INDIANA DEPARTMENT OF TRANSPORTATION

Driving Indiana's Economic Growth

Design Memorandum No. 10-20
Technical Advisory

August 24, 2010

TO: **All Design, Operations, and District Personnel, and Consultants**

FROM: ***/s/ David Boruff***
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SUBJECT **High-Mast Lighting Design**

REVISES: ***Indiana Design Manual*** **Section 78-7.0**

EFFECTIVE: **September 1, 2010, Letting**

The design of a high-mast lighting system uses the same design procedures as discussed in *Indiana Design Manual* Section 78-5.02. The following should also be considered.

1. Lighting Source. A 1000-W high-pressure sodium light source should be used. The number of required luminaires should be determined based on the area to be lighted as shown in Figure 10-20A.

Estimated Mounting Height, EMH (ft)	Estimated Mounting Height, EMH (m)	Lumens	Number of Luminaires
100	30	400,000	4
105 ≤ EMH ≤ 120	32 ≤ EMH ≤ 37	600,000	4 or 6
125 ≤ EMH ≤ 150	38 ≤ EMH ≤ 46	800,000	6 or 8
155 ≤ EMH ≤ 200	47 ≤ EMH ≤ 61	1,600,000	6, 8, 10, or 12

NUMBER OF LUMINAIRES FOR HIGH-MAST TOWER

Figure 10-20A

2. Estimated Mounting Height. This can range from 100 to 200 ft (30 to 61 m). Once determined, it should be specified to the higher 5-ft (1-m) increment. An EMH of 100 to 160 ft (30 to 47 m) has proven to be the most practical. An EMH of 165 ft (48 m) or greater requires more luminaires to maintain the illumination level. However, such an EMH allows for fewer towers and provides better uniformity. Use of such an EMH should be confirmed with the district traffic engineer.

3. Location. In determining the location for a tower, the plan view of the area should be reviewed to determine the more critical areas requiring lighting. In selecting the appropriate location for a tower, the following should be considered.

   a. Critical Area. A tower should be located such that the highest localized level of illumination occurs within a critical-traffic area, e.g., freeway/ramp junction, ramp terminal, merge point.

   b. Roadside Safety. A tower should be located a sufficient distance from the roadway so that the probability of a collision is virtually eliminated. It should not be placed at the end of a long tangent.

   c. Sign. A tower should be located so that it is not within a motorist's direct line of sight to a highway sign.

4. Design. The methodologies for checking the adequacy of uniformity are the point-by-point method and the template method. The point-by-point method checks illumination by using the manufacturer's Isolux diagram. The total illumination at a point is determined as the sum of the contributions of illumination from all luminaire assemblies within the effective range of the point. The template methodology uses isolux templates to determine the appropriate location for each tower. The templates may be moved to ensure that the minimum-maintained illumination is provided, and that the uniformity ratio has been satisfied. *Indiana Design Manual* Section 78-8.0 provides an example of using the template methodology.

   A retaining wall should be included with the concrete pad at the base of the tower if the surrounding ground's slope is steeper than 5:1. The height of the retaining wall should be determined from Figure 10-20B.

Slope, *S*:1	Height (ft)	Height (m)
$2{:}1 \leq S \leq 3{:}1$	3	1
$3{:}1 < S \leq 4{:}1$	2	0.75
$4{:}1 < S < 5{:}1$	1.5	0.5

HEIGHT OF RETAINING WALL AT HIGH-MAST-TOWER CONCRETE PAD

Figure 10-20B

5. Foundation and Soil Test. After the final location of each tower is determined, a geotechnical investigation should be requested from the Office of Geotechnical Engineering. The standard foundation of 20-ft (6.1-m) depth and 4-ft (1.2-m) diameter should be specified for each tower with the soil properties as follows.

   a. Soft Clay. Undrained shear strength of 750 lb/ft^2 (36 kPa), density of 120 lb/ft^3 (586 kg/m^3), and strain of 0.01 at half the maximum stress for an undrained triaxial test. The soil should not include excess rock.

   b. Sand. Angle of internal friction of 30 deg, density of 115 lb/ft^3 (562 kg/m^3), and modulus of subgrade reaction of 20 lb/in.^{3} (0.00055 kg/mm^3). The soil should include a minimum of gravel or clay.

   If a tower of 180 ft (55 m) or higher is required where soil is sandy, a foundation of 22-ft (6.7-m) depth and 4.5-ft (1.4-m) diameter should be specified, and its details should be shown on the plans.

   The standard foundation has been designed with the assumption that no groundwater is present. The Office of Geotechnical Engineering should be contacted if groundwater is present or if excess rock is present in clay soil.

   For other soil conditions or properties, the Office of Geotechnical Engineering may recommend an alternate foundation. Such alternate foundation should be shown on the plans.

6. Information to be Shown on Plans. This includes the tower location, foundation details if not standard, estimated mounting height, retaining-wall height if applicable, and number of luminaires.

7. Standard Documents. The applicable INDOT *Standard Drawings* that have been revised include 807-LTFD-07, 807-LTHI-05, 807-LTHM-01 through -04, and 807-LTPD-01 and -02. These are posted on the INDOT website, at http://www.in.gov/dot/div/contracts/standards/drawings/sep10/sep.htm. A complementary recurring special provision, 920-T-162, is attached herewith. It should be called for in each contract that includes high-mast-lighting-related pay items.

db:alu
Attachment

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920-T-162 HIGH MAST POLES

(Adopted 04-15-10)

The Standard Specifications are revised as follows:

SECTION 920, BEGIN LINE 223, DELETE AND INSERT AS FOLLOWS:

1. High Mast Poles

The poles shall be ~~made of steel in accordance with ASTM A 871 (A 871M). The steel shall have a minimum yield strength of 59,500 psi (410 MPa)~~ *tapered shafts having poly-sided or circular cross sections. The pole shaft sections shall be slip fitted and shall provide at least 1 in. (25 mm) radial clearance from all interior devices.*

All tower shaft components shall be fabricated from high strength, low alloy, steel in accordance with AASHTO M 270; ASTM A 595, Grade A or B; ASTM A 572, Grade 55; ASTM A 1011 (A 1011M); ASTM A 606, or ASTM A 808 (A 808M), with a minimum yield strength of 50,000 psi (345 MPa).

Sections which are slip fitted shall have slip joints with a minimum overlap of 1.5 times the diameter of the bottom of the upper section at the slip joint. Towers having slip joint construction shall be match marked at the factory and shall be shipped disassembled for assembly at the work site. Slip joints shall be marked to ensure that the 1.5 times diameter insertion is provided.

All steel used in the base plate and shaft shall meet an impact property of 15 ft·lbs (20.3 J) at 40°F (4°C) in the longitudinal direction using the Charpy V-Notch test. This shall be an average of 3 tests per mill heat with no test below 10 ft·lbs (13.6 J). A copy of the certified mill test reports for this steel and the Charpy V-Notch test results shall be submitted. Sufficient information shall be furnished to demonstrate that this material is traceable to the mill heat number shown on the test report.

~~The tapered pole shall be multi-sided or circular in shape. The pole shaft sections shall be welded together or slipfitted. The minimum diameter of the pole top shall be 7.5 in. (190 mm) and shall provide at least 1 in. (25 mm) radial clearance from all interior devices.~~

~~The exterior of the pole shall be thoroughly shotblasted or otherwise cleaned to a near white finish to remove all oily and foreign matter. The interior of the pole shall be cleaned of all mill scale and foreign matter by a pickling process or shotblasting.~~

~~Hardware~~ *All tower shaft hardware including hardware for the handhole door, and the latch mechanism* shall be stainless steel in accordance with ASTM A 276, type 304 or 305, except where otherwise specified.

~~For the slipfit design, the pole shall be made up of not more than four sections for poles up to and including 120 ft (36.6 m) in length. For the poles between 120 ft (36.6 m) and 150 ft (45.7 m), five sections will be permitted. For poles over 150 ft (45.7 m) and up to 200 ft (61 m), six sections will be permitted. The inside edge of the lower section of the slip joint shall be beveled to prevent the transition joint assembly from catching on the edge. Slip joints shall have a minimum overlap of 1 1/2 times the diameter of the~~

~~bottom of the upper section. The sections shall be pre-fitted and matchmarked at the factory.~~

After fabrication, the pole shall be cleaned and galvanized. Galvanized steel towers, including the handhole, handhole door, base plate, mounting plate, and all other elements welded to the shaft shall be hot-dip galvanized in accordance with AASHTO M 111.

2. Welding

The welding symbols and all information regarding location, type, size, welding sequence, and welding procedure specifications shall be shown on the shop drawings.

Welds shall be smooth and cleaned of flux and spatter in accordance with AWS procedure. Minimum preheats for welds shall be 100°F (38°C) for seams, and 225°F (107°C) for circumferential welds.

All welds shall be performed at the factory. Circumferential welds shall be backed-up welds with 100% penetration. Longitudinal welds shall have a minimum of 60% penetration except within 2 ft (0.6 m) of either side of the circumferential joint, the welds shall be backed-up and of 100% penetration. Base plate welds shall be 100% penetration. Circumferential welds and 100% penetration longitudinal welds shall be 100% ultrasonically inspected. The 60% penetration longitudinal welds shall be 100% ultrasonically or radiographically inspected for soundness. Welding shall be performed in accordance with *AWS D1.5 and* 711.32. *Weld filler shall provide Charpy V Notch equal to or greater than 20 ft·lbs (27.1 J) at 0° F (-18°C).*

a. *Inspection*

The manufacturer shall provide quality control, QC, inspection. The inspector shall be an AWS certified welding inspector, CWI, in accordance with AWS D1.5. The NDT, inspector shall be an independent non-destructive-testing inspector, certified as level II in RT, UT, or MT, or all as applicable. Copies of the inspection reports and NDT reports shall be provided to the Engineer.

The method for testing full penetration and partial penetration welds by the independent welding inspector shall be the same as specified above.

3. Handholes

Openings for handholes shall be reinforced to maintain the design strength of the pole. The handhole shall have a weatherproof gasket made of neoprene or silicone rubber. The gasket shall be formed for a forced fit around the handhole or be attached by mechanical means. Samples of the gaskets shall be furnished for approval. The door and hinges shall be the same type steel as the poles. The hinge pins and other securing hardware shall be stainless steel and tamperproof. The door shall be fabricated to allow for a padlock, which is not included in the hardware. The hasp used for padlocking shall be fabricated from stainless steel. Provisions shall be made to bolt the door securely shut. The door shall include a bug proof and weatherproof aperture with a minimum opening of 4 $in.^2$ (2580 mm^2). Nylon or non-corrosive screens, or other approved methods of bugproofing shall be furnished. Two bonding plates shall be furnished which are

accessible through the pole handhole for connecting the ground wires. A connection shall be furnished for an additional ground wire on the outside of the pole near the base plate.

4. Luminaire Ring Assembly

The ring shall be fabricated from ASTM A 666 Type 201 or 304 stainless steel and shall have a removable raceway cover. The ring shall be ~~designed~~ *fabricated* as an enclosed wire raceway to provide for the symmetrical mounting of *the* luminaires ~~having an effective projected area of 2.8 ft^2 (0.26 m^2) and a weight of 85 lb (38.5 kg) or actual projected area and weight, if greater~~. All structural connections shall be made with bolts and nuts.

The luminaire ring shall be supported by ~~three 3/16 in. (5mm)~~ *means of* stainless steel aircraft cables of seven strands with 19 wires ~~each~~ *per* strand with a minimum breaking strength of 3,900 lb (17,350 N). ~~The cables shall be secured to the ring, and to cable terminating devices within the poles by means of stainless steel hardware~~.

~~Positive positioning devices shall be incorporated into the ring assembly. These devices shall be designed to prevent any horizontal movement in the ring assembly. The ring assembly shall have a minimum of six non-abrasive rollers on the ring interior.~~