ODOT TRAFFIC STRUCTURES DESIGN

Version – *May, 2012*

MANUAL

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OREGON DEPARTMENT OF TRANSPORTATION

TRAFFIC STRUCTURES DESIGN MANUAL

The material contained herein is for information purposes only and may be used to aid new employees, and those unfamiliar with ODOT Traffic Engineering practices, in accessing and applying applicable standards, statutes, rules, and policies related to traffic structures practice.

Version – *May, 2012*

Traffic Structures Design Manual
Oregon Department of Transportation
Highway Division
Traffic-Roadway Section

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INTRODUCTION

Traffic structures are the most common structures that occur on the Oregon highway system. A traffic structure is defined as a structure that supports a signal, sign or luminaire. Currently there are over 200,000 traffic structures on the state highway system. The traffic structures portion of projects play a support role for other disciplines. Traffic structures primary role is to support highway devices, helping to make an efficient and effective transportation system.

This manual will guide regional technical center and consultant personnel in the design of traffic structures. Specifically, the designer will learn how to produce contract documents and cost estimates for projects, provide construction support, and address nonstandard design issues. In addition, the manual outlines common issues that occur with traffic structures and solutions.

This manual includes recommended guidelines that the Traffic Structures Designer can use for design and construction support on ODOT projects. This manual is only a guideline and does not cover all cases the designer may encounter in a project. For nonstandard issues not covered in this manual, contact the Traffic Structures Engineer at (503) 986-3069.

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Design Phase of Standard & Nonstandard Projects

1.1 GENERAL

Project teaming is the process of assembling a skilled team to conduct the third and fourth phases of project development, project design, alternative selection, and design. Every highway project in the Statewide Transportation Improvement Program (STIP) is assigned a Project Leader who, in turn, assembles and leads a Project Team. All projects are developed through this team process. The Project Team is responsible for project management, design decisions, and the technical quality of the project. The purpose of Project Teams is to focus on and manage critical process issues that cut across the organization and to make technical decisions. A team's principal duties are to manage the project development process and to produce the deliverables defined by the team members. Further information on Project Teams and how they operate can be found in the Project Leader Guidebook.

Each project is scoped by Region Traffic and then the Signal, Sign, Illumination, and Intelligent Transportation Systems (ITS) Designer is notified. The Signal, Sign, Illumination, and ITS Designer then notifies the Traffic Structures Designer of any traffic structures that are required on the project. Since traffic structures play a support role to the Signal, Sign, Illumination, and ITS Designer, the traffic structures portion will be started later in the project than other disciplines.

Each project has a Project Team made up of all various disciplines of engineering. Most projects will have a project leader (usually from the region Project Manager's office), a Roadway Designer, a Specification Writer, a Right-of-Way Specialist, a Signal/Sign/Illumination Designer, a maintenance person, an ITS Designer, an Erosion Control Specialist, an Environmental Specialist, a Bridge Engineer, a Geotechnical Engineer, a Utilities Specialist, a Traffic Control Designer, and a Traffic Structures Designer. Depending on the project, all or some of these people will be part of the Project Team. In some cases, people not listed above will be involved that represent special interests in the project. These members may include regional or district staff or specialty groups, like the wireless team. The roles of the regular team members are defined below.

- Project Leader: Coordinates the efforts of all the team members, sets up meetings, starts collecting the project documents from each discipline.

- Roadway Designer: Determines the roadway alignments, decides the clearances to traffic structures, generates the digital terrain model, and cuts cross sections of the roadway for the team members.

- Specification Writer: Collects the project documents from each discipline after preliminary plans.
- Right-Of-Way Specialist: Handles right-of-way issues that project may encounter with placement of traffic structures.
- Signal, Sign, and Illumination Designer: Places and aligns signal and illumination poles and sign supports on the project.
- Maintenance Person: Provides input on the maintenance aspect of pieces within the project that require maintenance from the region staff.
- ITS Designer: Provides placement and aligns ITS devices.
- Erosion Control Specialist: Addresses soil erosion problems and construction contamination issues. Provides design of erosion control systems during construction.
- Environmental Specialist: Determines if project will adversely affect special habitats in the project area.
- Bridge Engineer: Performs the structural design of bridges, structures mounted on bridges, and other custom project structures as needed.
- Geotechnical Engineer: Collects soil data from the field and writes a geotechnical report about the soil properties at the site. The report may recommend a suggested footing design depending upon the condition of the soil.
- Utilities Specialist: Locates utilities that are present in the project location and coordinates efforts between the existing utilities and the new structures installed from the project.
- Traffic Control Designer: Determines the traffic control devices that are required during construction to redirect traffic around construction.
- Traffic Structures Designer: Designs the traffic structures that will be used on the project. See the next section for a detailed explanation for a Traffic Structures Designer.

1.2 TYPES OF TRAFFIC STRUCTURES

1.2.1 STANDARD TRAFFIC STRUCTURES

Currently there are eleven standard traffic structures used on the state highway system. These standard traffic structures and associated ODOT Standard Drawings are:

- Multi-Post Breakaway (TM600, TM601, TM603)
- Triangular Base Breakaway (TM602, TM604)
- 90 deg Rotational Sign Support (TM605)

- Truss Type Variable Message Sign Bridge (TM606 through TM612)
- Truss Type Sign Bridge (TM614 through TM620)
- Monotube Cantilever Sign Support (TM622 through TM627)
- Slip Base and Fixed Base Luminaire Support (TM629, TM630)
- Traffic Signal Support (TM650 through TM653)
- Traffic Strain Pole Supports (TM660 and TM661)
- Wood Post Sign Supports (TM670)
- Square Tube Sign Supports (TM681, TM687, and TM688)

The standard drawings can be ordered by contacting the Contractor Plans Office and downloaded from the ODOT internet webpage.

1.2.2 NONSTANDARD TRAFFIC STRUCTURES

Nonstandard traffic structures will occasionally show up on a project. Nonstandard traffic structures are the responsibility of the Traffic Structures group and should be sent to Technical Services for design or review. Traffic Structures will either provide or review the design calculations, drawings, and any Special Provisions that are necessary for the structure. The Traffic Structures group will then evaluate if the nonstandard design will be used often enough to be given a standard detail number. After a certain time period, if a standard detail is used often enough, it will be considered for a standard drawing. A nonstandard structure is any structure that does not meet a standard drawing (i.e., strain poles or temporary strain poles) or new structures with no standard drawing associated developed for the structure (i.e., camera poles).

Currently the standard drawings do not apply to the following structures:

- Signal poles that exceed the maximum loading.
- Signal poles that include loading not shown on the standard drawing.
- All temporary wood poles.
- Any structure with poor soil does not meet the requirements of the standard drawings.
- Extreme cross sections that do not meet the requirements of the standard drawings.

In these cases, the standard procedure is to mail the submittal for the structures or foundation to the Traffic Structures group for review. Our office would review the structures and provide recommendations/comments.

1.2.3 TRAFFIC STRUCTURES MOUNTED ON BRIDGES

There is one exception to the process described in this chapter concerning traffic structures and that is when the structure is mounted onto a bridge. When a traffic structure is on a bridge, the region tech center bridge designer will design the structure and a bridge drafter will perform the drafting. In this case, the Traffic Structures Designer will have very limited involvement with the structure. The Traffic Structures Designer may be called upon to assist the bridge designer and drafter.

1.3 ROLE OF THE TRAFFIC STRUCTURES DESIGNER

In a project, the role of the Traffic Structures Designer is to compile project site data and then fit the proposed traffic structure to the location. After the traffic structure has been placed at the location, the Special Provisions and cost estimating are created and submitted to the Project Team. Two or three project meetings occur during the design phase of the project and the Project Team members will discuss the project plans, Special Provisions, and cost estimating. The design phase is completed once the project has finished the bid process.

It is extremely important to have complete stamped details in the project plans for the Contractor to make a complete bid. This will also help to make sure that stamped submittals do not have to be sent in to the Project Manager. This reduces the chances of construction time delays and costly change orders.

1.4 PROJECT PHASES

For a Traffic Structures Designer, a project is broken into three phases. The three phases are preliminary plans, advanced plans, and final plans. Refer to Appendix B for an outlined procedure that can be followed for each phase of a project. Each phase has it own set of benchmarks that need to be completed for the project to meet the timeline.

1.4.1 PRELIMNARY PLANS

Preliminary plans mark the 70% complete benchmark. This means the traffic structures that will be used on the project have to be placed on a roadway cross section and the preliminary cost estimate needs to be finished for the project leader.

In order to complete preliminary plans, the Traffic Structures Designer will need the types of traffic structures used in the project, a roadway cross section at each traffic structure, and the geotechnical report for soil design information.

The types of traffic structures used in a project will be determined by the Signal, Sign, Illumination, and ITS Designer. That team member will let the Traffic Structures Designer know the mile post (or station) of each traffic structure. Once the mile post (or station) is known, the Traffic Structures Designer will request from the Roadway Designer a roadway cross section to be cut from the digital terrain model.

Once the traffic structure locations have been provided, contact the Geotechnical Engineer and request a soils investigation at the footing locations for the project. The Geotechnical Investigation, which may include sub-surface explorations, shall be performed for each substructure element to provide the necessary verification of assumed soil conditions used in standard foundations or information for the design and construction of custom foundations. The extent of explorations will be based on subsurface conditions, structure type, and project requirements. If the Geotechnical Investigation has not been completed when early foundation design assumptions are being considered, get together with the assigned Geotechnical Engineer to review preliminary data and estimate foundation sizes.

In the case of traffic signals, discuss with the geotechnical engineer what type of soil investigation would be appropriate. The project may include a large distance and, so, investigating each intersection may not be necessary.

Once the cross section has been provided, the Traffic Structures Designer should draft to scale the footings and vertical support members onto the cross section with adequate clearance from the roadway. The design vertical clearance should be measured to the bottom of the sign at the center of the minimum and maximum. The elevation view should locate the distance to the foundation of the structure with reference to the fog line and the centerline of the roadway. The required roadway clearance should be provided by the Roadway Designer. In addition, more clearance may be necessary to take into account any need for extra clearance required by maintenance personnel to access the structure (trucks, lift buckets, etc.). Also, it is recommended to make sure the final elevation of the roadway includes the entire final pavement thickness. It is good practice to place the bottom of the sign between at 18'-6" to ensure that small errors in elevations do not break standards. For instance, if the bottom of the sign is detailed to 18' and the footing is installed 2" to low, then the clearance would be 17'-10" and would not satisfy the 18' minimum clearance requirement. Once the elevation is completed and the foundation is placed, the Traffic Structures Designer should review the layout with the Roadway Designer. This review is to verify that adequate right-of-way and construction easements have been provided for the project. The footings can be large for some structures, so the original right-of-way may not be adequate and additional right-of-way may need to be purchased; this is a lengthy process (usually at least six months). After the vertical support members are placed, determine the span (if required by the structure) and draft the rest of the traffic structure. Once the entire structure is drafted, fill in the data table (if necessary). Use the Microstation border file that is available from the Traffic Standards & Asset Management Unit website.

After the structure has been sized to fit the field conditions, use the cost estimating tool as provided by the Traffic Structure group to provide a cost estimate for the structure. The cost estimate gives the Project Leader a preliminary cost for the traffic structure to ensure the project funds are adequate to cover the cost of the project.

Any formal calculations that are done by the Traffic Structures Designer should be stored in a calculation book.

The preliminary plans and cost estimate are sent to the Project Leader. The Project Leader will then distribute the complete plan packet to the team for review.

After preliminary plans have been completed, the Project Leader may request a Preliminary Plans Meeting. At this meeting, the Team will discuss the preliminary plans, bring up any conflicts between disciplines, and the cost estimate. In some projects, this meeting may not occur and the

Traffic Structures Designer only has to review the plans and send their comments back to the Project Leader.

1.4.1.1 DESIGN TOOLS

The following is a list of engineering references the Traffic Structures Designer will need for design. The references provide guidance for a large range of topics associated with traffic structures. Contact the Traffic Structures Engineer with any questions associated with these references.

1. AASHTO Standard Specifications for Structural Supports for Highway Signs, Signals, and Luminaires, 4th Edition with 2001, 2002, 2003, AND 2006 interims.

2. Manual of Steel Construction Allowable Stress Design, 9th Edition

3. 1994 AASHTO Standard Specifications for Structural Supports for Highway Signs, Signals, and Luminaires (copies can be obtained from the Traffic Structures Engineer)

4. AASHTO Standard Specifications for Highway Bridges, 17th Edition

5. AWS D1.1 Structural Welding Code

6. AWS D1.2 Structural Welding Code – Aluminum

7. NCHRP 411 Structural Supports for Highway Signs, Luminaires, and Traffic Signals

8. NCHRP 412 Fatigue-Resistant Design of Cantilevered Signal, Sign and Light Supports

9. NCHRP 469 Fatigue-Resistant Design of Cantilevered Signal, Sign and Light Supports

10. Inch Fasteners Standards, 7th Edition

11. Aluminum Design Manual 2005

12. ASTM 01.01, 01.03, 01.04, 01.05, 01.06, and 01.08

13. National Design Specification for Wood Construction, 1997 Edition

The following is a list of engineering analysis programs that the Traffic Structures Designer will need for design:

1. ODOT Pole Version 1: Used to analyze signal, strain and illumination poles to the 1994 AASHTO.

2. Pole Analysis Program (PAP): Used to analyze signal, strain and illumination poles to the 2001 AASHTO.

3. Winstrudl Pro (Required for ODOT Pole Version 1).

4. Lpile 4 (this program may not be necessary if a geo/hydro designer can design the foundations): Used to design drilled shaft foundations.

5. Strain.exe: Used to evaluate horizontal forces on strain poles.

6. TBB Design Spreadsheet: Used to design triangular base breakaway sign supports and creates a printable shop drawing. Available for download at the Traffic Structures website.

7. MPB Design Spreadsheet: Used to design multi-post breakaway sign supports. Available for download at the Traffic Structures website.

8. Temporary Wood Strain Pole Spreadsheet: Used to size wood pole class, messenger and back guy cable diameter, helical anchor design, and foundation design (not completed at this time).

1.4.2 ADVANCE PLANS

Advance plans mark the 95% complete benchmark. This means the comments from the Preliminary Plans meeting should be incorporated into the project plans, the cost estimating should be updated for any changes, and the Special Provisions have to written for the project. All of these documents are delivered to the Specifications Writer.

The comments from the Preliminary Plans meeting need to be incorporated into the traffic structures project plans. These comments may affect the vertical or horizontal alignment of the structure, which is the main concern for the Traffic Structures Designer. If the vertical or horizontal alignment is changed, the traffic structure cost estimating will be affected. The cost estimate should be updated to reflect the new structure size. The Traffic Structures Designer may want to research previous jobs and see how much other projects with similar structures were bid.

The main piece for advance plans is the creation of the Special Provisions. Special Provisions are intended to modify the 2008 Oregon Standard Specifications for Construction document and provide bid quantities used once the project is released for bidding. These provisions can be downloaded from the ODOT Specifications website. Each type of traffic structure will have a different collection of Special Provisions that are used on a project.

Any additional calculations that are produced to supplement the preliminary calculations should be incorporated into the calculation book. See Section 1.9 for more information about the items contained in a calculation book.

The advance plans, cost estimate, and Special Provisions are sent to the Specifications Writer. The Specifications Writer will collect all the information and send out a set of advance plans and Special Provisions to the Team for review.

At this time, preliminary utility conflicts should be brought to attention so the design can be changed, if necessary. The Tech Center Designers should request a copy of the project Utilities Report from the Utilities Specialist and use the report to identify and mitigate potential utilities conflicts. This will usually be performed by the Roadway, Signing, Signal, Illumination, and ITS Designer.

After advance plans have been completed, the Project Leader will hold a Plans-In Hand meeting. At this meeting, the Team will perform quality control review on the plans and specifications. Any issues that are slowing down the progress of work should be brought to the Project Team. The Project Leader will need to know so the timeline can be adjusted for the project.

1.4.3 FINAL PLANS

Final plans mark the 100% complete benchmark. This means the comments from the Advance Plans meeting should be incorporated into the project plans, the cost estimating and Special Provisions should be finalized for any changes. The final plans, cost estimating and Special Provisions are sent to the Specifications Writer. The Specifications Writer will distribute the final copy of the project documents to each Design Team member.

Any final calculations used in the design should be incorporated into the calculation book to supplement the preliminary and advance calculations.

When all the documents are in their final form, then mylar plan drawings are printed, stamped and signed by a registered professional engineer in the State of Oregon. The signed mylar prints, final Special Provisions, and final cost estimates should be sent to the Specification Writer. The Specification Writer will send the prints and Special Provisions to printing so they can be distributed for bidding purposes.

1.4.3.1 CONSTRUCTION ASSISTANCE ESTIMATE

As a method of controlling and forecasting ODOT engineering expenditures for construction projects, the Construction Project Manager puts together a construction engineering budget for the Region Construction Engineer's approval. Other involved ODOT units submit their anticipated contract administration costs to the Project Manager before a project goes to contract. Each unit reports the estimated amount on the ODOT Project Budget Worksheet form.

Construction Assistance Estimate (*example calculations*)

Labor:	Checking Shop Drawings	4 days
	Field Trip	2 days
		6 days

Designer's wages = ($3581/173.33hr/mo)(1.74)(8hr/day) = $287/day
Designer's labor = (6 days)($287/day) = $ 1,722

Equipment:	Car @ $30/day + $0.20/mile	
	Car Expense, 2 days =	$60.00
	Mileage, 300 miles =	$60.00
		$120.00

1.5 STANDARD PLANS INFORMATION

Project plans that are produced for the project documents shall follow the standard format as provided by the border file available from the Traffic Standards & Asset Management Unit. The border file requires specific information and this section will discuss how that information is to be filled in. The specific information that pertains to traffic structures includes the drawing numbers, structure number, and calculation book number.

1.5.1 DRAWING NUMBERS

Each traffic structure type requires up to two drawing numbers depending on the type of structure and each drawing number has a different category. The first drawing number will be located in the lower right corner of the title block and it is generated from the Traffic Standards & Asset Management Unit in the Traffic-Roadway Section or the ITS Unit of the Office of Maintenance and Operations (OMO) Section. Section 4.1 discusses how to obtain a TRS or OMO drawing number. The second drawing number is the bridge drawing number. The bridge drawing number is generated by the Bridge Data System. Bridge drawing numbers are only given to the following types of structures: Standard Sign Bridges, Variable Message Sign Structures, Cantilever Monotubes, metal Camera Poles, and Highmast Illumination Poles. The instructions for generating a bridge drawing number can be found in the Bridge Data System Manual.

1.5.2 STRUCTURE NUMBERS

Each sign bridge (standard sign bridge or variable message sign [Type I] bridge), butterfly variable message sign [Type II], monotube cantilever, camera pole, and highmast illumination pole needs a structure number to be associated with the structure. The structure number is generated through the Bridge Data System (BDS) and instructions on using the BDS can be found in the BDS manual.

The structure number allows ODOT to put the structure into the bridge inventory and provides the maintenance crew a way to track maintenance for the structure. It also creates an entry in the Bridge Data System that can be referenced in the future.

In cases where the structure (cantilever, sign bridge, butterfly), that has a structure number, will be moved to a new milepoint, a new structure number is required. This method allows for the old structure number to be classified as a not used structure and direct users to the new structure number and drawings. This keeps the bridge log clear that there no longer exists a structure at the old milepoint.

Modifications to structural supports of existing structures can keep the same structure number because the location of the structure remains the same and only minor changes have been performed. Examples of modifications would be new signs, sign mount extensions, and arms on cantilever that are replaced with longer arms. The work that is performed requires a new structure work number that is associated to the structure number and this work will have new drawings. This would be similar to a bridge being jacked up to make room for the overlay below. The location and main components do not change, but some structural modifications have been done that require a Structural Work Number for the particular existing Structure number.

1.5.3 CALCULATION BOOK NUMBER

The calculation book numbering system is a calculation archive system set up by the Bridge Section. Each designer should have a calculation book that has been assigned to them for each project. The purpose of the calculation book is to provide a standard system to organize calculations for a project and then to archive the calculation book once the project is finished. To obtain a calculation book number, contact the Bridge Engineering Receptionist.

1.5.4 PROCEDURE FOR WELD DESIGNATIONS ON CONTRACT PLANS

Contract drawings will show the appropriate weld symbols, special weld details, special inspection requirements, structure dimensions to be field verified, structure layout, member sizes, and any nonstandard structural detailing. Weld symbols will conform to ANSI/AWS A2.4.

Contract drawings will show both the weld symbol and "CJP" for complete joint penetration welds.

Contract drawings will show the effective weld size (E) for non-tubular partial joint penetration (PJP) welds. For PJP T-Y-K tubular connections, the contract drawings will specify the use of AWS D1.1 Table 3.5 (Pre-qualified PJP Details for T-Y-K Tubular Connections).

Special inspection requirements will indicate the type of testing (UT/ RT/ MT/ PT/, etc.) and acceptance criteria. The AWS D1.1 requires visual inspection for all welds and additional inspection based on design requirements must be added to weld details on the contract plan drawings as required. The default acceptance criterion for UT or RT testing is static loading unless cyclic tension is specified. Welded critical connections that have loading resulting in stress reversals are required to have UT or RT 100% with the cyclic tension acceptance criteria.

1.6 STANDARD SPECIFICATIONS

The current Specifications for new projects in the State of Oregon are the 2008 Oregon Standard Specification for Construction book. This book outlines the current accepted materials and construction practices and procedures for most work that will be performed on a construction project. The main parts that are of concern to the Traffic Structures Designer are the sections that pertain to concrete, fasteners, reinforcement, structural steel, and submittals.

1.6.1 CONCRETE SPECIFICATIONS

The two main sections for concrete are Sections 00440: Commercial Grade Concrete and 00540: Concrete Bridges. Also included to support those two sections are 00920: Sign Support Footings, 00963: Signal Support Drilled Shafts, 02001: Concrete, 02020: Water, 02030: Modifiers, 02050: Curing Materials, and 02690: PCC Aggregates. These sections describe the possible different components of concrete, the placement techniques, quality control, and testing procedures.

1.6.2 FASTENERS SPECIFICATIONS

The sections that pertain to fasteners are spread between several different chapters of the Specification. They include 00560: Structural Steel Bridges, 00930.40d, e & f: Metal Sign Supports, 00962.46(j)(2): Metal Illumination and Traffic Signal Supports, and 02530: Fasteners. These sections describe the installation, testing, different pieces, and surface finishes.

1.6.3 REINFORCEMENT SPECIFICATIONS

The sections that pertain to fasteners are in select areas. They include Sections 00530: Steel Reinforcement for Concrete and 02510: Reinforcement. These sections describe material grades, construction tolerances, splices, and installation.

1.6.4 STRUCTURAL STEEL/ STEEL POLE SPECIFICATIONS

The three main sections for structural steel are Sections 00560: Structural Steel Bridges, 00930: Metal Sign Supports, and 00962: Metal Illumination And Traffic Signal Supports. Also included to support those three sections are 02530: Structural Steel. These sections describe material grades, fabrication tolerances, surface finishing, erection procedures, and chemical composition tolerances.

1.6.5 SUBMITTAL SPECIFICATIONS

The main section that addresses the submittal process is Section 00150.35b: Control of Work. Also included to support that section is 00930.02: Metal Sign Supports, 00962.02: Metal Illumination and Traffic Signal Supports, 00962.10: Metal Illumination and Traffic Signal Supports, and 02560: Structural Steel.

1.7 SPECIAL PROVISIONS

There are two types of Special Provisions. The first type is the standard Special Provisions. The standard Special Provisions are boiler plate documents used on every project that addresses known changes that need to occur and provides places for the bid quantities to be entered. The Special Provisions are available for download from the ODOT specifications website.

For each project you must use the current version of the Special Provisions. In a few cases, a Special Provision may change during the course of the project so the designer must check the Special Provision boiler plate periodically to make sure a new boiler plate has not been released. The second type is the unique Special Provisions. These Special Provisions can be requested from the Traffic Structures Engineer. The unique Special Provisions cover topics that were not incorporated into the 2008 Oregon Specification book. Some examples of these are the structural components of the variable message sign cabinets and camera poles. The unique Special Provisions are also available for download from the ODOT specifications website. As with the boiler plate Special Provisions, the designer must check the unique Special Provisions periodically during the project to see if a new release is available.

In some cases, a designer may be required to create a new unique Special Provision to cover a new structure that will be used in a project. It is recommended that you contact the Traffic Structures Engineer for guidance and recommendations. All unique Special Provisions must be reviewed by the Traffic Structures group before being used on a project.

Each type of structure has certain Special Provisions that need to be included. These Special Provisions give the designer the flexibility to mold the standard traffic structures to each project. It is recommended that any changes that need to be made to the project occur in the Special Provisions only when a drawing cannot adequately represent the desired result. The following table outlines which Special Provisions apply to each traffic structure. The unique Special Provisions have been included in the table for reference; however, each unique Special Provision needs to be reviewed to ensure all project specific requirements are being met.

SPECIAL PROVISION NUMBER	SPECIAL PROVISION TITLE	STANDARD SIGN BRIDGE	TYPE 1 VMS BRIDGE	TYPE 2 BUTTERFLY VMS SUPPORT	CANTILEVER MONOTUBE	CAMERA POLE	SIGNAL POLES
00330	Earthwork	X	X	X	X	X	X
00440	Commercial Grade Concrete w/ Structural					X	X
00510	Structure Excavation and Backfill	X	X	X	X	X	
00512	Drilled Shaft						X
00530	Steel Reinforcement for Concrete	X	X	X	X	X	X
00560	Structural Steel Bridges	X	X	X	X		
00910	Wood Sign Posts						
00920	Sign Support Footings	X	X	X	X	X	
00930	Metal Sign Supports	X	X	X	X		
00942	Variable Message Sign (Type 1) Structural Components		X				
00955	Variable Message Sign (Type 2) Structural Components			X			
00962	Metal Illumination and Traffic Signal Supports						X
00963	Signal Support Drilled Shafts						X
00965	Camera Poles and Foundation					X	
02001	Concrete	X	X	X	X	X	X
02010	Portland Cement	X	X	X	X	X	X
02030	Modifiers	X	X	X	X	X	
02050	Curing Materials	X	X	X	X	X	
02530	Structural Steel	X	X	X	X	X	
02690	PCC Aggregate	X	X	X	X	X	X

1.8 COST ESTIMATING TOOLS

The information used to develop the cost estimating tools was collected from previous projects and is occasionally adjusted to reflect current market conditions for materials. The most recent bid tabulations can be of interest when looking into how the market is adjusting to current conditions.

1.9 CALCULATION BOOK

Designers are responsible for well-organized, legible, and neat design calculations properly assembled in a calculation book.

REMEMBER:
YOUR CALCULATION BOOK COULD BECOME AN EXHIBIT

Each calculation book:

- Has its own number.
- Is limited to about 300 pages, which are numbered consecutively.
- Is permanently stored at the Archives Division's State Records Center when all design and construction work is complete.

CALCULATION BOOK NUMBERS –

Calculation book numbers are requested from and assigned by ODOT Bridge Section Business Management Unit personnel. At the time final plans are first distributed for review, the Designer will need a calculation book number for the title blocks of the drawings. List only the first book number assigned to the Designer or Checker, even though there is more than one book for a structure. Although you may expect to use more than one book for a structure or a project with several structures, do not reserve additional book numbers when requesting the first one. Book numbers for a structure or project are not required to run consecutively. Request additional book numbers when needed or when preparing your set or sets of calculations for binding. The additional books will be referenced in the first full book.

TABLE OF CONTENTS –

Place, as the first page, a table of contents for the entire book. If a set of calculations is divided among two or more books, each book should have a copy of the table of contents for the entire set, not just that portion of the set in that book.

PAGE NUMBERING –

Number the pages of each calculation book consecutively. Do not continue numbering from one book to another even though both books have calculations for the same structure. Always begin a book with "Page 1".

SET OF CALCULATIONS –

Should everything the Designer produce go into a calculation book? That's a tough question! Sometimes it's a judgment call. If in doubt about which documents to include in your calculation book, check with your supervisor. Try to be selective, including only calculations that actually support what the contract plans show. Think about eliminating those calculations that led down the wrong path or were really wasted effort. For a structure, the paperwork generated by the project design and construction stages (usually excluding most correspondence) becomes a "set of calculations". Typically, it includes:

- Calculation book cover sheet

- Preliminary estimate and supporting calculations
- Final design calculations, diagrams, sketches
- Checked final estimate and supporting calculations
- Checker's calculations and any written comments
- Project discussion memos

Fill out all heading blanks completely for each sheet used. You may want to number the sheets of a set with its own sequence of numbers while working on an assignment, but you will probably need to renumber with page numbers in the upper right corners when the set is bound into a calculation book. To make your calculations understandable to someone else:

- Put them in logical order.
- **Show design assumptions and formulas complete with references.**
- Reference the source of any numbers taken from other calculations. Do not pull numbers out of a hat!
- State reasons for a design change that deviates from normal procedures of design codes and ODOT design instructions and list who approved it.

Make sure other material such as computer output, diagrams on graph paper, or completed forms also have the same identifying information as the calculation sheets. Whenever possible, avoid oversize foldout sheets.

Calculation books should be archived when all work on the structure is complete and more than one structure can be put into the calculation book.

1.10 COMMUNICATIONS WITH PARTIES OUTSIDE OF ODOT

During the design phase, except during the contract advertising period, the Traffic Structures Designer may answer inquiries from people outside of ODOT about non-controversial projects. Questions about projects that are controversial, political, or environmentally sensitive should be referred to a spokesperson as directed by your supervisor.

All questions asked between the advertisement date and the date the project is awarded should be referred to the Project Manager. During this time period, the Project Manager has sole responsibility for answering questions about the project. This ensures equitable treatment of prospective bidders and avoids conflicting information about plans, specifications, and bid items. The Project Manager will field questions during this time period (instead of the Project Leader) because the Project Manager is responsible for the project during construction. Since a decision made between the advertisement date and the awarded date will directly affect the construction process, the logical person to make the decisions should be the Project Manager.

1.11 PROJECT DOCUMENTATION AFTER FINAL PLANS

After the project has been released for bid, the project documents and calculations have to be archived for storage. Once the final signed mylars are sent in for printing, they will be forwarded to the appropriate group for archiving. If the mylar is sent back to the Engineer of Record, contact the Traffic Structures Engineer for the appropriate course of action.

Designers are responsible for preparing legible, neat design documents and for keeping them well-organized. During project design, most records are kept at the Designer's desk. Two files will be generated for each project. The first file will be the Calculation Book. When all work on the structure is complete, appropriate design documents should be assembled and included in a Calculation Book. The Calculation Book should then be archived through the Bridge Engineering Section. See "Calculation Book" under "Section III: Construction Assistance – Guidelines for the Designer" in the Bridge Engineering Section Office Practice Manual for details. The other file is the Structural Design File. The Structural Design File consists of a copy of the final design calculations, transmittal letters, email transactions for the project, any pertinent reference drawings, copies of the final drawings, structure and drawing number request forms, print out of Bridge Data System entries, and PCS report.

A copy of the project design file should be sent to the Traffic Structures group for archiving in their system. The Engineer of Record should at least keep a copy of all documents associated with the project for future reference. The preferred order of documents in the Structural Design File is shown in Appendix A.

1.12 SUMMARY

Each design project is broken into three milestones: Preliminary Plans, Advance Plans, and Final Plans. Each milestone has specific goals that have to be reached in order to keep the project moving smoothly. A lot of coordination will have to occur between the different disciplines so the plans are accurate and achieve the goals of the project. A helpful design aid is provided in Appendix B that can be used to track the progress during the project. This aid is a list of different pieces to a project that allows the designer to check off each portion as it is completed.

When the project is completed, the designer will have a break while the bidding process is completed. After the bidding occurs, then the designer will begin the next role of providing construction support.

2

Design

2.1 GENERAL

The Traffic Structures designs are in accordance with the AASHTO Standard Specifications for Structural Supports for Highway Signs, Luminaires and Traffic Signals. This code specifically includes design items that pertain to Traffic Structures. Other codes may work for designing the structure, but this code has been developed over the years to address specific items that pertain to Traffic Structures. The use of the AASHTO code is required on projects that use Federal funds and must be satisfied for all traffic structures that will be installed on the Oregon State Highway system.

2.2 AASHTO STANDARD SPECIFICATIONS FOR STRUCTURAL SUPPORTS FOR HIGHWAY SIGNS, LUMINAIRES AND TRAFFIC SIGNALS HISTORY

The AASHTO Standard Specifications for Structural Supports for Highway Signs, Luminaires and Traffic Signals first code was published 1975. The booklet is 9” by 6”, has a yellow cover and is 94 pages. The wind pressure equation from Section 1.2.5 is equal to .00256(1.3V)^2CdCh, which is the same basic equation that was used until the 2001 4^{th} Edition AASHTO code was released. The next AASHTO publication was the 1985 AASHTO Standard Specifications for Structural Supports for Highway Signs, Luminaires and Traffic Signals. This manual switched to 8 ½” x 11”, still had a yellow cover, and is 69 pages. The wind pressure equation remained the same. Following the 1985 release was the 1994 AAASHTO Standard Specifications for Structural Supports for Highway Signs, Luminaires and Traffic Signals. It is 8 ½” x 11”, has a navy blue cover, and is 78 pages. The 94 code still has many existing standard designs existing that have not been converted to the newest code. The most recent code is the 4^{th} Edition 2001 AASHTO Standard Specifications for Structural Supports for Highway Signs, Luminaires and Traffic Signals. This code changed the wind speeds from fastest mile per hour to 3 second gust and included fatigue design requirements as a direct response to structural failures that occurred from hairline fatigue cracks. Since the release of the 2001 AASHTO code there have been 2002, 2003, and 2006 interims that apply.

2.3 STANDARD DRAWINGS

The use of the standard drawings is required unless a new design and calculations are sent in for review. There are two main reasons for the use of the standard drawings. The first is that analysis and detailing take a considerable amount of time and money. The money that is not spent for the design in the project is spent towards a more conservative structure that covers most cases in the State. Secondly, a standard drawing takes a long time to be adjusted to a level where there are little to no manufacturing and construction issues. Items that are found to be an issue are corrected and a new drawing is released. New designs each time have a high probability to make the same errors and omissions that passed designers have made.

The process to get a new detail or detail changed on a standard drawing is to submit a request for change to standard drawing form. This document and instructions can be found on the ODOT roadway internet webpage. The proposed modification will be routed to the Traffic Structures Group to get feedback and a consensus will be obtained about whether or not the detail should be changed. In many cases, a proposed change can be a substantial amount of work and current resource levels do not have the capacity to perform the work. Using this method will help ensure consistency and consensus of detail changes.

2.4 WIND SPEEDS AND PRESSURES

There are two main types of wind speeds that have been used for the design of traffic structures in the State of Oregon. The first is a fastest mile per hour wind speed and the second is a 3-second gusted wind speed. The fastest mile per hour wind speed was used in AASHTO codes published before the release of the 2001 AASHTO code. The 2001 AASHTO code introduced the 3-second gust wind speed and discusses the differences between the two wind speeds in section 3.8.2 - Basic Wind Speed of the 4th Edition AASHTO code. In addition, there is good background information about this topic in section 3.8.5 Gust Effect Factor G of the 4th Edition AASHTO code and discusses that the pressure is approximately the same but the equivalent 3-second wind velocity value is about 1.22 higher than the old fastest mile per hour wind velocity. The change from the fastest mile per hour to the 3-second gusted wind speed was necessary because most national weather service stations currently record and archive peak gust speeds and not fastest mile speeds. This resulted from a change in the equipment used to measure the wind. Using the gusted data, it was decided to take the average of the gusted wind velocities over 3 seconds as the standard. This decreased the sample size, moved the average closer to the maximum gust, and resulted in the value of the wind velocity from the fastest mile per hour to the 3-second gust method to increase. To make the pressure between the two codes approximately equal, the code adjusted the gust factor from (1.3)^2 = 1.69 down to 1.14.

Figure 3-2 of the 4th edition AASHTO code oversimplifies the minimum 3-second gusted wind speeds to use in Oregon. It shows hatched areas on the coast and the Cascades that signify a special wind region with no guidance about what to use. This resulted in investigating other alternatives to give designers guidance about the 3-second gusted wind speeds to use for their designs. The 2007 Oregon Structural Specialty Code Amendments in Chapter 16, Section 1612.1, and Figure 1609 shows an Oregon 3-second gusted wind speed map that, in general, is specified by County. This map was used to revise the 3-second gusted wind speed map shown on standard drawing TM671. The standard drawing TM671 shows a map of 3 second wind gusts for the State with a recurrence interval of 50 years. This 3-second gusted wind velocity with a 50 year recurrence interval is required to be used for every new design that uses the 2001 AASHTO code. Using this 50-year 3-second wind velocity does not result in designing every structure to the same requirements. To take into account the different types of structures and the level of risk that an owner is willing to accept, the wind pressure equation adjusts the 3-second gust velocity with a 50 year recurrence interval by applying a wind importance factor, Ir. The Ir is based on the recurrence interval for each structure type. A 10 year recurrence interval compared to a 50 year recurrence interval will have a significantly smaller wind importance factor in the wind pressure equation that will be used to design the specific structure type. For example, a truss sign bridge will use a 3-second gusted wind speed of 110 mph for a 50 year recurrence interval, select a recurrence interval of 50 years, and the resulting Ir is 1.00. The resulting truss sign bridge wind pressure will be .00256*.87*1.14*110^2*1.0*1.2 = 36.87-psf. A wood post for a specific location in the State will use a 3-second wind velocity of 110 mph for a 50 year recurrence interval, select a 10 year recurrence interval of 10 years, and the resulting Ir will be 0.54. There is an asterisk by the 0.54 and the note in Table 3-2 states the design wind pressure for hurricane wind velocities greater than 100 mph should not be less than the design wind pressure using 100 mph with the corresponding non-hurricane Ir value. This note provides a transition between the non-hurricane to hurricane wind pressures. See Figure 2 for a graphical representation of the 10 year recurrence velocity versus pressure. The resulting wood post wind pressure will be .00256*.87*1.14*100^2*.71*1.2 = 21.63-psf. This result shows a wind pressure for wood posts that is 0.59 of the pressure used to design a truss sign bridge. In addition, Figure 2 shows a horizontal pressure of 20-psf that was used for the designs on the old TM670 Wood Post Standard drawing. In many parts of the State, the wind pressures resulting from the 2001 AASHTO code are less than the 20-psf value used in the old TM670. Finally, for the higher wind areas in the State, the pressure has only been increased by 1.08.

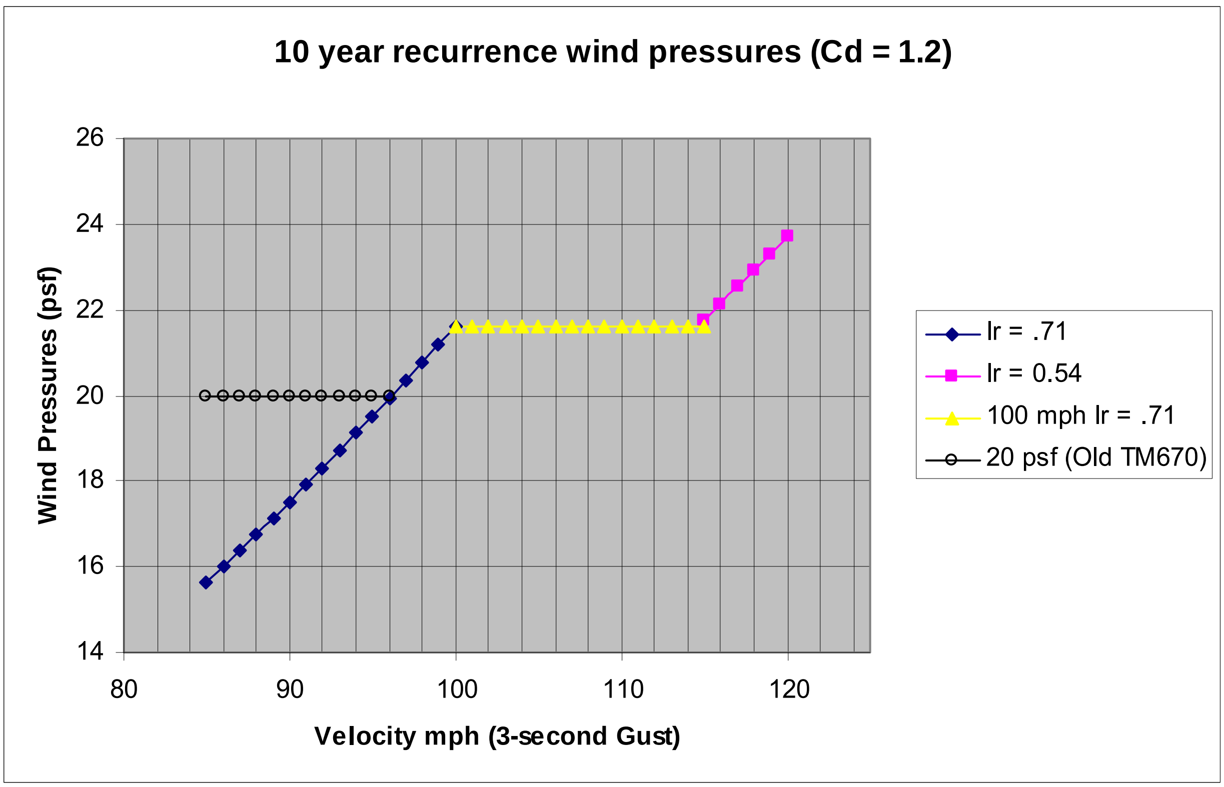

Figure 2 – Minor sign structures wind velocity versus pressure.

2.5 TRUSS SIGN AND VMS BRIDGES

Truss Sign and VMS Bridges use the design requirements shown on drawings TM606 through TM612 and TM614 through TM620. These drawings contain ODOT's Statewide standards for these structures. Any deviations from these standards for non-standard structures must be sent in to the Traffic Structures Group for review and approval.

2.6 MONOTUBE CANTILEVER SIGN SUPPORTS

Monotube Sign Supports use the design requirements shown on drawings TM622 through TM626. These drawings contain ODOT's Statewide standards for these types of structures. Any deviations from these standards for non-standard structures must be sent in to the Traffic Structures Group for review and approval.

The maximum length of arm that can be used on a monotube cantilever support is 50 ft and this value is shown on TM622. Monotube Cantilever arm lengths that are longer than 50 feet have not historically been used by ODOT on the State Highway System for non-redundant monotube cantilever sign supports. In addition, the Washington Department of Transportation and CALTRANS specify shorter arm lengths on their standard drawings than ODOT's 50 foot maximum.

2.6.1 VARIABLE MESSAGE SIGNS MOUNTED ON MONOTUBE CANTILEVER SUPPORTS

The use of Type 1 (30'-6" x 10'-0", 4,250#) Variable Message Signs on new non-redundant monotube cantilevers is not allowed on the State Highway system.

Smaller Variable Message Signs can be placed on non-redundant monotube cantilever supports when the Variable Message Sign weight and area is less than the Sign weights and areas shown on TM622. For example, TM622 specifies that the maximum sign area is 253 ft^2 on a 50 foot arm. The weight is approximately 1265 pounds (253 ft^2 times 5 lbs/ft^2), so the maximum Variable Message Sign weight on a 50 foot arm is 1,265 pounds with a maximum wind area of 253 ft^2. Also, the maximum weight is 1,750# (350 ft^3 times 5 lbs/ft) for a Variable Message Sign mounted on a 40'-0" arm length and the maximum area is 350 ft^2. Finally, the connection between the Variable Message Sign to the horizontal arm must be designed for the specific Variable Message Sign.

2.6.2 MONOTUBE BUTTERFLY SIGN SUPPORTS

A butterfly support has either one sign centered on the vertical post or two signs on two different arms attached on opposite sides of the vertical post. Most of the designs use the bolt and plate details from the monotube standard drawing for a specific arm length. Usually, both arms connect to the vertical post at the same elevation. Any differences in the bottom of sign elevation above the roadways are accommodated in the design. Attaching both arms at the same elevation will make the internal stiffener configuration different. Also, the fatigue cope at the bottom of the vertical post attachment plate will remove more section from the post that needs to be accounted for in the design. In addition, the single monotube cantilever usually has a handhole on the opposite side of the arm for wire access and having two arms will result in moving the handhole to a location between the arms. There are some rare cases that may need to have the arms at different elevations. In these cases, there must be enough space between the bottom of the copes from the upper arm and the top stiffeners from the bottom arm to not interfere. Each arm will require a handhole opposite the arm for wire access when the arms are at different elevations.

It is important to include the torsion forces as specified in the AASHTO code. For a single sign with the sign centered on the vertical post, the torsion is the force on the sign multiplied by 15 percent of the sign width. For two signs mounted on arms across from each other, the torsion is equal the larger torsion from only one sign and arm. The reduction of torsion from the other sign and arm is conservatively neglected by the AASHTO code.

2.6.3 MONOTUBE CANTILEVER FATIGUE LOADING

The monotube cantilever structures are susceptible to galloping, natural wind gusts, and truck-induced gusts. These load cases must be included in the designs.

The AASHTO code states "truck-induced gust loading shall be excluded unless required by the owner." There are significant truck induced loads applied to the monotube cantilevers and the code does not specify an alternative to address the truck-induced gusts. This requires the use of the loads specified in Section 11.7.4 until a satisfactory truck loading is addressed. For a custom design location, the truck speed may be reduced from 65 mph, which is the default in the code, to 55 mph. This reduction in speed may not be used for structures on I-5, I-84, I-405, I-205, US26 between mile points 64.3 through 73.0, I-105, I-82, and any other highway with similar characteristics to these highways.

2.7 MONOTUBE SIGN BRIDGES

Monotube Sign Bridges have been requested mainly for aesthetic purposes and typically range from 10 percent to 50 percent more expensive than a truss sign bridge. These are non-standard and require a review and approval from the ODOT Traffic Structures Group.

2.7.1 MONOTUBE SIGN BRIDGE FATIGUE LOADING

The commentary in the 4th Edition AASHTO code in sections 11-6 and 11-7 discusses that the research looks at cantilevered arms that have nonsymmetrical cross sections. The galloping that ODOT has experienced in the past is associated with the wind flow across a tapered arm and onto the back of a signal with a backboard and results in successively larger amplitudes of oscillation. The monotube sign bridge does not have a tapered nonsymmetrical cross section and it also has different dampening of the loads. The NCHRP 412 on pages 4, 5, and 6 discusses the onset of galloping on a cantilevered structure can be greatly reduced by changing the structures mass, stiffness, and/or damping. In the case of the monotube sign bridges, the structures stiffness has been greatly increased compared to a cantilever arm and this results in reducing the risk from galloping to the point where the galloping is not required to be considered in the design. In addition, the AASHTO code is going to address this item and galloping does not appear for these types of structures. Finally, if galloping was encountered after installation, horizontal sign blanks with bolt on mounts can be installed to stop the galloping.

For these reasons, galloping fatigue design loads from Section 11 of the 4th Edition AASHTO code do not have to be used in the design of monotube sign bridges. There should be additional clarification in the code about these types of structures in the near future and this will be used for future designs by ODOT.

The AASHTO code states "truck-induced gust loading shall be excluded unless required by the owner." There are significant truck induced loads applied to the monotube sign bridges and the code does not specify an alternative to address the truck-induced gusts. This requires the use of the loads specified in Section 11.7.4 until a satisfactory truck loading is addressed. For a custom design location, the truck speed may be reduced from 65 mph, which is the default in the code, to 55 mph. This reduction in speed may not be used for structures on I-5, I-84, I-405, I-205, US26 between mile points 64.3 through 73.0, I-105, I-82, and any other highway with similar characteristics to these highways.

2.8 MINOR SIGN SUPPORT STRUCTURES

2.8.1 WOOD POST SIGN SUPPORTS

ODOT specifies the installation requirements and design tables for permanent and temporary sign supports on standard drawing TM670.

The design tables shown on the drawing use an X*Y*Z value that is in cubic feet. For a single sign, the X*Y*Z can be calculated by taking the area of the sign times the distance from the ground surface to the center of the sign. The designer must take into account the additional distance resulting from a surface that slopes down from the roadway. When there is more than one sign on a single post, each sign area, X*Y, is multiplied by the distance from the surface to the center of that specific area, Z. Each of the sign's X*Y*X values are added together for a total X*Y*Z value to use in the permanent or temporary sizing tables shown on TM670. A single post may not support enough sign area and a multiple post installation may be required. It is not recommended to use signs orientated in multiple directions on multiple post installations.

The design of the wood support has two controlling parameters. The first is the wind speed and wind pressure. Section 2.4 has additional information about the wind speed and pressure. The second parameter is breakaway dynamic performance. The 4^{th} Edition 2001 AASHTO code Section 12 for breakaway sign supports describes these requirements. Once a material and setup is crash tested, it is very difficult to change the details of the installation without performing additional crash testing because the criterion that fails the test can be very difficult to determine from engineering analysis. For the wood posts, the crash testing that was performed used a Southern Yellow Pine No. 2. ODOT has matched the wood strength properties of Douglas Fir and Hem Fir to be equal to or less than the properties of the Southern Yellow Pine No.2. For more detailed information about the specifics of the design, please request to see the standard drawing TM670 baseline report from the Traffic Structures Engineer.

2.9 SIGNAL SUPPORT STRUCTURES

2.9.1 SIGNAL MASTARM STEEL SUPPORTS

ODOT primarily uses mastarm steel supports on the State Highway system. The design and detail requirements are shown on drawings TM650, TM651, TM652, and TM653. Any deviations from these standards are considered non-standard structures and must be submitted to the Traffic Structures Group for review and approval. ODOT's policy is to use Strain Pole Supports when intersection widths require mastarm lengths that exceed 55 feet.

Some issues that will drive a standard pole to become a nonstandard pole are as follows:

- Combining a standard traffic signal pole with a strain wire system.

- Dual Mastarm Signal Supports.
- Adding very large guide signs to the pole (over 60 ft2).
- Steep Site slope.
- Slope that starts closer than half the required footing depth for slopes on the opposite side of the mast-arm attachment face.
- Slope that starts closer than the required footing depth for slopes located on the mast-arm attachment face.
- Pole bases mounted on retaining walls at the back of the sidewalk that raise the pole base elevation.

Checking these items to see if they affect the traffic signal pole shop drawing is a straight-forward procedure. Typically between the contract plans and the Digital Video Log (DVL), the Traffic Structures Designer can determine if nonstandard conditions apply to the traffic poles. In the contract plans, review the sign plans and identify any signs supported on the vertical pole. Make sure the total sign area for a sign installation does not add up larger than 60 ft^2. Then verify the traffic signal poles do not support a span wire as shown on the traffic signal plans. The last three items can be verified with one resource. Having the highway number and milepost of the intersection allows the Traffic Structures Designer to access the DVL. In the DVL, navigate to the site location and review the roadside slopes. If the slope does not seem excessive, then the standard foundations will probably be sufficient. If the slope seems large or starts close to the pole, then the Traffic Structures Designer will need to collect site information for the pole installation. Contact the Traffic Signal Designer and they should be able to provide you cross sections at the traffic signal pole and possibly site photos that may provide additional information about the site conditions. That cross section will allow the Traffic Structures Designer to assess if the foundation should be nonstandard. If the foundation is determined to be nonstandard, then it should not be specified as an “X” pole, but a custom design should be provided in the contract plans.

Intersections that require the use of dual signal mastarms shall use an arm length that is listed on Standard Drawing TM650. The title of TM650 is Traffic Signal Supports General Details and Design Criteria and covers the design requirements for the custom dual mastarm. The required loading for each length of mastarm and the vertical post is shown on TM650. Some manufacturers have tried to use only the site specific loads for the steel and foundation designs, but that does not account for additional future loading requirements that are shown on TM650.

2.9.1.1 SIGNAL MASTARM FOUNDATION SUPPORTS

The details for the Mastarm Foundations are shown on Standard Drawing TM653. The depth of the foundation must be designed using site specific recommendations from a Geotechnical Engineer and the 4th Edition 2001 AASHTO Standard Specifications for Structural Supports for Highway Signs, Luminaires, and Traffic Signals with all interim revisions.

The drilled shaft (or other deep foundation) design must produce a foundation embedment depth equal to or exceeding the embedment depths resulting from the use of the Brom’s method as stated in the commentary of Section 13.6.1.1. The under-capacity factor to use is

0.7, the minimum overload factor to use is 2, and a 1.33 stress increase factor may be applied. This results in the working stress reactions, as shown on TM651, to be increased by a minimum safety factor equal to [(2/0.7) / 1.33] = 2.15. Using the Brom's method to design the depth of signal foundations with the overturning moment and shear will provide adequate resistance for applied torsional loads.

Figures 2-1 through 2-3 provide foundation depths for the standard types of signal pole mastarms as a function of soil type (either cohesionless or cohesive) and soil strength. Figure 2-1 shows foundation depths calculated for a cohesionless soil without any groundwater. Figure 2-2 provides foundation depths for cohessionless soils that are completely under water (totally saturated condition). Figure 2-3 provides a table of foundation embedment depths calculated for cohesive soils.

Foundation Depths - Cohesionless Soil – Without Groundwater											
Ø Soil Friction Angle degrees	γ Effective Unit Weight pcf	SM1 ft	SM2 ft	SM3 ft	SM4 ft	SM5 ft	SM1L ft	SM2L ft	SM3L ft	SM4L ft	SM5L Ft
25	100	9.5	10.0	11.0	11.5	11.5	10.5	11.0	11.5	12.0	12.5
26	102	9.0	10.0	11.0	11.0	11.5	10.0	10.5	11.0	12.0	12.0
27	104	9.0	9.5	10.5	11.0	11.0	10.0	10.5	11.0	11.5	12.0
28	106	8.5	9.5	10.5	10.5	11.0	9.5	10.5	10.5	11.5	11.5
29	108	8.5	9.5	10.0	10.5	10.5	9.5	10.0	10.5	11.0	11.5
30	110	8.5	9.0	10.0	10.0	10.5	9.0	10.0	10.0	11.0	11.0
31	111	8.0	9.0	9.5	10.0	10.5	9.0	9.5	10.0	10.5	11.0
32	112	8.0	8.5	9.5	9.5	10.0	9.0	9.5	9.5	10.5	10.5
33	113	8.0	8.5	9.5	9.5	10.0	8.5	9.5	9.5	10.5	10.5
34	114	7.5	8.5	9.5	9.5	9.5	8.5	9.0	9.5	10.0	10.5
35	115	7.5	8.5	9.0	9.5	9.5	8.5	9.0	9.5	10.0	10.5
36	116	7.5	8.0	9.0	9.0	9.5	8.5	9.0	9.0	9.5	10.0
37	118	7.5	8.0	8.5	9.0	9.0	8.0	8.5	9.0	9.5	10.0
38	120	7.0	7.5	8.5	8.5	9.0	8.0	8.5	8.5	9.5	9.5
39	122	7.0	7.5	8.5	8.5	8.5	7.5	8.5	8.5	9.0	9.5
40	123	7.0	7.5	8.0	8.5	8.5	7.5	8.0	8.5	9.0	9.0
41	124	6.5	7.5	8.0	8.0	8.5	7.5	8.0	8.0	8.5	9.0
42	125	6.5	7.0	8.0	8.0	8.5	7.5	8.0	8.0	8.5	9.0

Figure 2-1 – Foundation Depths calculated using the AASHTO Brom's Design method for Cohesionless soils without any groundwater.

Foundation Depths - Cohesionless Soil – Below the Water Table											
Ø Soil Friction Angle	γ Effective Unit Weight	SM1	SM2	SM3	SM4	SM5	SM1L	SM2L	SM3L	SM4L	SM5L
degrees	pcf	ft	ft	ft	ft	ft	ft	ft	ft	ft	ft
25	37.6	13.5	14.5	16.0	16.5	16.5	15.0	16.0	16.5	17.5	18.0
26	39.6	13.0	14.0	15.5	16.0	16.0	14.5	15.5	16.0	17.0	17.5
27	41.6	12.5	13.5	15.0	15.5	15.5	14.0	15.0	15.5	16.5	17.0
28	43.6	12.0	13.5	14.5	14.5	15.0	13.5	14.5	14.5	16.0	16.5
29	45.6	11.5	13.0	14.0	14.5	14.5	13.0	14.0	14.5	15.5	15.5
30	47.6	11.5	12.5	13.5	14.0	14.5	12.5	13.5	14.0	15.0	15.5
31	48.6	11.0	12.0	13.5	13.5	14.0	12.5	13.5	13.5	14.5	15.0
32	49.6	11.0	12.0	13.0	13.5	13.5	12.0	13.0	13.5	14.0	14.5
33	50.6	10.5	11.5	12.5	13.0	13.5	11.5	12.5	13.0	14.0	14.5
34	51.6	10.5	11.5	12.5	12.5	13.0	11.5	12.5	12.5	13.5	14.0
35	52.6	10.0	11.0	12.0	12.5	12.5	11.0	12.0	12.5	13.0	13.5
36	53.6	10.0	10.5	12.0	12.0	12.5	11.0	11.5	12.0	13.0	13.5
37	55.6	9.5	10.5	11.5	11.5	12.0	10.5	11.5	11.5	12.5	13.0
38	57.6	9.5	10.0	11.0	11.5	11.5	10.5	11.0	11.5	12.0	12.5
39	59.6	9.0	10.0	11.0	11.0	11.5	10.0	10.5	11.0	12.0	12.0
40	60.6	9.0	9.5	10.5	10.5	11.0	9.5	10.5	10.5	11.5	12.0
41	61.6	8.5	9.5	10.5	10.5	11.0	9.5	10.5	10.5	11.5	11.5
42	62.6	8.5	9.5	10.0	10.5	10.5	9.5	10.0	10.5	11.0	11.5

Figure 2-2 – Foundation Depths calculated using the AASHTO Brom's Design method for Cohesionless soils below the water table (completely saturated).

Foundation Depths - Cohesive Soil										
c_u Undrained Shear Strength psf	SM1 ft	SM2 ft	SM3 ft	SM4 ft	SM5 ft	SM1L ft	SM2L ft	SM3L ft	SM4L ft	SM5L ft
600	13.0	14.0	15.5	16.5	17.0	14.5	15.5	16.5	17.5	18.5
700	12.0	13.5	14.5	15.5	16.0	13.5	14.5	15.5	16.5	17.5
800	11.5	12.5	14.0	15.0	15.5	13.0	13.5	15.0	16.0	16.5
900	11.5	12.0	13.5	14.5	14.5	12.5	13.0	14.5	15.5	16.0
1000	11.0	11.5	13.0	14.0	14.5	12.0	12.5	14.0	14.5	15.5
1100	10.5	11.5	12.5	13.5	13.5	11.5	12.5	13.5	14.5	14.5
1200	10.5	11.0	12.0	13.0	13.5	11.5	12.0	13.0	14.0	14.5
1300	10.0	11.0	11.5	12.5	13.0	11.0	11.5	12.5	13.5	14.0
1400	10.0	10.5	11.5	12.5	12.5	10.5	11.5	12.5	13.5	13.5
1500	9.5	10.5	11.5	12.5	12.5	10.5	11.0	12.5	13.0	13.5
1600	9.5	10.0	11.0	12.0	12.5	10.5	11.0	12.0	12.5	13.0
1700	9.5	10.0	10.5	11.5	12.0	10.0	10.5	12.0	12.5	13.0
1800	9.5	10.0	10.5	11.5	12.0	10.0	10.5	11.5	12.5	12.5
1900	9.0	9.5	10.5	11.5	11.5	10.0	10.5	11.5	12.0	12.5
2000	9.0	9.5	10.5	11.5	11.5	9.5	10.5	11.5	12.0	12.0
2100	9.0	9.5	10.0	11.0	11.5	9.5	10.0	11.0	11.5	12.0
2200	8.5	9.5	10.0	11.0	11.0	9.5	10.0	11.0	11.5	12.0
2300	8.5	9.5	10.0	11.0	11.0	9.5	10.0	11.0	11.5	11.5
2400	8.5	9	9.5	10.5	11	9.5	9.5	10.5	11.5	11.5
2500	8.5	9	9.5	10.5	11	9	9.5	10.5	11	11.5
2600	8.5	9	9.5	10.5	10.5	9	9.5	10.5	11	11.5
2700	8.5	9	9.5	10.5	10.5	9	9.5	10.5	11	11
2800	8.5	8.5	9.5	10.5	10.5	9	9.5	10.5	11	11
2900	8.5	8.5	9.5	10.5	10.5	9	9.5	10.5	10.5	11
3000	8	8.5	9	10	10.5	8.5	9	10	10.5	11

Figure 2-3 – Foundation Depths calculated using the AASHTO Brom's Design method for Cohesive soils.

When the groundwater level is at a depth above the foundation depth calculated for the "dry" condition (no ground water), the foundation depth required can be determined by linear interpolation between the depth calculated for the "dry" condition and the depth for the "saturated" condition. The water level in the cohesionless soil is taken into account using the effective unit weight of the soil. Two embedment calculations are created. The first calculates the embedment depth using an effective unit weight where there is no water. The second calculates the depth based on an effective unit weight considering the water level is at the surface. For water levels between these two cases, the depth can be calculated based on the ratio of the two depth options. For the case where the water table is ½ of the foundation depth in the no water condition, the embedment length is increased by ½ the difference in the lengths of the two options. For a water table that extends over 75% of the length in the no water condition (25% not in water), then the dry foundation length adds 75% of the difference between the length options. Figure 2-4 shows a diagram of this calculation.

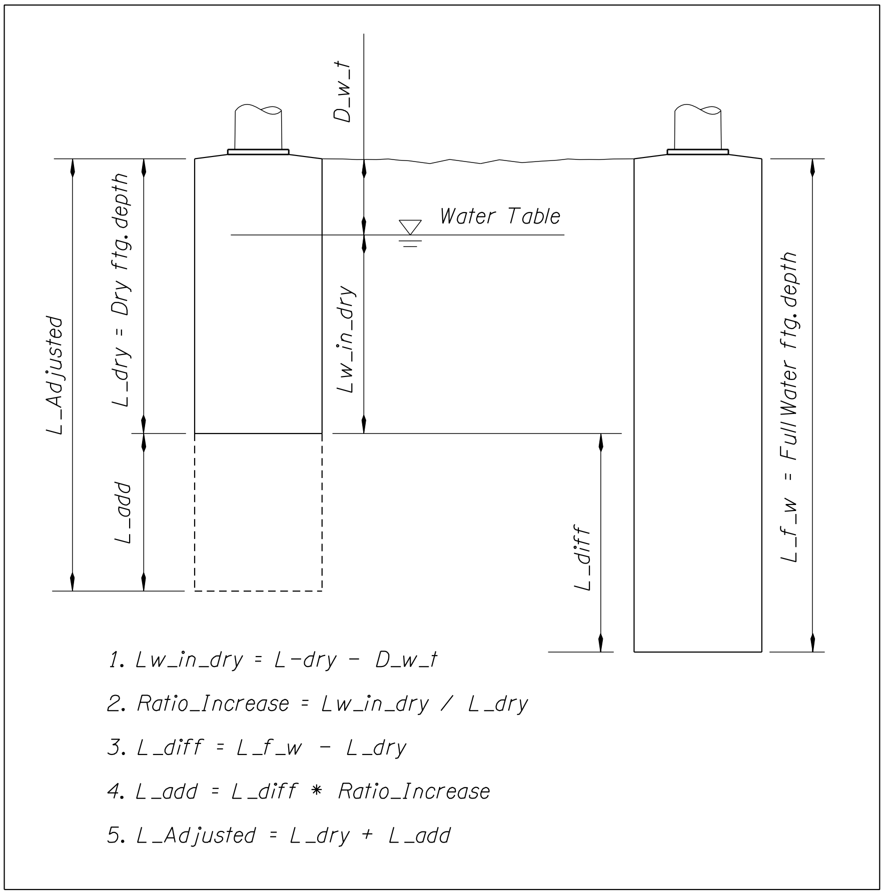

Figure 2-4 – Water Embedment Adjustments to the Brom's Design method for Cohesionless soils.

Alternative programs may be used for the design of the signal pole foundations and may be required in multiple layered and contrasting soils or for very poor soils where the soil friction angle is less than 25 degrees for cohesionless soils, when the undrained shear strength (c_u) is less than 600 psf, or when rock will be encountered at a depth deeper than 5 feet. The LPile 4.0 program has been used for these designs. A top of shaft deflection of one half of an inch or less should be maintained under working load analysis.

Foundations that will encounter fresh to moderately weathered and unfractured rock with an unconfined compressive strength (qu) greater than or equal to 100 psi within 5 feet of the surface must extend a minimum of 5 feet into the rock. Figure 2-5 shows the recommended detail to add to the project plans. The standard detail can be downloaded from the ODOT internet webpage.

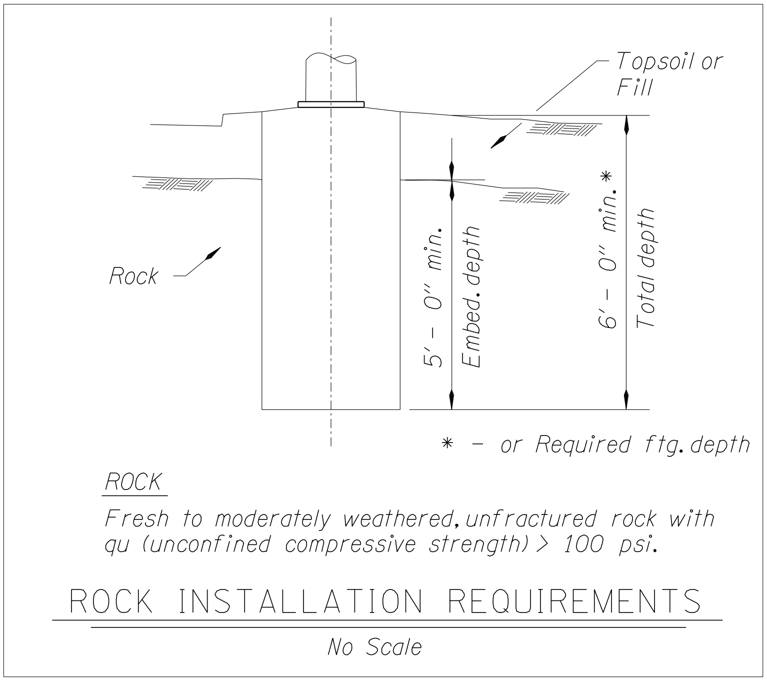

Figure 2-5 – Rock Installation Detail for project plans.

The Rutledge method is not an approved method for designs of new signal pole mastarm foundations according to the 4th Edition 2001 AASHTO code. Section 13.10 in the code has a figure that shows a nomograph similar to the Rutledge nomograph. This method is applicable to small lightly loaded poles or posts for lighting and roadside signs embedded directly in the earth. Typical signal pole foundations on the State Highway system do not fit into this category. In addition, the effects of water and different soil types are not clearly accounted for in this method.

A soils investigation and report is required for each intersection to perform the signal foundation design. The report shall be according to the ODOT Geotechnical Design Manual and must contain recommendations for the design parameters to use in either the Brom's method or LPile analysis as described above. The report should be distributed to the Traffic Structures Designer in charge of the signal foundation design. Geotechnical reports that are prepared for the signal designs are typically not included in the project plan set, but are made available to the contractors from the Project Manager's office.

For many poor soil conditions, temporary casings may be required and may be recommended in the Geotechnical report. A note should be added to the plans that states which of the foundations may require the temporary casing. No separate bid item will be listed in the special provisions to cover this because it is the responsibility of the contractor to use appropriate techniques for the installation of the foundation to the depth required in the plans.

2.9.2 SIGNAL STRAIN POLE STEEL SUPPORTS

One of the two main types of signal pole designs that ODOT uses on the State Highway system is the is the Strain Pole, or Span Wire as defined in the code. ODOT primarily uses the mastarm steel supports on the State Highway system unless the width of the intersection results in a mastarm that exceeds a length of 55 ft. In addition, the ODOT maintenance crews prefer maintaining mastarm poles rather than strain poles. The design and detail requirements are shown on drawings TM660, TM661, TM652, and TM653. Any deviations from these standards are considered non-standard structures and must be sent in to the Traffic Structures Group for review and approval.

The analysis of the loads on the messenger cable shall be designed according to Appendix A of the AASHTO code. The simplified method results in conservative tension cable forces. It is recommended to design according to the Detailed Method shown in Appendix A.8. The top deflections of the poles can be determined according to Appendix B.3 of the AASHTO code. For the design for the plans it is recommended to overestimate the stiffness of the pole to reduce the top deflection and increase the cable force. The shop drawings in the construction submittal should be reviewed to make sure that the poles provided will not make a significant change in the cable forces for the design of the poles.

2.9.2.1 SIGNAL STRAIN POLE FOUNDATION SUPPORTS

See Section 2.9.1.1 for foundation design guidance for Signal Strain Pole foundations.

2.9.3 TEMPORARY WOOD STRAIN SIGNAL POLE SUPPORTS

The following are the general requirements for design of temporary wood poles:

1. Dead Load and Wind Analysis using Appendix A of the 2001 AASHTO Standard Specifications for Structural Supports for Highway Signs, Luminaires and Traffic Signals using a wind speed of 110mph (3 second gust).
2. Importance Factor (Ir) equal to 0.71.
3. Structural calculations for the wood strain pole using Section 9 of the 2001 AASHTO Standard Specifications for Structural Supports for Highway Signs, Luminaires and Traffic Signals.
4. Calculate the messenger and guy wire tensions and compare to the allowable tensile load of the cable. (not the ultimate breaking strength)
5. Helical anchor calculation. (See Section 3.6.3.1)
6. Bearing calculation at the bottom of the wood pole. (See Section 3.6.3.1)

2.9.3.1 TEMPORARY WOOD STRAIN POLE SUPPORT FOUNDATIONS

The main foundation components are the helical anchor for the guy anchor and the bearing of the wood pole in the soil. If a project specific geotechnical report is not available then conservative soil design parameters can be assumed, however the assumed design values usually provide a deep foundation designs.

The guy cables from the top of the pole produce a large vertical force in the wood pole that must be supported at the base. The diameter of the wood pole at the base is relatively small and typically does not provide enough bearing area for the soil to resist the vertical forces. The solution that has been used on past projects is to pour a 2 ft diameter by 1 ft pad that will be installed under the base of the wood pole. It is recommended to drill out the hole, place 1 ft of well compacted material in the bottom of the hole, level it, place the 2 ft x 1 ft pad, place the wood pole, and backfill around the wood pole with well compacted granular material or a low density fill.

2.9.4 SIGNAL SUPPORT CRITICAL DESIGN ITEMS

The following are critical items that are incorporated into the ODOT designs:

1. Appropriate 3-second Gusted Wind Speed for the area. The wind map in Figure 3-2 in the 4th Edition 2001 AASHTO code does not always show the appropriate wind speed for the region.
2. A fatigue category of 1 or 2 must be used.
3. 50 year recurrence interval.
4. Hot-dipped galvanized steel and hardware. Include silicon content requirements from TM651.
5. Foundation design according to section 13.6 of the 4th Edition 2001 AASHTO code. This will address water, sand, and cohesive soils.
6. Soil Geotechnical Report to perform foundation design.
7. Future loading conditions like 5 section head at the end of the mastarm, 5 section head for the closest signal to the mastarm, street name sign to meet MUTCD requirements, Guide sign on the vertical post, and cameras.
8. Main structural items to include in the calculations:
    - Mastarm and Luminaire arm
    - Mastarm and Luminaire arm connection weld
    - Mastarm and Luminaire arm connection bolts
    - Mastarm and Luminaire Arm connection plates
    - Vertical post
    - Vertical post base weld
    - Base plate
    - Anchor bolts
    - Foundation concrete and rebar
    - Embedment depth
9. The design must be general enough that at least 3 manufacturers can bid on projects and provide poles on the State Highway system.
10. Quality control for the material documentation. This must include the “Buy America” steel for projects funded with Federal money.
11. Inspection of the fabrication.
12. Installations procedures for foundations, bolts, erection method, etc.

2.10 LUMINAIRE SUPPORT STRUCTURES

Galvanized Steel Slip base and fixed base Luminaire supports are typically used on the Oregon State Highway system. These standards are contained on ODOT Standard drawings TM629 and TM630.

There are projects that require the use of different style poles for aesthetic purposes and these are called ornamental or decorative lighting.

2.10.1 SLIP AND FIXED BASE LUMINAIRE SUPPORTS G

The design and detail requirements for slip base and fixed base poles are shown on drawings TM629 and TM630. Any deviations from these standards are considered non-standard structures and must be submitted to the Traffic Structures Group for review and approval. The current design for these standards use the 1994 AASHTO AASHTO Standard Specifications for Structural Supports for Highway Signs, Luminaires, and Traffic Signals with a fastest mile per hour wind speed of 100 mph. In addition, the slip base design has been crash tested and approved by the FHWA. The proper orientation must be installed in the field to make sure that the structure reacts properly when impacted by an errant vehicle.

Truss Sign Bridges, monotube cantilevers, signal poles, and square tube sign supports have currently been updated to the 4th Edition 2001 AASHTO Standard Specifications for Structural Supports for Highway Signs, Luminaires, and Traffic Signals. The illumination Standard Drawings are the next structure type scheduled to be updated to the new code.

2.10.1.1 SLIP AND FIXED BASE LUMINIARE SUPPORT FOUNDATIONS

The design of the foundations for the standard drawings TM629 and TM630 were based on the Rutledge method. This method can be referenced in the document “How to Design Pole-type Buildings” by Donald Patterson with copyright dates 1957, 1958, and 1962. The nomograph in Figure 1 shows the soil types and equations for determining the footing depths. This nomograph is very similar to the one that is shown in Figure 13-4 of the 4th Edition 2001 AASHTO code. Section 13.10 states “Small poles or posts for lighting and roadside signs may be embedded directly in the earth. An approximate procedure for calculating the required embedment depth, as outlined in the commentary, may be used”. It is ODOT’s interpretation that the Luminaire supports shown on drawings TM629 and TM630 include the maximum size of poles that can be supported using Section 13.10 for new foundation designs. The minimum embedment depth must be equal to or greater than the depth required according to Section 13.10 of the 4th Edition AASHTO code with an S1 value of 1500 psf.

2.10.2 DECORATIVE LUMINAIRE SUPPORTS

The use of decorative luminaire poles has increased over the past few years. These poles must satisfy the AASHTO Standard Specifications for Structural Support for Highway Signs, Luminaires, and Traffic Signals code requirements to be installed on the State Highway system. In addition, installation procedures and requirements must be specified in the project plans and specifications. This section provides the design requirements necessary to use decorative luminaire supports instead of the ODOT standard drawings and specifications for Slip Base and Fixed Base Luminaire Supports as shown on TM629 and TM630.

The current standard drawings for Slip Base and Fixed Base Luminaire Supports, which has been developed by ODOT over the years, has many qualified manufacturers, and has pre-qualified shop drawings to make the process more efficient. Decorative luminaire pole structural designs are typically based on the manufacturer’s testing and are selected for the desired appearance by local communities and/or utility companies. The selected decorative luminaire poles must satisfy the requirements of the AASHTO Standard Specifications for Structural Support for Highway Signs, Luminaires, and Traffic Signals, installed with generally accepted construction procedures, have material quality control, and allow lawful competition between manufacturers.

Traffic Designer responsibilities: A Traffic Designer that specifies a specific decorative luminaire support and associated foundation on the State Highway system before the contract is Let, or specifies general decorative pole requirements in the plans and has the Contractor submit the required information, must satisfy the following State requirements:

- The pole must meet the 4th Edition 2001 AASHTO Standard Specifications for Structural Support for Highway Signs, Luminiares, and Traffic Signals with all interims.
- Local 3-second gusted wind speed minimums must be satisfied.
- A minimum design life of at least 50 years must be used.
- A fatigue category II must be satisfied.
- Steel design must meet Section 5 of the 4th Edition 2001 AASHTO code.
- Aluminum design must meet Section 6 of the 4th Edition 2001 AASHTO code.
- The 1994 AASHTO Standard Specifications for Structural Support for Highway Signs, Luminaires, and Traffic Signals may be used instead of the 4th Edition 2001 AASHTO code with a fastest mile wind speed that is equal to or greater than the local requirements.
- Fluted poles are only allowed on vertical posts that have a single luminaire load at the top. No fluted vertical poles are allowed on the state Highways with luminaire arms that produce torsion in the vertical shaft.
- A fluted shell cover that fits around the standard round pole can be used. The fluted shell has a different drag coefficient and calculations are required for the pole and foundation.
- At least three manufacturers must be specified for each item of the decorative luminaire support to allow for lawful competition. If only one manufacturer is available, the statement “or approved equal” must be added. A public interest finding can be obtained if one specific product must be used.

Drawings, details, calculations, and a statement certifying that ODOT and AASHTO standards have been met shall be stamped by a Professional Engineer registered in the State of Oregon and submitted to the Traffic Designer according to 00150.35(b-1). This information will be forwarded to the Traffic Structures Engineer for review.

ODOT Traffic Structures Engineer responsibilities: Review the submittal and return comments within 21 days.

2.10.2.1 DECORATIVE LUMINIARE SUPPORT FOUNDATIONS

The design methodology from section 3.6.1.1 applies to the decorative support foundations. Many of the details from TM629 and TM630 should be considered when creating a custom foundation drawing. One method is for a designer to specify one of the footings from the ODOT Slip Base and Fixed Base Luminaire supports standard drawings TM629 and TM630.

Pre-cast footings are not recommended for use on ODOT projects. In many cases the tops of the curbs and sidewalks have not been located and it requires more expertise to survey each footing installation to result in the correct top of footing elevations. It should be noted that many times the elevations that are used during the project to set the top of the footings with accurate survey techniques may not be the final elevation that the curbs and sidewalks are poured to because of roadway construction issues that occur during the project. Special requirements must be included in the plans and specifications to ensure proper installation.

Provide details similar to those shown on the Slip Base and Fixed Base Luminaire supports standard drawing. In addition, at least 1 foot below the bottom of the footing shall be filled with well compacted material. Also, a minimum space of 1 foot shall be provided around the entire footing and replaced with well compacted material. A low density fill may be substituted for the compacted material. A note or special provision statement must specify that "a foundation installation will be rejected when the tops of the pre-cast foundation is lower than the surrounding sidewalks or curbs, the top of the pre-cast footing shall be no more than 2" above the top of the sidewalk or curb, and it shall not create a tripping hazard". Guidance for the grout between the base plate and the top of the foundation must be addressed and a drain hole must be specified.

2.10.2.2 DECORATIVE LUMINIARE CRITICAL DESIGN ITEMS

The basic principal for review calculations is to start at the luminaire and any material, bolt, welds, or plates that are shown must have calculations to show that the AASHTO code is satisfied. The following are critical design items for the decorative luminaire poles:

1. Appropriate 3-second Gusted Wind Speed for the area. The wind map in Figure 3-2 in the 4th Edition 2001 AASHTO code does not always show the appropriate wind speed for the region.
2. A fatigue category of 1 or 2 must be used.
3. 50 year recurrence interval.
4. Main structural items to include in the calculations:
    - Luminaire connection
    - Luminaire arm
    - Arm connection weld
    - Arm connection bolts
    - Arm connection plates
    - Vertical post
    - Vertical post base weld
    - Base plat or casting
    - Anchor bolts
    - Foundation concrete and rebar
    - Embedment depth
5. The design must be general enough that at least 3 manufacturers can bid on projects and provide poles on the State Highway system.
6. Quality control for the material documentation. This must include the "Buy America" steel for projects funded with Federal money.
7. Inspection of the fabrication.
8. Installations procedures for foundations, bolts, erection method, etc.

2.10.3 OTHER LUMINAIRE SUPPORTS

The use of other types of luminaire poles includes the use of aluminum, curved arm connections called davits, and many other alternatives. These poles must satisfy the AASHTO Standard Specifications for Structural Support for Highway Signs, Luminaires, and Traffic Signals code requirements to be installed on the State Highway system. In addition, installation procedures and requirements must be specified in the project plans and specifications. The information contained in Section 3.6.2 Decorative Luminaire Supports applies to these alternative types.

2.10.4 LUMINAIRE SUPPORT FATIGUE REQUIREMENTS

Luminaire pole fatigue requirements are differentiated by the height and importance of the support. The 5th Edition AASHTO code commentary C11.4 states "Common lighting poles and roadside signs are not included because they are smaller structures and normally have not exhibited fatigue problems. An exception would be square lighting poles, as they have exhibited poor fatigue performance". The definition of typical lighting poles, which is assumed to be the same as common lighting poles, can be found in the AASHTO code commentary C1.4.2 that states "The lighting of modern freeways includes the use of typical lighting poles, generally tubular pole shafts that support 1 to 2 luminaires and range in height from about 9 m (30 ft) to 17 m (55 ft)". Luminaire Poles that are 55 ft and less in height with 1 to 2 luminaire arms and do not have a square section are categorized as typical or common lighting poles and do not need to perform the fatigue calculations.

Luminaire Poles and High Mast Towers over 55 feet and less than or equal to 100 feet shall be designed to a Fatigue Category II. High Mast Towers in excess of 100 feet shall be designed to a Fatigue Category of I.

2.11 RE-USE AND RE-ANALYSIS OF EXISTING STRUCTURES

Sometimes a project will be scoped to re-use an existing sign, signal or illumination support. Each type of structure will have to be re-analyzed for new loading to ensure the structure is adequate. Each type of structure is addressed in the subsections below.

2.11.1 TRUSS SIGN BRIDGES AND MONOTUBE CANTILEVERS

In order to re-use a truss sign bridge or monotube cantilever, several steps have to be followed. The first step is to locate the construction drawings from the original installation. Those drawings may be found using the Bridge Data System (BDS). If the original drawings cannot be located using the Bridge Data System, then the Roadway drawing database (RIAS) may provide additional information about possible bridge drawing numbers that are referenced on the #V-## roadway drawings in the basement of the Transportation Building in Salem. Another method to find information on a structure is to check the field inspection reports. There are sometimes bridge number references listed in the comments sections from tags that are riveted to the vertical post of the structure. If the original construction documents cannot be located, a field crew will have to measure the structure and the designer will have to research the old standard drawings to find material grade and other pertinent information. The original design code can be used to analyze the structure, but no code older than the 1994 AASHTO Standard Specifications for Structural Supports for Highway Signs, Luminaires, and Traffic Signals code will be allowed. The 1994 AASHTO code uses very similar design values to the preceding codes. Cases where the sign loading is smaller or luminiare loading is stated in the notes can be used to analyze the structure without a full analysis by providing a comparative area calculation. <u>Changes in the area can effect the location of the area center and must be addressed when making this comparison. If the center of the proposed area is at a higher elevation with the same area size as the original, then the base reactions will be higher.</u> Some of the old horizontal truss designs used a standard design sign area for the horizontal truss. The design area was equal to the estimated distance between foglines with an assumed sign height and luminaire loading. It was stated in the old Bridge Design Manual that for a project total sign area that was less than the design area of the horizontal truss could be used to design the end vertical posts and the foundation, but the area could not be reduced to a value lower than 75% of the horizontal truss design area. Cases where the loading is larger or the designer is not comfortable using an approximated estimate, then the structure must be analyzed using the new loading conditions to determine if the old structure can support the new loads. Either hand calculations or a computer analysis program can be used to perform the structural analysis. The design shall check the steel members, member welds, connection plates, connection bolts, base plate, anchor bolts, and foundation for structural adequacy. A structure under the older code that requires small modifications (like adding some concrete to the top of the slab or a new vertical support that attaches the sign to the structure) can be made. More severe modifications are not allowed and the structure must be replaced using the most recent version of the 4th Edition of the AASHTO Standard Specifications for Structural Supports for Highway Signs, Luminaires, and Traffic Signals. Finally, the condition of the structure must be reviewed either by sending a field crew to inspect it or reviewing an inspection report that has been performed within the last 3 years.

2.11.2 MULTI-POST AND TRIANGULAR BASE BREAKAWAY POSTS

In order to re-use a multi-post and triangular base breakaway sign support, several steps will have to be followed. The step is to determine the date the sign support was constructed. This can be determined from shop drawings associated with the sign support, the "As Constructed" drawings, and possibly a sign inventory (depending upon the highway). Once the date has been determined, then the standard drawing for that time period should be referenced to find out the pertinent structural information. With the existing structure's information, the sign support should be analyzed to support the new sign using the 1994 AASHTO Standard Specification for Structural Supports for Highway Signs, Luminaires and Traffic Signals. The steel sign post(s), base plate(s), anchor bolts, and foundation should be checked. Another item that will require investigation is the condition of the sign support. Each sign support that will be re-used should be determined if it meets the current standards for breakaway devices. The support should also be inspected for structural damage, corrosion and whether a reasonable amount (3mm or more) of galvanizing is left. The inspection will probably require weld inspection of the structure. This may be costly if a lot of supports will be re-used. If the structure is determined to be able to support the new sign, is structurally sound, and meets breakaway standards, the support can be re-used. One point to consider is the cost associated with purchasing a new sign support; it may be reasonably comparable to reusing an existing sign support. A cost analysis should be done prior to the decision to re-use an existing breakaway sign support.

2.11.3 MASTARM SIGNAL SUPPORTS

The following are general design guidelines for analyzing existing mastarm signal poles that do not use ODOT standard drawings TM650 through TM653:

1.) Obtain all intersection and associated drawings that show plans and legends for the intersection. These may be obtained from the Region.

2.) Once the As Constructed date is known, determine which of the standard drawings are appropriate for that given date. There may be cases where the date is before a standard drawing was created.

3.) Determine the level of inspection that will be required of this pole.

a.) Before 1980, full visual inspection and galvanizing thickness measurements are required. Inspect that all bolts are tight, no damage to the pole exists, and that there are no areas where galvanizing touch-up may be required b.) 1980 through current, full visual inspection to make sure that all bolts are tight, no damage to the pole exists, and that there are no areas where galvanizing touch-up may be required.

4.) Send the spreadsheet "Mastarm Field Data Sheets (revision date)" with the field crew that will be doing the inspection. The spreadsheet can be downloaded from the Traffic Structures website. Many cases exist where the information from this spreadsheet does not check out or make sense and the crew will have to go out again. Emphasize that any questions about the measurements should be addressed before they get out in the field.

5.) From the field data, verify this information with the data from the appropriate standard drawing and As Constructed drawing. Any discrepancies between the two will have to be checked.

6.) The earlier design codes had the same wind pressures as the 1994 AASHTO code. All existing traffic structures are designed to the 1994 AASHTO code as a minimum requirement.

7.) The wind speed to use for the re-analysis is 90 mph. This is a fastest mile per hour basic wind speed.

8.) Run the pole using design requirements from the 1994 AASHTO code and check the CSR of the pole. Use a default yield strength of 48 ksi unless a more accurate value can be determined from project specific shop drawings.

9.) Check the anchor bolts using an assumed yield strength value of 36 ksi as a default bolt yield strength unless a more accurate value can be determined from project specific shop drawings.

10.) Check the base plate using a fixed condition at the bolt and a pinned condition at the pipe.

11.) Check the foundation depth using the Rutledge Method. The reference of this document is "How to Design Pole-type Buildings" by Donald Paterson. Use an allowable average soil stress of 1500 psf.

The preceding comments represent a minimum design that will be accepted by the State of Oregon for the analysis of existing poles.

2.11.4 SIGNAL STRAIN POLE SUPPORTS

Strain poles are commonly used on intersections where the length between poles is 105-ft or greater. There was no standard drawing for strain poles until the drawing 35010, dated January 7, 1980, was released. So, strain poles that are dated before this date will most likely have little design information to use to verify field information.

The following are general design guidelines for analyzing existing strain poles that do not use ODOT standard drawings TM660, TM661, TM652, and TM653:

1.) Obtain all intersection and associated drawings that show plans and legends for the intersection. These may be obtained from the Region.

2.) Once the As Constructed date is known, determine which of the standard drawings are appropriate for that given date. There may be cases where the date is before a standard drawing was created.

3.) Determine the level of inspection that will be required of this pole.

a.) Before 1980, full visual inspection and galvanizing thickness measurements. Inspect that all bolts are tight, no damage to the pole exists, and that there are no areas where galvanizing touch-up may be required
b.) 1980 through current, full visual inspection to make sure that all bolts are tight, no damage to the pole exists, and that there are no areas where galvanizing touch-up may be required.

4.) Send the spreadsheet "Mastarm Field Data Sheets (revision date)" with the field crew that will be doing the inspection. Many cases exist where the information from this spreadsheet does not check out or make sense and the crew will have to go out again. Emphasize that any questions about the measurements should be addressed before they get out in the field.
5.) From the field data, verify this information with the data from the appropriate standard drawing and As Constructed drawing. Any discrepancies between the two will have to be checked.
6.) The earlier design codes had the same wind pressures as the 1994 AASHTO code. All existing traffic structures are designed to the 1994 AASHTO code as a minimum requirement.
7.) The wind speed to use for the re-analysis is 90 mph. This is a fastest mile per hour basic wind speed.
8.) A reference to the 2001 AASHTO code Appendix A will help to solve for the dead load tension. A correlation of the dead load tension to the live load is stated on the old standard drawing TM632. This statement is under bubble note 2 and it states, "Dead load and wind load span wire design tension shall be 2.5 times the allowable span wire dead load tension." Calculate the dead load tension and multiply by 2.5 for the load to apply to the pole.
9.) Run the pole using design requirements from the 1994 AASHTO code and check the CSR of the pole. Use a default yield strength of 48 ksi unless a more accurate value can be determined from project specific shop drawings.
10.) Check the anchor bolts using an assumed yield strength value of 36 ksi as a default bolt yield strength unless a more accurate value can be determined from project specific shop drawings.
11.) Check the base plate using a fixed condition at the bolt and a pinned condition at the pipe.
12.) Check the foundation depth using the Rutledge Method. The reference of this document is "How to Design Pole-type Buildings" by Donald Paterson. Use an allowable average soil stress of 1500 psf.

The preceding comments represent a minimum design that will be accepted by the State of Oregon for the analysis of existing poles.

2.11.5 ILLUMINATION POLES

The re-use of illumination poles on projects is not recommended. These poles have a wide range of ages and in many cases the pole that is to be re-used may not have any information about it. There are problems with a pole to be re-used where the original standard had one orientation and the new standard has a different rotation, as is the case with slip base poles. Another example is a high mast pole that had an older design that used a different diameter of bolt than the new standard. If the new standard was used to install the anchor bolts, then the base plate would not fit on the bolts that were installed. In each of these cases it shows the requirement of investigating the exact pole that will be moved and to make sure it can support the proposed loading to the current standards and the pole is in good shape. This effort takes time and money and will still result in a pole that is older with added chance of mistakes.

The re-use of the pole still requires a new pole foundation, conduit, electrical wiring, and most likely a light. So, most of the installation is brought up to a new condition. The lighting pole cost is approximately $1,500 and this is approximately how much money may be spent to investigate the pole to relocate it. The end result is about the same amount of money is spent, but an older pole is installed and the life expectancy of the pole is reduced.

2.11.6 QUESTIONS TO INVESTIGATE BEFORE RE-USING A STRUCTURE

The following are questions to answer before a structure is re-used or modified to support additional loads:

1.) Is the intent of the project to bring the stretch of the highway up to all current standards?
   - Re-analyzing a structure to the 1994 AASHTO code does not necessarily bring the structure up to the current code. If a structure with new loading requires significant modifications or the signing can not be brought up to the most recent codes because the structure can not support it, then it is recommended to replace the structure. This will bring the signing and the structure up to the most recent codes, which is the intent of the project.

2.) Is the structure old enough that it needs to be replaced in the next 10 years?
   - Most of the traffic structures are galvanized and have a lifespan of 50 years. If the structure is 45 years old and it is not known when the next time the structure will be replaced, the structures galvanizing may be insufficient in 5 years, corrosion starts, there is loss of section, a design event occurs, and the structure will not be adequate.

3.) Is the structure in a location where there is currently a large project, a large amount of congestion with motorist inconvenienced during construction, and there is no project in the foreseeable future?
   - It may be cheaper during this project to not replace the structure, but if something happens to this structure because of its age or the modified signing is not sufficient, then going back into this area with a small project in the near future will not be received well by the traveling public.

4.) Can the loading on the structure remain the same or can the loading be reduced to the point where the structure will work without any modifications?
   - There are occasions where some of the loading can be reduced to make the structure work.

5.) Can the sign or signal be moved to another location on a different structure?

6.) Can the structure be removed and still satisfy current codes and traffic design practices?
   - There have been instances where an old sign bridge can be removed and the signs can be placed on roadside signs and still meet code requirements.

7.) Does the 50 percent rule apply?
   - The 50 percent rule recommends that if the cost of the repairs is 50 percent or less than the cost of a new structure, then the repairs should be completed.
   - This rule only applies when the previous questions have been answered and it is recommended to fix the structure.

2.12 REPLACING TRAFFIC STRUCTURES IN-KIND

There are many instances where re-analysis of an existing structure is not required as long as the loading on the structure has not changed. The most common occurrence is when a vehicle has hit a structure and damaged it beyond field repair. This results in the determination of whether or not the structure must be brought up to the full new standards. In this case, the replacement of the structure uses the term “In Kind”. Replacing a structure “In Kind” means that the original loading, dimensions, location, and elevation does not change from what was shown on the original stamped plans for the installation. The Engineering responsibility for the installation will still remain with the Engineer that stamped the original drawing. Changes to the loading, dimensions, location, and elevation that modify it from the original plans results in requiring a new drawing and Professional Engineers stamp from the State of Oregon.

A structure that is severely deteriorated and needs to be replaced will need to have an Engineer investigate and give a recommendation about whether or not it needs to be replaced “In Kind” or replaced with a structure that satisfies the latest designs. In many cases, there are many other structures in the area that will need to be replaced with the most recent design and it is not advisable to spend a lot of money to update one structure when it is known that many of the structures are going to be replaced with a project in the near future. It is recommended to work with the specific Region to determine when the next project will be able to update this area. If it is only in the next year, then a temporary fix may be the best alternative.

2.13 STEEL DESIGN

This section will discuss standard methods that can be used for the design of steel traffic structures. The methods are based on standard practice that have commonly been used and accepted.

2.13.1 BASE PLATES AND FLANGES

The calculation of the thickness of a base plate or flange is one of the most common designs that is used for traffic structures. The following method is a conservative design procedure that can be performed quickly with reasonable results.

The layout in Figure 2-6 shows a plan of a base plate attached to a pipe. There is a hole in the center with four keyed out sections that provide galvanizing drainage, which is called a zinc drain. At each one of the base plate corners there is a hole that is ¼” larger in diameter than the rod diameter, d_h. From the edge of the pipe to the center of the rod hole will be considered the cantilevered distance, L, to use for the Moment calculation. The Moment will be equal to the distance, L, from the center of the rod hole to the edge of the pipe times the rod tension force, P. This method assumes that the force applied from the pipe is a point load and the nut on the rod creates a clamping force that is similar to a fixed condition. Once the Moment is known, the critical cross section is determined to be the line at the center of the rod hole that is perpendicular to the line from the center of the pipe to the center of the rod hole. The width, b, is the distance along the perpendicular line and extends from the edge of the plate through the center of the rod hole and goes to the other edge of the plate. The effective width, b_eff, is the b distance minus the width of the hole. The actual stress, F_act, from the loading is calculated from the Moment divided by the section modulus. The moment of inertia, I, of the plate section is equal to Equation 2-1 and the distance to the extreme fiber is equal to t/2. The section modulus, S, is calculated according to Equation 2-2. Using an assumed thickness, t, the actual stress from the loads, F_act, can be calculated using Equation 2-3.

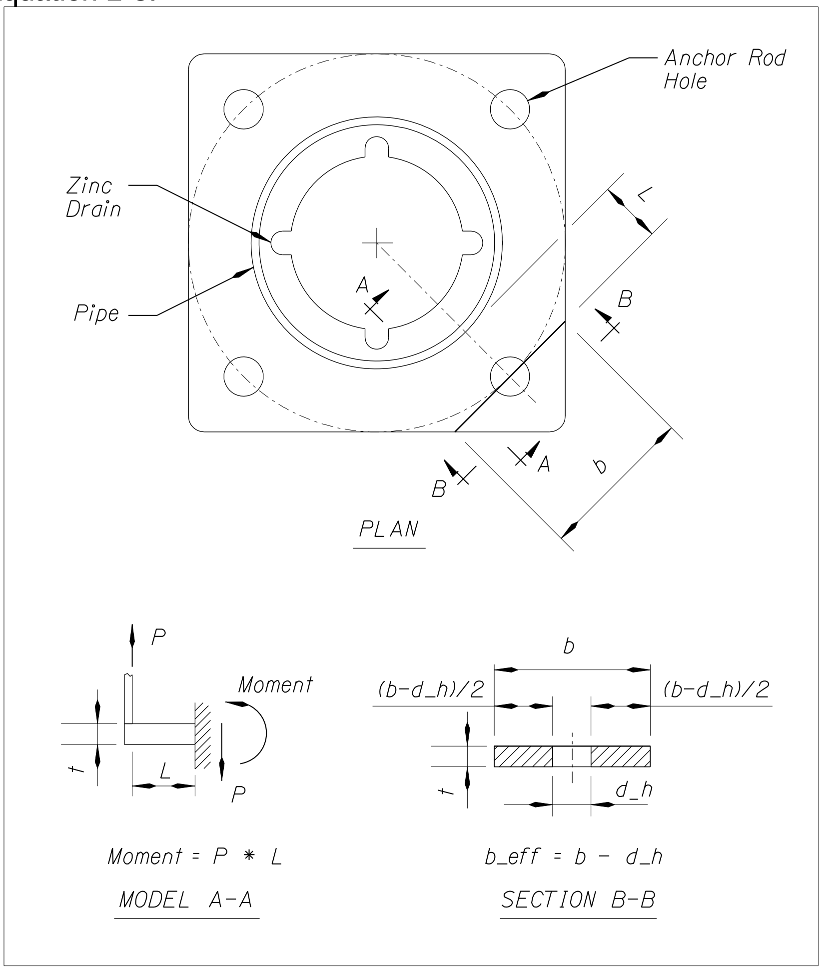

Figure 2-6 – Base Plate calculation layout.

$$I = \frac{b\_eff * t^3}{12}$$

Equation 2-1

$$S = \frac{I}{c} = \frac{\left(\frac{b\_eff * t^3}{12}\right)}{\left(\frac{t}{2}\right)} = \frac{b\_eff * t^2}{6}$$

Equation 2-2

$$F\_act = \frac{Moment}{S} = \frac{Moment}{\left(\frac{B\_eff * t^2}{6}\right)}$$

Equation 2-3

The 2001 4th Edition AASHTO Standard Specifications for Structural Supports for Highway Signs, Luminaires, and Traffic Signals Equation 5-8 specifes the allowable stress for rectangular plates to be Fb=.75*Fy. This allowable stress can be increased by 1/3 for Load Case 2 designs. If the actual stress, F_act, is less than or equal to the Allowable stress, Fb, then the base plate is structurally adequate.

2.13.2 BOLTING AND HARDWARE

The AASHTO Standard Specifications for Structureal Supports for Highway Signs. Luminaires, and Traffic Signals does not have design information for bolting hardware, except there is design information for anchor rods. It requires the use of the Standard Specifications for Highway Bridges, except for design guidance provided for anchor rods.

2.13.2.1 MINIMUM HIGH STRENGTH BOLT DIAMETERS

The use of ½ inch diameter A 325 high strength bolts requires Rotational Capacity tests during construction and some of the bolts have not passed this test. This results in the rejection of the hardware, new testing, and time delays. It is recommended to not use ½" diameter A325 high strength bolts and to use a minimum of 5/8" diameter A 325 high strength bolts.

2.14 PROPRIETARY ITEMS IN FEDERAL-AID CONTRACTS

- Basis for requirements: Competition
- 23 United States Code 112: "…the Secretary [of Transportation] shall require such plans and specifications and such methods of bidding as shall be effective in securing competition."
- Regulations apply to process or product specifications
- What is proprietary?
    - Product specified by brand name.
    - A specification written around a specific product in such a manner as to specify an attribute or process that is unique to that product and excludes other similar products.
    - Manufacture or use of the product by any party that would infringe on a patent or copyright or require payment of a premium royalty.
- A proprietary item on a Federal-aid project may be used only under the following conditions:
    - The proprietary item is allowed in competition with other equivalent products using one of following methods:

- Nonproprietary – Generic end result specification.

- Nonproprietary – Generic process or product attribute specification (may be pattered after a manufacturer's specification, but sanitized to eliminate reference to brand names and patented aspects and open enough to allow at least two alternatives).

- Proprietary – Multiple brands with all (at least two and, preferably, three) alternatives specified; interim use only in exceptional circumstances. Use either manufacturer's specification incorporated into contract (proprietary) or name brands only in the contract documents with or without reference to manufacturer's specification or in the approved products list (proprietary).

- A public interest statement can be developed by the Highway Agency and approved by FHWA when the product is either essential for synchronization (compatibility) with the existing system or it is the only suitable product or method that exists.

- Other products or processes will not work.

- Other products or processes may work but are otherwise unreasonable.

  Note: The two conditions above should be verified by the Highway Agency and documented. This finding should be periodically reviewed.

- It is experimental. The intent and use of the experimental program is to permit the State adequate time to test and/or evaluate new and untried materials or products capable of providing the intended function upon which they can further develop team research, not to otherwise circumvent the prohibition against brand name items. Reports must be prepared and submitted to FHWA for dissemination to other interested agencies.

3

Construction Phase of Standard & Nonstandard Projects

3.1 GENERAL

After the design phase is finished, the project will be advertised for bid. Contractors will pick up sets of bid documents from the Contractor Plans Office. The bid documents consist of the project plans and Special Provisions the Design Team produced. The contractors will review the plans and put together a bid based on the project plans and the material quantities reported in the Special Provisions. Each contractor will submit their bid packets to ODOT and then the bids are opened at the bid opening. The lowest bid at the time of opening wins the project. Once the bidding process is finished and the project is awarded to a contractor, the construction phase of the project begins.

During the construction phase, the ODOT Design Team will have a preconstruction meeting with the contractor. ODOT or the contractor will collect field data, submit shop drawings for review, have the traffic structures fabricated once the shop drawings are approved, and then the traffic structure will be erected in the field. Depending upon which traffic structure is/are being used in the project, the construction process can either have very minimal oversight by the Traffic Structures Designer or the Traffic Structures Designer can become quite involved. One change to the Design Team will be the changing from the Project Leader to the Project Manager. This change occurs when the advertisement for the project is posted.

The Project Manager (PM) is responsible for coordinating the efforts between the contractor and their subcontractors and ODOT personnel. This means all required project submittals, requests for information, construction problems, and material substitutions will be sent through the PM, who will be the point of contact for the project. All communications made to personnel outside of ODOT should be made through the Project Manager, unless the Traffic Structures Designer has received permission to respond to questions. However, requests for information or clarification by suppliers or fabricators may be answered directly if we have received written or verbal (with attached email confirmation) permission from the contractor to deal directly with the supplier and the Project Manager agrees. If the request involves a matter that might be a point of disagreement with the supplier and inspector or Project Manager, the Project Manager should be consulted before responding. Before making recommendations on problems or answering questions, consider the following:

- Review the plans for potential conflicts and consequences from problems or proposals.

- Review contract specifications and special provisions for potential conflicts, restrictions to and/or conformance of proposals.

- Discuss the problem with the Traffic Structures Engineer; it may have happened before and a good solution may have already been developed.

Note: Some proposals may require concurrence from the FHWA on Federal-Aid projects when changes to the contract are under consideration.

In all cases, the Project Manager should be copied on all communications to keep everyone informed of project information.

Each construction project proceeds differently. All of these steps should occur during construction; however, the order will vary from project to project. The following sections describe each portion of the construction phase and the goal of the Traffic Structures Designer.

3.1.1 PRECONSTRUCTION MEETING

The preconstruction meeting is intended to allow communication between the contractor and the Design Team. At this meeting, the Traffic Structures Designer should report any issues the contractor may encounter in the project. Some examples of this would be extreme slopes at the traffic structures installation site, special materials being used in the project, erection sequences using cranes, utility conflicts from changes being made after the project were let, and special foundation construction issues. We suggest providing any information that is special to the project and/or may be missed by the contractor during construction. Consider that if you make the contractor aware of special construction issues at the preconstruction meeting, it may prevent a construction problem later.

3.1.2 FIELD SURVEY DATA

The field data provided for the project will vary. For a majority of the traffic structures, the designer will not review field survey data. The other disciplines will review the survey data to verify the design is appropriate. The seven main structures the Traffic Structures Designer will review are Traffic Signal Support, Truss Type Variable Message Sign Bridge, Truss Type Sign Bridge, Butterfly VMS Support, Camera Pole, High Mast Illumination, and Monotube Cantilever Sign Supports. The pieces of information that you will want to check for these traffic structures are how the surveyed cross section compares to the cross section used in the design, post height, arm length (Monotube), footing cover, and span width (Sign Bridges). The field data will probably be submitted on paper, so the Traffic Structures Designer will have to transfer the data to Microstation for comparison. There are field verification forms that can be downloaded from the Traffic Structures for Truss Sign Bridges, Truss VMS Bridges, and Monotube Cantilevers. The new specification contains language that requires a field verification form for Major Sign Supports. For the traffic signal support, the survey data only needs to be reviewed if the site has special soil slope conditions.

For traffic signal poles, signs, and luminaire poles, the contractor will submit cross sections with elevations for certain points on the structures for review by the Signal/Illumination Designer. The difference in final grade elevation at the support post and the final grade elevation at the point of interest on the pavement should be field verified in order to account for differences in these elevations. Field verification of signal and lighting pole dimension “BL” and field verification of overhead sign support post height should be performed prior to preparation of working drawings. The field verification date shall be submitted for review along with the steel pole/steel shop drawing submittals. The post lengths for luminaire poles and signal poles are determined from the field data and should be confirmed by the Signal, Sign, Illumination, and ITS Designer prior to the Traffic Structures Designer's review.

The Project Manager is responsible for making sure that the contractor performs the field verification. The Project Manager is also responsible for forwarding the completed field verification data to the appropriate designer for review. Working drawings should not be prepared until ODOT has reviewed field verification data.

3.1.3 SHOP DRAWINGS / STRUCTURE FABRICATION

There are two types of shop drawing processes. The classification of each type is dependent upon if the shop drawing has been sealed by a Registered Engineer in the State of Oregon. The difference between the shop drawing being sealed by a Registered Engineer is once the shop drawing has been sealed, the sealing engineer takes responsibility of the structure during and after installation. If the shop drawings have not been sealed, then the engineer that sealed the original design is responsible for the structure during and after installation.

3.1.3.1 SEALED SHOP DRAWINGS

Per the 2008 Oregon Standard Specifications For Construction book, Sections 00150.35 and 00962.02, all supplier or manufacturer designed signal, luminaire, and sign support drawings (including the engineer's calculations) placed on a state highway will be submitted for review and are required to be prepared, signed, and stamped with the seal of an engineer registered to practice in the State of Oregon. This requirement also includes pre-qualified drawings from manufacturers, foundation details, and calculations.

Sealed shop drawings are submitted for several different conditions. Currently traffic structures have pre-qualified and non-pre-qualified structures. Pre-qualified structures encompass traffic signal poles and illumination poles. Pre-qualified structures have been reviewed and standard pole designs have been accepted for use. Any project can use a pre-qualified structure as long as the designer does not exceed the maximum design load criteria on the standard drawings. The Traffic Structures Designer may receive a copy of the shop drawings for their records. Shop drawings for standard traffic structures with pre-qualified shop drawings do not have to be reviewed; however, the Traffic Structures Designer may want to verify that correct poles and loading have been provided for the project. Nonstandard structures that reference pre-qualified structures have to be reviewed and encompass camera poles and some signal poles. Each project that includes a camera pole or nonstandard signal pole requires shop drawings to be reviewed by the Traffic Structures Designer. The Traffic Structures Designer should then comment on the shop drawings according to the procedure outlined in the 2008 Oregon Specification book, Section 00150.35(d)(1). Along with sealed shop drawings, calculations will be submitted from the Engineer of Record for shop drawings. The Traffic Structures Engineer should review the calculations to make sure there is agreement that the structure has been designed to support the loads as shown on the project plans. This review should cover any horizontal and vertical members, base plates, anchor bolts, and foundations required for the structure. Shop drawing review can be one of the most time consuming portions for the Traffic Structures Designer during the construction phase. As a general guideline, for nonstandard signal pole/strain pole submittals with one re-submittal being required, it may take up to 12 hours to finish four poles. This considers checking the calculations, verifying the pole loading, checking the site conditions for slope, and verifying the information on the shop drawings to the pre-qualified shop drawings. A general guideline for sign bridge or cantilever mono-tube submittals with one re-submittal being required, it may take up to 48 hours to finish one structure. This includes checking all the dimensions on the pieces, verifying field survey data with the shop drawing dimensions, checking material grades and ASTM designations, reviewing the weld submittals and welding procedures, checking the field data against the original design cross section and verifying general compliance with the requirements per the standard drawing.

When only minor notes are made on the details, the statement “reviewed and accepted” will be added. Critical changes that must be addressed will not have a stamp placed on the submittal. A transmittal that includes comments about the items that do not meet the plans, specifications, standards, and ODOT manuals shall be included with the returned unstamped document. It is extremely important to have complete stamped details in the project plans for the Contractor to make a complete bid. This will also help to make sure that stamped submittals do not have to be sent in to the Project Manager. This reduces the chances of construction time delays and costly change orders.

If concerns exist, write a memo to the Project Manager stating the concerns and requesting a re-submittal when the concerns are addressed. Concerns may be marked on the shop drawings and sent with the memo to the Project Manager. Retain one copy of the memo and marked shop drawings for the submittal file and discard any remaining copies. If possible, and with prior permission of the contractor and Project Manager, the Checker may talk by phone directly to the supplier to resolve concerns and decrease turn-around-time.

When all concerns are satisfied, write a memo or transmittal letter to the Project Manager stating the shop drawings are acceptable for the intended use. Retain one copy of the memo and shop drawings for the file, send one copy of the shop drawings to the Traffic Structures group and send the remaining copies to the Project Manager.

3.1.3.2 UNSEALED SHOP DRAWINGS

Unsealed shop drawings are submitted for review by the Traffic Structures Designer. These drawings are intended to be fully reviewed by the Traffic Structures Designer. Check the shop drawings to ensure they match the appropriate details from the project plans and standard drawings. Specifically check the material grades, bolt diameters and bolt circle, hole diameters, plate thickness, member size, member length, camber, reinforcement bar size and placement. The Traffic Structures Designer should then comment on the shop drawings according to the procedure outlined in the 2008 Oregon Specification book, Section 00150.35(d)(2). This procedure is as follows:

After checking submittals for in-house designs, mark the submittals as follows and return to the Project Manager:

- "Approved"
- "Approved As Noted"
- "Returned for Correction"
- “Rejected”

Use a stamp that indicates your Region Tech Center or company, the date you completed the review, and your name. Stamp the submittal clearly on the front page so the stamp is easily visible in the file.

For this type of review, the Engineer of Record is responsible for approving the shop drawings and fabrication cannot proceed until the shop drawings are provided in an approved form. Every time the shop drawing review is finished, the shop drawing must be returned to the Project Manager's office. A note should be included in the transmittal that a copy of the final approved "redlined" shop drawing should be sent to the Materials Inspection Crew Leader.

3.1.3.3 TRAFFIC STRUCTURES WITHOUT A STANDARD DRAWING

In these cases, the standard procedure during construction would be mailing the submittal for the steel poles or foundation to the Traffic Structures group for review. Our office would review the structures and provide recommendations/comments about the structures.

3.1.4 FIELD ERECTION

After shop drawings have been approved by the Traffic Structures Designer, the shop drawings are then returned to the Project Manager's office. The Project Manager will then send the shop drawings back to the contractor and send a courtesy copy to the ODOT Materials Inspection Crew Leader. See Section 2.5.8.4 for a description of the inspection process. In the sign bridge structures and the cantilever monotube sign supports, the standard drawings provide the accepted erection procedure. The contractor has the option to alter this procedure; however, to alter the procedure, the contractor has to submit the change for review. The submittal should clearly show how the procedure will be changed and provide calculations to support that the change will not adversely affect the structure during the erection process.

3.2 SHOP DRAWING REVIEW

3.2.1 GENERAL REQUIREMENTS

Six copies of the shop drawings should be sent in for approval. One of these copies can be used as a working drawing and the other five for the reviewed stamp and red marks. Once the drawings are finished, one copy is retained for the file and four are returned to the Project Manager or the assistant. Any details that do not meet the standard drawings must be accepted by the Traffic Structures Engineer. The process to get a new detail or detail changed on a standard drawing is to submit a request for change to standard drawing form. This document and instructions can be found on the ODOT roadway internet webpage. The proposed modification will be routed to the Traffic Structures Group to get feedback and a consensus will be obtained about whether or not the detail should be changed. In many cases, a proposed change can be a substantial amount of work and current resource levels do not have the capacity to perform the work. Using this method will help ensure consistency and consensus of detail changes.

Main items to check on sign bridge and monotube cantilever shop drawings are:

1. Anchor bolt material, grade, number, bolt circle diameter.
2. Base plate material, number of holes, bolt circle diameter.
3. Number of bolts in the arm connection.
4. Angle of flange on vertical post.
5. Angle of deflection required to achieve the camber.
6. Method used to obtain camber (smooth curved members or angled end plates).
7. Resulting angle of plate on the arm that will achieve the camber angle and takes into account the vertical post flange angle.
8. Location of arm and sign bridge attachment.
9. All structural details of plates, bolts at the connections.
10. Walkway layout and clearances for VMS bridge.
11. Verify field survey data matches original roadway cross section used in design.
12. Reinforcement size, grade, location, and quantity.

Main items to check on pre-qualified signal poles and luminaire poles are:

1. Check grade elevations to see if unusual ground profiles exist at the poles.
2. Verify pole loading does not create a nonstandard pole configuration.

Main items to check on nonstandard structures (such as signal poles, camera poles, foundations, unusual sign supports) are:

1. Verify pole loadings (signals, signs on mastarm and vertical post, and luminaries).
2. Check for pole reactions that are greater than allowed from a standard foundation.
3. Check grade elevations to see if unusual ground profiles exist at the poles.
4. Review pole foundation design and check conformance to TM631 or TM653.
5. Plate size, material, number of holes.
6. Anchor bolt and connection bolt size, material, number.

Many times these structures may be located throughout a plan set (Bridge, Roadway, Illumination, etc.), so the Traffic Structures Designer should do a quick visual check of the entire plan set.

Main items to check on weld submittals are:

1. Shop Drawings
    a. Weld symbols for all the welds on the contract drawings
    b. Joint designations
    c. Fabricator Welding Procedure Specification Identification Number (WPSID)
    d. Material grades
    e. Dimensions
    f. Special inspection requirement.
    g. Non-tubular partial penetration welds
        i. Effective weld size (E)
        ii. Groove depth (S) applicable for the weld
        iii. Applicable WPSID for T-Y-K tubular connections
2. Welding Procedure Specifications (See Section 2.5.8.5 for a detailed discussion)
    a. Check Welding Procedure Specification submitted for each Weld Procedure Specification Identification Number (WPSID) shown on the shop/working drawings.
    b. Weld symbols on the WPS match the weld symbols on the shop/working drawings and contract drawings.

c. When all WPS submittal requirements have been met, the Designer will forward the WPS to the appropriate welding expert who will check the WPS and return the checked WPS to the Designer. See Section 3.5, REVIEW OF STRUCTURAL WELDS AND WELDING PROCEDURE SPECIFICATION (WPS) for information on special topics in weld reviews.

3.3 TRAFFIC STRUCTURES CONSTRUCTION RECORDS

After every submittal is reviewed, the Traffic Structures Designer should keep a copy of the submittal and transmittal in a file folder. This folder is called the Traffic Structures Submittal folder. The submittals should be kept in chronological order at the bottom of the folder. The transmittals should be kept in chronological order and placed on top of the submittals. Other documents contained in the Traffic Structures Submittal file are job pertinent emails or plan revisions that may occur during the course of the project construction support.

Send in copies of finalized shop drawings to the Traffic Structures group and attach a memo summarizing any problems encountered in the project. This allows Technical Services to be aware of design issues and keep the standard drawings updated and accurate.

3.4 COMMUNICATIONS WITH THE OUTSIDE

After the project is awarded to a prime contractor, requests for additional information may be submitted for clarification of the project plans, specifications, or general questions. The requests for information should be sent to the Project Manager. The Construction Project Manager will then forward requests for information to the appropriate person. If a request for information is not made through the Project Manager (PM), the request should be redirected to the PM so they are kept informed of all information concerning the project.

In some instances the Project Manager may request that the Traffic Structures Designer field the questions directly from the contractor. This procedure should only be pursued if the Project Manager approves of the change and this change will help the project timeline. When the requests are sent directly to the Traffic Structures Designer, additional responsibilities have to be assumed. Any communication made with the contractor shall be documented and a courtesy email shall be sent to the Project Manager's office. Before any decision is made, the Traffic Structures Designer should discuss the situation with the Project Manager. Since the Project Manager is responsible for overseeing the construction progress and inspection, the Project Manager needs to be informed of all changes that are made.

3.5 SPECIAL TOPICS IN THE CONSTRUCTION PHASE

The construction phase can be a very challenging part of the overall project. Commonly, issues will arise during construction requiring immediate attention. Many times construction crews are sent home and construction delays can be attributed to a response that is not provided within a reasonable time. Requests for assistance should be given high priority and a timely response. In all issues, especially nonstandard issues, contact the Traffic Structures Engineer for acceptance and consultation. The Traffic Structures group is interested in all issues that occur during a project so we can stay aware of common problems that may be occurring. In addition, the issue may have already been solved in a previous project that could be used as a solution again. Construction assistance may include some or all of the following:

- Cost data reports
- Structure inventory sheets
- Checking shop drawings
- Review of temporary construction drawings
- Review of deviations from the standard drawings
- Interpretation of plans and specifications
- Resolving conflicts in the plans
- Providing recommendations on construction problems
- Field trips to resolve construction problems
- Field trips to review construction
- Review of price agreements
- Review contract change orders
- Review of Contractor proposals for resolving construction problems
- Review of Contractor value engineering proposals
- Preparation and archiving of Calculation Books

3.5.1 TRAFFIC SIGNAL POLES

Traffic signal poles are a pre-qualified structure with new standard drawings that should address 95% of traffic signal pole installations. The new standard drawings released in June, 2005 should account for most loading configurations. There are cases where a strain wire is attached, step slope, custom loading, or dual mastarms that can turn the pole into a non-standard "X" pole in the plans. In these cases, the contractor will submit stamped calculations and shop drawings for review. Many of the details and all of the design requirements from the Standard drawing and specifications apply to the design.

3.5.2 CANTILEVER MONOTUBES

Cantilever monotube sign supports are custom designed structures at each installation. The standard drawing has 10 different standard designs that fit to each installation site. Some issues that may arise during the construction phase of a cantilever monotube sign support are the following:

- Contractor's survey cross section does not match the plan cross section.

- The cantilever was fabricated differently than the standard drawing.
- The reinforcement cage does not match the reinforcement as shown in the standard drawing.

Reviewing these items is time consuming, so the Traffic Structures Designer should allocate enough time to completely check the discrepancy. Fabrication issues are one of the more difficult issues to resolve.

If the construction issue is that the survey cross section does not match the plan cross section, then the situation has more flexibility. Changes can still be made to the project, if necessary. The contractor's cross section may differ from the survey data in the design base map. First make sure the cross section was taken at the location used in the design of the traffic structure. If the cross section was not taken at the correct location, the contractor should be directed to the appropriate location for a new cross section. If the cross section was taken at the correct location and it still does not match the cross section in the plans, then further investigation is required. The Traffic Structures Designer needs to understand that the base map is constructed from a collection of survey points. The survey points are connected together to generate a three dimensional base map that can be used to create cross sections for the project. So each cross section is an interpolation between survey data. The contractor's survey data is the actual data collected from the structure's position in the project. The Traffic Structures Designer can expect a slight discrepancy between the two cross sections and verify the structure will continue to meet the standard drawings. In the case where the field cross section is considerably different from the cross section on the certified drawings in the plans and the structure no longer meets the standard drawing, then the Traffic Structures Designer should notify the Project Manager's office. The Project Manager, contractor, sign designer, and Traffic Structures Designer will determine a solution about how to correct the issue.

3.5.3 TRUSS SIGN BRIDGES AND TRUSS VMS BRIDGES

Truss type variable message sign bridges have had a number of problems associated with the construction of the end posts, the galvanizing process, and substitution for steel due to material composition. These issues required extensive meetings and a consensus was reached about how the issues should be handled. Contact the Traffic Structures Engineer for a complete explanation of the issues and the solution to each issue.

Another issue that has occurred was a contractor using the incorrect anchor bolt circle template. In one case, the shop drawings were redrawn to use a smaller tube size (per the standard drawing) so additional space could be provided for a smaller anchor bolt circle. In another case, the anchor bolt circle was larger than required so calculations had to be performed to check the increased moment arm between the tube wall and the anchor bolt.

3.5.3.1 TRUSS BRIDGE SHOP DRAWING REVIEWS

The shop drawings for these structures must be thoroughly reviewed by the Engineer of Record to make sure that all of the details shown on the standard drawing are used by the manufacturer. It is the responsibility of the Engineer to make sure the correct details as shown on the Standard drawings are used, because these details are based on many years of refinement that have been tested through successful project installations. Proposed detail modifications must be made to the drawing through a Standard Drawing Revision request that can be downloaded from the internet. This request will allow a review by a committee of technical people from the Regions, Technical Services, and Consultants to investigate the detail and whether or not it will be an improvement from the one currently shown on the drawing.

It is important to make sure that all diagonals are concentric so the forces from the chords and the diagonals pass as close as possible through the working point. The standard drawings and most of the shop drawings are two dimensional, so it can be difficult to see if these diagonals are concentric. At the field splice location; there are two of the four joints that will have the diagonals pointing to it. There will be the top or bottom face diagonal, the front or back diagonal, and an interior diagonal between the flanges (many times called the paddle). This issue also occurs at the horizontal to vertical end truss joints. Two of the four joints will have a top or bottom face diagonal, a front or back diagonal, and one diagonal from the vertical end truss.

3.5.4 TRIANGULAR BASE AND MULTI-POST BREAKAWAY

Breakaway structures are special due to the crash testing that is associated with the device. The triangular base breakaway (TBB) and the multi-post breakaway (MPB) have loading criteria that have to be met. The first criterion is the allowable wind force acting on the structure. Each standard has an associated design that allows different post sizes according to the size of sign being used at the installation. The second criterion is the breakaway action of the special base plate configuration. The most common issue that occurs for these types of structures is that the base plate is not oriented in the correct fashion to match the standard drawing. The accepted solution to this problem is to remove and replace the installation to be correct. Another common issue that occurs is the sign structure is installed on a steep slope.

3.5.5 CAMERA POLES

Camera poles have been used for several years and the design has become well defined. The few issues that have developed for these structures are the top tenon plate and the handhole. The camera manufacturer changed how the camera slip joint attaches to the pole, so the top tenon plate had to be increased to match the new connection. The handhole size has come under scrutiny because the maintenance crews were having difficulty using the old style of handhole (two smaller handholes aligned vertically over each other). The camera pole manufacturer has proposed using one larger handhole in place of the two smaller handholes. David Evans & Associates was retained to perform a finite element analysis of a pole with the larger handhole and write a report summarizing the results. From the report, the Traffic Structures group has accepted the use of the large handhole as long as the combined stress ratio at the location of the handhole does not exceed 0.60. Typically, the camera poles are controlled by the 1” deflection requirement to limit camera shake under service loads. Contact the Traffic Structures Engineer for details and requirements to include on a drawing. The special provision 965 is to be used for the camera pole projects.

3.5.6 HIGHMAST

Currently, a guideline exists that states in current projects highmast illumination poles will not be used. In some instances, a project may replace an existing highmast pole and then becomes an exception to the guideline. The old ODOT standard drawings for High Mast poles have been removed. The frequency of the use of this structure does not lend itself to be a standard. In addition, a structural designer needs to be involved to assign structure numbers, perform a foundation design, and provide stamped plans and specifications.

Traffic structures have encountered very few issues with highmast poles, mainly due to the lack of use of this type of structure. The first issue is reusing an existing highmast pole. In this case, the intent was to relocate an existing highmast pole. To perform this move, the highmast pole has to be disassembled for relocation and then a new foundation with the correct anchor bolt circle has to be placed. We have encountered problems with the slip connection on the highmast poles. Due to the repetitive temperature movements the slip joint can seize and the highmast pole cannot be disassembled. The Traffic Structures group has determined it is unacceptable to cut the highmast pole at the joint and then weld the pieces back together once the pole has been lowered. Another issue is the anchor bolt circle has to be placed correctly to fit the base plate. This will take considerable coordination between the field crew and the foundation contractor. The last issue is for new poles used to replace old poles. In the pole analysis calculations, the engineer needs to demonstrate the handhole rim will increase the area of the cross section to 120% of the original cross section. In addition to the 120% of the area, the handhole rim needs to maintain the section properties of the original area. This means the new area needs to equal 120% of the old area and the moment of inertia, section modulus, polar moment of inertia, and radius of gyration all need to be at least equal to the original values.

3.5.7 ILLUMINATION POLES

Illumination poles are currently a pre-qualified structure. The Illumination Designer will typically callout the location and height to luminaire on the project documents. Once the submittal is sent in for review, the Illumination Designer will verify the submitted poles match the field data. The Traffic Structures group has encountered very few problems with the illumination review process. Typically the illumination poles remain with the requirements of the standard drawing and the review process can be completed in a quick manner.

The only situation Traffic Structures has encountered, outside of the standard drawing, are luminaire poles supported upon a bridge rail. In this instance, the base reactions have to be checked against the reactions for the illumination poles. Each instance can be different and you have to work with the Bridge Engineer to determine how the base reaction review should be conducted. Another challenge for illumination poles are the slip base luminaire poles installed on slopes. In many instances, because the luminaire pole is installed on a slope, the base should probably be fixed; however, luminaire poles are usually specified to have a slip base. The slope can adversely affect the slip mechanism during a crash event and it may not be possible to install the foundation per the standard drawing.

3.5.8 GENERAL STEEL ITEMS

A small number of issues exist with steel used in traffic structures that may surface during a project. This section discusses some of the specific issues that have been addressed and provides the Traffic Structures recommendation, when appropriate.

3.5.8.1 CARBON EQUIVALENCY

The carbon equivalency is important to steel structures because the percentage of carbon equivalency (based upon the silicon content of the steel) will determine how susceptible the steel is to embrittlement during the hot-dip galvanizing process. For the ODOT project Biggs

Variable Message Sign, an end truss was hot-dip galvanized to meet the requirements of the standard drawing. When the end truss was removed from the zinc bath, the strut that connects the tops of the tubes for the end post had pulled out of the tube wall. After further investigation, ODOT decided to limit the carbon equivalency, silicon content, and tin content to very specific ranges and changed the steel detailing for the top and bottom struts for the end posted to bolted connections. These limitations were implemented to avoid cold cracking. Refer to Annex XI of the AWS D1.1 for additional discussions on this issue. Over the last few years ODOT has not had another failure in the galvanizing tank. The carbon equivalency requirement was added only to the Truss Bridges as a direct result of failures of end posts in the galvanizing tanks.

The lack of issues in the galvanizing tank has led to changing the wording in the note section of the truss bridge standard drawings. The note used to state "The maximum carbon equivalent (CE) is 0.40% for the base metal. Use the AWS D1.1 CE formula. Tin content of the galvanizing shall not exceed 0.18%". This note has been revised to state "The maximum carbon equivalent (CE) is 0.40% for the base metal. Use the AWS D1.1 CE formula. Preheat according to AWS D1.5 Annex VIII using the hydrogen control method and high degree of restraint when the carbon equivalent (CE) of the steel exceeds 0.40%". This revised statement notifies the manufacturers that they must follow CE requirements for truss bridges, but it allows for a quicker turn around time under construction.

3.5.8.2 HOT-DIP GALVANIZING

The purpose of hot-dip galvanizing is to coat a piece of steel with a covering of molten metal (of which a large percentage of the composition is zinc) in order to protect the steel from corrosion due to environmental conditions. The process of hot-dip galvanizing is controlled by ASTM Specifications ASTM A 123 & A 153. This process is performed by dipping a piece of steel (i.e., a signal mastarm) into a series of tanks that clean the steel, prepare the surface of the steel, and finally coat the steel in molten zinc. The zinc coating protects the steel from corrosion by sealing the surface so the steel does not come into contact with oxygen and moisture. In the event that the zinc coating becomes damaged, then the coating surrounding the damaged area will corrode and protect the steel. More information and a demonstration video are available from the American Galvanizers Association website.

3.5.8.3 TOUCH-UP GALVANIZING

Touch-up galvanizing is intended to repair a small section of a hot-dip galvanizing that has become damaged (i.e., the zinc from the hot-dip galvanizing process has been removed from the surface of the steel). The repair is achieved by resealing the steel surface to protect the structure from the environment. Touch-up galvanizing is controlled by ASTM Specification A 780. The galvanizing can be repaired by three different methods. These methods are hot stick, zinc paint, and zinc spray. Hot stick repair is achieved by applying a new coat of zinc to the steel by heating a zinc rod or powder with a low melting point over the damaged area. The steel being repaired must be heated to a temperature of 600 deg prior to application of the new zinc. The heat bonds the zinc rod or powder to the steel surface. Hot stick repair is the most time intensive repair. Zinc paint repair applies a thick layer of zinc rich primer over the damaged area. Zinc paint does not use heat to bond the paint to the steel surface; the seal is achieved by the paint drying on the steel structure and creates a band-aid over the damage. Zinc paint is faster than hot stick repair and slower than zinc spray. The last repair method, zinc spray, covers the damaged area with a thin layer of zinc paint that is discharged from a pressurized metal spray can. The repair method is the same as the zinc paint. Zinc spray is the fastest repair method of the three.

In general, touch-up galvanizing is not accepted for new structures being installed on projects. Traffic Structures has decided that for new projects, structures should be provided to the site without damage to the galvanizing. If the galvanizing is extensively damaged, the structure should be stripped of the galvanization and hot-dip galvanized again. The process of stripping and re-galvanizing will add time and cost to the project. The amount of time and cost will depend upon the schedule of the galvanizing facility. There are circumstances where the use of touch-up galvanizing is acceptable. Each case has to be handled individually and the circumstances and severity of the repair have to be considered. A request for information (RFI) must be submitted to the Project Manager to request acceptance of the proposed procedure. The RFI must include the project name, contract number, how the damage occurred, the extent of the galvanizing damage, what type of galvanizing repair method will be used, and any time or background issues that may affect the project.

3.5.8.4 MATERIAL LAB INSPECTORS

The Materials Lab group has a crew of inspectors that are responsible for inspecting steel components for sign bridges, butterfly supports, and cantilever monotubes. Every project that includes overhead signing or butterfly supports will require inspection from ODOT personnel. Portland Inspection Crew Leader has the responsibility for inspection of all fabricated overhead signing or butterfly supports. After the Traffic Structures Designer has finished their review of the shop drawings, the Traffic Structures Designer should request the Project Manager's office to send a courtesy copy of the shop drawing to Portland Inspection Crew Leader. The courtesy copy should include all the Traffic Structures Designer's comments (redlines) and a copy of each round of review should go the Materials Inspection Crew Leader. Once the shop drawing is approved by the Traffic Structures Designer, the Inspection Crew Leader will assign someone to visit the fabrication shop during the manufacturing of the structural support.

The inspector usually visits a fabrication shop several times during a project. During the inspection, the inspector will verify the critical member dimensions and lengths (end posts, bridge spans, and member sizes). If any discrepancies have occurred between the approved shop drawings and the fabricated structure, the inspector will notify the Project Manager. The Project Manager will then contact the Engineer of Record to begin discussions about possible solutions to the problem. Any changes made to a traffic structure that deviate from the standard drawings require approval from the Traffic Structures Engineer. Submit copies of all proposals for approval prior to fabrication.

The Traffic Structures group has developed a document that helps the Traffic Structures Designer to check the fabricated horizontal sign bridge to the field data from the footing placement. This document is titled "Sign Bridge Horizontal Span Inspection Sheet". This sheet requests the inspector to measure the centerline distance between the outside holes of the horizontal bridge on all four chords. This allows the Traffic Structures Designer to verify the four chord spans are within tolerance to place the bridge and verify the span distance between the sign bridge footings will allow the bridge to be placed.

3.5.8.5 REVIEW OF WELDS AND WELDING PROCEDURE SPECIFICATIONS (WPS)

The Traffic Structures designer must ensure that the welds shown on the shop drawings are in accordance with the standard drawing or custom detail. Welds that are different than those shown on the Standard drawing must be sent in for review by the Traffic Structures group. In many cases, the type of weld has been specified to accommodate fatigue design requirements from the AASHTO code.

3.5.8.5.1 WELD DESIGNATIONS ON SUBMITTALS

When shop drawings for a particular portion of the project are submitted for a review, the submittal will include weld designations that will be used to construct the traffic structure. As the Traffic Structures Reviewer, you should look for several specific items. These items are outlined in the list below:

1. Verify the weld symbol in the standard drawing, pre-qualified or nonstandard project drawing matches the weld symbol in the shop drawing. Look for the type of weld (Fillet, V-Groove, etc,), weld size, all around designation, grinding designations, weld length, weld spacing, and weld angle.
2. If the weld symbol is different and the company has provided a reasonable explanation why the weld was required to be changed, review the weld stress calculations for adequacy. Verify the correct yield stress was used and the shear flow has been calculated correctly at the weld location.
3. If the weld symbol is different and the company has not provided a reasonable explanation why the weld was changed, then change the shop drawing to reflect the correct weld symbol and return the submittal.

3.5.8.5.2 WELDING PROCEDURE SPECIFICATION (WPS) REVIEW

For each weld designation submitted in the shop drawings, a welding procedure specification will be submitted for review. The welding procedure specification will outline the details of a weld that will be used during the process of welding for each weld used in the fabrication of a structure. Due to the special nature of the welding procedure specification, the WPS should be sent to the Bridge Section's welding expert for review. Some manufacturers have already sent in WPS's for review and those particular submittals can be checked quickly against the approved sets.

3.5.9 GENERAL CONCRETE ITEMS

3.5.9.1 COMMERCIAL GRADE CONCRETE VS BRIDGE CONCRETE

Two types of concrete can be used on traffic structures. The first type is commercial grade concrete (CGC). Commercial grade concrete is also referred to as 440 concrete. This concrete is controlled by the Specification Section 440. CGC is specifically used for all traffic structures footings and is classified as a structural item for both Sign Bridge Structures, Cantilever Monotubes, and Butterfly Sign Supports. The specific qualities of CGC concrete are as follows:

- The minimum compressive strength is limited to 3000 psi (as modified by the Special Provisions for Specification Section 440).

- The Quality Control Technician (QCT) collects samples before pumping and performs testing.

The second type is bridge concrete. Bridge concrete is also referred to as 540 concrete or structural concrete. This concrete is controlled by the Specification Section 540. Bridge concrete is not typically used for traffic structures. The specific qualities of bridge concrete are as follows:

- The minimum class to be used is 3600 psi (as modified by the Special Provisions for Specification Section 540), unless specified otherwise.

- According to the ODOT Manual for Testing Procedures (MFTP).

The main differences between commercial grade concrete and structural concrete are the quality control testing and the concrete placement guidelines. Structural concrete placement guidelines are very stringent about the placement of concrete and how the concrete material is tested. Section 540 of the Specifications define what the Quality Control Technician (QCT) and Concrete Control Technician (CCT) have to test, the construction tolerances are defined, how the concrete can be transported, and limitations for handling and placing the concrete are listed. Section 440 of the Specifications only defines general guidelines for testing and placing of concrete.

3.5.9.2 MANUAL OF FIELD TEST PROCEDURES

This document can be obtained from Contractor Plans office. It documents quality control procedures to follow for non-field-tested and field tested materials.

An example of quality assurance for non-field-tested materials is signal poles. The specification 962.10 specifies steel poles 2930 and 2530.80 specifies “Acceptance of steel poles will be according to 165.35”. In 165.35 there are requirements for test results certificate, quality compliance certificate, Equipment List and Drawings, and Certificate of Origin of Steel Materials. The table at the front of the manual gives a listing under Section 990 of Q, E, O, and F. These designations are the same items that are in the specification.

An example of quality assurance for Field materials is for 440 concrete. Section 4(D) of the manual has a table that shows the requirements for the field testing of 440 concrete. The requirements list the material and operation, description, test method, Form, and quality assurance. The tests that are performed are sampling air content slump, concrete temperature, and strength. These requirements are not specifically listed in Section 440 of the specification, but are required under the statement “The QCT shall perform all required sampling and testing” in section 440.14.

3.5.9.3 CONCRETE COMPRESSIVE STRENGTH

The minimum compressive strength for concrete can be interpreted as four different values between the standard drawings and the 2008 Standard Specifications book. In the standard drawings, minimum compressive strengths are called out as 3600 psi, and 3000 psi. The English Standard Specifications 00440 and 00540 require compressive strengths of 3300 psi. The Special Provisions for 00440 and 00540 require compressive strengths of 3000 psi and

3600 psi. The four compressive strengths that are specified are 2900 psi, 3000 psi, 3300 psi, and 3600 psi. This section will discuss which structures should use which compressive strength.

The current standard of practice for contract documents is specified in Section 00150.10(a). Discrepancies between documents will be resolved with Contract Change Orders taking highest precedence, then Special Provisions, Agency prepared drawings specifically applicable to the project and bearing the project title, reviewed and accepted stamped working drawings, Standard Drawings, Approved Unstamped Working Drawings, Supplemental Specifications, Standard Specifications, and all other contract documents not listed. A note on a drawing shall take precedence over drawing details.

The first category addresses structures that specify the use of commercial grade concrete with a compressive strength of 3000 psi. These structures include Multi-post Breakaway Sign Supports (TM600), Triangular Base Breakaway Sign Supports (TM602), 90 deg Rotational Sign Support (TM605), Standard VMS Bridge (TM607), Standard Sign Bridge (TM15), Standard Cantilever Monotube (TM623), Luminaire Poles (TM629), Signal Poles (TM650), Butterfly Sign Supports (Nonstandard), and Camera Poles (Nonstandard). Multi-post and Triangular Base Breakaway Sign Supports specify “All concrete shall be Commercial Grace Concrete (f’c=3000 psi)”. The current Standard Specification for 440 concrete states under Section 440.12, Bullet 4 “Compressive Strength – Unless otherwise noted, CGC shall attain a 28-day compressive strength of at least 3300 psi.” The Special Provisions for 00440 alter the compressive strength to 3000 psi, however, the “Unless otherwise noted” language remains in the Specification. Under this set of information, the concrete used on the Breakaway Sign Supports should have a compressive strength of 3000 psi. Luminaire, Signal, and Camera Poles specify “Footing concrete shall be Commercial Grade Concrete (f’c=3000 psi) unless shown otherwise in the Special Provisions.” As stated earlier, the Special Provisions require 3000 psi concrete; however, in this case the standard drawing and Special Provisions specify the same compressive strength.

The second category are structures that specific the use of bridge concrete. Structures that use bridge concrete specify classes of concrete. The class corresponds to the compressive strength of the concrete. Bridge concrete also requires extra testing. That testing is explained in the Field Test Procedure Manual. The traffic structures typically do not require bridge concrete.

3.5.9.4 LOW STRENGTH CAST-IN-PLACE MEMBERS

For Commercial Grade Concrete with 28-day compressive strengths below 100% of specified compressive strength, concrete will have to be evaluated for structural adequacy. Section 440 of the Specifications discusses in detail how low strength concrete should be handled. In general, the Project Manager should contact the Traffic Structures Designer and the Traffic Structures Engineer to verify if the low strength concrete will be acceptable. If members are found to be adequate, then the concrete can be accepted at a reduced price that is determined by the Project Manager.

By comparison, for 540 Bridge Concrete any strengths below 100% of specified strength, the structural adequacy will be approved by Project Manager. The Designer will review each case and will send a written recommendation to the Project Manager to remove or leave the concrete in place. If members are found to be adequate, then the concrete will be accepted at a reduced price. For a detailed discussion of low strength bridge concrete, refer to Section 540.17(c)(4).

3.5.9.5 CONCRETE PLACEMENT

Concrete placed for a traffic structure is specified by Special Provision Section 440.40 (b) or 540.48(a). The Special Provision adds a sentence to the 440.40 (b) Specification to say "For sign supports, signal supports, and luminaire supports, place concrete according to 00540.48(a)." The two main points for placing concrete per 540.48 (a) is (1.) the placement should be made as close as possible to the final position and (2.) placing concrete that requires dropping more than 5 feet shall use a tremie. These two conditions ensure that during concrete placement, the aggregate will not segregate from the concrete mix. If the concrete mixture did segregate, then the compressive strength would not be achieved and the foundation would possibly need to be rejected.

3.5.10 GENERAL WOOD ITEMS

ODOT uses temporary wood strain poles and wood posts, but these topics were not finished at the time this manual was released.

3.5.11 GENERAL PRODUCTS

3.5.11.1 ACCEPTED PRODUCTS FOR TRAFFIC ENGINEERING AND OPERATIONS SECTION

The Traffic Engineering and Operations Section have created three lists of qualified products that can be used on state highways for traffic signal installations. The first list is referred to as the Blue Sheets. The Blue Sheets are reserved for items that are outside of the controller cabinet. The Green Sheets are reserved for items that are used in the controller cabinet, including the cabinet itself. The Red Sheets are reserved for products that have been given exempt status concerning the requirement of being UL of NRTL listed products. For a detailed discussion of the Blue, Green, and Red Sheets refer to the ODOT Traffic Signal Design Manual.

3.5.11.2 QUALIFIED PRODUCTS LIST

The Structure Services Unit is responsible for evaluating various products to determine if they meet ODOT´s Specifications for use on construction projects. The results are published semi-annually in the QUALIFIED PRODUCTS LIST or QPL. The QPL is a comprehensive listing of all finished products found to be acceptable by ODOT for use with specific categories in roadway construction and maintenance. Additional information and the list of products can be searched at the following QPL website.

Any proprietary product that is used on a project must be approved by the Structure Services Unit. If during a project, the Traffic Structures Designer encounters a new product the contractor wants to use, any information pertaining to the new product must be sent to the Traffic Structures Engineer for review. Once the Traffic Structures Engineer accepts the new product, the Structure Services Unit will be notified of the request for testing samples. See

Appendix F for a general description of the product review process through Structure Services Unit.

The QPL includes many different products; however, the list shown below includes the specific items that pertain to traffic structures:

- Admixtures for Concrete
- Portland Cement
- Coating for Rebar Splices
- Coating for Epoxy Coated Rebar
- Concrete Anchors, Mechanical & Resin
- Concrete Modifier: Fly Ash & Silica Fume
- Non-shrink Grout
- Rebar Manufacturers
- Rebar Slice, Mechanical
- Square tube sign supports

Most of the products listed above are not accounted for in the standard drawings and, if they are used in a project, have to be approved by the Traffic Structures Engineer. The items that do not have to be approved are Admixtures, Portland Cement, Non-shrink Grout and Rebar Manufacturers, as long as the product to be used is listed on the QPL.

4

Drafting

4.1 GENERAL

The Traffic Structures group was moved from the Bridge Section to the Traffic-Roadway Section in 2002. During this transition, it was decided that the Traffic border would be used for all projects that contained Traffic Structure designs except for those attached to bridges. In 2006, the ITS group moved from the Traffic-Roadway Section (TRS) to the Office of Maintenance and Operations (OMO) and this resulted in the assigning of OMO drawing numbers instead of TRS drawing numbers for plan sheets involving ITS traffic structures. The Traffic and OMO Borders use an 11-in. x 17-in. border instead of a full size 32-in. x 22-in. border. The 11-in. x 17-in. requires less desk space to review and copies can easily be made on most office copiers. In addition, the plans are distributed in 11-in. x 17-in., the drawing must be legible in this size, so having the drawing already in this size makes it easier to make sure it is legible.

A design request will be received from a Signal, Sign, Illumination, ITS, or Temporary Traffic Control designer. Once the specific group is identified, the border will be according to that group's standard practice and will use a drawing number from that group. It is recommended for the structural designer to obtain the TRS or OMO drawing number from the designer at the same time that the other TRS or OPO drawing numbers are assigned to ensure that the TRS or OMO drawing numbers will be sequentially ordered in the plans. Using the TRS or OMO drawing numbers requires the traffic structure design drawing be located in the plans with the loading used to design it. This eliminates the added step of searching for the traffic structural support that is contained somewhere in the Bridge drawings.

Traffic Structures that are mounted on a Bridge will use the Bridge Standards and procedures for creating the plan drawings. These structures are considered to be a part of the bridge structure that it is attached to and will have the same structure number as the Bridge structure number and will have a structural work number listed under the Bridge Structure.

4.1.1 LOCATION MAP

The use of a project location map in the upper right hand corner of the site specific traffic structures drawing increases the risk of a conflict where it will not match the roadway drawings and the signing drawings, so it is recommended to not include it on the plan drawings. In addition, the location map takes up space on the drawing that is needed when multiple structures are specified on one drawing. Finally, when multiple traffic structures are shown on one drawing, adding a location map that will cover each location can be difficult to accomplish and unclear.

4.2 BORDERS AND TITLE BLOCKS

The border will be according to the Signal, Sign, Illumination, ITS, or Temporary Traffic Control guidelines. The Traffic border for Traffic Structures can be created using the following steps:

1. Use Microstation V8 with the ODOT CAD workspace attachment.
2. Use Plotypus to place a B – 11 x 17 border, with Landscape orientation, and a sheet scale of 1200-1"=100'.
3. Select ODOT from the File Menu and then select Drafting.
4. Select Traffic and then Signal from the left pull down menu.
5. Select Title Blocks, 1st Sht TB, and place it on the bottom right corner of the Plotypus border.
6. Select Title Blocks, Structure Side Note, and place it to the left of the title block.

The ITS border for Traffic Structures can be created using the following steps:

1. Use Microstation V8 with the ODOT CAD workspace attachment.
2. Use Plotypus to place a B – 11 x 17 border, with Landscape orientation, and a sheet scale of 1200-1"=100'.
3. Select ODOT from the File Menu and then select Drafting.
4. Select ITS from the left pull down menu.
5. Select Plan Sheet Notes, Title Block Structural, and place it on the bottom right corner of the Plotypus border.

This will result in a Title Block that is similar to that shown in Figure 4-1. This is the starting point that will require additional changes to make the border fit the specific group format.

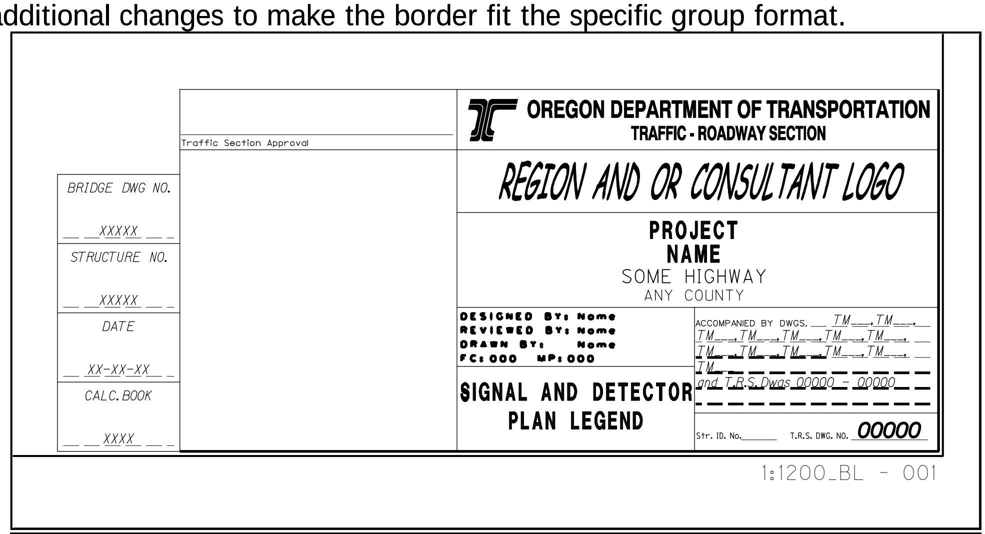

Figure 4-1 – Traffic Structures Title Block before modifications.

This border will need to be modified to fit the Signal, Sign, Illumination, ITS, or Temporary Traffic Control drafting guidelines. The FC stands for Filing Code and it is the Highway number. The MP is the milepoint that the structure is at on the highway. The Str. ID No. is not currently used and can be deleted. This number can sometimes be confused with the Structure Number and is not required. The Traffic Structures designer must investigate whether the Traffic Section Approval Signature is required according to the group that the design is for.

The Bridge DWG NO. and the Structure No. can be obtained from the Regional Bridge Drafter. Please see the section in this manual about CALC books for where to obtain a CALC book number. It is important to have these three items listed on the drawing when providing a major sign structure like Truss Sign Bridges, Monotube Cantilevers, or Butterflies. The reference bridge drawing number and structure number are used to track, inspect, and create reports of these structures in the future.

It is standard pratice to have either the stamping Engineer or designer working under the direction of the stamping Engineer specified in the Designed By Name location, the person that checks the work is placed in the Reviewed By Name location, and the drafter specified in the Drawn By Name location. Reviewing a design is not the same as checking a design, so “Reviewed By” can be changed to “Checked By”.

Traffic does not place a location map on the top right of the drawings. At the top right corner there can be up to three lines. The top line will be the type of support. The second line will be the intersection if applicable. The third line will be the highway name and the mile point. The sheet heading font style can be found under the signal Text Styles drop dropdown list. A location map can be added under the description lines if it is preferred to include it.

4.3 FONTS AND LINESTYLES

In general, the text and lines should follow the same standards that are used by the Bridge Section. Many of the Traffic Structures standard drawings contain text fonts, line styles, dimensions styles, arrows, etc, that have historically been used by the Bridge Section. There is no good reason to update to something different. The Bridge drafting standard will be used for everything besides the information listed in this Chapter. Reference the Bridge Design and Drafting Manual for additional information.

4.4 AS CONSTRUCTED DRAWINGS

The As Constructed Plan Technical Services Bulletin TSB08-01(B) has an effective date of 06/01/2008 and its purpose is to establish a uniform and consistent process for preparing and distributing As Constructed Plans. The Technical Bulletin requires that the Contract Plan Development Guide and the Construction Manual be updated to reflect the guidance in the TSB08-01(B) bulletin.

The Mylars for Traffic Structures drawings are specific to the Illumination, Signing, Signals, or ITS group and will have the drawing number for this group in the title block. The Project Manager’s office will assemble the project As Constructed plans and send them to the Region Technical center after a project is complete. A designer that is interested in reviewing the redlines made on the As Constructed drawing during construction to ensure that they are correct must contact the Region Technical center to coordinate the review. After the review process, the As Constructed plan drawing set for the project is sent to the ODOT Maps and Plans center and distributed to the specific Traffic or ITS group with which the original Mylar was archived. The Traffic or ITS As Constructed drawings are scanned for Filenet and the drawing is stored with the original Mylar.

Local Agency projects on the State Highway must send As Constructed drawings to the Local Agency Liaison for distribution. Permit projects on the State Highway must send As Constructed drawings to the Permit Specialist for distribution.

Appendix A

Structural File Document Order (from the top down):

1. Engineering Result
    a. Analysis cover sheet
    b. Letter
    c. Transmittal with remarks
    d. E-mail
2. Contacts Information
3. E-mails (placed in chronological order)
4. Engineering Calculations (placed in chronological order, if at all possible)
5. Pertinent reference drawings
6. Structure and drawing number information
    a. Structure and drawing number request form
    b. Printout of structure details window from the Bridge Data System
7. Transmittals and work request letters
8. Project prospectus
9. PCS Report, if applicable

Appendix B

Project Name: ______________________________
PCS Key Number: ______________________________
Highway Number: ____________________ Milepost: ____________________
Designer: ____________________

Preliminary Plans

Date:

- ☐ Find out types of structures used on the project from the designer.See TSOPM Sect. 1.4.1
- ☐ Find location of structures used on the project from the designer. See TSOPM Sect. 1.4.1
- ☐ Request cross sections from the rdwy. designer at each location. See TSOPM Sect. 1.4.1.
- ☐ Request a Geotech report at each loc. from Tech Center Geotech. See TSOPM Sect 1.4.1
- ☐ Recieve cross sections from the roadway designer.
- ☐ Recieve Geotechnical report at each structure location.
- ☐ Draft each structure on the border and reference the cross sections provided by roadway.
  - ☐ Check vertical clearance of structures (Bottom of sign @ middle of min & max road clearance).
  - ☐ Check horizontal clearnaces between structure and roadway.
  - ☐ Verify structures fall within the standard drawing for each structure type.
  - ☐ Fill in Data Table.
- ☐ Calculate cost estimate for structures. See TSOPM Sect. 1.4.1.
- ☐ Place calculations into Calculation Book. See TSOPM Sect. 1.6.4.
- ☐ Attend Preliminary Plans meeting. See TSOPM Sect. 1.4.1.

Advance Plans

Date:

- ☐ Recieve and incorporate Preliminary Plans meeting comments. See TSOPM Sect. 1.4.2.
- ☐ Update cost estimate from Prelimnary Plans meeting comments.
- ☐ Download the latest copy of the special provisions. See section 1.6.2 in Office Practice Manual for table of special provisions.
- ☐ Modify special provisions to match the project requirements.
- ☐ Send Advance Plans, updated cost estimates, and Special Provisions to Specification Writer.
- ☐ Add any additional calculations to the Calculation Book
- ☐ Attend Advance Plans meeting. See TSOPM Sect. 1.4.2.

Final Plans

Date:

- ☐ Recieve and incorporate Advance Plans meeting comments. See TSOPM Sect. 1.4.3.
- ☐ Update cost esitmate from Advance Plans meeting comments.
- ☐ Verify special provisions have not been updated on the website since Advance Plans.
- ☐ Send a final copy of documents (plans, specs, cost estimates) to the Spec. Writer.
- ☐ Attend Plans in Hand meeting if necessary. See TSOPM Sect. 1.4.3.
- ☐ Finish project documentation after project has been released for bid. See TSOPM Sect. 1.5

Bid Let

Date:

Appendix C

Revision History

Revision Date	Description	By	Check
May 2012	Added Section 2.6.2 Monotube Butterfly Sign Supports	S. Jollo	W. Woods
May 2012	Added Section 2.6.3 Monotube Cantilever Fatigue Loading.	S. Jollo	W. Woods
May 2012	Added Truck Gust guidance to Section 2.7.1.	S. Jollo	W. Woods
May 2012	Added area center comparison guidance to Section 2.11.1.	S. Jollo	W. Woods
May 2012	Added Section 2.11.6 Questions to Investigate before Re-Using a Structure.	S. Jollo	W. Woods
May 2012	Added Section 4.1.1 Location Map.	S. Jollo	W. Woods
May 2011	Added welding inspection information to Section 1.5.4.	S. Jollo	S. Lovejoy
May 2011	Changed reference in Section 2.9.2.1 from 1.6.4.2 to 2.9.1.1.	S. Jollo	W. Woods
May 2011	Added Section 2.10.4 Luminaire Support Fatigue Requirements.	S. Jollo	W. Woods
May 2011	Updated the number sequence in Section 3.5.8.5.1.	S. Jollo	W. Woods
May 2011	Added Section 4.4 As Constructed Drawings.	S. Jollo	S. Cramer
May 2010	Added that the ITS Unit is located in the OMO in Section 1.5.1.	S. Jollo	A. Bradford
May 2010	Added Wood Posts to list and revised PSST drawing number to Section 1.2.1	S. Jollo	S. Cramer
May 2010	Added Section 2.6.1 Variable Message Signs Mounted on Monotube Cantilever Supports.	S. Jollo	G. McGill
May 2010	Added that the ITS drawing information is located in the OMO to Section 4.1.	S. Jollo	A. Bradford
May 2010	Added method to create the ITS Structural border to Section 4.2.	S. Jollo	A. Bradford
May 2010	Added information about the personnel to specify in the Title Block.	S. Jollo	S. Cramer
May 2009	Added Appendix C Revision History	S. Jollo	S. Cramer
May 2009	Revised Section 1.4.2 Advanced and Section 1.4.3 Final Plans to have plans in hand meeting after the advanced plans have been completed	S. Jollo	S. Cramer
May 2009	Added Section 2.4 Wind Speeds and Pressures.	S. Jollo	S. Cramer
May 2009	Added Section 2.8.1 Wood Post Sign Supports.	S. Jollo	S. Cramer
May 2009	Added dual mastarm loading requirement clarification in Section 2.9.1.	S. Jollo	S. Cramer
May 2009	Added Section 2.12 Replacing Traffic Structures In-Kind	S. Jollo	S. Cramer
May 2009	Added Section 2.13 Steel Design and Section 2.13.1 Base Plates and Flanges.	S. Jollo	S. Cramer
May 2009	Added Section 3.5.3.1 Truss Bridge Shop Drawing Reviews.	S. Jollo	S. Cramer
May 2009	Added Chapter 4 Drafting.	S. Jollo	S. Cramer

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