

# STATE OF NEW HAMPSHIRE

## BRIDGE DESIGN MEMORANDUM

**FROM:** Mark W. Richardson, PE  
Administrator

**DATE:** March 20, 2014  
**AT (Office):** Bureau of Bridge Design

**SUBJECT:** Design Memorandum 2012-01 (Revision)  
Overhead Sign Structures and Foundations

**TO:** Bureau of Bridge Design staff, Bridge Design Consultants, FHWA, NHDOT Bureaus

The following are revisions made to the Design Memorandum 2012-01:

BDM Section	Affected Pages	Date of Revision	Revision Description	Background
<p> 1/12/2015 9:43:16 AM</p> <p>Memorandum is <b>inactive</b>. See current NHDOT Bridge Design Manual.</p>				
	Page 10.3-3, Page 10.3-10.3-A1	3/20/14	<p>Revised bullet to read:</p> <ul style="list-style-type: none"> <li>Each monotube upright post shall have a minimum of eight (8) foundation anchor rods. Each post of a multi post upright (truss) shall have a minimum of four (4) foundation anchor rods per post.</li> </ul> <p>From:</p> <ul style="list-style-type: none"> <li><del>Provide eight (8) anchor rods (minimum) for the cantilever overhead sign structure foundation and six (6) anchor rods (minimum) for each bridge sign structure foundation.</del></li> </ul>	Clarifies the required minimum of anchor rods per post instead of foundation.
Special Provision, Amendment to Section 615 – Traffic Signs: 3.4.1.2 (g)	Page 3 of 11	3/20/14	<p>Revised 3.4.1.2(g) to read:</p> <p>(g) Each monotube upright post shall have a minimum of eight (8) foundation anchor rods. Each post of a multi post upright (truss) shall have a minimum of four (4) foundation anchor rods per post.</p> <p>From:</p> <ul style="list-style-type: none"> <li><del>(g) Provide eight (8) anchor rods (minimum) for the cantilever overhead sign structure foundation and six (6) anchor rods (minimum) for each bridge sign structure foundation.</del></li> </ul>	Clarifies the required minimum of anchor rods per post instead of foundation.

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**BRIDGE DESIGN MEMORANDUM**

<b>BDM Section</b>	<b>Affected Pages</b>	<b>Date of Revision</b>	<b>Revision Description</b>	<b>Background</b>
10.3.2, Appendix 10.3-A1	Page 10.3-3, Page 10.3-A1-2	2/4/14	<p>Revised last bullet to:</p> <p><i>Cofferdams, Item 503.20x may be required if there is insufficient room to excavate for the footing using 1.5:1 slopes. Cofferdams with Sheet piling Left-in-Place, Item 503.30x, should be used when its removal would create a stability problem with adjacent structure of any type, including roadways and drainage structures, the sign itself or required by the geotechnical engineer.</i></p> <p>From:</p> <p><del>Cofferdams with Sheet piling Left in-Place, Item 503.30x may be required if there is insufficient room to excavate for the footing using 1:1 slopes. Do not use Cofferdams, Item 503.20x, unless approved by geotechnical engineer, because removal of the sheet piling weakens the bearing soil.</del></p>	Revision made from discussion at Bridge Issues of Common Concerns Meeting 1/28/14.
10.3.5	Page 10.3-6	2/4/14	<p>Revised paragraph 3) to include:</p> <p><i>Item 503.20x, Cofferdams (if required)</i></p>	Revision made from discussion at Bridge Issues of Common Concerns Meeting 1/28/14.



**STATE OF NEW HAMPSHIRE**  
**BRIDGE DESIGN MEMORANDUM**

1 of 2

**FROM:** Mark W. Richardson, PE  
Administrator

**DATE:** December 17, 2012  
**AT (Office):** Bureau of Bridge Design

**SUBJECT:** **Design Memorandum 2012-01**  
**Overhead Sign Structures and Foundations**

**TO:** **Bureau of Bridge Design staff, Bridge Design Consultants, FHWA, NHDOT Bureaus**

The Bureau of Bridge Design is rewriting and updating the Bridge Design Manual. During this process, certain completed sections of the new manual will be issued for immediate implementation. Consequently, the Bridge Design Manual and the NHDOT Standard Specifications for Road and Bridge Construction have been modified as follows:

A. Delete Sections 701 and 710 of the current Bridge Design Manual in their entirety and replace these Sections with the attached Chapter 10, Sections 1-3, Appendix 10.3-A1, Appendix 10.3-B1, and Appendix 10.3-B2.

B. Amend Section 615 – Traffic Signs of the NHDOT Standard Specifications for Road and Bridge Construction with the enclosed special provision:

C. Summary: The above noted revisions are being implemented to specify:

- Required loading and fatigue categories for overhead sign structures and foundations.
- NHDOT design requirements for overhead sign structures and foundations.
- Grout shall not be used between the sign structure base plate and the top of footing.
- Anchor rod assemblies shall include hardened washers. Lock washers shall not be used. Lock washers do not prevent the loss of preload in the anchor bolts, and their variability of deformation under load does not provide for proper bolt tensioning during installation.
- Stainless steel grade wire cloth (screen) shall be installed around the opening between the sign structure base plate and the top of footing. This screen is to prevent the build up of debris beneath the base plate, and to protect the electrical wires by keeping animals out of this area.
- The distance from the top of the footing to the bottom of the sign structure base plate shall equal the nut height plus 1-inch (preferred), or the nut height plus the diameter of the anchor rod (maximum).
- Design process and coordination required with Consultants and other Bureaus for overhead sign structures and foundations.
- Process for archiving the plans and calculations for overhead sign structures and foundations.
- Special Provision - Amendment to Section 615: This addresses the sign structure design, anchor rod installation, tensioning procedures, and UT testing for the double-nut connection to the foundation.
- DMS/VSL signs, structures, and foundations are now a separate item and a separate Special Provision (Item 677.xx).
- The foundation plan shall include the new anchor rod detail, screen detail, sign structure inventory number, detailed description of footing location, design bearing pressure, design sign area for each footing, and any new notes that may apply.
- The foundation sample plans (.dgn and .pdf format) are located on the Bureau of Bridge Design web page: <http://www.nh.gov/dot/org/projectdevelopment/bridgedesign/detailsheets/index.htm>

**STATE OF NEW HAMPSHIRE**  
**BRIDGE DESIGN MEMORANDUM**

**D. Background:**

This memorandum incorporates the recommendations from FHWA regarding "*Guidelines for the Installation, Inspection, Maintenance, and Repair of Structural Supports for Highway Signs, Luminaires, and Traffic Signals*", publication No. FHWA NHI 05-036, March 2005, as well as recommendations from other state DOTs. This memorandum also addresses the results from an investigation into the April 2010 failure of a NHDOT cantilever sign structure.

The results of the investigation determined that the sign structure failure was due to fatigue of the anchor rods from repeated bending over the anchor rod's excessive unsupported length of 3-inches, and due to corrosion of the anchor rods that resulted from cracking of the grout placed around them, which allowed moisture to enter but not escape.

In response to the structure failure, the anchor rods of 125 cantilever sign structures were UT tested and inspected with no similar deficiencies being found. In addition, the grout is being removed from existing sign structure foundations, and grout is no longer placed on new foundations. Also, the Bureau of Traffic is cleaning/repairing existing corroded anchor rods and a program is being developed for regular UT testing of all sign structure anchor rods. Further, a Special Provision was written specifically to describe the appropriate procedures for installation and tensioning of anchor rods.

This Memorandum clarifies NHDOT's procedures/requirements for the design and construction of overhead sign structures and their foundations, and incorporates the sample plans and Special Provision that shall be included in contract plans and proposals.

**D. Implementation:**

The deletion of Section 701 and 710 of the Bridge Design Manual and replacement with the new Chapter 10, Sections 1-3, and the Special Provision, Amendment to Section 615 – Traffic Signs of the NHDOT Standard Specifications for Road and Bridge Construction, shall be implemented as of the date of this memo and shall be used on all applicable projects.



Mark W. Richardson, PE  
Administrator, Bureau of Bridge Design

enclosures

## 10.2 Loads

### A. General

Overhead signs, bridge-mounted signs, non-standard traffic signals, intelligent transportation systems (CCTV, Road and Weather Information Station Systems, and Non-Invasive Pavement Sensor Systems), luminaire support structures, foundations, and soundwalls shall be designed in accordance with the current edition of AASHTO “*Standard Specifications for Structural Supports for Highway Signs, Luminaires, and Traffic Signals,*” including interims, NHDOT Standard Specifications for Road and Bridge Construction, and the NHDOT Bridge Design Manual.

### B. Dead Loads

- Sign  
(Incl. weight of sign & attachments (3 psf [14.6 kg/m<sup>2</sup>]) and weight of W6x9 sign support (2 psf [9.8 kg/m<sup>2</sup>]), minimum.) 5.0 psf (24.4 kg/m<sup>2</sup>)
- Dynamic Message Sign (DMS) per manufacturer
- Variable Speed Limit Sign (VSLS) per manufacturer
- Luminaire per manufacturer
- Standard Signal Head per manufacturer
- Bridge Mounted Sign Supports calculate
- Structural Members calculate
- Maintenance Walkway per manufacturer
- Closed Circuit Television per manufacturer

### C. Wind Loads

- The 3-second wind gust map in AASHTO Specifications shows the basic wind speed to be used when computing design wind pressure.
- Basic wind speed of 100 mph (160 km/hr) shall be used for the entire state of NH *except* in the Special Wind Region (i.e. regions along the NH-VT border and Franconia Notch) as shown in AASHTO Specifications, Fig. 3.8.3-5. The maximum-recorded wind speed in this area shall be used as the basic wind speed if it is greater than the NH basic wind speed of 100 mph (160 km/hr). See the wind speed map located at <http://www.windspeedbyzip.com/>, Appendix 10.2-A1 and weather stations in the special wind region for recorded wind speeds.

### D. Design Life and Recurrence Interval (Table 3.8.3-1,2,3 AASHTO Specifications)

- 50 years for all overhead sign structures (i.e. bridge or cantilevered), bridge-mounted sign supports, traffic signal mast arms with/without luminaires (all heights), ITS support poles and lighting poles (horizontal distance from roadway to pole ≤ height of pole).
- 25 years for ITS support poles, lighting poles (horizontal distance from roadway to pole > height of pole), and soundwalls.

### E. Ice Loads

- 3 psf (14.6 kg/m<sup>2</sup>) applied around all the surfaces of the structure and attachments but applied to only one face of sign panels per AASHTO Specifications.
- 3 psf (14.6 kg/m<sup>2</sup>) applied to the top, ends, and one face of a DMS or VSLS.

### F. Snow Loads

- 40 psf (195.3 kg/m<sup>2</sup>) applied simultaneously with ice load to the top panel and any other nearly horizontal projection surfaces of a DMS or VSLS.

## G. Fatigue Design:

Fatigue design shall conform to AASHTO Specifications and the following categories:

- 1) Cantilevered Fatigue Category I:
  - All overhead cantilever sign structures
    - ⇒ Galloping loads may be excluded for fatigue design of overhead cantilevered sign structures with four-chord horizontal trusses.
  - All bridge-mounted sign supports
  - High-mast lighting poles (horizontal distance from roadway to pole  $\leq$  height of pole)
  - ITS support poles (horizontal distance from roadway to pole  $\leq$  height of pole)
  - Typical lighting poles with mast arm (horizontal distance from roadway to pole  $\leq$  height of pole)
- 2) Cantilevered Fatigue Category II:
  - All traffic signal supports (mast arms)
    - ⇒ Natural Wind Gust loading shall be included.
    - ⇒ Truck Induced Gust loading and Gallop loading may be excluded
  - ITS support poles (horizontal distance from roadway to pole  $>$  height of pole)
  - Typical lighting poles with mast arm (horizontal distance from roadway to pole  $>$  height of pole)
  - High-level (high-mast) lighting poles (horizontal distance from roadway to pole  $>$  height of pole)
- 3) Non-Cantilevered Fatigue Category I:
  - Overhead bridge sign structures located along the Turnpike, Interstate, and Interstate ramps
- 4) Non-Cantilevered Fatigue Category II:
  - Overhead bridge sign structures located on non-Turnpike, non-Interstate, NH, and US numbered routes

H. Live Load: A live load consisting of a single load of 500 lbs. (226.8 kg) distributed over 2.0 ft. (0.6 m) transversely to the member shall be used for designing members for walkways and platforms (see AASHTO Specifications Section 3.6).

## I. Group Load Combinations:

Support structures are designed using the maximum of the following four load groups (AASHTO Specifications Section 3.4 and Table 3.4-1):

Group Load	Load Combination	Percent of *Allowable Stress
I	DL	100
II	DL+W**	133
III	DL+Ice+ $\frac{1}{2}$ (W**)	133
IV	Fatigue	See AASHTO Section 11 for fatigue loads and stress range
* No load reduction factors shall be applied in conjunction with these increased allowable stresses.		
** W = Wind Load		

## 10.3 Overhead Sign Structures

### 10.3.1 General

The design of overhead sign structures is a combined effort between the Bureau of Bridge Design and the supplier of the structure. Bridge Design is responsible for the preliminary and final design of the foundations for overhead sign structures for In-House projects. Consultants are responsible for the preliminary and final design of the foundations, with the guidance of Bridge Design, for Consultant projects. The supplier of overhead sign structures is responsible for the design of the structure and submits shop drawings to the Department for approval. The supplier's calculations and shop plans are reviewed for general conformity of plans and NHDOT's policies and specifications.

### 10.3.2 NHDOT Design Requirements

#### A. Structure

- Overhead sign structures shall be designed to accommodate sign surface areas 30 percent greater than those shown on the plans, unless otherwise noted.
- The structures shall be steel, galvanized in accordance with NHDOT Specification 550.2.9.
- Provide a 3-foot (1 meter) walkway with OSHA approved railing for access to any electronic message signs on overhead structures. The walkway shall extend to the edge of pavement to provide access to the DMS without having to use a bucket truck over the travel lane, or having to shut down travel lanes.
- The structure shop plans and calculations shall be prepared and stamped by a professional engineer licensed in the state of New Hampshire.
- 25 percent of the base plate-to-post weld shall be inspected by magnetic particle testing per AASHTO Specifications. This requirement shall be noted on the shop plans.
- Sign support members (W6x9) shall not be greater in length than the sign height.
- The Fabricator shall furnish a complete set of shop drawings and design calculations, along with the design forces and offsets, as noted in Special Provision Amendment to Section 615, Traffic Signs.
- The connection of the structure to the foundation shall be a double-nut moment connection.
- Lock washers shall not be used with the installation of high strength bolts per FHWA Guidelines.
- Triangular truss and tubular arch type overhead sign structures, as shown below, are not permitted due to concerns with their susceptibility to fatigue cracking.



Triangular truss and tubular arch type shall not be used in New Hampshire.



- NHDOT sign structure types include the following (see Figure 10.3.2-1):
  - 1) truss upright, truss horizontal
  - 2) monotube upright, truss horizontal
  - 3) monotube upright, monotube horizontal



monotube upright, truss horizontal



truss upright, truss horizontal



monotube upright, monotube horizontal



truss upright, truss horizontal

**NHDOT Sign Structure Types**

*Figure 10.3.2-1*

## B. Foundation

- NHDOT prefers spread footing type foundations for all sign structures.
- NHDOT policy for maximum allowed area of footing with uplift shall be the following:
  - ⇒ Sign bridge structure = 5 % of footing area.
  - ⇒ Cantilevered sign structure = 1 % of footing area.
- Use the same reinforcing bar size for both directions in the footing.
- The vertical stem reinforcing bars shall be checked for development length, into both the stem and footing and for splice length of the anchor rods.
- The overlap length of the vertical reinforcing bar and anchor rod shall be checked that the length is equivalent to a class c splice of the reinforcing bar.
- The distance from the top of the concrete stem to the bottom of the sign structure base plate shall equal the nut height plus 1-inch (25 mm) (preferred) or nut height plus the anchor rod diameter (maximum). (Note the nut height equals the rod diameter.)
- Anchor rods shall conform to the requirements of ASTM F1554 Grade 55 (minimum). Use of ASTM A615 reinforcing steel is not allowed. Galvanize the entire anchor rod per ASTM A153. Each anchor rod shall be supplied with a minimum of two hex nuts (ASTM A563 or ASTM A194) and a minimum of two flat hardened washers (ASTM F436).
- Anchor rods shall include hardened washers. Lock washers shall not be used as they do not prevent loss of the anchor bolt preload, and their variability of deformation under load does not provide for proper bolt tension during installation.
- Anchor rod size and layout shall be designed by the structure Fabricator and shall be identical for both left and right footings.
- For sign structures that are designed for Cantilevered Fatigue Category I, the anchor rods shall be designed for wind-induced cyclic loads per AASHTO Specifications Section 5.17.3.4.
- Each monotube upright post shall have a minimum of eight (8) foundation anchor rods. Each post of a multi post upright (truss) shall have a minimum of four (4) foundation anchor rods per post.
- The connection of the structure to the foundation shall be a double-nut moment connection.
- Grout shall not be used between the structure base plate and the top of the footing. The grout on existing footings has cracked, allowing water and chlorides to stay in the cracks and not dry out, which has led to corrosion of the anchor rods.
- A stainless steel standard grade wire cloth (1/4-in. (6.4 mm) maximum opening with minimum wire diameter of AWG No. 16) shall be installed around the structure base plate and top of footing with a 2-inch (51 mm) lap as shown and noted on the footing plans. The screen is to prevent debris from collecting beneath the base plate, keep animals out, and protect the electrical wires.
- Typical NHDOT sign footing plan is shown in Appendix 10.3-B1.
- Cofferdams, Item 503.20x may be required if there is insufficient room to excavate for the footing using 1.5:1 slopes. Cofferdams with Sheeting Left-in-Place, Item 503.30x, should be used when its removal would create a stability problem with adjacent structure of any type, including roadways and drainage structures, the sign itself or required by the geotechnical engineer.



**Typical NHDOT Sign  
Structure Footing**

*Figure 10.3.2-2*

## C. Geometry

- The top of the concrete stem shall be placed 3-inches  $\pm$  (76 mm) higher than the adjacent highest finished grade.
- The bottom of the foundation shall be placed a minimum of 5'-0" (1.5 m) below the lowest finished grade (normal to the ground surface) for frost cover.
- The upright face of the sign structure that is closest to traffic should be located outside the clear zone. If the sign structure is not located outside the clear zone, the upright face closest to traffic shall be located a minimum of 10-ft. (3 m) behind the guardrail for any Interstate or Turnpike location. Any exception to this shall be approved by the Bureau of Traffic.
- Overhead signs shall provide a vertical clearance of not less than 17'-6" (5.3 m) [18'-0" (5.5 m) preferred by Bureau of Traffic] over the entire width of the travel way and shoulders.
- The maximum overhead cantilever sign structure span is 50-ft. (15 m). Any exception to this shall be approved by the Design Chief, Bureau of Bridge Design.
- The foundation and structure shall be located within the state owned right-of-way, and without interference with utilities, drainage pipes, or structures.

**10.3.3 Installation**

- The foundation shall be constructed and the sign structure installed according to Section 615 – Traffic Signs, NHDOT Standard Specifications for Road and Bridge Construction, and the Special Provision, Amendment to Section 615 – Traffic Signs.
- The Special Provision, Amendment to Section 615 – Traffic Signs, shall be included in all project proposals that have a sign structure. This special provision addresses the anchor rod installation and pretensioning procedures for the double-nut connection to the foundation.
- The structure shall not be placed onto the leveling nuts until the foundation concrete has cured for at least 7 days or attained at least 80 percent of its design compressive strength.
- Sign mounting brackets shall be attached to the structure utilizing only bolted connections, which allow complete lateral and vertical adjustment of the sign over the roadway, as noted in Section 615.
- When the sign panels are not installed immediately upon installation of the structure, an equivalent loading, such as dampers, shall be installed temporarily for mono-tube cantilever structures only.

**10.3.4 Design Guidelines**

A guideline for the review of the sign structure shop plans and design, and drawing of the foundation plan, can be found in Appendix 10.3-A1. A sample plan of a sign footing can be found in Appendix 10.3-B1.

If the site being considered for a sign structure has poor soil conditions, a decision must be made on whether to use a bridge sign structure with two foundations or a cantilevered sign structure with one foundation on piles, a cost comparison will usually show that the cantilevered sign structure

with one foundation on piles is approximately twice the cost of a bridge sign structure. The pile foundation cost is higher due to the cost of providing pile driving equipment.

### 10.3.5 Design Process and Coordination

- 1) Upon initiation of a design for a new sign structure, the lead Bureau shall request borings and shall provide the following to the Bureau of Materials and Research:
  - Roadway plan and cross-sections showing the proposed location of the structure(s) and boring location by station and offset.
  - One boring should be requested for each foundation. If poor soils are encountered, the designer shall be contacted to determine if a boring should be taken at another location (i.e., the location moved or a sign bridge structure could be used instead of a cantilever structure).
  
- 2) The lead Bureau then requests a preliminary sign footing size and quantities from the Bureau of Bridge Design or the design Consultant. The request should include the following:
  - A “stick diagram” for each structure indicating the structure location, span, offset, signs, sign location on the structure, elevations, vertical clearance, dimensions, and any other attachments to the structure.
  - Roadway plan and cross-sections showing the proposed location of the structure(s).
  - Any other information that may affect the final location of the sign foundation.
  
- 3) In response to the Preliminary Sign Footing Request, the Bureau of Bridge Design or the design Consultant shall provide the following to the lead Bureau:
  - Approximate footing dimensions for each structure.
  - A cross-section of each structure with the preliminary footing drawn on the section, indicating the top and bottom footing elevations and showing cofferdams, if required.
  - Estimated quantities for construction of the footing:
    - ⇒ Item 206.1, Common Structure Excavation
    - ⇒ Item 503.20x, Cofferdams (if required)
    - ⇒ Item 503.30x, Cofferdams with Sheet piling Left-in-Place (if required)
    - ⇒ Item 508, Structural Fill (if required)
    - ⇒ Item 520.2, Concrete Class B
    - ⇒ Item 544.1, Reinforcing Steel (Roadway)
  
- 4) Contract Plan stage
 

The lead Bureau or design Consultant shall transfer the preliminary sign footing information onto the contract plans. The contract plans and/or proposal shall include the following:

  - “Stick diagram” of each structure with the latest information showing the structure location, span, offset, signs, sign location on the structure, elevations, vertical clearance, dimensions, and any other attachments to the structure.
  - Sign Text Layout Plan

- General Roadway Plan showing the structure and foundation locations
- Cross-sections showing the structures and foundations (transferred from the preliminary sign footing cross-section).
- Special Provision, Amendment to Section 615 – Traffic Signs
- The project estimate shall include funds for structural steel inspection during fabrication of the sign structure (approximately \$2,000 for each structure).

5) Award of the Contract stage

- The Contractor shall submit a complete set of sign structure shop drawings and design calculations, along with the design forces and offsets, as noted in Section 615.3.4.1.2, Structure Requirements, of the Special Provision Amendment to 615, Traffic Signs.
- The Bureau of Bridge Design, or the design Consultant, shall review the Fabricator's sign structure calculations and shop plans for conformity with the contract plans, proposal, specifications, and NHDOT policy. The shop plans shall be stamped "Approved", "Approved Except as Noted", or "Disapproved" and returned to the Bureau of Construction for distribution to the Contractor, Traffic Bureau, Steel Fabrication Inspector, and Fabricator.

The review shall conform to the requirements of the following:

- Contract plans
- Addendums
- Specifications
- Special Provision, Amendment to Section 615
- NHDOT Bridge Design Manual, Chapter 10 Non-Bridge Structures
- Sign Structure and Footing Design Guidelines (Appendix 10.3-A1)
- The Bureau of Bridge Design or the design Consultant will design the sign structure footing(s) using the design loads provided by the Fabricator of the sign structure. A footing plan shall be drawn (See Appendix 10.3-B1 for a sample Sign Structure Footing Plan) and shall include the following:
  - Plan, elevation, and sectional view of footing
  - Reinforcing layout and schedule
  - Item numbers and quantities
  - Item number of structure
  - Notes
  - Detailed description of the footing location (obtain from the Bureau of Traffic; the description shall be more than the structure stationing)
  - Traffic Inventory Number (obtain from the Bureau of Traffic)
  - Plan file number (Assign file number as instructed in the Sign Footing File Number document [S:\Bridge-Design\FORMS\PROJECT\Sign Footing Plan File Number.xls])
  - Anchor Rod detail as shown on the sample footing plan
  - Pay limits of Items 206.1 and 508 (if required)

6) Distribution of Plans

- Distribute the following to the Bureau of Construction:
  - Four (4) full-size and four (4) half-size copies of the sign structure footing plan(s).

- Four (4) copies of “Approved” stamped sign structure shop plans.
- Distribute the following to the Fabrication Engineer, Bureau of Bridge Design:
  - One (1) copy of the “Approved” stamped sign structure shop plans with a transmittal letter noting the project name, number, sign structure location, name of fabricator, and noting that the copy is to be distributed to the shop inspector.
- Email the Bureau of Traffic Engineering Section, noting that a copy of the “Approved” stamped sign structure shop plans and foundation drawings were scanned and placed as noted below in “Archiving the Plans”.

#### 7) Archiving the Plans

The sign structure shop plans and footing plans are stored in the Bureau of Bridge Design. The following shall be filed in Bridge Design for future reference:

- One (1) full size plan(s) of the sign structure footing, filed in the tub per the file number. (All sign footing plans are filed in file number 115-3)
- A folder labeled with the sign structure project name and project number, and placed in the Sign Structure file cabinet. The folder shall contain the following:
  - Half-size copy of the “Approved” stamped sign structure shop plans
    - ⇒ Mark the **Traffic Inventory Number** for the structure on the corresponding shop plans for future reference
  - Design calculations of the sign structure and footing
  - Half-size copy of the sign structure footing plans
  - “Stick Diagrams” of each structure from the contract plans
  - Cross-section of each structure from the contract plans  
(*Note: The final footing needs to be sketched on the cross-sections and noted since the cross-section shows the preliminary footing*)
  - Copy of any addendums or special provisions
  - Half-size copy of the General Roadway Plans showing the structure locations
  - Geotechnical Report and Boring Logs
  - Half-size copy of the Sign Text Layout Plan from the contract plans
- Scan a copy of the “Approved” stamped sign structure shop plans and foundation drawings.
  - Save the scanned documents in the V:\ directory (V:\Bureaus\B54-Traffic\ENGINEERING&RESEARCH\OHSS\Plans (Structure & Footing).
  - Create a sub-folder with the structure inventory number.
  - Save the documents in the sub-folder. The scanned structure shop plans should be named with the year approved (i.e., structure 2012.pdf). The scanned footing plans should also be named with the year designed (i.e., footing 2012.pdf). Include the word “original if a new structure and/or footing.

#### 8) Recording Sign Structure and Footing Details

- The sign structure and footing details shall be entered into the Bureau of Bridge Design Database by the project engineer as described in the Sign Structure and Footing Design Guidelines (Appendix 10.3-A1).

- If Bridge Design was not the lead Bureau of the sign structure project, the lead Bureau or design Consultant shall forward the plans and information as noted above (Archiving the Plans) to the Bureau of Bridge Design for archiving and recording.

### 10.3.6 Adding New Signs to an Existing Overhead Sign Structure

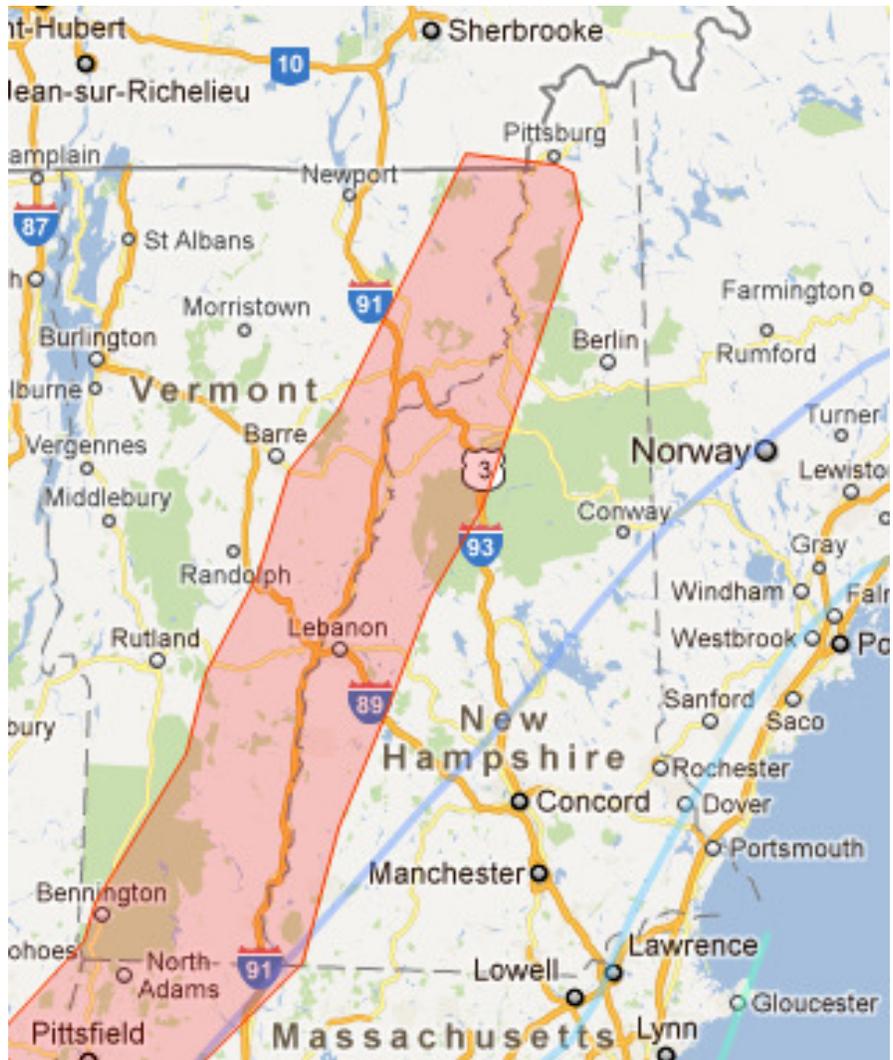
Existing sign structures and foundations that were constructed since 1975 have been designed to accommodate a total sign surface area 30% greater than the proposed sign area. If a sign(s) needs to be replaced or added to an existing overhead sign structure, the Bureau of Traffic shall coordinate the following:

- 1) The Traffic Engineer shall determine, from the existing project folder calculations and shop plans, the total sign surface area for which the structure and foundation were designed. If the Bureau of Traffic does not have a copy of the calculations and shop plans, the Traffic Engineer shall contact the Bureau of Bridge Design for a copy. Since the existing signs on the structure may not be the actual signs for which the structure was designed, the actual designed sign surface area needs to be confirmed by the design calculations and shop plans. The Bureau of Traffic has created a sign structure database to inventory each structure and its signs. Information regarding the total designed sign surface area for the structure will be added to the database for future reference.
- 2) For overhead sign structures where the centroid of each sign remains coincident with the mid-height of the horizontal truss, does not lower the vertical clearance and does not move laterally:
  - a) If the new total sign surface area is *less than* the total *designed* sign surface area (original sign surface area plus 30%), the Traffic Engineer can replace the existing sign with the new sign *without* any further analysis.
  - b) If the new total sign surface area is *greater than* the total *designed* sign surface area (original sign surface area plus 30%), the Traffic Engineer shall contact the Bureau of Bridge Design for analysis of the existing structure and foundation with the new loading.
- 3) For overhead sign structures where the centroid of an existing or new sign moves vertically from the mid-height of the horizontal truss and/or moves laterally to a different location on the horizontal, the Traffic Engineer shall contact the Bureau of Bridge Design for analysis of the existing structure and foundation with the new loading, *regardless* of whether the total sign area increases *or* decreases.
- 4) Any change of the sign(s) on the structure or the structure itself shall be updated in the Bridge Design Database.

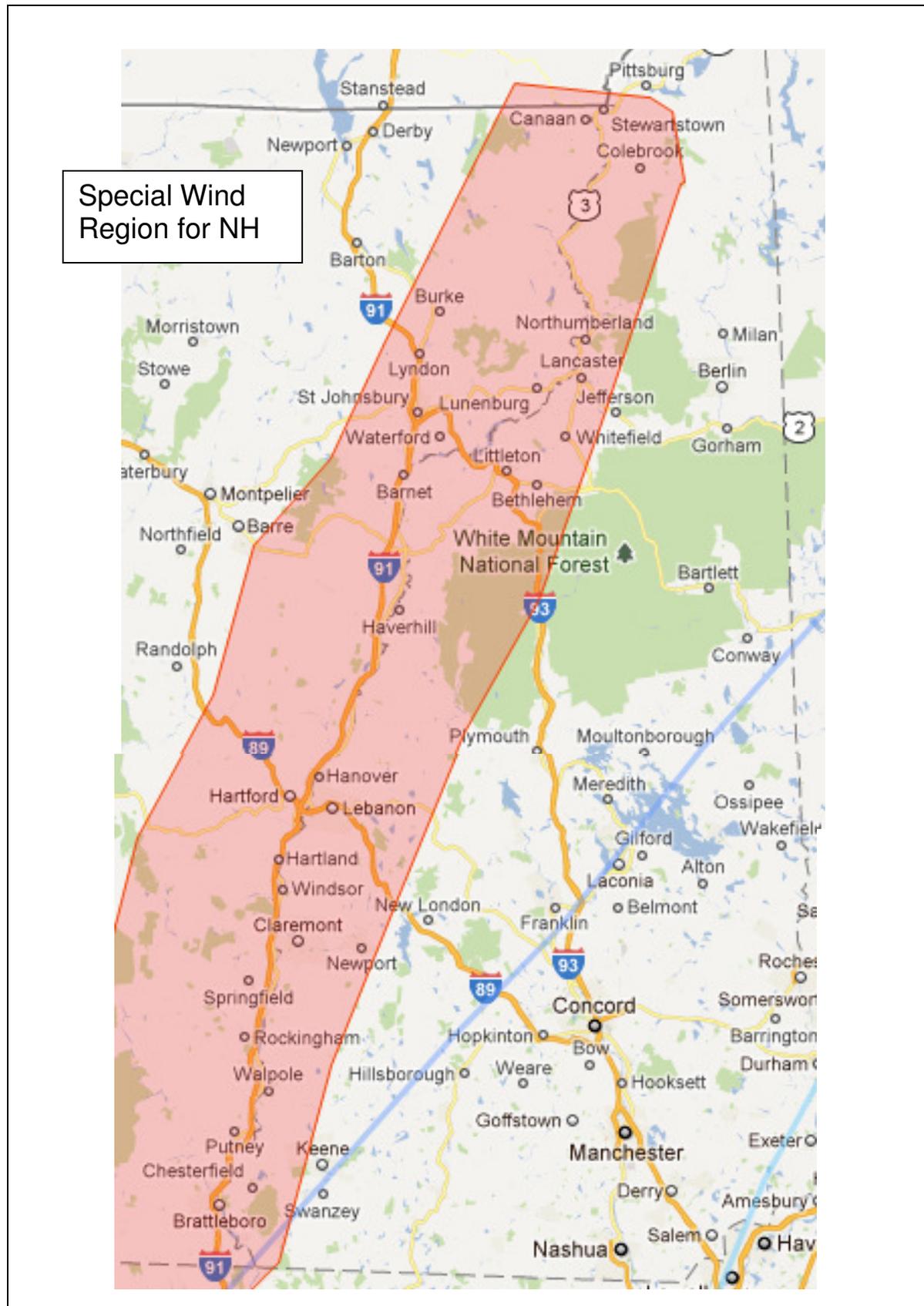
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### Basic Wind Speed Map for NH and Special Wind Region

- The map below shows the 3-second gust basic wind speed derived from figure 6-1 of ASCE 7-05 and the Special Wind Region. The following page is closer view of the special wind region. The map can also be viewed at: <http://www.windspeedbyzip.com/>.
- For wind speeds in the *Special Wind Region*, weather station data can be accessed by clicking on the markers (weather stations) on the weather underground map located at: <http://www.wunderground.com/wundermap/?lat=43.63526535&lon=-72.25418091&zoom=8&pin=Lebanon%2c%20NH>



\* 3-second gust basic wind speed derived from figure 6-1 of ASCE 7-05. Local codes and amendments may govern, verify with local building department.



## SIGN STRUCTURE & FOOTING DESIGN GUIDELINES

The Sign Structure and Footing Design Guidelines is a working document for use as a guide for reviewing sign structure shop plans, designing the foundation, and drawing the sign structure foundation plan. This guideline is intended to promote consistency and continuity of sign structure and foundation designs, and project coordination.

Overhead sign structures and foundations shall be designed or analyzed in accordance with the following, as appropriate:

- Current edition of AASHTO “*Standard Specifications for Structural Supports for Highway Signs, Luminaires, and Traffic Signals*,” including interims
- NHDOT Standard Specifications for Road and Bridge Construction.
- NHDOT Bridge Design Manual
- Special Provision, Amendment to Section 615 – Traffic Signs
- Special Provision Item 677.xx – Permanent Fixed Location Dynamic Message Sign

### A. Sign Structure Shop Drawings Check List

- Overhead signs shall provide a vertical clearance of not less than 17'-6" [5.3 m] (18'-0" [6.3 m] preferred by Bureau of Traffic) over the entire width of the pavement and shoulders.
- Check for any changes made after proposal (i.e., addendums).
- Check that signs are correctly oriented with respect to stationing (i.e., back of sign).
- Compare dimensions for signs and structure (post and truss lengths, sign dimensions, and offsets) with stick drawings, cross-sections, Prosecution of Work, addendums, and special provisions.
- Anchor rod size and layout shall be identical for both left and right footings, else disapprove.
- Check that the anchor rods are galvanized, include hardened washers, not lock washers, and two nuts (one above and one below base plate) per rod, are shown for the double-nut moment connection to the sign structure.
- Check for a licensed N.H. P.E. stamp.
- Check that the top of concrete stem elevation is 3-in. (75 mm)  $\pm$  higher than adjacent highest finished grade.
- 25 percent of the base plate-to-post weld shall be inspected by magnetic particle testing per AASHTO specification. This requirement shall be noted on the shop plans.
- Triangular truss type overhead sign structures shall not be allowed due to concerns with their susceptibility to fatigue cracking.
- Tubular arch type structures are not allowed due to concerns with their susceptibility to fatigue cracking.
- Sign support members (W6x9's) shall not be greater in length than the sign height.
- Check that the upright face closest to traffic of the sign structure support is a minimum of 10-ft. (3 m) behind the guardrail or is outside the clear zone, otherwise approval is required from Bureau of Traffic.

- The distance from the top of the concrete stem to the bottom of the sign structure base plate shall be the nut height plus 1-inch [25 mm] (preferred) or nut height plus the anchor rod diameter (maximum). If the shop plans are noted differently, cross-out the shop plan note and add in this note. See “Anchor Rod Detail” on Sign Footing Sample Plan.
- The connection of the structure to the foundation shall be a double-nut joint moment connection.
- The maximum overhead cantilever sign structure span is 50-ft. (15.2 m) Any exception to this shall be approved by the Design Chief of the Bureau of Bridge Design
- Anchor rods shall conform to the requirements of ASTM F1554 Grade 55 (minimum). Do not use ASTM A615 reinforcing steel. Galvanize the entire rod per ASTM A153. Each anchor rod shall be supplied with a minimum of two hex nuts (ASTM A563 or ASTM A194) and a minimum of two flat hardened washers (ASTM F436).
- Each monotube upright post shall have a minimum of eight (8) foundation anchor rods. Each post of a multi post upright (truss) shall have a minimum of four (4) foundation anchor rods per post.

**B. Check Input, Loads, and Reactions from Fabricator’s Sign Structure Program**

There have been many instances where computer programs have provided incorrect output and incorrect reactions (e.g: The values for the wind on the sign were 30% low, even though the input was correct.).

- Check for a licensed N.H. P.E. stamp.
- Check that the design was per the current edition of AASHTO “*Standard Specifications for Structural Supports for Highway Signs, Luminaires, and Traffic Signals,*” including interims
- Check that the Design Sign Area = 1.3 x Actual Sign Area
- Check input values and spot check output values. (See NHDOT Bridge Design Manual, Chapter 10, Section 10.2 Loads)
- Check that sign structures designed for Cantilevered Fatigue Category I, have the anchor rods designed for wind-induced cyclic loads per AASHTO Specifications Section 5.17.3.4.

**C. Check Constructability of Footing.**

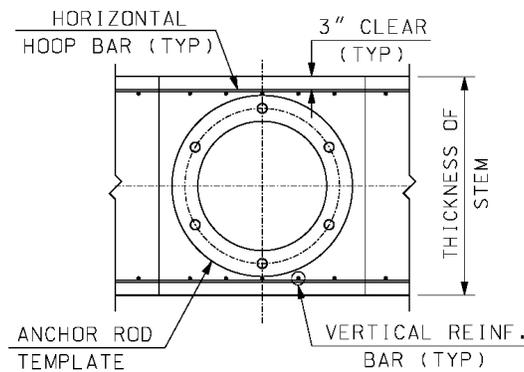
- Check if cofferdams are required. Include item number on sign footing plan, if the item is included in the contract items. Cofferdams, Item 503.20X may be required if there is not enough room to excavate for the footing using 1.5:1 slopes. Cofferdams with Sheeting Left-in-Place, Item 503.30x, should be used when its removal would create a stability problem with adjacent structure of any type, including roadways and drainage structures, the sign itself or required by the geotechnical engineer.
- Check that the sign structure and foundation are located to avoid any interference with utilities, drainage pipes, or structures.

D. Review Geotechnical Report.

- Check allowable bearing pressure
- Check frost depth:
  - ⇒ The bottom of the foundation shall be placed a minimum of 5'-0" (1.5 m) below the lowest finished grade measured normal to the ground surface for frost cover.
- Check with the Design Chief to confirm the necessity of structural fill below the footing.
- Check to determine if rock anchors or any other foundation requirements are specified.

E. Footing Design Check List

- There are In-House Design programs for the foundation design located at: S:/Design/Programs/Sign
- Minimum thickness of stem = anchor rod template outside diameter + 2\*(dia. vertical bar + dia. horizontal hoop bar + 3" [75 mm] clear)



- Length of stem base at top of footing = footing length – 1 ft. (300 mm)
- Length of stem at top of pedestal = post spacing + stem thickness
- If left and right footing are similar, use *identical* footings.
- Design method: ASD (Allowable Stress Design) per AASHTO
- Grout shall not be used between the bottom of the structure base plate and the top of the footing.
- Cantilever sign structure with more than one (1) sign:
 
$$L_{\text{sign}} = \frac{\sum(A_{\text{sign}} \times L_{\text{sign}})}{\sum A_{\text{sign}}}$$
- Sign Bridge sign structure: If using Sign.Exe program, the input load  $DL_{\text{truss+signs}}$  and  $IL_{\text{truss+signs}}$  = reaction of one leg due to the DL or IL of total signs and truss. The designer needs to run two programs, one for each leg, if signs are not the same size and/or are not symmetrical.
- Check bearing pressure:  $Q_{\text{max}} < Q_{\text{allow}}$

- ❑ If  $Q_{\min} < 0$  (negative soil pressure, footing uplift) use AASHTO Fig. 4.4.7.1.1.1C to calculate uplift.
- ❑ NHDOT policy for maximum allowed footing area with uplift is the following:
  - ⇒ Sign bridge structure = 5 % of footing area.
  - ⇒ Cantilevered sign structure = 1 % of footing area.
- ❑ If the area of footing having uplift is > 5% for sign bridge structure, or > 1% for cantilevered sign structure, *increase* footing size.
- ❑ Design the footing reinforcing for loading in both the transverse and longitudinal direction.
  - ⇒ Use the *same* size reinforcing bar for both directions, for ease of construction.
- ❑ Check the development length for stem reinforcement at the footing interface both into the stem and into the footing.
- ❑ Check that the overlap length of the vertical reinforcing bar and anchor rod is equivalent to a class c splice length of the reinforcing bar.
- ❑ If sign structure is a cantilever structure, the stem design should be checked for torsion.
- ❑ Check the area of reinforcing required for stem sections at the **bottom, top, middle**, and a **distance down from the top of the stem**, for both the transverse and longitudinal directions. (In some designs, the slope of the stem causes the bars to drop out of the section quickly, creating less area of steel at certain heights of the stem.) Make sure the stem design has adequate amount of reinf. required at all sections of the stem height.
- ❑ If the footing is founded on bedrock and if rock anchor rods are required:
  - ⇒ Check soils report for bearing capacity of bedrock
  - ⇒ Check the pullout capacity of the ledge. Per AASHTO Table 5.7.6.2B, granite = 50 k/ft.(74.4 Tn/m), FS = 3 for anchors in rock. (If anchor is drilled four feet into granite, then the granite can resist 4 ft. x 50 k/ft. /3 = 66.6 k force.)
  - ⇒ Check capacity of anchor =  $0.55(F_y)(A_{\text{bar}})$ .
  - ⇒ Rock anchors should be grade 60 ksi reinforcing steel.
  - ⇒ Anchor should be set in drilled holes =  $\frac{1}{2}$ " (12 mm) + Dia. bar.
  - ⇒ Hole should be filled with an approved high-strength non-shrink grout, minimum 2 ft. (600 mm) deep.

#### F. Drafting Footing Plan Using CADD Macro: Sign Footing

- Enter MicroStation
  - On the File Open splash screen, make sure the project is listed as “BRIDGE MISC ENGLISH” in the Workspace box.
    - ⇒ Open N:\CADD\Misc Accounts\BRD\Sign Footings
  - Create a sub-folder with the project name and number
  - Create a .dgn using the item number of the structure (e.g., 615\_10001.dgn). If a sign bridge structure, add the designation of “LT” or “RT” to distinguish the file name (e.g., 615\_10001\_LT.dgn)
  - Click on the “File” tab at the top of the File Open splash screen and click “New”.
  - Double click on the .dgn to open the drawing
  - Open Level Manager, attach Library: BRC.csv, close out Level Manager
    - ⇒ This needs to be done every time a .dgn is created for the macro to run.
    - ⇒ N:\CADD\CADD\v8i\_Workspace\Standards\dgnlib
  - Click on NHDOT (top menus), Sign Footing
  - Macro input menu opens. Input values as applicable on the “Footing”, “Rods”, “Reinforcing Bars” and “Pay Limit Details” tabs.
  - Click on “Do It” once all input is complete.
  - Click on full screen view when macro is done.
- ❑ Editing of the drawing may be required for job specific items.
- ❑ File number for new sign footing plans: **122-x-x** (old files are 115-3 [2013 -11], 105-2 [2010 -2007], 77-5 [2006 -1999], 45-4 [1998 – prior]) Log file number in sign footing plan file document S:\Bridge-Design\FORMS\PROJECT\Sign Footing Plan File.xls
  - ❑ Give a detailed description of the footing location (e.g., 250-ft. north from Exit 12, I-93 SB), not just a construction station location. Obtain this description from the Bureau of Traffic.
  - ❑ Indicate on the plans near the title box, the **Traffic Inventory Number** for the structure. Call Bureau of Traffic to obtain the inventory number they have assigned to the structure.
  - ❑ Check Item nos. and descriptions and check that they match the contract plans.
  - ❑ Indicate the footing design bearing pressure in the Sign Footing Notes on the plan.
  - ❑ Indicate the design sign area for each footing (including 30% increase) in the Sign Footing Notes on the plan.
  - ❑ If bedrock exists, the macro does not draw the bedrock location. Its approximate location will need to be drawn manually and the rock excavation item number added to the quantity box and excavation quantities adjusted.
  - ❑ Other minor editing may be required.
  - ❑ The macro draws an anchor rod detail and a stainless steel wire cloth detail. A note is added stating, “For the installation and pretensioning of anchor rods, see Special Provision, Amendment to Section 615 – Traffic Signs.
  - ❑ Check that all items shown on the sign footing plan are included in the proposal contract estimate, otherwise the item number on the plan needs to change to match the contract estimate.

### G. Pay Items and Limits

- ❑ Item 206.1, Common Structure Excavation
  - ⇒ Vertical pay limits shall extend from the bottom of footing (or structural fill) to the existing or proposed ground. If the existing ground is above the proposed ground line, excavation from existing ground to proposed ground is paid for under common excavation. Any additional excavation for the footing is paid for under common structure excavation (see Standard Specifications Section 203). No excavation payment shall be made if the sign footing is entirely above existing ground.
  - ⇒ Horizontal pay limits extend one foot (300 mm) beyond the footing limits on all sides unless founded on more than one foot (300 mm) of structural fill, or if cofferdams are used (see Appendix 10.3-B1).
- ❑ Item 206.1, Common Structure Excavation is measured to the nearest 1 CY
- ❑ Item 508, Structural Fill is measured to the nearest 1 CY
- ❑ Item 520.2, Concrete Class B is measured to the nearest 0.1 CY
- ❑ Item 544.1, Reinforcing Steel (Roadway) is measured to the nearest 1 LB
- ❑ No item is needed for fill since the same material excavated will usually be replaced. If ledge is excavated to construct the footing, check the contract estimate for a good draining replacement material such as Item 209.1, Granular Backfill. Quantify this item and include it in the quantity box on the footing plans.
- ❑ For DMS overhead sign structure and foundation, all items are subsidiary.

### H. Inputting Sign Structure and Footing Data into the Database

- Go to “Add/Change Projects, Bridges or Signs” button.
- Enter the project number
- If the project is past the advertising date, click on the “Unlock Project” button to enter information in the window.
- Click on the “Sign Footing” tab and enter in the year built, town, and inventory number for each sign structure.
- Close out window
- Click on the “Misc Menu” tab on the main menu
- Click on the “Sign Footing” tab
- Click on the “Edit” tab and enter the sign footing information for each sign structure

### I. Design Process and Coordination

See NHDOT Bridge Manual, Chapter 10, Section 10.3.5, Design Process and Coordination for the following:

- Design process and coordination of sign structures and foundations between bureaus and consultants
- Distribution of Plans
- Archiving Plans and Calculations







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**BEDFORD-MANCESTER  
25481**

September 3, 2013

**SPECIAL PROVISION**

**AMENDMENT TO SECTION 615 -- TRAFFIC SIGNS**

This special provision amends Section 615 and addresses (1) the design criteria for new cantilever and full-span bridge overhead traffic sign structures and bridge-mounted sign supports, and (2) the installation and pretensioning procedures of overhead sign structure anchor rods for double-nut moment connections (i.e. the base plate stands off from the concrete foundation, bears on leveling nuts, and is secured by top nuts).

**Amend 3.4.1** to read as follows:

**3.4.1** Overhead sign structures and bridge-mounted sign supports shall be designed and installed in accordance with the current edition of the AASHTO “Standard Specifications for Structural Supports for Highway Traffic Signs, Luminaires and Traffic Signals” including all interims, except as modified per NHDOT design criteria stated herein:

**3.4.1.1 Design Loads.**

**3.4.1.1.1 Dead Loads:**

- |   |  |
|---|--|
| (a) Sign  | 5 psf [24.4 kg/m <sup>2</sup> ] (min.) |
| (Includes weight of sign & attachments (3 psf [14.6 kg/m <sup>2</sup> ]) and weight of W6x9 sign support (2 psf [9.8 kg/m <sup>2</sup> ]) |  |
| (b) Dynamic Message Sign (DMS)  | per manufacturer                       |
| (c) Variable Speed Limit Sign (VSLS)  | per manufacturer                       |
| (d) Bridge Mounted Sign Supports  | Calculate                              |
| (e) Structural Member   | Calculate                              |
| (f) Maintenance walkway   | per manufacturer                       |

**3.4.1.1.2 Wind Loads:**

- (a) The 3-second wind gust map in AASHTO Specifications shows the basic wind speed to be used in computing design wind pressure.
- (b) Basic wind speed of 100 mph (161 km/hr) shall be used for the whole state of NH *except* in the Special Wind Region (i.e., regions along the NH-VT border and Franconia Notch) as shown in AASHTO Specifications, Fig. 3-2e. The maximum-recorded wind speed in this area shall be used as the basic wind speed if it is greater than the NH basic wind speed of 100 mph (161 km/hr).

**3.4.1.1.3 Design Life and Recurrence Interval (Table 3-3, AASHTO Specifications):**

- (a) 50 years for all overhead sign structures (i.e., bridge or cantilevered) and bridge-mounted sign supports.

**3.4.1.1.4 Ice Loads:**

- (a) 3 psf (14.6 kg/m<sup>2</sup>) applied around all the surfaces of the structure and attachments but applied to only one face of sign panels per AASHTO Specifications.
- (b) 3 psf (14.6 kg/m<sup>2</sup>) applied to the top, ends, and one face of a DMS or VSLS.

**3.4.1.1.5 Snow Loads:**

- (a) 40 psf (195.3 kg/m<sup>2</sup>) applied simultaneously with ice load to the top panel and any other nearly horizontal projection of a DMS or VSLS.

**3.4.1.1.6 Fatigue Design:**

Fatigue design shall conform to AASHTO Specifications (Table 11-1) and the following categories:

- (a) Cantilevered Fatigue Category I:
  - All overhead cantilever sign structures
    - ◆ Galloping loads may be excluded for fatigue design of overhead cantilevered sign structures with four-chord horizontal trusses.
  - All bridge-mounted sign supports
- (b) Non-Cantilevered Fatigue Category I:
  - Overhead bridge sign structures located along the Turnpike, Interstate, and Interstate ramps
- (c) Non-Cantilevered Fatigue Category II:
  - Overhead bridge sign structures located on non- Turnpike, non-Interstate NH, and US routes

**3.4.1.1.7 Live Load:**

A live load consisting of a single load of 500 lbs. (226.8 kg) distributed over 2.0 ft. (0.6 m) transversely to the member shall be used for designing members for walkways and platforms (see AASHTO Specifications Section 3.6).

**3.4.1.2 Structure Requirements**

- (a) Overhead sign structures shall be designed to accommodate sign surface areas of 30 percent greater than those shown on the plans, unless otherwise noted.
- (b) The structures shall be steel, galvanized in accordance with NHDOT Specification 550.2.9 .
- (c) Anchor rod size and layout shall be designed by the structure fabricator and shall be identical for both left and right footings.
- (d) The connection of the structure to the foundation shall be a double-nut moment connection. Do not place grout between the top of foundation and the base plate.
- (e) Anchor rods shall conform to the requirements of ASTM F1554 Grade 55 (minimum). Do not use ASTM A615 reinforcing steel. Galvanize the entire rod per ASTM A153. Each anchor rod shall be supplied with a minimum of two hex nuts (ASTM A563 or ASTM A194) and a minimum of two flat hardened washers (ASTM F436). Lock washers shall not be used.
- (f) For sign structures that are designed for Cantilevered Fatigue Category I, the anchor rods shall be designed for wind-induced cyclic loads per AASHTO Specifications Section 5.17.3.4.

- (g) Each monotube upright post shall have a minimum of eight (8) foundation anchor rods. Each post of a multi post upright (truss) shall have a minimum of four (4) foundation anchor rods per post.
- (h) 25 percent of the base plate-to-post weld shall be inspected by magnetic particle testing per AASHTO Specifications. This requirement shall be noted on the shop plans.
- (i) Triangular truss and tubular arch type overhead sign structures are not permitted due to concerns with their susceptibility to fatigue cracking.
- (j) Lock washers shall not be used with the installation of high strength bolts per FHWA Guidelines.
- (k) Sign support members (W6x9) shall not be greater in length than the sign height.
- (l) The Contractor shall furnish the design calculations and complete shop drawings for approval for the overhead structures, including method of attaching signs to the structure, in accordance with 105.02. The Contractor shall supply calculations and a list of the following design forces and offsets:

<b>Table of Structure Forces and Offsets</b>		
<b>Load Source:</b>	<b>Resultant Loading of Load Source:</b>	<b>Horizontal and Vertical Offset From Top of Foundation to Resultant Loading:</b>
Truss or Cantilever Dead Load		
Sign(s) Dead Load		
Post(s) Dead Load		
Wind Load on the Horizontal Sign Support		
Wind Load on the Sign(s)		
Wind Load on the Post(s)		
Ice Load on the Horizontal Sign Support		
Ice Load on the Sign(s)		

### 3.4.1.3 Geometry

- (a) The top of the foundation should be placed 3-inches  $\pm$  (75 mm) higher than adjacent highest soil.
- (b) The bottom of the foundation shall be placed a minimum of 5'-0" (1.5m) below the lowest finished grade (normal to the ground surface) for frost cover.
- (c) The face of the sign structure upright that is closest to traffic should be located outside the clear zone. If the sign structure is not located outside the clear zone, the upright face closest to traffic shall be located a minimum of 10 ft. (3 m) behind the guardrail for any Turnpike or Interstate location. Any exception to this shall be approved by the Bureau of Traffic.
- (d) Overhead signs shall provide a vertical clearance of not less than 17'-6" 95.3 m) [18'-0" (5.5 m) preferred by Bureau of Traffic] over the entire width of the travel way and shoulders.

- (e) The maximum overhead cantilever sign structure span is 50 ft. (15 m). Any exception to this shall be approved by the Design Chief, Bureau of Bridge Design.
- (f) The distance from the top of the concrete footing to the bottom of the sign structure base plate shall be the nut height plus 1-inch [25 mm] (preferred) or nut height plus the anchor rod diameter (maximum). (Note the nut height equals the rod diameter.)
- (g) The foundation and structure shall be located within the state owned right-of-way, and without interference with utilities, drainage pipes or structures.

**Delete 3.4.2.**

**Amend 3.4.6** to read as follows:

**3.4.6** When the sign panels are not installed immediately upon installation of the structure, an equivalent loading, such as dampers, shall be installed temporarily for mono-tube cantilever structures only. Dampers are not required for cantilever structures with a 4-sided truss arm.

**Amend 3.4.8** to read as follows:

**3.4.8** The applicable provisions of 550.3 apply to the sign structures and installation of sign structure connections made with high strength bolts (e.g., ASTM A325). The installation procedures for anchor rods are different than for high strength bolts and shall conform to the following:

1. AASHTO “Standard Specifications for Structural Supports for Highway Traffic Signs, Luminaires and Traffic Signals”;
2. FHWA Guidelines for the Installation, Inspection, Maintenance and Repair of Structural Supports for Highway Signs, Luminaires, and Traffic Signals (Publication No. FHWA NHI 05-036 March 2005). (See Sections 6.8 and 6.9)
3. NHDOT Special Provision for Section 615.

**Add to 3.4 Overhead Traffic Sign Structures.**

**3.4.11 Procedure for Installing Anchor Rods in the Foundation for Double-Nut Connections.**

The procedure for installing anchor rods in the foundation for double-nut connections is as follows:

1. The Foundation Contractor shall submit a written plan and procedure to the Department for approval for the installation, pretensioning, inspection, and testing of anchor rods.
2. The Contractor shall furnish necessary equipment, including a torque wrench, used for tensioning the rods or for final torque verification, that has a torque indicator that is calibrated annually. A certificate of calibration shall be furnished to the Department at the jobsite. A torque multiplier may be used. For hydraulic wrenches, the Contractor shall furnish a chart correlating torque with hydraulic pressure readings.
3. Anchor rods shall be installed as a group in the concrete form and secured against relative movement and misalignment, such as with a template set composed of metal rings with nuts on both sides at two locations along the length of the anchor rods. One of the rings is usually above the top of the concrete and is reused as a template.

4. The template set (or other device) with anchor rods shall be secured in its correct position in the concrete form in accordance with the drawings. The exposed threads shall be taped with duct tape to prevent contamination by concrete.
5. The concrete shall be placed and cured.
6. If a top template is above the concrete surface, it may be removed 24 hours after placing the concrete.
7. The exposed part of the anchor rods shall be cleaned with a wire brush or equivalent and lubricated. Use an approved paraffin-based stick wax, as listed on the NHDOT Qualified Products List for Item 550 fasteners, applied to the threads and the nut face in contact with the washer.
8. At least 24 hours after placing the concrete, the anchor rods shall be inspected visually to verify that there is no visible damage to the threads and that their position, elevation, and projected length from the concrete are within the tolerances specified on the drawings. In the absence of required tolerances, the position, elevation, and projected length from the concrete shall be according to the *AISC Code of Standard Practice for Steel Buildings and Bridges*. The misalignment from vertical shall be no more than 1:40. It is good practice to use a steel or wood template with the required hole pattern to check the base of the post and the anchor rods.

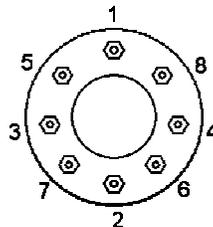
To check the thread condition the nuts shall be turned onto the rods full length well past the elevation of the bottom of the leveling nut and backed off by one worker using an ordinary wrench without a cheater bar. The threads are considered damaged if more than minimal effort (i.e. an unusually large effort) is required to turn the nut.

9. Once the concrete has reached sufficient strength (7 days minimum), anchor rods are ready to be subjected to erection loads.

**3.4.12 Procedure for Pretensioning Anchor Rods in Double-Nut Moment Connections.** The procedure for pretensioning anchor rods in double-nut moment connections in the installed concrete foundation is as follows:

1. The proper position of the anchor rods and the proper hole pattern on the post shall be verified (preferably with a template).
2. It shall be verified that the nuts can be turned onto the rods well past the elevation of the bottom of the leveling nut and backed off by one worker using an ordinary wrench without a cheater bar.
3. If the threads of anchor rods were lubricated more than 24 hours before placing the leveling nuts or have been wet since they were lubricated, the exposed threads of the anchor rod shall be relubricated. Leveling nuts shall be cleaned and the threads and bearing surfaces lubricated.
4. Leveling nuts shall be placed on the anchor rods and set level.
5. Leveling nut washers shall be placed on the anchor rods.
6. The template shall be placed on top of the leveling nuts to check the level of the nuts. Verify that the maximum clear distance between the bottom of the bottom leveling nut and the top of the concrete is not more than one anchor rod diameter. The preferred clear distance is one inch. Start by placing the leveling nuts one half inch clear distance above the concrete foundation. Bring all the nuts to the same level as the highest nut above the foundation. Do not exceed the maximum clear distance of one anchor rod diameter between the concrete

- foundation and the bottom of the leveling nuts. Remove the template once all the nuts are level.
7. The baseplate and structural element (e.g. post, end frame, or structure leg) shall be placed with a crane.
  8. The post, end frame, or structure leg shall be plumbed or the base plate leveled, and the anchor rods pretensioned. The following is the installation sequence for double-nut joints using the "turn-of-the-nut" method of pretensioning.
  9. Top nut washers shall be placed. (Note: Do not use lock washers when anchor rods are pretensioned for double-nut connections using the pretension procedures described herein.)
  10. Lubrication of the fastener components is required for proper installation. Anchor rod threads, nut threads, and the bearing surface of top nuts shall be lubricated, and the top nuts placed and tightened to the snug-tight condition (20-30% of the verification torque). See section 3.4.13 and Table 3. (Note: A snug-tight condition is the tightness attained by the full effort of a person using a wrench with a handle length equal to 14 times the diameter of the bolt but not less than 18 inches. Apply the full effort as close to the free end of the wrench as possible. Pull firmly by leaning back and using the entire body weight on the end of the wrench until the nut stops rotating.)
  11. Leveling (bottom) nuts shall be tightened to the snug-tight condition (i.e. 20-30% of the verification torque. See Table 3.) following a star pattern for two full tightening cycles. (Note: Use a minimum of two separate passes of tightening. Sequence the tightening in each pass so that the opposite side nut will be subsequently tightened (i.e. following a star pattern shown in Figure 8) until all the nuts in that pass have been snugged.)



**Figure 8. Star Pattern Tightening Sequence.**

12. At this point, the installation crew shall verify if beveled washers are necessary. Beveled washers may be necessary under the leveling or top nut if any face of the base plate has a slope greater than 1:20 and/or any nut could not be brought into firm contact with the base plate. If any beveled washer is required, the installation crew shall disassemble the joint as necessary, add the beveled washer(s) and retighten (in a star pattern) to the snug-tight condition for the top and leveling nuts.
13. Pretensioning by "Turn-of-the-Nut": Pretension the anchor rods to the minimum Installation Pretension listed in Table 3 in the following manner. Before turning the top nuts further, the reference position of the top nut in the snug-tight condition shall be marked relative to the rod and base plate with a suitable marking using a permanent paint marker. Mark the rod, nut, and base plate with marks in a straight line when viewed from above. Top nuts shall be turned in increments following a star pattern for at least two full tightening cycles to attain the nut rotation specified in Table 1 if UNC threads are used. After pretensioning, the nut rotation shall be verified.

<b>Table 1 - Nut Rotation for Turn-Of-Nut Pretensioning</b>		
<b>Anchor Rod Diameter, in.</b>	<b>Nut Rotation from Snug-Tight Condition a, b, c</b>	
	<b>F1554 Grade 36</b>	<b>F1554 Grades 55 and 105 A615 and A706 Grade 60</b>
1 1/2 or less	1/6 Turn (60°)	1/3 Turn (120°)
>1 1/2	1/12 Turn (30°)	1/6 Turn (60°)

- a. Nut rotation is relative to the anchor rod. The tolerance is plus 20 degrees.
  - b. Applicable only to double-nut joints.
  - c. Beveled washer shall be used if:
    - i) the nut is not in firm contact with the base plate; or
    - ii) the outer face of the base plate is sloped more than 1:40.
14. The load may be released from the crane.
15. **Initial check-** A torque wrench shall be used to verify that a torque at least equal to the computed verification torque,  $T_v$ , is required to additionally tighten the leveling nuts and the top nuts. See 3.4.13 and Table 3. An inability to achieve this torque (meaning that the nut moves before the torque is achieved) shall be interpreted to indicate that the threads have stripped and shall be reported to the Department. (**Note:** The installation procedure relies on the "Turn-of-the-Nut" method to achieve the Installation Pretension. Although torque is considered to be a poor way to ensure pretension (due to variable thread condition) it is the only way to check tension after tightening.) The Department may reject, and subsequently require replacement of, the entire base installation if the threads have stripped. All costs associated with replacing the base installation, if rejected, or performing other repairs shall be borne by the Contractor.
16. **Relaxation check-** After at least 48 hours have elapsed, and in the presence of the Department, the torque wrench shall be used to verify that a torque at least equal to 110 percent of the verification torque,  $T_v$ , is required to additionally tighten the leveling nuts and the top nuts on the anchor rods. See 3.4.13 and Table 3. An inability to achieve this torque (meaning that the nut moves before the torque is achieved) shall be interpreted to indicate that the threads have stripped and shall be reported to the Department.
17. **Ultrasonic testing (UT) -** The Contractor shall ultrasonically test (UT) the installed anchor rods using straight-beam transducers to verify the absence of flaws. (See Appendix A for UT procedures.) The Department will reject, and shall require replacement of, the entire base installation if reflectors are found with an indication rating less than 15 decibels. All costs associated with replacing the base installation, if rejected, will be borne by the Contractor.
18. During maintenance activities the Department intends to verify that the top nuts are not loose. Under no circumstance shall any nut be tack welded to the washer or the base plate nor shall the leveling nut be tack welded as a method of preventing nut loosening.

### 3.4.13 FHWA Guideline Reference:

1. In the FHWA Guideline document, the snug-tight condition for anchor rods is defined as nuts tightened to a torque between 20 and 30 percent of the verification torque computed using the following equation:

$$T_v = 0.12d_b F_t \quad \text{where}$$

$T_v$  = verification torque (inch-kips)

$d_b$  = nominal body diameter of the anchor rod (inches)

$F_t$  = minimum installation pretension (kips) equal to 50 percent of the specified minimum tensile strength of F1554 Grade 36 rods, and 60 percent for all other threaded fasteners.

(Note: the torque in "in-kips" can be multiplied by 83.3 to get ft-lb).

2. A very large torque may be required to properly tighten anchor rods greater than 1 inch in diameter. A "cheater bar" such as a pipe or extension handle as much as 10 feet long may be required for the torque wrench. For snugging the leveling nuts, an open-end wrench with a ten-foot long pipe or extension handle will typically suffice. Tightening the top nuts for anchor rods greater than 1 inch in diameter may require either of the following:
  - A hydraulic torque wrench, or
  - A box end "slug" or "knocker" wrench with a 10-ft, long pipe or extension handle.

The box end wrench may be moved by impacts with a 16-pound sledgehammer or by the efforts of three or more workers. It is essential that the workers have good traction during this effort.

<b>Tensile Property</b>	<b>ASTM F1554 Rod Grade 36</b>	<b>ASTM F1554 Rod Grade 55</b>	<b>ASTM F1554 Rod Grade 105</b>	<b>ASTM A706 Bars Grade 60 *</b>
Minimum Yield Strength $F_y$ , (ksi)	36	55	105	60
Minimum Tensile Strength $F_u$ , (ksi)	58	75	125	80

\* Reinforcing bars shall not be used for non-redundant, fatigue-susceptible support structures such as cantilevered overhead sign structures and high mast luminaires.

3. Note: According to AASHTO, anchor rods in single-nut connections may be either pretensioned or snug tightened, although pretensioned rods have shown better performance. Anchor rods in single-nut connections shall be tightened to at least one half of the double-nut pretension condition.

### **Add to 3.4 Overhead Traffic Sign Structures.**

**3.4.14 Screen.** Furnish, install, and secure stainless steel wire mesh around the space between the base plate and concrete foundation to prevent debris from collecting beneath the base plate, to keep animals out, and protect the electrical wires if present. The screen shall be secured in a manner that will permit its removal for maintenance activities.

**Amend 4.1** to read as follows:

**4.1** Fabrication and installation of overhead traffic sign structures and bridge-mounted sign supports, all materials, labor, equipment necessary or incidental to properly perform and complete the work specified will be measured as a unit. When more than one unit is specified in the Contract, separate item numbers will appear for each separate unit.

**Add** to **4.1** the following:

**4.1.3** Stainless steel wire mesh will not be measured.

**4.1.4** Ultrasonic testing of anchor rods will not be measured.

**Add** to **5.1** the following:

**5.1.6** Stainless steel wire mesh will be subsidiary.

**5.1.7** Ultrasonic testing of anchor rods will be subsidiary.

<b>Table 3 - Minimum Anchor Rod Pretension for Double-Nut Moment Joints</b>							
<b>ASTM F1554 Grades 36, 55, and 105 rod material:</b>							
Nom. Bolt diam D, (in)	Gross Area (sq in)	UNC Stress Area (sq in)		<b>Installation Pretension, Fi (kips)</b>	Snug Tight Torque check 20-30% Tv (ft-lb)	Verification Torque check Tv (ft-lb)	Relaxation Check 110% Tv (ft-lb)
<b>Yield 36</b>		Min. Tensile, Fu, 58 ksi	0.50 Fu (ksi)				
1.00	0.79	0.61	29	<b>18</b>	35-53	177	195
1.25	1.23	0.97	29	<b>28</b>	70-105	351	387
1.50	1.77	1.41	29	<b>41</b>	123-184	613	674
1.75	2.41	1.90	29	<b>55</b>	193-289	964	1,060
2.00	3.14	2.50	29	<b>73</b>	250-435	1,449	1,594
2.25	3.98	3.25	29	<b>94</b>	424-636	2,120	2,332
<b>Yield 55</b>		Min. Tensile, Fu, 75 ksi	0.60 Fu (ksi)				
1.00 *	0.79	0.61	45	<b>27</b>	55-82	274	302
1.25	1.23	0.97	45	<b>44</b>	109-164	545	600
1.50	1.77	1.41	45	<b>63</b>	190-285	951	1,047
1.75	2.41	1.90	45	<b>86</b>	299-449	1,496	1,645
2.00	3.14	2.50	45	<b>113</b>	450-675	2,249	2,474
2.25	3.98	3.25	45	<b>146</b>	658-987	3,289	3,618
<b>Yield 105</b>		Min. Tensile, Fu, 125 ksi	0.60 Fu (ksi)				
1.00	0.79	0.61	75	<b>45</b>	91-137	457	503
1.25	1.23	0.97	75	<b>73</b>	182-273	909	1000
1.50	1.77	1.41	75	<b>105</b>	317-476	1586	1744
1.75	2.41	1.90	75	<b>143</b>	499-748	2493	2742
2.00	3.14	2.50	75	<b>188</b>	750-1125	3749	4123
2.25	3.98	3.25	75	<b>244</b>	1096-1645	5482	6030
<b>ASTM A615 and A706 bar material **::</b>							
<b>Yield 60</b>		Min. Tensile, Fu, 80 ksi	0.60 Fu (ksi)				
1.00	0.79	0.61	48	<b>29</b>	59-88	293	322
1.25	1.23	0.97	48	<b>47</b>	116-175	582	640
1.50	1.77	1.41	48	<b>68</b>	203-304	1,015	1,116
1.75	2.41	1.90	48	<b>91</b>	319-479	1,595	1,755
2.00	3.14	2.50	48	<b>120</b>	480-720	2,399	2,639
2.25	3.98	3.25	48	<b>156</b>	702-1053	3,509	3,859

\*\* Reinforcing bars shall not be used for non-redundant, fatigue-susceptible support structures, such as cantilevered overhead sign structures and high mast luminaires.

\*Example:

$F_i = (0.60) (F_u) (\text{Stress Area})$	$F_i = (.6)(75 \text{ ksi})(0.61 \text{ sq in}) = 27 \text{ kips}$
$T_v = (F_i) (D) (0.12) (83.3)$	$T_v = (27 \text{ k})(1.0 \text{ in})(0.12)(83.3) = 274 \text{ k-ft}$
$\text{Snug} = (T_v) (30\%)$	$\text{Snug} = (274 \text{ k-ft})(.3) = 82 \text{ k-ft}$
$\text{Check} = (T_v) (110\%)$	$\text{Check} = (274 \text{ k-ft})(1.1) = 302 \text{ k-ft}$

## Appendix A

### **Anchor Rod Inspection by Ultrasonic Testing (UT)**

1. Certification - The UT operator must be certified as ASNT Level II, on recommended practice SNT-TC-1A, or specifically trained by an ASNT Level III for this application.
2. Preparation -
  - a. Grind the top surface of all anchor rods to be as smooth as reasonably possible, flat (i.e., a level surface), square (i.e. perpendicular to the shank), and with all galvanizing, rust, dirt, and debris removed. The finished contour shall allow intimate transducer contact. Sand off any rust bloom that may have formed after grinding.
  - b. Note that some rods may be marked to serve as bench marks. Only grind the rod enough to remove paint and to smooth the surface and not change its elevation.
  - c. Some rods may have a slanted end and cannot readily be ground to a flat, perpendicular surface. Note such rods on the inspection form for future attention.
3. Calibration -
  - a. Check calibration at each location before inspecting any anchor rods.
  - b. Operate the UT per AWS D1.5 unless described or approved otherwise.
  - c. Calibrate the ultrasonic unit for straight beam probe method using a 10-inch screen with a 1-inch diameter (2.25 MHz) straight beam probe. The probe is placed on a 10-inch calibration block (DSC block or a threaded section of anchor bolt) and the indications on the screen are adjusted so that the back reflection is positioned at 10 inches. Next, place the probe on a 10-inch long test bar (i.e. the threaded section of anchor bolt) that has a 1/8 inch deep saw cut at a set distance (3-inch from the end opposite the probe) in the threaded portion of the rod. Peak the back reflection from the 1/8 inch deep saw cut until the indication is at 60 or 80 percent of screen height. The dB reading is recorded to establish the "REFERENCE LEVEL." The "SCANNING LEVEL" is set by adding 14 to 30 dB over the reference level.
4. Test - Apply couplant to the top of the rods. Ultrasonically test the anchor rods using a circular motion inspection pattern and record the results. When scanning the anchor rods, there should be no indications on the CRT screen between the Main Bang (zero depth) and the end of the screen (10-inch depth). Any indication that is displayed after the Main Bang is a possible flaw. Record the depth of any discontinuity observed and the amount of dB required to bring the indication to the "REFERENCE LEVEL" on the screen. This is recorded as the "INDICATION LEVEL."
5. Cleanup - After UT inspection is completed, wipe off all the couplant with a wet rag, allow it to dry completely, and paint the rod ends with one or more coats of liquid cold galvanizing or zinc-rich paint to a minimum 3 mils dry film thickness (DFT). Check coating thickness with a gage.