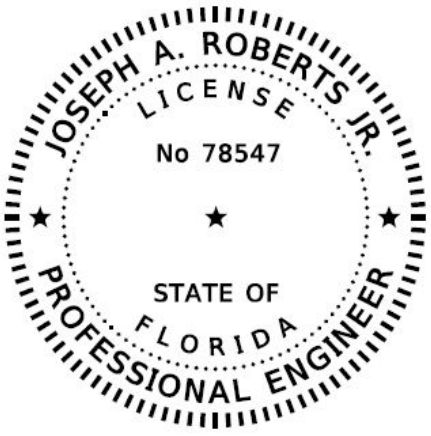
MAST ARM STRUCTURAL CALCULATIONS

LENA ROAD FROM NORTH OF 44TH AVENUE EAST TO SR 64

JULY 2023



This document has been digitally signed and sealed by:

on the date adjacent to the seal.

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Joseph A. Roberts Jr., P.E. No. 78547
Kimley-Horn and Associates, Inc.
189 S. Orange Avenue, Suite 1000
Orlando, FL 32801

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LIST OF APPENDICES

1.0 EXECUTIVE SUMMARY

Kimley-Horn and Associates was retained to design mast arm structures at the intersection of Lena Road and SR 64 in Manatee County, FL. The system of mast arms has two existing poles and three new poles (Poles 1, 4, and 5). The existing poles are to remain with no signal modifications. Per FDM 261.8.2.1 "For standard mast arm support, structures with additional loading on the horizontal member that produce a flexural demand/capacity ratio less than or equal to 1.10, no further analysis is required." Since no additional loading will be applied to the horizontal member, no additional analysis is required. Structural analysis of these new mast arms was performed using 2023-2024 FDOT Standard Plans. The poles were analyzed using FDOT Design Aid and the FDOT MathCAD Mast Arm V2.0. A geotechnical report is provided for this intersection by Tierra, Inc. and dated June 29, 2023. Table 1 below shows the results of the structural analysis.

For the detailed calculations showing all CSR, CD Ratios, and CFIs, see the calculations following this summary. A table is provided to summarize the designs. All ratios are below the 0.95 requirement stated in the FDOT standards.

The following design standards/codes were used for the analysis:

- FDOT Design Manual, January 2023
- AASHTO LRFD Specifications for Structural Supports for Highway Signs, Luminaires, and Traffic Signals, First Edition, 2015 (LRFDLTS-1)
- FDOT Modifications to LRFDLTS-1, January 2023
- FDOT Structures Manual, January 2023
- FDOT Standard Plans FY 2023-2024

Table 1: Mast Arm Design Summary Table

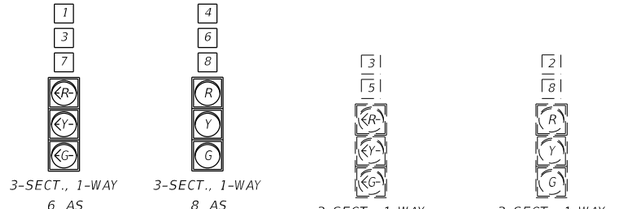
Pole Name	Arm Designation	Pole Designation	Mounting Height (UB)	Drilled Shaft Designation
Pole 1	A40/S	P2/S	21	DS/12/4.5
Pole 4	A60/S	P4/S	21	DS/22/4.5*
Pole 5	A78/D-A60/D	P6/D	21	DS/16/5.0

*Indicates a special drilled shaft

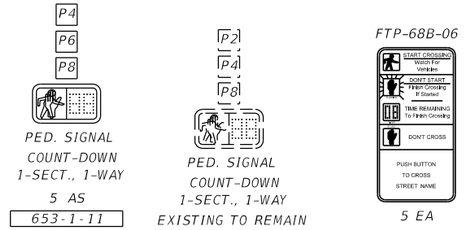
APPENDIX A:

PROPOSED SIGNALIZATION PLANS

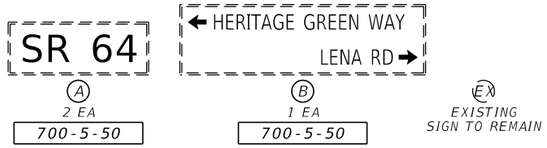
SIGNAL DISPLAY DETAILS



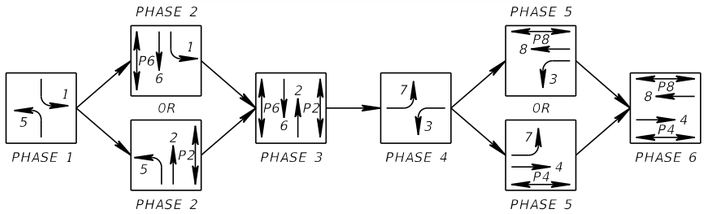
PEDESTRIAN DISPLAY DETAILS



EXISTING INTERNALLY ILLUMINATED OVERHEAD STREET NAME SIGN DETAILS



STANDARD SIGNAL OPERATING PLAN 10



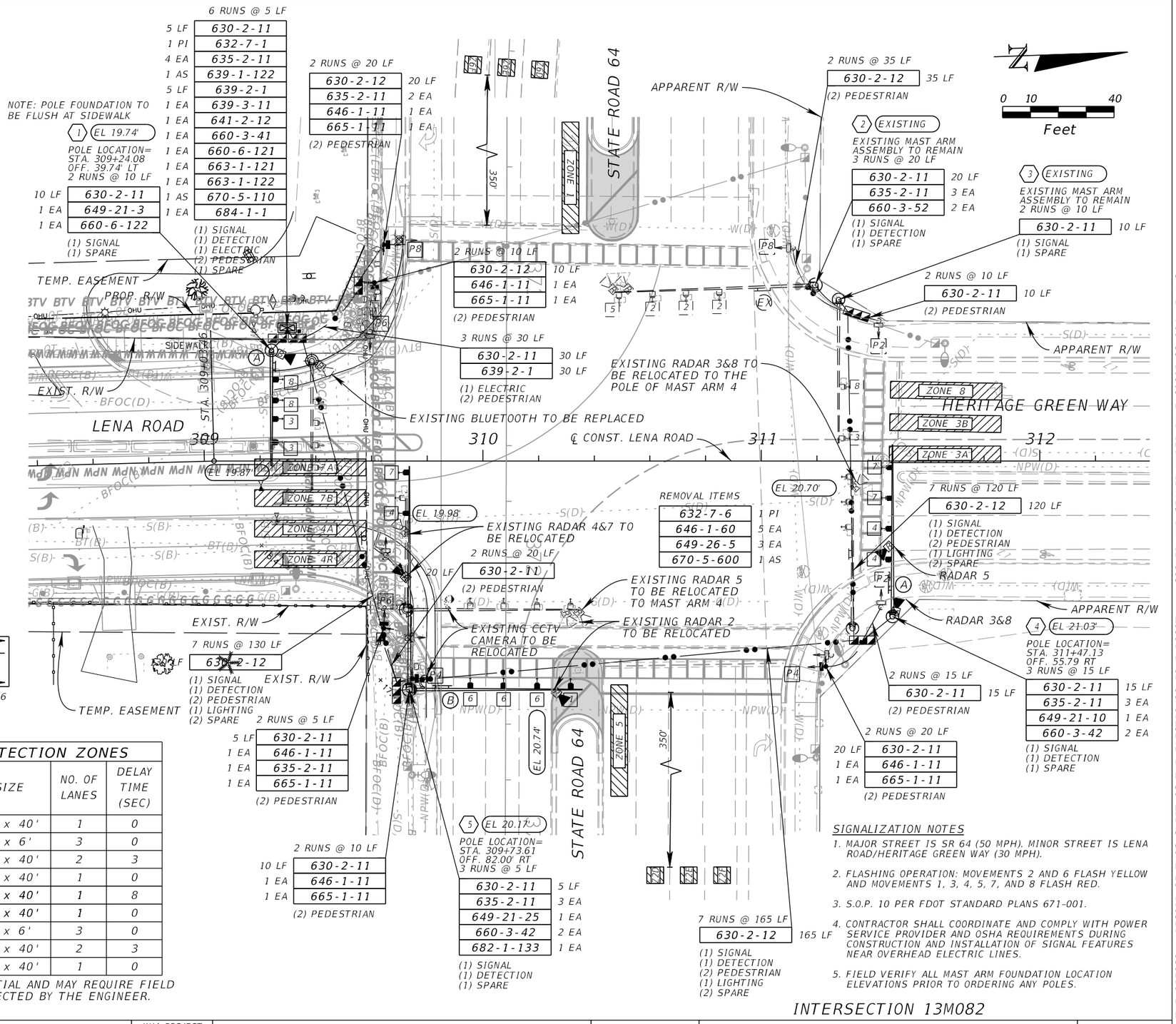
CONTROLLER TIMINGS

TIMING FUNCTION									
MOVEMENT NUMBER		1	2	3	4	5	6	7	8
TIMING FUNCTION	MINIMUM GREEN	5	15	5	7	5	15	5	7
	EXTENSION	3	5	3	3	3	5	3	3
	MAXIMUM GREEN 1	25	60	15	20	25	60	25	20
	MAXIMUM GREEN 2	20	90	25	25	30	90	25	45
	YELLOW CLEARANCE	5.1	5.1	3.7	3.7	5.1	5.1	3.7	3.7
	ALL RED	2.2	2.0	3.1	4.0	2.5	2.0	2.2	4.5
	PEDESTRIAN WALK	-	7	-	7	-	7	-	7
	PED. CLEARANCE	-	23	-	38	-	31	-	37
	RECALL	-	MIN	-	-	-	MIN	-	-

RADAR DETECTION ZONES

DETECTION ZONE	SIZE	NO. OF LANES	DELAY TIME (SEC)
ZONE 1	6' x 40'	1	0
ZONE 2D-F	6' x 6'	3	0
ZONE 3A-B	6' x 40'	2	3
ZONE 4A	6' x 40'	1	0
ZONE 4R	6' x 40'	1	8
ZONE 5	6' x 40'	1	0
ZONE 6D-F	6' x 6'	3	0
ZONE 7A-B	6' x 40'	2	3
ZONE 8	6' x 40'	1	0

DELAY TIME IS INITIAL AND MAY REQUIRE FIELD ADJUSTING AS DIRECTED BY THE ENGINEER.



SIGNALIZATION NOTES

1. MAJOR STREET IS SR 64 (50 MPH). MINOR STREET IS LENA ROAD/HERITAGE GREEN WAY (30 MPH).
2. FLASHING OPERATION: MOVEMENTS 2 AND 6 FLASH YELLOW AND MOVEMENTS 1, 3, 4, 5, 7, AND 8 FLASH RED.
3. S.O.P. 10 PER FDOT STANDARD PLANS 671-001.
4. CONTRACTOR SHALL COORDINATE AND COMPLY WITH POWER SERVICE PROVIDER AND OSHA REQUIREMENTS DURING CONSTRUCTION AND INSTALLATION OF SIGNAL FEATURES NEAR OVERHEAD ELECTRIC LINES.
5. FIELD VERIFY ALL MAST ARM FOUNDATION LOCATION ELEVATIONS PRIOR TO ORDERING ANY POLES.

INTERSECTION 13M082

No.	REVISIONS	DATE	BY

Kimley»Horn
© 2023 KIMLEY-HORN AND ASSOCIATES, INC.
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KHA PROJECT 148400100
DATE JULY 2023
SCALE AS SHOWN
DESIGNED BY YL
DRAWN BY EMB
CHECKED BY NRH

Manatee County FLORIDA

LICENSED PROFESSIONAL
NICOLE R. HECK, P.E.
FL LICENSE NUMBER 84306

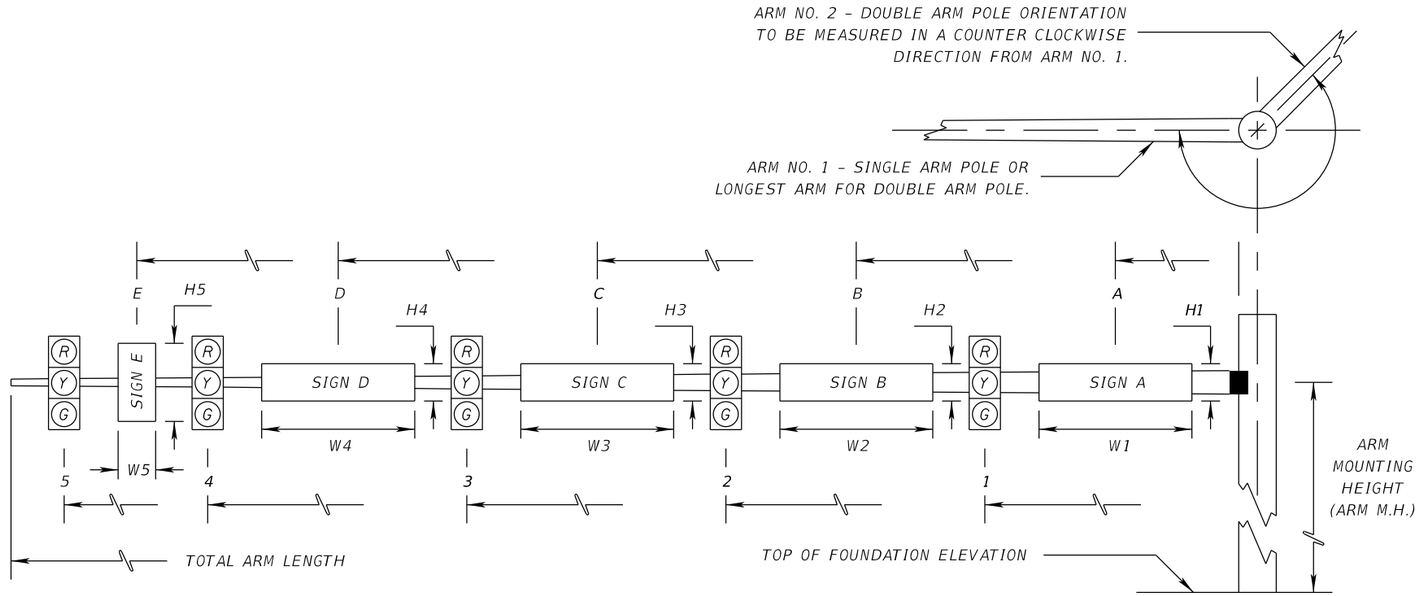
SIGNALIZATION PLAN

SHEET NUMBER T-6

THE OFFICIAL RECORD OF THIS SHEET IS THE ELECTRONIC FILE DIGITALLY SIGNED AND SEALED UNDER RULE 61G15-23.004, F.A.C.

SPECIAL INSTRUCTIONS

ID NO.	PED. BUTTON		PED. SIGNALS		HANDHOLE LOCATION



* DENOTES NUMBER OF SECTIONS IN SIGNAL HEAD ASSEMBLY

ID NO.	SHEET NO.	LOCATION BY STA.	TOP OF FOUND. ELEVATION	RDWY ARM NO.	CROWN ELEV.	LUMI-NAIRE Y/N	TERM. COMP. Y/N	SIGNAL DATA: SIGNAL V/H	BACK PLATES Y/N	PED. SIGNAL Y/N	DISTANCE FROM POLE: 1	*	2	*	3	*	4	*	TOTAL ARM LENGTH	ARM M.H.	ANGLE BETWEEN DUAL ARMS	SIGN DATA: DISTANCE FROM POLE/HEIGHT & WIDTH OF SIGN: A	H1	W1	B	H2	W2	DETECTION	PAINT COLOR
PROPOSED LOADING																													
1	T-6	309+24.08 39.74' LT	19.74'	1	19.87'	N	Y	V	Y	N	9.5'	3	17.0'	3	23.5'	3	32.0'	3	40.0'	TBD		5.0'	1.5'	4.0'				0' (BT)	GALVANIZED
---	-----	----------	-------	2																	-----								
2	T-6	EXISTING (NWC)	EXIST.	1	EXIST.	N	Y	V	Y	N	+	3	+	3	+	3	+	3	+	EXIST.		+	+	+				+ (RD), + (RD)	EXIST.
---	-----	----------	-------	2																	-----								
3	T-6	EXISTING (NWC)	EXIST.	1	EXIST.	N	Y	V	Y	N	+	3	+	3					+	EXIST.								EXIST.	
---	-----	----------	-------	2																	-----								
4	T-6	311+47.13 55.79 RT	21.03'	1	20.70'	N	Y	V	Y	N	19.5'	3	30.5'	3	41.5'	3	52.5'	3	60.0'	TBD		10.5'	1.5'	4.0'				0' (RD), 25.0' (RD)	GALVANIZED
---	-----	----------	-------	2																									
5	T-6	309+73.61 82.00' RT	20.17'	1	19.98'	N	Y	V	Y	N	61.5'	3	76.0'	3					78.0'	TBD	270							37.5' (RD)	GALVANIZED
---	-----	----------	-------	2	20.74'			V	Y		20.0'	3	32.0'	3	44.0'	3	56.0'	3	60.0'		-----	10.0'	2.8'	7.0'				3.0' (CC), 50.0' (RD)	GALVANIZED
FUTURE (DESIGN) LOADING																													
1	T-6	309+24.08 39.74' LT	19.74'	1	19.87'	N	Y	V	Y	N	9.5'	5	17.0'	3	23.5'	3	32.0'	3	40.0'	TBD		5.0'	1.5'	4.0'				0' (BT)	GALVANIZED
---	-----	----------	-------	2																	-----								

\+ = EXISTING SIGNAL HEAD, EXISTING SIGN, OR EXISTING RADAR DETECTOR TO REMAIN IN PLACE
RD = RADAR DETECTOR
CC = ITS CLOSED-CIRCUIT TELEVISION (CCTV) CAMERA
BT = BLUETOOTH

No.	REVISIONS	DATE	BY

Kimley»Horn

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KHA PROJECT 148400100
DATE JULY 2023
SCALE AS SHOWN
DESIGNED BY EMB
DRAWN BY EMB
CHECKED BY NRH

MANATEE COUNTY — FL

Manatee County FLORIDA

LENA ROAD

LICENSED PROFESSIONAL
NICOLE R. HECK, P.E.
FL LICENSE NUMBER 84306
DATE:

STANDARD MAST ARM TABULATION

SHEET NUMBER T-7

THE OFFICIAL RECORD OF THIS SHEET IS THE ELECTRONIC FILE DIGITALLY SIGNED AND SEALED UNDER RULE 61G15-23.004, F.A.C.

STANDARD MAST ARM ASSEMBLIES DATA TABLE

STRUCTURE ID NUMBERS	DESIGNATION	FIRST ARM		SECOND ARM		UF (deg)	LL (deg)	POLE			DRILLED SHAFT ID	SHAFT AND REINF.							
		ARM ID	FAA (ft.)	ARM ID	SAA (ft.)			POLE ID	UAA (ft.)	UB (ft.)		DA(ft)	DB(ft)	RA	RB	RC	RD(in)	RE	RF(in)
POLE 1	A40/S-P2/S	A40/S	-	-	-	-	-	P2/S	24	21	DS/12/4.5	–	–	–	–	–	–	–	–
POLE 4	A60/S-P4/S	A60/S	-	-	-	-	-	P4/S	24	21	DS/22/4.5	22	4.5	11	16	8	12	–	–
POLE 5	A78/D-A60/D-P6/D	A78/D	-	A60/D	-	-	-	P6/D	24	21	DS/16/5.0	–	–	–	–	–	–	–	–

NOTES:

1. IF AN ENTRY APPEARS IN COLUMN FAA, A SHORTER ARM IS REQUIRED. THIS IS OBTAINED BY REMOVING LENGTH FROM THE ARM TIP AND THE ARM LENGTH SHORTENED FROM FA TO FAA. SAA SIMILAR.
2. IF AN ENTRY APPEARS IN COLUMN UAA, A SHORTER POLE IS REQUIRED. THIS IS OBTAINED BY REMOVING LENGTH FROM THE POLE TIP AND THE POLE HEIGHT SHORTENED FROM UA TO UAA.
3. WORK THIS SHEET WITH THE SIGNAL DESIGNER'S "MAST ARM TABULATION". SEE "MAST ARM TABULATION" FOR SPECIAL INSTRUCTIONS THAT INCLUDE NON-STANDARD HANDHOLE LOCATION, PAINT COLOR, TERMINAL COMPARTMENT REQUIREMENT, AND PEDESTRIAN FEATURES.
4. WORK WITH INDEX 649-030 AND 649-031 (FY 2023-24).
5. DESIGN WIND SPEED = 150 MPH (MANATEE COUNTY)

FOUNDATION NOTES:

1. DESIGN BASED ON BORINGS PROVIDED BY TIERRA, INC., DATED JUNE 29, 2023.
2. DRILLED SHAFTS "4" AND "5" ARE NOT LOCATED IN SIDEWALKS. "1" HAS BEEN LENGTHENED 6" PER STANDARD, AND "D" HAS BEEN LENGTHENED 1' TO MEET VERTICAL CLEARANCE. SEE "STANDARD MAST ARM TABULATION" SHEET FOR TOP OF SHAFT ELEVATIONS.
3. GROUNDWATER SHOULD BE EXPECTED WITHIN 8.5 FEET OF THE EXISTING GROUND. THE CONTRACTOR SHOULD ANTICIPATE THE POTENTIAL NEED FOR WET CONSTRUCTION METHODS.
4. SPECIAL UNDERWATER CONCRETE PLACEMENT TECHNIQUES MAY BE REQUIRED IF THE BOTTOM OF THE SHAFT EXTENDS BELOW THE GROUNDWATER TABLE.
5. IF EXISTING SOILS VARY FROM THE CRITERIA PRESENTED ABOVE, CONTACT THE ENGINEER PRIOR TO CONSTRUCTION OF THE DRILLED SHAFT.
6. VERY DENSE SAND AND INDURATED CLAY WAS ENCOUNTERED WITHIN THE BORINGS. DRILLING INTO AND/OR THROUGH THESE MATERIALS MAY BE DIFFICULT AND WILL REQUIRE NON-CONVENTIONAL CONSTRUCTION TECHNIQUES AND SPECIALIZED EQUIPMENT. THE DEPTH AND CONSISTENCY OF THESE MATERIALS CAN VARY.
7. TEMPORARY CASING METHODS FOR SHAFT INSTALLATION BEYOND WHAT IS REQUIRED IN THE FDOT SPECIFICATIONS MAY BE REQUIRED IN ORDER TO PREVENT THE COLLAPSE OF SANDY SOILS AND/OR GROUNDWATER INTRUSION DURING SHAFT CONSTRUCTION.
8. FOUNDATION ASSUMPTIONS:

POLE 1:
BORING: SG-11
CLASSIFICIATION: COHESIONLESS SOIL (SAND)
FRICTION ANGLE: 30 DEG
UNIT WEIGHT: 50 PCF
N-SPT #: 11
SOIL LAYER THICKNESS: 12 FT
DESIGN WATER TABLE: 0' BELOW SURFACE (ASSUMED)

POLE 4:
BORING: SG-13
CLASSIFICIATION: COHESIONLESS SOIL (SAND)
FRICTION ANGLE: 29 DEG
UNIT WEIGHT: 43 PCF
N-SPT #: 6
SOIL LAYER THICKNESS: 19 FT
DESIGN WATER TABLE: 0' BELOW SURFACE (ASSUMED)

POLE 5:
BORING: SG-12
CLASSIFICIATION: COHESIONLESS SOIL (SAND)
FRICTION ANGLE: 30 DEG
UNIT WEIGHT: 50 PCF
N-SPT #: 19
SOIL LAYER THICKNESS: 16 FT
DESIGN WATER TABLE: 0' BELOW SURFACE (ASSUMED)

THE OFFICIAL RECORD OF THIS SHEET IS THE ELECTRONIC FILE DIGITALLY SIGNED AND SEALED UNDER RULE 61G15-23.004, F.A.C.

No.	REVISIONS	DATE	BY

Kimley»Horn

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KHA PROJECT 148400100
DATE JULY 2023
SCALE AS SHOWN
DESIGNED BY KD
DRAWN BY KD
CHECKED BY JAR

Manatee County FLORIDA
MANATEE COUNTY — LENA ROAD — EL.

LICENSED PROFESSIONAL
JOSEPH A. ROBERTS JR., P.E.
FL LICENSE NUMBER 78547

MAST ARM ASSEMBLIES DATA TABLE

SHEET NUMBER
T-8

APPENDIX B:

FDOT STANDARD PLANS

ARM AND BASE PLATE

Arm ID Axx-ArmLength S-SingleArm D-DoubleArm H-HeavyDuty	Total Arm Length (ft)	Arm			Arm Extension			Base Plate		
		FA/SA (ft)	FC/SC (in)	FD/SD (in)	FE/SE (ft)	FG/SG (in)	FH/SH (in)	HT (in)	FJ/SJ (in)	FK/SK (in)
A30/S	30	30	11	0.25	--	--	--	22	25	3
A30/S/H			12							
A30/D			11					30	36	
A30/D/H			12							
A40/S	40	40	13	0.25	--	--	--	22	27	3
A40/S/H			14							
A40/D			13					30	36	
A40/D/H			14							
A50/S	50	32.5	12	0.25	20.5	14	0.313	22	29	3
A50/S/H			13			15				
A50/D			12			14		30	36	
A50/D/H			13			15				
A60/S	60	35.5	12	0.25	27.5	15	0.375	30	36	3
A60/S/H			13			16				
A60/D			12			15				
A60/D/H			13			16				
A70/S	70	38	13	0.25	35	17	0.375	30	36	3
A70/S/H			14			18				
A70/D			13			17				
A70/D/H			14			18				
A78/S	78	39	13	0.25	42	18	0.375	30	36	3
A78/S/H			15			20				
A78/D			13			18				
A78/D/H			15			20				

POLE, BASE PLATE AND ARM CONNECTION

Pole ID Px-PoleNo S-SingleArm D-DoubleArm L-Luminaire	Upright				Base Plate					Arm-Upright Connection							
	UA (ft)	UD (in)	UE (in)	UG (ft)	No. Bolts	BA (in)	BB (in)	BC (in)	BF (in)	HT (in)	FJ/SJ (in)	FL/SL (in)	FN/SN (in)	FO/SO (in)	FP/SP (in)	FR/SR (in)	FS/SS (in)	FT/ST (in)
P1/S	25	16	0.375	37.5	6	32	2.5	2	40	22	25	0.75	0.438	14	1.25	2	8.5	0.438
P1/S/L	39																	
P1/D	25									30	36			23		2.75	12.5	
P1/D/L	39			37.5														
P2/S	25	18	0.375	37.5	6	34	2.5	2	40	22	27	0.75	0.438	15	1.25	2	8.5	0.438
P2/S/L	39																	
P2/D	25									30	36			23		2.75	12.5	
P2/D/L	39			37.5														
P3/S	25	20	0.375	37.5	6	36	2.5	2	40	22	29	0.75	0.438	16	1.25	2	8.5	0.438
P3/S/L	39																	
P3/D	25									30	36			23		2.75	12.5	
P3/D/L	39			37.5														
P4/S	25	22	0.375	37.5	8	38	2.5	2	40	30	36	0.75	0.438	17	1.25	2.5	12.5	0.438
P4/S/L	39																	
P4/D	25													23				
P4/D/L	39			37.5														
P5/S	25	24	0.375	37.5	8	40	2.5	2	40	30	36	0.75	0.5	18	1.25	2.5	12.5	0.5
P5/S/L	39																	
P5/D	25													23				
P5/D/L	39			37.5														
P6/S	25	24	0.5	37.5	8	40	2.5	2	40	30	36	0.75	0.625	18	1.5	2.5	12	0.625
P6/S/L	39																	
P6/D	25													23				
P6/D/L	39			37.5														
P7/S	25	26	0.5	37.5	8	42	2.5	2	40	30	36	0.75	0.625	19	1.5	2.5	12	0.625
P7/S/L	39																	
P7/D	25													23				
P7/D/L	39			37.5														

DRILLED SHAFT

Drilled Shaft ID	DA (ft)	DB (ft)	RA	RB	RC	RD (in)	RE	RF (in)
DS/12/4.0	12	4.0	11	14	8	12	--	--
DS/12/4.5	12	4.5	11	16	8	12	--	--
DS/14/4.5	14	4.5	11	16	10	8	--	--
DS/14/5.0	14	5.0	11	18	10	8	--	--
DS/16/4.5	16	4.5	11	16	10	8	--	--
DS/16/5.0	16	5.0	11	18	10	8	--	--
DS/18/5.0	18	5.0	11	18	10	8	--	--
DS/20/5.0	20	5.0	11	18	10	6	10	9
DS/25/5.0	25	5.0	11	18	10	6	10	9

LUMINAIRE AND CONNECTION

LA (ft)	LB (ft)	LC (in)	LD (in)	LE	LF (ft)	LG (in)	LH (in)	LJ (in)	LK (in)	LL (deg)	UG (ft)
40	10	3	0.125	0.5	8	0.5	0.75	0.25	0.25	0	37.5

NOTE:

1. Work this Index with Index 649-031.

10/6/2022 2:31:44 PM

LAST REVISION	REVISION	DESCRIPTION:				
11/01/22			FY 2023-24 STANDARD PLANS	Page 6 of 86	STANDARD MAST ARM ASSEMBLIES	INDEX 649-030 / SHEET 1 of 1

GENERAL NOTES:

1. Shop Drawings: This Index is considered fully detailed, only submit shop drawings for minor modifications not detailed in the Plans.

2. Prior to Fabrication: Verify the installed foundation elevation will result in the required signal elevation and adjust the Pole height as needed.

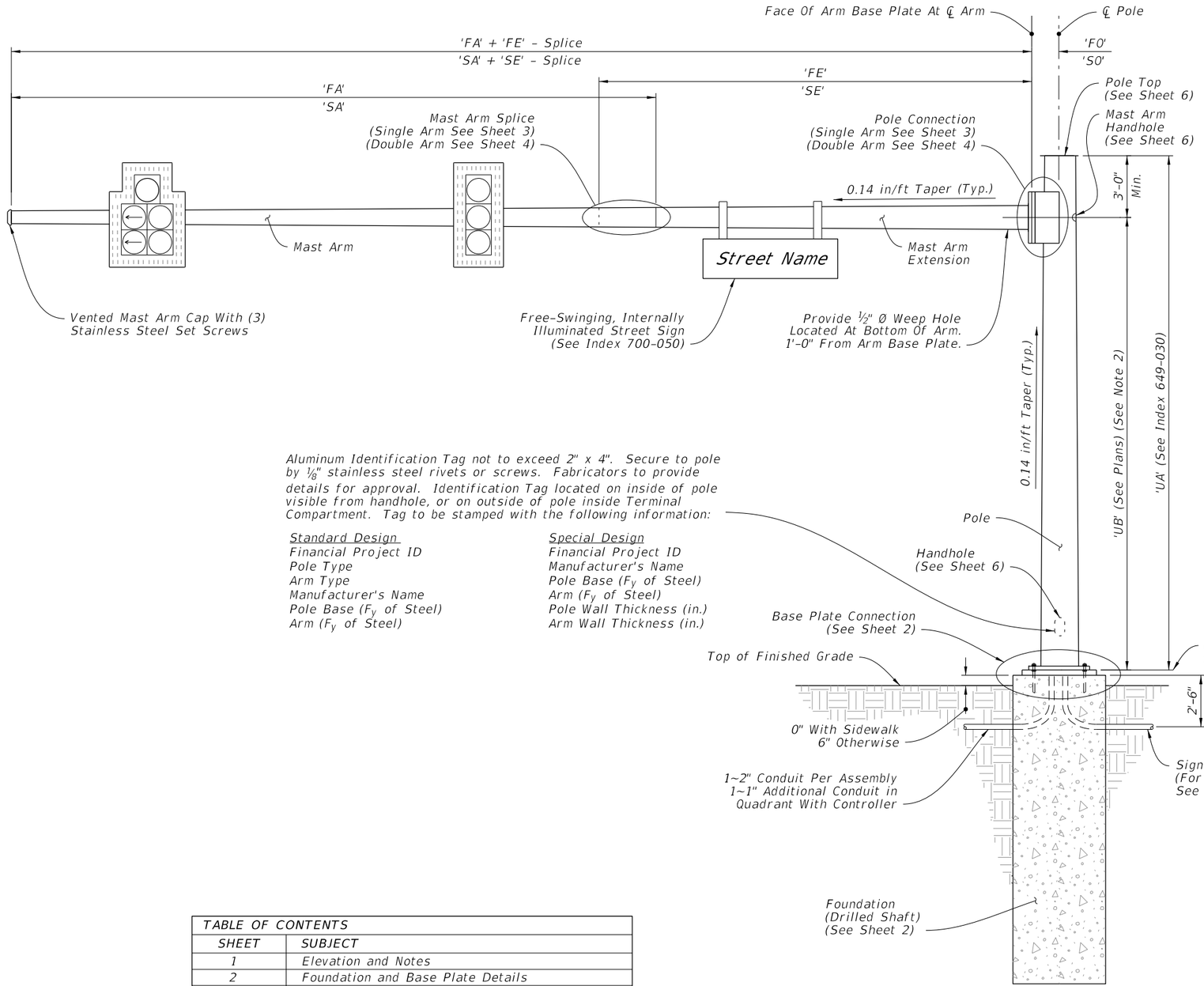
3. Details for Signal and Sign locations, Signal Head attachment, Sign attachment, Pedestrian Head attachment, and Foundation Conduit are not shown for simplicity.

4. Materials:
   - A. Poles, Mast Arms and Backing Rings:
     - a. Less than 3/16": ASTM A1011 Grade 50, 55, 60 or 65
     - b. Greater than or equal to 3/16": ASTM A572 Grade 50, 55, 60 or 65
     - c. ASTM A595 Grade A (55 ksi yield) or Grade B (60 ksi yield)
   - B. Steel Plates: ASTM A36
   - C. Weld Metal: E70XX
   - D. Bolts, Nuts and Washers:
     - a. High Strength Hex Head Bolts: ASTM F3125, Grade A325, Type 1
     - b. Nuts: ASTM A563 DH Heavy-Hex
     - c. Washers: ASTM F436 Type 1, one under turned element
   - E. Anchor Bolts, Nuts and Washers:
     - a. Anchor Bolts: ASTM F1554 Grade 55
     - b. Nuts: ASTM A563 Grade A Heavy-Hex (5 per anchor bolt)
     - c. Plate Washers: ASTM A36 (2 per bolt)
   - F. Threaded Bars/Studs: ASTM A36 or ASTM A307
   - G. Handhole Frame: ASTM A709 or ASTM A36, Grade 36
   - H. Handhole Cover: ASTM A1011 Grade 50, 55, 60 or 65
   - I. Pole Caps and Nut Covers: Fabricate from cast aluminum or galvanized carbon steel.
   - J. Stainless Steel Screws: AISI Type 316
   - K. Concrete: Class IV (Drilled Shaft) for all environmental classifications.
   - L. Reinforcing Steel: Specification 415

5. Fabrication:
   - A. Welding:
     - a. Specification 460-6.4 and
     - b. AASHTO LRFD Specification for Structural Supports for Highway Signs, Luminaires, and Traffic Signals Section 14.4.4
   - B. Poles and Mast Arms:
     - a. Round or 12-sided (Min.)
     - b. Taper pole diameter at 0.14 inches per foot
     - c. Upright poles must be a single section. For arms and upright poles, circumferential welds and laminated sections are not permitted.
     - d. Arms may be either one or two sections. See Sheet 4 for telescopic splice detail
     - e. Fabricate longitudinal seam welds with 60 percent minimum penetration or fusion welds except:
       1. Use a full-penetration groove weld within 6 inches of the circumferential tube-to-plate connection.
       2. Use full-penetration groove welds on the female end section of telescopic (i.e., slip type) field splices for a minimum length of one and one-half times the inside diameter of the female section plus 6 inches.
     - f. Locate longitudinal seams weld along the:
       1. Lower quadrant of the arms.
       2. Same side of the pole as the arm connections
     - g. Face handhole perpendicular from arm on single arm poles, perpendicular from the first arm of double arms poles facing away from traffic or see special instructions on the Mast Arm Tabulation Sheet.
     - h. Provide a 'J' or 'C' hook at the top of the pole for signal wiring support (See Sheet 6)
     - i. First and Second arm camber angle = 2°
     - j. Bolt holes diameters as follows:
       1. Bolts (except Anchor bolts): Bolt diameter plus 1/16" prior to galvanizing.
       2. Anchor Bolts: Bolt diameter plus 1/2" (Max.).

6. Coatings:
   - A. All Nuts, Bolts, Washers and Threaded Bars/Studs: ASTM F2329
   - B. All other steel items including plate washers ASTM A123

7. Construction:
   - A. Foundation: Specification 455 Drilled Shaft, except that payment is included in the cost of the Mast Arm.
   - B. Install Pole vertically.
   - C. Place structural grout pad with drain between top of foundation and bottom of baseplate in accordance with Specification 649-7.
   - D. Attach Sign Panels and Signals centered on the elevation of the Mast Arm.
   - E. Wire Access holes are 1½" or less in diameter.



Single Arm Shown, Double Arm Similar
(Luminaire Arm Not Shown)

MAST ARM ASSEMBLY

Aluminum Identification Tag not to exceed 2" x 4". Secure to pole by 1/8" stainless steel rivets or screws. Fabricators to provide details for approval. Identification Tag located on inside of pole visible from handhole, or on outside of pole inside Terminal Compartment. Tag to be stamped with the following information:

Standard Design	Special Design
Financial Project ID	Financial Project ID
Pole Type	Manufacturer's Name
Arm Type	Pole Base (F_y of Steel)
Manufacturer's Name	Arm (F_y of Steel)
Pole Base (F_y of Steel)	Pole Wall Thickness (in.)
Arm (F_y of Steel)	Arm Wall Thickness (in.)

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ELEVATION AND NOTES

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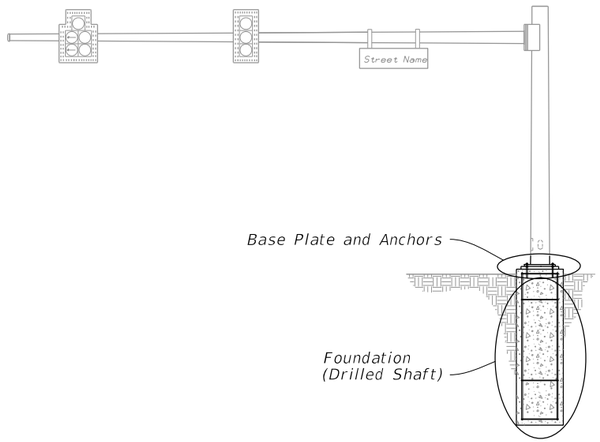
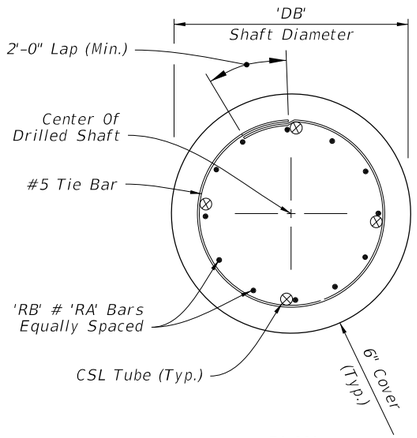


MAST ARM ASSEMBLY

NOTES:

1. The Structural Grout Pad diameter may be reduced where the footprint of the Grout Pad does not provide adequate clearance for the sidewalk and/or accessibility considerations.
2. See Index 649-030 and the plans for actual quantity of bolts in the Base Plate Connection.
3. The bottom hex nut of the Double Nuts shown in Section A-A may be substituted by a half-height anchor 'jam' nut. Provide individual nut covers (not shown) for each bolt.
4. Detail 'A' Silicone Caulk may be applied after installation. Consult with Manufacturer to determine the suitability of the caulk to be applied.



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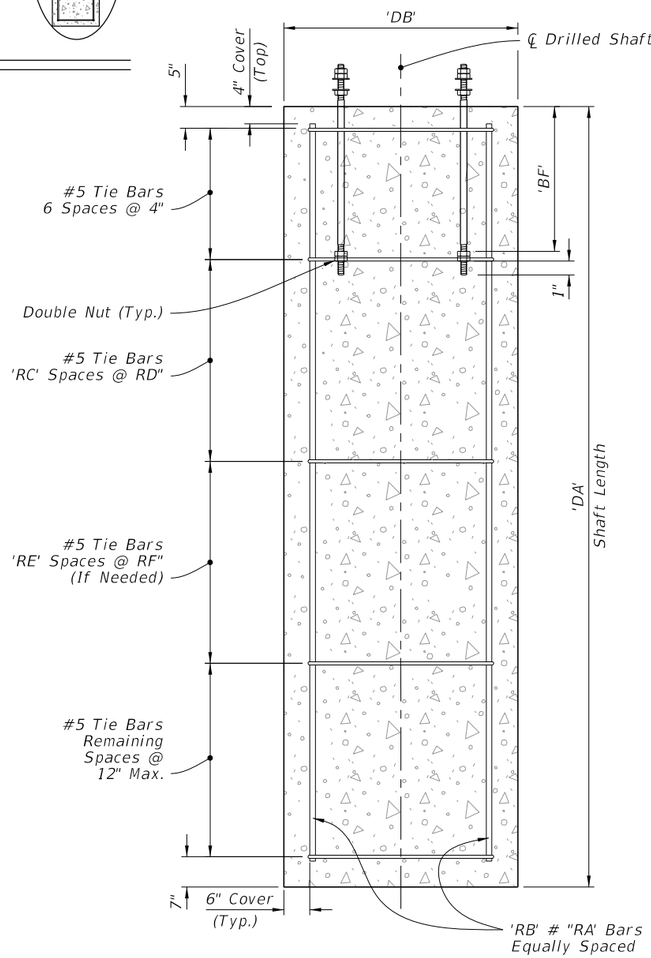
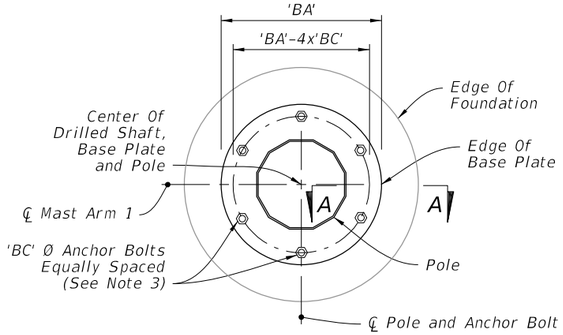
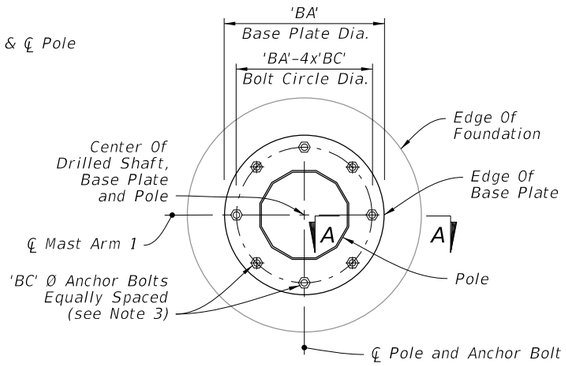


ELEVATION

FOUNDATION

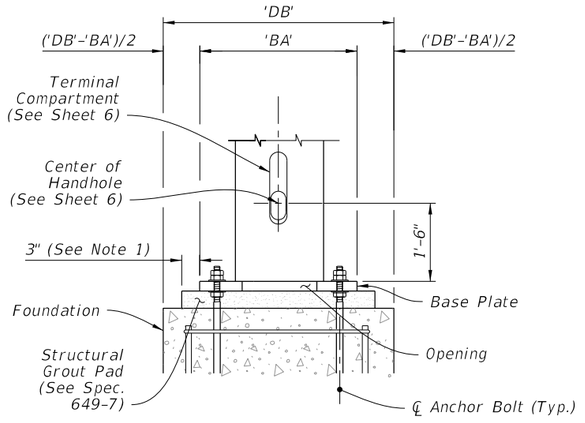


(6 Anchor Bolts)



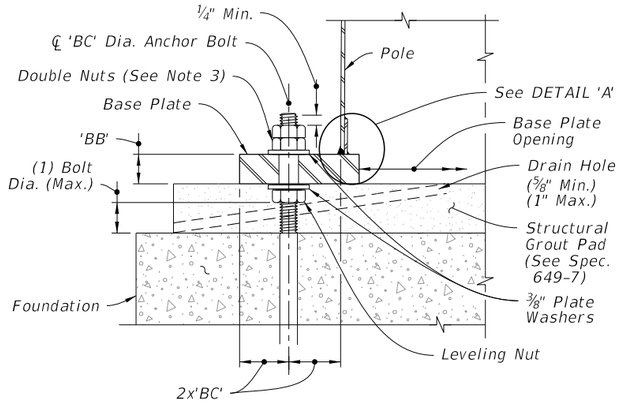
(8 Anchor Bolts)

PLAN

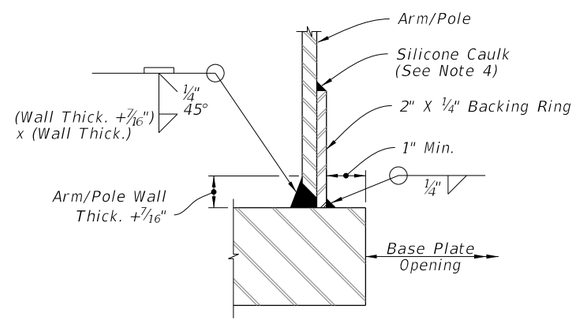


ELEVATION
(Back Face Shown)

BASE PLATE CONNECTION



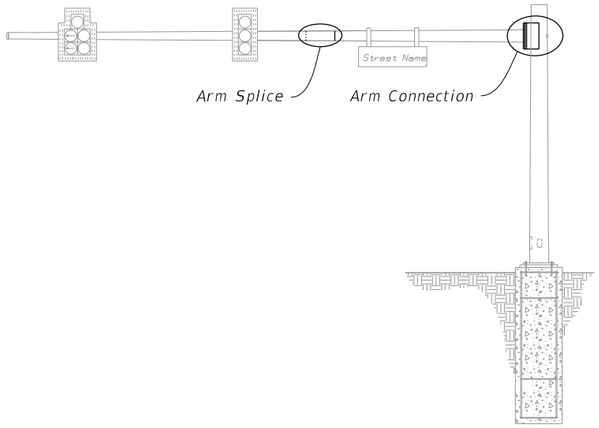
SECTION A-A



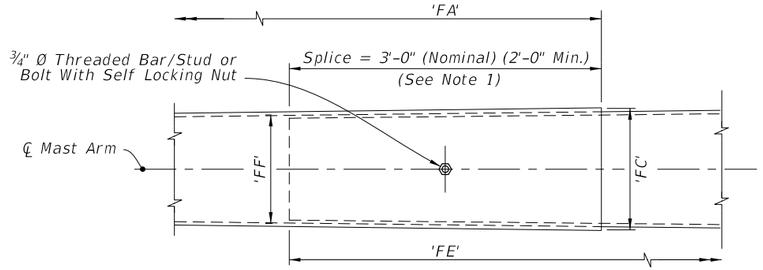
JOINT WELD DETAIL

DETAIL 'A'

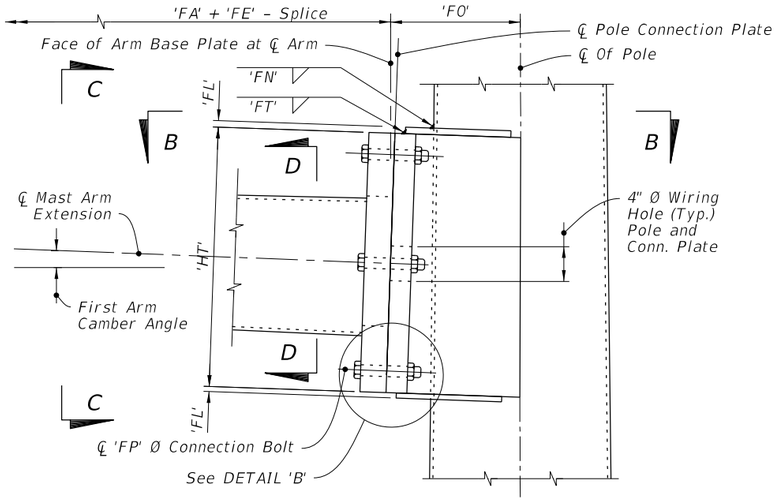
FOUNDATION AND BASE PLATE DETAILS



MAST ARM ASSEMBLY



ARM SPLICE



SINGLE ARM CONNECTION

SECTION B-B

SECTION C-C

SECTION D-D

DETAIL 'B'

DETAIL 'C'

NOTES:

1. Install the 'Slip Joint' splice with a tight fit and no change in the Mast Arm taper due to the splice.
2. Details shown on this sheet are for 12 sided pole sections. However, sections with more than 12 sides and round sections are permitted provided outside diameter and wall thickness are not reduced.
3. Match mark the Arm and Connection Plates to ensure proper assembly and the seam weld is in the proper location (seam located at the bottom side of the Arm).

SINGLE ARM CONNECTIONS & SPLICE DETAILS

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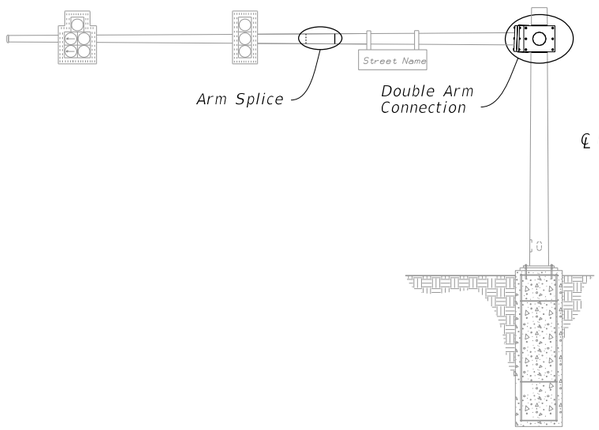
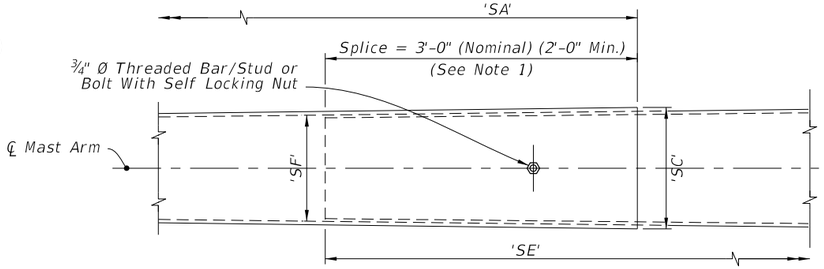
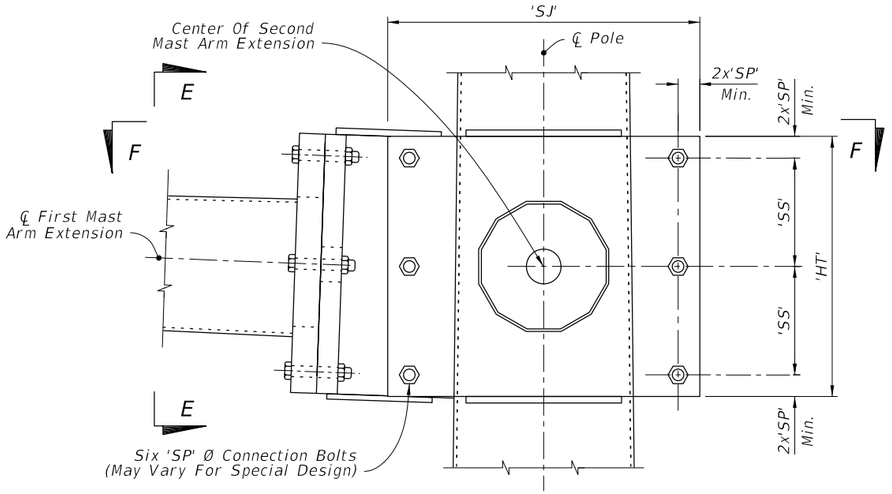


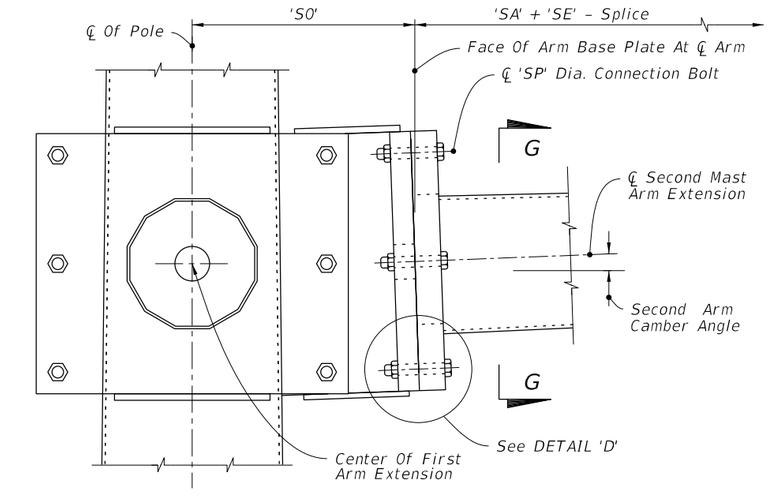
MAST ARM ASSEMBLY



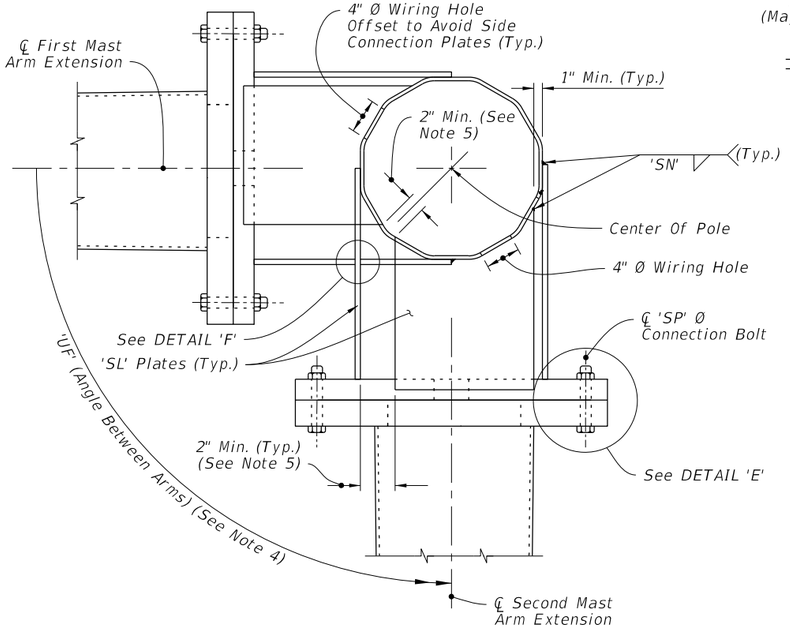
ARM SPLICE



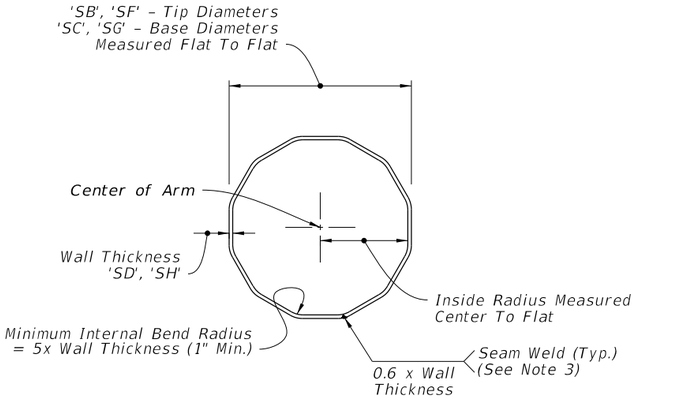
DOUBLE ARM CONNECTION



SECTION E-E



SECTION F-F



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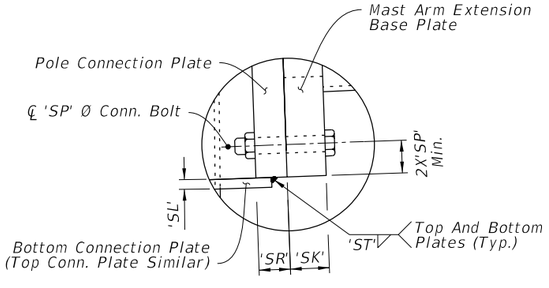

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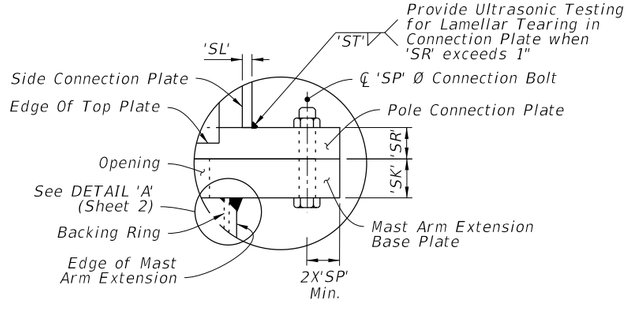

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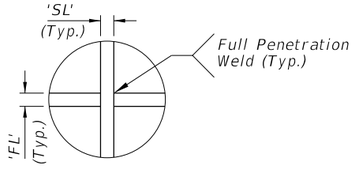

DETAIL 'F'

NOTES:

1. Install the 'Slip Joint' splice with a tight fit and no change in the Mast Arm taper due to the splice.
2. Details shown on this sheet are for 12 sided pole sections. However, sections with more than 12 sides and round sections are permitted provided outside diameter and wall thickness are not reduced.
3. Match mark the Arm and Connection Plates to ensure proper assembly and the seam weld is in the proper location (seam located at the bottom side of the Arm).
4. 'UF' measured counter clockwise from ℄ First Mast Arm Extension.
5. Adjust width of top and bottom Connection Plates to maintain minimum clearance shown.

DOUBLE ARM CONNECTIONS & SPLICE DETAILS

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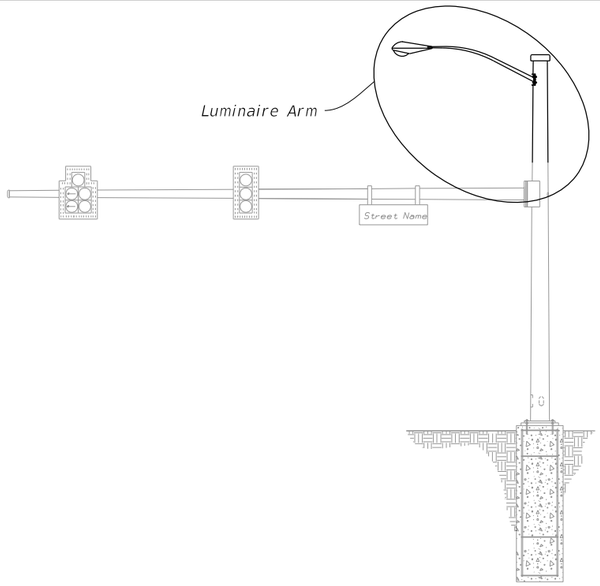
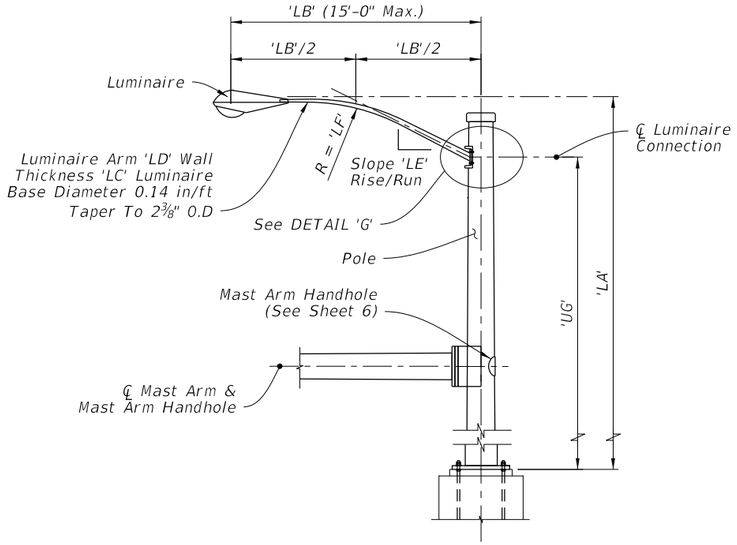
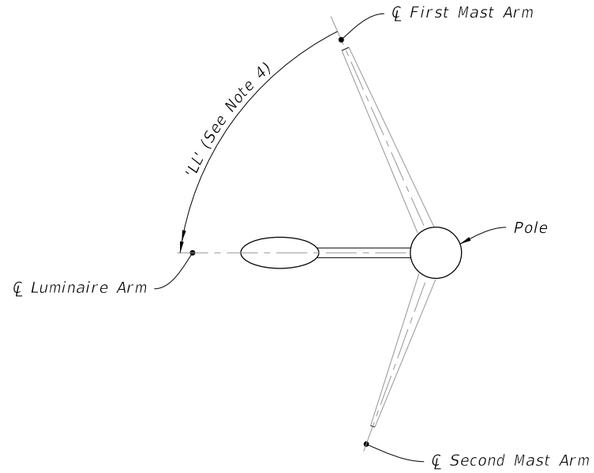


MAST ARM ASSEMBLY



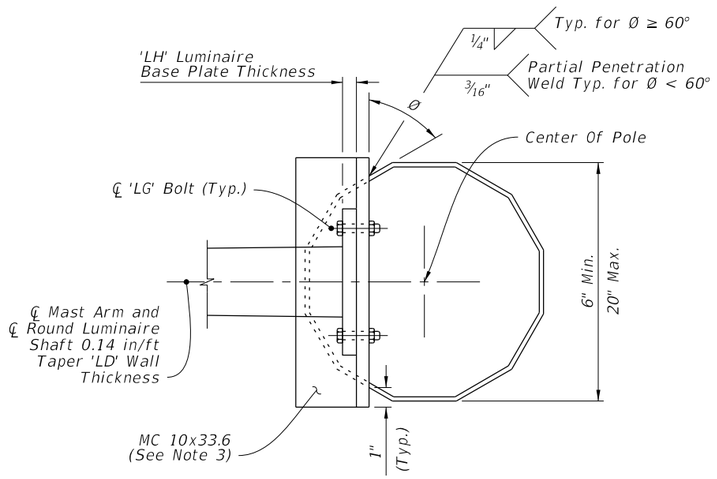
LUMINAIRE ELEVATION



LUMINAIRE ORIENTATION

NOTES:

1. Galvanized steel luminaire type and luminaire length may be found in the Lighting Plans.
2. Align Luminaire Arm with Single Mast Arm or First Arm of Double Mast Arm unless indicated otherwise in the plans.
3. The fabricator may substitute a ½" thick bent plate with the same flange width, height, and length as the MC 10x33.6 Channel section.
4. 'LL' measure counter clockwise from First Mast Arm.



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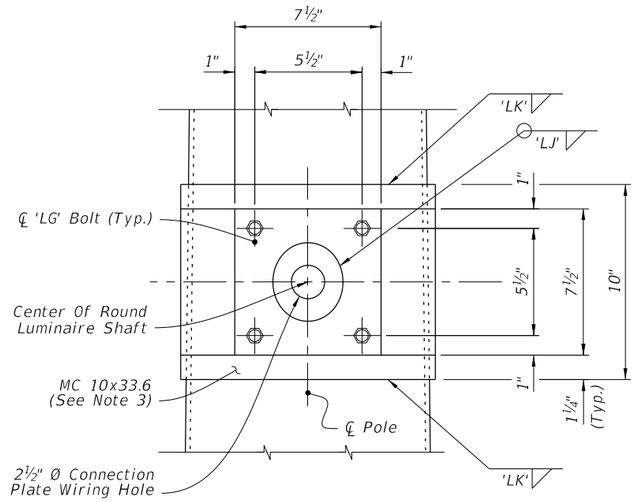
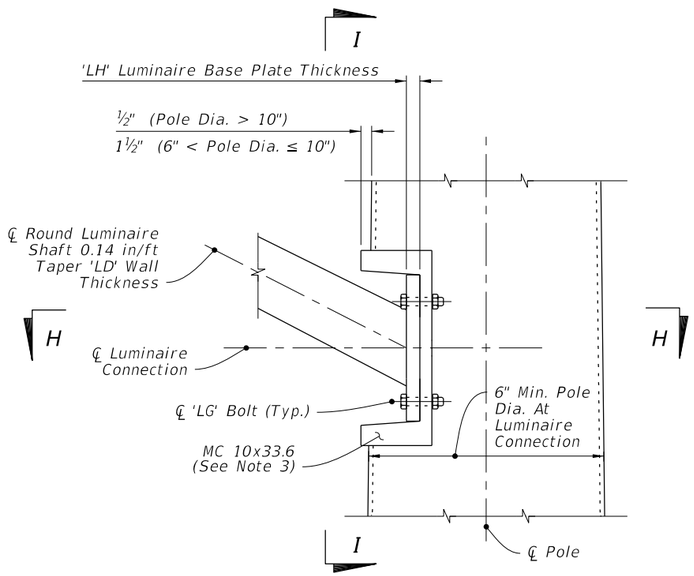


SECTION I-I



LUMINAIRE CONNECTION ELEVATION

DETAIL 'G'

LUMINAIRE ARM AND CONNECTION DETAILS

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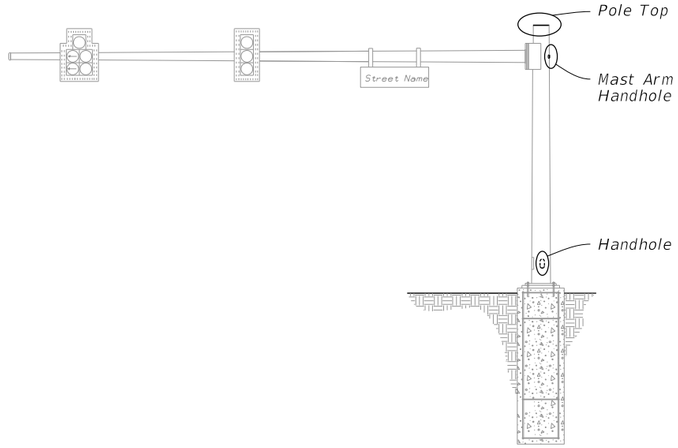
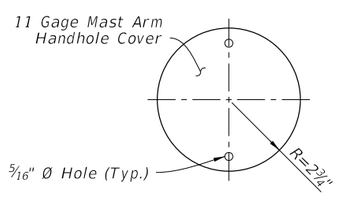


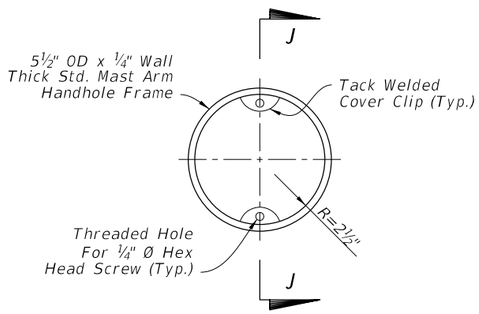
MAST ARM ASSEMBLY

NOTES:

1. Handhole covers may be omitted when Terminal Compartment is provided.
2. See Mast Arm Tabulation sheet to see if Terminal Compartment is required and for locations.
3. Terminal Compartment Frame Height 2'-0" minimum to 2'-6" maximum. Align bottom of Terminal Compartment a minimum of 1" below the bottom of the Handhole Frame.
4. Any combination of Option 'a' or 'b' may be used, provided both lifting and wiring is accommodated. Cap may be flat plate or domed cap with set screws.
5. An alternate terminal compartment frame detail is allowed where the compartment frame is of constant depth and cuts into the pole at the frame top and bottom but lays flush with the pole on the frame sides. The frame is then welded to the pole using fillet welds all around the outside.



COVER



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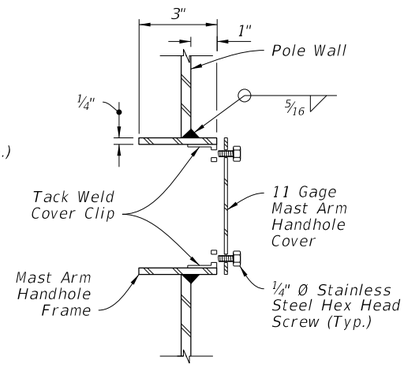
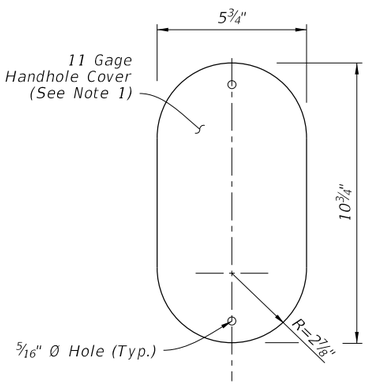


SECTION J-J

MAST ARM HANDHOLE



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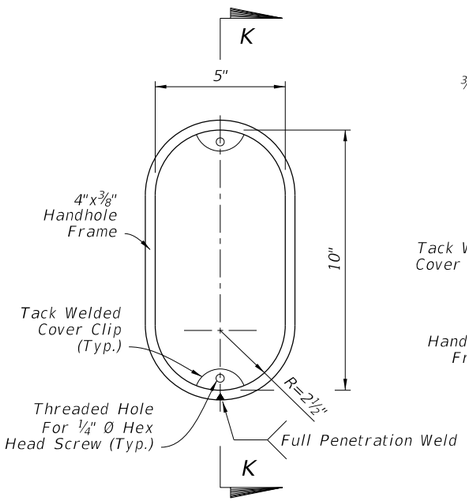

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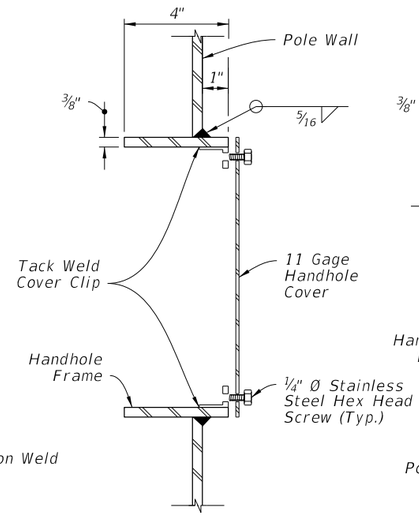
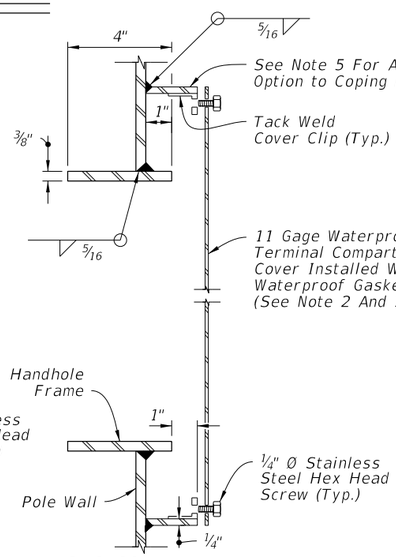
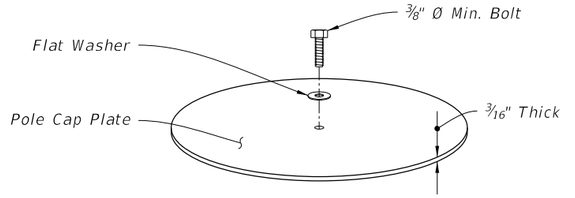


SECTION K-K
(Thru Handhole)

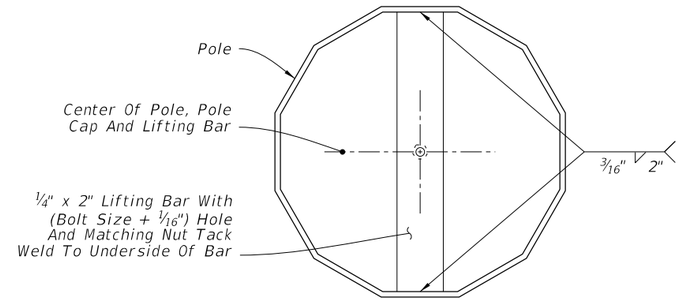


SECTION K-K
(Terminal Compartment)

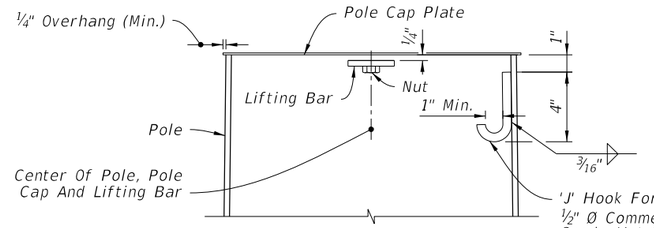
HANDHOLE



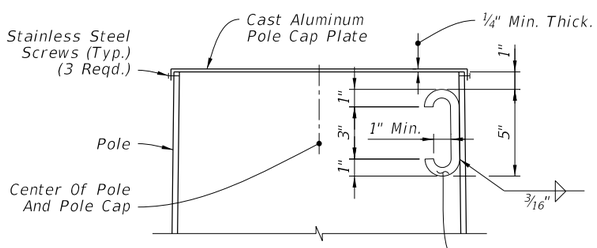
ISO VIEW
(Option 'a')



TOP VIEW
(Option 'a')



CUT-AWAY
(Option 'a')



CUT-AWAY
(Option 'b')

POLE TOP

HANDHOLE AND POLE TOP DETAILS

APPENDIX C:

GEOTECHNICAL REPORT

June 29, 2023

Kimley-Horn and Associates, Inc.
201 North Franklin St. Suite 1400
Tampa, FL 33602

Attn: Ms. Shari Barnwell, P.E.

RE: Report of Geotechnical Engineering Services
Lena Road from North of 44th Avenue East to SR 64
Manatee County, Florida
Manatee County Project No.: 6107560
Kimley-Horn Project No.: 148400100
Tierra Project No. 6511-22-127

Ms. Barnwell:

Tierra, Inc. (Tierra) has performed geotechnical engineering services for the proposed mast arm signal poles associated with the above-referenced project. This letter report presents the findings of our field exploration, results from laboratory testing, and geotechnical recommendations for design of the proposed mast arm signal pole structure foundations.

Project Information

Based on the design information provided by Kimley-Horn and Associates, Inc. (Kimley-Horn), three (3) mast arm signal poles are proposed at the intersection of Lena Road and SR 64 at approximate stations 309+24, 41' LT., 311+48, 79' RT. and 309+74, 82' RT. (C/L Const. Lena Road).

Soil Borings

To evaluate the subsurface conditions at the proposed mast arm signal pole foundation locations, Tierra performed Standard Penetration Test (SPT) borings to a depth of approximately 35 feet below existing grades.

Prior to performing the borings, a boring location plan was developed based on design information provided by Kimley-Horn, the guidelines provided in the Soils and Foundations Handbook published by the Florida Department of Transportation (FDOT) and our engineering judgment. The borings were located in the field by a representative of Tierra using a hand-held, non-survey grade Garmin eTrex® Global Positioning System (GPS) device with a manufacturer's reported accuracy of ±10 feet. The station and offset of each boring location were determined using the GPS coordinates obtained in the field in conjunction with project design files provided by Kimley-Horn. Some borings were offset from the originally planned locations due to utility and drill rig access constraints. The approximate boring locations are provided on the **Report of Core Borings** sheet in the **Attachments**. If an accurate determination of the boring locations and elevations is required, Tierra recommends that the locations be survey-located by the project surveyor.

The SPT borings were performed with the use of a mechanical drill rig equipped with an automatic hammer using Bentonite Mud drilling procedures. The soil sampling was performed in

general accordance with the American Society for Testing and Materials (ASTM) Test Designation D-1586. The initial 4 to 6 feet of the SPT borings were manually hand augered to verify utility clearance. SPT resistance N-values were then taken continuously to a depth of 10 feet and at intervals of 5 feet thereafter to the boring termination depths. Representative portions of the soil samples were sealed, labeled and transferred to our laboratory for classification and analysis.

General Soil Conditions within Borings

The subsurface conditions encountered within the borings generally consist of loose to medium dense sandy soils underlain by very stiff to hard silt to clay to the boring termination depths. Detailed results of the SPT borings are presented on the attached **Report of Core Borings** sheet.

Soil stratification was determined based on a review of recovered samples, laboratory test results, and interpretation of field boring logs. Stratification lines represent approximate boundaries between soil layers of different engineering properties; however, actual transitions between layers may be gradual. In some cases, small variations in properties that were not considered pertinent to our engineering evaluation may have been abbreviated or omitted for clarity. The soil profiles represent the conditions at the particular boring location and variations did occur among the borings. Specific details about subsurface conditions and materials encountered at each boring location can be obtained from the soil profiles presented on the attached **Report of Core Borings** sheet.

Groundwater Information

At the time of our field activities, the groundwater table was encountered within the borings at depths ranging from approximately 3 to 8½ feet below existing grades. The groundwater table levels are presented on the attached **Report of Core Borings** sheet.

Groundwater conditions will vary with environmental variations and seasonal conditions, such as the frequency and magnitude of rainfall patterns, as well as man-made influences (i.e., existing water management canals, swales, drainage ponds, underdrains, and areas of covered soils, such as paved parking lots and sidewalks).

General Recommendations

Shaft Installation

The proposed mast arm signal pole foundations should be installed in accordance with FDOT and/or Manatee County Specifications.

Very dense sand and indurated clay was encountered within the borings. Drilling into and/or through these materials may be difficult and will require non-conventional construction techniques and specialized equipment. The depth and consistency of these materials can vary.

Temporary casing methods for shaft installation beyond what is required in the FDOT Specifications may be required in order to prevent the collapse of sandy soils and/or groundwater intrusion during shaft construction.

Based on a review of the "Upper Floridan Aquifer Potentiometric Surface" maps published by the USGS, the potentiometric surface elevation in the project vicinity is reported up to approximately +30 feet, NGVD 29. Artesian flow conditions were not encountered within the borings performed at the time of the field activities; however, the contractor should be prepared to address artesian levels up to a head of +30 feet, NGVD 29.

Soil Parameters for Foundation Design

It is our understanding that the design of the mast arm signal pole foundations will be performed utilizing the approved FDOT Mathcad program. The FDOT programs model the subsurface as a uniform soil type with consistent strength properties; however, multilayered soil profiles with different soil types and properties were encountered within the boring depths. Based on our understanding of the FDOT Mathcad program and its one soil type modeling, Tierra has evaluated the results of the soil borings and developed equivalent average N-value tables and soil design parameters for use by the structural engineer. The recommended geotechnical input parameters for the FDOT Mathcad program are provided in the attached **Recommended Soil Parameters for FDOT Mathcad Program** and **Recommended Equivalent Average N-Values for FDOT Mathcad Program** tables. Tierra recommends that the foundations be designed based on saturated conditions, i.e. the groundwater table at the surface.

If the mast arm signal pole foundations are installed on side slopes, the design should include the portion of the shaft with less than 2.5D (D=shaft diameter) horizontal soil cover (face-of-shaft to face-of-slope) as unsupported length and design the portion of the shaft with more than 2.5D horizontal soil cover as though founded in level ground.

Shaft Embedment/Length

The mast arm signal pole foundations should not be tipped/embedded within one (1) shaft diameter of very loose soils to reduce the risk of excessive settlement of the shaft and potential for instability of the shaft bottom during construction. In the event that the shaft tip elevation is determined to be within one (1) shaft diameter of very loose soils based on the design calculations, the shaft should be extended below the very loose soils into denser underlying materials. It is recommended that Tierra be provided the design shaft tip elevations for review prior to the final plan submittal.

Tierra appreciates the opportunity to be of service to Kimley-Horn and Associated, Inc. on this project. If you have any questions or comments regarding this report, please contact our office at your earliest convenience.

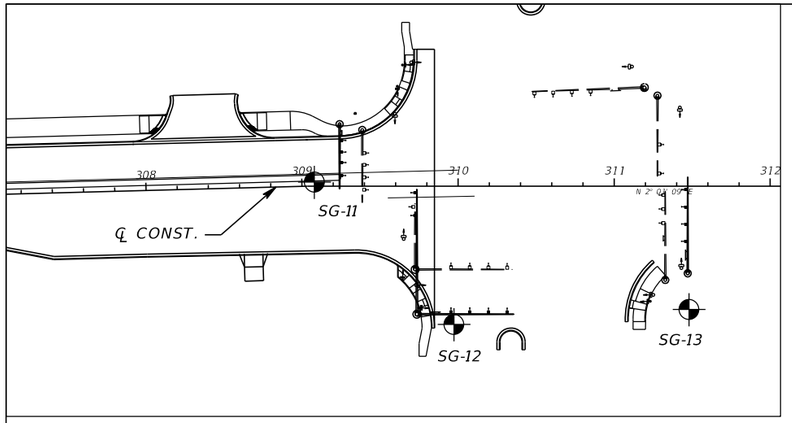
Respectfully Submitted,

TIERRA, INC.

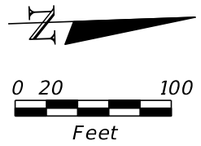
Trevor J. Bianco, E.I.
Geotechnical Engineer Intern

Kevin H. Scott, P.E.
Senior Geotechnical Engineer
Florida License No. 65514

Attachments: **Report of Core Borings Sheet**
Recommended Soil Parameters for FDOT Mathcad Program
Recommended Equivalent Average N-Values for FDOT Mathcad Program



BORING LOCATION PLAN



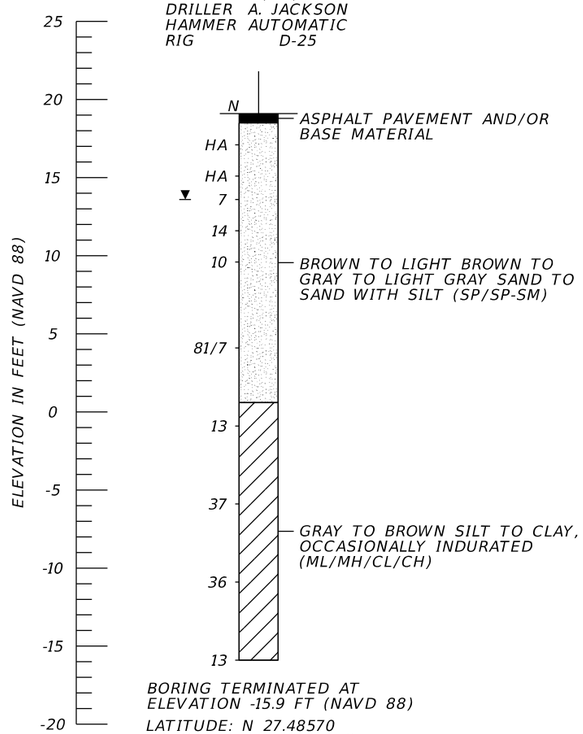
NOTES:

1. THE BORINGS WERE LOCATED IN THE FIELD USING A HAND-HELD GARMIN ETREX NON-SURVEY GRADE GLOBAL POSITIONING SYSTEM (GPS) DEVICE WITH A REPORTED ACCURACY OF ±10 FEET. THE BORING LOCATION STATION, OFFSET AND ELEVATION WERE DETERMINED USING THE GPS COORDINATES IN CONJUNCTION WITH THE DESIGN FILES PROVIDED BY KIMLEY-HORN. THE BORING LOCATIONS AND ELEVATIONS SHOULD BE CONSIDERED APPROXIMATE.
2. TEMPORARY CASING METHODS BEYOND WHAT IS REQUIRED IN THE PROJECT SPECIFICATIONS FOR THE SHAFT INSTALLATION MAY BE REQUIRED IN ORDER TO PREVENT THE COLLAPSE OF THE SANDY SOILS AND/OR GROUNDWATER INTRUSION DURING THE SHAFT INSTALLATION.
3. BASED ON THE REVIEW OF THE "UPPER FLORIDAN AQUIFER POTENTIOMETRIC SURFACE" MAPS PUBLISHED BY THE USGS, THE POTENTIOMETRIC SURFACE ELEVATION IN THE PROJECT VICINITY IS REPORTED UP TO APPROXIMATELY +30 FEET, NGVD 29. ARTESIAN FLOW CONDITIONS WERE NOT ENCOUNTERED WITHIN THE BORINGS PERFORMED AT THE TIME OF THE FIELD ACTIVITIES; HOWEVER, THE CONTRACTOR SHOULD BE PREPARED TO ADDRESS ARTESIAN LEVELS UP TO A HEAD OF +30 FEET, NGVD 29.
4. VERY DENSE SAND AND INDURATED CLAY WAS ENCOUNTERED WITHIN THE BORINGS. DRILLING INTO AND/OR THROUGH THESE MATERIALS MAY BE DIFFICULT AND WILL REQUIRE NON-CONVENTIONAL CONSTRUCTION TECHNIQUES AND SPECIALIZED EQUIPMENT. THE DEPTH AND CONSISTENCY OF THESE MATERIALS CAN VARY.

LEGEND

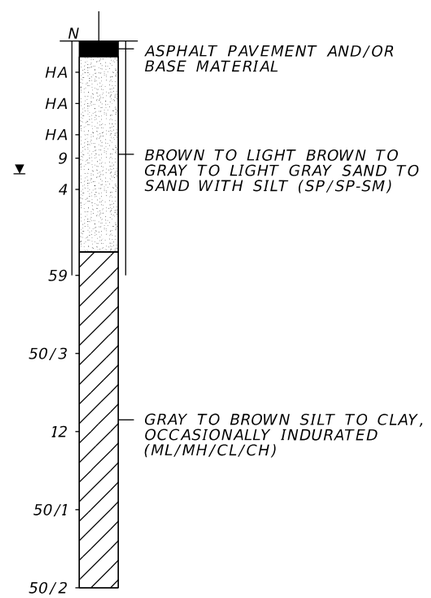
	BROWN TO LIGHT BROWN TO GRAY TO LIGHT GRAY SAND TO SAND WITH SILT (SP/SP-SM)
	GRAY TO BROWN SILT TO CLAY, OCCASIONALLY INDURATED (ML/MH/CL/CH)
	ASPHALT PAVEMENT AND/OR BASE MATERIAL
SP	UNIFIED SOIL CLASSIFICATION SYSTEM (ASTM D 2487) GROUP SYMBOL AS DETERMINED BY VISUAL REVIEW.
N	NUMBERS TO THE LEFT OF BORINGS INDICATE SPT VALUE FOR 12 INCHES OF PENETRATION (UNLESS OTHERWISE NOTED).
50/4	NUMBER OF BLOWS FOR 4 INCHES OF PENETRATION
HA	HAND AUGERED TO VERIFY UTILITY CLEARANCE
WH	SPLIT-SPOON SAMPLER ADVANCED UNDER WEIGHT OF ROD AND HAMMER
NAVD 88	NORTH AMERICAN VERTICAL DATUM OF 1988
	APPROXIMATE SPT BORING LOCATION
	CASING
	GROUNDWATER LEVEL ENCOUNTERED DURING FIELD EXPLORATIONS

BOR # SG-11
STA. 309+08
REF. C/L CONST.
OFF. 3' LT.
ELEV. 19.1
DATE 5/25/2023
DRILLER A. JACKSON
HAMMER AUTOMATIC
RIG D-25



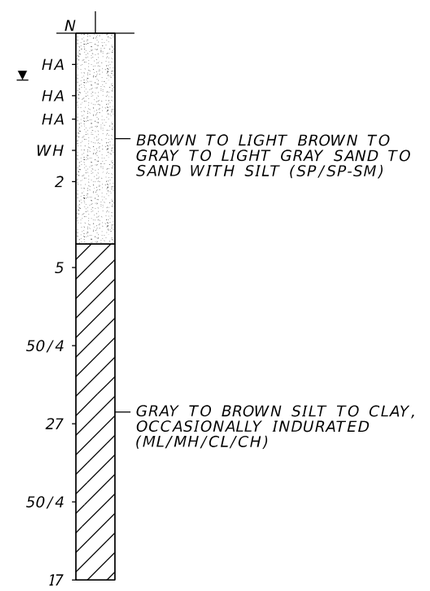
BORING TERMINATED AT ELEVATION -15.9 FT (NAVD 88)
LATITUDE: N 27.48570
LONGITUDE: W 82.45679

BOR # SG-12
STA. 309+97
REF. ℄ CONST.
OFF. 89' RT.
ELEV. 19.9
DATE 5/9/2023
DRILLER J. SHAW
HAMMER AUTOMATIC
RIG D-25



BORING TERMINATED AT ELEVATION -15.1 FT (NAVD 88)
LATITUDE: N 27.48593
LONGITUDE: W 82.45651

BOR # SG-13
STA. 311+48
REF. ℄ CONST.
OFF. 79' RT.
ELEV. 20.4
DATE 6/27/2023
DRILLER A. JACKSON
HAMMER AUTOMATIC
RIG D-25



BORING TERMINATED AT ELEVATION -14.6 FT (NAVD 88)
LATITUDE: N 27.48635
LONGITUDE: W 82.45652

	AUTOMATIC HAMMER
GRANULAR MATERIALS- RELATIVE DENSITY	SPT N-VALUE (BLOWS/FT.)
VERY LOOSE	LESS THAN 3
LOOSE	3 to 8
MEDIUM DENSE	8 to 24
DENSE	24 to 40
VERY DENSE	GREATER THAN 40
SILTS AND CLAYS CONSISTENCY	SPT N-VALUE (BLOWS/FT.)
VERY SOFT	LESS THAN 1
SOFT	1 to 3
FIRM	3 to 6
STIFF	6 to 12
VERY STIFF	12 to 24
HARD	GREATER THAN 24

THE OFFICIAL RECORD OF THIS SHEET IS THE ELECTRONIC FILE DIGITALLY SIGNED AND SEALED UNDER RULE 61G15-23.004, F.A.C.

No.	REVISIONS	DATE	BY

KEVIN H. SCOTT, P.E.
P.E. LICENSE NUMBER 65514
TIERRA, INC.
7351 TEMPLE TERRACE HIGHWAY
TAMPA, FLORIDA 33637

KHA PROJECT 148400100
DATE 5/2023
SCALE AS SHOWN
DESIGNED BY BJS
DRAWN BY BJS
CHECKED BY TB

Manatee County FLORIDA

LENA ROAD
MANATEE COUNTY FL

LICENSED PROFESSIONAL
KEVIN H. SCOTT, P.E.
FL LICENSE NUMBER 65514
DATE:

REPORT OF CORE BORINGS

SHEET NUMBER

bsawaska 6/28/2023 12:40:37 PM Default J:\6511\2022 Files\6511-22-127 Manatee Lena Rd Kimley\Microstation\Geotech\SPTBSG01.dgn

Recommended Soil Parameters for FDOT Mathcad Program
Lena Road from North of 44th Avenue East to SR 64
Manatee County, Florida
Manatee County Project No.: 6107560
Tierra Project No.: 6511-22-127

Structure Name	Intersection	Approximate Structure Location (C/L Const. Lena Road)		Reference Boring	Approximate Boring Location (C/L Const. Lena Road)		Soil Type	Submerged Unit Weight, γ (lb/ft^3)	Saturated Condition	Friction Angle, ϕ (degrees)
		Station	Offset		Station	Offset				
Mast Arm Pole 1	Lena Road at SR 64	309+24	41' LT.	SG-11	309+08	3' LT.	SAND	50	YES[1]	30
Mast Arm Pole 5	Lena Road at SR 64	309+74	82' RT.	SG-12	309+97	89' RT.	SAND	50	YES[1]	30
Mast Arm Pole 4	Lena Road at SR 64	311+47	56' RT.	SG-13	311+48	79' RT.	SAND	43	YES[1]	29

[1] Assume saturated conditions, i.e. analyze with the groundwater at the surface.

Recommended Equivalent Average N-Values for FDOT Mathcad Program
Lena Road from North of 44th Avenue East to SR 64
Manatee County, Florida
Manatee County Project No.: 6107560
Tierra Project No.: 6511-22-127

Approximate Boring Elevation (feet, NAVD 88):	19.1	Reference Boring:	SG-11
		Boring Station & Offset	309+08, 3' LT.
Approximate Ground Elevation at Structure Location (feet, NAVD 88):	19.5	Structure Station & Offset:	309+24, 41' LT.

Mast Arm Pole 1

Approximate Shaft Depth (feet)	Approximate Shaft Elevation (feet, NAVD 88)	Automatic Hammer SPT N-Value	Corrected Safety Hammer N-Value[1]	Average Weighted N-Value for use in Mathcad Torsional Calculation
1	18.1	HA [2]	4.0	4
2	17.1	HA [2]	4.0	4
3	16.1	HA [2]	4.0	4
4	15.1	HA [2]	4.0	4
5	14.1	7	8.7	5
6	13.1	7	8.7	6
7	12.1	14	17.4	8
8	11.1	14	17.4	10
9	10.1	10	12.4	10
10	9.1	10	12.4	11
11	8.1	10	12.4	11
12	7.1	10	12.4	11
13	6.1	10	12.4	11
14	5.1	81/7	50.0	12
15	4.1	81/7	50.0	12
16	3.1	81/7	50.0	12
17	2.1	81/7	50.0	13
18	1.1	81/7	50.0	13
19	0.1	13	16.1	13
20	-0.9	13	16.1	12
21	-1.9	13	16.1	12
22	-2.9	13	16.1	12
23	-3.9	13	16.1	12
24	-4.9	37	45.9	13
25	-5.9	37	45.9	14
26	-6.9	37	45.9	15
27	-7.9	37	45.9	15
28	-8.9	37	45.9	16
29	-9.9	36	44.6	16
30	-10.9	36	44.6	16
31	-11.5	36	44.6	16
32	-12.5	36	44.6	17
33	-13.5	36	44.6	17
34	-14.5	13	16.1	16
35	-15.5	13	16.1	16

[1] Automatic Hammer SPT N Value is corrected by a factor of 1.24 to equivalent Safety Hammer N-Value in accordance with the FDOT Soils and Foundations Handbook.

[2] HA: Hand augered. Corrected Safety Hammer N-Value treated as 4.

Recommended Equivalent Average N-Values for FDOT Mathcad Program
Lena Road from North of 44th Avenue East to SR 64
Manatee County, Florida
Manatee County Project No.: 6107560
Tierra Project No.: 6511-22-127

Approximate Boring Elevation (feet, NAVD 88):	19.9	Reference Boring:	SG-12
		Boring Station & Offset	309+97, 89' RT.
Approximate Ground Elevation at Structure Location (feet, NAVD 88):	19.9	Structure Station & Offset:	309+74, 82' RT.

Mast Arm Pole 5

Approximate Shaft Depth (feet)	Approximate Shaft Elevation (feet, NAVD 88)	Automatic Hammer SPT N-Value	Corrected Safety Hammer N-Value[1]	Average Weighted N-Value for use in Mathcad Torsional Calculation
1	18.9	HA [2]	4.0	4
2	17.9	HA [2]	4.0	4
3	16.9	HA [2]	4.0	4
4	15.9	HA [2]	4.0	4
5	14.9	HA [2]	4.0	4
6	13.9	HA [2]	4.0	4
7	12.9	9	11.2	5
8	11.9	9	11.2	7
9	10.9	4	5.0	6
10	9.9	4	5.0	6
11	8.9	4	5.0	6
12	7.9	4	5.0	5
13	6.9	4	5.0	5
14	5.9	59	50.0	12
15	4.9	59	50.0	16
16	3.9	59	50.0	19
17	2.9	59	50.0	22
18	1.9	59	50.0	24
19	0.9	50/3	50.0	25
20	-0.1	50/3	50.0	26
21	-1.1	50/3	50.0	27
22	-2.1	50/3	50.0	27
23	-3.1	50/3	50.0	27
24	-4.1	12	14.9	26
25	-5.1	12	14.9	24
26	-6.1	12	14.9	23
27	-7.1	12	14.9	22
28	-8.1	12	14.9	21
29	-9.1	50/1	50.0	21
30	-10.1	50/1	50.0	21
31	-11.1	50/1	50.0	21
32	-12.1	50/1	50.0	21
33	-13.1	50/1	50.0	21
34	-14.1	50/2	50.0	21
35	-15.1	50/2	50.0	21

[1] Automatic Hammer SPT N Value is corrected by a factor of 1.24 to equivalent Safety Hammer N-Value in accordance with the FDOT Soils and Foundations Handbook.

[2] HA: Hand augered. Corrected Safety Hammer N-Value treated as 4.

Recommended Equivalent Average N-Values for FDOT Mathcad Program
Lena Road from North of 44th Avenue East to SR 64
Manatee County, Florida
Manatee County Project No.: 6107560
Tierra Project No.: 6511-22-127

Approximate Boring Elevation (feet, NAVD 88):	20.4	Reference Boring:	SG-13
		Boring Station & Offset	311+48, 79' RT.
Approximate Ground Elevation at Structure Location (feet, NAVD 88):	21.0	Structure Station & Offset:	311+47, 56' RT.

Mast Arm Pole 4

Approximate Shaft Depth (feet)	Approximate Shaft Elevation (feet, NAVD 88)	Automatic Hammer SPT N-Value	Corrected Safety Hammer N-Value[1]	Average Weighted N-Value for use in Mathcad Torsional Calculation
1	19.4	HA [2]	4.0	4
2	18.4	HA [2]	4.0	4
3	17.4	HA [2]	4.0	4
4	16.4	HA [2]	4.0	4
5	15.4	HA [2]	4.0	4
6	14.4	HA [2]	4.0	4
7	13.4	WH	0.0	2
8	12.4	WH	0.0	2
9	11.4	2	2.5	2
10	10.4	2	2.5	2
11	9.4	2	2.5	2
12	8.4	2	2.5	2
13	7.4	2	2.5	2
14	6.4	5	6.2	2
15	5.4	5	6.2	2
16	4.4	5	6.2	3
17	3.4	5	6.2	3
18	2.4	5	6.2	3
19	1.4	50/4	50.0	6
20	0.4	50/4	50.0	9
21	-0.6	50/4	50.0	11
22	-1.6	50/4	50.0	13
23	-2.6	50/4	50.0	15
24	-3.6	27	33.5	15
25	-4.6	27	33.5	15
26	-5.6	27	33.5	14
27	-6.6	27	33.5	14
28	-7.6	27	33.5	14
29	-8.6	50/4	50.0	15
30	-9.6	50/4	50.0	15
31	-10.0	50/4	50.0	16
32	-11.0	50/4	50.0	16
33	-12.0	50/4	50.0	16
34	-13.0	17	21.1	16
35	-14.0	17	21.1	15

[1] Automatic Hammer SPT N Value is corrected by a factor of 1.24 to equivalent Safety Hammer N-Value in accordance with the FDOT Soils and Foundations Handbook.

[2] HA: Hand augered. Corrected Safety Hammer N-Value treated as 4.

APPENDIX D:

POLE 1 – DESIGN

APPENDIX D:

POLE 1 – VERTICAL CLEARANCE

Kimley»Horn

Project:	Lena Road		
Structure ID:	Pole 1		
Designed by:	JAS	*Date:*	07-05-2023
Checked by:	JAR	*Date:*	07-10-2023

General Info & Mounting Height Calculation

(Enter values in shaded cells only)

County (District) [1] =	Manatee (1)	
Wind Speed [1] =	150	mph
Backplates [2] =	Yes	
Arm Type =	See Mast Arm Excel	
Drop Distance [3] =	2.500	ft
Base El. =	+19.740	ft
Crown El. Arm #1 [4] =	+19.870	ft
Arm Mounting Height, UB [5] =	21.000	ft
MVC Arm #1 =	**18.370**	ft *(from 17.5' to 19')* [6]

Checks:

Ok, Vertical Clearance requirements satisfied at Arm #1

Ok, Mounting Height within FDOT limits

Notes & References:

(1) Per FDOT Structures Manual (Jan. 2023), Vol. 3 - Mod's to LTSLRFD-1, Section 3.8.2 - *"For the 700 year Extreme Event Limit State, use the wind speeds (mph) shown in FDOT SDG Table 2.4.1-1."*

(2) Per FDOT FDM (Jan. 1, 2023) Vol. 2, Chapter 261.4 - *"Design all structures assuming traffic signal assemblies have backplates in accordance with FDM 232.1.5"* Per FDOT FDM (Jan. 1, 2023) Vol. 2, Chapter 232.1.5, *"Install retroreflective signal backplates on traffic signals for all approaches."*

(3) *"Drop Distance"* is the vertical distance measured from the centerline of the arm to the bottom of signal or sign. Dimensions: 14" per head for standard signal section, 6" for backplate (each side), and 3" added to the end of the signal head to compensate for attachment hardware, per FDOT SPI 649-030 (FY 2023-24);

e.g. 3-Head = 0.5(3*14") + 6" + 3" = 30"; 4-Head = 37", 5-Head = 30" or 44", etc.

(4) Arm 1 is the larger of the two arms; if only 1 arm, Crown El. Arm #1 = Crown El. Arm #2

(5) In order to use FDOT Standard Assemblies, 18' ≤ UB ≤ 22' (per FDOT SPI 649-030, FY 2023-24).

(6) FDOT FDM (Jan. 1 2023), Section 210.10.3 Vertical Clearances: *"The required clearance for new signals on span wires, mast arms, or other structures is 17.5 feet. This clearance is the least distance measured between the lowest point on the signal structure and the traffic lane or shoulder directly below the signal structure. For any construction affecting existing signal clearances, FDOT minimum vertical clearance is 17 feet. Vertical clearances between 15 feet and 17 feet require a Design Variation. Signal clearances less than 15 feet are not allowed"*

FDOT Construction Specifications 2022, 650-3.3 Clearances: "*Unless directed otherwise by the Engineer for unusual circumstances at the site, provide a vertical clearance of not less than 17 feet-6 inches and not more than 19 feet for traffic signals placed over the roadway. Measure such clearance for each span directly under the most critical signal assembly (in regards to clearance) for the span. Place signal assemblies on each span as near as practical to the same elevation as the critical signal assembly. Ensure that the lowest point on pedestal-mounted and side-mounted signal heads is 12 feet above finished grade at the point of their installation"*

Version 2.0 (05/16/2022)

APPENDIX D:

POLE 1 – FDOT DESIGN AID

Kimley-Horn
189 S. Orange Ave., Suite 1000
Orlando, FL 32801

Design Aid for FDOT Standard Mast Arm Assemblies (Standard Plans Index 649-030)

Mast Arm Assembly Information

Wind Speed: ○ 130 mph ◉ 150 mph ○ 170 mph

Signal Orientation: ◉ Vertical ○ Horizontal

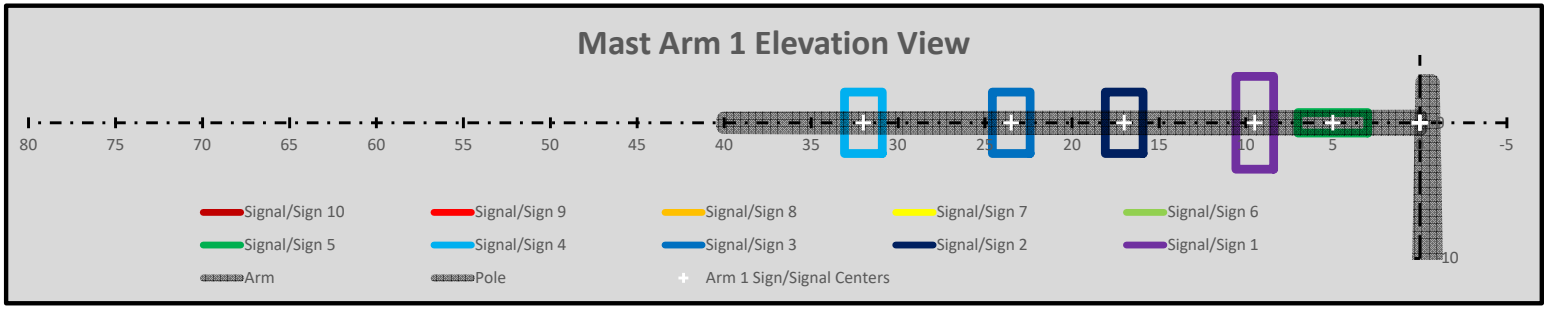
Back Plate Width: ◉ 6.0 in. ○ 2.5 in. ○ 0 in.

Luminaire? ○ Yes ◉ No

Arm 1 Length: 30 | [40] | 50 | 60 | 70 | 78

Arm 1 Length, Signal/Sign Location and Size

	Signal\Sign #10	Signal\Sign #9	Signal\Sign #8	Signal\Sign #7	Signal\Sign #6	Signal\Sign #5	Signal\Sign #4	Signal\Sign #3	Signal\Sign #2	Signal\Sign #1
	◉ None	◉ None	◉ None	◉ None	◉ None	○ None	○ None	○ None	○ None	○ None
	○ 3 Head	○ 3 Head	○ 3 Head	○ 3 Head	○ 3 Head	○ 3 Head	○ 3 Head	◉ 3 Head	◉ 3 Head	○ 3 Head
	○ 4 Head	○ 4 Head	○ 4 Head	○ 4 Head	○ 4 Head	○ 4 Head	○ 4 Head	○ 4 Head	○ 4 Head	○ 4 Head
	○ 5 Head	○ 5 Head	○ 5 Head	○ 5 Head	○ 5 Head	○ 5 Head	○ 5 Head	○ 5 Head	○ 5 Head	◉ 5 Head
	○ Sign	○ Sign	○ Sign	○ Sign	○ Sign	◉ Sign	○ Sign	○ Sign	○ Sign	○ Sign
Dist to Pole (ft.)						5	32	23.5	17	9.5
Sign Width (in.)						48				
Sign Height (in.)						18				
Area (SF)	0.0	0.0	0.0	0.0	0.0	6.0	9.8	9.8	9.8	14.9
*M_{wl}. (kip*ft)*	0	0	0	0	0	2	20	14	10	9



Arm 1 Length (ft)	40	
Standard Plans Index 649-030	**Regular**	**Heavy Duty**
Dia. at Arm Base (in)	13	14
Wall Thickness (in)	0.2500	0.2500
Resistance (M_r=ϕM_n) (kip*ft)	145	166
95% M_r (kip*ft)	138	158

Arm 1 Loads	Regular	Heavy Duty
1.1*Arm M_{dl} (kip*ft)	22	24
Arm M_{wl} (kip*ft)	25	28
1.1*Sign/Signal M_{dl} (kip*ft)	5	
Sign/Signal M_{wl} (kip*ft)	55	
Total Moment ($M_{extreme}$)	85	89

Mast Arm Assembly Designation
One Arm Assembly
A40/S-P2/S-DS/12/4.5

Notes:

Run the FDOT Mast Arm Mathcad Program for more accurate results.

For new designs, always design with 6" backplates.

Mast Arm Assembly ID consists of three parts for a single arm and 4 parts for a double Arm. Each part is separated by "-".

Part 1 is Arm 1: Axx/y/z, where xx is the arm length, y is "S" for single arm or "D" for double arms and z is "H" for heavy duty arm or blank for regular arm.

Part 2 is Arm 2 and has the same nomenclature as the 1st arm. For single arm assemblies, Part 2 is omitted.

Part 3 is the Pole: Px/y/z where x is the pole ID, y is "S" for single arm or "D" for double arms and z is "L" for luminaire or blank for no luminaire.

Part 4 is the Drilled Shaft: DS/xx/y where xx is the shaft length and y is the shaft diameter.

Arm to pole connection is assumed at 22 ft. above the base.

No foundation offset is considered. If the top of drilled shaft > 2 feet above ground, run the Mathcad Mast Arm Program.

APPENDIX D:

POLE 1 – MAST ARM DESIGN

FDOT Mast Arm Traffic Signal Support Analysis Program V2.0

This program works in conjunction with FDOT Mast Arm Standard Plans 649-030 & 649-031.

References:
AASHTO LRFD Specifications for Structural Supports for Highway Signs, Luminaires and Traffic Signals (LRFDLTS).
FDOT Structures Manual Volume 3 (SM V3).
AISC Steel Construction Manual

Reference

For more information see Reference.xmcd and Changes.xmcd.

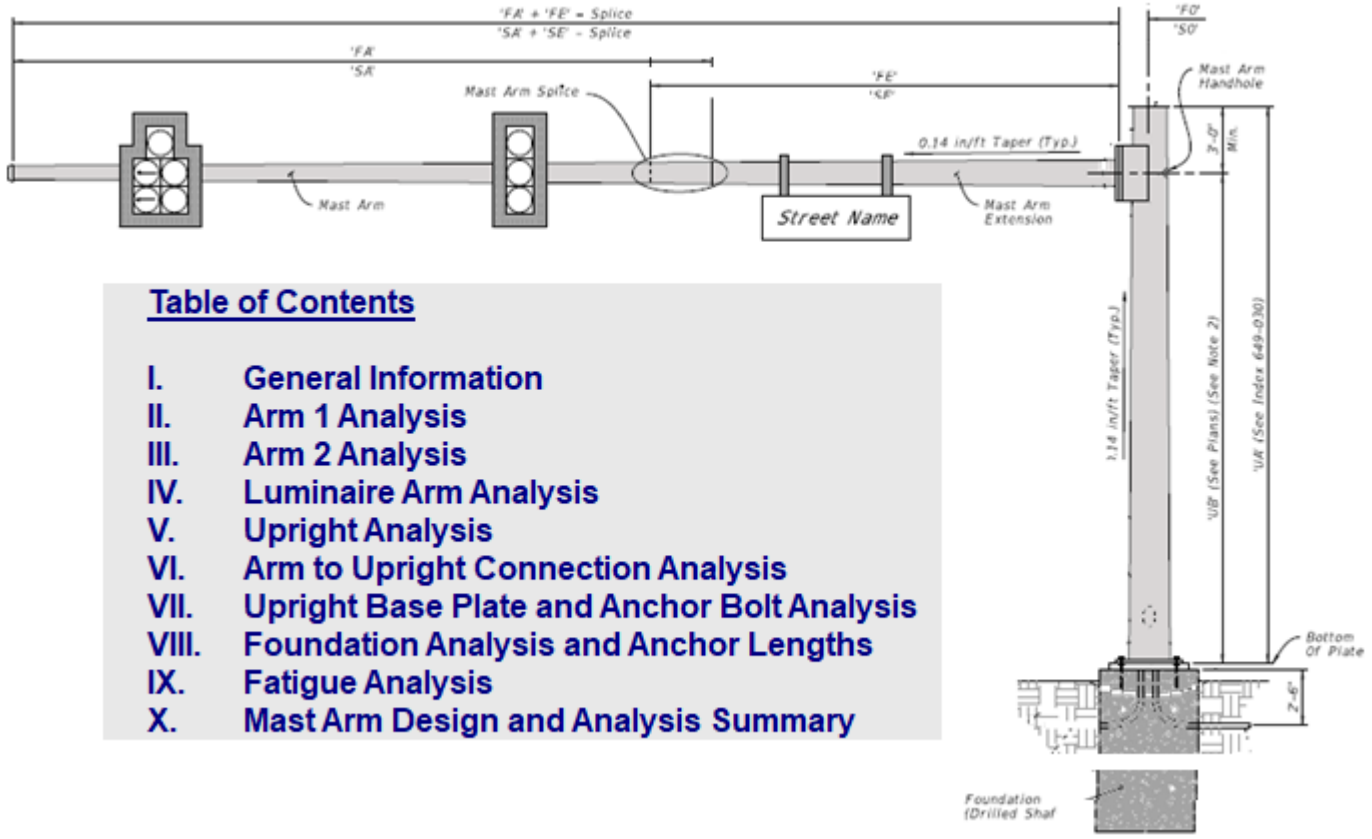


Table of Contents

Data Folder and Files

Data Files Folder

Change Folder

K:\ORL_Structures_Projects-Structures_MastArms\148400103 Lena Road\03_Calculations\Pole 1\MastArmV2.0\Data\

Required - Open Existing Data File. To save New Data Files, enter data variables at the end of Section IX.

Refresh List

Open File

A78D-A30D-P6DL.dat
A78D-A50D-P6DL.dat
A78D-A70D-P7DL.dat
A78DH-A40DH-P6DL.dat
A78DH-A60DH-P6DL.dat
A78DH-A78DH-P7DL.dat
A78SH-P6SL.dat
Pole 1.dat

I. General Information and Sign & Signal Data

Enter Project Information

Project Name	Lena Road		
Project No.	148400103		
Designed by	KED	*Date*	7/6/2023
Checked by	JAS	*Date*	7/10/2023
Signal Name	Pole 1		
Station/Offset	309+24.08 / 39.74' LT		

Bluetooth device mounted to the upright is ignored as it will have negligible affect on the base torque.

Enter Wind Speed

Design Wind Speed 150 *mph*

Extreme Event Wind Speed

SDG Wind Speeds by County

Enter Arm Lengths, Signal and Sign Data

Arm 1

Arm 1 Length 40 Reset Arm 1 Data

Arm1 Signal Number	*Distance to Signal (ft)*	*Number of Heads*
1	9.5	5
2	17	3
3	23.5	3
4	32	3
5		
6		
7		
8		
9		
10		

Arm 2 *Set Arm 2 Length = 0 for single arm Mast Arms*

Arm 2 Length 0 Reset Arm 2 Data

Arm2 Signal Number	*Distance to Signal (ft)*	*Number of Heads*
1		
2		
3		
4		
5		
6		
7		
8		
9		
10		

Arm 1 Sign Panels

Arm1 Sign Panel Number	*Distance to Panel (ft)*	*Panel Area (sf)*
1	5	6
2		
3		
4		
5		

Arm 2 Sign Panels

Arm2 Sign Panel Number	*Distance to Panel (ft)*	*Panel Area (sf)*
1		
2		
3		
4		
5		

Save Data for Signs and Signals

II. Arm 1 Analysis

InputDataFile = "Pole 1.dat" $V_{extreme} = 150 \cdot mph$

Reference:K:\ORL_Structures_Projects-Structures_Mast Arms\148400103 Lena Road\03_Calculations\Pole 1\MastArmV2.0\LRFD Equation M

Help - Base Diameters | Help - Tube Wall Thickness

Arm Extension (for 2 piece arms only)

Enter Arm 1 Data

Iterate on Base Diameters and Wall Thicknesses

Arm Length (ft)	*Base Diameter 1 (in)*	*Wall Thickness 1 (in)*	*Base Diameter 2 (in)*	*Wall Thickness 2 (in)*
$L_{total.arm1} = 40\,ft$	13	0.25		
feet, 40 ft. max. for 1 piece arms	*Measured flat to flat* **'FC'**	**'FD'**	*Measured flat to flat* **'FG'**	**'FH'**

Arm 1 Analysis including Existing Mast Arm Analysis (Additional Variables Required)

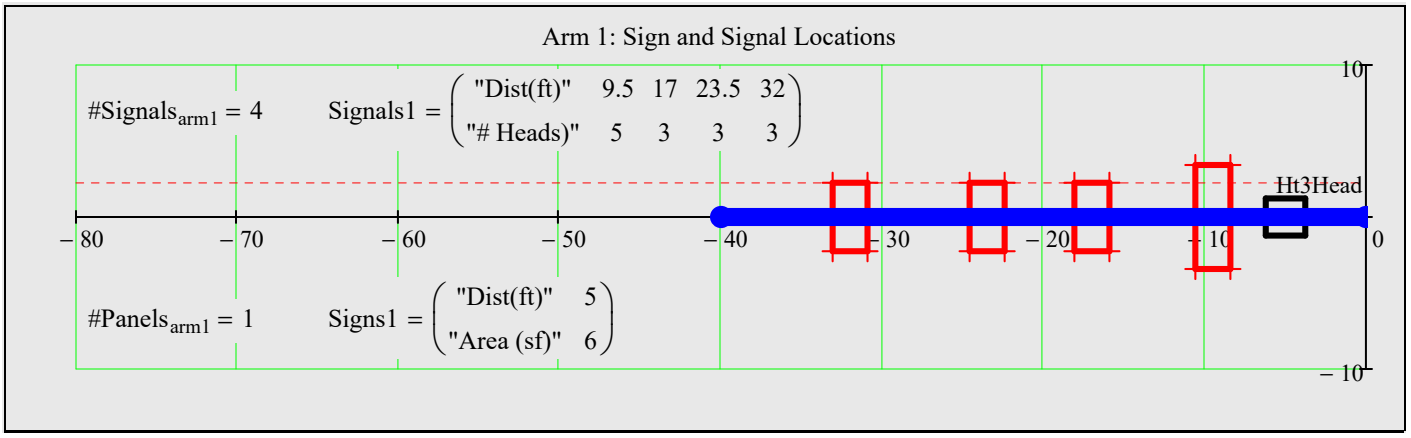
$L_{total.arm1} = 40\,ft$ **'FD'= 'FH'=** $t_{wall.arm1} = \begin{pmatrix} 0.250 \\ 0.000 \end{pmatrix} \cdot in$ **'FC'= 'FG'=** $Diameter_{base.arm1} = \begin{pmatrix} 13.00 \\ 0.00 \end{pmatrix} \cdot in$ BackPlate = "Rigid, 6 inches wide"

'FB'= 'FF'= $Diameter_{tip.arm1} = \begin{pmatrix} 7.40 \\ 0.00 \end{pmatrix} \cdot in$ $CheckTipDia_{arm1}$ = "OK" **'FA'= 'FE'=** $L_{arm1} = \begin{pmatrix} 40.0 \\ 0.0 \end{pmatrix} \cdot ft$ $CheckSectionLength_{arm1}$ = "OK"

$L_{splice.provided.arm1} = 0.0\,ft$ $Classification_{arm1} = \begin{pmatrix} \text{"Compact"} \\ \text{"N/A"} \end{pmatrix}$

Arm 1 Combined Force Interaction Ratio and Deflection

$\max(CFI_{arm1}) = 0.59$ $CheckMaxCFI_{arm1}$ = "OK" $\max(\Delta_{arm1}) = 3.8 \cdot in$ $2 \cdot deg \cdot L_{total.arm1} = 16.8 \cdot in$



III. Arm 2 Analysis

InputDataFile = "Pole 1.dat" $V_{extreme} = 150 \cdot mph$

Help - Base Diameters | Help - Tube Wall Thickness

Arm Extension (for 2 piece arms only)

Enter Arm 2 Data

Iterate on Base Diameters and Wall Thicknesses

Arm Length (ft)	*Base Diameter 1 (in)*	*Wall Thickness 1 (in)*	*Base Diameter 2 (in)*	*Wall Thickness 2 (in)*
$L_{total.arm2} = 0\,ft$				
feet, 40 ft. max. for 1 piece arms	*Measured flat to flat* **'SC'**	*for 1 & 2 piece arms* **'SD'**	*Measured flat to flat* **'SG'**	*for 2 piece arms only* **'SH'**

Arm 2 Analysis

$L_{total.arm2} = 0\,ft$ 'SD'= 'SH'= $t_{wall.arm2} = \begin{pmatrix} 0.000 \\ 0.000 \end{pmatrix} \cdot in$ 'SC'= 'SG'= $Diameter_{base.arm2} = \begin{pmatrix} 0.00 \\ 0.00 \end{pmatrix} \cdot in$ BackPlate = "Rigid, 6 inches wide"

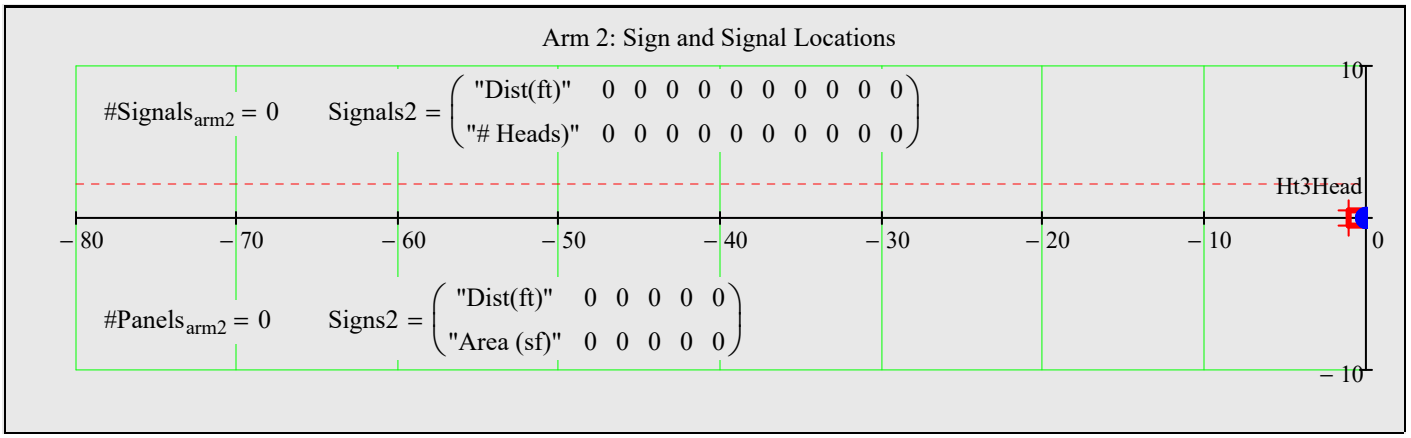
'SB'= 'SF'= $Diameter_{tip.arm2} = \begin{pmatrix} 0.00 \\ 0.00 \end{pmatrix} \cdot in$ $CheckTipDia_{arm2}$ = "N/A" 'SA'= 'SE'= $L_{arm2} = \begin{pmatrix} 0.0 \\ 0.0 \end{pmatrix} \cdot ft$ $CheckSectionLength_{arm2}$ = "N/A"

$L_{splice.provided.arm2} = 0.0\,ft$ $Classification_{arm2} = \begin{pmatrix} \text{"Compact"} \\ \text{"N/A"} \end{pmatrix}$

Arm 2 Combined Force Interaction Ratio and Deflection

$\max(CFI_{arm2}) = 0.00$ $CheckMaxCFI_{arm2}$ = "OK" $\max(\Delta_{arm2}) = 0.0 \cdot in$ $2 \cdot deg \cdot L_{total.arm2} = 0 \cdot in$

Arm 2: Sign and Signal Locations



IV. Luminaire Arm Analysis

InputDataFile = "Pole 1.dat" $V_{extreme} = 150 \cdot mph$

Enter Luminaire Data

Set Lum. Ht. = 0 for no Luminaire

See Design Standards 649-030 and 649-031 for input values.

Luminaire Height (ft)	*Lum Horiz Length (ft)*	*Lum Arm Base Dia (in)*	*Lum Wall Thickness (in)*	*Slope*	*Lum Arm Radius (ft)*	*Lum Bolt Dia (in)*	*Lum Base Plate Thickness (in)*
0							
Std = 40 feet	*10 feet*	*3 inches*	*0.125 inches*	*0.5*	*8 feet*	*0.5 inches*	*0.75 inches*

Analyze Luminaire

Summary - Luminaire Arm Geometry

$\begin{pmatrix} CFI_{base.lumarm} \\ CSR_{bolt.lum} \\ D/C_{baseplate.lum} \\ D/C_{conn.plate.lum} \end{pmatrix} = \begin{pmatrix} 0.00 \\ 0.00 \\ 0.00 \\ 0.00 \end{pmatrix}$

'LA'= $Y_{luminaire} = 0\,ft$ 'LB'= $X_{luminaire} = 0\,ft$ 'LC'= $Diameter_{base.lumarm} = 0 \cdot in$ 'LD'= $t_{wall.lumarm} = 0 \cdot in$

'LE'= $Slope_{lumarm} = 0$ 'LF'= $r_{lumarm} = 0\,ft$ 'LG'= $d_{bolt.lum} = 0 \cdot in$ 'LH'= $t_{baseplate.lum} = 0 \cdot in$

'LJ'= $w_{base.lum} = 0 \cdot in$ 'LK'= $w_{channel.lum} = 0 \cdot in$

V. Upright Analysis

InputDataFile = "Pole 1.dat" $V_{extreme} = 150 \cdot mph$

Help - Upright Base Diameter and Wall Thickness | Help - Gap Distance

Enter Upright Data

Total Height (ft)	Height to Arm Connection (ft)	Base Diameter (in)	Wall Thickness (in)	Gap (in)	
24	21	18	0.375	7.5	arm 1 gap
'UA'	'UB'	'UD' measured flat to flat	'UE'		arm 2 gap

Analyze Upright

Upright Combined Force Interaction Ratio and Deflections

$Classification_{pole}$ = "Compact"

$\max(CFI_{pole}) = 0.33$

$Check_{slope}$ = "OK"

$Check_{deflection}$ = "OK"

$\max(\Delta_{x.dl}) = 0.54 \cdot in$

$\max(\Delta_{z.dl}) = 0 \cdot in$

$Slope_z = 0 \cdot deg$

$Slope_x = 0.27 \cdot deg$

$Diameter_{conn.pole} = 15.1 \cdot in$

$\max(Diameter_{base.arm1}) = 13 \cdot in$

$\max(Diameter_{base.arm2}) = 0 \cdot in$

'UA'= $Y_{pole} = 24 \cdot ft$

'UB'= $Y_{arm.conn} = 21 \cdot ft$

'UC'= $Diameter_{tip.pole} = 14.7 \cdot in$

'UD'= $Diameter_{base.pole} = 18 \cdot in$

'UE'= $t_{wall.pole} = 0.375 \cdot in$

'UF'= $\alpha = 0 \cdot deg$

'UG'= $Y_{lum.conn} = 0 \, ft$

VI. Arm to Upright Connection Analysis

InputDataFile = "Pole 1.dat"

for double arms, both connection plate heights must be equal

Help - Arm Connection Dimensions

Enter Connection Data

Connection Plate Height(in)	Connection Plate Width (in)	Vertical Plate Thickness (in)	Bolt Diameter (in)	Arm Base Plate Thickness (in)
22	27	0.75	1.25	3
'HT'	'FJ', 'SJ'	'FL', 'SL'	'FP', 'SP'	'FK', 'SK'

Analyze Connection

Connection Summary

'HT'= $h_{conn.plate} = 22 \cdot in$ $D/C_{ht.conn.plate} = 0.73$ $CheckHt_{conn.plate} = "OK"$

$D/C_{width.conn.plate_0} = 1.00$

$CheckWidth_{conn.plate_0} = "OK"$

$\#Bolts_{conn_0} = 6$

'FO'= $Offset_{conn_0} = 15.0 \cdot in$

$\begin{pmatrix} D/C_{t.baseplate.arm_0} \\ CFI_{t.vert.plate_0} \\ CSR_{bolt.conn_0} \end{pmatrix} = \begin{pmatrix} 0.83 \\ 0.15 \\ 0.08 \end{pmatrix}$

'FJ'= $b_{conn.plate_0} = 27 \cdot in$

'FP'= $d_{bolt.conn_0} = 1.25 \cdot in$

'FK'= $t_{baseplate.arm_0} = 3.00 \cdot in$

'FR'= $t_{conn.plate_0} = 2.00 \cdot in$

'FL'= $t_{vertical.plate_0} = 0.75 \cdot in$

'FS'= $Spacing_{bolts.conn_0} = 8.5 \cdot in$

'FN'= $w_{vertical.plate_0} = \frac{3}{16} \cdot in$

'FT'= $w_{conn.plate_0} = \frac{1}{4} \cdot in$

$D/C_{width.conn.plate_1} = 0.00$

$CheckWidth_{conn.plate_1} = "OK"$

$\#Bolts_{conn_1} = 0$

'SO'= $Offset_{conn_1} = 0.0 \cdot in$

$\begin{pmatrix} D/C_{t.baseplate.arm_1} \\ CFI_{t.vert.plate_1} \\ CSR_{bolt.conn_1} \end{pmatrix} = \begin{pmatrix} 0.00 \\ 0.00 \\ 0.00 \end{pmatrix}$

'SJ'= $b_{conn.plate_1} = 0 \cdot in$

'SP'= $d_{bolt.conn_1} = 0 \cdot in$

'SK'= $t_{baseplate.arm_1} = 0.00 \cdot in$

'SR'= $t_{conn.plate_1} = 0.00 \cdot in$

'SL'= $t_{vertical.plate_1} = 0 \cdot in$

'SS'= $Spacing_{bolts.conn_1} = 0.00 \cdot in$

'SN'= $w_{vertical.plate_1} = 0 \cdot in$

'ST'= $w_{conn.plate_1} = 0 \cdot in$

VII. Upright Base Plate & Anchor Bolt Analysis

InputDataFile = "Pole 1.dat"

Enter Anchorage Data

Anchor Bolt Diameter (in): 2 — 'BC'

Number of Anchor Bolts: 6 — '#Bolts'

Help - Number of Anchor Bolts

$Diameter_{base.pole} = 18 \cdot in$

Analyze Base Plate & Anchors

Base Plate and Anchor Summary

'#Bolts'= #AnchorBolts = 6

'BB'= $t_{baseplate.pole} = 2.50 \cdot in$

$CSR_{anchor} = 0.10$

$Diameter_{boltcircle.pole} = 26 \cdot in$

'BC'= $d_{anchorbolt} = 2.00 \cdot in$

$CheckCSR_{anchorbolt} = "OK"$

'BA'= $Diameter_{baseplate.pole} = 34 \cdot in$

VIII. Foundation Analysis & Anchor Bolt Lengths

InputDataFile = "Pole 1.dat"

Enter Drilled Shaft Data

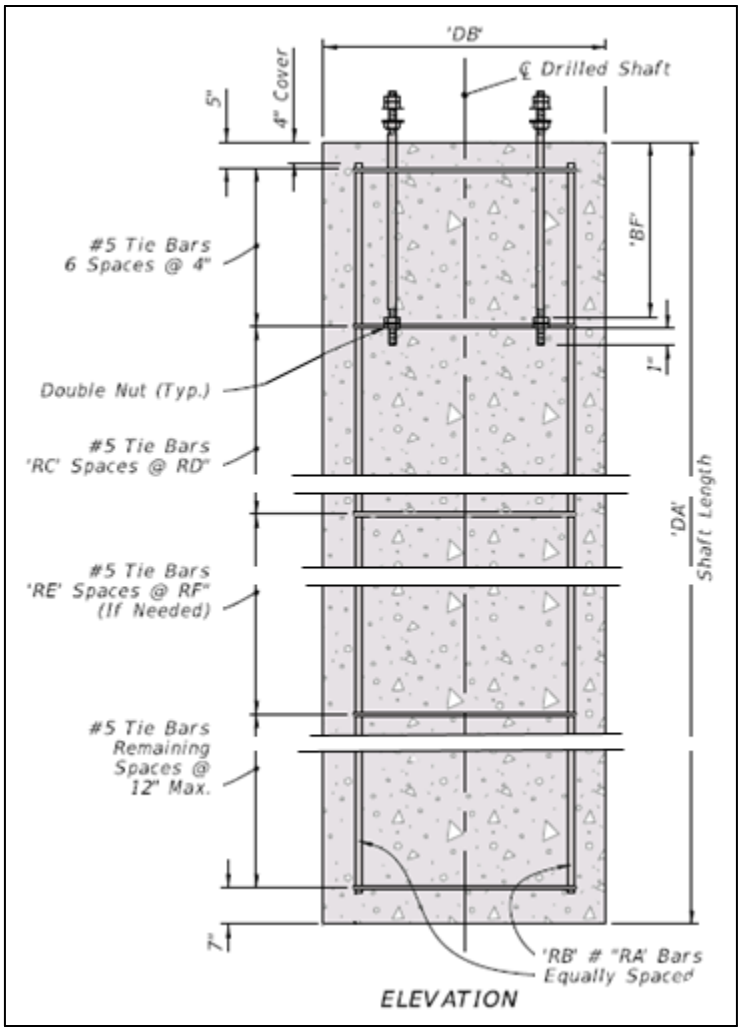
Soil Type	Sand / Clay	
Soil Density, γ_{soil} (45-50 pcf typ.)	50	pcf
Friction Angle, ϕ (Sands)	30	deg
SPT Number (N_{blows} 5 min.) (Sands)	11	
Shear Strength, c (Clays)		ksf
Ground to Top of Shaft Offset	0	ft

First Set of User Defined Stirrups:

Number of Stirrup Spaces	'RC' 8	
Stirrup Spacing	'RD' 12	in

Second Set of User Defined Stirrups:

Number of Stirrup Spaces enter zero for 12 inch spacing	'RE' 0	
Stirrup Spacing enter zero for 12 inch spacing	'RF' 0	in
Stirrup Bar Size, use #5 for all Standard Shafts	#5 / #6	



Analyze Foundation

Shaft Length $L_{shaft} = 10\,ft$

Stirrup spacing $s_v = \begin{pmatrix} 4 \\ 12 \\ 0 \\ 12 \end{pmatrix} \cdot in$

Number of stirrup spaces $\#Spaces_{vbar} = \begin{pmatrix} 6 \\ 8 \\ 0 \\ -1 \end{pmatrix}$

Length required to resist torsion= 10 ft
Provided shaft length= 10 ft

10/10 > 0.95

Change shaft length to standard of 12 ft.

Foundation Summary

CheckReinfClearSpacing = "OK"

CheckLongReinf$_{shr.tor}$ = "OK"

CheckMaxSpacingTransvReinf = "OK"

OverlapDesign = "Based on Overlap of Failure Cones"

OverlapTest = "Overlap of Failure Cones"

BreakoutTest = "OK"

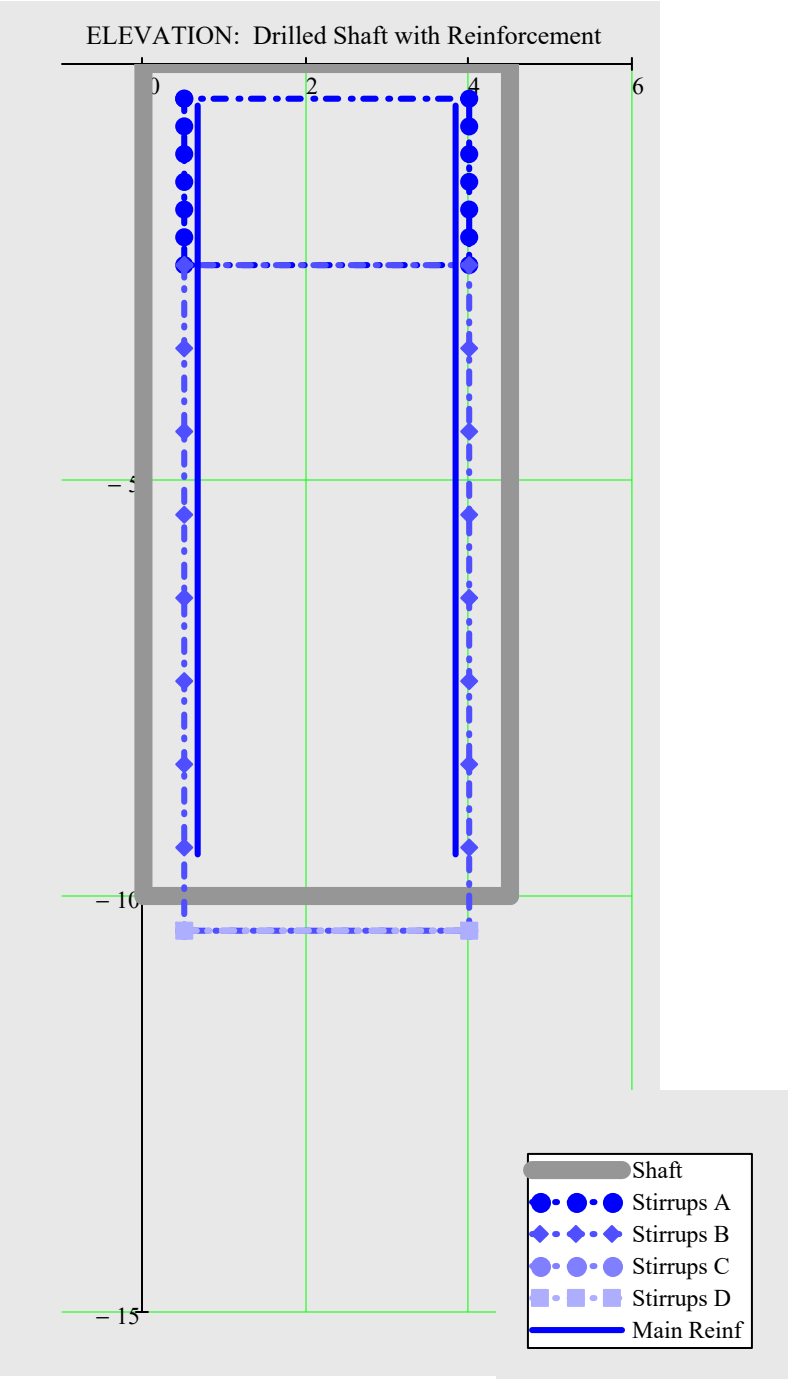
Stirrups $s_{v_0} = 4 \cdot in$ @ $\#Spaces_{vbar_0} = 6$: $D/C_{torsion_0} = 0.1$

Stirrups 'RC' ($s_{v_1} = 12 \cdot in$) @ 'RD' ($\#Spaces_{vbar_1} = 8$): $D/C_{torsion_1} = 0.3$

Stirrups 'RE' ($s_{v_2} = 0 \cdot in$) @ 'RF' ($\#Spaces_{vbar_2} = 0$):

$D/C_{torsion_2} = -8.2 \times 10^{-4}$

Stirrups $s_{v_3} = 12 \cdot in$ @ $\#Spaces_{vbar_3} = -1$



Offset = 0 ft

$d_{long.bar} = 1.41 \cdot in$

$Dia_{bar.circle} = 39.3 \cdot in$

'DA'= $L_{shaft} = 10 \cdot ft$

'DB'= $Diameter_{shaft} = 4.5 \cdot ft$

'BF'= $L_{embedment.anchor} = 40 \cdot in$

$L_{anchor.bolt} = 58 \cdot in$

'RA'= $round\left(\frac{d_{long.bar}}{0.125in}\right) = 11$

'RB'= $\#LongBars_{prov} = 16$

$\#Spaces_{vbar_0} = 6$

$s_{v_0} = 4 \cdot in$

'RC'= $\#Spaces_{vbar_1} = 8$

'RD'= $s_{v_1} = 12 \cdot in$

'RE'= $\#Spaces_{vbar_2} = 0$

'RF'= $s_{v_2} = 0 \cdot in$

$\#Spaces_{vbar_3} = -1$

$s_{v_3} = 12 \cdot in$

IX. Fatigue Analysis InputDataFile = "Pole 1.dat"

$FatigueCategory_{galloping} := 2$ $FatigueCategory_{natural.wind} := 2$ ***SM V3 11.6***

Analyze Structure for Fatigue

Fatigue Summary

K1 values within 2% of LTS thresholds of 3.0 and 4.0 may use next higher CAFT values

Arm and Pole Welds

$Check_{galloping.arm1} = "OK"$ $f_{galloping.arm1} = 4.4 \cdot ksi$ $CAFT_{fullpengroove.weld.arm1} = 10 \cdot ksi$

$Check_{galloping.arm2} = "NA"$ $f_{galloping.arm2} = 0.0 \cdot ksi$ $CAFT_{fullpengroove.weld.arm2} = "NA" \cdot ksi$

$Check_{galloping.pole} = "OK"$ $f_{galloping.pole} = 1.5 \cdot ksi$ $CAFT_{fullpengroove.weld.pole} = 4.5 \cdot ksi$

$Check_{nwg.arm1} = "OK"$ $f_{nwg.arm1} = 2.7 \cdot ksi$ $CAFT_{fullpengroove.weld.arm1} = 10 \cdot ksi$

$Check_{nwg.arm2} = "NA"$ $f_{nwg.arm2} = 0.0 \cdot ksi$ $CAFT_{fullpengroove.weld.arm2} = "NA" \cdot ksi$

$Check_{nwg.pole} = "OK"$ $f_{nwg.pole} = 1.7 \cdot ksi$ $CAFT_{fullpengroove.weld.pole} = 4.5 \cdot ksi$

$$CheckK1Values = \begin{pmatrix} "K1 \text{ is outside of 2\% of K1 thresholds}" \\ "K1 \text{ is outside of 2\% of K1 thresholds}" \\ "K1 \text{ is outside of 2\% of K1 thresholds}" \end{pmatrix} \quad \begin{pmatrix} K_{I.arm1} \\ K_{I.arm2} \\ K_{I.pole} \end{pmatrix} = \begin{pmatrix} 2.82 & "Arm\ 1\ Base\ Weld" \\ 100.0(& "Arm\ 2\ Base\ Weld" \\ 5.90 & "Upright\ Base\ Weld" \end{pmatrix}$$

A325 Connection Bolts

$Check_{g.conn.bolt} = \begin{pmatrix} "OK" \\ "OK" \end{pmatrix}$ $f_{t.g.bolt} = \begin{pmatrix} 2.7 \\ 0.0 \end{pmatrix} \cdot ksi$ $CAFT_{conn.bolt} = 16 \cdot ksi$

$Check_{nwg.conn.bolt} = \begin{pmatrix} "OK" \\ "OK" \end{pmatrix}$ $f_{t.nwg.bolt} = \begin{pmatrix} 1.7 \\ 0.0 \end{pmatrix} \cdot ksi$

Anchor Bolts

$Check_{g.anchor} = "OK"$ $f_{t.g.anchor} = 1.2 \cdot ksi$ $CAFT_{anchor.bolts} = 7 \cdot ksi$

$Check_{nwg.anchor} = "OK"$ $f_{t.nwg.anchor} = 1.4 \cdot ksi$

Save Data File (optional)

File Name Pole 1.dat

Note: Select an output folder by using the "Change Folder" option above.

Arm Designation Example

A70/D-A30/D/H-P5/D/L-DS/16/5

A70/D -	*Arm 70 feet long, Double Arm*
A30/D/H -	*Arm 30 feet long, Double Arm, Heavy Duty*
P5/D/L -	*Pole 5 , Double Arm, with Luminaire*
DS/16/5 -	*Drilled Shaft 16 ft deep, 5 foot diameter*

X. Mast Arm Design and Analysis Summary

InputDataFile = "Pole 1.dat"

If comparing results to Standard Index 649-030, some values in the index have been increased to reduce the number of variations.

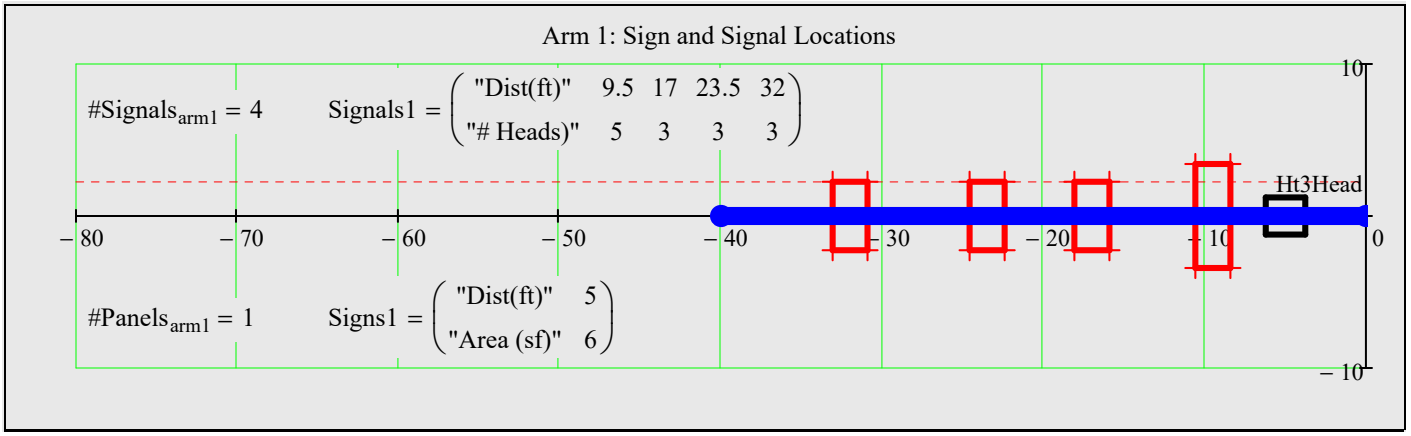
Subject = "Lena Road" **DesignedBy** = "KED" **PoleLocation** = "309+24.08 / 39.74' LT"

ProjectNo = "148400103" **CheckedBy** = "JAS" **Date** = "7/6/2023" ExistingMastArm = "No"

For FDOT Mast Arm Support Structures, max(CFI) ≤ 0.95 ***(See Structures Manual Volume3)***

1st Mast Arm

$V_{extreme} = 150 \cdot mph$ ExistingMastArm = "No" BackPlate = "Rigid, 6 inches wide"



$\max(CFI_{arm1}) = 0.59$ CheckMaxCFI_arm1 = "OK" $L_{total.arm1} = 40\,ft$ $L_{splice.provided.arm1} = 0 \cdot ft$ $\max(\Delta_{arm1}) = 3.8 \cdot in$

'FA'= 'FE'= $L_{arm1} = \begin{pmatrix} 40 \\ 0 \end{pmatrix} \cdot ft$ CheckSectionLength_arm1 = "OK"

'FC'= 'FG'= $Diameter_{base.arm1} = \begin{pmatrix} 13.00 \\ 0.00 \end{pmatrix} \cdot in$

'FB'= 'FF'= $Diameter_{tip.arm1} = \begin{pmatrix} 7.40 \\ 0.00 \end{pmatrix} \cdot in$ CheckTipDia_arm1 = "OK"

'FD'= 'FH'= $t_{wall.arm1} = \begin{pmatrix} 0.250 \\ 0.000 \end{pmatrix} \cdot in$

2nd Mast Arm

$\max(CFI_{arm2}) = 0.00$ CheckMaxCFI_arm2 = "OK" $L_{total.arm2} = 0\,ft$ $L_{splice.provided.arm2} = 0 \cdot ft$ $\max(\Delta_{arm2}) = 0 \cdot in$

'SA'= 'SE'= $L_{arm2} = \begin{pmatrix} 0 \\ 0 \end{pmatrix} \cdot ft$ CheckSectionLength_arm2 = "N/A"

'SC'= 'SG'= $Diameter_{base.arm2} = \begin{pmatrix} 0.00 \\ 0.00 \end{pmatrix} \cdot in$

'UF'= $\alpha = 0 \cdot deg$ (Angle Between Arms)

'SB'= 'SF'= $Diameter_{tip.arm2} = \begin{pmatrix} 0.00 \\ 0.00 \end{pmatrix} \cdot in$ CheckTipDia_arm2 = "N/A"

'SD'= 'SH'= $t_{wall.arm2} = \begin{pmatrix} 0.000 \\ 0.000 \end{pmatrix} \cdot in$

Luminaire Arm and Connection *(use MC10x33.6 channel for connection)*

$$\begin{pmatrix} CFI_{base.lumarm} \\ CSR_{bolt.lum} \\ D/C_{baseplate.lum} \\ D/C_{conn.plate.lum} \end{pmatrix} = \begin{pmatrix} 0.00 \\ 0.00 \\ 0.00 \\ 0.00 \end{pmatrix}$$

'LA'= $Y_{luminaire} = 0\ ft$

'LB'= $X_{luminaire} = 0\ ft$

'LC'= $Diameter_{base.lumarm} = 0 \cdot in$

'LD'= $t_{wall.lumarm} = 0 \cdot in$

'LE'= $Slope_{lumarm} = 0$

'LF'= $r_{lumarm} = 0\ ft$

'LG'= $d_{bolt.lum} = 0 \cdot in$

'LH'= $t_{baseplate.lum} = 0 \cdot in$

'LJ'= $w_{base.lum} = 0 \cdot in$

'LK'= $w_{channel.lum} = 0 \cdot in$

Upright

$max(CFI_{pole}) = 0.33$

$Check_{deflection} = "OK"$

$Check_{slope} = "OK"$

'UA'= $Y_{pole} = 24 \cdot ft$

'UB'= $Y_{arm.conn} = 21 \cdot ft$

'UC'= $Diameter_{tip.pole} = 14.7 \cdot in$

'UD'= $Diameter_{base.pole} = 18 \cdot in$

'UE'= $t_{wall.pole} = 0.375 \cdot in$

'UF'= $\alpha = 0 \cdot deg$

'UG'= $Y_{lum.conn} = 0\ ft$

1st Arm to Upright Connection

$D/C_{ht.conn.plate} = 0.73$

$CheckHt_{conn.plate} = "OK"$

$D/C_{width.conn.plate_0} = 1.00$

$CheckWidth_{conn.plate_0} = "OK"$

$$\begin{pmatrix} D/C_{t.baseplate.arm_0} \\ CFI_{t.vert.plate_0} \\ CSR_{bolt.conn_0} \end{pmatrix} = \begin{pmatrix} 0.83 \\ 0.15 \\ 0.08 \end{pmatrix}$$

'HT'= $h_{conn.plate} = 22 \cdot in$

$\#Bolts_{conn_0} = 6$

'FJ'= $b_{conn.plate_0} = 27 \cdot in$

'FK'= $t_{baseplate.arm_0} = 3 \cdot in$

'FL'= $t_{vertical.plate_0} = 0.75 \cdot in$

'FN'= $w_{vertical.plate_0} = \frac{3}{16} \cdot in$

'FO'= $Offset_{conn_0} = 15.0 \cdot in$

'FP'= $d_{bolt.conn_0} = 1.25 \cdot in$

'FR'= $t_{conn.plate_0} = 2 \cdot in$

'FS'= $Spacing_{bolts.conn_0} = 8.5 \cdot in$

'FT'= $w_{conn.plate_0} = \frac{1}{4} \cdot in$

2nd Arm to Upright Connection

$D/C_{width.conn.plate_1} = 0.00$

$CheckWidth_{conn.plate_1} = "OK"$

$$\begin{pmatrix} D/C_{t.baseplate.arm_1} \\ CFI_{t.vert.plate_1} \\ CSR_{bolt.conn_1} \end{pmatrix} = \begin{pmatrix} 0.00 \\ 0.00 \\ 0.00 \end{pmatrix}$$

'HT'= $h_{conn.plate} = 22 \cdot in$

$\#Bolts_{conn_1} = 0$

'SJ'= $b_{conn.plate_1} = 0 \cdot in$

'SK'= $t_{baseplate.arm_1} = 0 \cdot in$

'SL'= $t_{vertical.plate_1} = 0 \cdot in$

'SN'= $w_{vertical.plate_1} = 0 \cdot in$

'SO'= $Offset_{conn_1} = 0.0 \cdot in$

'SP'= $d_{bolt.conn_1} = 0 \cdot in$

'SR'= $t_{conn.plate_1} = 0 \cdot in$

'SS'= $Spacing_{bolts.conn_1} = 0 \cdot in$

'ST'= $w_{conn.plate_1} = 0 \cdot in$

Pole Base Plate

$CSR_{anchor} = 0.10$

$CheckCSR_{anchorbolt} = "OK"$

'#Bolts'= $\#AnchorBolts = 6$

$Diameter_{boltcircle.pole} = 26 \cdot in$

'BA'= $Diameter_{baseplate.pole} = 34 \cdot in$

'BB'= $t_{baseplate.pole} = 2.5 \cdot in$

'BC'= $d_{anchorbolt} = 2.00 \cdot in$

'BF'= $L_{embedment.anchor} = 40 \cdot in$

$L_{anchor.bolt} = 58 \cdot in$

Foundation

$D/C_{torsion.max} = 0$

$CheckD/C_{shear.and.torsion} = "OK"$

$CheckReinfClearSpacing = "OK"$

$CheckLongReinf_{shr.tor} = "OK"$

$CheckMaxSpacingTransvReinf = "OK"$

$OverlapDesign = "Based on Overlap of Failure Cones"$

$OverlapTest = "Overlap of Failure Cones"$

$BreakoutTest = "OK"$

$Clearance_{csl.to.nut} = 3.5 \cdot in$

$Offset = 0\ ft$

$d_{long.bar} = 1.41 \cdot in$

$Dia_{bar.circle} = 39.3 \cdot in$

'DA'= $L_{shaft} = 10 \cdot ft$

'DB'= $Diameter_{shaft} = 4.5 \cdot ft$

'RA'= $round\left(\frac{d_{long.bar}}{0.125\,in}\right) = 11$

'RB'= $\#LongBars_{prov} = 16$

'RC'= $\#Spaces_{vbar_1} = 8$

'RD'= $s_{v_1} = 12 \cdot in$

'RE'= $\#Spaces_{vbar_2} = 0$

'RF'= $s_{v_2} = 0 \cdot in$

Fatigue

$Check_{galloping.arm1} = "OK"$

$Check_{nwg.arm1} = "OK"$

$Check_{g.conn.bolt} = \begin{pmatrix} "OK" \\ "OK" \end{pmatrix}$

$Check_{galloping.arm2} = "NA"$

$Check_{nwg.arm2} = "NA"$

$Check_{nwg.conn.bolt} = \begin{pmatrix} "OK" \\ "OK" \end{pmatrix}$

$Check_{galloping.pole} = "OK"$

$Check_{nwg.pole} = "OK"$

$Check_{g.anchor} = "OK"$

$Check_{nwg.anchor} = "OK"$

K1 values within 2% of LTS thresholds may use next higher CAFT values

$$CheckK1Values = \begin{pmatrix} "K1 \text{ is outside of 2\% of K1 thresholds}" \\ "K1 \text{ is outside of 2\% of K1 thresholds}" \\ "K1 \text{ is outside of 2\% of K1 thresholds}" \end{pmatrix}$$

$$\begin{pmatrix} K_{I.arm1} \\ K_{I.arm2} \\ K_{I.pole} \end{pmatrix} = \begin{pmatrix} 2.825 \\ 100.000 \\ 5.900 \end{pmatrix} \begin{pmatrix} "Arm\ 1\ Base\ Weld" \\ "Arm\ 2\ Base\ Weld" \\ "Upright\ Base\ Weld" \end{pmatrix}$$

WRITE to Special Mast Arm Assembly Data Tables

Mast Arm Tip Deflection

Compare Mast Arm deflection of each arm to a proposed camber

$Camber_{arm1} := 2 \cdot deg$ $Camber_{arm2} := 2 \cdot deg$

$Deflection_{arm1} := Slope_x \cdot L_{total.arm1} + \max(\Delta_{arm1}) = 6.1 \cdot in$

$CamberArm1_{upward} := \sin(Camber_{arm1}) \cdot L_{total.arm1} = 16.8 \cdot in$

$Deflection_{arm2} := \left[Slope_z \cdot L_{total.arm2} \cdot (\sin(\alpha))\right] + Slope_x \cdot L_{total.arm2} \cdot \cos(\alpha) + \max(\Delta_{arm2}) = 0 \cdot in$

$CamberArm2_{upward} := \sin(Camber_{arm2}) \cdot L_{total.arm2} = 0 \cdot in$

Check Clearance Between Connection Plates *(for Two Arm Structures only)*

$\alpha = 0 \cdot deg$ $\alpha := if[(\alpha > 180 \cdot deg), (360 \cdot deg - \alpha), \alpha]$

$Offset_{conn_0} = 15 \cdot in$ $b_{conn.plate_0} = 27 \cdot in$ $h_{conn.plate} = 22 \cdot in$ $\alpha = 0 \cdot deg$

$Offset_{conn_1} = 0 \cdot in$ $b_{conn.plate_1} = 0 \cdot in$

$x1 := Offset_{conn_0} - t_{conn.plate_0} - h_{conn.plate} \cdot \frac{\sin(Camber_{arm1})}{2} = 12.7 \cdot in$ $y1 := \frac{b_{conn.plate_0}}{2} = 13.5 \cdot in$

$x2 := \left(Offset_{conn_1} - t_{conn.plate_1} - h_{conn.plate} \cdot \frac{\sin(Camber_{arm2})}{2}\right) \cdot \cos(\alpha) + \frac{b_{conn.plate_1}}{2} \cdot \sin(\alpha) = -0.4 \cdot in$

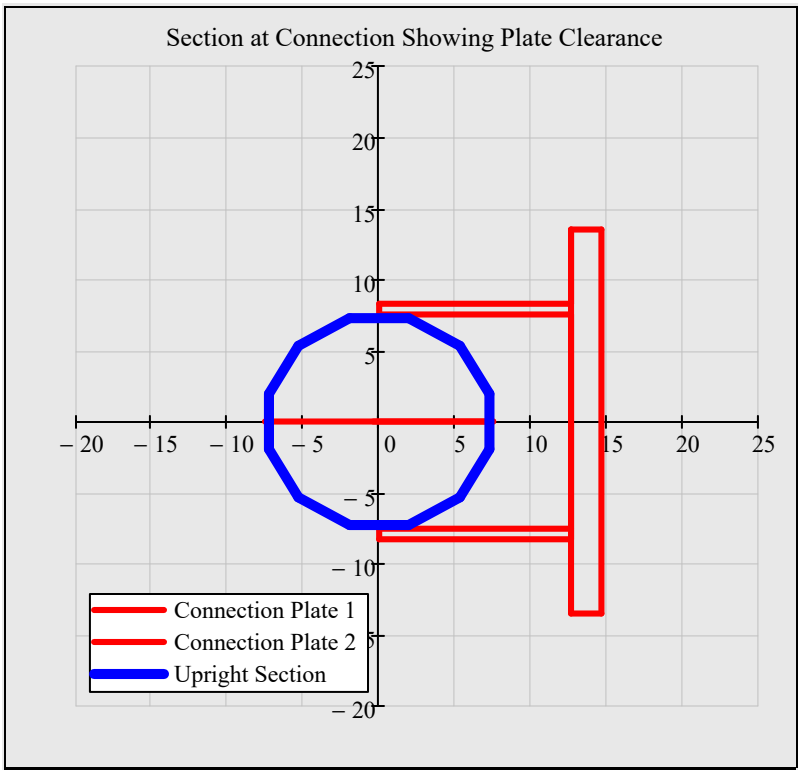
$y2 := \left(Offset_{conn_1} - t_{conn.plate_1} - h_{conn.plate} \cdot \frac{\sin(Camber_{arm2})}{2}\right) \cdot \sin(\alpha) - \frac{b_{conn.plate_1}}{2} \cdot \cos(\alpha) = 0 \cdot in$

$Clearance_{plate.to.plate} := if\left[(x1 > x2) \cdot (y2 > y1), \sqrt{(x1 - x2)^2 + (y1 - y2)^2}, 0 \cdot in\right] = 0 \cdot in$

(if Clearance < 2 inches, a redesign is required.

Coordinates for Drawings

Plan View - Connection Plate Clearance for Two Arm Connections



$Clearance_{plate.to.plate} = 0 \cdot in$

$Diameter_{conn.pole} = 15.1 \cdot in$

'FR'= $t_{conn.plate_0} = 2 \cdot in$

'FJ'= $b_{conn.plate_0} = 27 \cdot in$

'FL'= $t_{vertical.plate_0} = 0.75 \cdot in$

'FO'= $Offset_{conn_0} = 15.0 \cdot in$

$Gap_0 = 7.5 \cdot in$

'SR'= $t_{conn.plate_1} = 0 \cdot in$

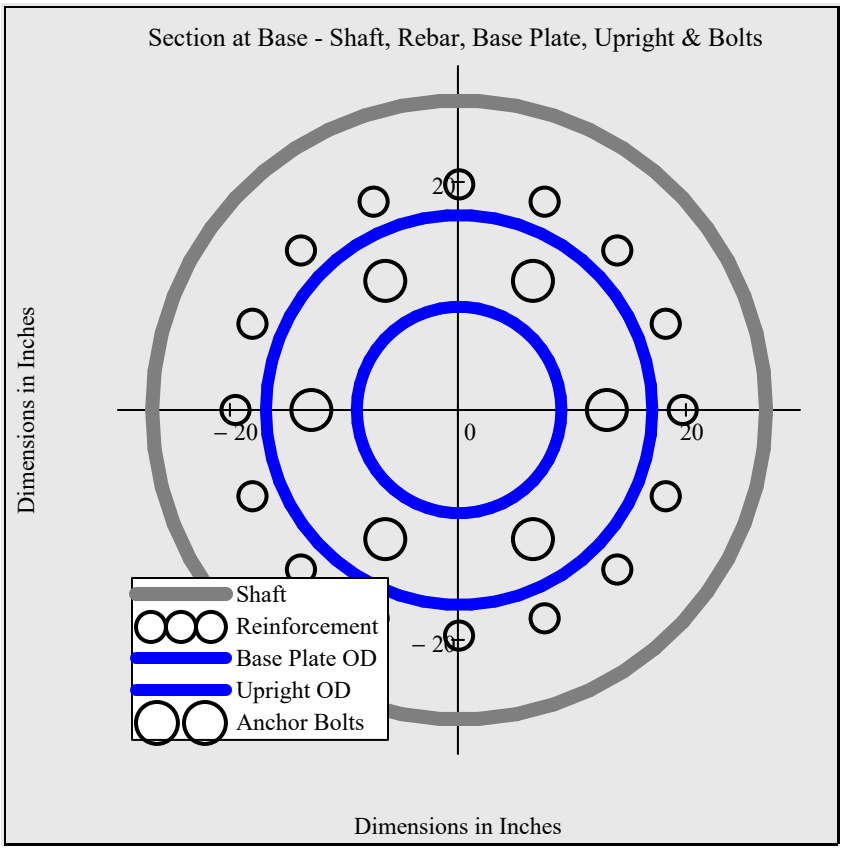
'SJ'= $b_{conn.plate_1} = 0 \cdot in$

'SL'= $t_{vertical.plate_1} = 0 \cdot in$

'SO'= $Offset_{conn_1} = 0.0 \cdot in$

$Gap_1 = 0 \cdot in$

Plan View - Drilled Shaft, Base Plate, Upright, Anchor Bolts, & Reinforcing Steel



$Clearance_{bar.to.nut} = 4.1 \cdot in$

'UD'= $Diameter_{base.pole} = 18 \cdot in$

'BA'= $Diameter_{baseplate.pole} = 34 \cdot in$

'DB'= $Diameter_{shaft} = 54 \cdot in$

$Diameter_{boltcircle.pole} = 26 \cdot in$

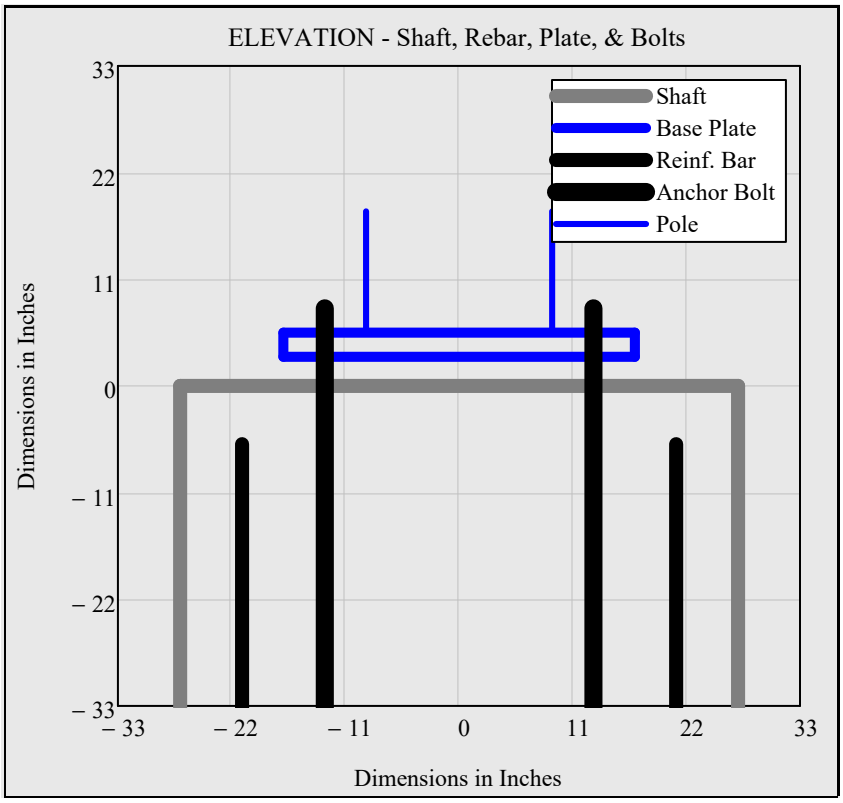
$Dia_{bar.circle} = 39.3 \cdot in$

$\#AnchorBolts = 6$

$\#LongBars_{prov} = 16$

Note: The Plan and Elevation Views do not show the 4 or 5 1.9" O.D. Nondestructive Integrity Testing Access Tubes that are tied to the inside of the reinforcing cage (see FDOT Spec 455-16.4).

Elevation View - Drilled Shaft, Base Plate, Anchor Bolts, & Reinforcing Steel



$Clearance_{bar.to.nut} = 4.1 \cdot in$

'UD'= $Diameter_{base.pole} = 18 \cdot in$

'BA'= $Diameter_{baseplate.pole} = 34 \cdot in$

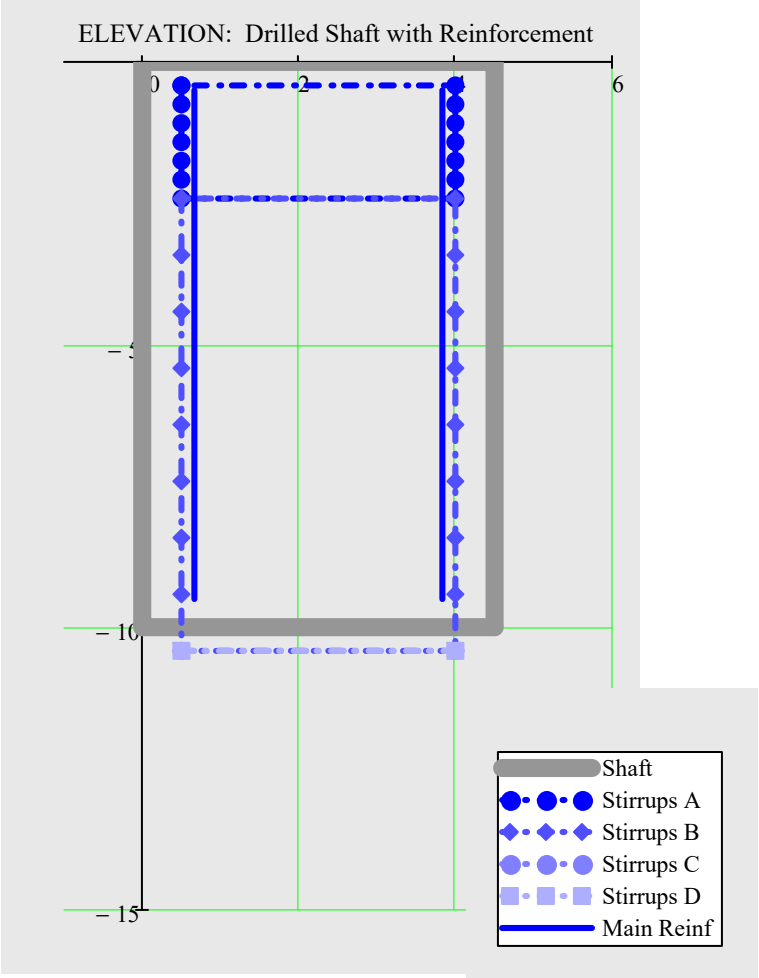
'BB'= $t_{baseplate.pole} = 2.5 \cdot in$

'DB'= $Diameter_{shaft} = 54 \cdot in$

$Diameter_{boltcircle.pole} = 26 \cdot in$

$Dia_{bar.circle} = 39.3 \cdot in$

Elevation View - Drilled Shaft with Main Reinforcement and Stirrups



$$s_v = \begin{pmatrix} 4 \\ 12 \\ 0 \\ 12 \end{pmatrix} \cdot in$$ *stirrup spacing*

$$\#Spaces_{vbar} = \begin{pmatrix} 6 \\ 8 \\ 0 \\ -1 \end{pmatrix}$$ *number of stirrup spaces*

APPENDIX E:

POLE 4 – DESIGN

APPENDIX E:

POLE 4 – VERTICAL CLEARANCE

Kimley»Horn

Project:	Lena Road		
Structure ID:	Pole 4		
Designed by:	KED	*Date:*	07-06-2023
Checked by:	JAS	*Date:*	07-10-2023

General Info & Mounting Height Calculation

(Enter values in shaded cells only)

County (District) [1] =	Manatee (1)	
Wind Speed [1] =	150	mph
Backplates [2] =	Yes	
Arm Type =	See Mast Arm Excel	
Drop Distance [3] =	2.500	ft
Base El. =	+21.030	ft
Crown El. Arm #1 [4] =	+20.700	ft
Arm Mounting Height, UB [5] =	21.000	ft
MVC Arm #1 =	**18.830**	ft *(from 17.5' to 19')* [6]

Checks:

Ok, Vertical Clearance requirements satisfied at Arm #1

Ok, Mounting Height within FDOT limits

Notes & References:

(1) Per FDOT Structures Manual (Jan. 2023), Vol. 3 - Mod's to LTSLRFD-1, Section 3.8.2 - *"For the 700 year Extreme Event Limit State, use the wind speeds (mph) shown in FDOT SDG Table 2.4.1-1."*

(2) Per FDOT FDM (Jan. 1, 2023) Vol. 2, Chapter 261.4 - *"Design all structures assuming traffic signal assemblies have backplates in accordance with FDM 232.1.5"* Per FDOT FDM (Jan. 1, 2023) Vol. 2, Chapter 232.1.5, *"Install retroreflective signal backplates on traffic signals for all approaches."*

(3) *"Drop Distance"* is the vertical distance measured from the centerline of the arm to the bottom of signal or sign. Dimensions: 14" per head for standard signal section, 6" for backplate (each side), and 3" added to the end of the signal head to compensate for attachment hardware, per FDOT SPI 649-030 (FY 2023-24);

e.g. 3-Head = 0.5(3*14") + 6" + 3" = 30"; 4-Head = 37", 5-Head = 30" or 44", etc.

(4) Arm 1 is the larger of the two arms; if only 1 arm, Crown El. Arm #1 = Crown El. Arm #2

(5) In order to use FDOT Standard Assemblies, 18' ≤ UB ≤ 22' (per FDOT SPI 649-030, FY 2023-24).

(6) FDOT FDM (Jan. 1 2023), Section 210.10.3 Vertical Clearances: *"The required clearance for new signals on span wires, mast arms, or other structures is 17.5 feet. This clearance is the least distance measured between the lowest point on the signal structure and the traffic lane or shoulder directly below the signal structure. For any construction affecting existing signal clearances, FDOT minimum vertical clearance is 17 feet. Vertical clearances between 15 feet and 17 feet require a Design Variation. Signal clearances less than 15 feet are not allowed"*

FDOT Construction Specifications 2022, 650-3.3 Clearances: "*Unless directed otherwise by the Engineer for unusual circumstances at the site, provide a vertical clearance of not less than 17 feet-6 inches and not more than 19 feet for traffic signals placed over the roadway. Measure such clearance for each span directly under the most critical signal assembly (in regards to clearance) for the span. Place signal assemblies on each span as near as practical to the same elevation as the critical signal assembly. Ensure that the lowest point on pedestal-mounted and side-mounted signal heads is 12 feet above finished grade at the point of their installation"*

Version 2.0 (05/16/2022)

APPENDIX E:

POLE 4 – FDOT DESIGN AID

Kimley-Horn
189 S. Orange Ave., Suite 1000
Orlando, FL 32801

Design Aid for FDOT Standard Mast Arm Assemblies (Standard Plans Index 649-030)

Mast Arm Assembly Information

Wind Speed: ○ 130 mph ◉ 150 mph ○ 170 mph

Signal Orientation: ◉ Vertical ○ Horizontal

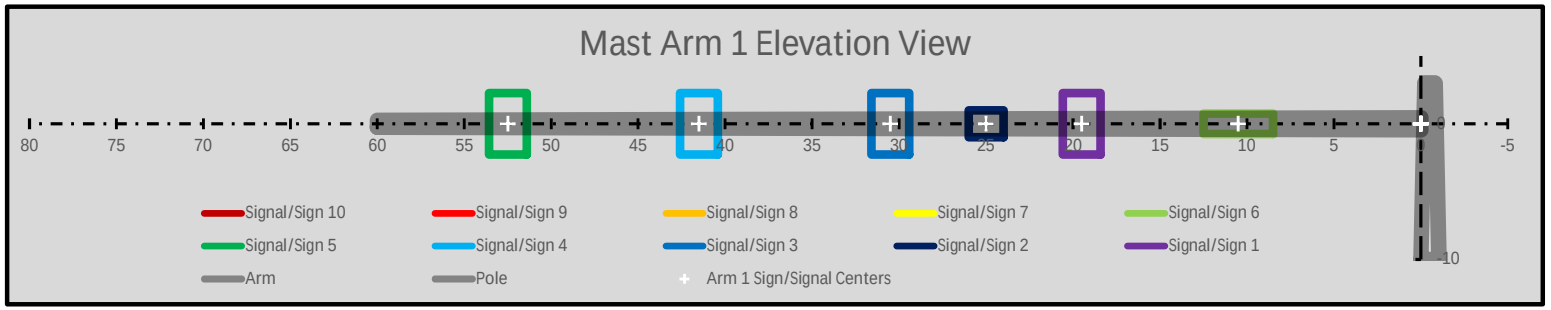
Back Plate Width: ◉ 6.0 in. ○ 2.5 in. ○ 0 in.

Luminaire? ○ Yes ◉ No

Arm 1 Length: 30 | 40 | 50 | [60] | 70 | 78

Arm 1 Length, Signal/Sign Location and Size

	Signal\Sign #10	Signal\Sign #9	Signal\Sign #8	Signal\Sign #7	Signal\Sign #6	Signal\Sign #5	Signal\Sign #4	Signal\Sign #3	Signal\Sign #2	Signal\Sign #1
	◉ None	◉ None	◉ None	◉ None	○ None	○ None	○ None	○ None	○ None	○ None
	○ 3 Head	○ 3 Head	○ 3 Head	○ 3 Head	○ 3 Head	◉ 3 Head	◉ 3 Head	◉ 3 Head	○ 3 Head	◉ 3 Head
	○ 4 Head	○ 4 Head	○ 4 Head	○ 4 Head	○ 4 Head	○ 4 Head	○ 4 Head	○ 4 Head	○ 4 Head	○ 4 Head
	○ 5 Head	○ 5 Head	○ 5 Head	○ 5 Head	○ 5 Head	○ 5 Head	○ 5 Head	○ 5 Head	○ 5 Head	○ 5 Head
	○ Sign	○ Sign	○ Sign	○ Sign	◉ Sign	○ Sign	○ Sign	○ Sign	◉ Sign	○ Sign
Dist to Pole (ft.)					10.5	52.5	41.5	30.5	25	19.5
Sign Width (in.)					48				24	
Sign Height (in.)					18				24	
Area (SF)	0.0	0.0	0.0	0.0	6.0	9.8	9.8	9.8	4.0	9.8
*M_{wl}. (kip*ft)*	0	0	0	0	4	32	26	19	6	12



Arm 1 Length (ft)	60	
Standard Plans Index 649-030	Regular	Heavy Duty
Dia. at Arm Base (in)	15	16
Wall Thickness (in)	0.3750	0.3750
Resistance (M_r=ϕM_n) (kip*ft)	300	342
95% M_r (kip*ft)	285	325

Arm 1 Loads	Regular	Heavy Duty
1.1*Arm M_{dl} (kip*ft)	62	68
Arm M_{wl} (kip*ft)	63	71
1.1*Sign/Signal M_{dl} (kip*ft)	9	
Sign/Signal M_{wl} (kip*ft)	99	
Total Moment ($M_{extreme}$)	177	187

Mast Arm Assembly Designation
One Arm Assembly A60/S-P4/S-DS/12/4.5

Notes:

Run the FDOT Mast Arm Mathcad Program for more accurate results.

For new designs, always design with 6" backplates.

Mast Arm Assembly ID consists of three parts for a single arm and 4 parts for a double Arm. Each part is separated by "-".

Part 1 is Arm 1: Axx/y/z, where xx is the arm length, y is "S" for single arm or "D" for double arms and z is "H" for heavy duty arm or blank for regular arm.

Part 2 is Arm 2 and has the same nomenclature as the 1st arm. For single arm assemblies, Part 2 is omitted.

Part 3 is the Pole: Px/y/z where x is the pole ID, y is "S" for single arm or "D" for double arms and z is "L" for luminaire or blank for no luminaire.

Part 4 is the Drilled Shaft: DS/xx/y where xx is the shaft length and y is the shaft diameter.

Arm to pole connection is assumed at 22 ft. above the base.

No foundation offset is considered. If the top of drilled shaft > 2 feet above ground, run the Mathcad Mast Arm Program.

APPENDIX E:

POLE 4 – MAST ARM DESIGN

FDOT Mast Arm Traffic Signal Support Analysis Program V2.0

This program works in conjunction with FDOT Mast Arm Standard Plans 649-030 & 649-031.

References:
AASHTO LRFD Specifications for Structural Supports for Highway Signs, Luminaires and Traffic Signals (LRFDLTS).
FDOT Structures Manual Volume 3 (SM V3).
AISC Steel Construction Manual

Reference

For more information see Reference.xmcd and Changes.xmcd.

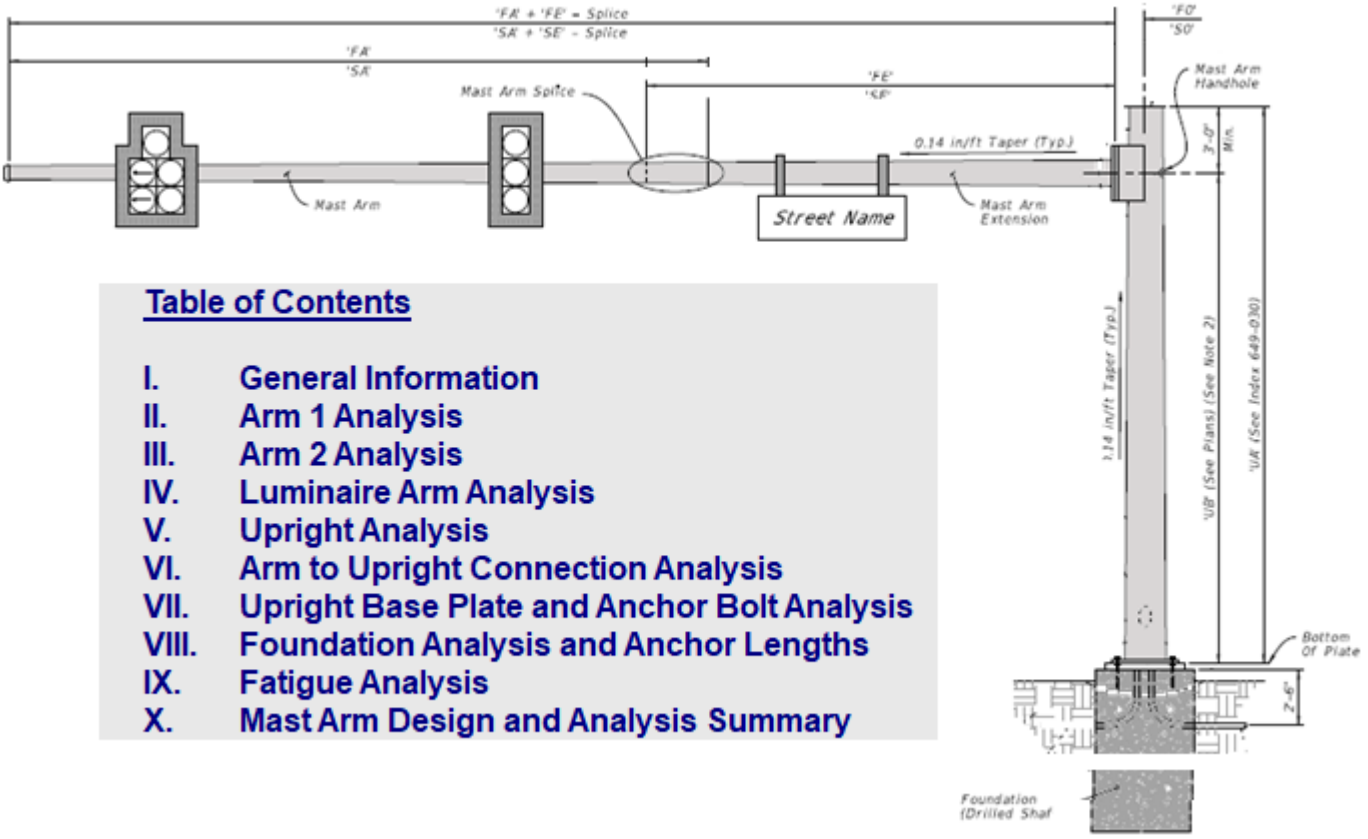


Table of Contents

Data Folder and Files

Data Files Folder

Change Folder

K:\ORL_Structures_Projects-Structures_MastArms\148400103 Lena Road\03_Calculations\Pole 4\MastArmV2.0\Data\

Required - Open Existing Data File. To save New Data Files, enter data variables at the end of Section IX.

Refresh List

Open File

A60D-A50DH-P4DL.dat
A60DH-A60D-P5DL.dat
A60SH-P4SL.dat
A70D-A30D-P5DL.dat
A70D-A40D-P5DL.dat
A70D-A60D-P6DL.dat
A70DH-A50DH-P5DL.dat
A70DH-A70DH-P6DL.dat
A70S-P5SL.dat

I. General Information and Sign & Signal Data

Enter Project Information

Project Name	Lena Road		
Project No.	148400103		
Designed by	KED	*Date*	7/6/2023
Checked by	JAS	*Date*	7/10/2023
Signal Name	Pole 4		
Station/Offset	311+47.13 / 55.79' RT		

Enter Wind Speed

Design Wind Speed 150 *mph*

Extreme Event Wind Speed

SDG Wind Speeds by County

Enter Arm Lengths, Signal and Sign Data

Arm 1

Arm 1 Length 60 Reset Arm 1 Data

Arm1 Signal Number	*Distance to Signal (ft)*	*Number of Heads*
1	19.5	3
2	30.5	3
3	41.5	3
4	52.5	3
5		
6		
7		
8		
9		
10		

Arm 2 *Set Arm 2 Length = 0 for single arm Mast Arms*

Arm 2 Length 0 Reset Arm 2 Data

Arm2 Signal Number	*Distance to Signal (ft)*	*Number of Heads*
1		
2		
3		
4		
5		
6		
7		
8		
9		
10		

Arm 1 Sign Panels

Arm1 Sign Panel Number	*Distance to Panel (ft)*	*Panel Area (sf)*
1	25	4
2		
3		
4		
5		

Arm 2 Sign Panels

Arm2 Sign Panel Number	*Distance to Panel (ft)*	*Panel Area (sf)*
1		
2		
3		
4		
5		

Save Data for Signs and Signals

II. Arm 1 Analysis

InputDataFile = "Pole 4.dat" $V_{extreme} = 150 \cdot mph$

Reference:K:\ORL_Structures_Projects-Structures_Mast Arms\148400103 Lena Road\03_Calculations\Pole 4\MastArmV2.0\LRFD Equation M

Help - Base Diameters | Help - Tube Wall Thickness

Arm Extension (for 2 piece arms only)

Enter Arm 1 Data

Iterate on Base Diameters and Wall Thicknesses

Arm Length (ft)	*Base Diameter 1 (in)*	*Wall Thickness 1 (in)*	*Base Diameter 2 (in)*	*Wall Thickness 2 (in)*
$L_{total.arm1} = 60\,ft$	12	0.25	15	0.375
feet, 40 ft. max. for 1 piece arms	*Measured flat to flat* 'FC'	'FD'	*Measured flat to flat* 'FG'	'FH'

Arm 1 Analysis including Existing Mast Arm Analysis (Additional Variables Required)

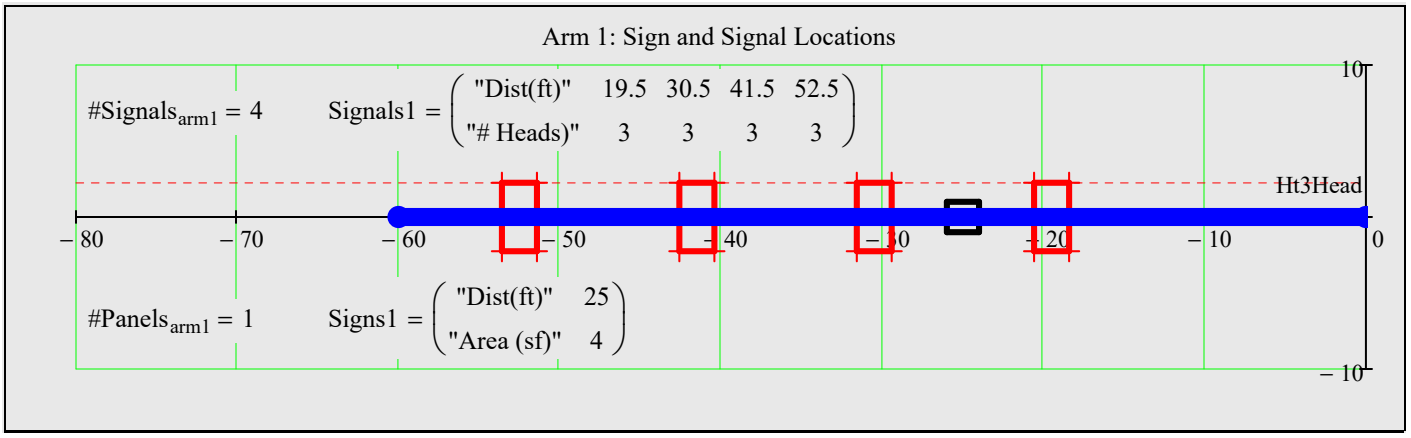
$L_{total.arm1} = 60\,ft$ 'FD'= 'FH'= $t_{wall.arm1} = \begin{pmatrix} 0.250 \\ 0.375 \end{pmatrix} \cdot in$ 'FC'= 'FG'= $Diameter_{base.arm1} = \begin{pmatrix} 12.00 \\ 15.00 \end{pmatrix} \cdot in$ BackPlate = "Rigid, 6 inches wide"

'FB'= 'FF'= $Diameter_{tip.arm1} = \begin{pmatrix} 7.03 \\ 11.15 \end{pmatrix} \cdot in$ $CheckTipDia_{arm1}$ = "OK" 'FA'= 'FE'= $L_{arm1} = \begin{pmatrix} 35.5 \\ 27.5 \end{pmatrix} \cdot ft$ $CheckSectionLength_{arm1}$ = "OK"

$L_{splice.provided.arm1} = 2.4\,ft$ $Classification_{arm1} = \begin{pmatrix} "Compact" \\ "Compact" \end{pmatrix}$

Arm 1 Combined Force Interaction Ratio and Deflection

$\max(CFI_{arm1}) = 0.58$ $CheckMaxCFI_{arm1}$ = "OK" $\max(\Delta_{arm1}) = 11.0 \cdot in$ $2 \cdot deg \cdot L_{total.arm1} = 25.1 \cdot in$



III. Arm 2 Analysis

InputDataFile = "Pole 4.dat" $V_{extreme} = 150 \cdot mph$

Help - Base Diameters | Help - Tube Wall Thickness

Arm Extension (for 2 piece arms only)

Enter Arm 2 Data

Iterate on Base Diameters and Wall Thicknesses

Arm Length (ft)	*Base Diameter 1 (in)*	*Wall Thickness 1 (in)*	*Base Diameter 2 (in)*	*Wall Thickness 2 (in)*
$L_{total.arm2} = 0\,ft$				
feet, 40 ft. max. for 1 piece arms	*Measured flat to flat* 'SC'	*for 1 & 2 piece arms* 'SD'	*Measured flat to flat* 'SG'	*for 2 piece arms only* 'SH'

Arm 2 Analysis

$L_{total.arm2} = 0\,ft$ 'SD'= 'SH'= $t_{wall.arm2} = \begin{pmatrix} 0.000 \\ 0.000 \end{pmatrix} \cdot in$ 'SC'= 'SG'= $Diameter_{base.arm2} = \begin{pmatrix} 0.00 \\ 0.00 \end{pmatrix} \cdot in$ BackPlate = "Rigid, 6 inches wide"

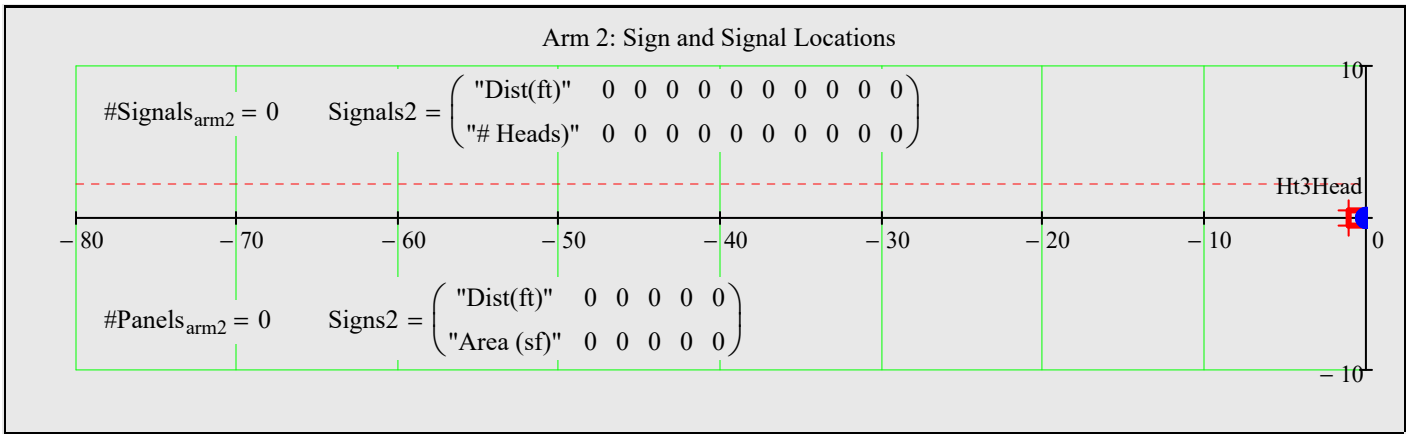
'SB'= 'SF'= $Diameter_{tip.arm2} = \begin{pmatrix} 0.00 \\ 0.00 \end{pmatrix} \cdot in$ $CheckTipDia_{arm2}$ = "N/A" 'SA'= 'SE'= $L_{arm2} = \begin{pmatrix} 0.0 \\ 0.0 \end{pmatrix} \cdot ft$ $CheckSectionLength_{arm2}$ = "N/A"

$L_{splice.provided.arm2} = 0.0\,ft$ $Classification_{arm2} = \begin{pmatrix} \text{"Compact"} \\ \text{"N/A"} \end{pmatrix}$

Arm 2 Combined Force Interaction Ratio and Deflection

$\max(CFI_{arm2}) = 0.00$ $CheckMaxCFI_{arm2}$ = "OK" $\max(\Delta_{arm2}) = 0.0 \cdot in$ $2 \cdot deg \cdot L_{total.arm2} = 0 \cdot in$

Arm 2: Sign and Signal Locations



IV. Luminaire Arm Analysis

InputDataFile = "Pole 4.dat" $V_{extreme} = 150 \cdot mph$

Enter Luminaire Data

Set Lum. Ht. = 0 for no Luminaire

See Design Standards 649-030 and 649-031 for input values.

Luminaire Height (ft)	Lum Horiz Length (ft)	Lum Arm Base Dia (in)	Lum Wall Thickness (in)	Slope	Lum Arm Radius (ft)	Lum Bolt Dia (in)	Lum Base Plate Thickness (in)
0							
Std = 40 feet	*10 feet*	*3 inches*	*0.125 inches*	*0.5*	*8 feet*	*0.5 inches*	*0.75 inches*

Analyze Luminaire

Summary - Luminaire Arm Geometry

$\begin{pmatrix} CFI_{base.lumarm} \\ CSR_{bolt.lum} \\ D/C_{baseplate.lum} \\ D/C_{conn.plate.lum} \end{pmatrix} = \begin{pmatrix} 0.00 \\ 0.00 \\ 0.00 \\ 0.00 \end{pmatrix}$

'LA'= $Y_{luminaire} = 0\,ft$ 'LB'= $X_{luminaire} = 0\,ft$ 'LC'= $Diameter_{base.lumarm} = 0 \cdot in$ 'LD'= $t_{wall.lumarm} = 0 \cdot in$

'LE'= $Slope_{lumarm} = 0$ 'LF'= $r_{lumarm} = 0\,ft$ 'LG'= $d_{bolt.lum} = 0 \cdot in$ 'LH'= $t_{baseplate.lum} = 0 \cdot in$

'LJ'= $w_{base.lum} = 0 \cdot in$ 'LK'= $w_{channel.lum} = 0 \cdot in$

V. Upright Analysis

InputDataFile = "Pole 4.dat" $V_{extreme} = 150 \cdot mph$

Help - Upright Base Diameter and Wall Thickness | Help - Gap Distance

Enter Upright Data

Total Height (ft)	Height to Arm Connection (ft)	Base Diameter (in)	Wall Thickness (in)	Gap (in)
24	21	22	0.375	7.5
'UA'	'UB'	'UD' measured flat to flat	'UE'	arm 1 gap / arm 2 gap

Analyze Upright

Upright Combined Force Interaction Ratio and Deflections

$Classification_{pole} = "Compact"$

$\max(CFI_{pole}) = 0.33$

$Check_{slope} = "OK"$

$Check_{deflection} = "OK"$

$\max(\Delta_{x.dl}) = 0.74 \cdot in$

$\max(\Delta_{z.dl}) = 0 \cdot in$

$Slope_z = 0 \cdot deg$

$Slope_x = 0.36 \cdot deg$

$Diameter_{conn.pole} = 19.1 \cdot in$

$\max(Diameter_{base.arm1}) = 15 \cdot in$

$\max(Diameter_{base.arm2}) = 0 \cdot in$

'UA'= $Y_{pole} = 24 \cdot ft$

'UB'= $Y_{arm.conn} = 21 \cdot ft$

'UC'= $Diameter_{tip.pole} = 18.7 \cdot in$

'UD'= $Diameter_{base.pole} = 22 \cdot in$

'UE'= $t_{wall.pole} = 0.375 \cdot in$

'UF'= $\alpha = 0 \cdot deg$

'UG'= $Y_{lum.conn} = 0 \, ft$

VI. Arm to Upright Connection Analysis

InputDataFile = "Pole 4.dat"

for double arms, both connection plate heights must be equal

Help - Arm Connection Dimensions

Enter Connection Data

Connection Plate Height(in)	Connection Plate Width (in)	Vertical Plate Thickness (in)	Bolt Diameter (in)	Arm Base Plate Thickness (in)
30	36	0.75	1.25	3
'HT'	'FJ', 'SJ'	'FL', 'SL'	'FP', 'SP'	'FK', 'SK'

Analyze Connection

Connection Summary

'HT'= $h_{conn.plate} = 30 \cdot in$ $D/C_{ht.conn.plate} = 0.60$ $CheckHt_{conn.plate} = "OK"$

$D/C_{width.conn.plate_0} = 0.86$

$CheckWidth_{conn.plate_0} = "OK"$ $\#Bolts_{conn_0} = 6$ 'FO'= $Offset_{conn_0} = 17.0 \cdot in$

$\begin{pmatrix} D/C_{t.baseplate.arm_0} \\ CFI_{t.vert.plate_0} \\ CSR_{bolt.conn_0} \end{pmatrix} = \begin{pmatrix} 0.83 \\ 0.20 \\ 0.22 \end{pmatrix}$

'FJ'= $b_{conn.plate_0} = 36 \cdot in$ 'FP'= $d_{bolt.conn_0} = 1.25 \cdot in$

'FK'= $t_{baseplate.arm_0} = 3.00 \cdot in$ 'FR'= $t_{conn.plate_0} = 2.00 \cdot in$

'FL'= $t_{vertical.plate_0} = 0.75 \cdot in$ 'FS'= $Spacing_{bolts.conn_0} = 12.5 \cdot in$

'FN'= $w_{vertical.plate_0} = \frac{1}{4} \cdot in$ 'FT'= $w_{conn.plate_0} = \frac{1}{4} \cdot in$

$D/C_{width.conn.plate_1} = 0.00$

$CheckWidth_{conn.plate_1} = "OK"$ $\#Bolts_{conn_1} = 0$ 'SO'= $Offset_{conn_1} = 0.0 \cdot in$

$\begin{pmatrix} D/C_{t.baseplate.arm_1} \\ CFI_{t.vert.plate_1} \\ CSR_{bolt.conn_1} \end{pmatrix} = \begin{pmatrix} 0.00 \\ 0.00 \\ 0.00 \end{pmatrix}$

'SJ'= $b_{conn.plate_1} = 0 \cdot in$ 'SP'= $d_{bolt.conn_1} = 0 \cdot in$

'SK'= $t_{baseplate.arm_1} = 0.00 \cdot in$ 'SR'= $t_{conn.plate_1} = 0.00 \cdot in$

'SL'= $t_{vertical.plate_1} = 0 \cdot in$ 'SS'= $Spacing_{bolts.conn_1} = 0.00 \cdot in$

'SN'= $w_{vertical.plate_1} = 0 \cdot in$ 'ST'= $w_{conn.plate_1} = 0 \cdot in$

VII. Upright Base Plate & Anchor Bolt Analysis

InputDataFile = "Pole 4.dat"

Enter Anchorage Data

Anchor Bolt Diameter (in)	*Number of Anchor Bolts*	Help - Number of Anchor Bolts
2	8	
'BC'	'#Bolts'	

$Diameter_{base.pole} = 22 \cdot in$

Analyze Base Plate & Anchors

Base Plate and Anchor Summary '#Bolts'= $\#AnchorBolts = 8$ 'BB'= $t_{baseplate.pole} = 2.50 \cdot in$

$CSR_{anchor} = 0.10$ $Diameter_{boltcircle.pole} = 30 \cdot in$ 'BC'= $d_{anchorbolt} = 2.00 \cdot in$

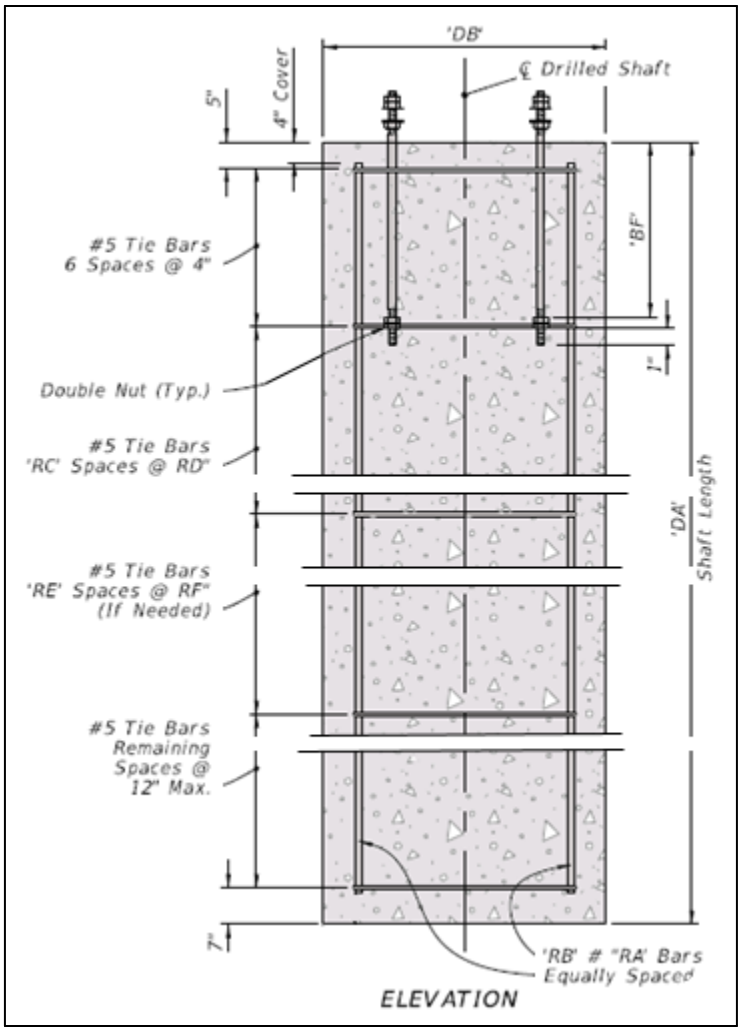
$CheckCSR_{anchorbolt} = "OK"$ 'BA'= $Diameter_{baseplate.pole} = 38 \cdot in$

VIII. Foundation Analysis & Anchor Bolt Lengths

InputDataFile = "Pole 4.dat"

Enter Drilled Shaft Data

Soil Type	Sand / Clay	
Soil Density, γ_{soil} (45-50 pcf typ.)	43	pcf
Friction Angle, ϕ (Sands)	29	deg
SPT Number (N_{blows} 5 min.) (Sands)	6	
Shear Strength, c (Clays)		ksf
Ground to Top of Shaft Offset	0.5	ft
First Set of User Defined Stirrups:		
Number of Stirrup Spaces 'RC'	8	
Stirrup Spacing 'RD'	12	in
Second Set of User Defined Stirrups:		
Number of Stirrup Spaces 'RE' *enter zero for 12 inch spacing*	0	
Stirrup Spacing 'RF' *enter zero for 12 inch spacing*	0	in
Stirrup Bar Size, use #5 for all Standard Shafts	#5 / #6	



Analyze Foundation

Shaft Length $L_{shaft} = 21.5\ ft$

Stirrup spacing $s_v = \begin{pmatrix} 4 \\ 12 \\ 0 \\ 12 \end{pmatrix} \cdot in$

Number of stirrup spaces $\#Spaces_{vbar} = \begin{pmatrix} 6 \\ 8 \\ 0 \\ 11 \end{pmatrix}$

Length required to resist torsion= 20.2 ft
Provided shaft length= 21.5 ft

20.2/21.5 < 0.95

Change shaft length to 22 ft.

Foundation Summary

CheckReinfClearSpacing = "OK"

CheckLongReinf$_{shr.tor}$ = "OK"

CheckMaxSpacingTransvReinf = "OK"

OverlapDesign = "Based on Overlap of Failure Cones"

OverlapTest = "Overlap of Failure Cones"

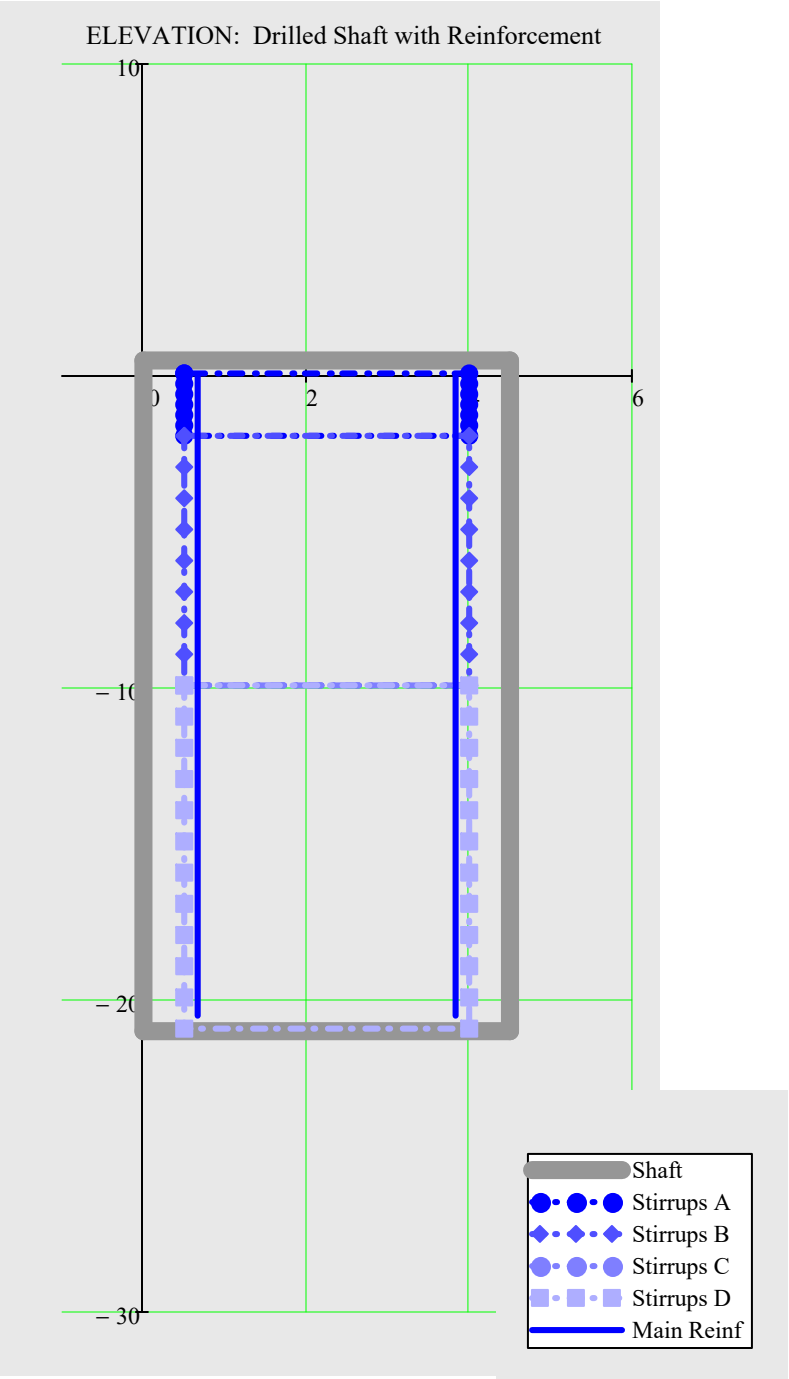
BreakoutTest = "OK"

Stirrups $s_{v_0} = 4 \cdot in$ @ $\#Spaces_{vbar_0} = 6$: $D/C_{torsion_0} = 0.2$

Stirrups 'RC' ($s_{v_1} = 12 \cdot in$) @ 'RD' ($\#Spaces_{vbar_1} = 8$) : $D/C_{torsion_1} = 0.6$

Stirrups 'RE' ($s_{v_2} = 0 \cdot in$) @ 'RF' ($\#Spaces_{vbar_2} = 0$) : $D/C_{torsion_2} = 0.4$

Stirrups $s_{v_3} = 12 \cdot in$ @ $\#Spaces_{vbar_3} = 11$



Offset = 0.5 ft

$d_{long.bar} = 1.41 \cdot in$

$Dia_{bar.circle} = 39.3 \cdot in$

'DA'= $L_{shaft} = 21.5 \cdot ft$

'DB'= $Diameter_{shaft} = 4.5 \cdot ft$

'BF'= $L_{embedment.anchor} = 40 \cdot in$

$L_{anchor.bolt} = 58 \cdot in$

'RA'= $\text{round}\left(\frac{d_{long.bar}}{0.125in}\right) = 11$

'RB'= $\#LongBars_{prov} = 16$

$\#Spaces_{vbar_0} = 6$

$s_{v_0} = 4 \cdot in$

'RC'= $\#Spaces_{vbar_1} = 8$

'RD'= $s_{v_1} = 12 \cdot in$

'RE'= $\#Spaces_{vbar_2} = 0$

'RF'= $s_{v_2} = 0 \cdot in$

$\#Spaces_{vbar_3} = 11$

$s_{v_3} = 12 \cdot in$

IX. Fatigue Analysis InputDataFile = "Pole 4.dat"

$FatigueCategory_{galloping} := 2$ $FatigueCategory_{natural.wind} := 2$ ***SM V3 11.6***

Analyze Structure for Fatigue

Fatigue Summary

K1 values within 2% of LTS thresholds of 3.0 and 4.0 may use next higher CAFT values

Arm and Pole Welds

$Check_{galloping.arm1} = "OK"$ $f_{galloping.arm1} = 3.8 \cdot ksi$ $CAFT_{fullpengroove.weld.arm1} = 7 \cdot ksi$

$Check_{galloping.arm2} = "NA"$ $f_{galloping.arm2} = 0.0 \cdot ksi$ $CAFT_{fullpengroove.weld.arm2} = "NA" \cdot ksi$

$Check_{galloping.pole} = "OK"$ $f_{galloping.pole} = 1.7 \cdot ksi$ $CAFT_{fullpengroove.weld.pole} = 4.5 \cdot ksi$

$Check_{nwg.arm1} = "OK"$ $f_{nwg.arm1} = 2.8 \cdot ksi$ $CAFT_{fullpengroove.weld.arm1} = 7 \cdot ksi$

$Check_{nwg.arm2} = "NA"$ $f_{nwg.arm2} = 0.0 \cdot ksi$ $CAFT_{fullpengroove.weld.arm2} = "NA" \cdot ksi$

$Check_{nwg.pole} = "OK"$ $f_{nwg.pole} = 1.3 \cdot ksi$ $CAFT_{fullpengroove.weld.pole} = 4.5 \cdot ksi$

$$CheckK1Values = \begin{pmatrix} "K1 \text{ is outside of 2\% of K1 thresholds}" \\ "K1 \text{ is outside of 2\% of K1 thresholds}" \\ "K1 \text{ is outside of 2\% of K1 thresholds}" \end{pmatrix} \quad \begin{pmatrix} K_{I.arm1} \\ K_{I.arm2} \\ K_{I.pole} \end{pmatrix} = \begin{pmatrix} 3.88 & "Arm\ 1\ Base\ Weld" \\ 100.0(& "Arm\ 2\ Base\ Weld" \\ 6.68 & "Upright\ Base\ Weld" \end{pmatrix}$$

A325 Connection Bolts

$Check_{g.conn.bolt} = \begin{pmatrix} "OK" \\ "OK" \end{pmatrix}$ $f_{t.g.bolt} = \begin{pmatrix} 3.8 \\ 0.0 \end{pmatrix} \cdot ksi$ $CAFT_{conn.bolt} = 16 \cdot ksi$

$Check_{nwg.conn.bolt} = \begin{pmatrix} "OK" \\ "OK" \end{pmatrix}$ $f_{t.nwg.bolt} = \begin{pmatrix} 2.8 \\ 0.0 \end{pmatrix} \cdot ksi$

Anchor Bolts

$Check_{g.anchor} = "OK"$ $f_{t.g.anchor} = 1.3 \cdot ksi$ $CAFT_{anchor.bolts} = 7 \cdot ksi$

$Check_{nwg.anchor} = "OK"$ $f_{t.nwg.anchor} = 1 \cdot ksi$

Save Data File (optional)

☑ Use current input file

File Name Pole 4.dat

Note: Select an output folder by using the "Change Folder" option above.

Save Data

Arm Designation Example

A70/D-A30/D/H-P5/D/L-DS/16/5

A70/D -	*Arm 70 feet long, Double Arm*
A30/D/H -	*Arm 30 feet long, Double Arm, Heavy Duty*
P5/D/L -	*Pole 5 , Double Arm, with Luminaire*
DS/16/5 -	*Drilled Shaft 16 ft deep, 5 foot diameter*

X. Mast Arm Design and Analysis Summary

InputDataFile = "Pole 4.dat"

If comparing results to Standard Index 649-030, some values in the index have been increased to reduce the number of variations.

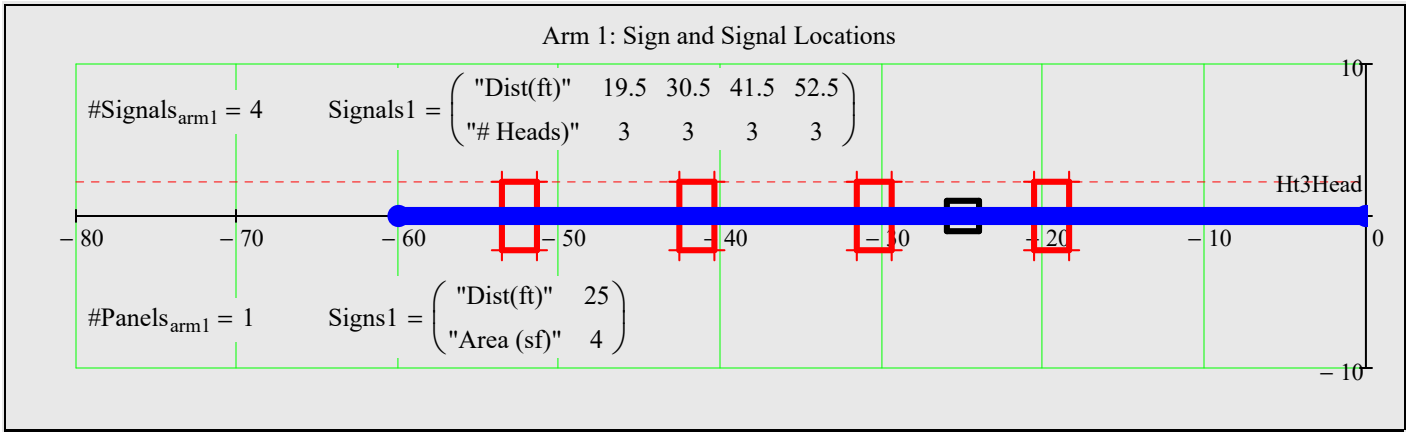
Subject = "Lena Road" **DesignedBy** = "KED" **PoleLocation** = "311+47.13 / 55.79' RT"

ProjectNo = "148400103" **CheckedBy** = "JAS" **Date** = "7/6/2023" ExistingMastArm = "No"

For FDOT Mast Arm Support Structures, $\max(CFI) \le 0.95$ ***(See Structures Manual Volume3)***

1st Mast Arm

$V_{extreme} = 150 \cdot mph$ ExistingMastArm = "No" BackPlate = "Rigid, 6 inches wide"



$\max(CFI_{arm1}) = 0.58$ CheckMaxCFI$_{arm1}$ = "OK" $L_{total.arm1} = 60\,ft$ $L_{splice.provided.arm1} = 2.4 \cdot ft$ $\max(\Delta_{arm1}) = 11 \cdot in$

'FA'= 'FE'= $L_{arm1} = \begin{pmatrix} 35.5 \\ 27.5 \end{pmatrix} \cdot ft$ CheckSectionLength$_{arm1}$ = "OK"

'FC'= 'FG'= $Diameter_{base.arm1} = \begin{pmatrix} 12.00 \\ 15.00 \end{pmatrix} \cdot in$

'FB'= 'FF'= $Diameter_{tip.arm1} = \begin{pmatrix} 7.03 \\ 11.15 \end{pmatrix} \cdot in$ CheckTipDia$_{arm1}$ = "OK"

'FD'= 'FH'= $t_{wall.arm1} = \begin{pmatrix} 0.250 \\ 0.375 \end{pmatrix} \cdot in$

2nd Mast Arm

$\max(CFI_{arm2}) = 0.00$ CheckMaxCFI$_{arm2}$ = "OK" $L_{total.arm2} = 0\,ft$ $L_{splice.provided.arm2} = 0 \cdot ft$ $\max(\Delta_{arm2}) = 0 \cdot in$

'SA'= 'SE'= $L_{arm2} = \begin{pmatrix} 0 \\ 0 \end{pmatrix} \cdot ft$ CheckSectionLength$_{arm2}$ = "N/A"

'SC'= 'SG'= $Diameter_{base.arm2} = \begin{pmatrix} 0.00 \\ 0.00 \end{pmatrix} \cdot in$

'UF'= $\alpha = 0 \cdot deg$ (Angle Between Arms)

'SB'= 'SF'= $Diameter_{tip.arm2} = \begin{pmatrix} 0.00 \\ 0.00 \end{pmatrix} \cdot in$ CheckTipDia$_{arm2}$ = "N/A"

'SD'= 'SH'= $t_{wall.arm2} = \begin{pmatrix} 0.000 \\ 0.000 \end{pmatrix} \cdot in$

Luminaire Arm and Connection *(use MC10x33.6 channel for connection)*

$$\begin{pmatrix} CFI_{base.lumarm} \\ CSR_{bolt.lum} \\ D/C_{baseplate.lum} \\ D/C_{conn.plate.lum} \end{pmatrix} = \begin{pmatrix} 0.00 \\ 0.00 \\ 0.00 \\ 0.00 \end{pmatrix}$$

'LA'= $Y_{luminaire} = 0\ ft$

'LB'= $X_{luminaire} = 0\ ft$

'LC'= $Diameter_{base.lumarm} = 0 \cdot in$

'LD'= $t_{wall.lumarm} = 0 \cdot in$

'LE'= $Slope_{lumarm} = 0$

'LF'= $r_{lumarm} = 0\ ft$

'LG'= $d_{bolt.lum} = 0 \cdot in$

'LH'= $t_{baseplate.lum} = 0 \cdot in$

'LJ'= $w_{base.lum} = 0 \cdot in$

'LK'= $w_{channel.lum} = 0 \cdot in$

Upright

$max(CFI_{pole}) = 0.33$

$Check_{deflection} = "OK"$

$Check_{slope} = "OK"$

'UA'= $Y_{pole} = 24 \cdot ft$

'UB'= $Y_{arm.conn} = 21 \cdot ft$

'UC'= $Diameter_{tip.pole} = 18.7 \cdot in$

'UD'= $Diameter_{base.pole} = 22 \cdot in$

'UE'= $t_{wall.pole} = 0.375 \cdot in$

'UF'= $\alpha = 0 \cdot deg$

'UG'= $Y_{lum.conn} = 0\ ft$

1st Arm to Upright Connection

$D/C_{ht.conn.plate} = 0.60$

$CheckHt_{conn.plate} = "OK"$

$D/C_{width.conn.plate_0} = 0.86$

$CheckWidth_{conn.plate_0} = "OK"$

$$\begin{pmatrix} D/C_{t.baseplate.arm_0} \\ CFI_{t.vert.plate_0} \\ CSR_{bolt.conn_0} \end{pmatrix} = \begin{pmatrix} 0.83 \\ 0.20 \\ 0.22 \end{pmatrix}$$

'HT'= $h_{conn.plate} = 30 \cdot in$

$\#Bolts_{conn_0} = 6$

'FJ'= $b_{conn.plate_0} = 36 \cdot in$

'FK'= $t_{baseplate.arm_0} = 3 \cdot in$

'FL'= $t_{vertical.plate_0} = 0.75 \cdot in$

'FN'= $w_{vertical.plate_0} = \frac{1}{4} \cdot in$

'FO'= $Offset_{conn_0} = 17.0 \cdot in$

'FP'= $d_{bolt.conn_0} = 1.25 \cdot in$

'FR'= $t_{conn.plate_0} = 2 \cdot in$

'FS'= $Spacing_{bolts.conn_0} = 12.5 \cdot in$

'FT'= $w_{conn.plate_0} = \frac{1}{4} \cdot in$

2nd Arm to Upright Connection

$D/C_{width.conn.plate_1} = 0.00$

$CheckWidth_{conn.plate_1} = "OK"$

$$\begin{pmatrix} D/C_{t.baseplate.arm_1} \\ CFI_{t.vert.plate_1} \\ CSR_{bolt.conn_1} \end{pmatrix} = \begin{pmatrix} 0.00 \\ 0.00 \\ 0.00 \end{pmatrix}$$

'HT'= $h_{conn.plate} = 30 \cdot in$

$\#Bolts_{conn_1} = 0$

'SJ'= $b_{conn.plate_1} = 0 \cdot in$

'SK'= $t_{baseplate.arm_1} = 0 \cdot in$

'SL'= $t_{vertical.plate_1} = 0 \cdot in$

'SN'= $w_{vertical.plate_1} = 0 \cdot in$

'SO'= $Offset_{conn_1} = 0.0 \cdot in$

'SP'= $d_{bolt.conn_1} = 0 \cdot in$

'SR'= $t_{conn.plate_1} = 0 \cdot in$

'SS'= $Spacing_{bolts.conn_1} = 0 \cdot in$

'ST'= $w_{conn.plate_1} = 0 \cdot in$

Pole Base Plate

$CSR_{anchor} = 0.10$

$CheckCSR_{anchorbolt} = "OK"$

'#Bolts'= $\#AnchorBolts = 8$

$Diameter_{boltcircle.pole} = 30 \cdot in$

'BA'= $Diameter_{baseplate.pole} = 38 \cdot in$

'BB'= $t_{baseplate.pole} = 2.5 \cdot in$

'BC'= $d_{anchorbolt} = 2.00 \cdot in$

'BF'= $L_{embedment.anchor} = 40 \cdot in$

$L_{anchor.bolt} = 58 \cdot in$

Foundation

$D/C_{torsion.max} = 0.56$

$CheckD/C_{shear.and.torsion} = "OK"$

$CheckReinfClearSpacing = "OK"$

$CheckLongReinf_{shr.tor} = "OK"$

$CheckMaxSpacingTransvReinf = "OK"$

$OverlapDesign = "Based on Overlap of Failure Cones"$

$OverlapTest = "Overlap of Failure Cones"$

$BreakoutTest = "OK"$

$Clearance_{csl.to.nut} = 1.5 \cdot in$

$Offset = 0.5\,ft$

$d_{long.bar} = 1.41 \cdot in$

$Dia_{bar.circle} = 39.3 \cdot in$

'DA'= $L_{shaft} = 21.5 \cdot ft$

'DB'= $Diameter_{shaft} = 4.5 \cdot ft$

'RA'= $round\left(\frac{d_{long.bar}}{0.125in}\right) = 11$

'RB'= $\#LongBars_{prov} = 16$

'RC'= $\#Spaces_{vbar_1} = 8$

'RD'= $s_{v_1} = 12 \cdot in$

'RE'= $\#Spaces_{vbar_2} = 0$

'RF'= $s_{v_2} = 0 \cdot in$

Fatigue

$Check_{galloping.arm1} = "OK"$

$Check_{nwg.arm1} = "OK"$

$Check_{galloping.arm2} = "NA"$

$Check_{nwg.arm2} = "NA"$

$Check_{galloping.pole} = "OK"$

$Check_{nwg.pole} = "OK"$

$Check_{g.conn.bolt} = \begin{pmatrix} "OK" \\ "OK" \end{pmatrix}$

$Check_{nwg.conn.bolt} = \begin{pmatrix} "OK" \\ "OK" \end{pmatrix}$

$Check_{g.anchor} = "OK"$

$Check_{nwg.anchor} = "OK"$

K1 values within 2% of LTS thresholds may use next higher CAFT values

$$CheckK1Values = \begin{pmatrix} "K1 \text{ is outside of 2\% of K1 thresholds}" \\ "K1 \text{ is outside of 2\% of K1 thresholds}" \\ "K1 \text{ is outside of 2\% of K1 thresholds}" \end{pmatrix}$$

$$\begin{pmatrix} K_{I.arm1} \\ K_{I.arm2} \\ K_{I.pole} \end{pmatrix} = \begin{pmatrix} 3.882 \\ 100.000 \\ 6.683 \end{pmatrix} \begin{pmatrix} "Arm\ 1\ Base\ Weld" \\ "Arm\ 2\ Base\ Weld" \\ "Upright\ Base\ Weld" \end{pmatrix}$$

WRITE to Special Mast Arm Assembly Data Tables

Mast Arm Tip Deflection

Compare Mast Arm deflection of each arm to a proposed camber

$Camber_{arm1} := 2 \cdot deg$ $Camber_{arm2} := 2 \cdot deg$

$Deflection_{arm1} := Slope_x \cdot L_{total.arm1} + \max(\Delta_{arm1}) = 15.5 \cdot in$

$CamberArm1_{upward} := \sin(Camber_{arm1}) \cdot L_{total.arm1} = 25.1 \cdot in$

$Deflection_{arm2} := \left[Slope_z \cdot L_{total.arm2} \cdot (\sin(\alpha))\right] + Slope_x \cdot L_{total.arm2} \cdot \cos(\alpha) + \max(\Delta_{arm2}) = 0 \cdot in$

$CamberArm2_{upward} := \sin(Camber_{arm2}) \cdot L_{total.arm2} = 0 \cdot in$

Check Clearance Between Connection Plates *(for Two Arm Structures only)*

$\alpha = 0 \cdot deg$ $\alpha := if[(\alpha > 180 \cdot deg), (360 \cdot deg - \alpha), \alpha]$

$Offset_{conn_0} = 17 \cdot in$ $b_{conn.plate_0} = 36 \cdot in$ $h_{conn.plate} = 30 \cdot in$ $\alpha = 0 \cdot deg$

$Offset_{conn_1} = 0 \cdot in$ $b_{conn.plate_1} = 0 \cdot in$

$x1 := Offset_{conn_0} - t_{conn.plate_0} - h_{conn.plate} \cdot \frac{\sin(Camber_{arm1})}{2} = 14.5 \cdot in$ $y1 := \frac{b_{conn.plate_0}}{2} = 18 \cdot in$

$x2 := \left(Offset_{conn_1} - t_{conn.plate_1} - h_{conn.plate} \cdot \frac{\sin(Camber_{arm2})}{2}\right) \cdot \cos(\alpha) + \frac{b_{conn.plate_1}}{2} \cdot \sin(\alpha) = -0.5 \cdot in$

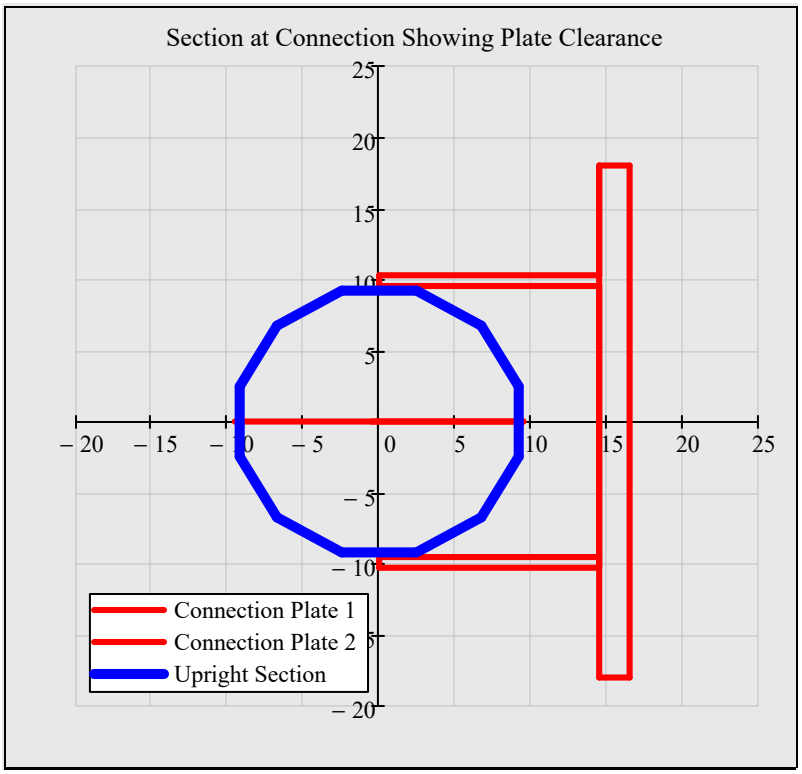
$y2 := \left(Offset_{conn_1} - t_{conn.plate_1} - h_{conn.plate} \cdot \frac{\sin(Camber_{arm2})}{2}\right) \cdot \sin(\alpha) - \frac{b_{conn.plate_1}}{2} \cdot \cos(\alpha) = 0 \cdot in$

$Clearance_{plate.to.plate} := if\left[(x1 > x2) \cdot (y2 > y1), \sqrt{(x1 - x2)^2 + (y1 - y2)^2}, 0 \cdot in\right] = 0 \cdot in$

(if Clearance < 2 inches, a redesign is required.

Coordinates for Drawings

Plan View - Connection Plate Clearance for Two Arm Connections



$Clearance_{plate.to.plate} = 0 \cdot in$

$Diameter_{conn.pole} = 19.1 \cdot in$

'FR'= $t_{conn.plate_0} = 2 \cdot in$

'FJ'= $b_{conn.plate_0} = 36 \cdot in$

'FL'= $t_{vertical.plate_0} = 0.75 \cdot in$

'FO'= $Offset_{conn_0} = 17.0 \cdot in$

$Gap_0 = 7.5 \cdot in$

'SR'= $t_{conn.plate_1} = 0 \cdot in$

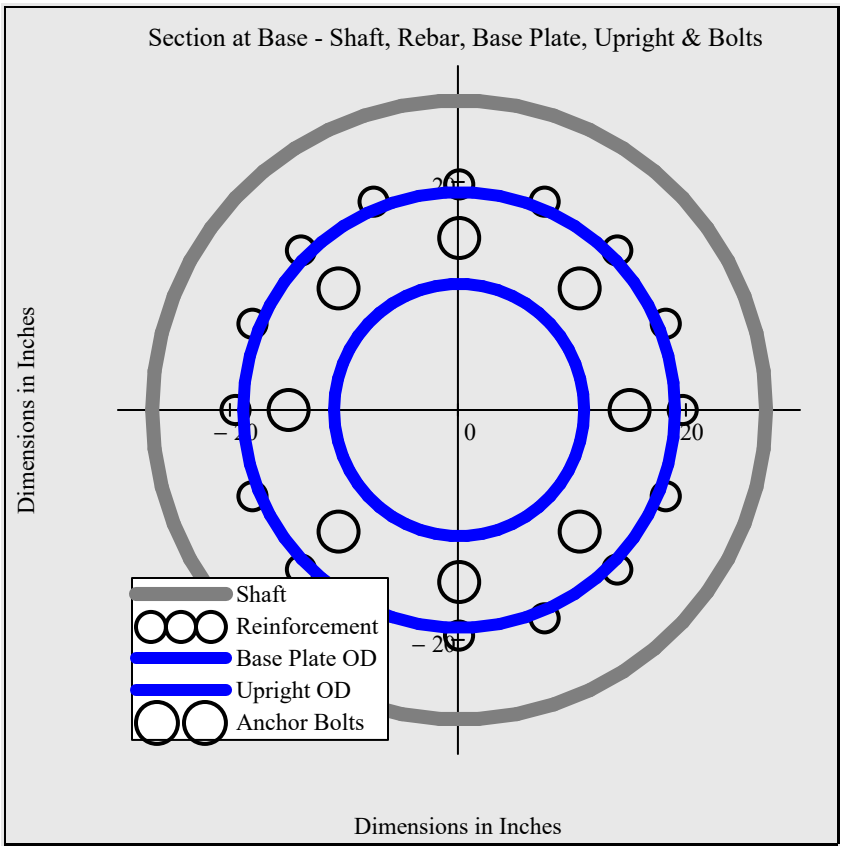
'SJ'= $b_{conn.plate_1} = 0 \cdot in$

'SL'= $t_{vertical.plate_1} = 0 \cdot in$

'SO'= $Offset_{conn_1} = 0.0 \cdot in$

$Gap_1 = 0 \cdot in$

Plan View - Drilled Shaft, Base Plate, Upright, Anchor Bolts, & Reinforcing Steel



$Clearance_{bar.to.nut} = 2.1 \cdot in$

'UD'= $Diameter_{base.pole} = 22 \cdot in$

'BA'= $Diameter_{baseplate.pole} = 38 \cdot in$

'DB'= $Diameter_{shaft} = 54 \cdot in$

$Diameter_{boltcircle.pole} = 30 \cdot in$

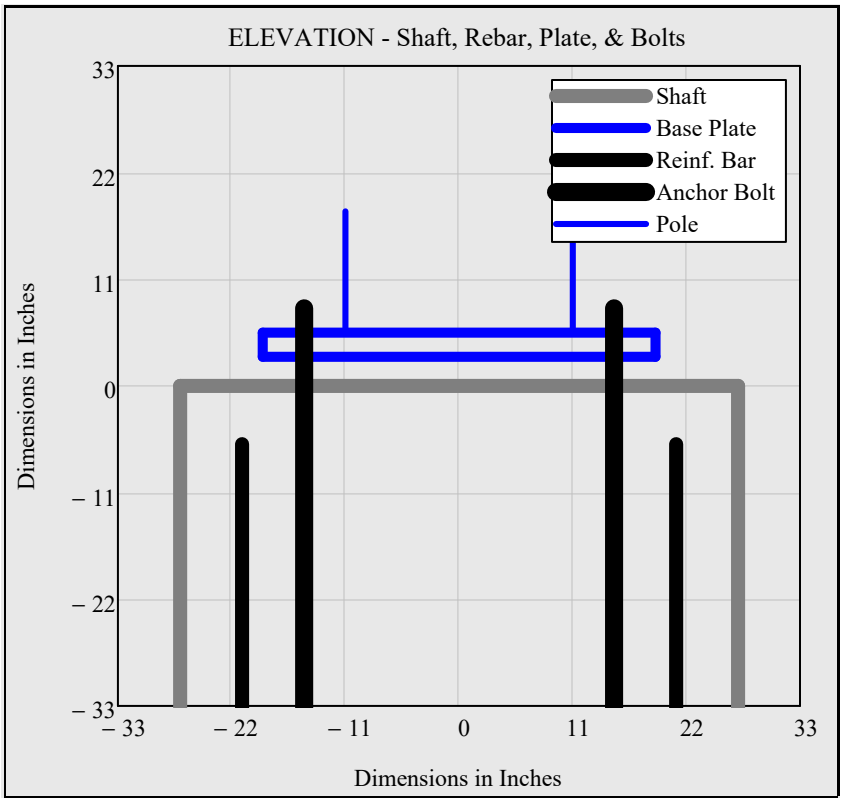
$Dia_{bar.circle} = 39.3 \cdot in$

$\#AnchorBolts = 8$

$\#LongBars_{prov} = 16$

Note: The Plan and Elevation Views do not show the 4 or 5 1.9" O.D. Nondestructive Integrity Testing Access Tubes that are tied to the inside of the reinforcing cage (see FDOT Spec 455-16.4).

Elevation View - Drilled Shaft, Base Plate, Anchor Bolts, & Reinforcing Steel



$Clearance_{bar.to.nut} = 2.1 \cdot in$

'UD'= $Diameter_{base.pole} = 22 \cdot in$

'BA'= $Diameter_{baseplate.pole} = 38 \cdot in$

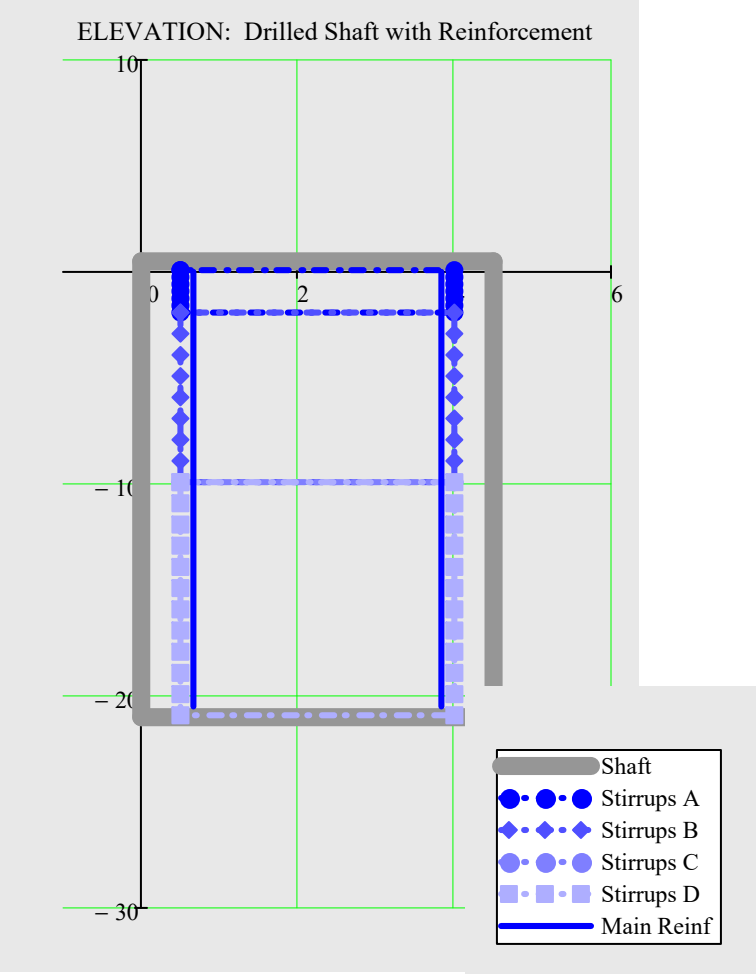
'BB'= $t_{baseplate.pole} = 2.5 \cdot in$

'DB'= $Diameter_{shaft} = 54 \cdot in$

$Diameter_{boltcircle.pole} = 30 \cdot in$

$Dia_{bar.circle} = 39.3 \cdot in$

Elevation View - Drilled Shaft with Main Reinforcement and Stirrups



$$s_v = \begin{pmatrix} 4 \\ 12 \\ 0 \\ 12 \end{pmatrix} \cdot in$$ *stirrup spacing*

$$\#Spaces_{vbar} = \begin{pmatrix} 6 \\ 8 \\ 0 \\ 11 \end{pmatrix}$$ *number of stirrup spaces*

APPENDIX F:

POLE 5 – DESIGN

APPENDIX F:

POLE 5 – VERTICAL CLEARANCE

Kimley»Horn

Project:	Lena Road		
Structure ID:	Pole 5		
Designed by:	KED	*Date:*	07-06-2023
Checked by:	JAS	*Date:*	07-10-2023

General Info & Mounting Height Calculation

(Enter values in shaded cells only)

County (District) [1] =	Manatee (1)	
Wind Speed [1] =	150	mph
Backplates [2] =	Yes	
Arm Type =	See Mast Arm Excel	
Drop Distance [3] =	2.500	ft
Base El. =	+20.170	ft
Crown El. Arm #1 [4] =	+19.980	ft
Crown El. Arm #2 [4] =	+20.740	ft
Arm Mounting Height, UB [5] =	21.000	ft
MVC Arm #1 =	**18.690**	ft *(from 17.5' to 19')* [6]
MVC Arm #2 =	**17.930**	ft *(from 17.5' to 19')* [6]

Checks:

Ok, Vertical Clearance requirements satisfied at Arm #1

Ok, Vertical Clearance requirements satisfied at Arm #2

Ok, Mounting Height within FDOT limits

Notes & References:

(1) Per FDOT Structures Manual (Jan. 2023), Vol. 3 - Mod's to LTSLRFD-1, Section 3.8.2 - *"For the 700 year Extreme Event Limit State, use the wind speeds (mph) shown in FDOT SDG Table 2.4.1-1."*

(2) Per FDOT FDM (Jan. 1, 2023) Vol. 2, Chapter 261.4 - *"Design all structures assuming traffic signal assemblies have backplates in accordance with FDM 232.1.5"* Per FDOT FDM (Jan. 1, 2023) Vol. 2, Chapter 232.1.5, *"Install retroreflective signal backplates on traffic signals for all approaches."*

(3) *"Drop Distance"* is the vertical distance measured from the centerline of the arm to the bottom of signal or sign. Dimensions: 14" per head for standard signal section, 6" for backplate (each side), and 3" added to the end of the signal head to compensate for attachment hardware, per FDOT SPI 649-030 (FY 2023-24);

e.g. 3-Head = 0.5(3*14") + 6" + 3" = 30"; 4-Head = 37", 5-Head = 30" or 44", etc.

(4) Arm 1 is the larger of the two arms; if only 1 arm, Crown El. Arm #1 = Crown El. Arm #2

(5) In order to use FDOT Standard Assemblies, 18' ≤ UB ≤ 22' (per FDOT SPI 649-030, FY 2023-24).

(6) FDOT FDM (Jan. 1 2023), Section 210.10.3 Vertical Clearances: *"The required clearance for new signals on span wires, mast arms, or other structures is 17.5 feet. This clearance is the least distance measured between the lowest point on the signal structure and the traffic lane or shoulder directly below the signal structure. For any construction affecting existing signal clearances, FDOT minimum vertical clearance is 17 feet. Vertical clearances between 15 feet and 17 feet require a Design Variation. Signal clearances less than 15 feet are not allowed"*

FDOT Construction Specifications 2022, 650-3.3 Clearances: "*Unless directed otherwise by the Engineer for unusual circumstances at the site, provide a vertical clearance of not less than 17 feet-6 inches and not more than 19 feet for traffic signals placed over the roadway. Measure such clearance for each span directly under the most critical signal assembly (in regards to clearance) for the span. Place signal assemblies on each span as near as practical to the same elevation as the critical signal assembly. Ensure that the lowest point on pedestal-mounted and side-mounted signal heads is 12 feet above finished grade at the point of their installation*"

Version 2.0 (05/16/2022)

APPENDIX F:

POLE 5 – FDOT DESIGN AID

Kimley-Horn
189 S. Orange Ave., Suite 1000
Orlando, FL 32801

Design Aid for FDOT Standard Mast Arm Assemblies (Standard Plans Index 649-030)

Mast Arm Assembly Information

Wind Speed: ○ 130 mph ◉ 150 mph ○ 170 mph

Signal Orientation: ◉ Vertical ○ Horizontal

Back Plate Width: ◉ 6.0 in. ○ 2.5 in. ○ 0 in.

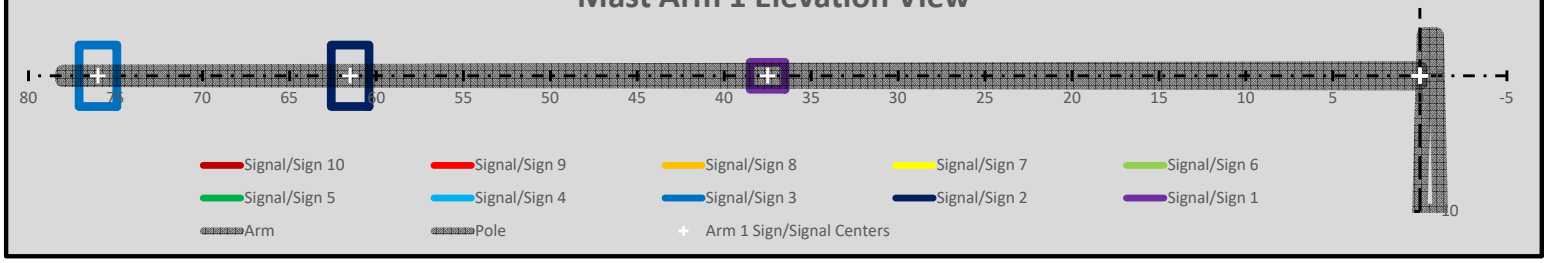
Luminaire? ○ Yes ◉ No

Arm 1 Length: 30 40 50 60 70 78

Arm 1 Length, Signal/Sign Location and Size

	Signal\Sign #10	Signal\Sign #9	Signal\Sign #8	Signal\Sign #7	Signal\Sign #6	Signal\Sign #5	Signal\Sign #4	Signal\Sign #3	Signal\Sign #2	Signal\Sign #1
	◉ None	◉ None	◉ None	◉ None	◉ None	◉ None	◉ None	○ None	○ None	○ None
	○ 3 Head	○ 3 Head	○ 3 Head	○ 3 Head	○ 3 Head	○ 3 Head	○ 3 Head	◉ 3 Head	◉ 3 Head	○ 3 Head
	○ 4 Head	○ 4 Head	○ 4 Head	○ 4 Head	○ 4 Head	○ 4 Head	○ 4 Head	○ 4 Head	○ 4 Head	○ 4 Head
	○ 5 Head	○ 5 Head	○ 5 Head	○ 5 Head	○ 5 Head	○ 5 Head	○ 5 Head	○ 5 Head	○ 5 Head	○ 5 Head
	○ Sign	○ Sign	○ Sign	○ Sign	○ Sign	○ Sign	○ Sign	○ Sign	○ Sign	◉ Sign
Dist to Pole (ft.)								76	61.5	37.5
Sign Width (in.)										24
Sign Height (in.)										24
Area (SF)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	9.8	9.8	4.0
*M_{wl}. (kip*ft)*	0	0	0	0	0	0	0	47	38	9

Mast Arm 1 Elevation View



Arm 1 Length (ft)	78	
Standard Plans Index 649-030	**Regular**	**Heavy Duty**
Dia. at Arm Base (in)	18	20
Wall Thickness (in)	0.3750	0.3750
Resistance (M_r=ϕM_n) (kip*ft)	423	513
95% M_r (kip*ft)	402	487

Arm 1 Loads	Regular	Heavy Duty
1.1*Arm M_{dl} (kip*ft)	121	143
Arm M_{wl} (kip*ft)	120	142
1.1*Sign/Signal M_{dl} (kip*ft)	8	
Sign/Signal M_{wl} (kip*ft)	94	
Total Moment ($M_{extreme}$)	250	281

Mast Arm Assembly Designation
Two Arm Assembly
A78/D-A60/D-P6/D-DS/14/5

Notes:

Run the FDOT Mast Arm Mathcad Program for more accurate results.

For new designs, always design with 6" backplates.

Mast Arm Assembly ID consists of three parts for a single arm and 4 parts for a double Arm. Each part is separated by "-".

Part 1 is Arm 1: Axx/y/z, where xx is the arm length, y is "S" for single arm or "D" for double arms and z is "H" for heavy duty arm or blank for regular arm.

Part 2 is Arm 2 and has the same nomenclature as the 1st arm. For single arm assemblies, Part 2 is omitted.

Part 3 is the Pole: Px/y/z where x is the pole ID, y is "S" for single arm or "D" for double arms and z is "L" for luminaire or blank for no luminaire.

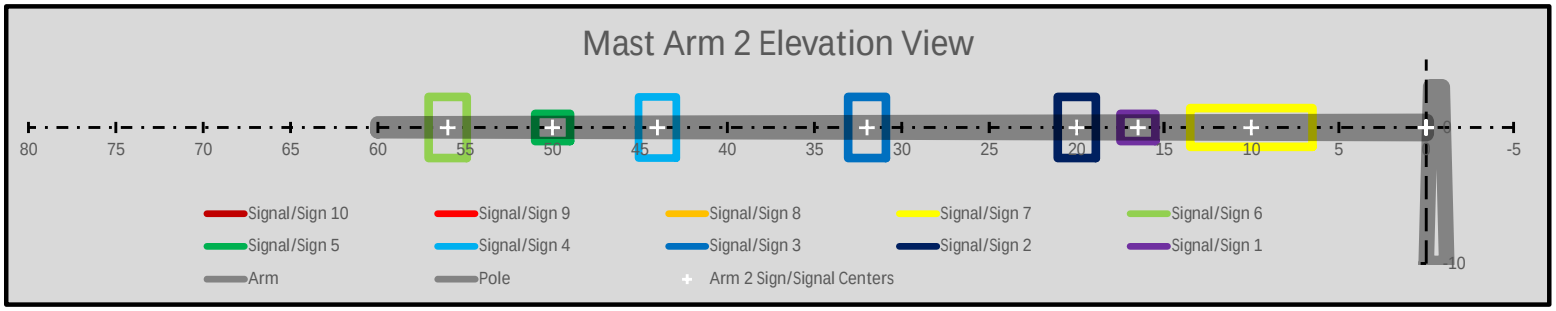
Part 4 is the Drilled Shaft: DS/xx/y where xx is the shaft length and y is the shaft diameter.

Arm to pole connection is assumed at 22 ft. above the base.

No foundation offset is considered. If the top of drilled shaft > 2 feet above ground, run the Mathcad Mast Arm Program.

Design Aid for FDOT Standard Mast Arm Assemblies (Standard Plans Index 649-030)

Mast Arm Assembly Information		Arm 2 Length, Signal/Sign Location and Size									
		Signal\Sign #10	Signal\Sign #9	Signal\Sign #8	Signal\Sign #7	Signal\Sign #6	Signal\Sign #5	Signal\Sign #4	Signal\Sign #3	Signal\Sign #2	Signal\Sign #1
Wind Speed = 150 mph Luminaire = No	Arm 2 Length: 60 (None, 30, 40, 50, 60, 70, 78)	None / 3 Head / 4 Head / 5 Head / Sign	None / 3 Head / 4 Head / 5 Head / Sign	None / 3 Head / 4 Head / 5 Head / Sign	None / 3 Head / 4 Head / 5 Head / Sign	None / 3 Head / 4 Head / 5 Head / Sign	None / 3 Head / 4 Head / 5 Head / Sign	None / 3 Head / 4 Head / 5 Head / Sign	None / 3 Head / 4 Head / 5 Head / Sign	None / 3 Head / 4 Head / 5 Head / Sign	None / 3 Head / 4 Head / 5 Head / Sign
	Dist from Pole (ft.)				10	56	50	44	32	20	16.5
Vertical Signal Orientation with 6 inch Backplates.	*Sign Width (in.)*				84		24				24
	Sign Height (in.)				34		24				24
	Area (SF)	0.0	0.0	0.0	19.8	9.8	4.0	9.8	9.8	9.8	4.0
	*M_{wl}. (kip*ft)*	0	0	0	12	35	13	27	20	12	4



Arm 2 Length (ft)	60		Arm 2 Loads	Regular	Heavy Duty
Standard Plans Index 649-030	Regular	Heavy Duty	1.1*Arm M_{dl} (kip*ft)	62	68
Dia. at Arm Base (in)	15	16	Arm M_{wl} (kip*ft)	63	71
Wall Thickness (in)	0.3750	0.3750	1.1*Sign/Signal M_{dl} (kip*ft)	10	
Resistance (M_r=ϕM_n) (kip*ft)	300	342	Sign/Signal M_{wl} (kip*ft)	123	
95% M_r (kip*ft)	285	325	Total Moment ($M_{extreme}$)	199	209

Mast Arm Assembly Designation
Two Arm Assembly A78/D-A60/D-P6/D-DS/14/5

Notes:

Run the FDOT Mast Arm Mathcad Program for more accurate results.

For new designs, always design with backplates.

Mast Arm Assembly ID consists of three parts for a single arm and 4 parts for a double Arm. Each part is separated by "-".

Part 1 is Arm 1: Axx/y/z, where xx is the arm length, y is "S" for single arm or "D" for double arms and z is "H" for heavy duty arm or blank for regular arm.

Part 2 is Arm 2 and has the same nomenclature as the 1st arm. For single arm assemblies, Part 2 is omitted.

Part 3 is the Pole: Px/y/z where x is the pole ID, y is "S" for single arm or "D" for double arms and z is "L" for luminaire or blank for no luminaire.

Part 4 is the Drilled Shaft: DS/xx/y where xx is the shaft length and y is the shaft diameter.

Arm to pole connection is assumed at 22 ft. above the base.

No foundation offset is considered. If the top of drilled shaft > 2 feet above ground, run the Mathcad Mast Arm Program.

APPENDIX F:

POLE 5 – MAST ARM DESIGN

FDOT Mast Arm Traffic Signal Support Analysis Program V2.0

This program works in conjunction with FDOT Mast Arm Standard Plans 649-030 & 649-031.

References:
AASHTO LRFD Specifications for Structural Supports for Highway Signs, Luminaires and Traffic Signals (LRFDLTS).
FDOT Structures Manual Volume 3 (SM V3).
AISC Steel Construction Manual

Reference

For more information see Reference.xmcd and Changes.xmcd.

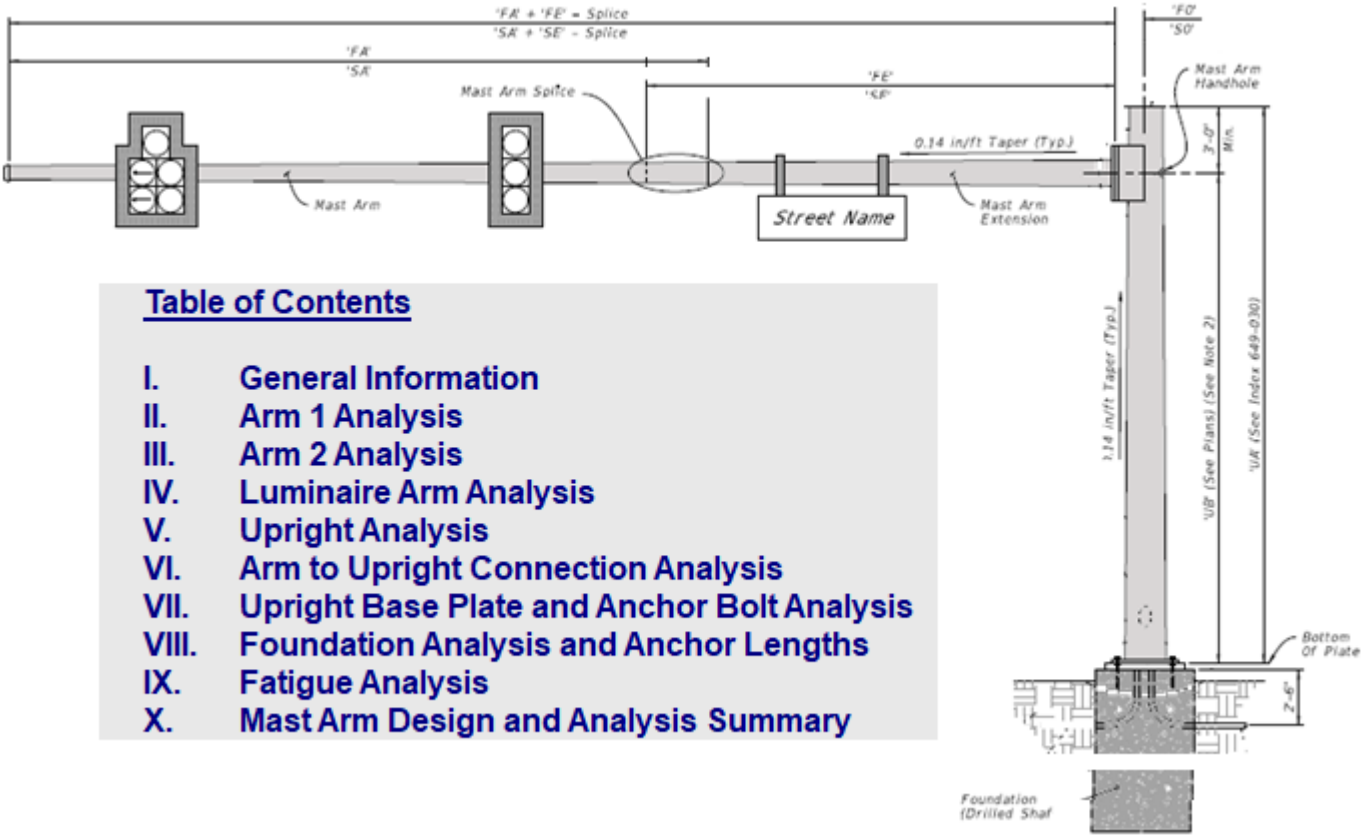


Table of Contents

Data Folder and Files

Data Files Folder

Change Folder

K:\ORL_Structures_Projects-Structures_MastArms\148400103 Lena Road\03_Calculations\Pole 5\MastArmV2.0\Data\

Required - Open Existing Data File. To save New Data Files, enter data variables at the end of Section IX.

Refresh List

Open File

- A78D-A30D-P6DL.dat
- A78D-A50D-P6DL.dat
- A78D-A70D-P7DL.dat
- A78DH-A40DH-P6DL.dat
- A78DH-A60DH-P6DL.dat
- A78DH-A78DH-P7DL.dat
- A78SH-P6SL.dat
- Pole 5.dat

I. General Information and Sign & Signal Data

Enter Project Information

Project Name	Lena Road		
Project No.	148400103		
Designed by	KED	*Date*	7/6/2023
Checked by	JAS	*Date*	7/10/2023
Signal Name	Pole 5		
Station/Offset	309+73.61 / 82' RT		

Enter Wind Speed

Design Wind Speed 150 *mph*

Extreme Event Wind Speed

SDG Wind Speeds by County

Enter Arm Lengths, Signal and Sign Data

Arm 1

Arm 1 Length 78 Reset Arm 1 Data

Arm1 Signal Number	*Distance to Signal (ft)*	*Number of Heads*
1	61.5	3
2	76	3
3		
4		
5		
6		
7		
8		
9		
10		

Arm 2 *Set Arm 2 Length = 0 for single arm Mast Arms*

Arm 2 Length 60 Reset Arm 2 Data

Arm2 Signal Number	*Distance to Signal (ft)*	*Number of Heads*
1	20	3
2	32	3
3	44	3
4	56	3
5		
6		
7		
8		
9		
10		

Arm 1 Sign Panels

Arm1 Sign Panel Number	*Distance to Panel (ft)*	*Panel Area (sf)*
1	37.5	4
2		
3		
4		
5		

Arm 2 Sign Panels

Arm2 Sign Panel Number	*Distance to Panel (ft)*	*Panel Area (sf)*
1	16.5	4
2	50	4
3	10	19.6
4		
5		

Camera moved from 16.5' to 3.0' from upright. Current design is conservative. OK.

Save Data for Signs and Signals

II. Arm 1 Analysis

InputDataFile = "Pole 5.dat" $V_{extreme} = 150 \cdot mph$

Reference:K:\ORL_Structures_Projects-Structures_Mast Arms\148400103 Lena Road\03_Calculations\Pole 5\MastArmV2.0\LRFD Equation M

Help - Base Diameters | Help - Tube Wall Thickness

Arm Extension (for 2 piece arms only)

Enter Arm 1 Data

Iterate on Base Diameters and Wall Thicknesses

Arm Length (ft)	*Base Diameter 1 (in)*	*Wall Thickness 1 (in)*	*Base Diameter 2 (in)*	*Wall Thickness 2 (in)*
$L_{total.arm1} = 78\,ft$	13	0.25	18	0.375
feet, 40 ft. max. for 1 piece arms	*Measured flat to flat* 'FC'	'FD'	*Measured flat to flat* 'FG'	'FH'

Arm 1 Analysis including Existing Mast Arm Analysis (Additional Variables Required)

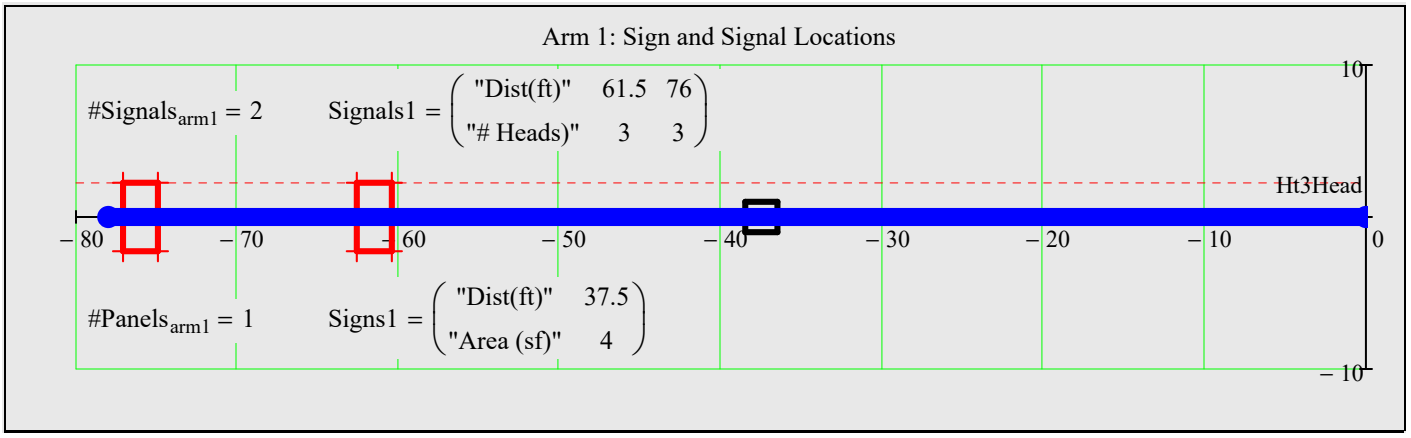
$L_{total.arm1} = 78\,ft$ 'FD'= 'FH'= $t_{wall.arm1} = \begin{pmatrix} 0.250 \\ 0.375 \end{pmatrix} \cdot in$ 'FC'= 'FG'= $Diameter_{base.arm1} = \begin{pmatrix} 13.00 \\ 18.00 \end{pmatrix} \cdot in$ BackPlate = "Rigid, 6 inches wide"

'FB'= 'FF'= $Diameter_{tip.arm1} = \begin{pmatrix} 7.54 \\ 12.12 \end{pmatrix} \cdot in$ $CheckTipDia_{arm1}$ = "OK" 'FA'= 'FE'= $L_{arm1} = \begin{pmatrix} 39.0 \\ 42.0 \end{pmatrix} \cdot ft$ $CheckSectionLength_{arm1}$ = "OK"

$L_{splice.provided.arm1} = 2.6\,ft$ $Classification_{arm1} = \begin{pmatrix} \text{"Compact"} \\ \text{"Compact"} \end{pmatrix}$

Arm 1 Combined Force Interaction Ratio and Deflection

$\max(CFI_{arm1}) = 0.60$ $CheckMaxCFI_{arm1}$ = "OK" $\max(\Delta_{arm1}) = 20.8 \cdot in$ $2 \cdot deg \cdot L_{total.arm1} = 32.7 \cdot in$



III. Arm 2 Analysis

InputDataFile = "Pole 5.dat" $V_{extreme} = 150 \cdot mph$

Help - Base Diameters | Help - Tube Wall Thickness

Arm Extension (for 2 piece arms only)

Enter Arm 2 Data

Iterate on Base Diameters and Wall Thicknesses

Arm Length (ft)	*Base Diameter 1 (in)*	*Wall Thickness 1 (in)*	*Base Diameter 2 (in)*	*Wall Thickness 2 (in)*
$L_{total.arm2} = 60\,ft$	12	0.25	15	0.375
feet, 40 ft. max. for 1 piece arms	*Measured flat to flat* 'SC'	*for 1 & 2 piece arms* 'SD'	*Measured flat to flat* 'SG'	*for 2 piece arms only* 'SH'

Arm 2 Analysis

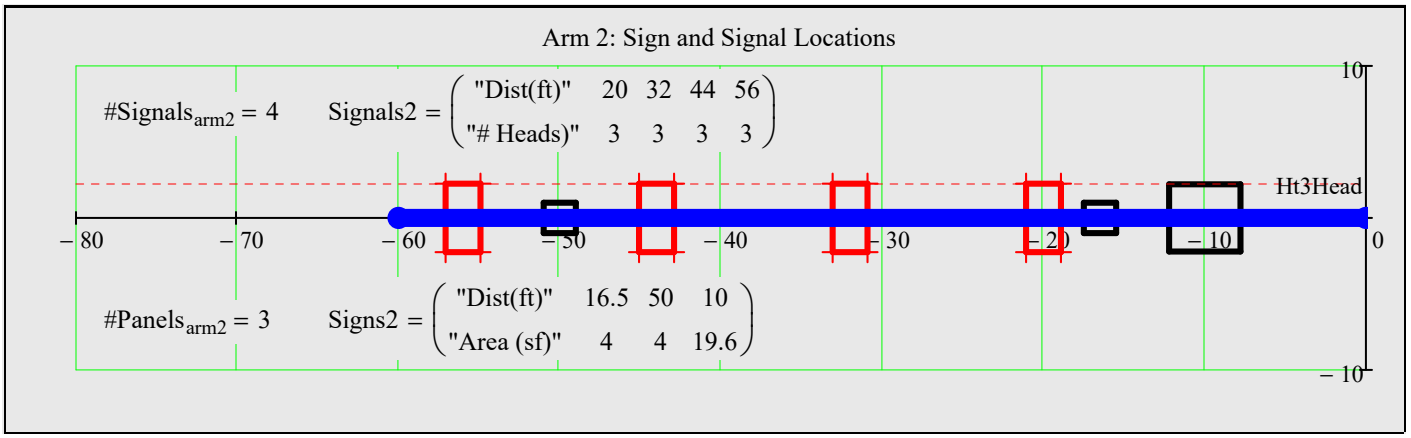
$L_{total.arm2} = 60\,ft$ 'SD'= 'SH'= $t_{wall.arm2} = \begin{pmatrix} 0.250 \\ 0.375 \end{pmatrix} \cdot in$ 'SC'= 'SG'= $Diameter_{base.arm2} = \begin{pmatrix} 12.00 \\ 15.00 \end{pmatrix} \cdot in$ BackPlate = "Rigid, 6 inches wide"

'SB'= 'SF'= $Diameter_{tip.arm2} = \begin{pmatrix} 7.03 \\ 11.15 \end{pmatrix} \cdot in$ $CheckTipDia_{arm2}$ = "OK" 'SA'= 'SE'= $L_{arm2} = \begin{pmatrix} 35.5 \\ 27.5 \end{pmatrix} \cdot ft$ $CheckSectionLength_{arm2}$ = "OK"

$L_{splice.provided.arm2} = 2.4\,ft$ $Classification_{arm2} = \begin{pmatrix} \text{"Compact"} \\ \text{"Compact"} \end{pmatrix}$

Arm 2 Combined Force Interaction Ratio and Deflection

$\max(CFI_{arm2}) = 0.67$ $CheckMaxCFI_{arm2}$ = "OK" $\max(\Delta_{arm2}) = 11.4 \cdot in$ $2 \cdot deg \cdot L_{total.arm2} = 25.1 \cdot in$



IV. Luminaire Arm Analysis

InputDataFile = "Pole 5.dat" $V_{extreme} = 150 \cdot mph$

Enter Luminaire Data

Set Lum. Ht. = 0 for no Luminaire

See Design Standards 649-030 and 649-031 for input values.

Luminaire Height (ft)	*Lum Horiz Length (ft)*	*Lum Arm Base Dia (in)*	*Lum Wall Thickness (in)*	*Slope*	*Lum Arm Radius (ft)*	*Lum Bolt Dia (in)*	*Lum Base Plate Thickness (in)*
0							
Std = 40 feet	*10 feet*	*3 inches*	*0.125 inches*	*0.5*	*8 feet*	*0.5 inches*	*0.75 inches*

Analyze Luminaire

Summary - Luminaire Arm Geometry

$\begin{pmatrix} CFI_{base.lumarm} \\ CSR_{bolt.lum} \\ D/C_{baseplate.lum} \\ D/C_{conn.plate.lum} \end{pmatrix} = \begin{pmatrix} 0.00 \\ 0.00 \\ 0.00 \\ 0.00 \end{pmatrix}$

'LA'= $Y_{luminaire} = 0\,ft$ 'LE'= $Slope_{lumarm} = 0$ 'LJ'= $w_{base.lum} = 0 \cdot in$

'LB'= $X_{luminaire} = 0\,ft$ 'LF'= $r_{lumarm} = 0\,ft$ 'LK'= $w_{channel.lum} = 0 \cdot in$

'LC'= $Diameter_{base.lumarm} = 0 \cdot in$ 'LG'= $d_{bolt.lum} = 0 \cdot in$

'LD'= $t_{wall.lumarm} = 0 \cdot in$ 'LH'= $t_{baseplate.lum} = 0 \cdot in$

V. Upright Analysis

InputDataFile = "Pole 5.dat" $V_{extreme} = 150 \cdot mph$

Help - Upright Base Diameter and Wall Thickness | Help - Gap Distance

Enter Upright Data

Total Height (ft)	Height to Arm Connection (ft)	Base Diameter (in)	Wall Thickness (in)	Gap (in)	
24	21	24	0.5	12.44	arm 1 gap
				12.44	arm 2 gap
'UA'	'UB'	'UD' measured flat to flat	'UE'		

Analyze Upright

Upright Combined Force Interaction Ratio and Deflections

Classification$_{pole}$ = "Compact"

$\max(CFI_{pole}) = 0.38$

$Check_{slope}$ = "OK"

$Check_{deflection}$ = "OK"

$\max(\Delta_{x.dl}) = 0.79 \cdot in$

$\max(\Delta_{z.dl}) = -0.45 \cdot in$

$Slope_z = 0.22 \cdot deg$

$Slope_x = 0.39 \cdot deg$

$Diameter_{conn.pole} = 21.1 \cdot in$

$\max(Diameter_{base.arm1}) = 18 \cdot in$

$\max(Diameter_{base.arm2}) = 15 \cdot in$

'UA'= $Y_{pole} = 24 \cdot ft$

'UB'= $Y_{arm.conn} = 21 \cdot ft$

'UC'= $Diameter_{tip.pole} = 20.7 \cdot in$

'UD'= $Diameter_{base.pole} = 24 \cdot in$

'UE'= $t_{wall.pole} = 0.5 \cdot in$

'UF'= $\alpha = 90 \cdot deg$

'UG'= $Y_{lum.conn} = 0\ ft$

VI. Arm to Upright Connection Analysis

InputDataFile = "Pole 5.dat"

for double arms, both connection plate heights must be equal

Help - Arm Connection Dimensions

Enter Connection Data

Connection Plate Height(in)	Connection Plate Width (in)	Vertical Plate Thickness (in)	Bolt Diameter (in)	Arm Base Plate Thickness (in)
30	36	0.75	1.5	3
	36	0.75	1.5	3
'HT'	'FJ', 'SJ'	'FL', 'SL'	'FP', 'SP'	'FK', 'SK'

Analyze Connection

Connection Summary

'HT'= $h_{conn.plate} = 30 \cdot in$ $D/C_{ht.conn.plate} = 0.70$ $CheckHt_{conn.plate} = "OK"$

$D/C_{width.conn.plate_0} = 0.97$

$CheckWidth_{conn.plate_0} = "OK"$

$\#Bolts_{conn_0} = 6$

'FO'= $Offset_{conn_0} = 23.0 \cdot in$

$$\begin{pmatrix} D/C_{t.baseplate.arm_0} \\ CFI_{t.vert.plate_0} \\ CSR_{bolt.conn_0} \end{pmatrix} = \begin{pmatrix} 0.83 \\ 0.48 \\ 0.31 \end{pmatrix}$$

'FJ'= $b_{conn.plate_0} = 36 \cdot in$

'FP'= $d_{bolt.conn_0} = 1.5 \cdot in$

'FK'= $t_{baseplate.arm_0} = 3.00 \cdot in$

'FR'= $t_{conn.plate_0} = 2.00 \cdot in$

'FL'= $t_{vertical.plate_0} = 0.75 \cdot in$

'FS'= $Spacing_{bolts.conn_0} = 12 \cdot in$

'FN'= $w_{vertical.plate_0} = \frac{3}{8} \cdot in$

'FT'= $w_{conn.plate_0} = \frac{3}{8} \cdot in$

$D/C_{width.conn.plate_1} = 0.97$

$CheckWidth_{conn.plate_1} = "OK"$

$\#Bolts_{conn_1} = 6$

'SO'= $Offset_{conn_1} = 23.0 \cdot in$

$$\begin{pmatrix} D/C_{t.baseplate.arm_1} \\ CFI_{t.vert.plate_1} \\ CSR_{bolt.conn_1} \end{pmatrix} = \begin{pmatrix} 0.83 \\ 0.37 \\ 0.16 \end{pmatrix}$$

'SJ'= $b_{conn.plate_1} = 36 \cdot in$

'SP'= $d_{bolt.conn_1} = 1.5 \cdot in$

'SK'= $t_{baseplate.arm_1} = 3.00 \cdot in$

'SR'= $t_{conn.plate_1} = 2.00 \cdot in$

'SL'= $t_{vertical.plate_1} = 0.75 \cdot in$

'SS'= $Spacing_{bolts.conn_1} = 12.00 \cdot in$

'SN'= $w_{vertical.plate_1} = \frac{1}{4} \cdot in$

'ST'= $w_{conn.plate_1} = \frac{1}{4} \cdot in$

VII. Upright Base Plate & Anchor Bolt Analysis

InputDataFile = "Pole 5.dat"

Enter Anchorage Data

Anchor Bolt Diameter (in)	*Number of Anchor Bolts*	Help - Number of Anchor Bolts
2	8	
'BC'	'#Bolts'	

$Diameter_{base.pole} = 24 \cdot in$

Analyze Base Plate & Anchors

Base Plate and Anchor Summary

'#Bolts'= #AnchorBolts = 8

'BB'= $t_{baseplate.pole} = 2.50 \cdot in$

$CSR_{anchor} = 0.27$

$Diameter_{boltcircle.pole} = 32 \cdot in$

'BC'= $d_{anchorbolt} = 2.00 \cdot in$

$CheckCSR_{anchorbolt} = "OK"$

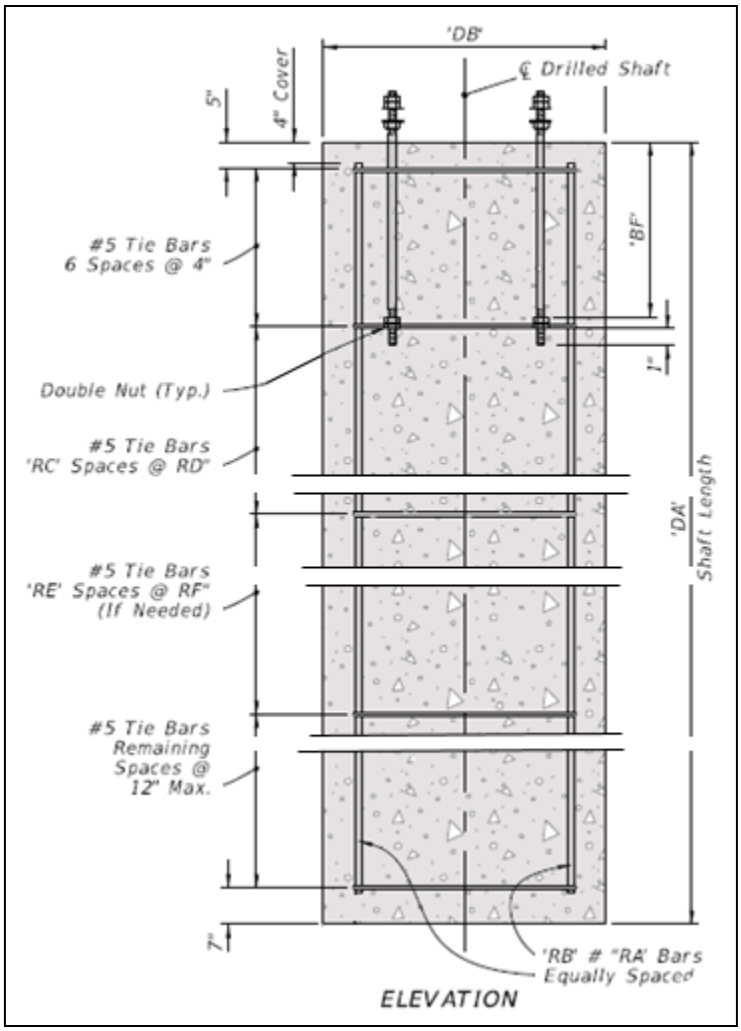
'BA'= $Diameter_{baseplate.pole} = 40 \cdot in$

VIII. Foundation Analysis & Anchor Bolt Lengths

InputDataFile = "Pole 5.dat"

Enter Drilled Shaft Data

Soil Type	Sand / Clay	
Soil Density, γ_{soil} (45-50 pcf typ.)	50	pcf
Friction Angle, ϕ (Sands)	30	deg
SPT Number (N_{blows} 5 min.) (Sands)	19	
Shear Strength, c (Clays)		ksf
Ground to Top of Shaft Offset	0.5	ft
First Set of User Defined Stirrups:		
Number of Stirrup Spaces 'RC'	10	
Stirrup Spacing 'RD'	8	in
Second Set of User Defined Stirrups:		
Number of Stirrup Spaces 'RE' *enter zero for 12 inch spacing*	0	
Stirrup Spacing 'RF' *enter zero for 12 inch spacing*	0	in
Stirrup Bar Size, use #5 for all Standard Shafts	#5 / #6	



Analyze Foundation

Shaft Length *Stirrup spacing* *Number of stirrup spaces*

$L_{shaft} = 15.5\ ft \quad s_v = \begin{pmatrix} 4 \\ 8 \\ 0 \\ 12 \end{pmatrix} \cdot in \quad \#Spaces_{vbar} = \begin{pmatrix} 6 \\ 10 \\ 0 \\ 6 \end{pmatrix}$

Length required to resist torsion= 14.3 ft
Provided shaft length= 15.5 ft

14.3/15.5 < 0.95

Change shaft length to standard of 16 ft.

Foundation Summary

CheckReinfClearSpacing = "OK"

CheckLongReinf$_{shr.tor}$ = "OK"

CheckMaxSpacingTransvReinf = "OK"

OverlapDesign = "Based on Overlap of Failure Cones"

OverlapTest = "Overlap of Failure Cones"

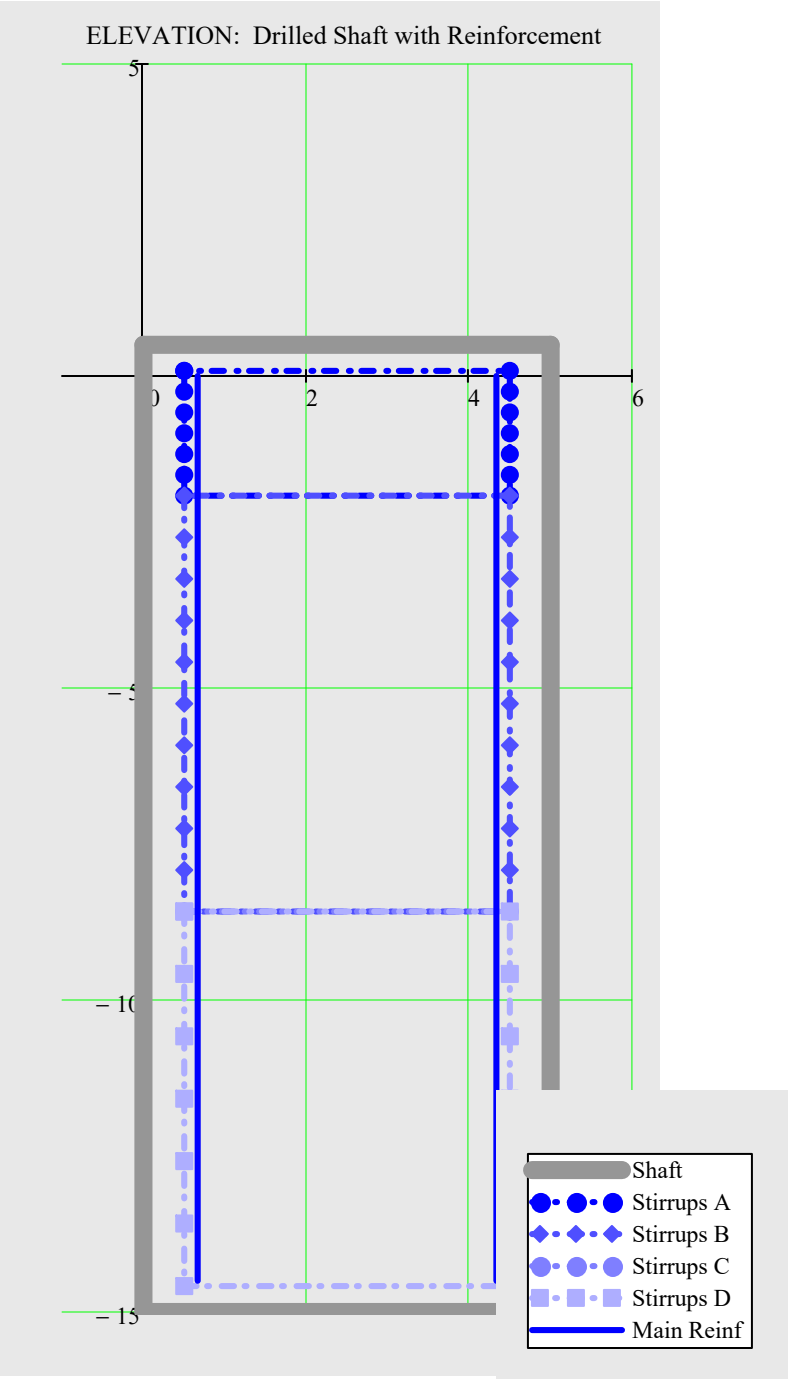
BreakoutTest = "OK"

Stirrups $s_{v_0} = 4 \cdot in$ @ $\#Spaces_{vbar_0} = 6$: $D/C_{torsion_0} = 0.3$

Stirrups 'RC' ($s_{v_1} = 8 \cdot in$) @ 'RD' ($\#Spaces_{vbar_1} = 10$) : $D/C_{torsion_1} = 0.5$

Stirrups 'RE' ($s_{v_2} = 0 \cdot in$) @ 'RF' ($\#Spaces_{vbar_2} = 0$) : $D/C_{torsion_2} = 0.3$

Stirrups $s_{v_3} = 12 \cdot in$ @ $\#Spaces_{vbar_3} = 6$



Offset = 0.5 ft

$d_{long.bar} = 1.41 \cdot in$

$Dia_{bar.circle} = 45.3 \cdot in$

'DA'= $L_{shaft} = 15.5 \cdot ft$

'DB'= $Diameter_{shaft} = 5 \cdot ft$

'BF'= $L_{embedment.anchor} = 40 \cdot in$

$L_{anchor.bolt} = 58 \cdot in$

'RA'= $round\left(\frac{d_{long.bar}}{0.125in}\right) = 11$

'RB'= $\#LongBars_{prov} = 18$

$\#Spaces_{vbar_0} = 6$

$s_{v_0} = 4 \cdot in$

'RC'= $\#Spaces_{vbar_1} = 10$

'RD'= $s_{v_1} = 8 \cdot in$

'RE'= $\#Spaces_{vbar_2} = 0$

'RF'= $s_{v_2} = 0 \cdot in$

$\#Spaces_{vbar_3} = 6$

$s_{v_3} = 12 \cdot in$

IX. Fatigue Analysis InputDataFile = "Pole 5.dat"

$FatigueCategory_{galloping} := 2$ $FatigueCategory_{natural.wind} := 2$ ***SM V3 11.6***

Analyze Structure for Fatigue

Fatigue Summary

Arm and Pole Welds

K1 values within 2% of LTS thresholds of 3.0 and 4.0 may use next higher CAFT values

$Check_{galloping.arm1} = "OK"$ $f_{galloping.arm1} = 2.6 \cdot ksi$ $CAFT_{fullpengroove.weld.arm1} = 4.5 \cdot ksi$

$Check_{galloping.arm2} = "OK"$ $f_{galloping.arm2} = 4.9 \cdot ksi$ $CAFT_{fullpengroove.weld.arm2} = 7 \cdot ksi$

$Check_{galloping.pole} = "OK"$ $f_{galloping.pole} = 1.4 \cdot ksi$ $CAFT_{fullpengroove.weld.pole} = 4.5 \cdot ksi$

$Check_{nwg.arm1} = "OK"$ $f_{nwg.arm1} = 2.8 \cdot ksi$ $CAFT_{fullpengroove.weld.arm1} = 4.5 \cdot ksi$

$Check_{nwg.arm2} = "OK"$ $f_{nwg.arm2} = 3.2 \cdot ksi$ $CAFT_{fullpengroove.weld.arm2} = 7 \cdot ksi$

$Check_{nwg.pole} = "OK"$ $f_{nwg.pole} = 1.0 \cdot ksi$ $CAFT_{fullpengroove.weld.pole} = 4.5 \cdot ksi$

$$CheckK1Values = \begin{pmatrix} "K1 \text{ is w/i 2\% of 4.0 K1 threshold (CAFT = 7.0 ksi)}" \\ "K1 \text{ is outside of 2\% of K1 thresholds}" \\ "K1 \text{ is outside of 2\% of K1 thresholds}" \end{pmatrix} \begin{pmatrix} K_{I.arm1} \\ K_{I.arm2} \\ K_{I.pole} \end{pmatrix} = \begin{pmatrix} 4.00 \\ 3.84 \\ 8.77 \end{pmatrix} \begin{pmatrix} "Arm\ 1\ Base\ Weld" \\ "Arm\ 2\ Base\ Weld" \\ "Upright\ Base\ Weld" \end{pmatrix}$$

A325 Connection Bolts

$$Check_{g.conn.bolt} = \begin{pmatrix} "OK" \\ "OK" \end{pmatrix} \quad f_{t.g.bolt} = \begin{pmatrix} 3.1 \\ 3.6 \end{pmatrix} \cdot ksi \quad CAFT_{conn.bolt} = 16 \cdot ksi$$

$$Check_{nwg.conn.bolt} = \begin{pmatrix} "OK" \\ "OK" \end{pmatrix} \quad f_{t.nwg.bolt} = \begin{pmatrix} 3.3 \\ 2.3 \end{pmatrix} \cdot ksi$$

Anchor Bolts

$Check_{g.anchor} = "OK"$ $f_{t.g.anchor} = 1.2 \cdot ksi$ $CAFT_{anchor.bolts} = 7 \cdot ksi$

$Check_{nwg.anchor} = "OK"$ $f_{t.nwg.anchor} = 1.2 \cdot ksi$

Save Data File (optional)

File Name Pole 5.dat

Note: Select an output folder by using the "Change Folder" option above.

Arm Designation Example

A70/D-A30/D/H-P5/D/L-DS/16/5

A70/D -	*Arm 70 feet long, Double Arm*
A30/D/H -	*Arm 30 feet long, Double Arm, Heavy Duty*
P5/D/L -	*Pole 5 , Double Arm, with Luminaire*
DS/16/5 -	*Drilled Shaft 16 ft deep, 5 foot diameter*

X. Mast Arm Design and Analysis Summary

InputDataFile = "Pole 5.dat"

If comparing results to Standard Index 649-030, some values in the index have been increased to reduce the number of variations.

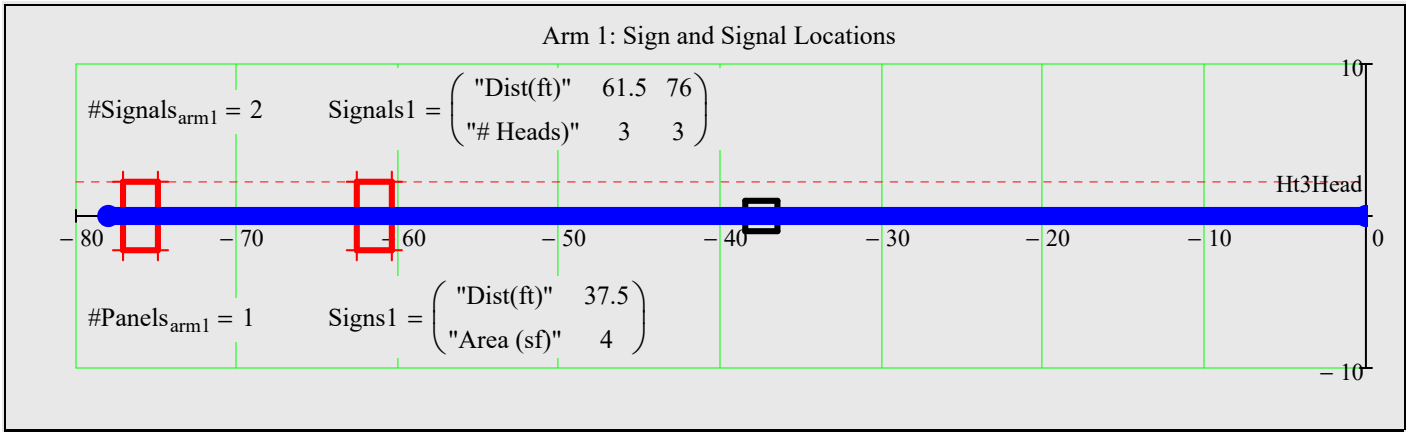
Subject = "Lena Road" **DesignedBy** = "KED" **PoleLocation** = "309+73.61 / 82' RT"

ProjectNo = "148400103" **CheckedBy** = "JAS" **Date** = "7/6/2023" ExistingMastArm = "No"

For FDOT Mast Arm Support Structures, max(CFI) ≤ 0.95 ***(See Structures Manual Volume3)***

1st Mast Arm

$V_{extreme} = 150 \cdot mph$ ExistingMastArm = "No" BackPlate = "Rigid, 6 inches wide"



$\max(CFI_{arm1}) = 0.60$ $CheckMaxCFI_{arm1}$ = "OK" $L_{total.arm1} = 78\ ft$ $L_{splice.provided.arm1} = 2.6 \cdot ft$ $\max(\Delta_{arm1}) = 20.8 \cdot in$

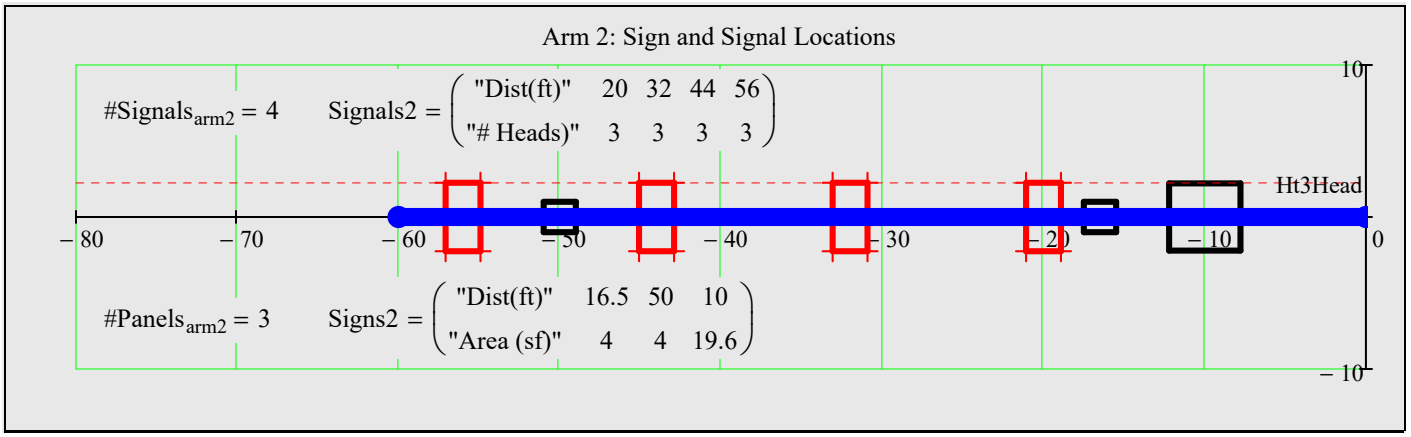
'FA'= 'FE'= $L_{arm1} = \begin{pmatrix} 39 \\ 42 \end{pmatrix} \cdot ft$ $CheckSectionLength_{arm1}$ = "OK"

'FC'= 'FG'= $Diameter_{base.arm1} = \begin{pmatrix} 13.00 \\ 18.00 \end{pmatrix} \cdot in$

'FB'= 'FF'= $Diameter_{tip.arm1} = \begin{pmatrix} 7.54 \\ 12.12 \end{pmatrix} \cdot in$ $CheckTipDia_{arm1}$ = "OK"

'FD'= 'FH'= $t_{wall.arm1} = \begin{pmatrix} 0.250 \\ 0.375 \end{pmatrix} \cdot in$

2nd Mast Arm



$\max(CFI_{arm2}) = 0.67$ $CheckMaxCFI_{arm2}$ = "OK" $L_{total.arm2} = 60\ ft$ $L_{splice.provided.arm2} = 2.4 \cdot ft$ $\max(\Delta_{arm2}) = 11.4 \cdot in$

'SA'= 'SE'= $L_{arm2} = \begin{pmatrix} 35.5 \\ 27.5 \end{pmatrix} \cdot ft$ $CheckSectionLength_{arm2}$ = "OK"

'SC'= 'SG'= $Diameter_{base.arm2} = \begin{pmatrix} 12.00 \\ 15.00 \end{pmatrix} \cdot in$

'UF'= $\alpha = 90 \cdot deg$ (Angle Between Arms)

'SB'= 'SF'= $Diameter_{tip.arm2} = \begin{pmatrix} 7.03 \\ 11.15 \end{pmatrix} \cdot in$ $CheckTipDia_{arm2}$ = "OK"

'SD'= 'SH'= $t_{wall.arm2} = \begin{pmatrix} 0.250 \\ 0.375 \end{pmatrix} \cdot in$

Luminaire Arm and Connection *(use MC10x33.6 channel for connection)*

$$\begin{pmatrix} CFI_{base.lumarm} \\ CSR_{bolt.lum} \\ D/C_{baseplate.lum} \\ D/C_{conn.plate.lum} \end{pmatrix} = \begin{pmatrix} 0.00 \\ 0.00 \\ 0.00 \\ 0.00 \end{pmatrix}$$

'LA'= $Y_{luminaire} = 0\ ft$

'LB'= $X_{luminaire} = 0\ ft$

'LC'= $Diameter_{base.lumarm} = 0 \cdot in$

'LD'= $t_{wall.lumarm} = 0 \cdot in$

'LE'= $Slope_{lumarm} = 0$

'LF'= $r_{lumarm} = 0\ ft$

'LG'= $d_{bolt.lum} = 0 \cdot in$

'LH'= $t_{baseplate.lum} = 0 \cdot in$

'LJ'= $w_{base.lum} = 0 \cdot in$

'LK'= $w_{channel.lum} = 0 \cdot in$

Upright

$\max(CFI_{pole}) = 0.38$

$Check_{deflection} = "OK"$

$Check_{slope} = "OK"$

'UA'= $Y_{pole} = 24 \cdot ft$

'UB'= $Y_{arm.conn} = 21 \cdot ft$

'UC'= $Diameter_{tip.pole} = 20.7 \cdot in$

'UD'= $Diameter_{base.pole} = 24 \cdot in$

'UE'= $t_{wall.pole} = 0.5 \cdot in$

'UF'= $\alpha = 90 \cdot deg$

'UG'= $Y_{lum.conn} = 0\ ft$

1st Arm to Upright Connection

$D/C_{ht.conn.plate} = 0.70$

'HT'= $h_{conn.plate} = 30 \cdot in$

$CheckHt_{conn.plate} = "OK"$

$\#Bolts_{conn_0} = 6$

'FO'= $Offset_{conn_0} = 23.0 \cdot in$

$D/C_{width.conn.plate_0} = 0.97$

'FJ'= $b_{conn.plate_0} = 36 \cdot in$

'FP'= $d_{bolt.conn_0} = 1.5 \cdot in$

$CheckWidth_{conn.plate_0} = "OK"$

'FK'= $t_{baseplate.arm_0} = 3 \cdot in$

'FR'= $t_{conn.plate_0} = 2 \cdot in$

$$\begin{pmatrix} D/C_{t.baseplate.arm_0} \\ CFI_{t.vert.plate_0} \\ CSR_{bolt.conn_0} \end{pmatrix} = \begin{pmatrix} 0.83 \\ 0.48 \\ 0.31 \end{pmatrix}$$

'FL'= $t_{vertical.plate_0} = 0.75 \cdot in$

'FS'= $Spacing_{bolts.conn_0} = 12 \cdot in$

'FN'= $w_{vertical.plate_0} = \frac{3}{8} \cdot in$

'FT'= $w_{conn.plate_0} = \frac{3}{8} \cdot in$

2nd Arm to Upright Connection

$D/C_{width.conn.plate_1} = 0.97$

'HT'= $h_{conn.plate} = 30 \cdot in$

$CheckWidth_{conn.plate_1} = "OK"$

$\#Bolts_{conn_1} = 6$

'SO'= $Offset_{conn_1} = 23.0 \cdot in$

$$\begin{pmatrix} D/C_{t.baseplate.arm_1} \\ CFI_{t.vert.plate_1} \\ CSR_{bolt.conn_1} \end{pmatrix} = \begin{pmatrix} 0.83 \\ 0.37 \\ 0.16 \end{pmatrix}$$

'SJ'= $b_{conn.plate_1} = 36 \cdot in$

'SP'= $d_{bolt.conn_1} = 1.5 \cdot in$

'SK'= $t_{baseplate.arm_1} = 3 \cdot in$

'SR'= $t_{conn.plate_1} = 2 \cdot in$

'SL'= $t_{vertical.plate_1} = 0.75 \cdot in$

'SS'= $Spacing_{bolts.conn_1} = 12 \cdot in$

'SN'= $w_{vertical.plate_1} = \frac{1}{4} \cdot in$

'ST'= $w_{conn.plate_1} = \frac{1}{4} \cdot in$

Pole Base Plate

$CSR_{anchor} = 0.27$

$CheckCSR_{anchorbolt} = \text{"OK"}$

'#Bolts'= $\#AnchorBolts = 8$

$Diameter_{boltcircle.pole} = 32 \cdot in$

'BA'= $Diameter_{baseplate.pole} = 40 \cdot in$

'BB'= $t_{baseplate.pole} = 2.5 \cdot in$

'BC'= $d_{anchorbolt} = 2.00 \cdot in$

'BF'= $L_{embedment.anchor} = 40 \cdot in$

$L_{anchor.bolt} = 58 \cdot in$

Foundation

$D/C_{torsion.max} = 0.51$

$CheckD/C_{shear.and.torsion} = \text{"OK"}$

$CheckReinfClearSpacing = \text{"OK"}$

$CheckLongReinf_{shr.tor} = \text{"OK"}$

$CheckMaxSpacingTransvReinf = \text{"OK"}$

$OverlapDesign = \text{"Based on Overlap of Failure Cones"}$

$OverlapTest = \text{"Overlap of Failure Cones"}$

$BreakoutTest = \text{"OK"}$

$Clearance_{csl.to.nut} = 3.5 \cdot in$

$Offset = 0.5\,ft$

$d_{long.bar} = 1.41 \cdot in$

$Dia_{bar.circle} = 45.3 \cdot in$

'DA'= $L_{shaft} = 15.5 \cdot ft$

'DB'= $Diameter_{shaft} = 5 \cdot ft$

'RA'= $round\left(\frac{d_{long.bar}}{0.125\,in}\right) = 11$

'RB'= $\#LongBars_{prov} = 18$

'RC'= $\#Spaces_{vbar_1} = 10$

'RD'= $s_{v_1} = 8 \cdot in$

'RE'= $\#Spaces_{vbar_2} = 0$

'RF'= $s_{v_2} = 0 \cdot in$

Fatigue

$Check_{galloping.arm1} = \text{"OK"}$

$Check_{galloping.arm2} = \text{"OK"}$

$Check_{galloping.pole} = \text{"OK"}$

$Check_{nwg.arm1} = \text{"OK"}$

$Check_{nwg.arm2} = \text{"OK"}$

$Check_{nwg.pole} = \text{"OK"}$

$Check_{g.conn.bolt} = \begin{pmatrix} \text{"OK"} \\ \text{"OK"} \end{pmatrix}$

$Check_{nwg.conn.bolt} = \begin{pmatrix} \text{"OK"} \\ \text{"OK"} \end{pmatrix}$

$Check_{g.anchor} = \text{"OK"}$

$Check_{nwg.anchor} = \text{"OK"}$

K1 values within 2% of LTS thresholds may use next higher CAFT values

$$CheckK1Values = \begin{pmatrix} \text{"K1 is w/i 2\% of 4.0 K1 threshold (CAFT = 7.0 ksi)"} \\ \text{"K1 is outside of 2\% of K1 thresholds"} \\ \text{"K1 is outside of 2\% of K1 thresholds"} \end{pmatrix} \quad \begin{pmatrix} K_{I.arm1} \\ K_{I.arm2} \\ K_{I.pole} \end{pmatrix} = \begin{pmatrix} 4.002 \\ 3.836 \\ 8.768 \end{pmatrix} \quad \begin{pmatrix} \text{"Arm 1 Base Weld"} \\ \text{"Arm 2 Base Weld"} \\ \text{"Upright Base Weld"} \end{pmatrix}$$

WRITE to Special Mast Arm Assembly Data Tables

Mast Arm Tip Deflection

Compare Mast Arm deflection of each arm to a proposed camber

$Camber_{arm1} := 2 \cdot deg$ $Camber_{arm2} := 2 \cdot deg$

$Deflection_{arm1} := Slope_x \cdot L_{total.arm1} + \max(\Delta_{arm1}) = 27.1 \cdot in$

$CamberArm1_{upward} := \sin(Camber_{arm1}) \cdot L_{total.arm1} = 32.7 \cdot in$

$Deflection_{arm2} := \left[Slope_z \cdot L_{total.arm2} \cdot (\sin(\alpha))\right] + Slope_x \cdot L_{total.arm2} \cdot \cos(\alpha) + \max(\Delta_{arm2}) = 14.1 \cdot in$

$CamberArm2_{upward} := \sin(Camber_{arm2}) \cdot L_{total.arm2} = 25.1 \cdot in$

Check Clearance Between Connection Plates *(for Two Arm Structures only)*

$\alpha = 90 \cdot deg$ $\alpha := if[(\alpha > 180 \cdot deg), (360 \cdot deg - \alpha), \alpha]$

$Offset_{conn_0} = 23 \cdot in$ $b_{conn.plate_0} = 36 \cdot in$ $h_{conn.plate} = 30 \cdot in$ $\alpha = 90 \cdot deg$

$Offset_{conn_1} = 23 \cdot in$ $b_{conn.plate_1} = 36 \cdot in$

$x1 := Offset_{conn_0} - t_{conn.plate_0} - h_{conn.plate} \cdot \frac{\sin(Camber_{arm1})}{2} = 20.5 \cdot in$ $y1 := \frac{b_{conn.plate_0}}{2} = 18 \cdot in$

$x2 := \left(Offset_{conn_1} - t_{conn.plate_1} - h_{conn.plate} \cdot \frac{\sin(Camber_{arm2})}{2}\right) \cdot \cos(\alpha) + \frac{b_{conn.plate_1}}{2} \cdot \sin(\alpha) = 18 \cdot in$

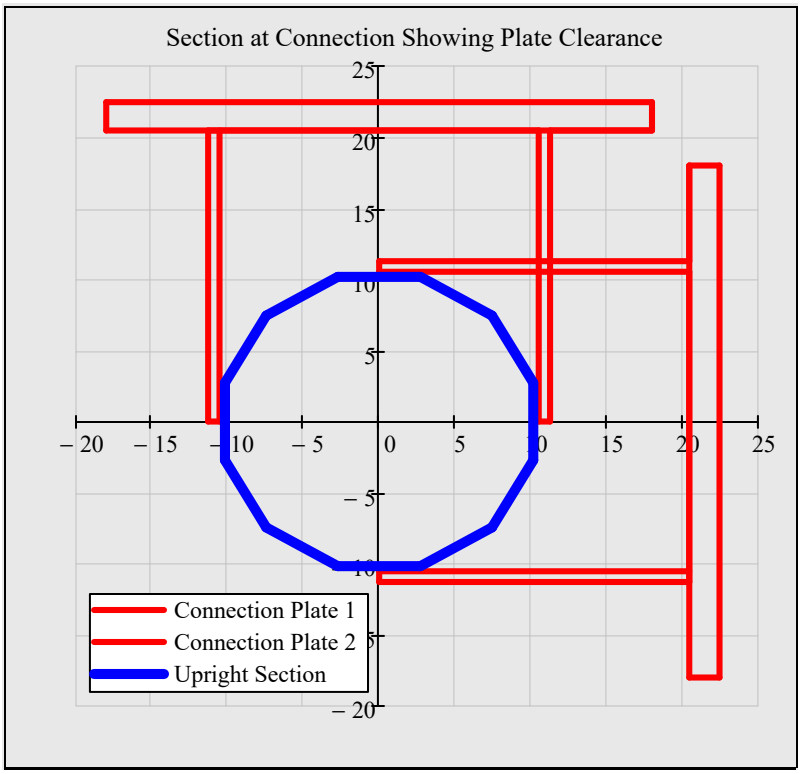
$y2 := \left(Offset_{conn_1} - t_{conn.plate_1} - h_{conn.plate} \cdot \frac{\sin(Camber_{arm2})}{2}\right) \cdot \sin(\alpha) - \frac{b_{conn.plate_1}}{2} \cdot \cos(\alpha) = 20.5 \cdot in$

$Clearance_{plate.to.plate} := if\left[(x1 > x2) \cdot (y2 > y1), \sqrt{(x1 - x2)^2 + (y1 - y2)^2}, 0 \cdot in\right] = 3.5 \cdot in$

(if Clearance < 2 inches, a redesign is required.

Coordinates for Drawings

Plan View - Connection Plate Clearance for Two Arm Connections



$Clearance_{plate.to.plate} = 3.5 \cdot in$

$Diameter_{conn.pole} = 21.1 \cdot in$

'FR'= $t_{conn.plate_0} = 2 \cdot in$

'FJ'= $b_{conn.plate_0} = 36 \cdot in$

'FL'= $t_{vertical.plate_0} = 0.75 \cdot in$

'FO'= $Offset_{conn_0} = 23.0 \cdot in$

$Gap_0 = 12.44 \cdot in$

'SR'= $t_{conn.plate_1} = 2 \cdot in$

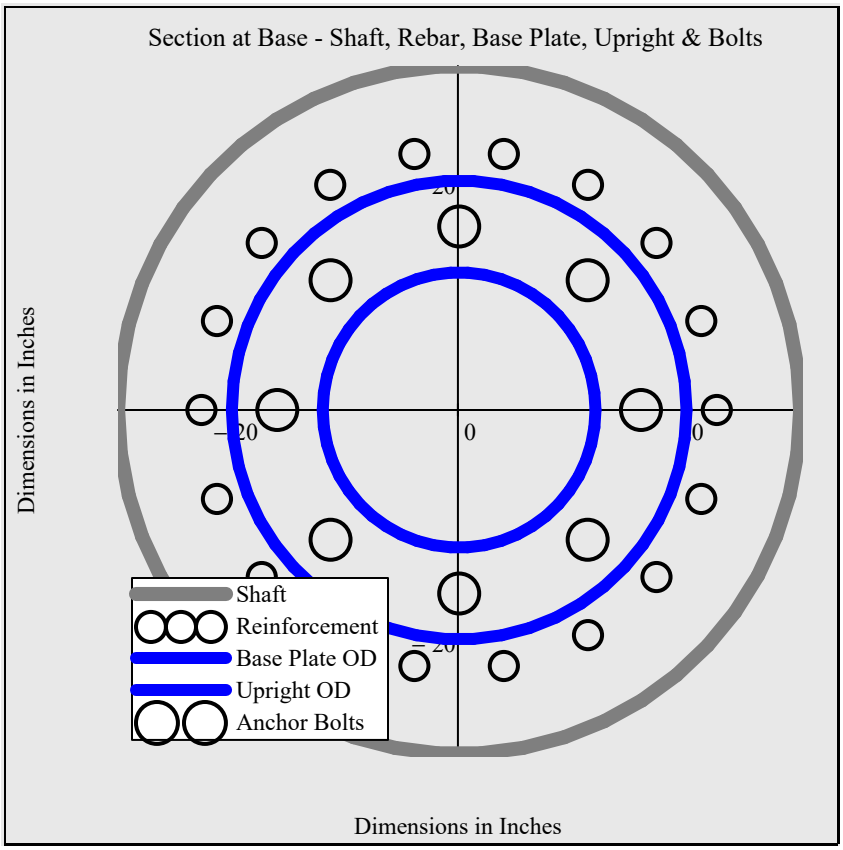
'SJ'= $b_{conn.plate_1} = 36 \cdot in$

'SL'= $t_{vertical.plate_1} = 0.75 \cdot in$

'SO'= $Offset_{conn_1} = 23.0 \cdot in$

$Gap_1 = 12.44 \cdot in$

Plan View - Drilled Shaft, Base Plate, Upright, Anchor Bolts, & Reinforcing Steel



$Clearance_{bar.to.nut} = 4.1 \cdot in$

'UD'= $Diameter_{base.pole} = 24 \cdot in$

'BA'= $Diameter_{baseplate.pole} = 40 \cdot in$

'DB'= $Diameter_{shaft} = 60 \cdot in$

$Diameter_{boltcircle.pole} = 32 \cdot in$

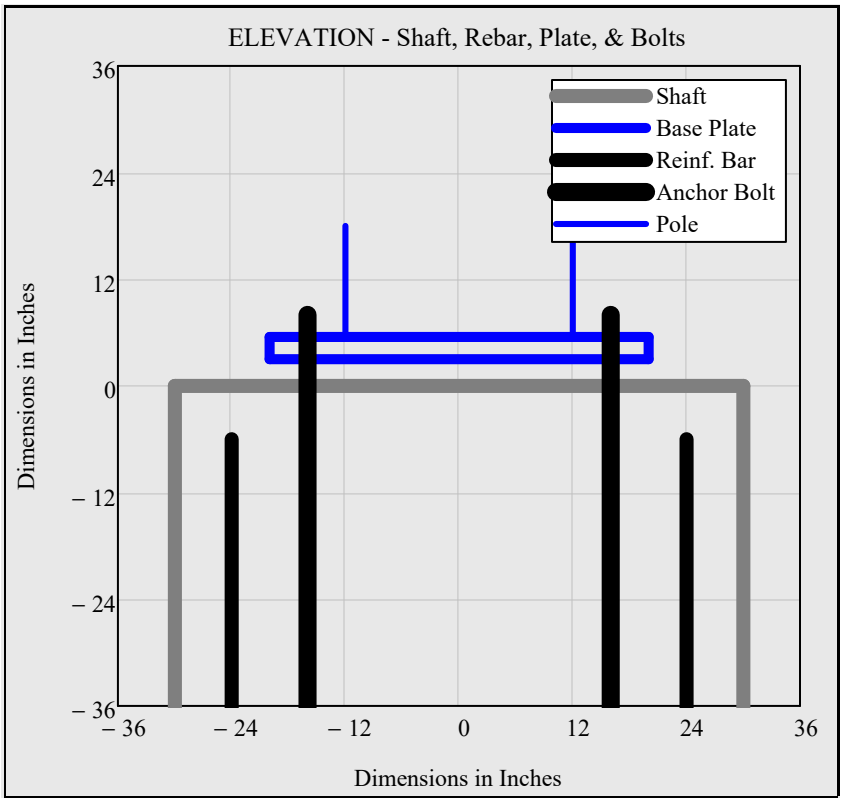
$Dia_{bar.circle} = 45.3 \cdot in$

$\#AnchorBolts = 8$

$\#LongBars_{prov} = 18$

Note: The Plan and Elevation Views do not show the 4 or 5 1.9" O.D. Nondestructive Integrity Testing Access Tubes that are tied to the inside of the reinforcing cage (see FDOT Spec 455-16.4).

Elevation View - Drilled Shaft, Base Plate, Anchor Bolts, & Reinforcing Steel



$Clearance_{bar.to.nut} = 4.1 \cdot in$

'UD'= $Diameter_{base.pole} = 24 \cdot in$

'BA'= $Diameter_{baseplate.pole} = 40 \cdot in$

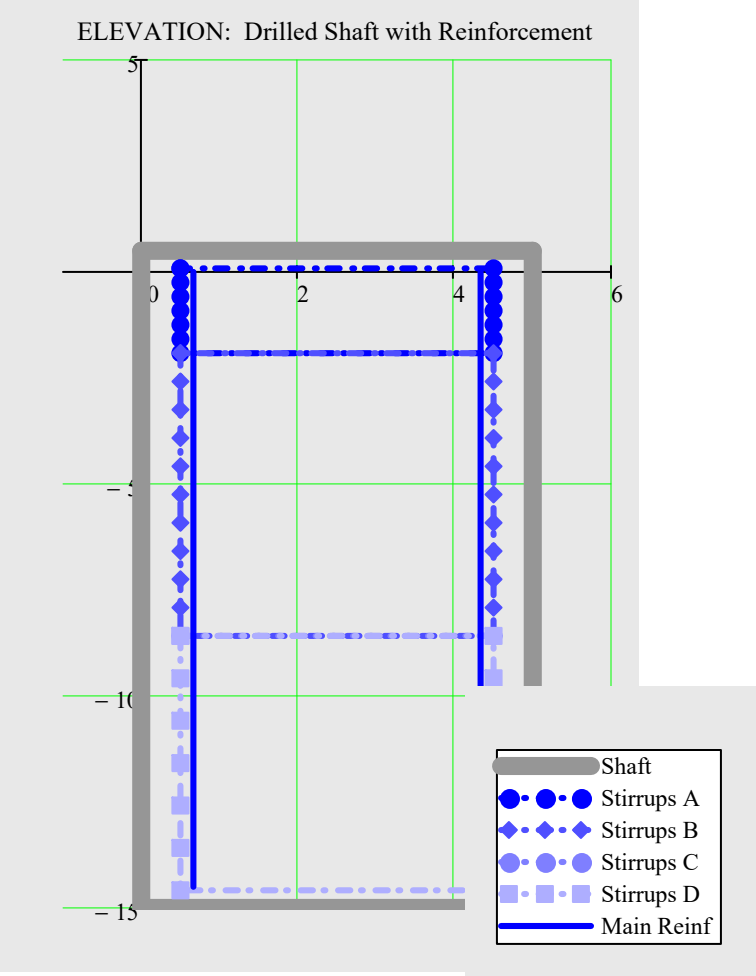
'BB'= $t_{baseplate.pole} = 2.5 \cdot in$

'DB'= $Diameter_{shaft} = 60 \cdot in$

$Diameter_{boltcircle.pole} = 32 \cdot in$

$Dia_{bar.circle} = 45.3 \cdot in$

Elevation View - Drilled Shaft with Main Reinforcement and Stirrups



$$s_v = \begin{pmatrix} 4 \\ 8 \\ 0 \\ 12 \end{pmatrix} \cdot in$$ *stirrup spacing*

$$\#Spaces_{vbar} = \begin{pmatrix} 6 \\ 10 \\ 0 \\ 6 \end{pmatrix}$$ *number of stirrup spaces*