



Project Special Provisions

(Version 06.2)

Signals and Intelligent Transportation Systems

*Prepared By: luhr
28-Sep-06*

Contents

- 1. 2006 STANDARD SPECIFICATIONS FOR ROADS & STRUCTURES – SECTION 1098 REVISIONS2
 - 1.1. GENERAL REQUIREMENTS (1098-1)2
- 2. ELECTRICAL REQUIREMENTS.....2
- 3. SIGNAL HEADS.....2
 - 3.1. MATERIALS.....2
 - A. General:2
 - B. Vehicle Signal Heads:.....3
 - C. Signal Cable:8
- 4. POLYCARBONATE SIGNAL HEADS8
 - 4.1. DESCRIPTION8
 - 4.2. MATERIAL8
 - 4.3. CONSTRUCTION METHODS9
 - 4.4. MEASUREMENT AND PAYMENT9
- 5. METAL TRAFFIC SIGNAL SUPPORTS.....9
 - 5.1. METAL TRAFFIC SIGNAL SUPPORTS – ALL POLES9
 - A. General:9
 - B. Materials:.....10
 - C. Construction Methods:.....10
 - 5.2. METAL POLE WITH MAST ARM12
 - A. Materials:.....12
 - B. Construction Methods:.....12
 - 5.3. DRILLED PIER FOUNDATIONS FOR METAL TRAFFIC SIGNAL POLES12
 - A. Description:12
 - B. Soil Test and Foundation Determination:12
 - C. Drilled Pier Construction:14
 - 5.4. CUSTOM DESIGN OF TRAFFIC SIGNAL SUPPORTS.....18
 - A. General:18
 - B. Metal Poles:19
 - C. Mast Arms:.....21
 - 5.5. MEASUREMENT AND PAYMENT21

1. 2006 STANDARD SPECIFICATIONS FOR ROADS & STRUCTURES – SECTION 1098 REVISIONS

The 2006 Standard Specifications are revised as follows:

1.1. General Requirements (1098-1)

Page 10-268, Subarticle 1098-1(H)

In the second paragraph, add “Use 200 amp meter base for underground electrical service”.

2. 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.

3. SIGNAL HEADS

3.1. MATERIALS

A. General:

Fabricate vehicle signal head housings and end caps from die-cast aluminum. Fabricate 12-inch and 16-inch pedestrian signal head housings and end caps from die-cast aluminum. Fabricate 9-inch pedestrian signal head housings, end caps, and visors from virgin polycarbonate material. Provide visor mounting screws, door latches, and hinge pins fabricated from stainless steel. Provide interior screws, fasteners, and metal parts fabricated from stainless steel or corrosion resistant material.

Fabricate tunnel and traditional visors from sheet aluminum.

Paint all surfaces inside and outside of signal housings and doors. Paint outside surfaces of tunnel and traditional visors, messenger cable mounting assemblies, pole and pedestal mounting assemblies, and pedestrian pushbutton housings. Have electrostatically-applied, fused-polyester paint in highway yellow (Federal Standard 595A, Color Chip Number 13538) a minimum of 2.5 to 3.5 mils thick. Do not apply paint to the latching hardware or rigid vehicle signal head mounting brackets.

Have the interior surfaces of tunnel and traditional visors painted an alkyd urea black synthetic baking enamel with a minimum gloss reflectance and meeting the requirements of MIL-E-10169, “Enamel Heat Resisting, Instrument Black.”

For pole mounting, provide side of pole mounting assemblies with framework and all other hardware necessary to make complete, watertight connections of the signal heads to the poles and pedestals. Fabricate the mounting assemblies and frames from aluminum with all necessary hardware, screws, washers, etc. to be stainless steel. Provide mounting fittings that match the positive locking device on the signal head with the serrations integrally cast into the brackets. Provide upper and lower pole plates that have a 1 ¼-inch vertical conduit entrance hubs with the hubs capped on the lower plate and 1 ½-inch horizontal hubs. Ensure that the assemblies provide rigid attachments to poles and pedestals so as to allow no twisting or swaying of the signal heads. Ensure that all raceways are free of sharp edges and protrusions, and can accommodate a minimum of ten Number 14 AWG conductors.

For pedestal mounting, provide a post-top slipfitter mounting assembly that matches the positive locking device on the signal head with serrations integrally cast into the slipfitter. Provide stainless

steel hardware, screws, washers, etc. Provide a minimum of six 3/8 X 3/4-inch long square head bolts for attachment to pedestal. Provide a center post for multi-way slipfitters.

B. Vehicle Signal Heads:

Comply with the ITE standard "Vehicle Traffic Control Signal Heads". Provide housings with provisions for attaching backplates.

Provide visors that are 8 inches in length for 8-inch vehicle signal head sections. Provide visors that are 10 inches in length for 12-inch vehicle signal heads.

Provide a termination block with one empty terminal for field wiring for each indication plus one empty terminal for the neutral conductor. Have all signal sections wired to the termination block. Provide barriers between the terminals that have terminal screws with a minimum Number 8 thread size and that will accommodate and secure spade lugs sized for a Number 10 terminal screw.

Mount termination blocks in the yellow signal head sections on all in-line vehicle signal heads. Mount the termination block in the red section on five-section vehicle signal heads.

Furnish vehicle signal head interconnecting brackets. Provide one-piece aluminum brackets less than 4.5 inches in height and with no threaded pipe connections. Provide hand holes on the bottom of the brackets to aid in installing wires to the signal heads. Lower brackets that carry no wires and are used only for connecting the bottom signal sections together may be flat in construction.

For messenger cable mounting, provide messenger cable hangers, wire outlet bodies, balance adjusters, bottom caps, wire entrance fitting brackets, and all other hardware necessary to make complete, watertight connections of the vehicle signal heads to the messenger cable. Fabricate mounting assemblies from malleable iron and provide serrated rings made of aluminum. Provide messenger cable hangers and balance adjusters that are galvanized before being painted. Fabricate balance adjuster eyebolt and eyebolt nut from stainless steel or galvanized malleable iron. Provide messenger cable hangers with U-bolt clamps. Fabricate washers, screws, bolts, clevis pins, cotter pins, nuts, and U-bolt clamps from stainless steel.

For mast-arm mounting, provide rigid vehicle signal head mounting brackets and all other hardware necessary to make complete, watertight connections of the vehicle signal heads to the mast arms and to provide a means for vertically adjusting the vehicle signal heads to proper alignment. Fabricate the mounting assemblies from malleable iron or aluminum, and provide serrated rings made of aluminum.

Provide light emitting diode (LED) vehicular traffic signal modules (hereafter referred to as modules) that consist of an assembly that uses 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°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.

1. LED Circular Signal Modules:

Provide modules in the following configurations: 12-inch circular sections, and 8-inch circular sections. All makes and models of LED modules purchased for use on the State Highway System shall appear on the current NCDOT Traffic Signal Qualified Products List (QPL).

Ensure, unless otherwise state in these specifications, that each module meets or exceeds the ITE "Vehicle Traffic Control Signal Heads – Light Emitting Diode (LED) Circular Signal Supplement" dated June 27, 2005 (hereafter referred to as VTCSH Circular Supplement).

Certify compliance with paragraphs 3.3.2, 3.3.3, 3.4.2, 4.1.1, 4.1.2, 4.1.3, 4.2.1, 4.2.2, 5.2.1, 5.2.2, 5.2.3, 5.2.4, 5.2.5, 5.3, 5.4, 5.5.1, 5.5.2, 5.6.2, 5.7 of the VTCSH Circular Supplement.

Provide quick connect Molex terminals (part # 19092026 female housing, part # 02091615 female pin, part # 19092027 male housing, and 02092101 male pin) or equivalent, and 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 the replacement module provided has the Molex male connector 6 inches from the module.

Ensure the power supply is integral to the module assembly. On the back of the module, permanently mark the date of manufacture (month & year) or some other method of identifying date of manufacture.

Tint the red, yellow and green lenses to correspond with the wavelength (chromaticity) of the LED. Transparent tinting films are unacceptable.

Provide modules that meet the requirements of Tables 1098-1 and 1098-2.

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 installation of the modules. During the warranty period, the manufacturer must provide replacement modules within 45 days of receipt of modules that have failed at no cost to the State. Provide manufacturer's warranty documentation to the Department during evaluation of product for inclusion on Qualified Products List (QPL).

Table 1098-1

Maximum Power Consumption (in Watts) at 77°F

	Red	Yellow	Green
12-inch circular	12	22	15
8-inch circular	8	13	12

Table 1098-2

Minimum Maintained Luminous Intensity/Minimum Initial Luminous Intensity (in cd) at 77°F

Vertical Angle	Horizontal Angle	Red 8"		Yellow 8"		Green 8"		Red 12"		Yellow 12"		Green 12"	
		Main.	Initial	Main.	Initial	Main.	Initial	Main.	Initial	Main.	Initial	Main.	Initial
+12.5	2.5	17	21	41	51	22	28	37	46	91	114	48	60
	7.5	13	16	33	41	17	21	29	36	73	91	38	48
+7.5	2.5	31	39	78	98	41	51	69	86	173	216	90	113
	7.5	25	31	62	78	32	40	55	69	137	171	71	89
	12.5	18	23	45	56	24	30	40	50	100	125	52	65
+2.5	2.5	68	85	168	210	88	110	150	188	373	466	195	244
	7.5	56	70	139	174	73	91	124	155	309	386	162	203
	12.5	38	48	94	118	49	61	84	105	209	261	109	136
	17.5	21	26	53	66	28	35	47	59	118	148	62	78
-2.5	22.5	12	15	29	36	15	19	26	33	64	80	33	41
	2.5	162	203	402	503	211	264	358	448	892	1115	466	583
	7.5	132	165	328	410	172	215	292	365	728	910	380	475
	12.5	91	114	226	283	118	148	201	251	501	626	261	326
	17.5	53	66	131	164	69	86	117	146	291	364	152	190
-7.5	22.5	28	35	70	88	37	46	62	78	155	194	81	101
	27.5	15	19	37	46	19	24	33	41	82	103	43	54
	2.5	127	159	316	395	166	208	281	351	701	876	366	458
	7.5	106	133	262	328	138	173	234	293	582	728	304	380
	12.5	71	89	176	220	92	115	157	196	391	489	204	255
	17.5	41	51	103	129	54	68	91	114	228	285	119	149
-12.5	22.5	21	26	53	66	28	35	47	59	118	148	62	78
	27.5	12	15	29	36	15	19	26	33	64	80	33	41
	2.5	50	63	123	154	65	81	110	138	273	341	143	179
	7.5	40	50	98	123	52	65	88	110	218	273	114	143
	12.5	28	35	70	88	37	46	62	78	155	194	81	101
	17.5	17	21	41	51	22	28	37	46	91	114	48	60
-17.5	22.5	8	10	21	26	11	14	18	23	46	58	24	30
	27.5	5	6	12	15	6	8	11	14	27	34	14	18
	2.5	23	29	57	71	30	38	51	64	127	159	67	84
	7.5	18	23	45	56	24	30	40	50	100	125	52	65
	12.5	13	16	33	41	17	21	29	36	73	91	38	48
-22.5	17.5	7	9	16	20	9	11	15	19	36	45	19	24
	22.5	3	4	8	10	4	5	7	9	18	23	10	13
	2.5	17	21	41	51	22	28	37	46	91	114	48	60
	7.5	13	16	33	41	17	21	29	36	73	91	38	48
-27.5	12.5	10	13	25	31	13	16	22	28	55	69	29	36
	17.5	5	6	12	15	6	8	11	14	27	34	14	18
	2.5	12	15	29	36	15	19	26	33	64	80	33	41
	7.5	8	10	21	26	11	14	18	23	46	58	24	30

Note 1: Luminous intensity values for equivalent left and right horizontal angles are the same.

Note 2: Tabulated values of luminous intensity are rounded to the nearest whole value.

2. LED Arrow Signal Modules

Ensure arrow modules meet or exceed the electrical and environmental operating requirements of sections 3 and 5 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), the 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 1098-3. 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 rms, and measure all parameters at this voltage.

**Table 1098-3
Maximum Power Consumption (in Watts) at 77°F**

	Red	Yellow	Green
12-inch arrow	9	10	11

Certify that the module meets the requirements of VTCSH-2, Section 5.7. Ensure all wiring meets the requirements of Section 5.1 of the VTCSH-2. In addition, provide quick connect Molex terminals (part # 19092026 female housing, part # 02091615 female pin, part # 19092027 male housing, and 02092101 male pin) or equivalent, and 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 the replacement module provided has the Molex male connector 6 inches from the module.

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 less, and on-state to be 40 Vrms or greater. Design the voltage to decay to 10 Vrms or less in 100 milliseconds. 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 Table 1098-4. 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 arrow modules for maintained luminous intensity at 165°F (ITE 6.4.2.2). Use LEDs that conform to the chromaticity requirements of VTCSH-2, Section 2 throughout the warranty period over the operating temperature range. Make chromaticity coordinate compliance measurements at 77°F.

**Table 1098-4
Minimum Initial and Maintained Luminance for Arrow Indications (in cd/ft²)**

	Red	Yellow	Green
Arrow Indication	511	1022	1022

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°F to +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. Group 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, yellow, and green lens to match the wavelength (chromaticity) of the LED.

Ensure that the module meets specifications stated in Chapter 2, Section 9.01 of the ITE Equipment and Materials Standards 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.**

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

- (a) **Photometric (Rated Initial Luminous Intensity)** - Measure at +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 +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)

NCDOT evaluates and approves all LED Traffic Signal modules for the QPL by a standard visual inspection and blind operational survey, a compatibility test, current flow, and other random tests, in addition to reviewing the lab reports and documentation from the manufacturer. The tests are conducted at the Traffic Electronics Center in Raleigh. Ensure each 12-inch arrow

module is visible at 300 feet 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 installation of the modules. During the warranty period, the manufacturer must provide replacement modules within 45 days of receipt of modules that have failed at no cost to the State. Provide manufacturer's warranty documentation to the Department during evaluation of product for inclusion on Qualified Products List (QPL).

C. Signal Cable:

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. Provide a cable jacket labeled with the IMSA specification number and provide conductors constructed of stranded copper.

4. POLYCARBONATE SIGNAL HEADS

4.1. DESCRIPTION

Furnish and install **polycarbonate** vehicle LED signal heads and signal cable with all necessary hardware in accordance with the plans and specifications. Comply with the provisions of Section 1700 of the 2006 Standard Specifications for Roads and Structures.

4.2. MATERIAL

Comply with the provisions of Section 3 of these Project Special Provisions with the following exceptions:

Fabricate signal head housings, end caps, and visors from virgin **polycarbonate** material. Provide U.V. stabilized **polycarbonate** plastic with a minimum thickness of 0.1 ± 0.01 inches that is dull black (Federal Standard 959A-37038) with a reflectance value not exceeding 25 percent as measured by ASTM E 97. Ensure the black color is incorporated into the plastic material before molding. Ensure the plastic formulation provides the following physical properties in the assembly (tests may be performed on separately molded specimens):

Test	Required	Method
Specific Gravity	1.17 minimum	ASTM D 792
Vicat Softening Temperature, °F	305-325	ASTM D 1525
Brittleness Temperature, °F	Below -200	ASTM D 746
Flammability	Self-extinguishing	ASTM D 635
Tensile Strength, yield, PSI	8500 minimum	ASTM D 638

Elongation at yield, %	5.5-8.5	ASTM D 638
Shear, strength, yield, PSI	5500 minimum	ASTM D 732
Izod impact strength, ft-lb/in [notched, 1/8 inch]	15 minimum	ASTM D 256
Fatigue strength, PSI at 2.5 mm cycles	950 minimum	ASTM D 671

4.3. CONSTRUCTION METHODS

Comply with the provisions of Section 1705 of the 2006 Standard Specifications for Roads and Structures with the following exception:

Install **polycarbonate** vehicle signal heads with mast arm mounting assemblies only.

4.4. MEASUREMENT AND PAYMENT

Polycarbonate Vehicle Signal Head () will be measured and paid for as the actual number of signal heads of each type, size, and number of sections with mounting hardware furnished, installed, and accepted.

See Article 1705-4 of the 2006 Standard Specifications for Roads and Structures for signal cable and incidental items.

Payment will be made under:

Polycarbonate Vehicle Signal Head ().....Each

5. METAL TRAFFIC SIGNAL SUPPORTS

5.1. METAL TRAFFIC SIGNAL SUPPORTS – ALL POLES

A. General:

Furnish and install metal poles with mast arms, grounding systems, and all necessary hardware. The work covered by this special provision includes requirements for the design, fabrication, and installation of both standard and custom/site specifically designed metal traffic signal supports and associated foundations.

Provide metal traffic signal support systems that contain no guy assemblies, struts, or stay braces. Provide designs of completed assemblies with hardware that equals or exceeds AASHTO *Standard Specifications for Structural Supports for Highway Signs, Luminaries and Traffic Signals* 4th Edition, 2001 (hereafter called 4th Edition AASHTO), including the latest interim specifications. Provide assemblies with a round or near-round cross-sectional design consisting of no less than six sides. The sides may be straight, convex, or concave.

Comply with Subarticle 1098-1B “General Requirements” of the *Standard Specifications* for submittal requirements. Furnish shop drawings for approval. Provide triplicate copies of detailed shop drawings for each type of structure. Ensure that shop drawings show materials specifications for each component and identifies welds by type and size. Do not release structures for fabrication until structural drawings have been approved. Provide an itemized bill of materials for all structural components and associated connecting hardware on the drawings.

If plans call for Standard Metal Signal Supports, comply with Subarticle 1098-1A "General Requirements" for QPL submittals.

B. Materials:

Fabricate monotube shafts with a uniform linear taper of 0.14 in/ft with steel that conforms to ASTM A-595 minimum Grade A or an approved equivalent. Galvanize in accordance with AASHTO M111.

Use the submerged arc process to continuously weld shafts for the entire length. Ground or roll smooth exposed welds until flush with the base metal. Ensure shafts have no circumferential welds except at the lower end joining the shaft to the base. Provide welding that conforms to Article 1072-20 of the *Standard Specifications*, except that no field welding on any part of the pole will be permitted.

Refer to Standard Drawings for Metal Poles M2 for fabrication details. Fabricate anchor bases from plate steel meeting the requirements of ASTM A 36M or cast steel meeting the requirements of ASTM A 27M Grade 485-250, AASHTO M270 grade 36 or an approved equivalent. Conform to the applicable bolt pattern and orientation specified by the design as shown on drawing M2.

Ensure hardware is galvanized steel or stainless steel.

Ensure material used in steel anchor bolts conforms to AASHTO M 314, and yield strength does not exceed 55,000 psi. Unless otherwise required by the design, ensure each anchor bolt is 2" in diameter and 60" in length. Provide 10" minimum thread projection at the top of the bolt, and 8" minimum at the bottom of the bolt. Galvanize each anchor bolt in accordance with AASHTO M232 or M298 from the top of the bolt to a minimum of 2" below the threads.

Provide a circular anchor bolt lock plate that will be secured to the anchor bolts at the embedded end with 2 washers and nuts. Provide a base plate template that matches the bolt circle diameter of the anchor bolt lock plate. Construct plates and templates from ¼" minimum thick steel with a minimum width of 4". Galvanizing is not required.

Provide 4 heavy hex nuts and 4 flat washers for each anchor bolt. For nuts, use AASHTO M291 grade 2H, DH, or DH3 or equivalent material. For flat washers, use AASHTO M293 or equivalent material.

Ensure end caps for poles or mast arms are constructed of cast aluminum conforming to Aluminum Association Alloy 356.0F.

C. Construction Methods:

Erect signal supports poles only after concrete has attained a minimum allowable compressive strength of 3000 psi. Follow anchor nut-tightening procedures below to complete the installation of the upright. For further construction methods, see construction methods for Metal Strain Poles, or Metal Pole with Mast Arm.

Connect poles to grounding electrodes and the intersection grounding systems.

For holes in the poles used to accommodate cables, install grommets before wiring pole or arm. Do not cut or split grommets.

Attach the terminal compartment cover to the pole by a sturdy chain or cable. Ensure the chain or cable is long enough to permit the cover to hang clear of the compartment opening when the cover is removed, and is strong enough to prevent vandals from being able to disconnect the cover from the pole. Ensure the chain or cable will not interfere with service to the cables in the pole base.

Attach cap to pole with a sturdy chain or cable. Ensure the chain or cable is long enough to permit the cap to hang clear of the opening when the cap is removed.

Perform repair of damaged galvanizing that complies with the *Standard Specifications*, Article 1076-6 "Repair of Galvanizing."

Anchor Nut Tightening Procedure

Compute the required projection of the anchor bolt above the foundation top. Compute the total projection based on the following:

- Provide between 3 and 5 threads of anchor bolt projection above the top nut after tightening is complete. Avoid any additional projection, or a normal depth socket torque wrench can not be used on top nuts.
- Include the sum of the thickness of top nut, top nut flat washer or top nut beveled washer, base plate, leveling nut flat washer or leveling nut beveled washer, and leveling nut.
- Set the maximum distance between the bottom of the leveling nut and the foundation top to one nut height to avoid excessive bending stresses in the anchor bolt under service conditions.
- Do not use lock washers.

Installation Procedure:

1. Place a leveling nut and washer on each anchor bolt and install a template on top of the leveling nuts to verify that the nuts are level and uniformly contact the template. Use beveled washers if the leveling nuts cannot be brought into firm contact with the template. Verify that the distance between the bottom of the leveling nuts and the top of the concrete is no more than one nut height. Consider how attachments and applied loads may affect the vertical nature of the metal pole after erected and fully loaded. If necessary, induce a rake to the upright in the opposite direction of the anticipated loads during the initial erection by adjusting the leveling nuts accordingly. Failure to consider this could result in the upright being out of the allowable vertical tolerance as specified in the Metal Strain Pole Construction Methods of this special provision.
2. Install the vertical upright on the anchor bolts, and tighten nuts in compliance with steps 3, 4, and 5 below. Do not attach cantilever arms or messenger cable to the vertical post until all of the top nuts and leveling nuts have been properly tightened on the anchor bolts.
3. Install top nuts and washers. Install flat washers under the top and leveling nuts. Use beveled washers if the nuts cannot be brought into firm contact with the base plate. Lubricate threads of the anchor bolts, nuts, and bearing surface of the nuts and tighten to a snug-tight condition with a spud wrench following a star pattern (using at least two increments). Snug-tight condition is defined as 20% to 30% of the verification torque (600 ft-lbs.). Ensure lubricant is beeswax, stick paraffin, or other approved lubricant.
4. After the top nuts have been snug tightened, snug tighten the bottom nuts up to the base plate using the same procedure as described above. The base-plate must be in firm contact with both the top and bottom nuts to achieve the proper pretension in the anchor bolts.
5. Before further turning of the nuts, mark the reference position of the top nut in the snug-tight condition by match marking each nut, bolt shank, and base plate. Use ink or paint that is not water-soluble.
6. Turn the top nuts in increments using the star pattern (using at least two full tightening cycles) to 1/6 of a turn. Use a torque wrench to verify that at least 600 ft-lbs. is required to further tighten the top nuts. At least 48 hours after the entire structure and any attachments are erected, use a

torque wrench again to verify that at least 600 ft-lbs. is still required to tighten the top nuts. Verify that the leveling nuts remain in firm contact with the base plate.

7. Do not place non-shrink grout between the base plate and foundation. This will allow for future inspection of leveling nuts and for adequate drainage of moisture.

5.2. METAL POLE WITH MAST ARM

A. Materials:

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

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

B. Construction Methods:

Install horizontal-type arms within 2 degrees of horizontal when loaded with signal heads and signs.

Attach cap to the mast arm with a sturdy chain or cable. Ensure that the chain or cable is long enough to permit the cap to hang clear of the arm opening when the cap is removed.

5.3. DRILLED PIER FOUNDATIONS FOR METAL TRAFFIC SIGNAL POLES

A. 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 B4 (Non-Standard Foundation Design) below.

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

B. Soil Test and Foundation Determination:

1. 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.

2. Soil Test:

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

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. Discontinue the boring if one of the following occurs:

- A total of 100 blows have been applied in any 2 consecutive 6-in. intervals.
- A total of 50 blows have been applied with < 3-in. 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.

3. Standard Foundation Determination:

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

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

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

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

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

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 2 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 2 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 Standard Foundations Chart (sheet M 8) 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 (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 Standard Foundations Chart 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 Standard Foundations Chart, is greater than the depth of the corresponding boring.

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

The Standard Foundations Chart 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 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.NC DOT.org/business/.
- 2) Click on "Geotechnical Engineering Unit Forms."
- 3) Click on "Metal Pole Standard Foundation Selection Form."

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

4. Non-Standard Foundation Design:

Design non-standard foundations based upon site-specific soil test information collected in accordance with Section 2 (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 at the top of the pier and a horizontal rotational movement of less than 1 inch at the edge of the pier. Contact the Engineer for pole loading diagrams for standard poles to be used for non-standard foundation designs. Submit any non-standard foundation designs including plans, calculations, and soil boring logs to the Engineer for review and approval before construction. A professional engineer registered in the state of North Carolina must seal all plans and calculations.

C. Drilled Pier Construction:

1. 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 *Standard Specifications*. Drilling spoils consist of all material excavated including water or slurry removed from the excavation either by pumping or with augers.

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

Construct drilled piers within the tolerances specified herein. If tolerances are exceeded, provide additional construction as approved by the Engineer to bring the piers within the tolerances specified. Construct drilled piers such that the axis at the top of the piers is no more than 3 inches 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 above and 2 inches above the finished grade elevation. Form the top of the pier such that the concrete is smooth and level.

If unstable, caving, or sloughing soils are anticipated or encountered, stabilize drilled pier excavations with either steel casing or polymer slurry. Steel casing may be either the sectional type or one continuous corrugated or non-corrugated piece. Ensure all steel casings consist of clean watertight steel of ample strength to withstand handling and driving stresses and the pressures imposed by concrete, earth or backfill. Use steel casings with an outside diameter equal to the specified pier size and a minimum wall thickness of 1/4 inches. Extract all temporary casings during concrete placement in accordance with this special provision unless the Contractor chooses to leave the casing in place in accordance with the requirements below.

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

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

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

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

Use slurry in accordance with the manufacturer's guidelines and recommendations unless approved otherwise by the Engineer. The Contractor should be aware that polymer slurry may not be

appropriate for a given site. Polymer slurry should not be used for excavations in soft or loose soils as determined by the Engineer.

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

2. Reinforcing Steel:

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

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

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

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.

In order to ensure a minimum of 3 inches 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 "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 intervals. Supply additional peripheral spacer wheels at closer intervals as necessary or as directed by the Engineer.

3. Concrete:

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

a) 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 *Standard Specifications*.

Designate the concrete as Drilled Pier Concrete with a minimum compressive strength of 4500 psi at 28 days. The Contractor may use a high early strength mix. Make certain the cementitious material content complies with one of the following options:

- Provide a minimum cement content of 640 lbs/yd³ and a maximum cement content of 800 lbs/yd³; 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 of fly ash per lb of cement removed.
- If Type IP blended cement is used, use a minimum of 665 lbs/yd³ Type IP blended cement and a maximum of 833 lbs/yd³ 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 for dry placement of concrete or 7 and 9 inches 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 or less.

b) Concrete Placement

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

Do not dewater any drilled pier excavations unless the excavation is entirely cased down to tip. Do not begin to remove the temporary casing until the level of concrete within the casing is in excess of 10 feet above the bottom of the casing being removed. Maintain the concrete level at least 10 feet 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 per half hour, the concrete placement is considered dry. If the water inflow rate is greater than 6 inches per half hour, the concrete placement is considered wet.

- **Dry Placement:** Before placing concrete, make certain the drilled pier excavation is dry so the flow of concrete completely around the reinforcing steel can be certified by visual inspection. Place the concrete by free fall with a central drop method where the concrete is chuted directly down the center of the excavation.
- **Wet Placement:** Maintain a static water or slurry level in the excavation before placing concrete. Place concrete with a tremie or a pump in accordance with the applicable parts of Sections 420-6 and 420-8 of the *Standard Specifications*. 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 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 of the drilled pier or as approved by the Engineer. Remove any contaminated concrete from the top of the drilled pier and wasted concrete from the area surrounding the drilled pier upon completion.

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

4. Concrete Placement Time:

Place concrete within the time frames specified in Table 1000-2 of the *Standard Specifications* 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.

5. Scheduling and Restrictions:

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

The foundation will be considered acceptable for loading when the concrete reaches a minimum compressive strength of 3000 psi. This provision is intended to allow the structure to be installed on the foundation in a shorter time frame, and does not constitute full acceptance of the drilled pier. Full acceptance will be determined when the concrete meets its full strength at 28 days.

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. Propose remedial measures for any defective drilled piers and obtain approval of all proposals from the Engineer before implementation. No additional compensation will be paid for losses or damage due to remedial work or any investigation of drilled piers found defective or not in accordance with these special provision or the plans.

5.4. CUSTOM DESIGN OF TRAFFIC SIGNAL SUPPORTS

A. General:

Design traffic signal supports with foundations consisting of metal poles with mast arms.

The lengths of the metal signal poles shown on the plans are estimated from available data for bid purposes. Determine the actual length of each pole from field measurements and adjusted cross-

sections. Furnish the revised pole heights to the Engineer. Use all other dimensional requirements shown on the plans.

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

- Design for a 50 year service life as recommended by Table 3-3 (Recommended Minimum Design Life) in the 2003 Interim to the 4th Edition AASHTO.
- Use the wind pressure map developed from 3-second gust speeds, as provided in Article 3.8.
- Ensure signal support structures include natural wind gust loading and truck-induced gust loading in the fatigue design, as provided for in Articles 11.7.3 and 11.7.4, respectively. Designs need not consider periodic galloping forces.
- Assume the natural wind gust speed in North Carolina is 11.2 mph.
- Design for Category II fatigue, as provided for in Article 11.6, unless otherwise specified.
- Calculate combined stresses to determine combined stress ratio (CSR) using applicable equations from Section 5. Maximum allowable CSR for all signal supports is 0.9.
- Conform to article 10.4.2 and 11.8 for all deflection requirements.

Ensure that the design permits cables to be installed inside poles and mast arms.

Unless otherwise specified by special loading criteria, the computed surface area for ice load on signal heads is:

- 3-section, 12-inch, Surface area: 26.0 ft²
- 4-section, 12-inch, Surface area: 32.0 ft²
- 5-section, 12-inch, Surface area: 42.0 ft²

The ice loading for signal heads defined above includes the additional surface area that back plates will induce. Special loading criteria may be specified in instances where back plates will not be installed on signal heads. Refer to the Loading Schedule on each Metal Pole Loading Diagram for revised signal head surface areas. The pole designer should revise ice loads accordingly in this instance. Careful examination of the plans when this is specified is important as this may impact sizing of the metal support structure and foundation design which could affect proposed bid quotes. Maximum allowable CSR of 0.9 still applies.

Assume the combined minimum weight of a messenger cable bundle (including messenger cable, signal cable and detector lead-in cables) is 1.3 lbs/ft. Assume the combined minimum diameter of this cable bundle is 1.3 inches.

Ensure that designs provide a removable pole cap with stainless steel attachment screws for each pole top and mast arm end.

B. Metal Poles:

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

Professional Engineer of this responsibility. Do not fabricate the assemblies until receipt of the Department's approval of the design drawings.

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

Design tapers for all pole shafts that begin at the base with diameters that decrease uniformly at the rate of 0.14 inch per foot of length.

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

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

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

where M = bending moment at the critical section of the base plate induced by one anchor bolt

P = anchoring force of each anchor bolt

D_1 = horizontal distance between the anchor bolt center and the outer face of the upright, or the difference between the bolt circle radius and the outside radius of the upright

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

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

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

where P = anchoring force of each anchor bolt

D_2 = horizontal distance between the face of the upright and the face of the anchor bolt nut

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

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

The following additional owner requirements apply concerning pole base plates.

- Ensure that whichever case governs as defined above, the anchor bolt diameter is set to match the base plate thickness. If the minimum diameter required for the anchor bolt exceeds the thickness required for the base plate, set the base plate thickness equal to the required bolt diameter.
- For dual mast arm supports, or for single mast arm supports 50' or greater, use a minimum 8 bolt orientation with 2" diameter anchor bolts, and a 2" thick base plate.
- For all metal poles with mast arms, use a full penetration groove weld with a backing ring to connect the pole upright component to the base. Refer to Standard Drawings for Metal Poles M4.

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

Ensure that the anchor bolts have the required diameters, lengths, and positions, and will develop strengths comparable to their respective poles.

Provide designs with a 6 x 12-inch hand hole with a reinforcing frame for each pole.

Provide designs with a terminal compartment with cover and screws in each pole that encompasses the hand hole and contains provisions for a 12-terminal barrier type terminal block.

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

Where required, design couplings on the pole for mounting pedestrian pushbuttons at a height of 42 inches above the bottom of the base. Provide mounting points consisting of 1-1/2 inch internally threaded half-couplings that comply with the NEC that are mounted within the poles. Ensure the couplings are essentially flush with the outside surfaces of the poles and are installed before any required galvanizing. Provide a threaded plug in each mounting point. Ensure that the surface of the plug is essentially flush with the outer end of the mounting point when installed and has a recessed hole to accommodate a standard wrench.

C. Mast Arms:

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

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

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

Use a full penetration groove weld with a backing ring to connect the mast arm to the pole. Refer to Standard Drawings for Metal Poles M5.

5.5. MEASUREMENT AND PAYMENT

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

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

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

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

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

Payment will be made under:

Metal Pole with Single Mast Arm	Each
Soil Test	Each
Drilled Pier Foundation.....	Cubic Yard
Mast Arm with Metal Pole Design	Each