



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

Prepared By: CEP
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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). 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 $+74^{\circ}\text{C}$ ($+165^{\circ}\text{F}$). 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 $+74^{\circ}\text{C}$ ($+165^{\circ}\text{F}$) 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.

(2) Pedestrian

Design the LED pedestrian traffic signal modules for installation into standard pedestrian traffic signal sections that do not contain the incandescent signal section reflector, lens, eggcrate visor, gasket, or socket. Provide a clear 0.25-inch (6.4-mm), non-glare, mat finish lens 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 surface of a

polycarbonate lens to make it more abrasion resistant. Ensure that the lens has light transmission properties equal to or greater than 80%.

Ensure installation of all modules requires no physical modification of the existing fixture other than the removal of the incandescent signal section reflector, lens, eggcrate visor and socket where applicable.

Design the countdown display as a double row of LEDs, and ensure the countdown display blanks-out during the initial cycle while it records the countdown time. Ensure that the countdown display is operational only during the flashing don't walk, clearance interval. Blank-out the countdown indication after it reaches zero until the beginning of the next don't walk indication, and design the controlling circuitry to prevent the timer from being triggered during the solid hand indication.

Design the man and hand to be a solid display, which meets the minimum requirements of "The Equipment and Materials Standards" of the Institute of Transportation Engineers (ITE) Chapter 3, Table 1 *Symbol Message*. Wire the LEDs such that a catastrophic loss or failure of one or more LEDs will result in the loss of not more than five percent of the signal module light output.

Ensure that the power consumption for the modules is equal to or less than the following in watts, and that the modules have EPA Energy Star compliance ratings, if applicable to that shape, size and color.

TEMPERATURE	77°F (25°C)	165°F (74°C)
HAND	10	12
MAN	9	12
COUNTDOWN	9	12

Provide 16-inch (400-mm) displays, where required by plan or bid document, that have the hand/man overlay on the left and the countdown on the right. Ensure the hand/man meets the dimension requirements cited in Chapter 3, Table 1 *Symbol Message* for Class 3 displays. Ensure that the countdown number display is at least 7 inches high by 6 inches wide. Configure the signal head with a sufficient number of LEDs to provide an average luminous intensity of at least 342 candela per square feet (3750 candela per square meter) of lighting surface for the "RAISED HAND" and "COUNTDOWN", and 483 candela per square feet (5300 candela per square meter) of lighting surface for the "WALKING PERSON". Ensure they meet this average luminous intensity throughout the warranty period over the operating temperature range.

Provide 12 inch (300 mm) displays, where required by plan or bid document, that meet the dimension requirements cited in Chapter 3, Table 1 *Symbol Message* for Class 2 displays. Furnish three types of modules, the solid hand/man module as an overlay, the solid hand module, and the solid man module. Configure the signal head with a sufficient number of LEDs to provide an average luminous intensity of at least 342 candela per square feet (3750 candela per square meter) of lighting surface for the "RAISED HAND" and "COUNTDOWN", and 483 candela per square feet (5300 candela per square meter) of lighting surface for the "WALKING PERSON". Ensure they meet this average luminous intensity throughout the warranty period over the operating temperature range.

Design all modules to operate using a standard 3 - wire field installation. Provide lead wires that are eighteen gauge (18AWG) minimum copper conductors with 221 degree F (105 degree C) insulation. Ensure that lead wires are a minimum of 30 inches (760 mm) long with NEMA "spade" terminals that are appropriate to the lead wires and sized for a #10 screw connection to the existing terminal block in the signal head. Solder the LEDs to the circuit board.

Ensure that modules are 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 80Vrms to 135Vrms. Provide control circuitry to prevent 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; and 170 cabinet 210ECL and 2010ECL conflict monitors (including red monitoring and so-called plus features such as dual indication detection and short yellow time detection).

Comply with the following sections: 3.3, 3.5, 3.6, 5.2, 5.3, 5.7, 6.1, 6.3.1, 6.3.3, 6.3.4, 6.3.5, 6.4.4, 6.4.5, and 6.4.6 of "The Equipment and Material Standards" of the Institute of Transportation Engineers "Vehicular Traffic Control Signal Heads" (VTCSH) Part 2, Chapter 2A.

Furnish Portland Orange LEDs for the hand and countdown that are the latest AlInGaP technology or higher, and Lunar White LEDs for the man that are the latest InGaN technology or higher.

Provide certification with the signal modules when offered for evaluation that your product complies with the sections of the ITE specification identified in paragraph 1.12 above and this specification. Provide test results showing that the signal modules meet or exceed the luminous intensity requirements of sections 1.8 and 1.9 of this specification.

Ship each module as a complete kit designed for retrofitting existing pedestrian signal sections with an LED display module. Provide modules that include, but are not limited to the following items: lens, LED display mounted on a circuit board, wire leads with strain relief, rigid housing, electronics including a power supply integral to the LED module which is protected by the housing, and a neoprene one piece gasket. Ensure that the module is compatible with standard, existing, pedestrian head mounting hardware.

Warrant performance for a period of 60 months from the date of installation and include repair or replacement of an LED signal module that exhibits light output degradation, which in the judgment of the Department, cannot be easily seen at 150 feet (45 meters) in bright sunlight with a visor on the housing or which drops below the luminous intensity output requirements. Warrant failure due to workmanship, materials, and manufacturing defects during the first 60 months after the date of installation. Repair or replace any failed modules within 30 calendar days of notification at no cost to the Department.

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. 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.

1.4. 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.”

In the first full paragraph, add the following sentence:

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

1.5. Type 170E Cabinets (1098-19)

Page 10-241, Subarticle 1098-19(B)

Add the following paragraph:

If additional surge protected power outlets are needed to accommodate fiber transceivers, modems, etc.; install a UL listed, industrial, heavy-duty type power outlet strip with a maximum rating of 15 A / 125 VAC, 60 Hz. Provide a strip that has a minimum of 3 grounded outlets. Ensure the power outlet strip plugs into one of the controller unit receptacles located on the rear of the PDA. Ensure power outlet strip is mounted securely; provide strain relief if necessary.

Pages 10-245-247, Subarticle 1098-19 (D) (**Model 2010 Enhanced Conflict Monitor**)

Replace Subarticle (D) with the following:

Furnish Model 2010 Enhanced Conflict Monitors with 16 channels. In addition to CALTRANS requirements, ensure that the conflict monitor monitors for the absence of a valid voltage level on at least one channel output of each load switch. Ensure that the absence of the programming card will cause the conflict monitor to trigger, and remain in the triggered state until reset.

Provide a conflict monitor that recognizes the faults specified by CALTRANS and the following additional per channel faults that apply for monitor inputs to each channel:

- consider a Red input greater than 70 Vrms as an “on” condition;
- consider a Red input less than 50 Vrms as an “off” condition (no valid signal);
- consider a Red input between 50 Vrms and 70 Vrms to be undefined by these specifications;
- consider a Yellow or Green input greater than 25 Vrms as an “on” condition;
- consider a Green or Yellow input less than 15 Vrms as an “off” condition; and
- consider a Green or Yellow input between 15 Vrms and 25 Vrms to be undefined by these specifications.

Ensure that the monitor will trigger upon detection of a fault and will remain in the triggered (failure detected) state until the unit is reset at the front panel or through the remote reset input for the following failures:

1. **Red Monitoring or Absence of Any Indication (Red Failure):** A condition in which no valid voltage signal is detected on any of the green, yellow, or red inputs to a given monitor channel. If a signal is not detected on at least one input (R, Y, or G) of a conflict monitor channel for a period greater than 1000 ms when used with a 170 controller and 1500 ms when used with a 2070L controller, ensure that the monitor will trigger and put the intersection into flash. If the absence of any indication condition lasts less than 750 ms when used with a 170 controller and 1200 ms when used with a 2070L controller, ensure that the conflict monitor will not trigger. Have red monitoring occur when the P20 Connector is installed and both of the following input conditions are in effect: a) the Red Enable input to monitor is active (Red Enable voltages are “on” at greater than 70 Vrms, off at less than 50 Vrms, undefined between 50 Vrms and 70 Vrms), and b) and neither Special Function 1 nor Special Function 2 inputs are active.
2. **Yellow Indication Sequence Error:** Yellow indication following a green is missing or shorter than 2.7 seconds (with ± 0.1 -second accuracy). If a channel fails to detect an “on” signal at the Yellow input following the detection of an “on” signal at a Green input for that channel, ensure that the monitor triggers and generates a sequence error fault indication.
3. **Dual Indications on the Same Channel:** In this condition, more than one indication (R,Y,G) is detected as “on” at the same time on the same channel. If dual indications are detected for a period greater than 500 ms, ensure that the conflict monitor triggers and displays the proper failure indication (Dual Ind fault). If this condition is detected for less than 250 ms, ensure that the monitor does not trigger.

Enable the monitor function for short/missing yellows and for dual indications on a per channel basis.

Provide Special Function 1 and Special Function 2 that comply with the Los Angeles City DOT Traffic Signal Specification DOT 170 ATSAC Universal and Related Equipment #54-053-02 to eliminate red failure monitoring while allowing other additional enhanced fault monitoring functions to continue.

Ensure that the removal of the P-20 ribbon cable will cause the monitor to recognize a latching fault condition and place the cabinet into flashing operation.

Ensure that when the Conflict Monitor is triggered due to a fault, it provides an LED indication identifying the type of failure detected by the monitor except for the P20 ribbon cable removal fault. Ensure that the monitor indicates which channels were active during a conflict condition and which channels experienced a failure for all other per channel fault conditions detected, and that these indications and the status of each channel are retained until the Conflict Monitor is reset.

Ensure that the conflict monitor will store at least nine of the most recent malfunctions detected by the monitor in EEPROM memory. For each malfunction, record at a minimum the time, date, type of malfunction, relevant field signal indications, and specific channels involved with the malfunction.

Provide communications from the monitor to the 170/2070L controller via an RS-232C/D port on the monitor in order to upload all event log information from the monitor to the controller or to a system computer via the controller. Ensure that the controller can receive the data through a controller Asynchronous Communications Interface Adapter (Type 170E) or Async Serial Comm Module (2070L) determined by the controller software. Provide software capable of communicating directly through the same monitor RS-232C/D to retrieve all event log information to a laptop computer.

In addition to the connectors required by the CALTRANS Specifications, provide the conflict monitor with a connector mounted on the front of the monitor (3M-3428-5302 with two polarizing keys or equal) which mates with a 20 pin ribbon cable connector that conducts the signals from the P20 connector on the cabinet assembly. Provide a P20 connector and terminal assembly that complies with the Los Angeles City DOT "Traffic Signal Specification DOT 170 ATSAC Universal and Related Equipment #54-053-02" in effect on the date of advertisement. Provide connector pins on the monitor with the following functions:

Pin #	Function	Pin #	Function
1	Channel 15 Red	11	Channel 9 Red
2	Channel 16 Red	12	Channel 8 Red
3	Channel 14 Red	13	Channel 7 Red
4	Chassis Ground	14	Channel 6 Red
5	Channel 13 Red	15	Channel 5 Red
6	Special Function 2	16	Channel 4 Red
7	Channel 12 Red	17	Channel 3 Red
8	Special Function 1	18	Channel 2 Red
9	Channel 10 Red	19	Channel 1 Red
10	Channel 11 Red	20	Red Enable

Provide a DB-9 female connector for the purpose of data communication with the controller. Electrically isolate the port interface electronics from all monitor electronics, excluding Chassis Ground. Furnish a communications connecting cable with pin connections as follows:

170		Conflict Monitor DB-9
RX pin L	Connect to	TX pin 2
TX pin K	Connect to	RX pin 3
+5 pin D	Connect to	DTR pin 4
GND pin N	Connect to	GND pin 5

2070L		Conflict Monitor DB-9
DCD pin 1	Connect to	DCD pin 1
RX pin 2	Connect to	TX pin 2
TX pin 3	Connect to	RX pin 3
GND pin 5	Connect to	GND pin 5
RTS pin 7	Connect to	CTS pin 7
CTS pin 8	Connect to	RTS pin 8

1.6. 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.

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. 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.

2.4. 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:

$$P_{TG} = 900C_d I_F \text{ (Pa)}$$
$$P_{TG} = 18.8C_d I_F \text{ (psf)}$$

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:

$$P_{TG} = 900C_d(V/30 \text{ m/s})^2 I_F \text{ (Pa)} \quad \text{Eq. C 11-6}$$
$$P_{TG} = 18.8C_d(V/65 \text{ mph})^2 I_F \text{ (psf)}$$

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 ft² (2.4 m²)
- 4-section, 12-inch (300-mm)

Surface area: 32.0 ft² (3.0 m²)

- 5-section, 12-inch (300-mm)
Surface area: 42.0 ft² (3.9 m²)”

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.

2.5. **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."

3. DIRECTIONAL DRILLING

3.1. 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.

3.2. 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.

3.3. 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.

3.4. 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.

3.5. 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)

4. DRILLED PIER FOUNDATIONS FOR METAL TRAFFIC SIGNAL POLES

4.1. 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.

4.2. 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:

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

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

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

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

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

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

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.

4.3. 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 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

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/yd³ (380 kg/m³) and a maximum cement content of 800 lbs/yd³ (475 kg/m³); 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/yd³ (395 kg/m³) Type IP blended cement and a maximum of 833 lbs/yd³ (494 kg/m³) 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.

4.4. 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.

4.5. 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)

5. DOUBLE MAST ARM WITH METAL POLE

5.1. 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.

5.2. MATERIALS

Comply with the provisions of section 1741-2.

5.3. CONSTRUCTION METHODS

Comply with the provisions of section 1741-3.

5.4. METHOD OF MEASUREMENT

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

5.5. 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