Evaluation of Overhead Support Inspection Program

Prepared by

Richard Gostautas
Infrastructure Group Leader
MISTRAS Group, Inc.

Douglas Nims, Ph.D., P.E.
Civil Engineering,
University of Toledo

Eric Steinberg, Ph.D., P.E.
Civil Engineering
Ohio University

Liangbo Hu, Ph.D., P.E.
Civil Engineering
University of Toledo

Ken Walsh, Ph.D.
Civil Engineering
Ohio University

Prepared for:
The Ohio Department of Transportation,
Office of Statewide Planning & Research

State Job Number: 134677
January 2015
Final Report

THIS PAGE INTENTIONALLY BLANK

Technical Report Documentation Page

1. Report No.	2. Government Accession No.	3. Recipient's Catalog No.
FHWA/OH-2015/2		

4. Title and Subtitle

Evaluation of Overhead Support Inspection Program

5. Report Date (Month and Year)

January 2015

6. Performing Organization Code

7. Author(s)

Richard Gostautas (MISTRAS Group, Inc.); Douglas Nims (University of Toledo); Eric Steinberg (Ohio University); Liangbo Hu (University of Toledo); Ken Walsh (Ohio University)

8. Performing Organization Report No.

9. Performing Organization Name and Address

MISTRAS Group, Inc.
195 Clarksville Road
Princeton Junction, NJ 08550

10. Work Unit No. (TRAIS)

11. Contract or Grant No.

SJN 134677

12. Sponsoring Agency Name and Address

Ohio Department of Transportation
Research Section
1980 West Broad St., MS 3280
Columbus, OH 43223

13. Type of Report and Period Covered

Final Report

14. Sponsoring Agency Code

15. Supplementary Notes

Prepared in cooperation with the Ohio Department of Transportation (ODOT) and the U.S. Department of Transportation, Federal Highway Administration

16. Abstract

This study evaluated the adequacy and frequency of the current structural support inspection program for overhead sign supports (including bridge mounted), mast arm signal supports and high mast light supports. While ODOT provides statewide guidance to all 12 districts with regards to support inspection, each district may implement different procedures to meet the needs of the representative district, as along as state requirements are met. To assess the current program, a detailed, hands-on inspection was conducted on 202 supports. These results were then compared to the previous ODOT inspection results which uses a ground based, visual inspection process with sounding of the anchor bolts by hammer. The hands-on inspection process found almost 1.87 times more deficiencies. While the majority of them would have likely been observed under the current ODOT process, some deficiencies observed during the field inspections would not have been observable from the ground. Additionally, it was observed that the different inspection procedures used by each district often produced inspection reports that varied in the amount information and level of detail collected during inspection. Overall, there was no evidence that indicated the current ground based, visual inspection process, or that the maximum 5 year inspection frequency, with regards to overhead sign suppports, was inadequate and should be changed at this time. Subsequent recommendations were made to address the inventory process and inspection procedures for each type of support and considers the need to establish the current condition (i.e. structural adequacy) of every support in the ODOT inventory at the time of inspection.

17. Key Words

Overhead sign supports, bridge mounted supports, high mast lights, signal supports, support inspection, inspection adequacy, inspection frequency, field inspection, condition assessment.

18. Distribution Statement

No restrictions. This document is available to the public through the National Technical Information Service, Springfield, Virginia 22161

19. Security Classif. (of this report)	20. Security Classif. (of this page)	21. No. of Pages	22. Price
Unclassified	**Unclassified**	**134**	**$ 702,301.00**

Form DOT F 1700.7 (8-72) **Reproduction of completed pages authorized**

Disclaimer

The contents of this report reflect the views of the author(s) who is (are) responsible for the facts and the accuracy of the data presented herein. The contents do not necessarily reflect the official views or policies of the Ohio Department of Transportation or the Federal Highway Administration. This report does not constitute a standard, specification, or regulation.

Abstract

Evaluation of Overhead Support Inspection Program

The goal of this study was to evaluate the adequacy and frequency of the current structural support inspection program for overhead signs (including bridge mounted), mast arm signal supports and high mast light supports. The Ohio Department of Transportation (ODOT) maintains over 6,000 support structures for overhead signs, signal and high mast lighting within the State of Ohio. An essential part of this program is the routine inspection and maintenance of these support structures in a manner that ensures the safety of the traveling public and yet is efficient and economical. The research team reviewed the existing program for three categories of supports:

1. Overhead Sign Supports (OSS) - currently inspected qualitatively from the ground at least once every 5 years;
2. Bridge Mounted Supports (BMS) – typically inspected qualitatively from the bridge deck during annual bridge inspections;
3. Signal Supports (SS) - functionally inspected annually and this inspection includes an inspection of the support foundation and structure;
4. High Mast Lighting Supports (HMLS) - maintained for function on a routine basis. Incidental observations of the structure may be made during the maintenance.

Presently, ODOT provides statewide guidance for inspection of overhead sign and signal supports. This includes a visual inspection of the structure, which is conducted from the ground, and sounding of the anchor bolts with a hammer as part of this routine inspection process. Statewide inspections are handled by the 12 ODOT districts, in compliance with the state requirements, but the procedures vary from district to district.

To assess the current condition of the supports, detailed, hands-on, arm's length inspections were conducted on 202 supports (129 OSS, 48 SS and 25 HMLS) in 10 of the 12 districts. Prior to the detailed inspection, contact with each District was made to acquire their inspection information and to become familiar with each district's inspection programs. Field inspections (hands-on) were performed by inspectors familiar with structural inspection, certified in several nondestructive testing (NDT) methods and used bucket trucks and/or inspectors certified in rope access. To ensure the detailed inspections were carried out systematically, the existing ODOT inspection form was modified and used for all the detailed inspections. The results of the detailed inspection and ODOT's most recent inspection were compared.

Based on the comparison between previous ODOT inspection results and the detailed, hands-on inspection results, the current ODOT inspection program was assessed for adequacy and frequency and subsequent recommendations made. The recommendations address the inventory process and inspection procedures for each type of support and considers the need to establish the current condition (i.e. structural adequacy) of every support in the ODOT inventory at the time of inspection.

Acknowledgements

Funding for this project was provided by ODOT. The ODOT Technical Panel members who guided this project were Jim Roth, P.E., Signing Engineer, Office of Traffic Operations and Dave Holstein, P.E., Administrator, Office of Traffic Operations. Additionally, members of the traffic department of several districts, particularly Dylan Foukes, P.E., Traffic Engineer from ODOT District 02, provided valuable background information. The researchers gratefully acknowledge the funding and appreciate how many members of the ODOT staff have graciously and enthusiastically shared their knowledge and insights concerning support inspection.

Hands-on field inspections were conducted by personnel from Mistras Group, Inc. Wayne Starcher, of the Mistras Office in Heath, Ohio, was the team leader and his leadership and expertise was invaluable. Richard Martinko, P.E., of the University of Toledo - University Transportation Center provided administrative oversight and guidance.

Several graduate students made significant contributions to this project. Hamed Ghaedi of the University of Toledo worked with Mistras on the inspections of the sign and signal supports in the north and west of the state and generated the initial report on the sign supports. Allan Domalski of the University of Toledo worked with Mistras on the high mast light supports and was the general editor of this report. Paul Leduc of Ohio University worked with Mistras on the inspection of supports in the south and east of the state. Completion of this work would not have been possible without the efforts of these students.

The team would like to extend our deepest appreciation and thanks to engineers in each District that were able to provide time to meet with team members to discuss their OSS, SS and HMLS programs and processes. All were helpful, insightful and forthcoming. Nothing is more useful to a researcher than when they ask a question and the answer is, “That’s a good question, but here is a more meaningful question.” And, the better question gets a thorough answer.

Table of Contents

Table of Figures

List of Tables

1 Introduction

1.1 Problem Statement

It is the responsibility of the Ohio Department of Transportation (ODOT) to ensure that the supports for overhead signs, signals and high mast lights in Ohio safely perform their design function. Recent support failures in Ohio, and nationally, have called attention to the performance of these structures. Many states are dealing with the issue of the aging inventory of supports and may be a potential root cause of previous failures. These states include Indiana, Iowa, Kansas, Maine, New York, and Virginia. However, routine inspection can successfully detect potential degradation and failure of supports before becoming a hazard. A successful example of this inspection process was detection by ODOT of the truss failure of the Dayton I-75 overhead sign. As such, the support was able to be removed without incident [1]; ensuring these supports continue to operate safely, reliably and economically is the primary goal of any inspection, inventory and assessment program.

While a formal inspection program exists for overhead sign supports (OSS), including bridge mounted supports (BMS), there are limited formal structural inspection programs for signal supports (SS) and high mast light supports (HMLS). For SS, they are part of an overall state wide program to ensure their functionality, but each district implements inspection of signals independently. In regards to HMLS, each district has their own procedure, which is often carried out as part of annual maintenance of the lighting. When the failure of SS or HMLS could endanger the traveling public or cause delays, the supports need to be inspected, inventoried and their reliability assessed. As such, ODOT wished to evaluate the adequacy and frequency of the current qualitative ground based inspection program that is conducted on 5 year intervals for OSS.

This evaluation examined the structural inspection procedures for OSS, BMS, SS and HMLS to determine if the current procedures needed to be revised and/or updated to address the aging support population and to develop (if needed) an unified, organized, and systematic inspection program appropriate to each type of support.

1.2 Goal

The overall goal of this research is to develop inspection recommendations that specify the frequency and methodology of inspections for the supports. The inspection procedures developed will allow ODOT to economically assess the condition of individual structures as well as collect data in an appropriate format for system wide inventory management, risk assessment, and maintenance planning.

1.3 Objectives

The objectives for this research included:

1. Reviewing the support inventory and inspection process of FHWA, AASHTO and other states;

2. Reviewing the current ODOT inventory and inspection processes for each type of support considered in this study for comparison to the processes used by other states and agencies;
3. Assessing the current ODOT inspection process by selecting and conducting inspections of 202 supports across the state using the ODOT process and a modified inspection process, including the use of NDT methods;
4. Assessing the condition of the supports by reviewing the previous inspection reports and comparing to the field inspection results;
5. Based on objectives 1 through 4, providing results and recommendations (as needed) in regards to the adequacy and frequency of inspection, inventory control, inspection procedures and record keeping for each type of support.

1.4 Research Approach

A direct hands on approach to meeting each of the objectives was taken by identifying a population of supports for field inspection, performing an in-depth inspection for each type of support, comparing the previous inspection reports with the results from the hands-on inspection, and assessing if the existing inspection process accurately captures the current condition of the support. This was accomplished under the following steps:

1. To better understand the ODOT inspection process, along with the processes and recommendations used by other states, and agencies, the inspection manuals and written procedures from other states, FHWA and ASSHTO were reviewed. This was accomplished by reaching out and speaking with staff members from the FHWA and other state DOTs. Additionally, research team members spoke with AASHTO, Subcommittee on Bridges and Structures, T-12 Structural Supports for Signs, Luminaries, and Traffic Signals committee members to gain a national perspective. This led to contacts in Iowa and Kansas, both of which have well-developed inspection processes and inventories.
2. Subsequent interviews were then conducted with traffic personnel in most ODOT districts in order to review inventory, obtain samples from previous inspection reports, and discuss inspection processes. Overall, it was determined that:
    a. For overhead sign supports, ODOT maintains a general sign support inspection report form (Form 296-4). While most districts have modified the form to suit the needs of that district, the personnel and inspection procedures may vary from district to district. In regards to inventory control, each district has a separate process for inventorying different support types;
    b. In the matter of bridge mounted supports, these types of supports are considered separately and are expected to be inspected annually by the bridge inspectors. These reports are kept with the bridge inspection files;
    c. Signal supports are handled separately and are generally inspected as part of the overall inspection of the signal. The primary focus of the signal inspection is to ensure signal functionality. These records are kept in ODOT Central Office;
    d. High mast light supports are also handled separately. For the districts interviewed, there was no formal process in place to inspect high mast light supports for structural deficiencies. Current practices ranged from a yearly maintenance

involving the lowering of all luminaries to replace any burnt out bulbs, to a weekly visual inspection to look for burnt out luminaries.

3. The condition of the supports discussed in this report were determined by in-depth, hands-on inspection of 202 supports (OSS, BMS, SS and HMLS) throughout the State of Ohio. Meetings with each district assisted in selection of an appropriate sample size for each support type and review of each district's inspection process. Additionally, basic direction on most aspects of support inspection from the FHWA Manual [2] and AASHTO Standard Specifications for Structural Supports for Highway Signs, Luminaires and Traffic Signals [3] includes:
    a. Identify flaws with visible and detectible indications with an in-depth, hands-on inspection procedure;
    b. Evaluate the current condition of sign supports using an organized and systematic method of inspection;
    c. Ensure the inspection process is economical as possible without compromising safety by minimizing the frequency of inspection and obstruction of traffic.

    Prior to start of the field inspections, a modified inspection form was created by Mistras and was based off the current ODOT Form 296-4. The modified form expanded the amount of information collected during a typical inspection, and instituted procedures used by other state DOTs. These additional procedures looked at the use of a rating system and other nondestructive testing (NDT) methods for assessing the condition of the support. These additions provided an opportunity to compare and assess the information collected against previous inspection reports and determine the impact (if any) on the support condition assessment, impact on inspection time and efficiency. All inspections used the modified form for each type of support and was conducted as follows:
    a. OSS, BMS and SS: Maintenance-of-traffic (MOT) was put in place, followed by an initial visual inspection and then hands-on inspections. Inspections were conducted from the ground, bucket/lift truck and/or use of rope access. This process provided arms-length inspection of most components for each type of support, with the latter providing access to locations, such as upper post arm connections, truss welds, etc., which may not be easily viewed or accessed from the ground.
    b. HMLS: Due to general locations of HMLS, no MOT was needed for these inspections. Following the same inspection procedures, foundations, plate-to-post weld connections, lower post area near the ground and anchor plates were inspected. In Districts 2, 7 and 12, every anchor bolt was inspected with ultrasonic testing (UT) and all anchor bolt buts tested with a wrench for general tightness. In Districts 5 and 6, the masts were on the ground and allowed for full length inspection.

    In concert with the development of the modified inspection form, a modified inspection procedure was developed and Mistras personnel trained on the procedures for field inspection. All personnel have extensive experience in inspection, primarily refinery inspections, with multiple certifications in a variety of NDT and access methods. This experience and cross training helped provide a systematic and organized approach to the inspection of each support. All results were recorded using the modified inspection form and photos submitted for each inspection. When possible, a comparison of the results from ODOT previous inspection reports and Mistras inspection reports was performed on the data gathered from the field.

The initial plan had been to do a random study for all supports. However, due to the state of the inventory and logistics within different districts, this was not always possible. Therefore, it is impossible to draw valid statistical inferences about the conditions of the overall populations of each type of support based on the sample inspected.

4. Based on the results of completing items 1 through 3 above, a set of recommendations were developed. They are based on the review of the processes in other states, research, interviews, a comparison of the ODOT inspection reports and Mistras inspection results with insight provided by Mistras based on inspection procures in other industries.

   All these tasks are aimed at developing an inspection procedure that assessed the current state of health of the supports, enabled comparison between the existing inspection records and an in-depth inspection and collected the data in a way that lends itself to inventory management and reliability assessment

1.5 Report Organization

The recommendations in this report are based on a summary of the inspection reports and a synthesis of the summary of the inspection reports presented here and practices of other states. An in-depth view of the work presented here requires access to the inspection database and is available through the ODOT Office of Research. The report is organized in the following manner:

- Chapter 1 – Introduction: A brief description of the scope of this study;
- Chapter 2 – Background: An introduction to the different types of supports and a literature review of the past studies;
- Chapter 3 – ODOT Support Inspection Program: A review of the current ODOT inspection program conducted by each District;
- Chapter 4 – Field Inspection Program: Providing a new detailed method of support inspection which is conducted by Mistras during inspections. Also a brief discussion of project tasks is presented;
- Chapter 5 – OSS/BMS Inspection Results;
- Chapter 6 – HMLS Inspection Results;
- Chapter 7 – SS Inspection Results;
- Chapter 8 – Discussion, Recommendations, Benefits and Implementation;
- Chapter 9 - Review of Supports with a Critical Rating
- Chapter 10 – Conclusions;
- Chapter 11 – References;
- Appendices.
    - Appendix A – Sample of Past and Current Inspection Forms
    - Appendix B – Sample of ODOT Inspection Reports
    - Appendix C – Mistras Inspection Procedures Using Modified Inspection Report

- Appendix D – Mistras Company/Certification Information

In addition to the report, the following data and summaries have been submitted electronically to the Office of Research. The data is archived by the ODOT and is available through the ODOT Office of Research website where a link to the data and summaries may be found [4], including this final report. This information includes:

1. UT Database of Reports.xlsx
   a. This is an excel sheet containing the results from all inspections performed by Mistras and The University of Toledo;
2. OU Districts.xlsx
   a. This is an excel sheet containing the results from all inspections performed by Mistras and Ohio University;
3. ODOT Mistras Comparison Table.xlsx
   a. This is a table comparing the results of former ODOT inspections and the inspections performed by Mistras and the University of Toledo;
4. UT-North Inspection Reports Database
   a. This folder contains electronic copies of all inspection reports performed by Mistras and the University of Toledo;
5. Inspection Reports – South
   a. This folder contains electronic copies of all inspection reports performed by Mistras and Ohio University.

2 Background

2.1 Introduction

The use of overhead sign structures, traffic signals and high mast lights are quite common throughout the state of Ohio and around the country. OSS are usually used on highways and roads with high volume of traffic, where there is a need to have a higher level of sign visibility. Overhead supports can also be used for other type of traffic utilities such as traffic signals or high mast lights. AASHTO Standard Specifications for Structural Supports for Highway Signs, Luminaires and Traffic Signals specifies all structural design specifications for overhead supports.

Corrosion and fatigue inexorably diminish the capacity of support structures. The failures that have occurred may reflect unusually adverse condition, past vehicular impacts or inordinately deleterious environments. It is also possible, that failures simply reflect normal aging, and that of an increasing proportion of the large population of the existing supports that are failing due to accumulated damage due to corrosion or fatigue. To protect the safety of the public, the support structures must be regularly inspected and properly maintained.

2.2 Support Types

All types of sign supports, including but not limited to box truss, cantilever, bridge-mounted supports, monotube, butterfly, span wire, semi-overhead sign supports, as well as signal supports and high mast lighting should be periodically inspected according to the ODOT Traffic Engineering Manual [5]. This study focuses on three major types of supports: overhead sign supports (including bridge mounted), signal supports (single, dual arm) and high mast lights. The following sections provide a brief description of each support type along with a sample of the ODOT standard drawing.

2.2.1 Cantilever Arm Supports (OSS)

Figure 2.1 Dual arm cantilever sign

Cantilever arm supports (Figure 2.1) include single mast arm supports and dual arm cantilever supports. The horizontal cantilever arm is supported by a vertical pole mounted on the ground, barrier or bridge. Single arm cantilevers typically hold one or more small signs where dual arms may hold one large or two medium size signs. Figure 2.2 is a sample of a single arm cantilever sign support detailing used by ODOT.

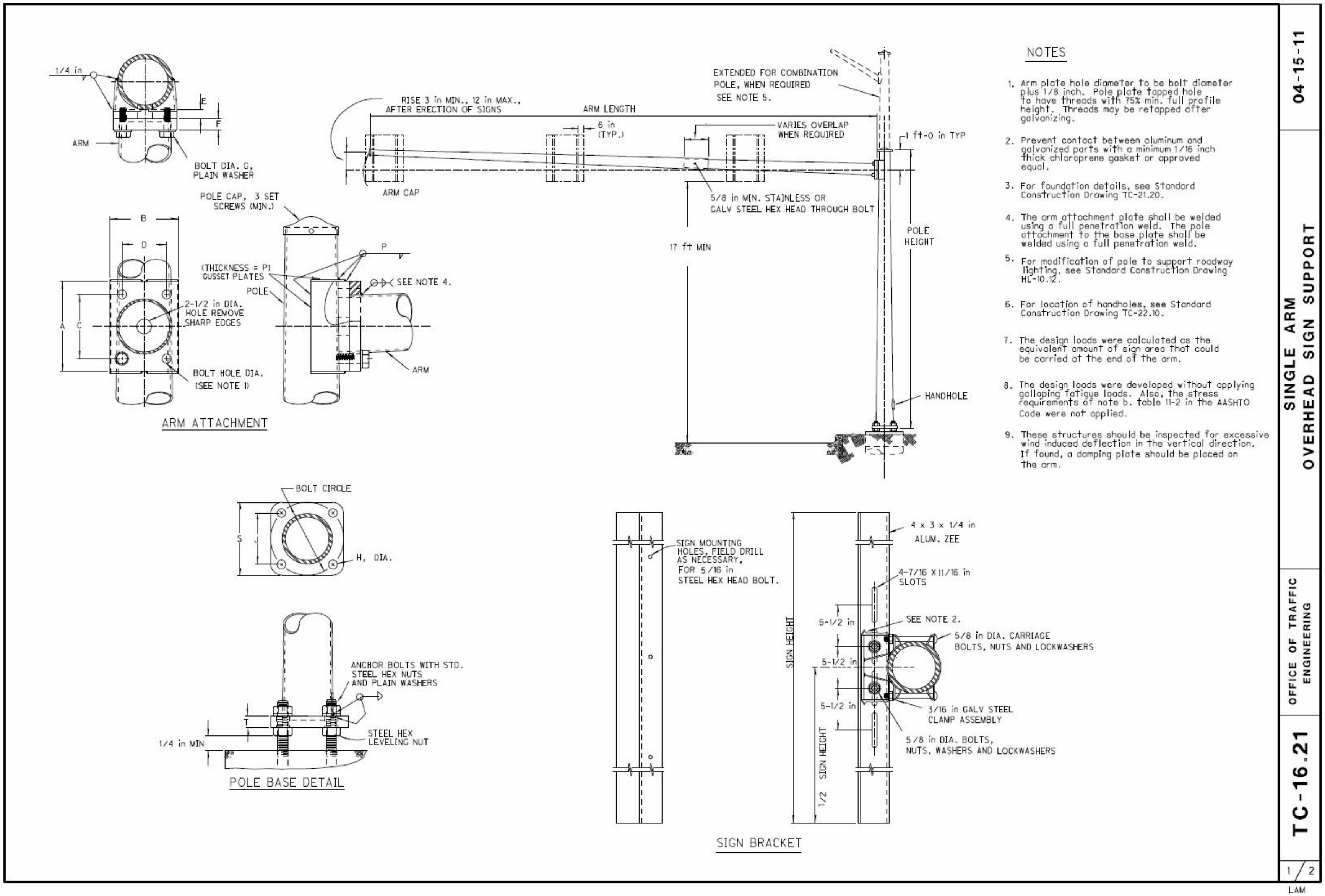
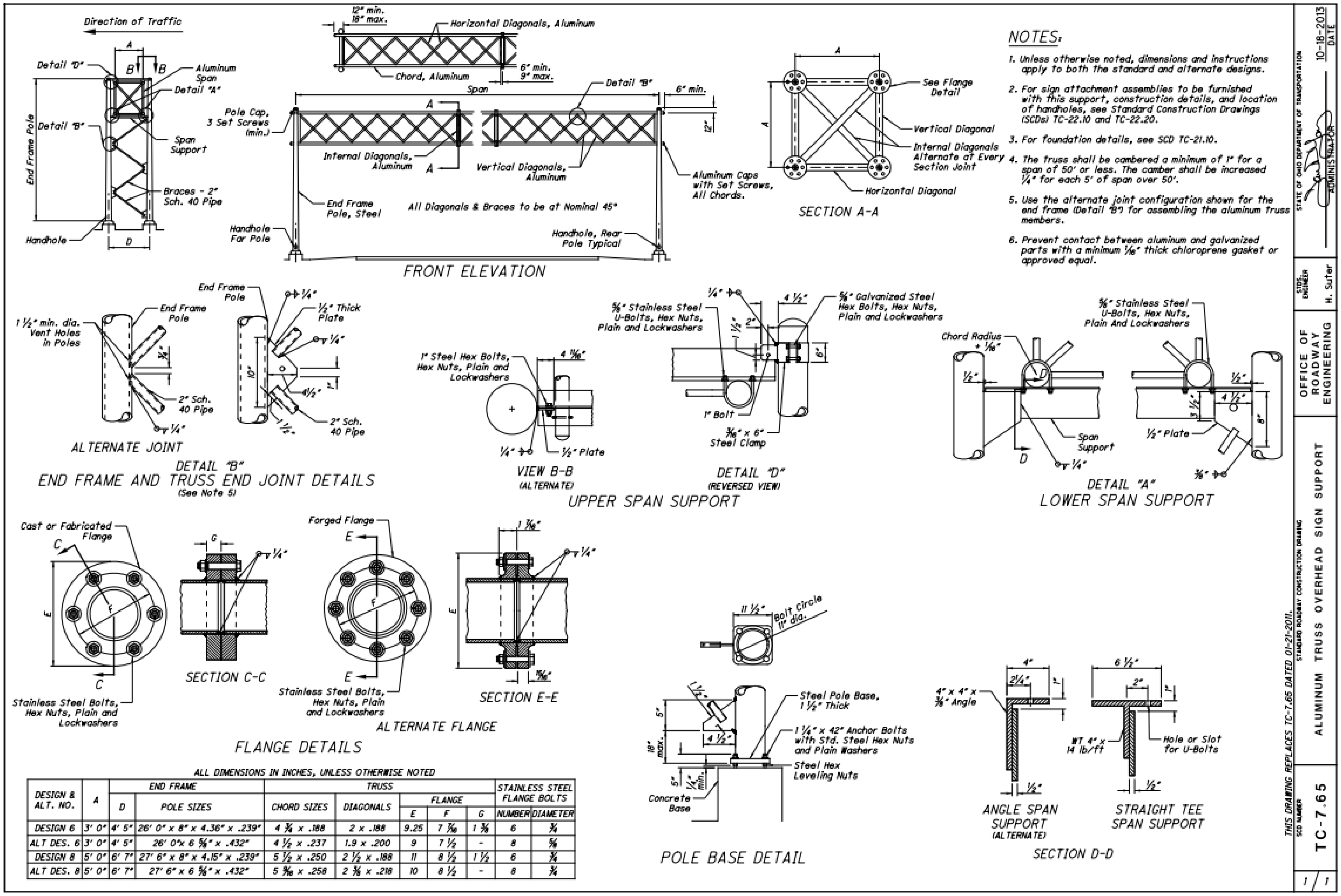


Figure 2.2 Sample of overhead single arm cantilever support detailing

2.2.2 Box Truss Supports (OSS)

Figure 2.3 Box truss Support

Box truss supports (Figure 2.3) consist of four horizontal chords mounted on 2 vertical posts at each end with long span length (usually over several traffic lanes). The vertical support is made of steel and the horizontal truss made of steel or aluminum; with aluminum being most common. Figure 2.4 is the standard drawing of ODOT box truss support.



ALL DIMENSIONS IN INCHES, UNLESS OTHERWISE NOTED

DESIGN & ALT. NO.	A	END FRAME		TRUSS					STAINLESS STEEL FLANGE BOLTS	
		D	POLE SIZES	CHORD SIZES	DIAGONALS	FLANGE E	FLANGE F	FLANGE G	NUMBER	DIAMETER
DESIGN 6	3' 0"	4' 5"	26' 0" x 8" x 4.36" x .239"	4 3/4 x .188	2 x .188	9.25	7 7/16	1 3/8	6	3/4
ALT DES. 6	3' 0"	4' 5"	26' 0"x 6 5/8" x .432"	4 1/2 x .237	1.9 x .200	9	7 1/2	-	8	5/8
DESIGN 8	5' 0"	6' 7"	27' 6" x 8" x 4.15" x .239"	5 1/2 x .250	2 1/2 x .188	11	8 1/2	1 1/2	6	3/4
ALT DES. 8	5' 0"	6' 7"	27' 6" x 6 5/8" x .432"	5 9/16 x .258	2 3/8 x .218	10	8 1/2	-	8	3/4

Figure 2.4 Sample of box truss detailing

2.2.3 Bridge Mounted Supports (BMS)

Figure 2.5 Bridge mounted sign (Flush)

Figure 2.6 Bridge mounted sign (support mounted on barriers)

Bridge mounted signs (Figure 2.5 and 2.6) are used to direct the moving traffic both in the direction of bridge and the road beneath the bridge. Typically, there are two types of bridge mounted supports: flush/skewed sign supports and barrier mounted sign support.

A flush/skewed support is mounted on the outside of a bridge and faces traffic passing under the bridge structure. A barrier mounted support is mounted on the bridge structure and faces traffic traveling over the bridge. Figure 2.7 provides a detail of an example of a flushed bridge mounted sign.

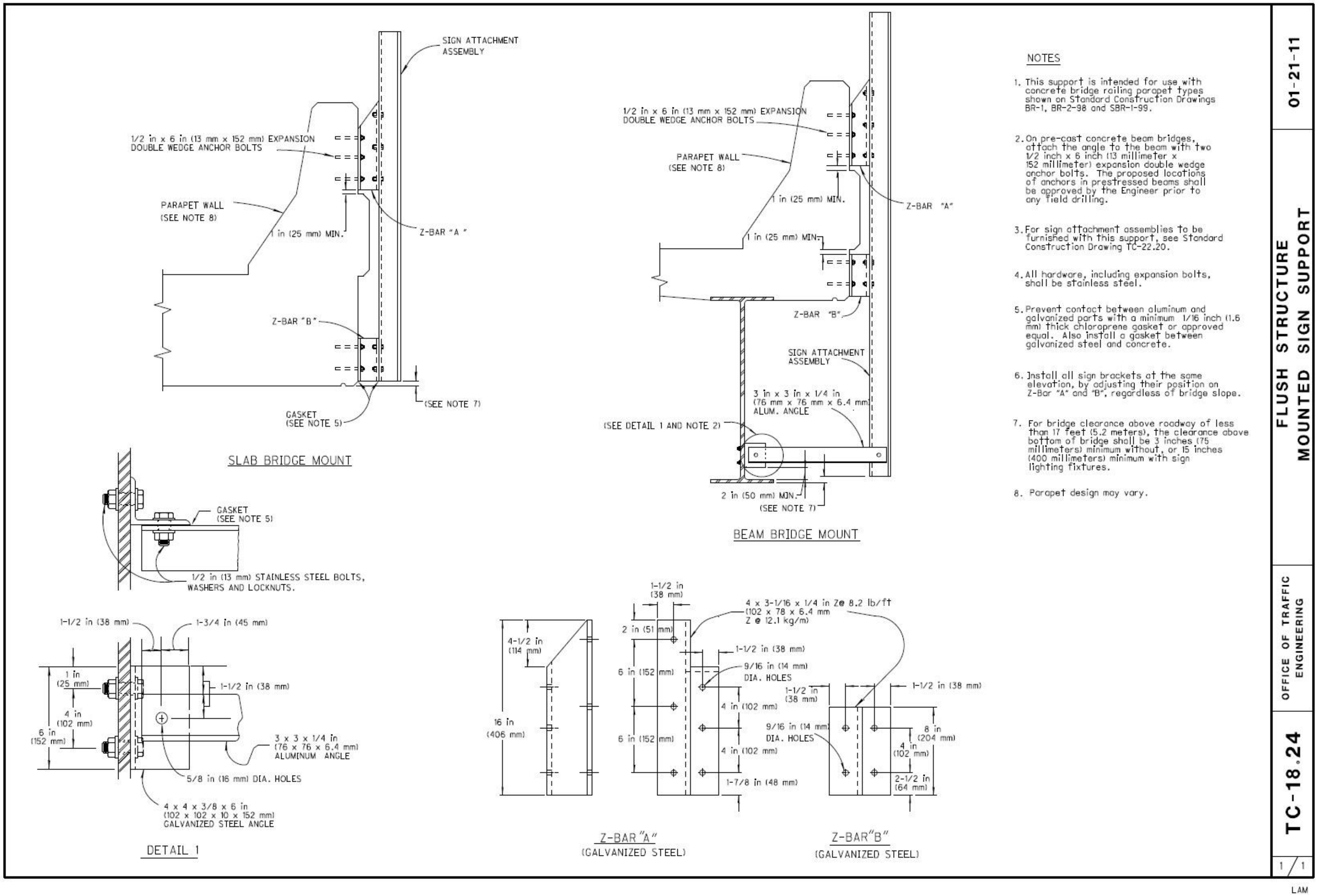


Figure 2.7 Bridge mounted sign detailing (Flush)

2.2.4 Mast Arm Signal Supports (SS)

Figure 2.8 An Example of a Single Mast Arm Signal Support

At intersections, traffic signals are typically mounted along a single mast arm cantilever and attached to an end post (Figure 2.8). Depending on the intersection, signal supports may include multiple mast arms to accommodate different directions of traffic. These supports consist of the same components as cantilever sign supports, and are attached to an end post. The end post is anchored to a concrete foundation by bolts. Figure 2.9 provides a detail of an example of a single arm (cantilever) overhead signal support.

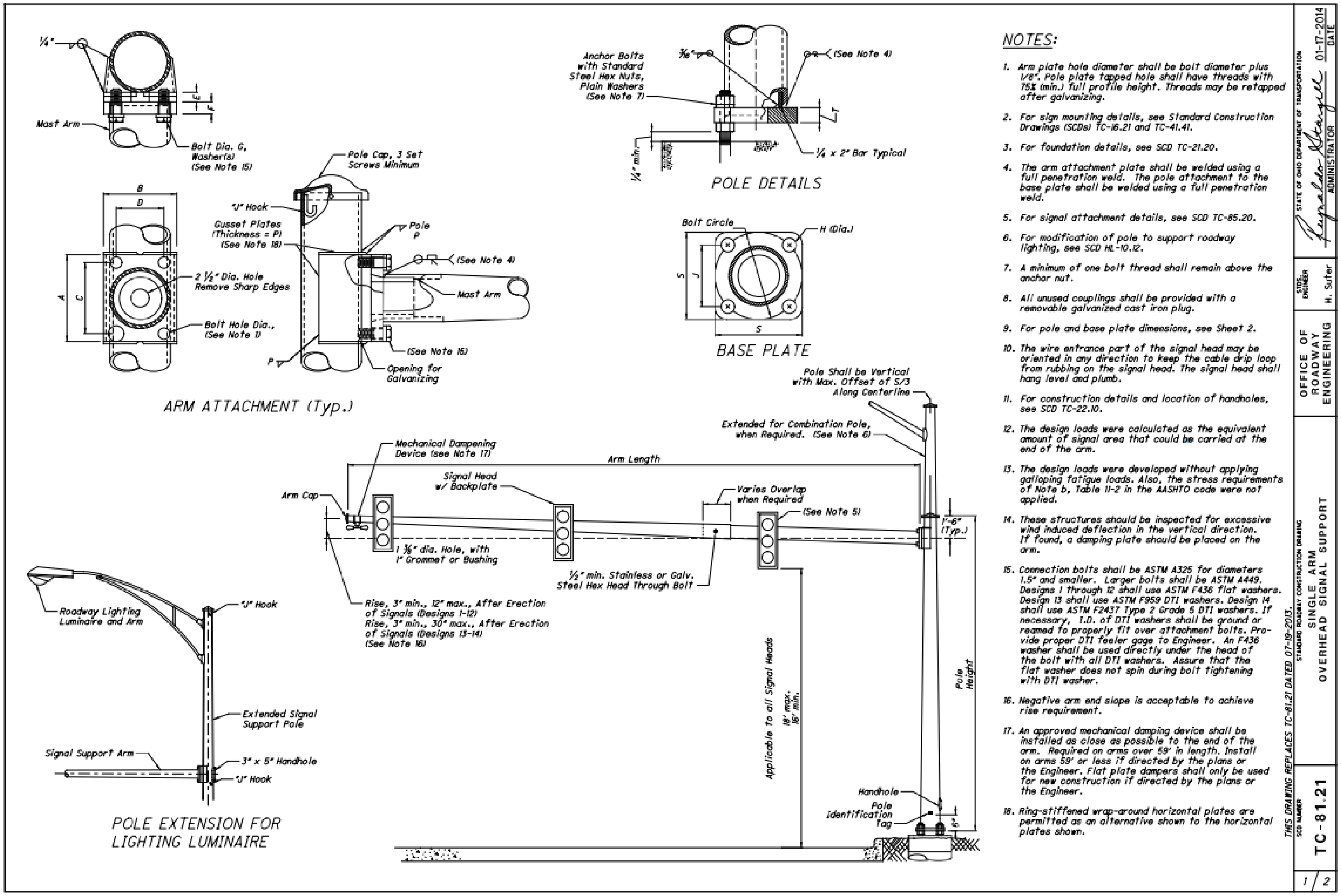


Figure 2.9 Single arm overhead signal support detailing

2.2.5 High Mast Light Supports (HMLS)

Figure 2.10 High Mast Light Found Near Toledo, Ohio

High mast lighting consists of a support structure (typically over 100’ tall) that is used to support luminaries (Figure 2.10), especially around limited access roadways such as interstates and other freeways. These lights are typically located in the grass median, or in the infield around interchanges. The supports are constructed from sections of galvanized steel tubing slip fit onto one another and bolted to a concrete base using four to six anchor bolts.

2.3 Literature Review

The Federal Highway Administration (FHWA) guidelines contain basic direction on most of the aspects of support inspection and these were used to identify critical types and structural areas of inspection. The researchers reviewed the inspection program of other states with similar issues. Some nearby states (Indiana, Virginia, New York, and Kansas) have done similar studies and the issue is of federal concern. Following is a brief discussion of reviewing inspection procedure of the four states above.

2.3.1 Indiana Study

In a study performed by Xuejun Li, Timothy Whalen, and Mark Bowman from Purdue University [6, 7], the investigation looked at the fatigue life of critical elements of typical overhead sign supports under different type of wind loads. These types of supports often have a very low natural frequency due to long span lengths, and a small cross-sectional area. As such, the supports can become very susceptible to large amplitude vibration during wind loading events and increased potential for subsequent fatigue cracking. This highlights the importance of periodic support inspections to assess potential issues. In Indiana, there is no formal inspection procedure to guide inspection of overhead sign supports. In this study the authors wanted to develop an inspection manual, including procedures and inspection intervals, based on fatigue criteria. This required an investigation of typical sign supports, subjected to different wind loadings, to study and assess the fatigue life expectancy of critical elements.

From this study, the following is a list of dual arm cantilever support components with the lowest fatigue life, ranked in order from the shortest life to longest life:

1. Post-to-base plate welded connections;
2. Fillet welds in the built-up box connection;
3. Chord-to-end plate weld connections;
4. Hand hole connection.

According to this study, details with infinite fatigue life for dual arm cantilever supports are: anchor rods, strut-to-gusset plate welded connections, and gusset plate-to-chord welded connections. One of the findings in this research is that for single mast arm cantilevers, galloping may be the most critical wind loading phenomena to cause major fatigue deterioration. Whereas, based on this research, box truss supports undergo very small wind induced fatigue issues in comparison to dual arm cantilever supports. This study suggests having routine inspection to perform in a maximum of four year interval for cantilever mast arm supports and eight year interval for the box truss supports since they are less susceptible to fatigue damage. Also, a hands-on, nondestructive evaluation (NDE) inspection of fatigue prone details is advisable.

2.3.2 Virginia State Inspection Manual

Virginia Department of Transportation (VDOT) developed a manual for inspection and inventory of traffic control device structures [8] including overhead sign supports, based on their Bridge Inspector's Reference manual. This manual provides guidelines to perform inspection of traffic structures both safely and thoroughly. These guidelines include inspection procedures and planning, describing different types of structures, component inspection guidelines, and maintenance directions. Based on this manual, support structures should be inspected every 60 months unless a more frequent inspection is required, which is similar to ODOT inspection intervals. An exception is the anchorage system of supports that VDOT suggests to inspect once every two years utilizing ultrasonic testing (UT), an NDE method. This manual was one of the inspection resources used to develop Mistras' inspection guidelines. For example, this manual proposes a sequence of support inspection as follows: reviewing available data for the structure, determining if MOT is required, and performing the inspection. It is recommended to determine the MOT planning before inspections start.

2.3.3 New York State Inspection Manual

This manual is a guide through the procedures required to document support information and inventory inspection results in an organized and systematic approach [9]. The guidelines are provided in two parts: Inventory and Inspections. The Inventory chapter discusses the information that is required to be collected for an overhead sign support. The Inspection chapter provides guidelines to conduct inspections properly. Additionally, the manual institutes a rating system from 1 – 9 to assess the condition of the sign structure. Part of this process was adapted for part of the Mistras inspection guidelines with regards to ratings. It is noteworthy to mention that this manual does not provide information regarding safety and maintenance of traffic aspects.

2.3.4 Kansas State Inspection Manual

The Kansas Department of Transportation (KDOT) manual serves as a guide for the inspection of signs and high mast lighting with their respect to inventory. It is currently the policy of KDOT to inspect OSS as well as high mast light supports. KDOT classifies inspections into three categories; routine inspection, in-depth inspection, and damage inspection [10]. Even though no federal inspection interval exists, it is the policy of KDOT to perform routine/in-depth inspections of signs and high mast light supports at a maximum of four year intervals.

KDOT also keeps a database regarding the inspections of all sign and high mast structures. The inventory and condition information is stored in the Kansas Ancillary and Wall Structure (KAWS) database. This database is connected to tables in other KDOT databases to facilitate the availability of the data. KDOT makes use of a specific inspection form that provides a summary of all the data that would be collected in a typical inspection. Each existing support has a serial number that identifies the support within the database. This serial number is mandated to be legible from each structure's assigned route. This helps to ensure clarity with repeated inspections.

The data gathered during the inspections include, but are not limited to: structure identification, location, structure data, project history, and any signs or attachments that are present on the support. Each structure's identification number follows the format of CCC-XSSS; where CCC represents a three digit county number, X is the structure class identification (this separates sign supports and light towers), and SSS represents a three digit serial number which is assigned to each structure. The database also has several parts devoted to the location of the sign and has fields containing the following information: KDOT jurisdiction (district/area/sub-area), county, route number, reference point (a point used to establish the location along the route, such as a mile marker), location description, latitude/longitude, and orientation of the sign.

Data regarding the actual structure of the support consists of a structure designation which denotes both the material and type of structure. Other structural information includes pole height, arm/truss span, vertical clearance of a structure over a roadway, whether the sign is bridge mounted, and footing type. The number, spacing, diameter, standoff, and minimum anchor rod length is also tracked along with the shape and dimensions of the baseplate. Project history includes the project number, letting date, contractor, and fabricator of the support for tracking purposes. Items are also noted with regards to the signs and any attachments that may be present on the support. The sign height, length, color, and contents are also noted.

The recorded inspection data provides KDOT with an overall indication of the health of the support, as well as indications of the health of individual parts of the structure. The entire structure is assigned a condition rating from 0-9, with 9 being like new condition, and 0 being a failed condition. The manual prescribes element level inspection indicators that range from condition states of 1-4, with 1 representing an element in the best condition, and 4 representing advanced deterioration. Those elements assigned a condition rating include: concrete foundations, coated steel elements, uncoated steel elements, aluminum elements, and connections. Smart flags are an item that follows the same format, and are used to indicate items that may be classified by any of the above elements. Examples of smart flags presented in the manual include pack rust, steel/aluminum fatigue, bridge elements connected to bride mounted sigs, and sign clips.

The KDOT inspection manual denotes a condition of a structure or its' elements that could pose a threat to the travelling public as a critical finding. It requires that if the finding requires immediate action, the inspector must contact the area engineer or area supervisor and advise them of the situation. If either of the above cannot be reached, the bridge inspector and/or the sign and light structure engineer should be contacted. The manual makes special mention that if the finding poses an immediate threat to the public that the inspector not leave the site until maintenance personnel arrive.

2.3.5 Inspection Methods Considered

As a part of the inspection process, some states use one or more nondestructive evaluation (NDE) or testing (NDT) methods as part of their regular inspection program. As the name suggest, the use of an NDE method is to assist in the evaluation of a deficiency, material property, or component without damaging the structure. Depending on the method, certain methods can assist in quantifying the deficiency (i.e. sizing of a crack in a weld) in order to assist in determining the impact on structural adequacy. The methods considered in this study are included in the following sections with those methods used as part of the in-depth, hands-on inspection process discussed in Section 4.4.

2.3.5.1 Visual Testing (VT) – This is the current method used by ODOT for inspection and is the traditional method used by many state DOTs. This method is typically ground based, in which the inspector uses a set of binoculars to inspect the different components of the support structure. Any deficiencies are recorded and then reported to the appropriate officials for follow-up testing, repair, rehabilitation or replacement (R3). Under ODOT policy, the ground based method includes sounding of the anchor bolts with a hammer to check for cracked and/or broken bolts.

2.3.5.2 Ultrasonic Testing (UT) – UT testing uses short, high frequency (0.5-+15MHz) mechanical sound waves transmitted into the material through a transducer to detect potential deficiencies and flaws on the surface or subsurface of the material. This process requires the use of a couplant for sound transfer. In metals, UT may be used for inspecting for cracks, inclusions, thickness measurements and even porosity of the material. Advantages include the ability to detect flaws deep in a material, high sensitivity, ability to size a flaw, material characterization, and utilizes a portable instrument. Some disadvantages include that the material surface must be prepared by cleaning (e.g. removing scale, debris), that the material surface to be inspected must not be rough or irregular so that the transducer makes proper contact, and operation of the instrument and assessment of the results requires experienced technicians.

2.3.5.3 Magnetic Particle Testing (MT) – requires magnetizing (direct or indirect) the material to induce a magnetic field. A particle powder (typically iron oxide) is then applied to the area of interest. The presence of a surface or subsurface flaw disrupts the magnetic field, causing it to leak, and results in the particles being drawn to the area of the leak and will build up to create an observable indication. Advantages are that the material and equipment costs are lower, large surface areas can be inspected rapidly and surface preparation is not as critical. The disadvantages are that the technique can only be used on ferromagnetic material, proper alignment of the magnetic field and defect is critical, and depth of detection is limited to very near surface.

2.3.5.4 Dye-penetrant Testing (PT) – is a technique that uses the application of a penetrant that is applied to the surface of the material. The penetrant is then allowed to soak in (dwell) into the flaw. The excess penetrant is then removed and a developer is applied. The developer will then draw the penetrant out of an existing flaw to the surface of the material and create a visible indication, typically known as bleed-out. In most cases, the major advantage of this method is the low cost, speed in which it can be performed, and the material does not have to be ferrous. However, the major disadvantage is that this method is only good for detection of surface flaws (i.e. hidden or subsurface flaws will not be detected). Another disadvantage is that it requires a higher level of surface preparation when compared to MT. Improperly cleaned surfaces will not allow the penetrant to enter the defect or can lead to false indications. Additionally, rough surfaces, such as welds, can make it extremely difficult to remove the excess penetrant and may result in false indications. It is also important to note here that the size of the resulting indication does not necessarily indicate the size of the flaw.

2.3.5.5 Eddy Current (EC) – is an electromagnetic induction method that uses alternating current to energize a coil and generate a magnetic field around the probe. When the probe is placed near a conductive material, an eddy current will be generated and begin flowing through the material. The eddy current then generates its own magnetic field and interacts with the field from the coil. The presence of a defect will alter the conductivity (magnetic permeability) of the material. This creates a variation in the magnetic field of the eddy current and results in a change of the electrical impedance of the coil. This change in phase and amplitude of the current can then be measured. Advantages include the ability to detect surface and near surface flaws, does not require a couplant or contact with the material, portable instrumentation, can measure nonconductive coatings (e.g. paint) and requires minimal surface preparation. The main disadvantages is that it can only be used on conductive material and flaws that lie parallel to the coil geometry will not be detected. Additionally the method requires a higher level of skill and training, has a limited depth of penetration, requires an appropriate reference standard for calibration prior to testing, and is very susceptible to variations in magnetic permeability, which can make testing of welds very difficult.

2.3.5.6 Acoustic Emission (AE) – is a passive technique that listens for the rapid release of energy, in the form of a transient elastic wave, which is generated by a discontinuity within the material that becomes active due to an applied stress in the material created by an external force. An AE sources or interest include those related to new crack initiation or propagation of existing cracks, crack fretting, weld discontinuities, corrosion, and impact. Transducers are coupled to the surface of the material which converts the mechanical energy of the elastic waves into an electrical signal that is transmitted by a sensor cable to the data acquisition system. The system records the waveform along with the waveform features, such as amplitude, energy, duration, freak centroid, and used to assist in discrimination between different types of AE sources. AE instrumentation includes portable, hand-held devices for screening and larger, integrated systems for long term structural health monitoring. The advantages include: ability to detect damage initiation in real-time; can assist in locating hidden/buried flaws; can be used for continuous, remote monitoring; can be used as a tool for condition ranking; and systems can be combined with external parametrics (e.g. strain, displacement, temperature, etc.) to assist in identifying the effects that may lead to damage. All combined, implementation can assist in keeping structures in service longer, and help prioritize future plans for R3. The biggest disadvantage, is that if the system is not designed correctly (i.e. improper filters, sensors or sensor mounting locations), it can be subjected to a high amount of background noise that makes discrimination between real AE signals and signals from background noise difficult. Additionally, different materials can produce different signals even if from the same source type (e.g. crack initiation). Different materials will have different responses and the test is not always reproducible (e.g. sudden crack initiation). As such, this is a method that requires sophisticated signal processing, and highly skilled technicians for designing the appropriate system and software setup, and for data interpretation when compared to other methods.

2.3.5.7 Camera Mounted Systems (CMS) – is a method that has been investigated by several DOTs for inspection of HMLS. For this method, the light ring is lowered, bulbs changed as needed, and then an adapter system is mounted to the light ring. The adapter carries up to three, battery powered, wireless cameras that collect video of all sides of the pole as the light system is hoisted back into position. The data is then collected by a laptop with a wireless receiver. The software on the laptop provides video from all cameras in real-time and allows for nominal measurements of a detected crack. Other adaptations include the use of a camera mounted system mounted to the end of an articulated boom. The advantages of these types of systems is the ability to detect flaws, particularly at slip join or welded connections on poles, that may not be readily viewed via binoculars or telescope from a ground location, estimate the nominal size of an observed cracked and have a video record of the inspection. The disadvantages is that most of these systems have not yet reached a commercial level, and may increase the time of inspection due to additional setup requirements based over the traditional inspection approach.

3 ODOT Support Inspection Program

3.1 Introduction

This chapter describes the current ODOT inspection process. At a maximum five year interval, it is mandatory that all 12 ODOT Districts perform inspections of all ODOT-maintained overhead sign supports (OSS) within each District. Bridge mounted supports (BMS) are to be inspected annually by the bridge inspectors as a part of the annual bridge inspection program in each District and signal supports (SS) inspected annually. Currently, there is no standard structural inspection interval for high mast lighting supports (HMLS).

FHWA recommends state DOT's conduct the inspections in an organized and systematic manner to ensure efficiency and to minimize the possibility of any inspection items being overlooked. As such, this requires an appropriate inspection form. ODOT uses inspection form (Form 296-4), which is provided in the Traffic Engineering Manual (TEM). However, the TEM allows each District to modify the form in order to comply with their inspection criteria, with a modified form used by many ODOT Districts.

ODOT Central Office offers training for personnel that will be conducting inspections of overhead sign supports. This helps ensure that: inspections take place in a systematic manner; personnel gain the necessary skills to perform the inspection; personnel gain a basic understanding of a support's potential deficiencies, deterioration and failure modes; and obtain uniformity in inspections. Training is currently provided by a senior Signing Engineer in the Office of Traffic Operations. For this study, the research team members underwent a shortened version of the training.

ODOT policy on the inspection process includes VT from the ground and sounding of the anchor bolts with a hammer, for all overhead sign supports inspected. It is recommended that inspectors carry binoculars to perform a visual inspection. NDT is not conducted on a routine basis, but can be used to determine the extent of a deficiency.
Signal supports are inspected annually by electrical technicians. The focus of the inspection is functional. There is a short section on the inspection form that addresses structural integrity. Inspection records of traffic signal supports are kept in the Ohio Signal Information System (OSIS) database.

As for HMLS, they are generally maintained annually to ensure they are functioning properly. However, in some districts, the lighting is surveyed regularly and the lights replaced as needed. The inspection is carried out by electrical contractors or district personnel with an electrical background. Any structural deficiencies observed during the maintenance are reported to the district. There is no formal record kept of structural deficiencies or their remediation.

3.2 Review of Support Inspection Procedures of ODOT Districts

3.2.1 Overview

ODOT is responsible for inspection of overhead sign supports, traffic signal supports and high mast light supports. All supports, whose failure could present a risk to the traveling public, must be inspected frequently using appropriate techniques to ensure that the supports will safely serve their design function. The adequacy of the current ground based inspection program to assess the condition and remaining useful life in these supports and the others in the ODOT inventory is under review.

As previously discussed, ODOT provides statewide guidance for structural inspection of OSS, and BMS. For SS and HMLS, the inspection process is one in regards to maintenance and function, not structure. However, observation of any deficiencies are noted. The routine inspection process for OSS includes VT of the structure, which is conducted from the ground, and sounding of the anchor bolts with a hammer. Statewide inspections are handled by the 12 ODOT districts, in compliance with the state requirements, but the procedures vary from district to district.

Almost all twelve Districts of the state of Ohio practice a different procedure to inspect overhead sign supports. It varies from a traditional paper-based method to more elaborate electronic systems that utilize hand held computers. The following sections include a brief discussion of the inspection procedures in ten of the twelve Districts of Ohio (Districts 1, 2, 3, 4, 5, 6, 7, 8, 9 and 12). Districts 10 and 11 are relatively rural districts with a small population of supports. Thus, the sampled districts represent the vast majority of the signs in the state. A sample of the inspection form from each District is provided in Appendix B. A map of ODOT District locations is provided in Figure 3.1.

Figure 3.1 Map of ODOT Districts

3.2.2 District 1 (Lima)

District 1 has a total of 65 OSS under their supervision. Form 296-4 from the ODOT TEM has been used to inspect OSS. District 1 has performed a ground based visual inspection of all OSS in 2004 and 2010. The inspection records for OSS are kept in a paper-based system. The BMS are inspected annually by the bridge inspectors. There is a small section of the bridge inspection form that addresses signs and other attachments. The bridge inspection forms are kept in the Central Office. This procedure for bridge mount supports is common to all districts.

In this District, SS are inspected annually by electricians hired by the District. The inspection of SS are performed using the OSIS inspection form. These forms are kept on file at ODOT Central Office.

There is currently no database for District 1 High Mast Lights.

3.2.3 District 2 (Bowling Green)

District 2 is responsible for 2258 OSS and 16 SS. District 2 has a well-established method of inspecting OSS using a Trimble GIS. The Trimble GIS software is used to collect inspection results and to keep OSS information. As a result, the district has a good database of support inspection reports and inventory in an electronic database. At the time of this report, not all of the OSS has data in the electronic database. They are using a common method of inspection for OSS similar to District 3.

Similar to District 1, the inspection of SS are performed using the OSIS inspection form. Inspection is mainly conducted by electricians hired by District 2.

The HMLS in District 2 are not inspected for any structural defects on a regular basis. The district employs an electrical contractor to perform annual maintenance on all of the HMLS. This maintenance involves the lowering and cleaning of the luminaries, as well as replacing burnt out bulbs. Observed structural deficiencies are reported to the District. However, the baseplate of the HMLS, the concrete foundation and other structural features are not systematically inspected.

3.2.4 District 3 (Ashland)

District 3 has 263 OSS under their supervision. They use a modified version of TEM 296-4 for inspections. As mentioned earlier, District 3 uses the same approach to inspect OSS as District 2. However, Districts 2 and 3 do not share their information or their database with each other. In this District, inspections are performed by construction transportation engineers who have been trained by ODOT in order to perform support inspections. Inspections of SS are performed by District traffic staff and ODOT Central Office staff performs random checks. The inspection of high mast lights are performed by District traffic staff and recorded into a score sheet.

3.2.5 District 4 (Akron)

District 4 is responsible for inspection of 1294 OSS. District 4 performs inspection of supports according to TEM section 221-3 to comply with the TEM recommended procedure. The paper inspection reports are then converted into a Microsoft Excel spreadsheet. Inspection of OSS in District 4 is performed by ODOT personnel on a routine basis to make sure all supports are inspected within the five year interval. Inspectors are trained by Mr. Jim Roth from ODOT Central Office. Similar to other Districts, they use a modified version of TEM 296-4 to perform inspections. Inspection of SS are conducted by signal electricians as part of District 4 annual signal inspection program. Inspections are recorded on the OSIS forms and the reports are kept at ODOT Central Office.

3.2.6 District 5 (Jacksontown)

District 5 has 158 OSS that are inspected every five years as required. Inspections are input into a spreadsheet file, with photos taken during the inspection, linked to the file. The file is a modified version of the TEM 296-4 form used to rate components and also to apply an overall appraisal, including a general life expectancy estimation. BMS are inspected yearly during bridge inspections while SS are inspected during electrical inspections.

3.2.7 District 6 (Delaware)

District 6 uses TEM 296-4 form (without modifications) for inspections, which are then saved as paper copies. BMS are inspected yearly during bridge inspections. SS are inspected during electrical inspections of the signals and saved in an Excel spreadsheet. HMLS are inspected if lights are burnt out. However, the control centers for multiple lights are inspected annually by electricians.

3.2.8 District 7 (Sidney)

There are 220 OSS under supervision of ODOT in District 7. In this District, the traffic department is responsible for inspecting OSS. Similar to some other Districts, District 7 uses form TEM 296-4 for inspection. District 7 keeps the inspection reports in a paper-based system but are planning to move to an electronic-based version. The inspection of SS are performed by signal electricians and kept in OSIS. HMLS are routinely maintained by signal electricians but there is no routine program of structural inspection of HMLS in this District.

3.2.9 District 8 (Lebanon)

District 8 has a total of 1280 OSS and over 300 high mast lights within the District. The OSS are inspected every five years. However, District 8 currently has a sign replacement program in place which includes an assessment of the condition of the support at the same time. If it is determined by the contractor that the support is not in good condition, the support, in addition to the sign, is also replaced. A maintenance contract exists with a contractor for the high mast lights.

3.2.10 District 9 (Chillicothe)

District 9 is responsible for the inspection of 91 OSS. Historically, the OSS have been inspected by construction inspectors and transportation engineers on a five year interval. However, it is planned that future inspection of OSS will be conducted by a District 9 engineer. Inspectors receive formal in-class training. For BMS, inspections are performed by the bridge inspector on an annual basis. All inspections are recorded using the TEM form 296-4, and hard copies of these inspections are kept on file. The process by which inspections are performed in District 9 is similar to that of District 10. There are no SS in District 9. Meanwhile, HMLS are inspected during routine maintenance by the electrician, and no inspection report inventory is maintained.

3.2.11 District 10 (Marietta)

District 10 has 97 OSS, conducted on a five year interval, and the last inspections were performed by construction personnel during the non-construction season. BMS are inspected yearly during bridge inspections using TEM form 296-4 in paper form, and stored in a 3-ring binder. The district only has one SS and it is inspected yearly during the electrical inspection. HMLS is not really inspected or inventoried.

3.2.12 District 11 (New Philadelphia)

District 11 has a combination of OSS, BMS, SS and HMLS. Past inspections of the OSS have been performed by a transportation engineer (E.I.T.) at a five year interval. Previous inspectors had no formal training. However, future inspections will be performed by trained District 11 personnel. Similar to other districts, the inspection of BMS is performed by the bridge inspector on an annual basis. All OSS inspections are recorded using a modified version of the TEM 296-4, and paper copies kept on file. Inspection of SS is performed by the traffic signal inspector on an annual basis, and the inspection is recorded on the TEM 496-1 form with paper copies kept on file. The inspector receives formal in-class training for OSS. On the other hand, the inspection of HMLS is performed by a contractor during routine maintenance. The contractor receives no formal training, and no inspection report inventory is maintained. It is reported that the inspection process for HMLS in District 11 is similar to that of Districts 9 and 10

3.2.13 District 12 (Garfield Heights)

District 12 is responsible for inspection of 666 OSS. Inspections are performed by transportation or highway technicians on a five year interval and are trained by ODOT Central Office. District 12 uses a unique method of keeping inspection reports using Microsoft Access database. Signal electricians are responsible for inspecting SS during their annual inspection program.

District 12 also has no formal procedure for inspecting HMLS. A weekly drive down across the District is performed to look for any burnt out luminaries that may exist. Typically, burnt out luminaries are replaced within a one week time period. However, no special care is taken to look for any structural deficiencies that may exist.

3.3 Summary of the ODOT Support Inspection Program

Overall, OSS are inspected within the required five year interval and most Districts use form TEM 296-4. Additionally, some Districts have gone further and modified TEM 296-4 to better suit the needs of their District. These modifications include electronic GPS adaptations, a MS Access database, and Excel spreadsheets. At the most basic level, reports are kept in paper form. All districts have a procedure to archive the forms and, generally, can retrieve information from their data base. Typical inspection is combination of ground based VT (using binoculars) and sounding of the anchor bolts using hammer. Significant deficiencies noted during the inspection are reported to the District for immediate action. However, there is no formal record regarding resolution of the reported deficiencies. Part of the inspection process may include minor maintenance, such as removing accumulated soil from the support base, in order to complete the visual assessment. Additionally, ODOT Central Office offers training and support for District personnel that will be participating in the support inspection program. The training introduces personnel to different sign types in the ODOT inventory, foundation, inspection policy, structural components and the potential deficiencies for each.

Looking at specific support types, BMS are inspected by the bridge inspectors annually with space on the bridge inspection form to note the conditions of signs and supports. The bridge inspectors do not always have any formal training in support inspection. BMS inspection is visually conducted from the deck of the bridge (using binoculars) and contains a numerical rating. Significant deficiencies noted during the inspection are reported to the District for immediate action. There are no formal requirements regarding the level of detail of the support inspection. Bridge inspection reports are archived in ODOT Central Office and kept in the Structure Management System (SMS) database. The team was able to locate the selected support samples, for the field inspections, in the SMS data base.

ODOT is currently in the process of reducing the number of BMS. When unavoidable, ODOT is looking to install the BMS at locations on the bridge with relatively low vibration, such as, over the piers.

In regards to SS, they are typically inspected by the electricians either from the district or electrical contractors. Across the state, the OSIS form is used to record information in the short structural inspection section of the form. The OSIS forms are then archived at ODOT Central Office. The training of the signal inspectors with respect to structural aspects of the signal supports is unknown.

Similar to SS, HMLS are maintained to ensure their illumination function of larger outdoor areas. In some districts, maintenance is performed on a routine electrical inspection basis. Other districts perform drive downs to identify nonfunctioning lights, and then schedule follow-up repair or replacement. This maintenance process does not typically include a formal structural inspection. However, structural deficiencies noted during the maintenance are reported to the district.

4 Field Inspection Program

4.1 Overview

The central task in this research is inspection. The approach that underlays this study is to identify a population of supports, select a significant sample, perform an in-depth inspection on each member of the sample, compare the in-depth inspection results to the existing inspection documents and then assess if the existing inspection documents accurately depict the current condition of the support and contain enough information to assess the structural adequacy of the support. The research team investigated OSS, BMS, SS and HMLS.

As a major portion of this study included field inspection of selected supports, a core strength of the team, was the inclusion of personnel with experience not only in structural inspection, but experience in variety of in advanced NDT techniques and monitoring of components. As such, team member Mistras Group, Inc., used existing assets within Ohio to perform inspections on multiple fronts, with trained inspectors, and a formal safety program; a team complemented by academic researchers. Additional Mistras company information can be found in Appendix C.

Given the number of inspections to be conducted across the state, sometimes along busy state and interstate routes, maintenance of traffic (MOT) was a critical aspect of field inspection. The team worked with a 3rd party company, Area Wide Protective, for statewide MOT services. Prior to each inspection a team consisting of a researcher, an inspector, a representative of the MOT contractor, and, sometimes the district drove down the candidate signs. Afterwards, the team worked with Traffic Engineers from each District to develop an MOT plan that provided minimal interruption of traffic, and considered the safety of the inspectors as well as the traveling public. The MOT plan was then submitted for approval by the district before the inspections were conducted.

4.2 Determining Sample Size

The initial goal was to select a set of random samples so that statistical information about the population could be drawn. However, due to the variation in records and processes between Districts, and lack of a standard inventory across the state, it was impossible to develop statistically valid samples for each support type. Therefore, two different methods were used in the selection of supports to inspect. The research team in the northern districts decided to select the samples based on the supports with some type of recorded deficiency. As such, the selected northern sample was biased toward signs that were older or with deficiencies. To minimize MOT and travel costs, the supports in the south were randomly selected in groups along higher traffic areas. While a truly random sample would have been more diverse, it would have been beyond the budget. The disadvantage in not having a random sample is that system wide inferences cannot be drawn from the data. The advantage in utilizing two selection methods, is that inferences could be drawn from the differences in the data.

The plan for the field inspections included the selection of up to 200 overhead supports from ODOT inventory, which provided a balance between the sample size, cost and time available to perform the study. The first criterion in selection of the support was based on the type of support. Based on the review of ODOT inventory and direction of the ODOT Technical Advisory Panel, the research team developed a list of the most numerous and critical type of supports for inspection. Following support types were considered in this project:

- Overhead Sign supports [OSS]
    - Cantilever arm supports (single or dual arm cantilever)
    - Box truss supports
- Bridge mounted sign supports [BMS] (flush/skewed or support mounted on barrier or parapet)
- Signal supports [SS] (mast arm);
- High mast light supports [HMLS]

Following the type of support, the next criterion considered was the age of the support. Unfortunately, very few supports have any type of age information recorded in past inspection reports. The next parameter for selection looked to determine supports that are more likely to have performance problems. This would allow a comparison of the deficiencies noted in ODOT inspection records and those recorded by Mistras inspections. Specifically, the intent was to determine the observed differences, if any, between ground based visual inspection and a hands-on inspection approach to be conducted by Mistras inspectors.

Due to the smaller population of BMS, SS and HMLS, the bulk of the overhead supports inspected were from the OSS category. For the OSS selected as part of the sample set for field inspection, the previous ODOT inspection reports were acquired, if available. While the existing inspection reports were reviewed by the majority of the team, the previous inspection reports were not shared with the Mistras inspectors that would be performing the field inspections. The intent was for a blind, hands-on, in-depth inspections to be performed for later comparison to the previous inspection results. Otherwise, the in-depth inspection would always find what was previously noted in addition to any new deficiencies.

Given the small population of HMLS, and that HMLS are typically in locations that do not require MOT to access the support, the HMLS selected for inspection was conducted differently. HMLS in Districts 2, 5 and 6 were chosen for geographic convenience and ease of access. The HMLS selected in District 7 were anecdotally among the oldest in the state. The HMLS in district 12 were selected because they were along the edge of Lake Erie and judged to be in one of the most challenging environments in the state; from a wind and corrosion perspective.

4.3 Field Inspection Overview

As discussed in Section 3.2, the state is divided into 12 Districts. In order to divide the work required for the field inspections, the state was split into a North and South division. In the North, the field inspections were performed by Mistras personnel, based out of the Millbury office, with assistance from the University of Toledo. In the South, the field inspection were performed by Mistras personnel, based out of the Heath office, with assistance from Ohio University.

The North division contained six ODOT Districts that covered the north and western portion of Ohio. These Districts included Districts 1, 2, 3, 4, 7 and 12. The South division included the six remaining ODOT Districts 5, 6, 8, 9, 10 and 11.

Starting with the kickoff meeting on October 2, 2012, discussion with ODOT experts and personnel provided great insight into the issues with supports and helped the team gain a better understanding of the current ODOT inspection program. From this meeting, and to acquire inspection information from each District, each District was contacted either through phones conversations or face to face meetings. The goal of these discussions was to gain information about each Districts' inspection practices, under the ODOT inspection program, and receive street-wise recommendations in regards to our research inspection methodology. These discussions also provided insight into support inventory and access to past ODOT inspection records.

In each District, before the inspections started, a drive-down of the sample to be inspected was made by the Mistras inspector(s) and a research team member from the University of Toledo or Ohio University. The team was often accompanied by representatives from the MOT contractor or ODOT. Visiting the supports before the inspection helped Mistras to coordinate inspection activities in each District and prearrange the required MOT setup at the site of the support. If MOT was required at the selected support location, the MOT setup was submitted to each District for approval, especially for shoulder and lane closures, before the inspection was conducted.

In the north, the research team started with a few preliminary support inspections around the city of Toledo to gain knowledge regarding inspection process, compare the process to other Districts, and then develop a comprehensive inspection procedure that would extend to other Districts. Then the northern research team sampled additional supports in District 2 and continued through Districts 3, 4, 12, 1 and 7. The team in the South followed a similar process starting with District 5, then continuing to Districts 6, 8 and 9.

4.4 Field Inspection Procedure Development

Since the goal of this study was to evaluate the adequacy and frequency of the current structural support inspection program for OSS, BMS, SS and HMLS, the research team developed an inspection procedure that assessed and combined several different approaches to assist in this effort.

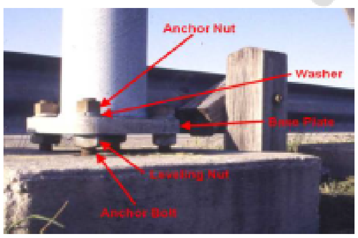
The field inspections conducted in this study used a hands-on, in-depth inspection process that utilized different policies, procedures and guidelines from FHWA, AASHTO and state DOTs. This approach was chosen so that an evaluation and comparison could be made on each process and determine the impact, if any, on ODOT's inspection program. Specifically, the hands-on, in-depth approach looked at each of the following aspects.

4.4.1 Inspection Methods Selected for Field

As discussed in Section 2.3.5, there were several different NDE methods considered for use in the field during the in-depth, hands-on inspection process performed by Mistras personnel, with assistance from the University of Toledo and Ohio University. Each of the methods have advantages and disadvantages that are based on material type as well as the type of deficiency that might be observed in a given material. Therefore, the methods selected were chosen based on the ability of the method to assist in qualifying or quantifying a given deficiency. Overall, the use of NDE should be considered as a complementary tool to the inspection process whether used as part of the standard inspection process or for follow-up investigations.

If a particular method was used as part of the field inspection process for a given component, the inspector selected the box for “NDT” on the inspection form, recorded the method used, and what was tested. For instance in Figure 4.1, the inspectors used the UT method to inspect four anchor bolts. In this case, the inspectors are looking for cracks in the anchor bolts. In each case where a NDT method was used, if a deficiency or what is called a ‘rejectable indication’ was identified, such as a crack, an inspection certification sheet was issued. Otherwise, no certification sheet was issued. Overall, for the components inspected on the 202 sign supports in the sample, zero certification sheets needed to be issued. The following NDT methods used as part of the inspection process are described in the following sections.

FOUNDATION



Picture: Example only

Base Plate/Anchor Bolt Assemblies

Missing nuts/washers	☐	Comments:
Loose nuts/bolts	▣	
Cracked/Broken bolts	☐	
Corrosion/Section Loss	☐	
Loss of galvanizing	☐	
Cracks in base plate weld	☐	
NDT (UT/ MT/ PT / EC)	▣	UT on 4 bolts Vt on pole and access door weld ok

Rating (Select One): 4 = Good, 1 = Poor — 4 ◉ 3 ○ 2 ○ 1 ○

A World of NDT Solutions

Figure 4.1 Sample inspection report with selected NDT.

4.4.1.1 Visual Testing (VT) – This method is the basis of any inspection process. This is the current method used by ODOT for their ground based inspection process, which includes sounding of the anchor bolts with a hammer. This is the primary method for identification of potential deficiencies of a support component that can then be confirmed with an additional NDT method. This process was used by Mistras inspectors and then supplemented with additional NDT, as applicable. However, it should also be noted that the process used by Mistras inspectors was done within arms-length with the use of a bucket truck or by climbing (rope-access certified) as opposed to being ground based. In addition, nuts were often checked for tightness with a wrench, and sign clips tapped for looseness.

4.4.1.2 Ultrasonic Testing (UT) – This technique was selected as it could be used for several different types of deficiencies that might be observed in the field. These potential deficiencies included inspection for cracks in anchor bolts, welds and other support components. Additionally, the same instrument, with a different transducer, could be used to conduct thickness measurements if severe corrosion or section loss was observed. Using different transducers can also assist in determining the location, size, and depth of a defect. Overall, UT was performed on most of the anchor bolts for each type of support. If the end of the anchor bolt had a rough or irregular shape (e.g. convex shape), the anchor bolt was not inspected as the face of the transducer could not make proper contact. In order to inspect bolts in this condition, the end of the bolt would have required machining or grinding to achieve a flat surface.

4.4.1.3 Magnetic Particle Testing (MT) – This technique was selected for the field as it could be used by the inspectors to quickly inspect large areas, as well as potential weld deficiencies at the pole-baseplate and, mast arm connections. In the event a deficiency is identified, the UT method could then be used to confirm location, depth and size of the deficiency (i.e. crack). Of course, the major limitation is that the method will not work on nonferrous materials, such as aluminum, copper, etc. MT was performed on multiple pole-baseplate connections during the early stages of the inspections.

4.4.1.4 Dye-penetrant Testing (PT) – This technique was not selected for use in the field. The main reason for not selecting this method is that it is only good for surface flaws. Subsurface flaws would not be detectable with this method as compared to MT or UT. Additionally, this method requires a significant amount of surface preparation to remove dirt, debris or oxides that may block the surface opening. This becomes particularly difficult with rough surfaces, such as welds. The advantage of course is that it could be used on nonferrous materials.

4.4.1.5 Eddy Current (EC) – This method was not selected for use in the field. The main reason is that the method requires a reference standard for calibration prior to testing. While the method is used to measure changes in magnetic permeability due to the presence of a flaw, the welding process itself can lead increased (localized) changes in conductivity. As such, the localized variation in conductivity, as well as probe lift off, can result in a significant amount of noise in the measurement due. Therefore a reference standard is needed to establish a baseline before measurement begins. While different probe configurations can help minimize some of these effects, the method still requires a higher level of skill and training, particularly for welds.

4.4.1.6 Acoustic Emission (AE) – This technique was originally considered for use in the field as a tool to monitor and track potential ongoing damage of a support structure. The intent was to identify potential support structures during initial inspection and then return later to instrument and monitor. The proposed system contained 4-6 AE sensors and the combination of strain gauges, vibration sensors or anemometers to measure the response of the structure due to an external force. As each support was inspected, the inspectors and team were looking for structures that contained several cracks, showed excessive rocking or had excessive vibration or motion due to natural wind or gusts from passing trucks. One or more of these parameters would have indicated a support that may be susceptible to fatigue loading and subsequent cracking. However, during the inspection process, no sign support was identified as a candidate for implementation of a structural health monitoring (SHM) program using AE.

4.4.1.7 Camera Mounted Systems (CMS) – This method may be considered an offshoot of VT and has the main advantage of a camera system to get within arms-length of the mast over the entire height of the structure. HMLS inspection started in the South, with an in-service lights in Columbus. This HMLS had been lowered to the ground due to excavation near the foundation. This allowed close VT of the entire mast with no major deficiencies observed. The next set of inspections occurred along the IR-70/77 interchange near Cambridge, Ohio. The importance of this second location is that the HMLS were in the process of being replaced due to difficulties in maintenance of the light systems as opposed to structural issues. The old HMLS had been removed, laid down on-site and allowed the inspection team to perform an in-depth inspection of the entire length of the HMLS, including all slip joints and welded connections. The HMLS at this location had been in service for over 40 years. The inspection of the four HMLS found no deficiencies. Given these results, it was determined that the CMS would not be applicable at this time.

Given the intended use of advanced NDE methods, the Mistras personnel selected for the field inspection teams each carried a wide range of certifications. All inspectors carried Level II certifications in one or more of the various NDE methods, including VT, UT, MT & PT. These certifications meet or exceed the requirements of ASNT Recommended Practice SNT-TC-1A and ANSI/ASNT CP-189. Level II inspectors are allowed to perform inspections, provide reports with results. Additionally, one of the inspectors is certified with rope access training and is a Certified Weld Inspector (CWI).

Using the information gathered from ODOT personnel, experts, engineers, and the literature review, the research team developed a preliminary set of guidelines and procedures for inspection. The guidelines addressed the traditional, visual based approaches, and incorporated, when appropriate, the use of the aforementioned advanced technologies to address invisible deterioration. The inspection guidelines also included an adaptation of a numerical rating system for each of the individual support components in the modified inspection form. The rating system is similar to what is used for bridge inspection; individual components are inspected and rated, and then the overall rating of the support is based on the worst component rating. The advantages of a rating system is that it can be easily implemented in the field during normal inspections. The rating can be added to the inventory information and can provide a historical trend over time for identifying potential degradation. The rating can also assist in prioritizing repair, rehabilitation or replacement actions based on available state or District resources.

4.4.2 Inspection Procedures and Rating System

As this study used a hands-on, in-depth inspection approach, a set of inspection procedures was developed to accommodate the modified inspection form with the inspectors then trained on the procedure, formatting and recording of data on the inspection form. The written inspection procedure described the inspection process, and covers the tools needed for inspection, areas to be inspected, types of potential deficiencies, remedial actions, recording of inspection results and introduction of the rating system. The specific areas of inspection included, when applicable:

- Concrete foundation or barrier;
- Soil around foundation;
- Base plate(s), and anchor bolt assemblies;
- End post or frame and associated web members and connections;
- Mast arm connections, and truss connections to end post;
- All members of truss and connections;
- Sign attachment assemblies;
- Surface coatings.

Based on the areas of inspection, a list of potential flaws or deficiencies were identified so that the inspectors knew what to look for during the inspection process. These deficiencies included:

- Cracks in the concrete foundation or barrier;
- Soil erosion, scour, overtopping of the foundation;
- Missing or loose bolts and washers, non-bearing leveling nuts, corrosion of assembly components, cracked/missing anchor bolts;
- Cracks in welds;
- Loss of galvanization, corrosion;
- Bent, cracked, damage structural members;
- Missing sign attachment assemblies (hardware).

The development of the inspection procedure included the introduction of a rating system. Given the different areas of inspection, and the different deficiencies that might be observed, the rating system was adapted for each area on a scale from 1-4. A rating of “4” was to indicate the component was either like new or in good overall with possible minor issues. A rating of “1” was used to indicate a critical condition state which would require repair, or replacement. The deficiencies to look for and condition ratings for each specific area are described in the following subsections.

4.4.2.1 Concrete Barrier/Foundation – things to look for included:

- Cracks in concrete foundation or barrier wall;
- Rust stains;
- Concrete spalling;
- Vegetation growth thru cracks;
- Overtopping of soil around foundation;
- Light sounding test with hammer to determine potential delamination or extent of spalling.

Figure 4.2 Cracked foundation

Ratings:
4 – No cracking spalling, staining – like new.
3 – Very minor cracking, spalling and/or staining.
2 – Significant deterioration, heavy cracking and spalling (Figure 4.2).
1 – Severe deterioration, foundation may not be performing as designed.

4.4.2.2 Soil (Around Foundation) – things to look for included:

- Soil overtopping the foundation. Clear as needed in order to perform inspection;
- Soil erosion;

Figure 4.3 Soil erosion

Ratings:
4 – No overtopping, erosion.
3 – Minor erosion (1 side).
2 – Significant erosion (2 or more sides).
1 – Severe erosion, footing undermined, tipping (Figure 4.3).

4.4.2.3 Base plate, Anchor Bolt Assemblies – things to look for included:

- Missing anchor nuts or washers;
- Incomplete thread engagement (at least one anchor bolt thread above top of anchor nut);
- Improper leveling or loose anchor nut(s);
- Gap between base plate and top of foundation. If not, check for corrosion, staining;
- Cracked, broken or missing anchor bolts;
- Corrosion of anchor bolts;
- Cracks in pole to base plate welds;
- Loss of galvanization;

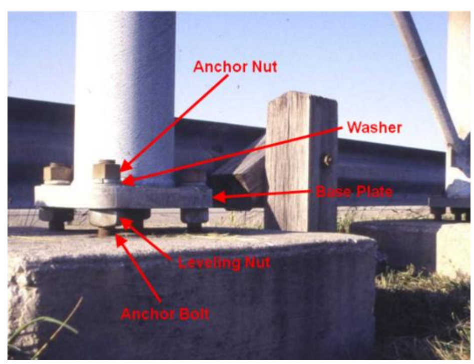


Figure 4.4 Anchor bolt assemblies

Ratings:
4 – Base plate and anchor bolts & nuts in good condition (Figure 4.4) or like new.
3 – Loose anchor nut(s), minor corrosion of assembly, loss of galvanization.
2 – Heavy corrosion, major section loss.
1 – Missing nuts/anchor bolts, sheared bolts, cracked weld(s) or baseplate.

4.4.2.4 End Post, Frame, Web Assemblies, and Connections – things to look for included:

- Bent or damaged members, possible impact.
- Cracked members;
- Cracked welds;
- Loss of galvanization;
- Corrosion, pitting, loss of section;

Figure 4.5 Cracked weld

Ratings:
4 – End posts, web assemblies in good condition – like new.
3 – Minor corrosion on end post, minor loss of galvanization with no section loss or medium corrosion of web members.
2 – Heavy corrosion, or loss of galvanization with section loss (localized).
1 – Severe deterioration, section loss, crack(s) in weld or web members, loss of structural integrity (Figure 4.5);

4.4.2.5 Connection of Arm, Truss to End Post – things to look for included:

- Cracks in welds at arm/truss connection to end post, cracked bolts;
- Missing nut(s), bolt(s) at connection plate(s);
- Loose nuts or bolts;
- Gaps between plates;
- Pitting, corrosion, loss of section;
- Loss of galvanization;

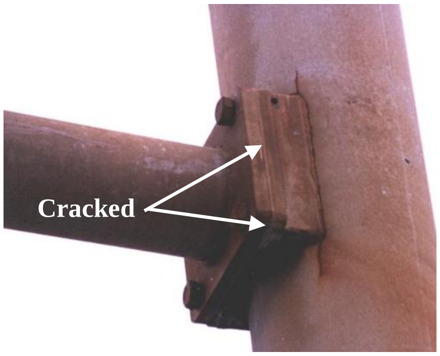


Figure 4.6 End post connection

Ratings:
4 – Connection(s) in good condition, no observable deficiencies.
3 – Minor corrosion, loss of galvanization, loose bolt, minor cracking or minor gap.
2 – Moderate corrosion, section loss, missing bolts, two or more cracks;
1 – Severe deterioration, section loss, cracking, missing or broken bolts (Figure 4.6).

4.4.2.6 Arm/Truss Member Assemblies – things to look for included:

- Cracks in weld(s) at truss connections;
- Missing nut(s) and U- bolt(s), especially at spliced chord connections;
- Cracked, loose nut(s) or bolt(s);
- Dented or broken diagonals, cracked chords;
- Gaps between plates;
- Pitting, corrosion, loss of section;
- Loss of galvanization.

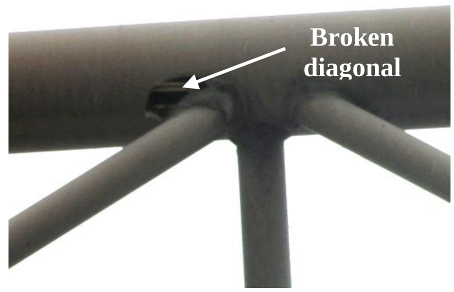


Figure 4.7 Truss assembly

Ratings:
4 – Connection(s) and truss members in good condition, no observable deficiencies.
3 – Minor loss of galvanization, minor corrosion, minor impact damage or misaligned connection(s),
2 – Serious corrosion to more than one member, medium impact damage, missing nut(s) or bolt(s), missing connection hardware.
1 – Cracked chord, broken diagonal, severe impact damage or misalignment (Figure 4.7).

4.4.2.7 Sign Attachment Assemblies – things to look for include:

- Missing sign attachment hardware, such as U-bolts, sign clips, nuts;
- Loose nut(s), bolt(s), sign clip(s);
- Missing, loose hardware for luminaries, if present;
- Pitting, corrosion, loss of section

Figure 4.8 Sign attachment assemblies

Ratings:
4 – Panels in good condition, no missing hardware (Figure 4.8) or like new.
3 – Minor impact damage, small number of missing hardware.
2 – Serious impact damage, or missing bolt(s), nut(s), connection hardware.
1 – Sign attachment in state of potential collapse.

Each of the component ratings were based on potential deficiencies that may be observed or identified in the field and will differ slightly for each component. The rating system and associated conditions for each rating can be generalized as shown in Table 4.1.

Table 4.1 Component rating description

Rating	Condition	Definition
4	Good	Some minor issues or nearly new; No repairs needed.
3	Fair	Minor deficiencies (e.g. loss of galvanization, corrosion, small cracks, minor spalling, etc.); Minor repairs needed.
2	Poor	Major deficiencies (e.g. large scale corrosion and/or section loss, fatigue cracks, etc.); Repair or rehabilitation needed.
1	Critical	Potential structural integrity impacted (e.g. loose anchors, missing anchor nuts, cracked anchor bolts); Major rehabilitation or replacement needed.

4.4.3 Modified Inspection Form

To perform inspections in a systematic and unified method, a modified inspection form, based on form TEM 296-4 and FHWA criteria was developed. A sample inspection report using this form is shown in Appendix A, Figures A.3-A.7.

The modified form includes a total of six pages. The inspection approach uses a hands-on, in-depth inspection method, with the implementation of a rating system. All support identification information is recorded along with selection of support type and collection pole base dimensions to verify design type for the support. For truss supports, information such as chord spacing, end post spacing, pole circumference and flange dimensions are collected for identifying the correct truss design. Each support component is broken into sections. For each section checkboxes were used to identify any deficiency, record comments, and then a condition rating for each component. If any NDT method was performed, the method used and results are recorded.

The paper form is used in the field to record information at the time of inspection. This information is then transferred to an electronic format (.PDF), along with any photos taken in the field. If implemented, the paper copy would then be kept in the local District office with the digital version uploaded into a database at ODOT Central Office.

5 Overhead Sign Supports (OSS) - Inspection Results

5.1 Introduction

In this chapter, the results of the Mistras inspections for OSS and BMS are summarized. A comparison between Mistras inspection reports and past ODOT inspection reports is provided; if it was possible for the research team to obtain the ODOT reports. Since each District has a different inspection inventory and procedure, the results are presented for each District and the differences between old inspection reports and Mistras inspection reports are summarized. At the end, an overall discussion of the inspections is presented. Because the ODOT inspection process is fundamentally different for the mast arm signal support and high mast light supports, they are addressed in later chapters.

The rating classification in the following sections uses Table 4.1 in Section 4.4.2 of the report. The average number of in-depth inspections conducted in a day was 3.5. While large box trusses spanning multiple lanes of traffic are inherently slow to inspect, the principal controlling factor was MOT.

5.2 Inspection Results Spreadsheet

For easy reference and to make the data sortable, the inspection data was compiled in an Excel spreadsheet. The researchers used MS Excel, over other data management software. Excel is the more commonly known and used software for sorting and categorizing data and is used by ODOT on a regular basis. This format helps facilitate the sharing of information with ODOT more easily. The inspection details, component rating, and support information in the spreadsheet can be found. The result spreadsheet includes the detailed inspection findings of each support based on both Mistras inspection reports and past ODOT inspection reports along with a description of the support and location information for each support.

5.3 District 1

In District 1, a total number of 9 overhead sign supports were inspected by Mistras (table 5.1). These supports include three dual arm cantilever supports, four box truss supports and two flushed/skewed bridge mounted supports. Inspection of supports in District 1 was performed in August 2013.

Table 5.1 Number and type of support inspected (District 1)

Cantilever Arm	3
Box Truss	4
Bridge Mounted	2
Total	9

In Table 5.2, a summary of the number and type of major deficiencies found in District 1 is provided based on Mistras inspection reports.

Table 5.2 Summary of deficiencies by occurrence (District 1)

Foundation	End Post/Frame/ Arm-Truss Members	Sign/Signal Attachment Assemblies
Loss of galvanizing (6)	Loss of galvanizing (6)	Cracked/Loose nuts/bolts (2)
Voids/Honeycombing (6)	Corrosion/Pitting/Section Loss (4)	Missing attachment hardware (2)
Loose nuts/bolts (5)	Gaps between plates (3)	

Figure 5.1 and 5.2 summarize the rating of each support component of cantilever arm and box truss supports.

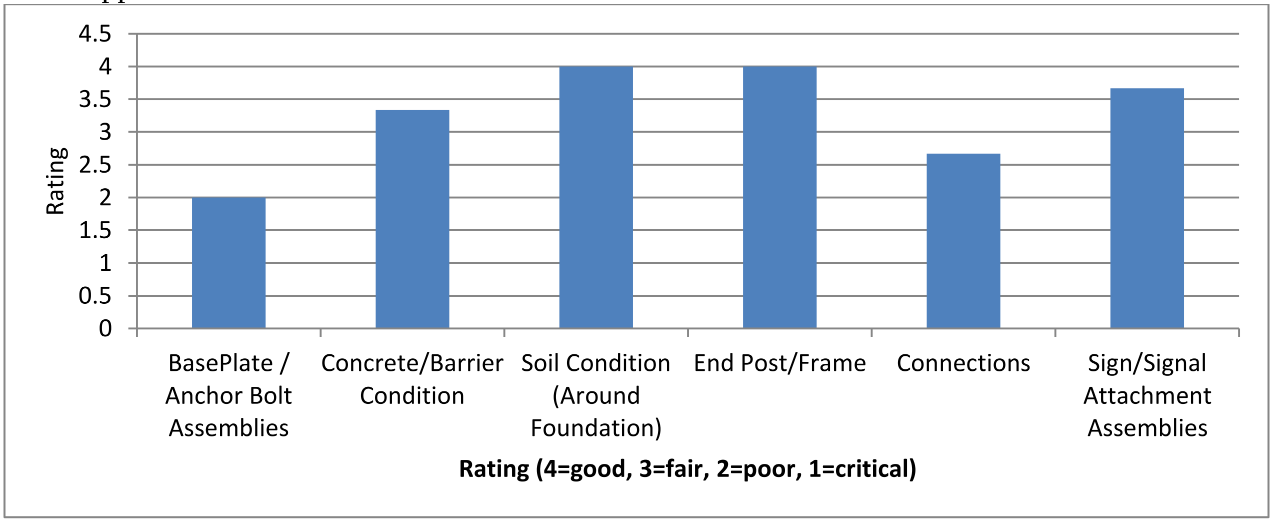


Figure 5.1 Cantilever arm supports: Average component rating (District 1)

Figure 5.1 shows that most of structural components of dual arm cantilever supports were in good condition. The deficiencies most observed for dual arm connections were the gaps between plates at the mast arm connection, and loss of galvanization.

Figure 5.2 indicates that box truss supports are performing fairly well. The foundation had a few deficiencies observed and included loose nuts/bolts, loss of galvanization on anchors, and voids/honeycombing of concrete footing.

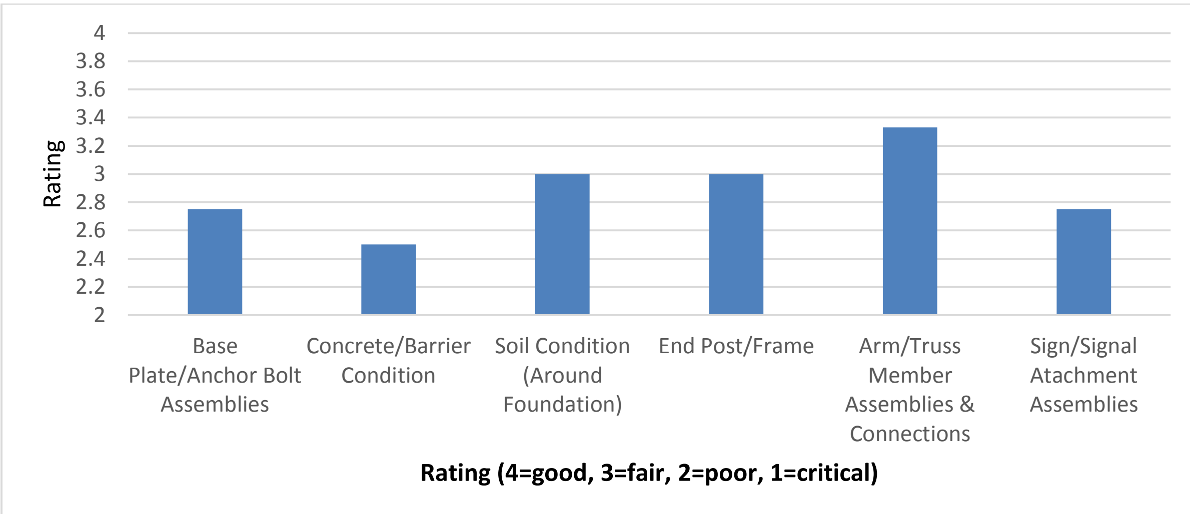


Figure 5.2 Box truss supports: Average component rating (District 1)

The overall rating (Figure 5.3) is based on the rating found from the rating of each individual component. Conservatively, the research team selected the lowest rated component rating as the overall condition rating of support. The overall rating of "2" for eight of the supports in the sample is mainly due to gaps noticed between the plates and mast arm connections. This might be considered conservative but a gap may indicate loss of pretension.

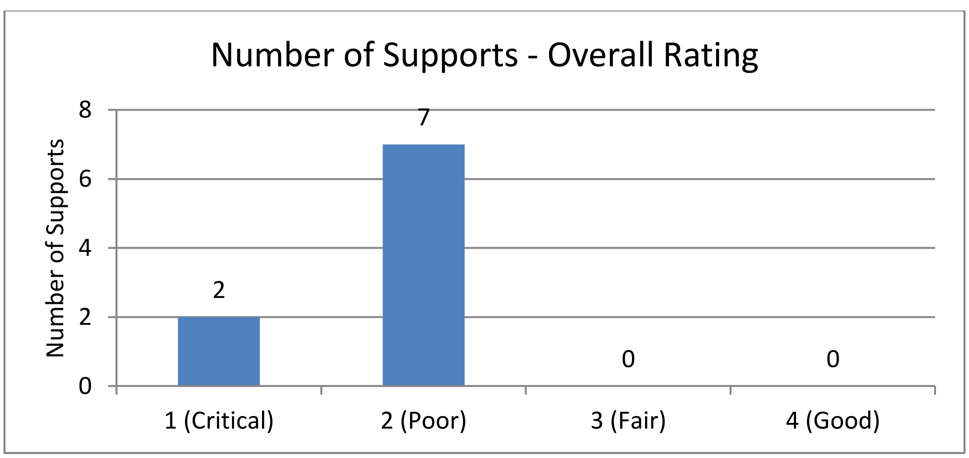


Figure 5.3 Number of supports for each overall rating (District 1)

5.4 District 2

The inspection results of the 15 OSS inspected in District 2 are provided below. These supports included cantilever arm supports, box truss supports and bridge mounted supports (both flush mounted and box truss). Table 5.3 is a summary of support types and numbers inspected in District 2 and Table 5.4 provides the summary of the most observed deficiencies observed.

Table 5.3 Number and type of signs inspected (District 2)

Cantilever Arm	7
Box Truss	5
Bridge Mounted	3
Total	15

Table 5.4 Summary of deficiencies by occurrence (District 2)

Foundation	End Post/Frame/ Arm-Truss Members	Sign/Signal Attachment Assemblies
Loose nuts/bolts (3)	Cracked/Loose nuts/bolts (6)	Cracked/Loose nuts/bolts (3)
Insufficient thread engagement (2)	Missing pole cap/hand hole cover (3)	Missing attachment hardware (2)

Figures 5.4 and 5.5 summarize the rating of each support component of cantilever arm and box truss supports respectively. Figure 5.4 shows that most of structural components of dual arm cantilevers are in good condition or better. The most observed deficiencies with dual arm connections were loose nuts/bolts, lack of thread engagement (i.e. less than one anchor bolt thread above the top of the anchor nut), and gaps between plates at the mast arm connection.

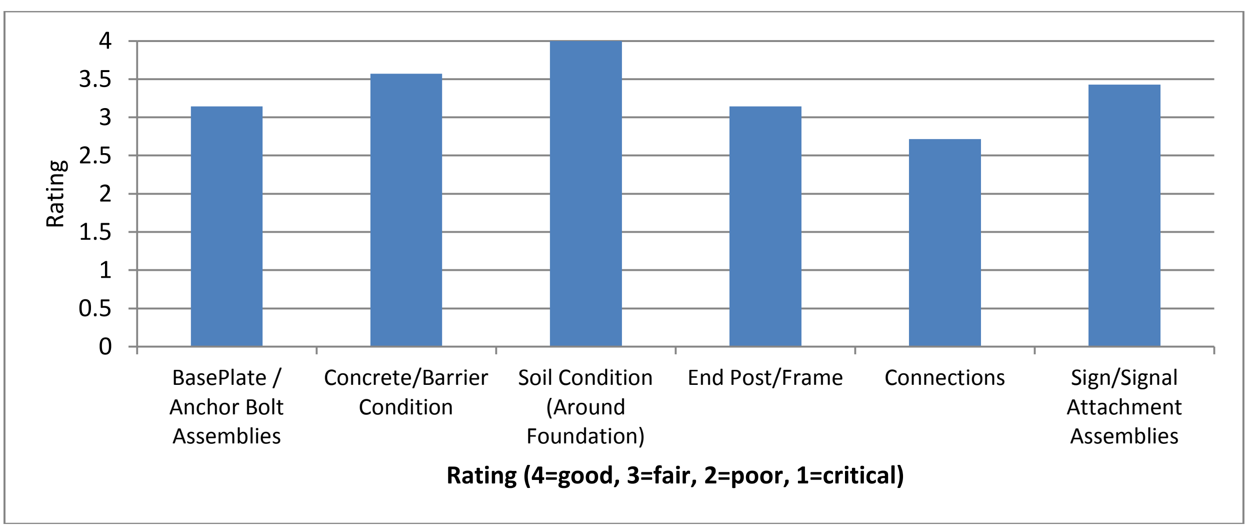


Figure 5.4 Cantilever arm supports: Average component rating (District 2)

Figure 5.5 indicates that the box truss supports are performing well and that there were no components with any significant deficiency observed. Two fairly new supports in the sample used an aesthetic tubular design (supports 20204 and 40203).

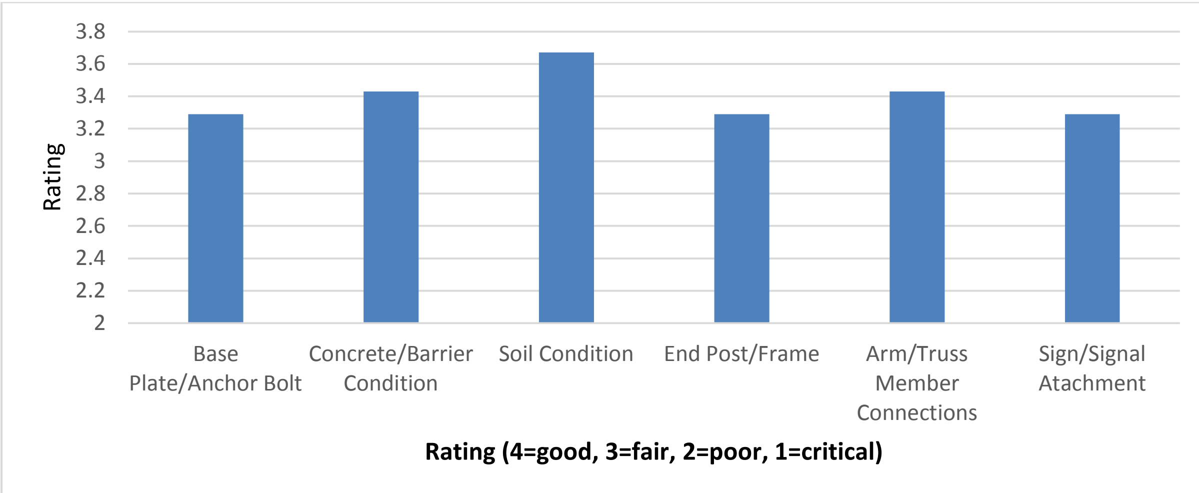


Figure 5.5 Box Truss supports: Average component rating (District 2)

Following the previous format, the overall rating is based on the rating found from the rating of each individual component. Conservatively, the researchers selected the lowest component rating as the overall condition rating of support. Figure 5.6 shows the number of sign supports within each (overall) rating category.

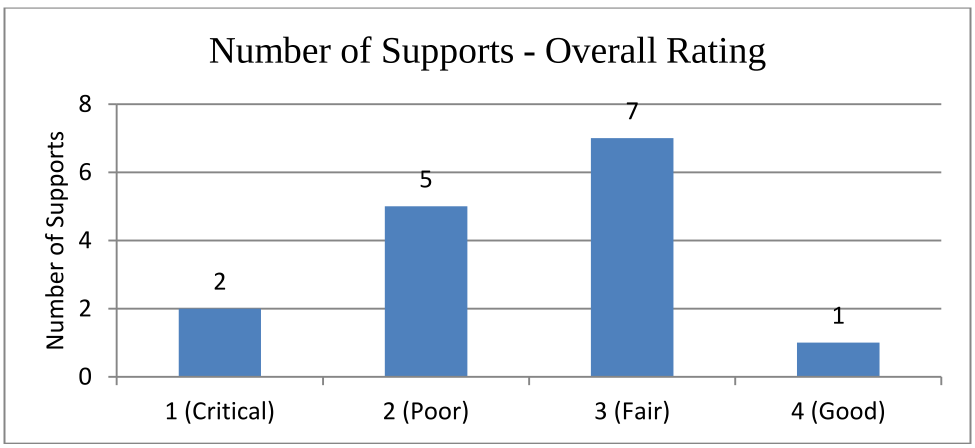


Figure 5.6 Number of supports for each overall rating (District 2)

As previously discussed, preliminary support inspection was started in District 2 as the University of Toledo and the Mistras office in Millbury is located in this region. This allowed members of the team to become familiar with the standard inspection process conducted by ODOT, and to further develop and test the modified inspection procedure to be used for the remaining in-depth, hands-on support inspections.

While ODOT had inspected all the supports in District 2 back in 2012, it was noted that when comparing the Mistras inspection results with ODOT inspection records, the information contained in the ODOT inspection records were considered vague; specifically in regards to documenting the observed deficiencies in the component details. Lack of inspection details in ODOT inspection reports made the comparison of results difficult. In case of box truss supports, ODOT records showed a better match with the Mistras reports, such as deficiencies in the foundation and end post of box truss supports. In some cases, a heavy coat of paint on supports prevented an in-depth or NDT inspection of structural components.

5.5 District 3

A total of 13 overhead sign supports were inspected in District 3. The type and number of supports investigated are provided in Table 5.5 and summary of observed deficiencies provided in Table 5.6.

Table 5.5 Number and type of the support inspected (District 3)

Cantilever Arm	6
Box Truss	5
Bridge Mounted	2
Total	13

Table 5.6 Summary of deficiencies by occurrence (District 3)

Foundation	End Post/Frame/ Arm-Truss Members	Sign/Signal Attachment Assemblies
Loose nuts/bolts (2)	Cracked/Loose nuts/bolts (6)	Cracked/Loose nuts/bolts (4)
Insufficient thread engagement (4)	Loss of galvanizing (3)	
Vegetation growth (6)		
Spalls (5)		
Loss of galvanizing (4)		

Figures 5.7 through 5.9 summarize the average ratings of each component for cantilever arm, box truss, and bridge mounted supports (flush/skewed).

The cantilever arm supports were determined to be in a fairly good shape. ODOT records indicated deficiencies in the foundation, especially with the anchor bolts and nuts. All cantilever arm supports had tightness and passed the sounding test based on ODOT inspection reports. These results matched with Mistras inspection report findings (Figure 5.7). The overall condition of the cantilever arm supports from both Mistras reports and ODOT records were very similar and shows that the members have not seen any significant degradation since the last ODOT inspection.

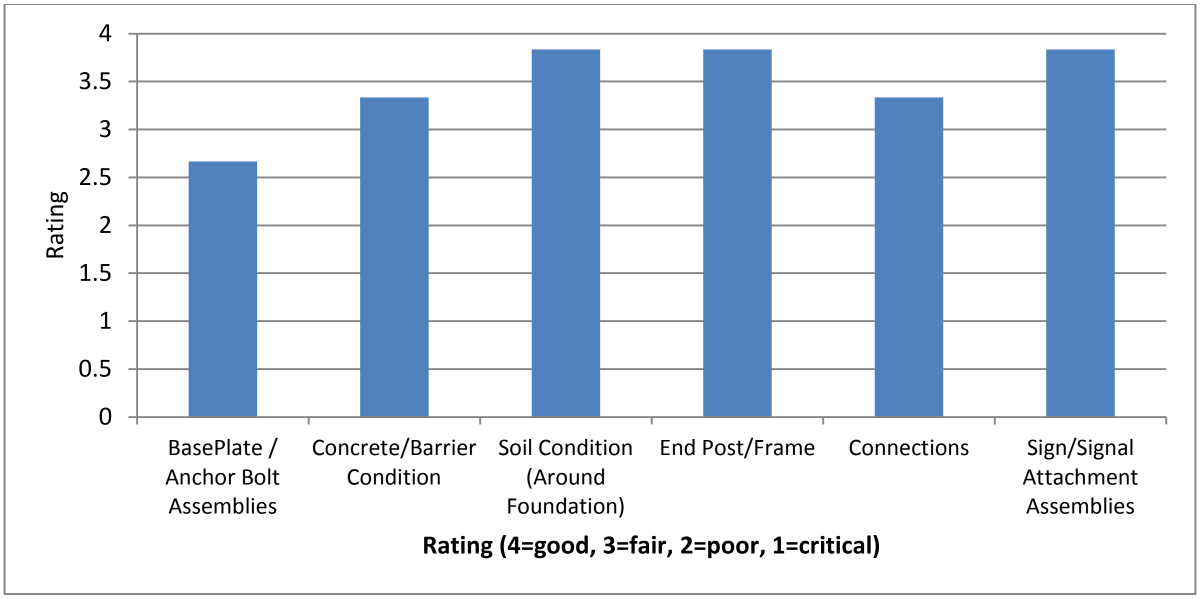


Figure 5.7 Cantilever arm supports: Average component rating (District 3)

The same could not be said for the box truss supports (Figure 5.8). Although the Mistras inspection reports indicate similar deficiencies, such as with the anchor bolts, tightness of the nuts, and loss of galvanization on frame, new deficiencies were observed. These included development of new concrete spalls, increased vegetation growth, and advancement in the loss of galvanization on the support. This shows increasing degradation of the support since the last ODOT inspection.

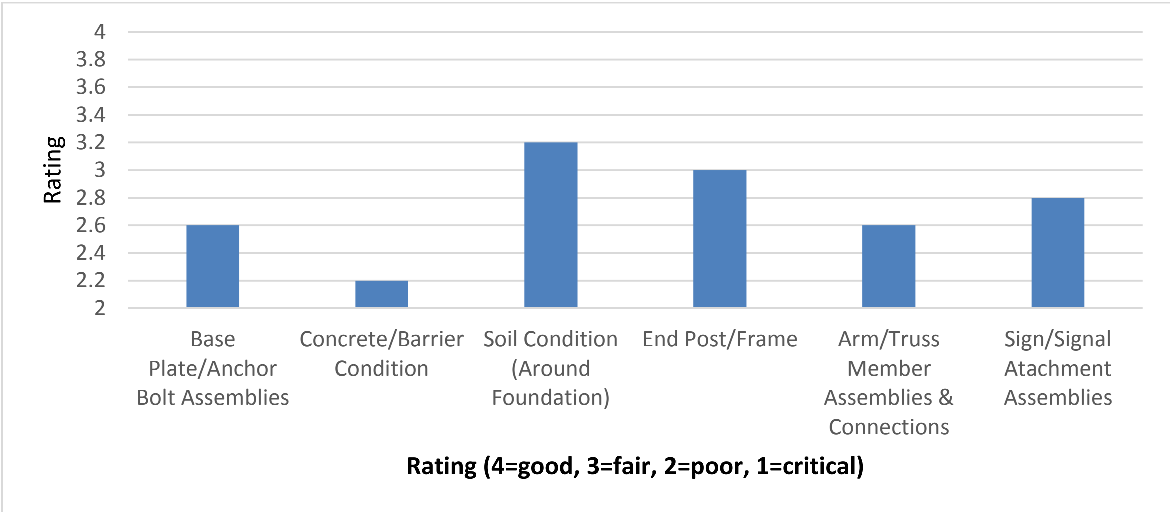


Figure 5.8 Box truss supports: Average component rating (District 3)

Following the same process for the flush bridge mounted supports, ongoing degradation of the supports was observed (Figure 5.9). Previous ODOT records showed deficiencies with anchorage tightness in the supports. Mistras inspection reports indicated a significant amount of deficiencies for the flush bridge mounted supports that included corrosion and pitting, and advanced degradation of the anchor bolts and tightness of the nuts. These deficiencies led to a critical rating of the flush bridge mounted supports.

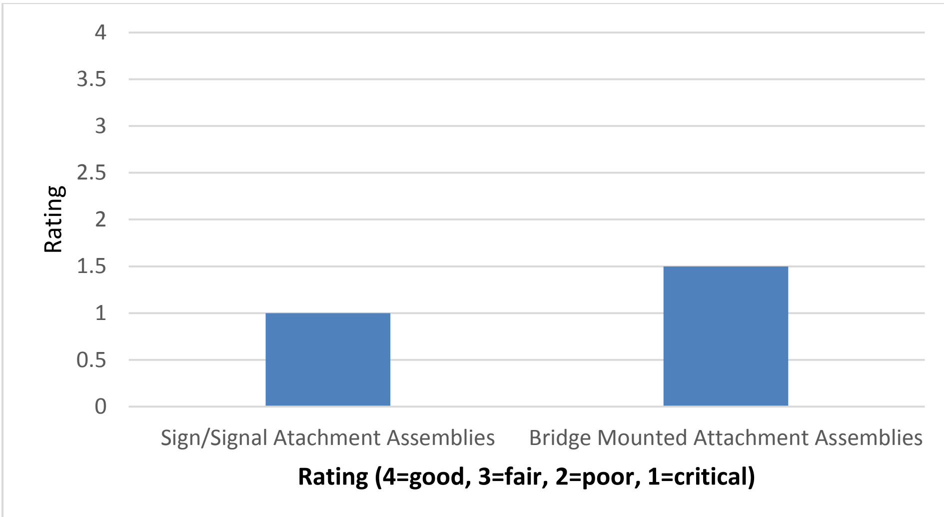


Figure 5.9 BMS (flushed/skewed): Average component rating (District 3)

The overall rating of the support is based on the (conservative) selection of the lowest rated component for that support. Figure 5.10 shows the number of sign supports for each overall rating category in District 3.

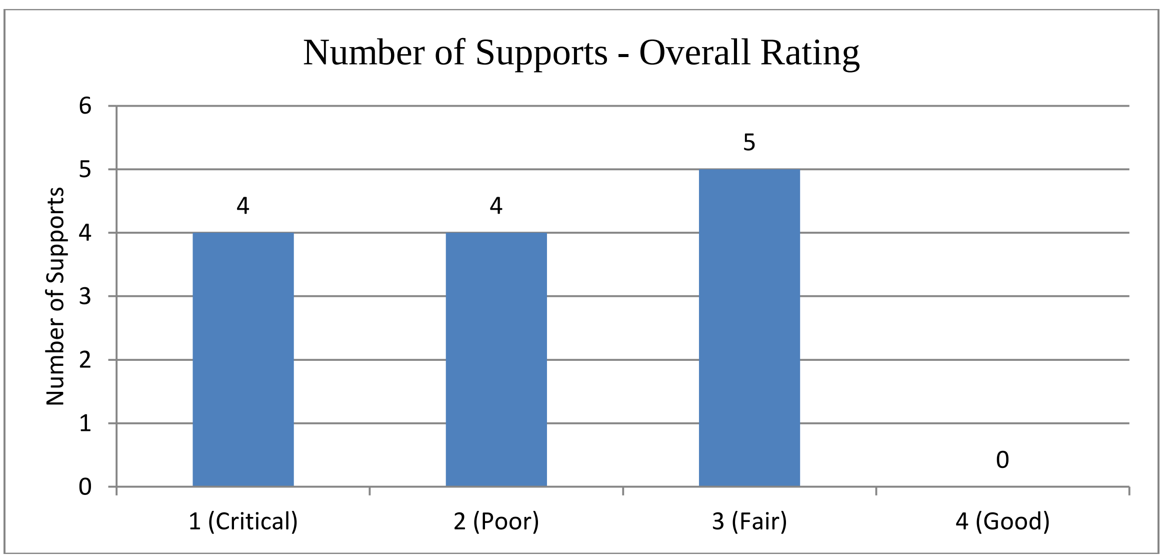


Figure 5.10 Number of supports for each overall rating (District 3)

5.6 District 4

In District 4, the research team selected 11 overhead sign supports to be investigated. Table 5.7 provides a list of different type of supports inspected in this District and Table 5.8 provides the number and most observed deficiencies found in District 4.

Table 5.7 Number and type of the signs inspected (District 4)

Cantilever Arm	6
Box Truss	2
Bridge Mounted	3
Total	11

Table 5.8 Summary of deficiencies by occurrence (District 4)

Foundation	End Post/Frame/ Arm-Truss Members	Sign/Signal Attachment Assemblies
Loss of galvanizing (6)	Loss of galvanizing (9)	Missing attachment hardware (6)
Spalls (4)	Surface Rust/Section Loss (end post) (8)	Cracked/Loose nuts/bolts (4)
Cracks (3)	Missing pole cap/handhole cover (6)	
Overtopping of soil (3)		

Figures 5.11 through 5.13 summarize the ratings of each support component for the cantilever arm, box truss, and bridge mounted supports.

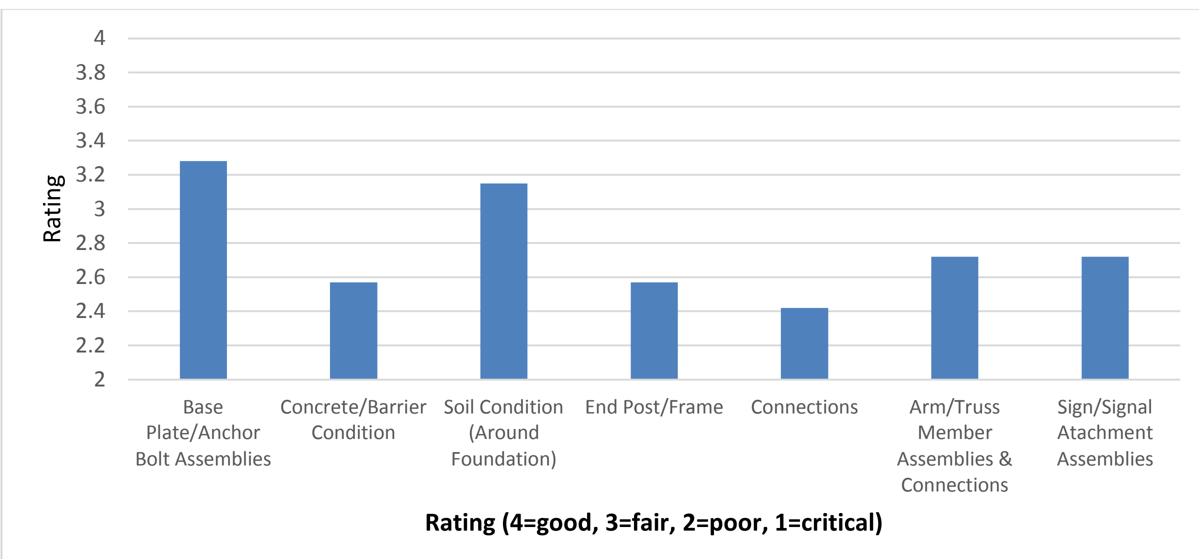


Figure 5.11 Cantilever arm supports: Average component rating (District 4)

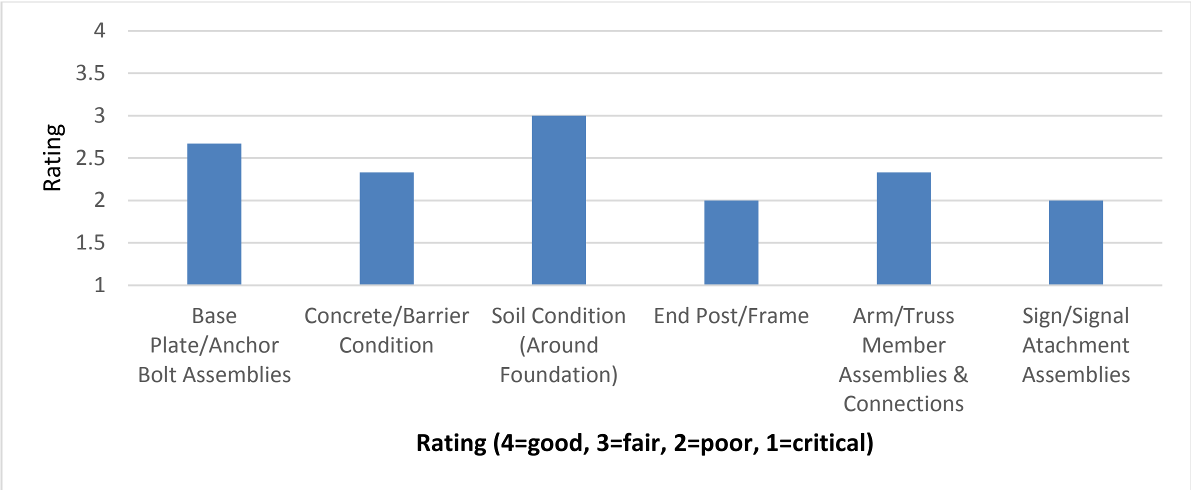


Figure 5.12 Box truss supports: Average component rating (District 4)

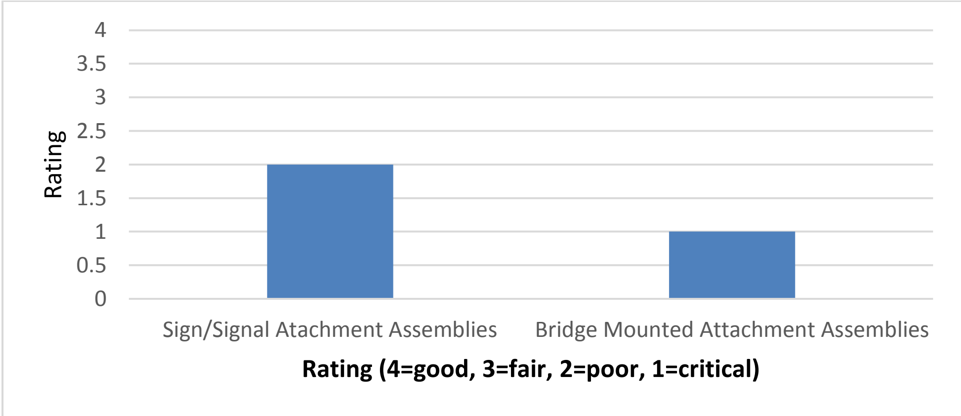


Figure 5.13 BMS (flushed/skewed): Average component rating (District 4)

As before, the overall rating is based on the lowest rating found from individual component for that support type. Figure 5.14 shows the number of sign supports under each overall rating category.

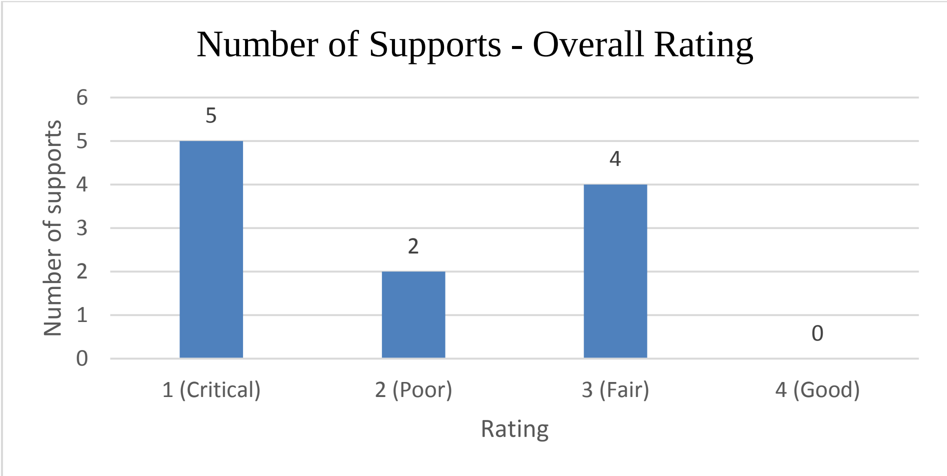


Figure 5.14 Number of supports for each overall rating (District 4)

5.7 District 5

21 OSS were selected in District 5 for inspection. Table 5.9 provides a list of different type of supports inspected and Table 5.10 provides the number and type of the most deficiencies observed.

Table 5.9 Number and type of the signs inspected (District 5)

Cantilever Arm	10
Box Truss	8
Bridge Mounted	3
Total	21

Table 5.10 Summary of deficiencies by occurrence (District 5)

Foundation	End Post/Frame/ Arm-Truss Members	Sign/Signal Attachment Assemblies
Loose nuts/bolts (3)	Surface Rust/Section Loss (6)	Cracked/Loose nuts/bolts (5)
Loss of galvanizing (6)	Loss of galvanizing (9)	Missing attachment hardware (2)
Spalls (2)	Missing pole cap/handhole cover (2)	
Cracks (4)		
Overtopping of soil (1)		
Vegetation Growth (4)		

Figures 5.15 through 5.17 summarize the ratings of each support component for the cantilever arm, box truss, and bridge mounted supports, respectively.

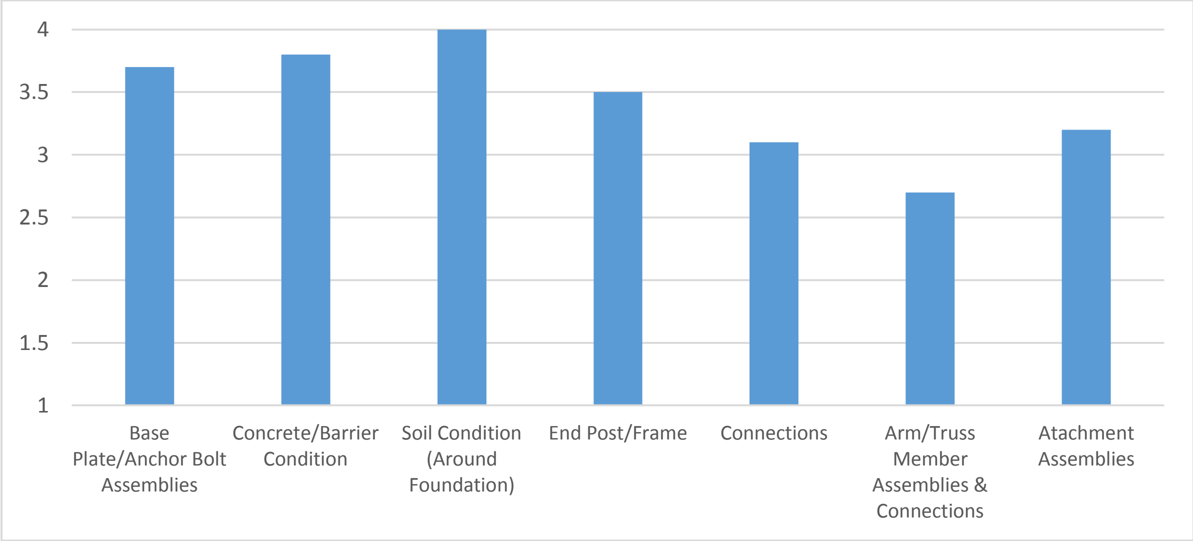


Figure 5.15 Cantilever arm supports: Average component rating (District 5)

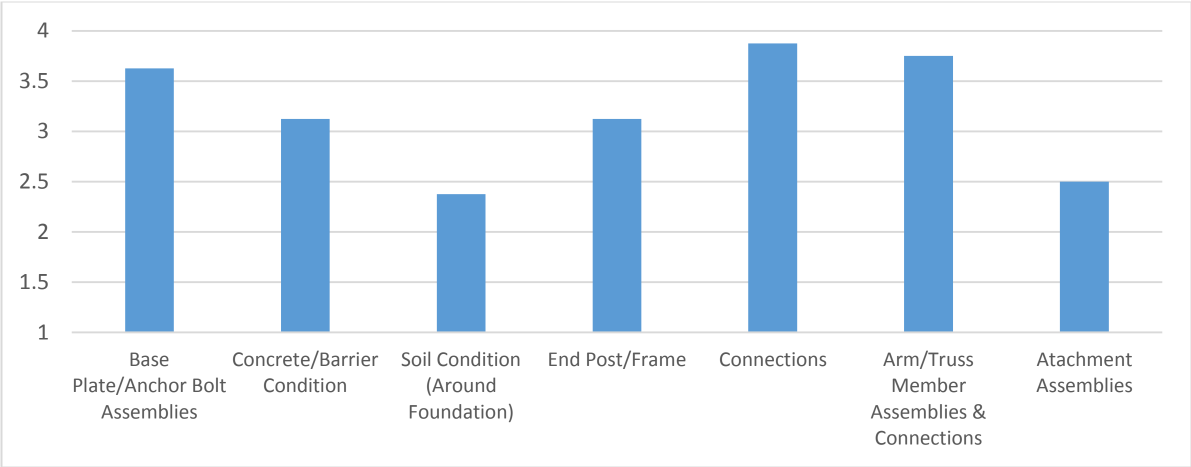


Figure 5.16 Box truss supports: Average component rating (District 5)

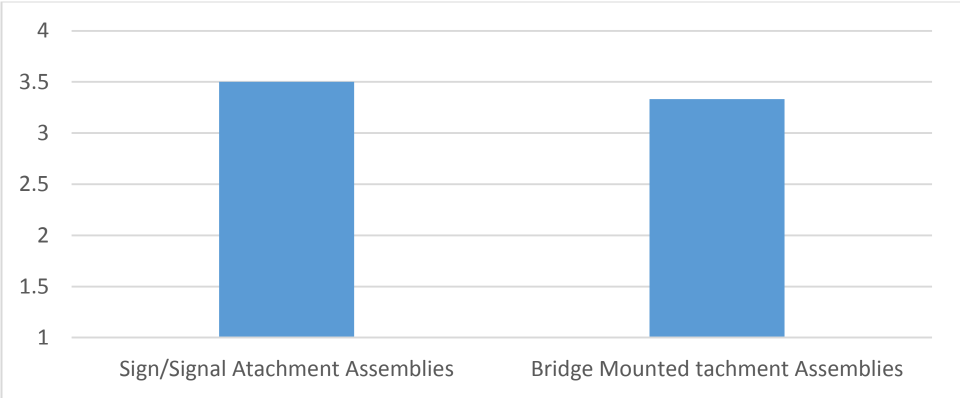


Figure 5.17 BMS (flushed/skewed): Average component rating (District 5)

Figure 5.18 shows the number of sign supports under each overall rating category, based on the lowest component rating for that support type.

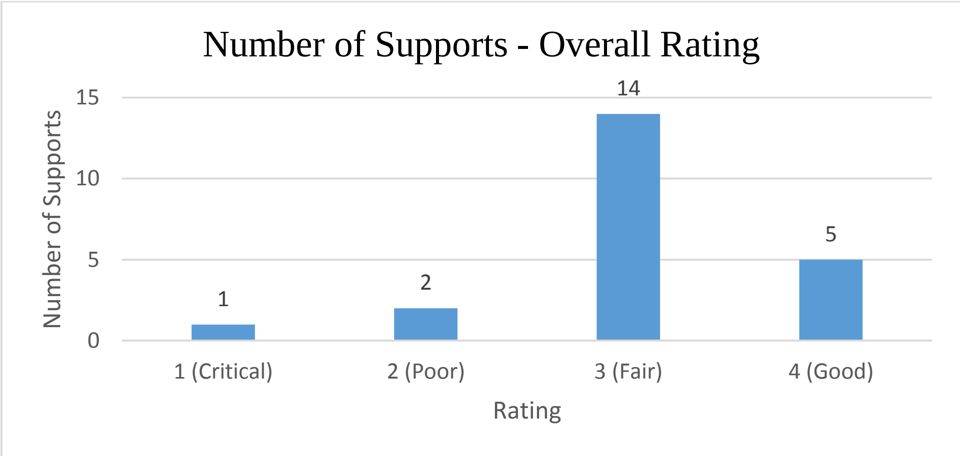


Figure 5.18 Number of supports for each overall rating (District 5)

5.8 District 6

Table 5.11 lists the 12 OSS selected for inspection by support type and Table 5.12 provides a summary of the deficiencies observed.

Table 5.11 Number and type of the signs inspected (District 6)

Cantilever Arm	3
Box Truss	5
Bridge Mounted	4
Total	12

Table 5.12 Summary of deficiencies by occurrence (District 6)

Foundation	End Post/Frame/ Arm-Truss Members	Sign/Signal Attachment Assemblies
Missing nuts/washers (1)	Surface Rust/Section Loss (1)	Cracked/Loose nuts/bolts (2)
Loss of galvanizing (2)	Loss of galvanizing (4)	Missing attachment hardware (2)
Overtopping of soil (3)	Missing pole cap/handhole cover (2)	
Vegetation Growth (3)		

Figures 5.19 through 5.21 summarize the rating of each support component cantilever arm, box truss, and bridge mounted supports, respectively.

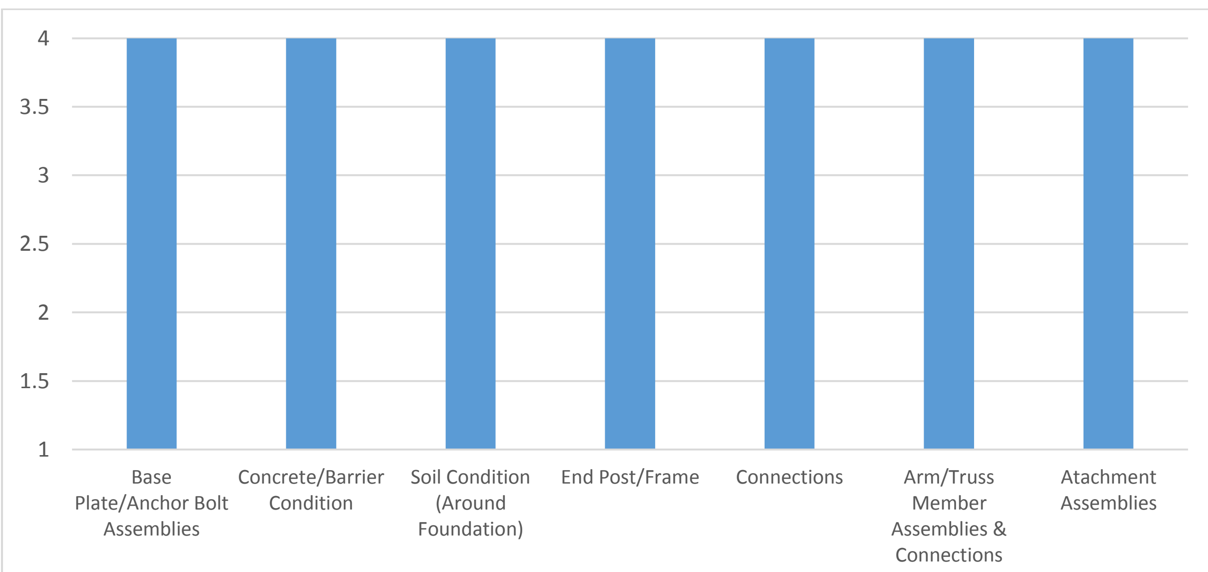


Figure 5.19 Cantilever arm supports: Average component rating (District 6)

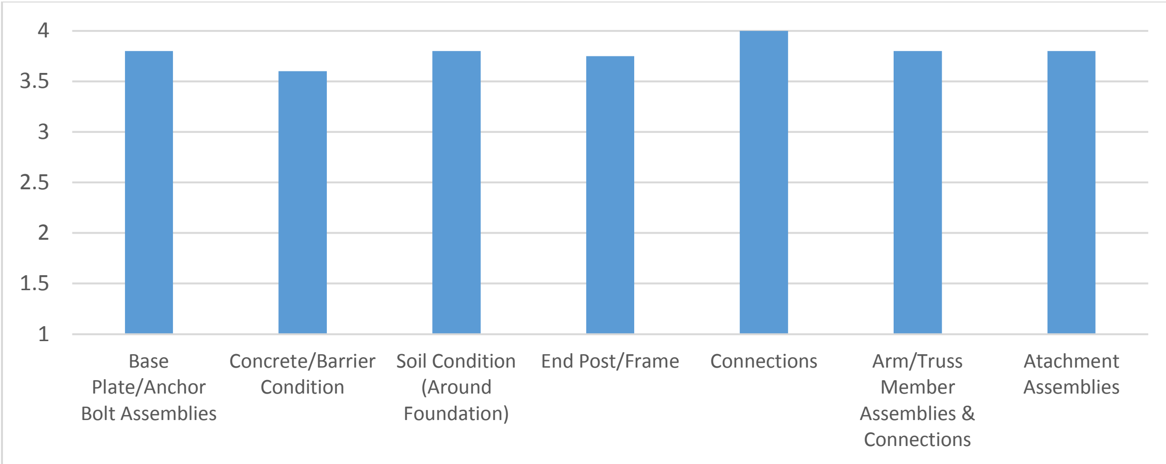


Figure 5.20 Box truss supports: Average component rating (District 6)

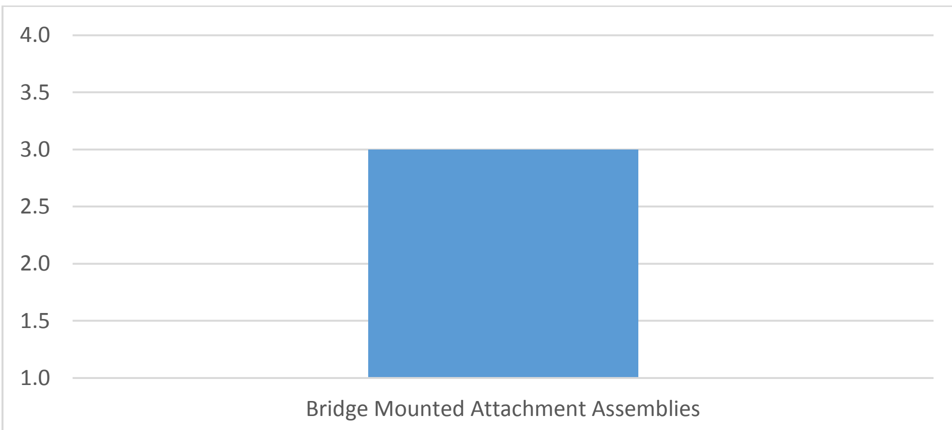


Figure 5.21 BMS (flush/skewed): Average component rating (District 6)

The overall rating is based on the lowest rating found from the rating of each individual component. The following figure 5.22 shows the number of sign supports under each overall rating category.

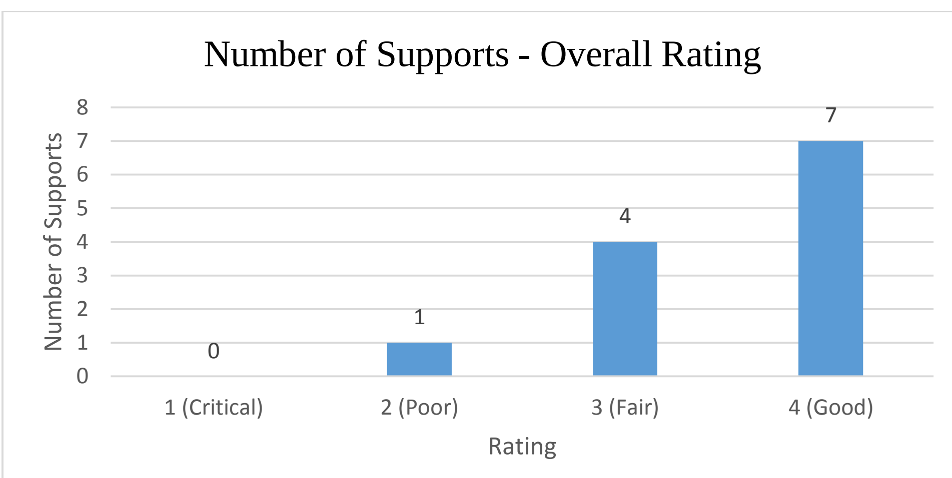


Figure 5.22 Number of supports for each overall rating (District 6)

5.9 District 7

After careful reviewing of ODOT inspection reports, 16 supports were selected for inspection in District 7; several of which had deficiencies noted in the ODOT inspection reports. Table 5.13 gives the number and type of the sign supports inspected while Table 5.14 provides a summary of the most observed deficiencies.

Table 5.13 Number and type of the signs inspected (District 7)

Cantilever Arm	11
Box Truss	2
Bridge Mounted	3
Total	16

Table 5.14 Summary of deficiencies by occurrence (District 7)

Foundation	End Post/Frame/ Arm-Truss Members	Sign/Signal Attachment Assemblies
Loose nuts/bolts (6)	Loss of Galvanizing (14)	Missing attachment hardware (14)
Loss of Galvanizing (5)	Cracked/Loose nuts/bolts (9)	
Spalls (5)	Gaps between plates (6)	
Voids/Honeycombing (3)	Surface Rust/Section Loss (5)	
Cracks (3)	Corrosion/Pitting/Section Loss (4)	
Insufficient thread engagement (1)		

Figures 5.23 through 5.25 summarize the rating of each support component cantilever arm, box truss, and bridge mounted supports.

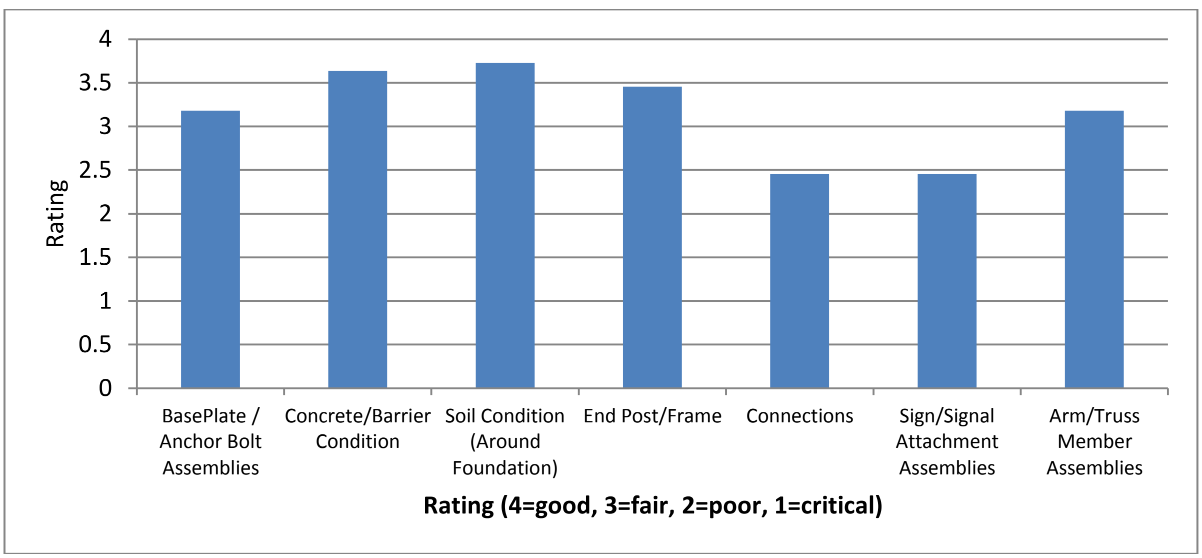


Figure 5.23 Cantilever arm supports: Average component rating (District 7)

Figure 5.24 Box truss supports: Average component rating (District 7)

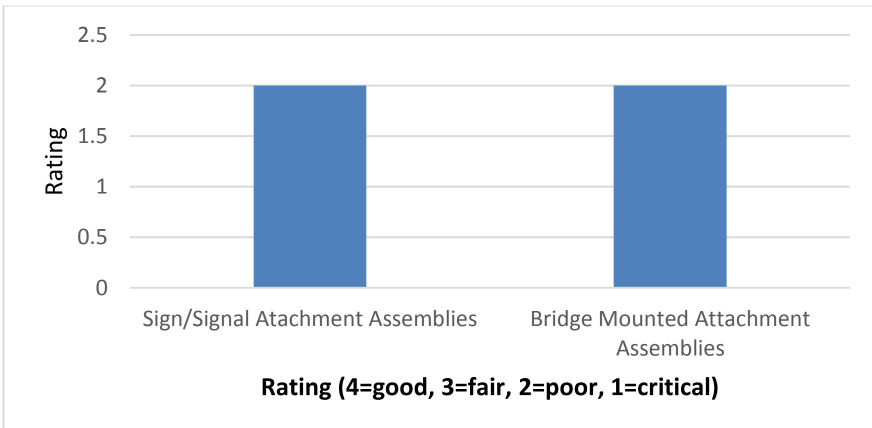


Figure 5.25 BMS (flushed/skewed): Average component rating (District 7)

Similar to other Districts, the overall rating is based on the lowest component rating for each support and the results shown in Figure 5.26.

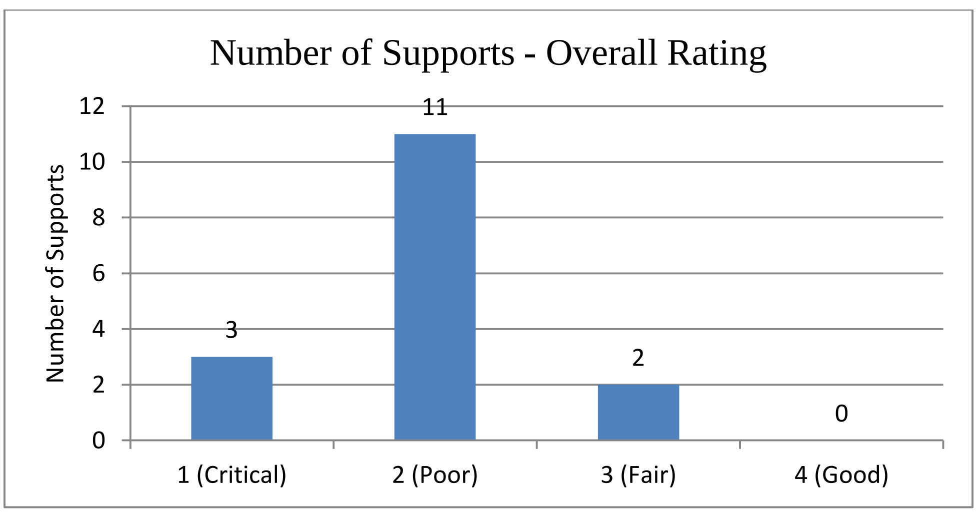


Figure 5.26 Number of supports for each overall rating (District 7)

5.10 District 8

A total of 9 OSS were selected in District 8. The types of supports selected, along with the most observed deficiencies, can be found in Tables 5.15 and 5.16 respectively.

Table 5.15 Number and type of the signs inspected (District 8)

Cantilever Arm	1
Box Truss	8
Bridge Mounted	0
Total	9

Table 5.16 Summary of deficiencies by occurrence (District 8)

Foundation	End Post/Frame/ Arm-Truss Members	Sign/Signal Attachment Assemblies
Loose nuts/bolts (1)	Surface Rust/Section Loss (1)	Missing attachment hardware (2)
Loss of galvanizing (1)	Loss of galvanizing (3)	
Overtopping of soil (1)	Missing pole cap/handhole cover (1)	
Vegetation Growth (3)	Bent/Broken/Damage pole or diagonals (2)	
	Cracks in welds (1)	

Figures 5.27 and 5.28 summarize the rating of each support component for the cantilever arm, box truss, and bridge mounted supports, respectively.

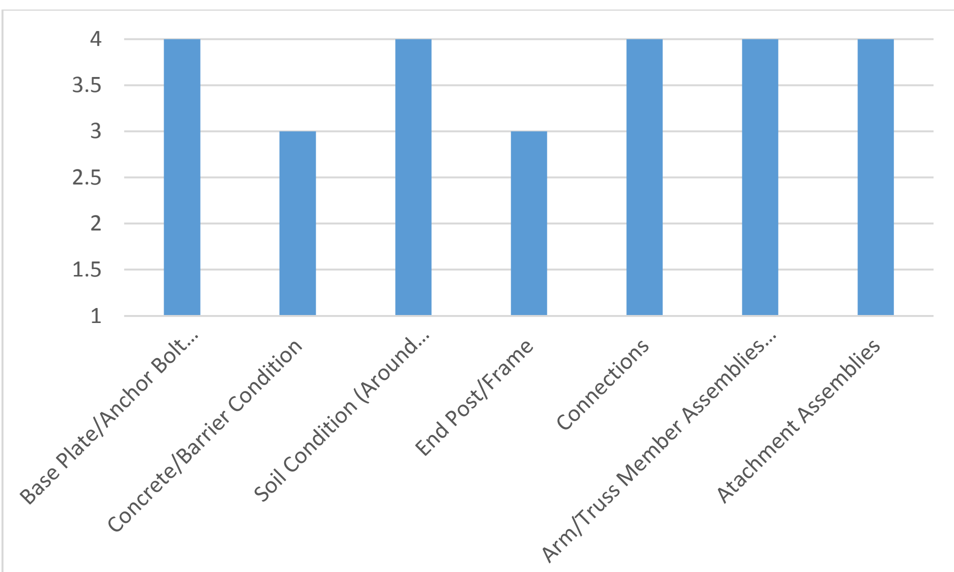


Figure 5.27 Cantilever arm support: Average component rating (District 8)

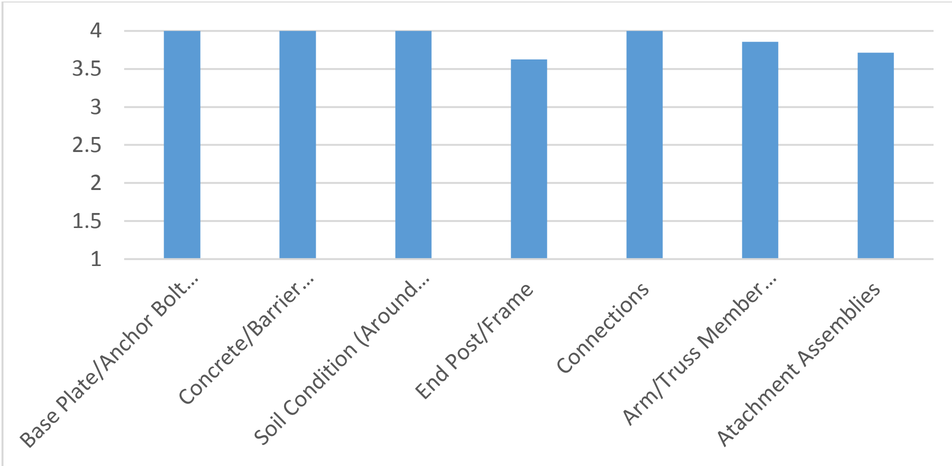


Figure 5.28 Box truss supports: Average component rating (District 8)

The one support rated as critical “1”, was a BMS box truss, in which the truss had been hit by a dump truck with its dump bed in the raised position. The truss was subsequently removed, but the end posts were still on the bridge at the time of inspection and the foundation components were inspected (Figure 5.29).

The overall rating is based on the lowest rating found from the rating of each individual component. Figure 5.30 shows the number of sign supports under each overall rating category.

Figure 5.29 Damaged BMS

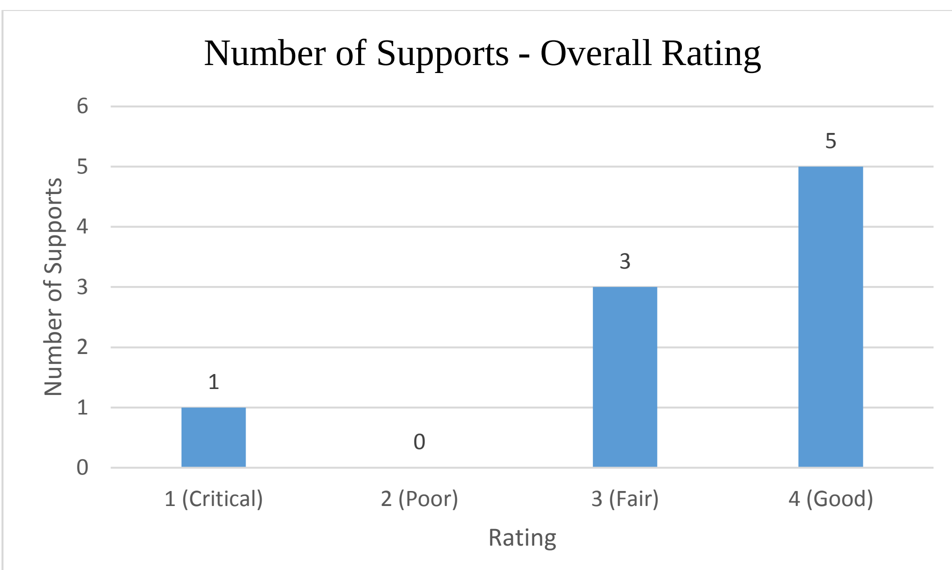


Figure 5.30 Number of supports for each overall rating (District 8)

5.11 District 9

In District 9, only one overhead sign support was inspected. This was done as an opportunity arose to perform the inspection alongside an ODOT inspection and resulted in savings in MOT and equipment rental costs. The particular sign inspected was a bridge mounted box truss with a broken diagonal that had been previously repaired with a carbon fiber wrap. Table 5.17 provides the number and type of most observed deficiencies for this support.

Table 5.17 Summary of deficiencies by occurrence (District 9)

Foundation	End Post/Frame/ Arm-Truss Members	Sign/Signal Attachment Assemblies
	Broken diagonal-previously repaired (1)	

Figure 5.31 summarizes the rating of each support component of the box truss support.

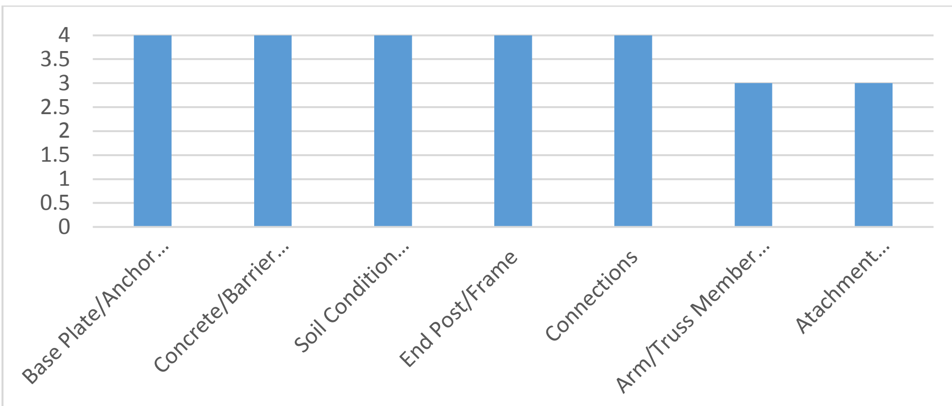


Figure 5.31 Box truss support: Component rating (District 9)

The overall support rating is based on the lowest component rating found for that support type. Figure 5.32 shows overall rating for the box truss support.

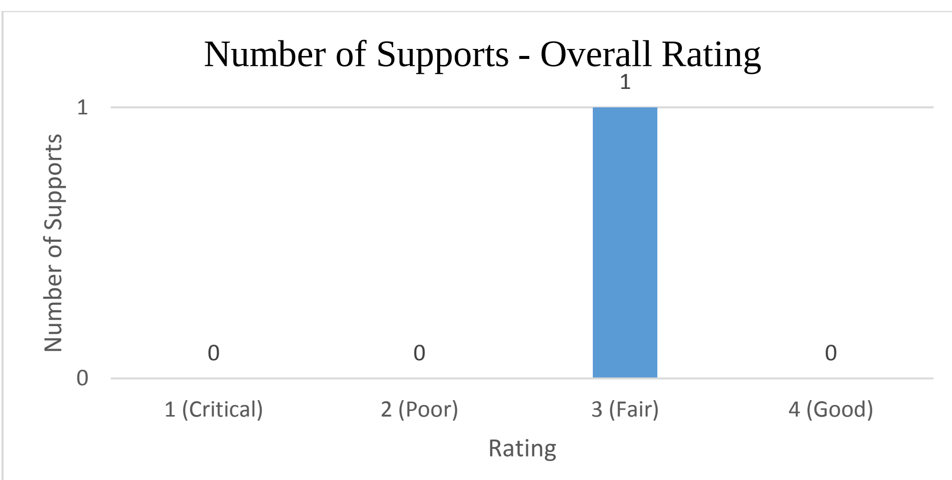


Figure 5.32 Number of supports for each overall rating (District 9)

5.12 District 12

In District 12, a total number of 23 overhead sign supports were inspected by Mistras. These supports included 9 dual arm cantilever supports, 6 box truss supports and 6 bridge mounted sign supports (Table 5.18). The number of most deficiencies observed are provided in Table 5.19.

Table 5.18 Number and type of the signs inspected (District 12)

Cantilever Arm	9
Box Truss	6
Bridge Mounted	8
Total	23

Table 5.19 Summary of deficiencies by occurrence (District 12)

Foundation	End Post/Frame/ Arm-Truss Members	Sign/Signal Attachment Assemblies
Corrosion/Section Loss (10)	Missing pole cap/handhole cover(12)	Missing attachment hardware (8)
Loss of Galvanizing (10)	Cracked/Loose nuts/bolts (8)	Cracked/Loose nuts/bolts (4)
Vegetation Growth (10)	Corrosion/Pitting/Section Loss (in frame both arm or truss) (4)	
Overtopping of Soil (7)		
Spalls (7)		

Figures 5.33 through 5.35 summarize the rating of each support component for the cantilever arm, box truss, and bridge mounted supports.

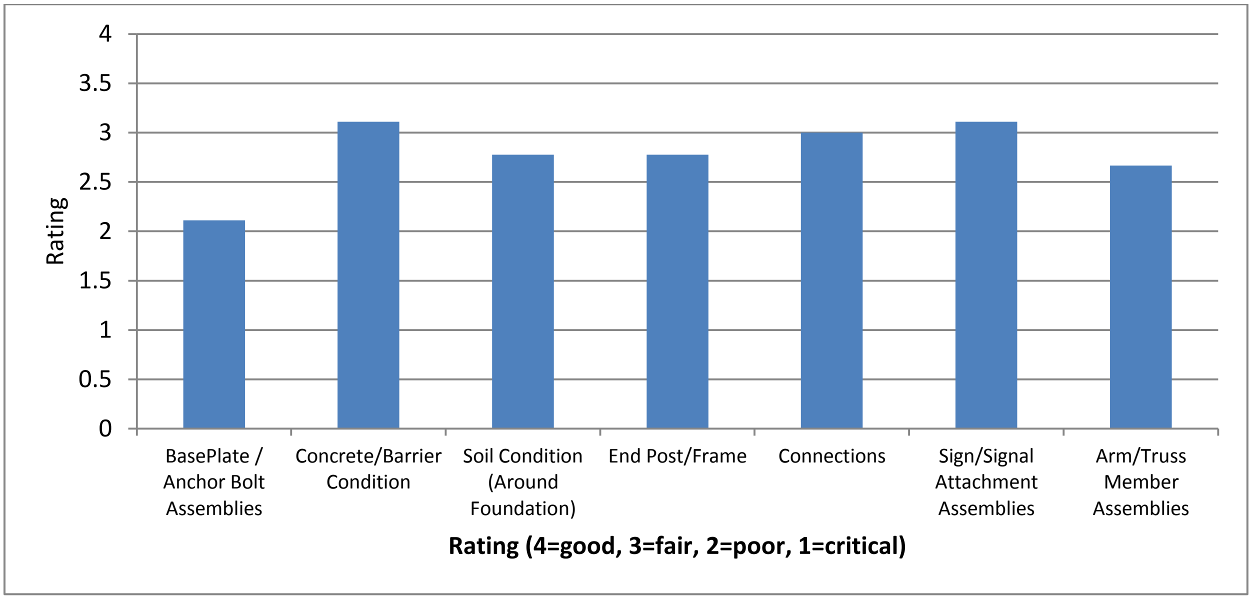


Figure 5.33 Cantilever arm supports: Average component rating (District 12)

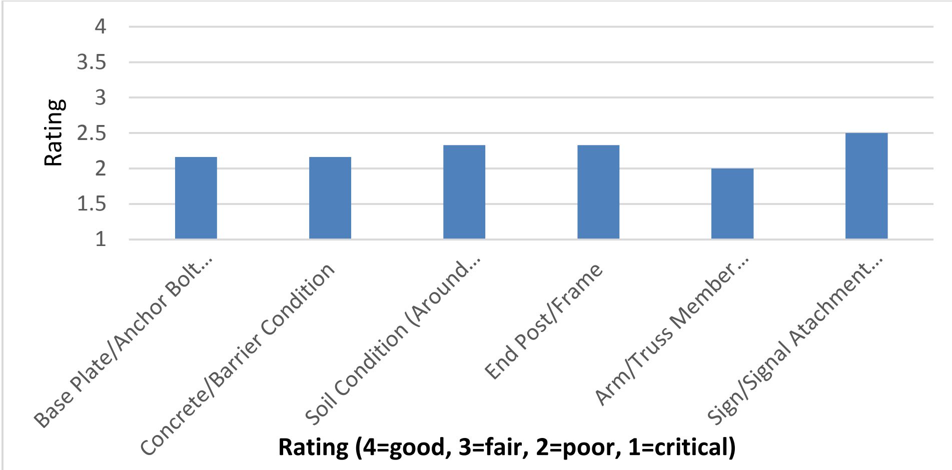


Figure 5.34 Box truss supports: Average component rating (District 12)

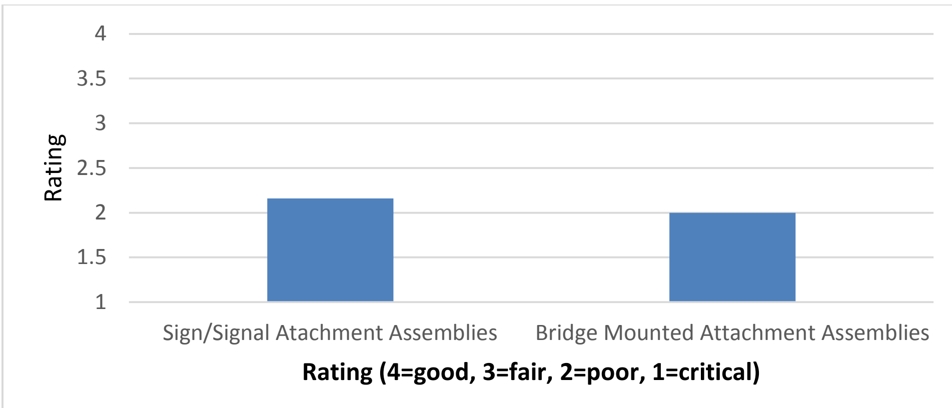


Figure 5.35 BMS (flush/skewed): Average component rating (District 12)

The overall support rating is based on the lowest component rating found for that support type. Figure 5.36 shows overall ratings for each support that was inspected.

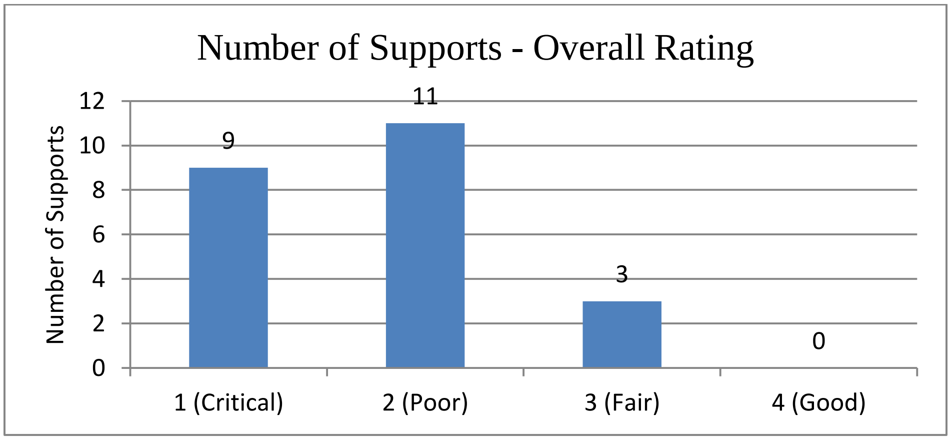


Figure 5.36 Number of supports for each overall rating (District 12)

5.13 Discussion of Results

The following information in this section is from the inspection results of ten out of twelve Districts for the state of Ohio. Additionally, the results cover a total of 129 OSS that were inspected using an in-depth, hands-on approach. The following sections provide a summary of major deficiencies observed, recorded and reported from Districts 1-9, and 12.

5.13.1 Foundation

A review of Table 5.20 provides a general assessment regarding the current condition of the foundations for the 129 OSS inspected. The most frequent deficiency observed was related to the loss of galvanization, a process that applies a zinc coating to the surface of the material to act as a barrier and sacrificial anode. This not only increases protection against corrosion, but can extend the service life of the support.

Table 5.20 Foundations: Most observed deficiencies by occurrence

Deficiency	D01	D02	D03	D04	D05	D06	D07	D08	D09	D12	Total
Loss of galvanizing	6	0	4	6	6	2	5	1	0	10	40
Vegetation Growth	0	3	6	0	4	3	0	3	0	10	29
Spalls	0	0	5	4	2	0	5	0	0	7	23
Loose nuts/bolts	5	3	2	0	3	0	6	1	0	0	20
Corrosion / section loss	0	0	0	0	0	0	0	0	0	10	10
Overtopping of soil	0	0	0	3	1	3	0	1	0	7	15
Cracks	0	0	0	3	4	0	3	0	0	0	10
Voids / Honeycombing	6	0	0	0	0	0	3	0	0	0	9
Insufficient thread engagement	0	2	4	0	0	0	1	0	0	0	7
Missing hardware	0	0	0	0	0	1	0	0	0	0	1

While loss of galvanization is not an immediate concern, continued loss and subsequent corrosion can lead to potential section loss and decrease in service life of the structure. In order to maintain the coating system, typical practices include cleaning debris from structure, removing vegetation growth around the foundation, painting the support, and touch up of galvanizing or recoating (20-25 years, based on anecdotal information). The next largest deficiency observed by occurrence was vegetation growth around foundation components. The high number of supports with vegetation growth issue shows that the current 5 year inspection frequency allows the vegetation to grow up around the support. This of course requires removal of all vegetation around the foundation in order to perform a thorough inspection. Again, this particular deficiency is not as critical as other deficiencies, and does not usually result in significant structural issues. However, persistent vegetation growth, coupled with overtopping of the foundation with soil, can lead to future corrosion issues of the bolts, plate and spalling of the concrete due to deterioration. This issue could be mitigated by more frequent routine maintenance and trimming of vegetation around the concrete foundation.

From the inspections, almost one third of the supports had some level of concrete spalling and pitting around the foundation. In terms of structural adequacy, concrete spalling might be considered a minor deficiency. However, if the spalls, combined with vegetation, cracking and overtopping of the soil continue, this process is likely to lead to widespread deterioration and propagate throughout the foundation. This may also result in damage to the anchorage bolts and nuts with the potential for total failure of foundation concrete.

Also from Table 5.20, the observation of loose nuts on the foundation anchor bolts occurred about as frequently as the concrete spalling. This deficiency may cause improper leveling at the support foundation, rocking due to wind loads or gusts from passing trucks, subsequent fatigue damage and ultimately structural issues at the foundation.

5.13.2 End Post/Frame/Arm-truss Members

Similar to foundation records, loss of galvanization is the most frequent deficiency observed on end post, frame or truss members of supports (Table 5.21). Performing touch ups of the galvanization or painting the support components is one way of mitigating the loss of galvanization flaw.

Table 5.21 End post/frame/arm-truss members: Most observed deficiencies by occurrence

Deficiency	D01	D02	D03	D04	D05	D06	D07	D08	D09	D12	Total
Loss of galvanizing	6	0	3	9	9	4	14	3	0	0	48
Cracked/loose nuts/bolts	0	6	6	0	0	0	9	0	0	8	29
Missing pole cap/handhole cover	0	3	0	6	2	2	0	1	0	12	26
Surface rust/section loss	0	0	0	8	6	1	5	1	0	0	21
Corrosion/pitting/section loss	4	0	0	0	0	0	4	0	0	4	12
Gaps between plates	3	0	0	0	0	0	6	0	0	0	9
Bent/broken/damaged pole(s) or diagonals	0	0	0	0	0	0	0	2	1*	0	3

Note(s): * - previously broken but repaired with an FRP wrap system.

Deficiencies with the nuts and bolts are a serious concern in inspection since the load gets transferred to the rest of anchor bolts if one anchor nut becomes loose or a bolt fails. Even one failed bolt or nut can overload the remaining bolts. Additionally, in the presence of loose nuts or cracked bolts, the support could see an increase in deflections and movement, and lead to premature degradation of other components. Any cracked, missing, broken or loose anchor bolts and nuts should be replaced or properly tightened.

Pole caps and hand hole covers can become an important safety issue when they are missing, especially when there is electrical power inside the post. Missing caps and covers should be repaired or replaced to mitigate potential nesting by birds and small animals and to prevent the accumulation of rain water inside the pole; which leads to loss of galvanization and corrosion from inside the poles and members.
Loss of galvanization of the support leads to corrosion. Further loss and ongoing corrosion can then ultimately lead to section loss and subsequent reduction of strength in the member. The

magnitude and location of the corrosion or section loss will determine how critical the degradation is and the subsequent treatment. If remediated in the early stages of corrosion, treatment would require light cleaning and touch up of galvanization/painting. Later stages may lead to the replacement of one or more members.

5.13.3 Sign/Signal Attachment Assemblies

The greatest deficiency observed during inspection of the attachment assemblies was missing hardware (Table 5.22). For example, a large number of supports had missing or loose sign clips. At the time of inspection, the number of sign clips typically used to attach a sign during construction, nor the minimum number of sign clips required to keep a sign in place was unknown. The sign clips provide a stiff connection between the sign panel and the z-bars attached to the support.

Table 5.22 Sign/Signal Attachment Assemblies: Most observed deficiencies by occurrence

Deficiency	D01	D02	D03	D04	D05	D06	D07	D08	D09	D12	Total
Missing attachment hardware	2	2	0	6	2	2	14	2	0	8	38
Cracked/loose nuts/bolts	2	3	4	4	5	2	0	0	0	4	24

During the hands-on inspection process, if missing hardware was observed, the inspectors would tap the remaining sign clips to check for tightness. In several cases, the sign clips were loose enough to fall when tapped with a hammer. In this event, the clip was put back into the original position and tightened by hand. However, torque is not reliably related to the bolt tension. While the detection of missing sign clips could be observed from a ground based inspection, missing sign clips would become a triggerable event for a follow-up, hands on inspection to check the tightness of the remaining sign clips in addition to replacing clips as needed for proper panel support.

5.13.4 Summary of Mistras and ODOT Inspection Records

Table 5.23 provides a comparison of the results between the historical ODOT inspection reports and Mistras inspection reports (from the hands-on inspection process) along with a summary of all significant deficiencies observed by Mistras and ODOT inspection records. A total number of 388 deficiencies were detected from both Mistras and ODOT inspection records. The number of flaws observed for each support is provided in the last three columns. Column “Both Observed” indicates the number of deficiencies observed by both Mistras and ODOT. Column “Only Mistras Observed” shows the number of deficiencies observed only by Mistras, in addition to the “Both Observed” deficiencies. Lastly, column “Only ODOT Observed” indicates the number of deficiencies obtained from ODOT inspection records, in addition to column “Both Observed” column.

Table 5.23 Summary of Mistras and ODOT Inspection Reports

District	support	Type	Mistras	ODOT	Both Observed	Only Mistras Observed	Only ODOT Observed
District 1	10101	Dual Arm Cantilever	Loss of Galv., concrete chipped, Plates Gap,	Nut tightness	0	3	1
	10102	Dual Arm Cantilever	Loss of galv., loose nuts, Corrosion, Plates gap	Nut/Bolt tightness, Nut/Bolt corrosion	2	2	0
	10103	Dual Arm Cantilever	Loose nuts, Loss og galv., Honeycombing, U-bolt misaligned	Nut/Bolt tightness, Concrete exposed	2	2	0
	20101	Box Truss	Loss og galv,. Cracks in foundation, Undermined footing, Corrosion	Nut tightness, Concrete Exposed, Corrosion	2	2	1
	20102	Box Truss	Loose nuts/bolts, Honeycombing, Loss of galv., Missing Z-clips	Nut/Bolts tightness, Corrosion, Concrete cracked	2	2	1
	20103	Box Truss	Loose nuts/bolts, Corrosion, concrete crack, concrete erosion, cross member bent, Loss of galv.	Anchor nuts/bolts tightness, anchor nut/bolts corrosion, concrete cracking, concrete spalling	4	2	0
	20104	Box Truss	Loose nuts/bolts, Rust on nuts/bolts, Concrete spalling, Loss og galv., U-bolt misaligned	Anchor nuts/bolts tightness, anchor nut/bolts corrosion, concrete exposed	3	2	0
	40101	Bridge Mounted	Loss of galv., Corrosion, Concrete chipping		0	3	0
	40102	Bridge Mounted	Loose bolt, Rust, Gap on loose bracket, comcrete cracked	Bolt corrosion,	1	3	0
District 2	10201	Dual Arm Cantilever	Loose nuts/bolts, Member bent		0	2	0
	10202	Dual Arm Cantilever	Loose nuts/bolts, concrete spalls, Bent	Loose nuts/bolts, Foundation appraisal is fair	2	1	0
	10203	Dual Arm Cantilever	Loose nuts/bolts	Foundation appraisal is fair, Vertical support is fair, horizontal support is fair	1	0	2
	10204	Dual Arm Cantilever	Cocrete honeycombing	Foundation appraisal is fair, Vertical support is fair, horizontal support is fair	1	0	2
	10205	Dual Arm Cantilever	Loose nuts/bolts	Foundation appraisal is fair, Vertical support is fair, horizontal support is fair	1	0	2
	10206	Dual Arm Cantilever	Concrete spalls, Loose nuts/bolts, Plates gap, Loose z clips	Foundation appraisal is fair, Vertical support is fair, horizontal support is fair	2	2	1
	10207	Dual Arm Cantilever	Loose nuts/bolts, Gaps between plates	Foundation appraisal is fair, Vertical support is fair, horizontal support is fair	2	0	1
	20201	Box Truss	Loss of galv.	Foundation appraisal is fair, Vertical support is fair, horizontal support is fair	0	1	3
	20202	Box Truss	Loose nuts/bolts, Concrete spalls	Foundation appraisal is fair, Vertical support is fair, horizontal support is fair	1	1	1
	20203	Box Truss	Loose nuts/bolts		0	1	0
	20204	Box Truss		Foundation appraisal, Soil erosion	0	0	2
	20205	Box Truss	Loose nuts/bolts, cocrete cracked/spalled	Foundation appraisal is fair, Vertical support is fair, horizontal support is fair	2	0	1
	40201	Bridge Mounted	Loose nuts/bolts, High vibration, Cracked concrete		0	3	0
	40202	Bridge Mounted	Loose nuts/bolts, Gap between plates, Cracks in concrete, Loose/missing z-clips	Rating 2	0	4	1
	40203	Bridge Mounted	Loos attachment clips		0	1	0

Cont. Table 5.23 Summary of Mistras and ODOT Inspection Reports

District	support	Type	Mistras	ODOT	Both Observed	Only Mistras Observed	Only ODOT Observed
District 3	10301	Dual Arm	Thread Engagement, Rust on weld	Nut tightness	1	1	0
	10302	Dual Arm Cantilever	Loss of Galv., Concrete flaw, Loose nuts, loose z-clip	Nut tightness	1	3	0
	10303	Dual Arm Cantilever	thread Engagement	Anchor nuts tightness, Sign lighting exist, Foundation is level with ground	1	0	2
	10304	Dual Arm Cantilever	Nuts are not fully engaged, Concrete spalls, Nuts on connections are loose	Anchor nuts tightness	1	2	0
	60301	Single Arm Cantilever	Anchorage tightness	Anchor nut tightness, Anchor bolt soundness	1	0	1
	60302	Single Arm Cantilever	anchors not fully engaged, cracks on surface of concrete	Anchor nut tightness, Anchor bolt soundness	1	1	1
	20301	Box Truss	Concrete spalls, U bolts are not fully engaged	Anchor nut tightness, Concrete foundation spalling, Anchor bolt soundness	1	2	1
	20302	Box Truss	Lack of thread engagement, Rusting on base plate, concrete spalls, Endposts are rusted, Loose nuts	Anchor nuts/bolts corrosion, Loss of galv.	2	3	0
	20303	Box Truss	Loss of galv., missing bolts, concrete issues, loose z-clip	Anchor nut tightness	1	3	0
	20304	Box Truss	Lights exist, anchors bent, loose nuts/bolts, Loss of galv., Cocrete spalls, soil erosion, Crack on diagonal members, Loose z-clips, overopping of soil	Anchor nut tightness, sign lighting present, overtopping by soil,	3	6	0
	20305	Box Truss	Crack in weld, Loose bolt on connections, U-bolt not fully engaged	Anchor nuts tightness, Loss of galv.	1	2	1
	40301	Bridge Mounted	Light housing rusting, Rust	Anchor nuts/bolts corrosion, anchor nuts tightness, Loss of galv.	2	0	1
	40302	Bridge Mounted	Gap between plates, Lighting present, Loss of galv., Loose bracket	Anchor nuts/bolts corrosion, Anchor nuts tightness, Lighting exist	2	2	1
District 4	10401	Dual Arm Cantilever	Frame rust, loss of galv, concrete chipping	Foundation corrosion, loose nuts/bolts, frame corrosion	2	1	1
	10402	Dual Arm Cantilever	sidewalk leveled with anchor plate, foundation cracked, loss of galv.,loose nuts/bolts, wrong Ubolt	severe corrosion, foundation crack	2	3	0
	10403	Dual Arm Cantilever	Loss of galv., cocrete spalls, pole dent, thread eng., rust, oversized U-bolt	Dented and bent, moderate corrosion, loose nuts/bolts	2	4	1
	10406	Dual Arm Cantilever	Poor drainage, holeon pole, rust and loss of galv., gap between plates, loose nuts/bolts, sign damage	Loose bolts/nuts, foundation debris, sign damage, moderate corrosion, covered with soil	3	4	2
	10407	Dual Arm Cantilever	Arm bent, loose nuts/bolts, concrete spalls, hole on pole, z-clip	Loose connection, missing washer, moderatre corrosion, gap in attachments, missing diagonal braces	1	4	4
	10408	Dual Arm Cantilever	Rust on anchor bolts/nuts, foundation spalls, holes	Loose bolts/nuts, Moderate Corrosion, Gap in arm, tightness, foundation damage	2	1	3
	20401	Box Truss	Overtopping of soil, Missing cap, Bent/damage/Loose bolts/nuts, z-clip	Moderate Corrosion, Foundation Debris, Missing anchorage washers, overtopping of soil	1	4	3
	20405	Box Truss	Anchorage rust, Loss of galv, frame rust, z-clip	z-clip, loose nuts/bolts, moderate corrosion	2	2	1
	40401	Bridge Mounted	Anchorage rust, concrete crack, concrete rust stain, voids, concrete spalls, holes, bent/dent, loose nuts	Holes, anchor rust, no structures ID signs	2	6	1
	40402	Bridge Mounted	Z-clip, gap between plates, bolt broken	brackets pulling away from parapet	1	2	0
	40403	Bridge Mounted	Loss of Galv, Concrete Crack, Ubolt/thread eng.	Severe corrosion, missing washer. Tightness	2	1	1

Cont. Table 5.23 Summary of Mistras and ODOT Inspection Reports

District	support	Type	Mistras	ODOT	Both Observed	Only Mistras Observed	Only ODOT Observed
District 7	10701	Dual Arm Cantilever	Loose z-clips	Loose anchor bolt	0	1	1
	10702	Dual Arm Cantilever	No lock washer, Bolts not fully tightened, Gap between plates, Loose/missing z-clips	Loose anchor bolt	1	3	0
	10703	Dual Arm Cantilever	Rust on anchor bolts/nuts, foundation spalls, Loss of galv., Rust, Gap on plates, Missing/broken z-clips, U-bolt misaligned	Loose anchor bolt, Minimal surface rust	2	5	0
	10704	Dual Arm Cantilever	Loose nuts, Rust, Concrete spalling, Loss of galv., loose z-clips	Loose nuts/bolts, Rust	2	3	0
	10705	Dual Arm Cantilever	Concrete spalls, Loss of galv., Tightness, Washers move, Missing z-clips	Loose nuts/bolts	1	4	0
	10706	Dual Arm Cantilever	Loose bolts, Soil erosion, Cocrete corrosion, Loss of galv., Rust, Gap between plates, brackets misaligned, missing nuts, missing z-clips	Loose anchor bolt, Rust	2	7	0
	10707	Dual Arm Cantilever	Concrete spalls, lighting exist, Rust, Loss of galv., Anchors not fully engaged, gap on top brackets, rusting welds, missing/broken z-clips	Loose anchor bolt	1	7	0
	10708	Dual Arm Cantilever	Cocrete spalls, Gap on plates, Rust, Missing z-clips	Loose anchor bolt	1	3	0
	10709	Dual Arm Cantilever	Thread engagement, Bolt sound dead, Rust, loose/missing z-clips	Loose anchor bolt	1	3	0
	10710	Dual Arm Cantilever	Loose nuts/bolts, Missing/broken z-clips	Loose anchor bolt	1	1	0
	10711	Dual Arm Cantilever	Undermined footing, Loose anchors, painted rusty area, Missing/broken z-clips	Loose anchor bolt	1	3	0
	20701	Box Truss	Loose nuts/bolts, Loss of galv., Rust, U-bolt misaligned	Loose nuts	1	3	0
	20702	Box Truss	Dead sound bolts, Concrete spalls, Lighting hardware, Rust, Loose U-bolt, Loss of galv, missing/broken z-clips	Loose nuts	1	6	0
	40701	Bridge Mounted	Missing diagonal members, Thread engagement, Missing nuts/bolts	Missing anchor bolt	1	2	0
	40702	Bridge Mounted	Foundation cracks, Rust, U-bolt misaligned/loose	Cracks found on diagonals	0	3	1
	40703	Bridge Mounted	Loss of galv., Thread engagement, Cracks in concrete, Missing/broken z-clips	Losse U-clamp	0	4	1
District 12	11201	Dual Arm Cantilever	Rusted nuts/bolts, Corrosion, Concrete spalls,	Corrosion on nuts	1	2	0
	11202	Dual Arm Cantilever			0	0	0
	11203	Dual Arm Cantilever	Heavy rust on nuts/bolts, Concrete cracks, Concrete spalls, Missing washers, Loose nuts, Thread engagement, U-bolts misaligned	Cracks, Spalling, Bolt corrosion, Nut corrosion, scuffs, Pole has a lean to it	3	4	3
	11204	Dual Arm Cantilever	Weld flaws, Concrete exposed, Gap between plates, loose nut, missing/broken z-clips	Erosion, Concrete exposed, soundness	3	2	0
	11205	Dual Arm Cantilever	Nuts/bolts heavy corrosion, Concrete spalls	Frame cracks, Concrete cracks, Spalling, Nut tightness, Thread engagement	1	1	4
	11206	Dual Arm Cantilever	Nuts/bolts corrosion, End post chipping, Pole dented, Rust, N	Nuts/bolts corrosion	1	5	0
	11207	Dual Arm Cantilever	Bolts are misaligned, Thread engagement, Loose bolts, U-bolts misaligned, Missing/broken z-clips	Foundation erosion, Nut tightness, Corrosion, Thread engagement	2	3	2
	11208	Dual Arm Cantilever	Undermined footing, Missing/broken z-clips, Loss of galv.	Foundation erosion, Concrete exposed, paint peeling	2	1	1
	11209	Dual Arm Cantilever	Corrosion, Concrete cracks, Rust on concrete, undermined footing, Loss of galv., thread engagement	Corrosion on nuts	1	5	0

Cont. Table 5.23 Summary of Mistras and ODOT Inspection Reports

District	support	Type	Mistras	ODOT	Both Observed	Only Mistras Observed	Only ODOT Observed
District 12	21201	Box Truss	Thread engagement, Rust on bolts/nuts, Rust/corrosion, Missing z-clips	Anchor bolt/nut corrosion	1	3	0
	21202	Box Truss	Loose nuts/bolts, Corrosion, Concrete spalls, U-bolt misaligend, Thread engagement, Missing z clips	Corrosion on nuts	1	5	0
	21204	Box Truss	Loss of galv., Concrete spalls, Footing exposed, Member bents	Concrete spalls, Erosion, Concrete exposed, Scuffs	3	1	0
	21205	Box Truss	Foundation corrosion, Weld flaws, rusted nuts/bolts, Thread engagemenet, cracks on foundation, Concrete spalls, Footing exposed, U-bolts misaligned, Mising/broken z-clips	Foundation erosion, bolt corrosion, nut corrosion	3	6	0
	21206	Box Truss	Rust on bolts/nuts, Corrosion, Loose nuts/U-bolts	Corrosion on nuts/bolts, Moderate rust	2	1	0
	21207	Box Truss	Corrosion on nuts/bolts, Concrete spalls, Bent/dent of frame, Loose bolts, Rust, U-bolt misaligned	Corrosion on nuts/bolts	1	4	0
	21208	Box Truss	Losse nuts, Rusted nuts/bolts, Loss of galv., Thread engagemenet, U-bolt misaligned, Loose/missing z-clips	Nut corrosion, Frame Scuffs,	2	4	0
	41201	Bridge Mounted	Heavy Corrosion, Foundation corrosion, thread engagement, Foundation cracks, U-bolts misaligned	Loose bolts	0	5	1
	41202	Bridge Mounted	Missing/broken z-clips, Rusted anchor bolts	Cracks on support	0	2	1
	41203	Bridge Mounted	Missinh attachmenet hardware, Rusted anchors	Missing anchor bolt	1	1	0
	41204	Bridge Mounted	Rust on foundatio, Loss of galv.	Missing anchor nuts	0	2	1
	41205	Bridge Mounted	Loose/missing z-clips, Impact damage, Gap on brackets	Collision	1	2	0
	41206	Bridge Mounted	Rust on nuts/bolts, Bracket gap	Rusting on nuts	1	1	0
	41207	Bridge Mounted	Missing/broken z-clips, thread engagement	Nuts are not fully tighten	0	2	1
	41208	Bridge Mounted	Rust on nuts/bolts	Nuts tusting section loss	1	0	0
				TOTAL	113	214	61

The results show that the in-depth, hands-on inspection process identified a higher number of deficiencies than the traditional ground based visual inspection. The final results show that the Mistras inspection program observed 327 deficiencies in comparison to the previous ODOT inspections of 174, of which 113 deficiencies were observed by both. This indicates that an in-depth, hands-on inspection procedure implemented by Mistras observed almost twice the number of deficiencies.

For Districts 5 and 6, they were not included in Table 5.23 as the inspection report formats and thus the data collected were significantly different than the North. As such, these differences did not allow for a similar comparison to be made. Table 5.24 provides the inspection results related to the foundation. It should be noted that from the ODOT inspection data it was not always easy to match up signs due to differences in descriptions on sign location. In addition, District 5 used a rating scale of 1-4 for the elements, in which "1" was used to indicate a better condition than a rating of "4" (worse condition). Therefore, these numbers were converted into the scale used for the research performed in this study (Table 4.1). Also for District 5, the final overall condition rating of the support was based on a scale of 1-10, with "10" being the best condition (Table 5.26). This scale was also converted into the 1-4 scale used in this study (Table 4.1), with the unconverted ODOT ratings are shown in parenthesis. In District 6, element ratings are based on a simple “satisfactory” or “unsatisfactory” rating with comments. As such, this was also converted into the 1-4 scale. Additionally, the final overall condition rating uses a scale of “poor”, “average”, and “good”. This was also converted into the 1-4 scale with the original rating in parenthesis.

In general, the inspection results were fairly similar with an occasional difference of a magnitude of 1. In a few cases, there was a difference in a magnitude of 2. Some of these cases involved ODOT being lower than that of the more recent Mistras inspection. This could occur for a variety of reasons such as differences of opinion between the different inspectors, changes to the sign support component from the last inspection (repair/replacement), or possibly the wrong sign from the ODOT data was compared.

Table 5.24 Foundation Inspections Mistras and ODOT

District	ID	Type	Base Plate/ Anchor Bolts		Concrete/Barrier Condition		Soil Condition	
			Mistras	ODOT	Mistras	ODOT	Mistras	ODOT
District 5	Box Truss (area 1)	Box Truss	4	3	4	4	4	4
	Box Truss (area 2)	Box Truss	4	3	4	4	4	4
	Box Truss 1	Box Truss	4	3	4	4	4	4
	Box Truss 4	Box Truss	4	3	2	4		4
	Box Truss 3	Box Truss	4	3	4	4		4
	Bridge 2	Box Truss	4	3		3		4
	Bridge 1	Box Truss	4	3	4	2	4	4
	Box Truss	Box Truss	1		3		3	
	Dual 10	Cantilever	4	3	4	4	4	4
	Dual 6	Cantilever	3	3	3	4	4	4
	Dual 7	Cantilever	4	4	4	4	4	4
	Dual 8	Cantilever	4	4	4	4	4	4
	Dual 9	Cantilever	4	4	4	4	4	4
	Dual 4 (area 3)	Cantilever	4	3	4	4	4	4
	Dual 3 (area 4)	Cantilever	3	3	4	4	4	4
	Dual 1 (area 5)	Cantilever	4	3	4	4	4	4
	Dual 2 (area 6)	Cantilever	3	3	4	4	4	4
	Dual 5	Cantilever	4	4	3	4	4	4
District 6	Box Truss	Box Truss	4		3	4	4	3
	Box Truss 14	Box Truss	4	4	4	2	4	
	Box Truss 11	Box Truss	4	4	4	4	4	3
	Box Truss 12	Box Truss	3	4	3	3	3	3
	Box Truss 15	Box Truss	4	2	4		4	4
	Bridge 13/62	BMS		4		2		3
	Bridge 16	BMS		3				
	Bridge 17	BMS		4				
	Dual 14	Cantilever	4	4	4		4	4
	Dual 15	Cantilever	4		4	4	4	4
	Dual 16	Cantilever	4	3	4	4	4	4

Table 5.25 Support Inspections Mistras and ODOT

District	ID	Type	End Post/Frame		Connections		Arm/Truss Member Assemblies & Connections	
			Mistras	ODOT	Mistras	ODOT	Mistras	ODOT
District 5	Box Truss (area 1)	Box Truss	3	4	4	4	4	4
	Box Truss (area 2)	Box Truss	3	4	4	4	4	4
	Box Truss 1	Box Truss		3	4	3	4	3
	Box Truss 4	Box Truss	4	4	4	4	4	4
	Box Truss 3	Box Truss	4	3	4	3	4	3
	Bridge 2	Box Truss	4	3	4	3	4	4
	Bridge 1	Box Truss	4	4	4	3	4	3
	Box Truss	Box Truss	3		3		2	
	Dual 10	Cantilever	4	3	4	3	3	3
	Dual 6	Cantilever	3	4	4	4	4	4
	Dual 7	Cantilever	4	4	3	4	4	4
	Dual 8	Cantilever	4	4	2	4	4	4
	Dual 9	Cantilever	4	4	4	4	4	4
	Dual 4 (area 3)	Cantilever	4	4	3	3		4
	Dual 3 (area 4)	Cantilever	4	3	4	3		3
	Dual 1 (area 5)	Cantilever	4	3	4	3	4	3
	Dual 2 (area 6)	Cantilever	4	3	3	3	4	3
	Dual 5	Cantilever		4		4		4
District 6	Box Truss	Box Truss	3			3	3	
	Box Truss 14	Box Truss	4		4	3	4	
	Box Truss 11	Box Truss	4		4	4	4	
	Box Truss 12	Box Truss	4		4	4	4	
	Box Truss 15	Box Truss			4	3	4	
	Bridge 13/62	BMS				3		
	Bridge 16	BMS				4		
	Bridge 17	BMS				4		
	Dual 14	Cantilever	4		4	4	4	
	Dual 15	Cantilever	4		4	3	4	
	Dual 16	Cantilever	4		4	4	4	

Table 5.26 Sign Attachment and Overall Condition Inspections Mistras and ODOT

District	ID	Type	Attachment Assemblies		Overall Rating	
			Mistras	ODOT	Mistras	ODOT
District 5	Box Truss (area 1)	Box Truss	4	4	3	4 (8)
	Box Truss (area 2)	Box Truss	4	4	3	3 (7)
	Box Truss 1	Box Truss		3	4	2 (5)
	Box Truss 4	Box Truss	4	4	2	3 (6)
	Box Truss 3	Box Truss	4	4	4	2 (5)
	Bridge 2	Box Truss		3	4	2 (5)
	Bridge 1	Box Truss	4	4	4	2 (4)
	Box Truss	Box Truss			1	
	Dual 10	Cantilever	4	3	3	2 (4)
	Dual 6	Cantilever	3	4	3	3 (7)
	Dual 7	Cantilever	3	4	3	4 (9)
	Dual 8	Cantilever	3	4	2	4 (9)
	Dual 9	Cantilever	3	4	3	4 (9)
	Dual 4 (area 3)	Cantilever	4	4	3	3 (6)
	Dual 3 (area 4)	Cantilever	4	3	3	2 (5)
	Dual 1 (area 5)	Cantilever	4	2	4	2 (5)
	Dual 2 (area 6)	Cantilever	4	3	3	2 (5)
	Dual 5	Cantilever		4	3	3 (7)
District 6	Box Truss	Box Truss	3	4	3	3 (Average)
	Box Truss 14	Box Truss	4		4	3 (Average)
	Box Truss 11	Box Truss	4	4	4	3 (Average)
	Box Truss 12	Box Truss	4	4	3	3 (Average)
	Box Truss 15	Box Truss	4	4	4	3 (Average)
	Bridge 13/62	BMS		2	2	2 (Poor)
	Bridge 16	BMS		4	3	2 (Poor)
	Bridge 17	BMS		4	4	4 (Good)
	Dual 14	Cantilever	4	4	4	3 (Average)
	Dual 15	Cantilever	4	4	4	3 (Average)
	Dual 16	Cantilever	4	4	4	4 (Good)

5.13.5 Reflection on the Mistras Inspection Process

It should be noted that the overall average inspection rating for the supports inspected in the South and the supports inspected in the North yielded a different average rating. The inspections performed in the North yielded an average rating of 2.25 while the supports inspected in the South yielded an average of about 3.25. This difference could have been caused by several factors. First, The University of Toledo focused their inspections on supports that have had previous reports of damage. This was done in order to obtain results that could be compared to older inspections, and as a result, verify if the new inspection procedure was finding flaws not previously noted. The controlling factor in the South was geographical location.

6 High Mast Light Supports (HMLS) - Inspection Results

6.1 Introduction and Inspection Procedure

This chapter discusses the results of the inspections performed on HMLS. The general procedure used for all of the high mast inspections was first to arrive at the site and secure a safe place to park the vehicles. Since all of the supports selected were in areas that did not require MOT, a safe place to park near the support off of the road was chosen. After arriving at the support, a visual inspection of the concrete foundation was conducted to check for any cracks or spalling. All of the bolts connecting the baseplate to the concrete foundation were visually inspected and tested using UT (Figure 6.1) to check for any cracked bolts that may have been present. After the UT was completed, the inspector attempted to loosen each nut with a large 24” wrench (Figure 6.2). The reasoning behind this method is as follows: Since all of the bolts are to be tightened utilizing the turn of the nut method during the construction process, an inspector should not be able to manually loosen a properly tightened nut by hand. If an inspector could loosen the nut by hand, the nut was considered loose. Care was also taken to visually inspect for any gaps between the nuts on the anchor bolts and the base plate, as well as checking to see if lock-washers (that were present) were properly flattened; indicating proper tightness (Figure 6.3). Following this check. VT was performed on the weld connecting the baseplate to the vertical support and the weld around the hand hole. Anecdotal evidence from other states, such as Kansas, suggested that cracks could develop around the hand hole due to stress concentrations. As such, additional care was taken to inspect the weld. The same modified inspection form and procedures developed for the hands-on process for OSS and BMS was used to inspect and record the HMLS results. Any deficiencies were noted on the forms and recorded in the same electronic database as the OSS and BMS data.

Figure 6.1 UT inspection of anchor bolts (District 2)

Figure 6.2 Checking looseness of anchor bolt - 24" wrench (District 2)

Figure 6.3 Checking for tightness (District 2)

6.2 District 2

District 2 currently has no procedure for specific and detailed structural inspections of HMLS. There is currently a basic, annual maintenance plan in place for the District HMLS. Around April, a contractor will send a team to go and perform basic maintenance on every light assembly in the District. The maintenance includes: lowering of all light assemblies so that the light fixtures are opened and wiped down; checking to see if any bulbs are burnt out, or are close to burning out and replaced as needed; greasing parts of the locking mechanism located on the top of the light assembly; raising the light assembly back to the original position, and making sure it locks in place properly. This process was observed by members from the University of Toledo. While this process ensures the lights are in working order, no special attention is given to inspection of the baseplate, bolts, foundation, welds, or any other structural component of the support. As such, any structural deficiency that is not immediately obvious, has a chance of being overlooked.

In District 2, six high mast lights were selected for inspection. The selection was based on ease of access, no MOT requirements and the age of the lights. Four of the supports were located at the interchange of I-75 and US 20 in Perrysburg, with easy access and no need for MOT. The two remaining HMLS selected were located within a rest stop along I-75, south of Bowling Green; these lights were selected due to their age.

6.2.1 District 2: Summary and Discussion of Results

Table 6.1 summarizes the results of the HMLS performed in District 2. A total of 34 anchor bolts, distributed amongst six poles, were inspected. Of the 34 anchor bolts inspected, 1 bolt location had a loose anchor nut. The nut was judged loose due to the fact that the inspector was able to turn the nut with a wrench. Of the six supports inspected, four supports received a rating of 4, and two supports received a rating of 3. No supports were found to be in poor or critical condition. Other minor issues, such as clogged drainage channels on foundations, and some soil overtopping were also noted during the inspections. The overall rating is provided in Figure 6.4.

Table 6.1 Summary of deficiencies by occurrence (District 2)

District 2 High Mast Light Deficiencies		
Towers With Loose Nuts	Total Number of Loose Nuts	Total Number of Bolts Inspected
1	1	34
Towers With Insufficient Thread Engagement	Soil Washout	Clogged Drainage Channel
1	1	1

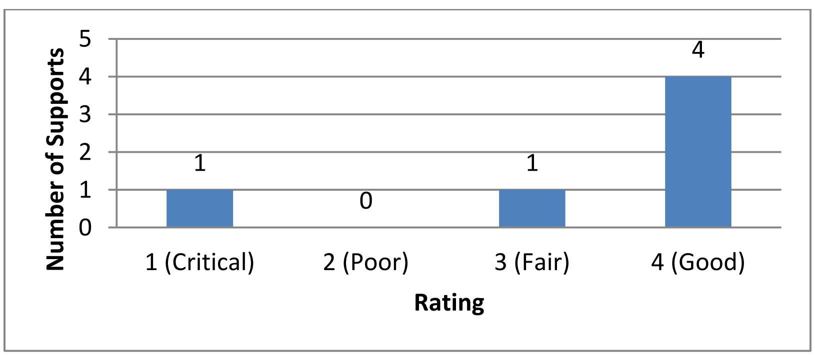


Figure 6.4 Number of Supports with Overall Rating (District 2)

6.3 District 5

A total of four HMLS were inspected. The inspection in this District was unique as the HMLS inspected were in the process of being replaced. According to district personnel the replacement was due to maintenance and difficulties with the replacement of the lights rather than structural support issues. District personnel also estimated that the HMLS were original to the interchange, which were built in the mid 1960's and thus making the service life of the support in excess of 45 years. The advantage of inspecting the masts during replacement was that the poles could be fully inspected on the ground. The disadvantage was that the tightness of the anchor bolt nuts at the foundation could not be checked. Fortunately, the foundations were still intact at the time of inspection and still could be inspected. Table 6.2 summarizes the results of the high mast inspections performed in District 5. All poles inspected had a 6-bolt pattern. Figures 6.5 and 6.6 provide the results on the overall rating and the inspection components, respectively.

Table 6.2 Summary of deficiencies by occurrence (District 5)

District 5 High Mast Light Deficiencies		
Foundation cracks (1)	Vegetation growth (1)	Post Corrosion/Pitting – Loss of galvanization (1)

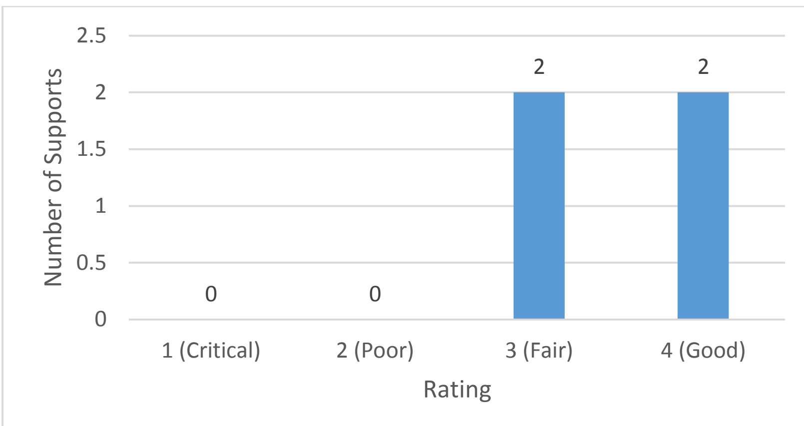


Figure 6.5 Number of Supports with Overall Rating (District 5)

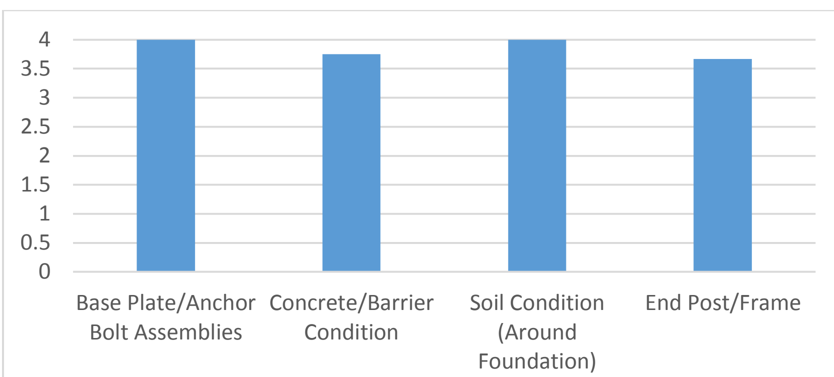


Figure 6.6 Component Rating of HMLS (District 5)

6.4 District 6

One high mast light supports was inspected in District 6. The inspection was unique in that the high mast light had been lowered to the ground in order for a contractor to dig a deep hole next to the foundation in order to inspect a gas line. The advantage of inspecting the high masts while it had been lowered allowed the pole to be fully inspected. The disadvantage was that the tightness of the bolts of the 4-bolt pattern at the foundation could not be checked. No deficiencies were found on the high mast light. Figure 6.7 provides the results on the inspection components. Note that the soil condition around the foundation was not rated due to the excavation that was taking place at the time of inspection.

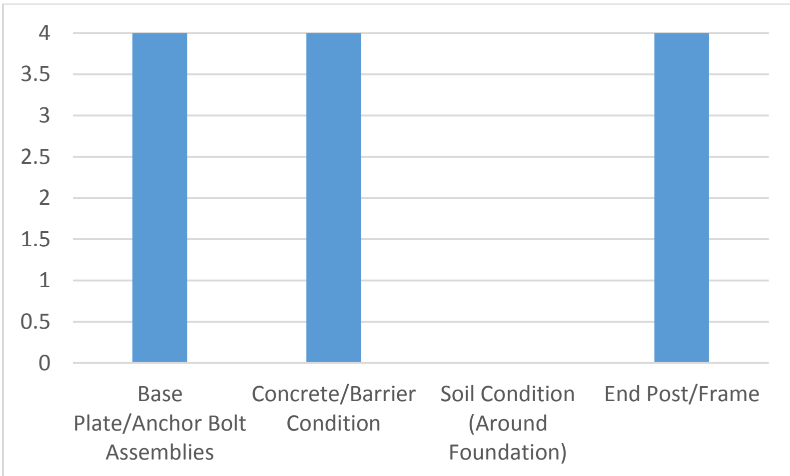


Figure 6.7 Component Rating of High Mast Lighting (District 6)

6.5 District 7

The supports selected in District 7 were located along I-75 near Troy and Piqua, in Miami County. The supports were selected due to the fact that they were some of the oldest supports still in service in Ohio. District 7 currently has no formal inspection procedure by which supports are checked for structural deficiencies on a regular basis. The supports selected were located at two interchanges along I-75, one of which is contracted out for maintenance by ODOT to the local municipality, and as such the ground around the bases of the supports were well groomed, and access to the base was simple.

6.5.1 District 7: Summary and Discussion of Results

Table 6.3 summarizes the results of the inspections performed on high mast light supports in District 7. Six supports were inspected in two separate locations along I-75. Of the supports selected three had 6 anchor bolts connecting the baseplate to the foundation and three had 4 anchor bolts, totaling 30 bolts. Of the 30 bolts inspected, two anchor nuts were found to be loose. The loose nuts were located on a pole that had been struck by a vehicle years prior to the inspection. This could indicate that the vehicle itself knocked the nuts loose. If the case was that the vehicle knocked the nuts loose, then improper maintenance or post impact inspection was the cause of the loose nuts, and not improper tightening. However, there is no method that can indicate whether the impact caused the loose nuts. Despite the age of the supports, all were rated as fair or good during the inspections. There was minor loss of galvanization and surface rust, especially around the baseplates. However, the loss of galvanization and corrosion was not enough to raise concern or affect the rating assigned to the support. Of the six supports inspected five were rated at a 4 and one was rated at a 3. A graph summarizing the ratings assigned to the supports can be found below.

Table 6.3 Summary of observed deficiencies by occurrence (District 7)

District 7 High Mast Light Deficiencies				
Towers With Loose Nuts	Total Number of Loose Nuts	Total Number of Bolts Inspected	Improperly Leveled Anchor Bolts	Soil Overtopping
1	2	30	1	1

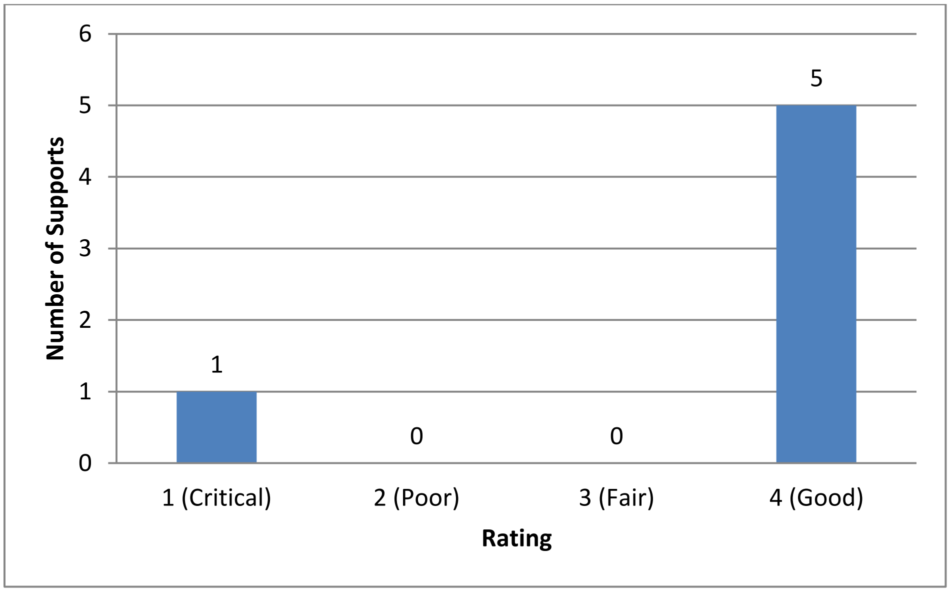


Figure 6.8 Number of Supports with Overall Rating (District 7)

6.6 District 12

District 12 currently has no specific procedure to check their high mast supports for structural deficiencies. The current maintenance is accomplished by ODOT personnel who drive the district once a week to check for any burnt out luminaries. Once the weekly assessment has been accomplished, a work plan is drawn up for crews to go out the following week and fix any issues that may be present. No special care is taken to check for structural issues. Since the personnel do not get close enough to the support to see any deficiencies that may be present around the base, any issues could go unnoticed.

The supports selected in District 12 were selected due to their proximity to Lake Erie. It was thought that special wind conditions may be present on the lake shore, and these conditions could have an adverse effect on the condition of the high mast supports in the area. The supports chosen were located along I-90 in Cleveland. The district traffic engineer accompanied the research team at the first location visited.

6.6.1 Summary and Discussion of District 12 Results

Figure 6.9 Missing anchor nut

Table 6.4 below summarizes the results of the high mast support inspections performed in District 12. Six poles were inspected resulting in a total of 32 anchor bolts inspected. As the table shows, the number of loose nuts was a concern. Out of the 32 anchor bolts inspected, 10 had loose anchor nuts. In one case, 5 of the 6 nuts for one tower were loose, while on the 6th bolt the nut was missing completely (Figure 6.9). The District Traffic Engineer accompanied the team during this inspection process for the first group of HMLS and directed District personnel to collect the broken lock washers. In the subsequent inspection, the District Traffic Engineer was informed immediately about the support where all bolts were missing or loose, as well as a support with 2 missing anchor nuts, but which only had 4 total bolts connecting the baseplate to the foundation.

Table 6.4 Summary of observed deficiencies by occurrence (District 12)

District 12 High Mast Light Deficiencies		
Towers With Loose Nuts	Total Number of Loose Nuts	Total Number of Bolts Inspected
4	11	32
Missing/Broken Lock Washers	Insufficient Thread Engagement	Overgrown Vegetation
3	1	3
Erosion Around Base	Cracked Foundation	Soil Overtopping
1	1	1

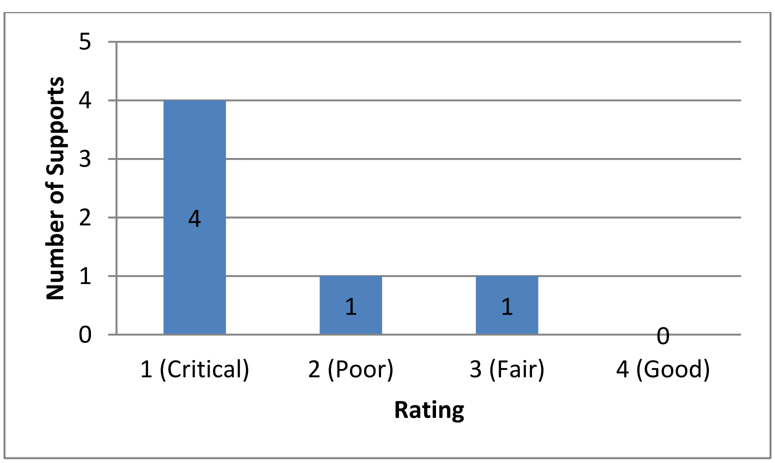


Figure 6.10 Number of Supports with Overall Rating (District 12)

A topic worth mentioning was the condition of the lock washers on the HMLS in District 12. Many of the lock washers on the inspected supports were very corroded and some were cracked (Figure 6.11, Left), broken, or missing completely. After notification by the inspection team, District 12 personnel performed follow up inspection and collected fragments of lock washers from the various HMLS (Figure 6.11, Right). The 13 fragments were collected from approximately 10 HMLS. In one instance, one HMLS had 3 out of 4 lock washers broken. These fragments were typical of broken washers versus those that may have corroded away. Additionally, the broken washers exhibited a fracture type interface.

Overall, many of the observed loose nuts were classified as loose due to missing or cracked lock washers. A detailed metallurgical analysis was not conducted at the time of this report. This common thread with regards to the lock washers could indicate a problem with the supply itself, or some other factor that leads to their accelerated corrosion. The nuts and bolts around these lock washers showed significantly less corrosion than the washers themselves.

Figure 6.11 (Left) Cracked washers; (Right) Cracked washers collected by District 12

7 Signal Supports (SS) - Inspection Results

7.1 North – Signal Inspections Results

A total of 16 SS were inspected and recorded throughout Districts 1, 2, 3, 4, and 12. Since most of the inspections were performed in District 2, and the other districts had few signals per district inspected, the results have been combined in the following tables. Table 7.1 shows the observed deficiencies noted by occurrence for all inspections performed on SS in the North. Figure 7.1 shows the total number of overall ratings assigned to the SS inspected by Mistras and the University of Toledo. And Figure 7.2 indicates the average rating of each component of the SS inspected.

Table 7.1 Summary of observed deficiencies by occurrence (Districts 1, 2, 3, 4, and 12)

Foundation	End Post/Frame/Arm-Truss Members	Sign/Signal Attachment Assemblies
Corroded Lock Washers (1)	Missing Pole Cap/Handhole Cover (1)	Corrosion/Pitting/Section Loss (1)
Voids/Honeycombing (2)	Surface Rust/Section Loss (4)	Cracked/Loose Nuts/Bolts (1)
Spalling (3)	Gaps Between Plates (6)	Missing Attachment Hardware (1)
Cracks (3)	Corrosion/Pitting - Loss of Galvanization (4)	
Insufficient Thread Engagement (5)	Loose Nuts/Bolts (5)	
Overtopping of Soil (1)		
Loose Nuts/Bolts (2)		
Vegetation Overgrowth (2)		

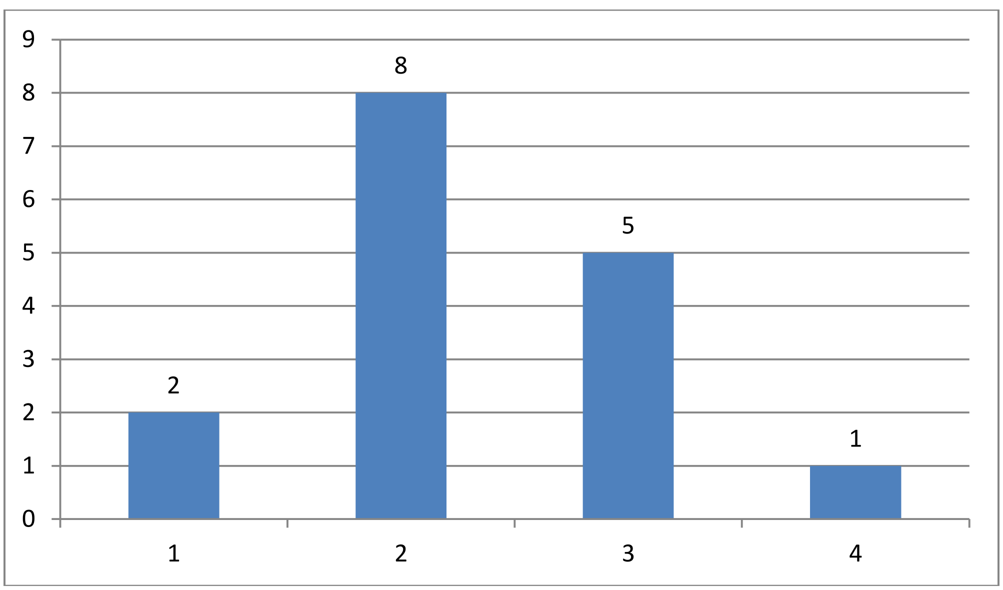


Figure 7.1 Number of Supports with Overall Rating (Districts 1, 2, 3, 4, and 12)

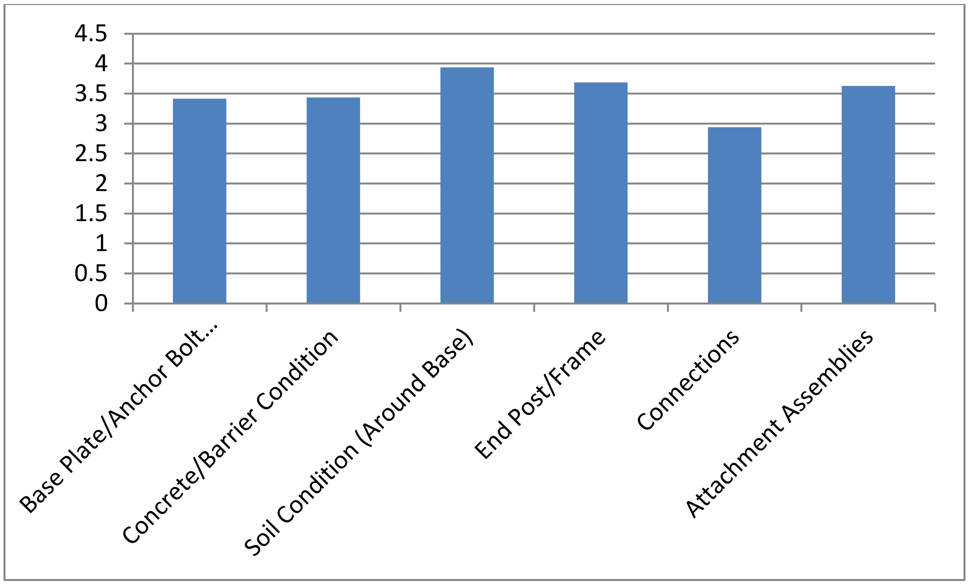


Figure 7.2 Component Rating of Signals (Districts 1, 2, 3, 4, and 12)

7.2 South – Signal Inspection Results

7.2.1 District 5

A total of 11 SS were inspected in District 5. Table 7.2 below summarizes the results of the signal inspections performed in District 5. Figures 7.3 and 7.4 provide the results on the overall rating and the inspection components, respectively.

Table 7.2 Summary of observed deficiencies by occurrence (District 5)

District 5 Signal Support Deficiencies		
Loss of Galvanizing (3)	Overtopping of Soil (2)	Post Corrosion/Pitting/Section Loss (1)
Foundation cracks (2)	Loose nuts/bolts (1)	Gaps between plates (2)

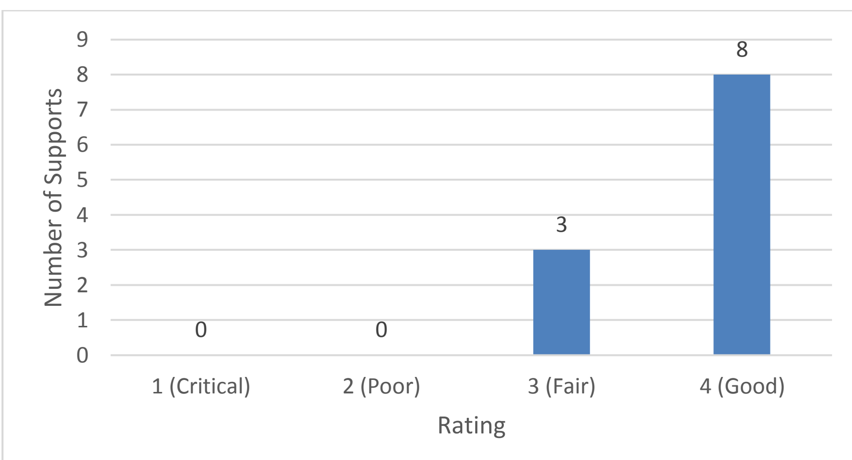


Figure 7.3 Number of Supports with Overall Rating (District 5)

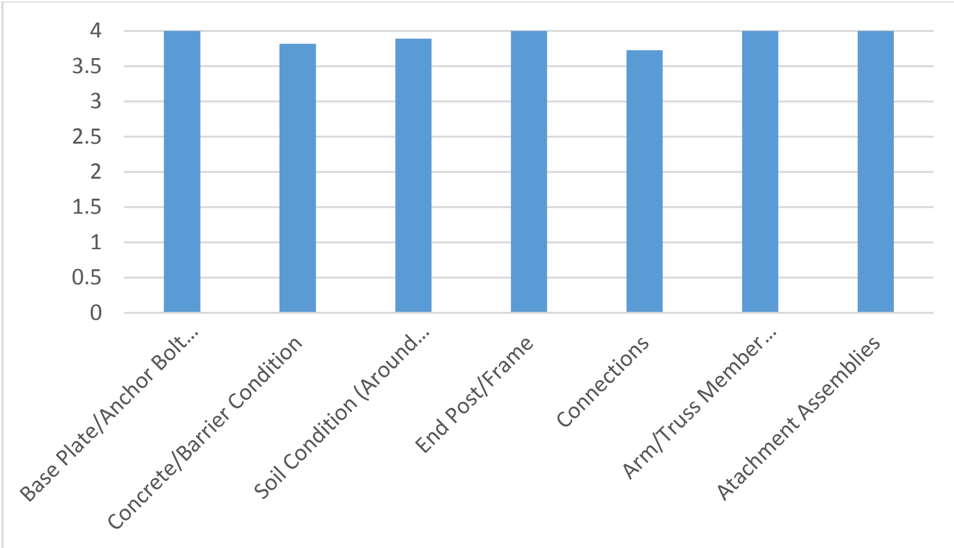


Figure 7.4 Component Rating of Signals (District 5)

7.2.2 District 6

A total of 8 Signal Supports were inspected in District 6. Table 7.3 below summarizes the results of the signal inspections. Figures 7.5 and 7.6 provide the results on the overall rating and the inspection components, respectively.

Table 7.3 Summary observed deficiencies by occurrence (District 6)

District 6 Signal Support Deficiencies		
Loss of Galvanizing (1)	Overtopping of Soil (1)	Gaps between plates (1)
Foundation cracks (2)	Vegetation growth (1)	

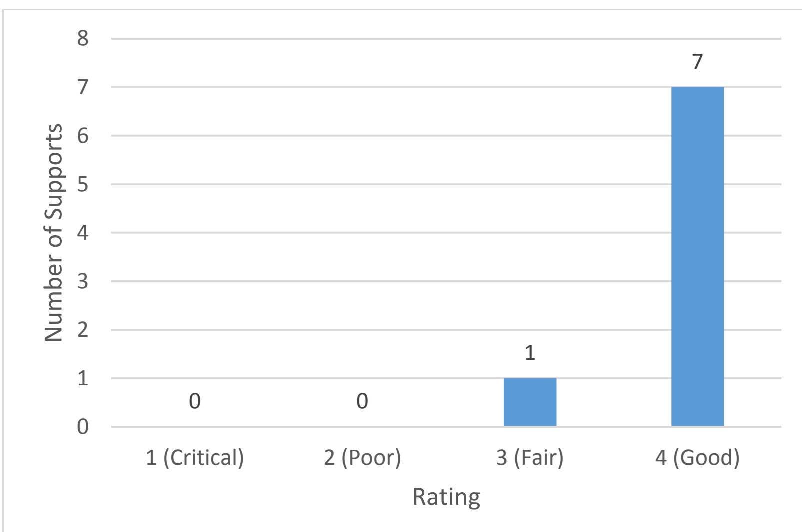


Figure 7.5 Number of Supports with Overall Rating (District 6)

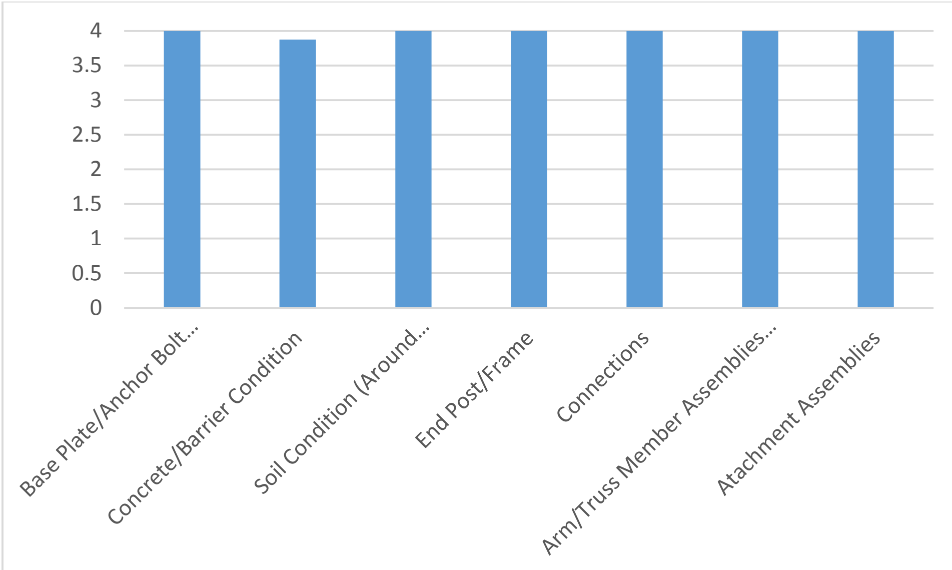


Figure 7.6 Component Rating of Signals (District 6)

7.2.3 District 8

A total of 13 Signal Supports were inspected in District 8. Table 7.4 below summarizes the results of the SS performed. Figures 7.7 and 7.8 provide the results on the overall rating and the inspection components, respectively.

Table 7.4 Summary of observed deficiencies by occurrence (District 8)

District 8 Signal Support Deficiencies		
Loss of Galvanizing (7)	Overtopping of Soil (5)	Vegetation growth (4)
Loose nuts/bolts (1)		

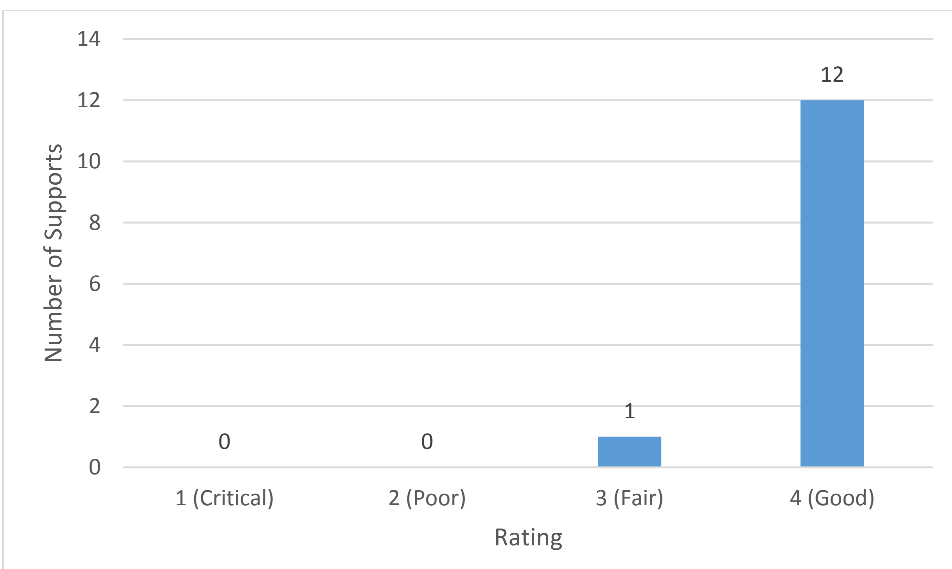


Figure 7.7 Number of Supports with Overall Rating (District 8)

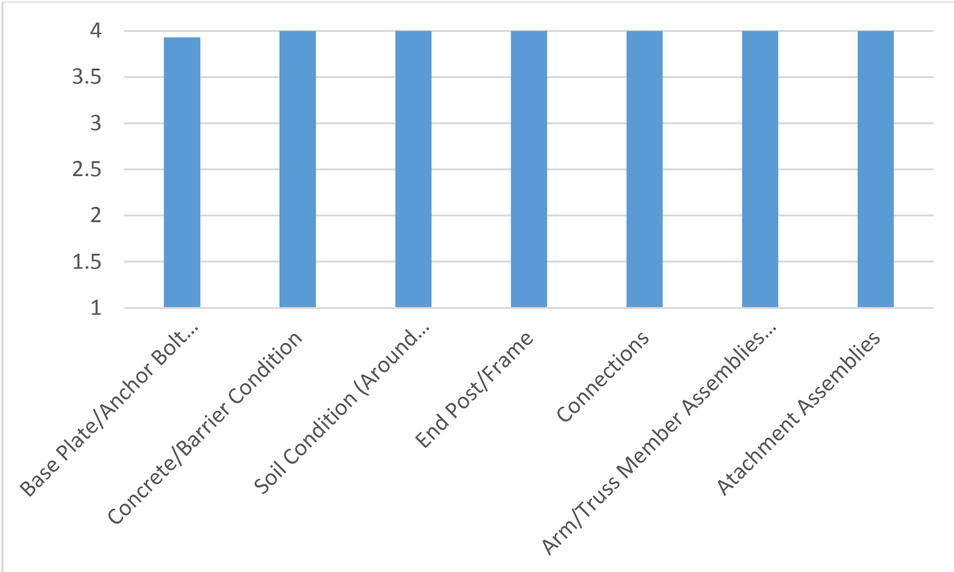


Figure 7.8 Component Rating of Signals (District 8)

Overall, the North and the South inspected random signals during field testing as SS were not easily identified within existing inventory databases. Out of the 16 signals inspected in the North, six had gaps between the connecting plates on the mast arm to pole connection. In the South, three of the 32 signals showed the same deficiency.

8 Review of Supports with a Critical Rating

This section of the report reviews the supports initially classified by Mistras inspectors. Each component of the support was rated (on a scale from "1" to "4") and then an overall rating assigned based on the lowest rated component for the support. This review was conducted researchers at the University of Toledo for quality control purposes and to determine if the critical rating (a rating of "1") was justified. Overall, a critical rating was given if one or more of the following was met:

1. One or more loose anchors in supports with a single anchorage (i.e. HMLS, cantilever OSS or SS) and defined as a non-gripped bottom plate due to either loose nuts, missing nuts, or broken or missing lock washers;
2. Two or more loose anchor nuts in supports with more than one anchorage (i.e. box truss).
3. Gaps in mast arm connections;

The criteria being that if the load path required moment in the anchorage for stability, under a lateral load, one loose anchor would be considered critical (e.g. single anchorage). Thus, if the moment in the anchorage is not required for stability under a lateral load, a few loose anchors would not be considered sufficient to deem the support as critical (e.g. multiple anchors). Excessive vegetation or rust without significant section loss, etc. was not considered a basis for a critical rating. As for gaps, a gap may indicate the loss of prestress in the bolt. However, it should be noted that if the gap was a result of the construction process (e.g. misalignment), it would not necessarily mean that there is an issue with prestress in the bolt. However, with no document or other evidence to determine if this was a construction error, all observed gaps were considered critical for this study.

Table 8.1 presents a detailed review of the 37 supports rated as critical. The review raised three concerns:

1) For support 40301 (No. 8 in the table), the reviewers judged the rust on the bolts to be more superficial than the inspector did. Therefore, it was concluded that a rating of "1" was not appropriate. After reviewing the photographs and inspection notes, it was determined that a rating of 2 was more suitable for the support.
2) For support 21201 (No.15), the report was incomplete. Therefore, the rating could not be reviewed. The data for this report should be recovered and the report made available in the data base.
3) Two high mast light supports (nos. 21 and 22) were judged critical because they had multiple loose anchors for each support. During our conversations, members of the traffic department indicated that one loose anchor on a support with a single anchorage connection was significant issue. If a single loose anchor is deemed critical, several other supports should be rated as a "1".

Table 8.1 Review of Supports with a Critical Rating			
No.	**Support Number**	**Reasoning behind "1" rating/Comments**	**Justified? Y/N**
		DISTRICT 1	
1	10102 – OSS	Prior rating "2". Reclassified as "1". Cantilever, loose anchor nut.	Y
2	10103 – OSS	Prior rating "3". Reclassified as "1". Cantilever; loose anchor nut.	Y
		DISTRICT 2	
3	10201 – OSS	Prior rating "2". Reclassified as "1". Cantilever with loose anchor (i.e. non-gripped plate), with NE bolt failing ping test.	Y
4	40201 – BMS	Majority of anchorage loose/not fully engaged. Gap present b/w plate and parapet.	Y
5	7022FP3 – HMLS	Prior rating "4". Reclassified as "1". Loose anchor nut.	Y
		DISTRICT 3	
6	20304 – OSS	Anchors on both sides of structure were bent/loose. Visible gaps between anchor nuts and lock washers.	Y
7	10304 – OSS	Prior rating "2". Reclassified as "1". Insufficient thread engagement. Top of bolt below top of anchor nut.	Y
8	40301 - BMS	Rust on bolts/connection plates. Dents and hole on sign. Review determined rust not significantly advanced, no section loss. *Rating left at "2" - potential hidden corrosion.*	*N*
9	40302 – BMS	Observed gaps of 1/4" to 1/2" (top brackets). The bottom bracket on the left side was also loose.	Y
		DISTRICT 4	
10	10403 – OSS	2 foot dent on lower section of pole. Rust and a loss of galvanization, as well as a missing cover plate.	Y
11	10406 – OSS	Very poor drainage around the concrete foundation, preventing inspection. 1/4" inch gap found on connection plate, coupled with loose nuts and rust on all connections. Missing/loose sign attachment clips.	Y
12	10407 – OSS	Prior rating "3". Reclassified as "1". Cantilever, loose anchor nut (back right corner).	Y
13	20401 – OSS	A bent (non-redundant) cross bar was found on truss – ability to support compression may be compromised; 2 missing top caps on the left side of the support.	Y
14	30401 – OSS	Prior rating was "2". Reclassified as "1". Front right anchor loose (i.e. non-gripped baseplate).	Y
15	30402 – OSS	Both arms out of level; a gap on the arm connection 3/16" to 1/4".	Y
16	40401 – BMS	Rear right concrete wall cracking and coming apart; Significant spalls have exposed the anchor rods.	Y
17	40402 – BMS	Top right bracket coming off wall, bolt broken in half.	Y
		DISTRICT 5	
18	NA - OSS	IR 70, Westbound, Exit 155. Multiple cracks at chord to diagonal welds. Corrosion/pitting, poor drainage, south foundation.	Y
		DISTRICT 7	
19	10702 – OSS	No lock washers, many bolts not tightened fully, and plates had gaps ranging from 1/4" to 3/8". The plates were also misaligned.	Y
20	10704 – OSS	Prior rating "3". Reclassified as "1". Cantilever, with 2 loose anchor nuts.	Y
21	10709 – OSS	Prior rating "3". Reclassified as "1". NE bolt failed ping test.	Y
22	707A1 – HMLS	Prior rating "3". Reclassified as "1". Loose anchor nut.	Y

Table 8.1 Review of Supports with a Critical Rating			
No.	**Support Number**	**Reasoning behind "1" rating/Comments**	**Justified? Y/N**
DISTRICT 8			
23	NA - BMS	Bridge No. 27 near Hamilton, over the Great Miami river. Overhead box truss that was mounted on the bridge, truss hit by dump truck with bed in raised position, truss removed but end posts still in place.	Y
DISTRICT 12			
24	11203 – OSS	Above ground concrete base heavily damaged with cracks and blow outs on the base. Heavy rust and corrosion (base plate) on anchors and nuts on the top and bottom.	Y
25	11204 – OSS	Sign has movement with the back right nut being loose. (observed movement due to loose anchor nut)	Y
26	11207 – OSS	Prior rating was "2". Reclassified as "1". Cantilever with 2 of 4 anchors loose (i.e. non-gripped baseplate).	Y
27	11209 – OSS	Corrosion on anchors and bolts, corrosion on top and bottom of plate. Combination of factors leads to reasonable probability that capacity may be reduced.	Y
28	21201 – OSS	Report on file is incomplete. Need to recover data and review.	-
29	21205 – OSS	An arm and truss member weld had a crack around the cross member connection. The welds were not complete in some areas, as well as being subpar. Attachment assembly U bolts misaligned coupled with missing sign clips. Heavy rust on the base plate.	Y
30	21206 – OSS	Frame and web assemblies - holes exposed on side. Corrosion on the right cross members, and missing cover plates. Arm and truss members had 2 loose nuts, hardware corrosion on both sides. Loose nuts on connection plates.	Y
31	41201 – BMS	Base plate/anchor bolt assemblies w/ rust and corrosion on both sides, anchor nuts not fully engaged. Anchor nuts with heavy corrosion and flaking. Concrete barrier has many cracks in foundation and down the sides. The frame had heavy corrosion on the cross members and many other parts of frame.	Y
32	41203 – BMS	Bottom left attachment hardware was missing/gone, 4 attachment points were present with one missing.	Y
33	41205 - BMS	Attachment clips (both signs) loose or missing - bottom of the sign and other areas. Left sign's mounting brackets had gaps up to 1/4".	Y
34	712EB10 – HMLS	Prior rating was "2". Reclassified as "1". Loose anchor nut.	Y
35	712EB11 – HMLS	Prior rating was "2". Reclassified as "1". Loose anchor nut.	Y
36	712EA4 – HMLS	The high mast light had a 6 anchor bolt assembly with 5 nuts loose and 1 nut completely missing.	Y
37	712FA1 - HMLS	The high mast light had 6 anchor bolt assembly with 2 nuts loose.	Y

Support numbering convention for 5 digit numbers: ABBCC

A= Type (1 = Dual arm cantilever, 2 = box truss, 3 = signal support, 4 = bridge mounted)
BB = District
CC = support number

Support number convention for 6 digit numbers: ABBCCD

A = Type (7 – high mast)
BB = district
CC
D = support number

9 Discussion, Recommendations, Benefits and Implementation

9.1 Introduction

The goal of this study was to evaluate the adequacy and frequency of the current structural support inspection program for over 6,000 overhead sign supports (OSS), bridge mounted supports (BMS), mast arm signal supports (SS) and high mast light supports (HMLS) maintained by ODOT. The essential part of this program is the routine inspection and maintenance of these support structures in a manner that ensures the safety of the traveling public and yet is efficient and economical.

This chapter presents a discussion and recommendations for each type of support that was inspected as part of this research. This includes a discussion of the benefits and how the recommendations could be implemented. The following recommendations and discussion are based on the results observed in the field, and comparison of the results from previous ODOT inspection reports.

9.1.1 OSS – Discussion

ODOT currently has a formal inspection process in place that requires that all OSS within each representative district be inspected using a ground based visual approach at a maximum interval of every 5 years. The policy also includes the sounding of the anchor bolt connections to check for cracked or broken anchor bolts. The use of a bucket truck or other means to access the structure is not required as part of the routine inspection. The use of NDT is also not part of the routine inspection, but may be used as necessary. For new OSS, the supports are to be inspected at the time of construction. Policy states that written documentation of the results should be kept and a sample form is provided (Form 296-4). While the TEM recommends the use of a form, it is not required by policy and Districts are allowed to modify Form 296-4 to address the needs of the District. In most Districts the inspections are handled by available personnel, whom may or may not have had training for sign supports.

The Districts generally had a good handle on the basic inventory. The information typically included the type, location, and most historical reports from previous inspections. However, the data regarding the individual supports was not easy to access or available and did not provide a good overview of the support condition across time. In several instances the details in previous inspection reports regarding the components and observed deficiencies were vague or lacking. This presented some difficulty when comparing inspection reports and determining if the deficiencies observed in the field previously existed or were new. The main issue this presents is that it becomes increasingly difficult, if not impossible to observe any trends related to degradation over time or the impact on structural integrity of the support. An additional observation is that the age of the support is very rarely recorded. There were a few cases where the age of the support could be determined based on the construction date but this required a significant amount of research by team members and District personnel to locate. As such, the ability to determine the age of the inventory and impact on structural integrity is limited. While inventory control was not part of the original scope of the project, the limited information made the selection of a truly random sample difficult.

As for the deficiencies observed in the field, there were a total of 327 deficiencies recorded by Mistras inspectors as compared to the 174 deficiencies observed by previous ODOT inspections. Of these deficiencies, 113 were observed by both inspections. Thus the in-depth inspections observed approximately 1.87 times more deficiencies than the ground based inspection process. In terms of deficiencies, the biggest observation was the loss of galvanization for the foundation components as well as the end posts, frame and truss members. Anecdotally, recoating of the supports is done on a 20-25 year basis. However, given that information regarding current age of the support was difficult to find, the recoating frequency could not be validated. While loss of galvanization may be a minor concern when it comes to structural integrity, when coupled with the next largest observation, vegetation growth around the foundation, this can lead to possible acceleration of corrosion of the bolts, plate, and degradation of the concrete foundation support; which will definitely impact structural integrity over time.

Loose anchors was the fourth largest observation with regards to foundation and the second largest observation with regards to the end post, frame and arm truss members as well as sign attachment assemblies. While loose anchors at the foundation can be determined with a wrench from a ground based approach, as well as gaps or missing lock washers, those at end post connections and frames would be difficult to observe without performing a hands-on inspection. Additionally, for the sign connection assemblies, loose and missing hardware was the number one observation made and would also require an in-depth inspection. The other concern is that ground based inspections may not detect deficiencies that occur along the top portions of the mast arm for cantilevers nor the same portions of box trusses.

The Mistras inspection process also implemented an element level condition rating system on a scale of 1-4 with 1 being critical (i.e. potential impact on structural integrity) and 4 being good (i.e. no major deficiencies or like new). This implementation was chosen due to the difficulty of trying to determine support condition or changes in degradation based on the information collected from the previous inspection records. There are several benefits to this type of rating system. The first is that it allows each element of a support to be rated based on current condition and could be easily implemented during the inspection process. Secondly, depending on the critical nature of the component to the structural integrity of the support, a criticality factor for each component could be determined, and then multiplied by the condition rating for that element. The total for each component is then added to one another to determine an overall total for the support. This information could be easily added to a database and tracked over time and would lend itself to a risk-based inspection approach. A decreasing value between subsequent inspections would alert the Districts to supports experiencing degradation, and be a trigger for a follow-up in-depth inspection. This could become a valuable tool for prioritizing not only the potential needed repairs, rehabilitation or replacement of the support, but help prioritize existing personnel and monetary resources.

9.1.2 BMS – Discussion

In regards to bridge mounted supports, the TEM states that these support types should be inspected annually, and included as part of the annual bridge inspection. The ODOT Manual of Bridge Inspection (MBI) [10] does instruct personnel to inspect the security and deterioration of the connection with the inspection concentrating primarily of the anchor bolts. A condition rating scale of 1-4 (good-critical) is given, but lacks the ability to provide any additional detail as to the deficiencies observed. Additionally, the bridge inspection database does not provide an identification flag to indicate a sign support on the bridge. The research team found the BMS anecdotally and then had to track back to the bridge inspection forms to find the previous reports. At the time of this report, it is recognized that the Structures Office is implementing a new Structural Management System (SMS) Database and so this issue may be being addressed already.

The biggest observations in the field were gaps between the support frame and concrete parapet, corrosion of the support components, as well as loose anchor bolt nuts. During the in-depth inspection in District 3, the degradation was of high enough concern to contact the District Traffic Engineer. Similar to the discussion on OSS, additional information, or expansion of the information that is recorded, would assist in assessing the structural adequacy of the support.

9.1.3 SS – Discussion

For the inspection of SS, there is currently no formal structural inspection procedure in place. In most cases, SS are inspected by electricians from the District or electrical contractors to ensure correct operation of the lights using the OSIS form. Similar to the discussion in OSS, the primary observations were deficiencies with loss of galvanization, corrosion, and overtopping of soil at the foundation level. Of the 16 SS in the North, 6 were observed to have gaps between the pole and mast arm, with 5 supports having issues with insufficient thread engagement (i.e. end of anchor bolt is below the top of the anchor nut). Overall, most of the above deficiencies would likely be observed from a ground based inspection.

9.1.4 HMLS – Discussion

There is currently no formal inspection procedure in place with regards to structural integrity. Additionally, very few districts have any type of inventory information in place. A few exceptions are District 2, which hires a contractor on an annual basis for maintenance of the luminaries, and District 12, which has a weekly drive down to check luminaries. However, these checks are for maintenance purposes only and have no structural check.

For the HMLS inspected, most supports were in fair to good condition. However, in District 12, there was a high number of HMLS that had issues with loose anchor bolt nuts, in which 10 of the 32 bolts inspected had loose nuts. These HMLS were selected due to their proximity to the shore line and the potential to be affected by special wind conditions. Specifically, one HMLS had 5 of 6 nuts loose, and a second pole was completely missing two nuts. Most of these issues were due to missing lock washers. Whether this was an issue related to corrosion of the washers or a deficiency in construction could not be confirmed. While, the high number of deficiencies were primarily localized to District 12, it serves as an obvious example of unknown deficiencies that were not identified until a formal inspection process for structural integrity was performed.

9.1.5 Adequacy and Frequency – Discussion

All of the supports inspected during this study used the same modified inspection form to record the field results from the in-depth, hands-on inspection process. Additionally, an element level condition rating was implemented for all support types. These steps provided a uniform inspection process and approach for assessing the structural condition. This was especially important since not all support types have a formal inspection process in place, and that the inspection processes differ across each District. The lack of uniformity can result not only in the amount of data being collected, but the quality of the collected data. At times, this became a principle limitation when trying to assess the adequacy and frequency of the current inspection process.

The current inspection frequency with regards to OSS is set on a 5-year interval. Based on the observations from the field inspections and this study, there is no evidence to demonstrate that the current ground based, visual inspection and anchor bolt sounding process used by ODOT is inadequate nor was it found that the maximum 5-year inspection interval should be changed at this time. Most deficiencies could be observed from a ground based approach. However, a case can be made for the need to supplement the current approach with a hands-on inspection after completion of new construction. A hands-on inspection after new construction will ensure proper fabrication and construction of the support. This process would be used to confirm proper alignment, leveling, thread engagement and correct tightening of all connection components. Additionally, this would provide a check that all components such as lock washers, sign clips, U-bolt and other connection hardware are present.

The current inspection frequency with regards to BMS is set on an annual basis. Based on the observations from the field inspections and this study, there is no evidence to demonstrate that the current bridge deck based, visual inspection process used by ODOT is inadequate nor was it found that the annual inspection interval should be changed at this time. Most deficiencies could be observed from a ground based approach.

Additional hands-on inspections should be performed during triggerable events and would include all support types. A triggerable event would be defined as an event in which two or major deficiencies are observed, or if the observed deficiencies would result in a condition rating of “1”, or other special or extreme events (e.g. fire, impact, special weather conditions). An example of a triggerable event would be a support that was subjected to vehicular impact. Even if the impact is minor and may not require immediate repair or replacement of the support or support components, there may be new deficiencies that are not visually apparent. *This would include inspection of the anchor bolts with UT to confirm integrity, as sounding of the anchor bolt with a hammer may not detect the development of small cracks within the portion of the bolt deep in the concrete foundation. Any indication may be critical*. This would also include a check of all welds with some form of NDT (UT, MT or EC for aluminum) to ensure no new cracks have developed beneath the surface or at the root of the weld. This would be followed by a check of the tightness of all connections, sign clips and an accounting of all connection hardware. Another example would be in the event that half or more of the anchor bolt connections are found to be deficient. This could be a combination of loose, broken or missing nuts, or broken anchor bolts. These deficiencies may lead to rocking of the support, which may not always be observable during the time of inspection, but could lead to the potential development of fatigue cracks. This hands-on inspection would then include an appropriate NDT method to assess the condition of the bolts and welds, particularly for cantilever supports. While some states, such as Virginia, currently inspect all anchor bolts every 2 years, the above approach would serve to find a balance between regular inspections versus hands-on inspection due to a triggerable event. When it comes to SS, there is currently no formal structural inspection procedure in place. Based on the observations from the field, it is recommended that SS, at a minimum, be placed on the same ground based inspection procedure. This would require training contractors or non-structural personnel on the components to inspect and deficiencies to be recorded. Most of the deficiencies observed centered on insufficient thread engagement, gaps in connection plates, and loose nuts. The issue of thread engagement may be more of a construction issue but presents a major concern in terms of structural integrity as only a portion of the bolt is now being used to secure the pole to the foundation. Additionally, gaps in the connection plates, no matter how small the gap, may indicate loss of pretension in the bolt or a bolt subjected to potential cracking. Given that these elements are above eye level, these deficiencies would also be considered a triggerable event for hands-on inspection.

Similarly to SS, there is currently no formal structural inspection procedure in place for HLMS and would require training of personnel performing the inspections. While the majority of the HMLS inspected in the South were found to be in fair to good condition, the HMLS in District 12 had major issues with loose anchor nuts, missing nuts and missing lock washers. Again, these issues may have been related to construction, or due to the local environment along the lakes, but either way, the deficiencies highlight what could be missed without a formal inspection procedure. As such, it is recommended that HMLS also be placed on the same ground based inspection and interval. The other difficulty here, aside from a few Districts, is that there is no formal inventory control in place.

9.1.6 Adequacy and Frequency by Support Type

Based on the results from the field inspections as well as the previous discussion, Table 9.1 provides a summary of the recommended frequency for inspection of the different support types. This includes regular inspections as well as hands-on inspections.

Table 9.1 Inspection Frequency by Support Type

Support Type	Inspection Type & Frequency (Yrs)	
	Regular	*Hands-On*
Overhead Sign Supports	5	Construction, Triggered Event
Bridge Mounted Supports	1	Construction, Triggered Event
Signal Supports	5	Construction, Triggered Event
High Mast Lighting Supports	5	Construction, Triggered Event

Notes:

1. Regular inspection is defined as the current ODOT policy for inspection of supports using a ground based, visual approach and includes sounding of the anchor bolts with a hammer. NDT may be used to determine the extent of a visually observed deficiency (e.g. cracks), if applicable.
2. Hands-On inspection is defined as the inspection procedure that includes arms-length inspection of all major support components. The hands-on procedure may often include the need for MOT to access the

structure as well as the use of one or more NDT methods to assess the structural integrity of one or more support components.
3. Construction – is defined as period of time following the erection of a new support prior to acceptance, or the period of time after one of more support components have been repaired, rehabilitated or replaced.
4. Triggered Event – is defined as an event in which two or major deficiencies are observed or if the observed deficiencies would result in a condition rating of “1”, or support subjected to a special event.

9.2 Follow-up Recommendations

The following section discusses and provides several recommendations for consideration by ODOT. While some of the recommendations were not part of the original scope, they highlight limitations or potential areas of improvement based on the results from this study. Additionally, the implementation of one or more of the recommendations may assist to enhance the assessment of the overall support inventory.

9.2.1 Discussion, Recommendations, and Benefits

One of the principle limitations of this study was the fact that none of the inventories for OSS, BMS, SS and HMLS were well developed. As such, when trying to select supports, or find previous inspection reports, the process required a significant amount of time cross referencing information between electronic databases, if they existed, and locating the paper based records.

Overall, the inventory should support a process for recording the inspection data in a way that facilitates usage, and contains data for assessing the adequacy and life expectancy of the individual support. Furthermore the process should allow for a searchable and sortable format in the form of a systemwide database. By having a universal approach across all districts, the support inventory, and subsequent maintenance/repair records can be simplified and easily accessed. Due to the differing methods of record keeping throughout the state, the work presented in this report does not represent a statistically random sample. As such, a reliability assessment could not be performed with the existing data. This type of assessment requires random samples to be taken from a large data set under a unified system that is representative of the condition of the support population statewide.

Suggested overall recommendations include:

1. *Unified inspection procedure under an element level approach with condition rating* – As all supports have some common failures modes, a long term recommendation is to put all the support inspections on a common basis and archive the results in an electronic database. A unified procedure could provide a better understanding of support conditions on a statewide level. Inclusion of a condition rating would assist in identification of supports experiencing ongoing or repeated degradation across time. Combining the condition rating with a weighted factor based on the critical nature of the support component would assist with ranking the supports or components for prioritization;
2. *Unified inspection form* – provides a process for recording the inspection data in a way that facilitates long-term control of the inventory and facilitates data mining for reliability assessment. Similar to this study, the information would be recorded on a paper or electronic form in the field, and then submitted to a database;
3. *Centralized database* – a centralized database of information would allow ODOT to compare similar supports across all Districts and evaluate differences in efficiency and

reliability. This would also help identify trends that may be related to design, inspection procedures, environmental effects or more importantly, structural details that can affect performance of the support. The age of the support should be added to assess reliability over time. This same process could be used for recording activities related to maintenance of the supports for assessing any changes in condition since the maintenance activity occurred;

4. *Improve support inspection procedure during fabrication and construction* - a common deficiency noted during inspection was insufficient thread engagement and loose anchor nuts. A hands-on inspection during fabrication and erection, or after construction activities to repair, rehabilitate or repair the support or support component would assist in mitigating issues of thread engagement, improperly leveled baseplates, tightness of connections, missing hardware, etc. The downside is that inspectors could be required to spend more time on site or visit the fabrication shop, which could increase initial cost of the project.

In lieu of the above recommendations, the specific recommendations regarding the current inspection program are as follows:

1. *Increased inspection training for all field personnel* – all personnel selected to perform inspection, regardless of support type, should be trained for inspection. Given that different personnel or contractors may be involved with the inspection process, they may not be familiar with inspection of supports for structural integrity. Frequent training and refresher courses will assist in maintaining consistency and quality of the inspections over time. Refresher courses could be given every 2-3 years. For personnel involved with BMS inspection, training would allow the bridge inspectors to become more familiar with the inspection process for supports and be able to expand on the information collected. Using current video technology and web conferencing, courses could be conducted remotely and mitigate associated costs. The training could also be provided using an online class format;
2. *Formal inspection procedure and inventory for HMLS* – given that no formal inspection program is in place, at a minimum the current ODOT procedures should be applied for a structural inspection process at the same interval;
3. *Expanded structural inspection procedure for SS* – while rudimentary inspections are conducted on an annual basis, the current inspections lean towards a maintenance approach, where a structural inspection approach would improve the quality of the data collected. Suggest moving to 5 year inspection frequency for structural inspection;
4. *Expanded structural inspection procedure for BMS* – inspections are conducted on an annual basis, but improving the inspection procedure will provide better details for tracking degradation and assessing the condition of the support. Additionally, the bridge inspection form should be clearly flagged to identify bridges with a support;
5. *Control vegetation growth* – excessive vegetation growth was a common deficiency observed for OSS, and HMLS. Vegetation can assist in the prevention of soil erosion and undermining of the support. However, excessive vegetation, and soil overtopping the foundation connection can accelerate potential corrosion of the foundation connections as well as degradation of the concrete itself. Observations in the field show that the 5 year interval can allow excessive vegetation. As such, landscaping crews that maintain the shoulders along roadways could be provided the additional task of trimming growth

around support foundations at a minimal cost. Initial costs may be higher for foundations with excessive growth but minimized over time with timely trimming;

6. *Periodic, hands-on inspection* – unfortunately there are elements of a support that can be missed from a ground based, visual inspection, particularly deficiencies that occur on the top of a horizontal or diagonal element. As such, a periodic, hands-on approach would mitigate these particular issues. Therefore using this approach during construction activities, a triggered event or special event will help improve the life of the support.

9.2.2 Ad Hoc Inspection Recommendations

The hands on inspections revealed two areas that are of concern to the research team: Loose and missing sign clips, that hold the sign panel to the z shaped vertical bars, were found in several districts; and a higher than normal observation of loose high mast anchor nuts in District 12. In the opinion of the research team, expanded inspections to better understand the extent of the issues and possible remediation should be considered.

1. During this project a total of four sign panels, from two different locations, fell during severe weather events in which both sites were subjected to high winds. As such, during the hands-on inspections for this project, inspectors began tapping on sign clips with a light hammer to check for loose or broken clips from a bucket or using rope access. In a few instances, loose, broken and missing sign clips were found. The sign failures themselves are not an issue of an inadequate inspection program. Since ODOT has already instituted changes regarding clip material certifications, increasing clip dimensions and instituting sign clip tightening procedures, in the future the identification of loose or missing connection hardware during the normal inspection process should be considered a triggerable event to institute a hands-on inspection. The hands-on inspection would assist in early detection of any potential issues.
2. The number of loose anchor nuts for the HMLS inspected in District 12 was unexpectedly high. In this case, the anchor nuts were considered loose as the lock washers between the nuts and plates were missing. This sample was concentrated in a geographic area, near the shore of Lake Erie, in which this area was judged to have a more challenging environment from a wind and corrosion perspective and may thus be a localized issue. In the case of the missing lock washers, it could not be determined whether this was due to a construction error or if the washers had corroded away due to lack of galvanization as compared to the rest of the components at the base of the support. Either way, these observations indicates a need for a wider inspection sample to determine root cause.

9.2.3 Summary of Recommendations

The summary of recommendations is provided in Table 9.2. At this time, one general recommendation is not to change the design standards for HMLS, anchor plates of cantilever supports or the post to plate welds as no cracks were observed in these connections. Thus, it is prudent to keep details that have not failed even when loose anchor bolt nuts were observed.

Table 9.2 Summary of Recommendations

Overall Recommendations (Long Term)	For all support types, the long term goal is for uniformity of inspection across all Districts for tracking degradation and assessing condition, prioritizing support needs, and effective and efficient maintenance planning using available resources. 1. Unified inspection procedure under an element level approach with condition rating; 2. Unified inspection form; 3. Centralized database; 4. Improved support inspection procedure during construction activities.
Specific Recommendations (Near Term)	1. Increased inspection training for all field personnel; 2. Adopt formal structural inspection procedure and inventory process for HMLS, 5 year interval; 3. Expanded structural inspection procedure for SS, 5 year interval; 4. Control vegetation growth; 5. Hands-on inspection during construction activities, trigger events or special events.
Ad Hoc Recommendations	1. Additional focus on sign connection assemblies during future inspections and conduct hands-on inspection as needed; 2. Increase inspection sample size to determine high rate of missing lock washers/loose anchor nuts on HMLS in District 12.

9.3 Implementation

For all support types studied, implementation of this research consists of improving the inspection process for all support types by moving to a unified format under the current ODOT process. Additionally, hands-on inspection should be considered on a more frequent, trigger based approach in order to accurately assess the condition of the supports. Improved inventory data should include location, age and condition of the supports, down to the element level, for all support types. This approach would improve the quality of the data collected and allow the data to be mined to establish degradation rates, and be retained in a manner that facilitates system wide condition assessment. Implementation of the near term recommendations would reduce the demand on resources and coordination across all Districts in trying to achieve the long term objectives.

10 Conclusion

This research evaluated the current ODOT structural inspection program for four support types: overhead sign supports, bridge mounted supports, signal supports and high mast lighting supports. Overall, for the 202 supports inspected, 36 of the supports were rated as critical (22 OSS, 8 BMS and 6 HMLS). The highest number of observed deficiencies were related to: loss of galvanization, corrosion, vegetation growth, loose anchors, and missing hardware. Critical deficiencies were typically loose anchors (i.e. non-gripped anchor plate due to loose nuts, missing lock washers, etc.) and gaps in end post connections. The hands-on inspection process found almost 1.87 times more deficiencies as compared to the ODOT process. While the majority of them would have likely been observed under the current ODOT process, some deficiencies during the field inspections, such as gaps in connection plates (for all support types), loose anchors on BMS and loose sign clips would not have been observable from the ground. There were additional concerns regarding deficiencies observed for BMS and HMLS but appear to be localized to a few Districts. These observations were passed on to each District and as such, these deficiencies have been or are currently being addressed.

No evidence was found that indicated the current ground based, visual inspection process used by ODOT, or that the maximum 5 year inspection frequency for OSS is inadequate and should be changed at this time. Bridge mounted supports are inspected annually as part of the bridge inspection process. The portion of the inspection form focused on structural inspection of supports in minimal. It is recommended that the structural inspection for the BMS conform to the same requirements as the OSS structural inspection. Signal supports have a rudimentary structural inspection process performed annually as a part of the Ohio Signal Inventory System functional inspection. A structural inspection process, which includes ground based visual inspection and anchor bolt sounding, at a minimum 5 year interval is recommended. High mast light supports currently have no structural inspection process. A structural inspection process, which includes ground based visual inspection and anchor bolt sounding, at a minimum 5 year interval is recommended.. Hands on inspection should be done when a triggerable event occurs. A triggerable event is an occurrence or an indication that the support condition warrants further investigation. Examples for triggerable events include a low overall “critical” rating of a support, construction activities and special events.

While all ODOT Districts perform the inspections to meet their needs and that of ODOT policy, there was an observed difference in the type of data and quality of data collected. The unfortunate aspect of differing methods in record keeping is that in working with limited information, it made selection of a truly random sample difficult. As such, systemwide statistical inferences could not be drawn in regards to a reliability assessment for the different support structures. Minor improvements in training for all personnel, regardless of support type, would improve the quality of the data collected. Moving towards a unified inspection report and the implementation of a condition rating system, would assist with condition assessment and tracking of degradation over time. Finally, implementation of a statewide database would allow for the evaluation of differences in efficiency and reliability across the state and help identify trends that may be related to design, inspection, environmental effects or more importantly, structural details that can affect performance of the support.

11 References

[1] Huckelbridge and Metzger, (2007). Investigation of the Dayton IR 75 Sign Truss Failure of 9/11/06, Department of Civil Engineering, Case Western Reserve University.

[2] FHWA (2005), Federal Highway Administration, Office of Bridge Technology *Guidelines for the installation, Inspection, Maintenance and Repair of Structural Supports for Highway Signs, Luminaires, and Traffic Signals*, FHWA NHI 05-036.

[3] AASHTO (2011), *Standard Specifications for Structural Supports for Highway Signs, Luminaires, and Traffic Signals*, Interim Fifth edition with interims through 2011.

[4] ODOT (2014), Final Reports, Division of Planning, Statewide Planning & Research Projects, http://www.dot.state.oh.us/Divisions/Planning/SPR/Research/reportsandplans/Pages/default.aspx

[5] ODOT (2013), Traffic Engineering Manual, Ohio Department of Transportation, Office of Traffic Engineering, http://www.dot.state.oh.us/Divisions/Engineering/Roadway/DesignStandards/traffic/TEM/Pages/TEMRevisionSets.aspx, accessed August 2014.

[6] Li, X., T. M. Whalen, and M. D. Bowman (2012). Fatigue Strength and Evaluation of Sign Structures, Volume 1: Analysis and Evaluation. Publication. FHWA/IN/JTRP-2006/16-1. Joint Transportation Research Program, Indiana, Department of Transportation and Purdue University, West Lafayette, Indiana.

[7] Li, X., T. M. Whalen, and M. D. Bowman (2012). Fatigue Strength and Evaluation of Sign Structures, Volume 2: Sign Structure Inspection Manual. Publication FHWA/IN/JTRP-2006/16-2. Joint Transportation Research Program, Indiana, Department of Transportation and Purdue University, West Lafayette, Indiana.

[8] VaDOT (2014), Traffic Ancillary Structures Inventory & Inspection Manual, Virginia Department of Transportation, Structure and Bridge Division.

[9] New York (1999), Overhead Sign Structures Inventory and Inspection Manual, NewYork Department of Transportation.

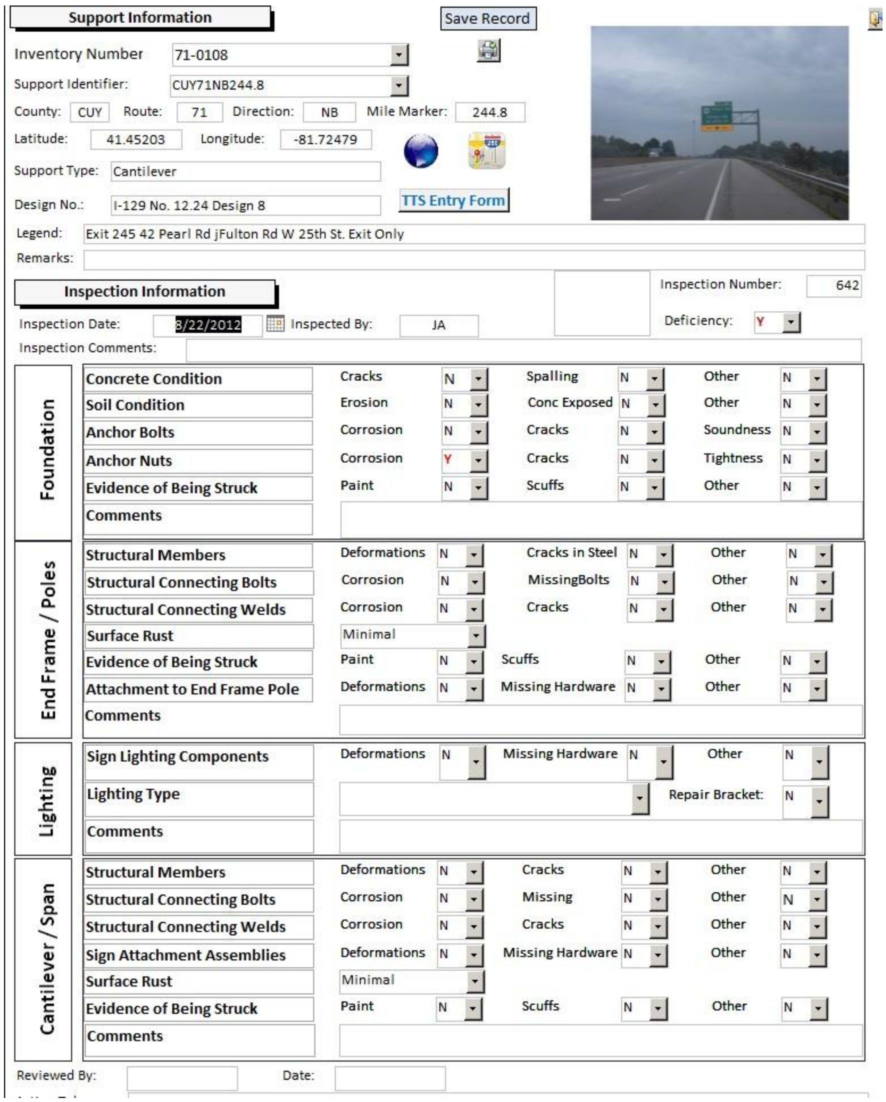
[10] KDOT (2014), Policies and Procedures for the Inspection of Light & Sign Structures, Kansas Department of Transportation.

[11] ODOT (2010), Manual of Bridge Inspection, Ohio Department of Transportation, Office of Structural Engineering, http://www.dot.state.oh.us/Divisions/Engineering/Structures/Pages/default.aspx

Appendix A

Sample of Past and Current Inspection Forms

A.1.1 ODOT Inspection Report (Sample: District 12-CUY71NB244.8)



Support Information

Save Record

Inventory Number: 71-0108

Support Identifier: CUY71NB244.8

County: CUY Route: 71 Direction: NB Mile Marker: 244.8

Latitude: 41.45203 Longitude: -81.72479

Support Type: Cantilever

Design No.: I-129 No. 12.24 Design 8

TTS Entry Form

Legend: Exit 245 42 Pearl Rd jFulton Rd W 25th St. Exit Only

Remarks:

Inspection Information

Inspection Number: 642

Inspection Date: 8/22/2012 Inspected By: JA

Deficiency: Y

Inspection Comments:

Foundation	Concrete Condition	Cracks	N	Spalling	N	Other	N
	Soil Condition	Erosion	N	Conc Exposed	N	Other	N
	Anchor Bolts	Corrosion	N	Cracks	N	Soundness	N
	Anchor Nuts	Corrosion	Y	Cracks	N	Tightness	N
	Evidence of Being Struck	Paint	N	Scuffs	N	Other	N
	Comments						
End Frame / Poles	Structural Members	Deformations	N	Cracks in Steel	N	Other	N
	Structural Connecting Bolts	Corrosion	N	MissingBolts	N	Other	N
	Structural Connecting Welds	Corrosion	N	Cracks	N	Other	N
	Surface Rust	Minimal					
	Evidence of Being Struck	Paint	N	Scuffs	N	Other	N
	Attachment to End Frame Pole	Deformations	N	Missing Hardware	N	Other	N
	Comments						
Lighting	Sign Lighting Components	Deformations	N	Missing Hardware	N	Other	N
	Lighting Type					Repair Bracket:	N
	Comments						
Cantilever / Span	Structural Members	Deformations	N	Cracks	N	Other	N
	Structural Connecting Bolts	Corrosion	N	Missing	N	Other	N
	Structural Connecting Welds	Corrosion	N	Cracks	N	Other	N
	Sign Attachment Assemblies	Deformations	N	Missing Hardware	N	Other	N
	Surface Rust	Minimal					
	Evidence of Being Struck	Paint	N	Scuffs	N	Other	N
	Comments						

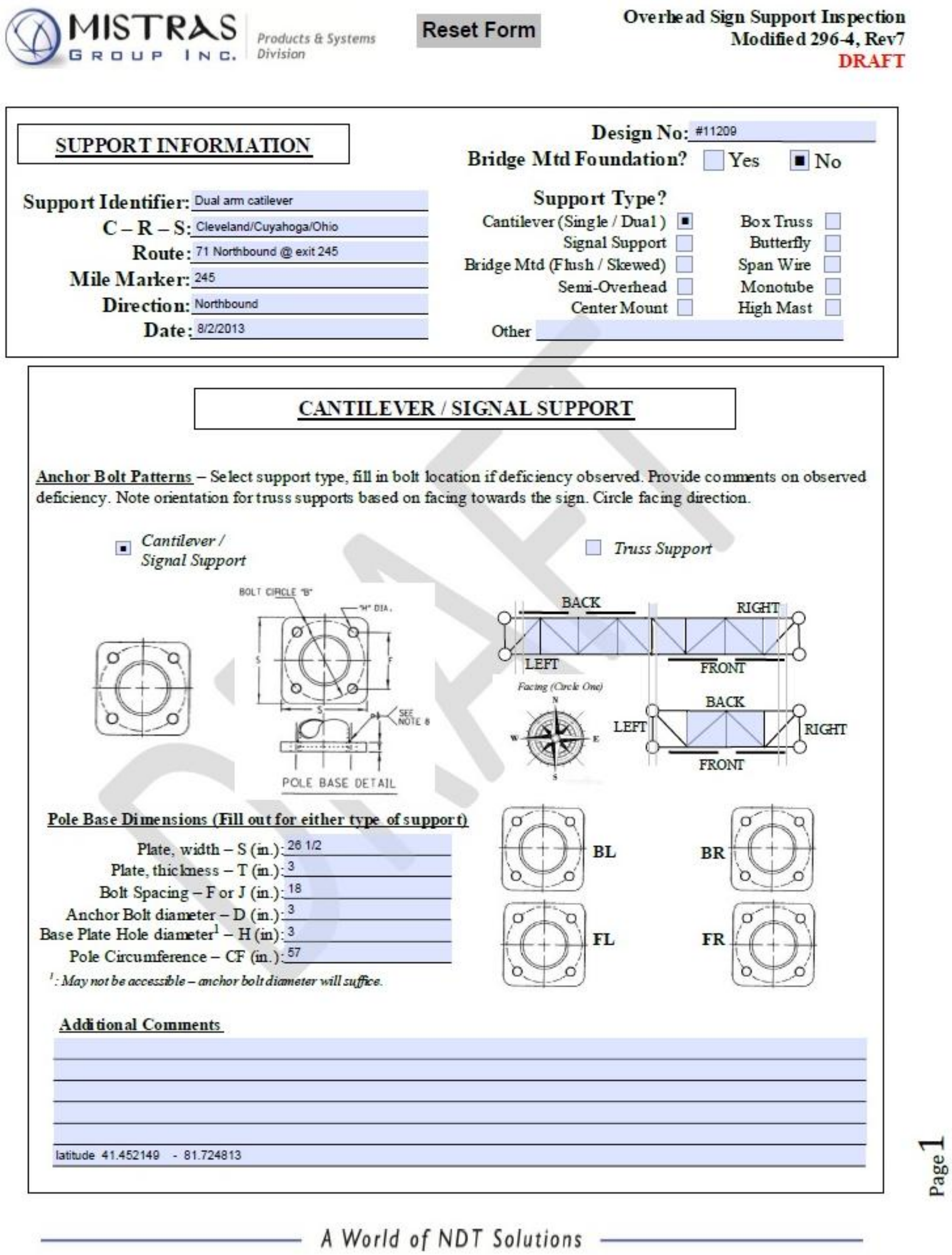
Reviewed By: Date:

Figure A.1-Sample of ODOT inspection form in D12 (ID# CUY71NB244.8)

A.1.2 Mistras Inspection Report (ID# 11209)

Figure A.2- Dual arm cantilever support (ID# 11209)

- Location: 71 northbound @ exit 245
- Design: #11209
- Type of method: VT
- Date: 8/2/2013



MISTRAS GROUP INC. Products & Systems Division

Reset Form

Overhead Sign Support Inspection
Modified 296-4, Rev7
DRAFT

SUPPORT INFORMATION

Design No: #11209
Bridge Mtd Foundation? ☐ Yes ■ No

Support Identifier: Dual arm catilever
C – R – S: Cleveland/Cuyahoga/Ohio
Route: 71 Northbound @ exit 245
Mile Marker: 245
Direction: Northbound
Date: 8/2/2013

Support Type?
Cantilever (Single / Dual) ■
Signal Support ☐
Bridge Mtd (Flush / Skewed) ☐
Semi-Overhead ☐
Center Mount ☐
Box Truss ☐
Butterfly ☐
Span Wire ☐
Monotube ☐
High Mast ☐
Other

CANTILEVER / SIGNAL SUPPORT

Anchor Bolt Patterns – Select support type, fill in bolt location if deficiency observed. Provide comments on observed deficiency. Note orientation for truss supports based on facing towards the sign. Circle facing direction.

■ *Cantilever / Signal Support*

☐ *Truss Support*

BOLT CIRCLE "B"
"H" DIA.
SEE NOTE 8
POLE BASE DETAIL

BACK
RIGHT
LEFT
FRONT
Facing (Circle One)
BACK
LEFT
RIGHT
FRONT

Pole Base Dimensions (Fill out for either type of support)

Plate, width – S (in.): 26 1/2
Plate, thickness – T (in.): 3
Bolt Spacing – F or J (in.): 18
Anchor Bolt diameter – D (in.): 3
Base Plate Hole diameter[1] – H (in): 3
Pole Circumference – CF (in.): 57

[1]: *May not be accessible – anchor bolt diameter will suffice.*

BL
BR
FL
FR

Additional Comments

latitude 41.452149 - 81.724813

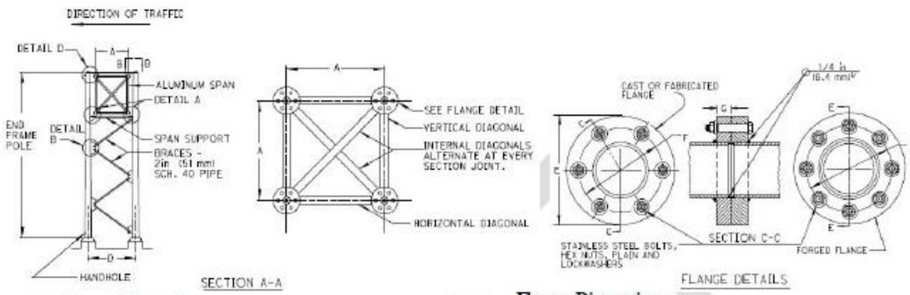
Page 1

A World of NDT Solutions

Figure A.3– Inspection form (ID# 11209)

TRUSS SUPPORT

■ *Section not applicable*



Truss Dimensions

Chord spacing – A[1] (in.): ____
End post spacing – D (in.): ____
Pole circumference – CF (in.): ____

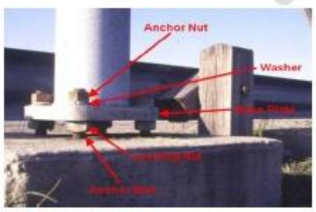
[1]: *In-depth only; verification of standard design drawing*

Flange Dimensions

Flange diameter[1] – E (in.): ____
Bolt line diameter[1] – F (in.): ____
Flange thickness[1] – G (in.): ____
Number of bolts: ____
Bolt diameter[1]: ____

Additional Comments

FOUNDATION



Picture: Example only

Base Plate/Anchor Bolt Assemblies

		Comments:
Missing nuts/washers	☐	corrosion on anchor and bolts/ top and bottom of plate
Loose nuts/bolts	☐	pic. ref. 1, 2, 3, 4,
Cracked/Broken bolts	☐	
Corrosion/Section Loss	■	
Loss of galvanizing	■	
Cracks in base plate weld	☐	
NDT (UT/ MT/ PT / EC)	☐	

Rating (Circle One): 4 (Good) 3 2 1 (Poor)

Page 2

A World of NDT Solutions

Figure A.4– Inspection form (ID# 11209)

Picture: Example only

Concrete/Barrier Condition

- Cracks ■
- Rust stains ■
- Overtopping of soil ☐
- Voids/Honeycombing ☐
- Spalls ☐

Comments:
crack spreading out from anchor
pic. ref. 4, 5,
rust
pic. ref. 1, 4, 5,

Rating (Circle One): 4 (Good) 3 2 1 (Poor)

Picture: Example only

Soil Condition (Around Foundation)

- Erosion ☐
- Poor drainage ☐
- Vegetation growth ☐
- Undermined footing ■

Comments:
footing
pic. ref. 5, 6,

Rating (Circle One): 4 (Good) 3 2 1 (Poor)

END POST / FRAME / ARM-TRUSS MEMBERS

Picture: Example only

☐ **End Post (Cantilever/Signal)** ☐ **Frame – Web Assemblies (Truss)**

- Bent/Damage pole or diagonals ☐
- Cracked pole/diagonals ☐
- Cracked welds ☐
- Corrosion/Pitting ☐
- Surface Rust/Section Loss ☐
- Loss of galvanizing ■
- Missing pole cap/handhole cover ■
- NDT (UT/ MT/ PT / EC) ☐

Comments:
paint chipping away on repair spot
pic. ref. 7
missing cover plate
pic. ref. 1

Rating (Circle One): 4 (Good) 3 2 1 (Poor)

Picture: Example only

- Cracks in welds ☐
- Loose nuts/bolts ■
- Cracked/Broken bolts ☐
- Missing nuts/bolts ☐
- Corrosion/Pitting/Section Loss ☐
- Gaps between plates ☐
- Loss of galvanizing ☐
- NDT (UT/ MT/ PT / EC) ☐

Comments:
lack of thread engagement on attachment arm
arm holes not plugged
pic. ref. 8

Rating (Circle One): 4 (Good) 3 2 1 (Poor)

Figure A.5– Inspection form (ID# 11209)

Pictures: Example only

Arm/Truss Member Assemblies & Connections

☒ *Section not applicable*

Bent/Damaged chords ☐	Comments:
Broken chords ☐	
Bent/Damaged diagonals ☐	
Broken diagonals ☐	
Cracks in welds ☐	
Cracked/Loose nuts/bolts ☐	
Missing nuts/bolts ☐	
Missing connection hardware ☐	
Corrosion/Pitting/Section Loss ☐	
Loss of galvanizing ☐	
NDT (UT/ MT/ PT / EC) ☐	

Rating (Circle One): 4 (Good) 3 2 1 (Poor)

Picture: Example only

SIGN/SIGNAL ATTACHMENT ASSEMBLIES

Attachment Assemblies

Impact damage ☐	Comments:
Cracked/Loose nuts/bolts ☐	good condition
Missing attachment hardware ☐	
Corrosion/Pitting/Section Loss ☐	
Loose/Cracked luminare supports ☐	
NDT (UT/ MT/ PT/ EC) ☐	

Rating (Circle One): 4 (Good) 3 2 1 (Poor)

Picture: Example only

BRIDGE MOUNTED (FLUSH/SKEWED)

☒ *Section not applicable*

Attachment Assemblies

Cracked/Loose nuts/bolts ☐	Comments:
Missing attachment hardware ☐	
Gap between plate/parapet ☐	
Corrosion/Pitting/Section Loss ☐	
☐	
☐	

Rating (Circle One): 4 (Good) 3 2 1 (Poor)

Inspected by: Marty Thorp	**Date:** 8/2/2013
Inspected by: Jeff Fearing	**Date:** 8/2/2013
Inspected by:	**Date:**

Page 4

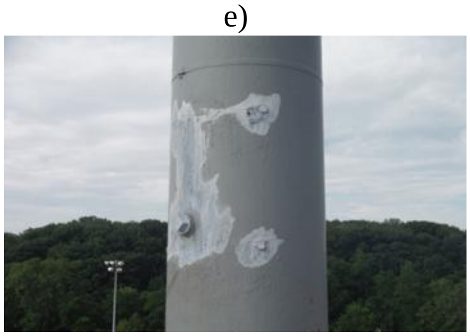
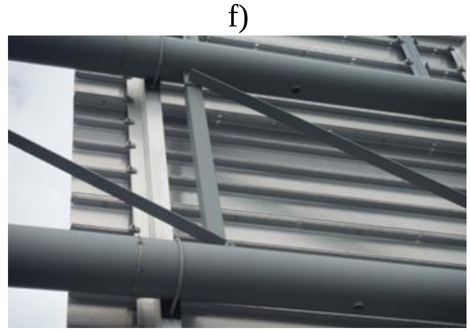
A World of NDT Solutions

Figure A.6– Inspection form (ID# 11209)


a) b)


c) d)


e) f)

g) h)

Figure A.7- Pictures taken during Mistras inspection (ID# 11209)

Appendix B

Sample of ODOT Inspection Reports

ODOT District 1 ~ Overhead Sign Support Inspection

Support Information

Inspected by: ______________________ Date: __________
Support Identifier: ________________ Direction: __________
County: __________ Route: __________ Mile Marker: __________

Design No.: __________ Bridge Mtd Foundation? ____ Yes ____ No

Support type : ____ Cantilever ____ Box Truss ____ Monotube
____ Mast Arm ____ Span Wire ____ Semi-Overhead
____ Bridge Mtd ____ Skewed Bridge Mtd ____ Butterfly
____ Other (explain): ______________________

Foundation

____ Concrete Condition ____ Soil Condition ____ Anchor Bolts/Nuts

Comments: ____

End Frame/Pole

____ Structural Members ____ Structural Connections
Damage: ____ Yes ____ No
Pitting: ____ Yes ____ No
Surface Rust: ____ Minimal ____ Moderate ____ Severe

Comments: ____

Cantilever/Span

____ Structural Members ____ Structural Connections
____ Sign Attachments ____ Attachments to End Frame/Pole
Damage: ____ Yes ____ No
Pitting: ____ Yes ____ No
Surface Rust: ____ Minimal ____ Moderate ____ Severe

Comments: ____

Structural Components of Sign Lighting

Type: ____ None ____ Fluorescent
Repair Bracket: ____ Yes ____ No
Mercury Vapor TC-31.21:
____ New ____ Old
Comments: ____

Figure B.1-Sample of District 1 inspection report

STATE OF OHIO DEPARTMENT OF TRANSPORTATION

OVERHEAD SIGN & SUPPORT INSPECTION FORM

County/Route/Section/Direction

LOCATION:____________________

INSPECTED BY:________________ DATE INSPECTED:______________

Sign #:__________ Sign #:__________ Sign #:__________ Sign #:__________

DISK #:_______ PICTURE #:______

SPAN CANTILEVER BUTTERFLY COMBINATION OTHER

ITEMS TO BE INSPECTED	DEFICIENCIES			COMMENTS
CONCRETE FOUNDATION	CRACKS Y N	SPALLING Y N	OTHER Y N	
SOIL AROUND FOUNDATION	EROSION Y N	CONC. EXPOSED Y N	OTHER Y N	
ANCHOR BOLTS	CORROSION Y N	CRACKS IN BOLTS Y N	SOUNDNESS Y N	
ANCHOR NUTS	CORROSION Y N	CRACKS IN NUTS Y N	TIGHTNESS Y N	
STRUCTURAL MEMBERS	DEFORMATIONS Y N	CRACKS IN STEEL Y N	OTHER Y N	
STRUCTURAL CONNECTING BOLTS	CORROSION Y N	MISSING BOLTS Y N	OTHER Y N	
STRUCTURAL CONNECTING WELDS	CORROSION Y N	CRACKS Y N	OTHER Y N	
EVIDENCE OF STRUCTURE AND/OR FOUNDATION BEING STRUCK	PAINT Y N	SCUFFS Y N	OTHER Y N	
EVIDENCE OF SIGN BEING STRUCK BY OVERHEIGHT VEHICLE	PAINT Y N	SCUFFS Y N	OTHER Y N	
SIGN ATTACHMENT ASSEMBLIES	DEFORMATIONS Y N	MISSING HARDWARE Y N	OTHER Y N	
STRUCTURAL COMPONENTS OF SIGN LIGHTING	PRESENT Y N	MISSING HARDWARE Y N	OTHER Y N	
SIGN CONDITION	DAMAGED Y N	FADED/CRACKED Y N	REPLACE Y N	
OVERALL CORROSION	MINIMAL	MODERATE	SEVERE	
OVERALL STRUCTURE CONDITION	POOR	AVERAGE	GOOD	

Sign Project Survey D03 Oct 11, 2012 p 3 of 7

Figure B.2-Sample of District 3 inspection report

OVERHEAD SIGN SUPPORT INSPECTION REPORT

SMAHIR00680**C   MAH-IR680-1.85   120

OFFICE USE: CO/RT/SEC MAH-680-0.00

ORIG. PROJ. NO. 506-03   PAGE 18/47

SIGN AREA:

16'×7'   20'×9.5'   15'×7'   ______

LABEL SIGN DIMENSIONS

SIGN SUPPORT #2 TC-7.65 DESIGN No 6 STA 506+72 EB

SIGNS: LABEL LEGEND OF EACH SIGN

680 SOUTH Youngstown	EXIT 3A 711 M L King Blvd 1 MILE	EXIT 2 Meridian Rd ↗	

CANTILEVER

COMMENTS: NEW SIGNS 2004

LIGHTS: LIST NUMBER & TYPE   A. M V TC-31.20   REPAIR BRACKET? YES NO
B. M V TC-31.21
C. FLOURESCENT

COMMENTS: LIGHTING REMOVED 2004

SUPPORT: BY TYPE (CIRCLE)

CANTILEVER   BOX TRUSS   BRIDGE MOUNT

SKEWED? YES NO

CORROSION: MODERATE SEVERE   K-BRACE? YES NO

COMMENTS: NEW SUPPORT 2004

Figure B.3-Sample of District 4 inspection report

District 5
Overhead Sign Support Inspection Form

County / Route / Section : ____________________

Location Description : ____________________

GPS Coordinates : ____________________

Vertical Structure Clearance: ____________ **Vertical Sign Clearance:** ____________

Support Information

Type: ☐ Cantilever ☐ Box Truss ☐ Bridge Mounted ☐ Skewed Bridge Mounted ☐ Butterfly
☐ Other:____________________

Foundation | **Foundation Type:** ☐ Ground Mounted ☐ Barrier Mounted

	Rating	Comments
Concrete Condition:		
Soil Condition:		
Anchor Bolts/Nuts Condition:		

End Frame or Poles **Pole Type:** ☐ Steel ☐ Aluminum

	Rating	Comments
Structural Member Condition:		
Structural Connection Condition:		
Surface Rust Condition:		

Cantilever or Truss:

	Rating	Comments
Structural Members Condition:		
Structural Connections Condition:		
Sign Attachments Condition:		
Attachments to End Frame Condition:		
Surface Rust Condition:		

General Appraisal:

Expected Life (years):	

Overall Rating: ______

Comments: ____________________

Inspected By: **Date:**

Figure B.4-Sample of District 5 inspection report

FRA270-1.86 NB

113

OVERHEAD SIGN & SUPPORT INSPECTION FORM

COUNTY: FRA N. W

ROUTE: I-270

SIGN TYPE: DUE ARM

SECTION (MM): 1.86

DIRECTION: W-B

SIGN DESCRIPTION: EXIT 2 62 3 GROVE CITY

DATE INSPECTED: 12-23-09

NOTES:

INSPECTED BY: RS

PICTURE #:

SPAN CANTILEVER BUTTERFLY COMBINATION SPANWIRE MONOTUBE OTHER

BRIDGE MOUNTED Y N

ITEMS TO BE INSPECTED	DEFICIENCIES						COMMENTS
CONCRETE FOUNDATION	CRACKS		SPALLING		OTHER		
	Y	N	Y	N	Y	N	
SOIL AROUND FOUNDATION	EROSION		CONC. EXPOSED		OTHER		
	Y	N	Y	N	Y	N	
ANCHOR BOLTS	CORROSION		CRACKS IN BOLTS		SOUNDNESS		
	Y	N	Y	N	Y	N	ONE BOLT SOUNDS BAD
ANCHOR NUTS	CORROSION		CRACKS IN NUTS		TIGHTNESS		
	Y	N	Y	N	Y	N	CAN'T SEE ANIMAL GUARD
STRUCTURAL MEMBERS	DEFORMATIONS		CRACKS IN STEEL		OTHER		
	Y	N	Y	N	Y	N	
STRUCTURAL CONNECTING BOLTS	CORROSION		MISSING BOLTS		OTHER		
	Y	N	Y	N	Y	N	
STRUCTURAL CONNECTING WELDS	CORROSION		CRACKS		OTHER		
	Y	N	Y	N	Y	N	
EVIDENCE OF STRUCTURE AND/OR FOUNDATION BEING STRUCK	PAINT		SCUFFS		OTHER		
	Y	N	Y	N	Y	N	
EVIDENCE OF SIGN BEING STRUCK BY OVERHEIGHT VEHICLE	PAINT		SCUFFS		OTHER		
	Y	N	Y	N	Y	N	
SIGN ATTACHMENT ASSEMBLIES	DEFORMATIONS		MISSING HARDWARE		OTHER		
	Y	N	Y	N	Y	N	
STRUCTURAL COMPONENTS OF SIGN LIGHTING	PRESENT		MISSING HARDWARE		OTHER		
	Y	N	Y	N	Y	N	Elec PICTURE
SIGN CONDITION	DAMAGED		FADED/CRACKED		REPLACE		
	Y	N	Y	N	Y	N	
OVERALL CORROSION	MINIMAL		MODERATE		SEVERE		
	X						
OVERALL STRUCTURE CONDITION	POOR		AVERAGE		GOOD		
					X		

Figure B.5-Sample of District 6 inspection report

James M
McGee Blvd
Exit ↓ Only

Form 296-4. Overhead Sign Support Inspection

Support Information

Support Identifier: ____________ Date: 3-18-11
Route: 435 ____________ Direction: WB
C - R - S: ____________ Mile Marker: 34.5

Design No.: ____________ Bridge Mtd Foundation? ____Yes ____No
Support Type: ____Cantilever ✓ Box Truss ____Bridge Mtd ____Skewed Bridge Mtd
____Span Wire ____Monotube ____Butterfly ____Semi-Overhead
____Other: ____________

Foundation

____Concrete Condition ____Soil Condition ____Anchor Bolts/Nuts
Comments: G

End Frame/Pole

____Structural Members ____Structural Connections
____Damage? ____Yes ____No ____Pitting? ____Yes ____No
____Surface Rust: ____Minimal ____Moderate ____Severe
Comments: G

Cantilever/Span

____Structural Members ____Structural Connections
____Sign Attachments ____Attachments to End Frame/Pole
____Damage? ____Yes ____No ____Pitting? ____Yes ____No
____Surface Rust: ____Minimal ____Moderate ____Severe
Comments: G

Structural Components of Sign Lighting

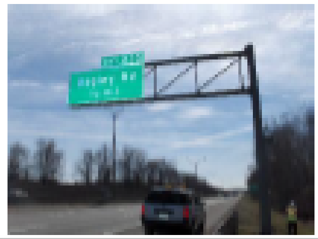
Type: ____Fluorescent ____Mercury Vapor TC-31.21 (New Design)
____Mercury Vapor TC-31.20 (Old Design) ____Repair Brkt? ____Yes ____No
Comments: ____________

Inspected by: DM. Date: 3-18-11

Figure B.6-Sample of District 7 inspection report

Overhead Sign Support Inspection

Support Information



Inventory Number: 71-0041

Support Identifier: CUY71S0236.0

County: CUY   Route: 71   Direction: CS   Mile Marker:

Latitude: Longitude:

Support Type: Cantilever

Design No.: TC-12.30 Design 5   TTS Entry Form

Legend: 71 South Columbus

Remarks: Bagley Road EB at 71 South Entrance

Inspection Information

Inspection Number: 642

Inspection Date: 8/22/2012   Inspected By: JA

Deficiency: Y

Inspection Comments:

Foundation	Concrete Condition	Cracks	N	Spalling	N	Other	N
	Soil Condition	Erosion	N	Conc Exposed	N	Other	N
	Anchor Bolts	Corrosion	N	Cracks	N	Soundness	N
	Anchor Nuts	Corrosion	Y	Cracks	N	Tightness	N
	Evidence of Being Struck	Paint	N	Scuffs	N	Other	N
	Comments						
End Frame / Poles	Structural Members	Deformations	N	Cracks in Steel	N	Other	N
	Structural Connecting Bolts	Corrosion	N	MissingBolts	N	Other	N
	Structural Connecting Welds	Corrosion	N	Cracks	N	Other	N
	Surface Rust	Minimal					
	Evidence of Being Struck	Paint	N	Scuffs	N	Other	N
	Attachment to End Frame Pole	Deformations	N	Missing Hardware	N	Other	N
	Comments						
Lighting	Sign Lighting Components	Deformations	N	Missing Hardware	N	Other	N
	Lighting Type					Repair Bracket:	N
	Comments						
Cantilever / Span	Structural Members	Deformations	N	Cracks	N	Other	N
	Structural Connecting Bolts	Corrosion	N	Missing	N	Other	N
	Structural Connecting Welds	Corrosion	N	Cracks	N	Other	N
	Sign Attachment Assemblies	Deformations	N	Missing Hardware	N	Other	N
	Surface Rust	Minimal					
	Evidence of Being Struck	Paint	N	Scuffs	N	Other	N
	Comments						

Reviewed By: Date:

Action Taken:

Figure B.7-Sample of District 12 inspection report

Appendix C

Mistras Inspection Procedures – Modified

HQTS: P: (609) 716-4000 ■ F: (609) 716-0706
195 Clarksville Road ■ Princeton Jct., NJ 08550
www.mistrasgroup.com

Project: Evaluation of Support Inspection Program
RC&A#: R13-090
Subject: Support Inspection Procedures – Rev5

1.0 INTRODUCTION

1.1 Description

The following document outlines the inspection process and the necessary tools for performing inspection of overhead sign supports (OSS), bridge mounted supports (BMS), signal supports (SS) and high mast lighting supports (HMLS). This will be a working document and updated/revised as necessary.

The intent of this document is to evaluate and make recommendations (if necessary) current ODOT Traffic Engineering Manual (TEM) procedures for a uniform practice of periodic inspection of overhead signs that maintains an organized, systematic and efficient inspection procedure. Overhead Sign Support Inspection is governed by Section 221-3 of the TEM and inspection of OSS on construction projects is addressed in Sections 250-4 and 250-5.

1.2 Current Practice

The current practice is to visually inspect overhead sign supports from the ground, with the aid of binoculars or when necessary, the use of a bucket truck for localized, detailed inspection if a potential discontinuity or deficiency is observed during routine (ground) inspection. The use of NDT/NDE is not performed on a routine basis unless a deficiency has been observed and would require more in-depth inspection to determine extent of the deficiency.

2.0 INSPECTION

2.1 Description

This section of the document is describes the inspection process and covers the information on tools, inspection areas, identification of deficiencies, condition rating, reporting and remedial actions. All signs selected for this project will receive a full, hands-on, in-depth inspection. This includes a hands-on examination of major components, members, welds, etc. This type of inspection may require aerial lift equipment, lane closures, rope access and the use of additional non-destructive examination using ultrasonics (UT), magnetic particle (MT) or other NDT techniques.

2.2 Areas of Inspection

The first few inspections will help in the development of an inspection method for each type of support as well as identify a systematic procedure that will help streamline the process as well as create an efficient procedural sequence. The following items to be inspection should include, but certainly not limited to:

1. Concrete foundation or barrier
2. Soil around foundation
3. Base plate(s) and anchor bolt assemblies to foundation
4. End post or frame and their web members and connections
5. Connection(s) of cantilever arm (single/dual) or truss (triangular/box) to end post (welded/bolted)
6. All members of truss and connections (welded/bolted)
7. Sign attachment assemblies
8. Surface coatings

2.3 Identification of Deficiencies

There are a variety of potential discontinuities or deficiencies that should be inspected for. These include, but certainly not limited to:

1. Cracks in concrete foundation or barrier
2. Soil erosion, scour, or overtopping of foundation
3. Missing or loose nuts and washers, non-bearing leveling nuts, corrosion, cracked/missing anchor bolts or nuts
4. Cracks in welds
5. Corrosion
6. Bent/cracked/damaged structural members
7. Missing sign attachment assemblies (hardware)

2.4 Remedial Action(s)

While the ODOT TEM indicates performing remedial/corrective actions or repairs for detected deficiencies, for this project the ONLY remedial/correction actions to be performed by our team is as follows:

1. Removal of soil that has overtopped foundation support, or been deposited in the gap between the baseplate and concrete foundation.
2. Removal of bolt caps/covers (if any) on support foundation. Current ODOT policy is to remove these and leave them off.
3. Other minor deficiencies such as scour, cracked welds, etc. will be recorded and reported in the established/modified inspection form.
4. ***Major deficiencies, such as fully cracked horizontal/vertical/diagonal struts, 2 or more fully cracked anchor bolts or anchor bolts missing from baseplate(s), and or damaged or bent structural members will be photographed and a notification sent within 24 hours of the observation(s) to Jim Roth and the District Contact where the sign is located so remedial action can be determined and performed by ODOT personnel.***

2.5 Recording of Inspection Results

After a review of the inspection process performed by each district, it has been determined that each district does not perform the inspection(s) the same way. Some districts use the general OSS Inspection Form (296-4, Appendix A), District 2 has adapted this form in to an electronic format/device for the inspector, and District 5 uses a rating system adapted from the ODOT Manual of Bridge Inspection, but is not included as part of the TEM. Additionally, the personnel performing the inspection are not always the same and/or may not be familiar with OSS inspection.

While there are differences in how the inspection is performed, no matter how good the inspector, there is always the potential that an item may be overlooked during the inspection process. Therefore, as part of this project, the team will be evaluating the current procedures while conducting our OSS inspections with the intention of determining a systematic and organized approach that will either maintain or enhance the accuracy and efficiency of the current process. The end result may include additional procedures and or steps as part of the overall inspection process. At a minimum, the team will use of the general OSS Inspection Form (296-4) as a baseline for recording of inspection results, and will include the adaptation of a rating system and other potential additions or modifications.

As needed, a photographic record of any observed deficiency will be taken along with a description of the observed deficiency recorded and will be part of the inspection report. In terms of the camera, it should have the ability to input the date and time stamp of when the photo was taken.

All component ratings will also be recorded on the Modified Inspection Form.

2.6 Inspection Tools

The following is a list that is likely to be required to perform an inspection. This list covers the expected equipment for both a standard visual inspection as well as an in-depth inspection. This list may be modified as needed.

General Equipment

• Shovel	• Mirror	• Tape measure (s)	• Calipers
• Broom	• Binoculars	• Magnifying glass	• Socket set
• Wire brush	• Digital Camera	• Level	• Allen/Hex set
• Hammer	• Flashlight	• Crescent wrench	• Screwdrivers, cutters
• Clip board	• Report forms	• Pencils/Pen	• Sketch pad
•	•	•	•

Safety Equipment

• Hard hat	• Reflective vest	• Boots	• Gloves
• Safety glasses	• Fall protection (harness and lanyards)	• Knee pads	•

NDT Equipment

• Pocket UT (or other)	• Eddy current	• MT Yoke	• UT scope
• PT Kit	• UT gel	• Video probe	•

2.7 Areas of Inspection (Specific)

This section will describe the procedures for performing an inspection for each of the areas of interest as previously highlighted in section 2.2.

2.7.1 CONCRETE FOUNDATION, BARRIER

Things to look for:

- Cracks in concrete foundation or barrier wall;
- Rust stains;
- Concrete spalling;
- Vegetation growth thru cracks;
- Overtopping of foundation by soil (clear away soil);
- Conduct (light) tapping test with hammer to determine extent of spalling or other potential damage. Unsound concrete will produce a "hollow" sound when tapped;
- Record comments/observations on OSS Inspection Form.

Ratings: (TBD)

4 - No cracking, spalling, staining – like new.
3 – Very minor cracking, spalling and or staining.
2 – Significant deterioration, heavy cracking and spalling.
1 – Severe deterioration, foundation may not be performing as designed.

2.7.2 SOIL (AROUND FOUNDATION)

Things to look for:

- Soil erosion;

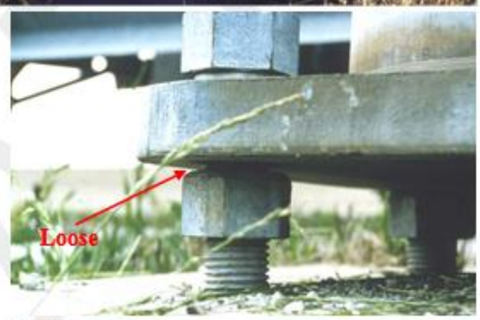
Ratings: (TBD)

4 – No erosion.
3 – Minor erosion (around 1 side).
2 – Significant erosion (around 2 or more sides)
1 – Severe erosion, footing undermined, tipping.

2.7.3 BASE PLATE, ANCHOR BOLT ASSEMBLIES

Things to look for:

- Missing anchor nuts or washers;
- Incomplete thread engagement (at least 1 thread from anchor bolt should be above top of anchor nut);
- Loose leveling or anchor nut(s) – allows OSS to rock back and forth and can cause fatigue and subsequent failure in anchor bolt – typ. seen with cantilever supports;
- Gap between base plate and top of foundation. If no gap, look for corrosion at bottom of end support or staining of concrete;
- Cracked or broken anchor bolts. Use hammer to tap each anchor nut and bolt for soundness. If 1 anchor bolt is cracked, use UT to inspect remaining bolts;
- Corrosion of anchor bolts (due to existing covers – remove and leave off);
- Inspect base plate weld for cracks, condition of galvanizing. Visually mark observed cracks, perform additional NDT (UT, PT, EC) to determine size of crack, and then photograph. Record position and orientation;
- Measure and record bolt pattern, distance between centerline of bolts, size of baseplate and diameter of end pole;
- Record comments/observations on OSS Inspection Form.



Ratings: (TBD)

4 – Base plate and anchor bolts/nuts in good condition – like new.
3 – Loose nut(s), minor corrosion of base plate, anchor bolt assembly.
2 – Heavy corrosion, loss of galvanization.
1 – Missing nuts or anchor bolts, sheared bolts, cracked weld(s) or baseplate.

2.7.4 END POST, FRAME, WEB ASSEMBLIES, CONNECTIONS

Things to look for:

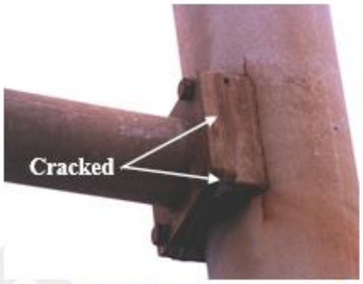
- Inspect end post and web assemblies for bent, or damaged members due to impact;
- Inspect for cracked members;
- Inspect for cracked welds;
- Check for corrosion, piting, or loss of section;
- Check conditon of galvanzing;
- Record comments/observations on OSS Inspection Form.

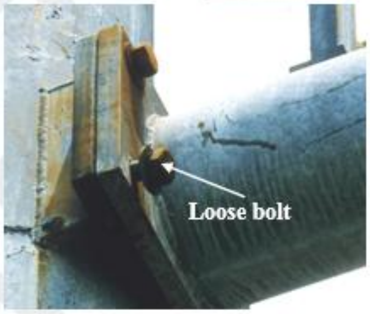
Ratings: (TBD)
4 – End posts in good condition – like new.
3 – Minor corrosion of end post, minor loss of galvanizing with no section loss or medium corrosion of web members;
2 – Heavy corrosion, or loss of galvanization with section loss (localized);
1 – Severe deterioration, section loss, crack(s) in welds or web members, loss of structural integrity.

2.7.5 CONNECTION OF ARM, TRUSS TO END POST

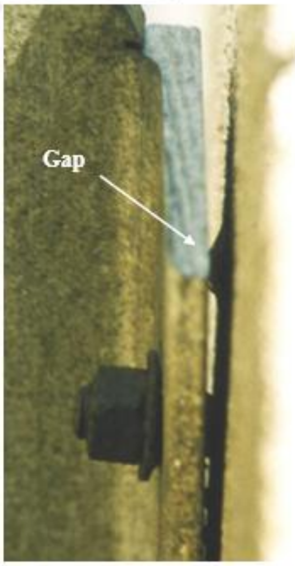
Things to look for:

- Inspect welds for cracks at arm/truss connection to end post;
- Inspect for missing nuts and bolts of connection plate(s);
- Inspect for loose nuts and bolts;
- Check for gaps between plates;
- Check for corrosion, piting, or loss of section;
- Check conditon of galvanzing;
- Record comments/observations on OSS Inspection Form.





Ratings: (TBD)
4 – Connection(s) in good condition, no observable deficiencies.
3 – Minor corrosion of connection, minor loss of galvanizing with no section loss;
2 – Moderate corrosion, or loss of galvanization with section loss;
1 – Severe deterioration, section loss, crack(s) in welds, missing or broken bolts.



2.7.6 ARM/TRUSS MEMBER ASSEMBLIES

Things to look for:

- Inspect welds at truss conections for cracks;
- Inspect for missing nuts and bolts, especially for spliced chord connections;
- Inspect for cracked/loose nuts and bolts (using hammer);
- Inspect for dented, broken diagonals or cracked chords;
- Check for gaps between plates;
- Check for corrosion, piting, or loss of section;
- Check conditon of galvanzing;
- Record comments/observations on OSS Inspection Form.

Ratings: (TBD)

4 – Connection(s) and truss members in good condition, no observable deficiencies.
3 – Minor corrosion, minor loss of galvanizing with no section loss; minor impact damage or misaligned connections;
2 – Serious corrosion to one or more member, medium impact damage, or missing bolts/nuts, connection hardware;
1 – Cracked chord, broken diagonal, severe impact damage, or severe misalignment.

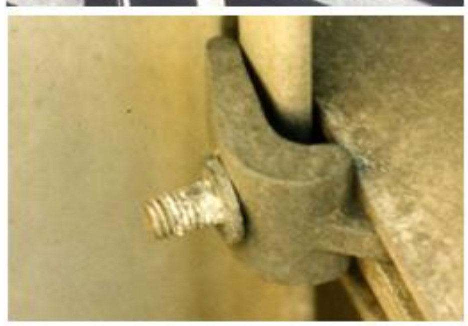
2.7.7 SIGN ATTACHMENT ASSEMBLIES

Things to look for:

- Missing sign attachment hardware, such as U-bolts, clips, bolts and nuts;
- Inspect for cracked/loose nuts and bolts (using hammer);
- Inspect for sign face for impact damage;
- Inspect luminaries (in most cases, sign lighting is no longer used, but if hardware in place, check to make sure nothing is loose);
- Check for corrosion, piting, or loss of section;
- Record comments/observations on OSS Inspection Form.

Ratings: (TBD)

4 – Sign panels in good condition – like new.
3 – Minor impact damage, small number of missing hardware;
2 – Serious impact damage, or missing bolts/nuts, connection hardware;
1 – Sign attachment in state of potential collapse.



Appendix D

Mistras Group, Inc.

Company Information & Experience

Mistras Corporation

Mistras Group, Inc. is the largest NDT and Structural Health Monitoring (SHM) company in the world, with more than 38 years of experience and approximately 3,500 NDT experts. Mistras provides worldwide inspection services, with specialized NDT products to aid in field of inspection. In the U.S., Mistras has 58 US lab and office locations, with a wide presence of 5 labs/offices throughout the state of Ohio. Mistras designs, develops, manufactures and implements NDT and SHM solutions for universities, FHWA, DOTs and Engineering firms. Expertise includes the developing of risk based assessment programs for management of inspection and maintenance of many types of facilities, with primary development for refineries in the oil and gas industry.

Mr. Richard Gostautas from Mistras was the overall project leader, with broad and deep experience in bridge inspection, and familiarity with a wide variety of NDT techniques. Support was provided by Mr. Terry Tamutus, who can effectively mobilize expertise to support this project throughout the Mistras Corporation.

The Mistras personnel used for the field inspection services were primarily based out of the lab in Heath, Ohio. There are approximately 60 employees at this facility that provide field services in a variety of sectors (e.g. aerospace, transportation, oil and gas, etc.) and also provide onsite NDT of parts and components from a wide range of industries within the state of Ohio.

As such, the inspectors from this facility have a wide range of certifications for the various NDT methods in which the Quality Assurance and Quality Control operate under ISO9001:2000 Quality Program with certification provided per Mistras written practice 100-QC-005.2 which meets or exceeds the requirements of ASNT Recommended practice SNT-TC-1A and ANSI/ASNT CP-189.

These inspectors are Level II certified in VT, UT, MT & PT. Additionally, one of the inspectors is a CWI (Certified Weld Inspector) certified directly through the American Welding Society with rope access training.

To become a level II inspector the following is required:

> Classroom Training – 80 hours for UT, 24 Hours for VT, 20 Hours for MT and 16 Hours for PT. To meet ASNT requirements this includes on the job training of 840 hours for UT, 210 hours for VT, 280 hours for MT and 210 hours for PT. All on the job training hours are conducted under the watch of a Level II or Level III inspector. Examinations for each method will be different but include an eye exam, General exam, Specific exam and a Practical exam. Once all the aforementioned requirements are met, Mistras can certify the individual as a Level II. The Level II is allowed to perform inspections, provide reports with results and can accept or reject.