DERRY-LONDONDERRY EXIT 4A
13065

FEBRUARY 6, 2020

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

AMENDMENT TO SECTION 616 – TRAFFIC SIGNALS

This special provision amends Section 616 and addresses the design and installation criteria for new traffic signal structures and foundations, including. installation and pretensioning procedures of 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 1.1 to read:

1.1 This work shall consist of furnishing and installing traffic signals, pedestrian signals, or flashing beacons including poles, mast arms, foundations, excavation, backfill, and all necessary fittings, cables and components as ordered.

Amend 2.4 to read as follows:

2.4 Traffic Signal Poles, Mast Arms and Foundations.

2.4.1 General. Traffic signal structures and foundations 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:

2.4.1.1 Design Loads.

2.4.1.1.1 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 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. 3.8.3-5. 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.

2.4.1.1.2 Design Life and Recurrence Interval (Table 3.8.3-2, AASHTO Specifications):

(a) 50 years for all traffic signal mast arms with/without luminaires (all heights).

2.4.1.1.3 Fatigue Design:

Fatigue design shall conform to AASHTO Specifications (Table 11.6-1) and the following categories:

1. Cantilevered Fatigue Category II:
   a. All traffic signal supports (mast arms)
      i. Natural Wind Gust loading shall be included.
      ii. Truck Induced Gust loading, Gallop loading and vortex shedding effects may be excluded.

2.4.1.2 Structure Requirements.

(a) The maximum mast arm span is 60 feet. Any exception to this shall be approved by the Design Chief, Bureau of Bridge Design and the Bureau of Traffic.

(b) The standard layout plan TS-7 shows configurations of the traffic signal supports with combinations of signals, attachments and luminaire and the corresponding foundation that should be used with that configuration. The foundation configurations shall be based on current Department standard plans for either the Type 1 or Type 2 foundation (TS-1, TS-2, TS-3 and TS-4 Standard Plans) as directed and as modified by the Engineer. Any traffic signal structure with a different configuration or dimensions greater than what is shown on the standard layout plan TS-7 shall not be accepted, unless approved by the Design Chief, Bureau of Bridge Design and the Bureau of Traffic.

(c) The structures shall be steel, galvanized in accordance with NHDOT Specification 550 Section 2.9.

(d) Anchor rod size, length, and layout shall be designed by the traffic signal structure Fabricator. A minimum of 6 anchor rods shall be provided.

(e) 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.

(f) 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 three flat hardened washers (ASTM F436). Lock washers shall not be used. The embedded end of the anchor rod shall have either one nut tack welded or double nuts. Bent (i.e. hooked or J-shaped anchor rods) shall not be used.

(g) Ultrasonic testing (UT) - The top ten inches of anchor rods shall be ultrasonically tested (UT) by the supplier, prior to shipment and installation, using a straight-beam transducer to verify the absence of flaws. The Design-Build Team shall provide written documentation and traceability of the anchor rods supplied to the site. The Department will reject an anchor rod if reflectors are found with an indication rating less than 15 decibels.

(h) Twenty five 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) The Design-Build Team shall furnish the design calculations and complete shop drawings for the traffic signal structure and foundation (when required) for approval in accordance with Section 105.02.

(j) 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. Provide a

stainless steel standard grade wire cloth (1/4" maximum opening with minimum wire diameter of AWG No. 16) with a 2-inch overlap.

(k) Mast arm spans greater than 50 ft. shall have a vibration mitigation device. The mitigation device shall consist of a horizontal sign blank 60"x16"x1/8" placed within 5 ft. of the mast arm tip and provide at least 6-inches of clearance from the top of any signal assembly or sign panel.

2.4.1.3 Geometry.

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

(b) The bottom of the foundation shall be placed a minimum of 5'-0" below the lowest finished grade for frost protection.

(c) Provide minimum vertical clearance from the bottom of overhead signal housings of not less than 16 feet above the traveled way.

(d) The distance from the top of the concrete footing to the bottom of the signal mast arm 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.)

(e) The foundation and structure shall be located without interference with utilities, drainage pipes or structures.

2.4.1.4 Concrete for a circular shaft foundation, Type 2, shall be Concrete Class A for cast in place or Concrete Class AAA for precast, conforming to Section 520. Concrete for foundation Type 1 shall be Concrete Class B, conforming to Section 520. Reinforcing steel shall conform to AASHTO M31/ 31M, Grade 60 (420), and Section 544, unless noted otherwise.

2.4.1.5 Wood poles shall be Class IV, with a minimum fiber bending stress of 8,000 psi, to a length specified conforming to Rural Electrification Administration (REA) Specification DT-5C.

2.4.1.6 Messenger cable and guy cable shall be seven-strand wire with a minimum breaking strength of 8,000 pounds, ~~double~~ galvanized in accordance with NHDOT Specification 550, Section 2.9.

Amend 3.14 Installation of signals and equipment to read as follows:

3.14 Installation of Signals, Equipment, Signal Structures and Foundations.

Add to 3.14 Installation of Signals, Equipment, Signal Structures and Foundations the following:

3.14.4 The applicable provisions of 550.3 apply to the signal structures and installation of signal 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. See Appendix A for anchor rod installation and pretensioning requirements.

Appendix A -

Procedure for Signal Mast Arm Anchor Rod Installation

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. Any alterations to the following procedures for the installation, pretensioning, and inspection of anchor rods by the Design-Build Team shall be submitted to the Department for approval.
2. [blank]
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.

Procedure for Pretensioning Anchor Rods for in Double-Nut Joint Moment Connections.

The procedure for pretensioning anchor rods in double-nut joint 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. See section 3.14.7, FHWA Guideline Reference. (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 (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.)

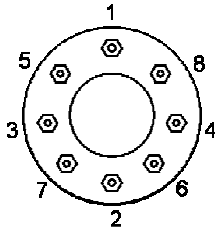

Figure 8. Star Pattern Tightening Sequence.

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 3.14.7 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.)
16. 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.
17. 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 3.14.7 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.
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.

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 *
Min. Yield Strength F_y, (ksi)	36	55	105	60
Min. 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.

1. 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.

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