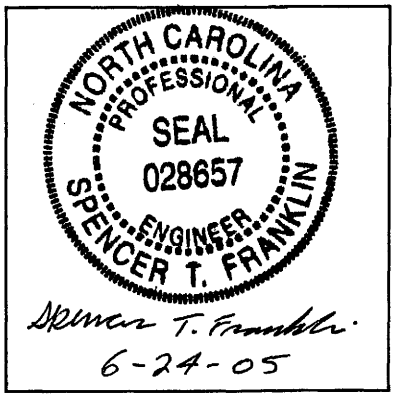
B-3681
Signals & Intelligent Transportation Systems



Project Special Provisions
(Version 02.14)
Signals and Intelligent Transportation Systems

Prepared By: STF
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Contents

1. 2002 Standard Specifications for Roads & Structures – Section 1098 Revisions

The 2002 Standard Specifications are revised as follows:

1.1. General Requirements (1098-1)

Page 10-220, Subarticle 1098-1(A)

In the last paragraph, sentence 1, revise "by the date of advertisement of the project" to "by the date of equipment installation."

Pages 10-222,3 Subarticle 1098-1(H)

Replace paragraphs 2, 3, and 4 with the following paragraphs:

Except for grounding conductors, provide signal cable conductors of size Number 16 AWG that are fabricated from stranded copper. **Number 16 AWG cable can only be used with an all LED traffic signal intersection.** Repairs to a non-LED traffic signal intersection must use Number 14 AWG cable.

Provide either 0.05 x 0.30 inch (1.3 x 7.6 mm) aluminum wrapping tape or 0.06 inch (1.5 mm) stainless steel lashing wire for the purpose of lashing cables, except fiber-optic communications cables, to a messenger cable. Use 0.045-inch (1.14-mm) stainless steel lashing wire for the aerial installation of fiber-optic communications cable to messenger cable.

1.2. Signal Heads (1098-2)

Page 10-223, Subarticle 1098-2(A)

In paragraph 5, sentence 4, revise "1 3/8 inch (32 mm) vertical conduit entrance hubs" to "1 1/4 inch (32 mm) vertical conduit entrance hubs" and revise "1 5/8 inch (40 mm) horizontal hubs" to "1 1/2 inch (40 mm) horizontal hubs."

In the last paragraph, sentence 3, revise "2/5 x 3/4 inch (9.5 mm x 19.1 mm) square head bolts" to "3/8 x 3/4 inch (9.5 mm x 19.1 mm) square head bolts."

Page 10-225, Subarticle 1098-2(C)

Replace paragraphs 2 and 3 with the following paragraphs:

Unless otherwise required by the plans, provide single-section pedestrian heads with 6 inch (150 mm) minimum deep traditional visors that prevent the sun phantom illumination of the indication.

Where required by the plans, provide two-section pedestrian signal heads with traditional three-sided, rectangular visors 12 inches (300 mm) long.

Replace the last paragraph with the following:

Provide lead-in cable that complies with the loop lead-in cable section of these project special provisions.

Pages 10-225-227, Subarticle 1098-2(E) [**Light Emitting Diode (LED) Sections**]

Replace the entire subarticle with the following two subarticles:

(1) Vehicular

Provide light emitting diode (LED) traffic signal modules (hereafter referred to as modules) that consist of an assembly that utilizes LEDs as the light source in lieu of an incandescent lamp for use in traffic signal sections. Use LEDs that are aluminum indium gallium phosphorus (AlInGaP) technology for red and yellow indications and indium gallium nitride (InGaN) for green indications. Install the ultra bright type LEDs that are rated for 100,000 hours of continuous operation from -40°C to +74°C (-40°F to +165°F). Design modules to have a minimum useful life of 60 months, and to meet all parameters of this specification during this period of useful life.

Ensure, unless otherwise stated in these specifications, that each module meets or exceeds the requirements of the Interim Purchase Specification of the ITE VTCSH part 2 (Light Emitting Diode (LED) Vehicular Traffic Signal Modules (hereafter referred to as VTCSH-2). Ensure arrow displays meet or exceed the electrical and environmental operating requirements of VTCSH-2 sections 3 and 5, chromaticity requirements of section 4.2, and the requirements of sections 6.3 (except 6.3.2) and 6.4 (except 6.4.2).

Provide modules that meet the requirements of Table 1098-1. Design the modules to operate from a 60 ±3 HZ AC line voltage ranging from 80 volts to 135 volts. Ensure that fluctuations of line voltage have no visible effect on the luminous intensity of the indications. Design the module to have a normal operating voltage of 120 VAC, and measure all parameters at this voltage.

Table 1098-1
Maximum Power Consumption (in Watts) at 25°C (77°F)

	Red	Yellow	Green
300 mm circular	17	34	24
200 mm circular	10	16	12
300 mm arrow	9	10	11

Certify that the module has a power factor of 0.90 or greater, and that total harmonic distortion (THD) (current and voltage) induced into an AC power line by the module does not exceed 20 percent for modules with power ratings above 15W, and 40 percent for modules with power ratings of 15W or less. Design the module's onboard circuitry to include voltage surge protection to withstand high repetition noise transients as stated in Section 2.1.6 of NEMA Standard TS-2, 1992. Ensure all wiring meets the requirements of Section 13.02 of the ITE Publication: Equipment and Material Standards, VTCSH-2. Provide spade terminals appropriate to the lead wires and sized for a #10 screw connection to the existing terminal block in a standard signal head.

Ensure that the module is compatible with signal load switches and conflict monitors. Design the module to provide sufficient current draw to ensure proper load switch operation while the voltage is varied from a regulated 80 Vrms to 135 Vrms. Design off-state for green and yellow modules to be 30Vrms or greater, and on-state to be 40 Vrms or greater. Design the voltage decay to 10 Vrms or less to be 100 milliseconds or less for green and yellow modules. Ensure

that the control circuitry prevents current flow through the LEDs in the off state to avoid a false indication.

Design all modules to meet existing NCDOT monitor specifications for each of the following types of signal monitors: NEMA TS-1 conflict monitors (including so-called NEMA plus features such as dual indication detection and short yellow time detection); NEMA TS-2 Malfunction Management Units (MMU); and 170 cabinet Type 210ECL and 2010ECL conflict monitors (including red monitoring and so-called plus features such as dual indication detection and short yellow time detection).

Ensure that the modules and associated onboard circuitry meet Class A emission limits referred to in Federal Communications Commission (FCC) Title 47, Subpart B, Section 15 regulations concerning the emission of electronic noise.

Provide modules that meet the requirements of Tables 1098-2, 3, and 4. Test all ball modules for luminous intensity at 25°C (77°F) to meet 115% of values in tables 1098-2 and 4. Design and certify the modules to meet or exceed the maintained minimum luminous intensity values throughout the warranty period based on normal use in a traffic signal operation over the operating temperature range. Test the Red and Green modules for maintained luminous intensity (Tables 1098-2, 3, and 4) at 74°C (165°F) (ITE 6.4.2.2). Use LEDs that conform to the chromaticity requirements of VTCSH-2, Section 8.04 throughout the warranty period over the operating temperature range. Make chromaticity coordinate compliance measurements at 25°C (77°F).

Table 1098-2
Specification for 12 inch (300 mm) Extended View Signals

Minimum Luminous Intensity Values (In Candelas)				
Expanded View Vertical Angle	Horizontal Angle (Left/Right)	RED	YELLOW	GREEN
+/-2.5	2.5	339	678	678
	7.5	251	501	501
	12.5	141	283	283
	17.5	77	154	154
+/-7.5	2.5	226	452	452
	7.5	202	404	404
	12.5	145	291	291
	17.5	89	178	178
	22.5	38	77	77
	27.5	16	32	32
+/-12.5	2.5	50	101	101
	7.5	48	97	97
	12.5	44	89	89
	17.5	34	69	69
	22.5	22	44	44
	27.5	16	32	32
+/-17.5	2.5	22	44	44
	7.5	22	44	44
	12.5	22	44	44
	17.5	22	44	44
	(Not Extended View) 22.5	20	41	41
	(Not Extended View) 27.5	16	32	32
+/-22.5	2.5	20	40	40
	17.5	20	40	40

Notes
1. Design signal modules to meet these requirements as a minimum throughout the warranty period.
2. Design signal modules to have a minimum initial intensity equal to 115% of Table 2 at 25°C.
3. Independent laboratory test reports are required to validate the initial intensity.

Table 1098-3
Minimum Initial and maintained Intensities for Arrow Indications (in cd/m2)

	Red	Yellow	Green
Arrow Indication	5,500	11,000	11,000

Table 1098-4
Specification for 8 inch (200 mm) Extended View Signals

Minimum Luminous Intensity Values (In Candelas)for circular indications				
Expanded View Vertical Angle	Horizontal Angle (Left/Right)	RED	YELLOW	GREEN
+/-2.5	2.5	133	267	267
	7.5	97	194	194
	12.5	57	113	113
	17.5	25	48	48
+/-7.5	2.5	101	202	202
	7.5	89	178	178
	12.5	65	129	129
	17.5	41	81	81
	22.5	18	37	37
	27.5	10	20	20
+/-12.5	2.5	37	73	73
	7.5	32	65	65
	12.5	28	57	57
	17.5	20	41	41
	22.5	12	25	25
	27.5	9	16	16
+/-17.5	2.5	16	32	32
	7.5	14	28	28
	12.5	10	20	20
	17.5	9	16	16
	(Not Extended View) 22.5	6	12	12
	(Not Extended View) 27.5	4	9	9

Notes

4. Design signal modules to meet these requirements as a minimum throughout the warranty period.
5. Design signal modules to have a minimum initial intensity equal to 115% of Table 4 at 25°C.
6. Independent laboratory test reports are required to validate the initial intensity.

Table 1098-5
Chromaticity Standards (CIE Chart)

Red	Y: not greater than 0.308, or less than 0.998 - x
Yellow	Y: not less than 0.411, nor less than 0.995 - x, nor less than 0.452
Green	Y: Not less than 0.506 -.519x, nor less than 0.150 + 1.068x, nor more than 0.730 - x

Design the modules as retrofit replacements for installation into standard incandescent traffic sections that do not contain the incandescent lens, reflector assembly, lamp socket and lens gasket. Ensure that installation does not require special tools or physical modification for the existing fixture other than the removal of the incandescent lens, reflector assembly, lamp socket, and lens gasket.

Provide modules that are rated for use in the operating temperature range of –40°C (-40°F) to +74°C (+165°F). Ensure that the modules (except yellow) meet all specifications throughout this range. Fabricate the module to protect the onboard circuitry against dust and moisture intrusion per the requirements of NEMA Standard 250-1991 for Type 4 enclosures to protect all internal components.

Design the module to be a single, self-contained device with the circuit board and power supply for the module inside and integral to the unit.

Design the assembly and manufacturing process for the module to ensure all internal components are adequately supported to withstand mechanical shock and vibration from high winds and other sources. Wire the individual LEDs such that a catastrophic loss or the failure of one LED will result in the loss of not more than 20 percent of the signal module light output. Solder the LEDs to the circuit board.

Fabricate the lens and signal module from material that conforms to ASTM specifications. Ensure enclosures containing either the power supply or electronic components of the module are made of UL94VO flame retardant materials. The lens of the signal module is excluded from this requirement.

Permanently mark the manufacturer's name, trademark, model number, serial number, date of manufacture (month & year), and lot number as identification on the back of the module.

Permanently mark the following operating characteristics on the back of the module: rated voltage and rated power in watts and volt-amperes.

If a specific mounting orientation is required, provide permanent markings consisting of an up arrow, or the word "UP" or "TOP" for correct indexing and orientation within the signal housing.

Provide a lens that is integral to the unit with a smooth outer surface and UV stabilized to withstand ultraviolet exposure for a minimum period of 60 months without exhibiting evidence of deterioration. Coat the front of a polycarbonate lens to make it more abrasion resistant. Seal the lens to the module to prevent moisture and dust from entering the module.

Tint the red and yellow lens to match the wavelength (chromaticity) of the LED. Provide a green lens that is either colorless or tinted to match the wavelength (chromaticity) of the LED.

For 12-inch (300-mm) arrow modules, ensure that the module meets specifications stated in Section 9.01 of the ITE VTCSH for arrow indications. Design arrow displays to be solid LEDs (spread evenly across the illuminated portion of the arrow or other designs), not outlines. **Determine the luminous intensity using the CALTRANS 606 method or similar procedure.**

Provide test results for ball modules from an independent testing laboratory showing wattage and compliance with ITE VTCSH-2 specifications 6.4.2, 6.4.4.1, 6.4.4.2, 6.4.4.3, 6.4.5, and 6.4.6.1 as a minimum. Ensure the 6.4.2.1 test meets the requirements of Tables 1098-2 and 4 of this specification. The 6.4.2.2 test is for Red and Green only. Ensure that the LED signal modules tested are typical, average production units.

Burn In - Energize the sample module(s) (a sample of one module minimum) for a minimum of 24 hours, at 100 percent on-time duty cycle, at a temperature of +74°C (+165°F) before performing any qualification testing. Any failure of the module, which renders the unit non-compliant with the specification after burn-in, is cause for rejection. All specifications will be measured including, but not limited to:

Photometric (Rated Initial Luminous Intensity) - Measure at +25°C (+77°F). Measure luminous intensity for red and green modules upon the completion of a 30 minute 100 percent on-time duty cycle at the rated voltage. Measure luminous intensity for yellow modules immediately upon energizing at the rated voltage.

Chromaticity (Color) - Measure at +25°C (+77°F). Measure chromaticity for red and green modules upon the completion of a 30 minute 100 percent on-time duty cycle at the rated voltage. Measure chromaticity for yellow modules immediately upon energizing at the rated voltage.

Electrical - Measure all specified parameters for quality comparison of production quality assurance on production modules. (rated power, etc)

Equipment Compatibility - In addition to the 6.4.4.5 test of modules for compatibility with controllers, conflict monitors, and load switches, perform the following test, and certify the results. Connect each signal module to the output of a standard load switch connected to a variable AC voltage supply (95 to 135 VAC). With the load switch "off," vary the AC voltage from 95 Vrms to 135 Vrms, and measure the drop across the module. Readings greater than 15 Vrms are unacceptable.

NCDOT evaluates and approves all LED Traffic Signal modules for the QPL by a standard visual inspection and blind operational survey, a compatibility test, current flow, and other random tests, in addition to reviewing the lab reports and documentation from the manufacturer. The tests are conducted at the Traffic Electronics Center in Raleigh. Ensure each 12-inch (300-mm) ball module is visible at 450 feet (135 meters) during sway conditions (extended view) until obscured by the visor. Ensure each 8-inch ball (200-mm) and 12-inch (300-mm) arrow modules are visible at 300 feet (90 meters) during sway conditions (extended view) until obscured by the visor. Sufficient luminance during the extended views will be determined during this blind survey evaluation.

In addition to meeting the performance requirements for the minimum period of 60 months, provide a written warranty against defects in materials and workmanship for the modules for a period of 60 months after shipment acceptance of the modules. Provide replacement modules within 30 days of receipt of modules that have failed at no cost to the State. Provide warranty documentation to the Department prior to QPL acceptance. Provide luminous intensity testing at an independent lab, to determine degradation, for two modules of each color provided by NCDOT at the end of two and four years of operation.

Provide testing at an independent laboratory for a designated module to be tested for maintained luminous intensity at 25°C (77°F) once each year during the five year warranty period.

1.3. Wood Poles (1098-6)

Page 10-228, Article 1098-6

Replace the entire article with the following:

Provide poles of treated southern pine or treated Douglas fir that meet the requirements of ANSI 05.1. Provide Class 3 or better wood poles that are a minimum length of 40 feet (12.2 meters) unless otherwise shown on the plans and are of a sufficient length to maintain minimum required distances above the roadway, obstructions and affected railroad tracks. Mark each pole in accordance with ANSI 05.01. First roof and bore poles and then give them a full-length preservative treatment.

Provide poles with pentachlorophenol or chromated copper arsenate (CCA) preservative, in accordance with AWPA Standard C4-99. Ensure the retention of preservative is a minimum of 0.45 lb. per cubic foot (7.2 kg per cubic meter) for pentachlorophenol and 0.6 lb. per cubic foot (9.6 kg per cubic meter) for CCA.

1.4. Guy Assemblies (1098-7)

Page 10-228, Article 1098-7

Add the following to paragraph two:

Anchor assemblies with double-strand eyes may be used in lieu of those with the tripleye feature when only one guy cable is to be attached. Ensure anchor assemblies are 7 feet (2.13 meters) minimum in length.

1.5. Loop Lead-In Cable (1098-9)

Page 10-230, Article 1098-9

Replace the entire article with the following:

Furnish lead-in cable with conductors of size 18 AWG that are fabricated from stranded copper, and that complies with IMSA Specification 50-2 except as follows:

- Provide the following two pair (4 conductor) conductor insulation pair colors: clear-yellow and red-green.
- Provide the following four pair (8 conductor) conductor insulation pair colors: clear-yellow, red-green, clear with black stripe tracer-yellow with black stripe tracer, and red with black stripe tracer-green with black stripe tracer. Apply continuous stripe tracer on conductor insulation with a longitudinal or spiral pattern.
- Ensure each pair is completely covered with a spirally wrapped Aluminum Mylar tape with aluminum side out.
- Provide cable jacket formed from black polyethylene. Ensure the finished jacket provides environmental stress resistance, outdoor weatherability, toughness, low temperature performance, and ultraviolet resistance.
- Provide a ripcord to allow the cable jacket to be opened without using a cutter.
- Install all underground lead-in cable in non-metallic conduit.

1.6. Fiber-optic Cable (1098-11)

Page 10-233, Subarticle 1098-11(A)

In paragraph 3, sentence 5, delete "Construct buffer tubes with an inner layer made of polycarbonate and an outer layer made of polyester."

1.7. Metal Poles (1098-15)

Page 10-236, Subarticle 1098-15(A)

In paragraph 1, sentence 2, delete the phrase "(AASHTO Specifications) in effect on the date of advertisement" and insert the words "4th Edition, 2001, including the latest interim specifications."

Page 10-238, Subarticle 1098-15(B)

In paragraph 1 (partial), sentence 2, delete the phrase "6 x 6 x 3/4 inches (150 x 150 x 18 mm)" and insert the words "circular anchor bolt lock."

In the first full paragraph, add the following sentence:

Where splicing is necessary, use butt splice and heat shrink tubing.

2. 2002 Standard Specifications for Roads & Structures – Section 1700 Revisions

The 2002 Standard Specifications are revised as follows:

2.1. General Requirements (1700)

Page 17-2, Subarticle 1700-3 (D), add the following paragraph

In the event the contractor fails to perform in accordance with the plans and specifications within the time frame specified, the Department reserves the right to perform the maintenance and emergency service necessary to assure continuous traffic signal operation. Further, all expenses incurred by the Department in implementing this option will be deducted from the payment due the contractor, plus a $250 liquidated damage per occasion, per day, or any portion thereof, until corrected. The liquidated damages are due to increased public hazard resulting from the malfunction.

Page 17-2, Subarticle 1700-3 (F)

In paragraph 2, sentence 2, delete "type 1."

Page 17-3, Subarticle 1700-3 (J)

In paragraph 2, sentence 2, revise "detectable metallic burial tape" to "marker tape."

Page 17-3, Article 1700-3, add Subarticle (K) to read as follows:

(K) Electrical Bonding

Using an approved termination means, connect a Number 14 AWG min. 19-strand copper conductor (Type THW) with green insulation to serve as an equipment grounding conductor to metal poles with mast arm supports, vehicular and pedestrian signal pedestals, and other metallic components which are not otherwise bonded through means approved by the Engineer.

2.2. Underground Conduit (1715)

Page 17-8, Subarticle 1715-3(A)

Add the following paragraph:

Install metallic conduit at all locations where conduits traverse railroad tracks or as shown on the plans. For all other locations, install nonmetallic conduit unless otherwise shown on the plans. Backfill with excavated material and compact to 95% of its original density. Remove any rock and debris from backfill material.

Page 17-8, Subarticle 1715-3(C)

Delete the first paragraph.

Page 17-8, Subarticle 1715-3(D)

Replace reference to Article 342-3 with reference to Article 1540-3 (A&B).

Page 17-8, Subarticle 1715-3(E)

Revise the last sentence to:

Label all tracer wires. Terminate tracer wire to equipment ground bus as specified in the plans.

2.3. Wood Poles (1720)

Page 17-10, Article 1720-3

Replace the fourth paragraph with the following paragraph:

On joint use poles and NCDOT owned poles, at signal and traffic management systems equipment installations (i.e. controller cabinets, CCTV cabinets, DMS cabinets, etc.), bond the messenger cable(s) to the existing pole ground using burndy clamps at each end and at 1300-foot intervals. On multiple messenger cable arrangements, connect all messenger cable ends with #6 solid bare copper wire and bond with split bolt connectors or burndy clamps (UCG25RS) or equivalent. On joint use and NCDOT owned poles, if an existing pole ground does not exist, install a grounding system consisting of a #6 AWG bare copper wire that is exothermically welded to a ground rod.

In the last paragraph, last sentence, revise "5/8 inch x 8 foot (16 mm x 2.4 m) ground rod" to "5/8 inch x 10 foot (16 mm x 3.0 m) ground rod."

2.4. Riser Assemblies (1722)

Page 17-12, Article 1722-3

In paragraph 4 add the following after the last sentence:

Install condulet on all risers for lead-in cable.

2.5. Loop Lead-In Cable (1726)

Page 17-14, Article 1726-3

Replace paragraph 1 with the following:

Install lead-in cable.

Delete paragraph 3.

In paragraph 4, delete "type 1."

In paragraph 6, revise "less than 0.0036 ohms per foot (0.012 ohms per meter)" to "less than 0.00885 ohms per foot (0.0295 ohms per meter)."

Page 17-15, Article 1726-4

Replace the last sentence with the following:

No measurement will be made between 2-pair and 4-pair lead-in cable as this will be considered incidental to furnishing and installing lead-in cable.

3. ELECTRICAL REQUIREMENTS

Ensure that an IMSA certified, or equivalent, Level II traffic qualified signal technician is standing by to provide emergency maintenance services whenever work is being performed on traffic signal controller cabinets and traffic signal controller cabinet foundations. Stand by status is defined as being able to arrive, fully equipped, at the work site within 30 minutes ready to provide maintenance services.

4. DIRECTIONAL DRILLING

4.1. DESCRIPTION

Furnish and install conduit(s) and all necessary hardware by using the horizontal directional drilling method in accordance with the plans and specifications. Comply with the provisions of Section 1700 of the 2002 Standard Specifications for Roads and Structures.

4.2. MATERIALS

A. General:

Provide conduit that is suitable for underground use in an ambient temperature range of -30 to 130 degrees F (-35 to 55 degrees C) without degradation of material properties.

Provide conduit that is resistant to benzene, calcium chloride, ethyl alcohol, fuel oil, gasoline, lubricating oil, potassium chloride, sodium chloride, sodium nitrate, and transformer oil, and is protected against degradation due to oxidation and general corrosion.

Provide conduit(s) with an outer diameter to minimum wall thickness ratio that complies with ASTM-D3035, Standard Dimension Ratio (SDR) 13.5.

Provide conduit(s) that meets or exceeds the following:

ASTM-D638	Tensile Strength - 3,000 psi (20 Mpa), minimum Elongation - 400 percent, minimum
ASTM-D1238	Melt Index - 0.4 maximum
ASTM-D1505	Density - (0941-0955 g/cc)
ASTM-D1693	Condition B - 20 percent failure, maximum
ASTM-D2444	Impact - NEMA Standards Publication Number TC7
ASTM-D3350	Cell classification - 334420 or 344420

Furnish conduits with a coefficient of friction of 0.09 or less in accordance with Belcore GR-356.

Dependent upon the number of conduits required, furnish conduits in black, orange, blue and white colors. Provide conduits that are factory extruded with the appropriate colors.

Furnish ½-inch (12.7-mm), prelubricated, woven polyester tape, pull line with a minimum rated tensile strength of 2,500 lb (11 kN).

B. Polyethylene Conduit:

Furnish factory lubricated, low friction, coilable conduit constructed of virgin high-density polyethylene (HDPE). Furnish conduits with inside diameter as required by the plans. Provide conduit with a smooth outer wall and ribbed inner wall and ensure the conduit is capable of being coiled on reels in continuous lengths, transported, stored outdoors, and subsequently uncoiled for installation without affecting its properties or performance.

Furnish duct plugs that provide a watertight barrier when installed in an unused conduit. Furnish duct plugs sized in accordance with the conduit furnished. Provide duct plugs that are removable.

Furnish mechanical sealing devices that provide a watertight barrier between the conduit and communications cable. Furnish mechanical sealing devices sized in accordance with the conduit furnished and with appropriately sized holes for the communications cable. Provide mechanical sealing devices that are removable.

4.3. CONSTRUCTION METHODS

A. Pre-Approvals and Minimum Depth Requirements:

Obtain the Engineer's approval prior to beginning drilling operations.

At all points where the proposed conduit will traverse under city streets, state roads, driveways, sidewalks, and/or "Controlled Access Areas" including entrance/exit ramps, ensure the conduit(s) maintains a minimum depth of 4 feet (1.2 meters) or 8 times the back reamer's diameter, whichever is deeper. For an installation that runs parallel to a controlled access area or entrance and exit ramps ensure the conduit maintains a minimum depth of 30 inches (760 mm) below grade. Maintain a minimum clearance of 30 inches (760 mm) below grade when crossing ditch lines. For the following man-made structures, the minimum clearance requirements are shown in the table below:

Man-made Structure	Minimum Clearance Requirement
Bridge foundation	5' (1.5 m) horizontal & 4' (1.2 m) vertical (clearances greater than minimum horizontal should continue to use the 4V:5H ratio, i.e., 10' horizontal should be no deeper than 8')
Drainage pipes less than 60"	1' (0.3 m) above or below [while maintaining a minimum depth of 30" (760 mm) below grade]
Drainage pipes greater than 60"	1' (0.3 m) above or 4' (1.2 m) below [while maintaining a minimum depth of 30" (760 mm) below grade]
Box Culverts	1' (0.3 m) above or 4' (1.2 m) below [while maintaining a minimum depth of 30" (760 mm) below grade]
Slope protection	2' (0.6 m) below
Slope protection foundation footing	5' (1.5 m) below

Guarantee the drill rig operator and digital walkover locating system operator are factory-trained to operate the make and model of the equipment provided and have a minimum of one year's experience operating the make and model of drill rig. Submit written documentation of the operators' training and experience for review by the Engineer at least two weeks prior to commencing directional drilling operations.

Provide a means of collecting and containing drilling fluid/slurry that returns to the surface such as a slurry pit. Provide measures to prevent drilling fluids from entering drainage ditches and storm sewer systems. Prevent drilling fluid/slurry from accumulating on or flowing onto sidewalks, other pedestrian walkways, driveways or streets. Immediately remove any drilling fluids/slurry that is accidentally spilled.

B. Directional Drill Operations:

Provide grounding for the drill rig in accordance with the manufacturer's recommendations.

Place excavated material near the top of the working pit and dispose of as required. Backfill pits or trenches excavated to facilitate drilling operations immediately after the drilling has been completed.

Utilize a drill head suitable for the type of material being drilled and sized no more than 2 inches (50 mm) larger than the outer diameter of the conduit to be installed. Direct the drill head as needed to obtain the proper depth and desired destination. Pressure grout with an approved bentonite/polymer slurry mixture to fill any voids. Do not jet alone or wet bore with water.

During each drilling operation, locate the drill head every 10 feet (3 meters) along the drill path and prior to traversing any underground utility or structure. Use the digital walkover locating system to track the drill head during the directional drilling operation. Ensure the locating system is capable of determining the pitch, roll, heading, depth and horizontal position of the drill head at any point. Unless otherwise approved, do not deviate from the proposed line and grade by more than two percent.

Once the drill head has reached its final location, remove the head, and install a reamer of appropriate size (no more than 2 inches (50 mm) larger than the outer diameter of the ducts) to

simultaneously facilitate back drilling of the drill hole and installation of the conduit. The reamer is sized larger than the actual conduits to ensure the conduits are not subjected to extraneous deviations caused by the original drill operation and are as straight as possible in their final position.

The intent of these specifications is to limit the diameter of the actual drill shaft/hole such that it is no more than 2 inches (50 mm) larger than the conduit(s) outer diameter. The 2-inch (50-mm) larger diameter can be accomplished during the original bore or during the back reaming/conduit installation process.

Once the physical installation of the conduit has started, continue performing the installation without interruption to prevent the conduit from becoming firmly set. Ensure the bentonite/polymer slurry mixture is applied as the conduit installation process is occurring.

Upon completion of the conduit installation perform a mandrel test on the conduit system to ensure that no conduit(s) has been damaged. Furnish a non-metallic mandrel having a diameter of approximately 50% of the inside diameter of the conduit in which it is to be pulled through. If damage has occurred, replace the entire length of conduit.

Extend the ends of the conduit such that upon completion of the installation the conduit will extend a minimum of 2 inches (50 mm) above concrete surfaces and 4 inches (100 mm) above crushed stone bases.

C. Drilling Fluids:

Furnish and use lubrication for subsequent removal of material and immediate installation of the pipe. The use of water and other fluids in connection with the directional drilling operation will be permitted only to the extent necessary to lubricate cuttings. Do not jet alone or wet bore with water. Use a drilling fluid/slurry consisting of at least 10 percent high-grade bentonite to consolidate excavated material and seal the walls of the drill hole.

Transport waste drilling fluid/slurry from the site and dispose of such slurry in a method that complies with Local, State and Federal laws and regulations.

D. Splicing of the Conduit:

Do not splice or join sections of conduit(s). Upon approval, a junction box may be installed at locations where splicing or coupling of the conduit is necessary due to problems encountered with the installation.

E. Duct Plugs and Mechanical Sealing Devices:

Following the installation of the conduit(s) where the communications cable is not immediately installed use a duct plug to seal the ends of the conduit. Secure the pull line to the duct plug in such a manner that it will not interfere with the installation of the duct plug and provide a watertight seal.

In conduits containing communications cable, seal the conduit with an approved mechanical sealing device. Ensure the installation provides a watertight seal.

F. Plan of Record Drawings:

Upon completion of the drilling operation and conduit installation furnish the Engineer with a plan of record profile drawing and a plan drawing for the drilled conduit showing the horizontal and vertical locations of the installed conduit.

4.4. METHOD OF MEASUREMENT

Measured horizontal linear feet (meters) of directionally drilled polyethylene conduit(s) furnished, installed and accepted. Measurement of the drill path will be from point-to-point horizontally along the approximate centerline.

No additional payment will be made for vertical and horizontal sweeps, excavation of drill pits, backfill, site restoration, seeding and mulching, removal of excess material, duct organizers, mechanical sealing devices, duct plugs, pulling lubricants, mandrel test, and plan of record drawings, as these will be considered incidental to the directional drill and/or conduit installation.

4.5. BASIS OF PAYMENT

The quantity of directional drilled polyethylene conduit(s), measured as provided above, will be paid for at the contract unit price per linear foot (meter) as "Directional Drill Polyethylene Conduit(s), (size)(quantity of conduits) and (size)(quantity of conduits)."

As examples, an installation of a single 1.25" HDPE conduit would be paid as:

Directional Drill Polyethylene Conduit(s), (1.25")(1).....Linear Foot (Meter)

Payment will be made under:

Directional Drill Polyethylene Conduit(s), (Size)(Qty).....Linear Foot (Meter)

5. UNDERGROUND POLYETHYLENE CONDUIT

5.1. DESCRIPTION

Furnish and install underground polyethylene conduit systems with all necessary hardware in accordance with the plans and specifications. Comply with the provisions of Section 1700 of the 2002 Standard Specifications for Roads and Structures.

5.2. MATERIALS

Furnish factory lubricated, low friction, coilable, conduit constructed of virgin high-density polyethylene (HDPE). Furnish conduits with nominal diameter as required by the plans. Provide individual conduits with smooth outer walls and ribbed inner walls and ensure the conduit is capable of being coiled on reels in continuous lengths, transported, stored outdoors, and subsequently uncoiled for installation without affecting its properties or performance.

Provide conduit that is suitable for underground use in an ambient temperature range of – 30 to 130 degrees F (-35 to 55 degrees C) without degradation of material properties.

Provide conduit that is resistant to benzene, calcium chloride, ethyl alcohol, fuel oil, gasoline, lubricating oil, potassium chloride, sodium chloride, sodium nitrate, and transformer oil, and is protected against degradation due to oxidation and general corrosion.

Provide conduit(s) with an outer diameter to minimum wall thickness ratio that complies with ASTM-D3035, Standard Dimension Ratio (SDR) 13.5.

Provide conduit(s) that meets or exceeds the following:

ASTM-D638	Tensile Strength - 3,000 psi (20 Mpa), minimum Elongation - 400 percent, minimum
ASTM-D1238	Melt Index - 0.4 maximum
ASTM-D1505	Density - (0941-0955 g/cc)
ASTM-D1693	Condition B - 20 percent failure, maximum
ASTM-D2444	Impact - NEMA Standards Publication Number TC7
ASTM-D3350	Cell classification - 334420 or 344420

Furnish conduits with a coefficient of friction of 0.09 or less in accordance with Belcore GR-356.

Dependent upon the number of conduits required, furnish conduits in black, orange, blue and white colors. Provide conduits that are factory extruded with the appropriate colors.

Furnish conduit organizers at all points where multiple conduits enter and exit a junction box or cabinet. Furnish conduit organizers that are appropriately sized with regards to the conduits. Provide conduit organizers that are removable.

Furnish duct plugs that provide a watertight barrier when installed in an unused conduit. Furnish duct plugs sized in accordance with the conduit furnished. Provide duct plugs that are removable.

Furnish mechanical sealing devices that provide a watertight barrier between the conduit and communications cable. Furnish mechanical sealing devices sized in accordance with the conduit furnished and with appropriately sized penetration holes for the communications cable. Provide mechanical sealing devices that are removable.

Furnish conduit spacers to bind the individual conduits together when installed in a common trench. Furnish conduit spacers that are appropriately sized with regards to the conduits.

Furnish ½-inch (12.7-mm), prelubricated, woven polyester tape, pull line with a minimum rated tensile strength of 2,500 lb (11 kN) in all conduit(s).

Furnish non-detectable underground marker tape with the wording "WARNING -- Fiber Optic Cable" in all trenches.

5.3. CONSTRUCTION METHODS

A. General:

Pull the tracer wire simultaneously with the fiber-optic communications cable in a continuous length. When multiple pulls of fiber-optic cable are required, only one tracer wire is required. Where tracer wire is spliced, provide waterproof butt splices. Splicing is allowed only in cabinets and junction boxes. Label all tracer wires. Terminate tracer wire to equipment ground bus as specified in the plans.

In non-used/spare conduits, seal each end of the conduit with a duct plug. Secure each end of the pull line to the duct plug prior to installing the duct plug. Ensure that the placement of the pull line does not interfere with the installation of the duct plug and provides a watertight seal.

In conduits containing communications cable, seal the conduit with an approved mechanical sealing device. Ensure the installation provides a watertight seal.

For underground polyethylene conduit installations (trenched or plowed), backfill in accordance with Article 300-7 of the 2002 Standard Specifications for Roads and Structures.

B. Underground Polyethylene Conduit Installation in Trench:

Install underground polyethylene conduit system along the route of the trench. Install conduit organizers at points where multiple conduits enter or exit the junction box or cabinet, etc.

Maintain a minimum trench depth of 30 inches (760 mm) below finished grade or 6 inches (150 mm) below roadway subgrade, whichever is deeper.

Install longitudinal runs of conduit at a minimum of 1 foot (300 mm) from the back of curb or 6 feet (1.8 m) from the edge of pavement in the absence of curb.

Use one common trench with approved conduit spacers to bind the individual conduits together at no more than every 50 feet (15 meters). Install the non-detectable marker tape approximately 15 inches (380 mm) below the finished grade.

Extend the ends of the conduits such that upon completion of the installation the conduits will extend a minimum of 2 inches (50 mm) above concrete surfaces and 4 inches (100 mm) above crushed stone bases.

Remove all rock and debris from backfill material. Remove excess material from the site and compact the excavation according to Article 300-7 of the 2002 Standard Specifications for Roads and Structures.

Finish unpaved areas flush with the surrounding natural ground. Restore damaged grassed areas. Seed and mulch within 7 days after the occurrence of the damage.

Finish paved areas with materials matching the damaged area within 7 days of the occurrence of the damage. Cut neatly and replace only the width of the trench for damages caused by trenching. Place graded stone material to temporarily maintain traffic where repairs cannot be performed immediately. Comply with Section 545 of the 2002 Standard Specifications for Roads and Structures.

Backfill the trench at locations along the trench path where non-movable objects, such as rocks and boulders, cannot be avoided, thus causing a deviation in the elevation height of the underground polyethylene conduit system. The purpose of the backfill is to provide a gradual change in the elevation of the trench, from the bottom elevation to the highest point of the obstruction such that excessive bending and stress will not be transferred to the conduits once the underground polyethylene conduit system is installed.

After the installation of the conduits and upon completion of the tamping and backfill process, perform a mandrel test on each individual conduit to ensure that no conduit has been damaged. Furnish a non-metallic mandrel having a diameter of approximately 50% of the inside diameter of the conduit in which it is to be pulled through. If damage has occurred replace the entire length of conduit.

C. Underground Polyethylene Conduit Installation by Plowing:

Direct plow the number of HDPE ducts called for in the plans simultaneously using chute plow method. Direct plow ducts at a minimum depth such that the top of the highest duct is 30 inches (760 mm) deep unless otherwise approved by the Engineer.

Use equipment that is of a sufficient size and horsepower to accommodate the chute plowing of up to four (4) reels of duct to the depth called for in these Project Special Provisions. Do not exceed reel dimensions, burial depths, and weight limits called for by the equipment manufacturer. Follow all procedures required or recommended by the equipment manufacturer.

Provide sufficient personnel to feed chute, operate prime mover and equipment carrying reels (if separate equipment is used), observe chute feeding, observe plowing, and observe reel payout. Use chute with adequate dimensions to allow for passage of duct and cable without damage to either.

During the plow operation, continuously check the chute opening and path to be sure there are no obstructions and monitor the payout reels to be sure that the reels are turning at a steady rate.

D. Splicing of Underground Polyethylene Conduits:

Splicing or joining of underground polyethylene conduits is prohibited. With the Engineer's approval, install a junction box at all locations where splicing or coupling of the underground polyethylene conduits is necessary due to problems encountered with the installation method.

E. Plan of Record Drawings:

Upon completion of the underground polyethylene conduit system installation, furnish the Engineer with a plan of record profile drawing and plan drawing showing the horizontal and vertical locations of the installed conduit system.

5.4. METHOD OF MEASUREMENT

Measured horizontal linear feet (meters) of each HDPE system (containing the individual conduit(s) called for in the plans) that is furnished, installed underground (via plowed and/or trench and backfill), and accepted. Measurement of the HDPE conduit system will be from point-to-point horizontally along the approximate centerline.

Vertical segments will not be paid for as these will be considered incidental to the installation of the conduit system.

No additional payment will be made for trenching (paved or unpaved), seeding and mulching, removal of excess material, furnishing and placing incidental stone, furnishing and placing paved material, marker tape, pull lines, mechanical sealing devices, duct plugs, pulling lubricants, conduit organizers, mandrel test, and plan of record drawings, as they will be considered incidental.

5.5. BASIS OF PAYMENT

The quantity of HDPE conduit installed underground, measured as provided above, will be paid for at the contract unit price per linear foot (meter) as "Underground polyethylene conduit(s), (size)(quantity of conduits) and (size)(quantity of conduits)."

As examples, an installation of a single 2" HDPE conduit would be paid as:

Underground Polyethylene Conduit(s), (2")(1) .....Linear Foot (Meter)

Payment will be made under:

Underground Polyethylene Conduit(s), (Size)(Qty) .....Linear Foot (Meter)

6. FIBER OPTIC CABLE

6.1. Description:

Furnish and install multi-mode (MMFO) fiber-optic communications cable and all necessary hardware in accordance with the plans and specifications. Comply with the provisions of Section 1700 of the 2002 Standard Specifications for Roads and Structures.

6.2. Materials:

A. General:

Furnish MMFO communications cable with grounding systems, communications cable identification markers, lashing wire, and all necessary hardware.

B. MMFO Communications Cable:

Furnish loose tube fiber-optic cable with required fiber count that complies with RUS CFR 1755.900, multi-mode, 12 fiber with a dielectric central member. Use multi-mode fiber in the cable that does not exceed 3.5 dB/km @ 850 nm and 1.0 dB/km @ 1300nm. Provide fiber optic cable with all fibers that are useable and with a surface sufficiently free of imperfections and inclusions to meet the optical, mechanical, and environmental requirements. Provide fiber optic cable with operating temperature of at least –40 degrees C to +70 degrees C.

Use a dual layered, UV cured acrylate fiber coating applied by the by the fiber optic cable manufacturer that may be stripped mechanically or chemically without damaging the fiber.

Provide fibers inside a loose buffer tube. Use a doped silica core surrounded by a concentric silica cladding for each fiber. Distinguish each fiber and buffer tube from others by means of color coding meeting the requirements of EIA/TIA-598, "Color Coding of Fiber Optic Cables. In buffer tubes containing multiple fibers, ensure that the colors are stable during temperature cycling and not subject to fading, sticking, or smearing into each other or into the gel filling material. Construct buffer tubes with an inner layer made of polycarbonate and an outer layer made of polyester. Use fillers in cable core if necessary to provide a symmetrical cross-section of cable. Fill buffer tubes with non-hygroscopic, non-nutritive to fungus, electrically non-conductive, homogenous gel. Ensure gel is free from dirt and foreign matter, and is removable with conventional nontoxic solvents.

Provide a central member consisting of a dielectric glass reinforced plastic rod. Apply binders with sufficient tension to secure buffer tubes and binders to the central member without crushing buffer tubes. Ensure binders are non-hygroscopic, non-wicking (or rendered so by the flooding compound), and dielectric with low shrinkage.

Provide cable that has cable core interstices filled with super-absorbent, water-blocking compound that is non-conductive and homogenous. Ensure compound is free from dirt and foreign matter, and is removable with conventional nontoxic solvents.

Provide cable with high tensile strength aramid yarns or fiberglass yarns that are helically stranded evenly around the cable core.

Provide cable jacket of consistent thickness that is free of holes, splits, and blisters, and containing no metal elements. Provide outer jacket of medium density polyethylene with minimum

nominal sheath thickness of 0.050 inch (1.25 mm). Ensure polyethylene contains carbon black for ultraviolet light protection and does not promote the growth of fungus.

Provide length markings in sequential feet and within one percent of actual cable length. Ensure character height of the markings is approximately 0.10 inch (2.5 mm).

C. Communications Cable Identification Markers:

Furnish yellow communications cable identification markers that are resistant to fading when exposed to UV sources and changes in weather. Use markers designed to coil around fiber-optic cable, and that do not slide or move along the surface of the cable once installed. Ensure exposure to UV light and weather does not affect the markers natural coiling effect or deteriorate performance. Provide communications cable wraps that permit writing with an indelible marking pen and that contain the following text in black:

WARNING
CITY OF ROCKY MOUNT FIBER OPTIC CABLE
CONTACT TELEPHONE NUMBER: (252) 972-1121

WARNING
CITY OF ROCKY MOUNT FIBER OPTIC CABLE
CONTACT TELEPHONE NUMBER: (252) 972-1121

Overall Marker Dimensions: 7(l) x 4 (w) inches (175 mm(l) x 100 mm(w))
Lettering Height: 3/8 inch (9.5 mm) for "WARNING"
1/4 inch (6.5 mm) for all other lettering

Submit a sample of the proposed communications cable identification markers to the Engineer for approval before installation.

6.3. CONSTRUCTION METHODS:

A. General:

Provide cable manufacturer's attenuation and Optical Time Domain Reflectometer (OTDR) testing data for each reel of cable.

Install single mode and multi-mode fiber-optic communications cable with grounding systems, communications cable identification markers, lashing wire, and all necessary hardware.

Comply with NESC and manufacturer's recommendations. Install communications cable on signal poles, utility poles, on messenger cable, and in conduits as required to bring the fiber-optic cable into and, if necessary, out of each splice enclosure.

Take all precautions necessary to ensure cable is not damaged during storage, handling, and installation. Do not violate the minimum bending radius of 20 times the radius of the cable diameter or the manufacturer's recommendation, whichever is greater. Do not step on cable nor run over cable with vehicles or equipment. Do not pull cable over or around obstructions, or along the ground.

Determine lengths of cable necessary to reach from termination-point to termination-point. Install cable in continuous lengths between approved splicing facilities. Additionally, provide slack cable as designated in the plans. Measure slack cable by extending cable straight out of the cabinet door.

Keep cable ends sealed at all times during installation to effectively prevent the ingress of moisture. Use approved heat shrink cable end cap. Do not use tape to seal cable ends.

Before installing cable, provide three copies of the cable manufacturer's recommended and maximum pulling tension. Do not exceed the manufacturer's recommended pulling tension. Use pulling grips containing a rotating swivel. Coil cable in a "figure-8" configuration whenever cable is unreeled for subsequent pulling.

Install fiber-optic cable in separate 2-inch (50-mm) risers with heat shrink tubing. Do not share risers with other type cable.

B. Aerial Installation:

Double lash fiber-optic cable to messenger cable with one 360-degree spiral per foot (304 mm).

Use pole attachment hardware and roller guides with safety clips to install aerial run cable.

Maintain tension during the pulling process for aerial run cable by using an approved mechanical clutch (dynamometer) device. Do not allow cable to contact the ground or other obstructions between poles during installation. Do not use a motorized vehicle to generate cable-pulling forces.

Use a cable suspension clamp when attaching cable tangent to a pole. Select and place cable blocks and corner blocks so as not to exceed the cable's minimum bending radius. Do not pull cable across J-hooks.

Install one communications cable identification marker within 36 inches (1 meter) of pole attachment points and at locations where more than one cable originates or terminates.

Maintain electrical continuity of messenger cable at all poles.

C. Underground Installation:

Install fiber-optic cable underground in conduit using cable-pulling lubricants approved by the fiber-optic cable manufacturer and the Engineer.

Obtain approval of cable pulling lubricant and method of pulling before installing underground fiber-optic cable.

Use a dynamometer (clutch device) so as not to exceed the maximum allowable pulling tension if the cable is pulled by mechanical means. Do not use a motorized vehicle to generate cable-pulling forces.

Keep tension on the cable reel and pulling line at the start of each pull. Do not release tension if the pulling operation is halted. Restart the pulling operation by gradually increasing tension until the cable is in motion.

For pulling cable through manholes, junction boxes, and vaults, place the cable reel using a method approved by the manufacturer. Feed cable by manually rotating the reel. Do not pull cable through intermediate junction boxes, handholds, or openings in conduit unless otherwise approved.

6.4. METHOD OF MEASUREMENT:

Actual linear feet (meters) of MMFO fiber-optic cable of each fiber count furnished, installed, and accepted. Measurement will be made by calculating the difference in length markings located on the outer jacket of the fiber-optic cable from the start of the fiber run to the end of the fiber run for each fiber run. All fibers shall be terminated before determining the length of the cable run.

No measurement will be made for terminating, splicing, and testing of the fiber-optic cable, as this will be considered incidental to the installation of the fiber optic cable.

6.5. BASIS OF PAYMENT:

The quantity of MMFO fiber-optic cable, measured as provided above, will be paid for at the contract unit price per linear foot (meter) for " MMFO Communications Cable (___-Fiber)."

Payment will be made under:

MMFO Communications Cable (____-Fiber) .....Foot (Meter)

7. MULTI-MODE INTERCONNECT CENTERS

7.1. DESCRIPTION:

Furnish and install fiber-optic interconnect centers and all necessary hardware in accordance with the plans and specifications. Comply with the provisions of Section 1700 of the 2002 Standard Specifications for Roads and Structures.

7.2. MATERIALS:

A. General:

Furnish interconnect centers and all necessary hardware.

B. Interconnect Center:

Furnish compact, modular interconnect centers designed to mount inside equipment cabinets. Design and size interconnect centers to accommodate all fibers entering equipment cabinets.

Provide splice trays that hold, protect, and organize optical fibers, and that secure fibers inside the splice tray. Design and size splice trays to be dielectric, to accommodate all fibers entering the splice tray, and to provide sufficient space to prevent macrobending of optical fibers.

Provide connector panels with ST-type connectors.

Furnish MMFO pigtails with each interconnect center. Provide pigtails that are a minimum of 6 feet (1.8 meters) in length with a factory assembled PC-ST connector on one end. Ensure the MMFO pigtails meet the operating characteristics of the cable in which it is to be coupled.

Furnish MMFO jumpers that are a minimum of 3 feet (0.9 meters) in length with factory assembled PC-ST connectors on each end. Ensure the MMFO jumpers meet the operating characteristics of the cable in which it is to be coupled. Longer lengths may be required.

7.3. CONSTRUCTION METHODS:

A. General:

Install interconnect centers with connector panels, splice trays, storage for slack cable or fibers, mounting and strain relief hardware, and all necessary hardware.

Fusion splice and secure the cable in splice trays inside the splice enclosure.

Do not exceed 0.1 dB of attenuation per splice for multi-mode cable.

Furnish strain relief so that no tensile force is on the cable when it is held within the interconnect center or aerial splice enclosure.

B. Termination and Splicing within Interconnect Center:

Terminate and splice all fibers including unused fibers and cap and seal other fibers, all as designated in the plans.

Label all fiber-optic connectors, whether on jumpers, connector panels, or other equipment, to prevent improper connection. Obtain approval of the fiber-optic connectors labeling method.

Ensure that all buffer tubes are contained within the splice tray so that no bare fibers are outside the tray.

For all fibers designated for termination to a connector panel within the interconnect center, fusion splice the fibers to the pigtails.

For all cut fibers designated to be expressed through the interconnect center, fusion splice the fibers.

For all buffer tubes designated to be expressed through the interconnect center, neatly coil the excess tubing inside the interconnect center. Do not damage the cable or violate the minimum-bending radius of the cable.

C. Testing:

Provide written notification a minimum of ten days before beginning fiber-optic cable testing.

After completion of splicing, perform the two-patch cable test procedure and the OTDR test on each fiber, including unused fibers, to ensure the following:

- fusion splice loss shall not exceed 0.1 dB, for multi-mode cable
- terminations and connections have a loss of 0.1 dB or less, for multi-mode cable
- and reflection loss is 40 dB or greater for each connector.

If exceeded, remake splices until the loss falls below 0.1 dB for multi-mode cable. The Department will record each attempt for purposes of acceptance.

Furnish durable labeled plots of test results for each fiber including engineering calculations demonstrating that OTDR test results meet or exceed the attenuation requirements and that optical properties of the cable have not been impaired. Provide engineering calculations and tests for fiber-optic cable that demonstrates the loss budget where the fiber originates and the point where the fiber meets an electronic device.

If any fiber exceeds the maximum allowable attenuation or if the fiber-optic properties of the cable have been impaired, take approved corrective action including replacement of complete

segments of fiber-optic cable if required. Corrective action will be at no additional cost to the Department.

7.4. METHOD OF MEASUREMENT:

Actual number of multi-mode, fiber optic interconnect centers furnished, installed and accepted.

No measurement will be made of splice trays, pigtails, jumpers and connector panels as this will be considered incidental to furnishing and installing fiber optic interconnect centers and aerial splice enclosures.

7.5. BASIS OF PAYMENT:

The quantity of multi-mode, fiber optic interconnect centers, measured as provided above, will be paid for at the contract unit price each for "MMFO Interconnect Center."

Payment will be made under:

MMFO Interconnect Center.....Each

8. FIBER OPTIC TRANSCEIVER

8.1. DESCRIPTION

Furnish and install a multi-mode fiber optic transceiver and all necessary hardware in accordance with the plans and specifications. Comply with the provisions of Section 1700 of the 2002 Standard Specifications for Roads and Structures.

8.2. MATERIALS

A. General:

Comply with NEMA Standards Publication TS-1 (NEMA TS-1) in effect on the date of installation except as otherwise stated herein.

B. Fiber Optic Transceiver:

Furnish an integral (internal), multi-mode, fiber optic transceiver designed for insertion and proper operation with an existing PEEK TRAFFIC 3000 traffic signal controller, along with all necessary hardware that is compatible with the system equipment and designed for RS-232 drop-and-repeat communications. Provide a transceiver capable of being interchanged throughout the system.

Ensure that transceivers are capable of operating at distances up to 5,000 feet without the need to boost the signal and without distortion of the signal.

Comply with the following:

Input Power:	24 VDC (provided by controller)
Operating Wavelength:	850 nm
Optical Connectors:	4 ST (Tx1, Rx1, Tx2, Rx2)
Temperature Range:	0 to 150 degrees F (-17 to 65 degrees C)

8.3. CONSTRUCTION METHODS

A. General:

Install fiber optic transceiver into the existing traffic signal controller at Signal No. 04-1324 (US 301 Business [Centura Hwy] at US 64 Westbound Ramp) and comply with the manufacturer's installation instructions.

Furnish only, a fiber optic transceiver at the Traffic Control Center in City Hall.

B. System Interconnection:

When interconnection of signals is required, install interface equipment and hardware for signals. Demonstrate proper operation of the interconnection using manual commands after interconnection is complete.

8.4. METHOD OF MEASUREMENT

Actual number of fiber optic transceivers furnished, installed, and accepted.

No measurement will be made of required system interconnection as this will be considered incidental to furnishing and installing the fiber optic transceiver.

Actual number of fiber optic transceivers furnished and accepted.

8.5. BASIS OF PAYMENT

The quantity of fiber optic transceivers, measured as provided above, will be paid for at the contract unit price each for "Fiber Optic Transceiver."

The quantity of fiber optic transceivers, measured as provided above, will be paid for at the contract unit price each for "Furnish Fiber Optic Transceiver."

Payment will be made under:

Fiber Optic Transceiver ..... Each

Furnish Fiber Optic Transceiver ..... Each

9. DRILLED PIER FOUNDATIONS FOR METAL TRAFFIC SIGNAL POLES

9.1. DESCRIPTION

Perform a soil test at each proposed metal pole location. Furnish and install foundations for NCDOT metal poles with all necessary hardware in accordance with the plans and specifications.

Metal Pole Standards have been developed and implemented by NCDOT for use at signalized intersections in North Carolina. If the plans call for a standard pole, then a standard foundation may be selected from the plans. However, the Contractor is not required to use a standard foundation. If the Contractor chooses to design a non-standard site-specific foundation for a standard pole or if the plans call for a non-standard site-specific pole, design the foundation to conform to the applicable provisions in the NCDOT Metal Pole Standards and Section 2D (Non-Standard Foundation Design)

below. Comply with the provisions of Section 1700 of the 2002 Standard Specifications for Roads and Structures.

If the Contractor chooses to design a non-standard foundation for a standard pole and the soil test results indicate a standard foundation is feasible for the site, the Contractor will be paid the cost of the standard foundation (drilled pier and wing wall, if applicable). Any additional costs associated with a non-standard site-specific foundation including additional materials, labor and equipment will be considered incidental to the cost of the standard foundation. All costs for the non-standard foundation design will also be considered incidental to the cost of the standard foundation.

9.2. SOIL TEST AND FOUNDATION DETERMINATION

A. General:

Drilled piers are reinforced concrete sections, cast-in-place against in situ, undisturbed material. Drilled piers are of straight shaft type and vertical.

Some standard drilled piers for supporting poles with mast arms may require wing walls to resist torsional rotation. Based upon this provision and the results of the required soil test, a drilled pier length and wing wall requirement may be determined and constructed in accordance with the plans.

For non-standard site-specific poles, the contractor-selected pole fabricator will determine if the addition of wing walls is necessary for the supporting foundations.

B. Soil Test:

Perform a soil test at each signal location. Complete all required fill placement and excavation at each signal pole location to finished grade before drilling each boring. Drill one boring to a depth of 26 feet (7.9 meters).

Perform standard penetration tests (SPT) in accordance with ASTM D 1586 at depths of 1, 2.5, 5, 7.5, 10, 15, 20 and 26 feet (0.3, 0.8, 1.5, 2.3, 3.0, 4.6, 6.1 and 7.9 meters). Discontinue the boring if one of the following occurs:

- A total of 100 blows have been applied in any 2 consecutive 6-in. (0.15-m) intervals.
- A total of 50 blows have been applied with < 3-in. (.08-m) penetration.

Describe each intersection as the "Intersection of *(Route or SR #)*, *(Street Name)* and *(Route or SR #)*, *(Street Name)*, _____ County, Signal Inventory No. _____". Label borings with "B- *N, S, E, W, NE, NW, SE or SW*" corresponding to the quadrant location within the intersection. For each boring, submit a legible (hand written or typed) boring log signed and sealed by a licensed geologist or professional engineer registered in North Carolina. Include on each boring the SPT blow counts and N-values at each depth, depth of the boring, and a general description of the soil types encountered.

C. Standard Foundation Determination:

Use the following method for determining the Design N-value:

$$N_{AVG} = \frac{(N@1' + N@2.5' + \ldots\ldots N@\text{Deepest Boring Depth})}{\text{Total Number of N-values}}$$

$$Y = (N@1')^2 + (N@2.5')^2 + \ldots\ldots (N@\text{Deepest Boring Depth})^2$$

$$Z = (N@1' + N@2.5' + \ldots\ldots N@\text{Deepest Boring Depth})$$

$$N_{STD\ DEV} = \left(\frac{(\text{Total Number of N-values} \times Y) - Z^2}{(\text{Total Number of N-values}) \times (\text{Total Number of N-values} - 1)} \right)^{0.5}$$

Design N-value equals lesser of the following two conditions:

$N_{AVG} - (N_{STD\ DEV} \times 0.45)$

Or

$$\text{Average of First Four N-Values} = \frac{(N@1' + N@2.5' + N@5' + N@7.5')}{4}$$

Note: If less than 4 N-values are obtained because of criteria listed in Section B above, use average of N-values collected for second condition. Do not include the N-value at the deepest boring depth for above calculations if the boring is discontinued at or before the required boring depth because of criteria listed in Section B above. Use N-value of zero for weight of hammer or weight of rod. If N-value is greater than 50, reduce N-value to 50 for calculations.

If standard NCDOT poles are shown on the plans and the Contractor chooses to use standard foundations, determine a drilled pier length, "L," for each signal pole from the Foundation Selection Table based on the Design N-value and the predominant soil type. For each standard pole location, submit a completed "Metal Pole Standard Foundation Selection Form" signed by the contractor's representative. Include the Design N-value calculation and resulting drilled pier length, "L," on each form.

If non-standard site-specific poles are shown on the plans, submit completed boring logs collected in accordance with Section B (Soil Test) above along with pole loading diagrams from the plans to the contractor-selected pole fabricator to assist in the pole and foundation design.

If one of the following occurs, the Foundation Selection Table shown on the plans may not be used and a non-standard foundation may be required. In such case, contact the Engineer.

- The Design N-value is less than 4.
- The drilled pier length, "L", determined from the Foundation Selection Table, is greater than the depth of the corresponding boring.

In the case where a standard foundation cannot be used, the Department will be responsible for the additional cost of the non-standard foundation.

The Foundation Selection Table is based on level ground around the traffic signal pole. If the distance between the edge of the drilled pier and the top of a slope steeper than 2:1 (H:V) is less than 10 feet (3 meters) or the grade within 10 feet is steeper than 2:1 (H:V), contact the Engineer.

The "Metal Pole Standard Foundation Selection Form" may be found as follows:

1) Go to www.NCDOT.org/business/.
2) Click on "Geotechnical Engineering Unit Forms."
3) Click on "Metal Pole Standard Foundation Selection Form."

If assistance is needed with the required calculations, contact the Signals and Geometrics Structural Engineer at (919) 733-3915. However, in no case will the failure or inability to contact the Signals and Geometrics Structural Engineer be cause for any claims or requests for additional compensation.

D. Non-Standard Foundation Design:

Design non-standard foundations based upon site-specific soil test information collected in accordance with Section B (Soil Test) above. Provide a drilled pier foundation for each pole with a length and diameter that results in a horizontal lateral movement of less than 1 inch (25 mm) at the top of the pier and a horizontal rotational movement of less than 1 inch (25 mm) at the edge of the pier. Contact the Engineer for pole loading diagrams for standard poles to be used for non-standard foundation designs. Submit any non-standard foundation designs including plans, calculations, and soil boring logs to the Engineer for review and approval before construction. A professional engineer registered in the state of North Carolina must seal all plans and calculations.

9.3. DRILLED PIER CONSTRUCTION

A. Excavation:

Perform excavations for drilled piers to the required dimensions and lengths including all miscellaneous grading and excavation necessary to install the drilled pier. Depending on the subsurface conditions encountered, excavation in weathered rock or removal of boulders may be required.

Dispose of drilling spoils as directed and in accordance with Section 802 of the 2002 Standard Specifications for Roads and Structures. Drilling spoils consist of all material excavated including water or slurry removed from the excavation either by pumping or with augers.

Construct all drilled piers such that the piers are cast against undisturbed soil. If a larger casing and drilled pier are required as a result of unstable or caving material during drilling, backfill the excavation before removing the casing to be replaced. No additional payment will be made for substituting a larger diameter drilled pier in order to construct a drilled pier cast against undisturbed soil.

Construct drilled piers within the tolerances specified herein. If tolerances are exceeded, provide additional construction as approved by the Engineer to bring the piers within the tolerances specified. Construct drilled piers such that the axis at the top of the piers is no more than 3 inches (75 mm) in any direction from the specified position. Build drilled piers within 1% of the plumb deviation for the total length of the piers. Construct the finished top of pier elevation between 5 inches (125 mm) above and 2 inches (50 mm) above the finished grade elevation. Form the top of the pier such that the concrete is smooth and level.

If unstable, caving, or sloughing soils are anticipated or encountered, stabilize drilled pier excavations with either steel casing or polymer slurry. Steel casing may be either the sectional type or one continuous corrugated or non-corrugated piece. Ensure all steel casings consist of clean

watertight steel of ample strength to withstand handling and driving stresses and the pressures imposed by concrete, earth or backfill. Use steel casings with an outside diameter equal to the specified pier size and a minimum wall thickness of 1/4 inches (7 mm). Extract all temporary casings during concrete placement in accordance with this special provision unless the Contractor chooses to leave the casing in place in accordance with the requirements below.

Any temporary steel casing that becomes bound or fouled during pier construction and cannot be practically removed may constitute a defect in the drilled pier. Improve such defective piers to the satisfaction of the Engineer by removing the concrete and enlarging the drilled pier, providing a replacement pier or other approved means. All corrective measures including redesign as a result of defective piers will not be cause for any claims or requests for additional compensation.

Any steel casing left in place will be considered permanent casing. Permanent steel casings are only allowed for strain poles. When installing permanent casing, do not drill or excavate below the tip of the permanent casing at any time such that the permanent casing is against undisturbed soil. The Contractor may excavate a hole smaller than the specified pier size to facilitate permanent casing installation. Ensure the sides of the excavation do not slough during drilling. Ensure the hole diameter does not become larger than the inside diameter of the casing. No additional compensation will be paid for permanent casing.

If polymer slurry is chosen to stabilize the excavation, use one of the following polymers listed in the table below:

PRODUCT	MANUFACTURER
SlurryPro EXL	KB Technologies Ltd 3648 FM 1960 West Suite 107 Houston, TX 77068 (800) 525-5237
Super Mud	PDS Company 105 West Sharp Street El Dorado, AR 71730 (800) 243-7455
Shore Pac GCV	CETCO Drilling Products Group 1500 West Shure Drive Arlington Heights, IL 60004 (800) 527-9948

Use slurry in accordance with the manufacturer's guidelines and recommendations unless approved otherwise by the Engineer. The Contractor should be aware that polymer slurry may not be appropriate for a given site. Polymer slurry should not be used for excavations in soft or loose soils as determined by the Engineer.

In wet pour conditions, advise and gain approval from the Engineer as to the planned construction method intended for the complete installation of the drilled pier before excavating.

B. Reinforcing Steel:

Completely assemble a cage of reinforcing steel consisting of longitudinal and spiral bars and place cage in the drilled pier excavation as a unit immediately upon completion of drilling unless the excavation is entirely cased. If the drilled pier excavation is entirely cased down to the tip, immediate placement of the reinforcing steel is not required.

Lift the cage so racking and cage distortion does not occur. Keep the cage plumb during concrete operations and casing extraction. Check the position of the cage before and after placing the concrete.

Securely cross-tie the vertical and spiral reinforcement at each intersection with double wire. Support or hold down the cage so that the vertical displacement during concrete placement and casing extraction does not exceed 2 inches (50 mm).

Do not set the cage on the bottom of the drilled pier excavation. Place plastic bolsters under each vertical reinforcing bar that are tall enough to raise the rebar cage off the bottom of the drilled pier excavation a minimum of 3 inches (75 mm).

In order to ensure a minimum of 3 inches (75 mm) of concrete cover and achieve concentric spacing of the cage within the pier, tie plastic spacer wheels at five points around the cage perimeter. Use spacer wheels that provide a minimum of 3 inches (75 mm) "blocking" from the outside face of the spiral bars to the outermost surface of the drilled pier. Tie spacer wheels that snap together with wire and allow them to rotate. Use spacer wheels that span at least two adjacent vertical bars. Start placing spacer wheels at the bottom of the cage and continue up along its length at maximum 10-foot (3-m) intervals. Supply additional peripheral spacer wheels at closer intervals as necessary or as directed by the Engineer.

C. Concrete:

Begin concrete placement immediately after inserting reinforcing steel into the drilled pier excavation. If the drilled pier excavation is entirely cased down to the tip, immediately placement of the concrete is not required.

1) Concrete Mix

Provide the mix design for drilled pier concrete for approval and, except as modified herein, meeting the requirements of Section 1000 of the 2002 Standard Specifications for Roads and Structures.

Designate the concrete as Drilled Pier Concrete with a minimum compressive strength of 4500 psi (31.0 MPa) at 28 days. The foundation will be considered acceptable for loading when the concrete reaches a minimum compressive strength of 3000 psi (20.7 Mpa). This provision is intended to allow the structure to be installed on the foundation in a shorter time frame, and does not constitute full acceptance of the drilled pier. Full acceptance will be determined when the concrete meets its full strength at 28 days. The Contractor may use a high early strength mix. Make certain the cementitious material content complies with one of the following options:

- Provide a minimum cement content of 640 lbs/yd^3 (380 kg/m^3) and a maximum cement content of 800 lbs/yd^3 (475 kg/m^3); however, if the alkali content of the cement exceeds 0.4%, reduce the cement content by 20% and replace it with fly ash at the rate of 1.2 lb (1.2 kg) of fly ash per lb (kg) of cement removed.
- If Type IP blended cement is used, use a minimum of 665 lbs/yd^3 (395 kg/m^3) Type IP blended cement and a maximum of 833 lbs/yd^3 (494 kg/m^3) Type IP blended cement in the mix.

Limit the water-cementitious material ratio to a maximum of 0.45. Do not air-entrain drilled pier concrete.

Produce a workable mix so that vibrating or prodding is not required to consolidate the concrete. When placing the concrete, make certain the slump is between 5 and 7 inches (125 and 175 mm) for dry placement of concrete or 7 and 9 inches (175 and 225 mm) for wet placement of concrete.

Use Type I or Type II cement or Type IP blended cement and either No. 67 or No. 78M coarse aggregate in the mix. Use an approved water-reducer, water-reducing retarder, high-range water-reducer or high-range water-reducing retarder to facilitate placement of the concrete if necessary. Do not use a stabilizing admixture as a retarder in Drilled Pier Concrete without approval of the Engineer. Use admixtures that satisfy AASHTO M194 and add admixtures at the concrete plant when the mixing water is introduced into the concrete. Redosing of admixtures is not permitted.

Place the concrete within 2 hours after introducing the mixing water. Ensure that the concrete temperature at the time of placement is 90°F (32°C) or less.

2) Concrete Placement

Place concrete such that the drilled pier is a monolithic structure. Temporary casing may be completely removed and concrete placement may be temporarily stopped when the concrete level is within 42 to 48 inches (1067 to 1220 mm) of the ground elevation to allow for placement of anchor bolts and conduit. Do not pause concrete placement if unstable caving soils are present at the ground surface. Remove any water or slurry above the concrete and clean the concrete surface of all scum and sediment to expose clean, uncontaminated concrete before inserting the anchor bolts and conduit. Resume concrete pouring within 2 hours.

Do not dewater any drilled pier excavations unless the excavation is entirely cased down to tip. Do not begin to remove the temporary casing until the level of concrete within the casing is in excess of 10 feet (3 m) above the bottom of the casing being removed. Maintain the concrete level at least 10 feet (3 m) above the bottom of casing throughout the entire casing extraction operation except when concrete is near the top of the drilled pier elevation. Maintain a sufficient head of concrete above the bottom of casing to overcome outside soil and water pressure. As the temporary casing is withdrawn, exercise care in maintaining an adequate level of concrete within the casing so that fluid trapped behind the casing is displaced upward and discharged at the ground surface without

contaminating or displacing the drilled pier concrete. Exerting downward pressure, hammering, or vibrating the temporary casing is permitted to facilitate extraction.

Keep a record of the volume of concrete placed in each drilled pier excavation and make it available to the Engineer.

After all the pumps have been removed from the excavation, the water inflow rate determines the concrete placement procedure. If the inflow rate is less than 6 inches (150 mm) per half hour, the concrete placement is considered dry. If the water inflow rate is greater than 6 inches (150 mm) per half hour, the concrete placement is considered wet.

- **Dry Placement:** Before placing concrete, make certain the drilled pier excavation is dry so the flow of concrete completely around the reinforcing steel can be certified by visual inspection. Place the concrete by free fall with a central drop method where the concrete is chuted directly down the center of the excavation.
- **Wet Placement:** Maintain a static water or slurry level in the excavation before placing concrete. Place concrete with a tremie or a pump in accordance with the applicable parts of Sections 420-6 and 420-8 of the 2002 Standard Specifications for Roads and Structures. Use a tremie tube or pump pipe made of steel with watertight joints. Passing concrete through a hopper at the tube end or through side openings as the tremie is retrieved during concrete placement is permitted. Use a discharge control to prevent concrete contamination when the tremie tube or pump pipe is initially placed in the excavation. Extend the tremie tube or pump pipe into the concrete a minimum of 5 feet (1.5 m) at all times except when the concrete is initially introduced into the pier excavation. If the tremie tube or pump pipe pulls out of the concrete for any reason after the initial concrete is placed, restart concrete placement with a steel capped tremie tube or pump pipe.

Once the concrete in the excavation reaches the same elevation as the static water level, placing concrete with the dry method is permitted. Before changing to the dry method of concrete placement, remove any water or slurry above the concrete and clean the concrete surface of all scum and sediment to expose clean, uncontaminated concrete.

Vibration is only permitted, if needed, in the top 10 feet (3 m) of the drilled pier or as approved by the Engineer. Remove any contaminated concrete from the top of the drilled pier and wasted concrete from the area surrounding the drilled pier upon completion.

Permanently mark the top of each foundation with a stamp or embedded plate to identify the depth of the foundation.

D. Concrete Placement Time:

Place concrete within the time frames specified in Table 1000-2 of the 2002 Standard Specifications for Roads and Structures for Class AA concrete except as noted herein. Do not place concrete so fast as to trap air, water, fluids, soil or any other deleterious materials in the vicinity of the reinforcing steel and the annular zone between the rebar cage and the excavation walls. Should a delay occur because of concrete delivery or other factors, reduce the placement rate to maintain some movement of the concrete. No more than 45 minutes is allowed between placements.

A. Scheduling and Restrictions:

If caving or sloughing occurs, no additional compensation will be provided for additional concrete to fill the resulting voids.

During the first 16 hours after a drilled pier has achieved its initial concrete set as determined by the Engineer, do not drill adjacent piers, install adjacent piles, or allow any heavy construction equipment loads or "excessive" vibrations to occur at any point within a 20 foot (6 m) radius of the drilled pier.

In the event that the procedures described herein are performed unsatisfactorily, the Engineer reserves the right to shut down the construction operations or reject the drilled piers. If the integrity of a drilled pier is in question, use core drilling, sonic or other approved methods at no additional cost to the Department and under the direction of the Engineer. Dewater and backfill core drill holes with an approved high strength grout with a minimum compressive strength of 4500 psi (31.0 Mpa). Propose remedial measures for any defective drilled piers and obtain approval of all proposals from the Engineer before implementation. No additional compensation will be paid for losses or damage due to remedial work or any investigation of drilled piers found defective or not in accordance with these special provision or the plans.

1.2. METHOD OF MEASUREMENT

Actual number of soil tests with SPT borings drilled furnished and accepted.

Actual volume of concrete poured in cubic yards (cubic meters) of drilled pier foundation furnished, installed and accepted.

1.3. BASIS OF PAYMENT

The quantity of soil tests with SPT borings, measured as provided above, will be paid for at the contract unit price each as "Soil Test."

The quantity of drilled pier lengths, measured as provided above, will be paid for at the contract unit price per cubic yard (cubic meter) as "Drilled Pier Foundation".

Payment will be made under:

Soil Test ..... Each

Drilled Pier Foundation ..... Cubic Yard (Cubic Meter)

2. STRUCTURE DESIGN OF SIGNAL SUPPORTS

2.1. GENERAL

As required by the plans, design traffic signal supports with foundations consisting of metal poles with mast arms and foundations.

Design metal signal poles and support systems that contain no guy assemblies, struts, rods, stay braces, clamps or U-bolts, except where noted otherwise. Provide designs of completed assemblies with hardware that equals or exceeds AASHTO Standard Specifications for Structural Supports for Highway Signs, Luminaires and Traffic Signals 4th Edition, 2001 (hereafter called 4th Edition AASHTO), including the latest interim specifications. Provide assemblies with a round or near-

round cross-sectional design consisting of no less than six sides. The sides may be straight, convex, or concave.

The lengths of the metal signal poles shown on the plans are estimated from available data for bid purposes. Determine the actual length of each pole from field measurements and adjusted cross-sections. Furnish the revised pole heights to the Engineer. Use all other dimensional requirements shown on the plans.

Design all traffic signal support structures using the following 4th Edition AASHTO specifications:

- Use the wind pressure map developed from the 3-second gust speeds, as provided in Article 3.8.
- Ensure signal support structures include natural wind gust loading and truck-induced gust loading in the fatigue design, as provided for in Articles 11.7.3 and 11.7.4, respectively. Designs need not consider periodic galloping forces.
- Assume the natural wind gust speed in North Carolina is 11.2 mph.
- Design for Category II fatigue, as provided for in Article 11.6, unless otherwise shown on the plans.
- Calculate combined stresses to determine combined stress ratio (CSR) using applicable equations from Section 5. Maximum allowable CSR for all signal supports is 0.9.
- Conform to article 10.4.2 and 11.8 for all deflection requirements. North Carolina's 3% vertical dead load tip deflection criteria for mast arms is no longer required.

Ensure that the design permits cables to be installed inside poles and mast arms. For holes in the poles and arms used to accommodate cables, provide full-circumference grommets.

The computed surface area for ice load on signal heads is:

- 3-section, 12-inch (300-mm), Surface area: 26.0 ft^2 (2.4 m^2)
- 4-section, 12-inch (300-mm), Surface area: 32.0 ft^2 (3.0 m^2)
- 5-section, 12-inch (300-mm), Surface area: 42.0 ft^2 (3.9 m^2)

10.2. METAL POLES

Submit design drawings for approval showing all the necessary details and calculations for the metal poles including the foundation and connections. Include signal inventory number on design drawings. Include as part of the design calculations the ASTM specification numbers for the materials to be used. Provide the types and sizes of welds on the design drawings. Include a Bill of Materials on design drawings. Ensure design drawings and calculations are signed, dated, and sealed by the responsible Professional Engineer licensed in the State of North Carolina. Immediately bring to the attention of the Engineer any structural deficiency that becomes apparent in any assembly or member of any assembly as a result of the design requirements imposed by these Specifications, the plans, or the typical drawings. Said Professional Engineer is wholly responsible for the design of all poles and arms and review and acceptance of these designs by the Department does not relieve said Professional Engineer of this responsibility. Do not fabricate the assemblies until receipt of the Department's approval of the design drawings.

Design for either steel or aluminum poles as indicated on the plans.

Comply with the following for Aluminum Poles:

- Fabricate poles from Aluminum Association Alloy 6061-T6, 6063-T6, or approved equivalent.
- Taper shafts by spinning and cold-working a seamless extruded tube of the aluminum alloy.
- Ensure shafts have no longitudinal or circumferential welds except at the lower end joining the shaft to the base.
- Ensure shafts are satin brush finished and individually "tire wrapped."
- Fabricate shaft bases in accordance with the Aluminum Association Alloy 356.0-T6 Ensure base is of adequate strength, shape and size, and capable of withstanding the design load of the shaft.
- Coat aluminum surfaces in contact with concrete or dissimilar metal with bituminous paint.

Comply with the following for Steel Poles:

- Fabricate shafts of the tapered tubular type and steel conforming to ASTM A-595 Grade A or an approved equivalent
- Galvanize in accordance with ASTM A-123, including field-drilled holes.
- Use the submerged arc process to continuously weld shafts for the entire length. Ground or roll smooth exposed welds until flush with the base metal. Ensure shafts have no circumferential welds except at the lower end joining the shaft to the base. Provide welding that conforms to Article 1072-20, except that no field welding on any part of the pole will be permitted.
- Fabricate anchor bases from plate steel meeting the requirements of ASTM A 36M or cast steel meeting the requirements of ASTM A 27M Grade 485-250 or an approved equivalent.

For mast arm poles, provide designs with provisions for pole plates and associated gussets and fittings for the attachment of required mast arms. As part of each mast arm attachment, provide a grommeted cable passage hole in the pole to allow passage of the signal cables from the pole to the arm.

Design tapers for all pole shafts that begin at the base and that have diameters which decrease uniformly at the rate of 0.14 inch per foot (11.7 millimeters per meter) of length.

Design for a base plate on each pole. The minimum base plate thickness for all poles is determined by the following criteria:

Case 1 Circular or rectangular solid base plate with the upright pole welded to the top surface of base plate with full penetration butt weld, and where no stiffeners are provided. A base plate with a small center hole, which is less than 1/3 of the upright diameter, and located concentrically with the upright pole, may be considered as a solid base plate.

The magnitude of bending moment in the base plate, induced by the anchoring force of each anchor bolt is $M = (P \times D_1) / 2$,

where M = bending moment at the critical section of the base plate induced by one anchor bolt
P = anchoring force of each anchor bolt
D_1 = horizontal distance between the center of the anchor bolt and the outer face of the upright, or the difference between the radius of the bolt circle and the outside radius of the upright

Locate the critical section at the face of the anchor bolt and perpendicular to the radius of the bolt circle. The overlapped part of two adjacent critical sections is considered ineffective.

Case 2 Circular or rectangular base plate with the upright pole socketed into and attached to the base plate with two lines of fillet weld, and where no stiffeners are provided, or any base plate with a center hole that is larger in diameter than 1/3 of the upright diameter.

The magnitude of bending moment induced by the anchoring force of each anchor bolt is $M = P \times D_2$,

where P = anchoring force of each anchor bolt
D_2 = horizontal distance between the face of the upright and the face of the anchor bolt nut

Locate the critical section at the face of the anchor bolt top nut and perpendicular to the radius of the bolt circle. The overlapped part of two adjacent critical sections is considered ineffective.

If the base plate thickness calculated for Case 2 is less than Case 1, use the thickness calculated for Case 1.

Ensure that designs have anchor bolt holes with a diameter 1/4 inch (7 mm) larger than the anchor bolt diameters in the base plate.

Provide designs using anchor bolts with two anchor nuts and two washers for each pole. Fabricate the anchor bolts from steel with minimum yield strength of 55,000 psi (370 MPa) and a minimum ultimate tensile strength of 70,000 psi (483 MPa). Ensure that the anchor bolts have the required diameters, lengths, and positions, and will develop strengths comparable to their respective poles.

Provide designs with a 6 x 12 inch (150 x 300 mm) hand hole with a reinforcing frame for each pole.

Provide designs with a terminal compartment with cover and screws in each pole that encompasses the hand hole and contains provisions for a 12-terminal barrier type terminal block. Attach the terminal compartment cover to the pole by a sturdy chain or cable. Ensure that the chain or cable is long enough to permit the cover to hang clear of the compartment opening when the cover is removed, and is strong enough to prevent vandals from being able to disconnect the cover from the pole. Ensure that the chain or cable will not interfere with service to the cables in the pole base.

For each pole, provide designs with provisions for a 1/2 inch (12 mm) minimum thread diameter, coarse thread stud and nut for grounding which will accommodate a Number 6 AWG ground wire. Ensure that the lug is electrically bonded to the pole and is conveniently located inside the pole at the hand hole.

Ensure that designs provide a removable pole cap with stainless steel attachment screws for the top of each pole. Ensure that the cap is cast aluminum conforming to Aluminum Association Alloy 356.0F. Have the cap attached to the pole with a sturdy chain or cable. Ensure that the chain or cable is long enough to permit the cap to hang clear of the pole-top opening when the cap is removed.

10.3. MAST ARMS

Design all arm plates and necessary attachment hardware, including bolts and brackets.

Design for grommeted holes on the arms to accommodate the cables for the signals.

Design arms with weatherproof connections for attaching to the shaft of the pole.

Ensure all hardware is galvanized steel or stainless steel.

Design an arm slope that compensates for the deflection as defined in Section A of these project special provisions. Design a removable cap with stainless steel attachment screws for the end of each mast arm. Ensure that the cap is cast aluminum conforming to Aluminum Association Alloy 356.0F. Attach cap to the mast arm with a sturdy chain or cable. Ensure that the chain or cable is long enough to permit the cap to hang clear of the arm opening when the cap is removed.

Comply with the following for Aluminum Arms:

- Conform to Aluminum Association Alloy 6061-T6, 6063-T6 or approved equivalent.
- Conform to the welding requirements of the aluminum poles.
- Ensure arms are satin brush finished and furnished individually wrapped.

Comply with the following for Steel Arms:

- Fabricate arms from standard weight black steel pipe conforming to ASTM A 53-90a, Type E or Type S, Grade B or an approved equivalent.
- Conform to the welding requirements of the steel poles.

After all fabricating, cutting, punching, and welding is completed, hot-dip galvanize the structure in accordance with the 4th Edition AASHTO M111.

10.4. METHOD OF MEASUREMENT

Actual number of designs for mast arms with metal poles furnished and accepted.

No measurement will be made of foundation designs prepared as these will be considered incidental to designing signal support structures.

10.5. BASIS OF PAYMENT

The quantity of mast arms with metal pole designs, measured as provided above, will be paid for at the contract unit price each for "Mast Arm with Metal Pole Design."

Payment will be made under:

Mast Arm with Metal Pole Design .....Each

11. DOUBLE MAST ARM WITH METAL POLE

11.1. DESCRIPTION

Furnish and install signal support double mast arms with metal poles and all necessary hardware in accordance with the plans and specifications. Comply with the provisions of Section 1700 of the 2002 Standard Specifications for Roads and Structures.

Furnish signal support double mast arms with metal poles, grounding systems, and all necessary hardware. Provide either steel or aluminum arms as indicated on the plans.

11.2. MATERIALS

Comply with the provisions of section 1741-2.

11.3. CONSTRUCTION METHODS

Comply with the provisions of section 1741-3.

11.4. METHOD OF MEASUREMENT

Actual number of double mast arms with metal poles furnished, installed, and accepted.

11.5. BASIS OF PAYMENT

The quantity of double mast arms with metal poles, measured as provided above, will be paid for at the contract unit price each for "Double Mast Arm with Metal Pole."

Payment will be made under:

Double Mast Arm with Metal Pole.....Each

12. METAL SIGNAL POLE REMOVALS

12.1. DESCRIPTION

Remove and dispose of existing metal signal poles including mastarms, and remove and dispose of existing foundations, associated anchor bolts, electrical wires and connections.

12.2. CONSTRUCTION METHODS

A. Metal Poles:

Assume ownership of the metal signal poles, remove the metal signal poles, and promptly transport the metal signal poles from the project. Use methods to remove the metal signal poles and attached traffic signal equipment that will not result in damage to other portions of the project or facility. Repair damages that are a result of the Contractor's actions at no additional cost to the Department.

B. Foundations:

Remove and promptly dispose of the metal signal pole foundations include reinforcing steel, electrical wires, and anchor bolts to a minimum depth of two feet below the finished ground elevation. At the Contractor's option, remove the complete foundation.

Transport and properly dispose of the materials.

Backfill and compact disturbed areas to match the finished ground elevation. Seed unpaved areas.

Use methods to remove the foundations that will not result in damage to other portions of the project or facility. Repair damages that are a result of the Contractor's actions at no cost to the Department.

12.3. METHOD OF MEASUREMENT

Actual number of metal signal poles removed and disposed.

Actual number of metal signal pole foundations removed and disposed.

12.4. BASIS OF PAYMENT

The quantity of metal poles removed, measured as provided above, will be paid for at the contract unit price each for "Metal Pole Removal."

The quantity of metal pole foundations removed, measured as provided above, will be paid for at the contract unit price each for "Metal Pole Foundation Removal."

Payment will be made under:

Metal Pole Removal.....Each

Metal Pole Foundation Removal .....Each

13. EMERGENCY VEHICLE PREEMPTION

13.1. DESCRIPTION

Remove the existing Opticom™ optical detector unit from the existing messenger cable and install them on the appropriate mast arm.

At locations where existing Opticom™ optical detector cable is of insufficient length to reach cabinet locations, remove the existing cable and install new cable.

13.2. MATERIALS

Reuse existing Opticom™ optical detector unit and Model 562 phase selector.

Furnish 3M Opticom™ Model 138 optical detector cable.

13.3. CONSTRUCTION METHODS

Remove existing Opticom™ optical detector unit from existing messenger cable. Install the appropriate optical detector unit on the appropriate mast arm according to the plans.

At locations where existing optical detector cable is of insufficient length to reach new cabinet locations, disconnect the cable from the optical detector and remove the cable. Install new cable from the existing optical detector to the new cabinet. Connect the new optical detector cable to the existing optical detector and to the cabinet's input file according to the plans and the manufacturer's recommendations.

13.4. METHOD OF MEASUREMENT

No separate payment will be made for transferring optical detector unit from existing messenger cable to new mast arm. This work is considered incidental to furnishing and install the new metal pole and mast arm.

Actual linear feet of new optical detector cable furnished, installed and accepted. The cost of removing existing optical detector cable shall be included in the cost to install new cable.

13.5. BASIS OF PAYMENT

The quantity of optical detector cable measured as provided above, will be paid for at the contract unit price per linear foot for "Optical Detector Cable"

Payment will be made under:

Optical Detector Cable.....Linear Foot

14. VIDEO EQUIPMENT

14.1. DESCRIPTION

Furnish and install video equipment described in this Section. The unit shall be fully compatible with all features of the existing matrix switcher at the City of Rocky Mount, Traffic Operations Center and the CCTV control software, unless otherwise approved by the Engineer.

Furnish and install video equipment necessary to control and monitor the CCTV assemblies installed at locations shown in the Plans. The video equipment shall include (but not be limited to) CCTV camera assemblies, video/data transmitters, video/data receivers and video multiplexers.

14.2. MATERIAL

A. CCTV Camera Assembly:

1. General

Furnish and install, at the locations shown on the Plans, new CCTV camera assemblies. Each assembly consists of the following:

- One Pelco Spectra Series III Dome CCTV, or approved equivalent, that contains in a single enclosed unit the following functionality and accessories:
  - CCTV color digital signal processing camera unit with zoom lens, filter, control circuit, and accessories,
  - Motorized pan, tilt, and zoom,
  - Pole-mount camera attachment assembly;
- All necessary cables, connectors and incidental hardware to make a complete and operable system,
- A lightning arrestor shall be furnished and installed in-line between the CCTV camera and the equipment cabinet components,
- Camera Unit housing shall be a NEMA Type 4, IP 66 enclosure constructed of aluminum with a clear acrylic dome or approved equivalent.

2. Cameras

Furnish new charged coupled device (CCD) color cameras. The cameras shall provide automatic gain control (AGC) for clear images in varying light levels. The cameras shall meet the following minimum requirements:

- Video signal format: NTSC composite color video output, 1 volt peak to peak
- Automatic Gain Control (AGC): 0-20 dB, peak-average adjustable
- Automatic focus: Automatic with manual override
- White balance: Automatic through the lens and manual adjustable from remote controller.
- Electronic-Shutter: dip-switch selectable electronic shutter with speed range from 1/60 of a second (off) to 1/30,000th of a second
- Overexposure protection: The camera shall have built-in circuitry or a protection device to prevent any damage to the camera when pointed at strong light sources, including the sun
- Sensitivity: 1.5 lux at 90% scene reflectance
- Signal to noise ratio: Greater than 48-dB
- Video output Connection: 1-volt peak to peak, 75 ohms terminated, BNC connector
- Power: 24 VAC or less

3. Zoom lens

Furnish each camera with a motorized zoom lens that is a Pelco Spectra III high performance integrated dome system or approved equivalent with automatic iris control with manual override and neutral density spot filter. Furnish lenses that meet the following optical specifications:

- Focal length: 0.16" – 3.45", 22X optical zoom, 12X electronic zoom
- Preset positioning: 64 Presets

The lens shall be capable of both automatic and remote manual control iris and focus override operation. The lens shall be equipped for remote control of zoom and focus, including automatic movement to any of the preset zoom and focus positions. Mechanical or electrical means shall be provided to protect the motors from overrunning in extreme positions. The operating voltages of the lens shall be compatible with the outputs of the camera control.

4. Camera Housing

Furnish new dome style enclosures for the CCTV assemblies that are Pelco Spectra III high performance integrated dome systems or approved equivalents. Equip each housing with mounting assembly for attachment to the CCTV camera pole. The enclosures shall be equipped with a sunshield and be fabricated from corrosion resistant aluminum and finished in a neutral color of weather resistant enamel. The enclosures shall meet or exceed NEMA 4X ratings. The viewing area of the enclosures shall be tempered glass.

5. Pan and Tilt Unit

Each new dome style assembly shall be equipped with a pan and tilt unit. The pan and tilt unit shall be integral to the Pelco Spectra III high performance integrated dome system or approved equivalent. The pan and tilt unit shall be rated for outdoor operation, provide dynamic braking for instantaneous stopping, prevent drift, and have minimum backlash. The pan and tilt units shall meet or exceed the following specifications:

- Pan: continuous 360 Degrees
- Tilt: up/down 180 degrees minimum
- Input voltage: 24 VAC 50/60Hz
- Motors: Two phase induction type, continuous duty, instantaneous reversing
- Preset Positioning: 64 PTZ presets per camera

6. Control Receiver/Driver

Each new camera unit shall contain control receiver/driver that is integral to the CCTV dome assembly. The control receiver/driver shall receive serial asynchronous data initiated from a camera control unit, decode the command data, perform error checking, and drive the pan/tilt unit, camera controls, and motorized lens. As a minimum, the control receiver/drivers shall provide the following functions:

- Zoom in/out
- Automatic focus with manual override
- Tilt up/down
- Automatic iris with manual override
- Pan right/left
- Minimum 64 preset positions for pan, tilt, and zoom

In addition, each control receiver/driver shall accept status information from pan/tilt unit and motorized lens for preset positioning of those components. The control receiver/driver shall relay pan, tilt, zoom, and focus positions from the field to remote camera control units. The control receiver/driver shall accept "goto" preset commands from the camera control unit, decode the command data, perform error checking, and drive the pan/tilt and motorized zoom lens to the correct preset position. The preset commands from the camera control unit will consist of unique values for the desired pan, tilt, zoom, and focus positions.

7. CCTV Camera Attachment to Pole

At locations shown in the Plans where new CCTV cameras are to be installed on new CCTV poles, design, fabricate, and furnish an attachment assembly for the CCTV camera unit. Use stainless steel banding approved by the Engineer. Submit shop drawings for review and approval by the Engineer prior to installation.

Furnish CCTV attachment that allows for the removal and replacement of the CCTV enclosure as well as providing a weatherproof, weather tight, seal that does not allow moisture to enter the enclosure.

Furnish CCTV Camera Attachment Assembly that is able to withstand wind loading at the maximum wind speed and gust factor called for in these Project Special Provisions and can support a minimum camera unit dead load of 45 pounds (20.4 kg).

8. Surge Suppression

All equipment at the top of the pole shall be protected by grounded metal oxide varistors connecting each power conductor to ground.

Coaxial cable from each camera shall be protected by a surge protector equal to Vicon V15LP, at each end of the cable.

B. Video/Data Transmitters and Receivers:

1. At the CCTV Equipment Cabinet:

Furnish and install a multimode video/data transmitter capable of transmitting one channel of composite video in one direction and one channel of bidirectional data, all over one multimode optical fiber. Furnish an Optelecom Model 9225DT/MM-ST video/data transmitter, or approved equivalent, with the following features:

- Video
  - Video Format: NTSC, PAL, SECAM,
  - Voltage: 1V p-p into 75,
  - Video SNR: $\geq$ 63 dB over entire optical budget,
  - Bandwidth: 5 Hz to 6.5 MHz (–3 dB),
  - Differential Gain: $\leq$ 2%,
  - Differential Phase: $\leq$ 1°,
  - Connectors: BNC,
- Data
  - Max Baud Rate: 115.2 Kbps,
  - Formats: Switch selectable RS232, 2- or 4-wire RS422, 2- or 4-wire RS485, or Manchester (Burle and American Dynamics),
- Fiber Optic Connectors: Type ST,
- Range: 3.7 miles (6 km),
- Wavelength: Tx to Rx: 1310 nm, Rx to Tx: 850 nm,
- Power Adapter: For 110 VAC, 60 Hz, Model 9014PS (or approved equivalent),
- Operating Temperature: –40° F to +165° C (–40° C to +74° C),
- Relative Humidity: 0 to 95% noncondensing.

2. At Intersection 04-0051 (US 301 Business [Church St] at NC 43 [Grace St/Grand Ave]):

Furnish and install a multimode video/data receiver and a single-mode video/data transmitter together capable of receiving and transmitting one channel of composite video in one direction and one channel of bidirectional data, all over one multimode and one single-mode optical fibers respectively. Furnish an Optelecom Model 9221DR/MM-ST video/data receiver and an Optelecom Model 9221DT/SM-ST video/data transmitter, or approved equivalents.

Furnish and install the receiver and transmitter into a two-card chassis to transition from multimode to single-mode optical fibers. Furnish and install an Optelecom Model 9003-2 Two-Card Mini Chassis and an Optelecom 9010PS Power Supply, or approved equivalents.

Furnish video/data receivers and transmitters with the following features:

- Video
  - Video Format: NTSC, PAL, SECAM,
  - Voltage: 1V p-p into 75,
  - Video SNR: $\geq$ 63 dB over entire optical budget,
  - Bandwidth: 5 Hz to 6.5 MHz (–3 dB),
  - Differential Gain: $\leq$ 2%,
  - Differential Phase: $\leq$ 1°,
  - Connectors: BNC,
- Data
  - Max Baud Rate: 115.2 Kbps,
  - Formats: Switch selectable RS232, 2- or 4-wire RS422, 2- or 4-wire RS485, or Manchester (Burle and American Dynamics),
- Fiber Optic Connectors: Type ST
- Range: Multimode: 3.7 miles (6 km)
  Single-Mode: 35 miles (57 km)
- Wavelength Multimode: Tx to Rx -1310 nm, Rx to Tx: 850 nm,
  Single-Mode: Tx to Rx -1310 nm, Rx to Tx: 1550 nm,
- Power Adapter: For 110 VAC, 60 Hz, Model 9014PS (or approved equivalent),
- Operating Temperature: –40° F to +165° C (–40° C to +74° C),
- Relative Humidity: 0 to 95% noncondensing.

3. At the Traffic Control Center in City Hall:

Furnish only, a single-mode video/data receiver capable of receiving one channel of composite video and one channel of bidirectional data, all over one single-mode optical fiber. Furnish an Optelecom Model 9225DR/SM-ST video/data receiver, or approved equivalent, with the following features:

- Video
  - Video Format: NTSC, PAL, SECAM,
  - Voltage: 1V p-p into 75,
  - Video SNR: ≥ 63 dB over entire optical budget,
  - Bandwidth: 5 Hz to 6.5 MHz (–3 dB),
  - Differential Gain: ≤ 2%,
  - Differential Phase: ≤ 1°,
  - Connectors: BNC,
- Data
  - Max Baud Rate: 115.2 Kbps,
  - Formats: Switch selectable RS232, 2- or 4-wire RS422, 2- or 4-wire RS485, or Manchester (Burle and American Dynamics),
- Fiber Optic Connectors: Type ST,
- Range: 35 miles (57 km),
- Wavelength: Tx to Rx: 1310 nm, Rx to Tx: 1550 nm,
- Power Adapter: For 110 VAC, 60 Hz, Model 9014PS (or approved equivalent),
- Operating Temperature: –40° F to +165° C (–40° C to +74° C),
- Relative Humidity: 0 to 95% noncondensing.

The video/data receiver will be installed by others.

C. Video Multiplexer:

Furnish a Protronix D7260-DNM 16:1 video multiplexer, or approved current equivalent, with the following features:

- Minimum of 16 NTSC inputs
- Minimum of 1 NTSC output
- Minimum output formats:
  - full screen for each input individually
  - quad view with 4 inputs shown in the quadrants of a full screen
- RS422 remote control
- Title generator providing up to 8 characters for each channel
- Built in Real Time Clock
- Dimensions:
  - Height: ≤ 1.75" (1U)
  - Width: Fits in normal 19" rack
  - Depth: < 11"
- Power Requirements: ≤ 10 W at 12 VDC (± 10%)
- Operating software

14.3. CONSTRUCTION METHODS

A. Electrical and Mechanical Requirements

Ground all equipment as called for in the NCDOT Standard Specifications, these project special provisions, and the Plans.

Install surge protectors on all ungrounded conductors entering the CCTV enclosure. House the protectors in a small, ventilated weatherproof cabinet attached near the CCTV attachment point in a manner approved by the Engineer. The air terminal ground wire shall not pass through this cabinet.

Install coaxial cable as required to interconnect video transceivers with the CCTV units. Insure that all connections are tight and fully secure.

B. CCTV Camera

Install CCTV assemblies at the locations shown on the Plans. Mount CCTV camera on side of wood pole nearest intended field of view and avoid occluding the view with the pole. Mount CCTV camera units at a height sufficient to adequately see traffic in all direction and as approved by the Engineer. The minimum height shall be 33 feet (10 meters) above ground level and the maximum height shall be 38 feet (12 meters) above ground level. Electrically bond each camera and pan/tilt/zoom mechanism and its housing to the CCTV camera attachment assembly using a number 6 AWG braided copper conductor. Integrate CCTV camera unit with equipment cabinet, and equipment cabinet power supply.

C. Video/Data Transmitters and Receivers:

Install fiber optic transceivers in each equipment cabinet and comply with the manufacturer's installation instructions. Provide all necessary hardware and cables.

Furnish only, a single-mode video/data receiver at the Traffic Control Center in City Hall.

D. Video Multiplexer:

The video multiplexer is a "furnish only" item. Furnish the video multiplexer with software to the Engineer at a location to be designated by the Engineer. There are no construction requirements for this item.

14.4. METHOD OF MEASUREMENT

Actual number of CCTV camera assemblies furnished, installed, integrated, and accepted. No separate measurement will be made for cabling, connectors, CCTV camera attachment assemblies, conduit, condulets, grounding equipment, CCTV camera enclosures, surge protectors, or any other equipment or labor required to install the CCTV assembly and integrate it with the wireless communications equipment. No separate measurement will be made for integration of CCTV unit with Video Software.

Actual number of multimode video/data transmitters furnished, installed, integrated, and accepted. No separate measurement will be made for cabling, connectors, 2-card mini chassis, power supplies, surge protectors, or any other equipment or labor required to install the video/data transmitters and integrate it with the other video equipment.

Actual number of multimode video/data receivers furnished, installed, integrated, and accepted. No separate measurement will be made for cabling, connectors, 2-card mini chassis, power supplies, surge protectors, or any other equipment or labor required to install the video/data receivers and integrate it with the other video equipment.

Actual number of single-mode video/data transmitters furnished, installed, integrated, and accepted. No separate measurement will be made for cabling, connectors, 2-card mini chassis, power supplies, surge protectors, or any other equipment or labor required to install the video/data transmitters and integrate it with the other video equipment.

Actual number of single-mode video/data receivers (furnished only) furnished and accepted.

Actual number of video multiplexers with software furnished and accepted.

No separate payment will be made for coaxial cable. Coaxial cable, furnished and installed in the quantities required, will be incidental to the "CCTV Camera Assembly" pay item.

14.5. BASIS OF PAYMENT

The quantity of CCTV camera assemblies as provided above will be paid for at the contract unit price each for "CCTV Camera Assembly".

The quantity of multimode video/data transmitters as provided above will be paid for at the contract unit price each for "Multimode Video/Data Transmitter".

The quantity of multimode video/data receivers as provided above will be paid for at the contract unit price each for "Multimode Video/Data Receiver".

The quantity of single-mode video/data transmitters as provided above will be paid for at the contract unit price each for "Single-Mode Video/Data Transmitter".

The quantity of single-mode video/data receivers (furnished only) as provided above will be paid for at the contract unit price each for "Single-Mode Video/Data Receiver (furnished only)".

The quantity of video multiplexers with software as provided above will be paid for at the contract unit price each for "Video Multiplexer".

Payment will be made under:

CCTV Camera Assembly ..... Each

Multimode Video/Data Transmitter ..... Each

Multimode Video/Data Receiver ..... Each

Single-Mode Video/Data Transmitter ..... Each

Single-Mode Video/Data Receiver (furnished only) ..... Each

Video Multiplexer ..... Each

15. CCTV EQUIPMENT CABINETS

15.1. DESCRIPTION

Furnish and install equipment cabinets and all necessary hardware in accordance with the plans and specifications. Comply with the provisions of Section 1700 of the 2002 Standard Specifications for Roads and Structures.

15.2. MATERIALS

A. General:

Comply with NEMA Standards Publication TS-1 (NEMA TS-1) in effect on the date of installation except as otherwise stated herein.

B. Cabinets:

Furnish unpainted, natural, aluminum cabinet shells. Ensure that all non-aluminum hardware on the cabinet is stainless steel or a Department approved non-corrosive alternate. Provide a roof with a slope from front to back at a minimum ratio of 1-inch (25-mm) drop per 2 feet (0.6 m). Ensure that each exterior cabinet plane surface is constructed of a single sheet of aluminum and is seamless.

Provide a handle and three point latching mechanism designed to be disassembled using hand tools. Provide a shaft connecting the latching plate to the door handle by passing through the door within a bushing, bearing, or equivalent device. Provide a latching plate at least 3/16 inch (4.5 mm) thick and that mates securely with the lock bolt. Provide a lock bolt with a flat end (no bevel) and that has at least 1/4 inch (6.4 mm) of length in contact with the latching plate.

Ensure that the handle and lock are positioned so that the lock does not lie in the path of the rotating handle as the door is unlatched and that the handle points down in the latched position.

Provide a cabinet that is neat in appearance. Provide continuous welds made form the inside wherever possible. On the exterior, provide joints that are smooth and flush. Ensure there are no superfluous holes in the outside of the cabinet. Ensure that no screws, bolts, nuts or rivets protrude to the outside of the cabinet shell. Ensure that the surface of the cabinet is smooth and free of blemishes and discoloration.

- Provide a main door opening that encompasses the full frontal area of the cabinet shell exclusive of the area reserved for plenums and flanges.

Ensure that the cabinet shell is sturdy and does not exhibit noticeable flexing, bending or distortion under normal conditions except that a minor amount of flexing is permitted in the main door and rear door only when the cabinet is open. In such case, the flexing must not result in permanent deformation of the door or damage to components mounted on the door. Ensure that pedestal-mounted cabinets have sufficient framing around the slipfitter attachment so that no noticeable flexing will occur at or about this point.

Ensure that the cabinet is large enough to accommodate all of the required equipment, specified future equipment, and wiring within the cabinet to provide sufficient room for servicing. Provide ample space in the bottom of the cabinet for the entrance and forming of all necessary wires and cables without interference with the operation, viewing, and servicing of the equipment. Ensure that the size of the cabinet permits all required and specified future equipment to be mounted in the upright position with sufficient space around it to provide adequate ventilation. Ensure at least 2 inches (50 mm) of clearance is provided around all vents and fans to insure proper air circulation. Ensure the interior size of the cabinets is at least:

Pole- and pedestal-mounted controller cabinets:	4.98 ft^3 (141,000 cm^3)
Base-mounted controller cabinets:	11.6 ft^3 (328,000 cm^3)
Pole- and pedestal-mounted on-street master cabinets:	3.5 ft^3 (98,000 cm^3)
Base-mounted on-street master cabinets:	7.52 ft^3 (213,000 cm^3)

If specified on the bid list or the plans, controller cabinets as small as 3.3 ft^3 (93,000 cm^3) may be provided for pole- and pedestal-mounted cabinets provided all other requirements are satisfied. Unless otherwise noted, ensure that cabinets are not to exceed the following dimensions:

	Maximum Outside Dimensions		
Type of Cabinet	Height	Width	Depth
Pole-mounted	52 inches (1320 mm)	30 inches (765 mm)	22 inches (560 mm)
Pedestal-mounted	36 inches (915 mm)	30 inches (765 mm)	22 inches (560 mm)
Base-mounted	None	None	None

Provide at least two sturdy shelves having an unobstructed depth of at least 13 inches (330 mm). Ensure the top shelf is at least 12 inches (305 mm) below the top of the door opening. Secure any

card rack to the walls or shelves. Ensure equipment and components that are mounted on the cabinet walls require no more than the use of a screwdriver to accomplish their easy removal for servicing. Ensure shelf-mounted units are placed in their proper positions on the shelves without having to twist or turn them during the placement process.

Provide a minimum 12 x 14 inch (305 x 355 mm) plastic envelope or container located in the cabinet so that it is convenient for service personnel. Furnish two sets of non-fading cabinet wiring diagrams and schematics in a paper envelope or container and placed in the plastic envelope or container.

Provide a roof with a shield that prevents water from dripping into the cabinet. Equip the roof with a thermostatically controlled exhaust fan and suitably screened exhaust vents that will permit the flow of air for which the fan is rated. Ensure that base-mounted cabinets have a fan rated for at least 47 L/s and pole- and pedestal-mounted cabinets have a fan rated for at least 23 L/s. Ensure that the fan does not protrude to the outside of the cabinet and that it is mounted in such a way that it can be easily removed for servicing. Fusing the fan is not required. Ensure that the roof assembly is formed in such a way that it facilitates air exhaust from the fan.

Provide an additional vent or vents at or near the bottom to permit the intake of air. Ensure that the size of the vents permit the flow of air corresponding to the rated flow of the fan. Ensure that the vents are not smaller than 29.45 in^2 (19,000 mm^2). Equip the vents with standard-size replaceable fiberglass filters. Ensure that the vents do not permit the entrance of rain or snow.

Furnish a fluorescent fixture as required by NEMA TS-2 Specifications with a second lighting fixture mounted under the bottom shelf to light the terminals. Ensure that the second fixture is a fluorescent lighting fixture that complies with NEMA TS-2 Specifications or is a flexible gooseneck fixture containing a protected incandescent reflector bulb of a least 25 Watts. Furnish all bulbs. Ensure that the lamps are door switch actuated.

Provide the cabinet with an adjustable thermostat located in the upper portion of the inside the roof and connected to control the fan. Ensure that it is manually adjustable within the range of at least 78 to 170 degrees F (26 to 77 degrees C) with a calibrated scale. Ensure that the thermostat has contacts rated for use with the fan. Ensure that the thermostat turns the fan on at the set temperature and turns it off when the temperature is 4.5 degrees F (2.5 degrees C) below the set temperature.

Provide sufficient electrical and electronic noise suppression in the cabinet to enable all equipment in it to function properly. Ensure that the cabinet is equipped with one or more radio interference filters connected between the stages of the power line surge protector. Ensure that the filter(s) minimize interference generated in the cabinet in both the broadcast and aircraft frequencies. Ensure that the filter(s) provide attenuation of at least 50 decibels over a frequency range of 200 kilohertz to 75 megahertz. Provide filters that are hermetically sealed in metal cases and are insulated. Ensure that the filter is rated at least at the rated current of the main circuit breaker, 125-volt, 60 Hertz.

Provide duplex receptacle in the cabinet located conveniently for service personnel and in such a position that no electrical hazard will be presented to such personnel when using the receptacle. Ensure that the receptacle is a 3-wire ground fault interrupt type that will also accept a standard 2-prong, non-grounding plug. Ensure that the receptacle is reserved for the use of service personnel. Ensure normal control cabinet equipment is not connected to the receptacle.

Provide the cabinet with a NEMA standard circuit breaker box having at least two circuit breakers. Alternatively, provide circuit breakers that are installed in such a way that personnel

servicing the cabinet cannot inadvertently be exposed to a hazard. Ensure that a terminal block connected to the circuit breakers accommodates service wire as large as Number 6 AWG. Ensure that these circuit breakers are in addition to any fuses that are a part of the individual control equipment components. Provide a clear plastic guard or the equivalent to prevent incidental contact and shock hazard that protects exposed 120-volt AC terminals on the power panel.

Provide a cabinet with a ground bus having at least 20 terminals. Ensure that the bus is attached and electrically bonded to the wall of the cabinet. Provide terminals to accommodate Number 10, 12, and 14 AWG conductors. Ensure that at least one terminal on each end is grounded and accommodates a Number 4 AWG conductor.

Provide a cabinet with an AC Neutral bus having at least 24 terminals. Ensure that the bus is isolated electrically from the cabinet ground. Provide terminals to accommodate Number 10, 12, and 14 AWG conductors.

Provide surge suppression in the cabinet and ensure that all devices operate over the temperature range of –40 to 185 degrees F (-40 to 85 degrees C).

Provide a power line surge protector that is a two-stage device that will allow connection of the radio frequency interference filter between the stages of the device. Ensure that a maximum continuous current is at least 10A at 120V. Ensure that the device can withstand a minimum of 20 peak surge current occurrences at 20,000A for an 8x20 microsecond waveform. Provide a maximum clamp voltage of 280V at 20,000A with a nominal series inductance of 200μh. Ensure that the voltage does not exceed 280V. Provide devices that comply with the following:

Frequency (Hz)	Minimum Insertion Loss (dB)
60	0
10,000	30
50,000	55
100,000	50
500,000	50
2,000,000	60
5,000,000	40
10,000,000	20
20,000,000	25

Ensure that no direct inter-equipment connection is made. Ensure that all equipment is connected to other items of equipment at the cabinet terminal blocks.

Ensure that all equipment and circuit cards are designed or keyed so that it is physically impossible to connect the unit to the wrong connector or insert it into an incorrect slot. Equip the cabinet with terminal blocks (strips) for the termination of all field conductors and all internal wires and harness conductors. Ensure that all wires are terminated at the terminals. Provide field terminals that are readily accessible without the removal of equipment and located conveniently to the wires, cables and harnesses. Ensure that each terminal block is of electrical grade thermoplastic or thermosetting plastic and each terminal block is a closed back design and has recessed-screw terminals with molded barriers between the terminals.

Ensure that each terminal of a terminal block consists of two terminal screws with a removable shorting bar between them. However, if the terminal block is part of a fabricated panel, each terminal may consist of a single terminal screw with a feed-through binding post to which

conductors are soldered behind the panel. Ensure that each terminal block is labeled with a block designation and each terminal is labeled with a number. Provide labels that are visible when the terminal block is fully wired. Ensure that the labels are shown on the cabinet wiring diagrams. Ensure that no terminals are closer than 4 inches (100 mm) to the bottom of the cabinet and provide those in base-mounted cabinets at least 6 inches (150 mm) from the bottom. Ensure that terminals serving similar functions are grouped together. Ensure that no terminals are located on the under side of shelves or at other places where they are not readily visible and accessible or where they may be a hazard to personnel who might inadvertently touch them.

Ensure that all equipment in the cabinet is connected to the cabinet, to the other items of equipment and to the field circuits at the cabinet terminal blocks by means of neatly trained harnesses.

Provide harnesses in the cabinet for non-permanently mounted equipment that are long enough to allow the equipment to be relocated in an upright position to the roof of the cabinet or to be located to the ground 12 inches (300 mm) below cabinet level. Provide a secondary ground conductor of sufficient size to safely carry any fault current for harnesses that supply power or an AC+ input greater than 24 volts. Ensure that all harnesses are neatly dressed along the cabinet walls either parallel to or perpendicular to the floor. Ensure that they do not run diagonally. Ensure that the harness, which connects the components on the door to the remainder of the cabinet, does not touch the doorjamb in any door position, including fully open.

Ensure that each conductor, including unused conductors, within or entering the cabinet is connected to a terminal. Ensure that no more than two conductors are connected to any single terminal screw with the following exception. Multiple conductors may be attached to a terminal used to distribute AC and DC power functions (AC+, AC-, Earth Ground, 24VDC, Logic Ground, etc.) or similar multi-use signals under the following conditions:

- it is unlikely that the conductors attached to such terminals will be removed by the cabinet user and,
- there exists at least one terminal for each of the functions that has two or fewer conductors connected to it that is available for customer use.

This exception does not alter other requirements in these specifications which define the required number of terminals for power or other specific circuits.

Ensure that each conductor has a crimped spade lug when connected to a terminal screw. Connections such as quick connectors and barrel connectors are not acceptable. No in-line splices are permitted in any conductor.

Ensure that the outgoing circuits are of the same polarity as the line side of the AC supply. Ensure that the common return is of the same polarity as the grounded side of the AC supply.

Ensure that all wiring is formed into neatly packaged and neatly dressed harnesses and laced, braided or tied with nylon tie wraps at closely spaced intervals. Where wires, cables or harnesses must be attached to the cabinet walls or door for support or to prevent undue wear or flexing, ensure that the attachment is made using nylon tie straps or metal clamps with rubber or neoprene insulators. Ensure that these attachment devices are screwed to the cabinet. Stick-on clamps or straps are not permitted.

Ensure that all field wiring and all internal conductors that are likely to be disconnected from time to time are tagged with non-fading, permanent sleeve labels at the ends of the conductors at the

terminals. Ensure that sleeve labels are shrunk tightly to grip the conductors. Alternatively, hot stamp labels on the insulation of internal conductors at intervals of no greater than 4 inches (100 mm). Ensure that all jumpers are wire conductors or metal plates.

15.3. CONSTRUCTION METHODS

Install base-mounted cabinets on a signal cabinet-type foundation.

Provide an external electrical service disconnect

15.4. METHOD OF MEASUREMENT

Actual number of CCTV equipment cabinets (base mounted) furnished, installed, and accepted.

15.5. BASIS OF PAYMENT

The quantity of CCTV equipment cabinets, measured as provided above, will be paid for at the contract unit price each for "CCTV Equipment Cabinet (Base Mounted)."

Payment will be made under:

CCTV Equipment Cabinet (Base Mounted) ..... Each

16. TS-1 DETECTOR UNIT

16.1. DESCRIPTION

Furnish and install TS-1 detector unit and all necessary hardware in accordance with the plans and specifications. Comply with the provisions of Section 1700 of the 2002 Standard Specifications for Roads and Structures.

16.2. MATERIALS

Comply with NEMA Standards Publication TS-1 (NEMA TS-1) in effect on the date of installation except as otherwise stated herein.

Furnish NEMA TS-1 single-channel or multi-channel detectors.

Provide multi-channel detectors that sequentially scan each of its channels. Ensure that the multi-channel detectors can turn a channel off and disable its operation from the front panel.

Provide channels with a minimum of eight sensitivity levels.

Ensure detector units meet the requirements of NEMA TS-1 Specifications except as follows:

- Class 2 vehicle output is maintained for a minimum of 4 minutes, and
- Class 3 vehicle output is maintained for a minimum of 30 minutes, but not more than 120 minutes.

Where required, furnish detectors equipped with required timing features. Provide a delay that is settable in one second increments (maximum) over the range of zero to thirty seconds. Provide an extend that is settable in 1/4 second increments (maximum) over the range of zero to fifteen seconds. Provide detectors that can set both delay and extend timing for the same channel. If both timings are set, ensure the delay operates first. After the delay condition has been satisfied, ensure that the extend timer operates normally and that it is not necessary to satisfy the delay timing for an actuation arriving during the extend portion.

Ensure that the detectors register a permanent call during tuning operations, as a result of a loop fault, and when power is removed. Ensure that the detectors completely self-tuned within 10 seconds after application of power or restoration of interrupted power and within 10 seconds after correction of a loop fault.

Provide detectors that monitor the loop for fault conditions on each channel. Upon detection of a fault condition, even if the condition is subsequently corrected, ensure the detectors provide an indication of the occurrence and maintain the indication until a manual reset. The fault conditions are:

- An open-circuited loop system:
- A short to ground; and
- A 25 percent reduction in inductance.

Ensure a two-channel detector operates normally with the same loop connected to both channels.

Provide lightning and surge protection that is incorporated into the design of the detector. Ensure that each channel operates properly when used with the loop detector surge protector.

In addition to NEMA TS-1 Specifications, ensure each channel is capable of tuning to and operating on any loop system inductance within the range of 50 to 2,000 μh. Ensure that the channel will operate properly even on a loop system that has a single-point short to earth ground.

Provide detectors with a durably finished nonferrous housing. Ensure that the removal of the housing can be accomplished by using simple hand tools. Ensure each printed circuit board has a moisture resistant coating and that the components are readily accessible with the housing removed.

Provide a wiring harness with a minimum length of 6 feet (1.8 meters) for each detector. Ensure each wire is permanently labeled, numbered, or color-coded.

16.3. CONSTRUCTION METHODS

Take existing equipment out of service only at the time directed.

Install detector sensor units, and hardware that provide the required vehicle detection.

16.4. METHOD OF MEASUREMENT

Actual number of detector units furnished, installed, and accepted.

No measurement will be made of required system interconnection, surge protection, and grounding systems as this will be considered incidental to furnishing and installing controllers with cabinets.

16.5. BASIS OF PAYMENT

The quantity of detector units, measured as provided above, will be paid for at the contract unit price each for "Detector Unit NEMA TS-1."

Payment will be made under:

Detector Unit NEMA TS-1 ..... Each