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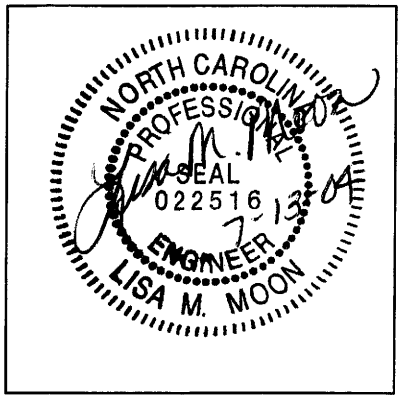


# Project Special Provisions
*(Version 02.13)*
# Signals and Traffic Management Systems

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*13-Jul-04*

## 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:

**(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). Arrow displays shall 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, shall be cause for rejection. All specifications will be measured including, but not limited to:

(a) **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.**

(b) **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.

(c) **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. Each 12-inch (300-mm) ball module shall be visible at 450 feet (135 meters) during sway conditions (extended view) until obscured by the visor. Each 8-inch ball (200-mm) and 12-inch (300-mm) arrow module shall be 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. Replacement modules shall be provided 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.

Page 10-227, Subarticle 1098-2(F)

Replace the first sentence in the paragraph with the following:

Furnish 16-4 and 16-7 signal cable that complies with IMSA specification 20-1 except provide the following conductor insulation colors:

- For 16-4 cable: white, yellow, red, and green

- For 16-7 cable: white, yellow, red, green, yellow with black stripe tracer, red with black stripe tracer, and green with black stripe tracer. Apply continuous stripe tracer on conductor insulation with a longitudinal or spiral pattern.

Provide a ripcord to allow the cable jacket to be opened without using a cutter. IMSA specification 19-1 will not be acceptable.

### 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. 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.
- 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.

### 1.5. 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."

### 1.6. 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 "Fourth 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."

## 1.7. Type 2070L Controllers (1098-20)

Page 10-247, Article 1098-20

Replace the entire article with the following:

Conform to CALTRANS Traffic Signal Control Equipment Specifications and all addenda in effect on the date of advertisement except as required herein. Where an item is no longer cited, the last applicable specification applies.

Furnish Model 2070L controllers. Ensure that removal of the program module from the controller will place the intersection into flash.

The Department will provide software at the beginning of the burning-in period. Contractor shall give 5 working days notice prior to needing software. Program software provided by the Department.

Provide model 2070L controllers with the latest version of OS9 operating software and device drivers, composed of the unit chassis and at a minimum the following modules and assemblies:

- MODEL 2070 1B, CPU Module, Single Board
- MODEL 2070-2A, Field I/O Module (FI/O)
- MODEL 2070-3B, Front Panel Module (FP), Display B (8x40)
- MODEL 2070-4A, Power Supply Module, 10 AMP
- MODEL 2070-7A, Async Serial Com Module (9-pin RS-232)

Furnish one additional MODEL 2070-7A, Async Serial Com Module (9-pin RS-232) for all master controller locations.

Furnish one removable data key with each 2070L controller unit.

For locations designated as master locations, furnish a Hayes or approved equivalent auto-dial/auto-answer external modem to accomplish the interface to the microcomputers unless otherwise required (minimum baud rate of 53K and downward compatible to the master and microcomputer communication baud rates). Include all necessary hardware to ensure telecommunications.

## 1.8. Closed Loop System (1098-23)

Page 10-257, Article 1098-23

*Note: This section now applies only to NEMA TS-2 Closed Loop Systems.*

Change the title to "**CLOSED LOOP SYSTEM NEMA TS-2.**"

## 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 shall 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."

### 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).

### 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

Delete the last sentence.

## 2.6. Structure Design of Signal Supports (1744)

Page 17-26-28, Subarticle 1744-2(A)

In paragraph 2, sentence 2, delete the phrase "(AASHTO specifications) in effect on the date of advertisement" and insert the words "Fourth Edition, 2001, including the latest interim specifications." Revise "with a 1.3 gust factor" to "with a minimum 1.14 gust factor."

Add the following paragraph after paragraph 2:

"Use the following in design, which is taken from The Standard Specifications for Structural Supports for Highway Signs, Luminaires and Traffic Signals, 4th Edition, 2001:

- The wind pressure map that is developed from the 3-second gust speeds, as provided in Article 3.8, shall be used.
- Signal support structures shall include natural wind gust loading and truck-induced gust loading in the fatigue design, as provided for in Article 11.7.3 and 11.7.4, respectively. Designs need not consider periodic galloping forces.
- The natural wind gust speed in North Carolina is assumed to be 11.2 mph.
- The fatigue importance category used in the design, for each type of structure, as provided for in Article 11.6, Fatigue Importance Factors, shall be Category II unless otherwise shown on the contract plans.
- Deflection induced by truck gust, as provided in Article 11.8, at the free end of single-arm sign supports and all traffic signal arms, shall be limited to 8 inches (200 mm) vertically, when the equivalent static design wind effect from truck-induced gusts are applied to the structure.
- Conform to article 10.4.2 of the 2001 AASHTO Specification

The maximum allowable vertical deflection at the tip of the mast arm due to the combined deflection of the pole and the arm shall not exceed 3.0% of the total mast arm length under maximum dead loading conditions.

For span wire mounted signal support structures, wind loads shall be applied as shown in Figure 3-5 of the AASHTO Specification. For Group III loading, where ice is present, half wind shall also be applied to the span wire cable bundle diameter shown above as well as to the increased diameter of the cable bundle due to the presence of ice around the full perimeter of the cable bundle."

"Use the following in design, which modifies The Standard Specifications for Structural Supports for Highway Signs, Luminaires and Traffic Signals, 4th Edition, 2001":

Revise Article 11.7.4, Truck-Induced Gust, Equation 11-6 to read as follows:

$P_{TG} = 900C_dI_F$ (Pa)

$P_{TG} = 18.8C_dI_F$ (psf)

Revise the third sentence of Article 11.7.4, Truck-Induced Gust, to read as follows:

"The pressure range shall be applied along any 3.7 m (12 ft) length to create the maximum stress range, excluding any portion of the structure not located directly above a traffic lane."

In Article 11.7.4, Truck-Induced Gust, after the first paragraph, add a paragraph to read as follows:

"The magnitude of applied pressure range may be varied depending on the height of the horizontal support and the attachments above the traffic lane. Full pressure shall be applied for heights up to and including 6 m (19.7 ft), and then the pressure may be linearly reduced for heights above 6 m (19.7 ft) to a value of zero at 10 m (32.8 ft)."

Revise the third paragraph of the Commentary to Article 11.7.4, Truck-Induced Gust, to remove the following two sentences in their entirety:

"To improve fuel economy ... created by the trailer. It has been proposed ... (Desantis and Haig, 1996)."

Revise the fourth paragraph of the Commentary to Article 11.7.4, Truck-Induced Gust, to read as follows:

"The design pressure calculated from Equation 11-6 is based on a truck speed of 30 m/s (65 mph). For structures installed at locations where the posted speed limit is much less than 30 m/s (65 mph), the design pressure may be recalculated based on this lower truck speed. The following may be used:

$P_{TG} = 900C_d(V/30\ m/s)^2I_F$ (Pa) Eq. C 11-6

$P_{TG} = 18.8C_d(V/65\ mph)^2I_F$ (psf)

Where V is the truck speed in m/s (mph), V may be taken as either the posted speed limit or the design speed (if known), whichever is higher."

Revise the Commentary to Article 11.7.4, Truck-Induced Gust, to remove in their entirety, the fifth and seventh paragraphs, which deal with the application length, and variability of truck gust pressure range.

In the last paragraph, add the following after the last sentence:

"The computed surface area for ice load on signal heads shall be:

- 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 $m^2$)"

Page 17-29, Subarticle 1744-2(B)

In the third paragraph, second sentence, revise the phrase "3 percent" to "2.5 percent."

In the fourth paragraph, following the first sentence, add the following:

"The base plate thickness for all uprights and poles shall be no less than that determined by the following criteria and design:

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 shall be $M = (P \times D_1) / 2$,
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

The critical section shall be located at the face of the anchor bolt and perpendicular to the radius of the bolt circle. The overlapped part of two adjacent critical sections shall be 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 shall be $M = P \times D_2$,
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

The critical section shall be located 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 shall be considered ineffective.

The thickness of base plate of Case 2 shall not be less than that calculated based on formula for Case 1."

Page 17-30, Subarticle 1744-2(C)

Delete paragraphs 1 and 2.

## 2.7. Controllers with Cabinets (1751)

Page 17-34, Subarticle 1751-3(A)

In paragraph 3, replace sentence 2 with the following:

For all other installations, do not program the controller for late night flashing operation unless otherwise directed.

Page 17-34, Subarticle 1751-3(B)

Add the following paragraph after the first paragraph:

Program telemetry command sequences and enable devices necessary for testing of communication between local controllers and field master controllers, and between field master controllers and the central computer.

Page 17-34, Article 1751-4

Replace paragraph 2 with the following:

Actual number of each type of detector cards (2-channels) furnished, installed, and accepted. If 4-channel detector cards are used in order to fulfill the requirements of the plans, payment will be allowed for two detector cards for each 4-channel detector card.

In paragraph 3, revise "No measurement will be made..." to include "modems."

Page 17-35, Article 1751-5

Replace paragraph 2 with the following:

The quantity of detector cards, measured as provided above, will be paid for at the contract unit price each for "Detector Card (_____)."

In paragraph 3, revise "Detector Channel" to "Detector Card."

## 2.8. Closed Loop System Master Controllers (1752)

Page 17-35, Section 1752

*Note: This section now applies only to NEMA TS-2 Closed Loop Systems.*

Change the title to **"CLOSED LOOP SYSTEM MASTER CONTROLLER NEMA TS-2".**

# 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<br>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)
An installation of two 1.25" and four 2" HDPE conduits would be paid as:
Directional Drill Polyethylene Conduit(s), (1.25")(2)&(2")(4).....Linear Foot (Meter)

Payment will be made under:

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

## 5. FIBER-OPTIC SYSTEM SUPPORT EQUIPMENT

### 5.1. DESCRIPTION

Furnish fiber-optic system support equipment 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 SMFO transceivers identical to the type installed in the traffic signal controller cabinets to be used for emergency restoration of the system and the fiber-optic communications system.

### 5.3. METHOD OF MEASUREMENT

Actual number of fiber-optic transceivers furnished and accepted.

### 5.4. BASIS OF PAYMENT

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:

Furnish Fiber-optic Transceiver ..... Each

## 6. CABLE TRANSFERS

### 6.1. DESCRIPTION

Remove and reinstall communications cable due to pole relocations. Comply with the provisions of Section 1700 of the 2002 Standard Specifications for Roads and Structures.

### 6.2. CONSTRUCTION METHODS

During the course of the project, transfers of existing communications cable to new poles may be required. Perform such transfers where directed by the Engineer. Remove the existing cables from the pole to be removed and reinstall these cables and any existing attachment hardware on the new pole. Furnish and install any new attachment hardware as required.

### 6.3. METHOD OF MEASUREMENT

Actual number of cable transfers with attachment hardware to new poles furnished, installed, and accepted.

### 6.4. BASIS OF PAYMENT

The quantity of cable transfers, measured as provided above, will be paid for at the contract unit price each for "Cable Transfer."

Payment will be made under:

Cable Transfer ..... Each

## 7. DRILLED PIER FOUNDATIONS FOR METAL TRAFFIC SIGNAL POLES

### 7.1. 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 2, Item D (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. 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.

## 7.2. 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 soil tests. 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) at each signal pole location.

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 for each signal pole location:

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

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

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

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

**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 2, Item 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.

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 "Other Industry Links."
3) Scroll down and click on "Soils and Foundation Design Section Forms."
4) Click on "Metal Pole Standard Foundation Selection Form."

If assistance is needed with the required calculations, contact the Signals and Geometrics Structures Engineer at (919) 733-3915. However, in no case will the failure or inability to contact the Signals and Geometrics Structures 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 2, Item 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 prior to construction. A professional engineer registered in the state of North Carolina must seal all plans and calculations.

## 7.3. 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 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. All steel casings should consist of clean watertight steel of ample strength to withstand handling and driving stresses and the pressures imposed by concrete, earth or backfill. Use temporary steel casings with an outside diameter equal to the specified size of the pier 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 steel casing left in place will be considered permanent casing and must be installed before excavating or drilling such that the permanent casing is against undisturbed soil. Permanent steel casings are only allowed for strain poles as approved by the Engineer and prohibited for mast arm poles. No additional compensation will be paid for permanent casing. If the Contractor chooses to use permanent steel casing, include all costs for permanent casing in the cost of the contract unit price bid for the "Drilled Pier Foundation" pay item.

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

All slurry use must be in strict conformance with the manufacturer's guidelines and recommendations and as directed 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.

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 prior to 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.

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.

**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 and the concrete 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.

**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 Contractor may use a high early strength mix design as approved by the Engineer. 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. If approved by the Engineer, 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 prior to 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:** Prior to 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 prior to 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.

**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.

**E. 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, do not install adjacent piles and do not allow any equipment wheel 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 prior to 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.

## 7.4. METHOD OF MEASUREMENT

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

Vertical linear feet (meters) of drilled pier length (top of pier elevation minus tip elevation, "L") furnished, installed and accepted.

## 7.5. 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 linear foot (linear meter) as "Drilled Pier Foundation (____-inch (mm) diameter)".

Payment will be made under:

Soil Test ..... Each
Drilled Pier Foundation (____-inch (mm) diameter) ..... Linear Foot (Meter)

## 8. DOUBLE MAST ARM WITH METAL POLE

### 8.1. 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.

### 8.2. MATERIALS

Comply with the provisions of section 1741-2.

### 8.3. CONSTRUCTION METHODS

Comply with the provisions of section 1741-3.

### 8.4. METHOD OF MEASUREMENT

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

### 8.5. 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

## 9. CABINET BASE ADAPTER

### 9.1. DESCRIPTION

Furnish and install cabinet base adapters in accordance with the plans and specifications. Comply with the provisions of Section 1700 of the 2002 Standard Specifications for Roads and Structures.

### 9.2. MATERIALS

Fabricate base adapters out of the same materials and with the same finish as the cabinet housing. Fabricate the base adapter in the same manner as the controller cabinets, meeting all applicable specifications called for in Section 6.2.2 of the CALTRANS Traffic Signal Control Equipment Specifications (TSCES). Provide base adapters that are a minimum height of 12 inches (300 mm).

### 9.3. CONSTRUCTION METHODS

Install cabinet base adapters at every location requiring a new base mounted cabinet whether on new or existing/modified foundations.

### 9.4. METHOD OF MEASUREMENT

Actual number of cabinet base adapters furnished, installed, and accepted.

### 9.5. BASIS OF PAYMENT

The quantity of cabinet base adapters, measured as provided above, will be paid for at the contract unit price each for "Cabinet Base Adapter."

Payment will be made under:

Cabinet Base Adapter .....Each

## 10. TS-1 CONTROLLERS WITH CABINETS

### 10.1. DESCRIPTION

Modify existing controller and cabinet 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.

### 10.2. MATERIALS

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

### 10.3. CONSTRUCTION METHODS

Modify controllers, cabinets, detector sensor units, and hardware that provide the required phasing, color sequence, flash sequence, interconnection, railroad clearance and preemption, and emergency vehicle clearance and preemption as shown in the plans.

Modify proposed phasing and timing of existing controllers.

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

### 10.4. METHOD OF MEASUREMENT

Actual number of controllers with cabinets modified and accepted.

No measurement will be made of maintenance of existing traffic signal after contractor accepts responsibility of traffic signal as this will be considered incidental to modifying controllers with cabinets.

### 10.5. BASIS OF PAYMENT

The quantity of controllers with cabinets, measured as provided above, will be paid for at the contract unit price each for "Modify Controller with Cabinet NEMA TS-1."

Payment will be made under:

Modify Controller with Cabinet NEMA TS-1 .....Each

## 11. METAL SIGNAL POLE REMOVALS

### 11.1. 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.

### 11.2. 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.

### 11.3. METHOD OF MEASUREMENT

Actual number of metal signal poles removed and disposed.

Actual number of metal signal pole foundations removed and disposed.

### 11.4. 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