord splices. Refer to Photographs 4-10 and 4-11 for components of this element.



PHOTOGRAPH 4-10: TYPICAL ROUND SPLICE

PHOTOGRAPH 4-11: TYPICAL BOX CHORD SPLICE

S.08 Sign Panels – This element shall include the sign panel members and the sign panel hangers, and all associated hardware. The elements include flat panels, extruded panel strips, stitch bolts, panel hangers, panel bolts and clips. The bolts connecting the panel hangers to the span hangers are part of Element S.08 Sign Panels. Refer to Photograph 4-12 for components of this element. The inspector shall gather horizontal and vertical measurements in decimal feet, for each sign panel. The number designation for the sign panels are included on Figures 4-05 thru 4-07.



PHOTOGRAPH 4-12: SIGN PANEL NOMENCLATURE

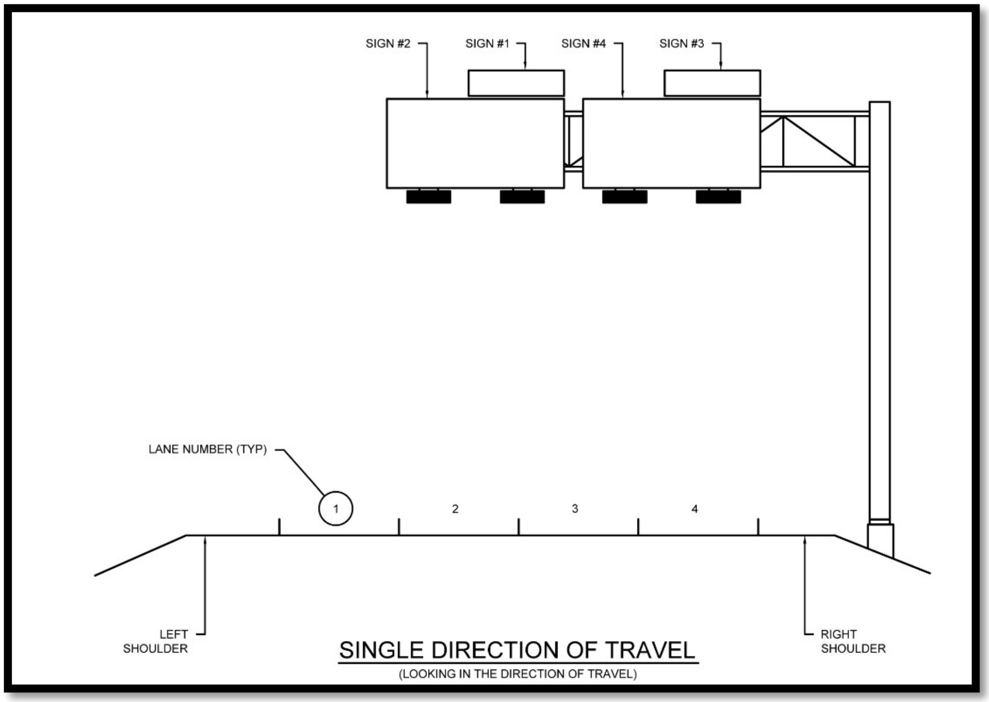


FIGURE 4-05: SIGN PANEL NUMBERING DIAGRAM (CANTILEVER)

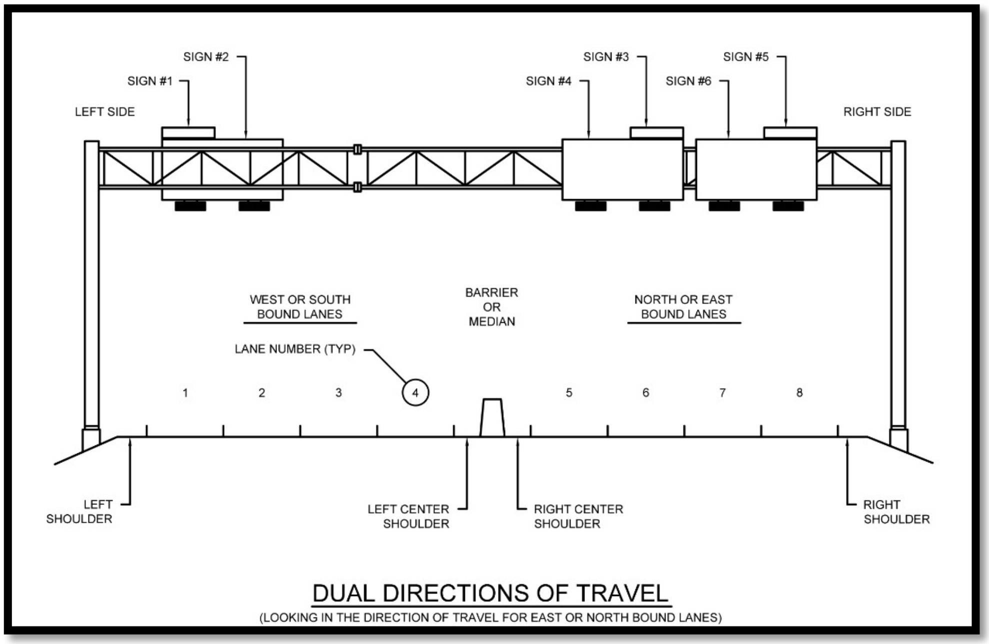


FIGURE 4-06: SIGN PANEL NUMBERING DIAGRAM (FULLSPAN)

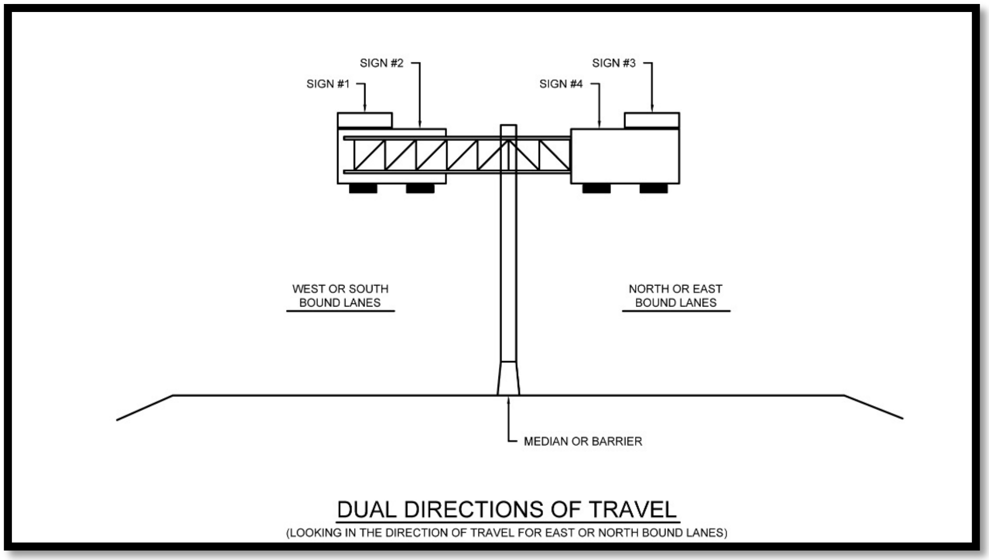
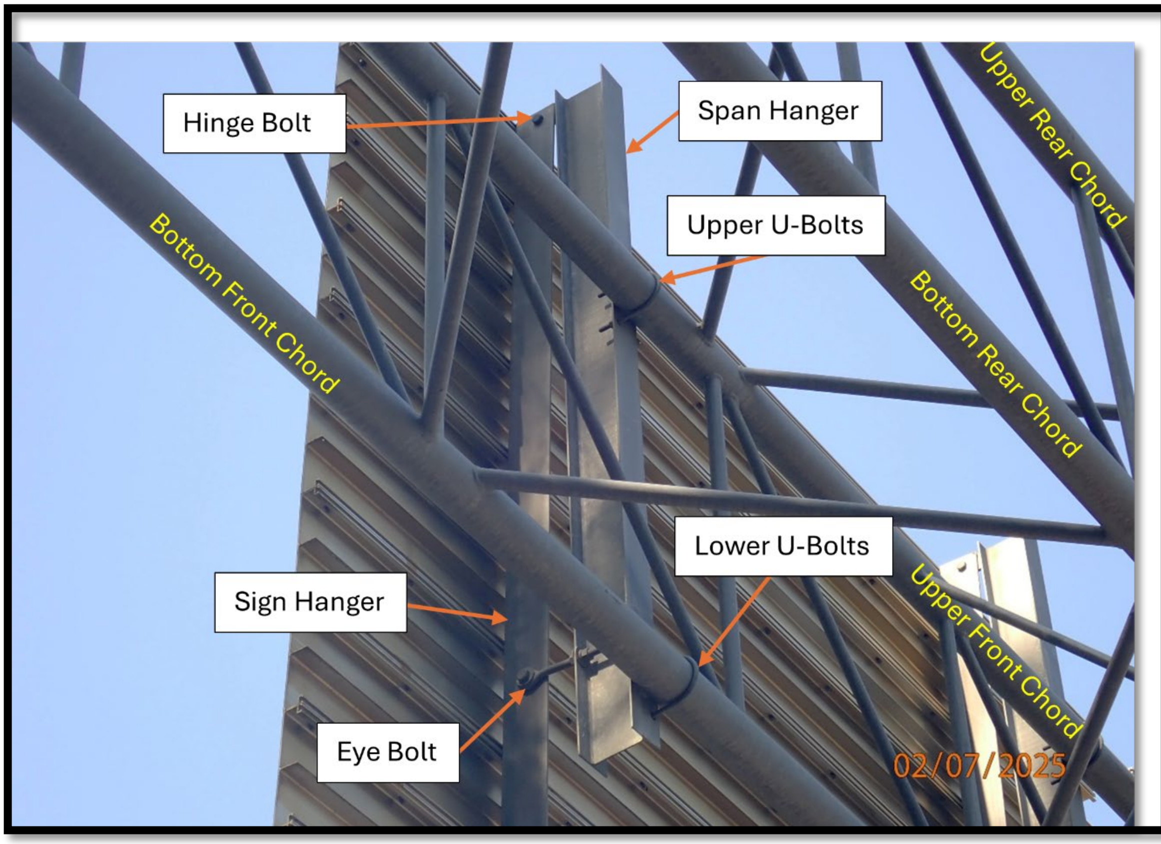


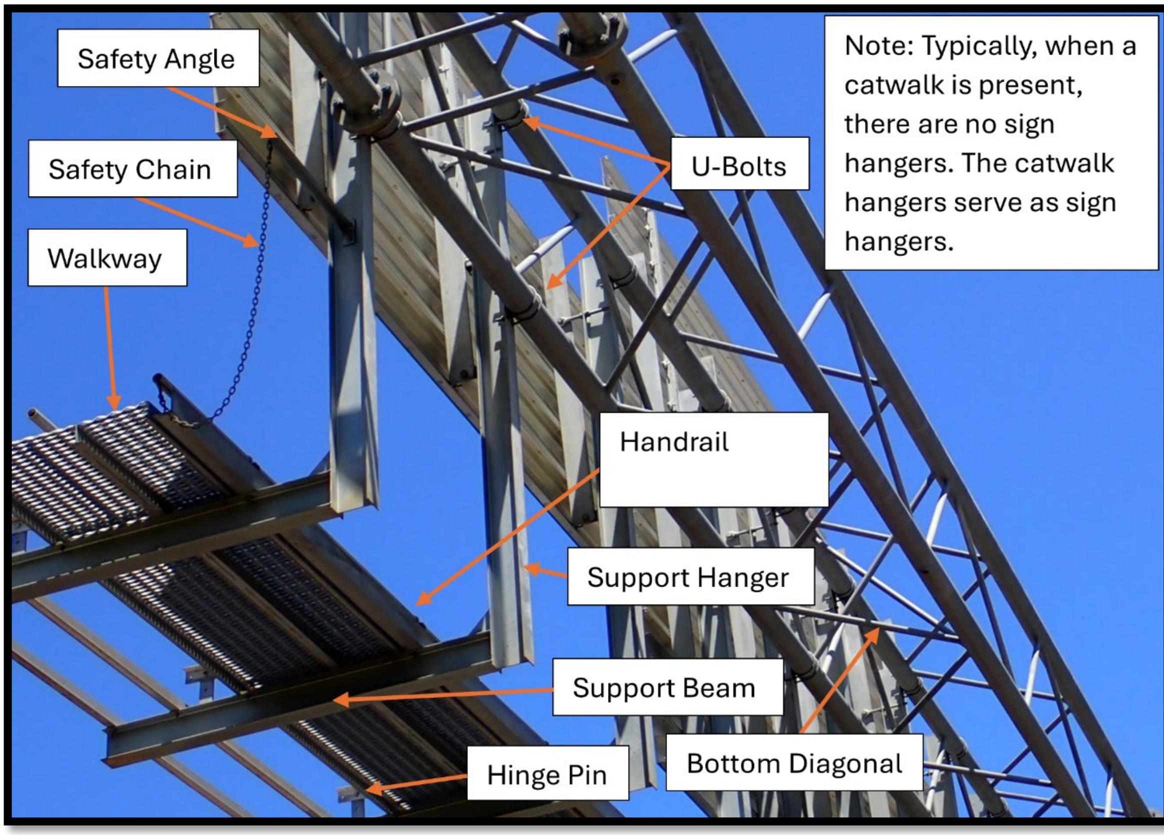
FIGURE 4-07: SIGN PANEL NUMBERING DIAGRAM (BUTTERFLY)

S.09 Connections – Sign Panels – This element shall include the members that form the connections of the sign to the panel hangers and to the span. The elements include span hangers (if no catwalk is present), threaded rods, eyebolts, connection bolts and u-bolts. Refer to Photograph 4-13 for components of this element.



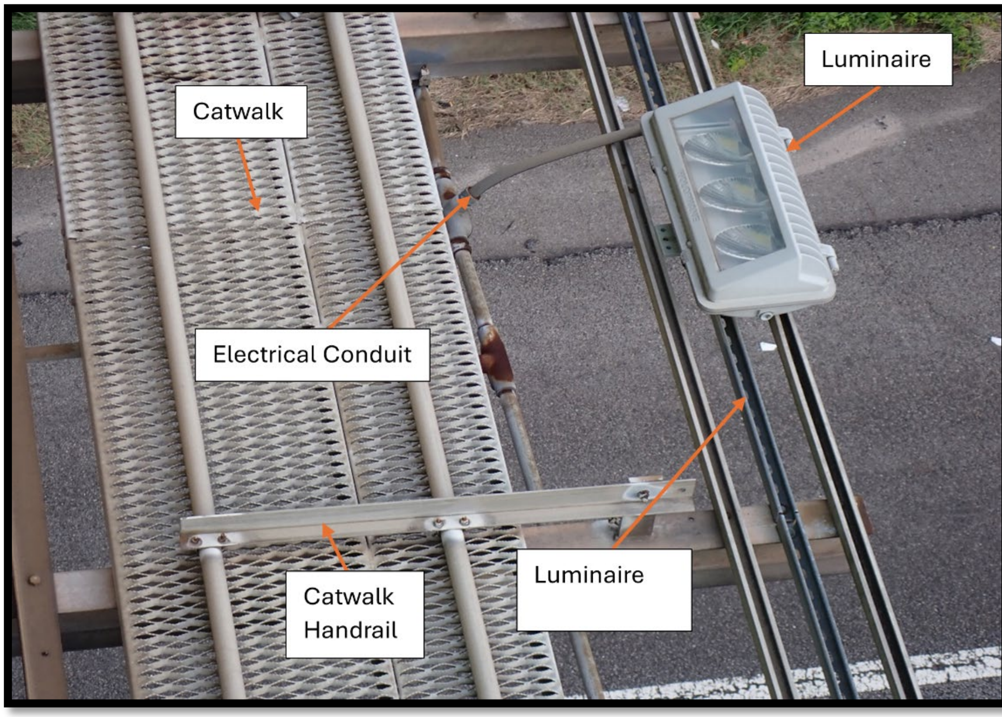
PHOTOGRAPH 4-13: SIGN CONNECTION NOMENCLATURE

S.10 Catwalk – This element shall include all components of the catwalk system, including the walkway grating, handrail, support beam, support hanger, luminaire support unistrut beams and all associated bolts and small hardware. Refer to Photograph 4-14 for components of this element.



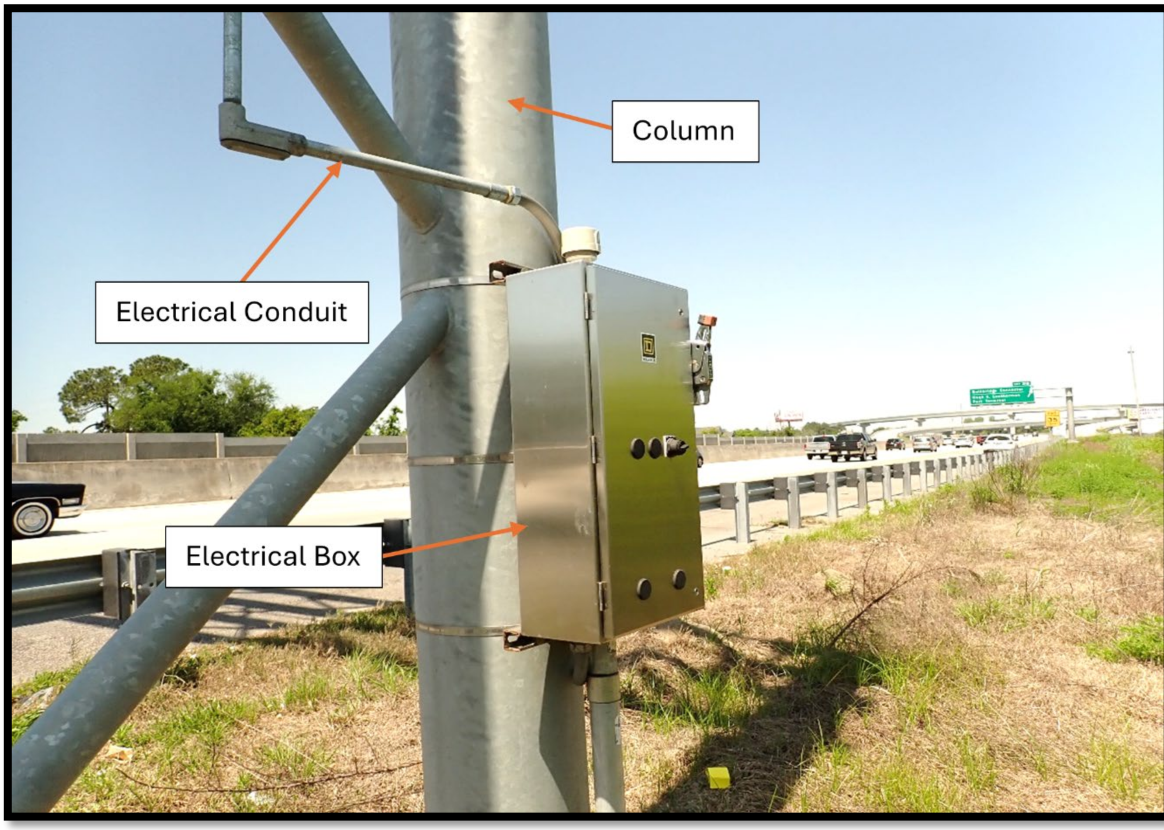
PHOTOGRAPH 4-14: CATWALK NOMENCLATURE

S.11 Luminaire – This element shall include the luminaire (housing, bulb, lens) and shall be used to rate structural deficiencies. Use Element S.12 Electrical to note operational deficiencies. Refer to Photograph 4-15 for components of this element.



PHOTOGRAPH 4-15: LUMINAIRE NOMENCLATURE

S.12 Electrical – This element shall be used for all exposed components of the electrical system up to the luminaires or VMS sign panels. The components shall include the conduit, flex conduit, wiring and connection straps or clips. This is generally used for rating corrosion, open connections, open junction boxes and exposed wiring. Notes can be made for luminaires not on during night, or on during day. Refer to Photograph 4-16 for components of this element.



PHOTOGRAPH 4-16: ELECTRIC ELEMENTS

S.13 Miscellaneous Attachment(s) – This element shall includes any miscellaenous components that are attached to the structure and connection hardware. Refer to Photographs 4-17 thru 4-20 for examples of this element.

PHOTOGRAPH 4-17: SIGN ATTACHMENT TO THE COLUMN

PHOTOGRAPH 4-18: ELECTRIC BOX ATTACHED TO COLUMN

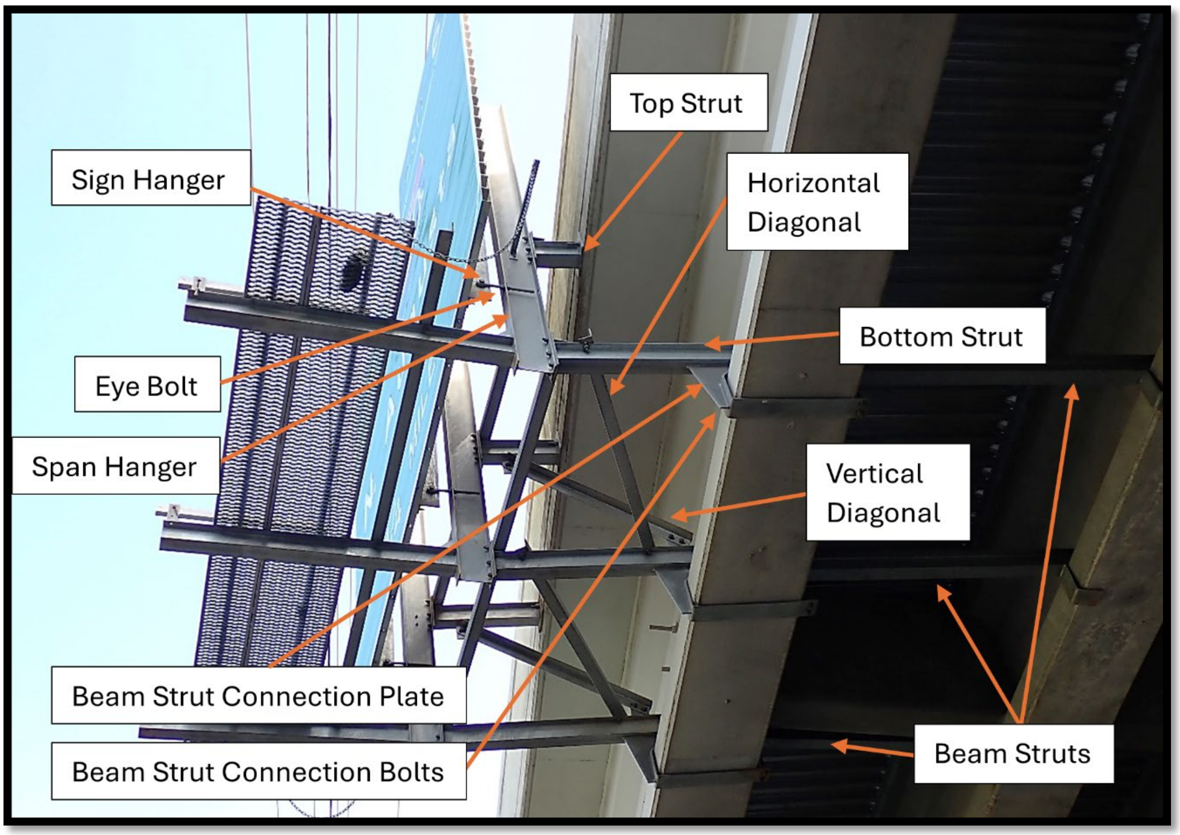
PHOTOGRAPH 4-19: CAMERAS ATTACHED TO TRUSS

PHOTOGRAPH 4-20: SUPPLEMENTAL SIGN ATTACHED TO SIGN PANEL

S.14 Crash Protection – This element shall include the presence of protection between the roadway and the structure. This includes guardrails, concrete barriers, and concrete curbs.

4.3 BRIDGE MOUNT SIGN STRUCTURES

The support elements for bridge mount structures are quite different than those of a typical overhead sign structure. The following must be used to match bridge mount structure elements to those of the typical overhead sign structure. There will be no rating for Elements S.01 through S.04. Element S.05 Upright-to-Span Connection shall be used to rate the components connecting the structural frame to the bridge beams or deck. Element S.06 Truss Chord(s) shall be used to rate the strut members of the supporting frame. Element S.07 Splice shall apply if present (strut splice). Elements S.08 though S.13 shall be as previously defined above. Refer to Photograph 4-21 for components of this type of structure.



PHOTOGRAPH 4-21: BRIDGE MOUNTED STRUCTURE NOMENCLATURE

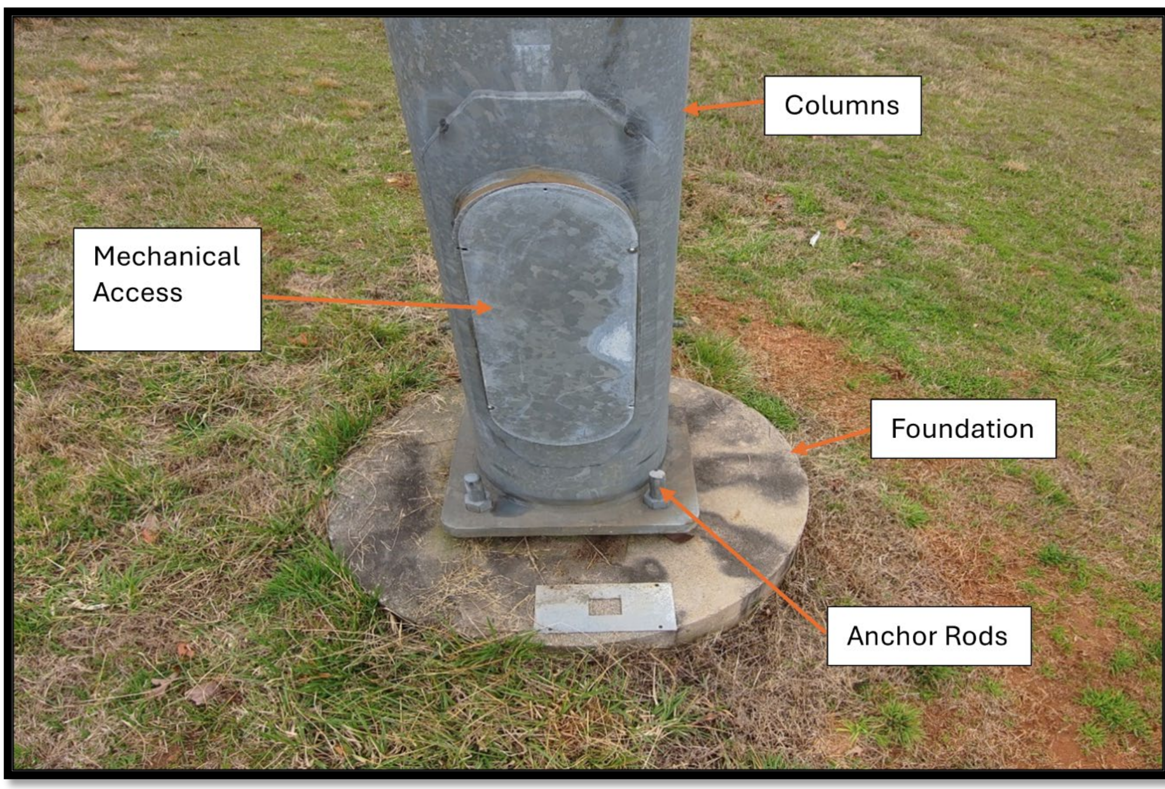
4.4 HIGH MAST LIGHT POLE STRUCTURES ELEMENTS AND COMPONENTS

H.01 Foundation – This element shall include the concrete foundation and grout pad. In addition to these components, any erosion of the surrounding grade shall be evaluated. Refer to Photograph 4-22 for components of this element.

H.02 Anchor Rod – This element shall include the anchor rods and all associated washers and nuts. The nuts and washers located on the underside of the base plate shall be labeled as leveling nuts and washers. The washers and nuts located on the top side of the base plate shall be labeled anchor nuts and washers. If a second nut is placed on top of the anchor nut, it shall be labeled jam nut. Refer to Photograph 4-22 for components of this element.

H.03 Base Plate – This element shall include the base plate and stiffener plates (if present).

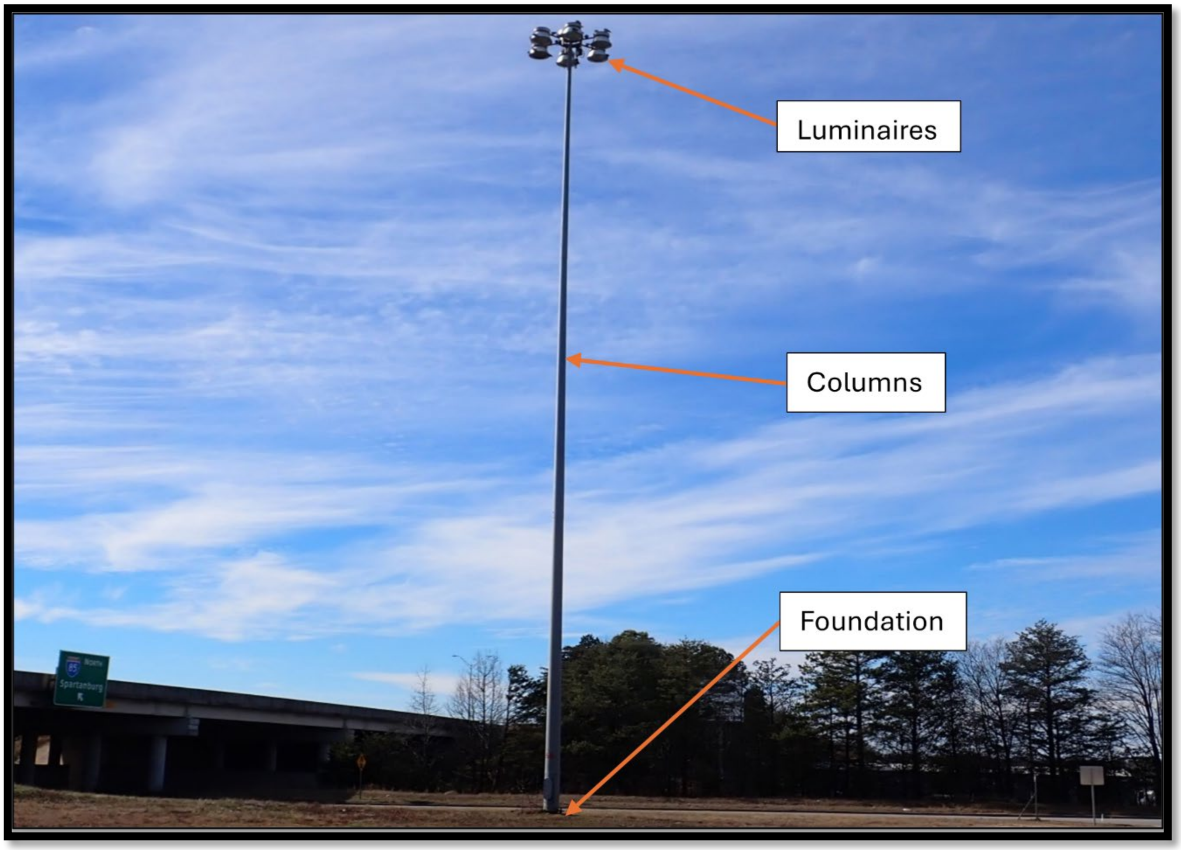
H.04 Column(s)/Support Frame(s) – This element shall include the column and associated stiffener plates and welds at the base plate connection.



PHOTOGRAPH 4-22: HIGH MAST LIGHT POLE BASE

H.07 Splice – This element includes the slip joints on the column.

H.11 Luminaire – This element shall include the luminaire (housing, bulb, lens) and shall be used to rate structural deficiencies.



PHOTOGRAPH 4-23: HIGH MAST LIGHT POLE NOMENCLATURE

H.12 Electrical – This element shall be used for all exposed components of the electrical system up to the luminaires or VMS sign panels. The components shall include the conduit, flex conduit, wiring and connection straps or clips. This is generally used for rating corrosion, open connections, open junction boxes and exposed wiring. Notes can be made for luminaires not on during night, or on during day.

H.13 Miscellaneous Attachment(s) – This element shall includes any miscellaenous components that are attached to the structure and connection hardware.

H.14 Crash Protection – This element shall include the presence of protection between the roadway and the structure. This includes guardrails, concrete barriers, and concrete curbs.

RECORDING

All inventory and inspection records are documented in SCDOT's Atom Database. The Atom Database can be access online with a user specific username and password. Contact the SCDOT Program Manager for access into the Atom Database.

This chapter will cover the ratings for structural elements, repair recommendations, and repair priorities.

5.1 RATINGS

In order to provide consistency among inspectors and ratings, the following was developed. These are not hard rules, but shall serve as a guide. The inspector shall use his or her expertise in evaluating and rating observed defects. The type of affected component or location of the defect may have a significant impact on the severity of the defect.

GENERAL DEFINITIONS

- 0 – Not Applicable
- 1 – Element performs intended function with a high degree of reliability (Good)
- 2 – Element performs intended function with a small reduction in reliability (Fair)
- 3 – Element performs intended function with a significant reduction in reliability (Poor)
- 4 – Element does not perform intended function with any degree of reliability (Critical)

The following are more detailed rules to be applied per element or type of material:

1 – Element Performs Intended Function With High Degree In Reliability (Good)

- No noticeable deficiencies
- Corrosion – Light (no pitting) or none
- Metal Cracks – Very minor or none
- Concrete Cracks – Hairline (temperature or shrinkage) or none
- Concrete Spalls – Insignificant spalls (typically mechanical corner or edge chips, rather than internal corrosion-caused spall)
- Bolts – Connections are tight, or a few loose minor connections

2 – Element Performs Intended Function With Small Reduction In Reliability (Fair)

- Corrosion – Minor (Light to Moderate) corrosion – can have some pitting, but no section loss of metal
- Metal Cracks – Cracks in secondary members
- Concrete Cracks – Minor cracks (approximately 3/16 in. or less, with no corrosion bleed out)
- Concrete Spalls – Minor spalls. (May have one exposed reinforcement, but the exposed length is less than 2 in. and the location is not impacting strength or serviceability)
- Bolts – Less than 20 percent of connections have loose or missing nuts and bolts

3 – Element Performs Intended Function With Significant Reduction In Reliability (Poor)

- Corrosion – Moderate to heavy corrosion – loss of section could be up to 30 percent
- Metal Cracks – Cracks in 20 percent of secondary members, or <20 percent if concentrated in same area. Cracks in primary members or connections to primary members
- Concrete Cracks – Large cracks (approximately equal to greater than ¼ in.) that reduces strength or serviceability
- Concrete Spalls – Large or deep spalls with exposed, corroded reinforcing
- Bolts – Between 20 percent and 50 percent of connections have loose, missing or heavily corroded nuts and bolts.

4 – Element Does Not Perform Intended Function With Any Degree Of Reliability (Critical)

- Corrosion – Major loss of section in metal (more than 30 percent)
- Metal Cracks – Cracking in critical stress areas. Minor cracks in fracture critical members.
- Concrete Cracks – Flexural or shear cracks
- Bolts – More than 50 percent of connections have loose, missing or heavily corroded nuts and bolts.

5.2 REPAIR RECOMMENDATIONS

General Repair Recommendation:

- Corrosion – corrosion on bolts, nuts, and other small parts is generally best repaired by replacing the part rather than cleaning and recoating it. A corroded bolt can rarely be thoroughly cleaned of corrosion such that corrosion does not reoccur within several years.

Areas of corrosion on primary and secondary members and plates can be adequately cleaned and coated with a liquid-applied cold galvanizing compound.

Low Priority:

- Fill Erosion
  - Place suitable fill-in erosion areas around the structure and grade to allow drainage away from the structure.
- Remove, Fill, and Regrade
  - The grade around the structure is higher than the foundation. Remove soil around the structure so that the foundation is exposed, and the remaining soil is graded to prevent water from pooling around or on the structure.
- Remove Grout Pad
  - Not damaging the structure, chip out the grout pad between the base plate and foundation.
- Replace Sign Panel Connectors
  - Reinstall or tighten the sign panel clips connecting the extruded sign panels to the vertical hanger beams.
- Replace Conduit Plug(s)
  - Reinstall the conduit plug(s).
- Secure Conduit
  - Fasten loose conduit to the structure.
- Secure or Replace End Cap(s)
  - Tighten or replace end caps on the horizontal truss chords.
- Secure or Replace Handhole Cover(s)
  - Tighten or replace the handhole cover(s) on the support column(s).
- Secure or Replace Post Cap(s)
  - Tighten bolts on or replace the post cap(s).

Medium Priority:

- Repair Foundation
  - Concrete Cracks – Generally, concrete cracks in sign structure foundations rarely get significant enough to warrant repair. Typically, an area may have signs of concrete deterioration rather than a significant crack. Epoxy crack repair can be used, or deleterious concrete can be removed and replaced with a concrete patch for significant deterioration.
  - Concrete Spalls – Concrete spalls are rare in overhead sign structure foundations. Spalls can be repaired with a concrete patch.
- Tension Anchor Rod(s)
  - Use turn of nut method or torque wrenches to tighten anchor rods.

  - All the anchor rod nuts should be tightened per the recommended procedure in the Guidelines.
  - Lock washers should be removed to allow for anchor rod connections.
- Install Beveled Washer(s)
  - Place beveled washers on anchor rod(s) or other connection bolt(s) as required and tighten.
- Tension Splice Bolt(s)
  - Tighten the bolt(s) on the chord splice(s).
  - Verify that washers are present before repair.
- Replace Sign Panel Connectors
  - Reinstall or tighten the sign panel clips connecting the extruded sign panels to the vertical hanger beams.
- Tension or Replace End Support to Truss Connection Bolt(s)
  - Tighten or replace the bolts connecting the end support to the truss.
- Install or Replace U-Bolt(s)
  - Install or relace U-Bolt(s).
- Repair Crack(s)
  - Cracks in metal components can be repaired through arresting techniques, repairing welds, installing splices or wraps, or replacing the cracked member or component.
- Perform Anchor Rod Analysis – Exceeds Standoff Distance
  - An engineer will analyze the structure's strength based on observed conditions.

High Priority:

- Tension or Replace End Support to Truss Connection bolt(s)
  - Tighten or replace the bolts connecting the end support to the truss.
- Replace Splice Bolt(s)
  - Install new bolt(s) at the truss chord splice(s).
- Install Vertical Sign Support
  - Install a new hanger beam to support the indicated sign panel.
- Replace the Sign Panel Connector
  - Reinstall or tighten the sign panel clips connecting the extruded sign panels to the vertical hanger beams.
- Repair Crack(s)
  - Cracks in metal components can be repaired through arresting techniques, repairing welds, installing splices or wraps, or replacing the cracked member or component.
- Monitor structure on 12-month Inspection Frequency.
  - Return to structure on a 12-month frequency due to observed deficiencies to monitor the structure's status.

- Remove or Replace Structure
  - The structure is too damaged to remain in service. Remove the structure and replace it if needed.
- Replace or Strengthen Member
  - Damage to the truss or upright member is too significant for simple repair and should be replaced or additional materials added to strengthen the member.
- Perform Structural Analysis Due to Damage or Deterioration

Have an engineer perform a structural analysis to determine if the structure is serviceable.

APPENDIX A:
STAND-OFF GUIDELINES

STANDOFF GUIDELINES				
Cantilever or Butterfly				
DIA	Min (in.)	Max (in.)	Rating	Repair
1"	0"	1.25"	1	NO REPAIR
1"	1.375"	1.5"	2	Analysis
1"	1.625"	2.5"	3	Analysis
1"	2.625"		4	Analysis
1.25"	0"	1.5"	1	NO REPAIR
1.25"	1.625"	1.875"	2	Analysis
1.25"	2"	3.125"	3	Analysis
1.25"	3.25"		4	Analysis
1.5"	0"	1.875"	1	NO REPAIR
1.5"	2"	2.25"	2	Analysis
1.5"	2.375"	3.75"	3	Analysis
1.5"	3.875"		4	Analysis
1.75"	0"	2.187"	1	NO REPAIR
1.75"	2.25"	2.625"	2	Analysis
1.75"	2.75"	4.375"	3	Analysis
1.75"	4.5"		4	Analysis
2"	0"	2.25"	1	NO REPAIR
2"	2.375"	2.5"	2	Analysis
2"	2.625"	3.5"	3	Analysis
2"	3.625"		4	Analysis
2.25"	0"	2.812"	1	NO REPAIR
2.25"	3"	3.375"	2	Analysis
2.25"	3.5"	5.625"	3	Analysis
2.25"	5.75"		4	Analysis
2.5"	0"	3.125"	1	NO REPAIR
2.5"	3.25"	3.75"	2	Analysis
2.5"	3.875	6.25"	3	Analysis
2.5"	6.375"		4	Analysis

STANDOFF GUIDELINES				
Fullspan				
DIA	Min (in.)	Max (in.)	Rating	Repair
1"	0"	1.5"	1	NO REPAIR
1"	1.625"	2.5"	2	Analysis
1"	2.625"	3.5"	3	Analysis
1"	3.625"		4	Analysis
1.25"	0"	1.875"	1	NO REPAIR
1.25"	2"	3.125"	2	Analysis
1.25"	3.25"	4.375"	3	Analysis
1.25"	4.5"		4	Analysis
1.5"	0"	2.25"	1	NO REPAIR
1.5"	2.375"	3.75"	2	Analysis
1.5"	3.875"	5.25"	3	Analysis
1.5"	5.375"		4	Analysis
1.75"	0"	2.625"	1	NO REPAIR
1.75"	2.75"	4.375"	2	Analysis
1.75"	4.5"	6.125"	3	Analysis
1.75"	6.25"		4	Analysis
2"	0"	3"	1	NO REPAIR
2"	3.125"	5"	2	Analysis
2"	5.125"	7"	3	Analysis
2"	7.125"		4	Analysis
2.25"	0"	3.375"	1	NO REPAIR
2.25"	3.5"	5.625"	2	Analysis
2.25"	5.75"	7.875"	3	Analysis
2.25"	8"		4	Analysis
2.5"	0"	3.75"	1	NO REPAIR
2.5"	3.875	6.25"	2	Analysis
2.5"	6.375"	8.75"	3	Analysis
2.5"	9"		4	Analysis

APPENDIX B:
LOOSE ANCHOR ROD NUTS GUIDELINES

Cantilever, Butterfly, or High Mast Light		
# Loose	Total #	Rating
1	4	Poor
2 to 4	4	Critical
1	6	Fair
2	6	Poor
3 to 6	6	Critical
1	8	Fair
2, 3	8	Poor
4 to 8	8	Critical
1, 2	10	Fair
3, 4	10	Poor
5 to 10	10	Critical
1, 2	12	Fair
3, 4, 5	12	Poor
6 to 12	12	Critical

Fullspan - One Column (One Side)		
# Loose	Total #	Rating
1	4	Poor
2 to 4	4	Critical
1, 2	6	Fair
3	6	Poor
4 to 6	6	Critical
1, 2	8	Fair
3, 4	8	Poor
5 to 8	8	Critical
1 to 3	10	Fair
4, 5	10	Poor
6 to 10	10	Critical
1 to 3	12	Fair
4 to 6	12	Poor
7 to 12	12	Critical

Fullspan - Two Frame (One Side)		
# Loose	Total #	Rating
1 to 3	8	Fair
4 to 5	8	Poor
6 to 8	8	Critical
1 to 4	12	Fair
5 to 7	12	Poor
8 to 12	12	Critical
1 to 5	16	Fair
6 to 9	16	Poor
10 to 16	16	Critical

Fullspan - Two Frame (Single Base Plate)		
# Loose	Total #	Rating
4	4	Critical
5	6	Critical
7,8	8	Critical