DERRY-LONDONDERRY
13065

February 6, 2020

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

SECTION 677 – INTELLIGENT TRANSPORTATION SYSTEMS (ITS) EQUIPMENT

Item 677.4101 – Closed Circuit Television (CCTV) System
Item 677.41001 – Closed Circuit Television (CCTV) System Foundation
Item 677.417 – Relocate Closed Circuit Television (CCTV) System

This Special Provision provides for installation of Closed Circuit Television (CCTV) Systems with support poles and foundations. All provisions of Section 677 (Special Provision to Section 677 - Intelligent Transportation Systems (ITS) Equipment – Base Specification), except as modified or changed below, shall apply.

Add to Description (Special Provision to Section 677 - Intelligent Transportation Systems (ITS) Equipment – Base Specification):

1.4 This work shall consist of designing, furnishing, installing, and providing GPS as-built documentation of a new Closed Circuit Television (CCTV) System, with support pole and CCTV camera lowering devices.

1.5 This work shall also consist of constructing either a steel-reinforced concrete circular shaft foundation, constructed within a drilled excavation, or a steel-reinforced concrete spread footing foundation for the CCTV support pole. The Design-Build Team may select either foundation type for CCTV support pole foundation locations, and shall assess the work effort and bid price for the selected foundation system based on the preliminary foundation designs provided on Contract plan sheet details and work described in section 2.8 of this Special Provision.

Add to 2.1 General Standards Requirements (Special Provision to Section 677 - Intelligent Transportation Systems (ITS) Equipment – Base Specification):

2.1.6 Geotechnical Engineering Services. All Geotechnical services for these items will be provided by NHDOT Bureau of Materials and Research.

Add to 2.3 Technical Submittal (Special Provision to Section 677 - Intelligent Transportation Systems (ITS) Equipment – Base Specification):

2.3.9 Additional submittal requirements for CCTV system installations shall include the following:

2.3.9.1 Documentation of any software modifications required to interface equipment to NHDOT's existing statewide Advanced Traffic Management System (ATMS).

2.3.9.2 Underwriter's Laboratory (UL) approval certifications for all proposed equipment.

2.3.9.3 Typical life expectancy of each system component.

2.3.9.4 A list of parts that will require periodic replacement, including their typical life expectancy.

2.3.9.5 The address where the proposed equipment will be produced and serviced and the turnaround time for replacement and/or repair of equipment.

2.3.9.6 Available maintenance plans.

2.3.9.7 Environmental operating requirements for all equipment and associated equipment including heating, cooling, circuit, and grounding requirements.

2.3.9.8 Documentation and user instructions for any CCTV system control software provided by the CCTV camera manufacturer.

2.3.9.9 Complete electronic user documentation for the CCTV system, including instructions on operation and calibration.

2.3.9.10 Maintenance manuals for the CCTV system, which shall include instructions suitable for technicians to perform routine services and minor repairs.

2.3.9.11 Documentation of any Manufacturer's warranties provided for the proposed equipment.

2.3.9.12 Video recordings of multiple, accurate 360-degree field-of-view video images, with camera tilt range from 20 degrees above horizon to 90 degrees below horizon, captured from the precise site location and camera height of the proposed installation. Video images shall be obtained by the Design-Build Team and delivered to NHDOT for use by the Department to determine camera preset views. The Design-Build Team shall submit video images prior to installation, at the same time as all other shop drawings for the proposed CCTV system equipment.

2.3.10 When a camera lowering device system is required, provide the following:

2.3.10.1 The lowering device manufacturer, upon request, shall furnish independent laboratory testing documents certifying adherence to the stated wind force criteria utilizing, either the actual effective projected area (EPA) or an EPA greater than that of the camera system to be attached.

2.3.10.2 The Design-Build Team shall ensure the installer is qualified, according to the Manufacturers installation requirements, such that the device and safety features are installed and operate correctly.

Add to Materials (Special Provision to Section 677 - Intelligent Transportation Systems (ITS) Equipment – Base Specification):

2.6 CCTV camera with Pan-Tilt-Zoom (PTZ) capabilities.

2.6.1 All proposed CCTV cameras shall include a Milestone XProtect Corporate Edition (latest version) device license with Milestone Care Premium Support for 1 year. A compatibility list can be found on the Milestone website.

2.6.2 The CCTV camera and associated equipment shall provide video coverage as directed by the ITS Project Manager (227-0016).

2.6.3 The CCTV camera shall be Underwriter's Laboratory (UL) approved. UL certification shall be provided with the catalog cuts in the Technical Submittal.

2.6.4 The CCTV camera shall weigh no more than 10 pounds.

2.6.5 The CCTV camera shall be digital, IP addressable and Ethernet ready.

2.6.6 The CCTV interface shall be an RJ45 type connector for 10BASE-T/100BASE-TX, and shall include an IP66-rated RJ45 connector kit.

2.6.7 The CCTV camera shall be compatible with existing CCTV software at the NHDOT Transportation Management Center (TMC), including the Milestone Video Management System, Corporate Edition, latest version.

2.6.8 The CCTV shall have the following image setting functionalities: Wide dynamic range (WDR), manual shutter time, compression, color, brightness, sharpness, white balance, exposure control, exposure zones, backlight compensation, fine tuning of behavior at low light, rotation, text and image overlay, 32 individual 3D privacy masks, image freeze on PTZ, electronic image stabilization and automatic defog.

2.6.9 The CCTV shall provide a camera imaging system that automatically shifts from daytime mode to nighttime mode, and shifts from color mode to a black-and-white mode under very low light conditions, in order to render a more detailed video image.

2.6.10 The CCTV shall provide automatic and manual control of camera imaging characteristics (such as exposure and contrast).

2.6.11 The CCTV shall return operational status and report system faults to the NHDOT TMC.

2.6.12 The CCTV shall receive and process camera positioning and camera configuration commands received from the NHDOT TMC.

2.6.13 The CCTV shall have the capability to be viewed, controlled, and tested locally at the camera site utilizing a laptop computer with OEM software. This shall include the capability to locally retrieve operational status and fault data for the CCTV.

2.6.14 The CCTV camera dome shall be constructed of clear polycarbonate with a sun shield.

2.6.15 The lower exterior dome shall be made of seamless polycarbonate, optically clear with no distortion, optical discontinuities, or anomalies of any type in any portion of the dome up to 20-degrees above horizontal.

2.6.16 The CCTV camera dome drive system shall consist of an integral camera pan-tilt assembly with a variable high speed drive unit with continuous 360-degree rotation, CCD camera, optical and digital zoom, auto focusing, motorized zoom lens and integral camera control receiver.

2.6.17 The CCTV shall have user-defined "pre-sets" for position, zoom, exposure and focus, to be defined by the NHDOT Transportation Systems Management and Operations (TSMO) Bureau.

2.6.18 The CCTV shall have a minimum Pan/Tilt/Zoom functionality of: 100 preset positions, 360° endless pan at a speed of 0.05 - 450°/sec; Tilt - 220° at a speed of 0.05 - 450°/sec.

2.6.19 NHDOT TMC control of CCTV PTZ features shall have a latency of no greater than one second.

2.6.20 The CCTV shall have an automatic variable pan-tilt speed adjustment operating as a function of degree of zoom.

2.6.21 The CCTV shall have a minimum 30x optical zoom and 12x digital zoom, total 360x zoom.

2.6.22 The CCTV shall have the following intelligent video analytics: video motion detection, auto-tracking.

2.6.23 The CCTV shall have alarm triggers from multiple sources including intelligent video, PTZ position.

2.6.24 The CCTV shall have a minimum 1/3-inch progressive scan CCD image sensor.

2.6.25 The CCTV shall have a minimum illumination of: Color: 0.2 lux at 30 IRE; B/W: 0.04 lux at 30 IRE.

2.6.26 The CCTV shall have minimum resolution range of: HDTV 320x180 up to 1280x720, 720p.

2.6.27 The CCTV shall provide H.264 (MPEG-4 Part 10/AVC) and Motion JPEG video compression formats.

2.6.28 The CCTV shall have a minimum frame rate of: H.264 25/30 frames per second (fps) (50/60 Hz) in all resolutions, M-JPEG: up to 25/30 fps (50/60 Hz) in all resolutions.

2.6.29 The CCTV shall be capable of multi-streaming in H.264 and Motion JPEG formats: Multiple individually configured streams in maximum resolution at 30/25 (60 / 50 Hz) fps. The frame rate and bandwidth shall be controllable.

2.6.30 The CCTV shall have the following security features: password protection, IP address filtering, HTTPS encryption, IEEE 802.1X network access control, digest authentication, user access log.

2.6.31 The CCTV shall support the following protocols: IPv4/v6, HTTP, HTTPSa, SSL/TLSa, QoS Layer 3 DiffServ, FTP, CIFS/SMB, SMTP, Bonjour, UPnPTM, SNMPv1/v2c/v3 (MIB-II), DNS, DynDNS, NTP, RTSP, RTP, TCP, UDP, IGMP, RTCP, ICMP, DHCP, ARP, SOCKS, SSH, and NTCIP.

2.6.32 The CCTV shall conform to the ONVIF Profile S standard and have an open Application Programming Interface for software integration.

2.6.33 The CCTV camera shall be able to process, at a minimum, the following alarm events:

(a) File upload: FTP, HTTP, and network share.

(b) Email notification: email, HTTP and TCP.

(c) Data transmitted from CCTV system: PTZ preset, guard tour, video recording to edge storage, auto-tracking, day/night mode, and pre- and post-alarm video buffering.

2.6.34 The CCTV system shall include transient voltage surge suppression (TVSS) to protect against transients and surges within 5 feet of the camera enclosure.

2.6.35 The CCTV system shall be powered by an industrial grade Power Over Ethernet Injector (POEI).

2.6.35.1 The POEI shall provide operating power and Ethernet data to the CCTV system. The POEI power consumption shall not exceed 60 watts.

2.6.35.2 The POEI shall include integral TVSS to protect against transients and surges on the incoming power and data (Ethernet) connections to the POEI, as well as to protect against transients and surges on the outgoing data (Ethernet) connection to the camera. The TVSS shall be a product approved by the CCTV system manufacturer for use with the camera.

2.6.36 The CCTV shall be housed in an environmentally hardened aluminum enclosure suitable for continuous outdoor use and shall feature an internal temperature regulation system. The CCTV shall be IP66-, NEMA 4X- and IK09-rated and shall have an operating temperature range of -40°F to +122°F, minimum.

2.6.37 The CCTV shall be mechanically and functionally compatible with the camera pole mounted lowering device.

2.7 CCTV Support Pole with CCTV Lowering Device.

2.7.1 The CCTV support pole and all associated members shall be designed by a NH licensed Professional Engineer and designed and fabricated in accordance with the current edition of *AASHTO LRFD Specifications for Structural Supports for Highway Signs, Luminaires, and Traffic Signals* and *NHDOT Standard Specifications* Section 550, except as noted below:

Basic Wind Speed: 1700-year Mean Recurrence Interval (MRI) basic wind speed of 130 mph (209 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 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 (209 km/hr).

Fatigue Importance Category: Cantilevered Category II (poles with distance to roadway > height of pole)

Fatigue Importance Category: Cantilevered Category I (poles with distance to roadway ≤ height of pole)

2.7.2 The pole shaft shall be one or two-piece construction and shall conform to ASTM A595 Grade A with a minimum yield strength of 55 ksi or ASTM A572 with a minimum yield strength of 55 ksi.

2.7.3 The pole shaft and all associated ancillary members shall be steel, galvanized in accordance with the current *AASHTO LRFD Specifications for Structural Supports for Highway Signs, Luminaires, and Traffic Signals and NHDOT Standard Specifications Section 550, 2.9*.

2.7.4 The CCTV support pole shall be designed to support all cameras, lowering devices, radio units, sensors, lightning dissipaters, antennas, and other appurtenances in the quantities and locations indicated on the CCTV Detail plan sheets. Close consideration shall be given to the

effective projected area of the complete lowering system and equipment to be mounted on the pole along with the weight of attached hardware when designing the pole to meet the specified deflection performance criteria, including consideration for all possible loading combinations; and the factored design forces and resistances for all components which comprise the proposed structure. The top of the pole total deflection shall not exceed the following:

(a) 1 percent of pole height due to 90 MPH (non-gust) winds; and

(b) 1 inch due to 30 MPH (non-gust) winds.

2.7.5 The calculations shall include a pole, base plate, and anchor rod analysis (embedded length shall be confirmed by the Engineer designing the foundation). The pole calculations shall be analyzed at the pole base and at 5-foot pole intervals along the full height of the pole. At each of these locations, the following information shall be provided by the Design-Build Team:

(a) The pole's diameter, thickness, section modulus, moment of inertia, and cross sectional area.

(b) The centroid, weight, projected area, drag coefficient, velocity pressure, and wind force of each trapezoidal pole segment.

(c) The factored axial force, shear force, primary moment, total moment, axial resistance, bending resistance, and capacity demand ratio (CDR) at each elevation.

(d) The pole's angular and linear deflection at each location.

2.7.6 Hand Holes: The hand hole openings shall be reinforced with a minimum 2-inch wide hot rolled steel rim. The nominal outside dimension is 6 inches x 27 inches. The hand hole shall have a galvanized steel cover secured with a clip on lock and tamper proof bolts. The hand hole shall have a tapped hole for mounting a portable lowering tool. The hand holes shall be fully compatible with the portable lowering tool.

2.7.7 Weatherhead: Two-inch galvanized steel weatherheads shall be factory installed in the camera pole for wire access to mounted equipment as shown on the support pole plan details. No field drilling will be permitted.

2.7.8 Pole Top Tenon: The pole shall have a plate-mounted tenon that allows the field modification of the arms/camera orientation up to 360 degrees. The Engineer can then make slight orientation modifications to the camera mounts to allow optimum viewing in case of future road development; change in terrain or a change in the viewing needs priority. The tenon shall have mounting holes and slot for the mounting of the camera-lowering systems. The tenon shall be of dimensions necessary to facilitate dual camera lowering device component installations. Each slot shall be parallel to the pole centerline for mounting the lowering devices.

2.7.9 Cable Supports / Wire Eyes and Park Stands: Two wire eyes and three park stands shall be located within the pole. One wire eye shall be positioned 2 inches below the hand hole

and the other shall be positioned one inch directly below the top of tenon. Two park stands shall be positioned a maximum of 2.0 inches below the top of the hand hole and located at 90 and 270 degrees from the hand hole. A third park stand shall be located in the center of the upper inside edge of the hand hole as shown on the drawings. These park stands shall be a minimum of ¼ inch O.D. and a max 3/8-inch O.D.

2.7.10 Base Plate: Base plates shall conform to ASTM A36 or A572 Grade 42.

2.7.11 Lightning Dissipater: The CCTV support pole shall be supplied with a lightning dissipater, consisting of a series of at least four spot dissipaters in a candelabra arrangement with a single mounting assembly. The lightning dissipater system shall include surge suppressor devices of the type recommended by the lightning dissipater manufacturer, and shall properly interface with the pole mounted dissipater, and the size and type of cables used for communication and control of any installed equipment.

2.7.12 Camera Junction Boxes: The camera junction boxes shall be of clamshell design with one hinge side and one latch side to facilitate easy opening. The general shape of the box shall be cylindrical to minimize the EPA. The Camera Junction Boxes shall have stabilizing weights on the outside of the box to increase room on the interior. The boxes shall be capable of having up to 40 pounds of stabilizing weights. The bottom of the Camera Junction Boxes shall be drilled and tapped to accept industry standard dome housings and be able to be modified to accept a wide variety of other camera mountings. The junction boxes shall be gasketed to prevent water intrusion. The bottom of the box shall incorporate a screened and vented hole to allow airflow and reduce internal condensation per the manufacturer's specifications.

2.7.13 Camera Lowering Systems: The camera lowering systems shall be designed to support and lower an IP driven CCTV camera, lens, housing, pan-tilt-zoom (PTZ) mechanism, cabling, connectors and other supporting field components without damage or causing degradation of camera operations. The lowering systems shall consist, at a minimum, of a pole, suspension contact unit, divided support arm, and a pole adapter for attachment to a pole top tenon, pole top junction box, and camera connection box. The divided support arm and receiver brackets shall be designed to self-align the contact unit with the pole center line during installation and ensure the contact unit cannot twist under high wind conditions. The support arms shall be designed such that the arm will be locked in place to withstand camera support arm rotation under high wind conditions by either geometry, through-bolt construction, or other means.

2.7.13.1 The camera-lowering devices shall withstand wind forces of 100 MPH with a 30 percent gust factor using a 1.65 safety factor.

2.7.14 Suspension Contact Unit: The suspension contact unit shall have a load capacity of 600 pounds with a 4 to 1 safety factor. There shall be a locking mechanism between the fixed and moveable components of the lowering device. The movable assembly shall have a minimum of 2 latches. This latching mechanism shall securely hold the device and its mounted equipment.

The contact unit housing shall be weatherproof with a gasket provided to seal the interior from dust and moisture.

2.7.14.1 The prefabricated components of the lift unit support systems shall be designed to preclude the lifting cables from contacting the power or video cabling. The lowering device manufacturer shall provide conduit mount adapters for housing and isolating the lowering cables inside the pole.

2.7.14.2 The female and male socket contact halves of the connector block shall be made of a UL94, V-0 rated thermosetting synthetic rubber or approved equivalent. The female barrel contacts and the male pin contacts shall be encased into the connector block body.

2.7.14.3 All electrical and communication connections between the fixed and lowerable portion of the contact block shall be rated for outdoor use and protected from exposure to the weather by a waterproof seal to prevent moisture infiltration and degradation of the electrical contacts.

2.7.14.4 The electrical connections between the fixed and movable lowering device components shall be designed to conduct high frequency data transmission rated for 1000Base-T (CAT5e, CAT6, CAT6a) and 1 volt peak-to-peak video signals as well as the power requirements for operation of dome environmental controls.

2.7.14.5 All current carrying male pin connections and female socket contacts shall be gold plated copper alloy per ASTM-B-488.

2.7.14.6 All pin connections shall have a 12 gauge (0.08 in) minimum diameter solid core pin with a maximum height of 0.5 inches protruding from the connector block body.

2.7.14.7 The interface and locking components shall be made of stainless steel and/or aluminum. All external components of the lowering device shall be made of corrosion resistant materials, powder coated, galvanized, or otherwise protected from the environment by industry-accepted coatings to withstand exposure to a corrosive environment. The corrosion resistance materials shall be as per manufacturer's specifications and procedures.

2.7.14.8 The camera assembly manufacturer shall provide the power and signal connectors for attachment to the bare leads in the pole top and camera junction boxes.

2.7.14.9 The camera assembly manufacturer shall provide a mounting flange sufficient for mounting their respective camera assembly to the bottom of the camera connection box.

2.7.15 **Portable Lowering Tool:** The manufacturer shall provide a variable speed, heavy-duty reversible drill motor and a lowering tool. The lowering tool shall be made of durable and corrosion resistant materials, powder coated, galvanized, or otherwise protected from the environment by industry-accepted coatings to withstand exposure to a corrosive environment. This tool shall be compatible with accessing the support cable through the hand hole of the pole. The tool shall support itself and the load assuring lowering operations and shall provide a means

to prevent freewheeling when loaded. The lowering tool shall have a reduction gear to reduce the manual effort required to operate the lifting handle to raise and lower a capacity load.

2.7.15.1 The lowering tool shall be provided with an adapter for operating the lowering device by a portable drill using a clutch mechanism. The lowering tool shall be equipped with a positive breaking mechanism to secure the cable reel during raising and lowering operations and prevent freewheeling.

2.8 CCTV Support Pole Foundation.

2.8.1 The CCTV support pole foundation shall be designed by the Department in accordance with the current *AASHTO LRFD Specifications for Structural Supports for Highway Signs, Luminaires, and Traffic Signals* and the *NHDOT Standard Specifications*. As described in Sections 2.3.8 and 2.7, the top of foundation reaction loads for the specified wind speeds shall be submitted to verify or modify the preliminary foundation design in the contract for final design.

2.8.2 The preliminary foundation design configurations for the drilled shafts and the spread footings are provided in the contract plan sheets. These configurations were designed by the Department based on estimated loads for the proposed camera pole structure. The preliminary drilled shaft lengths are summarized in the following table:

Road	Station	MM	Foundation Item	Pole Item	Drilled Shaft Length (ft)
I-93 Northbound	1138+27, 52’ RT	50.8	677.41001	677.4101	13’

2.8.3 As described in 2.3.8, the ITS device submittal shall include the top of foundation reactions for the specified wind speeds for each pole location. This information shall be used by the Department to verify or modify the preliminary foundation design for final design. Modifications of the preliminary foundation design made by the Department may result in an increase or decrease in the preliminary foundation design dimensions. Payment for construction of any modified foundation designs will be in accordance with Sections 4.9.2 and 5.8.2 of this Special Provision.

2.8.4 The drilled shaft material, construction requirements, and the test boring logs for the proposed CCTV support pole foundation locations are provided in Appendix B (509 – Drilled Shafts) of this Special Provision. Additional requirements for drilled shafts are included in Appendix B of this Special Provision (Section 509 – Drilled Shafts). The test boring locations are summarized below in reference to the proposed CCTV System item numbers.

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2.8.5 Concrete shall be Class A for drilled shaft foundations and Class B for spread footing foundations, and shall conform to *NHDOT Standard Specifications* Section 520.

2.8.6 All reinforcing steel shall conform to AASHTO M 31M/M 31, Grade 60 (420), and Section 544, unless noted otherwise.

2.8.7 Anchor rods for the foundation 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). Lock washers shall not be used. 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.

2.8.8 Stainless steel standard grade wire cloth surrounding the tower base plate shall have a 1/4 inch maximum opening with minimum wire diameter of AWG No. 16. stainless steel banding to secure the wire cloth shall be ¾ inches wide.

2.9 ITS Cables.

2.9.1 All equipment shall be supplied with the Manufacturer's recommended cables.

2.9.2 All Ethernet cable shall be shielded, weatherproof Category 6.

2.9.3 Any Ethernet cable not installed within a cabinet, conduit, or other enclosed space shall be UV protected and weatherproof.

2.9.4 All free-hanging Ethernet cable shall be plenum type.

2.9.5 When specifically called for in the Contract plans, Ethernet cable shall be armored, ruggedized, or gel-filled as required for rodent control or underground burial.

Add to Construction Requirements (Special Provision to Section 677 - Intelligent Transportation Systems (ITS) Equipment – Base Specification):

3.12 The CCTV system and support poles shall be installed in accordance with the National Electric Safety Code (NESC).

3.13 The Design-Build Team shall install CCTV cameras to provide unobstructed roadway views as indicated or directed by the Engineer.

3.13.1 The Design-Build Team shall establish camera preset views as directed by the Engineer. Preset camera views will be based on video recordings provided as part of the Technical Submittal, Section 2.3.9 above. The Design-Build Team shall request the specific pre-set views from the Engineer a minimum of 15 working days prior to CCTV system installation.

3.13.2 The CCTV camera shall be mounted to the support structure using mounting hardware and accessories as recommended by the CCTV camera manufacturer.

3.13.3 The CCTV camera shall be connected to the proposed communication system using manufacturer recommended cabling. Ethernet connections shall be shielded and environmentally sealed.

3.13.4 Power over Ethernet Injectors shall be installed securely within equipment cabinets.

3.14 CCTV Support Pole with Lowering Devices.

3.14.1 The Design-Build Team shall supply and install internal conduits inside the pole to isolate and separate the lowering cables from all other equipment cables. These conduits shall interface with the lowering device through Manufacturer supplied mounting adapters. Only the lowering cable shall be permitted to move within the pole or lowering device during lowering or raising operations.

3.14.2 The lowering system shall be provided and installed with all components as per manufacturer's specifications and procedures. The Design-Build Team shall arrange for the Manufacturer's factory representative to be present on site assist with the assembly, installation and testing of the lowering system.

3.14.3 Camera lowering devices shall be installed to provide unobstructed camera views along the mainline roadway.

3.14.4 Weights and/or counterweights shall be provided by the Manufacturer as necessary to assure that the alignment of pins and connectors are proper for the camera support to be raised into position without binding. The lowering unit shall have sufficient weight to disengage the camera and its control components for lowering.

3.14.5 The Design-Build Team shall provide a sealant between the lowering device and the camera assembly to assure water tightness of the camera assembly.

3.14.6 The camera lowering tool shall be delivered to the Department.

3.15 CCTV System Foundation.

3.15.1 See Appendix A of this Special Provision for additional installation requirements. These installation requirements shall be made applicable to the CCTV support pole and foundation.

3.15.2 All foundations shall be cast-in-place.

3.15.3 A minimum of 12 inches of structural fill shall be placed at the bottom of all spread footing foundations.

3.15.4 For the drilled shaft option, the CCTV support pole foundation shall be constructed in accordance with the requirements described in Appendix B of this Special Provision, and the contract plans.

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

3.15.6 Backfill shall be constructed in accordance with NHDOT Standard Specifications Section 206, Section 209, or Section 508 as required in the Contract Documents. Structural fill used within the conduit trenches shall conform to NHDOT Standard Specifications Section 508.

3.15.7 CCTV support poles shall not be placed on the leveling nuts until the concrete has cured for at least 7 days or attained a minimum of at least 80% of its design compressive strength.

3.15.8 The connection of the pole to the foundation shall be a double-nut joint moment connection.

3.15.9 The applicable provisions of Section 550.3 apply to structural steel 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:

(a) *AASHTO LRFD Specifications for Structural Supports for Highway Signs, Luminaires, and Traffic Signals*;

(b) *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).

3.15.10 Concrete foundations shall be constructed against undisturbed material.

3.15.11 Support structure foundations shall be placed in a dewatered drilled hole or in an excavated hole using the proper forms.

3.15.11.1 If the drilled hole method is performed and the soils are found to be unsuitable, an excavated hole shall be completed as approved by the Engineer.

3.15.12 The foundation shall have a formed appearance from the top of the shaft to a depth of at least 12 inches below the final grade, with the top having a smooth level finish.

3.15.13 The top of the foundation should be placed 4 inches higher than the adjacent highest soil.

3.15.14 The bottom of the foundation shall be placed a minimum of 5’-0” below the lowest finished grade for frost protection.

3.15.15 The top of the foundation shall be coated with water repellent to 1'-0" below finished grade in accordance with Section 534.

3.15.16 Install stainless steel wire cloth at the base of the support structure with a 2" lap and secure with stainless steel banding after anchor bolts are tightened. The purpose of the screen is to eliminate debris beneath the base plate, keep animals out and protect electrical wires if no other base protection is provided. Secure cloth in a manner that will permit its removal for maintenance. Grout shall not be used between the opening of the structure base plate and the top of the foundation.

3.15.17 Trenches for the adjacent conduits shall be hand dug near the proposed footing, disturbing as little soil as possible in placing the conduits. The resulting trenches shall be backfilled with structural fill conforming to Section 508.

3.16 Grounding, Bonding and Transient Voltage Surge Suppression.

3.16.1 The Design-Build Team shall furnish and install Transient Voltage Surge Suppressor (TVSS) devices for all power and communications conductors installed.

3.16.2 The Design-Build Team shall provide and install a TVSS between the AC power mains and all installed equipment.

3.16.3 If the CCTV is not mounted to another ITS device that already has transient protection, the CCTV shall include integral TVSS to protect against transients and surges on all incoming power and data connections to the CCTV. The TVSS shall be a product approved by the CCTV manufacturer for use with the CCTV.

3.16.4 The CCTV support pole shall be supplied with an air terminal that is bonded by an insulated wire to the earth terminal-wire attachment at the base of the pole.

3.16.5 The CCTV support pole's air terminal and ground terminal wires shall be bonded to the pole using an attached electric lug that allows for removal of the wires and independent resistance measurement of the earth ground resistance.

3.16.6 The CCTV support pole shall be supplied with an air terminal that is attached to a minimum #6 AWG stranded bare copper wire bonded to the grounding system at the base of the pole.

3.16.7 Ground connections to any cabinet installed on the CCTV support pole shall be made to a suitable common threaded heavy-gauge lug that can be attached to both sides (inside and outside) of the cabinet. The lug shall have the same composition as the cabinet.

3.16.8 The Design-Build Team shall supply and install a ground array system to be installed at the base of the CCTV support pole. The ground rod array system shall be connected to the pole through an appropriate ground clamp. A #6 AWG copper wire shall be installed between the CCTV support pole and any equipment cabinets, providing a common ground system for each

terminus. A conduit through the foundation to the inside of the pole shall provide the means to connect the ground wire from the inside of the pole to the ground rods.

3.16.9 The CCTV support pole shall be bonded to the earth terminal using an earth ground array system with a resistance no greater than 25 Ohms to ground. All metallic enclosures, lightning arrestors, and instrument mounting brackets shall be bonded to this system.

3.16.9.1 Additional ground rods shall be installed to meet the manufacturer's recommended resistance to ground for any installed equipment, or a maximum of 25 ohms, whichever is less.

3.16.9.2 The external earth terminals shall not be encased in any foundation.

3.16.10 All electrical connections to and within the grounding system shall be exothermically welded where possible.

3.16.11 Anti-oxidation electrical compound shall be used on all attachment points of the ground system where dissimilar metals intended for grounding and bonding come in contact with each other, and on ground wire attachment points when exothermic welding cannot be used.

3.16.12 The CCTV support pole shall be supplied with a lightning dissipater that is attached to a #6 AWG stranded bare copper wire bonded to the ground terminal.

3.16.13 The CCTV support pole lightning dissipater shall consist of a series of at least four spot dissipaters in a candelabra arrangement with a single mounting assembly. The lightning dissipater system shall include surge suppressor devices of the type recommended by the lightning dissipater manufacturer, and shall properly interface with the pole mounted dissipater, and the size and type of cables installed in the CCTV support pole.

3.16.14 The lightning dissipater shall be attached to the CCTV support pole using manufacturer-recommended clamps that are attached to the pole. These clamps shall rigidly hold the lightning dissipater to the CCTV support pole in winds up to 100 MPH.

3.16.15 The lightning dissipater shall be offset from the CCTV support pole and provide protection for the site above any installed equipment without interfering with the functionality of any equipment or sensors.

3.16.16 When installed on the CCTV support pole, the CCTV lowering systems shall also be grounded to the same system as the CCTV support pole. The CCTV support pole shall also include provisions to allow for grounding connections of CCTV cameras through a lug located in the camera junction box. All installed CCTV cameras, lowering systems, and any other installed equipment shall be grounded.

3.17 ITS Cables.

3.17.1 All equipment shall be installed using the Manufacturer's recommended cables.

3.17.2 The Design-Build Team shall furnish, install, connectorize, and test all Category 6 (Cat. 6) cables, of the types required for the application, at locations shown in the plans or as required to construct a complete, functional system.

3.17.3 The Cat. 6 cables shall not exceed 325 feet in length unless the Design-Build Team is granted written permission from the Engineer.

3.17.4 All cables shall be installed in a continuous run. Splicing will not be allowed.

3.18 **Camera Licensing.** The Design-Build Team shall provide Milestone XProtect Corporate Edition camera licenses to the Department for each CCTV camera installed. The Design-Build Team shall purchase the initial camera licenses plus the first year renewal cost, with upgrade protection. Licenses shall be provided for the Milestone software version used by the NHDOT TMC at the time of camera installation.

Appendix A

General Installation Requirements for CCTV Pole and Foundation

The applicable provisions of 550.3 apply to the steel structure installation of 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. Current *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)*.

Procedure for Installing Anchor Rods in the Foundation for Double-Nut Connections is as follows:

1. The Foundation Design-Build Team 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 in accordance to Section 520.
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. After at least 24 hours after placing 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. The structure shall not be placed onto the leveling nuts until the foundation concrete has cured for at least 7 days minimum or attained a minimum of at least 80 percent of its design compressive strength and the foundation backfilled to final ground.
10. Final ground elevations shall be taken from the roadway cross sections. If actual final ground elevations differ by more than 1'-0", then a complete redesign of the sign foundation will be required.

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 re-lubricated. 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 FHWA Guideline Reference 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.)

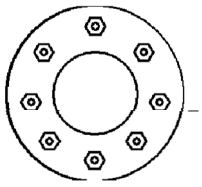

Figure 8. Star Pattern Tightening Sequence.

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 Section FHWA Guideline Reference 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 FHWA Guideline Reference 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.

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.

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, F_I (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

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 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 the 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.

Appendix B

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

SECTION 509 -- DRILLED SHAFTS

Description

1.1 This work shall be covered under Item 677.410XX (CCTV System Foundation).

Materials

2.1 Concrete. The Design-Build Team's mix design shall meet the requirements of a Class A concrete in accordance with Section 520, except as modified herein. The slump shall be 8 inches plus or minus 1 inch after batching. The maximum aggregate size shall be 3/8 inches. The concrete shall be designed with the necessary admixtures to maintain the required slump and sufficient workability throughout the entire concrete placement and temporary casing removal operation.

2.2 Reinforcing Steel. Reinforcing steel shall conform to Section 544 and shall be Grade 60.

2.2.1 Clearance Spacers for Reinforcing Cage. Spacers used to provide the required sidewall and bottom clearance for the reinforcing cage shall be constructed of non-corrosive material that is equal in quality and durability to the shaft concrete, and shall be subject to approval. The spacers shall be of adequate dimension to ensure that the minimum clearance tolerances for the reinforcing cage are met, and that the reinforcing cage location is maintained during the concrete placement.

2.3 Temporary Casing for Drilled Shafts. Temporary casing shall be metal, smooth, watertight and of ample strength to withstand installation and removal stresses, and the pressure of both fluid concrete and the surrounding soils and/or water pressure, if the casing is to be pumped dry. Temporary casing shall have a minimum outside diameter equal to the design outside diameter of the drilled shaft.

2.4 Drilling Slurry. Slurry used in the drilling process shall be mineral, polymer or blended mineral-polymer slurries that conform to the requirements defined herein.

2.4.1 Mineral Slurry. The mineral slurry shall be sodium bentonite or attapulgite, and shall have both a mineral grain size that will remain in suspension and sufficient viscosity and gel characteristics to transport excavated material to a suitable screening system. The percentage and specific gravity of the material used to make the mineral suspension shall be sufficient to maintain the stability of the excavation and to allow proper concrete placement. The acceptable range of physical properties for the mineral slurry include the following:

Table 1 – Mineral Slurry Property Requirements

Property (Units)	**At Time of Slurry Introduction**	**In Hole at Time of Concreting**	**Test Method**
Density (pcf)	64.3 to 69.1	64.3 to 75.0	API 13B-1 Section 1
Viscosity (sec./quart)	28 to 45	28 to 45	API 13B-1 Section 2.2 Marsh Funnel and Cup
pH	8 to 11	8 to 11	pH paper or meter
Sand Content	Less than 4% (by volume)	Less than 4% (by volume)	API 13B-1 Section 5

Notes:

1. Increase density by 2 pcf in salt water.

2. Tests should be conducted when the slurry temperature is above 40 °F.

2.4.2 Polymer Slurry. A submittal shall be provided for all polymer slurries proposed for use. The submittal shall include a detailed plan for quality control of the polymer slurry and shall include: a) tests and test methods to be performed, and b) the minimum and maximum property requirements that must be met to ensure that the slurry functions as intended, considering the subsurface conditions, the shaft construction method, the slurry manufacturer's recommendations and these provisions. The polymer slurry is subject to approval.

2.4.3 Blended Mineral-Polymer Slurry. If the Design-Build Team proposes to use a blended mineral-polymer slurry, a detailed report specific to the project and prepared by a qualified slurry consultant shall be submitted. The report shall include the qualifications of the slurry consultant and shall describe the slurry materials, mix proportions, mixing methods and quality control methods. The blended mineral-polymer slurry is subject to approval.

2.4.4 Slurry Testing. The Design-Build Team shall provide all the necessary equipment and personnel to test the slurry using the prescribed methods. The frequency of tests shall be as directed. A copy of the Test Method Specifications shall also be provided.

Construction Requirements

3.1 Qualifications. The Design-Build Team and the Design-Build Team's project superintendent for the drilled shaft work covered under this special provision shall have a minimum of three years experience in constructing drilled shaft foundations within the past five years. The Design-Build Team's project superintendent shall be present at all times during execution of the work covered by this special provision. The Design-Build Team's drill operator shall have a minimum of two years experience within the last four years. A summary of the experience and qualifications shall be submitted in writing to the

Engineer at least four weeks prior to the start of the drilled shaft installation. The submittal shall include the name, address and phone number of the owner's representative who can verify the information provided. Acceptance of the Design-Build Team or any Firm to perform the drilled shaft work shall be subject to approval.

3.2 Installation Plan Submittal. At least four weeks prior to constructing drilled shafts, the Design-Build Team shall submit an installation plan in accordance with 105.02 to the Engineer for review and approval. This plan shall be stamped by a licensed NH Professional Engineer knowledgeable in the design and construction of drilled shafts.

3.2.1 The Design-Build Team's submittal shall contain as a minimum, the following specific information:

a. A complete description of the equipment to be used, including manufacturer's specifications and catalog data for all rigs, drilling tools, rock coring tools, cleaning equipment, desanding equipment, pumps, tremie pipes, casing, and other necessary tools

b. A description of the overall construction operation sequence and the sequence of shaft construction

c. Method of constructing the drilled shaft within the horizontal location tolerances including details of frames and templates

d. The method of shaft excavation and cleaning including obstruction removal, temporary casing installation and removal, and bedrock excavation

e. If slurry is proposed for shaft excavation, the type of slurry and the details of the methods to mix, circulate, de-sand and dispose of the slurry

f. The method of shaft construction, including details of reinforcing steel installation, reinforcing steel overlaps and connections, and concrete placement

g. Method of forming the exposed portion of the drilled shaft

h. Details of the proposed concrete mix design

i. Methods of complying with all applicable environmental regulations

3.2.2 The Engineer will evaluate the Installation Plan for conformance with the plans, specifications and this special provision. Within 21 days after receipt of the plan, the Engineer will notify the Design-Build Team of additional information or changes needed to meet the contract requirements. Approval of the installation plan shall not relieve the Design-Build Team of the responsibility to install the drilled shafts in accordance with the plans and specifications.

3.3 Subsurface Information. The geotechnical report for the CCTV pole foundation is available through the Materials and Research Bureau (603-271-3151). Appointments to review the report shall be made at least 3 days in advance. It is the Design-Build Team's sole responsibility to make interpretations and draw conclusions with respect to the character of material to be encountered and its effect on the drilled shaft installation.

3.4 Pre-Drilled Shaft Construction Meeting. A meeting shall be held prior to initiating the drilled shaft construction. The purpose of the meeting shall be to review all aspects of the drilled shaft construction and to facilitate coordination between all parties involved. Individuals attending the meeting shall include the Engineer, the Geotechnical Engineer from the Materials and Research Bureau, the Design-Build Team, the Firm performing the drilled shaft work and all other personnel deemed appropriate by the previously mentioned personnel. The Geotechnical Engineer shall be notified at least 7 days in advance.

3.5 Drilled Shaft Tolerance. The drilled shafts shall be constructed to the following tolerances:

a. The drilled shaft shall be within 3 inches of the plan position in the horizontal plane at the top of shaft elevation. In situations where the anchor rods will be located within a rock socket, the center of the rock socket shall be within 1 inch of the plan position in the horizontal plane at the top of shaft elevation. (Note: the center of the drilled shaft is defined as the center of the reinforcing cage). Additionally, the minimum required clear distance between the outside of the cage and the excavation sidewall shall be provided.

b. The vertical alignment of a vertical drilled shaft excavation shall be within 2 percent of plumb over the total length of the shaft.

c. The shaft and rock sockets shall have the diameter and configuration that is indicated in the contract plans.

d. The excavation equipment and methods shall be designed so that the completed shaft excavation will have a planar bottom. The cutting edges of excavation equipment shall be normal to the vertical axis of equipment within a tolerance of 3/8 inch per foot of diameter.

e. The bottom of the reinforcing cage shall be placed 3 inches, plus or minus 1 inch above the bottom of the shaft excavation.

f. During concrete placement, the top of the reinforcing steel cage shall not move more than 1 inch above or below the plan position.

g. The top elevation of the shaft concrete shall be as indicated on the plans.

h. The anchor rods shall be set to the dimensions and tolerances shown on the plans and detailed in Appendix A.

i. The exposed portion of the shaft and to a depth of at least 12 inches shall have a formed appearance with the top having a smooth level finish.

3.6 Drilling Equipment and Tools. The excavation and drilling equipment shall have adequate capacity including power, torque and down thrust to excavate a hole of both the maximum diameter and to a depth of 25 percent beyond the estimated lengths in the contract. The excavation equipment and tools shall be of adequate design, size and strength to perform the work as indicated on the plans or described herein. When the material encountered cannot be drilled using conventional drill buckets and earth augers with soil and rock teeth, the Design-Build Team shall provide special drilling equipment/procedures including but not limited to rock core barrels, rock tools, chisels, boulder breakers, air tools and other equipment necessary to construct the shaft excavation to the required depth.

3.7 Construction Methods. The Design-Build Team shall perform the excavation required for the shafts, through whatever materials and groundwater that are encountered, to the dimensions and elevations shown on the plans or otherwise required by these special provisions. The Design-Build Team's methods and equipment shall be suitable for the intended purpose and the materials encountered. Drilled shafts shall be constructed as indicated on the plans by the most appropriate method described below. Permanent casing will not be permitted.

3.7.1 Dry Construction Method. The dry construction method without temporary casing shall be used only if the groundwater table and soil conditions are suitable to permit construction of the shaft in a relatively dry excavation, and where the sides and bottom of the shaft may be visually inspected by the Engineer immediately prior to placing concrete in the excavation. The dry method consists of excavating the shaft, removing accumulated water and loose material from the excavation, placing the reinforcing cage, and concreting the shaft in a dry excavation as defined below.

3.7.1.1 The dry construction method will only be approved if the sides and bottom of the excavation remain stable and if any loose material and water can be satisfactorily removed immediately prior to inspection and concrete placement without detrimental caving. Residual water depths of 3 inches or less shall be considered as dry. The Design-Build Team shall use the temporary casing and/or slurry displacement method(s) for shafts that do not meet the above requirements.

3.7.2 Temporary Casing Construction Method. The temporary casing method consists of excavating the shaft after a temporary casing is installed, and then placing the reinforcing cage and shaft concrete in the excavation, after which the casing is removed.

3.7.2.1 The temporary casing shall be advanced into the ground by twisting, driving or vibrating prior to drilling below the bottom of the casing. Drilling ahead of the temporary casing

will be permitted only if the sides of the excavation remain stable prior to advancing the temporary casing through the pre-drilled depth.

3.7.2.2 If the Design-Build Team elects to remove a casing from the shaft and substitute a longer casing in caving soils, the excavation shall be stabilized with slurry or backfilled before the substitution is made. Other methods, subject to the approval of the Engineer, may be used to control the stability of the excavation and protect the integrity of the foundation soils. The slurry displacement method with temporary casing may be necessary if the casing does not prevent water or soils from entering the excavation at the bottom of the casing.

3.7.2.3 Telescoping through larger diameter casing will be permitted and shall meet the casing removal requirements defined in 3.11.

3.7.2.4 The temporary casing construction method will only be approved if all loose material can be satisfactorily removed and if the sides and the bottom of the excavation remain stable throughout the concreting and casing withdrawal process.

3.7.3 **Slurry Displacement Construction Method.** The slurry displacement method may be used with or without casing if the requirements of 2.4 are met. This method consists of using a drilling fluid to maintain stability of the excavation while advancing the excavation to final depth, placing the reinforcing cage and concreting the shaft.

3.7.3.1 Concreting the drilled, slurry filled excavation shall be completed the same day that the shaft excavation is completed. If this is not possible, the excavation shall be re-drilled, cleaned and the slurry tested before concreting. Slurry shall be continually fed into the shaft excavation as drilling progresses so that the top of the slurry remains a minimum of 5 feet above the groundwater table or higher if needed to maintain a stable excavation. The pump used to reclaim the slurry shall be self-priming. A standby pump shall be available during the drilling operation.

3.8 **Shaft Excavation.** The shaft excavation shall consist of soil and obstruction removal, and also bedrock excavation to create a rock socket. Shaft excavations shall be made at the locations shown on the project plans. Excavations shall be made according to the dimensions shown on the plans, and within the tolerances set forth in 3.5 and the following. The bedrock surface elevation and the bottom elevation of the rock socket shall be determined by the Engineer during the excavation. Excavation methods that result in disturbance of soil or rock materials below the bottom of shaft shall not be used. Dewatering of the shaft excavation for excavation purposes will not be required. All excavated materials shall be disposed of in approved areas.

3.8.1 Soil Excavation. The soil, which is defined as all the material above the bedrock surface except obstructions, shall be completely removed within the shaft excavation to the required depth. Excavation of the soil shall be performed with conventional drilling tools as described in 3.6. Material, which in the judgment of the Engineer cannot be removed after reasonable effort using conventional tools, shall be considered as an obstruction and shall be treated

as described in 3.8.2. Reasonable effort shall include operating the approved drilling equipment at maximum power, torque and down thrust for a period of at least 15 minutes.

3.8.2 Obstruction Removal. Obstructions shall be defined as any natural material or man-made objects above the bedrock surface that cannot be removed by conventional excavation methods and tools described in 3.6 and 3.8.1. Fill materials placed as part of this contract will not be considered as obstructions. Drilling tools lost in the excavation will not be considered obstructions and shall be removed by the Design-Build Team without compensation. Special drilling tools or removal procedures described in 3.6 that are not detrimental to the shaft excavation shall be employed by the Design-Build Team to remove obstructions. Blasting of obstructions shall not be permitted unless specifically approved in writing by the Engineer. The Design-Build Team shall provide the necessary means to accurately measure the obstruction lengths and all measurements shall take place in the presence of the Engineer.

3.8.2.1 Obstruction removal shall be paid as extra work in accordance with Section 109.04. Obstruction removal requiring specialized methods will be measured by the linear foot to the nearest 0.1 of a foot from the top of the obstruction to the bottom of the obstruction. No measurements will be taken unless this work is authorized by the Engineer prior to the start of obstruction clearance operations. Obstruction removal will not be measured at any depth within fill material placed as part of this construction project.

3.8.3 Rock Socket Excavation. For design purposes, the rock socket excavation shall extend from the lowest point of the bedrock surface within the drilled shaft excavation to the bottom of the minimum rock socket length indicated in the contract plans, or to the prescribed foundation depth, whichever is reached first. The rock socket diameter shall be within the tolerances set forth in 3.5. Methods and tools used to excavate the rock socket shall include, but are not limited to the special methods described in 3.6. Blasting for the rock socket excavation shall not be permitted. A separate pay item will be included in the contract for projects that require a rock socket.

3.8.4 Shaft Excavation Acceptance. A shaft excavation including the rock socket shall be accepted by the Engineer based on the results of a visual inspection.

3.8.4.1 Acceptance of the shaft excavation by the Engineer shall be required prior to placement of the steel reinforcement cage and concrete. The completed shaft excavation shall be thoroughly cleaned of all sediment including loose soil, debris and loose or pulverized bedrock prior to inspection. The excavation bottom shall be cleaned so that a minimum of 50 percent of the base will have less than 1/2 inch of sediment and at no place on the base more than 1-1/2 inches of sediment.

3.8.4.2 The Design-Build Team shall make the completed excavation available to the Engineer for inspection. The Design-Build Team shall also provide suitable access for inspection, safety lines and equipment, communication equipment, electric power, and devices for checking dimensions, alignment and plumbness as needed.

3.8.4.3 Should the Engineer have reason to believe that the drilled shaft excavation techniques or workmanship has been deficient with respect to a given shaft excavation such that the integrity of the excavation is in question, work on the drilled shaft shall be stopped. The Design-Build Team will not be allowed to proceed with the shaft excavation in question or any subsequent shaft excavations until the deficient excavation techniques or workmanship have been changed to the Engineer's satisfaction.

3.9 **Steel Reinforcement Construction and Installation.** The reinforcing steel, which consists of longitudinal bars and transverse bars or spirals along with stiffeners, spacers and centralizers, shall be assembled into a cage prior to installation according to the plans. The reinforcing bars shall be 100 percent tied and braced sufficiently to allow lifting and installation as a single unit without damage, racking or deformation. Splicing of the longitudinal bars shall not be allowed, except using approved mechanical splices or approved overlap lengths. The reinforcement cage shall be placed into the shaft excavation to within the horizontal and vertical tolerances described in 3.5.

3.9.1 Spacers and other means as necessary shall be used to maintain the horizontal tolerance criteria set forth in 3.5. The spacers shall be securely attached to the reinforcing cage and shall be in firm contact with the sidewalls of the drilled shaft excavation. The spacers shall be used at regular intervals of 5 feet or less. When the size of the longitudinal reinforcing steel exceeds one inch, such spacing may be increased to a maximum of 10 feet. Each shaft shall have a minimum of 2 rows and 3 vertical lines of spacers. The spacers shall be dimensioned to meet the tolerance criteria set forth in 3.5.

3.9.2 An approved method to restrain the upward and downward movement of the reinforcing cage shall be used to prevent uplift or downdrag of the cage during concrete placement. The elevation of the top of the reinforcing steel shall be checked before and after the concrete is placed. If movement greater than that allowed under 3.5 has occurred, the drilled shaft shall be considered defective and corrective measures shall be undertaken by the Design-Build Team to the satisfaction of the Engineer. Furthermore, no additional shafts shall be constructed until the Design-Build Team has modified his restraining system to prevent the uplift or downdrag problem from reoccurring. Corrective measures shall be the responsibility of the Design-Build Team and shall be at no cost to the Department.

3.10 **Concrete Placement.** Applicable portions of Section 520 shall be followed for concrete placement, except as modified herein. Either the free fall method or underwater placement method shall be used, as defined below. For both methods, concrete shall be placed in one continuous operation from the bottom to the top of the shaft, unless otherwise approved. Removal of the temporary casing shall be in conformance with 3.11. Cold joints in the concrete shall not be allowed unless approved.

3.10.1 Concrete Placement – Free Fall Method. The free fall method of concrete placement shall only be allowed in a stable, dry excavation as defined in 3.7.1. Excavations that have a greater depth of water or measurable seepage shall be concreted using underwater placement procedures.

3.10.1.1 Free falling concrete shall be placed at the center of the excavation using a hopper with attached hose, or other approved system that centers the concrete fall into the excavation. The maximum concrete drop height shall be limited to a height that is less than 20 times the inside diameter of the reinforcing cage. Shorter drop heights and other adjustment in the placement procedure shall be required as directed, to prevent the concrete from striking the reinforcing cage during placement.

3.10.2 Concrete Placement – Underwater Method. Underwater placement procedures shall be required within excavations where the criteria for a dry excavation and free fall placement methods cannot be met. The underwater placement method consists of placing the concrete below the water at the bottom of the drilled shaft excavation, using either tremie or pumping methods and equipment as defined below. The water level within the drilled shaft shall be at a stabilized, static level at the time of concrete placement.

3.10.2.1 Concrete Placement Pipe. The placement pipe used for the tremie or pumping methods shall consist of a steel or iron tube of sufficient length and diameter to discharge concrete at the bottom elevation of the excavation. Aluminum pipe will not be permitted. The minimum pipe diameter shall be 10 inches for the tremie placement method and 4 inches for the pumping placement method. The length of the placement pipe shall be clearly marked in one foot increments along the outside of the pipe, measured upward from the discharge end. The inside and outside surfaces of the tremie pipe shall be clean and smooth to permit both flow of concrete and unimpeded withdrawal during concrete placement. The wall thickness of the pipe shall be adequate to prevent crimping and bending. The pipe wall and joints shall be strong enough to resist concrete pumping pressures and shall be watertight.

3.10.2.2 The discharge end of the placement pipe shall be equipped with a watertight valve or disposable plate that prevents water from filling the interior of the pipe when inserted into the excavation. Alternately, a plug that maintains separation between the concrete and water within the pipe may be used at the top of the pipe. The valve, plate or plug shall provide a seal in the pipe until concrete discharge begins, to minimize contamination of the concrete. Disposable plates or plugs shall be of a material non-detrimental to the drilled shaft, as approved by the Engineer. Air inflated plugs shall not be used. The discharge end of the pipe shall be designed to allow free radial flow of concrete during placement operations.

3.10.2.3 The placement pipe shall be installed in the center of the shaft excavation and extend to the bottom of the excavation. The pipe shall be properly secured and braced within the excavation to prevent uplift or drift during concrete discharge. The pipe and bracing shall be designed to allow progressive and steady removal as the concrete fills the excavation. Methods to remove air trapped in tremie or pump pipes shall be provided if necessary as determined by the Engineer.

3.10.2.4 The placement pipe discharge end shall be immersed in at least 5 feet of concrete at all times after the start of concrete placement. The flow of concrete in the pipe shall be continuous,

and a positive pressure differential shall be maintained at all times to prevent water or slurry intrusion into the pipe. If at any time during concrete placement the pipe discharge orifice is removed or uplifts from the fluid concrete with concrete discharge occurring, the entire drilled shaft shall be considered defective. In such a case, the Design-Build Team shall completely remove the reinforcing cage and concrete by approved methods. The shaft shall then be redone according to these provisions. All costs for replacement of defective shafts shall be the responsibility of the Design-Build Team and shall be at no cost to the Department. If concrete discharge has not occurred, then the placement pipe shall be re-immersed into the concrete with a closed valve, disposable plate or plug on the discharge end, so that water and air are not delivered into the fluid concrete.

3.10.2.5 The Design-Build Team shall maintain the concrete in a workable state throughout the entire underwater placement operation, and also during temporary casing removal operations (described in 3.11). In addition to designing the concrete mix with any necessary admixtures, the Design-Build Team shall lubricate the pumping system and cool the placement pipes as necessary, to maintain acceptable workability of the concrete. Concrete that has lost sufficient workability to the extent that the provisions of 3.10.2 cannot be met will result in rejection of the drilled shaft, as described in 3.10.2.4.

3.10.2.6 In cases where the concrete cutoff grade is below the ground surface, the concrete shall be placed a minimum of 2 feet above the plan top elevation, unless otherwise approved. The excess 2 feet of concrete shall then be removed back down to the proposed concrete grade or lower, if necessary to reach sound concrete using chipping or other approved methods.

3.11 **Temporary Casing Removal.** Temporary casings shall not be left in place and shall be completely removed.

3.11.1 During all phases of the temporary casing removal, the height of concrete within the casing shall be maintained at a sufficient height above the bottom of casing so that the internal fluid concrete pressure exceeds the external fluid and soil pressure at all levels below the temporary casing. For drilled shafts less than 20 feet in length, removal of the temporary casing shall not be initiated until after the concrete has been placed to at least the top elevation of the drilled shaft, unless otherwise approved.

3.11.2 During the temporary casing removal, the concrete surface within the casing shall be monitored to verify that the concrete surface does not drop below the level required through 3.11.1 at the time of removal. A means of access to measure the concrete surface during all phases of the temporary casing removal shall be provided. If necessary to meet the requirements of 3.11.1, concrete shall be added in an approved manner during the temporary casing removal.

3.11.3 Static pull or rotary extraction methods shall be required to remove the temporary casing. Vibratory methods to initially free the temporary casing are subject to approval.

3.11.4 If telescoped temporary casings have been used, the casings shall be concreted and pulled progressively from the inner casing to the outer casing in an approved manner.

3.12 **Anchor Rods.** The anchor rods embedded into the shaft for the support pole connection shall be installed prior to, or immediately after concrete placement while the concrete is still plastic. Drilling to set the anchor rods after concrete placement shall not be allowed. The anchor rods shall be set to the dimensions and tolerances shown on the plans and in Section 677. Material requirements and payment for anchor rods shall be covered under Section 677.

3.13 **Acceptance of Completed Drilled Shaft.** The final acceptance of each drilled shaft shall be the decision of the Engineer based on the conformance to tolerance limits set forth in 3.5. If the drilled shaft integrity is questionable, the Engineer shall require a core hole through the shaft to evaluate its condition. If a defect is confirmed, the Design-Build Team shall pay for all coring costs. If no defect is encountered, the Department shall pay for all coring and grouting costs. In the case that any shaft is deemed unacceptable, the Design-Build Team shall submit a plan for remedial action with calculations and working drawings prepared and stamped by a licensed NH Professional Engineer. Materials and work required to perform remedial shaft actions, including engineering analysis and redesign, shall be provided at no cost to the Department.

3.14 **Design-Build Team's Records.** The Design-Build Team shall keep a record independent of that which may be kept by the Engineer, of all pertinent data relative to the installation of the drilled shaft. This record shall be available for the Engineer's inspection, and shall be transmitted as directed. The Design-Build Team’s record shall include the following:

a. Shaft location and dates of installation.

b. Slurry data including test data.

c. Total length of each shaft.

d. Plumbness of shaft.

e. Placement and condition of reinforcing cage

f. The time, method and duration of the concrete placement, with a log of the temperature at the time of placement.

g. The quantity of concrete versus depth of filled shaft

3.14.1 The Design-Build Team shall maintain a construction method log during shaft excavation. The log shall contain information such as: the top and bottom elevation of each soil and obstruction layer, the bedrock surface elevation, groundwater depth, drilling rate and remarks. The log shall be provided to the Engineer a minimum of 24 hours prior to concreting the drilled shaft.