DERRY-LONDONDERRY EXIT 4A
13065

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S P E C I A L P R O V I S I O N

AMENDMENT TO SECTION 615 -- TRAFFIC SIGNS

Overhead and Bridge-Mounted Sign Structures

This special provision amends Section 615, specifically Section 615.4, and addresses (1) the design criteria for new cantilever and full-span bridge overhead traffic sign structures and their foundations, 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 **2.5.1.2** to read as follows:

2.5.1.2 Overhead sign structures shall be galvanized in accordance with 550.2.9.

Replace 3.4 with the following:

3.4 Overhead Traffic Sign Structures.

3.4.1 Overhead sign structures and foundations and bridge-mounted sign supports shall be designed and installed in accordance with the current edition of the *AASHTO LRFD Specifications for Structural Supports for Highway Signs, Luminaires, and Traffic Signals*, *ASCE/SEI 7 Minimum Design Loads For Buildings and other Structures,* and *NHDOT Standard Specifications Section 550* 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 (Includes weight of sign & attachments (3 psf) and weight of W6x9 sign support (2 psf)	5 psf (min.)
(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) 1700-year MRI basic wind speed of 130 mph 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 LRFD Specifications, Fig. 3.8-2b*. 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 130 mph.

3.4.1.1.3 Mean Recurrence Interval (Table 3.8-1, AASHTO LRFD Specifications):

(a) Risk Category: Typical 1700

3.4.1.1.4 Ice Loads (Applied to a DMS or VSLS only):

(a) Applied to the top, ends, and front face.

(b) Ice load per *ASCE 7, Chapter 10*. Factored load combinations using Strength Design per *ASCE 7, Sections 2.3.2 and 2.3.4*.

3.4.1.1.5 Snow Loads (Applied to a DMS or VSLS only):

(a) Applied to the top panel and any other horizontal projection of a DMS or VSLS.

(b) Ground snow load (p_g) taken at a specific elevation and location in New Hampshire as noted in *US Army Corps of Engineers Ground Snow Loads for NH (February 2002)*, *Table 1*. Reduce or increase value for the design elevation as noted in footnote.

(c) Use flat roof snow load (p_f) per equation 7.3-1 in *ASCE 7*.

(d) Use load combinations with Strength Design per *ASCE 7, Section 2.3.2 and 2.3.4*.

3.4.1.1.6 Fatigue Design: Fatigue design shall conform to *AASHTO LRFD Specifications (Table 11.6-1)* 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. distributed over 2.0 ft. transversely to the member shall be used for designing members for walkways and platforms (*AASHTO LRFD Specifications Section 3.6*).

3.4.2 Structure Requirements.

(a) Overhead sign structures shall be designed for 130% of the sign surface areas shown on the plans. The additional 30% shall be accounted for by increasing the lengths (horizontal dimension) of each sign.

(b) The structures shall be steel, galvanized in accordance with *NHDOT Specification 550.2.9*.

(c) 25 percent of the base plate-to-post weld shall be inspected by magnetic particle testing per *AASHTO LRFD Specifications*. This requirement shall be noted on the shop plans.

(d) Triangular truss and tubular arch type overhead sign structures are not permitted due to concerns with their susceptibility to fatigue cracking.

(e) Lock washers shall not be used with the installation of high strength bolts per *FHWA Guidelines*.

(f) Sign support members (W6x9) shall not be greater in length than the sign height.

(g) Three (3) foot interior walkways, with OSHA approved railing, shall be provided for access to the back side of the variable or dynamic message signs on overhead sign Structures. The maintenance walkway and railing system shall be designed to avoid conflicts with the sign(s), electric sign(s) and hardware, mounting hardware, or other appurtenances that are part of or affixed to the sign panel when the walkway is folded. The Design-Build Team shall verify the clearance is met by taking appropriate field measurements prior to installation of the maintenance walkway and railing system, to assure a complete operating walkway and railing system is in place.

(h) 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. behind the guardrail for any Turnpike or Interstate location. Any exception to this shall be approved by the Bureau of Traffic.

(i) Overhead signs shall provide a vertical clearance of not less than 17’-6” [18’-0” preferred by Bureau of Traffic] over the entire width of the travel way and shoulders.

(j) The maximum overhead cantilever sign structure span is 50 ft. Any exception to this shall be approved by the Design Chief, Bureau of Bridge Design.

(k) The foundation and structure shall be located within the state owned right-of-way, and without interference with utilities, drainage pipes or structures.

3.4.3 Foundation Requirements

(a) The top of the foundation should be placed 3-inches ± higher than adjacent highest soil.

(b) The bottom of the foundation shall be placed a minimum of 5’-0” below the lowest finished grade (normal to the ground surface) for frost cover.

(c) 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 (preferred) or nut height plus the anchor rod diameter (maximum). (Note the nut height equals the rod diameter.)

(d) Spread footing foundations shall be used for all sign structures, unless directed otherwise by the Geotechnical Engineer.

(e) 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.

(f) Use the same reinforcing bar size for both directions in the footing.

(g) The vertical stem reinforcing bars shall be checked for development length, into both the stem and footing.

(h) The minimum overlap length of the vertical reinforcing bar and anchor rod shall be equivalent to a Class B splice of the reinforcing bar in accordance with current *AASHTO LRFD Bridge Design Specifications*.

(i) 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.

(j) Anchor rod size and layout shall be designed by the structure Fabricator and shall be identical for both left and right footings.

(k) Anchor rods shall be straight and 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 three hex nuts (ASTM A563 or ASTM A194) and a minimum of two flat hardened washers (ASTM F436). The embedded end of the anchor rod shall have either one nut tack welded or double nuts. Bent (hooked or J-bolt) anchor rods shall not be used.

(l) 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.

(m) The connection of the structure to the foundation shall be a double-nut moment connection.

(n) 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, leading to corrosion of the anchor rods.

(o) 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, and be noted on the foundation plans. The screen is to prevent debris from collecting beneath the base plate, keep animals out, and protect the wiring, if applicable.

3.4.4 Technical Submittal. The Design-Build Team shall submit plans and calculations for all Design-Build Team designed components for approval to the NHDOT Bureau of Bridge Design in accordance with 105.02 and shall not proceed with fabrication or construction until the Engineer has approved the submittals.

3.4.4.1 The plans and calculations shall be prepared, stamped, and signed by a Licensed Professional Engineer licensed in the State of New Hampshire.

3.4.4.2 The calculations shall be a complete and thorough set of calculations that are specific to this project. The calculations shall include all applicable references to the LRFD specifications. A detailed explanation of any symbols and computer programs used in the design shall be provided. Calculations shall be performed in English units, with the final calculation results shown in English units.

3.4.4.3 The technical submittal shall include the following:

- Design calculations and shop drawings with elevations and dimensions.
- If not provided with the contract documents, the Design-Build Team shall submit cross-section(s) and plan view(s) showing the structure(s) location, the foundation(s) and the proposed slopes plotted on cross-sections showing no

interference with utilities, drainage pipes or structures and showing cofferdams with sheeting left-in-place if needed for construction of foundation.

- Geotechnical services as noted in **Section 3.4.14** of this special provision.

3.4.4.4 When more than one Engineer is responsible for the design of separate components (i.e. structure, foundation, geotechnical information, attachment information), the Design-Build Team shall make one submittal containing *all* the components unless otherwise allowed by the Department.

3.4.5 Concrete shall be constructed in accordance with 520. Reinforcing steel shall be constructed in accordance with 544.

3.4.6 Backfill shall be constructed in accordance with 209 or 508 as called for on the plans.

3.4.7 Supporting columns shall not be mounted on the leveling nuts until the concrete has cured for at least 7 days or attained a minimum of at least 80 percent of its design compressive strength.

3.4.8 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.

3.4.9 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.

3.4.10 The applicable provisions of 550.3 apply to the sign structures and installation of sign structure connections made with high strength bolts (e.g., F3125 Gr A325). The installation procedures for anchor rods are different than for high strength bolts and shall conform to the following:

1. *AASHTO LRFD Specifications for Structural Supports for Highway 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.

3.4.11 When overhead sign structures are ordered removed or relocated, the entire structure, mounting brackets, signs, and bases down to 1 foot (300 mm) below final ground elevation, shall be removed. Unless otherwise shown on the plans, the structure removed shall become the property of the Design-Build Team.

3.4.12 Sheeting and shoring, if required, shall conform to the applicable provisions of 503 and 506, as appropriate.

3.4.13 Foundation must be backfilled to the elevation shown on the plans, prior to installation of the sign structure.

3.4.14 Geotechnical Engineering Services

3.4.14.1 The Design-Build Team shall employ the services of a professional geotechnical engineering firm to provide geotechnical design and construction services for the sign structure foundations as needed. The Design-Build Team's geotechnical engineer shall be responsible for identifying and performing all geotechnical investigations, engineering analyses, and constructability

assessments required to design and construct the sign structure foundations. Design and analysis methods, construction control, quality assurance and documentation shall be prepared in accordance with current *AASHTO LRFD Specifications for Structural Supports for Highway Signs, Luminaires, and Traffic Signals;* the accepted standards of practice in the industry; Department standard specifications, special provisions, and FHWA design manuals for the selected foundation systems; and other standards as applicable. The results of any subsurface investigations, geotechnical evaluation, and engineering shall be summarized in a geotechnical report. The geotechnical engineering firm shall be subject to review and approval by the Department.

3.4.14.2 The Design-Build Team shall conduct geotechnical explorations and testing as needed to design and construct the selected foundation system. The geotechnical explorations and testing shall conform to the current *AASHTO LRFD Bridge Design Specifications*. The number and location of geotechnical explorations shall follow the guidance provide in Table 10.4.2-1 of the AASHTO manual for the foundation type and size. In general, one test boring per foundation location shall be completed. The test boring report shall meet the standards of Section 10.4.2 in AASHTO. The evaluation of the subsurface conditions shall be the full responsibility of the Design-Build Team, and shall be sufficiently thorough to ensure that all geotechnical related aspects of the project are covered. The Design-Build Team shall access subsurface exploration or field-testing locations through State-owned Right-of-Way unless the Design-Build Team makes their own arrangements with private landowners for access through private property. Subsurface explorations and field testing shall be conducted with proper traffic control devices in place, as needed according to the Manual of Uniform Traffic Control Devices (MUTCD) and Department standards, and the work shall be conducted in compliance with Dig Safe and environmental regulations.

3.4.14.3 The Design-Build Team shall select a suitable foundation system for each foundation location based on an evaluation of the subsurface conditions and design in accordance with *AASHTO LRFD Specifications for Structural Supports for Highway Signs, Luminaires, and Traffic Signals.* Possible foundation configurations include spread footings, spread footings with ground improvements, driven pile foundations with various pile types, drilled shafts, and drilled micropiles.

3.4.14.4 The Design-Build Team shall provide to the Department geotechnical calculations, computer analysis results (e.g. LPile), laboratory and field test results, and subsurface information in accordance with the standard of practice that demonstrate the design basis of the selected foundation system, and the ability of the foundation to meet the performance criteria for the structure. Brom's design procedure will not be accepted for the final design.

3.4.14.5 The Design-Build Team shall select the foundation construction method and provide construction control and documentation in accordance with the standard of practice. Where applicable, the *NHDOT Standard Specifications for Road and Bridge Construction* shall be used for material, construction and testing requirements of the foundation. For foundation systems such as drilled shafts, micropiles, or any other foundation system not covered by the Standard Specifications, the Design-Build Team (or their Geotechnical Consultant) shall develop specifications for materials, construction and testing that shall be modeled on similar NHDOT special provisions and/or AASHTO specifications for the selected foundation system. The specifications shall be provided to the NHDOT for review and comment before their use. Construction control and performance testing shall also be supported by geotechnical instrumentation if needed. All field personnel responsible for construction control shall have experience with the foundation system that is selected, and shall report directly to the Geotechnical Consultant.

3.4.14.6 Prior to initiating any foundation construction, the Design-Build Team shall provide the Department with an Installation Plan for review and comment that provides a complete description of

the methods for foundation construction and quality assurance, equipment, and all Subcontractors that will be involved in the foundation construction.

3.4.14.7 The Design-Build Team shall provide the Department with daily reports for each day of foundation construction, including the results of all foundation testing for that day, a description of any changes in the Installation Plan that were required, and all quality assurance testing for that day. At the completion of the foundation construction, provide a summary of the foundation construction and testing, which certifies that the foundation meets the project design requirements and criteria.

3.4.14.8 All geotechnical services shall be completed prior to the construction of any foundations.

3.4.15 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 Design-Build Team 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 Design-Build Team 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.

3.4.16 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 3.4.14 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.)

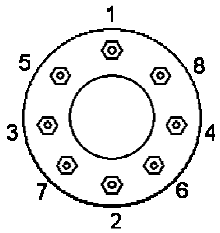

Figure 8. Star Pattern Tightening Sequence.

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.

Table 1 - Nut Rotation for Turn-Of-Nut Pretensioning

Anchor Rod Diameter, in.	Nut Rotation from Snug-Tight Condition [a, b, c]	
	F1554 Grade 36	F1554 Grades 55 and 105 A615 and A706 Grade 60
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, Tv, is required to additionally tighten the leveling nuts and the top nuts. See 3.4.17 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 Design-Build Team.

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, Tv, is required to additionally tighten the leveling nuts and the top nuts on the anchor rods. See 3.4.17 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 Design-Build Team 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 Design-Build Team.
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.

3.4.17 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:

   $T_v = 0.12 d_b F_I$ where

   T_v = verification torque (inch-kips)

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

   F_I = 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.

Table 2 - Tensile Properties for Anchor Rods

Tensile Property	ASTM F1554 Rod Grade 36	ASTM F1554 Rod Grade 55	ASTM F1554 Rod Grade 105	ASTM A706 Bars Grade 60 *
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.

Replace Subsection 4 Method of Measurement and Subsection 5 Basis of Payment to read as follows:

All work on the project as covered by the plans, standard specifications, special provisions, and all other contract documents related to the work shall be performed on a Lump Sum Basis. No separate measurement of payment shall be made for this item.

Table 3 - Minimum Anchor Rod Pretension for Double-Nut Moment Joints							
ASTM F1554 Grades 36, 55, and 105 rod material:							
Nom. Bolt diam D, (in)	Gross Area (sq in)	UNC Stress Area (sq in)		**Installation Pretension, Fi (kips)**	Snug Tight Torque check 20-30% Tv (ft-lb)	Verification Torque check Tv (ft-lb)	Relaxation Check 110% Tv (ft-lb)
Yield 36		Min. Tensile, Fu, 58 ksi	0.50 Fu (ksi)				
1.00	0.79	0.61	29	**18**	35-53	177	195
1.25	1.23	0.97	29	**28**	70-105	351	387
1.50	1.77	1.41	29	**41**	123-184	613	674
1.75	2.41	1.90	29	**55**	193-289	964	1,060
2.00	3.14	2.50	29	**73**	250-435	1,449	1,594
2.25	3.98	3.25	29	**94**	424-636	2,120	2,332
Yield 55		Min. Tensile, Fu, 75 ksi	0.60 Fu (ksi)				
1.00 *	0.79	0.61	45	**27**	55-82	274	302
1.25	1.23	0.97	45	**44**	109-164	545	600
1.50	1.77	1.41	45	**63**	190-285	951	1,047
1.75	2.41	1.90	45	**86**	299-449	1,496	1,645
2.00	3.14	2.50	45	**113**	450-675	2,249	2,474
2.25	3.98	3.25	45	**146**	658-987	3,289	3,618
Yield 105		Min. Tensile, Fu, 125 ksi	0.60 Fu (ksi)				
1.00	0.79	0.61	75	**45**	91-137	457	503
1.25	1.23	0.97	75	**73**	182-273	909	1000
1.50	1.77	1.41	75	**105**	317-476	1586	1744
1.75	2.41	1.90	75	**143**	499-748	2493	2742
2.00	3.14	2.50	75	**188**	750-1125	3749	4123
2.25	3.98	3.25	75	**244**	1096-1645	5482	6030
ASTM A615 and A706 bar material **:							
Yield 60		Min. Tensile, Fu, 80 ksi	0.60 Fu (ksi)				
1.00	0.79	0.61	48	**29**	59-88	293	322
1.25	1.23	0.97	48	**47**	116-175	582	640
1.50	1.77	1.41	48	**68**	203-304	1,015	1,116
1.75	2.41	1.90	48	**91**	319-479	1,595	1,755
2.00	3.14	2.50	48	**120**	480-720	2,399	2,639
2.25	3.98	3.25	48	**156**	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:	Fi = (0.60) (Fu) (Stress Area)	Fi = (.6)(75 ksi)(0.61 sq in) = 27 kips
	Tv = (Fi) (D) (0.12) (83.3)	Tv = (27 k)(1.0 in)(0.12)(83.3) = 274 k-ft
	Snug = (Tv) (30%)	Snug = (274 k-ft)(.3) = 82 k-ft
	Check = (Tv) (110%)	Check = (274 k-ft)(1.1) = 302 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.