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4.2 OVERHEAD SIGN/SIGNAL STRUCTURES

4.2.1 Introduction

Sign structures, per Chapter 39.5 of the WisDOT Bridge Manual, are composed of “sign bridges” and “overhead sign supports”. Sign bridges are typically designed by the Bureau of Structures or a consultant prior to bid letting. The typical use for these structures is to support large signs, or Dynamic Message Signs (DMS).

Overhead sign supports are smaller structures that are typically designed by the contractor, or their representative. These structures include mast arms, trombone arms, full span monotubes, etc. These structures typically carry signs indicating detour routes, upcoming lane changes, highway directional information and a variety of additional information for the traveling public.

Signal Mast Arms, also referred to as signal monotubes, are quite similar to the mast arms that carry signs in the above paragraph. The primary difference is they carry signal heads and have electrical conduit to power the signals. They are extremely common in urban settings and are responsible for the efficient conveyance of traffic information on a lane by lane basis.

These structures are comprised of either steel or aluminum. Currently, all new structures are fabricated of steel. Aluminum structures are being phased out in Wisconsin. The steel is typically galvanized, although it may be painted. Standard overhead sign structure members are either round structural tubes/pipes, or angles and are connected to the structures via welded and bolted gusset plates. Wide-flange shapes and angles are used in sign connections and other places where a flat surface is required. The new, galvanized steel structures being fabricated are typically comprised of angle members in lieu of tubular members. Overhead sign supports are typically comprised of galvanized structural tubes.

The sheer number of structures that need to be inspected and their typical location in high density traffic settings place importance on having well-planned and well-managed inspection procedures to eliminate errors and inconsistencies. Proper traffic control and access equipment is paramount for the inspection crew’s and traffic’s safety during inspection. Some of the factors that will affect the sequence of the inspection are the type and size of the structure, the time of day (rush hour), traffic density at a particular location, the availability of special equipment, and requirements for traffic control.

The following sections cover the various types of overhead structures mentioned above, proper inspection methods, documentation requirements, and the basic elements and assessments associated with these structures.

4.2.1.1 Overhead Sign Bridges

There are several types of overhead sign bridges used in the State of Wisconsin: the simple-span (or full-span) sign bridge (including four-chord, tri-chord, two chord and monotube configurations), the cantilever sign bridge, the single pole or “Butterfly” sign bridge, and the structure-mounted sign bridge.

Four-Chord Overhead Sign Bridge

The standard four-chord simple-span sign bridge consists of an all-welded or combination welded-bolted three-dimensional space frame of four chords. Diagonal members run along all four faces of the space frame with intermediate diagonals running between the front and back faces of the frame, alternatively. A camber is typically built into the space frame. The space frame is simply supported at each end by a single post, a two-column support frame, or a reinforced concrete column. Refer to Figure 4.2.1-1 for an overall view of an aluminum sign structure. Refer to Figure 4.2.1-2 for a modified galvanized steel structure.

Figure 4.2.1-1: Typical Four-Chord Aluminum Sign Bridge Structure.

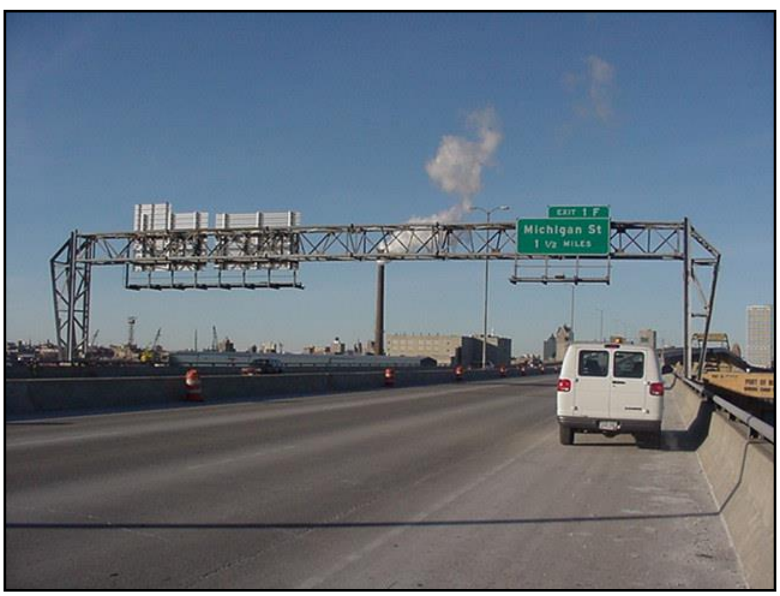

Figure 4.2.1-2: Modified Galvanized Steel Sign Bridge Structure.

Tri-Chord Overhead Sign Bridge

The Wisconsin Department of Transportation (WisDOT) does not have a standard design for the tri-chord simple-span sign bridge. In the past, design engineers have designed many of these structures on a job-specific basis.

The tri-chord simple-span sign bridge is similar in basic concept to the four-chord simple-span sign structure. The notable difference between the four-chord and the tri-chord designs is that instead of having a second parallel truss to form a space frame, the tri-chord design utilizes a single chord behind the front vertical truss, which is connected with diagonals to the top and bottom chords of the truss to form the space frame. In cross section, the tri-chord space frame looks like an equilateral triangle, with the top and bottom chords of the front vertical truss forming the two vertices in the vertical plane and the back chord forming the third vertex. Refer to Figure 4.2.1-3 for a typical tri-chord structure.

Figure 4.2.1-3: Typical Tri-Chord Sign Bridge.

Two-Chord Overhead Sign Support

The two-chord full-span sign support consists of a single vertical parallel-chord plane truss that is supported at each end by a single post. The details of the truss are similar to those of the four-chord design, except typically the truss section will be a Pratt Truss Pattern instead of a Warren Truss pattern. The diagonals on a Pratt Truss do not alternate directions, instead the diagonals angle down toward the center of the span. Refer to Figure 4.2.1-4 for a typical two-chord sign structure.

Two-chord full-span sign supports are generally inspected with a bucket lift in conjunction with a lane closure and traffic control. If the spans cannot be climbed safely; each lane under the structure will need to be closed off incrementally for the structure to be inspected. It is the inspector's decision as to whether the structure can be climbed safely.

Figure 4.2.1-4: Typical Two-Chord Sign Support Structure.

Full Span Monotube Overhead Sign Support

Monotube sign supports consist of a single horizontal chord supported by a single tapered steel post at each end. The monotube structures are typically made with tapered members instead of pipe members. The chord is comprised of two tapered members, with the large diameter ends connected at the middle of the span. If a long span is required, a pipe member is placed between the tapered members. Refer to Figure 4.2.1-5 for an overall view of a monotube structure.

Figure 4.2.1-5: Typical Monotube Sign Support Structure.

Cantilever Sign Bridge

The standard four-chord cantilever sign bridge structure consists of a three-dimensional space frame rigidly supported at one end by a single steel post, or a reinforced concrete column. The cantilever space frame is always fabricated as one unit. The member configuration of the space frame is similar to that of a four-chord sign structure. Refer to Figure 4.2.1-6 for a typical four-chord cantilever structure.

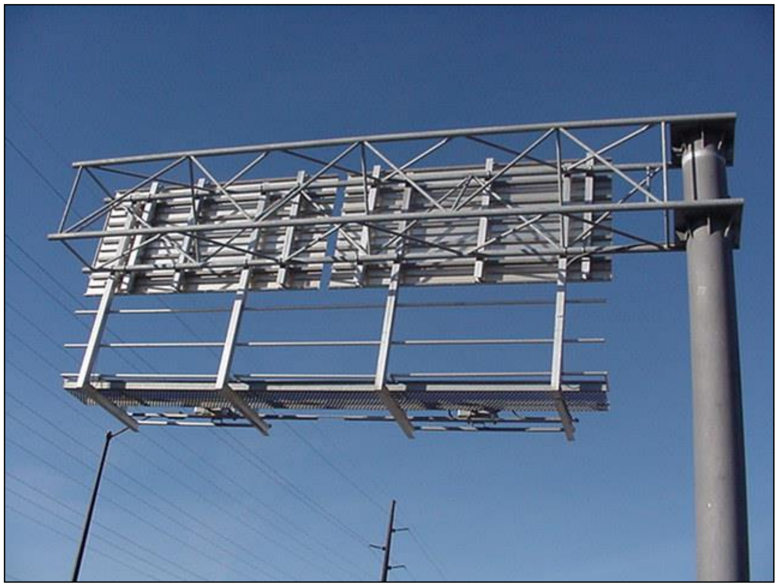

Figure 4.2.1-6: Typical Four-Chord Cantilever Sign Bridge.

Butterfly Sign Bridge

A Single Pole or "Butterfly" sign bridge structure consists of a single vertical steel pipe or reinforced concrete column for the support with horizontal members centered about the column supporting signing. These structures may have two dimensional or three dimensional horizontal members or frames supporting signage on both sides of the column. A Butterfly Sign Bridge with a concrete column will have a short steel pipe section which will be bolted to the top of the column for connection to the sign panels. Alternate configurations may be identified in the field, such as secondary truss members placed between the horizontal tubes, or four-chord box trusses cantilevered off each side of the vertical post. Refer to Figure 4.2.1-7 for a typical single pole butterfly sign bridge.

Figure 4.2.1-7: Typical Single-Pole Sign Structure with a Single Sign Panel.

Structure-Mounted Sign Bridge

This category consists of sign bridges that are mounted directly to the highway infrastructure. The most common style is the bridge-mounted sign structure; however, there are also examples of sign structures that are mounted to retaining walls. Refer to Figure 4.2.1-8 for a structure-mounted sign bridge.

Figure 4.2.1-8: Typical Structure-Mounted Sign Structure, Mounted to a Retaining Wall.

4.2.1.2 Overhead Sign/Signal Supports

Mast arm structures typically fall under the same layout of a vertical post connecting a horizontal arm out over a roadway. The height, length and size of the vertical and horizontal members is dependent on the size of the roadway and/or the number of signal heads and/or size of type II signs being supported overhead. The following section describes the typical layout the inspector may expect to find in the field.

Mast Arm Sign Supports

Mast arm sign supports are comprised of a single support post and a single cantilever arm. Both members are typically tapered at 0.14 inch-per-foot. Mast arm structures are made of steel, usually galvanized, and are typically used to carry small regulatory signs and street name signs. The post base plate is anchored to the foundation typically with four to eight anchor bolts embedded in a concrete foundation. The base plates rest on leveling nuts, creating a space between the base plate and the foundation. Some structures may be mounted to a trapezoidal breakaway transformer base, which is anchored to the foundation.

At the supported end of the mast arm, a vertical plate is shop welded to the end of the tube. A matching vertical plate is welded to the side of the support post. The plates are aligned and field bolted together. The mast arm is connected to the support post typically with four to eight bolts. The bolts secure the arm base plate to the post connection plate. The arm lengths range from 15 feet to over 50 feet, although they typically range from 25 to 45 feet. In some instances, an arm may have an extension at the end of it to get a longer length. These extensions are spliced with an overlap slip joint. Refer to Figure 4.2.1-9 for a typical mast arm sign support structure and Figure 4.2.1-10 for a typical mast arm to post connection.

Figure 4.2.1-9: Typical Mast Arm Sign Support.

Figure 4.2.1-10: Typical Mast Arm Support Post Connection.

Trombone Arm

Trombone arms are comprised of two members clamped to the single cantilever support post. The trombone arm members are typically farther apart at the support post to provide stability. Trombone arms are made of either aluminum of galvanized steel and are typically used to carry traffic signal heads, small regulatory signs, and street name signs. The post base plate is anchored to the foundation with four anchor bolts. The base plates are either attached to a breakaway transformer base or to the foundation directly.

The trombone arm is connected to the support post by a clamp at the top and bottom chord locations. The clamps are bolted to the support post. The clamps can be over-stressed if the bolts are over-tightened. The clamps should be inspected for over/under tightening and possible fatigue cracking. Refer to Figure 4.2.1-11 for a typical trombone arm.

Figure 4.2.1-11: Typical Trombone Arm Sign Support Structure.

Traffic Signal Mast Arms Supports

Traffic signal mast arm supports are comprised of a single support post and a single cantilever arm. Mast arm supports are made of steel, usually galvanized, and are primarily used to carry traffic signals, small regulatory signs and street name signs. WisDOT currently uses four variations of these structures:

- Type 9 (15' – 30' arm without street luminaires)
- Type 10 (15' – 30' with street luminaires)
- Type 12 (35' – 55' arm without street luminaires)
- Type 13 (35' – 55' arm with street luminaires).

The post base plate is anchored to the foundation with six anchor bolts embedded in a concrete foundation. The base plates rest on leveling nuts, creating a space between the base plate and the foundation.

The mast arm is connected to the support post with six bolts (Type 9 and 10) or eight bolts (Type 12 and 13). The bolts secure the arm base plate to the post connection plate. In some instances, an arm may have an extension at the end of it to get a longer length. These extensions are spliced with an overlap slip joint. Refer to Figure 4.2.1-12 and Figure 4.2.1-13 for a typical traffic signal mast arm support.

Figure 4.2.1-12: Typical Type 12 Traffic Signal Mast Arm Structure.

Figure 4.2.1-13: Typical Type 13 Traffic Signal Mast Arm Structure.

4.2.1.3 Nomenclature

The inspector shall know the proper nomenclature of the different components of each of the different types on structures. This will be necessary to properly address defects as they are found. Refer to Figure 4.2.1-14 through Figure 4.2.1-17 for the typical nomenclature for each of the main types of structures.

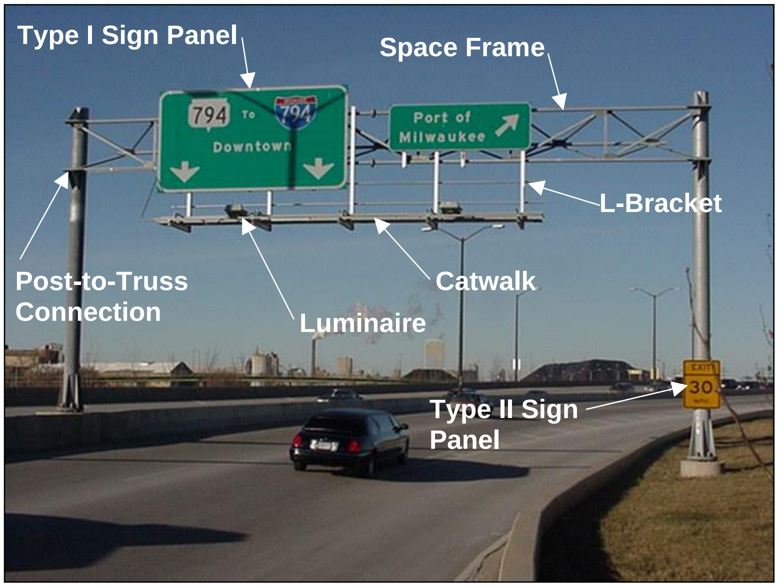

Figure 4.2.1-14: Full Span Sign Structure Nomenclature

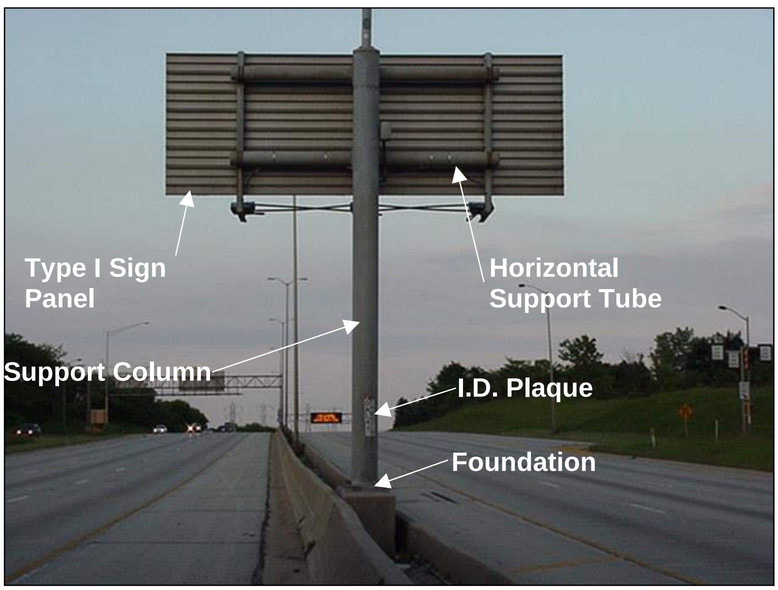

Figure 4.2.1-15: Single Pole (Butterfly) Sign Structure Nomenclature.

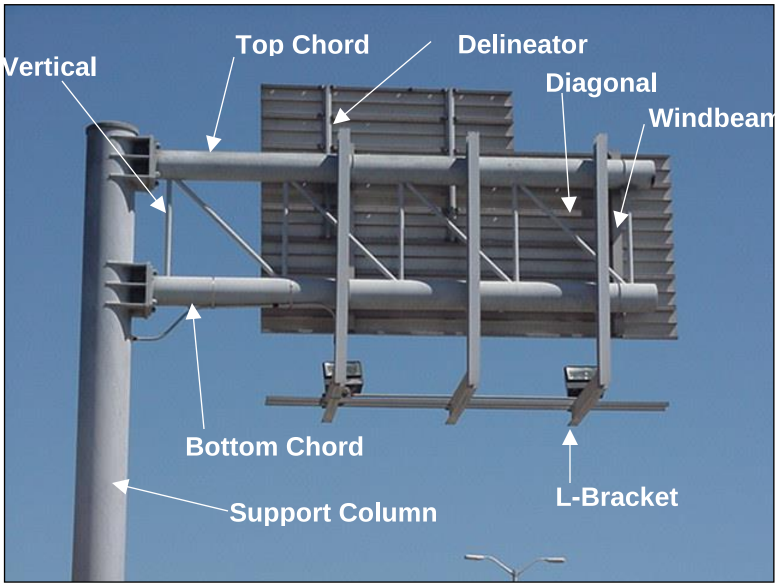

Figure 4.2.1-16: Cantilever Sign Structure Nomenclature.

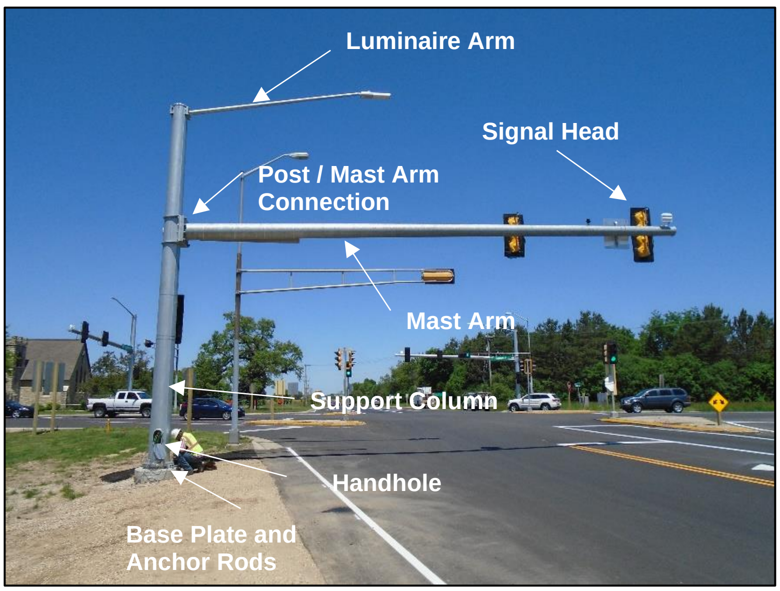

Figure 4.2.1-17: Signal Mast Arm Nomenclature

Sign Member Numbering System

Refer to Figure 4.2.1-18 through Figure 4.2.1-20 for the correct numbering system to be used when referencing the members in a frame. In this system, the side of the frame with the signs mounted on it will always be referred to as the front side. If the structure spans both directions of traffic, and signs are located on both sides, the signs for northbound or eastbound traffic are considered to be on the front. The four chords will be referenced as LF, lower front; UF, upper front; UB, upper back; and LB, lower back. The panel points will be numbered from left to right, (while looking at the front of the frame) starting at zero. To describe any member on the space frame, the reference points at its two ends are used. For example, the second vertical on the front of the frame would be called member UF1-LF1.

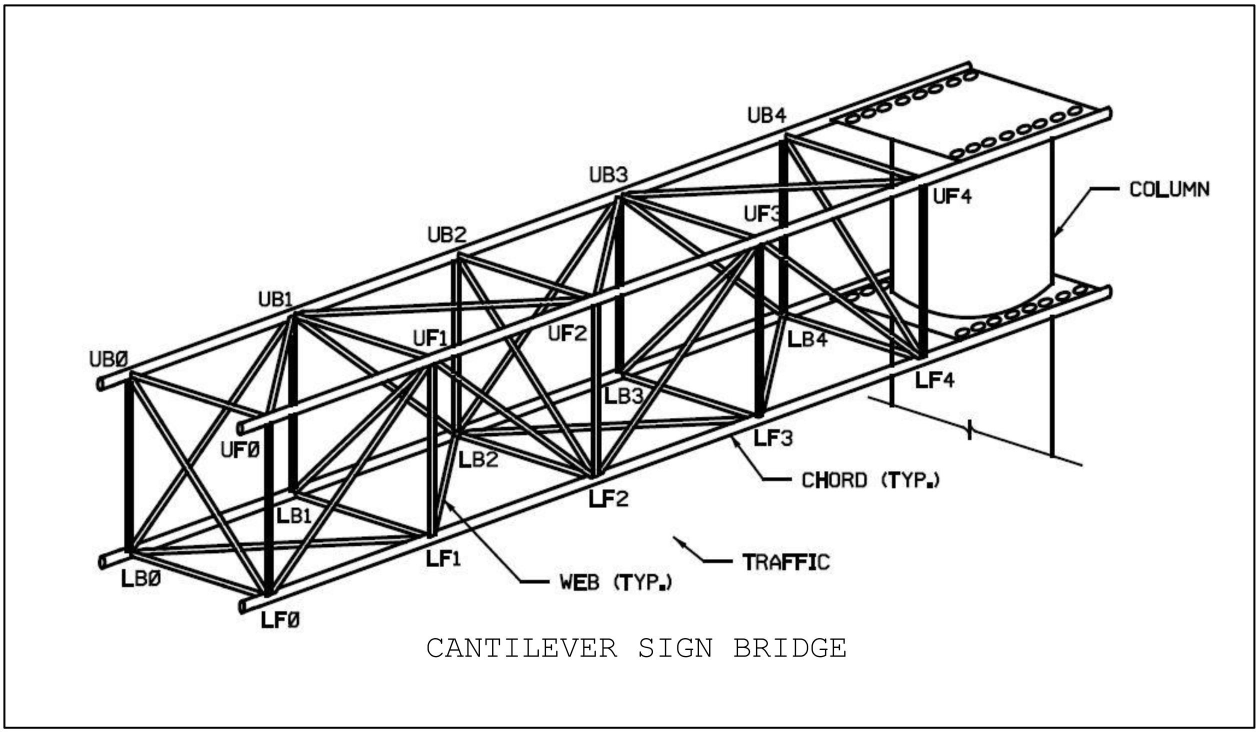

Figure 4.2.1-18: Typical Inspection Numbering System for Cantilever Sign Bridge.

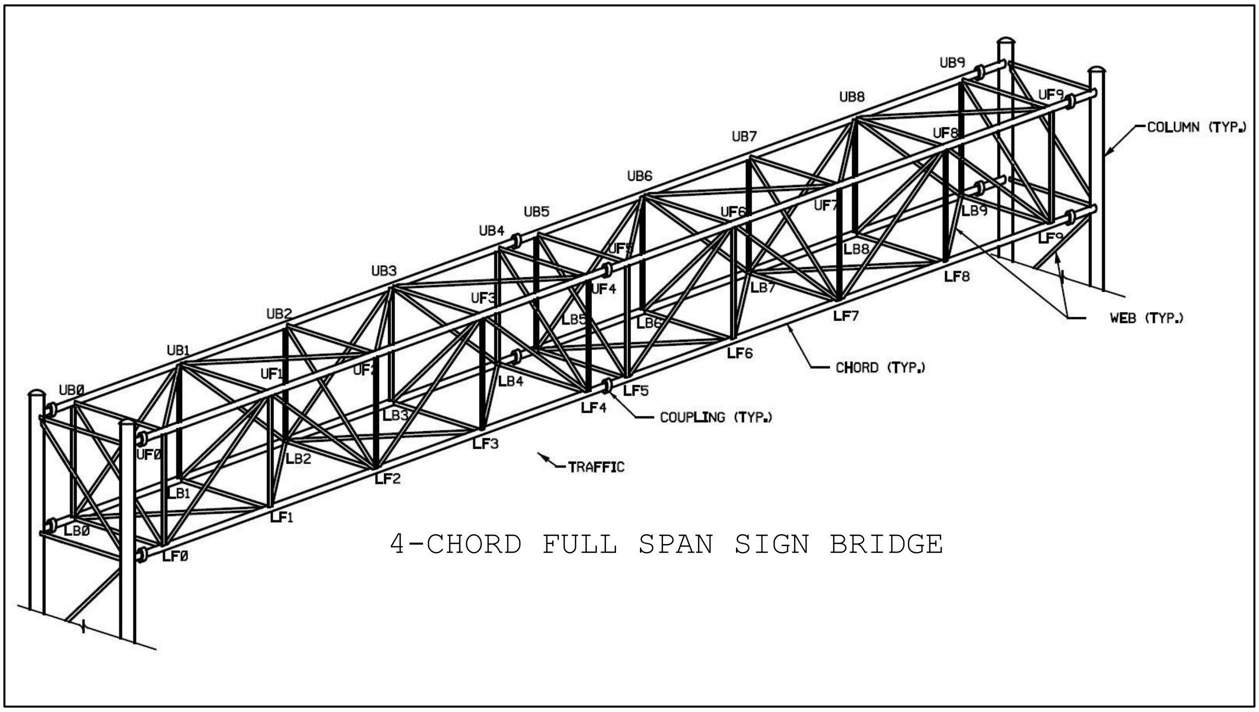

Figure 4.2.1-19: Typical Inspection Numbering System for 4-Chord Full Span Sign Bridge.

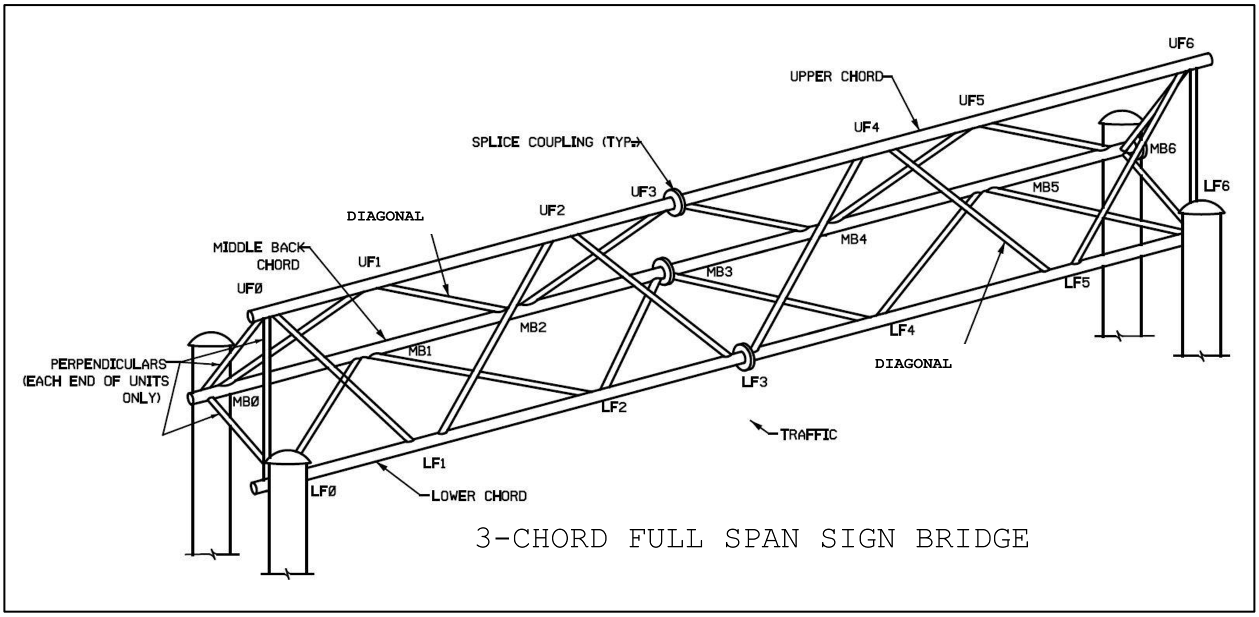

Figure 4.2.1-20: Typical Inspection Numbering System for 3-Chord Full Span Sign Bridge.

4.2.2 Overhead Structure Inspection

A successful, quality inspection incorporates proper safety procedures, a well-planned sequence, and sound inspection methods. Other Parts in this Manual establish the basics for conducting inspections. Part 1, Administration, reviews the inspector qualifications and duties.

Due to the large number of overhead structures that typically need to be inspected, it is important to have well-planned and well-managed inspection procedures to eliminate errors and inconsistencies. Some of the factors that will affect the sequence of the inspection are the type and size of the systems, traffic density, and availability of special equipment, preferences of the inspection supervisor, and requirements for traffic control.

The inspection equipment to complete inspections of these structures shall vary depending on structure type, structure geometry, height, traffic and clear zone adjacent to the structure. Inspectors have an array of options for inspecting overhead sign structures including climbing, bucket truck and miscellaneous tools for hands-on. General inspection procedure recommendations are provided at the end of this chapter.

Climbing

The support frames of the overhead sign supports should be climbed with a body harness and two lanyards per OSHA standards. Attach one lanyard to the lower horizontal. Stand on that member and attach the second lanyard to the next higher horizontal. Release the first lanyard, and climb onto the upper horizontal and repeat until the top is reached. Refer to Figure 4.2.2-1 for an inspector climbing the end support frame. The support frames and space frames are climbed with one lanyard attached to the structure at all times. The lanyards should be attached to the top of the frame whenever possible to shorten the fall distance. If it must be attached to a vertical or diagonal, the lanyard should be wrapped around the member and under itself at least once, forming a hitch knot, to keep the attachment from slipping down the member. If the lanyard is attached to a lower member of the frame, and a fall occurs, the inspector may fall into the path of a passing vehicle, and will be exposed to a potentially lethal fall factor. It is the inspector's responsibility to have the proper lanyards for climbing a sign structure, and use the proper connection points on the sign structure.

Figure 4.2.2-1: Inspector Climbing an End Support Frame.

Bucket Truck

Depending on the support tower, a bucket truck may be required to elevate an inspector into the truss or structure. Overhead sign bridges commonly have concrete tower pedestals and require the use of a bucket truck to gain access. Furthermore, an inspector may use a bucket truck in lieu of climbing a steel tower. However, unless a full roadway closure is available, use of a bucket truck to perform an entire truss inspection is rare and time consuming when compared to climbing. Other structures, such as butterfly and cantilever structures may be accessed and inspected entirely from within a bucket.

Sign support structures are typically very difficult to efficiently and safely climb. Consequently, bucket trucks are typically used for sign support inspections. Inspectors shall have harnesses on with a minimum of one lanyard secured to the bucket during an inspection. The inspector shall also have all pertinent inspection tools available within the bucket during inspection to safely and efficiently perform the inspection.

Inspectors shall have harnesses on with a minimum of one lanyard secured to the bucket during an inspection. When transferring from the bucket to the truss, the inspector shall secure his/her second lanyard to the truss prior to removing the lanyard from the bucket.

Traffic Control

Traffic control is paramount whenever using a bucket truck. It is necessary for the protection of the inspector and to inform and notify the travelling public of work ahead and overhead. This is especially true on highly trafficked roadways. The inspection project manager and inspector shall be well versed in entering lane closures within the Lane Closure System (LCS) whenever inspection of a sign on a state highway is required. The inspection project manager should contact the Regional Ancillary Inspection Program Manager to coordinate appropriate lane closures. Whenever possible, the inspector should make use of the shoulder and clear zone away from any lanes. On off-system roadways where space for a bucket truck is limited, it may be possible to take a lane closure under the structure. The inspector should have numerous signs in place to caution approaching traffic of work ahead or possible lane shifts.

Miscellaneous Tools

All members and connections should be inspected by close visual examination. The inspection mirror is a useful tool for viewing opposite sides, undersides, or other hard-to-reach areas. During the inspection, reference points should be marked on the structure with chalk, keel, or permanent marker. These reference points are useful for describing the location of damaged members. A stick rule and/or measuring tape is a useful tool when taking photographs for scale or measuring deficiencies. Laser distance finders are also beneficial for a climbing inspector to determine the minimum vertical clearance on a structure. A camera should be on hand at all times to photograph any condition state 3 or 4 defects on the structure.

When climbing a structure, it is important for the inspector to secure these tools to his/her person so as to not have them fall onto traffic below. Retractable devices are easily attached to an inspector's harness or inspection bag and permit ease of use while preventing falls.

4.2.2.1 Visual Inspection

Overhead Sign Structures

Visual inspection of vertical frame supports should detect most deficiencies such as corrosion; buckled, bent, ruptured, cracked or missing members; cracked, incomplete or excessively-ground welds; and gusset plate cracks.

When paint loss or surface corrosion is observed, the adjacent area should be sounded with a hammer to check for internal corrosion. In addition, the lower five feet of the support should be sounded. These areas are more susceptible to internal corrosion of the members, leading to either partial or complete section loss. This condition is most often found around the base of the supports, especially if a grout pad is present. Internal corrosion also causes weep holes in the grout pad to be blocked with rust scale, thereby trapping moisture and intensifying the problem. The weep holes should be checked for blockage, and cleared out whenever possible.

On painted structures, isolated areas of cracked or splitting paint can be an indication of an overstressed section. These areas should be examined for other signs of distress. If an area is suspected of internal corrosion, the remaining thickness of the member needs to be determined. An ultrasonic thickness gage (D-meter) should be used in and around the suspected areas to determine the extent (if any) of section loss.

The connections of the spans to the support frames should be visually inspected, and the bolts hand checked for tightness. Typical problems which may be encountered include missing post-to-truss connection bolts; loose nuts on the post-to-truss connection bolts; improper use of lock washers; bolts that are not long enough to fully engage all of the threads of the nuts; and oversized holes (cut in field) for the post-to-truss connection bolts. All deficiencies should be recorded. Any burned or otherwise rough holes should be closely inspected for cracks.

Vertical post supports should be inspected similar to the support frames. All nuts and bolts should be checked for tightness. Loose bolts can cause some of the connection plates to bend or shift.

Space frames are visually inspected for corrosion; buckled, bent, ruptured, cracked, or missing members; incomplete, excessively-ground, or cracked welds; porous splice flange castings; cracked splice flange plates; and span camber. Refer to Figure 4.2.2-2 through Figure 4.2.2-6 for typical deterioration of steel and aluminum members. The flange splice nuts and bolts should be hand checked for tightness using a wrench or inspection hammer. Corroded areas may need to be checked for internal corrosion by a D-meter as described for the vertical frame supports.

Figure 4.2.2-2: Steel Corrosion in a Vertical Member.

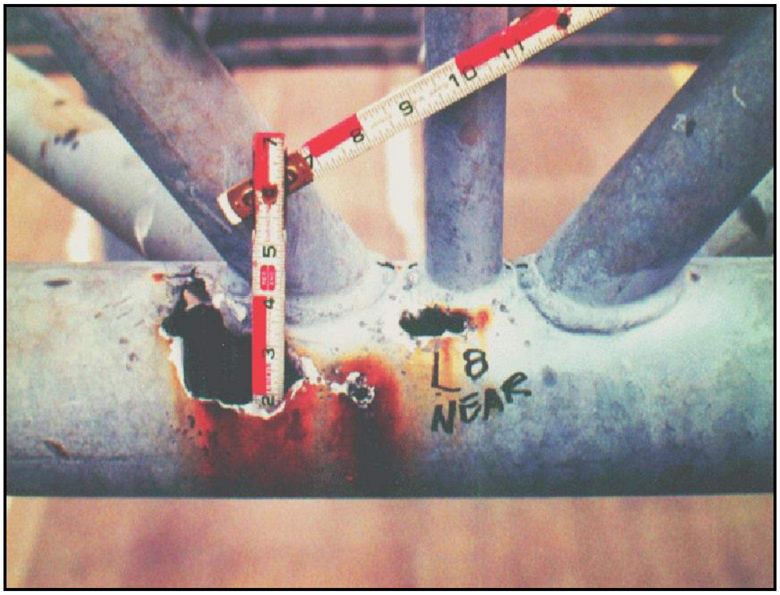

Figure 4.2.2-3: Corrosion in a Horizontal Steel Chord Member.

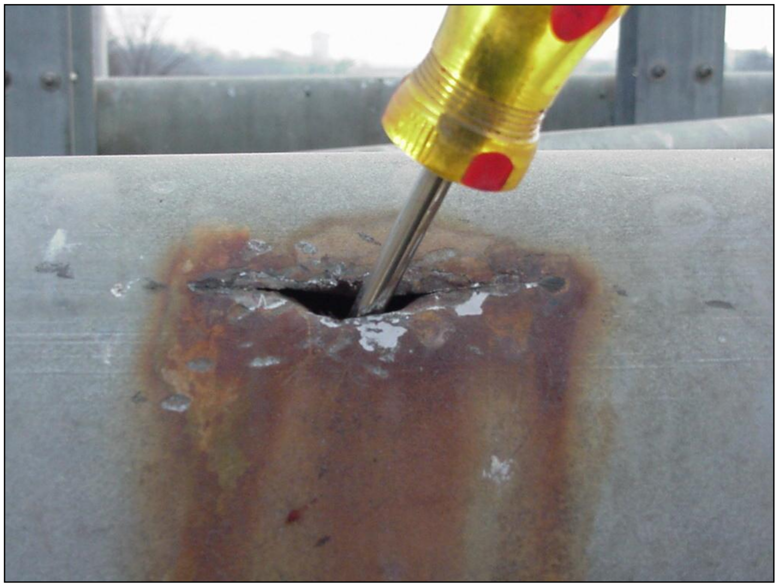

Figure 4.2.2-4: Split Associated with Corrosion in a Horizontal Chord Member.

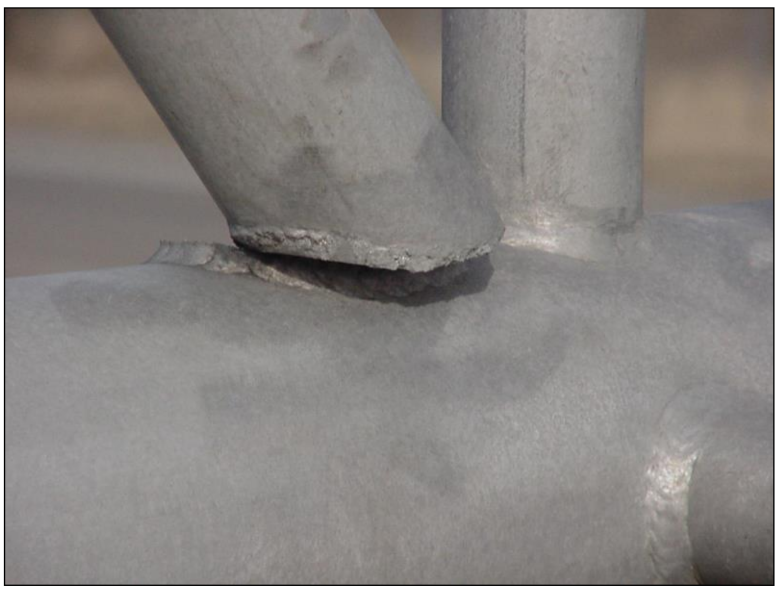

Figure 4.2.2-5: Broken Weld at an Aluminum Diagonal Member.

Figure 4.2.2-6: Crack through an Aluminum Gusset Plate.

On the full span structures, the space frames should be checked to insure there is a positive camber present in the frame. The space frames on the full span structures are either fabricated with this camber built in, or shims are bolted between the top flange splice plates to create a camber. If the space frame is sagging, the inspector should check for proper assembly/ shim placement. If assembled improperly, the frame may have distorted and may have serious structural problems. During the initial inspection of a sign structure, the inspector should briefly review the shop drawings and compare versus the structure in the field to ensure proper installation of the truss. Refer to Figure 4.2.2-7 and Figure 4.2.2-8 for examples of sign structures with improperly installed trusses.

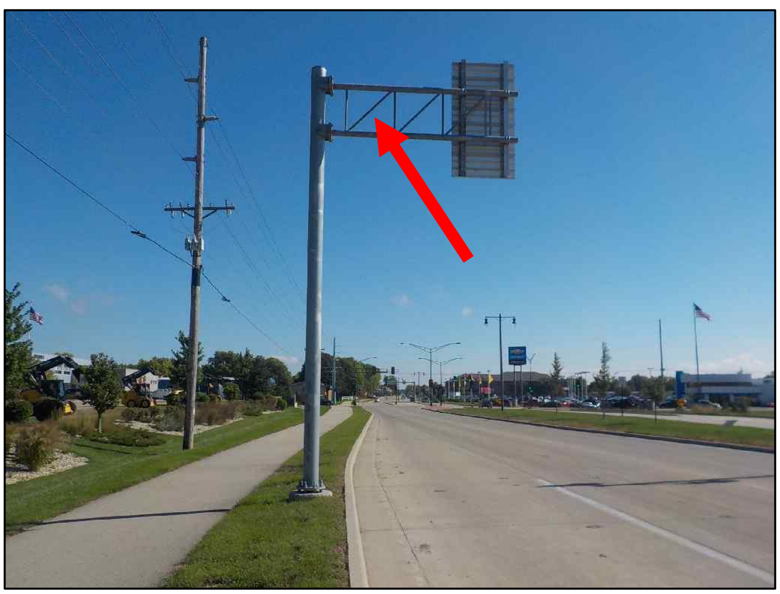

Figure 4.2.2-7: Truss installed upside down. Diagonals of Cantilever Should Angle Down Towards Sign Panel.

Figure 4.2.2-8: Right Truss Installed Upside Down. Truss Diagonals Should Run Down Towards Center From Upper Chord.

The vertical clearance shall be measured at the lowest point over each lane and the lowest reading recorded on the inspection form. This is usually from the catwalk L-bracket or the bottom of the sign panel. If the lowest point cannot be reached safely by hand, the measurement can be taken from a higher point. The distance from the higher point to the lowest point is measured and subtracted from the first measurement. If available, a laser distance meter is an excellent tool for obtaining these clearance measurements; however care must be taken when purchasing these as cheaper models lose accuracy in cold weather. The accuracy of the meter should be checked periodically with the survey rod, or other measuring device. Also, if a laser distance meter is used, a minimum of three measurements should be taken at each location with the minimum measurement being recorded as the vertical clearance. Alternatively, the clearance may be measured from the ground with an inverted survey rod held on the lowest point on the structure. Several positions should be checked to determine the minimum clearance, and suitable traffic control must be in place.

Overhead Sign Supports and Signal Mast Arm Structures

Regardless the support structure type, special attention should be given to the welded connection of the mast arm to the connection plate. This weld is subject to a high level of stress due to the weight of the arm and a high number of cycles from wind vibrations, truck induced loads, etc., which contributes to the development of fatigue cracks. The connections of mast arms to posts should be visually inspected, and the connection bolts hand checked for tightness.

Typically the mast arm will be fabricated with an upward angle in at the connection plate. This creates an increase in elevation as the arm extends outward over traffic. The inspector shall inspect post to mast arm connection faying surface to ensure the plates are flush. The use of washers to provide camber is not allowed. If assembled improperly, the arm may deflect downward with vertical clearance issues with the traffic below. Refer to Figure 4.2.2-10 for an example of an improperly installed column to arm connection.

Figure 4.2.2-9: Typical Column to Traffic Signal Mast Arm Connection.

Figure 4.2.2-10: Column to Sign Mast Arm Connection with Washers Between Faying Surfaces.

Typical problems observed in post-to-mast arm connections encountered in the field include faying surfaces not flush or gapped due to washers installed between plates; loose nuts on the connection bolts; improper use of lock washers; bolts that are not long enough to fully engage all of the threads of the nuts. Improper installation of DTIs includes placing a washer between the DTI and the bolt head / nut; and observing the feeler gauge inserts all the way to the bolt shank between the DTI dimples (non-refusal). Refer to Figure 4.2.2-11 for non-refusal of a feeler gauge at a DTI bolted connection. All deficiencies should be recorded. Any burned or otherwise rough holes should be closely inspected for cracks.

Figure 4.2.2-11: Non-Refusal of Feeler Gauge at DTI Installation.

The vertical clearance shall be measured at the lowest point over each lane and the lowest reading recorded on the inspection form. This is usually from the bottom of a signal or sign closest to the post. If available, a laser distance meter is an excellent tool for obtaining these clearance measurements; however care must be taken when purchasing these as cheaper models lose accuracy in cold weather. The accuracy of the meter should be checked periodically with the survey rod, or other measuring device. Also, if a laser distance meter is used, a minimum of three measurements should be taken at each location with the minimum measurement being recorded as the vertical clearance. Alternatively, the clearance may be measured from the ground with an inverted survey rod held on the lowest point on the structure. Several positions should be checked to determine the minimum clearance, and suitable traffic control must be in place.

Element Level Inspection

On the inspection report form, each overhead sign structure and support element is recorded in units of Each, save for truss chords and mast arms. It is important to note that sign structure and support elements do not possess any material defects. Rather, each element condition state definition provides all the defect language within it. Therefore, the inspector is tasked with noting all defects observed during the inspection under the element notes and determining the appropriate element condition state. For an Each unit of measure, the coded Condition State applies to the entire element. In this manner, an Each unit of measure essentially acts as an overall rating for that element. This will quantify the element's state of deterioration and help generate quantity/cost estimates for future remedial work.

4.2.3 Overhead Sign Elements

All overhead sign structures and supports are broken down into basic components and recorded within the inspection report. For continuity throughout the state, the structures shall be evaluated under designated elements. All sign elements are recorded in units of each with the exception of the truss chords and mast arms which are recorded in lineal feet.

Each element shall be evaluated in its entirety and assessed under the appropriate element condition state. Generalized material defects and common deficiencies typically observed in these elements are included within condition state definitions as noted within this chapter.

For truss chords and mast arms, each linear foot includes the three dimensional projection through all of the of the truss members within the cross section. This cross section is inspected and evaluated for any distress with deficiencies captured and quantified under the appropriate element condition state. The element condition states quantify the element's state of deterioration and help generate quantity/cost estimates for future remedial work.

4.2.3.1 Base/Foundation (Element 8701)

As discussed in various other sections of this Manual, the most common signs of concrete deterioration on the foundations include: cracking, scaling, spalling, and delamination.

Impact damage, spalling, scaling, and most cracking are typically visible to the naked eye. Some cracking or delamination may be below the surface; therefore, the concrete can be typically struck with a standard inspection hammer to locate these deficiencies. The delaminated or internally cracked areas will reveal a hollow sound when struck with a standard inspection hammer. When these delaminated sections are encountered, the loose outer sections should be broken off to determine the extent of the deterioration. The inspector should also determine if there is any erosion or undermining of the footing that could lead to an instability problem.

All deficiencies shall be recorded by describing the type of deficiency (spall, crack, etc.), location, size (length, width, and depth), orientation, and severity of the defect. Exposed steel reinforcement should be noted, as well as the severity of corrosion. If corrosion has caused section loss, then the percentage of section loss should be determined and noted. Refer to Figure 4.2.3-1 through Figure 4.2.3-6 for views of common foundation deterioration.

Figure 4.2.3-1: Map Cracking with Efflorescence on a Four Chord Sign Structure (Condition State 3).

Figure 4.2.3-2: Map Cracking with Delamination and Spall on a Butterfly Foundation (Condition State 3).

Figure 4.2.3-3: Mast Arm Foundation Initially Installed Below Grade (Condition State 2)

Figure 4.2.3-4: Cracked, Delaminated and Spalled Concrete Foundation (Condition State 3)

Figure 4.2.3-5: Foundation Spall Exposing Anchor Rod (Condition State 3).

Figure 4.2.3-6: Anchor Rods Installed Offset from Center Foundation (Condition State 2 if Verified by Engineer within Report).

The Wisconsin Department of Transportation (WisDOT) has phased out the use of grout pads on the foundations of traffic operations support systems, due to past problems. The current practice is to leave the void created by the leveling nuts between the concrete foundation and the base plate empty, and to wrap the exterior edge of the base plate with metal screening to prevent rodents from nesting in the void when electrical conduit or wires are present. The open void allows moisture to drain down the support tubes and evaporate, rather than saturating the grout pad, which in turn would contribute to the corrosion of the base plate and anchor bolts.

However, some older structures may still have grout pads in place. Problems found with the foundation grout typically include: cracks, delamination, moisture, voids, and loose grout. Sources of grout problems include poor grout mix; poor consolidation; freeze-thaw cycles; poor installation; and the action of deicing salts. Grout pads should be visually inspected for cracking, scaling, delamination, efflorescence, the presence of moisture, and loss of grout. The grout pad should also be sounded with a standard inspection hammer to detect subsurface problems similar to the base/foundation. If the grout pad is deteriorated, the recommended course of action is to have the grout pad removed in its entirety and a metal rodent screen installed around the base plate if electrical conduit or wires are present. Prior to removing substantial portions of the existing grout, the inspector should verify that leveling nuts are in place and tight against the bottom of the base plate. Refer to Figure 4.2.3-7 for an example of typical deterioration of a grout pad on a sign structure.

Signal mast arm structures should be constructed with the top of the concrete foundation at or just above the surrounding grade. Soil covering the foundation acts to promote the deterioration of the protective coatings on the sign structure members. It may be necessary for the inspector to remove fill material from a top the foundation.

This element includes reinforced concrete foundations used for High Mast Lighting Structures, Overhead Sign Structures and Overhead Sign Supports. Four chord, two-chord, cantilever and butterfly structures will commonly be supported by vertical concrete columns. There columns are seen as extensions of the foundation and shall be included under this element. If a grout pad is present, it is also evaluated in this element. If Anchor Rod(s) were placed eccentrically, but the configuration has been approved by structural engineers, note that eccentricity in the notes with measurements for off-set.

Element Condition States

Below defines the Condition States specific to each element. The defects are expounded on and critical areas are discussed to aid the inspector in determining the severity of a defect. The Condition States are comprised of general descriptions and uniquely colored to follow the severity the description represents. Condition states consider material and structural defects of the element.

- Condition State 1: The element shows no deterioration.

- Condition State 2: Minor cracks and spalls may be present in the foundation, but only minimal reinforcing steel is exposed. When efflorescence is present, it is minor and there is no evidence of rust staining. Grout pad (if present) is in good condition. Minor erosion around foundation may be present, but does not affect structural capacity.

- Condition State 3: Many spalls are present. Corrosion of reinforcement and/or loss of concrete section is evident though not sufficient to warrant structural analysis. Grout pad (if present) has moderate cracking, spalls, or delaminations. Erosion may be present that reduces the foundation embedment significantly but does not pose a threat to the stability of the structure.

- Condition State 4: The condition warrants a structural review to determine the effect on strength or serviceability of the element, or a review has been completed and it has been found that the defects impact strength or serviceability.

Figure 4.2.3-7: Deteriorated Grout Pad (Condition State 3).

4.2.3.2 Steel Anchor Rods (Element 8702)

Anchor rods are typically secured to the sign structure via leveling nuts, anchor nuts and jam nuts. Jam nuts should not be confused with lock nuts which have a ring of nylon around the interior to "lock" the nut to the threads of a bolt.

Problems with anchorages include: bent or corroded anchor bolts; missing washers; loose or missing anchor rod jam nuts/ leveling nuts; and fatigue cracks. Sources of anchorage problems include misaligned anchor rods during construction (which is typically a result of the failure to use a template); poor or damaged galvanized coating; and incorrect or poor tightening methods.

Anchor rods, nuts, and washers should be visually inspected for corrosion; loose or missing lock nuts, leveling nuts, and washers; bent rods; and nuts not fully engaged (threaded). The tops of anchor rods should be tapped with a standard inspection hammer. This may reveal dull or hollow sounds, which could indicate a loose anchor rod or a possible fatigue crack in the rod. If a crack is suspected, the anchor rod should be ultrasonically tested to verify the presence and location of a crack. All cantilever structure anchor rods shall be ultrasonically tested with each routine inspection. Due to the excessive galloping of the structure from natural and induced wind loading, fatigue and overstressing is more prevalent in anchor rods for these structures.

The nuts and washers should be tapped with a standard inspection hammer to check for looseness. If a nut is not clamping the base plate to the foundation (or to the leveling nut), the anchor bolt is ineffective. This results in increased stress for the other anchor rods. Base plates installed flush to the foundation should have anchor rod nuts snug tight (snug tight defined as the full effort of an ironworker on an anchor nut using a 12 inch spud wrench). Base plates to leveling nuts shall be installed following the required torque and tensioning requirements. The washers should also be tapped as a nut could be tight on the anchor rod, but not on the base plate and the nut may not move when tapped with a hammer. A loose washer will reveal an under-tightened nut. Excessive rod length between the base plate and foundation, “stand-off” distance, may also create increased stresses within the anchor rods. The length from the bottom of the leveling nut to the top of the foundation should not measure more than the diameter of the anchor rod. The inspector shall note any anchor rods with excessive standoff and may recommend load rating to determine whether the rods are stressed beyond capacity.

All initial sign structure inspections with base plate to leveling nut foundations shall have torque verification testing performed on one anchor rod. The inspector shall note within the inspection report which anchor rod was tested and results of the verification. All sign mast arm structures and cantilever sign structures shall have the anchor rod located closest to the centerline of the superstructure and below the mast arm or chords torque verified. Refer to Figure 4.2.3-8 for the required anchor rod torque verification testing location on mast arm and cantilever structures. The importance of verifying this anchor rod is due to the loading of the foundation by the superstructure. This area of base plate and anchor rod will typically be in compression once the superstructure is installed. If the anchor rods were tensioned prior to the superstructure installation, the loading on the rods below the cantilevered superstructure may take the rod out of tension thus creating an improperly installed structure susceptible to elevated stresses within the other anchor rods.

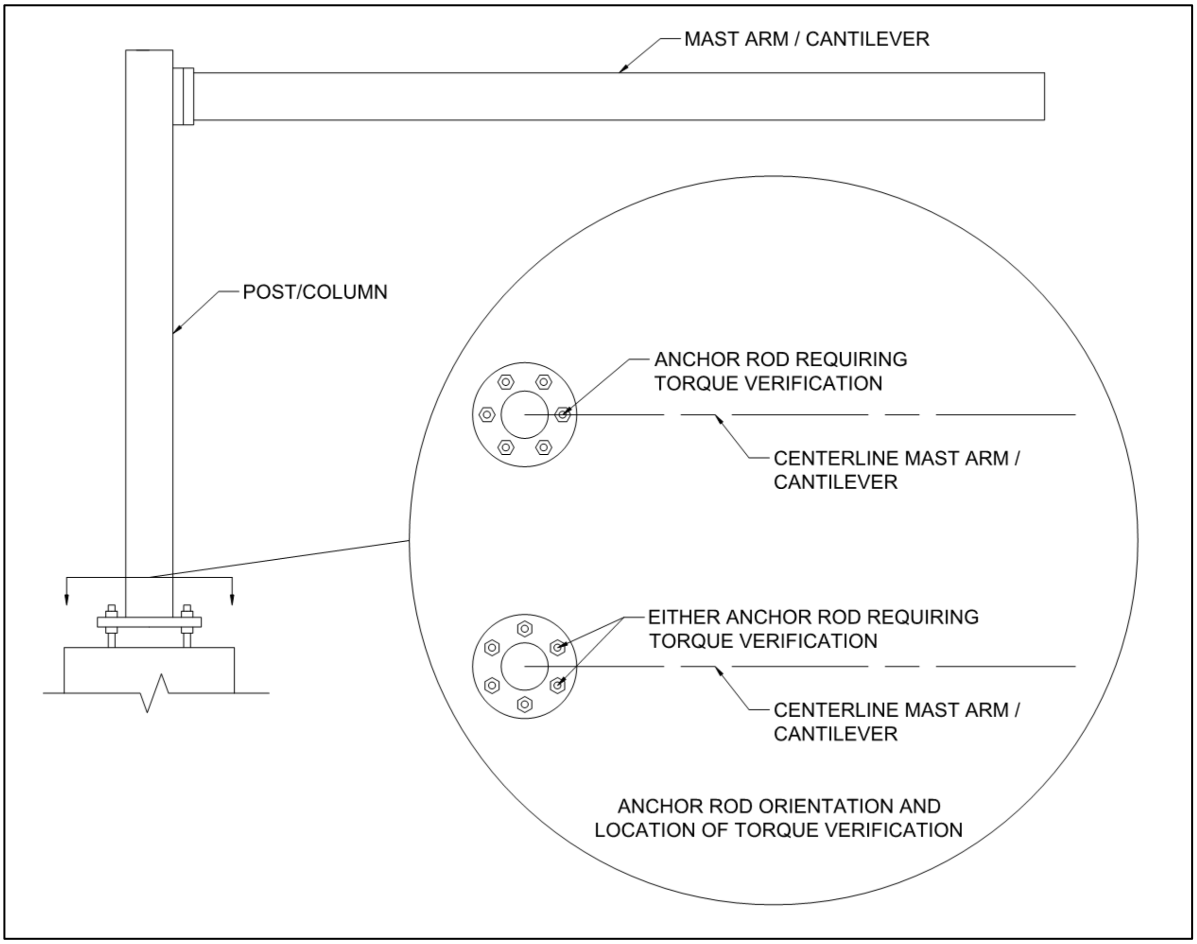

Figure 4.2.3-8: Varying Anchor Rod Orientations and Required Location of Torque Verification for Mast Arm / Cantilevered Structures.

Torque verification testing for each subsequent routine inspection after is at the inspector's discretion. Torque verification testing requires the use of a calibrated torque wrench. The inspector may also find it advantageous to use a torque multiplier to reduce the amount of torque the inspector has to apply to the wrench during verification (the inspector must be aware of the appropriate torque conversions when using the multiplier). Refer to Figure 4.2.3-9 for view of an inspector using a torque multiplier for a torque verification test.

Figure 4.2.3-9: Inspector Using Torque Multiplier to Verify Anchor Rod Tension.

On older structures, the inspector may find various details, such as the anchor rods having lock nuts or lock washers. The first top nut shall be fully engaged (threaded), and the second top nut shall be engaged so the anchor rod has the threads are exposed through the second (lock) nut. The second top nut (lock nut) is not always a normal structural nut. Frequently, a jam nut (low profile nut) is used as the lock nut. A jam nut should only be used as a lock nut in conjunction with a normal structural nut. Refer to Figure 4.2.3-10 through Figure 4.2.3-15 for typical problems of anchor bolts found by inspectors. If a lock washer is encountered on an anchor rod, it should be noted as such in the report. Since the anchor rod assembly is a tensioned connection, lock washers are not permitted to be used as they can creep out of the connection.

This element defines anchor rods, anchor nuts, leveling nuts, and washers connecting the column support to the foundation. Quantity is per each rod.

Element Condition States

Below defines the Condition States specific to each element. The defects are expounded on and critical areas are discussed to aid the inspector in determining the severity of a defect. The Condition States are comprised of general descriptions and uniquely colored to follow the severity the description represents. Condition states consider material and structural defects of the element.

- Condition State 1: The element shows no deterioration.

- Condition State 2: Minor corrosion of the element is present, but the rods appear to be properly tensioned and the nuts are fully engaged. Anchor rods may be slightly out of plumb (1:40 or less) without need for remediation, or out of plumb between 1:20 and 1:40 with proper beveled washers, and PE Stamped calculations on file to certify the configuration is ok. Anchor rod standoff exceeds current standards, but is within acceptable limits based on calculations.

- Condition State 3: Moderate corrosion of the elements may be present, but not enough to warrant structural analysis. Lock washers may be present. Anchor rod standoff exceeds current standards, and there is no analysis on file and rods appear to be performing adequately.

- Condition State 4: Severe corrosion is present. Anchor rods are not properly tensioned, nuts may be missing or not fully engaged. Anchor rods are greater than 1:40 out of plumb w/o remediation (Greater than 1:20 requires immediate replacement). Anchor rod standoff exceeds current standards, and rod(s) show signs of bending, movement, buckling, or elongation. The condition warrants a structural review to determine the effect on strength or serviceability of the element, or a review has been completed and it has been found that the defects impact strength or serviceability.

Figure 4.2.3-10: Anchor Bolt Installed Out-of-Plumb Greater than 1:40 (Condition State 3).

Figure 4.2.3-11: Severe Corrosion of the Leveling Nuts (Condition State 4).

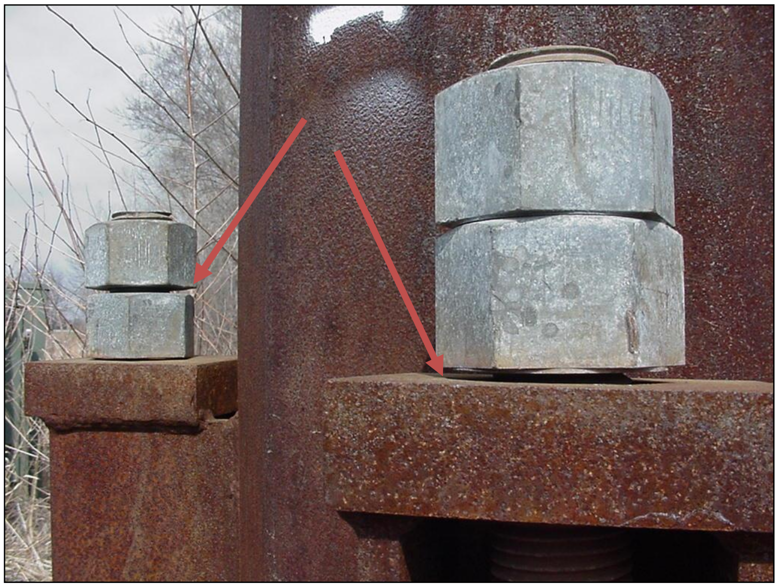

Figure 4.2.3-12: Anchor Nuts and Jam Nuts not Fully Tight to the Base Plate, or to Each Other (Condition State 4)

Figure 4.2.3-13: Leveling Nuts Not Fully In Contact with the Base Plate (Condition State 4).

Figure 4.2.3-14: Excessive Anchor Rod Stand-Off from Foundation (Condition State 3).

Figure 4.2.3-15: Anchor Bolt Out-of-Plumb Due to Impact (Condition State 3).

4.2.3.3 Base Plate(s) (Aluminum or Steel) (Element 8703)

The vertical posts for sign structures will typically be welded to a horizontal base plate. The base plate is fastened to the foundation via the anchor rods. It is common for base plates to have stiffeners welded between the anchor rod locations to add rigidity to the welded socket connection and reduce the impact of fatigue on the connection.

Aluminum columns for sign supports are rare if not non-existent in Wisconsin. However, they still exist for sign structures. For aluminum columns, the column does not connect directly to the base plate. Base casting clamps are used to clamp the bottom of the support frame. The base casting clamps are bolted to the concrete foundation utilizing anchor bolts embedded in concrete. The vertical support frame is clamped between two base-casting clamp halves and secured by horizontal collar bolts. Base casting clamps can be over tightened, thus causing over stressing, and possible failure. Refer to Figure 4.2.3-16 for a base casting clamp that has failed due to over stressing.

Figure 4.2.3-16: Failed Aluminum Base Casting Clamp Initiated by Over-tightening the Stainless Steel Horizontal Column Bolts.

The base plate shall be visually inspected for any deformity due to installation or unlevel foundation. The welds of the post to plate connection and stiffener welds (vertical to post and horizontal to base plate) shall be inspected. If castings are present, cracking and bolt tightness shall be inspected. If necessary, ultrasonic or magnetic particle testing may be required to determine the extent of weld cracking if visually present during routine inspections.

This element defines the base plates, flanges, casting clamps, gusset plates, seam welds, and welds at the connection of the column support to the foundation. Quantity is one each per base plate.

Element Condition States

Below defines the Condition States specific to each element. The defects are expounded on and critical areas are discussed to aid the inspector in determining the severity of a defect. The Condition States are comprised of general descriptions and uniquely colored to follow the severity the description represents. Condition states consider material and structural defects of the element.

- Condition State 1: The element shows no deterioration.

- Condition State 2: Minor corrosion of the element is present. No cracking of the element is observed. Casting clamp, if used, has no more than one horizontal bolt loose.

- Condition State 3: Moderate corrosion of the element is present. Cracks may be present on the base plate to column support connection weld, but have been arrested or are no longer active and do not affect the capacity of the plate. The base plate may be distorted (dished). Casting clamp, if used, has no more than two horizontal bolts loose.

- Condition State 4: Severe corrosion is present. Cracks may be present on the base plate to column support connection weld that have not been arrested. Section loss is significant and may affect the ultimate strength or serviceability of the element. Three or more horizontal casting clamp bolts are loose or missing, or cracks exist in the casting clamp assembly. The condition warrants a structural review to determine the effect on strength or serviceability of the element, or a review has been completed and it has been found that the defects impact strength or serviceability.

4.2.3.4 Column Support(s) (Aluminum or Steel) (Element 8704)

For two-column supports, the frame consists of two steel or aluminum pipe columns connected by diagonal bracing pipe or angle members. Some two-column support frames also have horizontal pipe or angle members between each diagonal branch member. The column base design differs for steel and aluminum. Aluminum casting plates shall be evaluated under 4.2.3.3 Base Plate(s) (Aluminum or Steel) (Element 8703).

Tri-chord full-span sign structures may be supported at each end by either a two-column support frame or by a single column. Two-chord and monotube sign structures will be supported at each end by a single column. All sign supports are comprised of a single post. Typical design includes a slight angle from vertical between the column and base plate during fabrication. Once the mast arm and signs/signals are installed, the intent is the loading will deflect the column to plumb. The inspector shall note whether the column is out of plumb (taking into account the column is most likely tapered).

This element includes the vertical posts, diagonal members, and circumferential welds for the column support(s) on the structure. The quantity is one each per vertical column. Depending on the structure type and configuration, there may be one or two columns per support.

Element Condition States

Below defines the Condition States specific to each element. The defects are expounded on and critical areas are discussed to aid the inspector in determining the severity of a defect. The Condition States are comprised of general descriptions and uniquely colored to follow the severity the description represents. Condition states consider material and structural defects of the element.

- Condition State 1: The element shows no deterioration.

- Condition State 2: Minor corrosion is present. Standing water may be observed inside the post.

- Condition State 3: Moderate damage or corrosion is present, but does not warrant structural review. Cracks may be present on the pole, but have been arrested or is no longer active.

- Condition State 4: Heavy damage or corrosion of elements with section loss. Cracks may be present on the pole that have not been arrested. Elements may be misaligned or have severe impact damage that warrants structural analysis to ascertain the impact on strength or serviceability, or a review has been completed and it has been found that the defects impact strength or serviceability.

Figure 4.2.3-17: Square Support Column Cantilever (Condition State 1).

Figure 4.2.3-18: Base of Post Distorted Out of Plane Due to Impact (Condition State 3).

4.2.3.5 Truss Chord(s) / Mast Arm(s) (Aluminum or Steel) (Element 8705)

For a four-chord sign structure, each space frame is constructed of two vertical parallel-chord plane trusses. Each truss consists of a top and bottom chord connected by vertical and diagonal members. The diagonals are arranged in the pattern of a Warren Truss where the diagonals alternate between being directed down toward the center of the span and being directed up toward the center of the span.

To form the space frame, the two trusses are set parallel to each other and joined together by horizontal transverse members and horizontal diagonal members. These members are welded/bolted in place between the two top chords and between the two bottom chords, thus forming the rectangular cross-section of the space frame. Interior diagonal members are also framed between the two vertical trusses. Each interior diagonal connects a top panel point of one truss with the corresponding bottom panel point of the other truss. The interior diagonals alternate in direction with each panel. Refer to Figure 4.2.3-19 for an example of a four chord truss.

Figure 4.2.3-19: Four Chord Truss.

Butterfly structures will typically be comprised of one or two pairs of horizontal steel tubes without trussing, or two to four chords with trussing. The total length for the inspection shall be the measurement from end to post connection for tubes bolted directly to post, refer to figure below, or end to end of tubes / truss when continuous and connected to post. The exact makeup of the structure is dependent on whether the structure has one or two sign panels as well as the age of the structure. Refer to Figure 4.2.3-20 for an example of a butterfly structure with two pipes bolted to a single post with no trussing. Refer to Figure 4.2.3-21 and Figure 4.2.3-22 for an example of a single and dual mast arm support structure, respectively.

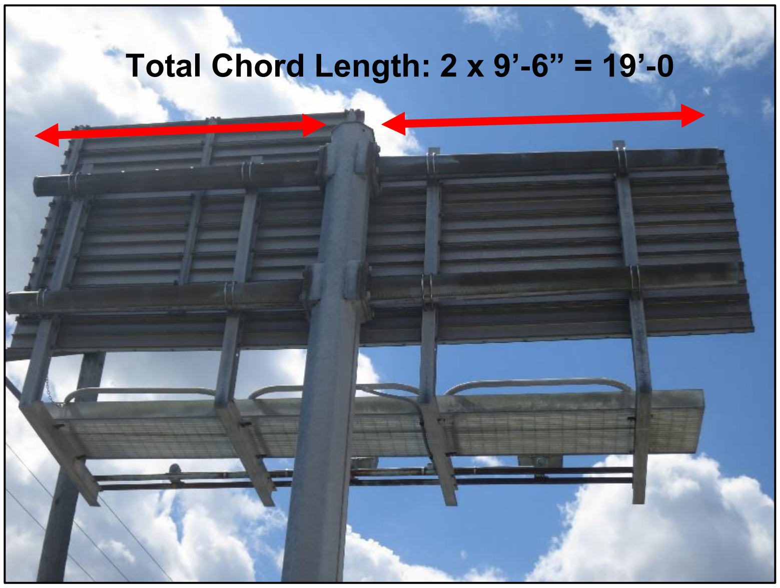

Figure 4.2.3-20: Butterfly Chords Without Trussing.

Figure 4.2.3-21: Signal Mast Arm Length.

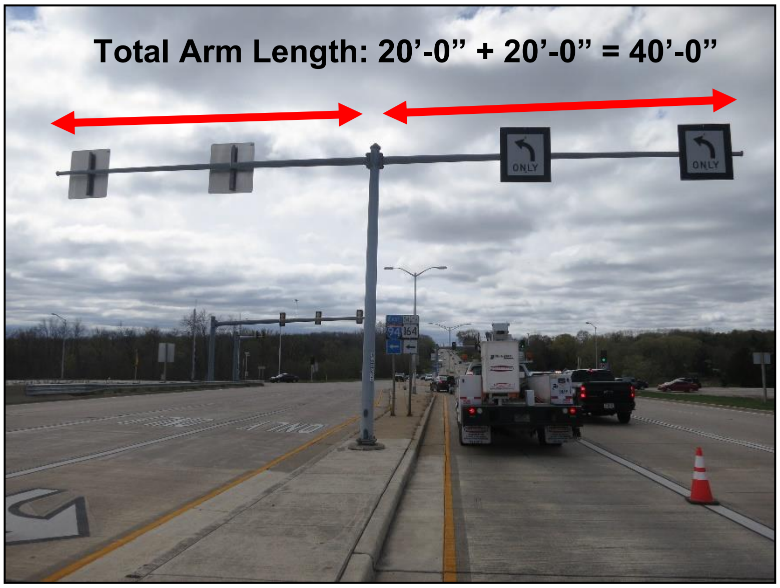

Figure 4.2.3-22: Dual Sign Mast Arm Length.

Cantilever structures are typically two-chord or four-chord truss systems.

Sign support mast arms are typically constructed of steel plate rolled into a tapered pipe section with a wider base located at the post to arm connection. A seam weld runs down the center of the arm. On longer arms, a slip joint splice may be observed to extend the arm a greater distance. This splice joint shall be evaluated under the element 4.2.3.7 Connection(s) - Splices for Columns, Chords, Arms (Element 8707).

Mast arms are typically fabricated with a slight angle of incline from the post to arm connection. This ensures that the tip of the arm is higher out over traffic reducing the vertical clearance impacts. The inspector shall sight down the mast arm to determine whether the arm deflects lower than the post to arm connection or if an angle of ascent is not present at the post to arm connection. It should be noted that shimming or altering the leveling nuts of the column base is not permitted to provide the appropriate camber in the mast arm. Refer to Figure 4.2.3-23 for an example of a mast arm with a fabricated angle of ascent.

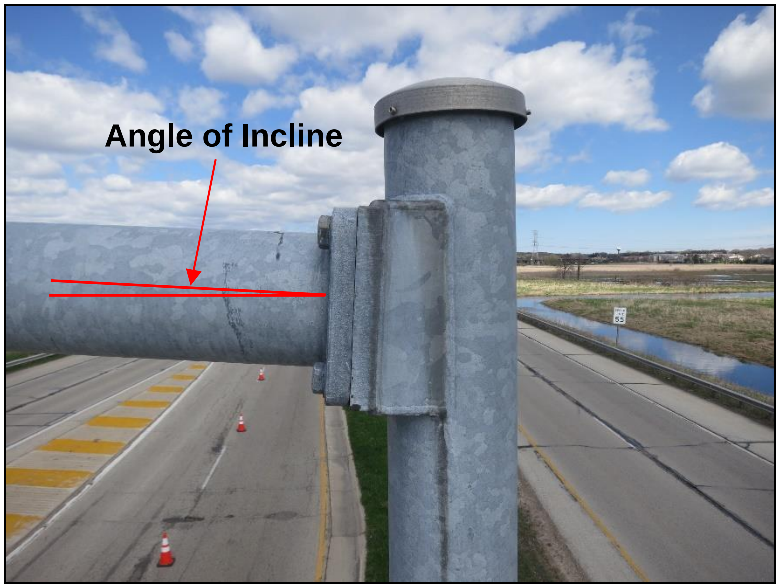

Figure 4.2.3-23: Angle of Incline in Mast Arm from Post to Arm Connection.

This element defines the chords of a truss system, or mast-arms. It also includes all diagonal members and struts integral to the truss. Total Quantity is the length of the truss or mast arm span, regardless of number of chords. (i.e. if Truss is 40' long, quantity is 40 LF regardless if 2, 3, or 4 chord truss; if mast arm is 40' long, quantity is 40 LF; dual arm structure where each arm is 20', quantity is 40 LF).

Element Condition States

Below defines the Condition States specific to each element. The defects are expounded on and critical areas are discussed to aid the inspector in determining the severity of a defect. The Condition States are comprised of general descriptions and uniquely colored to follow the severity the description represents. Condition states consider material and structural defects of the element.

- Condition State 1: The element shows no deterioration.
- Condition State 2: Minor corrosion is present, but with no discernable section loss. Superficial damage to the element may exist.
- Condition State 3: Moderate damage or corrosion is present, but does not warrant structural review. Cracks may be present, but have been arrested or are no longer active.
- Condition State 4: Heavy damage or corrosion of elements with section loss. Cracks may be present that are active. Elements may be misaligned or have severe impact damage that warrants structural analysis to ascertain the impact on strength or serviceability, or a review has been completed and it has been found that the defects impact strength or serviceability.

4.2.3.6 Connection(s) - Column to Truss Chord/Arm (Element 8706)

Four chord structure chord to truss connections are typically comprised of saddles welded to each of the two-column frames which support the ends of the chords of the four-chord full-span. Horizontal holes are drilled into the ends of each of the chords. The four-chord space frame is placed in the saddles and bolted to the saddles. The bolts on the older structures were not stainless steel, and typically exhibit heavy corrosion. Heavily corroded end connection bolts should be noted in the inspection report. Refer to Figure 4.2.3-24 for an example of a saddle bracket connection for a four chord truss to post connection.

Figure 4.2.3-24: Four Chord Truss to Post Saddle Bracket Connection.

Another style of four-chord cantilever sign support found throughout the State utilizes flange plates to connect the space frame to a square support column. Square stubs are welded to the square support column, which support the space frame. The welds between the support column and the space frame have been prone to cracking. Refer to Figure 4.2.3-25 for a view of the square stubs welded to the square support column.

Figure 4.2.3-25: Square Stubs Welded to Support Column.

If a single post supports the tri-chord space frame truss, the typical connection will be bolted to the top and bottom chord members to the post by plates welded to the chord members. If a two-column support frame supports the tri-chord space frame, the bottom chord is U-bolted to a “T-beam” welded between the two support columns. The back chord member is U-bolted to the back support column. In the past, the T-beam welds have exhibited cracks along the bottom edge of the weld. Many tri-chord structures have been retrofitted with T-section repairs to correct the cracked welds. Close attention should be paid to these areas to ensure welds are not cracking. Refer to Figure 4.2.3-26 for a tri-chord truss to single post connection. Refer to Figure 4.2.3-27 for retrofitted T-section repairs.

Figure 4.2.3-26: Tri-Chord Truss to Post Connection for Single Post Structure.

Figure 4.2.3-27: Tri-Chord Bolted T-Section Repair.

For cantilevered structures, the supported end of the space frame, a horizontal plate is welded to the inside end of each of the four cantilever chords. Large plates and plate stiffeners are welded to the support column. Matching holes are fabricated in the support post plates and the horizontal plates on the chord members. Refer to Figure 4.2.3-28 for a typical space frame to support column on a cantilever structure.

Figure 4.2.3-28: Typical Space Frame to Post Connection on a Cantilever Structure.

Two-chord and monotube structure horizontal members are secured to a single post at each end by a bolted clamp connection. The clamping assembly is bolted to the post and an alignment pin is used to secure the horizontal tube to the clamp. Refer to Figure 4.2.3-29 for a monotube to support post connection.

Figure 4.2.3-29: Typical Monotube Chord to Support Column Connection.

Butterfly structures will typically have the horizontal tubes U-bolted to saddle brackets welded to the pipe column. Refer to Figure 4.2.3-30 for a view of a typical butterfly saddle connection.

Figure 4.2.3-30: Corroded U-Bolt Connection Securing Horizontal Sign Support Member to the Post of a Butterfly Sign Structure (Condition State 2).

Column to arm connections on sign support mast arms are typically comprised of welded and bolted plate connections. A vertical plate, plane parallel to the traffic lane, is welded to vertical or horizontal plates extending off the vertical post. A socket weld connects a vertical base plate to the mast arm. Corresponding bolt holes are located in both the vertical post connection plate and mast arm plate and subsequently bolted together with high strength bolts. Depending on the span and sign or signal load located on the mast arm, the number of bolts securing the mast arm to post connection will range from 4 to 8 bolts. Refer to Figure 4.2.3-31 and Figure 4.2.3-32 for typical column to mast arm connections.

On older structures, the mast arm may be connected to the column via a clamping casting. This type of connection is not common for signal mast arm connections, however the premise of the connection is similar but without the welded plates to the column. The inspector should carefully check for any loose, corroded or missing connection bolts. The socket weld of the plate to mast arm connection should be inspected. Refer to Figure 4.2.3-33 for a post to arm clamped connection. Refer to Figure 4.2.3-34 for an example of missing bolts on a column to mast arm connection.

As these arms are cantilevered from the connection, the connection experiences high stresses in all dimensions. Therefore, inspection of the welds on the column, socket weld on the arm and bolts connecting the plates is critical. Cracked or poor welding and missing bolts will highly impact the structural capacity of the mast arm. The bolts on the older structures were not stainless steel, and typically exhibit heavy corrosion. Heavily corroded end connection bolts should be noted in the inspection report. The faying surface between the post and mast arm plates should be flush. Washers are not permitted between the plates. Refer to Figure 4.2.3-35 for cracks along a mast arm socket weld.

Figure 4.2.3-31: Column to Arm Connection with Horizontal Column Plates Welded to Vertical Plate. Note Washers Improperly Included Between Plates.

Figure 4.2.3-32: Column to Arm Connection with 8 Bolts. Note Horizontal and Vertical Plates Welded to Vertical Plate.

Figure 4.2.3-33: Column to Mast Arm Clamped Connection.

Figure 4.2.3-34: Missing Lower Connection Bolts of a 4 Bolt Connection (Condition State 4).

Figure 4.2.3-35: Transverse Weld Cracks Along Circumferential Socket Weld of Mast Arm to Vertical Plate Connection (Condition State 3)

Newer structures may be designed with the column to mast arm/cantilever connection being fastened with structural bolts and direct tension indicators (DTIs). An inspector can determine if a DTI was used by observing circumferential indentations on the edge of the component. Refer to Figure 4.2.3-36 for an example of a DTI. When DTIs are present the inspector shall note whether the WisDOT form DT2322 was submitted by the contractor and within HSI. Verification of proper DTI installation requires a 0.005 inch thick feeler gauge. Proper installation is verified by the number of refusals of the feeler gauge in the DTI gaps. It is important to note that a seemingly snug nut on a DTI connection does not necessarily represent a properly installed connection. The inspector shall refer to DT2322 for determining proper DTI installation.

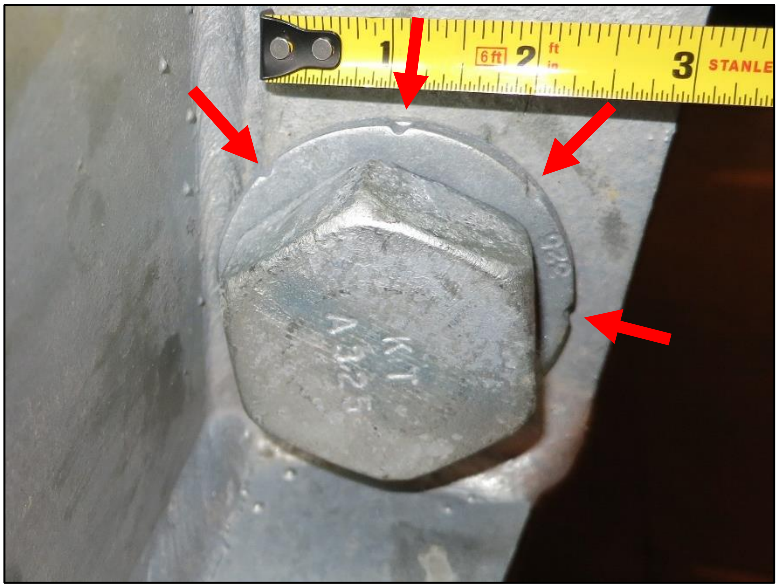

Figure 4.2.3-36: Indentations Along Edge Indicate the Component is a DTI.

This element defines the flange, gusset plates and hardware/fasteners connecting the span arms or chords to the column supports. Quantity is one each per connection location.

Refer to the following for condition state descriptions:

- Condition State 1: The element shows no deterioration.
- Condition State 2: Minor corrosion is present, but with no discernable section loss. Superficial damage to the element may exist, as may minor misalignments. The connection is solid and is performing the intended function with no loss in capacity. Faying surface contact (0.01 in) is >75%. DTI installation verification yields appropriate refusals per structural bolt connection.
- Condition State 3: Moderate damage, corrosion or misalignment is present, but does not warrant structural review. Faying surface contact (0.01 in) is between 50~75%. Connection is performing the intended function with no loss in capacity. DTI installation verification yields improper number of gap refusals per bolt on 5-20% DTIs of each connection.
- Condition State 4: Heavy damage or corrosion of elements with section loss. Cracks may be present that are active. Faying surface contact (0.01 in) is less than 50%. DTI installation verification yields improper number of gap refusals per bolt on >20% DTIs of each connection. Elements may be misaligned or have severe impact damage that warrants structural analysis to ascertain the impact on strength or serviceability, or a review has been completed and it has been found that the defects impact strength or serviceability.

4.2.3.7 Connection(s) - Splices for Columns, Chords, Arms (Element 8707)

Longer sign structures require several sections to be joined to span between supports. This joining of separate sections, which can be up to 40 feet long each, is accomplished through chord splices. Splice flanges, approximately twice the diameter of the chord members, are welded to the chords at the end of each of the frame sections. The sections are field bolted together at these splice flanges. To provide camber in the structure, filler plates are often used in the upper chord connections. The inspector should verify a camber or level chord system across the span. Splice flanges are the typical splice connection for all Wisconsin full span overhead sign structures. Refer to Figure 4.2.3-37 for an example of a splice in a four chord overhead sign structure.

Column splices may be present on taller two post supports of four-chord or tri-chord structures. The splice flange shall be inspected in the same manner as a chord splice with the inspector verifying bolt snugness, weld condition and flushness of the flanges.

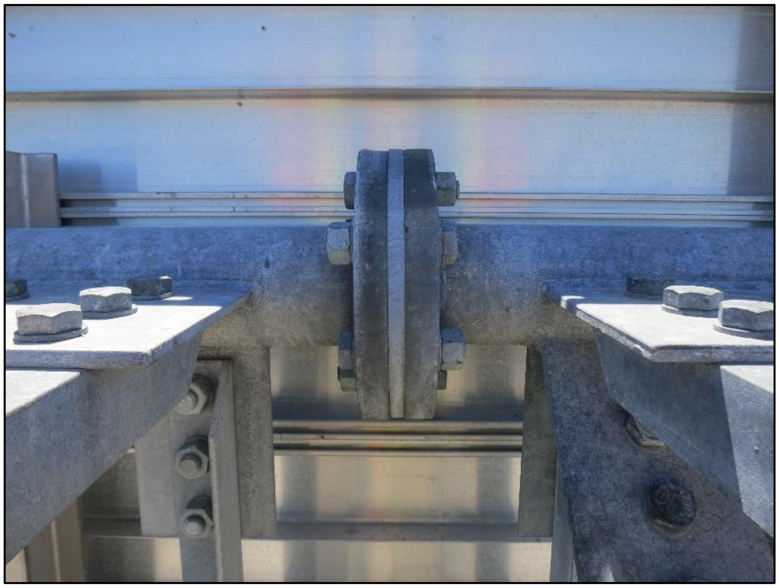

Figure 4.2.3-37: Four-Chord Truss Chord Splice with Filler Plate.

Mast arms over multiple lane roadways may require additional length. Due to fabrication length restrictions prohibiting the pipe to be constructed in one solid piece, an extension is provided that slides over the end of the mast arm. To prevent the extension from sliding off the end, a through bolt is installed through the overlapping joint. The inspector should verify slip joint bolt nut snugness and inspect the exposed seam weld of the extension pipe. Refer to Figure 4.2.3-38 and Figure 4.2.3-39 for a view of a slip joint and slip joint through bolt, respectively.

Figure 4.2.3-38: Slip Joint Extending Length of Mast Arm.

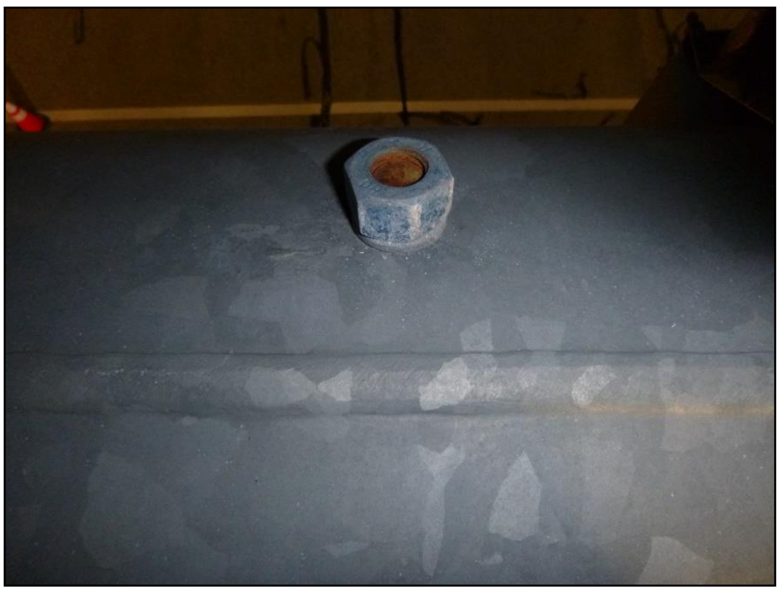

Figure 4.2.3-39: Slip Joint Through Bolt Nut Not Fully Engaged.

This element defines the splice(s) used to connect members together. Quantity is one each per connection location. The inspector shall pay close attention to proper bolt tightening, the use of filler plates between splice flanges (if present) and the circumferential welds between the chords and flange. The inspector shall note any looseness of extensions in slip joint connections.

Element Condition States

Below defines the Condition States specific to each element. The defects are expounded on and critical areas are discussed to aid the inspector in determining the severity of a defect.

The Condition States are comprised of general descriptions and uniquely colored to follow the severity the description represents. Condition states consider material and structural defects of the element.

- Condition State 1: The element shows no deterioration.
- Condition State 2: Minor corrosion is present, but with no discernable section loss. Superficial damage to the element may exist, as may minor misalignments. The connection is solid and is performing the intended function with no loss in capacity. Less than 5% of the connection Bolts/fasteners are loose or missing. Faying surface contact (0.01 in) is >75%. DTI installation verification yields appropriate refusals per structural bolt connection.
- Condition State 3: Moderate damage, corrosion or misalignment is present, but does not warrant structural review. Faying surface contact (0.01 in) is between 50~75%. 5~20% of the connection bolts/fasteners may be loose or missing, though the connection is performing the intended function. DTI installation verification yields improper number of gap refusals per bolt on 5-20% DTIs of each connection.
- Condition State 4: Heavy damage or corrosion of elements with section loss. Cracks may be present that are active. Faying surface contact (0.01 in) is less than 50%. Greater than 20% of the connection bolts/fasteners are loose or missing. DTI installation verification yields improper number of gap refusals per bolt on >20% DTIs of each connection. Elements may be misaligned or have severe impact damage that warrants structural analysis to ascertain the impact on strength or serviceability, or a review has been completed and it has been found that the defects impact strength or serviceability.

4.2.3.8 Overhead Sign Panels (Element 8708)

Reflective sign panels are either connected to catwalk L-brackets, or to sign panel hanger wind beams (vertical sign supports) with sign panel clips/connectors. Refer to Figure 4.2.3-40 and Figure 4.2.3-41 for a typical reflective sign panels. There are two categories of sign panels: Type I and Type II. Type I signs are comprised of extruded aluminum panels and are typically connected to the superstructure by vertical windbeams and sign panel connectors (discussed under element 4.2.3.10 Connection(s) - Overhead Sign Panel / Signal Heads (Element 8710)). Type II signs are smaller in size, comprised of plywood or flat sheet aluminum and typically connected to overhead sign supports by steel straps or brackets.

Sign panels should be visually inspected for peeling or delamination of the sign letters or sign backgrounds; loose sign edging; missing signs; and sign vandalism. When signs with defects are encountered, the deficient sign panel should be photographed or the message sketched with the location(s) of the defect(s) noted. Refer to Figure 4.2.3-42 through Figure 4.2.3-44 for typical sign defects.

Figure 4.2.3-40: Typical Type I Reflective Sign Panel.

Figure 4.2.3-41: Typical Type II Reflective Sign Panel.

Figure 4.2.3-42: Damaged Sign Panel with Reflective Coating Beginning to Tear and Peel (Condition State 2)

Figure 4.2.3-43: Damaged Sign Panel with Reflective Coating Missing and Fading (Condition State 3).

Figure 4.2.3-44: Sign Surface Cracked and Fading (Condition State 3)

Dynamic Message Signs (DMS) are located throughout major routes where heavy traffic and congestion are present. These signs are controlled from the State Traffic Operations Center (STOC). The messages displayed are typically drive time and accident reports. These messages are useful to the traveling public to warn them about delays along their path of travel. DMS's can be mounted to four-chord full span, or cantilever structures. The inspector shall verify the condition of the displayed message and note any missing burnt out bulbs or discrepancies in the display. The message should be clearly legible to all on-coming traffic. Refer to Figure 4.2.3-45 and Figure 4.2.3-46 for a typical DMS sign.

Figure 4.2.3-45: Typical Dynamic Message Sign.

Figure 4.2.3-46: Typical Dynamic Message Sign, Rear View.

This defines the overhead sign panel(s) of a sign structure. The rating shall include the legibility as well as condition of the panel(s). Quantity is one each per sign. The inspector shall indicate dimension(s) of the signs in notes for this element. All sign types installed along the horizontal structure members shall be evaluated under this element.

Element Condition States

Below defines the Condition States specific to each element. The defects are expounded on and critical areas are discussed to aid the inspector in determining the severity of a defect. The Condition States are comprised of general descriptions and uniquely colored to follow the severity the description represents. Condition states consider material and structural defects of the element.

- Condition State 1: The element(s) are present and show no deterioration. The sign is legible and up to current standards.
- Condition State 2: Minor loss of element legibility due to dulled paint or reflectorization. Minor deterioration may be present.
- Condition State 3: Moderate corrosion or damage may exist but not significantly affecting element legibility, nor stability.
- Condition State 4: Signs are illegible, or there is significant deterioration or damage to the sign panel that needs attention immediately.

4.2.3.9 Signal Head(s) (Element 8709)

Signal heads connected to the mast arm shall be inspected by the inspector to verify the signals are operating and functioning as intended. Typically the bottoms of signal heads on mast arms will be the points of lowest vertical clearance. Consequently, signal heads should be inspected for any indications of vehicular impact. The connection brackets attaching the signal heads to the mast arms shall be evaluated under the following element 4.2.3.10 Connection(s) - Overhead Sign Panel / Signal Heads (Element 8710).

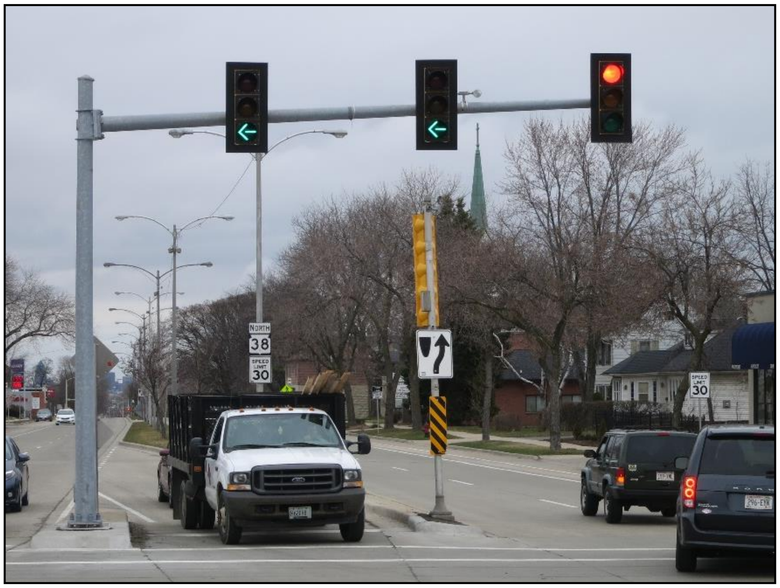

Figure 4.2.3-47: Signal Mast Arm with Three Properly Functioning Signal Heads.

This defines the signal heads on a structure. Quantity is one each per signal head.

Element Condition States

Below defines the Condition States specific to each element. The defects are expounded on and critical areas are discussed to aid the inspector in determining the severity of a defect. The Condition States are comprised of general descriptions and uniquely colored to follow the severity the description represents. Condition states consider material and structural defects of the element.

- Condition State 1: The element(s) are present and show no deterioration.

- Condition State 2: Minor deterioration and/or damage is present, but signal is still performing the intended function with no apparent loss in visibility.

- Condition State 3: Moderate deterioration or damage may be present. Signal head orientation is not in correct and should be adjusted. All bulbs appear to be functioning as intended.

- Condition State 4: Signal bulbs may be burned out, or orientation does not allow for signal to be used by traffic. There is sufficient damage to warrant analysis ASAP by Traffic Engineers.

4.2.3.10 Connection(s) - Overhead Sign Panel / Signal Heads (Element 8710)

Reflective sign panels are secured to windbeams or vertical hangers by sign panel connectors, commonly referred to as “SPCs” in the field. All sign panel connectors are to be inspected for deteriorated, missing or loose sign panel connectors. Note the number of deficient sign panel connectors and the total number of sign panel connectors under the element notes. The inspector should check by hand all SPCs for snugness. When loose connectors are encountered, the inspector should make all attempts to tighten the connector with a tied off wrench.

Dissimilar metal corrosion has been found on some sign panel connectors and bolts. Many aluminum sign panel connectors have had spilt nuts and broken studs. Each connector should be checked to ensure the stud is not broken (by trying to move the sign panel connector by hand). Current standards will have stainless steel studs and nuts. Furthermore, current design standards (state plate A4-6) state that when Type I signs are mounted over live traffic, sign panel connectors shall be installed on each side of the vertical windbeam on each extruded aluminum rib. Refer to Figure 4.2.3-48 for missing sign panel connectors on a Type I sign.

For butterfly structures, vertical sign mounting I-beams are U-bolted to the horizontal tubes to support the sign panel.

VMS’s are typically mounted to the space frame with U-bolts. Due to the weight of the unit, numerous U-bolts are used, and all are essential for proper mounting. Care should be taken to ensure that all U-bolts are installed with the nuts fully engaged and tight.

On older structures, catwalks may be present. The catwalks are secured to L-brackets which are fastened to the space frame of the sign structure typically with U-bolts.

Type II signs and signal heads are connected to mast arms with a variety of connections. Commonly, aluminum castings are strapped to the arm via stainless steel bands. Stainless steel U-bolts are found on smaller structures with thinner mast arms. When loose, fractured, or corroded connectors are encountered, the inspector should make notes within the report and attempt to tighten the connector if possible, also noting results within the report.

Monotube sign structures commonly have signal heads connected to the horizontal member via clamping connections. As monotubes tend to be more flexible when wind loaded, these connections may experience more intense cyclical loading and are commonly found to have fractured or failed connection components. Care should be taken to look closely at these overhead connections and as failures may result in the signal head falling onto traffic below. Refer to Figure 4.2.3-49 and Figure 4.2.3-50 through Figure 4.2.3-52 for examples of signal heads with deficient or failed connections.

This element defines the L-brackets, vertical hangers, horizontal braces, U-bolts, sign panel connectors, sign connection clamps, banding, and other structural members that mount the sign panels or signal heads to the structure. Quantity is one per vertical connection (e.g. Windbeam, Hanger, L-bracket, etc.)

Element Condition States

Below defines the Condition States specific to each element. The defects are expounded on and critical areas are discussed to aid the inspector in determining the severity of a defect.

The Condition States are comprised of general descriptions and uniquely colored to follow the severity the description represents. Condition states consider material and structural defects of the element.

- Condition State 1: The element(s) are present and show no deterioration.
- Condition State 2: Minor deterioration and/or minimal loose connections are present.
- Condition State 3: Moderate deterioration or damage may be present. Multiple connection components may not be fully functioning. Multiple loose/missing sign clips that could significantly affect the strength and/or serviceability.
- Condition State 4: Connection components may be cracked, sheared or missing. There is sufficient concern to warrant structural analysis to ascertain the impact on strength or serviceability, or a review has been completed and it has been found that the defects impact strength or serviceability.

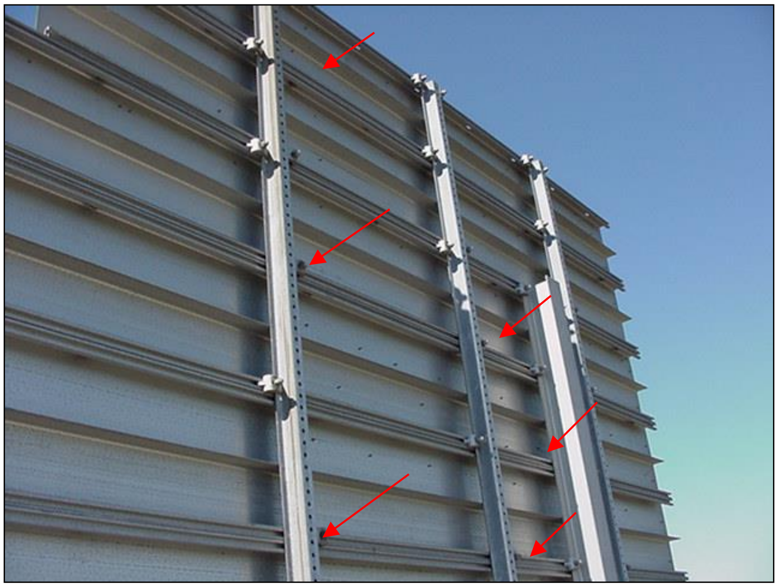

Figure 4.2.3-48: Missing Sign Panel Connectors (Condition State 4)

Figure 4.2.3-49: Monotube Sign Structure with Signal Heads Attached to Horizontal and Vertical Members.

Figure 4.2.3-50: Failed Bracket to Vertical Post Connection on Monotube Structure (Condition State 4)

Figure 4.2.3-51: Cracked Aluminum Signal Bracket (Condition State 4)

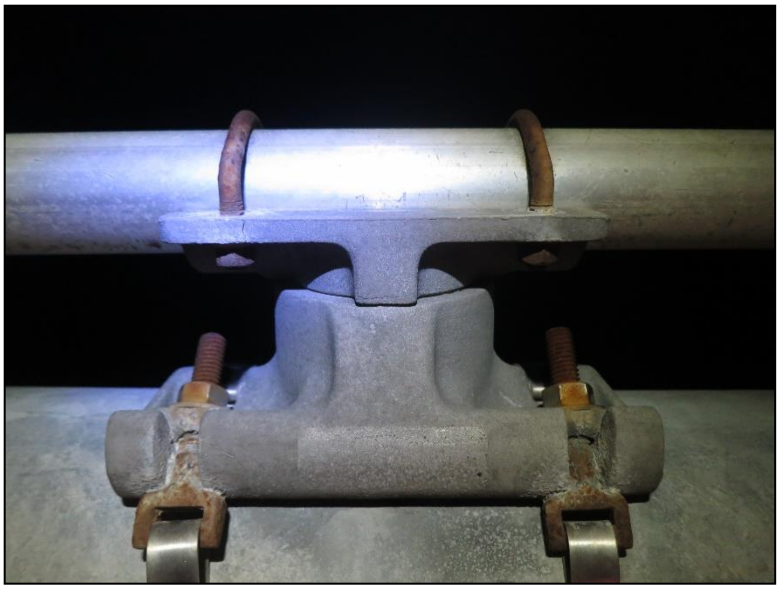

Figure 4.2.3-52: Moderately Corroded Bracket Bolts and U-Bolts (Condition State 2)

4.2.3.11 Luminarie Arm, Head, and Connections (Element 8711)

Luminaire arms, heads and connections are typically found on Mast Arm Structures

Inspection of the luminaire arm, head and connections should include a cursory inspection of the hand holes, if present, the material condition of the components and checking the snugness of all connections. Refer to Figure 4.2.3-53 for a luminaire base connection.

Figure 4.2.3-53: Signal Mast Arm with Luminaire Post Anchored to Top of Post. All of Luminaire is Inspected Under Element 8711.

This defines the connection, arm, and luminaire head on some signal and sign structures. Quantity is one each per assembly.

Element Condition States

Below defines the Condition States specific to each element. The defects are expounded on and critical areas are discussed to aid the inspector in determining the severity of a defect. The Condition States are comprised of general descriptions and uniquely colored to follow the severity the description represents. Condition states consider material and structural defects of the element.

- Condition State 1: The element(s) are present and show no deterioration.
- Condition State 2: Minor deterioration and/or minor loose connections are present.
- Condition State 3: Moderate damage or corrosion is present, but does not warrant structural review. Cracks may be present, but have been arrested or are no longer active.
- Condition State 4: Connection components may be cracked, sheared or missing. There is sufficient concern to warrant structural analysis to ascertain the impact on strength or serviceability, or a review has been completed and it has been found that the defects impact strength or serviceability.

4.2.4 Assessments

To provide additional refinement to the sign structure inventory, WisDOT also requires the inclusion and evaluation of secondary members or those components that if failing, missing or damaged would not necessarily compromise the structural integrity of the structure. All assessments observed on a sign structure shall be included, inspected and assigned an assessment state within the inspection report. All assessments are in units of each. Therefore the inspector shall evaluate each assessment as a whole taking into account the size of the particular assessment when determining the appropriate assessment state.

4.2.4.1 Aesthetic Treatment (Assessment 9010)

This assessment defines the conditions of the aesthetic coatings or treatments on a sign structure. Examples of aesthetic treatments include concrete staining, form liners and rustications. The inspector must be aware that this assessment is for the evaluation of the aesthetics on the structure but not the structural members; similar to the protective coating element.

Inspection of aesthetic treatments should include noting the type(s) of aesthetic treatments on a sign structure and locations of distress under the assessment notes. It is the inspector's task to examine each aesthetic treatment assessment and reasonably assign the most appropriate condition state to the whole assessment. Refer to Figure 4.2.4-1 for a concrete pedestal with multiple aesthetics.

This assessment defines the staining, form lining or other aesthetic treatments that may be found on a sign structure that is not part of the protective coating element for the superstructure elements. Quantity is one each per sign structure.

Figure 4.2.4-1: Concrete Pedestal Supporting Four-Chord Cantilever with Form Lined and Stained Concrete.

Refer to the following assessment states:

- Good: System is in good condition, with no notable issues.
- Fair: Aesthetic system is in fair condition, with some fading or discoloration. Minor issues.

- Poor: Aesthetic system is in poor condition, with fading or discoloration.

- Severe: Aesthetic system is in severe condition and is not functioning as intended.

4.2.4.2 Rodent Screen (Assessment 9200)

If electrical conduit or wires are present, the base plate must be wrapped with a rodent screen. The rodent screen should have no gaps between the base plate/screen interface, and the screen/concrete foundation interface. If the structure has electrical conduit or wires, and the base is missing the metal rodent screening, it should be noted in the inspection report. Refer to Figure 4.2.4-2 for an example of properly installed rodent screen.

Figure 4.2.4-2: Rodent Screen Around Base Plate of Sign Structure.

This assessment defines the presence and condition of the screen used to keep rodents from accessing the underside of the baseplate area.

Refer to the following assessment states:

- Good: Rodent screen is present and is in good condition.

- Fair: Rodent screen is present - it may have some damage or deterioration but it is performing the intended function.

- Poor: Rodent screen is present - it may have some damage or deterioration and is not performing the intended function.

- Severe: Rodent screen is absent on structures were it is required, or incorrectly installed where it does not function properly.

4.2.4.3 Miscellaneous Mounted Attachments (Assessment 9202)

This assessment defines the presence and condition of cameras, walk signals, miscellaneous signs, electrical boxes, traffic control counters, dampeners, etc. mounted to the structure, as well as connections for these items. Type II signs mounted to the vertical posts of the structure shall be evaluated under this assessment.

Inspection of VMS structures should include a cursory inspection of the electrical conduit throughout the structure. The conduit will be placed inside the space frame to house the electrical wires. All conduit should be securely fastened to the space frame members.

Current design practice is phasing out sign lighting due to the high reflectivity of the sign panels. However, several of the structures are equipped with luminaires to illuminate the sign panel(s). The inspection of the electrical components consists of a visual inspection of the luminaire fixture, junction boxes, and the conduits. The inspector should note any impact damage; non-working luminaires; broken or missing luminaire fixtures; broken or missing fixture covers; and rusted shut or broken cover latches. The electrical circuits for the lighting should be checked for exposed wiring; open electrical boxes; loose electrical boxes; loose, broken, or missing sections of conduit; and missing cover plates. The uni-strut should also be inspected for corrosion, broken connections to the L-brackets and overall strength to support the luminaires. Refer to Figure 4.2.4-3 for an example of a luminaire and Figure 4.2.4-4 for an example of a failed luminaire connection.

Refer to the following assessment states:

- Good: Components appear to be fully functioning.
- Fair: The element(s) exist and are performing the intended function. Minor corrosion or damage exists.
- Poor: Moderate damage or misalignment exists. The elements may be loose and need tightening.
- Severe: Element is missing, or is significantly damaged and not performing the intended function.

Figure 4.2.4-3: Typical Sign Structure Luminaire.

Figure 4.2.4-4: Failed Connections of a Luminaire to U-Bracket on a Butterfly Sign Structure (Condition State 4)

4.2.4.4 Handhole Covers and Caps (Assessment 9205)

All handhole covers and fasteners and column caps shall be inspected. Loose or corroded fasteners shall be noted under the assessment notes. Refer to Figure 4.2.4-5 and Figure 4.2.4-6 for an example of a handhole cover and column cap, respectively.

Figure 4.2.4-5: Handhole Cover Unsecured at Base of Signal Mast Arm Column (Condition State 3).

Figure 4.2.4-6: Column Cap for a Two-Chord Sign Structure.

This assessment defines handhole covers and caps for columns, chords, and mast-arms.

Refer to the following assessment states:

- Good: The element(s) are present and show no deterioration.
- Fair: The element(s) exist and are performing the intended function. Minor corrosion or damage exists.

- Poor: Moderate corrosion or damage exists. The element may be loose and need tightening.

- Severe: Element is missing, or is significantly damaged and not performing the intended function.

4.2.4.5 Catwalk/Handrail/Safety Chains (Assessment 9206)

Catwalks, handrails and safety chains are found only on larger older sign structures. This assessment will not be used on sign support structures.

Current design practice is phasing out the use of catwalks on structures; however, older structures still have catwalks in place. Catwalks should be visually inspected for collision impact damage; tripping hazards due to unequal grating elevations; missing or misaligned grating sections, and corroded connection bolts. Catwalks can usually be accessed from the supporting space frames; however, sometimes the sign extends beyond the end of the catwalk, making access difficult or impossible without the use of a bucket lift. Refer to Figure 4.2.4-7 and Figure 4.2.4-8 for views of a catwalk.

Handrails should be visually inspected for collision impact damage; gaps; missing hinge bolts and broken or misaligned locking pins. Handrails should be operated to ensure stability and proper operation. All handrails should always be equipped with safety end chains. Safety chains should be visually inspected for latches that are rusted shut; inaccessible safety chains (i.e. chains that are attached behind the signs); latches that cannot be opened; and chains that are corroded or missing.

This assessment defines the walkway gratings, handrails, safety chains, and connections on the structure.

Refer to the following assessment states:

- Good: The element shows no deterioration.

- Fair: Minor damage and/or deterioration may be observed. Handrails and locking pins may be misaligned. Safety chains may be deteriorated.

- Poor: Moderage deterioration and/or damage. Sections of gratings or handrails may be unstable, damaged or missing. Safety chains are missing, or inoperable. Handrails and locking pins may be inoperable.

- Severe: Significant damage or deterioration is visible that threatens separation of component from the structure. There is sufficient concern to warrant structural analysis to ascertain the impact on strength or serviceability, or a review has been completed and it has been found that the defects impact strength or serviceability.

Figure 4.2.4-7: Catwalk with Handrails in Collapsed Position.

Figure 4.2.4-8: Catwalk with Handrails in Upright Position.

4.2.4.6 Crash Protection (Guardrail, Barrier, etc.) (Assessment 9207)

Overhead sign structures are located throughout the state adjacent to heavily trafficked roadways. It is common for these structures' foundations and columns to be protected from errant vehicle impacts. The inspector shall visually inspect the condition and function of all crash protection adjacent to and protecting the structure. Sign structures located on bridge superstructures shall not include this assessment as the barrier is inspected during routine bridge inspections as its own element. Refer to Figure 4.2.4-9 for an example of a distressed crash protection system at the foundation of a sign structure.

Figure 4.2.4-9: Deteriorated Barrier Wall with Approach Guardrail Protecting the Foundation of a Butterfly Sign Structure (CS 2)

This assessment defines the state of devices used to protect the structure. Evaluate for a distance of no more than 50FT from the structure, or as deemed appropriate by the engineer.

Refer to the following assessment states:

- Good: The element shows no deterioration.
- Fair: Minor damage or deterioration is noted. Element is still performing its intended function.
- Poor: Minor damage or deterioration is noted. Element is still performing its intended function.
- Severe: Significant damage or deterioration is visible. There is sufficient concern to warrant structural analysis to ascertain the impact on strength or serviceability, or a review has been completed and it has been found that the defects impact strength or serviceability.

4.2.4.7 Structure ID Plaque (Assessment 9208)

Each structure should be marked with an Identification Number plaque. The plaque consists of an alphanumeric series, which identifies the type of structure, Region, and structure number. New structures and all lighting structures/appurtenances are also required to have an electrical circuit plaque. Refer to Part 1, Chapter 5 for an explanation of the numbering.

Figure 4.2.4-10: Structure ID Plaque on Column of Sign Mast Arm Structure.

This assessment defines the plaque used to identify the structure.

Refer to the following assessment states:

- Good: The element is present and show no deterioration.
- Fair: The element is present, but has minor deterioration.
- Poor: The element is present, though may not be installed in the correct location. The element may have moderate deterioration.
- Severe: The element is missing, illegible, or incorrect.

4.2.4.8 Protective Coating(s) (Galvanization, Paint, etc.) (Assessment 9209)

In general, overhead sign structures will be comprised of galvanized steel although painted coatings may also be observed in the field. Painted concrete columns supporting four-chord, cantilever and butterfly structures are not applicable under this assessment. Only protective coatings on metal components shall be coded and evaluated.

It is important for the inspector to evaluate the effectiveness of the coating. A loss of coating is, in effect, an indication of failure as it is no longer present and performing as intended. Therefore, it is the inspector's responsibility to evaluate the entire structure and apply the most appropriate element state to the condition of all protective coatings present. Refer to Figure 4.2.4-11 and Figure 4.2.4-12 for a view of galvanized steel protective coating. Refer to Figure 4.2.4-13 and Figure 4.2.4-14 for protective coatings on sign supports.

Figure 4.2.4-11: Galvanized Coating on a Steel Column of an Overhead Sign Structure. (Condition State 1).

Figure 4.2.4-12: Cracked, Chipped and Peeling Galvanized Protective Coating on a Four-Chord Upper Diagonal Member (Condition State 3)

Figure 4.2.4-13: Scraped Galvanized Coating at Base of Column Due to Impact. Bare Steel Exposed in Several Locations (Condition State 3).

Figure 4.2.4-14: Painted Coating on a Steel Signal Mast Arm Structure (Condition State 1).

This assessment defines the overall condition of the protective system(s) of the metal components of the structure.

Refer to the following assessment states:

- Good: The coating(s) are fully effective.
- Fair: The coating(s) are substantially effective, though small areas of peeling, dulling, bubbling or cracking of the coating may be present.

- Poor: The coating(s) have limited effectiveness and need touch-up work.
- Severe: The coating system has failed, and provides no protection to the underlying metal for a majority of the structure.

4.2.5 Recommended Inspection Procedures

The following general sequence can be used as a guideline for Traffic Operations Support System inspections:

1. Arrive at site and implement traffic control.
2. Identify structure number and record pertinent information.
3. Perform Inspection:
    - Base/Foundation; Grout pad; Anchor bolts, nuts and washers.
    - Base plate socket weld
    - Support pole or end frame.
    - Column to mast arm connection.
    - Repeat above two steps for other support, if applicable.
    - Span frame or member.
    - Sign(s)/Signal head(s) and connection members.
    - Catwalks, railings, and safety chains, if applicable.
    - Lighting, if applicable.
    - Obtain minimum vertical clearance measurement.
    - Obtain edge-of-lane to support distance and any other needed measurements.
    - Perform NDT on anchor bolts, if applicable.
    - Torque verification testing of anchor rod if not previously completed and noted within inspection report.
4. Review photographs and inspection notes to ensure completeness and correctness.
5. Remove traffic control and leave site.

For a full span sign structure, inspect both foundations prior to climbing. This procedure ensures that one is not forgotten after the structure is inspected. Climb and inspect the structure from left to right, this way the panel point numbers increase as the inspection proceeds. The inspector can either inspect the entire span, come back to inspect the catwalks and signs; or inspect half of the span, inspect the catwalks, etc., and then complete the other half of the span.

For a cantilever structure or a tri-chord span with a single post support, a bucket lift shall be used by the inspector to inspect the post, then to lift the inspector up to the truss section. Once there, the inspector can exit the bucket to inspect the space frame span by climbing or remain in the bucket in the case of two-chord and monotube spans. The connections of the span to the support can be inspected by climbing or with the bucket lift. The support post for this type of structure should be checked for plumb alignment. Any leaning should be recorded for monitoring of this misalignment at the next inspection.

Monotube structures are inspected with a bucket lift with a lane closure and traffic control. The foundations are inspected similar to other full-span sign support structures.

A bucket lift shall be used by the inspector to inspect the post, then to lift the inspector up to the post to mast arm connection and each sign/signal head. The support post for this type of structure should be checked for plumb alignment. Any leaning should be recorded for monitoring at the next inspection.

Structure-mounted frames will normally be inspected with a bucket lift and traffic control with possible lane closures. It may be possible to climb down onto the frame behind the sign from the bridge upon which it is mounted. However, this is usually only possible if the bridge is at a skew, creating a larger space between the sign and the bridge.

There are so few members to inspect for these supports that a sequence is not necessary. The inspection should include all frame components; L-brackets, lighting and accessories, bracket connections to the bridge, anchor or connecting bolts, and all signs and attachment hardware.

All members and connections of structure-mounted frames should be inspected as described above for similar components. In addition, the anchorage to the concrete must be checked for corrosion, bolt pullout, and cracked concrete.

For structure-mounted frames, the L-brackets support the sign catwalk and lights (if present). The L-brackets are connected to their supports with U-bolts. These U-bolts should be checked for tightness and full engagement of the nuts.

4.2.6 Initial Inspections

Due to the large number of sign structures and supports being installed throughout the State, a thorough initial inspection shall be performed prior to the contractor leaving the site. WisDOT has mandated these inspections due to past poor construction practices on installation procedures. These third-party inspections assist in verifying the correctness of the construction installation. Furthermore, a contractor punchlist is assembled and delivered to the Project Manager. This forces the contractor to correct all deficient items prior to project closeout. Currently, initial inspections should take place before traffic is under the structure to ensure safety to the travelling public. If this is not feasible, the inspection should take place within two weeks of erection. Major construction projects will install structures during certain stages of a project and may not have the correct signage for the final roadway pattern. WisDOT requires that these structures be inspected immediately after installation to ensure safety to the travelling public. Once the signs are replaced with the correct roadway pattern, the new sign connections must be inspected to ensure safety to the travelling public.

Many of the procedures for initial inspection are identical to the inspection procedures outlined in Section 4.2.5; however, special attention must be paid to the plan set, shop drawings, and design details. State details and specifications need to be checked for adequacy and correctness. In addition to the typical structural inspection, some of the details that the inspector should be cognizant of are as follows:

- Footing Elevation: Properly placed above the grade.
- Drainage: Water properly flows away from the foundation
  Water does not pond on the foundation/surrounding areas.
- Anchor Rods: Proper placement within foundation and installed plumb.
  Correctly tensioned.
- Stand-Off: Base plate is at proper elevation above foundation.
- Post Alignment: Erected plumb.
- Mast Arm Orientation: Installed with camber up.
- Truss Orientation: Installed per plan or shop drawing.
- Sign Connections: Proper material, amount, and spacing. Structural bolts are properly tensioned (using DTI's)
- ID Plaque Installed properly on structure, with correct ID noted.
- Rodent Screen For VMS and other structures with electrical connections, this must be installed.
- Vertical Clearance: Meets State minimum and maximum for the structure type.

Prior to inspection, certain WisDOT DT forms must be obtained by the inspection crew. These are as follows:

- DT2321: High Strength Steel Anchor Rod Installation Tensioning Record.
- DT2322: Ancillary Structures Pre-Installation Verification of High Strength Bolts

Other forms that should be completed by the contractor and available, but not required, for the inspector's information prior to the initial inspection:

- DT2113: Rotational Capacity Test/Record.
- DT2114: Pre-Installation Verification Test of High Strength Bolts.

These documents should be reviewed prior to the initial installation and attached to HSIS as a PDF attachment to the final report.