Oregon Department of Transportation

Traffic Structures Design Manual

Delivery & Operations Division | Traffic Roadway Section

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Oregon Department of Transportation

Statewide Project Delivery Branch – Engineering & Technical Services Branch

Traffic-Roadway Section

4040 Fairview Industrial Drive SE, MS#5

Salem, Oregon 97302

503-986-3568

www.oregon.gov/odot/Engineering/Pages/Traffic-Roadway.aspx

Foreword

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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1 Design Phase of Standard & Non-Standard 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. You can find more information on project teams and how they operate 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 start 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 resident engineer'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 the 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 type of maintenance required from region maintenance staff.
- **ITS designer:** Provides placement and aligns ITS devices.
- **Erosion Control specialist:** Addresses soil erosion problems and construction contamination issues. Provides erosion control systems design 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.
- **Traffic Control designer:** Determines the traffic control devices that are required during construction to redirect traffic.
- **Traffic Structures designer:** Designs the traffic structures that will be used on the project. See the next section for a detailed explanation.

1.2 Types of Traffic Structures

1.2.1 Standard Traffic Structures

Currently there are 13 standard traffic structures used on the state highway system. These standard traffic structures and associated ODOT Standard Drawings are:

- Multi-Post Breakaway (TM600, TM601).
- Triangular Base Breakaway (TM602).
- Truss Type VMS Bridge (TM606 through TM612).
- Truss Type Sign Bridge (TM614 through TM620).
- Monotube Cantilever Sign Support (TM621 through TM628).
- Slip Base and Fixed Base Luminaire Support (TM629, TM630).

- Traffic Signal Support (TM650 through TM653).
- Traffic Signal 60’ Through 75’ Mast Arm Supports (TM655 through TM658).
- Wood Post Sign Supports (TM670).
- Perforated Steel Square Tube (PSST) Sign Supports (TM681, TM687, and TM688).
- Monotube Walk-in VMS Cantilever (TM690 and TM691).
- Monotube VMS/Sign Bridge (TM693 and TM697).
- Monotube Type 1 VMS Walk-In Bridge (TM698).

The standard drawings can be downloaded from the ODOT internet web page.

1.2.2 Non-Standard Traffic Structures

Nonstandard traffic structures will occasionally show up on a project. Nonstandard traffic structures are the responsibility of the engineer of record and should be sent to the State Traffic Standards group for design or review. The State Traffic Structures group will either provide or review the design calculations, drawings, and any Special Provisions that are necessary for the structure. The State Traffic Structures group will then evaluate if the nonstandard design will be used often enough to be given a standard detail number. If a standard detail is used often enough, it will be added to the TM600 series standard drawings. 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 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 State Traffic Structures group for review.

1.2.3 Traffic Structures Mounted on Bridges

There is one exception to the traffic structures process described in this chapter and that is when the structure is mounted onto a bridge. When a traffic structure is on a bridge, the 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

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 is placed at the location, the designer creates and submits the Special Provisions and the cost estimate to the project team. Two or three project meetings occur during the design phase of the project and the project team members discuss the project plans, Special Provisions and cost estimate. 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 resident engineer. This reduces the chances of construction time delays and costly change orders.

1.4 Project Phases

For a Traffic Structures designer, the typical work on a project is scoping, DAP, preliminary plans, advance plans and final plans. Refer to Appendix B for an outlined procedure that you can follow for each phase of a project. Each phase has its own set of benchmarks that need to be completed for the project to meet the timeline. Reference the Project Delivery Guide for additional thorough guidance about the project phases in addition to the information covered in this manual.

1.4.1 Scoping

Traffic designers may contact Traffic Structure designers for advice or they may be placed on a scoping team to determine the type of traffic structures required on a STIP project. The Traffic Structures designers will determine which traffic structures will need to be replaced from corrosion, reanalyzed for additional loading, and/or added to support new traffic devices. In addition, a cost estimate will be required for the superstructure and substructure based on historical cost data. You can obtain this data from the Bridge Section's yearly Bridge Cost Data document that includes traffic structures or by contacting the Specifications Unit for a recommended cost value for a specific traffic structures bid item.

1.4.2 Design Acceptance Package

This phase of the project establishes geometric boundaries to move the project forward. Traffic structures that are required must be identified and have critical items finished to move past the DAP stage gate.

1.4.3 Preliminary 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 Signal, Sign, Illumination, and ITS designer will determine the types of traffic structures used in a project. 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 that the Roadway designer cut a roadway cross section from the digital terrain model.

Once you receive the traffic structure locations, 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, ask the Geotechnical engineer what type of soil investigation would be appropriate. The project may cover a large distance 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″ too 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 provided by the Traffic Structure group to create 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.

1.4.3.1 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. Allowable Stress Design (ASD)
2. AASHTO Standard Specifications for Structural Supports for Highway Signs, Signals, and Luminaires. Load and Resistance Factor Design (LRFD).
3. Manual of Steel Construction Allowable Stress Design.
4. 1994 AASHTO Standard Specifications for Structural Supports for Highway Signs, Signals, and Luminaires (copies can be obtained from the Traffic Structures engineer).
5. AASHTO Standard Specifications for Highway Bridges, 17th Edition.
6. AWS D1.1 Structural Welding Code.

7. AWS D1.2 Structural Welding Code – Aluminum.
8. AWS D1.5 Bridge Welding Code.
9. NCHRP 411 Structural Supports for Highway Signs, Luminaires, and Traffic Signals.
10. NCHRP 412 Fatigue-Resistant Design of Cantilevered Signal, Sign and Light Supports.
11. NCHRP 469 Fatigue-Resistant Design of Cantilevered Signal, Sign and Light Supports.
12. Inch Fasteners Standards.
13. Aluminum Design Manual.
14. ASTM 01.01, 01.03, 01.04, 01.05, 01.06, and 01.08.
15. National Design Specification for Wood Construction.

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

1. Pole Analysis Program (PAP): Used to analyze signal mast arm poles, strain poles, illumination poles, and monotube cantilevers to the AASHTO ASD code.
2. Pole Structural Analysis Program (PSAP): Used to analyze signal mast arm poles, strain poles, illumination poles, monotube cantilevers, and monotube bridges to the AASHTO ASD and LRFD codes.
3. Lpile (this program may not be necessary if a geo/hydro designer can design the foundations): Used to design drilled shaft foundations.
4. Span_Wire_WL_Tension_Calcs_4th_Four_Cables_AASHTO.xls: Used to evaluate horizontal forces on strain poles. Available from the Traffic Structures engineer.
5. 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.
6. MPB Design Spreadsheet: Used to design multi-post breakaway sign supports. Available for download at the Traffic Structures website.

1.4.4 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, it will affect the traffic structure cost estimating. 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.

Special Provisions are created at advance plans. Special Provisions are intended to modify the Oregon Standard Specifications for Construction document and provide bid quantities used once the project is released for bidding. You can download these provisions 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, you should consider any preliminary utility conflicts 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 are complete, the project leader will hold a Plans In Hand meeting. At this meeting, the team will perform a 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.

1.4.5 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 and the cost estimate and Special Provisions should be finalized for any changes. The final plans, cost estimate 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 finalized, then digital plans and Special Provisions are signed by a registered professional engineer in the State of Oregon. The signed drawings, signed Special Provisions, and final cost estimates should be sent to the Specification writer who will compile this information and submit for bidding purposes.

1.4.5.1 Construction Assistance Estimate

As a method to control and forecast ODOT engineering expenditures for construction projects, the Construction resident engineer 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 resident engineer 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:

$$Checking\ Shop\ Drawings\ Time = 4\ days$$

$$Field\ trip\ time = 2\ days$$

$$Designer's\ time = 4\ days + 2\ days = 6\ days$$

$$Monthly\ Salary = \$3{,}581/month$$

$$Work\ Hours\ per\ month = 52\frac{weeks}{year} * \frac{40\frac{hours}{week}}{12\frac{months}{year}} = 1733.33\ hours/month$$

$$Loaded\ Rate\ Factor = 1.74$$

$$Designer's\ wages = \frac{\$3{,}581/month}{173.33\ hours/month} * 1.74 * 8\ hours/day = \$288/\text{day}$$

$$Designer's\ labor\ cost = 6\ days * \frac{\$288}{day} = \$1{,}728$$

Equipment:

$$Car\ Expense = \frac{\$30}{day} * 2\ days = \$60$$

$$Mileage\ Expense = \frac{\$0.20}{mile} * 300\ miles = \$60$$

$$Car\ Rental\ Cost = Car\ Expense + Mileage\ Expense = \$60 + \$60 = \$120$$

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 to fill in that information. 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 on the left top side of title block and it is generated from the Traffic Standards & Asset Management Unit in the Traffic Roadway Section (TRS) or the ITS Unit of the Maintenance and Operations Branch (MOB). Section 4.1 discusses how to obtain a TRS or MOB drawing number. The second drawing number is the bridge drawing number. The bridge drawing number is generated by the Bridge Data System (BDS). Bridge drawing numbers are only given to the following types of structures: Truss sign /VMS bridges, monotube sign/VMS cantilevers, monotube sign/VMS bridges, butterfly supports, and highmast illumination poles. You can find the instructions for generating a bridge drawing number 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 associated with the structure. The structure number is generated through the BDS and you can find instructions on using the BDS in the BDS Manual.

The following is the minimum information that must be entered into BDS for major sign support structures:

1. Name
2. Status
3. Year built
4. Type
5. Sub type
6. District
7. Region
8. County
9. Highway
10. Direction
11. Mile point

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.

A new structure number is required in cases where a structure (cantilever, sign bridge, butterfly) is moving to a new milepoint. This method allows for the old structure number to be classified as an unused structure and direct users to the new structure number and drawings. The bridge log now shows a structure at the old milepoint no longer exists.

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 are new signs, sign mount extensions and arms on a cantilever that are replaced with longer arms. The work that is performed requires a new structure work number that is associated with the structure number, necessitating new drawings. This is 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 that 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, field-verified structure dimensions, 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" that stands 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 State of Oregon Standard Specification for Construction book outlines the current accepted materials and construction practices and procedures for most work that is 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, 00921: Major Sign Support Drilled Shafts, 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 00150.35: Plans, 3D Models, Working Drawings, and 3D Construction Models. 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 boilerplate documents used on every project that address known changes that need to occur and provides places to enter bid quantities. Download the Special Provisions 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 boilerplate periodically to find out if a new boilerplate has been released. The second type is the unique Special Provisions. Request these unique Special Provisions from the Traffic Structures engineer. The unique Special Provisions cover topics that were not incorporated into the Oregon Specification book. Some examples of these are the structural components of the variable message sign cabinets and camera poles. You can also download the unique Special Provisions from the ODOT Specifications website. As with the Boilerplate 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. You should 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. Any changes that need to be made to the project should 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.

Table 1: CAPTION THIS TABLE

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

Special Provision Number	Special Provision Title	Standard Sign Bridge	Type 1 VMS Bridge	Type 2 Butterfly VMS Support	Cantilever Monotube	Camera Pole	Signal Poles
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	
00921	Major Sign Support Drilled Shafts	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

Special Provision Number	Special Provision Title	Standard Sign Bridge	Type 1 VMS Bridge	Type 2 Butterfly VMS Support	Cantilever Monotube	Camera Pole	Signal Poles
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.

1.9.1 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.

1.9.2 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.

1.9.3 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."

1.9.4 Set of Calculations

Should everything the designer produce go into a calculation book? That's a tough question! Sometimes it is 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 a 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 Communication with Parties Outside of ODOT

During the design phase, the Traffic Structures designer may answer inquiries from people outside of ODOT about non-controversial projects, but not during the contract advertising period. 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 resident engineer. During this period, the resident engineer 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 resident engineer will field questions during this time (instead of the project leader) because the resident engineer 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 resident engineer.

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 drawings are sent in, they will be forwarded to the appropriate group for archiving.

Designers are responsible for preparing legible and neat design documents that are 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 number request forms, drawing number request forms, documentation 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 process is complete, the designer will provide construction support.

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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 AASHTO code is required on projects that use federal funds and for all traffic structures 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 fourth 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 AASHTO 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 fourth 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.

The last version of the Allowable Stress Design (ASD) AASHTO Standard Specifications for Structural Supports for Highway Signs, Luminaires and Traffic Signals is the sixth edition 2013. The Load and Resistance Factor Design (LRFD) was released in the first edition 2015 AASHTO Standard Specifications for Structural Supports for Highway Signs, Luminaires and Traffic Signals. This is a significant modification from ASD that transitions the design of Highway Signs, Luminaires and Traffic Signals to the LRFD design methodology that is also currently used for Bridge designs.

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 have a high probability each time to make the same errors and omissions that past designers have made.

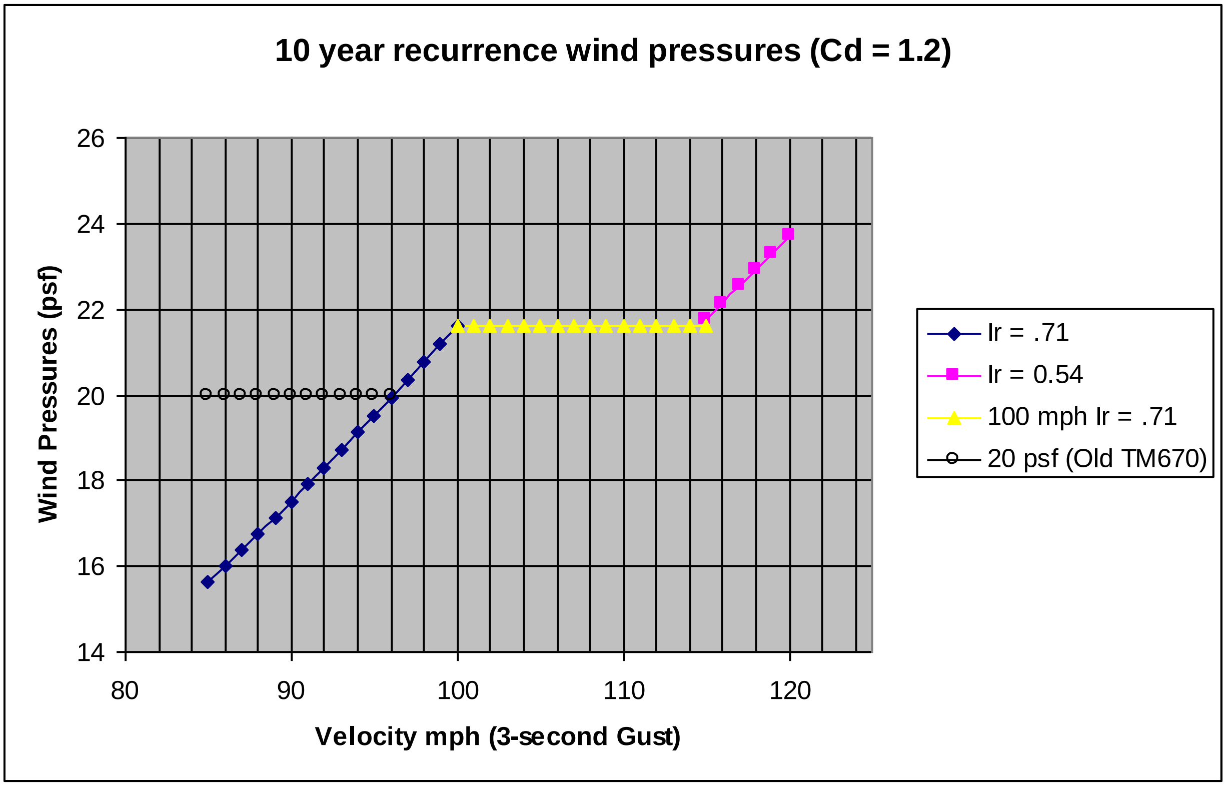
To get a new detail on a standard drawing or get an existing detail changed, submit a request for change to standard drawing form. You can find this document and instructions on the ODOT Roadway internet web page. The proposed modification will be routed to the Traffic Structures group to get feedback and consensus 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. Two other methods to update a Traffic Structures standard drawing is to contact the State Traffic Structures engineer to discuss the issue or to work through an issue that involves the standard during construction.

2.4 Wind Speeds and Pressures

There are two main types of wind speeds that have been used for the ASD 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 fourth edition AASHTO code. In addition, there is good background information about this topic in section 3.8.5 Gust Effect Factor G of the fourth 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 takes 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 fourth 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 1 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 1 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 1: Minor Sign Structures Wind Velocity vs. Pressure



2.4.1 LRFD Wind Speeds

The first edition 2015 LRFD Specifications for Structural Support for Highway Signs, Luminaires and Traffic Signals contains Figures 3.8-1, 3.8-2, 3.8-3, and 3.8-4 that are based on the ASCE/SEI 7-10 Minimum Design Loads for Buildings and Other Structures Figures 26.5-1A, 26.5-1B, and 26.5-1C. There are locations in Oregon that are shaded and defined as special wind regions and no wind speed is specified, but note 4 states "Mountainous terrain, gorges, ocean promontories and special wind regions shall be examined for unusual wind conditions." Also, Section 3.8.3 of the AASHTO LRFD code allows increasing the basic wind speed based on the records or experience.

The 2014 Oregon Structural Specialty code in Chapter 16 contains Figures 1609A, 1609B, and 1609C that have wind speeds on the east side of the state that match the ASCE 7-10 maps and the AASHTO LRFD maps. The Oregon Structural Specialty code wind maps also specify LRFD wind speeds to use in areas of the state with special wind regions. As a result, the LRFD ultimate wind speeds shown in the Oregon Structural Specialty Code wind maps have been used as minimum wind speeds on TM672.

The AASHTO LRFD 10-year Mean Recurrence Interval (MRI) map does not have a corresponding Oregon Structural Specialty Code wind map to address the special wind regions.

As a result, a conversion based on the 1700-year wind map has been made to estimate the 10-year wind velocities in the Oregon higher special wind regions. The conversion is based on the velocity increase from the 1700-year MRI from the higher wind speed to the lowest wind speed for each area. This results in the lowest wind speed shown in the AASHTO LRFD map of 72 mph being multiplied by (130 mph / 115 mph) = 1.13 and (145 mph / 115 mph) = 1.26 to obtain the higher wind region area wind speeds of 72 mph * 1.13 = 81.39 mph rounded up to 82 mph and 72 mph * 1.26 = 90.8 mph rounded up to 91 mph.

2.4.1.1 Wind Directionality Factor Kd

The values of Kd shown in Table 3.8.5-1 are for the overall structure type and applied to everything on the structure, regardless of the configuration. The Kd has the effect of reducing the wind forces based on the probability that the alignment of the overall structure in the site-specific location will not produce the maximum load effect from the design. Structures with arms will have a lower probability that wind forces from different angles at the site-specific location will be the same as the maximum load effect from the design and results in a lower Kd value. A round vertical pole with a round appurtenance at the top will have a higher probability that the wind forces at the site-specific location will be similar to the maximum load effect from the design and results in a higher Kd value.

For example, the overall signal mast arm support has a vertical post, mast arm, luminaire arm, signals, signs, cameras, VMSs, and luminaires. The overall signal mast arm support will have a lower probability that wind forces from different angles at the site-specific location will be similar to the maximum load effect from the design. This results in a lower Kd value of 0.85 for the vertical post, mast arm, luminaire arm, signals, signs, cameras, VMSs and luminaires.

Another example is the design of a rounded vertical mount with a rounded appurtenance at the top that is part of the overall signal mast arm structure. There is a higher probability that wind forces from different angles at the site-specific mount on the signal mast arm will be similar to the maximum load effect used in the design of the mount. This results in a higher Kd value of 0.95 for the round vertical member and rounded appurtenance at the top. A conservative Kd of 1.0 can also be used.

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.

2.5.1 Roadway Vertical Clearance under Truss Sign and VMS Bridges

It is important for designers to accommodate the vertical clearance of a future 10′- 0″ minimum sign height mounted at any location on the horizontal truss over the travelled way. The 10′-0″ high sign will ensure that the bottom centerline of the chord will be at least 1′-6″ above the bottom of the sign for the largest 7′-0″ truss height. The resulting centerline of the horizontal truss from the roadway will be a minimum of 23′-0″ that is calculated from the 18′-0″ minimum vertical clearance plus the 5′-0″ distance from the bottom of the sign to half the distance of a 10′-0″ sign. This additional space from the bottom of the sign to the bottom chord gives the additional flexibility to remove signs and create more clearance to pass high loads under it if it is needed.

There are installations where the truss sign bridge only has signs on one side of the highway, but there is the possibility of the addition of a 10′-0″ high sign at any location and the vertical clearance must be maintained at all locations over the traveled way. Also, the roadway can be sloped and the vertical clearance may be acceptable directly under the sign, but the vertical clearance may be inadequate at other adjacent locations when a future 10′-0″ sign is added with the bottom of the sign located 5′-0″ below the centerline of the horizontal truss.

The range of vertical clearance is between 18′-0″ and 19′-0″. During the design, you should use 18′-6″ inches for determining the end post heights that will allow a tolerance of 6 inches for unplanned circumstances. An example of an unplanned circumstance is an overlay that may not have been included in the cross section that a Traffic Structures designer used for determining the clearances and resulting end post lengths.

2.5.2 Small Sign Placement

Signs that are shorter than the truss height can be centered on the truss at the request of the sign designer. The truss must satisfy the roadway vertical clearance requirements from section 2.5.1.

2.6 Monotube Cantilever Sign Supports

Monotube sign supports use the design requirements shown on drawings TM621 through TM628. 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 feet and this value is shown on TM621. 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

Variable message signs use the design requirements shown on drawings TM621 through TM628, TM690, and TM691. 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 VMS support is 50 feet and this value is shown on TM621. 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.

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% 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 VMS/Sign Bridges

Monotube VMS and sign bridges use the design requirements shown on drawings TM693, TM627, TM628, TM694, TM695, TM696, and TM697. 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 monotube bridge design is based on the vehicle speed VMS loading shown and the maximum amount of sign loading was optimized based on the structural details.

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 fourth edition 2001 AASHTO code Section 12 for breakaway sign supports describes these requirements. For more detailed information about the specifics of the design, please go to the ODOT Standard Drawings website to view the Standard Drawing TM670 baseline report.

2.9 Signal Support Structures

2.9.1 Signal 0’ through 55’ Mast Arm Steel Supports

ODOT primarily uses 0’ through 55’ mast arm steel supports on the state highway system. The design and detail requirements are shown on drawings TM650, TM651, TM652, and TM653. The design uses the AASHTO Standard Specifications for Structural Supports for Highway Signs, Luminaires and Traffic Signals Allowable Stress Design (ASD). Any deviations from these standards are considered non-standard structures and must be submitted to the Traffic Structures group for review and approval.

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 mast arm 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 straightforward 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 mast arms 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 mast arm. The required loading for each length of mast arm 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.

2.9.2 Signal 60' through 75' Mast Arm Supports

The 60' through 75' mast arm steel supports design and detail requirements are shown on drawings TM655, TM656, TM657, TM658, and TM628. The design uses the AASHTO Standard Specifications for Structural Supports for Highway Signs, Luminaires and Traffic Signals Load and Resistance Factor Design (LRFD). The purpose of the longer mast arms is to remove the use of strain wire signal supports that are more difficult to maintain. The longer mast arm designs are more critical structures and the designs follow the Major Sign Support design guidance with the exception that galloping is not required. TM655 requires the use of a horizontal 2.5 ft. x 3.0 ft. horizontal sign blank close to the end of the arm to prevent fatigue loads. In the event that the horizontal sign blank does not prevent fatigue loads, then the use of a dampener will be used for the site-specific conditions. Any deviations from these standards are considered non-standard structures and must be submitted to the Traffic Structures group for review and approval.

2.9.3 Signal Mast Arm Foundations

The details for the signal mast arm foundations are shown on Standard Drawing TM653 for 5 foot through 55 foot mast arm lengths and TM628 for 60 foot through 75 foot mast arms. The depth of the foundation must be designed using site-specific recommendations from a Geotechnical engineer and the AASHTO Standard Specifications for Structural Supports for Highway Signs, Luminaires, and Traffic Signals either the ASD version or the LRFD version as needed.

The drilled shaft design depth shall follow the guidance in Chapter 16 of the Geotechnical Design Manual.

2.9.4 Signal Strain Pole Steel Supports

ODOT does not as a standard use strain pole, or span wire as defined in the code on the state highway system for new installations, except for the modification of an existing strain pole installation that is constructing a combination mast arm and strain pole.

The analysis of the loads on the messenger cable shall be designed according to Appendix A of the AASHTO code and to use 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 by overestimating the stiffness of the pole to reduce the top deflection and increase the cable force. A spreadsheet can be provided upon request from the State Traffic Structures engineer.

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.

2.9.4.1 Signal Strain Pole Foundation Supports

The drilled shaft design depth shall follow the guidance in Chapter 16 of the Geotechnical Design Manual.

2.9.5 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 2.9.3.1)
6. Bearing calculation at the bottom of the wood pole. (See Section 2.9.3.1)

2.9.5.1 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 design.

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. Another method that has been used is to compact ¾” +/- granular material under the wood pole for bearing. The width of the excavation is calculated from an assumed 45 degree angle from the bottom of the wood pole through the compacted material to the native soil. The required diameter or width is calculated to determine what is needed to resist the bearing. You should drill out the hole, compact the material in the bottom of the hole, level it, place the 2 ft. x 2 ft. x 1 ft. pad (or the compacted ¾" +/- granular material), place the wood pole, and backfill around the wood pole with well compacted granular material or a low density fill.

2.9.6 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 fourth 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 fourth 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 mast arm, 5 section head for the closest signal to the mast arm, street name sign to meet MUTCD requirements, guide sign on the vertical post and cameras.
8. Main structural items to include in the calculations:
    a. Mast arm and luminaire arm.
    b. Mast arm and luminaire arm connection weld.
    c. Mast arm and luminaire arm connection bolts.
    d. Mast arm and luminaire arm connection plates.
    e. Vertical post.
    f. Vertical post base weld.
    g. Base plate.
    h. Anchor bolts.
    i. Foundation concrete and rebar.
    j. Embedment depth.
9. The design must be general enough that at least three 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

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 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 fourth 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 Luminaire 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 fourth 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 fourth edition AASHTO code with an S1 value of 1500 psf.

Many luminaire foundations are installed on steeper slopes than the details shown on the standard drawings. This results in additional required length and custom foundation details. The additional depth can be stated in the luminaire project specific drawing table or a custom detail can be added for clarity.

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 fourth edition 2001 AASHTO Standard Specifications for Structural Support for Highway Signs, Luminaires, 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 fourth edition 2001 AASHTO code.
- Aluminum design must meet Section 6 of the fourth 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 fourth 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 Luminaire 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 might 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 top 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 Luminaire 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 fourth 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 three 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 fifth 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 feet 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 Mounts to Structures and Supports

Mounts to structures and supports are the members and connections that attach a sign, signal, VMS, or access walkway to a structure like a bridge, sign bridge, monotube cantilever, signal mast arm support, multi-post breakaway, triangular base breakaway, wood post, perforated steel square tube, etc.

2.11.1 Sign Mounts on Bridges

Sign mounts on bridges do not have design details in the Standard Drawings or standard details. The design of a new sign mount on a bridge shall use the most recent accepted versions of the AASHTO Standard Specifications for Structural Supports for Highway Signs, Luminaires, and Traffic Signals ASD or LRFD.

The following are the minimum requirements for sign mounts design on bridges:

1. Satisfy the requirements in the Bridge Design Manual Section 1.27.2.
2. Sign mounts on bridges shall have a corrosion resistant lifespan of at least 50 years.

   a. Use galvanized steel for the mounts, anchor rods, and hardware. Galvanized steel provides at least a 50-year corrosion lifespan at most locations that are not exposed to the coastal areas within 1 air mile of the Pacific Ocean.

3. Span Limitations by Mount Type:
   a. Single member cantilevered mounts are permitted to span up to 8 feet.
   b. Trusses, oriented in the vertical plane, are permitted to span up to 15 feet.
   c. Span is defined as the distance from the furthest out mount connection to the bridge to the location where the sign is attached to the mount.
4. Signs:
   a. Sign material is sheet aluminum, plywood or extruded aluminum.
   b. Extruded signs can be unsupported horizontally a maximum of 8’-6” between sign mounts.
   c. Extruded signs can be cantilevered horizontally a maximum of 3’-0” past the mount. Use at least two sign mounts for signs wider than 6’-0”.
5. Detail mounts to support the bottom of the sign. This typically includes a plate or angle, mount to the bottom of the vertical sign mount members. Example details are available in TM602 “extruded sign mounting details” and TM618 “vertical sign mount bracket.”
6. Bolted Connection Requirements
   a. Design bolted connections to steel bridge members according to AASHTO Standard Specifications for Highway Bridges and the ODOT Bridge Design Manual.
   b. When bolts are not tightened to the proof load, use double nuts or locknuts.
   c. Connect mounts to bridges in at least two locations with at least two bolts per location.
   d. The minimum distance between bolted connections on a mount is 2 feet.
   e. The minimum horizontal distance between mounts is 3 feet.
   f. Follow the concrete anchors guidance in the ODOT Bridge Design Manual.
   g. Verify that anchors will not interfere with rebar, pre-tensioned cables, post-tensioned cables, other through bolts, utilities, etc.
   h. Provide adequate access to the bolts to tighten the anchor rods from the outside and inside.
7. Wind directions – The following are the wind directions to consider to determine the maximum reactions of wind from any direction:

i. Wind perpendicular to the bridge longitudinal axis and towards the bridge.

ii. Wind perpendicular to the bridge longitudinal axis and away from the bridge.

    1. Satisfy the number 8 requirements as needed.

iii. Wind perpendicular to the sign face plan and towards the front face of the sign.

    1. Include mount members exposed to the wind.

iv. Wind perpendicular to the sign face plane towards the back of the sign.

    1. Include mount members exposed to the wind.
    2. Satisfy the number 8 requirements as needed.

v. Wind parallel to the bridge longitudinal axis towards the font face of the sign or the side of the sign if applicable.

    1. Include mount members exposed to the wind.

vi. Wind parallel to the bridge longitudinal axis towards the back face of the sign.

    1. Include mount members exposed to the wind.

8. Investigate signs extending above the bridge deck for the following two load cases:
    a. The bridge blocks wind on the sign and mounts. Wind is applied only to the area of the sign and mounts exposed above or below the bridge.
    b. The bridge does not block wind on the sign and mounts. Wind is applied to the full sign and mounts.
9. The bridge at the location where the sign mount attaches shall be structurally sound (CS≤2).
    a. Condition of the bridge can be obtained from the inspection report.
    b. Contact the region Bridge inspector about additional field inspections that may need to be performed.
10. Fatigue shall be considered in both the vertical and horizontal directions.
    a. Use the AASHTO Standard Specifications for Structural Supports for Highway Signs, Luminaires, and Traffic Signals ASD or LRFD Section 11 Natural Wind gust loading applied in the wind directions specified in number 7 above.
    b. Use AASHTO Standard Specifications for Structural Supports for Highway Signs, Luminaires, and Traffic Signals ASD or LRFD Section 11 Truck Gust loading applied in the vertical direction.

c. Determine whether or not movement of the bridge will induce significant sign mount fatigue loads that must be investigated. When vertical movement is a concern, consider relocating the sign mount. When relocation is not possible, contact the state Traffic Structures engineer.

11. Seismic – The AASHTO Standard Specifications for Structural Supports for Highway Signs, Luminaires, and Traffic Signals does not require a seismic design for sign mounts.
12. Clearances – Follow the Overhead Structures Vertical Clearance Standards and Guidance in this Manual, the Highway Directive TRA 07-15, and the Tech Bulletin RD17-02(B).
    a. See the ODOT Bridge Design Manual for bottom of sign placement relative to the bridge.
    b. Locations where the clearance under the bottom of bridge exceeds 18 feet 10 inches and results in the lowest bottom of sign clearance exceeding 19 feet shall obtain approval of the final bottom of sign clearance from the region Sign engineer and region Mobility coordinator.

2.12 Re-Use and Re-Analysis of Existing Structures

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

2.12.1 Truss Sign Bridges and Monotube Cantilevers

In order to reuse 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 BDS, 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. You can use the original design code 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 luminaire loading is stated in the notes can be used to analyze the structure without a full analysis by providing a comparative area calculation. Changes in the area can affect 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. 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. You can use either hand calculations or a computer analysis program 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. You can make 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). More severe modifications are not allowed and the structure must be replaced using the most recent version of the fourth 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 by sending a field crew to inspect it or by reviewing an inspection report that has been performed within the last three years.

2.12.2 Multi-Post and Triangular Base Breakaway Posts

In order to reuse a multi-post and triangular base breakaway sign support, there are several steps you will have to follow. The first 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 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 reused 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 many supports will be reused. If the structure is determined to be able to support the new sign, is structurally sound, and meets breakaway standards, the support can be reused. 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 reuse an existing breakaway sign support.

2.12.3 Mast Arm Signal Supports

The Signal Mast Arm Support Standard Drawings were in the Bridge Section until 2003 and then transferred to the Traffic Section. The design loading was increased in the TM650 design to accommodate future traffic safety requirements and results in more simplified analysis techniques.

2.12.3.1 Mast Arm Signal Supports before TM650

The following are general design guidelines for analyzing existing mast arm 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 there are no areas where galvanizing touch-up may be required.
4. Send the spreadsheet “Mast arm Field Data Sheets (revision date)” to the field personnel that will be performing the work and include the name of the field crew doing the inspection. You can download the spreadsheet 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. Signal mast arm supports installed according to standard drawings with the design loading specified can often use an X*Y*Z loading comparison analysis. This method

adds the shear area (X*Y) or weight in the X, Y, Z directions. It also adds the moment of area (X*Y) times the distance from the base to the area center about the X, Y, and Z axes. The design and proposed total shear and total moments are compared. Do not accept a 5% proposed loading over the original design loading.

The following items are not required when a comparison method can be used.

7. 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.
8. The wind speed to use for the reanalysis is 90 mph. This is a fastest mile per hour basic wind speed.
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.

2.12.3.2 Mast Arm Signal Supports TM650 and after

The design loading shown on the Standard Drawing TM650 added arm lengths up to 55 feet, a street name sign, a 5 section head at the end of the mast arm, a 5 section head on the mast arm closest to the pole, larger directional signs that increased from 2 feet x 2.5 feet to 2.5 feet x 3 feet, a 60 ft^2 guide sign on the vertical post, cameras and appurtenances on the vertical post. The increased design loading allows additional safety devices with easier analysis methods.

The following are general design guidelines for analyzing existing mast arm signal poles that 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. Poles built to TM650 that were installed after 2003 are within the expected 50-year corrosion design life and a corrosion condition inspection is not required. Verify that the pole does not have dents, missing nuts, etc.
3. Compare the proposed loading to the original design loading to determine if the pole is structurally adequate to support the new loads.

   a. For signal mast arm supports where the structural adequacy is not easily determined by reviewing the proposed loading to the TM650 design loading, an X*Y*Z loading comparison can be made according to Section 2.12.3.1.
   b. The foundation depths on the project have been designed for the TM650 loading and additional foundation analysis is not needed if the proposed loading is less than the design loading.
4. You may need to perform a more detailed analysis, but this does not occur often. The following are items that can reduce the loads for the analysis:
   a. Use the site-specific wind speed for the signal mast arm support location.
   b. TM650 uses an 8-sided pole for the design based on manufacturer’s capabilities. Adjust the shape factor for site-specific pole details as needed.

2.12.4 Signal Strain Pole Supports

Strain poles were commonly used on intersections with varying lengths of spans depending on the installation date. 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:

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 there are no areas where galvanizing touch-up may be required.
4. Send the spreadsheet “Mast arm Field Data Sheets (revision date)” to the field personnel that will be performing the work and include the name of the field crew doing the inspection. There are many cases 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. The later ASD and LRFD versions of the code may be used for the reanalysis.
7. The wind speed to use with the 1994 AASHTO code for the reanalysis is 90 mph unless a more accurate site-specific wind speed can be used. This is a fastest mile per hour basic wind speed. The ASD AASHTO codes after 2001 use the 3-second wind gusts shown on TM671 and the LRFD AASHTO codes use the 3-second wind gusts shown on TM672.
8. A reference to the AASHTO code Appendix A will help solve for the messenger cable dead load tension and wind load tension. The drag coefficient for the signals and signs may be reduced to 0.7 from 1.2 based on the swing effect after the lower tether breaks away when an "S" hook is used. A correlation of the dead load tension to the live load is stated on the old Standard Drawings 40397, 47231, BR966, and TM632 and can be used with the 1994 AASHTO code analysis. This statement is under bubble note 2 on the drawing 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 when performing calculations that used these standard drawings.
9. A historic conservative design method applies a single resultant messenger load to the attachment point on the pole from the full force of each messenger cable calculated from the wind perpendicular to each cable span. An optional and less conservative design approach takes into account different wind directions to the pole and applies the messenger cable loads to the attachment points on the pole from the messenger cable forces calculated from the different wind angles.
10. Run the pole using design requirements from the 1994 AASHTO code, or later versions as required, 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. The yield strength of the pole maybe difficult to determine. In some cases, the pole tag will have the manufacturer on it and a yield strength can be estimated based on the installation date. Another option to determine the yield strength is to obtain Brinell hardness test readings in the field, determine the tensile strength from ASTM A370 and then estimate the yield from the ratio of minimum yield stress to minimum tensile stress.
11. 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. The Brinell hardness test method used for the pole steel can also be used on the anchor rods during the same site visit.

12. Check the base plate using a fixed condition at the bolt and a pinned condition at the pipe. This is a conservative method and a double curvature condition can be used based on engineering judgement for reanalysis.
13. 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.

2.12.5 Illumination Poles

The reuse 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 reused may not have any information about it. There are problems with reusing a pole 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 case, the requirement of investigating the exact pole that will be moved to make sure it can support the proposed loading to the current standards and to make sure the pole is in good shape takes time and money and results in a pole that is older with potential for additional mistakes.

The reuse of the pole still requires a new pole foundation, conduit, electrical wiring and most likely a light which brings most of the installation up to a new condition. The cost of the lighting pole 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.

2.12.6 Questions to Investigate Before Re-Using a Structure

The following are questions to answer before a structure is reused 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?
    - Reanalyzing 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 cannot be brought up to the most recent codes because the structure cannot support it, then you should 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?
3. 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, then you should consider that the structure's galvanizing may be insufficient in five years. If corrosion starts, then there can be loss of section, and lower loads than the design load could fail the structure.
4. 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 planned 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.
5. 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.
6. Can the sign or signal be moved to another location on a different structure?
7. 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.
8. Does the 50% rule apply?
    - The 50% rule recommends that if the cost of the repairs is 50% 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.

2.13 Replacing Traffic Structures In-Kind

There are many instances where reanalysis 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 still remains 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 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. Work with the region to determine if there is a project in the near future that will update this area. If it is only in the next year, then a temporary fix may be the best alternative.

2.14 Steel Design

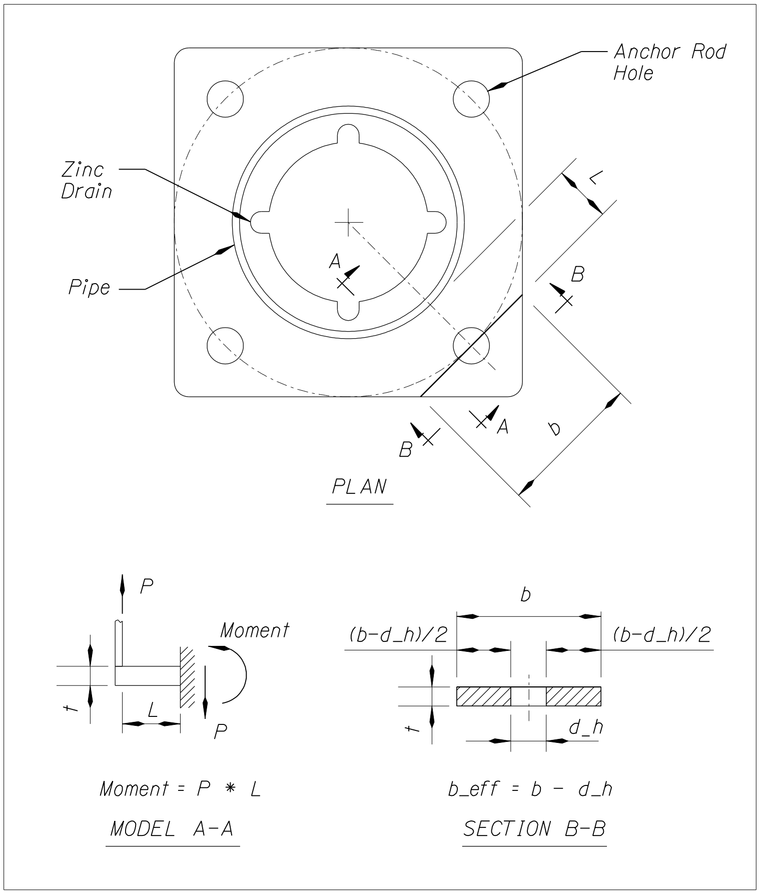
This section will discuss standard methods that can be used for the design of steel traffic structures. The methods are based on standard practice that have commonly been used and accepted.

2.14.1 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 Equation 2-1 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 is 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: Base Plate Calculation Layout



Equation 2-1

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

Equation 2-2

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

Equation 2-3

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

The 2001 fourth edition AASHTO Standard Specifications for Structural Supports for Highway Signs, Luminaires, and Traffic Signals Equation 5-8 specifies 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.

2.14.2 Bolting and Hardware

The AASHTO Standard Specifications for Structural 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.

2.14.2.1 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.

2.15 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 patterned 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.

2.16 Overhead Structures Vertical Clearance Standards and Guidance

The standard drawings for the truss sign bridge, VMS sign bridge, monotube cantilever, signal mast arm, and signal strain pole supports specify clearances of the bottom of signs to be between 18'-0" to 19'-0". Submit proposed vertical clearances under traffic support structures to the region Mobility liaison to verify that the vertical clearance above the state highway is acceptable for the project specific corridor. Vertical clearances for traffic support structures that are above 19'-0" are considered non-standard and require submitting a design exception for approval to the Traffic Roadway Section according to Chapter 14 of the ODOT Highway Design Manual. The design exception request process for increasing the vertical clearance greater than the above mentioned 19'-0" will need to consider safety, operations and impact to other design features in order to support the approval of the design exception.

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3 Construction Phase of Standard & Non-Standard Projects

3.1 General

After the design phase is finished, the project is advertised for bid. The bid documents consist of the project plans and Special Provisions produced by the Design team. 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. 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 minimal oversight by the Traffic Structures designer or the Traffic Structures designer can become quite involved. One change to the design team is changing from the project leader to the resident engineer. This change occurs when the project advertisement t is posted.

The resident engineer (RE) 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 RE, who will be the point of contact for the project. All communications made to personnel outside of ODOT should be made through the RE, 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 RE agrees. If the request involves a matter that might be a point of disagreement with the supplier and inspector or RE, the RE 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 RE should be copied on all communications to keep everyone informed.

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 Pre-Construction 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 is 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, VMS 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 specific 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 resident engineer is responsible for making sure that the contractor performs the field verification. The resident engineer 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. If the shop drawings are sealed by a registered engineer, then 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 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 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.

For submittals that have no comments, place a stamp on the submittal that states "accepted." When only minor notes are made on the details and the drawings do not need to be resubmitted, use the statement "accepted with comments." Critical changes that must be addressed and must be resubmitted will have a stamp placed on the submittal that states "returned for correction." An email or 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 resident engineer. This reduces the chances of construction time delays and costly change orders.

If you have concerns, write an email to the resident engineer stating your concerns and request a re-submittal when the concerns are addressed. Concerns may be marked on the shop drawings and sent with the email to the resident engineer. Retain a copy of the email and marked shop drawings for the submittal file and discard any remaining copies. If possible, and with prior permission of the contractor and resident engineer, the checker may talk by phone directly to the supplier to resolve concerns and decrease turn-around-time.

When all concerns are satisfied, write an email to the resident engineer stating the shop drawings are acceptable for the intended use. Retain a copy of the email and shop drawings for the file and send one copy of the shop drawings to the Traffic Structures group.

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 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 resident engineer:

- "Approved."
- "Approved As Noted."
- "Returned for Correction."

Use a stamp that indicates 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 resident engineer'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 is mailing the submittal for the steel poles or foundation to the Traffic Structures engineer of record for review. The structures will be reviewed and recommendations/comments provided 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 resident engineer's office. The resident engineer will then send the shop drawings back to the contractor and send a courtesy copy to the ODOT Materials Inspection crew leader. It is important that the ODOT Materials group receive a copy to know that the project needs to be inspected and who is the engineer of record. 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

Shop drawings are submitted electronically for approval. You can use a copy as a working drawing and use the original later for final comments and the review stamp. Once the drawings are finished, one copy is retained for the file and an email is sent to the resident engineer 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. You can find this document and instructions on the ODOT Roadway internet web page. The proposed modification is routed to the Traffic Structures group to get feedback and consensus 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 mast arm 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.
    1. Weld symbols for all the welds on the contract drawings.
    2. Joint designations.
    3. Fabricator welding procedure specification identification number (WPSID).
    4. Material grades.
    5. Dimensions.
    6. Special inspection requirement.
    7. 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).
    1. Check welding procedure specification submitted for each weld procedure specification identification number (WPSID) shown on the shop/working drawings.
    2. Weld symbols on the WPS match the weld symbols on the shop/working drawings and contract drawings.
    3. 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 to the designer. See Section 3.5, Review of Structural Welds and Welding Procedure Specification 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 with any explanations summarizing 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 Communication 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 resident engineer (RE). The Construction resident engineer will then forward requests for information to the appropriate person. If a request for information is not made through the RE, the request should be redirected to the RE so they are kept informed of all information concerning the project.

In some instances, the RE may request that the Traffic Structures designer field the questions directly from the contractor. You should only pursue this procedure if the RE approves of the change and this change will help the project timeline. When the requests are sent directly to the Traffic Structures designer, you have to assume additional responsibilities. Any communication made with the contractor shall be documented and a courtesy email shall be sent to the RE's office. Before any decision is made, the Traffic Structures designer should discuss the situation with the RE. Since the RE is responsible for overseeing the construction progress and inspection, the RE 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 and could be used again as a solution. 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 can have project shop drawing submittals with or without pre-qualified drawings. If pre-qualified drawings have been reviewed by the Traffic Standards group to verify that the details satisfy the requirements shown on the standard drawings, then this information does not need to be reviewed again as long as each drawing number and revision matches the project special provisions.

3.5.1.1 Signal Pole Shop Drawing Reviews with Pre-qualified Drawings

Project signal shop drawing submittals that use pre-qualified drawings do not need to be reviewed by a designer with a structural emphasis. The Signal engineer of record will perform the review for the project.

3.5.1.2 Signal Pole Shop Drawing Reviews without Pre-qualified Drawings

Project signal shop drawing submittals that do not have pre-qualified drawings, according to the project special provisions, must be reviewed by a designer with a structural emphasis to check the details shown are according to the contract plans and specifications. Details not shown in the contract plans and specifications require stamped calculations. The Signal engineer of record will perform the general review for the project and verify all the information is there before forwarding the signal shop drawing submittal to the structural designer. The following are items to perform during the structural signal pole shop drawing submittal process:

1. The signal shop drawings and calculations must be stamped by a professional engineer licensed in the State of Oregon.
2. The signal shop drawings must be submitted separately from the luminaire shop drawings in accordance with the bid items used on the project.
3. Obtain the project plan drawings and make sure that there are no conflicts for the signal pole details to determine what pole types must be used. The following are some conflicts that have been found on previous projects:
    a. Mast arm and luminaire arm lengths.
    b. Handhole orientations.
    c. Pole types.
4. Conflicts in the plans require the Signal engineer of record to give direction about the correct details to use.
5. The manufacturer's last approved shop drawings are typically used as a reference. The project and reference shop drawings are printed and all items on the project drawings are checked and highlighted to make sure the information is correct and has not changed. Manufacturers have made small changes from one project to the next that can be difficult to find.
6. Check the terminal cabinets, handholes, and hubs orientation and elevation.
7. Answer any questions or comments on the shop drawings from the manufacturer. In many cases, the questions are a result of a conflict in the plans that require a clarification.
8. Poles that have been independently analyzed before do not need to be run again, but poles that have not been run require an independent analysis to check the poles, plates, and bolts to verify they are structurally adequate.
9. Check the connection bolt lengths to make sure that there is enough thread that the nut does not bottom out on the shank and that there is enough threads past the end of the nut after tightening.
10. Check the pipe weld to the bolt washer physical fit.
11. Check the bolt physical fit at the top and bottom of the mast arm connection plates on the pole side to make sure that the bolt washers do not hit the gusset and ring stiffener welds. The flange plate is angled and results in an acute angle on the bottom that reduces the clearances for the bolt to be inserted and for tools to tighten the bolt.

12. The electronic drawings and calculations are marked up with the redline comments and a review stamp is placed on the drawings in accordance with Specifications Section 00150.35 and calculations. An email is sent to the Signal engineer of record with the reviewed files attached and a summary of the comments. This email summary adds additional information to the redline comments to help clarify the issues.
13. The signal pole field verification forms on the Construction Forms website for the super structure and the foundation must be completed. This is usually performed by the signal designer, construction office and contractor.

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 for any discrepancies. 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. You can still make changes 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, you should direct the contractor 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 resident engineer's office. The resident engineer, 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 to reach a consensus 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 new calculations were 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. To correct this, the accepted solution is to remove and replace the installation. 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 concern 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. We retained David Evans & Associates to perform a finite element analysis of a pole with the larger handhole and write a report summarizing the results. Based on the report finding, the Traffic Structures group 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. Use Special Provision 00965 for the camera pole projects.

3.5.6 Highmast

There is a guideline that states not to use highmast illumination poles in current projects. 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 Highmast Poles have been removed because it is not used frequently enough to be considered 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 concerns 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.

One situation that Traffic Structures has encountered in relation to illumination poles, 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 conduct the base reaction review. Another challenge for illumination poles are the slip base luminaire poles installed on slopes. In many instances, if the luminaire pole is installed on a slope, then 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. In addition, the slope can provide less support at the top and the foundation may need to be increased from the depth shown on the standard drawing.

3.5.8 General Steel Items

There are a small number of issues 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. In the case of 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 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 turnaround 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 mast arm) 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 degrees 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. You must submit a request for information (RFI) to the Resident Engineer 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. A Portland Inspection crew leader is responsible for inspecting all fabricated overhead signing or butterfly supports. After the Traffic Structures designer is finished reviewing the shop drawings, they should ask the resident engineer’s office to send a courtesy copy of the shop drawing to the 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 resident engineer. The resident engineer will then contact the engineer of record to discuss 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.” In this sheet, the inspector is instructed 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

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 from those shown on the standard drawing must be sent in to the Traffic Structures group for review. 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 includes 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 change was required, 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 Review

For each weld designation submitted in the shop drawings, a welding procedure specification (WPS) will be submitted for review. The WPS outlines the details for each weld used in the fabrication of a structure. Due to the special nature of the WPS, it should be sent to the Bridge Section's welding expert for review. Some manufacturers have already sent in WPS's for review and those 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. Commercial grade concrete is specifically used for all traffic structure 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 use 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 defines what the QCT and Concrete Control Technician (CCT) have to test, the construction tolerances, how the concrete can be transported, and limitations for handling and placing the concrete. Section 440 of the Specifications only defines general guidelines for testing and placing concrete.

3.5.9.2 Manuals for Construction Testing

The Nonfield-tested Materials Acceptance Guide and Manual of Field Test Procedures are documents that can be downloaded from the ODOT website. It documents quality control procedures to follow for non-field tested and field tested materials.

The following is an example of signal pole quality control using the Nonfield-tested Materials Acceptance Guide. The specification 00962.10 requires to furnish steel pole material meeting the requirements of 02530 and 2530.80 states "Acceptance of steel poles will be according to 165.35." In 165.35 there are requirements for a Test Results Certificate, Quality Compliance Certificate and Certificate of Origin of Steel Materials. The table in the Nonfield-tested

Materials Acceptance Guide gives a listing under Section 00962 of T, Q, and O. These designations are the same quality control items that are required in the specification.

The following is an example of 00440 concrete quality control for field tested materials. Section 4(D) of the manual has a table that shows the requirements for field testing 00440 commercial grade 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 00440.15 that requires quality control according to Section 00165. Section 00165.10 requires field tested materials will be accepted according to the ODOT Manual of Field Test Procedures.

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 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 grade 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 addresses structures that specify 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. 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, it 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 resident engineer 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 resident engineer.

By comparison, for 540 Bridge Concrete any strengths below 100% of specified strength, the resident engineer will approve the structural adequacy. The designer will review each case and will send a written recommendation to the resident engineer 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 does segregate, then the compressive strength may not be achieved and the foundation may 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 for traffic signal installations on state highways. 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 the Traffic Structures designer encounters a new product during a project that 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 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 (TRS) in 2002. During this transition, ODOT 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 to the Maintenance and Operations Branch (MOB) and therefor began assigning MOB drawing numbers instead of TRS drawing numbers for plan sheets with ITS traffic structures. The Traffic and MOB 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. so having the drawing already in this size makes it easier to ensure it is legible.

A Signal, Sign, Illumination, ITS, or Temporary Traffic Control designer sends design requests. Once the specific group is identified, the border will be according to that group's standard practice and will use a drawing number associated with that group. It is recommended that the structural designer obtain the TRS or MOB drawing number from the designer at the same time that the other TRS or MOB drawing numbers are assigned to ensure that the TRS or MOB drawing numbers are in sequential order in the plans. Placing the Traffic structures support drawings with the associated traffic drawings eliminates searching the often voluminous bridge drawing section of the plans.

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 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

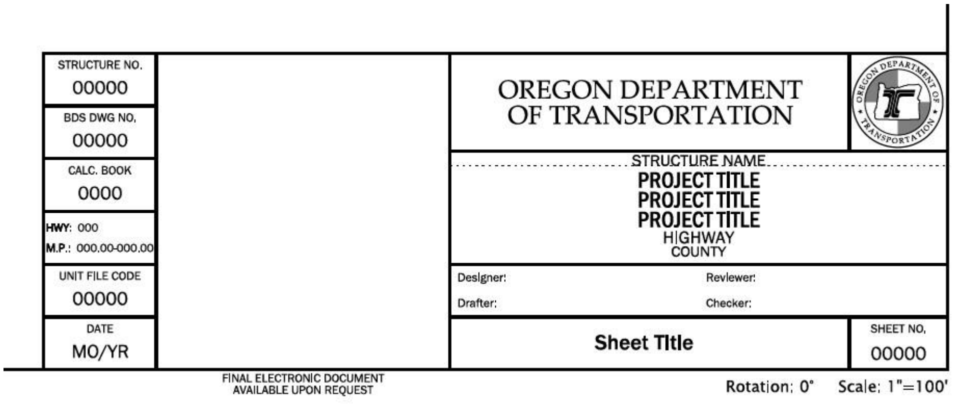
Using a project location map in the upper right hand corner of the site-specific Traffic Structures drawing increases the risk that it will not match the Roadway and Signing drawings and is best not to include it on the plan drawings. In addition, the location map takes up space on the drawing that is needed when multiple structures are specified on one drawing. Finally, when multiple traffic structures are shown on one drawing, adding a location map that covers 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 title block shown in Figure 3 represents a project plans sample. This is where additional changes will be required to make the border fit the specific group format. Enter the structure No., BDS DWG. No., CALC Book, and structure name as needed.

Figure 3: Traffic Structures Title Block Modifications



The bridge DWG. No., structure No., and structure name can be obtained from the regional Bridge drafter. Please see the CALC Books section in this manual 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 bridge drawing number, structure number, and structure name are used to track, inspect, create reports, and search for these structures in the future.

It is standard practice to have either the stamping engineer or the designer working under the direction of the stamping engineer, specified in the “Designed by Name” location. In addition, the person who 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 dropdown list. You can add a location map if you prefer under the description lines.

4.3 Fonts and Line Styles

In general, the text and lines should follow the same standards that are used by the Bridge Section. 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 Sheet Title

The sheet title will be according to the Contract Plans Manual for the Signal, Sign, Illumination, ITS, or Temporary Traffic Control series that applies.

4.4.1 Geotechnical Data Sheet

Place Geotechnical data sheets for Traffic Structures according to the Geo, Hydro and Environmental CAD Standards Manual.

4.5 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 resident engineer’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 that were 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.

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Appendix A – Structural File Order

Structural file document order (from the top down):

1. Engineering result.
    a. Analysis cover sheet.
    b. Letter.
    c. Transmittal with remarks.
    d. Email.
2. Contacts information.
3. Emails (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.

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Appendix B – Project Checklist

Project Name:

PCS Key Number:

Highway Number:

Milepost:

Designer:

Preliminary Plans: Date:

- o Find out types of structures used on the project from the designer. See Section 1.4.1.
- o Find location of structures used on the project from the designer. See Section 1.4.1.
- o Request cross sections from the roadway designer at each location. See Section 1.4.1.
- o Request a Geotechnical Report at each location. See Section 1.4.1.
- o Receive cross sections.
- o Receive Geotechnical Reports.
- o Draft each structure on the border and reference the cross sections provided by Roadway.
    - o Check vertical clearances of the sign and structure over the roadway.
    - o Check the horizontal clearances between the structure and the roadway.
    - o Verify structures fall within the standard drawings for each structure type.
    - o Notify region Motor Carrier liaison of new vertical clearances approval.
- o Calculate cost estimate for structures. See Section 1.4.1.
- o Place calculations in calculation book. See Section 1.6.4.
- o Attend Preliminary Plans meeting. See Section 1.4.1.

Advanced Plans: Date:

- o Receive and incorporate Preliminary Plans meeting and comments. See Section 1.4.2.
- o Update cost estimate from Preliminary Plans meeting comments.
- o Download the latest copy of the special provisions. See Section 1.6.2.
- o Modify special provisions to match the project requirements.

- o Send advanced plans, updated cost estimates, and special provisions to Specifications writer.
- o Add any additional calculations to the calculation book.
- o Attend advanced plans meeting. See Section 1.4.2.

Finals Plans: Date:

- o Receive and incorporate advanced plans meeting comments. See Section 1.4.3.
- o Update cost estimate from advanced plans meeting comments.
- o Verify special provisions from advanced plans meeting comments.
- o Send a final copy of documents (plans, specs, cost estimates) to the Specification writer.
- o Attend Plans in Hand meeting if necessary. See Section 1.4.3.
- o Finish project documentation after project has been released for bid. See Section 1.5.

Bid Let: Date:

Appendix C – Revision History

Table 2: Revision Log

Revision Date	Description	By	Check
June 2020	Reformatted Manual and updated Manual date to June 2020.	S. Jollo	S. Cramer
June 2020	Minor revisions throughout manual.	S. Jollo	S. Cramer
June 2020	Added Scoping and DAP guidance.	S. Jollo	S. Cramer
June 2020	Added 60' through 75' Mast Arm Supports.	S. Jollo	S. Cramer
June 2020	Removed Mast Arm Foundation guidance.	S. Jollo	S. Cramer
June 2020	Updated Title block, added Sheet Titles guidance, and added Geotechnical Data Sheet guidance.	S. Jollo	S. Cramer
July 2021	Added BDS input requirements to 1.5.2.	S. Jollo	S. Cramer
July 2021	Added 2.11 and 2.11.1 for Mounts on structures and sign mounts on bridges.	S. Jollo	S. Cramer
July 2021	Revised 2.12.3 and added 2.12.3.2 Mast Arm Signal Supports TM650 and after	S. Jollo	S. Cramer
July 2021	Grammatical revisions throughout manual.	S. Jollo	

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