Erie Rd. and SR 62 Improvements

HDR Project No. 10151274

Miscellaneous Structures

Structural Design Notebook

For Manatee County Public Works

Book 1 of 1

Erie Rd. and SR 62 Improvements

CLIENT: Manatee County Public Works
HDR Project Number: 10151274

Miscellaneous Structures

CHESTER A. SMITH III
LICENSE
No 70756
STATE OF
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PROFESSIONAL ENGINEER

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Chester A Smith III 2021.10.26 10:23:25-04'00'

ON THE DATE ADJACENT TO THE SEAL

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Calculation Cover Sheets

Client:	Manatee County Public Works		
Project:	**Erie Rd. and SR 62 Improvements**		
Project No:	850-6094060	Rev:	
Calculation No:		Page:	of
Title:	Mast Arm Signals Design		
Purpose:	This document presents the design of 3 Mast Arm signal poles at the intersection of SR 62 and Erie Rd.		
Originator:	Rohit Tallur	Date:	6/2/2021
Checked by:	csmith	Date:	06/11/2021
QC Review by:		Date:	
Approved by:		Date:	

Supersedes Calculation No:

Superseded by Calculation No:

Erie Rd. and SR 62 Improvements

HDR Project Number: 10151274

Miscellaneous Structures

1.1 Standard Plans Information

For: Manatee County Public Works

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	0.250				22	25	3
A30/S/H		30	12	0.250						
A30/D		30	11	0.250				30	36	
A30/D/H		30	12	0.250						
A40/S	40	40	13	0.250				22	27	3
A40/S/H		40	14	0.250						
A40/D		40	13	0.250				30	36	
A40/D/H		40	14	0.250						
A50/S	50	32.5	12	0.250	20.5	14	0.313	22	29	3
A50/S/H		32.5	13	0.250	20.5	15				
A50/D		32.5	12	0.250	20.5	14		30	36	
A50/D/H		32.5	13	0.250	20.5	15				
A60/S	60	35.5	12	0.250	27.5	15	0.375	30	36	3
A60/S/H		35.5	13	0.250	27.5	16				
A60/D		35.5	12	0.250	27.5	15				
A60/D/H		35.5	13	0.250	27.5	16				
A70/S	70	38	13	0.250	35	17	0.375	30	36	3
A70/S/H		38	14	0.250	35	18				
A70/D		38	13	0.250	35	17				
A70/D/H		38	14	0.250	35	18				
A78/S	78	39	13	0.250	42	18	0.375	30	36	3
A78/S/H		39	15	0.250	42	20				
A78/D		39	13	0.250	42	18				
A78/D/H		39	15	0.250	42	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		6	32	2.5	2	40	22	25	0.75	0.438	14	1.25	2	8.5	0.438
P1/S/L	39			37.5														
P1/D	25									30	36			23		2.75	12.5	
P1/D/L	39			37.5														
P2/S	25	18	0.375		6	34	2.5	2	40	22	27	0.75	0.438	15	1.25	2	8.5	0.438
P2/S/L	39			37.5														
P2/D	25									30	36			23		2.75	12.5	
P2/D/L	39			37.5														
P3/S	25	20	0.375		6	36	2.5	2	40	22	29	0.75	0.438	16	1.25	2	8.5	0.438
P3/S/L	39			37.5														
P3/D	25									30	36			23		2.75	12.5	
P3/D/L	39			37.5														
P4/S	25	22	0.375		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			37.5														
P4/D	25													23				
P4/D/L	39			37.5														
P5/S	25	24	0.375		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			37.5														
P5/D	25													23				
P5/D/L	39			37.5														
P6/S	25	24	0.5		8	40	2.5	2	40	30	36	0.75	0.625	18	1.5	2.5	12	0.625
P6/S/L	39			37.5														
P6/D	25													23				
P6/D/L	39			37.5														
P7/S	25	26	0.5		8	42	2.5	2	40	30	36	0.75	0.625	19	1.5	2.5	12	0.625
P7/S/L	39			37.5														
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.

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.

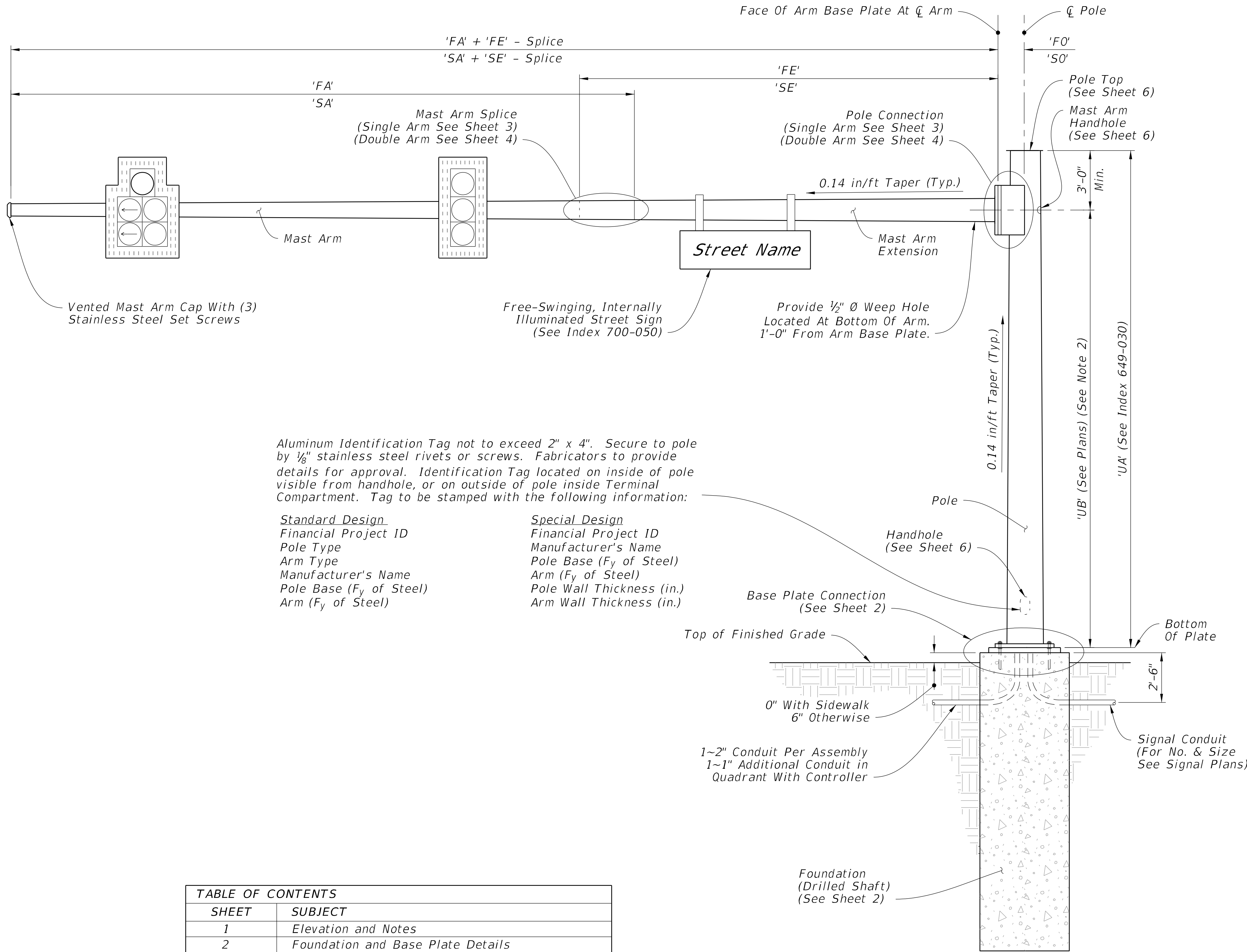
3. Details for Signal and Sign locations, Signal Head attachment, Sign attachment, Pedestrian Head attachment, and Foundation Conduit are not shown for simplicity.

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. Aluminum Pole Caps and Nut Covers: ASTM B26 (319-F)
   - 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.



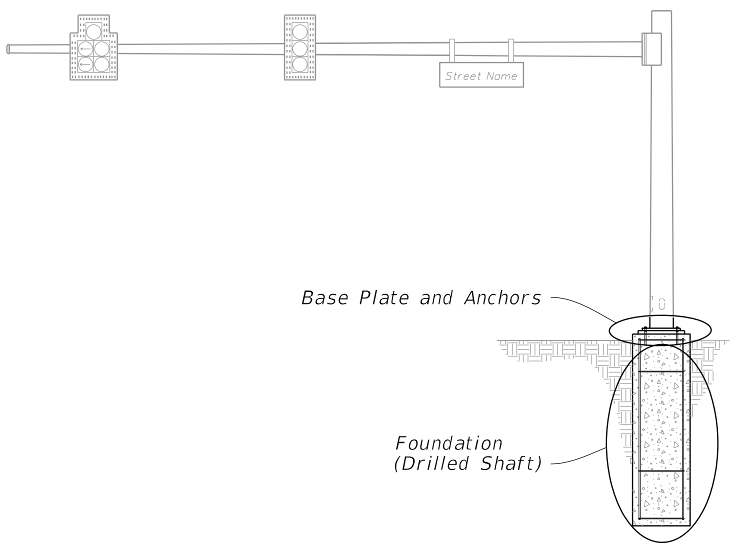
Single Arm Shown, Double Arm Similar
(Luminaire Arm Not Shown)

MAST ARM ASSEMBLY

ELEVATION AND NOTES

10/12/2020 8:22:07 AM

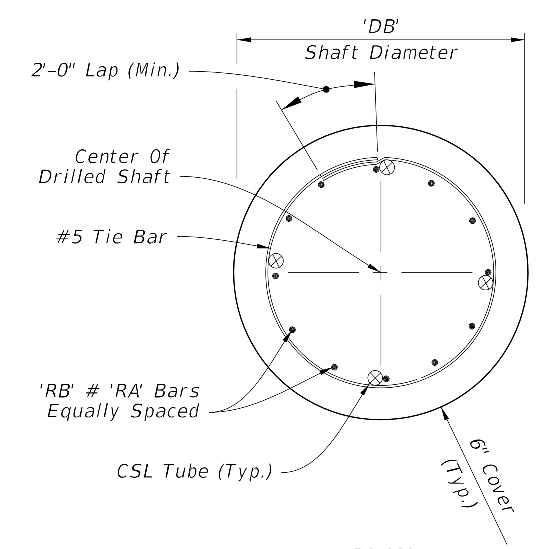
LAST REVISION	REVISION	DESCRIPTION:	FDOT	FY 2021-22 STANDARD PLANS	MAST ARM ASSEMBLIES	INDEX	SHEET
11/01/18						649-031	1 of 6



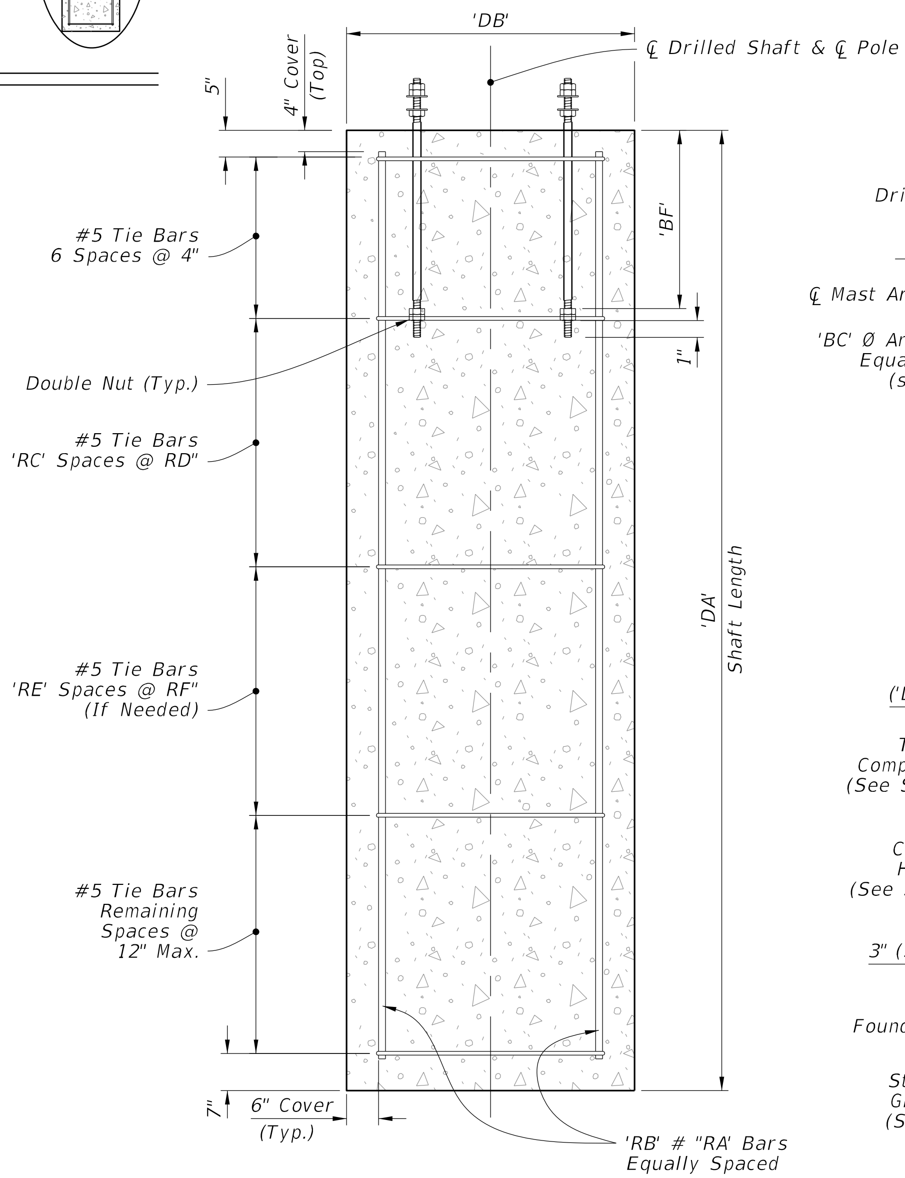
MAST ARM ASSEMBLY

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.

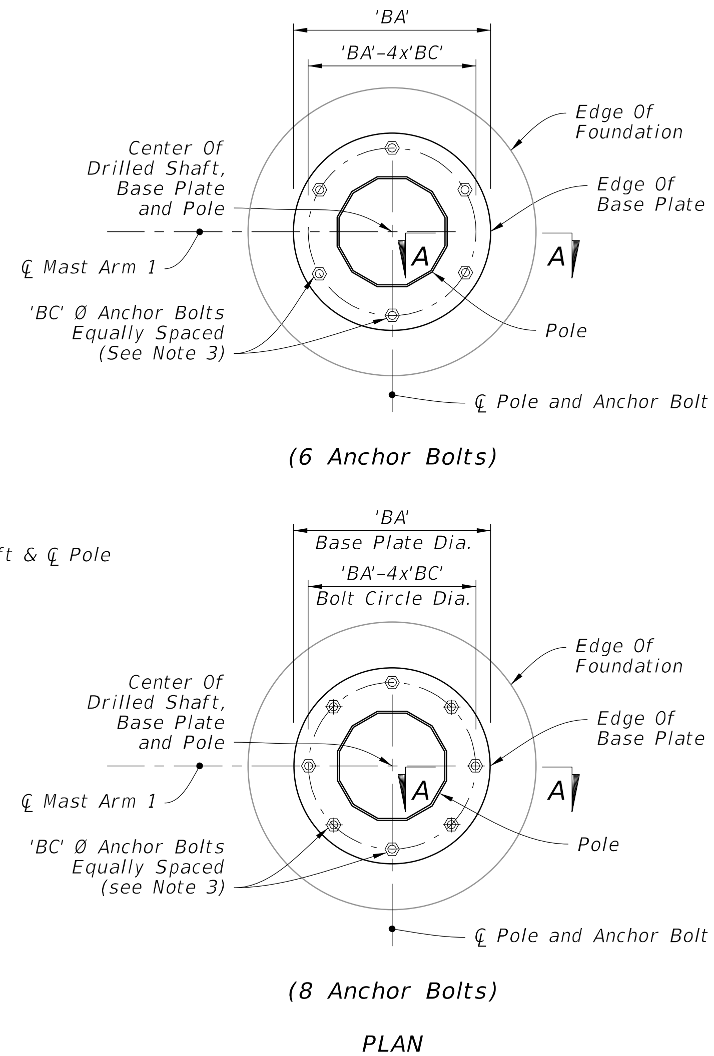


PLAN

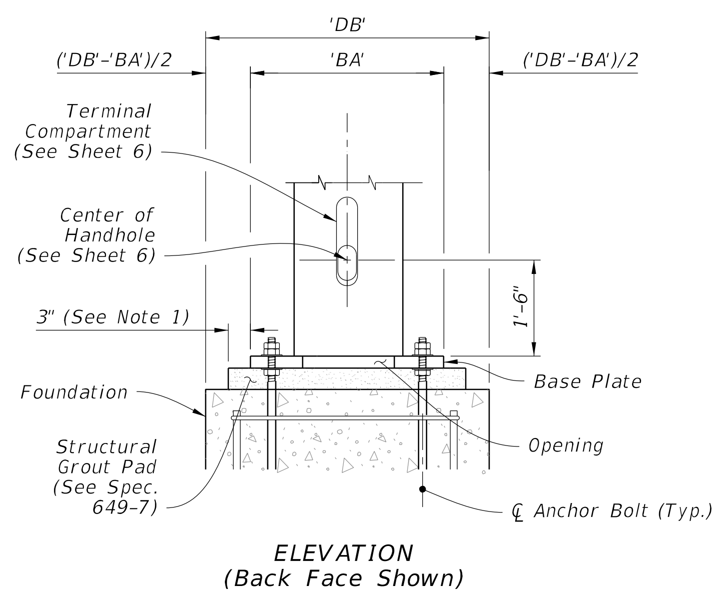


ELEVATION

FOUNDATION

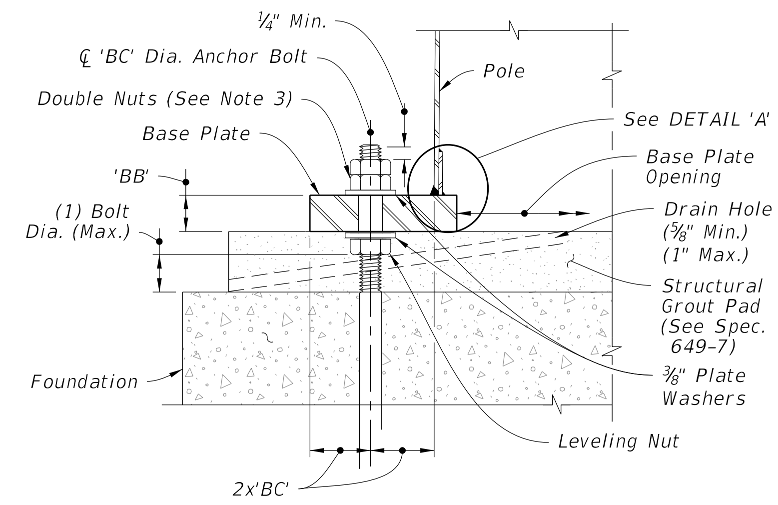


PLAN

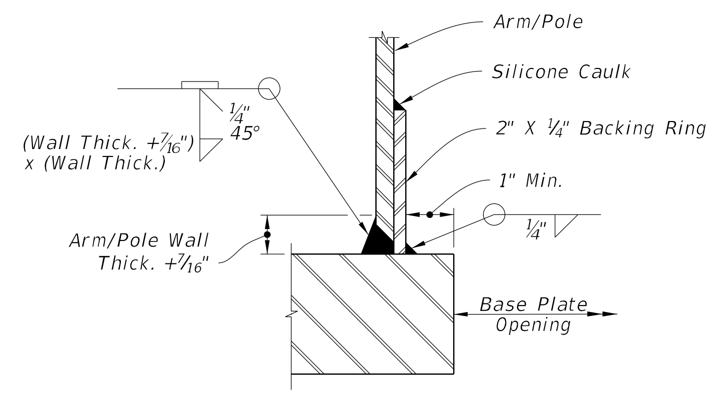


ELEVATION
(Back Face Shown)

BASE PLATE CONNECTION



SECTION A-A



JOINT WELD DETAIL

DETAIL 'A'

FOUNDATION AND BASE PLATE DETAILS

LAST REVISION	REVISION	DESCRIPTION:	FDOT FY 2021-22 STANDARD PLANS	MAST ARM ASSEMBLIES	INDEX	SHEET
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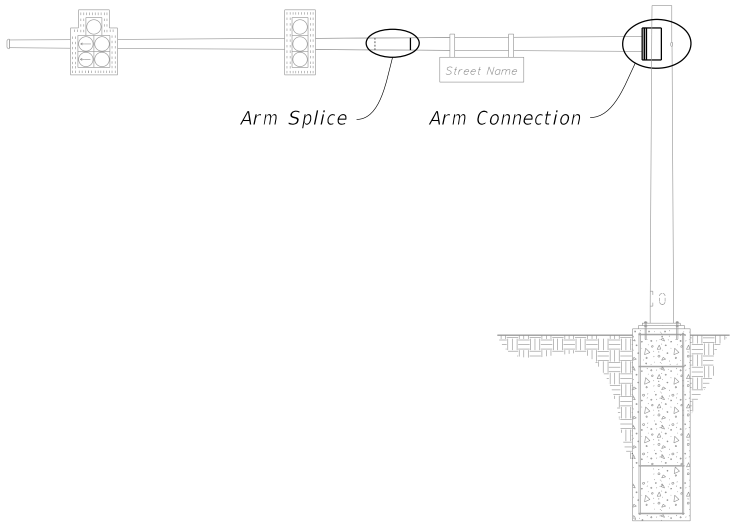
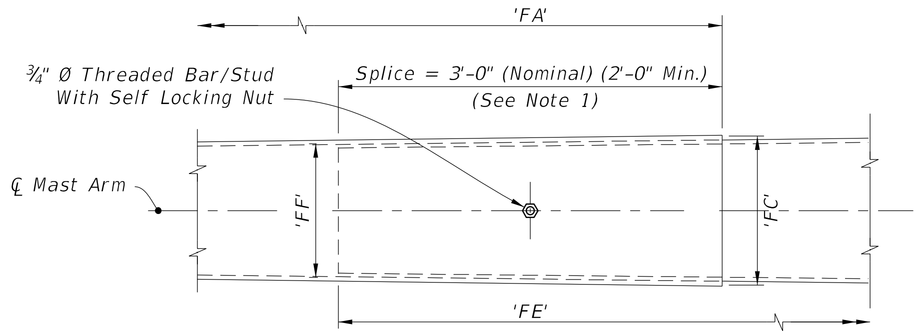
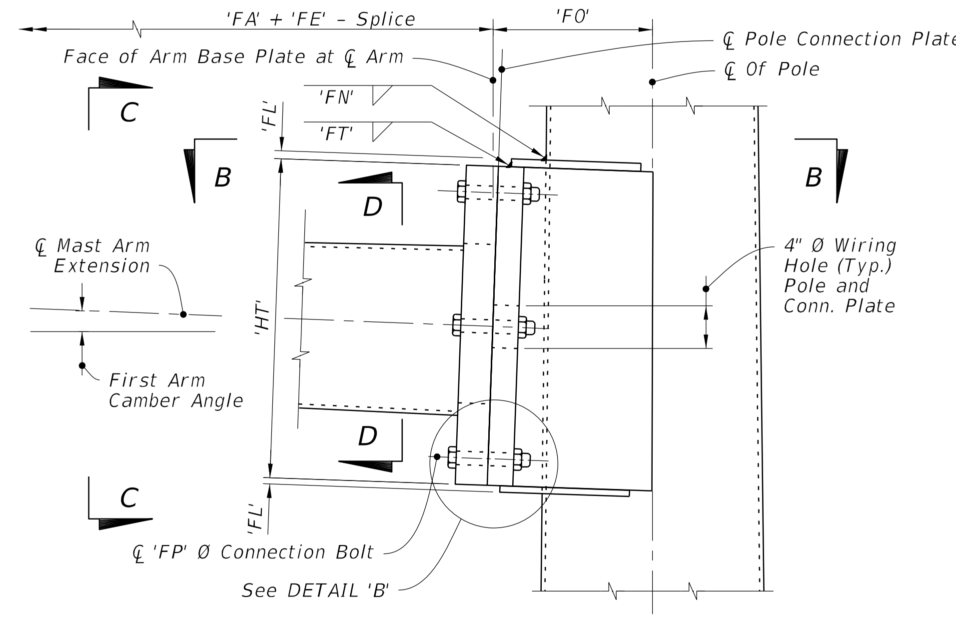


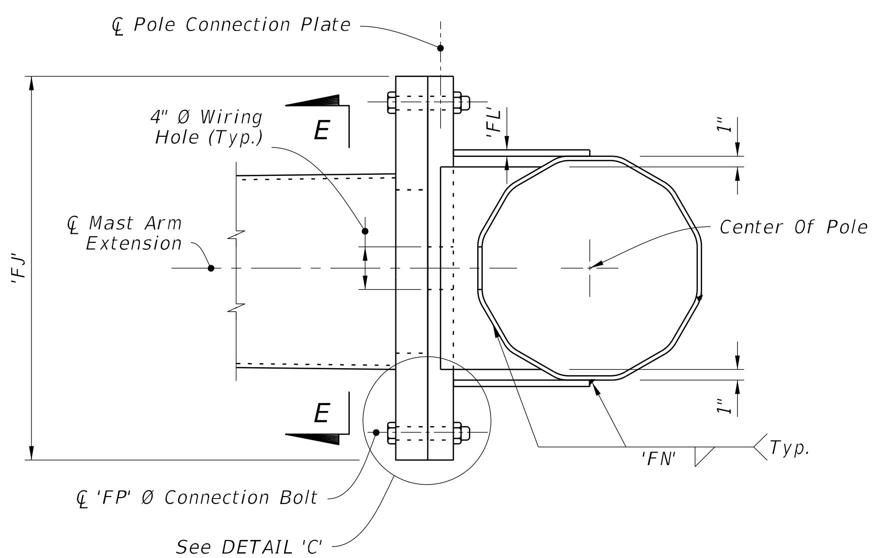
MAST ARM ASSEMBLY



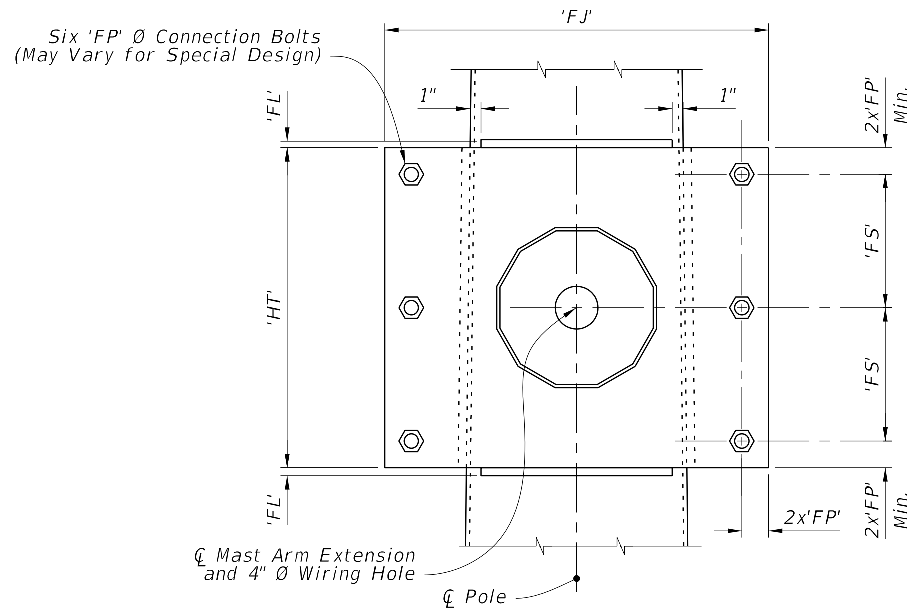
ARM SPLICE



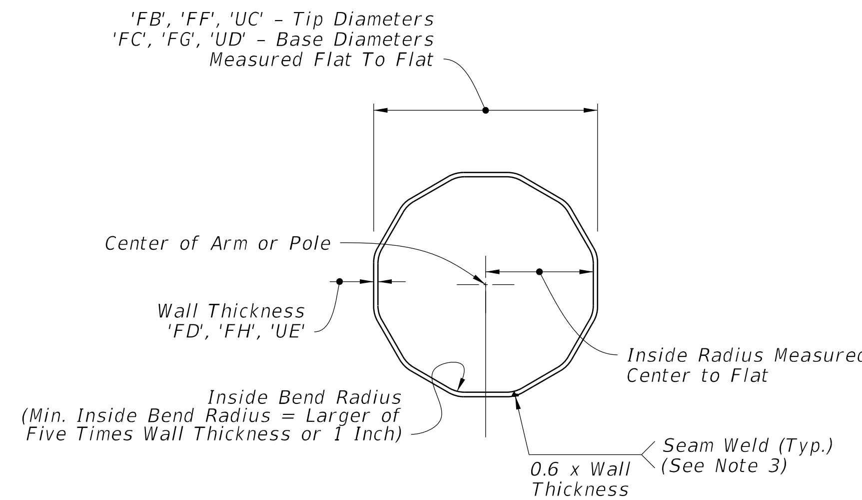
SINGLE ARM CONNECTION



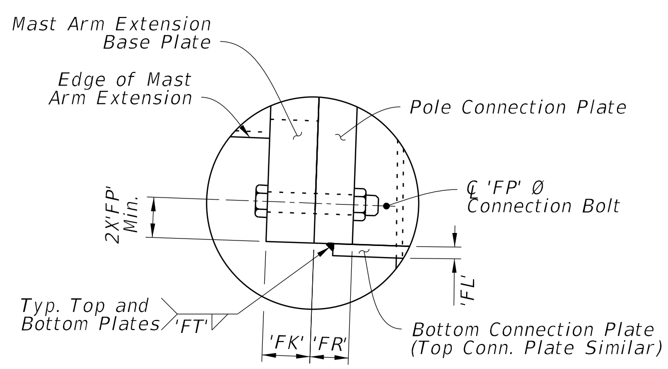
SECTION B-B



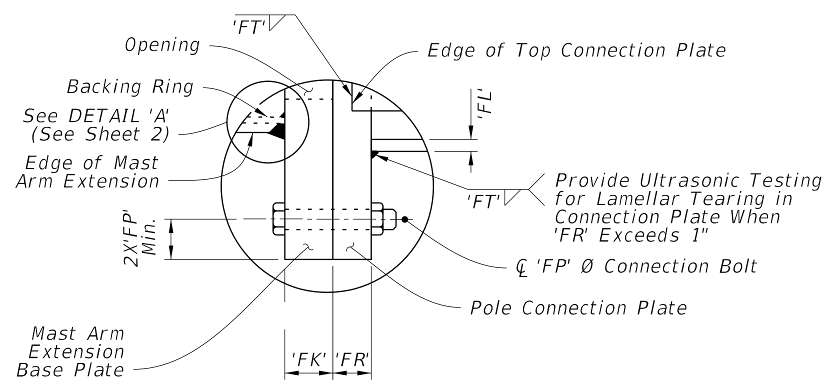
SECTION C-C



SECTION D-D



DETAIL 'B'



DETAIL 'C'

NOTE:

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).

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SINGLE ARM CONNECTIONS & SPLICE DETAILS

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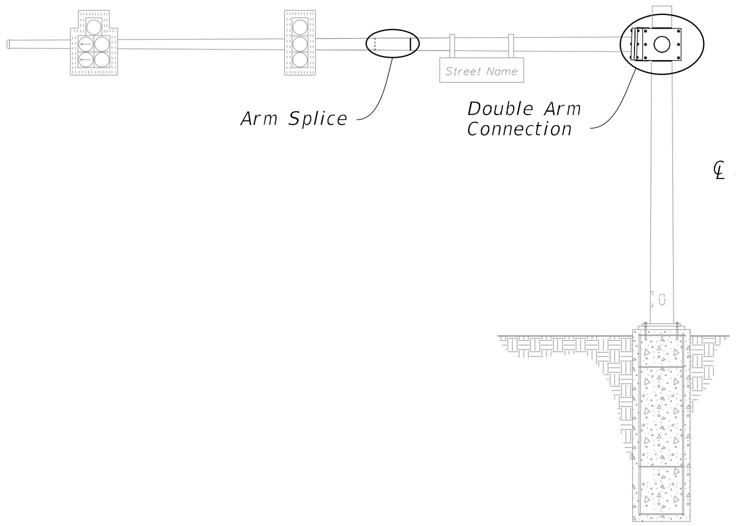
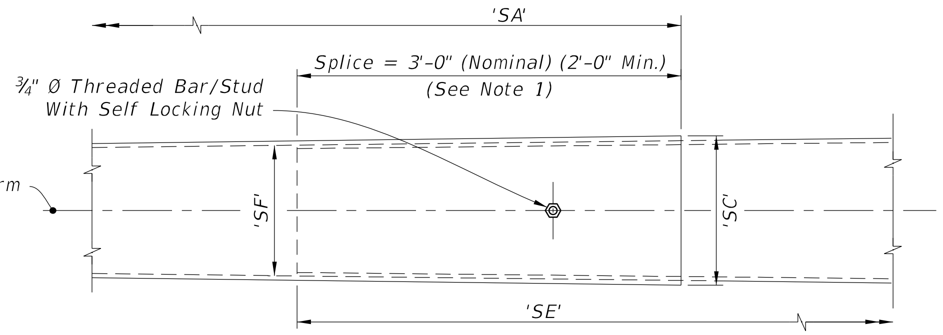
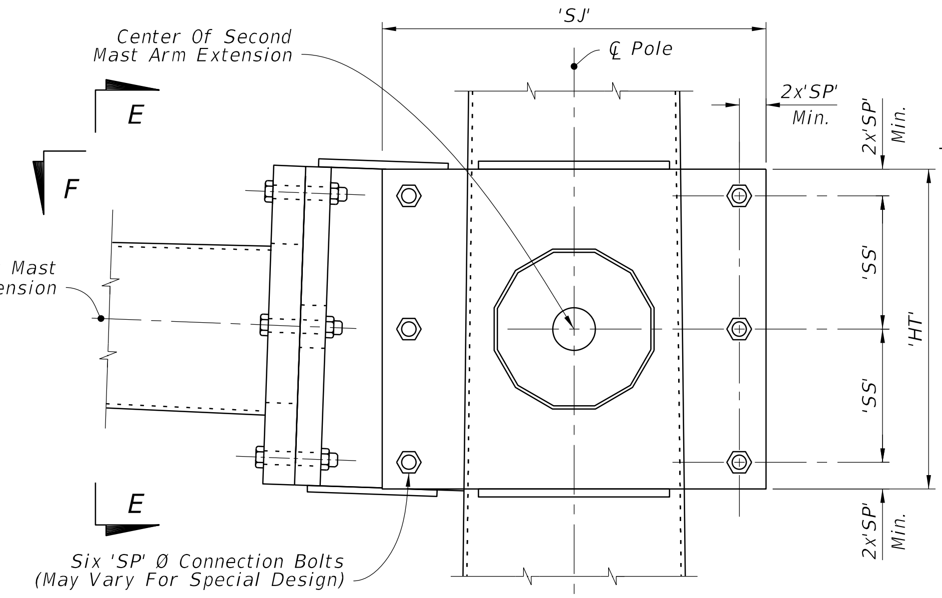
11/01/18						649-031	3 of 6



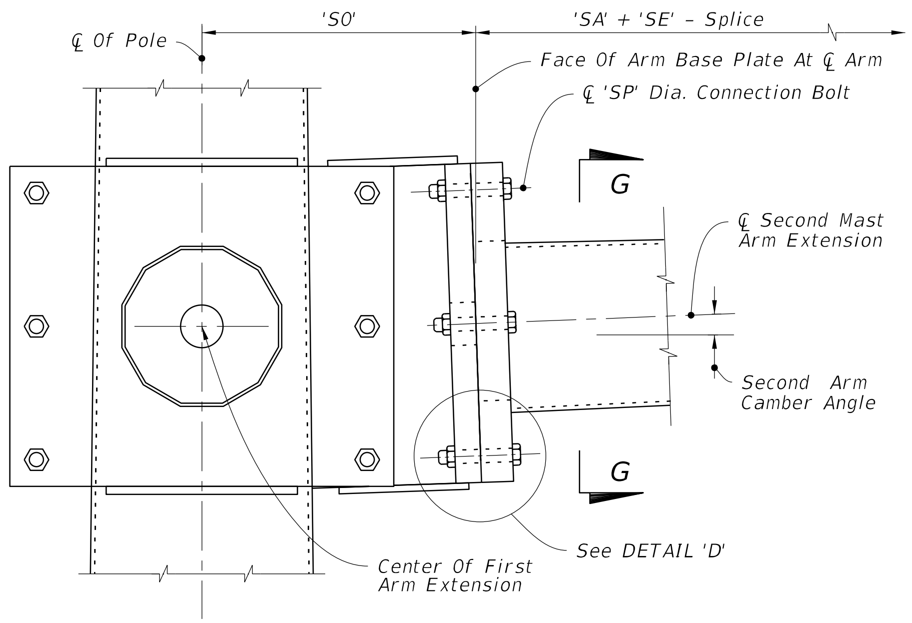
MAST ARM ASSEMBLY



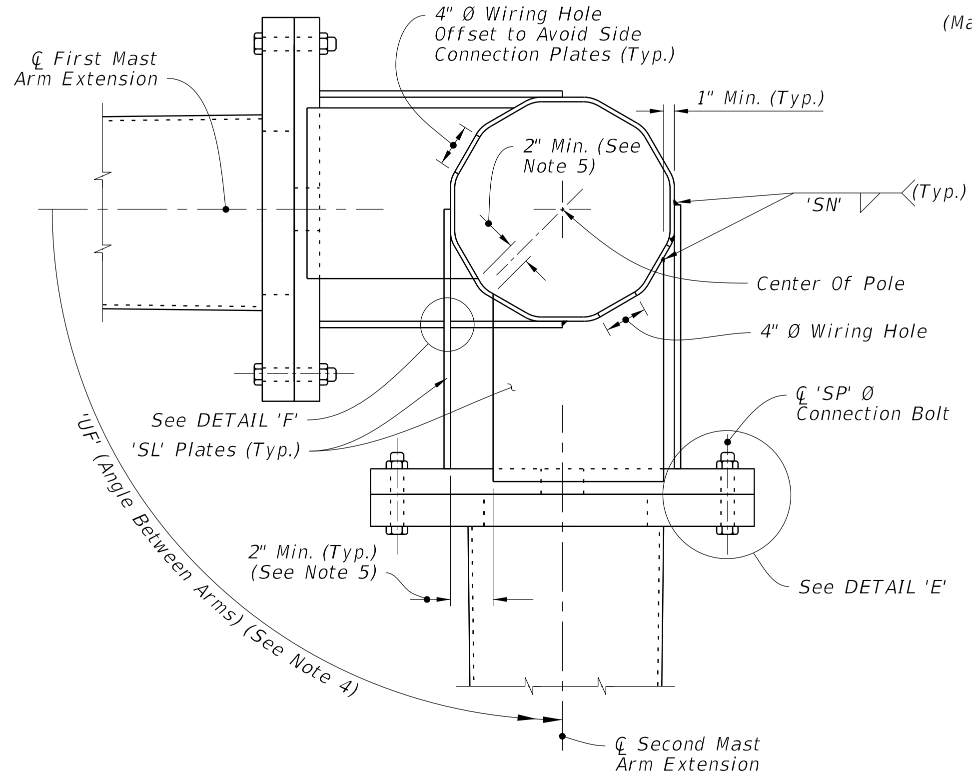
ARM SPLICE



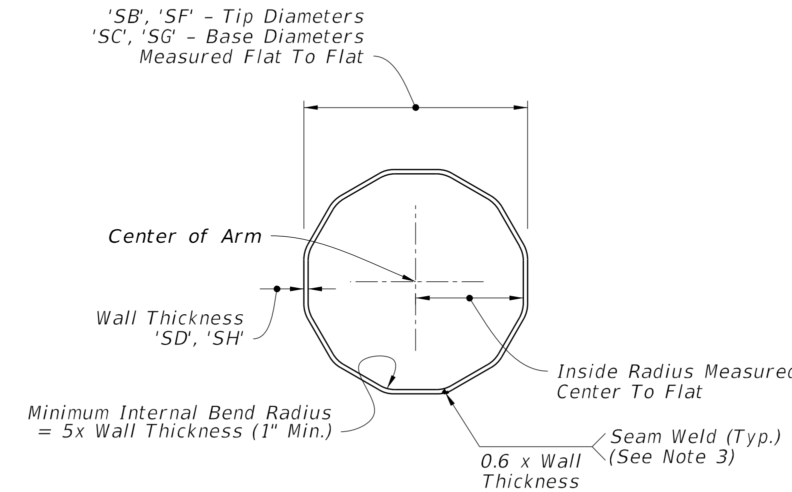
DOUBLE ARM CONNECTION



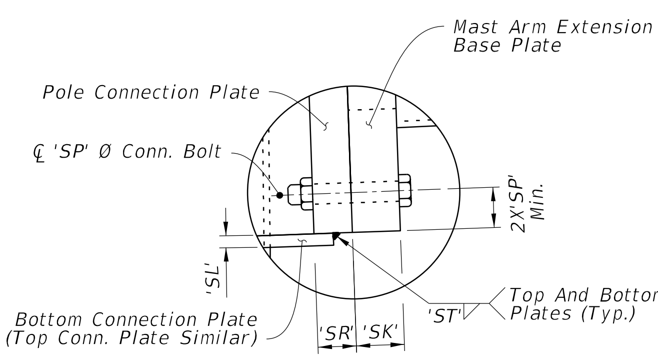
SECTION E-E



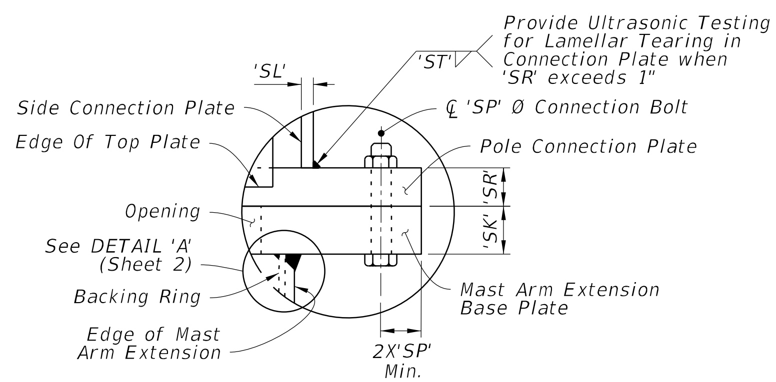
SECTION F-F



SECTION G-G



DETAIL 'D'



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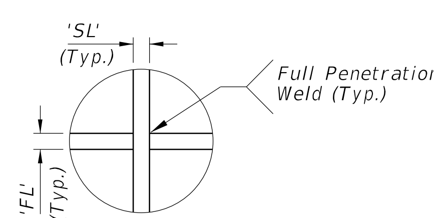
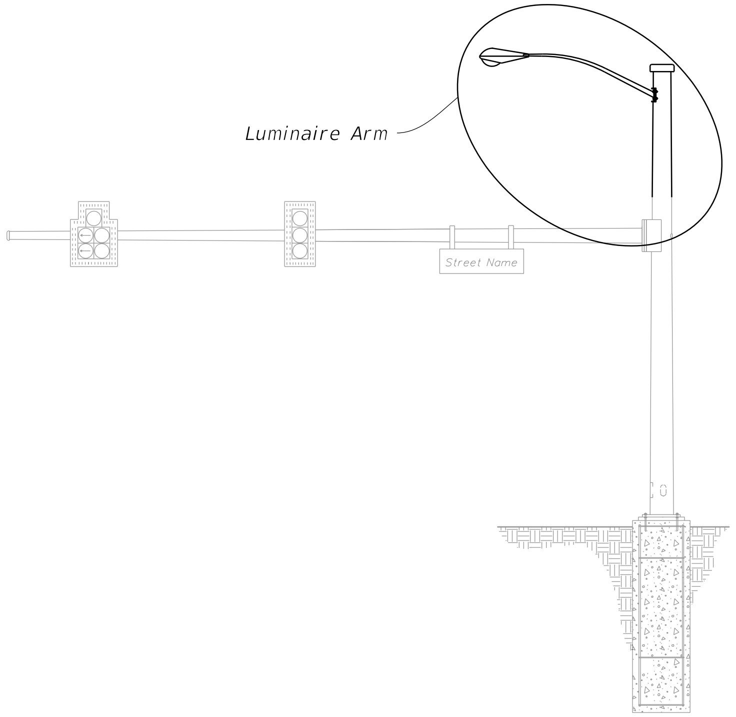


DETAIL 'F'

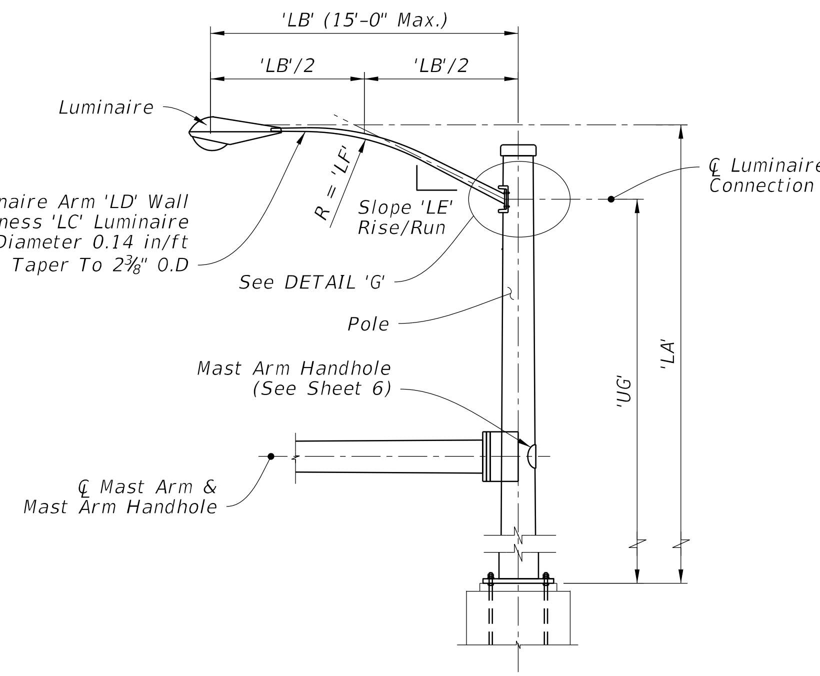
NOTE:

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.

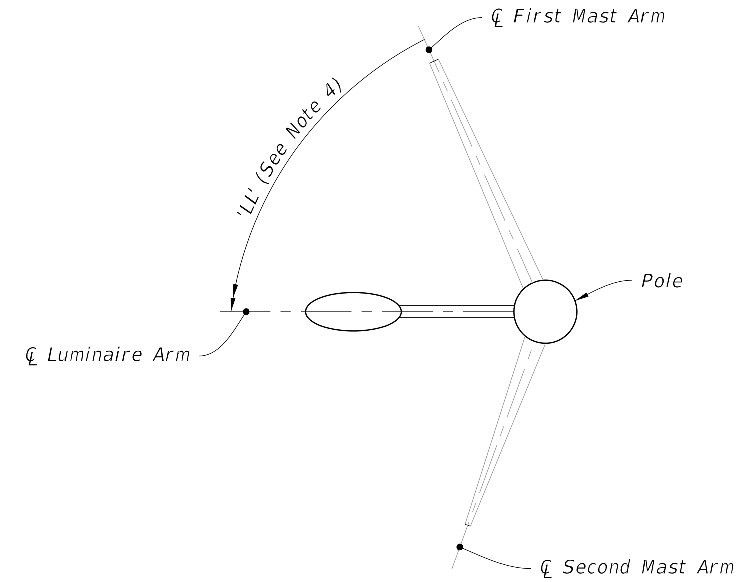
DOUBLE ARM CONNECTIONS & SPLICE DETAILS



MAST ARM ASSEMBLY



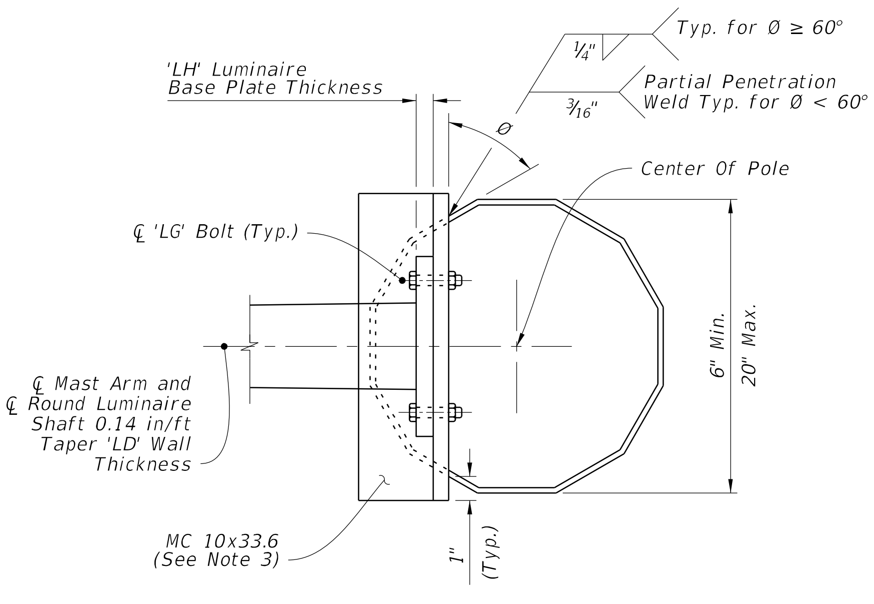
LUMINAIRE ELEVATION



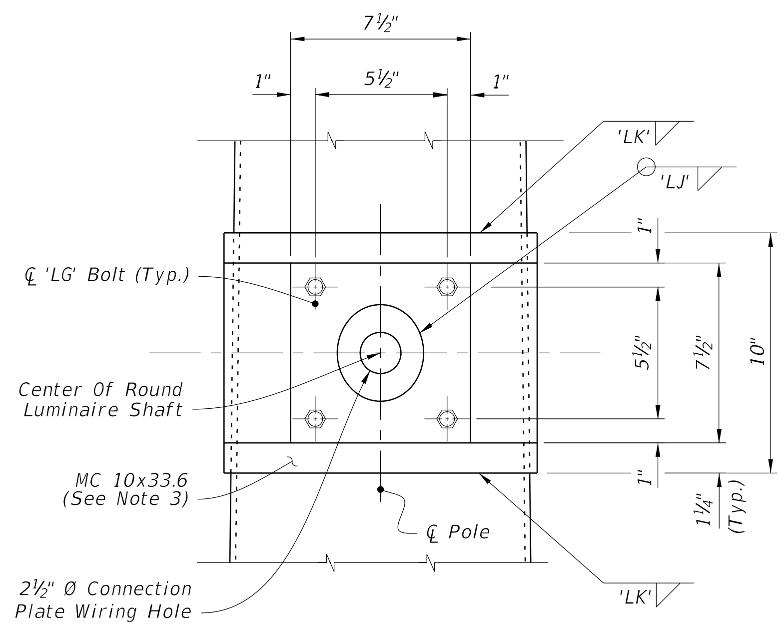
LUMINAIRE ORIENTATION

NOTES:

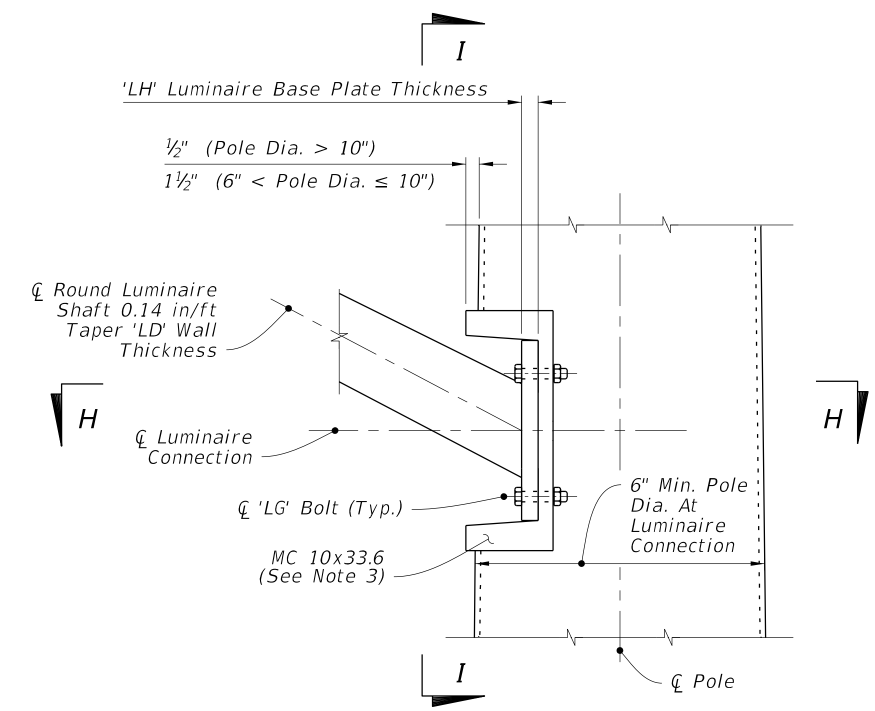
1. Galvanized steel luminaire type and luminaire length may be found in the Lighting Plans.
2. Align Luminaire Arm with Single Mast Arm or First Arm of Double Mast Arm unless indicated otherwise in the plans.
3. The fabricator may substitute a ½" thick bent plate with the same flange width, height, and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



SECTION H-H



SECTION I-I

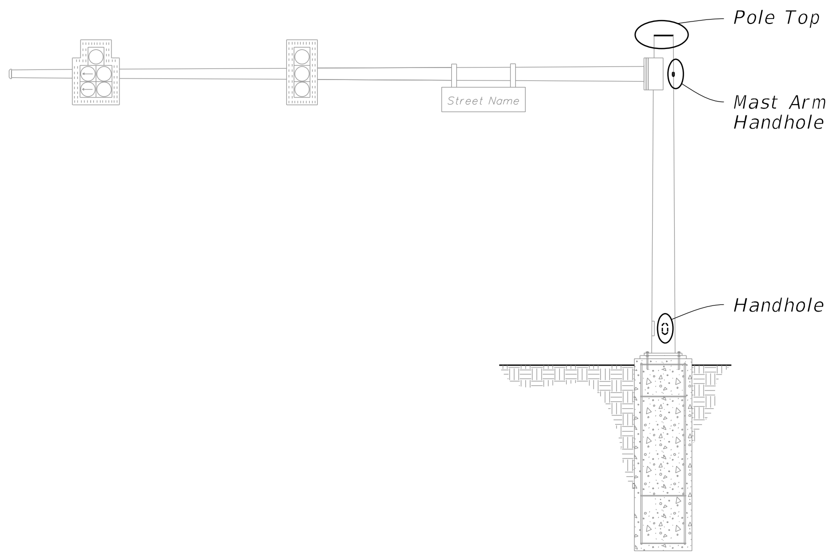


LUMINAIRE CONNECTION ELEVATION

DETAIL 'G'

LUMINAIRE ARM AND CONNECTION DETAILS

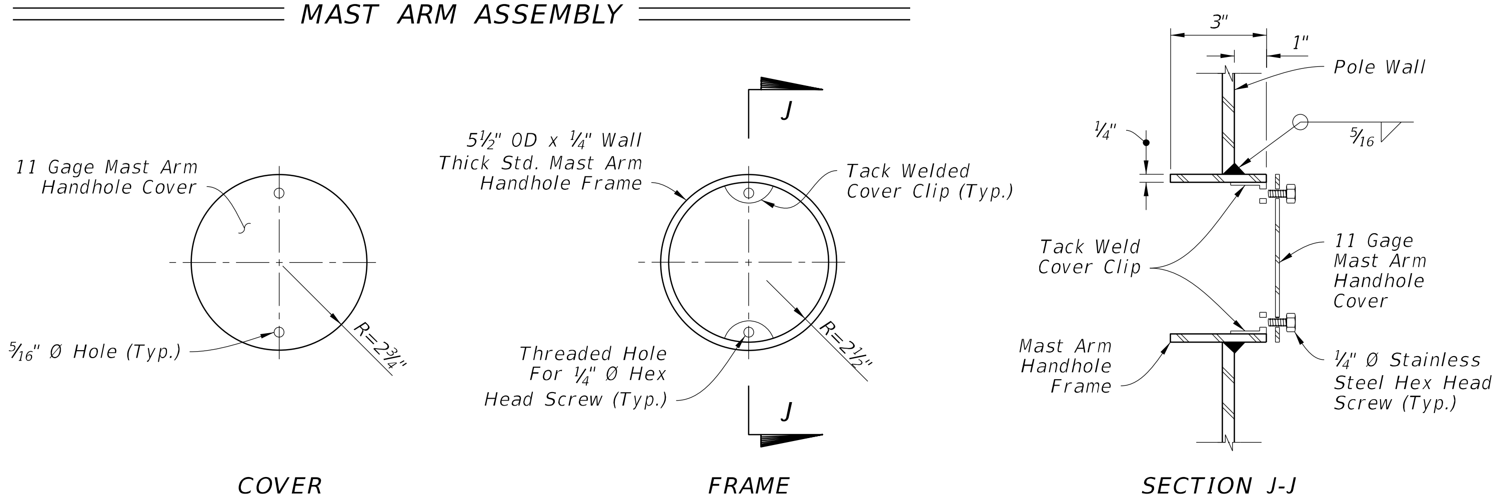
LAST REVISION	REVISION	DESCRIPTION:	FDOT	FY 2021-22 STANDARD PLANS	MAST ARM ASSEMBLIES	INDEX	SHEET
11/01/19						649-031	5 of 6



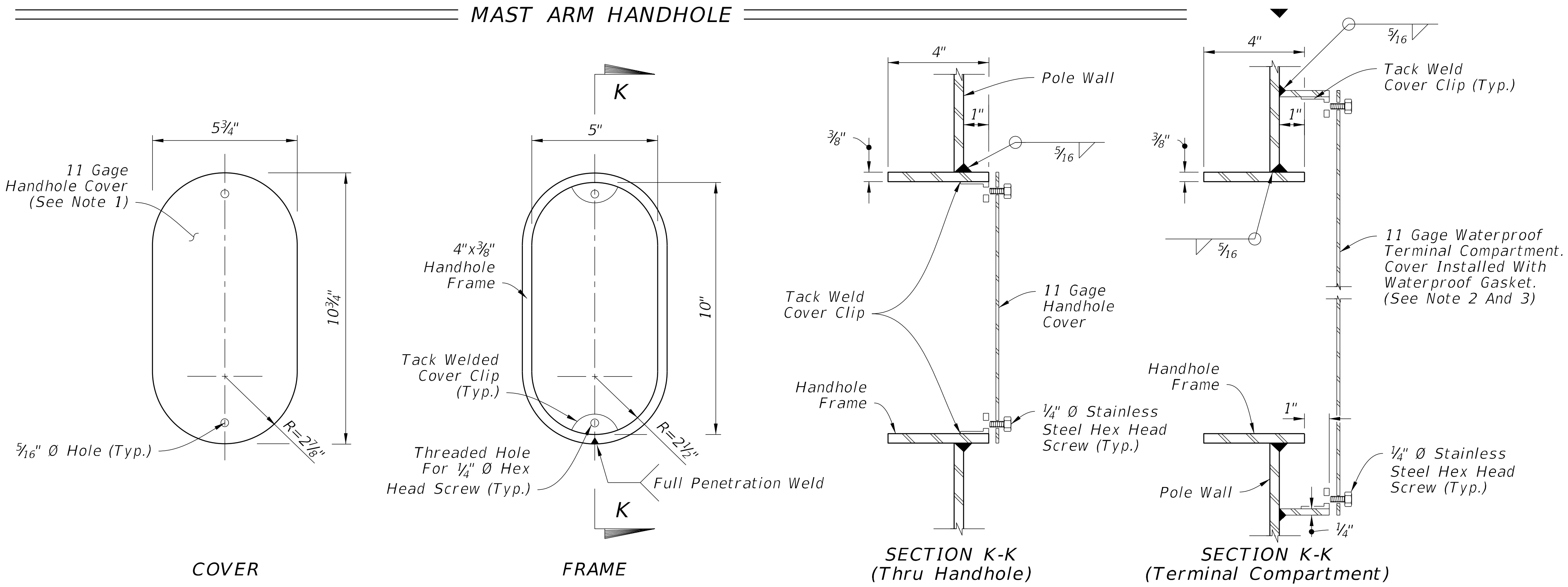
MAST ARM ASSEMBLY

NOTES:

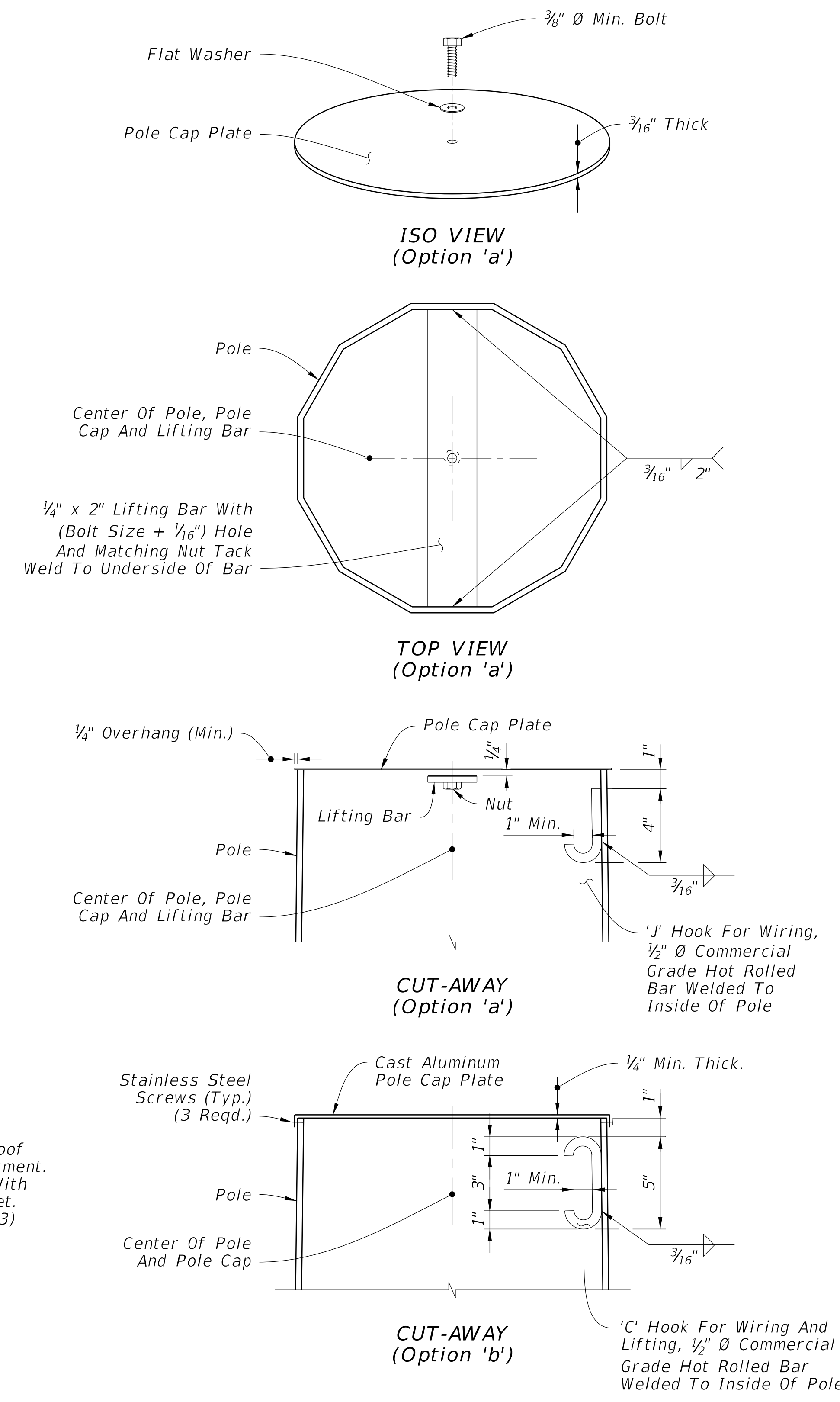
1. Handhole covers may be omitted when Terminal Compartment is provided.
2. See Mast Arm Tabulation sheet to see if Terminal Compartment is required and for locations.
3. Terminal Compartment Frame Height 2'-0" minimum to 2'-6" maximum. Align bottom of Terminal Compartment a minimum of 1" below the bottom of the Handhole Frame.
4. Any combination of Option 'a' or 'b' may be used, provided both lifting and wiring is accommodated.



MAST ARM HANDHOLE



HANDHOLE



POLE TOP

HANDHOLE AND POLE TOP DETAILS

10/12/2020 8:22:28 AM

LAST REVISION	REVISION	DESCRIPTION:	FDOT	FY 2021-22 STANDARD PLANS	MAST ARM ASSEMBLIES	INDEX	SHEET
11/01/20						649-031	6 of 6

Indexes 649-030 and 649-031 Mast Arm Assemblies

Design Criteria

AASHTO LRFD Specifications for Structural Supports for Highway Signs, Luminaires and Traffic Signals (LRFDLTS-1); ***Structures Manual (SM)***, Volume 3, FDOT Modifications to LRFDLTS-1; ***Structures Manual (SM)*** Introduction, I.6 References; ***FDOT Design Manual (FDM)***

Design Assumptions and Limitations

See ***FDM 232***, ***FDM 261***, and ***Structures Manual (SM)***, Volume 3 for additional design criteria. **FDOT Signal Support Programs** website provides mast arm design programs to support both “Standard” and “Special” (Custom) designs

Design all mast arm assemblies with backplates in accordance with ***FDM 232***.

Knowing galvanizing thickness may vary, mast arm assemblies are designed for a 3 foot splice. If actual galvanizing thicknesses are as specified, the splice length will be 3 feet and the arm length will be the design length. However, if actual galvanizing thicknesses are significantly larger than specified (not uncommon), the arm may be a foot or so longer than designed, while the splice length will still comply with AASHTO requirements.

Standard Mast Arm Assemblies:

The maximum span length of Standard Mast Arm Assemblies is 78 feet. Mast arms with an arm length greater than 78 feet require a Variation approved by the District Structures Design Engineer, in accordance with ***FDM 261***. Standard Mast Arm Assemblies comply with the minimum requirements and details shown on ***Index 649-031***.

Standard Mast Arm Assemblies may be single arm, single arm with luminaire, double arms, or double arms with luminaire. Standard double arms are limited to arm orientations of 90° or 270° only.

The mast arm design Excel program, located on the **Structures Design Programs Library** website, will provide design loads and arm, pole and foundation capacities which the designer can use to choose arm type(s), pole type and foundation type for Standard designs. Additionally, the mast arm Mathcad program is also provided for detailed design evaluations/validations of Standard Mast Arm Assemblies. Available arm(s) and pole combinations are shown on ***Index 649-030***.

Arm mounting height UB must be between 18-22 feet.

Pole types P2 and larger require a minimum 4.5 foot diameter drilled shaft. Pole types P5 and larger require a minimum 5.0 foot diameter drilled shaft.

Standard foundation (Drilled Shaft) capacities are based on the following soil criteria:

Classification: Cohesionless (Fine Sand)

Friction Angle:	30 Degrees
Unit Weight:	50 pcf (assumed submerged)
N-blowcount:	15

When the designer considers soil types at the specific site location to be of lesser strength properties than shown above, an analysis is required. Auger borings, SPT borings, or CPT soundings may be used as needed to verify the assumed soil properties, and at sites confirmed to be uniform, a single boring or sounding may cover several foundations. Borings in the area that were performed for other purposes may be used to confirm the assumed soil properties. The Geotechnical Engineer must justify the differing soil criteria to the District Structures Design Engineer during the design phase of the project.

If Index 649-031 is used, shop drawings are not required.

Mast Arms with Luminaires

Mount luminaires on mast arms only where project constraints do not allow for placement of independent light poles. Prior to use, contact applicable construction and maintaining agencies, verify responsible parties, and include a written summary with the project documents.

Special (Custom) Mast Arm Assemblies:

Special mast arms are those with unique loadings, soil conditions, and/or geometric constraints that contain any component (arm, pole, or drill shaft) that is outside the range of those available on ***Index 649-030***.

The mast arm Mathcad program, located on the **Structures Design Programs Library** website, will provide the necessary variables to be shown in the "*Special Mast Arm Assemblies Data Table*" cell from the FDOT CADD Menu.

Plan Content Requirements

The signal designer completes the "*Mast Arm Tabulation Sheets*", and the structures designer completes the "*Standard Mast Arm Assemblies Data Table*" or "*Special Mast Arm Assemblies Data Table*", as appropriate. See samples of these sheets below. These are the only plan sheets required for mast arm assemblies. The structures data table may be placed on a signal plan sheet, if space permits.

The following instructions are for use with the "*Mast Arm Tabulation Sheets*":

1. Each mast arm assembly is identified by a unique ID number.
2. Dimensions 1-5 are for signals and dimensions A-E are for signs. Record the horizontal distance from the face of arm baseplate to the center of the signal or sign (similar to arm length measurement, see Index 649-031).

3. Signals may be mounted vertically or horizontally. Indicate the mounting in the appropriate column in the table.
4. The entire line for arm #2 and the space for the angle between dual arms are left blank for single arm assemblies.
5. All arms and poles will be galvanized. If a color is required, indicate the color in the table, otherwise leave blank.
6. Starting at the pole, select the signals and/or signs that match the configuration you are tabulating. The spaces representing the signs or signals not used will be blank. Example 1: If no sign is located between the pole and signal 1, the spaces for Sign A would be blank. Example 2: A configuration for three signals and one sign between signal 1 and signal 2 - Only the spaces for signals 1, 2, 3 and sign B would be completed; the others will be blank.
7. Record the number of sections in each signal head in the space following the distance to that head.
8. Record the height and width of each sign in the space following the distance to the sign.
9. When double arm poles are used for a skewed intersection, the standard design should be used whenever possible. The standard orientation for arm #2 is 90 or 270 degrees measured in a counter clockwise direction from arm #1. The normal orientation of the mast arm is perpendicular to the roadway. Adjustments in mounting hardware can compensate for a skew angle of approximately 15 degrees or more from the normal, depending upon the attachment method. The designer should verify the mounting hardware capability before specifying an arm with a skew greater than 15 degrees.
10. The arm mounting height should be calculated to provide a minimum vertical clearance of 17'-6" from the roadway crown elevation to the lowest sign or signal. A standard signal section is approximately 14" square. Therefore the length of a 3-section head is about 42" and a 5-section is about 70". The use of back plates will add about 6" to each side of the signal head. Additionally, approximately 3" should be added to the end of the signal head to compensate for the attachment hardware. This information may be used to determine the arm mounting height. The designer should coordinate with the maintaining agency to insure the signal assembly and all appropriate hardware has been considered in determining the vertical clearance. The maintaining agency can also provide guidance on the vertical or horizontal mounting of the signal assemblies.
11. The standard handhole location is 90 degrees from arm #1 facing away from traffic. Other handhole locations must be noted in the Special Instructions.
12. A free swinging internally illuminated street name sign may be attached to the pole by an independent bracket arm if the sign area does not exceed 18 square feet and weigh more than 144 pounds. The Structures Design Engineer must review other

signs attached to the pole or any size sign of this type attached to the signal mast arm.

13. The "Special Instructions" Table is used to tabulate pedestrian buttons and pedestrian signal locations and handhole locations when the handholes are not in the standard location. Tabulate the ID No. and the orientation of the pedestrian buttons and signals in degrees measured counter clockwise from arm #1. The handhole location should be left blank if the handhole is in the standard location (see note 11).

14. Arm #1 is the arm for a single arm assembly or the longer arm for a double arm assembly. If the arms are equal length, arm #1 is over the project roadway.

15. Identify assemblies that require a terminal compartment with a “yes” in the correct column. For assemblies with a “no”, only handholes will be provided.

Standard Mast Arm Assemblies Data Table:

STANDARD MAST ARM ASSEMBLIES DATA TABLE											Table Date 11-01-16
STRUCTURE ID NUMBERS	DESIGNATION	FIRST ARM		SECOND ARM		UF (deg)	LL (deg)	POLE			DRILLED SHAFT ID
		ARM ID	FAA (ft.)	ARM ID	SAA (ft.)			POLE ID	UAA (ft.)	UB (ft.)	

NOTES [Notes Date 11-01-16]:

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 Indexes 649-030 and 649-031.

Special Mast Arm Assemblies Data Table:

SPECIAL MAST ARM ASSEMBLIES DATA TABLE (Table Date 01-01-12)

NUMBER OF LOCATIONS	STRUCTURE NUMBER	FIRST ARM				FIRST ARM EXTENSION				SECOND ARM				SECOND ARM EXTENSION				POLE						
		FA(ft)	FB(in)	FC(in)	FD(in)	FE(ft)	FF(in)	FG(in)	FH(in)	SA(ft)	SB(in)	SC(in)	SD(in)	SE(ft)	SF(in)	SG(in)	SH(in)	UA(ft)	UB(ft)	UC(in)	UD(in)	UE(in)	UF(deg)	UG(ft)

SPECIAL MAST ARM ASSEMBLIES DATA TABLE (CONT.) (Table Date 01-01-12)

STRUCTURE NUMBER	FIRST ARM CONNECTION (in)					First Arm Camber Angle = 2 Degrees						SECOND ARM CONNECTION (in)					Second Arm Camber Angle = 2 Degrees					
	#Bolts	HT	FJ	FK	FL	FN	FO	FP	FR	FS	FT	#Bolts	HT	SJ	SK	SL	SN	SO	SP	SR	SS	ST

SPECIAL MAST ARM ASSEMBLIES DATA TABLE (CONT.) (Table Date 07-01-15)

STRUCTURE NUMBER	POLE BASE CONNECTION (in)					SHAFT AND REINF.								LUMINAIRE AND LUMINAIRE CONNECTION										
	#Bolts	BA	BB	BC	BF	DA(ft)	DB(ft)	RA	RB	RC	RD(in)	RE	RF(in)	LA(ft)	LB(ft)	LC(in)	LD(in)	LE	LF(ft)	LG(in)	LH(in)	LJ(in)	LK(in)	LL(deg)

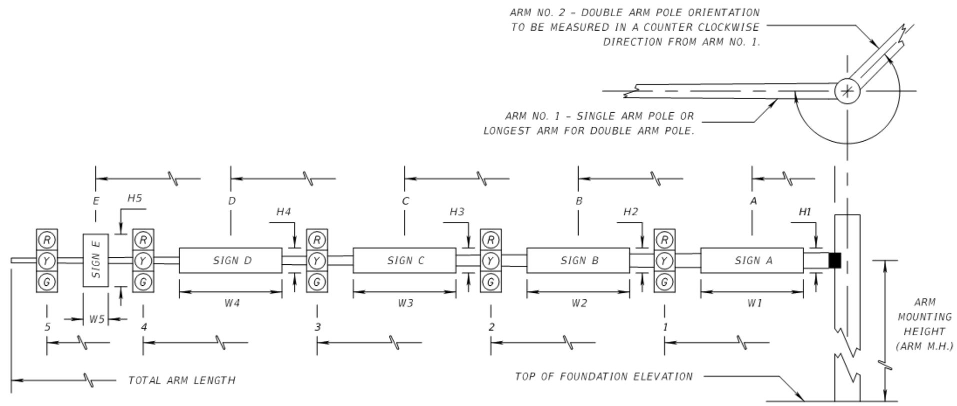
NOTES [Notes Date 07-01-13]:
1. Work with Index 649-031.
2. Design Wind Speed = mph

FOUNDATION NOTES [Notes Date 01-01-12]:
1. Design based on Borings taken sealed by
2. Assumptions and Values used in design:
   Soil Type
   Soil Layer Thickness = ft.
   Soil Friction Angle = deg.
   Soil Weight = pcf
   Design Water Table is ft. below surface

Mast Arm Tabulation Sheet:

SPECIAL INSTRUCTIONS

ID NO.	PED. BUTTON		PED. SIGNALS		HANDHOLE LOCATION



* DENOTES NUMBER OF SECTIONS IN SIGNAL HEAD ASSEMBLY

								SIGNAL DATA																SIGN DATA															
ID NO.	SHEET NO.	LOCATION BY STA.	TOP OF FOUND. ELEVATION	RDWY ARM NO.	CROWN ELEV.	LUMINAIRE Y/N	TERM. COMP. Y/N	SIGNAL V/H	BACK PLATES Y/N	PED. SIGNAL Y/N	DISTANCE FROM POLE										TOTAL ARM LENGTH	ARM M.H.	ANGLE BETWEEN DUAL ARMS 90/270	DISTANCE FROM POLE / HEIGHT AND WIDTH OF SIGN															PAINT COLOR
											1	*	2	*	3	*	4	*	5	*				A	H1	W1	B	H2	W2	C	H3	W3	D	H4	W4	E	H5	W5	
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REVISIONS			
DATE	DESCRIPTION	DATE	DESCRIPTION

STATE OF FLORIDA
DEPARTMENT OF TRANSPORTATION

ROAD NO.	COUNTY	FINANCIAL PROJECT ID

STANDARD MAST ARM TABULATION

SHEET NO.

Payment

Item number	Item Description	Unit Measure
649-2A-BB	Steel Mast Arm Assembly	EA
715-5-AB	Luminaire & Bracket Arm	EA

See the ***BOE*** and ***Specification 649 & 715*** for additional information on payment, pay item use and compensation.

Note: *Project Specific Pay Items are required for Special Mast Arm Assemblies with arm lengths greater than 78 feet.*

Examples

EXAMPLE 1

1. Select Arm and Pole Combination.

   Select A40/S - P2/S from the Mast Arm Combinations Tables.
   Specify shorter arm, enter 36 under FAA.
   Leave Second Arm, UF and LL blank as there is no second arm or luminaire.

2. Determine Arm Mounting Height.

   UB + 10' = 12.5' + 17.5'min. + 2'
   UB = 22' min.   Use 22'

3. Select Drilled Shaft ID.

   Select DS/12/4.5.

4. Use the **FDOT Signal Support Programs** to verify adequacy of the arm, pole, and foundation.

EXAMPLE 2

1. Select Arms and Pole Combination.

   Select A60/D - A40/D - P4/D from the Mast Arm Combinations Tables.
   Specify shorter arms, enter 27.5 under FAA for First Arm.
   FAA = FA - (60' - 52') = 35.5' - 8' = 27.5'

2. Enter angle between arms.

   Angle UF is measured counter-clockwise from the First Arm and must be either 90° or 270°.

3. Specify shorter Pole.

   Enter 23.5 under UAA.

4. Determine Arm Mounting Height.

UB + 10' = 9.5' + 17.5' min. + 2'
UB = 19' min.   Use 20'

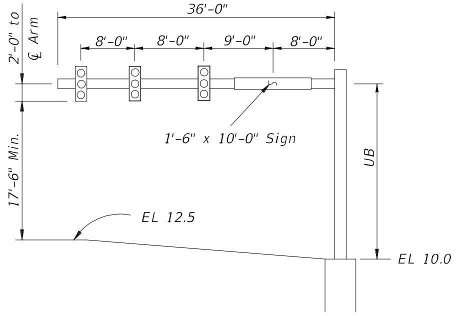
5. Select Drilled Shaft ID.

   Select DS/16/4.5

6. Use the **FDOT Signal Support Programs** to verify adequacy of the arm, pole, and foundation.

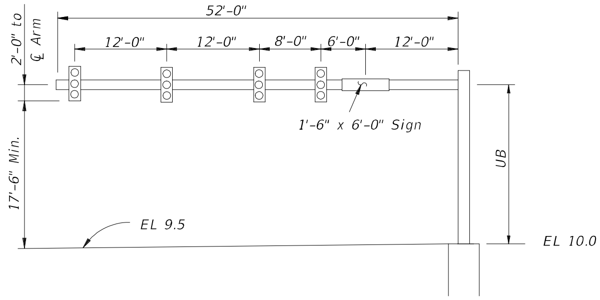
EXAMPLE 1

Single Arm Structure as shown,
130 mph Wind Speed with Signal Backplates.



EXAMPLE 2

First Arm Structure as shown, Second Arm same as Example 1
except 150 mph Wind Speed with Signal Backplates.



STANDARD MAST ARM ASSEMBLIES DATA TABLE

Table Date 11-01-16

STRUCTURE ID NUMBERS	DESIGNATION	FIRST ARM		SECOND ARM		UF (deg)	LL (deg)	POLE			DRILLED SHAFT ID
		ARM ID	FAA (ft.)	ARM ID	SAA (ft.)			POLE ID	UAA (ft.)	UB (ft.)	
Example 1	A40/S - P2/S	A40/S	36					P2/S		22	DS/12/4.5
Example 2	A60/D - A40/D - P4/D	A60/D	27.5	A40/D	36	90		P4/D	23.5	20	DS/16/4.5

NOTES [Notes Date 11-01-16]:

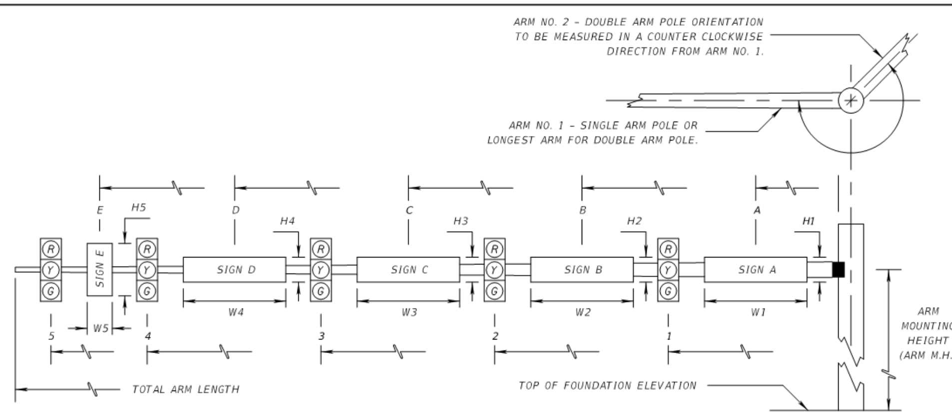
1. If an entry appears in column FAA, a shorter arm is required. This is obtained by removing length from the arm tip and the arm length shortened from FA to FAA. SAA Similar.

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 Indexes 649-030 and 649-031.

Mast Arm Tabulation Sheet Example:



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.	LUMINAIRE 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	*	5	*	TOTAL ARM LENGTH	ARM M.H.	ANGLE BETWEEN DUAL ARMS 90/270	SIGN DATA: DISTANCE FROM POLE / HEIGHT AND WIDTH OF SIGN: A	H1	W1	B	H2	W2	C	H3	W3	D	H4	W4	E	H5	W5	PAINT COLOR
1	T-4	123+45.67 Ex1	10.00	1	12.50	N	Y	V	Y		17.0	3	25.0	3	33.0	3					40	22		8	1.5	10												
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2	T-5	456+78.90 Ex2	10.00	1	9.50	N	Y	V	Y		18.0	3	26.0	3	38.0	3	50.0	3			40	22	270	12	1.5	6												
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REVISIONS: DATE	DESCRIPTION	DATE	DESCRIPTION		STATE OF FLORIDA DEPARTMENT OF TRANSPORTATION: ROAD NO.	COUNTY	FINANCIAL PROJECT ID	STANDARD MAST ARM TABULATION	SHEET NO.

Design Aids

30 Foot Mast Arm Combinations						
Arm 1 Length	**Arm 2 Length**	**Regular or Heavy Duty**	**Luminaire?**	**Designation**		
30'	N/A	Reg	No	A30/S		P1/S
			Yes	A30/S		P1/S/L
		HD	No	A30/S/H		P1/S
			Yes	A30/S/H		P1/S/L
	30'	Reg/Reg	No	A30/D	A30/D	P2/D
			Yes	A30/D	A30/D	P2/D/L
		Reg/HD	No	A30/D	A30/D/H	P2/D
			Yes	A30/D	A30/D/H	P2/D/L
		HD/Reg	No	A30/D/H	A30/D	P2/D
			Yes	A30/D/H	A30/D	P2/D/L
		HD/HD	No	A30/D/H	A30/D/H	P2/D
			Yes	A30/D/H	A30/D/H	P2/D/L
30 foot Mast Arm Total = 12						

40 Foot Mast Arm Combinations						
Arm 1 Length	**Arm 2 Length**	**Regular or Heavy Duty**	**Luminaire?**	**Designation**		
40'	N/A	Reg	No	A40/S		P2/S
			Yes	A40/S		P2/S/L
		HD	No	A40/S/H		P2/S
			Yes	A40/S/H		P2/S/L
	30'	Reg/Reg	No	A40/D	A30/D	P2/D
			Yes	A40/D	A30/D	P2/D/L
		Reg/HD	No	A40/D	A30/D/H	P2/D
			Yes	A40/D	A30/D/H	P2/D/L
		HD/Reg	No	A40/D/H	A30/D	P2/D
			Yes	A40/D/H	A30/D	P2/D/L
		HD/HD	No	A40/D/H	A30/D/H	P2/D
			Yes	A40/D/H	A30/D/H	P2/D/L
	40'	Reg/Reg	No	A40/D	A40/D	P2/D
			Yes	A40/D	A40/D	P2/D/L
		Reg/HD	No	A40/D	A40/D/H	P2/D
			Yes	A40/D	A40/D/H	P2/D/L
		HD/Reg	No	A40/D/H	A40/D	P2/D
			Yes	A40/D/H	A40/D	P2/D/L
		HD/HD	No	A40/D/H	A40/D/H	P2/D
			Yes	A40/D/H	A40/D/H	P2/D/L
40 foot Mast Arm Total = 20						

50 Foot Mast Arm Combinations						
Arm 1 Length	**Arm 2 Length**	**Regular or Heavy Duty**	**Luminaire?**	**Designation**		
50'	N/A	Reg	No	A50/S		P3/S
			Yes	A50/S		P3/S/L
		HD	No	A50/S/H		P3/S
			Yes	A50/S/H		P3/S/L
	30'	Reg/Reg	No	A50/D	A30/D	P3/D
			Yes	A50/D	A30/D	P3/D/L
		Reg/HD	No	A50/D	A30/D/H	P3/D
			Yes	A50/D	A30/D/H	P3/D/L
		HD/Reg	No	A50/D/H	A30/D	P3/D
			Yes	A50/D/H	A30/D	P3/D/L
		HD/HD	No	A50/D/H	A30/D/H	P3/D
			Yes	A50/D/H	A30/D/H	P3/D/L
	40'	Reg/Reg	No	A50/D	A40/D	P3/D
			Yes	A50/D	A40/D	P3/D/L
		Reg/HD	No	A50/D	A40/D/H	P3/D
			Yes	A50/D	A40/D/H	P3/D/L
		HD/Reg	No	A50/D/H	A40/D	P3/D
			Yes	A50/D/H	A40/D	P3/D/L
		HD/HD	No	A50/D/H	A40/D/H	P3/D
			Yes	A50/D/H	A40/D/H	P3/D/L
	50'	Reg/Reg	No	A50/D	A50/D	P4/D
			Yes	A50/D	A50/D	P4/D/L
		Reg/HD	No	A50/D	A50/D/H	P4/D
			Yes	A50/D	A50/D/H	P4/D/L
		HD/Reg	No	A50/D/H	A50/D	P4/D
			Yes	A50/D/H	A50/D	P4/D/L
		HD/HD	No	A50/D/H	A50/D/H	P4/D
			Yes	A50/D/H	A50/D/H	P4/D/L
50 foot Mast Arm Total = 28						

60 Foot Mast Arm Combinations						
Arm 1 Length	**Arm 2 Length**	**Regular or Heavy Duty**	**Luminaire?**	**Designation**		
60'	N/A	Reg	No	A60/S		P4/S
			Yes	A60/S		P4/S/L
		HD	No	A60/S/H		P4/S
			Yes	A60/S/H		P4/S/L
	30'	Reg/Reg	No	A60/D	A30/D	P4/D
			Yes	A60/D	A30/D	P4/D/L
		Reg/HD	No	A60/D	A30/D/H	P4/D
			Yes	A60/D	A30/D/H	P4/D/L
		HD/Reg	No	A60/D/H	A30/D	P4/D
			Yes	A60/D/H	A30/D	P4/D/L
		HD/HD	No	A60/D/H	A30/D/H	P4/D
			Yes	A60/D/H	A30/D/H	P4/D/L
	40'	Reg/Reg	No	A60/D	A40/D	P4/D
			Yes	A60/D	A40/D	P4/D/L
		Reg/HD	No	A60/D	A40/D/H	P4/D
			Yes	A60/D	A40/D/H	P4/D/L
		HD/Reg	No	A60/D/H	A40/D	P4/D
			Yes	A60/D/H	A40/D	P4/D/L
		HD/HD	No	A60/D/H	A40/D/H	P4/D
			Yes	A60/D/H	A40/D/H	P4/D/L
	50'	Reg/Reg	No	A60/D	A50/D	P4/D
			Yes	A60/D	A50/D	P4/D/L
		Reg/HD	No	A60/D	A50/D/H	P4/D
			Yes	A60/D	A50/D/H	P4/D/L
		HD/Reg	No	A60/D/H	A50/D	P4/D
			Yes	A60/D/H	A50/D	P4/D/L
		HD/HD	No	A60/D/H	A50/D/H	P4/D
			Yes	A60/D/H	A50/D/H	P4/D/L
	60'	Reg/Reg	No	A60/D	A60/D	P5/D
			Yes	A60/D	A60/D	P5/D/L
		Reg/HD	No	A60/D	A60/D/H	P5/D
			Yes	A60/D	A60/D/H	P5/D/L
		HD/Reg	No	A60/D/H	A60/D	P5/D
			Yes	A60/D/H	A60/D	P5/D/L
		HD/HD	No	A60/D/H	A60/D/H	P5/D
			Yes	A60/D/H	A60/D/H	P5/D/L
60 foot Mast Arm Total = 36						

70 Foot Mast Arm Combinations						
Arm 1 Length	**Arm 2 Length**	**Regular or Heavy Duty**	**Luminaire?**	**Designation**		
70'	N/A	Reg	No	A70/S		P5/S
			Yes	A70/S		P5/S/L
		HD	No	A70/S/H		P5/S
			Yes	A70/S/H		P5/S/L
	30'	Reg/Reg	No	A70/D	A30/D	P5/D
			Yes	A70/D	A30/D	P5/D/L
		Reg/HD	No	A70/D	A30/D/H	P5/D
			Yes	A70/D	A30/D/H	P5/D/L
		HD/Reg	No	A70/D/H	A30/D	P5/D
			Yes	A70/D/H	A30/D	P5/D/L
		HD/HD	No	A70/D/H	A30/D/H	P5/D
			Yes	A70/D/H	A30/D/H	P5/D/L
	40'	Reg/Reg	No	A70/D	A40/D	P5/D
			Yes	A70/D	A40/D	P5/D/L
		Reg/HD	No	A70/D	A40/D/H	P5/D
			Yes	A70/D	A40/D/H	P5/D/L
		HD/Reg	No	A70/D/H	A40/D	P5/D
			Yes	A70/D/H	A40/D	P5/D/L
		HD/HD	No	A70/D/H	A40/D/H	P5/D
			Yes	A70/D/H	A40/D/H	P5/D/L
	50'	Reg/Reg	No	A70/D	A50/D	P5/D
			Yes	A70/D	A50/D	P5/D/L
		Reg/HD	No	A70/D	A50/D/H	P5/D
			Yes	A70/D	A50/D/H	P5/D/L
		HD/Reg	No	A70/D/H	A50/D	P5/D
			Yes	A70/D/H	A50/D	P5/D/L
		HD/HD	No	A70/D/H	A50/D/H	P5/D
			Yes	A70/D/H	A50/D/H	P5/D/L
	60'	Reg/Reg	No	A70/D	A60/D	P6/D
			Yes	A70/D	A60/D	P6/D/L
		Reg/HD	No	A70/D	A60/D/H	P6/D
			Yes	A70/D	A60/D/H	P6/D/L
		HD/Reg	No	A70/D/H	A60/D	P6/D
			Yes	A70/D/H	A60/D	P6/D/L
		HD/HD	No	A70/D/H	A60/D/H	P6/D
			Yes	A70/D/H	A60/D/H	P6/D/L

70 Foot Mast Arm Combinations						
Arm 1 Length	**Arm 2 Length**	**Regular or Heavy Duty**	**Luminaire?**	**Designation**		
70'	70'	Reg/Reg	No	A70/D	A70/D	P6/D
			Yes	A70/D	A70/D	P6/D/L
		Reg/HD	No	A70/D	A70/D/H	P6/D
			Yes	A70/D	A70/D/H	P6/D/L
		HD/Reg	No	A70/D/H	A70/D	P6/D
			Yes	A70/D/H	A70/D	P6/D/L
		HD/HD	No	A70/D/H	A70/D/H	P6/D
			Yes	A70/D/H	A70/D/H	P6/D/L
70 foot Mast Arm Total = 44						

78 Foot Mast Arm Combinations						
Arm 1 Length	**Arm 2 Length**	**Regular or Heavy Duty**	**Luminaire?**	**Designation**		
78'	N/A	Reg	No	A78/S		P6/S
			Yes	A78/S		P6/S/L
		HD	No	A78/S/H		P6/S
			Yes	A78/S/H		P6/S/L
	30'	Reg/Reg	No	A78/D	A30/D	P6/D
			Yes	A78/D	A30/D	P6/D/L
		Reg/HD	No	A78/D	A30/D/H	P6/D
			Yes	A78/D	A30/D/H	P6/D/L
		HD/Reg	No	A78/D/H	A30/D	P6/D
			Yes	A78/D/H	A30/D	P6/D/L
		HD/HD	No	A78/D/H	A30/D/H	P6/D
			Yes	A78/D/H	A30/D/H	P6/D/L
	40'	Reg/Reg	No	A78/D	A40/D	P6/D
			Yes	A78/D	A40/D	P6/D/L
		Reg/HD	No	A78/D	A40/D/H	P6/D
			Yes	A78/D	A40/D/H	P6/D/L
		HD/Reg	No	A78/D/H	A40/D	P6/D
			Yes	A78/D/H	A40/D	P6/D/L
		HD/HD	No	A78/D/H	A40/D/H	P6/D
			Yes	A78/D/H	A40/D/H	P6/D/L

78 Foot Mast Arm Combinations						
Arm 1 Length	**Arm 2 Length**	**Regular or Heavy Duty**	**Luminaire?**	**Designation**		
78'	50'	Reg/Reg	No	A78/D	A50/D	P6/D
			Yes	A78/D	A50/D	P6/D/L
		Reg/HD	No	A78/D	A50/D/H	P6/D
			Yes	A78/D	A50/D/H	P6/D/L
		HD/Reg	No	A78/D/H	A50/D	P6/D
			Yes	A78/D/H	A50/D	P6/D/L
		HD/HD	No	A78/D/H	A50/D/H	P6/D
			Yes	A78/D/H	A50/D/H	P6/D/L
	60'	Reg/Reg	No	A78/D	A60/D	P6/D
			Yes	A78/D	A60/D	P6/D/L
		Reg/HD	No	A78/D	A60/D/H	P6/D
			Yes	A78/D	A60/D/H	P6/D/L
		HD/Reg	No	A78/D/H	A60/D	P6/D
			Yes	A78/D/H	A60/D	P6/D/L
		HD/HD	No	A78/D/H	A60/D/H	P6/D
			Yes	A78/D/H	A60/D/H	P6/D/L
	70'	Reg/Reg	No	A78/D	A70/D	P7/D
			Yes	A78/D	A70/D	P7/D/L
		Reg/HD	No	A78/D	A70/D/H	P7/D
			Yes	A78/D	A70/D/H	P7/D/L
		HD/Reg	No	A78/D/H	A70/D	P7/D
			Yes	A78/D/H	A70/D	P7/D/L
		HD/HD	No	A78/D/H	A70/D/H	P7/D
			Yes	A78/D/H	A70/D/H	P7/D/L
	78'	Reg/Reg	No	A78/D	A78/D	P7/D
			Yes	A78/D	A78/D	P7/D/L
		Reg/HD	No	A78/D	A78/D/H	P7/D
			Yes	A78/D	A78/D/H	P7/D/L
		HD/Reg	No	A78/D/H	A78/D	P7/D
			Yes	A78/D/H	A78/D	P7/D/L
		HD/HD	No	A78/D/H	A78/D/H	P7/D
			Yes	A78/D/H	A78/D/H	P7/D/L
78 foot Mast Arm Total = 52						

Erie Rd. and SR 62 Improvements

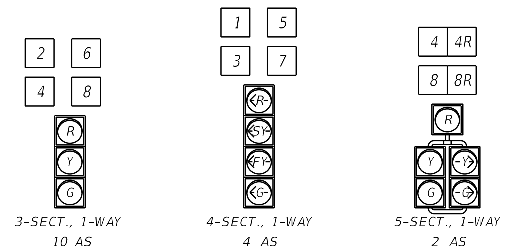
HDR Project Number: 10151274

Miscellaneous Structures

1.2 Signal Plans

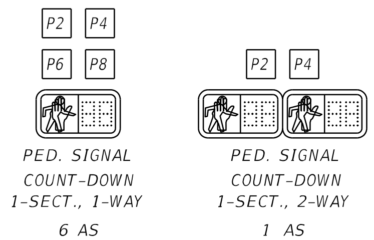
For: Manatee County Public Works

SIGNAL HEAD DETAILS

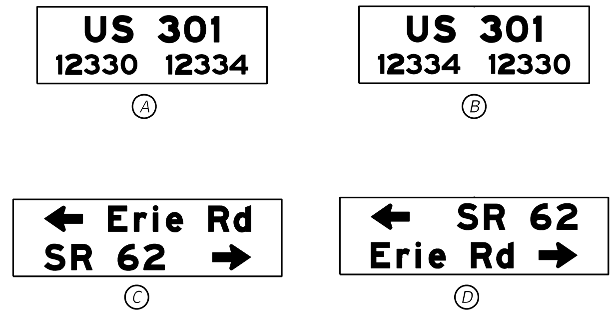


650-1-14 | 650-1-16 | 650-1-19

PEDESTRIAN SIGNAL HEAD DETAILS

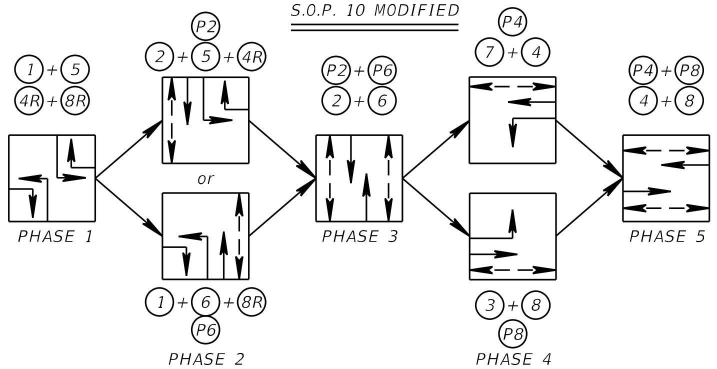


653-1-11 | 653-1-12



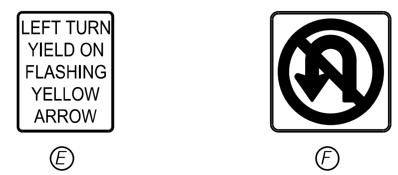
700-5-22 4 EA

S.O.P. 10 MODIFIED



FTP-85-13
30" x 36"

R3-4
36" x 36"



700-3-201 4 EA | 700-3-201 2 EA

CONTROLLER OPERATIONS:

1. MAJOR STREET IS US 301 (MOVEMENTS 1, 2, 5, 6 AND 6R) AND MINOR STREET IS ERIE RD & SR 62 (MOVEMENTS 3, 4, 4R, 7, 8 AND 8R).
2. WHILE IN FLASH MODE, MOVEMENTS 2 & 6 SHALL FLASH YELLOW. ALL OTHER MOVEMENTS SHALL FLASH RED.
3. CONTROLLER CABINET SHALL BE WIRED AS AN S.O.P. 10 AND OPERATED WITH S.O.P 10 MODIFIED (WITH RIGHT TURN OVERLAPS) AS SHOWN WITH THE FOLLOWING: CONCURRENT/ACTUATED PEDESTRIANS FOR MOVEMENT 2 (P2), 4 (P4), 6 (P6) AND 8 (P8).
4. REQUEST UPDATED SIGNAL TIMINGS FROM FDOT TSM&O ENGINEER – ARTERIALS (863-519-2216) WHEN ALL LANES, STRIPING, SIGNALS AND PEDESTRIAN FACILITIES ARE IN THEIR FINAL CONFIGURATION AND THE SIGNAL IS OPERATING AS DESIGNED. PROVIDE FDOT WITH ALL 'AS-BUILT' INFORMATION NECESSARY TO DEVELOP THE BASIC SIGNAL TIMING PARAMETERS AND ALLOW THREE (3) WEEKS FOLLOWING THE REQUEST FOR FDOT TO DEVELOP THE UPDATED TIMINGS. PROGRAM THE CONTROLLER PER THE TIMINGS PROVIDED BY FDOT.
5. PROGRAM PHASE RESTRICTIONS TO OMIT MOVEMENT 1 AND REDIRECT CALLS FROM MOVEMENT 1 TO MOVEMENT 6, WHEN MOVEMENT 2 IS GREEN, AND TO OMIT MOVEMENT 5 AND REDIRECT CALLS FROM MOVEMENT 5 TO MOVEMENT 2, WHEN MOVEMENT 6 IS GREEN.
6. OVERLAP PHASES AND NOTES:
   4R = 5 WITH MINIMUM GREEN = 7 SEC., YELLOW = 4.8 SEC., ALL RED = 2.1 SEC.
   8R = 1 WITH MINIMUM GREEN = 7 SEC., YELLOW = 4.8 SEC., ALL RED = 2.1 SEC.
7. PROGRAM A START-UP DELAY OF 2 SECONDS FOR THE FLASHING YELLOW ARROW ON MOVEMENTS 1, 3, 5 AND 7 (RELATIVE TO THE OPPOSING THROUGH MOVEMENTS).

SIGNALIZATION NOTES:

1. POWER SERVICE METER BASE AND DISCONNECT SHALL BE INSTALLED ON THE CONCRETE SERVICE POLE AS SHOWN ON THE PLANS AND PER STANDARD PLANS INDEX NUMBERS 639-001 AND 639-002.
2. THE CONTRACTOR SHALL COORDINATE WITH MANATEE COUNTY AND THE POWER COMPANY REGARDING THE EXACT LOCATION AND TIMING OF INSTALLATION.
3. SEE LIGHTING PLANS FOR INTERSECTION LIGHTING DETAILS.

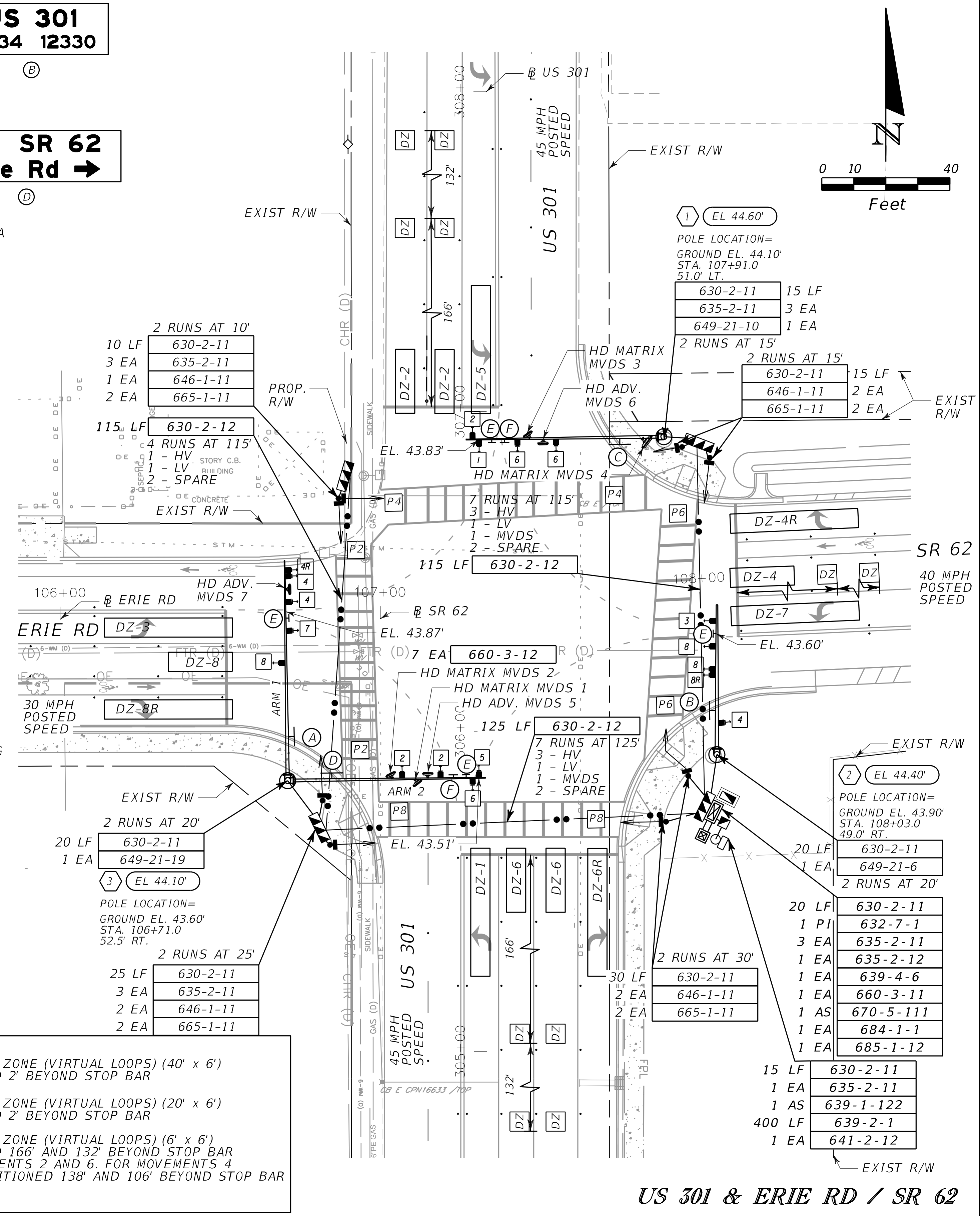
CONTROLLER TIMINGS

MOVEMENT # (CONTROLLER PHASE ∅)	1	2	3	4	5	6	7	8	NOTES
DIRECTION	NBL	SB	EBL	WB	SBL	NB	WBL	EB	
TURN TYPE	PROT/PERM		PROT/PERM		PROT/PERM		PROT/PERM		
MINIMUM GREEN	7	20	7	10	7	20	7	10	
EXTENSION	3	2	3	4	3	2	3	4	
YELLOW CLEARANCE	4.8	4.8	4.4	4.4	4.8	4.8	4.4	4.4	
ALL RED	2.1	2.1	2.7	2.7	2.1	2.1	2.7	2.7	
MAXIMUM GREEN 1	30	50	30	30	30	50	30	30	
MAXIMUM GREEN 2	—	—	—	—	—	—	—	—	
MAXIMUM LIMIT									
ADJUST BY									
PEDESTRIAN WALK	—	7	—	7	—	7	—	7	
PED. CLEARANCE	—	28	—	30	—	23	—	24	
DETECTOR MEMORY									
DET. CROSS SWITCH									
DUAL ENTRY									
RECALL	—	MIN	—	—	—	MIN	—	—	

HD MATRIX AND ADVANCE MVDS SMART SENSOR DETECTION ASSIGNMENTS

HD MVDS DETECTION	DETECTION ZONE	DELAY TIME (SECS.)
HD MATRIX MVDS 1	DZ-1	3
	DZ-6	
	DZ-6R	8
HD MATRIX MVDS 2	DZ-3	3
	DZ-8	
	DZ-8R	8
HD MATRIX MVDS 3	DZ-2	
	DZ-5	3
HD MATRIX MVDS 4	DZ-4	
	DZ-4R	8
	DZ-7	3
HD ADV MVDS 5	DZ-2	
HD ADV MVDS 6	DZ-6	
HD ADV MVDS 7	DZ-4	

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



LEGEND

- DZ — DETECTION ZONE (VIRTUAL LOOPS) (40' x 6') POSITIONED 2' BEYOND STOP BAR
- DZ — DETECTION ZONE (VIRTUAL LOOPS) (20' x 6') POSITIONED 2' BEYOND STOP BAR
- DZ — DETECTION ZONE (VIRTUAL LOOPS) (6' x 6') POSITIONED 166' AND 132' BEYOND STOP BAR FOR MOVEMENTS 2 AND 6, FOR MOVEMENTS 4 AND 8, POSITIONED 138' AND 106' BEYOND STOP BAR
- HD MVDS

US 301 & ERIE RD / SR 62

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

SCALE: AS NOTED
DESIGNED BY: MO
DRAWN BY: GS
CHECKED BY: IR

HDR Engineering, Inc.
4830 W Kennedy Blvd,
Suite 400
Tampa, FL 33609-2548

DATE: 06/2021
PROJECT NO.: 850-6094060

Manatee County FLORIDA

MANATEE COUNTY PUBLIC WORKS

DESIGN ENGINEER: MICHAEL J. OATES
FL. LICENSE NO.: 49282

SIGNALIZATION PLAN

SHEET NO.: T-6

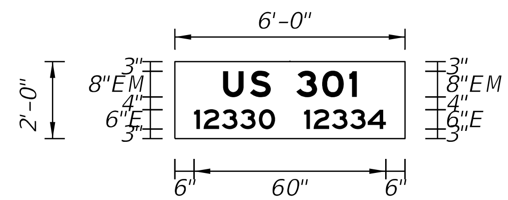
10:51:37 AM 6/10/2021 PW:\3658\10001573\10151274\6.0_CAD_BIM\6.2_WIP\12345615201\signals\Plansg01.dgn

SIGN A

SIGN NAME	A	QTY	1	SIGN NO.	STATION(S)
PANEL		BORDER			
WIDTH	6'-0"	WIDTH	0"		
HEIGHT	2'-0"	RADII	0"		
LEGEND	White	COLOR	Green		
COLOR	Green				

SYMBOL(S)	ANGLE	X	Y	WID	HT

SIGN NO.	NO. OF POSTS	EDGE OF LANE CLEARANCE	COLUMN SIZE	AVERAGE LENGTH



NO. OF LIGHT FIXTURES		FIXTURE SPACING		PHOTOMETRIC CURVE		WATT		VOLTAGE	

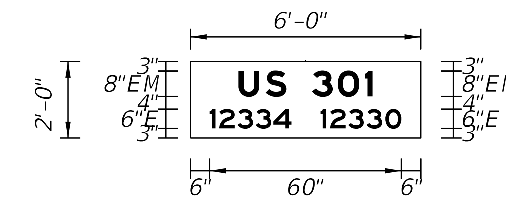
COPY		U	S		3	0	1		L					
SPACE	15	8.5	6.5	8	8.1	8.5	2.4	15	41.9					
COPY		1	2	3	3	0		1	2	3	3	4		L
SPACE	6	3	5.7	5.7	5.9	5	9.1	3	5.7	5.7	5.5	5.6	6	60
COPY														
SPACE														
COPY														
SPACE														
COPY														
SPACE														
COPY														
SPACE														

SIGN B

SIGN NAME	B	QTY	1	SIGN NO.	STATION(S)
PANEL		BORDER			
WIDTH	6'-0"	WIDTH	0"		
HEIGHT	2'-0"	RADII	0"		
LEGEND	White	COLOR	Green		
COLOR	Green				

SYMBOL(S)	ANGLE	X	Y	WID	HT

SIGN NO.	NO. OF POSTS	EDGE OF LANE CLEARANCE	COLUMN SIZE	AVERAGE LENGTH



NO. OF LIGHT FIXTURES		FIXTURE SPACING		PHOTOMETRIC CURVE		WATT		VOLTAGE	

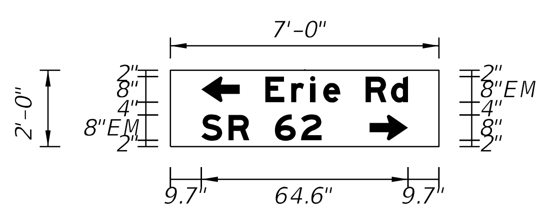
COPY		U	S		3	0	1		L					
SPACE	15	8.5	6.5	8	8.1	8.5	2.4	15	41.9					
COPY		1	2	3	3	4		1	2	3	3	0		L
SPACE	6	3	5.7	5.7	5.5	5.6	9.1	3	5.7	5.7	5.9	5	6	60
COPY														
SPACE														
COPY														
SPACE														
COPY														
SPACE														
COPY														
SPACE														

SIGN C

SIGN NAME	C	QTY	1	SIGN NO.	STATION(S)
PANEL		BORDER			
WIDTH	7'-0"	WIDTH	0"		
HEIGHT	2'-0"	RADII	0"		
LEGEND	White	COLOR	Green		
COLOR	Green				

SYMBOL(S)	ANGLE	X	Y	WID	HT
AR_Type D	90	9.7	14	8	12
AR_Type D	270	62.3	2	8	12

SIGN NO.	NO. OF POSTS	EDGE OF LANE CLEARANCE	COLUMN SIZE	AVERAGE LENGTH



NO. OF LIGHT FIXTURES		FIXTURE SPACING		PHOTOMETRIC CURVE		WATT		VOLTAGE	

COPY		E	r	i	e		R	d		L				
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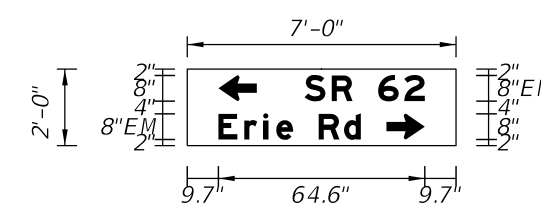
COPY		S	R		6	2		L						
SPACE	9.7	8.5	6.5	8	8.2	6.5	36.7	37.6						
COPY														
SPACE														
COPY														
SPACE														
COPY														
SPACE														
COPY														
SPACE														

SIGN D

SIGN NAME	D	QTY	1	SIGN NO.	STATION(S)
PANEL		BORDER			
WIDTH	7'-0"	WIDTH	0"		
HEIGHT	2'-0"	RADII	0"		
LEGEND	White	COLOR	Green		
COLOR	Green				

SYMBOL(S)	ANGLE	X	Y	WID	HT
AR_Type D	90	9.7	14	8	12
AR_Type D	270	62.3	2	8	12

SIGN NO.	NO. OF POSTS	EDGE OF LANE CLEARANCE	COLUMN SIZE	AVERAGE LENGTH



NO. OF LIGHT FIXTURES		FIXTURE SPACING		PHOTOMETRIC CURVE		WATT		VOLTAGE	

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SPACE	36.7	8.5	6.5	8	8.2	6.5	9.7	37.6						
COPY		E	r	i	e		R	d		L				
SPACE	9.7	8.1	5.9	4.1	5.3	8	7.9	5.3	29.7	44.6				
COPY														
SPACE														
COPY														
SPACE														
COPY														
SPACE														
COPY														
SPACE														

No.	REVISIONS	DATE	BY

SCALE AS NOTED
DESIGNED BY MO
DRAWN BY GS
CHECKED BY IR

HDR Engineering, Inc.
4830 W Kennedy Blvd,
Suite 400
Tampa, FL 33609-2548

DATE 06/2021
PROJECT NO. 850-6094060

Manatee County FLORIDA

MANATEE COUNTY PUBLIC WORKS

DESIGN ENGINEER MICHAEL J. OATES
FL. LICENSE NO. 49282

GUIDE SIGN WORKSHEET

SHEET NO. T-7

IT SHALL BE THE RESPONSIBILITY OF THE CONTRACTOR TO FIELD VERIFY ALL ELEVATIONS PRIOR TO POLE MANUFACTURING.

CONTRACTOR SHALL ALSO INSURE THAT TOP OF POLE FOUNDATION WILL NOT BE INSTALLED BELOW NATURAL GROUND LEVEL.

INFORMATION BELOW IS FOR DESIGN PURPOSES ONLY. FIELD ADJUSTMENTS MAY BE REQUIRED.

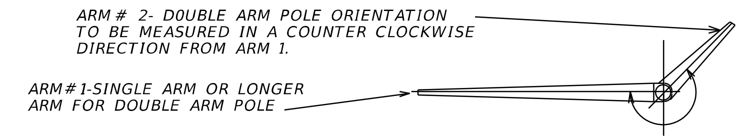
SEE APPROPRIATE PLAN SHEET FOR PROPOSED SIGNAL HEAD ALIGNMENTS AND SIGN CONFIGURATION/LOCATION.

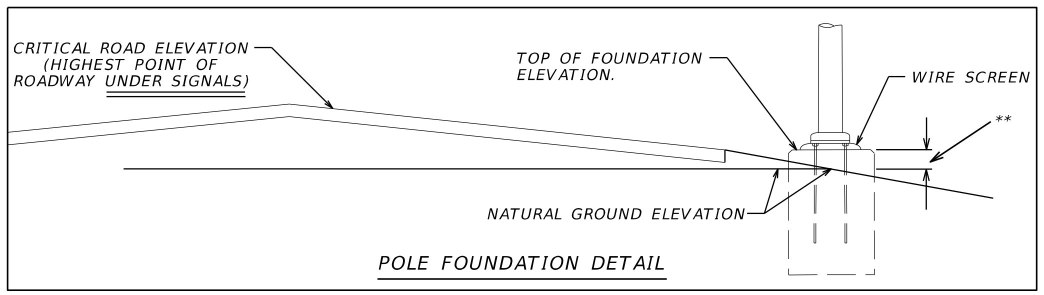
SPECIAL NOTES:

A. EACH POLE AND MAST ARM SHALL BE IDENTIFIED WITH A PERMANENT ONE INCH (1") HIGH ENGRAVED OR IMPRESSED MARK WHICH BEARS THE POLE IDENTIFICATION NUMBER SHOWN ON THE PLANS.

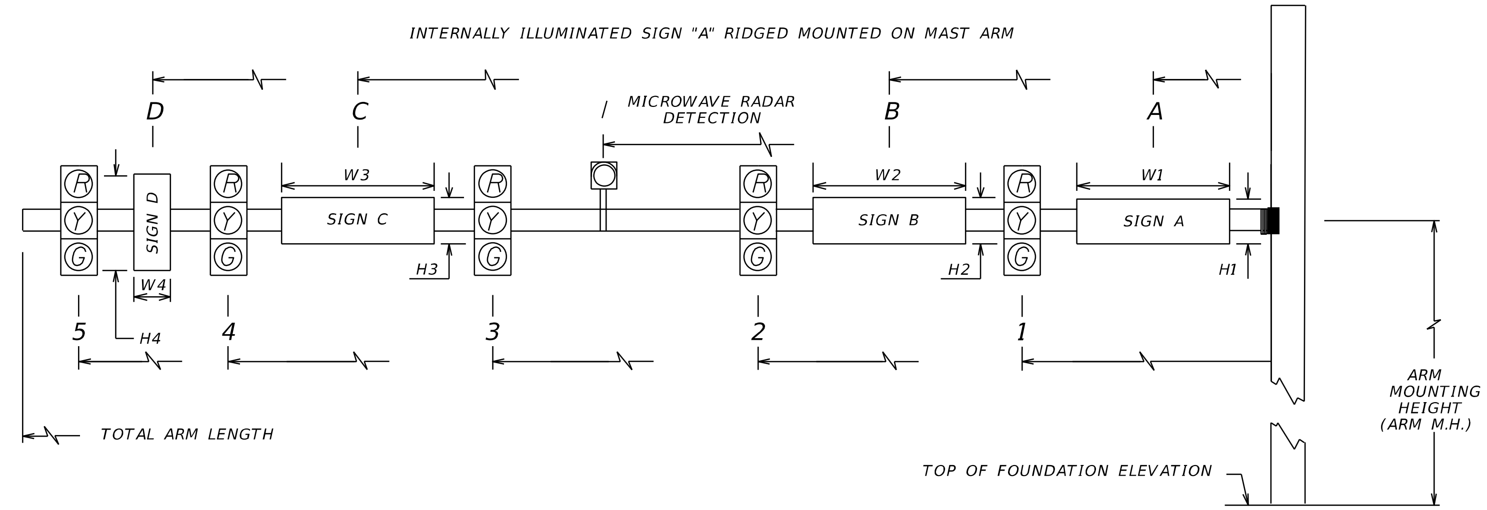
B. ANCHOR BOLT COVERS (ORNAMENTAL, NON-ORNAMENTAL, AND/OR PAINTED) SHALL BE GALVANIZED STEEL OR CAST ALUMINUM AND SHALL BE SECURED BY A MINIMUM OF TWO (2) THREADED FASTENERS. THE BOLT COVERS SHALL BE OF SUFFICIENT SIZE SO THAT THERE IS NO GAP BETWEEN ITSELF AND THE POLE SHAFT.

C. MAST ARMS SHALL BE GALVANIZED, NON-PAINTED.





POLE FOUNDATION DETAIL



NOTE

-IN SIGN DATA TABLE, SIGN DESIGNATION (A, B, C, D, E) IS FOR POSITION REFERENCE ONLY. PLAN SHEETS AND SIGN DETAILS SHOULD BE REFERENCED FOR THE EXACT SIGNS TO BE INSTALLED ON MAST ARMS.

* DENOTES NUMBER OF SECTIONS IN SIGNAL HEAD ASSEMBLY

** DENOTES FOUNDATION IS DESIGNED AS 0.5' ABOVE GRADE

STRUCT. ID NO.	POLE ID NO.	SHEET NO.	LOCATION BY STA.	TOP OF FOUNDATION ELEV.	CRITICAL ROAD ELEV.	RDWY ARM NO.	SIGNAL DATA: SIGNAL V/H	BACK PLATES Y/N	PED. SIGNAL Y/N	DISTANCE FROM POLE: 1	*	2	*	3	*	4	*	5	*	6	*	TOTAL ARM LENGTH	ARM M.H.	ANGLE BETWEEN DUAL ARMS 90/270	SIGN DATA (DISTANCE FROM POLE / HEIGHT AND WIDTH OF SIGN): A	H1	W1	B	H2	W2	C	H3	W3	D	H4	W4	E	H5	W5	LUMINAIRE ANGLE	MVDS DISTANCE FROM POLE: 1	2	3
13M178	1	T-6	107+91.0	**44.60'	43.83'	1	V	Y	N	32	3	44	3	56	4	58.0	3					60		NA	12	2	7	48	3	3	52	3	2.5								5	36	40
---	----	----	------------		------																			-----																			
13M178	2	T-6	108+03.0	**44.40'	43.60'	1	V	Y	N	8	3	24	5	32	3	40	4					45		NA	12	2	6	36	3	2.5													
---	----	----	------------		------																			-----																			
13M178	3	T-6	106+71.0	**44.10'	43.87'	1	V	Y	N	35	3	45	4	54	3	63	5					67		270	12	2	6	49	3	2.5											58		
---	-----	----	------------		43.51'	2	V	Y	N	34	3	46	3	56	3	58	4					60		-----	12	2	7	50	3	3	54	3	2.5								31	38	42
																								NA																			
FUTURE SCENARIO					------																			-----																			
13M178	1	T-6	107+91.0	**44.60'	43.83'	1	V	Y	N	25	5	44	3	56	4	58.0	3					60		NA	12	2	7	31	3	3	48	3	3	52	3	2.5					5	36	40
---	----	----	------------		------																			-----																			
13M178	2	T-6	108+03.0	**44.40'	43.60'	1	V	Y	N	8	3	24	5	32	3	40	4					45		NA	12	2	6	36	3	2.5	43	3	3										
---	----	----	------------		------																			-----																			
13M178	3	T-6	106+71.0	**44.10'	43.87'	1	V	Y	N	35	3	45	4	54	3	63	5					67		270	12	2	6	49	3	2.5											58		
---	-----	----	------------		43.51'	2	V	Y	N	34	3	46	3	56	3	58	4					60		-----	12	2	7	27	3	3	50	3	3	54	3	2.5					31	38	42
																								NA																			
---	-----	----	------------		------																			-----																			

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

SCALE AS NOTED
DESIGNED BY MO
DRAWN BY GS
CHECKED BY IR

HDR Engineering, Inc.
4830 W Kennedy Blvd,
Suite 400
Tampa, FL 33609-2548

DATE 06/2021
PROJECT NO. 850-6094060

Manatee County FLORIDA

MANATEE COUNTY PUBLIC WORKS

DESIGN ENGINEER MICHAEL J. OATES
FL. LICENSE NO. 49282

MAST ARM TABULATION

SHEET NO. T-8

10:17:56 AM 6/10/2021 PW:\3658\10001573\10151274\6.0_CAD_BIM\6.2_WIP\12345615201\signals\MSSGSG01.DGN

Erie Rd. and SR 62 Improvements

HDR Project Number: 10151274

Miscellaneous Structures

1.3 Mast Arm Data Table

For: Manatee County Public Works

STANDARD MAST ARM ASSEMBLIES DATA TABLE												
STRUCTURE ID NUMBERS	POLE ID NUMBERS	DESIGNATION	FIRST ARM		SECOND ARM		UF (deg)	LL (deg)	POLE			DRILLED SHAFT ID
			ARM ID	FAA (ft.)	ARM ID	SAA (ft.)			POLE ID	UAA (ft.)	UB (ft.)	
13M178	POLE 1	A70/S/H-P5/S	A70/S/H	28					P5/S	22.75	19.75	**
	POLE 2	A50/S/H-P3/S	A50/S/H	27.5					P3/S	22.75	19.75	**
	POLE 3	A70/D-A70/D-P6/D	A70/D	35	A70/D	28	270		P6/D	23.25	20.25	**

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.
5. Due to the proposed loading for Pole 1 - Arm 1 the A70/S/H arm is specified to be used for satisfying design requirements with FAA = 28 ft. resulting in 60 ft. arm length. Similarly Pole 3 - Arm 2 is specified as A70/D arm with SAA = 28 ft. to satisfy design requirements.

**SPECIAL FOUNDATION DATA TABLE									
POLE ID NUMBERS	SHAFT AND REINFORCEMENT								
	DA (ft.)	DB (ft.)	RA	RB	RC	RD (in.)	RE	RF (in.)	
POLE 1	22	5	11	18	10	8	-	-	
POLE 2	22	4.5	11	16	10	8	-	-	
POLE 3	22	5	11	18	10	8	-	-	

FOUNDATION NOTE:

Assumptions and Values used in design:

FOUNDATION DESIGN PARAMETERS					
POLE ID NUMBERS	SOIL LAYER THICKNESS (ft.)	SOIL FRICTION ANGLE (deg)	SOIL WEIGHT (pcf) (1)	SOIL TYPE (2)	WEIGHTED AVERAGE N-VALUE (3)
POLE 1	30	28	43	SAND	9
POLE 2	30	29	43	SAND	6
POLE 3	30	29	43	SAND	12

(1) Design water table is 0 ft. below surface
(2) Soil type is sand (cohesionless) or clay (cohesive)
(3) This value is determined over the length of the drilled shaft 'DA'

No.	REVISIONS	DATE	BY

SCALE AS NOTED
DESIGNED BY RT
DRAWN BY KE
CHECKED BY CAS

HDR Engineering, Inc.
2601 Cattlemen Road
Suite 400
Sarasota, FL 34232-6233

DATE 05/2021
PROJECT NO. 850-6094060

Manatee County FLORIDA
MANATEE COUNTY PUBLIC WORKS

DESIGN ENGINEER CHESTER A. SMITH III
FL. LICENSE NO. 70756

STANDARD MAST ARM DATA TABLES

8:08:12 AM 6/11/2021 PW:\3658\10001573\10151274\6.0_CAD_BIM\6.2_WIP\12345615201\struct\MiscStrMastArm01.dgn

Erie Rd. and SR 62 Improvements

HDR Project Number: 10151274

Miscellaneous Structures

1.4 Pole 1

For: Manatee County Public Works

Erie Rd. and SR 62 Improvements

HDR Project Number: 10151274

Miscellaneous Structures

1.4 Pole 1

1.4.1 Geometry and Loading

For: Manatee County Public Works

Project:	Erie Rd. and SR 62 Improvements	Computed:	RT	Date:	5/26/2021
Subject:	Misc. Structures	Checked:		Date:	
Task:	Pole 1	Page:	1	of:	1
Job #:	850-6094060	No:			

General Input

Pole No.	1		
Station	107+91.00		
Offset	51.0 LT		
County	Manatee		Choose "County" from drop-down list
Wind speed	150	mph	Basic wind speed for Manatee County is 150 per FDOT SDG, Jan. 2018, Table 2.4.1-1
Luminaire Orientation	N		Enter N for no luminaire, otherwise enter angle measured CCW from arm 1 (0, 45, 90)
Signal Orientation (V or H)	V		V for vertical, H for horizontal
Arm 2 Orientation	N		Enter N for no arm 2, otherwise enter angle between dual arms
Backplates (Y or N)	Y		Used in determining arm con. ht. (FDM 232 req. the use of backplates on Mast Arms)
Elevation below Arm 1 tip	43.83	ft	
Elevation below Arm 2 tip	N		Enter N for no arm 2
Elevation at top of foundation	44.60	ft	
Arm center to signal / sign bottom	2.83	ft	Tabulated based on input for Arm 1 Signals and Signs
Arm connection height (min)	19.34	ft	Based on 17.5 ft clearance
Arm connection height	19.75	ft	Dimension 'UB'; Use 0.25 ft increments
Arm connection height (max)	20.84	ft	Based on 19.0 ft clearance
Arm 1 length	60	ft	Arm 1 is the longer arm.
Arm 2 length	N		Enter N for no arm 2.
Soil type	1		0 for clay (cohesive soil), 1 for sand (cohesionless soil)
Effective soil weight	43	pcf	
Phi	28	deg.	
N-blowcount	9		Enter initial value from 'Average N-count V2.0.xls' or as directed by geotech
Foundation offset	0.5	ft	Distance from finish ground to top of shaft

Arm 1 Signals and Signs - Vertical Geometry Check

Signal Head Type	1/2 Signal Height (ft.)	Height of Sign Dim. (ft.)	Width of Sign Dim. (ft).	Sign Attachment	Sign Location	Sign Area Check	Sign Location Check	1/2 Sign Height (ft.)
5-Doghouse	*2.25*	2.00	7.00	n/a	outside roadway	*n/a*	*n/a*	*0*
4	*2.83*	3.00	3.00	n/a	over roadway	*n/a*	*n/a*	*1.5*
3	*2.25*	3.00	2.50	n/a	over roadway	*n/a*	*n/a*	*1.5*
n/a	*0.00*	0.00	0.00	n/a	n/a	*n/a*	*n/a*	*0*
n/a	*0.00*	0.00	0.00	n/a	n/a	*n/a*	*n/a*	*0*

Arm 2 Signals and Signs - Vertical Geometry Check

Signal Head Type	1/2 Signal Height (ft.)	Height of Sign Dim. (ft.)	Width of Sign Dim. (ft).	Sign Attachment	Sign Location	Sign Area Check	Sign Location Check	1/2 Sign Height (ft.)
n/a	*0.00*	0.00	0.00	n/a	n/a	*n/a*	*n/a*	*0*
n/a	*0.00*	0.00	0.00	n/a	n/a	*n/a*	*n/a*	*0*
n/a	*0.00*	0.00	0.00	n/a	n/a	*n/a*	*n/a*	*0*
n/a	*0.00*	0.00	0.00	n/a	n/a	*n/a*	*n/a*	*0*
n/a	*0.00*	0.00	0.00	n/a	n/a	*n/a*	*n/a*	*0*

Due to proposed loading the arm and pole size are increased to meet the fatigue stress range for galloping based on Mathcad Analysis.

Analysis Requirement

Mathcad Analysis Required = **Yes**

The following criteria are not satisfied:
1 Effective soil weight < 50 pcf
2 Friction angle < 30 deg
3 N-value < 15

Information for Standard Mast Arm Assemblies Data Table

Arm 1 Type =	Heavy Duty	Arm 2 Type = n/a
Designation	***~~A60/S/H - P4/S~~***	***A70/S/H-P5/S***
Arm 1 ID	***~~A60/S/H~~***	***A70/S/H***
FAA (ft)	***28***	
Arm 2 ID		Leave blank in data table
SAA (ft)		Leave blank in data table
UF (deg)		Leave blank in data table
LL (deg)		Leave blank in data table
Pole ID	***~~P4/S~~***	***P5/S***
UAA (ft)	***22.75***	
UB (ft)	***19.75***	

Pay Item Number

649-2A-BB Steel Mast Arm Assembly

Operation =	(Furnish & Install)	Choose correct "Operation" from drop-down list
AA =	1	
Arm 1 =	60	Arm length used to determine Pay Item Number, See SPI for Arm Combinations
Arm 2 =	Single	If Arm 2 = N or Arm 2 Orientation = N, then 'Single' will be displayed
BB =	10	
Pay Item Number is	***649-21-10***	Provide to Signal Designer for verification

Arm 1 remains at 60' length-No change to pay Item.

Signal Inputs:

The design accounts for MVDS devices as a 14" X 14" sign.

FDOT's 'mastarm-index-649-030-v1-4.xlsx' program limits the total number of signal / sign inputs to 10, and does not have an option for 1-section signal head; so the devices are accounted for by using a 14" X 14" sign.

FDOT's 'MastArmV1.2.xmcd' limits the number of sign inputs to 5, and does not have an option for 1-section signal head; so the the devices are accounted for by using a 14" X 14" sign.

Based on the inputs being limited to 5 signs in FDOT's 'MastArmV1.2.xmcd', the MVDS at some locations are combined with other signs or other MVDS and entered as a single location using the centroid as the offset distance from the pole upright. The following changes are made:

1. Sign A; Area=14sf; Distance=12ft is combined with MVDS Location 1 Area=1.4 sf; Distance=5ft. The combined sign Area = 15.4sf; Distance = 12ft (Weighted Average rounded up).

2. MVDS Location 2; Area=1.4sf; Distance=36ft is combined with MVDS Location 3 Area=1.4 sf; Distance=40ft. The combined sign Area = 2.8sf; Distance = 38ft (Weighted Average).

Analysis:

1. FDOT's 'MastArmV1.2.xmcd' is used only to perform the foundation analysis. Other design sections are collapsed as individual components of the Mast Arm do not require detailed design based on the results from FDOT's 'mastarm-index-649-030-v1-4.xlsx'.

2. The signal and sign configuration for "Future Scenario" is chosen for foundation design due to higher moment demand as indicated by FDOT's 'mastarm-index-649-030-v1-4.xlsx'.

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

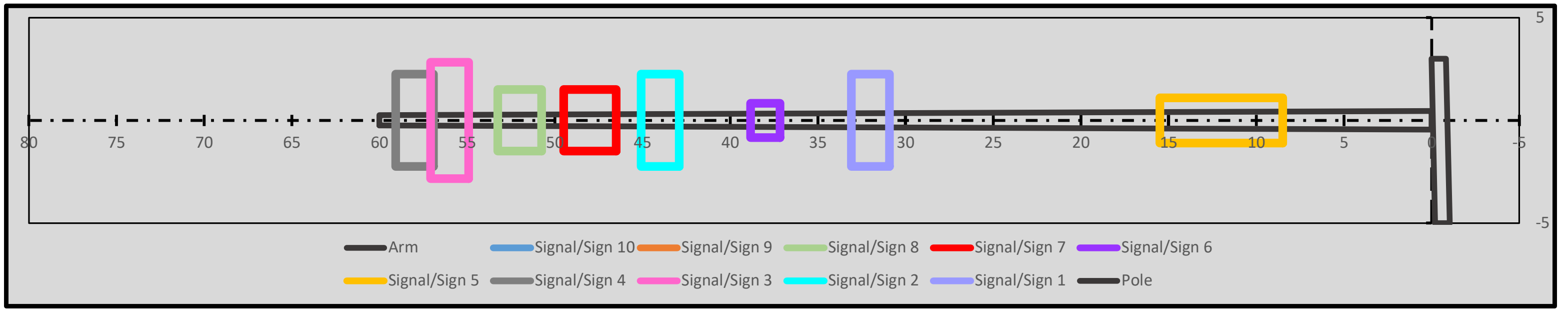
Arm 1 Length: 30, 40, 50, [60], 70, 78

Back Plates?: ● Yes ○ No

Luminaire?: ○ Yes ● No

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
Dist from Pole (ft.)			52	48	38	12	58	56	44	32
Type (None / 3 Head / 4 Head / 5 Head / Sign)	● None	● None	● Sign	● Sign	● Sign	● Sign	● 3 Head	● 4 Head	● 3 Head	● 3 Head
Sign Width (in.)			30	36	20	84				
Sign Height (in.)			36	36	20	26				
Area (SF)	0.0	0.0	7.5	9.0	2.8	15.4	9.8	12.3	9.8	9.8
M_{wl}, (kip*ft)	0	0	26	29	7	12	38	46	29	21



Arm 1 Length (ft)	60	
Design Standard Index 17743	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	340

Arm 1 Loads	Regular	Heavy Duty
1.1*Arm M_{dl} (kip*ft)	62	68
Arm M_{wl} (kip*ft)	64	71
1.1*Sign/Signal M_{dl} (kip*ft)	16	
Sign/Signal M_{wl} (kip*ft)	208	
Total Moment ($M_{extreme}$)	283	292

Mast Arm Assembly Designation
~~One Arm Assembly~~ ~~A60/S-P4/S-DS/14/5~~

Analysis requires A70/S/H-P5/S

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 at 22 ft.

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)

FUTURE SCENARIO

Mast Arm Assembly Information

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

Signal Orientation: ◉ Vertical ○ Horizontal

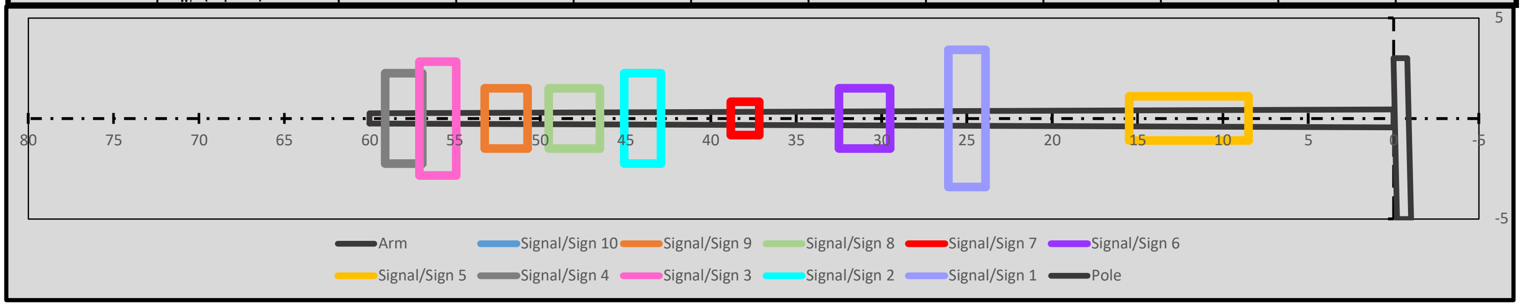
Back Plates?: ◉ Yes ○ No

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

Luminaire?: ○ Yes ◉ No

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
Dist from Pole (ft.)		52	48	38	31	12	58	56	44	25
Type (None / 3 Head / 4 Head / 5 Head / Sign)	◉ None	◉ Sign	◉ Sign	◉ Sign	◉ Sign	◉ Sign	◉ 3 Head	◉ 4 Head	◉ 3 Head	◉ 5 Head
Sign Width (in.)		30	36	20	36	84				
Sign Height (in.)		36	36	20	36	26				
Area (SF)	0.0	7.5	9.0	2.8	9.0	15.4	9.8	12.3	9.8	14.8
M_{wl} (kip*ft)	0	26	29	7	19	12	38	46	29	25



Arm 1 Length (ft)	60	
Design Standard Index 17743	Regular	Heavy Duty
Dia. at Arm Base (in)	15	16
Wall Thickness (in)	0.3750	0.3750
Resistance ($M_r = \phi M_n$) (kip*ft)	300	340

Arm 1 Loads	Regular	Heavy Duty
1.1*Arm M_{dl} (kip*ft)	62	68
Arm M_{wl} (kip*ft)	64	71
1.1*Sign/Signal M_{dl} (kip*ft)	18	
Sign/Signal M_{wl} (kip*ft)	231	
Total Moment ($M_{extreme}$)	305	314

Mast Arm Assembly Designation
~~One Arm Assembly~~ ~~A60/S/H-P4/S-DS/16/4.5~~

Analysis requires A70/S/H-P5/S

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 at 22 ft.
No foundation offset is considered. If the top of drilled shaft > 2 feet above ground, run the Mathcad Mast Arm Program.

Erie Rd. and SR 62 Improvements

HDR Project Number: 10151274

Miscellaneous Structures

1.4 Pole 1

1.4.2 Average N-count

For: Manatee County Public Works

Project:	Erie Rd and SR-62 Improvement	Computed:	RT	Date:	5/26/2021
Subject:	Misc. Structures	Checked:		Date:	
Task:	Average N Count	Page:	1	of:	1
Job #:	850-6094060				

Boring Details		
Depth (ft)		N-count
Total	Step	
2	2	7
4	2	3
6	2	2
8	2	4
10	2	3
12.5	2.5	4
15	2.5	11
17.5	2.5	14
20	2.5	18
22.5	2.5	13
25	2.5	28
27.5	2.5	3
30	2.5	5
Average N-count		9.27
Initial Design N_{AVG}		11.00

Pole #	Pole 1
Boring #	B-2
Station	107+91.00/51.0 LT
N-multiplier	1.2

Automatic Hammer Used; therefore N-multiplier = 1.24

Notes: (Calculate N-value for drilled shaft)

1- Automatic hammer N value multiplier and Boring details (soil layers thicknesses and number of counts) should be entered as inputs.
2- Initial design N value from "Boring Details" table is used to determine drilled shaft lengths in Mathcad.
3- Drilled shaft length output from the Mathcad file should be entered in the table below.
4- Final design N value for each shaft based on the average of layers where drilled shaft is surrounded with will be calculated in the "Drilled Shaft Details" table.
5- If New N value is smaller than original value, Mathcad file should be updated with new N value to calculate final drilled shaft length.

Drilled Shaft Length After Initial Analysis
19.5

(Mathcad First Output)

Drilled Shaft Details		
Depth (ft)		N-count
Total	Step	
2	2	7
4	2	3
6	2	2
8	2	4
10	2	3
12.5	2.5	4
15	2.5	11
17.5	2.5	14
20	2.5	18
-	-	-
-	-	-
-	-	-
-	-	-
Average N-count		7.78
Final Design N_{AVG}		9.00
Update N_{AVG}? (Y/N)		YES

Final Drilled Shaft Length
22

(Mathcad Final Output)

Erie Rd. and SR 62 Improvements

HDR Project Number: 10151274

Miscellaneous Structures

1.4 Pole 1

1.4.3 Foundation Analysis

For: Manatee County Public Works

FDOT Mast Arm Traffic Signal Support Analysis Program V1.2

State Structures Design Office

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

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

Reference

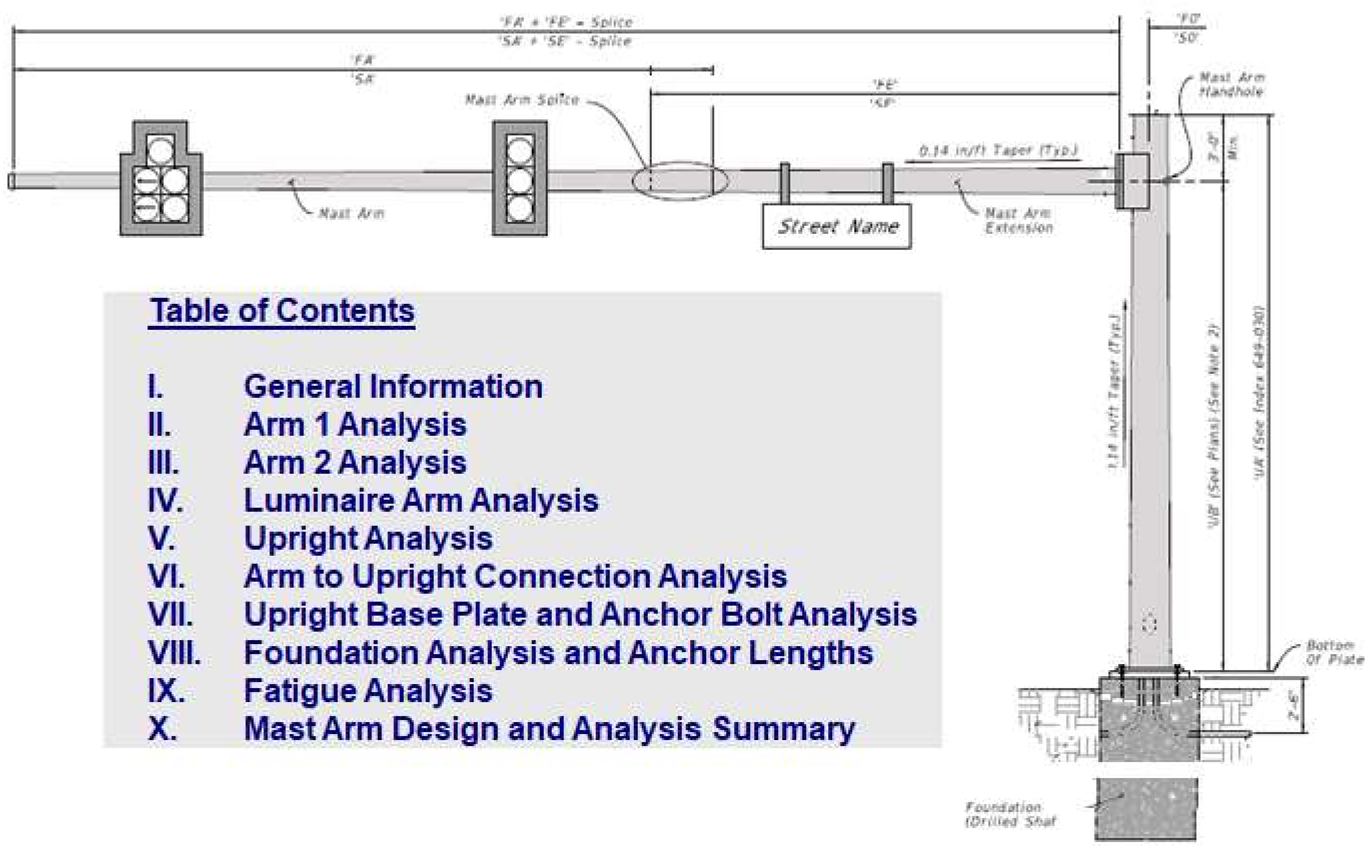


Table of Contents

Data Folder and Files

Data Files Folder

Change Folder

C:\Users\rtallur\Desktop\Data\

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

A70SH-P5SL-DS165.dat

Refresh List

Open File

I. General Information and Sign & Signal Data

Enter Project Information

Project Name	Erie Rd and SR 62 Improvements
Project No.	850-6094060
Designed by	RT
Date	5 / 27 / 2021
Checked by	
Date	
Signal Name	Pole 1
Station/Offset	107+91.00/51.0 LT

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	25	5
2	44	3
3	56	4
4	58	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	12	15.4
2	31	9
3	38	2.8
4	48	9
5	52	7.5

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 = "A70SH-P5SL-DS165.dat" $V_{extreme} = 150 \cdot mph$

Values for $Dist_{splice.from.base.arm}$ *that give a base diameter in even inches*

"Wall Thickness"	"dia-1in"	"dia-2in"	"dia-3in"	"dia-4in"	"dia-5in"	"d-6in"
$t_{wall.arm} = 0.179 \cdot in$	**9.9**·ft	**17.0**·ft	**24.2**·ft	**31.3**·ft	**38.5**·ft	**45.6**·ft
$t_{wall.arm} = 0.25 \cdot in$	**10.9**·ft	**18.0**·ft	**25.2**·ft	**32.3**·ft	**39.4**·ft	**46.6**·ft

Help - Base Diameters | Help - Arm Tip Diameter | Help - Tube Wall Thickness | Help - Arm Lengths | Recommended Distance to Splice

Reference:C:\Users\rtallur\Desktop\LRFD Equation Module.xmcd(R)

Enter Arm 1 Data

Arm Length (ft)	Base Diameter (in)	Wall Thickness 1 (in)	Wall Thickness 2 (in)	Distance to Splice (ft)
$L_{total.arm1} = 60\,ft$	18	0.25	0.375	32
feet, 40 ft. max. for 1 piece arms	*Measured flat to flat* **'FG'**	*for 1 & 2 piece arms* **'FD'**	*for 2 piece arms only* **'FH'**	*for 2 piece arms only* (**'Larm' - 'FA'**)

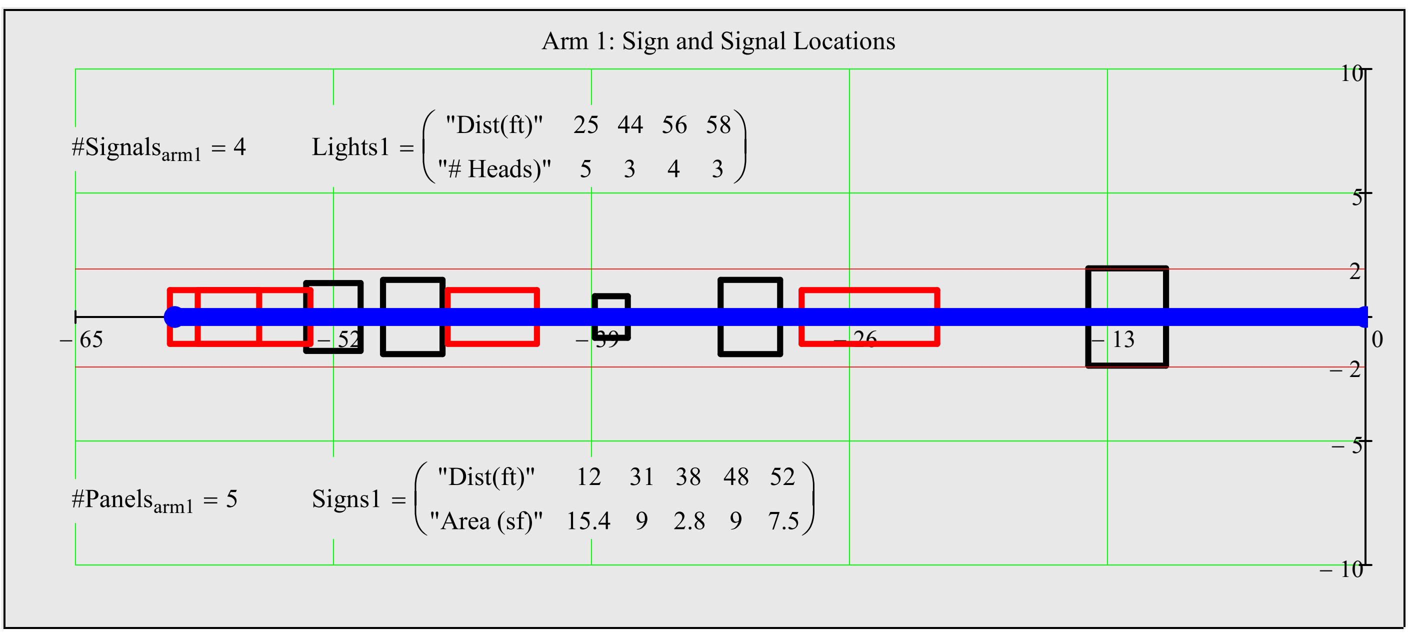
Arm 1 Analysis including Existing Mast Arm Analysis (Additional Variables Required)

Arm 1 Combined Force Interaction Ratio and Deflection

BackPlate = "Rigid, 6 inches wide"

$\max(CFI_{arm1}) = 0.74$ $\max(\Delta_{arm1}) = 8.8 \cdot in$ $2 \cdot deg \cdot L_{total.arm1} = 25.1 \cdot in$

Summary - Arm 1 Geometry and Loading



$\max(CFI_{arm1}) = 0.74$

$\max(\Delta_{arm1}) = 8.8 \cdot in$

$L_{total.arm1} = 60\,ft$

'FA'= 'FE'= $L_{fabricated.arm1} = \begin{pmatrix} 28.0 \\ 35.0 \end{pmatrix} \cdot ft$

'FB'= 'FF'= $Diameter_{tip.arm1} = \begin{pmatrix} 10.12 \\ 13.10 \end{pmatrix} \cdot in$

'FC'= 'FG'= $Diameter_{base.arm1} = \begin{pmatrix} 14.04 \\ 18.00 \end{pmatrix} \cdot in$

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

$Classification_{arm1} = \begin{pmatrix} \text{"Compact"} \\ \text{"Compact"} \end{pmatrix}$

$L_{splice.provided.arm1} = 3 \cdot ft$

III. Arm 2 Analysis

InputDataFile = "A70SH-P5SL-DS165.dat" $V_{extreme} = 150 \cdot mph$

$Dist_{splice.from.base.arm}$ *values that give a base diameter in even inches*

"Wall Thickness"	$\Delta dia = 1 \cdot in$	$\Delta dia = 2 \cdot in$	$\Delta dia = 3 \cdot in$	$\Delta dia = 4 \cdot in$	$\Delta dia = 5 \cdot in$	$\Delta dia = 6 \cdot in$
$t_{wall.arm} = 0.179 \cdot in$	***9.9***·ft	***17.0***·ft	***24.2***·ft	***31.3***·ft	***38.5***·ft	***45.6***·ft
$t_{wall.arm} = 0.25 \cdot in$	***10.9***·ft	***18.0***·ft	***25.2***·ft	***32.3***·ft	***39.4***·ft	***46.6***·ft

Help - Base Diameters | Help - Arm Tip Diameter | Help - Tube Wall Thickness | Help - Arm Lengths | Recommended Distance to Splice

Enter Arm 2 Data

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

Arm 2 Analysis including Existing Mast Arm Analysis

Arm 2 Combined Force Interaction Ratio and Deflection

$\max(CFI_{arm2}) = 0.00$ BackPlate = "Rigid, 6 inches wide"

Summary - Arm 2 Geometry and Loading $\max(\Delta_{arm2}) = 0.0 \cdot in$ $2 \cdot deg \cdot L_{total.arm2} = 0 \cdot in$

Arm 2: Sign and Signal Locations

10

$\#Signals_{arm2} = 0$ $Lights2 = \begin{pmatrix} \text{"Dist(ft)"} & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\ \text{"\# Heads)"} & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \end{pmatrix}$

$\#Panels_{arm2} = 0$ $Signs2 = \begin{pmatrix} \text{"Dist(ft)"} & 0 & 0 & 0 & 0 & 0 \\ \text{"Area (sf)"} & 0 & 0 & 0 & 0 & 0 \end{pmatrix}$

– 10

$-(L_{total.arm2} + 5 \cdot ft)$ 0

$\max(CFI_{arm2}) = 0.00$

'SB'= 'SF'= $Diameter_{tip.arm2} = \begin{pmatrix} 0.00 \\ 0.00 \end{pmatrix} \cdot in$

$Classification_{arm2} = \begin{pmatrix} \text{"Compact"} \\ \text{"N/A"} \end{pmatrix}$

$\max(\Delta_{arm2}) = 0.0 \cdot in$

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

$L_{splice.provided.arm2} = 0 \cdot ft$

$L_{total.arm2} = 0$ ft

'SA'= 'SE'= $L_{fabricated.arm2} = \begin{pmatrix} 0.0 \\ 0.0 \end{pmatrix} \cdot ft$

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

IV. Luminaire Arm Analysis

InputDataFile = "A70SH-P5SL-DS165.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 = "A70SH-P5SL-DS165.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)	
22.75	19.75	24	0.375	7.4	***arm 1 gap***
'UA'	'UB'	'UD' *measured flat to flat*	'UE'		***arm 2 gap***

Analyze Upright

Upright Combined Force Interaction Ratio and Deflections

$Classification_{pole} = "Compact"$

$max(CFI_{pole}) = 0.50$

$Check_{slope} = "OK"$

$Check_{deflection} = "OK"$

$max(\Delta_{x.dl}) = 0.71 \cdot in$

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

$Slope_z = 0 \cdot deg$

$Slope_x = 0.37 \cdot deg$

$Diameter_{conn.pole} = 21.3 \cdot in$

$$max\left(\begin{pmatrix} Diameter_{base.arm1_0} \\ Diameter_{base.arm2_0} \end{pmatrix}\right) = 14 \cdot in$$

'UA'= $Y_{pole} = 22.75 \cdot ft$

'UB'= $Y_{arm.conn} = 19.75 \cdot ft$

'UC'= $Diameter_{tip.pole} = 20.8 \cdot in$

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

'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 = "A70SH-P5SL-DS165.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'= $h_{conn.plate} = 30 \cdot in$ $D/C_{ht.conn.plate} = 0.80$ $CheckHt_{conn.plate} = \text{"OK"}$

$D/C_{width.conn.plate_0} = 0.92$

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

$$\begin{pmatrix} D/C_{t.baseplate.arm_0} \\ CFI_{t.vert.plate_0} \\ CSR_{bolt.conn_0} \end{pmatrix} = \begin{pmatrix} 0.83 \\ 0.46 \\ 0.55 \end{pmatrix}$$

$\#Bolts_{conn_0} = 6$

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

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

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

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

'FO'= $Offset_{conn_0} = 18.0 \cdot in$

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

'FR'= $t_{conn.plate_0} = 2.50 \cdot in$

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

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

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

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

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

$\#Bolts_{conn_1} = 0$

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

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

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

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

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

VII. Upright Base Plate & Anchor Bolt Analysis

InputDataFile = "A70SH-P5SL-DS165.dat"

Enter Anchorage Data

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

Help - Number of Anchor Bolts

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

Analyze Base Plate & Anchors

Base Plate and Anchor Summary

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

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

$CSR_{anchor} = 0.24$

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

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

$CheckCSR_{anchorbolt} = \text{"OK"}$

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

VIII. Foundation Analysis & Anchor Bolt Lengths

InputDataFile = "A70SH-P5SL-DS165.dat"

Enter Drilled Shaft Data

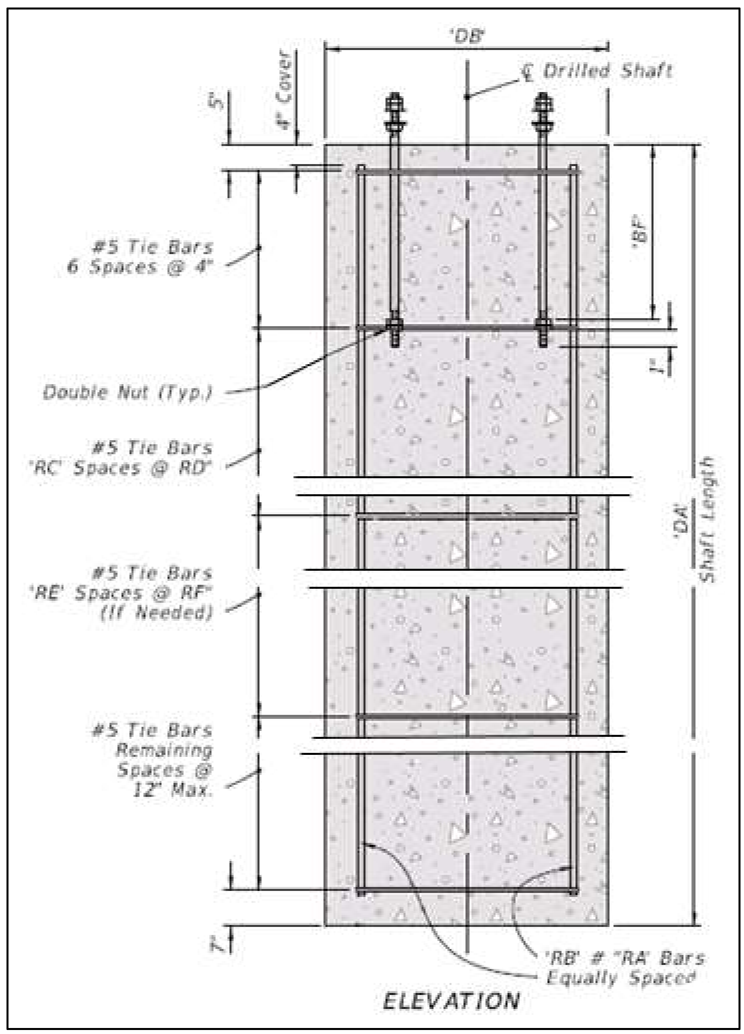
Soil Type	Sand / Clay (Sand selected)	
Soil Density, γ_{soil} (45-50 pcf typ.)	43	pcf
Friction Angle, ϕ (Sands)	28	deg
SPT Number (N_{blows} 5 min.) (Sands)	9	
Shear Strength, c (Clays)	2000	psf
Ground to Top of Shaft Offset	0.5	ft

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 (#5 selected)	



Analyze Foundation

define variable for saving in output file

$$inpLuminaire := \begin{pmatrix} inpYLuminaire \\ inpXLuminaire \\ inpLumBaseDia \\ inpLumWallThk \\ inpLumSlope \\ inpLumRadius \\ inpLumBoltDia \\ inptLumBasePlate \end{pmatrix} \qquad outLuminaire := inpLuminaire$$

$$inpUpright := \begin{pmatrix} inpUprightTotHeight \\ inpUprightHtToConn \\ inpUprightBaseDia \\ inpUprightWallThk \\ inpAnchorBoltDia \\ inpNumOfAnchorBolts \\ inpConnPlateHeight \end{pmatrix} \qquad outUpright := inpUpright$$

$$inpConn := \begin{pmatrix} inpArm1Gap & inpArm1VertPlateThk & inpArm1BoltDia & inpArm1BasePlateThk & inpArm1BasePlateWidth \\ inpArm2Gap & inpArm2VertPlateThk & inpArm2BoltDia & inpArm2BasePlateThk & inpArm2BasePlateWidth \end{pmatrix}$$

$$outConn := inpConn$$

$$inpShaft := \begin{pmatrix} num2str(inpSoilType) \\ inpSoilDensity \\ inpFrictionAngle \\ inpNumBlows \\ inpShearStrength \\ "0.0" \\ "0.0" \\ "0.0" \\ inpShaftOffset \\ inpNumSpacesB \\ inpStirrupSpacingB \\ inpNumSpacesC \\ inpStirrupSpacingC \\ inpStirrupSize \end{pmatrix} \qquad outShaft := inpShaft$$

Foundation Data

$SoilType := inpSoilType = 0$

$\gamma_{soil} := str2num(inpSoilDensity) \cdot pcf = 43 \cdot pcf$

$\phi_{soil} := str2num(inpFrictionAngle) \cdot deg = 28 \cdot deg$

$N_{blows} := \text{str2num}(\text{inpNumBlows}) = 9$

$c_{soil} := \text{str2num}(\text{inpShearStrength}) \cdot psf = 2000 \cdot psf$

$\text{Offset} := \text{str2num}(\text{inpShaftOffset}) \cdot ft = 0.5\, ft$

$\text{NumSpacesStirrupsB} := \text{str2num}(\text{inpNumSpacesB}) = 10$

$s_{v_1} := \text{str2num}(\text{inpStirrupSpacingB}) \cdot in = 8 \cdot in$

$\text{NumSpacesStirrupsC} := \text{str2num}(\text{inpNumSpacesC}) = 0$

$s_{v_2} := \text{str2num}(\text{inpStirrupSpacingC}) \cdot in = 0 \cdot in$

$\text{StirrupBarSize} := \text{inpStirrupSize} = 5$

$\gamma_{water} := 62.4 \cdot pcf = 62.4 \cdot pcf$ *(not used)*

Foundation Design References

LRFD = AASHTO LRFD Bridge Design Specifications

SDG = FDOT Structures Design Guidelines

ACI = ACI 318 Structural Concrete Building Code

SM V3 = FDOT Structures Manual Volume 3

Spec = FDOT Standard Specifications

UF Report = FDOT/University of Florida Report BD545 RPWO #54

Applied Loads

(From Arm1 Design)

$V_{extreme} = 150 \cdot mph$

(from Base Plate Design)

$\#AnchorBolts = 8$

$d_{anchorbolt} = 2 \cdot in$

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

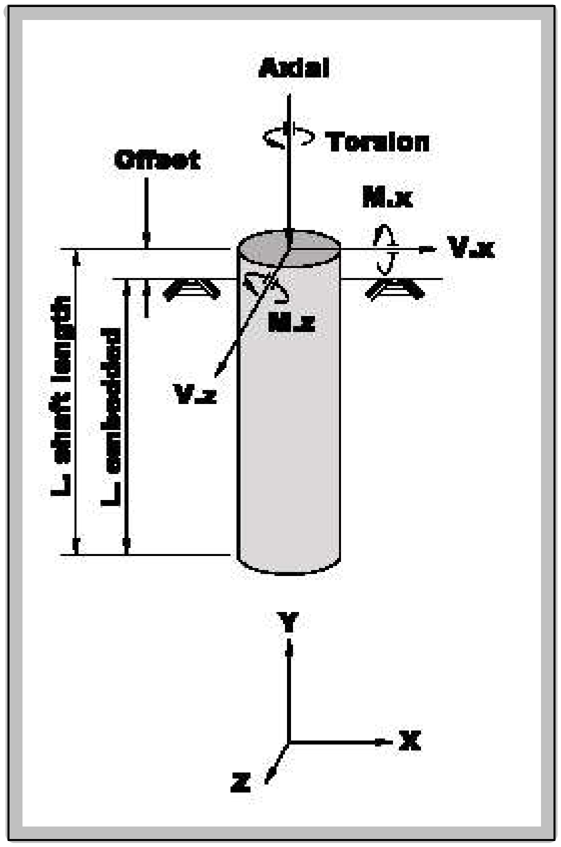
$T_{u.anchor} = 40.6 \cdot kip$

(from Upright Design)

$M_{x.polebase} = \begin{pmatrix} 0 \\ 187.5 \\ 187.5 \end{pmatrix} \cdot kip \cdot ft$

$M_{y.polebase} = \begin{pmatrix} 310.7 \\ 0 \\ 310.7 \end{pmatrix} \cdot kip \cdot ft$

$M_{z.polebase} = \begin{pmatrix} 0 \\ 107.7 \\ 107.7 \end{pmatrix} \cdot kip \cdot ft$



$LoadCaseT = 0$ $LoadCaseOT = 1$ $LoadCaseCFI = 2$

$V_{x.polebase} = \begin{pmatrix} 0 \\ 0 \\ 0 \end{pmatrix} \cdot kip$ $AxialForce_{polebase} = \begin{pmatrix} 5.9 \\ 5.9 \\ 5.9 \end{pmatrix} \cdot kip$ $V_{z.polebase} = \begin{pmatrix} 0 \\ 10 \\ 10 \end{pmatrix} \cdot kip$

Foundation Diameter

$Diameter_{shaft} := Diameter_{boltcircle.pole} + 12 \cdot in + 12 \cdot in = 4.67\,ft$

round shaft diameter up to the nearest half foot dimension to accommodate available coring equipment

$Diameter_{shaft} := Ceil\left(Diameter_{shaft}, \frac{1}{2} \cdot ft\right) = 5\,ft$

$Diameter_{shaft.custom} := 5 \cdot ft$

$Diameter_{shaft} := if\left[\left(Diameter_{shaft.custom} > 0 \cdot ft\right), Diameter_{shaft.custom}, Diameter_{shaft}\right] = 1.5$

$b := Diameter_{shaft}$

Shaft Depth Required to Resist Overturning

the following calculations are consistent with FDOT's Drilled Shaft Program V1.1

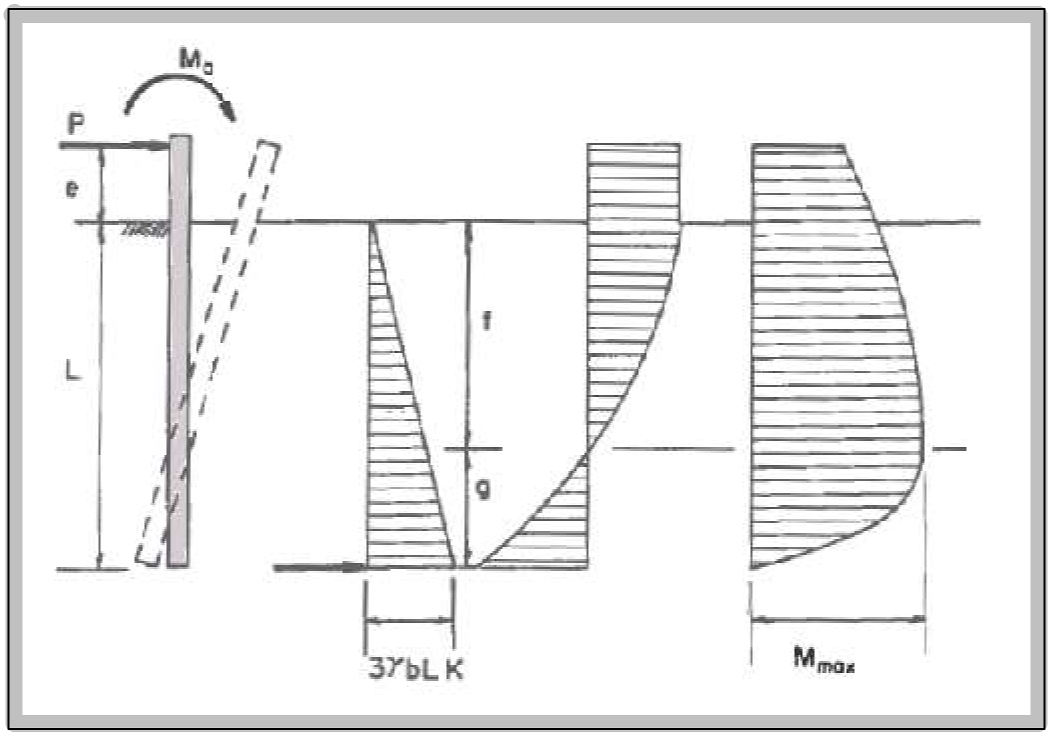
$\phi_{ot} := 0.6$ **SM V3 13.6** Offset = 0.5·ft *vertical distance between top of foundation and ground line*

$$M_u := \sqrt{\left(M_{x.polebase_{LoadCaseOT}}\right)^2 + \left(M_{z.polebase_{LoadCaseOT}}\right)^2} = 216.3 \cdot kip \cdot ft$$

$$P_u := \sqrt{\left(V_{x.polebase_{LoadCaseOT}}\right)^2 + \left(V_{z.polebase_{LoadCaseOT}}\right)^2} = 10.04 \cdot kip$$

$$T_u := M_{y.polebase_{LoadCaseT}} = 310.7 \cdot kip \cdot ft$$

short free-head pile in ***cohesionless soil*** *using Broms method*



Deflection, load, shear and moment diagram for a short pile in cohesionless soil that is unrestrained against rotation.

$$K_p := \tan\left(45 \cdot deg + \frac{\phi_{soil}}{2}\right)^2 = 2.8 \qquad e_{sand} := Offset = 0.5\,ft$$

Guess value $L_{otSand} := 8 \cdot ft$

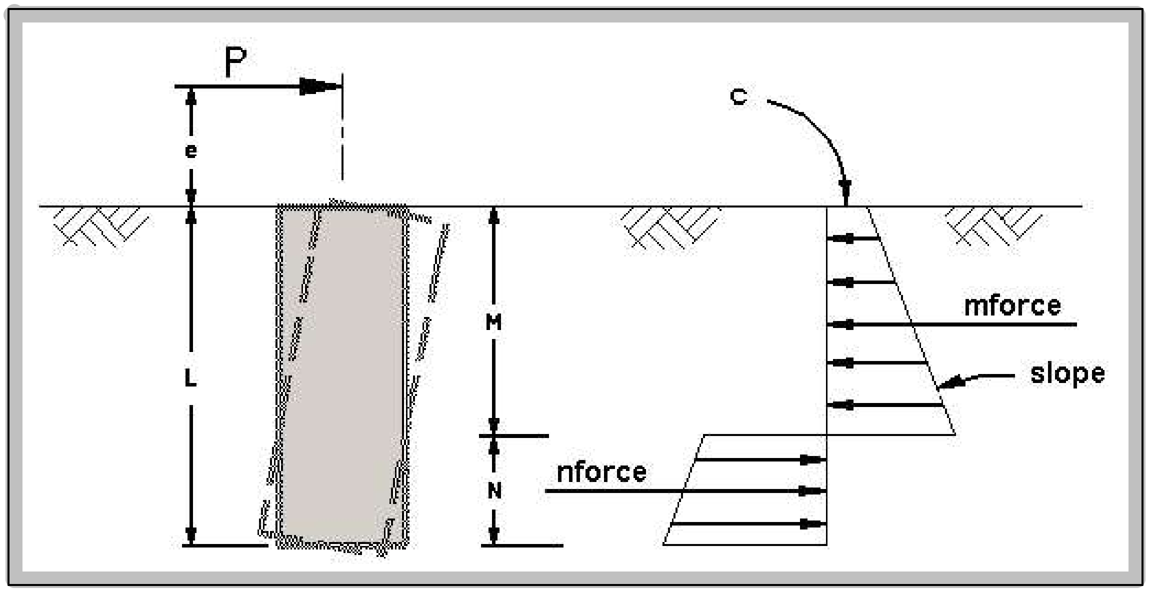
Given $P_u \cdot \left(e_{sand} + L_{otSand}\right) + M_u = \phi_{ot} \cdot \left[\left(3 \cdot \gamma_{soil} \cdot b \cdot L_{otSand} \cdot K_p\right) \cdot \left(\frac{1}{2} \cdot L_{otSand}\right) \cdot \left(\frac{1}{3} \cdot L_{otSand}\right)\right]$

$L_{otSand} := Find\left(L_{otSand}\right) = 12.5\,ft$

$L_{otSand} := \text{ceil}\left(\frac{L_{otSand}}{ft}\right)\cdot ft = 13\,ft$ *(round up to next foot)*

$$D/C_{otSand} := \frac{M_u + P_u\cdot(e_{sand} + L_{otSand})}{\frac{(\phi_{ot})\cdot\gamma_{soil}\cdot b\cdot L_{otSand}^{3}\cdot K_p}{2}} = 0.9$$

short free-head pile in cohesive soil using Modified Broms method for L < 3b (see reference file for derivation)



Deflection, load, shear and moment diagram for a short pile in cohesive soil that is unrestrained against rotation.

$c_{soil} := \text{if}[(c_{soil} = 0\cdot ksf), 0.1\cdot ksf, c_{soil}] = 2\cdot ksf$ $c_{soil} = 2000\cdot psf$

$Slope := 8\cdot\frac{c_{soil}}{3\cdot b} = 1.1\cdot\frac{kip}{ft^3}$ $e_{clay} := \frac{M_u}{P_u} + Offset = 22\,ft$

$nforce(M,N) := [Slope\cdot(2\cdot M + N) + 2\cdot c_{soil}]\cdot N\cdot\frac{b}{2}$ $mforce(M) := (2\cdot c_{soil} + M\cdot Slope)\cdot M\cdot\frac{b}{2}$

$$m\_arm(M) := e_{clay} + \frac{M}{3}\cdot\frac{2\cdot(M\cdot Slope + c_{soil}) + c_{soil}}{M\cdot Slope + 2\cdot c_{soil}}$$

$$n\_arm(M,N) := e_{clay} + M + \frac{N}{3}\cdot\frac{2\cdot(N\cdot Slope + M\cdot Slope + c_{soil}) + (M\cdot Slope + c_{soil})}{Slope\cdot(2\cdot M + N) + 2\cdot c_{soil}}$$

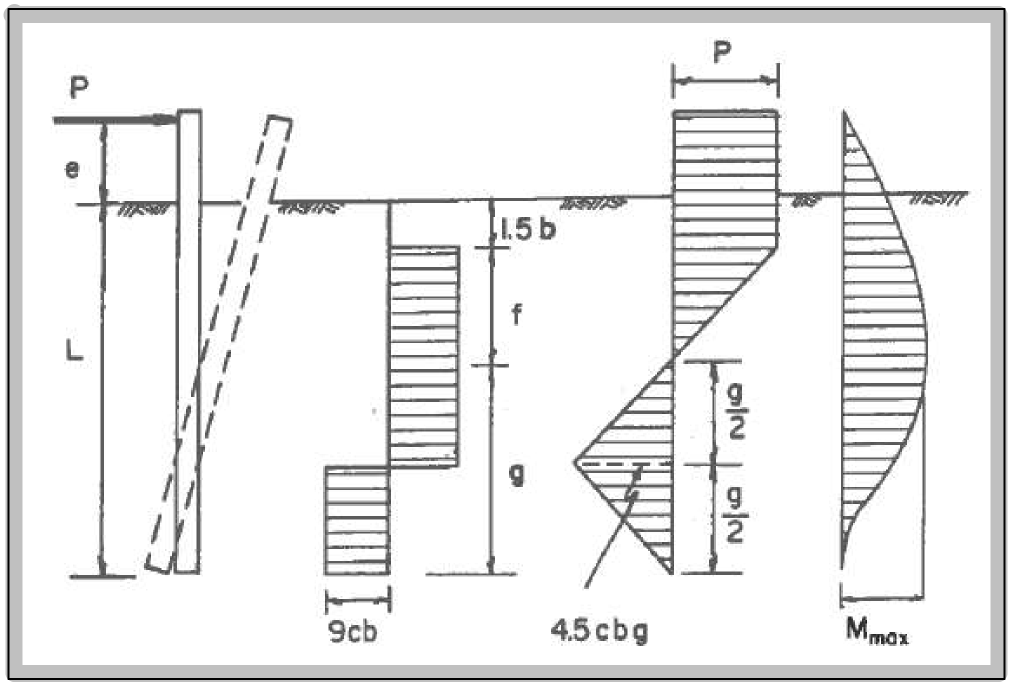
Guess value $M := 4.0\cdot ft$ $N := 4.0\cdot ft$

Given $P_u + \phi_{ot}\cdot nforce(M,N) = \phi_{ot}\cdot mforce(M)$ $mforce(M)\cdot m\_arm(M) = nforce(M,N)\cdot n\_arm(M,N)$

$\begin{pmatrix} M \\ N \end{pmatrix} := Find(M,N)$ $L_{ot1Clay} := M + N = 8.1\,ft$

$L_{ot1Clay} := ceil\left(\frac{L_{ot1Clay}}{ft}\right)\cdot ft = 9\ ft$ *(round up to next foot)*

*short free-head pile in **cohesive soil** using Regular Broms method for L > 3b*



Deflection, load, shear and moment diagram for a short pile in cohesive soil that is unrestrained against rotation.

$M_{max.clay}$ *equation is derived from the integration of the upper part of the shear diagram to the point of zero shear.*

$$f := \frac{P_u}{\phi_{ot}\cdot 9\cdot c_{soil}\cdot b} = 0.2\ ft$$

$$M_{max.clay} := P_u\cdot\left(e_{clay} + 1.5\cdot b + 0.5\cdot f\right) = 297.5\cdot kip\cdot ft$$

$$g := \sqrt{\frac{M_{max.clay}}{2.25\cdot\phi_{ot}\cdot c_{soil}\cdot b}} = 4.7\ ft$$

$$L_{ot2Clay} := (1.5\cdot b + f + g) = 12.4\ ft$$

$L_{ot2Clay} := ceil\left(\frac{L_{ot2Clay}}{ft}\right)\cdot ft = 13\ ft$ *(round up to next foot)*

$L_{otClay} := if\left[\left(L_{ot1Clay} < 3\cdot b\right), L_{ot1Clay}, L_{ot2Clay}\right] = 2.7$ *(If $L_{ot} < 3b$, use Modified Broms method)*

$$L_{reqdOT} := if\left[(SoilType = 0), L_{otSand}, L_{otClay}\right]$$

$L_{reqdOT} = 13\ ft$ *required shaft embedment depth to resist overturning*

Shaft Depth Required to Resist Torsion

$\phi_{tor} := 1.0$ ***SM V3 13.6***

*short free-head pile in **cohesionless soil***

NOTE: ω_{fdot} is based upon concrete soil interaction. This torsion methodology is not to be used with permanent casing.

$N_{blows} = 9$

$$\omega_{fdot} := \text{if}\left[\left(N_{blows} < 5\right), 0, \text{if}\left[\left(N_{blows} \ge 15\right), 1.5, 1.5 \cdot \frac{N_{blows}}{15}\right]\right] = 0.9$$

load transfer ratio, If 5<N<15, ω_{fdot} is reduced by a factor of $\frac{N_{blows}}{15}$ ***SM Vol-3 13.6***

Guess value $L_{torSand} := L_{reqdOT} = 13\ ft$

Given $T_u = \phi_{tor} \cdot \left[\left(\pi \cdot b \cdot L_{torSand}\right) \cdot \left(\gamma_{soil} \cdot \frac{L_{torSand}}{2}\right) \cdot \left(\omega_{fdot}\right) \cdot \frac{b}{2}\right]$

$L_{torSand} := \text{Find}\left(L_{torSand}\right) = 20.2\ ft$

$L_{torSand} := \text{ceil}\left(\frac{L_{torSand}}{ft}\right) \cdot ft = 21\ ft$ *(round up to next foot)*

*short free-head pile in **cohesive soil***

$CohesionFactor := 0.55$

$f_{se} := CohesionFactor \cdot c_{soil} = 1.1 \cdot ksf$

Guess value $L_{torClay} := L_{reqdOT}$

Given $T_u = \phi_{tor} \cdot \left[f_{se} \cdot (\pi \cdot b) \cdot \left(L_{torClay} - 1.5 \cdot ft\right) \cdot \frac{b}{2}\right]$

$L_{torClay} := \text{Find}\left(L_{torClay}\right) = 8.7\ ft$

$L_{torClay} := \text{ceil}\left(\frac{L_{torClay}}{ft}\right) \cdot ft = 9\ ft$ *(round up to next foot)*

$SoilType = 0$ *0 - Sand*
1 - Clay

$L_{reqdTor} := \text{if}\left[(SoilType = 0), L_{torSand}, L_{torClay}\right]$ $L_{reqdTor} = 21\ ft$ *required shaft embedment depth to resist torsion*

$L_{embedded} := \text{if}\left[\left(L_{reqdTor} > L_{reqdOT}\right), L_{reqdTor}, L_{reqdOT}\right] = 21 \cdot ft$

$L_{shaft} := L_{embedded} + Offset$ $L_{shaft} = 21.5\ ft$ *shaft length*

Maximum Moment in Shaft

short free-head pile in cohesionless soil using Broms method

$$f_{sand} := \sqrt{\frac{2 \cdot P_u}{3 \cdot \gamma_{soil} \cdot b \cdot K_p \cdot \phi_{ot}}} = 4.3\ ft$$

$$M_{maxSand} := P_u \cdot (e_{sand} + f_{sand}) - \frac{P_u \cdot f_{sand}}{3} + M_u = 250.3 \cdot kip \cdot ft$$

short free-head pile in ***cohesive soil*** *using Modified Broms method for L < 3b (see reference file for derivation)*

Guess value $f_{mod} := 4.0 \cdot ft$

Given $P_u = \frac{f_{mod} \cdot b}{2} \cdot (2\phi_{ot} \cdot c_{soil} + \phi_{ot} \cdot f_{mod} \cdot Slope)$

$f_{mod} := Find(f_{mod}) = 1.3\ ft$

$$M_{modBroms} := P_u \cdot (e_{clay} + f_{mod}) - \frac{\phi_{ot} \cdot c_{soil} \cdot b \cdot f_{mod}^2}{2} - \frac{\phi_{ot} \cdot b \cdot f_{mod}^3 \cdot Slope}{6} = 228.1 \cdot kip \cdot ft$$

short free-head pile in ***cohesive soil*** *using Regular Broms method for L > 3b*

$$M_{Broms} := P_u \cdot (e_{clay} + 1.5 \cdot b + 0.5 \cdot f) = 297.5 \cdot kip \cdot ft$$

$$M_{maxClay} := if[(L_{ot1Clay} < 3 \cdot b), M_{modBroms}, M_{Broms}] = 228.1 \cdot kip \cdot ft$$ *(If $L_{ot} < 3b$, use Modified Broms method)*

$$M_{max} := if[(SoilType = 0), M_{maxSand}, M_{maxClay}] = 250.3 \cdot kip \cdot ft$$

Minimum Reinforcing and Spacing

$F_{y.rebar} := \mathbf{60} \cdot ksi$ *reinforcing yield strength*

$f_c := \mathbf{4.0} \cdot ksi$ *concrete strength* ***Spec 346-3***

$Cover := \mathbf{6} \cdot in$ *cover* ***SDG Table 1.4.2-1***

$A_{long.bar} := \mathbf{1.56} \cdot in^2$ *longitudinal bar area*

$d_{long.bar} := \mathbf{1.41} \cdot in$ *longitudinal bar diameter*

$A_{v.bar} := if(StirrupBarSize = 5, 0.31 \cdot in^2, 0.44 \cdot in^2) = 0.31 \cdot in^2$ *stirrup area* ***SM V3 13.6.2***

$d_{v.bar} := if(StirrupBarSize = 5, 0.625 \cdot in, 0.75 \cdot in) = 0.625 \cdot in$ *stirrup diameter*

SM V3 13.6.2

$$s_v := \begin{pmatrix} 4 \cdot in \\ s_{v_1} \\ s_{v_2} \\ 12 \cdot in \end{pmatrix} = \begin{pmatrix} 4 \\ 8 \\ 0 \\ 12 \end{pmatrix} \cdot in \quad \begin{pmatrix} \text{"Stirrups A"} \\ \text{"Stirrups B"} \\ \text{"Stirrups C"} \\ \text{"Stirrups D"} \end{pmatrix}$$

stirrup spacing defined in Index 649-031, depth = 0 ft-2 ft
stirrup spacing, depth = 2 ft-depth.stir
stirrup spacing, depth > depth.stir
stirrup spacing, depth > depth.stirA

$$\#Spaces_{vbar} := \begin{pmatrix} 6 \\ NumSpacesStirrupsB \\ NumSpacesStirrupsC \\ 1 \end{pmatrix} = \begin{pmatrix} 6 \\ 10 \\ 0 \\ 1 \end{pmatrix} \qquad \begin{pmatrix} \text{"Stirrups A"} \\ \text{"Stirrups B"} \\ \text{"Stirrups C"} \\ \text{"Stirrups D"} \end{pmatrix}$$

$$s_v = \begin{pmatrix} 4 \\ 8 \\ 0 \\ 12 \end{pmatrix} \cdot in \qquad \#Spaces_{vbar} = \begin{pmatrix} 6 \\ 10 \\ 0 \\ 1 \end{pmatrix}$$

$$\#Spaces_{vbar_2} := if\left[\#Spaces_{vbar_2} = 0, floor\left[\frac{L_{shaft} - 5 \cdot in - \sum_{i=0}^{1} \left(s_{v_i} \cdot \#Spaces_{vbar_i}\right)}{s_{v_3}}\right], \#Spaces_{vbar_2}\right] = 12$$

$$\#Spaces_{vbar_3} := floor\left[\frac{L_{shaft} - 5 \cdot in - \sum_{i=0}^{2} \left(s_{v_i} \cdot \#Spaces_{vbar_i}\right)}{s_{v_3}}\right] = 12$$

$L_{shaft} = 21.5\ ft \qquad \sum_{i=0}^{3} \left(s_{v_i} \cdot \#Spaces_{vbar_i}\right) = 20.7\ ft$

$b = 5\ ft$ *shaft diameter*

$$\#LongBars_{reqd_1} := \frac{0.01}{A_{long.bar}} \cdot \frac{\pi \cdot b^2}{4} = 18.1$$

LRFD 5.7.4.2

$$\#LongBars_{reqd_2} := \frac{0.135}{A_{long.bar} \cdot F_{y.rebar}} \cdot \left(\frac{\pi \cdot b^2}{4} \cdot f_c\right) = 16.3$$

$\#LongBars_{prov} := ceil\left(max\left(\#LongBars_{reqd_1}, \#LongBars_{reqd_2}\right)\right) = 19$ (struck through) *number of longitudinal bars*

Use 18

$Dia_{bar.circle} := b - 2 \cdot Cover - 2 \cdot d_{v.bar} - d_{long.bar} = 45.3 \cdot in$

$Spacing_{vert.reinf} := Dia_{bar.circle} \cdot \frac{\pi}{\#LongBars_{prov}} = 7.5 \cdot in \quad Clearance_{vert.reinf} := Spacing_{vert.reinf} - d_{long.bar} = 6.09 \cdot in$

$CheckReinfClearSpacing := if\left(Clearance_{vert.reinf} \ge 6in, \text{"OK"}, \text{"No Good"}\right)$ $CheckReinfClearSpacing = \text{"OK"}$

SDG 3.6.10

Check Shear and Torsion

$\phi_v := 0.90$ *Shear Resistance Factor* LRFD 5.5.4.2.1

$$V_u := \sqrt{\left(V_{x.polebase_{LoadCaseOT}}\right)^2 + \left(V_{z.polebase_{LoadCaseOT}}\right)^2} = 10 \cdot kip$$

$T_u = 310.7 \cdot kip \cdot ft$

Effective shear depth

$$D_r := b - 2 \cdot \left(Cover + d_{v.bar} + \frac{d_{long.bar}}{2}\right) = 3.8\,ft \qquad d_e := \frac{b}{2} + \frac{D_r}{\pi} = 3.7\,ft$$ LRFD C5.8.2.9-2

$d_v := \max\left(0.9 \cdot d_e, 0.72 \cdot b\right) = 3.6\,ft$

Check Shear Strength

$$V_c := 0.0316 \cdot (2.0) \cdot \sqrt{f_c \cdot ksi} \cdot \left(d_v\right) \cdot b = 327.6 \cdot kip$$ LRFD Eqn 5.8.3.3-3 LRFD 5.8.3.4.1 ACI 11.3.3

$$V_s := \frac{A_{v.bar} \cdot F_{y.rebar} \cdot d_v}{\max\left(s_{v_0}, s_{v_1}, s_{v_2}\right)} = 100.4 \cdot kip$$ LRFD Eqn 5.8.3.3-4

$$D/C_{shear} := \max\left(\begin{pmatrix} \frac{V_u - \phi_v \cdot V_c}{\phi_v \cdot V_s} \\ 0 \end{pmatrix}\right) = 0$$

Check Torsion Strength

$$A_{cp} := \pi \cdot \left(\frac{b}{2}\right)^2 = 2827.4 \cdot in^2 \qquad p_{cp} := 2 \cdot \pi \cdot \left(\frac{b}{2}\right) = 188.5 \cdot in$$ *Area and perimeter of concrete cross-section*

$$d_{oh} := b - 2 \cdot \left(Cover + \frac{d_{v.bar}}{2}\right) = 47.4 \cdot in \qquad p_h := \pi \cdot d_{oh} = 148.8 \cdot in$$ *Diameter, perimeter and area enclosed by the centerline of the outermost closed transverse torsion reinforcement*

$$A_{oh} := \pi \left(\frac{d_{oh}}{2}\right)^2 = 1.8 \times 10^3 \cdot in^2 \qquad A_o := 0.85 \cdot A_{oh} = 1.5 \times 10^3 \cdot in^2$$

$$T_{n.torsion_0} := \frac{2 \cdot A_o \cdot A_{v.bar} \cdot F_{y.rebar}}{s_{v_0}} = 1161.2 \cdot kip \cdot ft$$ LRFD Eqn 5.8.3.6.2-1

$$T_{n.torsion_1} := \frac{2 \cdot A_o \cdot A_{v.bar} \cdot F_{y.rebar}}{s_{v_1}} = 580.6 \cdot kip \cdot ft$$ LRFD 5.8.3.4.1

$$T_{n.torsion_2} := T_{n.torsion_1} \text{ on error } \frac{2 \cdot A_o \cdot A_{v.bar} \cdot F_{y.rebar}}{s_{v_2}} = 580.6 \cdot kip \cdot ft$$

$\phi_v = 0.9$ $\qquad T_u = 310.7 \cdot kip \cdot ft$ $\qquad L_{reqdTor} = 21\,ft$

$$depth_{stir} := \begin{array}{|l} \text{for } i \in 0..1 \\ \quad depth_i \leftarrow \sum_{j=0}^{i} \left(s_{v_j} \cdot \#Spaces_{vbar_j}\right) \\ depth \end{array}$$

$$depth_{stir} = \begin{pmatrix} 2 \\ 8.7 \end{pmatrix} ft$$

$$T_{u.section_0} := T_u$$

$$T_{u.sand_1} := T_u - if\left[\left(depth_{stir_0} > Offset\right), \left[\pi \cdot b \cdot \left(depth_{stir_0} - Offset\right) \cdot \gamma_{soil} \cdot \left(\frac{depth_{stir_0} - Offset}{2}\right) \cdot \left(\omega_{fdot}\right) \cdot \frac{b}{2}\right], 0 \cdot kip \cdot ft\right] = 309 \cdot kip \cdot ft$$

$$T_{u.sand_2} := T_u - if\left[\left(depth_{stir_1} > Offset\right), \left[\pi \cdot b \cdot \left(depth_{stir_1} - Offset\right) \cdot \gamma_{soil} \cdot \left(\frac{depth_{stir_1} - Offset}{2}\right) \cdot \left(\omega_{fdot}\right) \cdot \frac{b}{2}\right], 0 \cdot kip \cdot ft\right] = 260.1 \cdot kip \cdot ft$$

$$T_{u.clay_1} := T_u - if\left[\left(depth_{stir_0} - 1.5ft > Offset\right), \left[f_{se} \cdot (\pi \cdot b) \cdot \left(depth_{stir_0} - Offset - 1.5 \cdot ft\right) \cdot \frac{b}{2}\right], 0 \cdot kip \cdot ft\right] = 310.7 \cdot kip \cdot ft$$

$$T_{u.clay_2} := T_u - if\left[\left(depth_{stir_1} - 1.5ft > Offset\right), \left[f_{se} \cdot (\pi \cdot b) \cdot \left(depth_{stir_1} - Offset - 1.5 \cdot ft\right) \cdot \frac{b}{2}\right], 0 \cdot kip \cdot ft\right] = 22.8 \cdot kip \cdot ft$$

$$T_{u.section_1} := if\left[(SoilType = 0), T_{u.sand_1}, T_{u.clay_1}\right] = 309 \cdot kip \cdot ft$$

$$T_{u.section_2} := if\left[(SoilType = 0), T_{u.sand_2}, T_{u.clay_2}\right] = 260.1 \cdot kip \cdot ft$$

$$T_{u.section} = \begin{pmatrix} 310.7 \\ 309 \\ 260.1 \end{pmatrix} \cdot kip \cdot ft \qquad T_{n.torsion} = \begin{pmatrix} 1161.2 \\ 580.6 \\ 580.6 \end{pmatrix} \cdot kip \cdot ft$$

$$D/C_{torsion} := \frac{T_{u.section}}{\phi_{tor} \cdot T_{n.torsion}} = \begin{pmatrix} 0.27 \\ 0.53 \\ 0.45 \end{pmatrix} \qquad D/C_{max.torsion} := max\left(D/C_{torsion}\right) = 0.53$$

$$T_{cr} := 0.125\sqrt{\frac{f_c}{ksi}} \cdot \left(\frac{A_{cp}^{\ 2}}{p_{cp} \cdot in^3}\right) \cdot kip \cdot in = 883.6 \cdot kip \cdot ft$$

LRFD Eqn 5.8.2.1-4

$$T_u = 310.7 \cdot kip \cdot ft \qquad 0.25 \cdot \phi_{tor} \cdot T_{cr} = 220.9 \cdot kip \cdot ft$$

$$D/C_{torsion.max} := if\left[\left(T_u \le 0.25 \cdot \phi_{tor} \cdot T_{cr}\right), 0, max\left(D/C_{torsion}\right)\right] = 0.532$$

LRFD Eqn 5.8.2.1-3

$$D/C_{shear} = 0.000 \qquad D/C_{torsion.max} = 0.532$$

$$CheckD/C_{shear.and.torsion} := if\left[\left(D/C_{shear} + D/C_{torsion.max} \le 1\right), \text{"OK"}, \text{"No Good"}\right]$$

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

Check Maximum Spacing Transverse Reinforcement

$v_u := \frac{V_u}{\phi_v \cdot b \cdot d_v} = 0.0043 \cdot ksi$ $\quad 0.125 \cdot f_c = 0.5 \cdot ksi$ **LRFD Eqn 5.8.2.9-1**

$s_{max1} := if[(0.8 \cdot d_v < 24 \cdot in), 0.8 d_v, 24 \cdot in] = 24 \cdot in$ **LRFD Eqn 5.8.2.7-1**

$s_{max2} := if[(0.4 \cdot d_v < 12 \cdot in), 0.4 d_v, 12 \cdot in] = 12 \cdot in$ **LRFD Eqn 5.8.2.7-2**

$s_{max} := if[(v_u < 0.125 \cdot f_c), s_{max1}, s_{max2}] = 24 \cdot in$

$max(s_v) = 12 \cdot in$

CheckMaxSpacingTransvReinf := if[(max(s_v) ≤ s_{max}), "OK" , "No Good"] CheckMaxSpacingTransvReinf = "OK"

Check Longitudinal Reinforcement for Combined Shear and Torsion **LRFD Eqn 5.8.3.6.3-1** **LRFD 5.8.3.4.1**

$M_u = 216.3 \cdot kip \cdot ft$

$$V_{temp} := if\left(\frac{V_u}{\phi_v} - 0.5 \cdot V_s > 0 \cdot kip, \frac{V_u}{\phi_v} - 0.5 \cdot V_s, 0 \cdot kip\right) = 0 \cdot kip$$

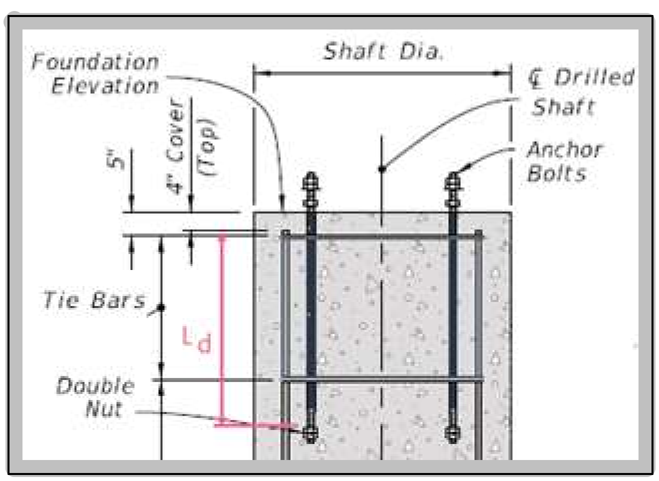
$$LongReinf_{shr.tor} := \frac{\frac{M_u}{\phi_v \cdot d_v} + \sqrt{(V_{temp})^2 + \left(\frac{0.45 \cdot p_h \cdot T_u}{2 \cdot A_o \cdot \phi_v}\right)^2}}{F_{y.rebar}} = 2.66 \cdot in^2$$

$\#LongBars_{prov} \cdot A_{long.bar} = 29.6 \cdot in^2$

$CheckLongReinf_{shr.tor}$:= if[($\#LongBars_{prov} \cdot A_{long.bar} \ge LongReinf_{shr.tor}$), "OK" , "No Good"] $CheckLongReinf_{shr.tor}$ = "OK"

Anchor Bolt Embedment

$T_{u.anchor} = 40.6 \cdot kip$ *tension force in anchor*



$Dia_{bar.circle} = 45.3 \cdot in$

$Dia_{anchor.circle} := Diameter_{boltcircle.pole} = 32 \cdot in$

center-to-center distance

$$Dist_{bar.to.bolt} := \frac{Dia_{bar.circle} - Dia_{anchor.circle}}{2} = 6.7 \cdot in$$

$$Num_{bars.per.anchor} := \min\left(\frac{\#LongBars_{prov}}{\#AnchorBolts}, 3\right) = 2.4$$

Use a maximum of three rebar per anchor bolt (conservative)

$$\phi := 0.9$$

$$Num_{bars.reqd.per.anchor} := \frac{T_{u.anchor}}{A_{long.bar}\cdot(\phi\cdot F_{y.rebar})}\cdot\frac{Dia_{anchor.circle}}{Dia_{bar.circle}} = 0.34$$

$$AreaRatio := \min\left(\frac{Num_{bars.reqd.per.anchor}}{Num_{bars.per.anchor}}, 1\right) = 0.14$$

2015 AASHTO Development Length of Deformed Bars in Tension ***5.11.2.1***

$$Cover = 6\cdot in$$

c_b = *the smaller of the distance from center of bar or wire being developed to the nearest concrete surface and one half the center-to-center spacing of the bars or wires being developed*

$$c_b := \min\left(\left(\begin{matrix} Cover + d_{v.bar} + \dfrac{d_{long.bar}}{2} \\ \dfrac{Spacing_{vert.reinf}}{2} \end{matrix}\right)\right) = 3.7\cdot in$$

$k_{tr} := 0\cdot in$ *assume no transverse bars:*

$$\lambda_{rc} := \min\left[\left[\begin{matrix} 1.0 \\ \max\left(\left(\begin{matrix} 0.4 \\ \dfrac{d_{long.bar}}{c_b + k_{tr}} \end{matrix}\right)\right) \end{matrix}\right]\right] = 0.4$$

LRFD Eqn 5.11.2.1.3-1

$$L_{d.bar} := \max\left(\left(\begin{matrix} 12\cdot in \\ \lambda_{rc}\cdot 2.4\cdot d_{long.bar}\cdot\dfrac{F_{y.rebar}}{\sqrt{f_c\cdot ksi}} \end{matrix}\right)\right) = 40.6\cdot in$$

tension development length ***LRFD Eqn 5.11.2.1.1-2***

$$SpacingFactor := \max\left[\left(\begin{matrix} 0.5 \\ Num_{bars.per.anchor}\cdot 0.5 - 0.5 \end{matrix}\right)\right] = 0.7$$

$$L_{embedment.added} := \sqrt{(Clearance_{vert.reinf}\cdot SpacingFactor)^2 + Dist_{bar.to.bolt}^{\ 2}} = 7.9\cdot in$$

$$L_{embedment.anchor} := \max\left[\left[\begin{matrix} L_{d.bar}\cdot(AreaRatio) + 12\cdot in + L_{embedment.added} \\ 20\cdot d_{anchorbolt} \end{matrix}\right]\right] = 40\cdot in$$

Note: $20 d_{anchor.bolt}$ *minimum embedment is in LTS,3rd Ed. 1994, Section 3, 1.3.4 and still a good rule of thumb.*

$$L_{anchor.bolt.exposed} := \max\left(\left(\begin{matrix} 8\cdot in \\ 2\cdot d_{anchorbolt} + t_{baseplate.pole} + 2\cdot d_{anchorbolt} + 2\cdot in \end{matrix}\right)\right) = 12.5\cdot in$$

$L_{anchor.bolt} := Ceil\left(L_{embedment.anchor} + L_{anchor.bolt.exposed}, in\right) = 53 \cdot in$ $L_{anchor.bolt} = 53 \cdot in$

Anchor Bolt Shear Break-Out Strength

References:
ACI 318-05 Appendix D.
FDOT/University of Florida Report BD545 RPWO #54,
Anchor Embedment Requirements for Signal/Sign Structures, July 2007.

$\#AnchorBolts = 8$ *number of anchor bolts*

$d_{anchorbolt} = 2 \cdot in$ *anchor bolt diameter*

$Diameter_{boltcircle.pole} = 32 \cdot in$ *anchor bolt circle diameter*

$L_{embedment.anchor} = 40 \cdot in$ *anchor bolt embedment*

$b = 60 \cdot in$ *shaft diameter*

$$r_b := \frac{Dia_{anchor.circle}}{2} = 16 \cdot in$$

$$r := \frac{b}{2} = 30 \cdot in$$

$$c_{a1} := \frac{\sqrt{r_b^{2} + 3.25 \cdot \left(r^{2} - r_b^{2}\right)} - r_b}{3.25} = 10 \cdot in$$

adjusted cover

UF Report Eqn 3-2

$$L_e := \min\left(\begin{pmatrix} 8 \cdot d_{anchorbolt} \\ L_{embedment.anchor} \end{pmatrix}\right) = 16 \cdot in$$

load bearing length of anchor for shear

ACI D.6.2.2

$$V_b := 13 \cdot \left(\frac{L_e}{d_{anchorbolt}}\right)^{0.2} \cdot \sqrt{\frac{d_{anchorbolt}}{in}} \cdot \sqrt{\frac{f_c}{psi}} \left(\frac{c_{a1}}{in}\right)^{1.5} \cdot lbf = 55.6 \cdot kip$$

shear break-out strength (single anchor)
UF Report Eqn 2-11

$$A_{bolt.sector} := \frac{(360 \cdot deg)}{\#AnchorBolts} = 45 \cdot deg$$

UF Report Fig 3-7

$$\alpha_{cone} := 2\, asin\left[\frac{\left(1.5 \cdot c_{a1}\right)}{r}\right] = 59.9 \cdot deg$$

$OverlapTest := if\left(A_{bolt.sector} \le \alpha_{cone}, \text{"Overlap of Failure Cones"}, \text{"No Overlap of Failure Cones"}\right) = \text{"Overlap of Failure Cones"}$

$$chord := 2 \cdot r \cdot \sin\left(\frac{A_{bolt.sector}}{2}\right) = 23 \cdot in$$

UF Report Fig 3-7

$A_{Vco} := 4.5 \cdot c_{a1}^{2} = 449.1 \cdot in^{2}$

projected concrete failure area (single anchor)

ACI Eqn D-23

$A_{Vc} := chord \cdot 1.5 \cdot c_{a1} = 344.1 \cdot in^{2}$

projected concrete failure area (group)

ACI D.6.2.1

$A_{Vc} := if\left[\left(A_{Vc} > A_{Vco}\right), A_{Vco}, A_{Vc}\right] = 344.1 \cdot in^{2}$

$\psi_{ecV} := \mathbf{1.0}$ *eccentric load modifier* ***ACI D.6.2.5***

$\psi_{edV} := \mathbf{1.0}$ *edge effect modifier* ***ACI D.6.2.6***

$\psi_{cV} := \mathbf{1.0}$ *cracked section modifier* ***ACI D.6.2.7*** *(stirrup spacing <= 4")*

$\psi_{hV} := \mathbf{1.0}$ *member thickness modifier* ***ACI D.6.2.8***

$\phi_{breakout} := \mathbf{0.75}$ *strength reduction factor* ***ACI D.4.4.c.i*** *(shear breakout, condition A)*

$$V_{cbg} := \#AnchorBolts\cdot\left(\frac{A_{Vc}}{A_{Vco}}\right)\cdot\left(\psi_{ecV}\cdot\psi_{edV}\cdot\psi_{cV}\cdot\psi_{hV}\right)\cdot V_b = 341.1\cdot kip$$

concrete breakout strength - shear

ACI Eqn D-22 *Shear force ⊥ to edge*

$V_{cbg\_parallel} := 2\cdot V_{cbg} = 682.1\cdot kip$ ***ACI D.6.2.1.c*** *Shear force ∥ to edge*

$T_{n.breakout} := V_{cbg\_parallel}\cdot r_b = 909.5\cdot kip\cdot ft$ *concrete breakout strength - torsion*

$\phi_{breakout}\cdot T_{n.breakout} = 682.1\cdot kip\cdot ft$

$T_u = 310.7\cdot kip\cdot ft$

$BreakoutTest := if\left[\left(\phi_{breakout}\cdot T_{n.breakout} \ge T_u\right), \text{"OK"}, \text{"No Good"}\right]$

BreakoutTest = "OK"

$OverlapDesign := if\left[\left(A_{bolt.sector} \le \alpha_{cone}\right), \text{"Based on Overlap of Failure Cones"}, \text{"Based on No Overlap of Failure Cones"}\right]$

OverlapDesign = "Based on Overlap of Failure Cones"

Clearance Between Vertical Reinforcement and Anchor Bolt Nut

$Dist_{bar.to.bolt} = 6.7\cdot in$ *center-to-center distance*

$d_{anchor.nut} := 1.85\cdot d_{anchorbolt} = 3.7\cdot in$ *use an .to account for anchor nut*

$$Clearance_{bar.to.nut} := Dist_{bar.to.bolt} - \left(\frac{d_{anchor.nut} + d_{long.bar}}{2}\right) = 4.1\cdot in$$

$CheckAnchorageClearance := if\left[\left(Clearance_{bar.to.nut} \ge 2\cdot in\right), \text{"OK"}, \text{"No Good, increase shaft diameter"}\right]$

CheckAnchorageClearance = "OK"

CSL tubes can be relocated plus/minus 2 inches from planned position (see Specifications)

$d_{csl.tube} := 2\cdot in$

$Clearance_{csl.to.nut} := Dist_{bar.to.bolt} + 0.5 \cdot d_{long.bar} - d_{csl.tube} - 0.5 \cdot d_{anchor.nut} = 3.5 \cdot in$

Draw Drilled Shaft Section with Reinforcement

fDrawStirrups(spacing, #spaces, inix, iniy) :=

```
coord[0,0] ← inix
coord[0,1] ← iniy
for i ∈ 1 .. #spaces
    coord[i,0] ← coord[0,0]
    coord[i,1] ← coord[i−1,1] − spacing
index ← 1
for i ∈ #spaces + 1 .. 2·#spaces + 1
    coord[i,0] ← b − inix
    coord[i,1] ← coord[i−index,1]
    index ← index + 2
coord[2·#spaces+2,0] ← inix
coord[2·#spaces+2,1] ← iniy
coord
```

$StirrupsA := fDrawStirrups\left(s_{v_0}, \#Spaces_{vbar_0}, Cover, Offset - 5 \cdot in\right)$

$StirrupsB := fDrawStirrups\left(s_{v_1}, \#Spaces_{vbar_1}, Cover, \min\left(StirrupsA^{\langle 1 \rangle}\right)\right)$

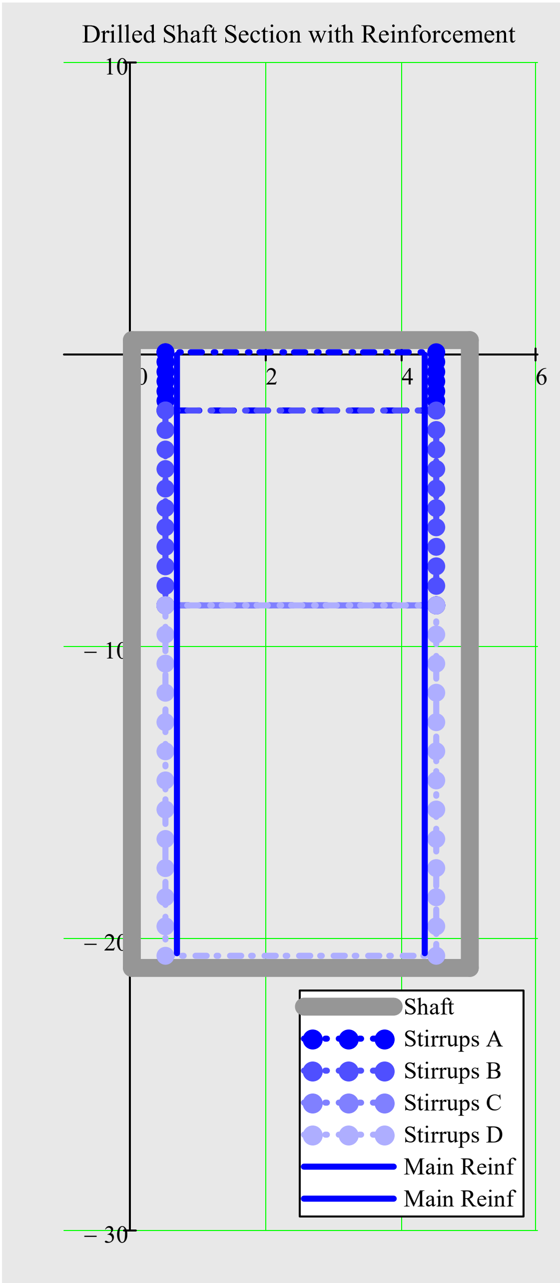
$StirrupsC := fDrawStirrups\left(s_{v_2}, \#Spaces_{vbar_2}, Cover, \min\left(StirrupsB^{\langle 1 \rangle}\right)\right)$

StirrupsD :=

```
coord ← ( Cover       min(StirrupsC) )
        ( b − Cover   min(StirrupsC) )
coord ← fDrawStirrups(s_v3, #Spaces_vbar3, Cover, min(StirrupsC⟨1⟩))  if  min(StirrupsC) > −L_shaft + Cover + 6·in
coord
```

$$Shaft := \begin{pmatrix} 0 \cdot in & Offset \\ b & Offset \\ b & -L_{shaft} + Offset \\ 0 \cdot in & -L_{shaft} + Offset \\ 0 \cdot in & Offset \end{pmatrix} = \begin{pmatrix} 0 & 0.5 \\ 5 & 0.5 \\ 5 & -21 \\ 0 & -21 \\ 0 & 0.5 \end{pmatrix} ft$$

$$Rebar := \begin{bmatrix} (Cover + 2 \cdot in) & -Cover + Offset & (b - Cover - 2 \cdot in) \\ (Cover + 2 \cdot in) & (-L_{shaft} + Cover + Offset) & (b - Cover - 2 \cdot in) \end{bmatrix} = \begin{pmatrix} 8 & 1.1 \times 10^{-15} & 52 \\ 8 & -246 & 52 \end{pmatrix} \cdot in$$



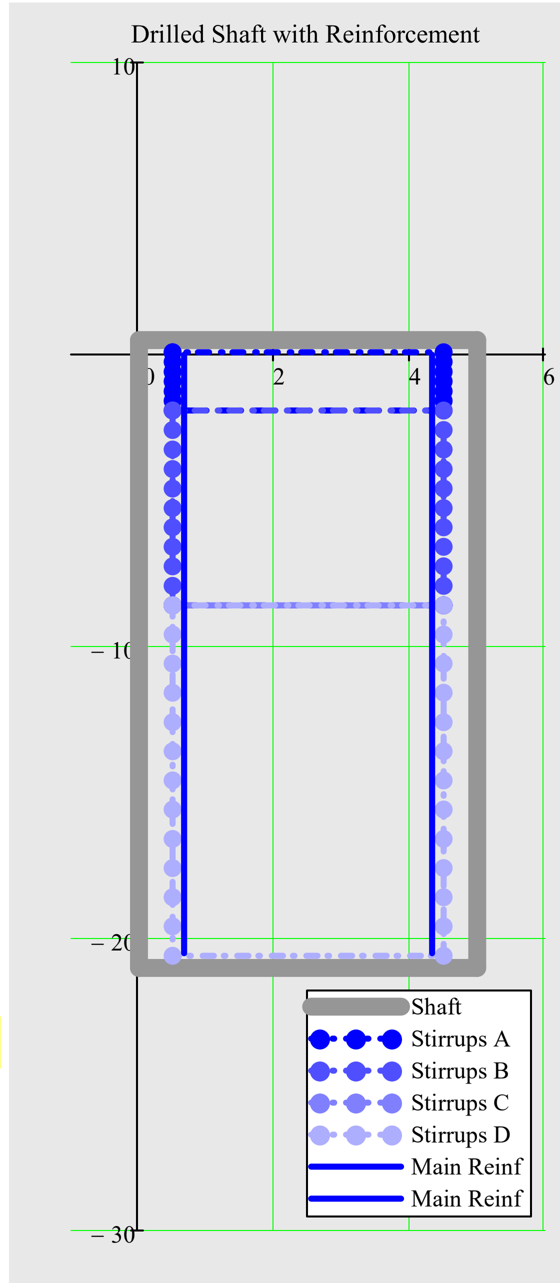
$$s_v = \begin{pmatrix} 4 \\ 8 \\ 0 \\ 12 \end{pmatrix} \cdot in$$ *stirrup spacing*

$$\#Spaces_{vbar} = \begin{pmatrix} 6 \\ 10 \\ 12 \\ 12 \end{pmatrix}$$ *number of stirrup spaces*

Analyze Foundation

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

$L_{shaft} = 21.5\,ft$ $s_v = \begin{pmatrix} 4 \\ 8 \\ 0 \\ 12 \end{pmatrix} \cdot in$ $\#Spaces_{vbar} = \begin{pmatrix} 6 \\ 10 \\ 12 \\ 12 \end{pmatrix}$



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' ($\#Spaces_{vbar_2} = 12$) : $D/C_{torsion_2} = 0.4$

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

Use 22 ft

$Offset = 0.5\,ft$

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

$Dia_{bar.circle} = 45.3 \cdot in$

'DA'= $L_{shaft} = 21.5 \cdot ft$ (struck through)

'DB'= $Diameter_{shaft} = 5 \cdot ft$

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

$L_{anchor.bolt} = 53 \cdot in$

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

'RB'= $\#LongBars_{prov} = 19$

Page 16 of the Mathcad sheets in this documentation shows required total number of longitudinal rebar is 18.1. Provide 18 to match FDOT Standard Plans Index 649-030 typical drilled shaft longitudinal reinforcement. This reinforcement is considered to be the 1% requirement per FDOT Modifications to LRFDLTS-1 provision 13.6.2 (within 1%), which is considered to typically be a conservative flexural design. Meets Eq. 5.6.4.2-3 of the AASHTO LRFD Bridge Design Specifications.

$\#Spaces_{vbar_0} = 6$

$s_{v_0} = 4 \cdot in$

'RC'= $\#Spaces_{vbar_1} = 10$

'RD'= $s_{v_1} = 8 \cdot in$

'RE'= $\#Spaces_{vbar_2} = 12$

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

$\#Spaces_{vbar_3} = 12$

$s_{v_3} = 12 \cdot in$

IX. Fatigue Analysis

InputDataFile = "A70SH-P5SL-DS165.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"	$f_{galloping.arm1} = 6.0 \cdot ksi$	$CAFT_{fullpengroove.weld.arm1} = 7 \cdot ksi$
$Check_{galloping.arm2}$ = "NA"	$f_{galloping.arm2} = 0.0 \cdot ksi$	$CAFT_{fullpengroove.weld.arm2}$ = "NA"·ksi
$Check_{galloping.pole}$ = "OK"	$f_{galloping.pole} = 3.3 \cdot ksi$	$CAFT_{fullpengroove.weld.pole} = 4.5 \cdot ksi$
$Check_{nwg.arm1}$ = "OK"	$f_{nwg.arm1} = 3.4 \cdot ksi$	$CAFT_{fullpengroove.weld.arm1} = 7 \cdot ksi$
$Check_{nwg.arm2}$ = "NA"	$f_{nwg.arm2} = 0.0 \cdot ksi$	$CAFT_{fullpengroove.weld.arm2}$ = "NA"·ksi
$Check_{nwg.pole}$ = "OK"	$f_{nwg.pole} = 1.6 \cdot ksi$	$CAFT_{fullpengroove.weld.pole} = 4.5 \cdot ksi$

CheckK1Values = ("K1 is outside of 2% of K1 thresholds" ; "K1 is outside of 2% of K1 thresholds" ; "K1 is outside of 2% of K1 thresholds")

$$\begin{pmatrix} K_{I.arm1} \\ K_{I.arm2} \\ K_{I.pole} \end{pmatrix} = \begin{pmatrix} 3.875 \\ 100.000 \\ 7.033 \end{pmatrix}$$ ("Arm 1 Base Weld" ; "Arm 2 Base Weld" ; "Upright Base Weld")

A325 Connection Bolts

$Check_{g.conn.bolt}$ = ("OK" ; "OK") $f_{t.g.bolt} = \begin{pmatrix} 7.6 \\ 0.0 \end{pmatrix} \cdot ksi$

$CAFT_{conn.bolt} = 16 \cdot ksi$

$Check_{nwg.conn.bolt}$ = ("OK" ; "OK") $f_{t.nwg.bolt} = \begin{pmatrix} 4.3 \\ 0.0 \end{pmatrix} \cdot ksi$

Anchor Bolts

$Check_{g.anchor}$ = "OK" $f_{t.g.anchor} = 2.8 \cdot ksi$ $CAFT_{anchor.bolts} = 7 \cdot ksi$

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

Save Data File (optional)

☑ Use current input file

File Name A70SH-P5SL-DS165.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 = "A70SH-P5SL-DS165.dat"

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

Subject = "Erie Rd and SR 62 Improvements" **DesignedBy** = "RT" **PoleLocation** = "107+91.00/51.0 LT"

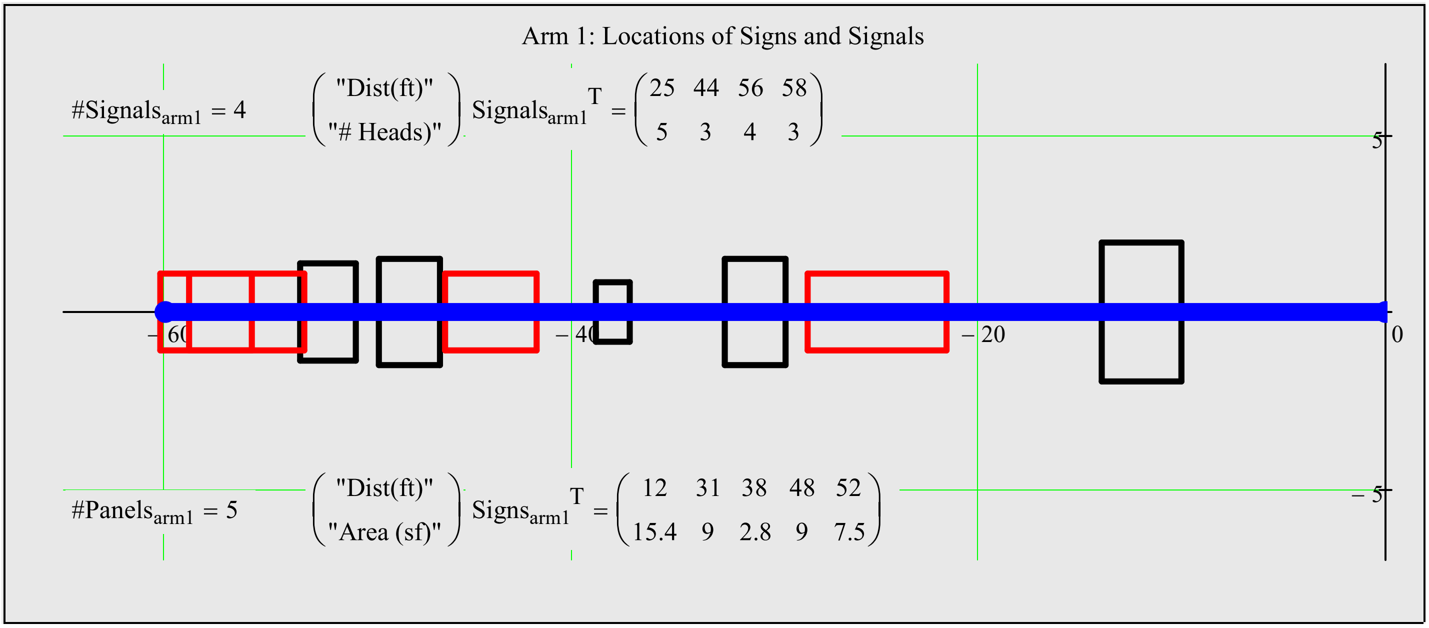
ProjectNo = "850-6094060" **CheckedBy** = "" **Date** = "5 / 27 / 2021"

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"



$\max(CFI_{arm1}) = 0.74$ $L_{total.arm1} = 60\,ft$ $L_{splice.provided.arm1} = 3 \cdot ft$ $\max(\Delta_{arm1}) = 8.8 \cdot in$

'FA'= 'FE'= $L_{fabricated.arm1} = \begin{pmatrix} 28 \\ 35 \end{pmatrix} \cdot ft$

'FC'= 'FG'= $Diameter_{base.arm1} = \begin{pmatrix} 14.04 \\ 18.00 \end{pmatrix} \cdot in$

'FB'= 'FF'= $Diameter_{tip.arm1} = \begin{pmatrix} 10.12 \\ 13.10 \end{pmatrix} \cdot in$

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

2nd Mast Arm

Arm 2: Locations of Signs and Signals

7

$\#Signals_{arm2} = 0$ $\begin{pmatrix} \text{"Dist(ft)"} \\ \text{"\# Heads)"} \end{pmatrix}$ $Signals_{arm2}^{T} = \begin{pmatrix} 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \end{pmatrix}$

$\#Panels_{arm2} = 0$ $\begin{pmatrix} \text{"Dist(ft)"} \\ \text{"Area (sf)"} \end{pmatrix}$ $Signs_{arm2}^{T} = \begin{pmatrix} 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 \end{pmatrix}$

− 7

$-\left(L_{total.arm2}+5\cdot ft\right)$ 0

$max\left(CFI_{arm2}\right) = 0.00$ $L_{total.arm2} = 0\ ft$ $L_{splice.provided.arm2} = 0\cdot ft$ $max\left(\Delta_{arm2}\right) = 0\cdot in$

'SA'= 'SE'= $L_{fabricated.arm2} = \begin{pmatrix} 0 \\ 0 \end{pmatrix}\cdot ft$

'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'= $Diameter_{tip.arm2} = \begin{pmatrix} 0.00 \\ 0.00 \end{pmatrix}\cdot in$

'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)*

$$\begin{pmatrix} CFI_{base.lumarm} \\ CSR_{bolt.lum} \\ D/C_{baseplate.lum} \\ D/C_{conn.plate.lum} \end{pmatrix} = \begin{pmatrix} 0.00 \\ 7.17\times 10^{-9} \\ 0.00 \\ 0.00 \end{pmatrix}$$

'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

$max\left(CFI_{pole}\right) = 0.50$ $Check_{deflection} = \text{"OK"}$ $Check_{slope} = \text{"OK"}$

'UA'= $Y_{pole} = 22.75\cdot ft$

'UB'= $Y_{arm.conn} = 19.75\cdot ft$

'UC'= $Diameter_{tip.pole} = 20.8\cdot in$

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

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

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

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

1st Arm to Upright Connection

$D/C_{ht.conn.plate} = 0.80$

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

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

$\#Bolts_{conn_0} = 6$

'FO'= $Offset_{conn_0} = 18.0 \cdot in$

$D/C_{width.conn.plate_0} = 0.92$

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

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

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

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

'FR'= $t_{conn.plate_0} = 2.5 \cdot in$

$$\begin{pmatrix} D/C_{t.baseplate.arm_0} \\ CFI_{t.vert.plate_0} \\ CSR_{bolt.conn_0} \end{pmatrix} = \begin{pmatrix} 0.83 \\ 0.46 \\ 0.55 \end{pmatrix}$$

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

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

'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

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

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

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

$\#Bolts_{conn_1} = 0$

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

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

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

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

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

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

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

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

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

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

Pole Base Plate

$CSR_{anchor} = 0.24$

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

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

$CheckCSR_{anchorbolt} = "OK"$

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

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

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

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

$L_{anchor.bolt} = 53 \cdot in$

Foundation

$D/C_{torsion.max} = 0.53$

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

$CheckReinfClearSpacing = "OK"$

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

$CheckMaxSpacingTransvReinf = "OK"$

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

$OverlapTest = "Overlap of Failure Cones"$

$BreakoutTest = "OK"$

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

$Offset = 0.5\,ft$

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

$Dia_{bar.circle} = 45.3 \cdot in$

'DA'= $L_{shaft} = 21.5 \cdot ft$ 22

'DB'= $Diameter_{shaft} = 5 \cdot ft$

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

'RB'= $\#LongBars_{prov} = 19$ 18

'RC'= $\#Spaces_{vbar_1} = 10$

'RD'= $s_{v_1} = 8 \cdot in$

'RE'= $\#Spaces_{vbar_2} = 12$

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

Fatigue

$Check_{galloping.arm1} = "OK"$ $Check_{galloping.arm2} = "NA"$ $Check_{galloping.pole} = "OK"$

$Check_{nwg.arm1} = "OK"$ $Check_{nwg.arm2} = "NA"$ $Check_{nwg.pole} = "OK"$

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

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

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

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

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

$\begin{pmatrix} K_{I.arm1} \\ K_{I.arm2} \\ K_{I.pole} \end{pmatrix} = \begin{pmatrix} 3.875 \\ 100.000 \\ 7.033 \end{pmatrix}$ $\begin{pmatrix} "Arm 1 Base Weld" \\ "Arm 2 Base Weld" \\ "Upright Base Weld" \end{pmatrix}$

WRITEPRN to Line 1-2-3 for Mast Arm Data Table

Mast Arm Tip Deflection

Compare Mast Arm deflection of each arm to a proposed camber

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

$Deflection_{arm1} := Slope_x \cdot L_{total.arm1} + max(\Delta_{arm1}) = 13.4 \cdot in$

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

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

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

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

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

$Offset_{conn_0} = 18 \cdot in$ $\quad b_{conn.plate_0} = 36 \cdot in$ $\quad h_{conn.plate} = 30 \cdot in$ $\quad \alpha = 0 \cdot deg$

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

$$x1 := Offset_{conn_0} - t_{conn.plate_0} - h_{conn.plate} \cdot \frac{\sin(Camber_{arm1})}{2} = 15 \cdot in \qquad y1 := \frac{b_{conn.plate_0}}{2} = 18 \cdot in$$

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

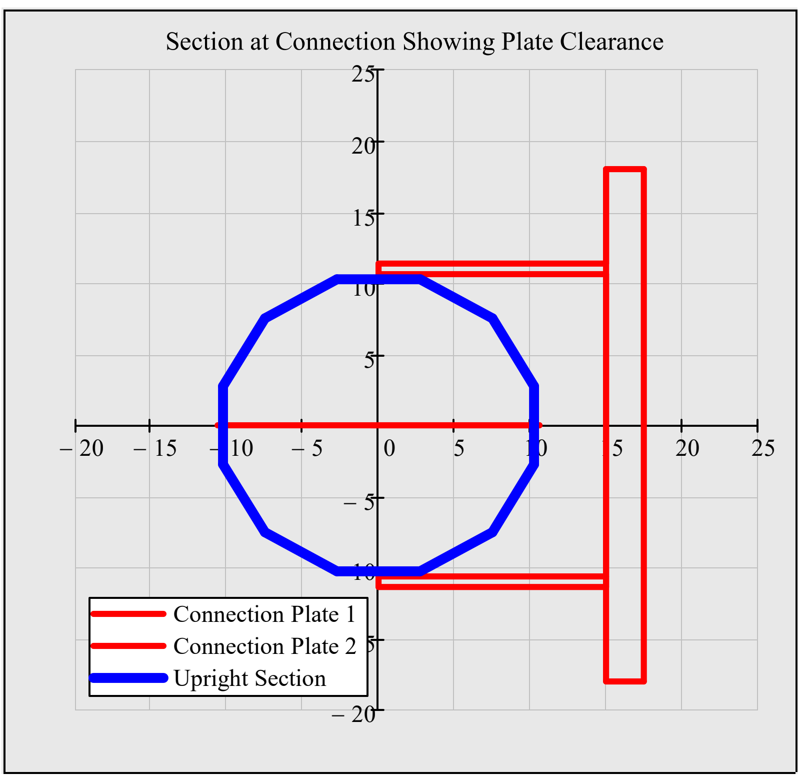
$$y2 := \left(Offset_{conn_1} - t_{conn.plate_1} - h_{conn.plate} \cdot \frac{\sin(Camber_{arm2})}{2}\right) \cdot \sin(\alpha) - \frac{b_{conn.plate_1}}{2} \cdot \cos(\alpha) = 0 \cdot in$$

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

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

Coordinates for Drawings

Plan View - Connection Plate Clearance for Two Arm Connections



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

$Diameter_{conn.pole} = 21.3 \cdot in$

'FR'= $t_{conn.plate_0} = 2.5 \cdot in$

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

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

'FO'= $Offset_{conn_0} = 18.0 \cdot in$

$Gap_0 = 7.4 \cdot in$

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

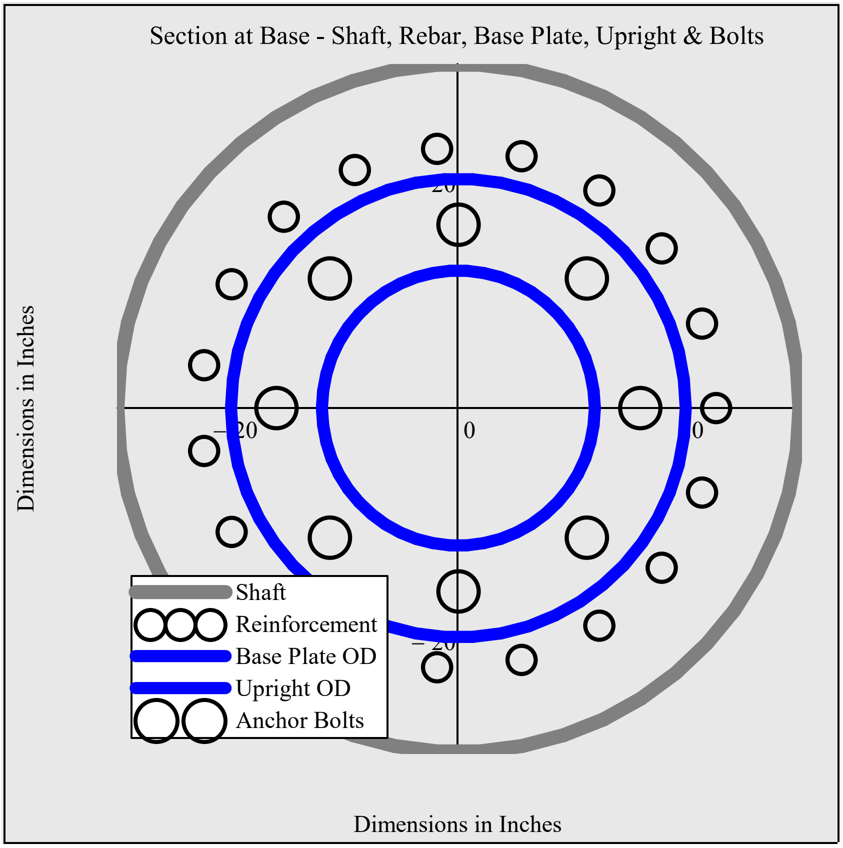
'SJ'= $b_{conn.plate_1} = 0 \cdot in$

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

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

'DB'= $Diameter_{shaft} = 60 \cdot in$

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

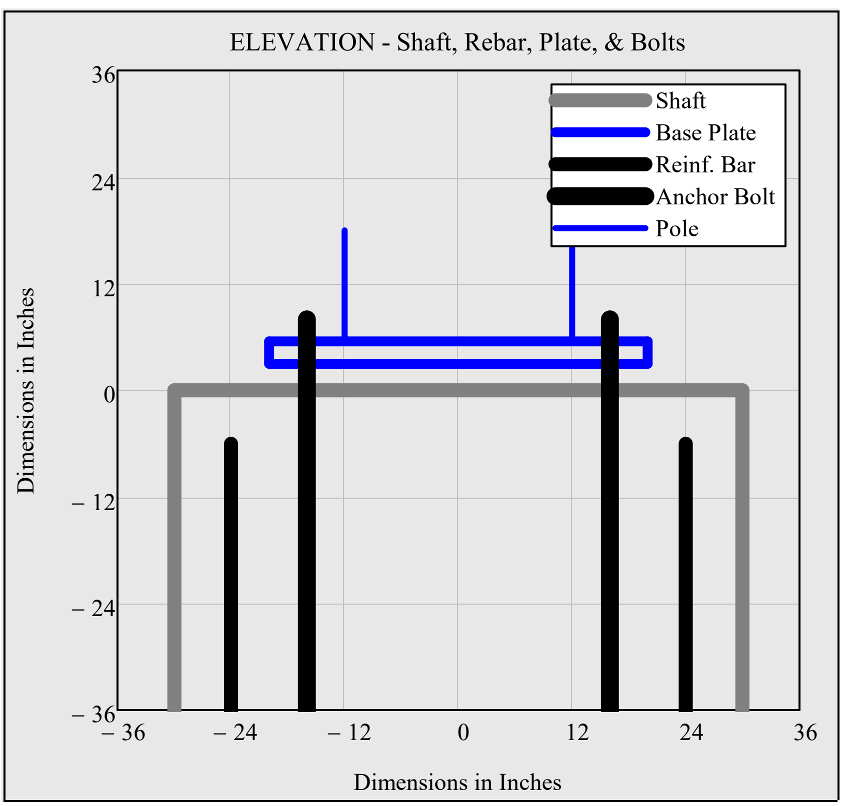
$Dia_{bar.circle} = 45.3 \cdot in$

$\#AnchorBolts = 8$

$\#LongBars_{prov} =$ ~~19~~ 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'= $Diameter_{baseplate.pole} = 40 \cdot in$

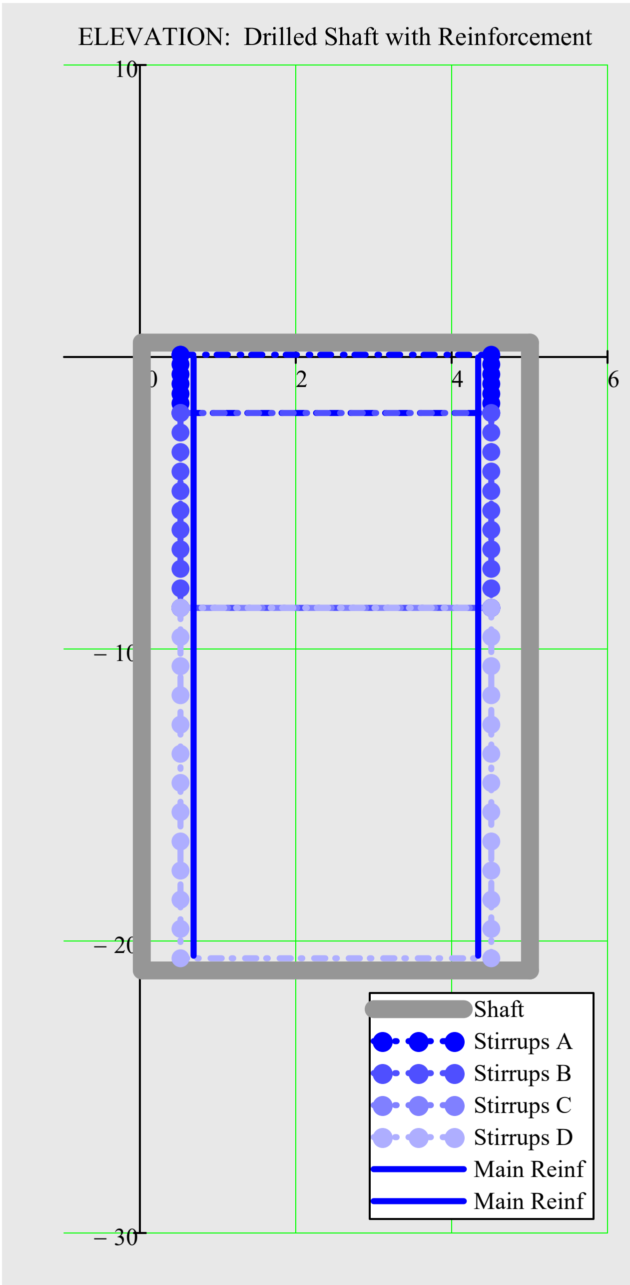
'BB'= $t_{baseplate.pole} = 2.5 \cdot in$

'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*

$\#Spaces_{vbar} = \begin{pmatrix} 6 \\ 10 \\ 12 \\ 12 \end{pmatrix}$ *number of stirrup spaces*

Erie Rd. and SR 62 Improvements

HDR Project Number: 10151274

Miscellaneous Structures

1.5 Pole 2

For: Manatee County Public Works

Erie Rd. and SR 62 Improvements

HDR Project Number: 10151274

Miscellaneous Structures

1.5 Pole 2

1.5.1 Geometry and Loading

For: Manatee County Public Works

General Input

Pole No.	2		
Station	108+03.00		
Offset	49.0' RT		
County	Manatee		Choose "County" from drop-down list
Wind speed	150	mph	Basic wind speed for Manatee County is 150 per FDOT SDG, Jan. 2018, Table 2.4.1-1
Luminaire Orientation	N		Enter N for no luminaire, otherwise enter angle measured CCW from arm 1 (0, 45, 90)
Signal Orientation (V or H)	V		V for vertical, H for horizontal
Arm 2 Orientation	N		Enter N for no arm 2, otherwise enter angle between dual arms
Backplates (Y or N)	Y		Used in determining arm con. ht. (FDM 232 req. the use of backplates on Mast Arms)
Elevation below Arm 1 tip	43.60	ft	
Elevation below Arm 2 tip	N		Enter N for no arm 2
Elevation at top of foundation	44.40	ft	
Arm center to signal / sign bottom	2.83	ft	Tabulated based on input for Arm 1 Signals and Signs
Arm connection height (min)	19.31	ft	Based on 17.5 ft clearance
Arm connection height	19.75	ft	Dimension 'UB'; Use 0.25 ft increments
Arm connection height (max)	20.81	ft	Based on 19.0 ft clearance
Arm 1 length	45	ft	Arm 1 is the longer arm.
Arm 2 length	N		Enter N for no arm 2.
Soil type	1		0 for clay (cohesive soil), 1 for sand (cohesionless soil)
Effective soil weight	43	pcf	
Phi	29	deg.	
N-blowcount	6		Enter initial value from 'Average N-count V2.0.xls' or as directed by geotech
Foundation offset	0.5	ft	Distance from finish ground to top of shaft

Arm 1 Signals and Signs - Vertical Geometry Check

Signal Head Type	1/2 Signal Height (ft.)	Height of Sign Dim. (ft.)	Width of Sign Dim. (ft).	Sign Attachment	Sign Location	Sign Area Check	Sign Location Check	1/2 Sign Height (ft.)
5-Doghouse	*2.25*	2.00	6.00	n/a	outside roadway	*n/a*	*n/a*	*0*
4	*2.83*	3.00	2.50	n/a	over roadway	*n/a*	*n/a*	*1.5*
3	*2.25*	3.00	3.00	n/a	over roadway	*n/a*	*n/a*	*1.5*
n/a	*0.00*	0.00	0.00	n/a	n/a	*n/a*	*n/a*	*0*
n/a	*0.00*	0.00	0.00	n/a	n/a	*n/a*	*n/a*	*0*

Arm 2 Signals and Signs - Vertical Geometry Check

Signal Head Type	1/2 Signal Height (ft.)	Height of Sign Dim. (ft.)	Width of Sign Dim. (ft).	Sign Attachment	Sign Location	Sign Area Check	Sign Location Check	1/2 Sign Height (ft.)
n/a	*0.00*	0.00	0.00	n/a	n/a	*n/a*	*n/a*	*0*
n/a	*0.00*	0.00	0.00	n/a	n/a	*n/a*	*n/a*	*0*
n/a	*0.00*	0.00	0.00	n/a	n/a	*n/a*	*n/a*	*0*
n/a	*0.00*	0.00	0.00	n/a	n/a	*n/a*	*n/a*	*0*
n/a	*0.00*	0.00	0.00	n/a	n/a	*n/a*	*n/a*	*0*

Analysis Requirement

Mathcad Analysis Required = **Yes**

The following criteria are not satisfied: *1 Effective soil weight < 50 pcf*
2 Friction angle < 30 deg
3 N-value < 15

Information for Standard Mast Arm Assemblies Data Table

Arm 1 Type =	Heavy Duty	Arm 2 Type = n/a
Designation	***A50/S/H - P3/S***	
Arm 1 ID	***A50/S/H***	
FAA (ft)	***27.5***	
Arm 2 ID		Leave blank in data table
SAA (ft)		Leave blank in data table
UF (deg)		Leave blank in data table
LL (deg)		Leave blank in data table
Pole ID	***P3/S***	
UAA (ft)	***22.75***	
UB (ft)	***19.75***	

Pay Item Number

649-2A-BB Steel Mast Arm Assembly

Operation =	(Furnish & Install)	Choose correct "Operation" from drop-down list
AA =	1	
Arm 1 =	50	Arm length used to determine Pay Item Number, See SPI for Arm Combinations
Arm 2 =	Single	If Arm 2 = N or Arm 2 Orientation = N, then 'Single' will be displayed
BB =	6	
Pay Item Number is	***649-21-6***	Provide to Signal Designer for verification

Signal Inputs:

The design accounts for MVDS devices as a 14" X 14" sign.

FDOT's 'mastarm-index-649-030-v1-4.xlsx' program limits the total number of signal / sign inputs to 10, and does not have an option for 1-section signal head; so the devices are accounted for by using a 14" X 14" sign.

FDOT's 'MastArmV1.2.xmcd' limits the number of sign inputs to 5, and does not have an option for 1-section signal head; so the the devices are accounted for by using a 14" X 14" sign.

Analysis:

1. FDOT's 'MastArmV1.2.xmcd' is used only to perform the foundation analysis. Other design sections are collapsed as individual components of the Mast Arm do not require detailed design based on the results from FDOT's 'mastarm-index-649-030-v1-4.xlsx'.

2. The signal and sign configuration for "Future Scenario" is chosen for foundation design to account for the higher moment demand due to the addition of Sign C.

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

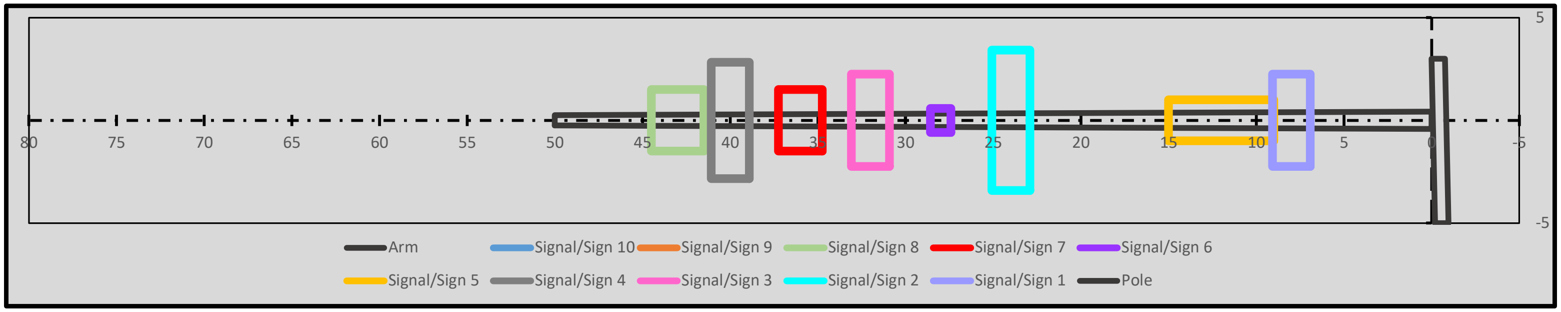
Back Plates?: (●) Yes ( ) No

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

Luminaire?: ( ) Yes (●) No

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
Dist from Pole (ft.)			43	36	28	12	40	32	24	8
Selection (None / 3 Head / 4 Head / 5 Head / Sign)	None	None	Sign	Sign	Sign	Sign	4 Head	3 Head	5 Head	3 Head
Sign Width (in.)			36	30	14	72				
Sign Height (in.)			36	36	14	24				
Area (SF)	0.0	0.0	9.0	7.5	1.4	12.0	12.3	9.8	14.8	9.8
M_{wl} (kip*ft)	0	0	26	18	3	10	33	21	24	5



Arm 1 Length (ft)	50	
Design Standard Index 17743	**Regular**	**Heavy Duty**
Dia. at Arm Base (in)	14	15
Wall Thickness (in)	0.3125	0.3125
Resistance (M_r=ϕM_n) (kip*ft)	215	244

Arm 1 Loads	Regular	Heavy Duty
1.1*Arm M_{dl} (kip*ft)	40	44
Arm M_{wl} (kip*ft)	44	49
1.1*Sign/Signal M_{dl} (kip*ft)	11	
Sign/Signal M_{wl} (kip*ft)	139	
Total Moment ($M_{extreme}$)	190	197

Mast Arm Assembly Designation

~~One Arm Assembly~~

~~A50/S-P3/S-DS/14/4.5~~

Analysis requires A50/S/H-P3/S

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 at 22 ft.

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

Erie Rd. and SR 62 Improvements

HDR Project Number: 10151274

Miscellaneous Structures

1.5 Pole 2

1.5.2 Average N-count

For: Manatee County Public Works

Project: Erie Rd and SR-62 Improvement	Computed: RT	Date: 5/27/2021
Subject: Misc. Structures	Checked:	Date:
Task: Average N Count	Page: 1	of: 1
Job #: 850-6094060		

Boring Details		
Depth (ft)		N-count
Total	Step	
2	2	6
4	2	3
6	2	5
8	2	8
10	2	2
12.5	2.5	3
15	2.5	7
17.5	2.5	5
20	2.5	21
22.5	2.5	25
25	2.5	22
27.5	2.5	9
30	2.5	10
Average N-count		10.10
Initial Design N_{AVG}		12.00

Pole #	Pole 2
Boring #	B-3
Station	108+03.00/49.0 RT
N-multiplier	1.24

Automatic Hammer Used; therefore N-multiplier = 1.24

<u>Notes:</u> (Calculate N-value for drilled shaft)

1- Automatic hammer N value multiplier and Boring details (soil layers thicknesses and number of counts) should be entered as inputs.
2- Initial design N value from "Boring Details" table is used to determine drilled shaft lengths in Mathcad.
3- Drilled shaft length output from the Mathcad file should be entered in the table below.
4- Final design N value for each shaft based on the average of layers where drilled shaft is surrounded with will be calculated in the "Drilled Shaft Details" table.
5- If New N value is smaller than original value, Mathcad file should be updated with new N value to calculate final drilled shaft length.

Drilled Shaft Length After Initial Analysis
15.5

(Mathcad First Output)

Drilled Shaft Details		
Depth (ft)		N-count
Total	Step	
2	2	6
4	2	3
6	2	5
8	2	8
10	2	2
12.5	2.5	3
15	2.5	7
17.5	2.5	5
-	-	-
-	-	-
-	-	-
-	-	-
-	-	-
Average N-count		4.89
Final Design N_{AVG}		6.00
Update N_{AVG}? (Y/N)		YES

Final Drilled Shaft Length
22

(Mathcad Final Output)

Erie Rd. and SR 62 Improvements

HDR Project Number: 10151274

Miscellaneous Structures

1.5 Pole 2

1.5.3 Foundation Analysis

For: Manatee County Public Works

FDOT Mast Arm Traffic Signal Support Analysis Program V1.2

State Structures Design Office

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

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

Reference

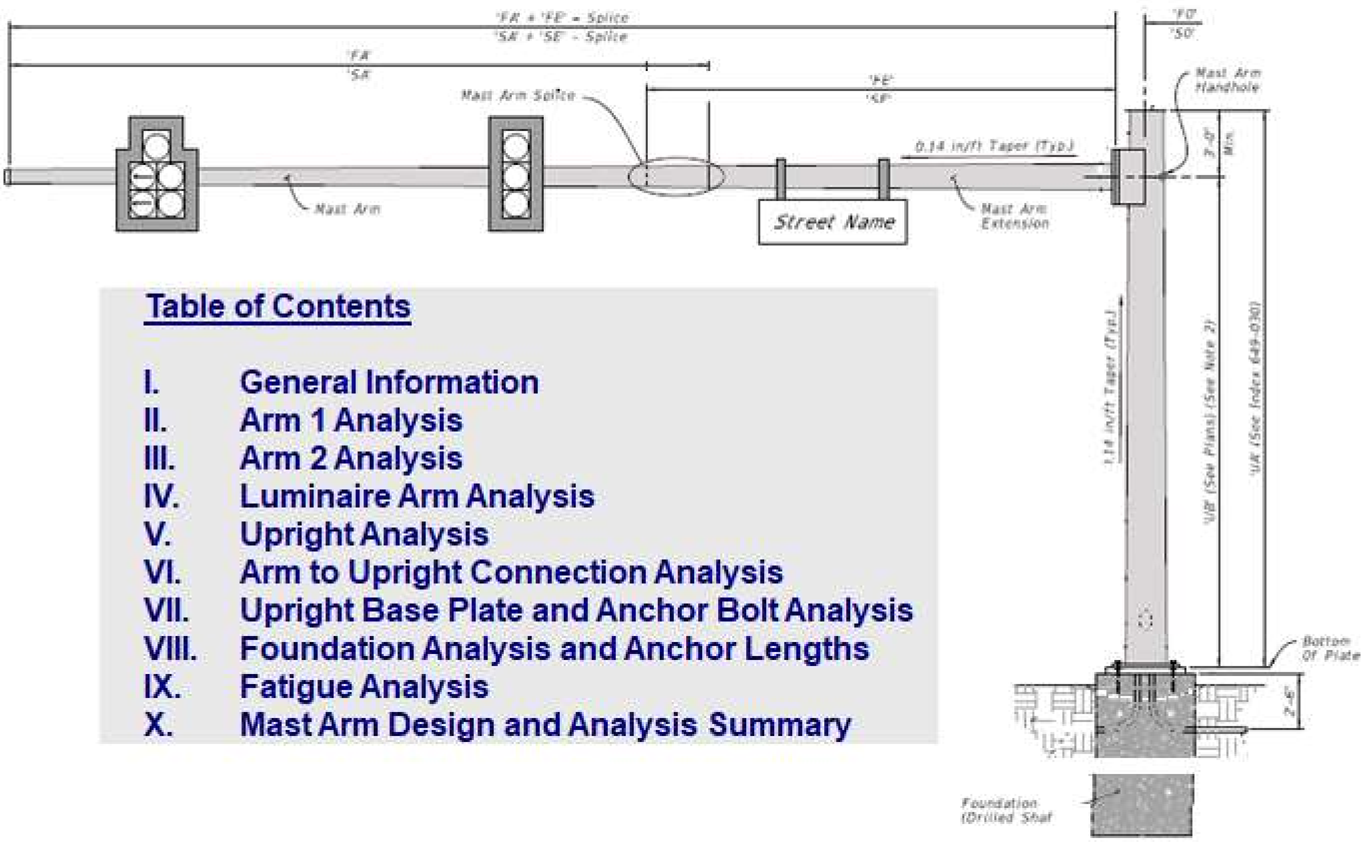


Table of Contents

Data Folder and Files

Data Files Folder

Change Folder

C:\Users\rtallur\Desktop\Data\

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

A50SH-P3S-DS1445.dat

Refresh List

Open File

I. General Information and Sign & Signal Data

Enter Project Information

Project Name	Erie Rd and SR 62 Improvements
Project No.	850-6094060
Designed by	RT
Date	5 / 27 / 2021
Checked by	
Date	
Signal Name	Pole 2
Station/Offset	108+03.00/49.0 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 45

Reset Arm 1 Data

Arm1 Signal Number	*Distance to Signal (ft)*	*Number of Heads*
1	8	3
2	24	5
3	32	3
4	40	4
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	12	12
2	28	1.4
3	36	7.5
4	43	9
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 = "A50SH-P3S-DS1445.dat" $V_{extreme} = 150 \cdot mph$

Values for $Dist_{splice.from.base.arm}$ *that give a base diameter in even inches*

"Wall Thickness"	"dia-1in"	"dia-2in"	"dia-3in"	"dia-4in"	"dia-5in"	"d-6in"
$t_{wall.arm} = 0.179 \cdot in$	***9.9***·ft	***17.0***·ft	***24.2***·ft	***31.3***·ft	***38.5***·ft	***45.6***·ft
$t_{wall.arm} = 0.25 \cdot in$	***10.9***·ft	***18.0***·ft	***25.2***·ft	***32.3***·ft	***39.4***·ft	***46.6***·ft

Help - Base Diameters | Help - Arm Tip Diameter | Help - Tube Wall Thickness | Help - Arm Lengths | Recommended Distance to Splice

Reference:C:\Users\rtallur\Desktop\LRFD Equation Module.xmcd(R)

Enter Arm 1 Data

Arm Length (ft)	*Base Diameter (in)*	*Wall Thickness 1 (in)*	*Wall Thickness 2 (in)*	*Distance to Splice (ft)*
$L_{total.arm1} = 45\,ft$	15	0.25	0.313	17.5
feet, 40 ft. max. for 1 piece arms	*Measured flat to flat* **'FG'**	*for 1 & 2 piece arms* **'FD'**	*for 2 piece arms only* **'FH'**	*for 2 piece arms only* (**'Larm' - 'FA'**)

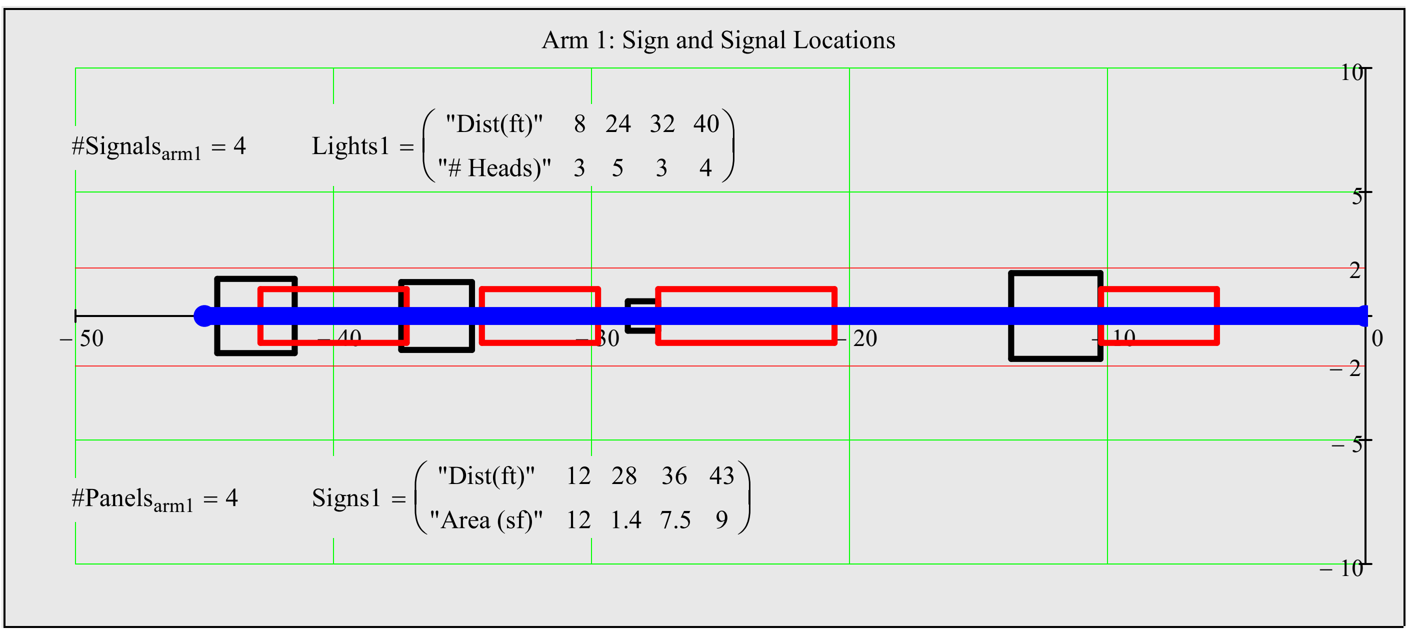
Arm 1 Analysis including Existing Mast Arm Analysis (Additional Variables Required)

Arm 1 Combined Force Interaction Ratio and Deflection

BackPlate = "Rigid, 6 inches wide"

$\max(CFI_{arm1}) = 0.72$ $\max(\Delta_{arm1}) = 4.7 \cdot in$ $2 \cdot deg \cdot L_{total.arm1} = 18.8 \cdot in$

Summary - Arm 1 Geometry and Loading



$\max(CFI_{arm1}) = 0.72$

$\max(\Delta_{arm1}) = 4.7 \cdot in$

$L_{total.arm1} = 45\,ft$

'FA'= **'FE'=** $L_{fabricated.arm1} = \begin{pmatrix} 27.5 \\ 20.5 \end{pmatrix} \cdot ft$

'FB'= **'FF'=** $Diameter_{tip.arm1} = \begin{pmatrix} 9.22 \\ 12.13 \end{pmatrix} \cdot in$

'FC'= **'FG'=** $Diameter_{base.arm1} = \begin{pmatrix} 13.07 \\ 15.00 \end{pmatrix} \cdot in$

'FD'= **'FH'=** $t_{wall.arm1} = \begin{pmatrix} 0.250 \\ 0.313 \end{pmatrix} \cdot in$

$Classification_{arm1} = \begin{pmatrix} \text{"Compact"} \\ \text{"Compact"} \end{pmatrix}$

$L_{splice.provided.arm1} = 3 \cdot ft$

III. Arm 2 Analysis

InputDataFile = "A50SH-P3S-DS1445.dat" $V_{extreme} = 150 \cdot mph$

$Dist_{splice.from.base.arm}$ *values that give a base diameter in even inches*

"Wall Thickness"	Δdia = 1·in	Δdia = 2·in	Δdia = 3·in	Δdia = 4·in	Δdia = 5·in	Δdia = 6·in
$t_{wall.arm}$ = 0.179·in	***9.9***·ft	***17.0***·ft	***24.2***·ft	***31.3***·ft	***38.5***·ft	***45.6***·ft
$t_{wall.arm}$ = 0.25·in	***10.9***·ft	***18.0***·ft	***25.2***·ft	***32.3***·ft	***39.4***·ft	***46.6***·ft

Help - Base Diameters | Help - Arm Tip Diameter | Help - Tube Wall Thickness | Help - Arm Lengths | Recommended Distance to Splice

Enter Arm 2 Data

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

Arm 2 Analysis including Existing Mast Arm Analysis

Arm 2 Combined Force Interaction Ratio and Deflection

$\max(CFI_{arm2}) = 0.00$ BackPlate = "Rigid, 6 inches wide"

Summary - Arm 2 Geometry and Loading $\max(\Delta_{arm2}) = 0.0 \cdot in$ $2 \cdot deg \cdot L_{total.arm2} = 0 \cdot in$

Arm 2: Sign and Signal Locations

10

$\#Signals_{arm2} = 0$ $Lights2 = \begin{pmatrix} \text{"Dist(ft)"} & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\ \text{"\# Heads)"} & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \end{pmatrix}$

$\#Panels_{arm2} = 0$ $Signs2 = \begin{pmatrix} \text{"Dist(ft)"} & 0 & 0 & 0 & 0 & 0 \\ \text{"Area (sf)"} & 0 & 0 & 0 & 0 & 0 \end{pmatrix}$

−10

$-(L_{total.arm2} + 5 \cdot ft)$ … 0

$\max(CFI_{arm2}) = 0.00$

'SB'= 'SF'= $Diameter_{tip.arm2} = \begin{pmatrix} 0.00 \\ 0.00 \end{pmatrix} \cdot in$

$Classification_{arm2} = \begin{pmatrix} \text{"Compact"} \\ \text{"N/A"} \end{pmatrix}$

$\max(\Delta_{arm2}) = 0.0 \cdot in$

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

$L_{splice.provided.arm2} = 0 \cdot ft$

$L_{total.arm2} = 0$ ft

'SA'= 'SE'= $L_{fabricated.arm2} = \begin{pmatrix} 0.0 \\ 0.0 \end{pmatrix} \cdot ft$

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

IV. Luminaire Arm Analysis

InputDataFile = "A50SH-P3S-DS1445.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 = "A50SH-P3S-DS1445.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)	
22.75	19.75	20	0.375	7.4	arm 1 gap
'UA'	'UB'	'UD' *measured flat to flat*	'UE'		arm 2 gap

Analyze Upright

Upright Combined Force Interaction Ratio and Deflections

$Classification_{pole} = \text{"Compact"}$

$max(CFI_{pole}) = 0.45$

$Check_{slope} = \text{"OK"}$

$Check_{deflection} = \text{"OK"}$

$max(\Delta_{x.dl}) = 0.6 \cdot in$

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

$Slope_z = 0 \cdot deg$

$Slope_x = 0.31 \cdot deg$

$Diameter_{conn.pole} = 17.3 \cdot in$

$$max\left(\begin{pmatrix} Diameter_{base.arm1_0} \\ Diameter_{base.arm2_0} \end{pmatrix}\right) = 13.1 \cdot in$$

'UA'= $Y_{pole} = 22.75\,ft$

'UB'= $Y_{arm.conn} = 19.75\,ft$

'UC'= $Diameter_{tip.pole} = 16.8\,in$

'UD'= $Diameter_{base.pole} = 20\,in$

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

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

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

VI. Arm to Upright Connection Analysis

InputDataFile = "A50SH-P3S-DS1445.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	29	0.75	1.25	3
'HT'	'FJ', 'SJ'	'FL', 'SL'	'FP', 'SP'	'FK', 'SK'

Analyze Connection

Connection Summary

'HT'= $h_{conn.plate} = 22 \cdot in$ $D/C_{ht.conn.plate} = 0.85$ $CheckHt_{conn.plate} = \text{"OK"}$

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

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

$$\begin{pmatrix} D/C_{t.baseplate.arm_0} \\ CFI_{t.vert.plate_0} \\ CSR_{bolt.conn_0} \end{pmatrix} = \begin{pmatrix} 0.83 \\ 0.41 \\ 0.28 \end{pmatrix}$$

$\#Bolts_{conn_0} = 6$

'FO'= $Offset_{conn_0} = 16.0 \cdot in$

'FJ'= $b_{conn.plate_0} = 29 \cdot in$

'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'= $w_{vertical.plate_0} = \frac{5}{16} \cdot in$

'FT'= $w_{conn.plate_0} = \frac{5}{16} \cdot in$

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

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

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

$\#Bolts_{conn_1} = 0$

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

'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 = "A50SH-P3S-DS1445.dat"

Enter Anchorage Data

Anchor Bolt Diameter (in)	*Number of Anchor Bolts*
2	6
'BC'	'#Bolts'

Help - Number of Anchor Bolts

$Diameter_{base.pole} = 20 \cdot in$

Analyze Base Plate & Anchors

Base Plate and Anchor Summary

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

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

$CSR_{anchor} = 0.23$

$Diameter_{boltcircle.pole} = 28 \cdot in$

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

$CheckCSR_{anchorbolt} = \text{"OK"}$

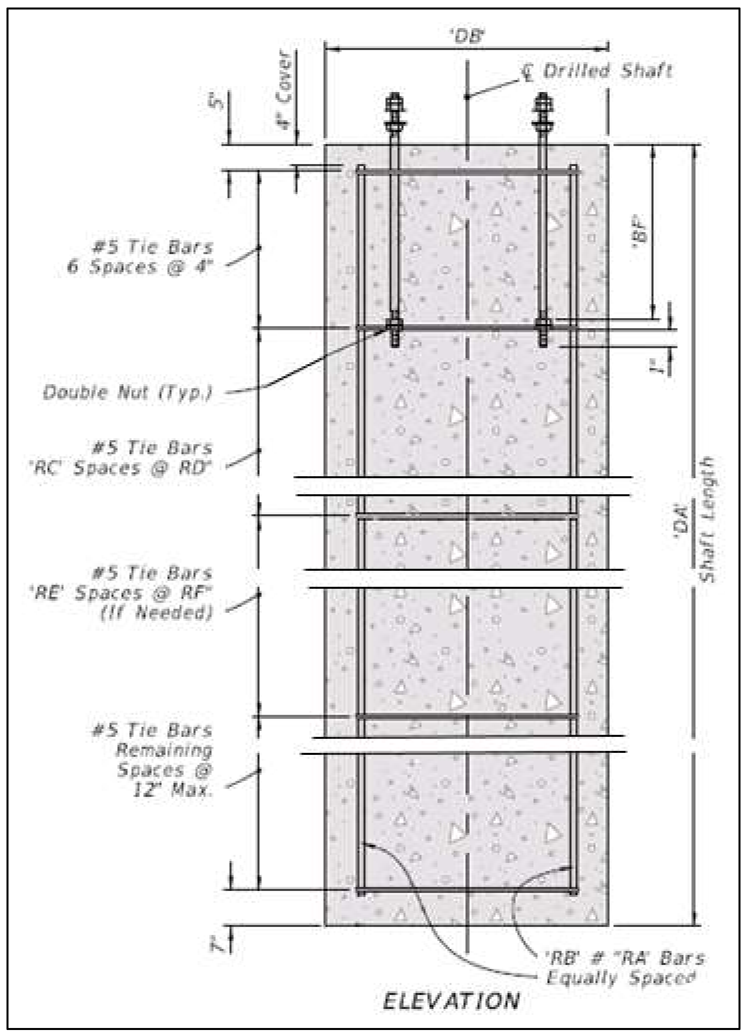
'BA'= $Diameter_{baseplate.pole} = 36 \cdot in$

VIII. Foundation Analysis & Anchor Bolt Lengths

InputDataFile = "A50SH-P3S-DS1445.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)		2000	psf
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 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

define variable for saving in output file

$$inpLuminaire := \begin{pmatrix} inpYLuminaire \\ inpXLuminaire \\ inpLumBaseDia \\ inpLumWallThk \\ inpLumSlope \\ inpLumRadius \\ inpLumBoltDia \\ inptLumBasePlate \end{pmatrix} \qquad outLuminaire := inpLuminaire$$

$$inpUpright := \begin{pmatrix} inpUprightTotHeight \\ inpUprightHtToConn \\ inpUprightBaseDia \\ inpUprightWallThk \\ inpAnchorBoltDia \\ inpNumOfAnchorBolts \\ inpConnPlateHeight \end{pmatrix} \qquad outUpright := inpUpright$$

$$inpConn := \begin{pmatrix} inpArm1Gap & inpArm1VertPlateThk & inpArm1BoltDia & inpArm1BasePlateThk & inpArm1BasePlateWidth \\ inpArm2Gap & inpArm2VertPlateThk & inpArm2BoltDia & inpArm2BasePlateThk & inpArm2BasePlateWidth \end{pmatrix}$$

$$outConn := inpConn$$

$$inpShaft := \begin{pmatrix} num2str(inpSoilType) \\ inpSoilDensity \\ inpFrictionAngle \\ inpNumBlows \\ inpShearStrength \\ "0.0" \\ "0.0" \\ "0.0" \\ inpShaftOffset \\ inpNumSpacesB \\ inpStirrupSpacingB \\ inpNumSpacesC \\ inpStirrupSpacingC \\ inpStirrupSize \end{pmatrix} \qquad outShaft := inpShaft$$

Foundation Data

$SoilType := inpSoilType = 0$

$\gamma_{soil} := str2num(inpSoilDensity) \cdot pcf = 43 \cdot pcf$

$\phi_{soil} := str2num(inpFrictionAngle) \cdot deg = 29 \cdot deg$

$N_{blows} := \text{str2num}(\text{inpNumBlows}) = 6$

$c_{soil} := \text{str2num}(\text{inpShearStrength}) \cdot psf = 2000 \cdot psf$

$\text{Offset} := \text{str2num}(\text{inpShaftOffset}) \cdot ft = 0.5\,ft$

$\text{NumSpacesStirrupsB} := \text{str2num}(\text{inpNumSpacesB}) = 10$

$s_{v_1} := \text{str2num}(\text{inpStirrupSpacingB}) \cdot in = 8 \cdot in$

$\text{NumSpacesStirrupsC} := \text{str2num}(\text{inpNumSpacesC}) = 0$

$s_{v_2} := \text{str2num}(\text{inpStirrupSpacingC}) \cdot in = 0 \cdot in$

$\text{StirrupBarSize} := \text{inpStirrupSize} = 5$

$\gamma_{water} := 62.4 \cdot pcf = 62.4 \cdot pcf$ *(not used)*

Foundation Design References

LRFD = AASHTO LRFD Bridge Design Specifications

SM V3 = FDOT Structures Manual Volume 3

SDG = FDOT Structures Design Guidelines

Spec = FDOT Standard Specifications

ACI = ACI 318 Structural Concrete Building Code

UF Report = FDOT/University of Florida Report BD545 RPWO #54

Applied Loads

(From Arm1 Design)

$V_{extreme} = 150 \cdot mph$

(from Base Plate Design)

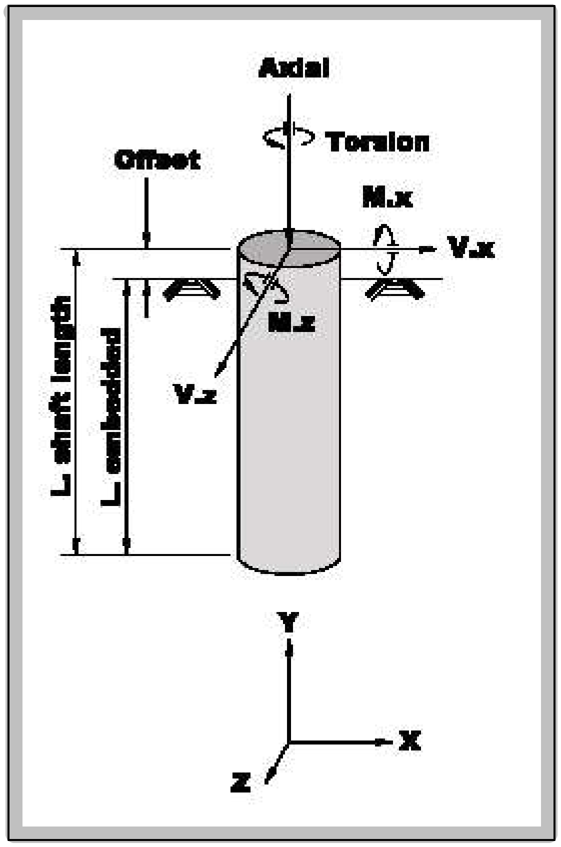
$\#AnchorBolts = 6$

$d_{anchorbolt} = 2 \cdot in$

$Diameter_{boltcircle.pole} = 28 \cdot in$

$T_{u.anchor} = 44.5 \cdot kip$

(from Upright Design)



$$M_{x.polebase} = \begin{pmatrix} 0 \\ 147.3 \\ 147.3 \end{pmatrix} \cdot kip \cdot ft$$

$$M_{y.polebase} = \begin{pmatrix} 179.9 \\ 0 \\ 179.9 \end{pmatrix} \cdot kip \cdot ft$$

$$M_{z.polebase} = \begin{pmatrix} 0 \\ 51 \\ 51 \end{pmatrix} \cdot kip \cdot ft$$

$LoadCaseT = 0$ $LoadCaseOT = 1$ $LoadCaseCFI = 2$

$$V_{x.polebase} = \begin{pmatrix} 0 \\ 0 \\ 0 \end{pmatrix} \cdot kip \qquad AxialForce_{polebase} = \begin{pmatrix} 4 \\ 4 \\ 4 \end{pmatrix} \cdot kip \qquad V_{z.polebase} = \begin{pmatrix} 0 \\ 7.9 \\ 7.9 \end{pmatrix} \cdot kip$$

Foundation Diameter

$Diameter_{shaft} := Diameter_{boltcircle.pole} + 12 \cdot in + 12 \cdot in = 4.33\ ft$

round shaft diameter up to the nearest half foot dimension to accommodate available coring equipment

$$Diameter_{shaft} := Ceil\left(Diameter_{shaft}, \frac{1}{2} \cdot ft\right) = 4.5\ ft$$

$Diameter_{shaft.custom} := 4.5 \cdot ft$

$Diameter_{shaft} := if\left[\left(Diameter_{shaft.custom} > 0 \cdot ft\right), Diameter_{shaft.custom}, Diameter_{shaft}\right] = 1.4$

$b := Diameter_{shaft}$

Shaft Depth Required to Resist Overturning

the following calculations are consistent with FDOT's Drilled Shaft Program V1.1

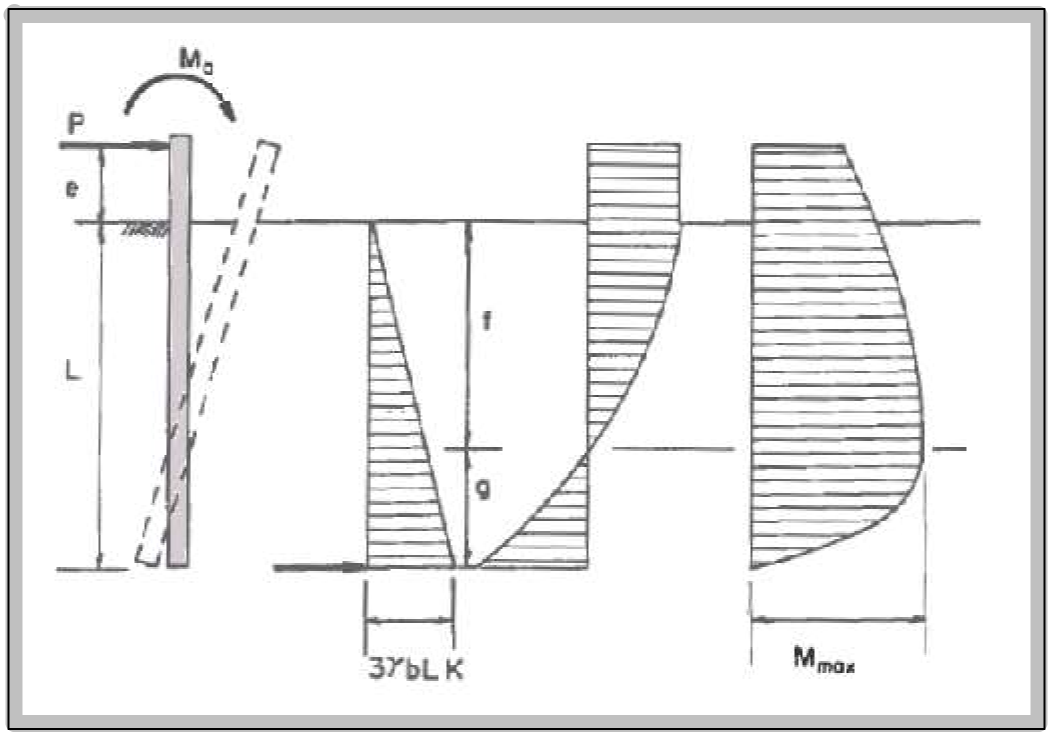
$\phi_{ot} := 0.6$ **SM V3 13.6** $Offset = 0.5 \cdot ft$ *vertical distance between top of foundation and ground line*

$$M_u := \sqrt{\left(M_{x.polebase_{LoadCaseOT}}\right)^2 + \left(M_{z.polebase_{LoadCaseOT}}\right)^2} = 155.8 \cdot kip \cdot ft$$

$$P_u := \sqrt{\left(V_{x.polebase_{LoadCaseOT}}\right)^2 + \left(V_{z.polebase_{LoadCaseOT}}\right)^2} = 7.91 \cdot kip$$

$$T_u := M_{y.polebase_{LoadCaseT}} = 179.9 \cdot kip \cdot ft$$

*short free-head pile in **cohesionless soil** using Broms method*



Deflection, load, shear and moment diagram for a short pile in cohesionless soil that is unrestrained against rotation.

$K_p := \tan\left(45 \cdot deg + \frac{\phi_{soil}}{2}\right)^2 = 2.9$ $e_{sand} := Offset = 0.5\,ft$

Guess value $L_{otSand} := 8 \cdot ft$

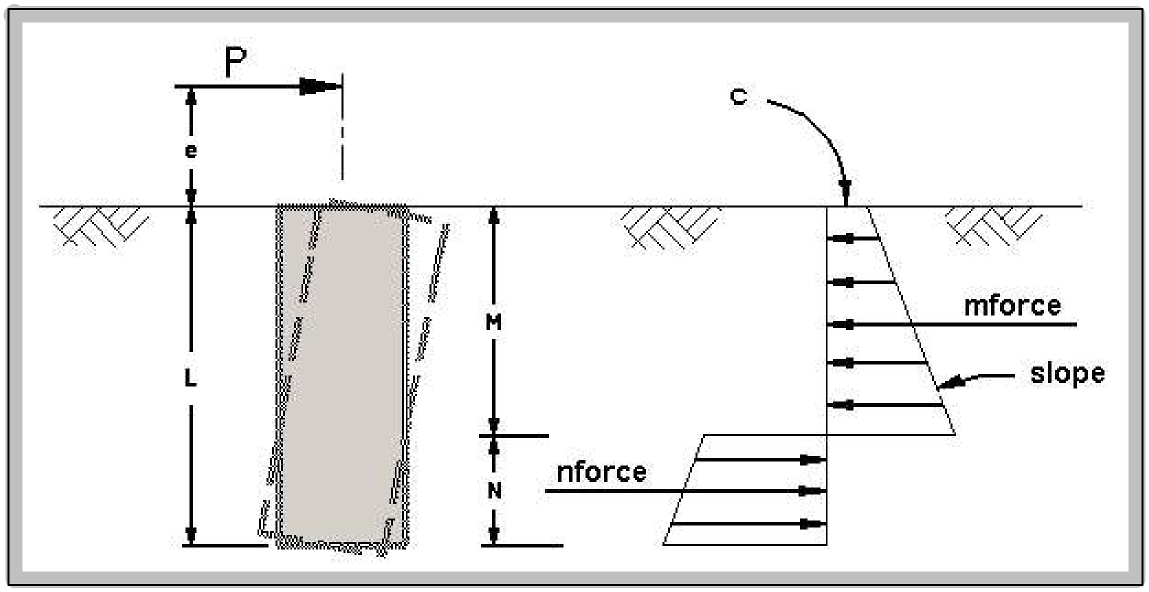
Given $P_u \cdot \left(e_{sand} + L_{otSand}\right) + M_u = \phi_{ot} \cdot \left[\left(3 \cdot \gamma_{soil} \cdot b \cdot L_{otSand} \cdot K_p\right) \cdot \left(\frac{1}{2} \cdot L_{otSand}\right) \cdot \left(\frac{1}{3} \cdot L_{otSand}\right)\right]$

$L_{otSand} := Find\left(L_{otSand}\right) = 11.4\,ft$

$L_{otSand} := ceil\left(\frac{L_{otSand}}{ft}\right) \cdot ft = 12\,ft$ *(round up to next foot)*

$$D/C_{otSand} := \frac{M_u + P_u \cdot (e_{sand} + L_{otSand})}{\frac{(\phi_{ot}) \cdot \gamma_{soil} \cdot b \cdot L_{otSand}^3 \cdot K_p}{2}} = 0.88$$

short free-head pile in <u>cohesive soil</u> using Modified Broms method for L < 3b (see reference file for derivation)



Deflection, load, shear and moment diagram for a short pile in cohesive soil that is unrestrained against rotation.

$c_{soil} := if[(c_{soil} = 0 \cdot ksf), 0.1 \cdot ksf, c_{soil}] = 2 \cdot ksf$ $c_{soil} = 2000 \cdot psf$

$Slope := 8 \cdot \frac{c_{soil}}{3 \cdot b} = 1.2 \cdot \frac{kip}{ft^3}$ $e_{clay} := \frac{M_u}{P_u} + Offset = 20.2\,ft$

$nforce(M,N) := [Slope \cdot (2 \cdot M + N) + 2 \cdot c_{soil}] \cdot N \cdot \frac{b}{2}$ $mforce(M) := (2 \cdot c_{soil} + M \cdot Slope) \cdot M \cdot \frac{b}{2}$

$$m\_arm(M) := e_{clay} + \frac{M}{3} \cdot \frac{2 \cdot (M \cdot Slope + c_{soil}) + c_{soil}}{M \cdot Slope + 2 \cdot c_{soil}}$$

$$n\_arm(M,N) := e_{clay} + M + \frac{N}{3} \cdot \frac{2 \cdot (N \cdot Slope + M \cdot Slope + c_{soil}) + (M \cdot Slope + c_{soil})}{Slope \cdot (2 \cdot M + N) + 2 \cdot c_{soil}}$$

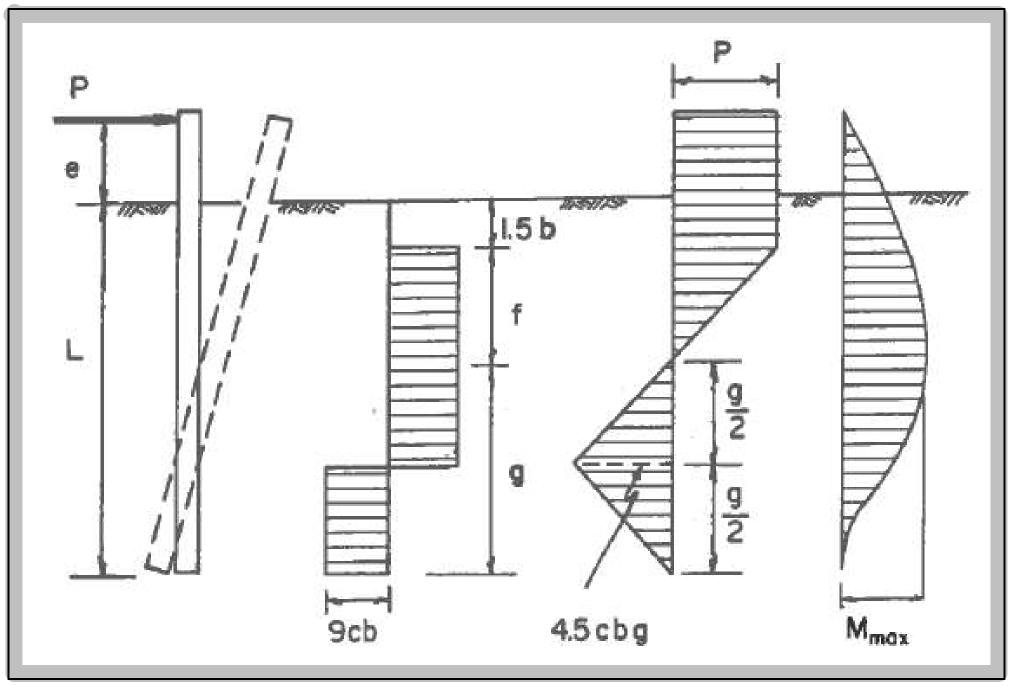
Guess value $M := 4.0 \cdot ft$ $N := 4.0 \cdot ft$

Given $P_u + \phi_{ot} \cdot nforce(M,N) = \phi_{ot} \cdot mforce(M)$ $mforce(M) \cdot m\_arm(M) = nforce(M,N) \cdot n\_arm(M,N)$

$\begin{pmatrix} M \\ N \end{pmatrix} := Find(M,N)$ $L_{ot1Clay} := M + N = 7.2\,ft$

$L_{ot1Clay} := \text{ceil}\left(\frac{L_{ot1Clay}}{ft}\right) \cdot ft = 8\ ft$ *(round up to next foot)*

short free-head pile in ***cohesive soil*** *using Regular Broms method for L > 3b*



Deflection, load, shear and moment diagram for a short pile in cohesive soil that is unrestrained against rotation.

$M_{max.clay}$ *equation is derived from the integration of the upper part of the shear diagram to the point of zero shear.*

$$f := \frac{P_u}{\phi_{ot} \cdot 9 \cdot c_{soil} \cdot b} = 0.2\ ft$$

$$M_{max.clay} := P_u \cdot \left(e_{clay} + 1.5 \cdot b + 0.5 \cdot f\right) = 213.8 \cdot kip \cdot ft$$

$$g := \sqrt{\frac{M_{max.clay}}{2.25 \cdot \phi_{ot} \cdot c_{soil} \cdot b}} = 4.2\ ft$$

$$L_{ot2Clay} := (1.5 \cdot b + f + g) = 11.1\ ft$$

$L_{ot2Clay} := \text{ceil}\left(\frac{L_{ot2Clay}}{ft}\right) \cdot ft = 12\ ft$ *(round up to next foot)*

$L_{otClay} := \text{if}\left[\left(L_{ot1Clay} < 3 \cdot b\right), L_{ot1Clay}, L_{ot2Clay}\right] = 2.4$ *(If L_{ot} < 3b, use Modified Broms method)*

$$L_{reqdOT} := \text{if}\left[(\text{SoilType} = 0), L_{otSand}, L_{otClay}\right]$$

$L_{reqdOT} = 12\ ft$ *required shaft embedment depth to resist overturning*

Shaft Depth Required to Resist Torsion

$\phi_{tor} := 1.0$ ***SM V3 13.6***

*short free-head pile in **cohesionless soil***

NOTE: ω_{fdot} is based upon concrete soil interaction. This torsion methodology is not to be used with permanent casing.

$N_{blows} = 6$

$$\omega_{fdot} := \text{if}\left[\left(N_{blows} < 5\right), 0, \text{if}\left[\left(N_{blows} \geq 15\right), 1.5, 1.5 \cdot \frac{N_{blows}}{15}\right]\right] = 0.6$$

load transfer ratio, If 5<N<15, ω_{fdot} is reduced by a factor of $\frac{N_{blows}}{15}$ ***SM Vol-3 13.6***

Guess value $L_{torSand} := L_{reqdOT} = 12\,ft$

Given $T_u = \phi_{tor} \cdot \left[\left(\pi \cdot b \cdot L_{torSand}\right) \cdot \left(\gamma_{soil} \cdot \frac{L_{torSand}}{2}\right) \cdot \left(\omega_{fdot}\right) \cdot \frac{b}{2}\right]$

$L_{torSand} := \text{Find}\left(L_{torSand}\right) = 20.9\,ft$

$L_{torSand} := \text{ceil}\left(\frac{L_{torSand}}{ft}\right) \cdot ft = 21\,ft$ *(round up to next foot)*

*short free-head pile in **cohesive soil***

$\text{CohesionFactor} := 0.55$

$f_{se} := \text{CohesionFactor} \cdot c_{soil} = 1.1 \cdot ksf$

Guess value $L_{torClay} := L_{reqdOT}$

Given $T_u = \phi_{tor} \cdot \left[f_{se} \cdot (\pi \cdot b) \cdot \left(L_{torClay} - 1.5 \cdot ft\right) \cdot \frac{b}{2}\right]$

$L_{torClay} := \text{Find}\left(L_{torClay}\right) = 6.6\,ft$

$L_{torClay} := \text{ceil}\left(\frac{L_{torClay}}{ft}\right) \cdot ft = 7\,ft$ *(round up to next foot)*

$\text{SoilType} = 0$ *0 - Sand*
1 - Clay

$L_{reqdTor} := \text{if}\left[(\text{SoilType} = 0), L_{torSand}, L_{torClay}\right]$ $L_{reqdTor} = 21\,ft$ *required shaft embedment depth to resist torsion*

$L_{embedded} := \text{if}\left[\left(L_{reqdTor} > L_{reqdOT}\right), L_{reqdTor}, L_{reqdOT}\right] = 21 \cdot ft$

$L_{shaft} := L_{embedded} + \text{Offset}$ $L_{shaft} = 21.5\,ft$ *shaft length*

Maximum Moment in Shaft

short free-head pile in cohesionless soil using Broms method

$$f_{sand} := \sqrt{\frac{2 \cdot P_u}{3 \cdot \gamma_{soil} \cdot b \cdot K_p \cdot \phi_{ot}}} = 4\ ft$$

$$M_{maxSand} := P_u \cdot (e_{sand} + f_{sand}) - \frac{P_u \cdot f_{sand}}{3} + M_u = 180.7 \cdot kip \cdot ft$$

*short free-head pile in **cohesive soil** using Modified Broms method for L < 3b (see reference file for derivation)*

Guess value $f_{mod} := 4.0 \cdot ft$

Given $P_u = \frac{f_{mod} \cdot b}{2} \cdot (2\phi_{ot} \cdot c_{soil} + \phi_{ot} \cdot f_{mod} \cdot Slope)$

$f_{mod} := Find(f_{mod}) = 1.1\ ft$

$$M_{modBroms} := P_u \cdot (e_{clay} + f_{mod}) - \frac{\phi_{ot} \cdot c_{soil} \cdot b \cdot f_{mod}^2}{2} - \frac{\phi_{ot} \cdot b \cdot f_{mod}^3 \cdot Slope}{6} = 164.5 \cdot kip \cdot ft$$

*short free-head pile in **cohesive soil** using Regular Broms method for L > 3b*

$$M_{Broms} := P_u \cdot (e_{clay} + 1.5 \cdot b + 0.5 \cdot f) = 213.8 \cdot kip \cdot ft$$

$M_{maxClay} := if[(L_{ot1Clay} < 3 \cdot b), M_{modBroms}, M_{Broms}] = 164.5 \cdot kip \cdot ft$ *(If $L_{ot} < 3b$, use Modified Broms method)*

$$M_{max} := if[(SoilType = 0), M_{maxSand}, M_{maxClay}] = 180.7 \cdot kip \cdot ft$$

Minimum Reinforcing and Spacing

$F_{y.rebar} := 60 \cdot ksi$ *reinforcing yield strength*

$f_c := 4.0 \cdot ksi$ *concrete strength* ***Spec 346-3***

$Cover := 6 \cdot in$ *cover* ***SDG Table 1.4.2-1***

$A_{long.bar} := 1.56 \cdot in^2$ *longitudinal bar area*

$d_{long.bar} := 1.41 \cdot in$ *longitudinal bar diameter*

$A_{v.bar} := if(StirrupBarSize = 5, 0.31 \cdot in^2, 0.44 \cdot in^2) = 0.31 \cdot in^2$ *stirrup area* ***SM V3 13.6.2***

$d_{v.bar} := if(StirrupBarSize = 5, 0.625 \cdot in, 0.75 \cdot in) = 0.625 \cdot in$ *stirrup diameter*

<u>***SM V3 13.6.2***</u>

$$s_v := \begin{pmatrix} 4\cdot in \\ s_{v_1} \\ s_{v_2} \\ 12\cdot in \end{pmatrix} = \begin{pmatrix} 4 \\ 8 \\ 0 \\ 12 \end{pmatrix}\cdot in \qquad \begin{pmatrix} \text{"Stirrups A"} \\ \text{"Stirrups B"} \\ \text{"Stirrups C"} \\ \text{"Stirrups D"} \end{pmatrix}$$

stirrup spacing defined in Index 649-031, depth = 0 ft-2 ft

stirrup spacing, depth = 2 ft-depth.stir

stirrup spacing, depth > depth.stir

stirrup spacing, depth > depth.stirA

$$\#Spaces_{vbar} := \begin{pmatrix} 6 \\ NumSpacesStirrupsB \\ NumSpacesStirrupsC \\ 1 \end{pmatrix} = \begin{pmatrix} 6 \\ 10 \\ 0 \\ 1 \end{pmatrix} \qquad \begin{pmatrix} \text{"Stirrups A"} \\ \text{"Stirrups B"} \\ \text{"Stirrups C"} \\ \text{"Stirrups D"} \end{pmatrix}$$

$$s_v = \begin{pmatrix} 4 \\ 8 \\ 0 \\ 12 \end{pmatrix}\cdot in \qquad \#Spaces_{vbar} = \begin{pmatrix} 6 \\ 10 \\ 0 \\ 1 \end{pmatrix}$$

$$\#Spaces_{vbar_2} := if\left[\#Spaces_{vbar_2} = 0, floor\left[\frac{L_{shaft} - 5\cdot in - \sum_{i=0}^{1} \left(s_{v_i}\cdot \#Spaces_{vbar_i}\right)}{s_{v_3}}\right], \#Spaces_{vbar_2}\right] = 12$$

$$\#Spaces_{vbar_3} := floor\left[\frac{L_{shaft} - 5\cdot in - \sum_{i=0}^{2} \left(s_{v_i}\cdot \#Spaces_{vbar_i}\right)}{s_{v_3}}\right] = 12$$

$$L_{shaft} = 21.5\ ft \qquad \sum_{i=0}^{3} \left(s_{v_i}\cdot \#Spaces_{vbar_i}\right) = 20.7\ ft$$

$b = 4.5\ ft$ *shaft diameter*

$$\#LongBars_{reqd_1} := \frac{0.01}{A_{long.bar}}\cdot\frac{\pi\cdot b^2}{4} = 14.7$$

<u>***LRFD 5.7.4.2***</u>

$$\#LongBars_{reqd_2} := \frac{0.135}{A_{long.bar}\cdot F_{y.rebar}}\cdot\left(\frac{\pi\cdot b^2}{4}\cdot f_c\right) = 13.2$$

$$\#LongBars_{prov} := ceil\left(max\left(\#LongBars_{reqd_1}, \#LongBars_{reqd_2}\right)\right) = 15$$ ~~15~~ 16 *number of longitudinal bars*

$$Dia_{bar.circle} := b - 2\cdot Cover - 2\cdot d_{v.bar} - d_{long.bar} = 39.3\cdot in$$

$Spacing_{vert.reinf} := Dia_{bar.circle} \cdot \frac{\pi}{\#LongBars_{prov}} = 8.2 \cdot in$ $Clearance_{vert.reinf} := Spacing_{vert.reinf} - d_{long.bar} = 6.83 \cdot in$

$CheckReinfClearSpacing := if(Clearance_{vert.reinf} \geq 6in, "OK", "No Good")$ $CheckReinfClearSpacing = "OK"$

SDG 3.6.10

Check Shear and Torsion

$\phi_v := 0.90$ *Shear Resistance Factor*   LRFD 5.5.4.2.1

$$V_u := \sqrt{\left(V_{x.polebase_{LoadCaseOT}}\right)^2 + \left(V_{z.polebase_{LoadCaseOT}}\right)^2} = 7.9 \cdot kip$$

$T_u = 179.9 \cdot kip \cdot ft$

Effective shear depth

$$D_r := b - 2 \cdot \left(Cover + d_{v.bar} + \frac{d_{long.bar}}{2}\right) = 3.3\,ft \qquad d_e := \frac{b}{2} + \frac{D_r}{\pi} = 3.3\,ft$$

LRFD C5.8.2.9-2

$d_v := \max(0.9 \cdot d_e, 0.72 \cdot b) = 3.2\,ft$

Check Shear Strength

$$V_c := 0.0316 \cdot (2.0) \cdot \sqrt{f_c \cdot ksi} \cdot (d_v) \cdot b = 265.4 \cdot kip$$

LRFD Eqn 5.8.3.3-3   LRFD 5.8.3.4.1   ACI 11.3.3

$$V_s := \frac{A_{v.bar} \cdot F_{y.rebar} \cdot d_v}{\max\left(s_{v_0}, s_{v_1}, s_{v_2}\right)} = 90.4 \cdot kip$$

LRFD Eqn 5.8.3.3-4

$$D/C_{shear} := \max\left(\begin{pmatrix} \frac{V_u - \phi_v \cdot V_c}{\phi_v \cdot V_s} \\ 0 \end{pmatrix}\right) = 0$$

Check Torsion Strength

$$A_{cp} := \pi \cdot \left(\frac{b}{2}\right)^2 = 2290.2 \cdot in^2 \qquad p_{cp} := 2 \cdot \pi \cdot \left(\frac{b}{2}\right) = 169.6 \cdot in$$

Area and perimeter of concrete cross-section

$$d_{oh} := b - 2 \cdot \left(Cover + \frac{d_{v.bar}}{2}\right) = 41.4 \cdot in \qquad p_h := \pi \cdot d_{oh} = 130 \cdot in$$

Diameter, perimeter and area enclosed by the centerline of the outermost closed transverse torsion reinforcement

$$A_{oh} := \pi \left(\frac{d_{oh}}{2}\right)^2 = 1.3 \times 10^3 \cdot in^2 \qquad A_o := 0.85 \cdot A_{oh} = 1.1 \times 10^3 \cdot in^2$$

$$T_{n.torsion_0} := \frac{2 \cdot A_o \cdot A_{v.bar} \cdot F_{y.rebar}}{s_{v_0}} = 885.7 \cdot kip \cdot ft$$

LRFD Eqn 5.8.3.6.2-1

$$T_{n.torsion_1} := \frac{2 \cdot A_o \cdot A_{v.bar} \cdot F_{y.rebar}}{s_{v_1}} = 442.8 \cdot kip \cdot ft$$ ***LRFD 5.8.3.4.1***

$$T_{n.torsion_2} := T_{n.torsion_1} \text{ on error } \frac{2 \cdot A_o \cdot A_{v.bar} \cdot F_{y.rebar}}{s_{v_2}} = 442.8 \cdot kip \cdot ft$$

$\phi_v = 0.9$ $T_u = 179.9 \cdot kip \cdot ft$ $L_{reqdTor} = 21\,ft$

$$depth_{stir} := \left| \begin{array}{l} \text{for } i \in 0..1 \\ \quad depth_i \leftarrow \sum_{j=0}^{i} \left(s_{v_j} \cdot \#Spaces_{vbar_j}\right) \\ depth \end{array} \right.$$

$$depth_{stir} = \begin{pmatrix} 2 \\ 8.7 \end{pmatrix} ft$$

$$T_{u.section_0} := T_u$$

$$T_{u.sand_1} := T_u - if\left[\left(depth_{stir_0} > Offset\right), \left[\pi \cdot b \cdot \left(depth_{stir_0} - Offset\right) \cdot \gamma_{soil} \cdot \left(\frac{depth_{stir_0} - Offset}{2}\right) \cdot \left(\omega_{fdot}\right) \cdot \frac{b}{2}\right], 0 \cdot kip \cdot ft\right] = 179 \cdot kip \cdot ft$$

$$T_{u.sand_2} := T_u - if\left[\left(depth_{stir_1} > Offset\right), \left[\pi \cdot b \cdot \left(depth_{stir_1} - Offset\right) \cdot \gamma_{soil} \cdot \left(\frac{depth_{stir_1} - Offset}{2}\right) \cdot \left(\omega_{fdot}\right) \cdot \frac{b}{2}\right], 0 \cdot kip \cdot ft\right] = 152.6 \cdot kip \cdot ft$$

$$T_{u.clay_1} := T_u - if\left[\left(depth_{stir_0} - 1.5ft > Offset\right), \left[f_{se} \cdot (\pi \cdot b) \cdot \left(depth_{stir_0} - Offset - 1.5 \cdot ft\right) \cdot \frac{b}{2}\right], 0 \cdot kip \cdot ft\right] = 179.9 \cdot kip \cdot ft$$

$$T_{u.clay_2} := T_u - if\left[\left(depth_{stir_1} - 1.5ft > Offset\right), \left[f_{se} \cdot (\pi \cdot b) \cdot \left(depth_{stir_1} - Offset - 1.5 \cdot ft\right) \cdot \frac{b}{2}\right], 0 \cdot kip \cdot ft\right] = -53.3 \cdot kip \cdot ft$$

$$T_{u.section_1} := if\left[(SoilType = 0), T_{u.sand_1}, T_{u.clay_1}\right] = 179 \cdot kip \cdot ft$$

$$T_{u.section_2} := if\left[(SoilType = 0), T_{u.sand_2}, T_{u.clay_2}\right] = 152.6 \cdot kip \cdot ft$$

$$T_{u.section} = \begin{pmatrix} 179.9 \\ 179 \\ 152.6 \end{pmatrix} \cdot kip \cdot ft \qquad T_{n.torsion} = \begin{pmatrix} 885.7 \\ 442.8 \\ 442.8 \end{pmatrix} \cdot kip \cdot ft$$

$$D/C_{torsion} := \frac{T_{u.section}}{\phi_{tor} \cdot T_{n.torsion}} = \begin{pmatrix} 0.2 \\ 0.4 \\ 0.34 \end{pmatrix} \qquad D/C_{max.torsion} := \max\left(D/C_{torsion}\right) = 0.40$$

$$T_{cr} := 0.125 \sqrt{\frac{f_c}{ksi}} \cdot \left(\frac{A_{cp}^{\,2}}{p_{cp} \cdot in^3}\right) \cdot kip \cdot in = 644.1 \cdot kip \cdot ft$$ ***LRFD Eqn 5.8.2.1-4***

$T_u = 179.9 \cdot kip \cdot ft$ $\quad 0.25 \cdot \phi_{tor} \cdot T_{cr} = 161 \cdot kip \cdot ft$

$D/C_{torsion.max} := if\left[\left(T_u \le 0.25 \cdot \phi_{tor} \cdot T_{cr}\right), 0, max\left(D/C_{torsion}\right)\right] = 0.404$ ***LRFD Eqn 5.8.2.1-3***

$D/C_{shear} = 0.000$ $\quad D/C_{torsion.max} = 0.404$

$CheckD/C_{shear.and.torsion} := if\left[\left(D/C_{shear} + D/C_{torsion.max} \le 1\right), "OK", "No Good"\right]$ $\quad CheckD/C_{shear.and.torsion} = "OK"$

Check Maximum Spacing Transverse Reinforcement

$v_u := \frac{V_u}{\phi_v \cdot b \cdot d_v} = 0.0042 \cdot ksi$ $\quad 0.125 \cdot f_c = 0.5 \cdot ksi$ ***LRFD Eqn 5.8.2.9-1***

$s_{max1} := if\left[\left(0.8 \cdot d_v < 24 \cdot in\right), 0.8 d_v, 24 \cdot in\right] = 24 \cdot in$ ***LRFD Eqn 5.8.2.7-1***

$s_{max2} := if\left[\left(0.4 \cdot d_v < 12 \cdot in\right), 0.4 d_v, 12 \cdot in\right] = 12 \cdot in$ ***LRFD Eqn 5.8.2.7-2***

$s_{max} := if\left[\left(v_u < 0.125 \cdot f_c\right), s_{max1}, s_{max2}\right] = 24 \cdot in$

$max\left(s_v\right) = 12 \cdot in$

$CheckMaxSpacingTransvReinf := if\left[\left(max\left(s_v\right) \le s_{max}\right), "OK", "No Good"\right]$ $\quad CheckMaxSpacingTransvReinf = "OK"$

Check Longitudinal Reinforcement for Combined Shear and Torsion ***LRFD Eqn 5.8.3.6.3-1***

LRFD 5.8.3.4.1

$M_u = 155.8 \cdot kip \cdot ft$

$V_{temp} := if\left(\frac{V_u}{\phi_v} - 0.5 \cdot V_s > 0 \cdot kip, \frac{V_u}{\phi_v} - 0.5 \cdot V_s, 0 \cdot kip\right) = 0 \cdot kip$

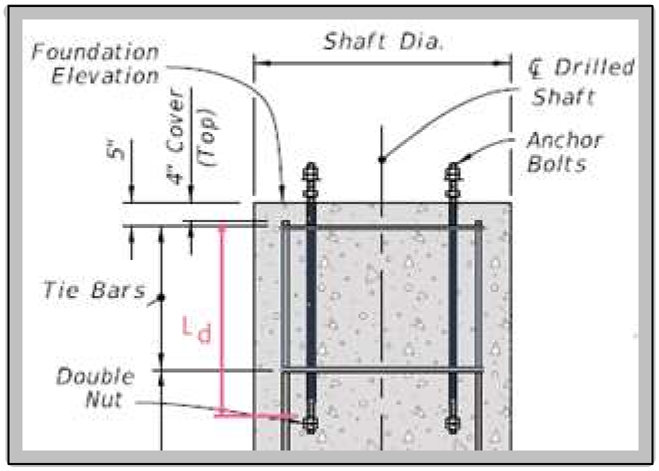
$$LongReinf_{shr.tor} := \frac{\frac{M_u}{\phi_v \cdot d_v} + \sqrt{\left(V_{temp}\right)^2 + \left(\frac{0.45 \cdot p_h \cdot T_u}{2 \cdot A_o \cdot \phi_v}\right)^2}}{F_{y.rebar}} = 1.91 \cdot in^2$$

$\#LongBars_{prov} \cdot A_{long.bar} = 23.4 \cdot in^2$

$CheckLongReinf_{shr.tor} := if\left[\left(\#LongBars_{prov} \cdot A_{long.bar} \ge LongReinf_{shr.tor}\right), "OK", "No Good"\right]$ $\quad CheckLongReinf_{shr.tor} = "OK"$

Anchor Bolt Embedment

$T_{u.anchor} = 44.5 \cdot kip$ *tension force in anchor*



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

$Dia_{anchor.circle} := Diameter_{boltcircle.pole} = 28 \cdot in$

center-to-center distance

$$Dist_{bar.to.bolt} := \frac{Dia_{bar.circle} - Dia_{anchor.circle}}{2} = 5.7 \cdot in$$

$$Num_{bars.per.anchor} := \min\left(\frac{\#LongBars_{prov}}{\#AnchorBolts}, 3\right) = 2.5$$ *Use a maximum of three rebar per anchor bolt (conservative)*

$\phi := 0.9$

$$Num_{bars.reqd.per.anchor} := \frac{T_{u.anchor}}{A_{long.bar} \cdot (\phi \cdot F_{y.rebar})} \cdot \frac{Dia_{anchor.circle}}{Dia_{bar.circle}} = 0.38$$

$$AreaRatio := \min\left(\frac{Num_{bars.reqd.per.anchor}}{Num_{bars.per.anchor}}, 1\right) = 0.15$$

2015 AASHTO Development Length of Deformed Bars in Tension ***5.11.2.1***

$Cover = 6 \cdot in$

$c_b =$ *the smaller of the distance from center of bar or wire being developed to the nearest concrete surface and one half the center-to-center spacing of the bars or wires being developed*

$$c_b := \min\left(\left(\begin{matrix} Cover + d_{v.bar} + \dfrac{d_{long.bar}}{2} \\ \dfrac{Spacing_{vert.reinf}}{2} \end{matrix}\right)\right) = 4.1 \cdot in$$

$k_{tr} := 0 \cdot in$ *assume no transverse bars:*

$$\lambda_{rc} := \min\left[\left[\begin{matrix} 1.0 \\ \max\left(\left(\begin{matrix} 0.4 \\ \dfrac{d_{long.bar}}{c_b + k_{tr}} \end{matrix}\right)\right) \end{matrix}\right]\right] = 0.4$$ ***LRFD Eqn 5.11.2.1.3-1***

$$L_{d.bar} := \max\left(\left(\begin{matrix} 12 \cdot in \\ \lambda_{rc} \cdot 2.4 \cdot d_{long.bar} \cdot \dfrac{F_{y.rebar}}{\sqrt{f_c \cdot ksi}} \end{matrix}\right)\right) = 40.6 \cdot in$$ *tension development length* ***LRFD Eqn 5.11.2.1.1-2***

$$SpacingFactor := \max\left[\begin{pmatrix} 0.5 \\ Num_{bars.per.anchor} \cdot 0.5 - 0.5 \end{pmatrix}\right] = 0.8$$

$$L_{embedment.added} := \sqrt{\left(Clearance_{vert.reinf} \cdot SpacingFactor\right)^2 + Dist_{bar.to.bolt}{}^2} = 7.6 \cdot in$$

$$L_{embedment.anchor} := \max\left[\begin{bmatrix} L_{d.bar} \cdot (AreaRatio) + 12 \cdot in + L_{embedment.added} \\ 20 \cdot d_{anchorbolt} \end{bmatrix}\right] = 40 \cdot in$$

Note: $20d_{anchor.bolt}$ *minimum embedment is in LTS,3rd Ed. 1994, Section 3, 1.3.4 and still a good rule of thumb.*

$$L_{anchor.bolt.exposed} := \max\left(\begin{pmatrix} 8 \cdot in \\ 2 \cdot d_{anchorbolt} + t_{baseplate.pole} + 2 \cdot d_{anchorbolt} + 2 \cdot in \end{pmatrix}\right) = 12.5 \cdot in$$

$$L_{anchor.bolt} := Ceil\left(L_{embedment.anchor} + L_{anchor.bolt.exposed}, in\right) = 53 \cdot in$$

$L_{anchor.bolt} = 53 \cdot in$

Anchor Bolt Shear Break-Out Strength

References:
ACI 318-05 Appendix D.
FDOT/University of Florida Report BD545 RPWO #54,
Anchor Embedment Requirements for Signal/Sign Structures, July 2007.

$\#AnchorBolts = 6$ — *number of anchor bolts*

$d_{anchorbolt} = 2 \cdot in$ — *anchor bolt diameter*

$Diameter_{boltcircle.pole} = 28 \cdot in$ — *anchor bolt circle diameter*

$L_{embedment.anchor} = 40 \cdot in$ — *anchor bolt embedment*

$b = 54 \cdot in$ — *shaft diameter*

$$r_b := \frac{Dia_{anchor.circle}}{2} = 14 \cdot in$$

$$r := \frac{b}{2} = 27 \cdot in$$

$$c_{a1} := \frac{\sqrt{r_b{}^2 + 3.25 \cdot \left(r^2 - r_b{}^2\right)} - r_b}{3.25} = 9.2 \cdot in$$

adjusted cover

UF Report Eqn 3-2

$$L_e := \min\left(\begin{pmatrix} 8 \cdot d_{anchorbolt} \\ L_{embedment.anchor} \end{pmatrix}\right) = 16 \cdot in$$

load bearing length of anchor for shear

ACI D.6.2.2

$$V_b := 13 \cdot \left(\frac{L_e}{d_{anchorbolt}}\right)^{0.2} \cdot \sqrt{\frac{d_{anchorbolt}}{in}} \cdot \sqrt{\frac{f_c}{psi}} \left(\frac{c_{a1}}{in}\right)^{1.5} \cdot lbf = 49.2 \cdot kip$$

shear break-out strength (single anchor)
UF Report Eqn 2-11

$A_{bolt.sector} := \frac{(360 \cdot deg)}{\#AnchorBolts} = 60 \cdot deg$ ***UF Report Fig 3-7***

$\alpha_{cone} := 2\,asin\left[\frac{(1.5 \cdot c_{a1})}{r}\right] = 61.5 \cdot deg$

$OverlapTest := if\left(A_{bolt.sector} \le \alpha_{cone}, \text{"Overlap of Failure Cones"}, \text{"No Overlap of Failure Cones"}\right) = \text{"Overlap of Failure Cones"}$

$chord := 2 \cdot r \cdot sin\left(\frac{A_{bolt.sector}}{2}\right) = 27 \cdot in$ ***UF Report Fig 3-7***

$A_{Vco} := 4.5 \cdot c_{a1}^{2} = 381.2 \cdot in^{2}$ *projected concrete failure area (single anchor)*

ACI Eqn D-23

$A_{Vc} := chord \cdot 1.5 \cdot c_{a1} = 372.7 \cdot in^{2}$ *projected concrete failure area (group)*

ACI D.6.2.1

$A_{Vc} := if\left[\left(A_{Vc} > A_{Vco}\right), A_{Vco}, A_{Vc}\right] = 372.7 \cdot in^{2}$

$\psi_{ecV} := \mathbf{1.0}$ *eccentric load modifier* ***ACI D.6.2.5***

$\psi_{edV} := \mathbf{1.0}$ *edge effect modifier* ***ACI D.6.2.6***

$\psi_{cV} := \mathbf{1.0}$ *cracked section modifier* ***ACI D.6.2.7*** *(stirrup spacing <= 4")*

$\psi_{hV} := \mathbf{1.0}$ *member thickness modifier* ***ACI D.6.2.8***

$\phi_{breakout} := \mathbf{0.75}$ *strength reduction factor* ***ACI D.4.4.c.i*** *(shear breakout, condition A)*

$$V_{cbg} := \#AnchorBolts \cdot \left(\frac{A_{Vc}}{A_{Vco}}\right) \cdot \left(\psi_{ecV} \cdot \psi_{edV} \cdot \psi_{cV} \cdot \psi_{hV}\right) \cdot V_b = 288.7 \cdot kip$$

concrete breakout strength - shear

ACI Eqn D-22 *Shear force ⊥ to edge*

$V_{cbg\_parallel} := 2 \cdot V_{cbg} = 577.4 \cdot kip$ ***ACI D.6.2.1.c*** *Shear force ‖ to edge*

$T_{n.breakout} := V_{cbg\_parallel} \cdot r_b = 673.7 \cdot kip \cdot ft$ *concrete breakout strength - torsion*

$\phi_{breakout} \cdot T_{n.breakout} = 505.3 \cdot kip \cdot ft$

$T_u = 179.9 \cdot kip \cdot ft$

BreakoutTest := if[($\phi_{breakout} \cdot T_{n.breakout} \geq T_u$), "OK" , "No Good"]

BreakoutTest = "OK"

OverlapDesign := if[($A_{bolt.sector} \leq \alpha_{cone}$), "Based on Overlap of Failure Cones" , "Based on No Overlap of Failure Cones"]

OverlapDesign = "Based on Overlap of Failure Cones"

Clearance Between Vertical Reinforcement and Anchor Bolt Nut

$Dist_{bar.to.bolt} = 5.7 \cdot in$ *center-to-center distance*

$d_{anchor.nut} := 1.85 \cdot d_{anchorbolt} = 3.7 \cdot in$ *use* an *.to account for anchor nut*

$$Clearance_{bar.to.nut} := Dist_{bar.to.bolt} - \left(\frac{d_{anchor.nut} + d_{long.bar}}{2}\right) = 3.1 \cdot in$$

CheckAnchorageClearance := if[($Clearance_{bar.to.nut} \geq 2 \cdot in$), "OK" , "No Good, increase shaft diameter"]

CheckAnchorageClearance = "OK"

CSL tubes can be relocated plus/minus 2 inches from planned position (see Specifications)

$d_{csl.tube} := 2 \cdot in$

$Clearance_{csl.to.nut} := Dist_{bar.to.bolt} + 0.5 \cdot d_{long.bar} - d_{csl.tube} - 0.5 \cdot d_{anchor.nut} = 2.5 \cdot in$

Draw Drilled Shaft Section with Reinforcement

fDrawStirrups(spacing, #spaces, inix, iniy) :=

```
coord[0,0] ← inix
coord[0,1] ← iniy
for i ∈ 1 .. #spaces
    coord[i,0] ← coord[0,0]
    coord[i,1] ← coord[i−1,1] − spacing
index ← 1
for i ∈ #spaces + 1 .. 2·#spaces + 1
    coord[i,0] ← b − inix
    coord[i,1] ← coord[i−index,1]
    index ← index + 2
coord[2·#spaces+2,0] ← inix
coord[2·#spaces+2,1] ← iniy
coord
```

$StirrupsA := fDrawStirrups\left(s_{v_0}, \#Spaces_{vbar_0}, Cover, Offset - 5 \cdot in\right)$

$StirrupsB := fDrawStirrups\left(s_{v_1}, \#Spaces_{vbar_1}, Cover, \min\left(StirrupsA^{\langle 1 \rangle}\right)\right)$

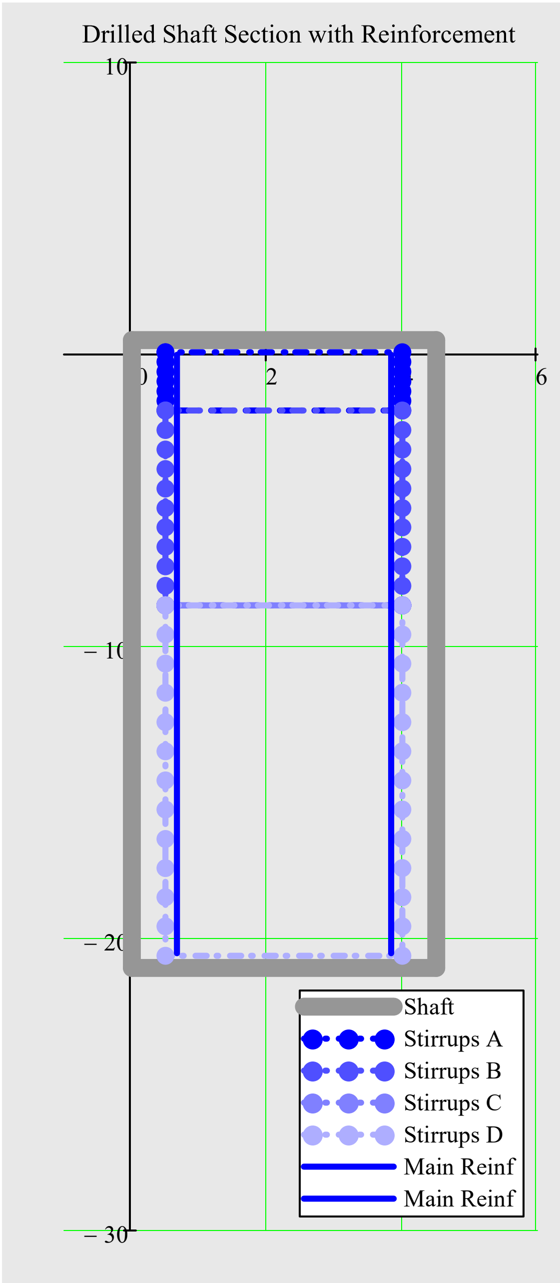
$StirrupsC := fDrawStirrups\left(s_{v_2}, \#Spaces_{vbar_2}, Cover, \min\left(StirrupsB^{\langle 1 \rangle}\right)\right)$

StirrupsD :=

```
coord ← ( Cover        min(StirrupsC) )
        ( b − Cover    min(StirrupsC) )
coord ← fDrawStirrups(s_v[3], #Spaces_vbar[3], Cover, min(StirrupsC<1>))  if  min(StirrupsC) > −L_shaft + Cover + 6·in
coord
```

$$Shaft := \begin{pmatrix} 0 \cdot in & Offset \\ b & Offset \\ b & -L_{shaft} + Offset \\ 0 \cdot in & -L_{shaft} + Offset \\ 0 \cdot in & Offset \end{pmatrix} = \begin{pmatrix} 0 & 0.5 \\ 4.5 & 0.5 \\ 4.5 & -21 \\ 0 & -21 \\ 0 & 0.5 \end{pmatrix} ft$$

$$Rebar := \begin{bmatrix} (Cover + 2 \cdot in) & -Cover + Offset & (b - Cover - 2 \cdot in) \\ (Cover + 2 \cdot in) & \left(-L_{shaft} + Cover + Offset\right) & (b - Cover - 2 \cdot in) \end{bmatrix} = \begin{pmatrix} 8 & 1.1 \times 10^{-15} & 46 \\ 8 & -246 & 46 \end{pmatrix} \cdot in$$



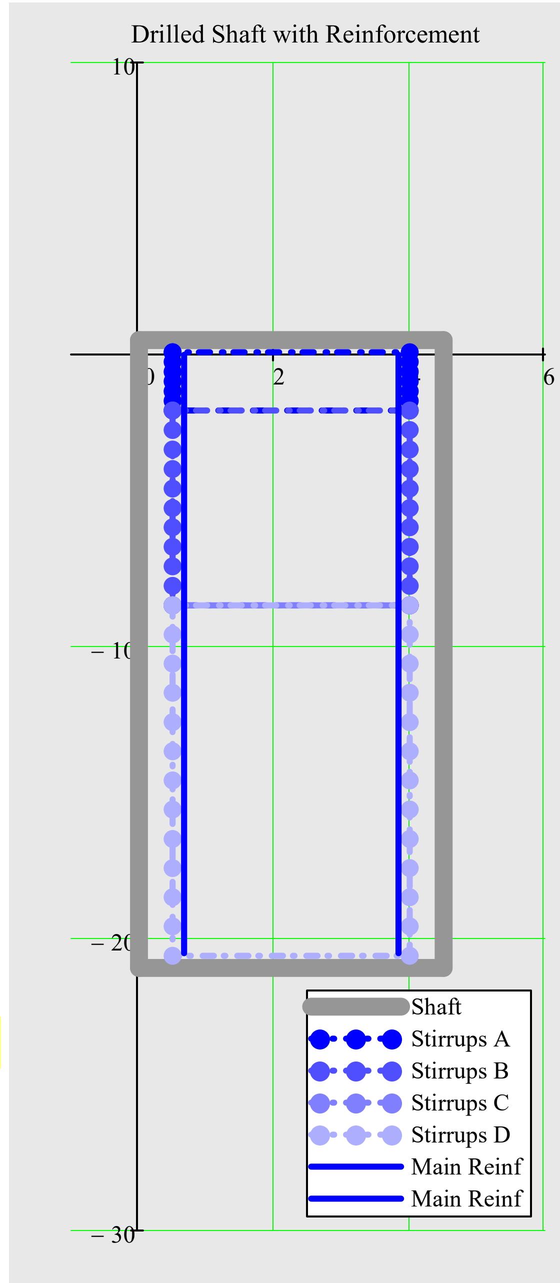
$$s_v = \begin{pmatrix} 4 \\ 8 \\ 0 \\ 12 \end{pmatrix} \cdot in$$ *stirrup spacing*

$$\#Spaces_{vbar} = \begin{pmatrix} 6 \\ 10 \\ 12 \\ 12 \end{pmatrix}$$ *number of stirrup spaces*

Analyze Foundation

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

$L_{shaft} = 21.5\ ft$ $s_v = \begin{pmatrix} 4 \\ 8 \\ 0 \\ 12 \end{pmatrix} \cdot in$ $\#Spaces_{vbar} = \begin{pmatrix} 6 \\ 10 \\ 12 \\ 12 \end{pmatrix}$



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' ($s_{v_1} = 8 \cdot in$) @ 'RD' ($\#Spaces_{vbar_1} = 10$) : $D/C_{torsion_1} = 0.4$

Stirrups 'RE' ($s_{v_2} = 0 \cdot in$) @ 'RF' ($\#Spaces_{vbar_2} = 12$) : $D/C_{torsion_2} = 0.3$

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

Offset = 0.5 ft

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

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

Use 22

'DA'= $L_{shaft} = 21.5 \cdot ft$ (struck through)

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

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

$L_{anchor.bolt} = 53 \cdot in$

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

'RB'= $\#LongBars_{prov} = 15$ (struck through) Use 16

$\#Spaces_{vbar_0} = 6$

$s_{v_0} = 4 \cdot in$

'RC'= $\#Spaces_{vbar_1} = 10$

'RD'= $s_{v_1} = 8 \cdot in$

'RE'= $\#Spaces_{vbar_2} = 12$

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

$\#Spaces_{vbar_3} = 12$

$s_{v_3} = 12 \cdot in$

IX. Fatigue Analysis

InputDataFile = "A50SH-P3S-DS1445.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"	$f_{galloping.arm1} = 6.2 \cdot ksi$	$CAFT_{fullpengroove.weld.arm1} = 7 \cdot ksi$
$Check_{galloping.arm2}$ = "NA"	$f_{galloping.arm2} = 0.0 \cdot ksi$	$CAFT_{fullpengroove.weld.arm2}$ = "NA"·ksi
$Check_{galloping.pole}$ = "OK"	$f_{galloping.pole} = 2.9 \cdot ksi$	$CAFT_{fullpengroove.weld.pole} = 4.5 \cdot ksi$
$Check_{nwg.arm1}$ = "OK"	$f_{nwg.arm1} = 3.3 \cdot ksi$	$CAFT_{fullpengroove.weld.arm1} = 7 \cdot ksi$
$Check_{nwg.arm2}$ = "NA"	$f_{nwg.arm2} = 0.0 \cdot ksi$	$CAFT_{fullpengroove.weld.arm2}$ = "NA"·ksi
$Check_{nwg.pole}$ = "OK"	$f_{nwg.pole} = 1.9 \cdot ksi$	$CAFT_{fullpengroove.weld.pole} = 4.5 \cdot ksi$

$$CheckK1Values = \begin{pmatrix} \text{"K1 is outside of 2\% of K1 thresholds"} \\ \text{"K1 is outside of 2\% of K1 thresholds"} \\ \text{"K1 is outside of 2\% of K1 thresholds"} \end{pmatrix} \quad \begin{pmatrix} K_{I.arm1} \\ K_{I.arm2} \\ K_{I.pole} \end{pmatrix} = \begin{pmatrix} 3.235 \\ 100.000 \\ 6.307 \end{pmatrix} \begin{pmatrix} \text{"Arm 1 Base Weld"} \\ \text{"Arm 2 Base Weld"} \\ \text{"Upright Base Weld"} \end{pmatrix}$$

A325 Connection Bolts

$$Check_{g.conn.bolt} = \begin{pmatrix} \text{"OK"} \\ \text{"OK"} \end{pmatrix} \quad f_{t.g.bolt} = \begin{pmatrix} 5.8 \\ 0.0 \end{pmatrix} \cdot ksi$$

$$CAFT_{conn.bolt} = 16 \cdot ksi$$

$$Check_{nwg.conn.bolt} = \begin{pmatrix} \text{"OK"} \\ \text{"OK"} \end{pmatrix} \quad f_{t.nwg.bolt} = \begin{pmatrix} 3.0 \\ 0.0 \end{pmatrix} \cdot ksi$$

Anchor Bolts

$Check_{g.anchor}$ = "OK"	$f_{t.g.anchor} = 2.6 \cdot ksi$	$CAFT_{anchor.bolts} = 7 \cdot ksi$
$Check_{nwg.anchor}$ = "OK"	$f_{t.nwg.anchor} = 1.7 \cdot ksi$	

Save Data File (optional)

☑ Use current input file

File Name A50SH-P3S-DS1445.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 = "A50SH-P3S-DS1445.dat"

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

Subject = "Erie Rd and SR 62 Improvements" **DesignedBy** = "RT" **PoleLocation** = "108+03.00/49.0 RT"

ProjectNo = "850-6094060" **CheckedBy** = "" **Date** = "5 / 27 / 2021"

ExistingMastArm = "No"

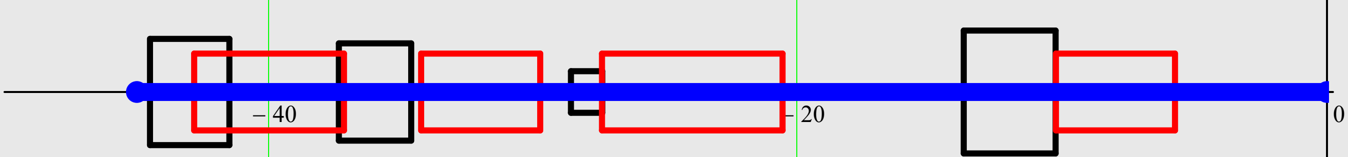
For FDOT Mast Arm Support Structures, $\max(CFI) \le 0.95$ ***(See Structures Manual Volume3)***

1st Mast Arm

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

Arm 1: Locations of Signs and Signals

$\#Signals_{arm1} = 4$ $\begin{pmatrix} \text{"Dist(ft)"} \\ \text{"\# Heads)"} \end{pmatrix}$ $Signals_{arm1}^T = \begin{pmatrix} 8 & 24 & 32 & 40 \\ 3 & 5 & 3 & 4 \end{pmatrix}$



$\#Panels_{arm1} = 4$ $\begin{pmatrix} \text{"Dist(ft)"} \\ \text{"Area (sf)"} \end{pmatrix}$ $Signs_{arm1}^T = \begin{pmatrix} 12 & 28 & 36 & 43 \\ 12 & 1.4 & 7.5 & 9 \end{pmatrix}$

$\max(CFI_{arm1}) = 0.72$ $L_{total.arm1} = 45\,ft$ $L_{splice.provided.arm1} = 3 \cdot ft$ $\max(\Delta_{arm1}) = 4.7 \cdot in$

'FA'= 'FE'= $L_{fabricated.arm1} = \begin{pmatrix} 27.5 \\ 20.5 \end{pmatrix} \cdot ft$

'FC'= 'FG'= $Diameter_{base.arm1} = \begin{pmatrix} 13.07 \\ 15.00 \end{pmatrix} \cdot in$

'FB'= 'FF'= $Diameter_{tip.arm1} = \begin{pmatrix} 9.22 \\ 12.13 \end{pmatrix} \cdot in$

'FD'= 'FH'= $t_{wall.arm1} = \begin{pmatrix} 0.250 \\ 0.313 \end{pmatrix} \cdot in$

2nd Mast Arm

Arm 2: Locations of Signs and Signals

7

$\#Signals_{arm2} = 0$ $\begin{pmatrix} \text{"Dist(ft)"} \\ \text{"\# Heads)"} \end{pmatrix}$ $Signals_{arm2}^{T} = \begin{pmatrix} 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \end{pmatrix}$

$\#Panels_{arm2} = 0$ $\begin{pmatrix} \text{"Dist(ft)"} \\ \text{"Area (sf)"} \end{pmatrix}$ $Signs_{arm2}^{T} = \begin{pmatrix} 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 \end{pmatrix}$

− 7

$-(L_{total.arm2}+5\cdot ft)$ 0

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

'SA'= 'SE'= $L_{fabricated.arm2} = \begin{pmatrix} 0 \\ 0 \end{pmatrix}\cdot ft$

'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'= $Diameter_{tip.arm2} = \begin{pmatrix} 0.00 \\ 0.00 \end{pmatrix}\cdot in$

'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)*

$$\begin{pmatrix} CFI_{base.lumarm} \\ CSR_{bolt.lum} \\ D/C_{baseplate.lum} \\ D/C_{conn.plate.lum} \end{pmatrix} = \begin{pmatrix} 0.00 \\ 7.17 \times 10^{-9} \\ 0.00 \\ 0.00 \end{pmatrix}$$

'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

$max(CFI_{pole}) = 0.45$ $Check_{deflection} = \text{"OK"}$ $Check_{slope} = \text{"OK"}$

'UA'= $Y_{pole} = 22.75\ ft$

'UB'= $Y_{arm.conn} = 19.75\ ft$

'UC'= $Diameter_{tip.pole} = 16.8\cdot in$

'UD'= $Diameter_{base.pole} = 20\cdot in$

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

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

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

1st Arm to Upright Connection

$D/C_{ht.conn.plate} = 0.85$

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

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

$\#Bolts_{conn_0} = 6$

'FO'= $Offset_{conn_0} = 16.0 \cdot in$

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

'FJ'= $b_{conn.plate_0} = 29 \cdot in$

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

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

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

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

$$\begin{pmatrix} D/C_{t.baseplate.arm_0} \\ CFI_{t.vert.plate_0} \\ CSR_{bolt.conn_0} \end{pmatrix} = \begin{pmatrix} 0.83 \\ 0.41 \\ 0.28 \end{pmatrix}$$

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

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

'FN'= $w_{vertical.plate_0} = \frac{5}{16} \cdot in$

'FT'= $w_{conn.plate_0} = \frac{5}{16} \cdot in$

2nd Arm to Upright Connection

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

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

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

$\#Bolts_{conn_1} = 0$

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

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

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

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

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

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

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

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

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

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

Pole Base Plate

$CSR_{anchor} = 0.23$

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

'BA'= $Diameter_{baseplate.pole} = 36 \cdot in$

$CheckCSR_{anchorbolt} = \text{"OK"}$

$Diameter_{boltcircle.pole} = 28 \cdot in$

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

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

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

$L_{anchor.bolt} = 53 \cdot in$

Foundation

$D/C_{torsion.max} = 0.4$

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

CheckReinfClearSpacing = "OK"

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

CheckMaxSpacingTransvReinf = "OK"

OverlapDesign = "Based on Overlap of Failure Cones"

OverlapTest = "Overlap of Failure Cones"

BreakoutTest = "OK"

$Clearance_{csl.to.nut} = 2.5 \cdot in$

$Offset = 0.5\,ft$

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

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

'DA'= $L_{shaft} = 21.5 \cdot ft$ 22

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

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

'RB'= $\#LongBars_{prov} = 15$ 16

'RC'= $\#Spaces_{vbar_1} = 10$

'RD'= $s_{v_1} = 8 \cdot in$

'RE'= $\#Spaces_{vbar_2} = 12$

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

Fatigue

$Check_{galloping.arm1}$ = "OK" $Check_{galloping.arm2}$ = "NA" $Check_{galloping.pole}$ = "OK"

$Check_{nwg.arm1}$ = "OK" $Check_{nwg.arm2}$ = "NA" $Check_{nwg.pole}$ = "OK"

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

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

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

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

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

$\begin{pmatrix} K_{I.arm1} \\ K_{I.arm2} \\ K_{I.pole} \end{pmatrix} = \begin{pmatrix} 3.235 \\ 100.000 \\ 6.307 \end{pmatrix} \begin{pmatrix} \text{"Arm 1 Base Weld"} \\ \text{"Arm 2 Base Weld"} \\ \text{"Upright Base Weld"} \end{pmatrix}$

WRITEPRN to Line 1-2-3 for Mast Arm Data Table

Mast Arm Tip Deflection

Compare Mast Arm deflection of each arm to a proposed camber

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

$Deflection_{arm1} := Slope_x \cdot L_{total.arm1} + max(\Delta_{arm1}) = 7.6 \cdot in$

$CamberArm1_{upward} := sin(Camber_{arm1}) \cdot L_{total.arm1} = 18.8 \cdot in$

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

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

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

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

$Offset_{conn_0} = 16\cdot in$ $\qquad b_{conn.plate_0} = 29\cdot in$ $\qquad h_{conn.plate} = 22\cdot in$ $\qquad \alpha = 0\cdot deg$

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

$$x1 := Offset_{conn_0} - t_{conn.plate_0} - h_{conn.plate}\cdot\frac{\sin(Camber_{arm1})}{2} = 13.6\cdot in \qquad y1 := \frac{b_{conn.plate_0}}{2} = 14.5\cdot in$$

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

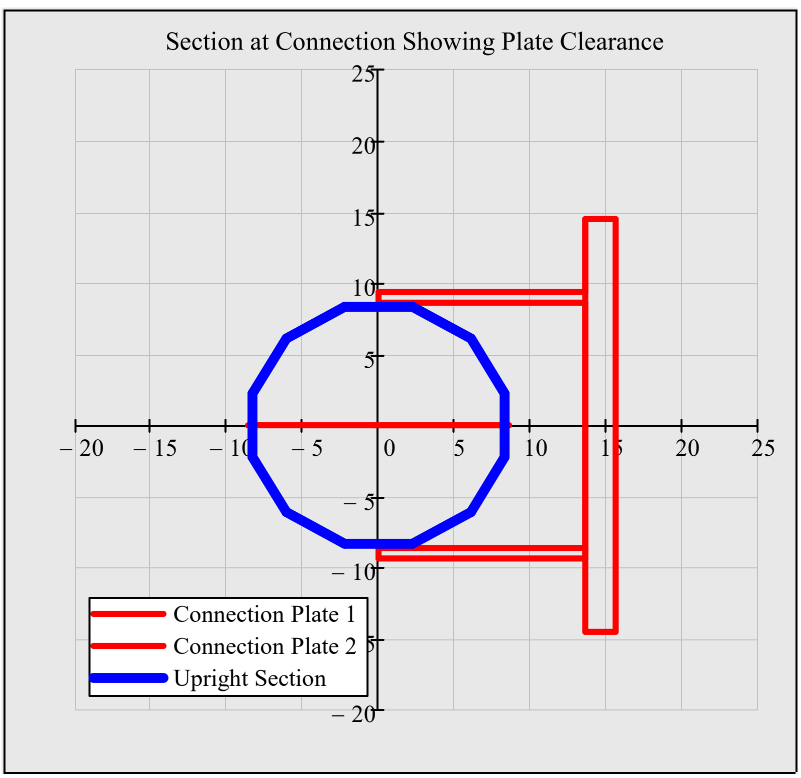
$$y2 := \left(Offset_{conn_1} - t_{conn.plate_1} - h_{conn.plate}\cdot\frac{\sin(Camber_{arm2})}{2}\right)\cdot\sin(\alpha) - \frac{b_{conn.plate_1}}{2}\cdot\cos(\alpha) = 0\cdot in$$

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

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

Coordinates for Drawings

Plan View - Connection Plate Clearance for Two Arm Connections



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

$Diameter_{conn.pole} = 17.3\cdot in$

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

'FJ'= $b_{conn.plate_0} = 29\cdot in$

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

'FO'= $Offset_{conn_0} = 16.0\cdot in$

$Gap_0 = 7.4\cdot in$

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

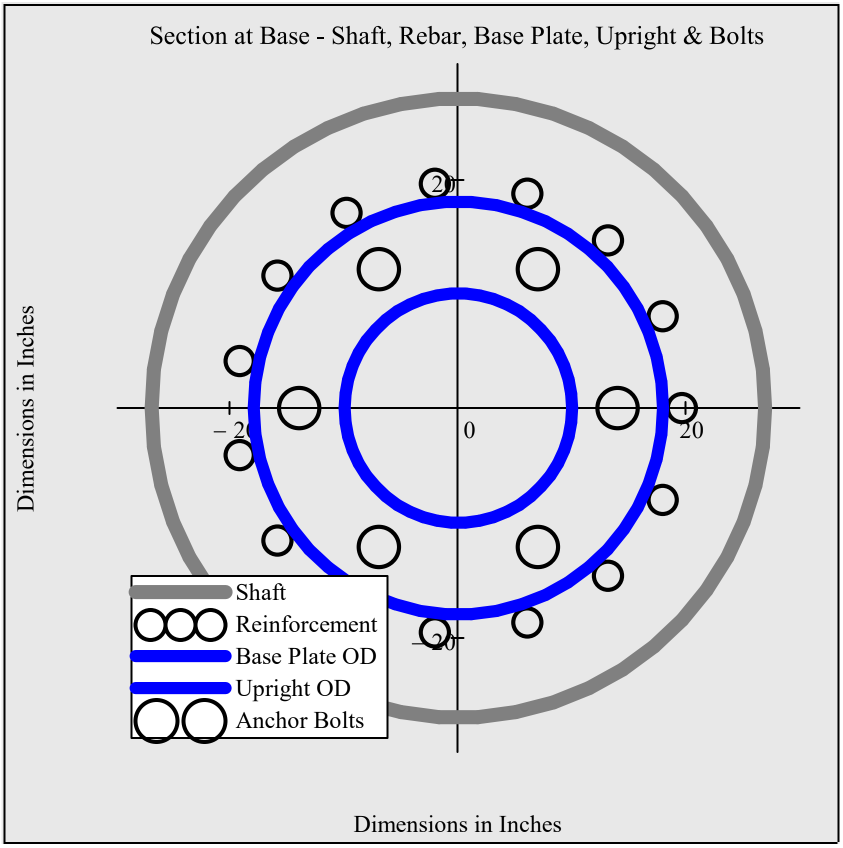
'SJ'= $b_{conn.plate_1} = 0\cdot in$

'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



$\text{Clearance}_{bar.to.nut} = 3.1 \cdot in$

'UD'= $\text{Diameter}_{base.pole} = 20 \cdot in$

'BA'= $\text{Diameter}_{baseplate.pole} = 36 \cdot in$

'DB'= $\text{Diameter}_{shaft} = 54 \cdot in$

$\text{Diameter}_{boltcircle.pole} = 28 \cdot in$

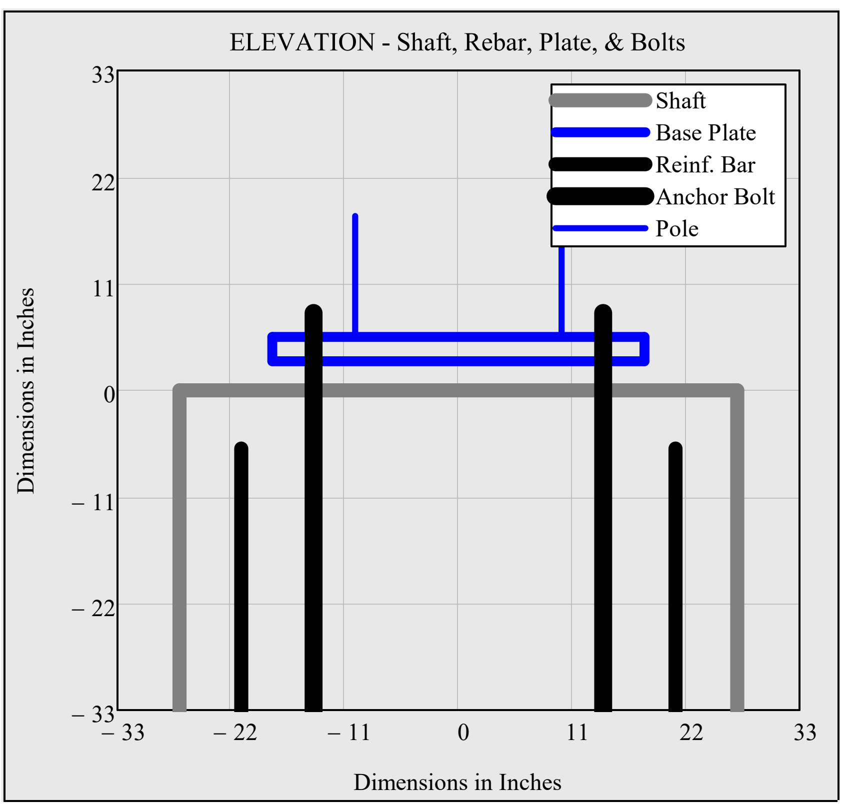
$\text{Dia}_{bar.circle} = 39.3 \cdot in$

$\#\text{AnchorBolts} = 6$

$\#\text{LongBars}_{prov} =$ ~~15~~ 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



$\text{Clearance}_{bar.to.nut} = 3.1 \cdot in$

'UD'= $\text{Diameter}_{base.pole} = 20 \cdot in$

'BA'= $\text{Diameter}_{baseplate.pole} = 36 \cdot in$

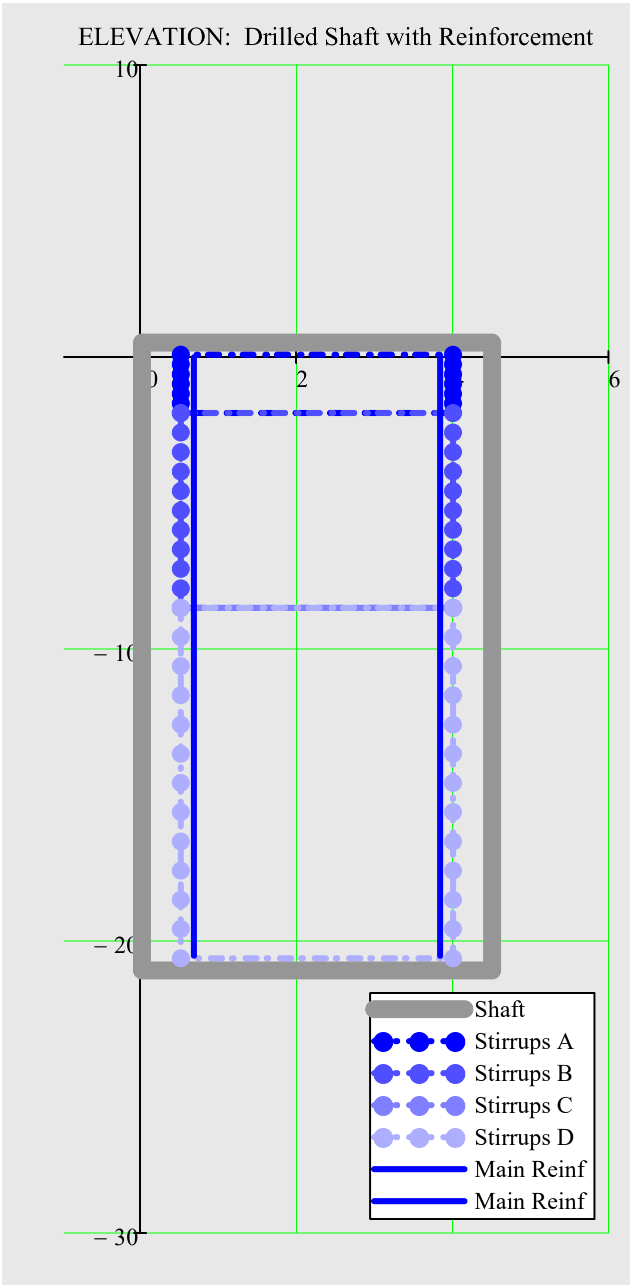
'BB'= $t_{baseplate.pole} = 2.5 \cdot in$

'DB'= $\text{Diameter}_{shaft} = 54 \cdot in$

$\text{Diameter}_{boltcircle.pole} = 28 \cdot in$

$\text{Dia}_{bar.circle} = 39.3 \cdot in$

Elevation View - Drilled Shaft with Main Reinforcement and Stirrups



$$s_v = \begin{pmatrix} 4 \\ 8 \\ 0 \\ 12 \end{pmatrix} \cdot in$$ *stirrup spacing*

$$\#Spaces_{vbar} = \begin{pmatrix} 6 \\ 10 \\ 12 \\ 12 \end{pmatrix}$$ *number of stirrup spaces*

Erie Rd. and SR 62 Improvements

HDR Project Number: 10151274

Miscellaneous Structures

1.6 Pole 3

For: Manatee County Public Works

Erie Rd. and SR 62 Improvements

HDR Project Number: 10151274

Miscellaneous Structures

1.6 Pole 3

1.6.1 Geometry and Loading

For: Manatee County Public Works

General Input

Pole No.	3		
Station	106+71.00		
Offset	52.5' RT		
County	Manatee		Choose "County" from drop-down list
Wind speed	150	mph	Basic wind speed for Manatee County is 150 per FDOT SDG, Jan. 2018, Table 2.4.1-1
Luminaire Orientation	N		Enter N for no luminaire, otherwise enter angle measured CCW from arm 1 (0, 45, 90)
Signal Orientation (V or H)	V		V for vertical, H for horizontal
Arm 2 Orientation	270	deg.	Enter N for no arm 2, otherwise enter angle between dual arms
Backplates (Y or N)	Y		Used in determining arm con. ht. (FDM 232 req. the use of backplates on Mast Arms)
Elevation below Arm 1 tip	43.87	ft	
Elevation below Arm 2 tip	43.51	ft	Enter N for no arm 2
Elevation at top of foundation	44.10	ft	
Arm center to signal / sign bottom	2.83	ft	Tabulated based on input for Arm 1 & Arm 2 Signals and Signs
Arm connection height (min)	19.88	ft	Based on 17.5 ft clearance
Arm connection height	20.25	ft	Dimension 'UB'; Use 0.25 ft increments
Arm connection height (max)	21.02	ft	Based on 19.0 ft clearance
Arm 1 length	67	ft	Arm 1 is the longer arm.
Arm 2 length	60	ft	Enter N for no arm 2.
Soil type	1		0 for clay (cohesive soil), 1 for sand (cohesionless soil)
Effective soil weight	43	pcf	
Phi	28	deg.	
N-blowcount	11		Enter initial value from 'Average N-count V2.0.xls' or as directed by geotech
Foundation offset	0.5	ft	Distance from finish ground to top of shaft

Arm 1 Signals and Signs - Vertical Geometry Check

Signal Head Type	1/2 Signal Height (ft.)	Height of Sign Dim. (ft.)	Width of Sign Dim. (ft).	Sign Attachment	Sign Location	Sign Area Check	Sign Location Check	1/2 Sign Height (ft.)
5-Doghouse	*2.25*	2.00	6.00	n/a	over roadway	*n/a*	*n/a*	*1*
4	*2.83*	3.00	2.50	n/a	over roadway	*n/a*	*n/a*	*1.5*
3	*2.25*	0.00	0.00	n/a	n/a	*n/a*	*n/a*	*0*
n/a	*0.00*	0.00	0.00	n/a	n/a	*n/a*	*n/a*	*0*
n/a	*0.00*	0.00	0.00	n/a	n/a	*n/a*	*n/a*	*0*

Arm 2 Signals and Signs - Vertical Geometry Check

Signal Head Type	1/2 Signal Height (ft.)	Height of Sign Dim. (ft.)	Width of Sign Dim. (ft).	Sign Attachment	Sign Location	Sign Area Check	Sign Location Check	1/2 Sign Height (ft.)
4	*2.83*	2.00	7.00	n/a	over roadway	*n/a*	*n/a*	*1*
3	*2.25*	3.00	3.00	n/a	over roadway	*n/a*	*n/a*	*1.5*
n/a	*0.00*	3.00	2.50	n/a	over roadway	*n/a*	*n/a*	*1.5*
n/a	*0.00*	0.00	0.00	n/a	n/a	*n/a*	*n/a*	*0*
n/a	*0.00*	0.00	0.00	n/a	n/a	*n/a*	*n/a*	*0*

Due to proposed loading the arm size for Arm 2 is increased to meet the fatigue stress range for galloping based on Mathcad Analysis.

Analysis Requirement

Mathcad Analysis Required = **Yes**

The following criteria are not satisfied: *1 Effective soil weight < 50 pcf*
2 Friction angle < 30 deg
3 N-value < 15

Information for Standard Mast Arm Assemblies Data Table

Arm 1 Type =	Regular	Arm 2 Type = Regular
Designation	~~***A70/D - A60/D - P6/D***~~	***A70/D-A70/D-P6/D***
Arm 1 ID	***A70/D***	
FAA (ft)	***35***	
Arm 2 ID	~~***A60/D***~~	***A70/D***
SAA (ft)	***28***	
UF (deg)	***270***	
LL (deg)		Leave blank in data table
Pole ID	***P6/D***	
UAA (ft)	***23.25***	
UB (ft)	***20.25***	

Pay Item Number

649-2A-BB Steel Mast Arm Assembly

Operation = (Furnish & Install) Choose correct "Operation" from drop-down list

AA = 1

Arm 1 = 70 Arm length used to determine Pay Item Number, See SPI for Arm Combinations

Arm 2 = 60

BB = 19

Pay Item Number is ***649-21-19*** Provide to Signal Designer for verification ***Arm 2 remains at 60' length-No change to pay Item.***

Signal Inputs:

The design accounts for MVDS devices as a 14" X 14" sign.

FDOT's 'mastarm-index-649-030-v1-4.xlsx' program limits the total number of signal / sign inputs to 10, and does not have an option for 1-section signal head; so the devices are accounted for by using a 14" X 14" sign.

FDOT's 'MastArmV1.2.xmcd' limits the number of sign inputs to 5, and does not have an option for 1-section signal head; so the the devices are accounted for by using a 14" X 14" sign.

Based on the inputs being limited to 5 signs in FDOT's 'MastArmV1.2.xmcd', for Arm 2, the MVDS at some locations are combined with other signs or other MVDS and entered as a single location using the centroid as the offset distance from the pole upright. The following changes are made:

1. Sign B; Area=9sf; Distance=27ft is combined with MVDS Location 1 Area=1.4 sf; Distance=31ft. The combined sign Area = 10.4sf; Distance = 28ft (Weighted Average rounded up).

2. MVDS Location 2; Area=1.4sf; Distance=38ft is combined with MVDS Location 3 Area=1.4 sf; Distance=42ft. The combined sign Area = 2.8sf; Distance = 40ft (Weighted Average).

Analysis:

1. FDOT's 'MastArmV1.2.xmcd' is used only to perform the foundation analysis. Other design sections are collapsed as individual components of the Mast Arm do not require detailed design based on the results from FDOT's 'mastarm-index-649-030-v1-4.xlsx'.

2. The signal and sign configuration for "Future Scenario" is chosen for foundation design to account for the higher moment demand due to the addition of Sign B at 27'.

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

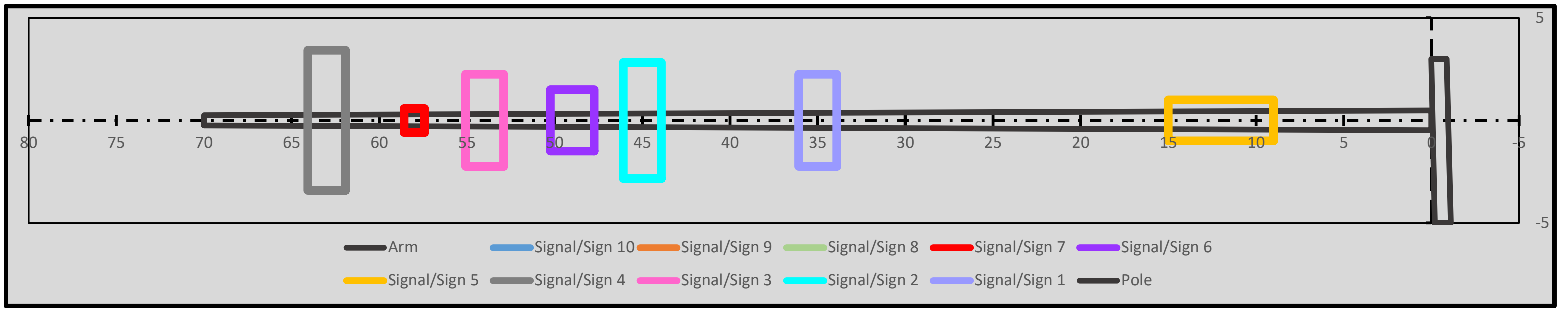
Back Plates?: ◉ Yes ◯ No

Arm 1 Length: 30, 40, 50, 60, 70, 78 (selected: 70)

Luminaire?: ◯ Yes ◉ No

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
Dist from Pole (ft.)	75	68	65	58	49	12	63	54	45	35
Selection (None / 3 Head / 4 Head / 5 Head / Sign)	None	None	None	Sign	Sign	Sign	5 Head	3 Head	4 Head	3 Head
Sign Width (in.)				14	30	72				
Sign Height (in.)				14	36	24				
Area (SF)	0.0	0.0	0.0	1.4	7.5	12.0	14.8	9.8	12.3	9.8
M_{wl} (kip*ft)	0	0	0	5	25	10	62	35	37	23



Arm 1 Length (ft)	70	
Design Standard Index 17743	Regular	Heavy Duty
Dia. at Arm Base (in)	17	18
Wall Thickness (in)	0.3750	0.3750
Resistance ($M_r = \phi M_n$) (kip*ft)	380	422

Arm 1 Loads	Regular	Heavy Duty
1.1*Arm M_{dl} (kip*ft)	94	110
Arm M_{wl} (kip*ft)	95	103
1.1*Sign/Signal M_{dl} (kip*ft)	16	
Sign/Signal M_{wl} (kip*ft)	197	
Total Moment ($M_{extreme}$)	312	326

Mast Arm Assembly Designation
~~Two Arm Assembly~~
~~A70/D-A60/D/H-P6/D-DS/18/5~~

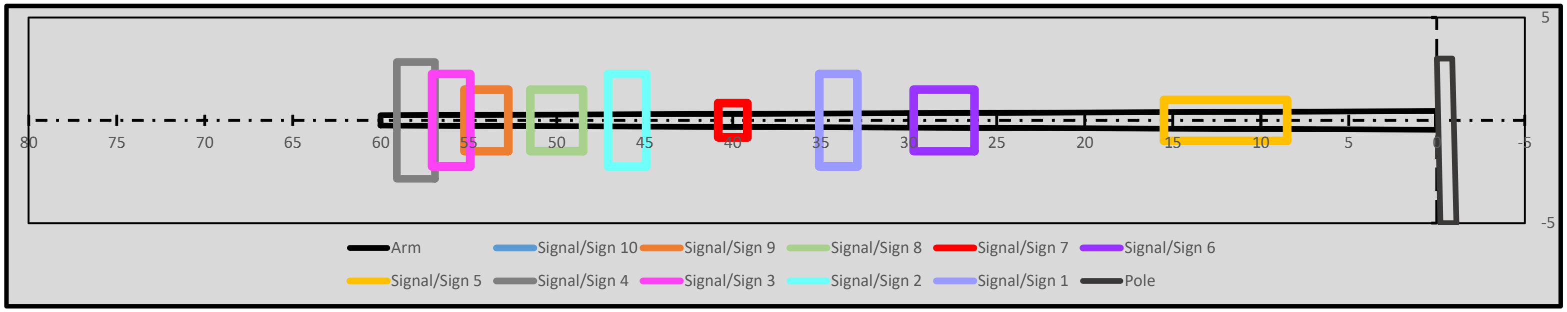
Analysis requires A70/D-A70/D-P6/D

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 at 22 ft.
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		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
		Arm 2 Length, Signal/Sign Location and Size									
	Dist from Pole (ft.)		54	50	40	28	12	58	56	46	34
Wind Speed = 150 mph Luminaire = No	Arm 2 Length: None, 30, 40, 50, 60 (selected), 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
Vertical Signal Orientation with Backplates.	Sign Width (in.)		30	36	20	42	84				
	Sign Height (in.)		36	36	20	36	24				
	Area (SF)	0.0	7.5	9.0	2.8	10.4	14.0	12.3	9.8	9.8	9.8
	M_{wl}. (kip*ft)	0	27	30	7	19	11	48	37	30	22



Arm 2 Length (ft)	60	
Design Standard Index 17743	**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	340

Arm 2 Loads	Regular	Heavy Duty
1.1*Arm M_{dl} (kip*ft)	62	68
Arm M_{wl} (kip*ft)	64	71
1.1*Sign/Signal M_{dl} (kip*ft)	16	
Sign/Signal M_{wl} (kip*ft)	232	
Total Moment ($M_{extreme}$)	306	315

Mast Arm Assembly Designation
~~Two Arm Assembly~~ ~~A70/D-A60/D/H-P6/D-DS/18/5~~

Analysis requires A70/D-A70/D-P6/D

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 at 22 ft.

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

Erie Rd. and SR 62 Improvements

HDR Project Number: 10151274

Miscellaneous Structures

1.6 Pole 3

1.6.2 Average N-count

For: Manatee County Public Works

Boring Details		
Depth (ft)		N-count
Total	Step	
6	6	5
8	2	3
10	2	7
12.5	2.5	4
15	2.5	5
17.5	2.5	29
20	2.5	23
22.5	2.5	19
25	2.5	30
27.5	2.5	14
30	2.5	3
Average N-count		12.25
Initial Design N_{AVG}		15.00

Pole #	Pole 3
Boring #	B-1
Station	106+71.00/52.5 RT
N-multiplier	1.2

Automatic Hammer Used; therefore N-multiplier = 1.24

<u>Notes:</u> (Calculate N-value for drilled shaft)

1- Automatic hammer N value multiplier and Boring details (soil layers thicknesses and number of counts) should be entered as inputs.

2- Initial design N value from "Boring Details" table is used to determine drilled shaft lengths in Mathcad.

3- Drilled shaft length output from the Mathcad file should be entered in the table below.

4- Final design N value for each shaft based on the average of layers where drilled shaft is surrounded with will be calculated in the "Drilled Shaft Details" table.

5- If New N value is smaller than original value, Mathcad file should be updated with new N value to calculate final drilled shaft length.

Drilled Shaft Length After Initial Analysis
19.5

(Mathcad First Output)

Drilled Shaft Details		
Depth (ft)		N-count
Total	Step	
6	6	5
8	2	3
10	2	7
12.5	2.5	4
15	2.5	5
17.5	2.5	29
20	2.5	23
-	-	-
-	-	-
-	-	-
-	-	-
Average N-count		10.13
Final Design N_{AVG}		12.00
Update N_{AVG}? (Y/N)		YES

Final Drilled Shaft Length
22

(Mathcad Final Output)

Erie Rd. and SR 62 Improvements

HDR Project Number: 10151274

Miscellaneous Structures

1.6 Pole 3

1.6.3 Foundation Analysis

For: Manatee County Public Works

FDOT Mast Arm Traffic Signal Support Analysis Program V1.2

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

State Structures Design Office

Reference

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

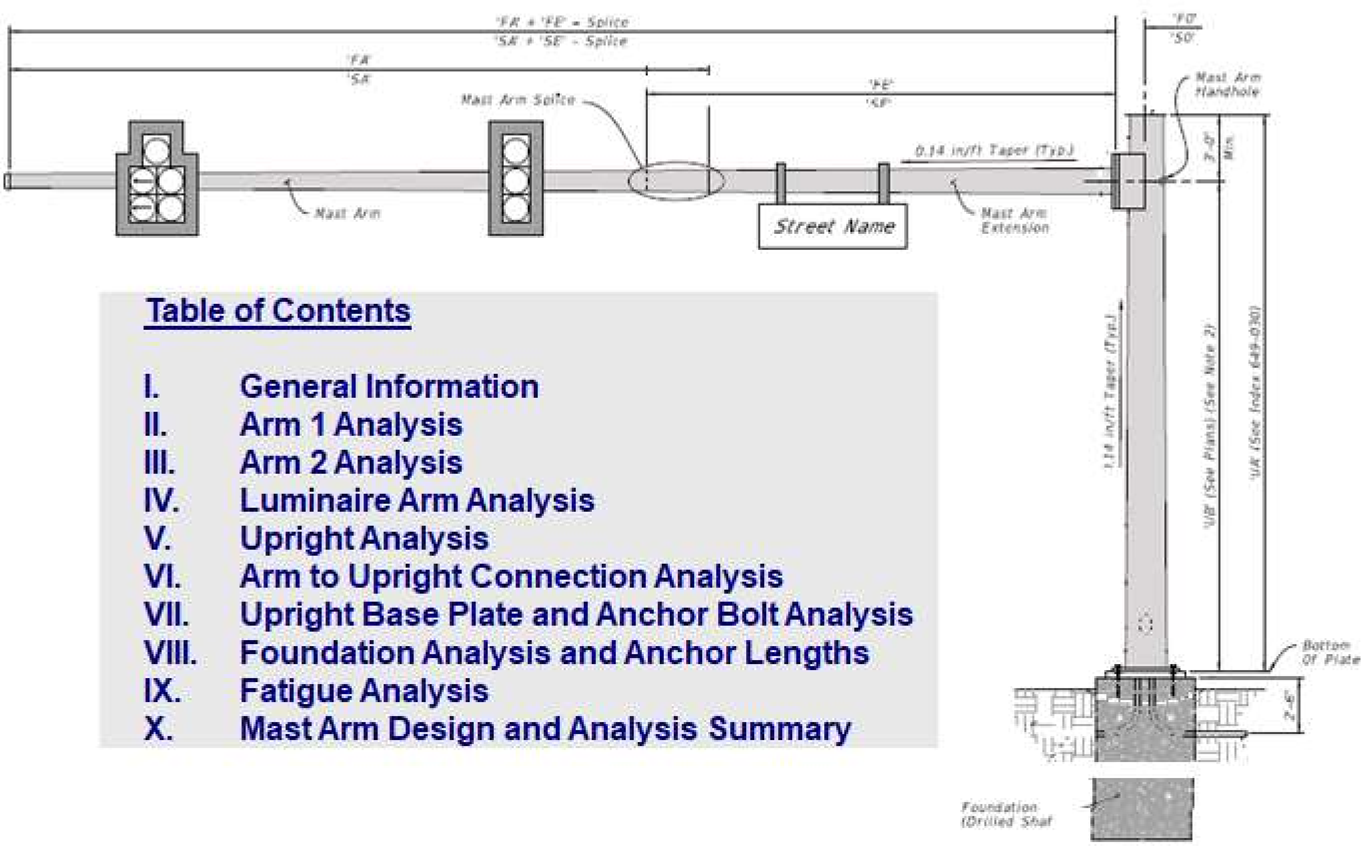


Table of Contents

Data Folder and Files

Data Files Folder

Change Folder

C:\Users\rtallur\Desktop\Data\

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

A70D-A70D-P6D-DS185.dat

Refresh List

Open File

I. General Information and Sign & Signal Data

Enter Project Information

Project Name	Erie Rd and SR 62 Improvements
Project No.	850-6094060
Designed by	RT
Date	5 / 27 / 2021
Checked by	
Date	
Signal Name	Pole 3
Station/Offset	106+71.00/52.5 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 67

Reset Arm 1 Data

Arm1 Signal Number	*Distance to Signal (ft)*	*Number of Heads*
1	35	3
2	45	4
3	54	3
4	63	5
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	34	3
2	46	3
3	56	3
4	58	4
5		
6		
7		
8		
9		
10		

Arm 1 Sign Panels

Arm1 Sign Panel Number	*Distance to Panel (ft)*	*Panel Area (sf)*
1	12	12
2	49	7.5
3	58	1.4
4		
5		

Arm 2 Sign Panels

Arm2 Sign Panel Number	*Distance to Panel (ft)*	*Panel Area (sf)*
1	12	14
2	28	10.4
3	40	2.8
4	50	9
5	54	7.5

Save Data for Signs and Signals

II. Arm 1 Analysis

InputDataFile = "A70D-A70D-P6D-DS185.dat" $V_{extreme} = 150 \cdot mph$

Values for $Dist_{splice.from.base.arm}$ *that give a base diameter in even inches*

"Wall Thickness"	"dia-1in"	"dia-2in"	"dia-3in"	"dia-4in"	"dia-5in"	"d-6in"
$t_{wall.arm}$ = 0.179·in	9.9·ft	17.0·ft	24.2·ft	31.3·ft	38.5·ft	45.6·ft
$t_{wall.arm}$ = 0.25·in	10.9·ft	18.0·ft	25.2·ft	32.3·ft	39.4·ft	46.6·ft

Help - Base Diameters | Help - Arm Tip Diameter | Help - Tube Wall Thickness | Help - Arm Lengths | Recommended Distance to Splice

Reference:C:\Users\rtallur\Desktop\LRFD Equation Module.xmcd(R)

Enter Arm 1 Data

Arm Length (ft)	Base Diameter (in)	Wall Thickness 1 (in)	Wall Thickness 2 (in)	Distance to Splice (ft)
$L_{total.arm1} = 67\,ft$	17	0.25	0.375	32
feet, 40 ft. max. for 1 piece arms	*Measured flat to flat* 'FG'	*for 1 & 2 piece arms* 'FD'	*for 2 piece arms only* 'FH'	*for 2 piece arms only* ('Larm' - 'FA')

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

Arm 1 Combined Force Interaction Ratio and Deflection

BackPlate = "Rigid, 6 inches wide"

$\max(CFI_{arm1}) = 0.77$ $\max(\Delta_{arm1}) = 14.4 \cdot in$ $2 \cdot deg \cdot L_{total.arm1} = 28.1 \cdot in$

Summary - Arm 1 Geometry and Loading

$\max(CFI_{arm1}) = 0.77$

$\max(\Delta_{arm1}) = 14.4 \cdot in$

$L_{total.arm1} = 67\,ft$

'FA'= 'FE'= $L_{fabricated.arm1} = \begin{pmatrix} 35.0 \\ 35.0 \end{pmatrix} \cdot ft$

'FB'= 'FF'= $Diameter_{tip.arm1} = \begin{pmatrix} 8.14 \\ 12.10 \end{pmatrix} \cdot in$

'FC'= 'FG'= $Diameter_{base.arm1} = \begin{pmatrix} 13.04 \\ 17.00 \end{pmatrix} \cdot in$

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

$Classification_{arm1} = \begin{pmatrix} \text{"Compact"} \\ \text{"Compact"} \end{pmatrix}$

$L_{splice.provided.arm1} = 3 \cdot ft$

III. Arm 2 Analysis

InputDataFile = "A70D-A70D-P6D-DS185.dat" $V_{extreme} = 150 \cdot mph$

$Dist_{splice.from.base.arm}$ *values that give a base diameter in even inches*

"Wall Thickness"	Δdia = 1·in	Δdia = 2·in	Δdia = 3·in	Δdia = 4·in	Δdia = 5·in	Δdia = 6·in
$t_{wall.arm}$ = 0.179·in	***9.9***·ft	***17.0***·ft	***24.2***·ft	***31.3***·ft	***38.5***·ft	***45.6***·ft
$t_{wall.arm}$ = 0.25·in	***10.9***·ft	***18.0***·ft	***25.2***·ft	***32.3***·ft	***39.4***·ft	***46.6***·ft

Help - Base Diameters | Help - Arm Tip Diameter | Help - Tube Wall Thickness | Help - Arm Lengths | Recommended Distance to Splice

Enter Arm 2 Data

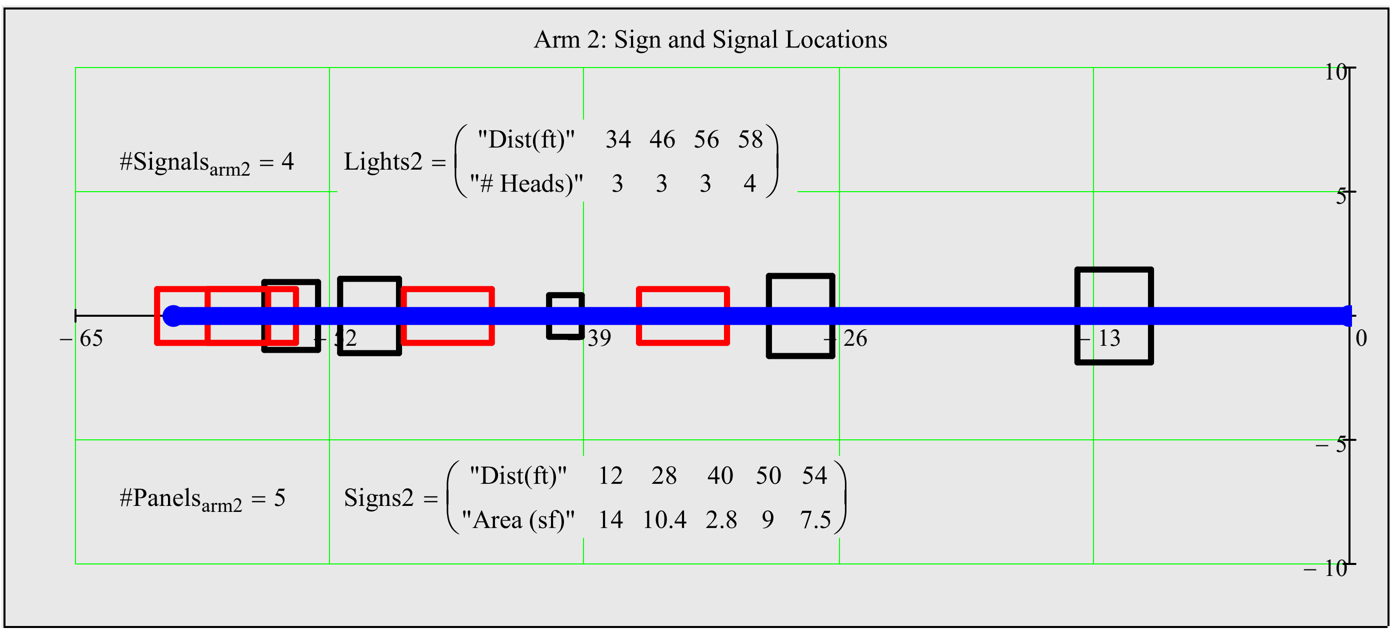
Arm Length (ft)	*Base Diameter (in)*	*Wall Thickness 1 (in)*	*Wall Thickness 2 (in)*	*Distance to Splice (ft)*
$L_{total.arm2} = 60\,ft$	17	0.25	0.375	32
feet, 40 ft. max. for 1 piece arms	*Measured flat to flat* 'SG'	*for 1 & 2 piece arms* 'SD'	*for 2 piece arms only* 'SH'	*for 2 piece arms only* ('Larm' - 'SA')

Arm 2 Analysis including Existing Mast Arm Analysis

Arm 2 Combined Force Interaction Ratio and Deflection

$\max(CFI_{arm2}) = 0.81$ BackPlate = "Rigid, 6 inches wide"

Summary - Arm 2 Geometry and Loading $\max(\Delta_{arm2}) = 10.1 \cdot in$ $2 \cdot deg \cdot L_{total.arm2} = 25.1 \cdot in$



$\max(CFI_{arm2}) = 0.81$

$\max(\Delta_{arm2}) = 10.1 \cdot in$

$L_{total.arm2} = 60\,ft$

'SB'= 'SF'= $Diameter_{tip.arm2} = \begin{pmatrix} 9.12 \\ 12.10 \end{pmatrix} \cdot in$

'SC'= 'SG'= $Diameter_{base.arm2} = \begin{pmatrix} 13.04 \\ 17.00 \end{pmatrix} \cdot in$

$Classification_{arm2} = \begin{pmatrix} \text{"Compact"} \\ \text{"Compact"} \end{pmatrix}$

$L_{splice.provided.arm2} = 3 \cdot ft$

'SA'= 'SE'= $L_{fabricated.arm2} = \begin{pmatrix} 28.0 \\ 35.0 \end{pmatrix} \cdot ft$

'SD'= 'SH'= $t_{wall.arm2} = \begin{pmatrix} 0.250 \\ 0.375 \end{pmatrix} \cdot in$

IV. Luminaire Arm Analysis

InputDataFile = "A70D-A70D-P6D-DS185.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 = "A70D-A70D-P6D-DS185.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)	
23.25	20.25	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

$Classification_{pole} = "Compact"$

$max(CFI_{pole}) = 0.50$

$Check_{slope} = "OK"$

$Check_{deflection} = "OK"$

$max(\Delta_{x.dl}) = 0.59 \cdot in$

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

$Slope_z = 0.27 \cdot deg$

$Slope_x = 0.3 \cdot deg$

$Diameter_{conn.pole} = 21.2 \cdot in$

$$max\left(\begin{pmatrix} Diameter_{base.arm1_0} \\ Diameter_{base.arm2_0} \end{pmatrix}\right) = 13 \cdot in$$

'UA'= $Y_{pole} = 23.25\,ft$

'UB'= $Y_{arm.conn} = 20.25\,ft$

'UC'= $Diameter_{tip.pole} = 20.8\,in$

'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 = "A70D-A70D-P6D-DS185.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'= $h_{conn.plate} = 30 \cdot in$ $D/C_{ht.conn.plate} = 0.75$ $CheckHt_{conn.plate} = \text{"OK"}$

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

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

$$\begin{pmatrix} D/C_{t.baseplate.arm_0} \\ CFI_{t.vert.plate_0} \\ CSR_{bolt.conn_0} \end{pmatrix} = \begin{pmatrix} 0.83 \\ 0.52 \\ 0.31 \end{pmatrix}$$

$\#Bolts_{conn_0} = 6$

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

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

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

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

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

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

'FR'= $t_{conn.plate_0} = 2.50 \cdot in$

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

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

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

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

$$\begin{pmatrix} D/C_{t.baseplate.arm_1} \\ CFI_{t.vert.plate_1} \\ CSR_{bolt.conn_1} \end{pmatrix} = \begin{pmatrix} 0.83 \\ 0.54 \\ 0.31 \end{pmatrix}$$

$\#Bolts_{conn_1} = 6$

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

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

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

'SN'= $w_{vertical.plate_1} = \frac{3}{8} \cdot in$

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

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

'SR'= $t_{conn.plate_1} = 2.50 \cdot in$

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

'ST'= $w_{conn.plate_1} = \frac{3}{8} \cdot in$

VII. Upright Base Plate & Anchor Bolt Analysis

InputDataFile = "A70D-A70D-P6D-DS185.dat"

Enter Anchorage Data

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

Help - Number of Anchor Bolts

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

Analyze Base Plate & Anchors

Base Plate and Anchor Summary

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

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

$CSR_{anchor} = 0.38$

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

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

$CheckCSR_{anchorbolt} = $ "OK"

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

VIII. Foundation Analysis & Anchor Bolt Lengths

InputDataFile = "A70D-A70D-P6D-DS185.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)	12	
Shear Strength, c (Clays)	2000	psf
Ground to Top of Shaft Offset	0.5	ft

First Set of User Defined Stirrups:

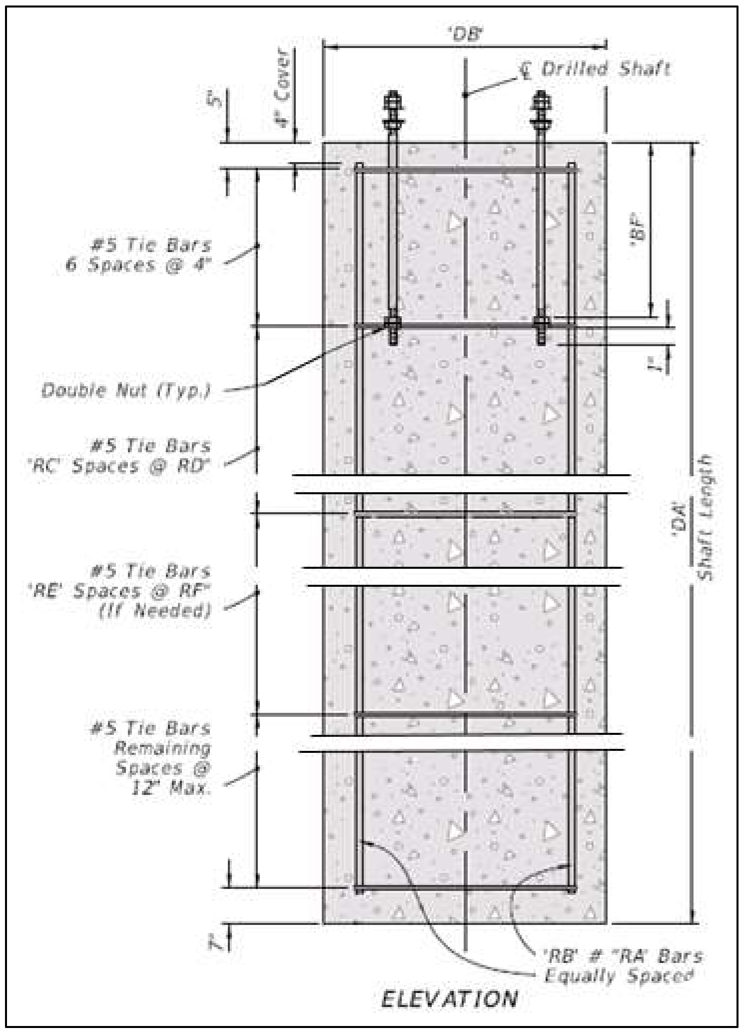
Number of Stirrup Spaces	'RC'	10	
Stirrup Spacing	'RD'	8	in

Second Set of User Defined Stirrups:

Number of Stirrup Spaces 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

define variable for saving in output file

$$inpLuminaire := \begin{pmatrix} inpYLuminaire \\ inpXLuminaire \\ inpLumBaseDia \\ inpLumWallThk \\ inpLumSlope \\ inpLumRadius \\ inpLumBoltDia \\ inptLumBasePlate \end{pmatrix}$$

$outLuminaire := inpLuminaire$

$$inpUpright := \begin{pmatrix} inpUprightTotHeight \\ inpUprightHtToConn \\ inpUprightBaseDia \\ inpUprightWallThk \\ inpAnchorBoltDia \\ inpNumOfAnchorBolts \\ inpConnPlateHeight \end{pmatrix}$$

$outUpright := inpUpright$

$$inpConn := \begin{pmatrix} inpArm1Gap & inpArm1VertPlateThk & inpArm1BoltDia & inpArm1BasePlateThk & inpArm1BasePlateWidth \\ inpArm2Gap & inpArm2VertPlateThk & inpArm2BoltDia & inpArm2BasePlateThk & inpArm2BasePlateWidth \end{pmatrix}$$

$outConn := inpConn$

$$inpShaft := \begin{pmatrix} num2str(inpSoilType) \\ inpSoilDensity \\ inpFrictionAngle \\ inpNumBlows \\ inpShearStrength \\ \text{"0.0"} \\ \text{"0.0"} \\ \text{"0.0"} \\ inpShaftOffset \\ inpNumSpacesB \\ inpStirrupSpacingB \\ inpNumSpacesC \\ inpStirrupSpacingC \\ inpStirrupSize \end{pmatrix}$$

$outShaft := inpShaft$

Foundation Data

$SoilType := inpSoilType = 0$

$\gamma_{soil} := str2num(inpSoilDensity) \cdot pcf = 43 \cdot pcf$

$\phi_{soil} := str2num(inpFrictionAngle) \cdot deg = 29 \cdot deg$

$N_{blows} := \text{str2num}(\text{inpNumBlows}) = 12$

$c_{soil} := \text{str2num}(\text{inpShearStrength}) \cdot psf = 2000 \cdot psf$

$\text{Offset} := \text{str2num}(\text{inpShaftOffset}) \cdot ft = 0.5\,ft$

$\text{NumSpacesStirrupsB} := \text{str2num}(\text{inpNumSpacesB}) = 10$

$s_{v_1} := \text{str2num}(\text{inpStirrupSpacingB}) \cdot in = 8 \cdot in$

$\text{NumSpacesStirrupsC} := \text{str2num}(\text{inpNumSpacesC}) = 0$

$s_{v_2} := \text{str2num}(\text{inpStirrupSpacingC}) \cdot in = 0 \cdot in$

$\text{StirrupBarSize} := \text{inpStirrupSize} = 5$

$\gamma_{water} := 62.4 \cdot pcf = 62.4 \cdot pcf$ *(not used)*

Foundation Design References

LRFD = AASHTO LRFD Bridge Design Specifications

SDG = FDOT Structures Design Guidelines

ACI = ACI 318 Structural Concrete Building Code

SM V3 = FDOT Structures Manual Volume 3

Spec = FDOT Standard Specifications

UF Report = FDOT/University of Florida Report BD545 RPWO #54

Applied Loads

(From Arm1 Design)

$V_{extreme} = 150 \cdot mph$

(from Base Plate Design)

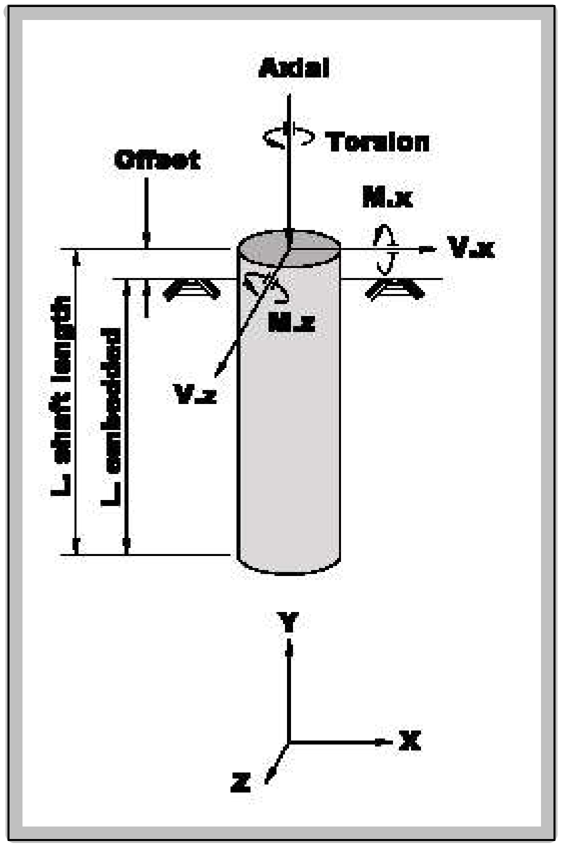
$\#AnchorBolts = 8$

$d_{anchorbolt} = 2 \cdot in$

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

$T_{u.anchor} = 45.2 \cdot kip$

(from Upright Design)



$$M_{x.polebase} = \begin{pmatrix} 0 \\ 265.9 \\ 13.6 \end{pmatrix} \cdot kip \cdot ft$$

$$M_{y.polebase} = \begin{pmatrix} 421.5 \\ 0 \\ 421.5 \end{pmatrix} \cdot kip \cdot ft$$

$$M_{z.polebase} = \begin{pmatrix} 0 \\ 112 \\ 240.8 \end{pmatrix} \cdot kip \cdot ft$$

$LoadCaseT = 0$ $LoadCaseOT = 1$ $LoadCaseCFI = 2$

$$V_{x.polebase} = \begin{pmatrix} 0 \\ 1.3 \times 10^{-15} \\ 6.8 \end{pmatrix} \cdot ł \quad AxialForce_{polebase} = \begin{pmatrix} 10 \\ 10 \\ 10 \end{pmatrix} \cdot kip \qquad V_{z.polebase} = \begin{pmatrix} 0 \\ 8.6 \\ 6.1 \end{pmatrix} \cdot kip$$

Foundation Diameter

$Diameter_{shaft} := Diameter_{boltcircle.pole} + 12 \cdot in + 12 \cdot in = 4.67\,ft$

round shaft diameter up to the nearest half foot dimension to accommodate available coring equipment

$$Diameter_{shaft} := Ceil\left(Diameter_{shaft}, \frac{1}{2} \cdot ft\right) = 5\,ft$$

$Diameter_{shaft.custom} := 0 \cdot ft$

$$Diameter_{shaft} := if\left[\left(Diameter_{shaft.custom} > 0 \cdot ft\right), Diameter_{shaft.custom}, Diameter_{shaft}\right] = 1.5$$

$b := Diameter_{shaft}$

Shaft Depth Required to Resist Overturning

the following calculations are consistent with FDOT's Drilled Shaft Program V1.1

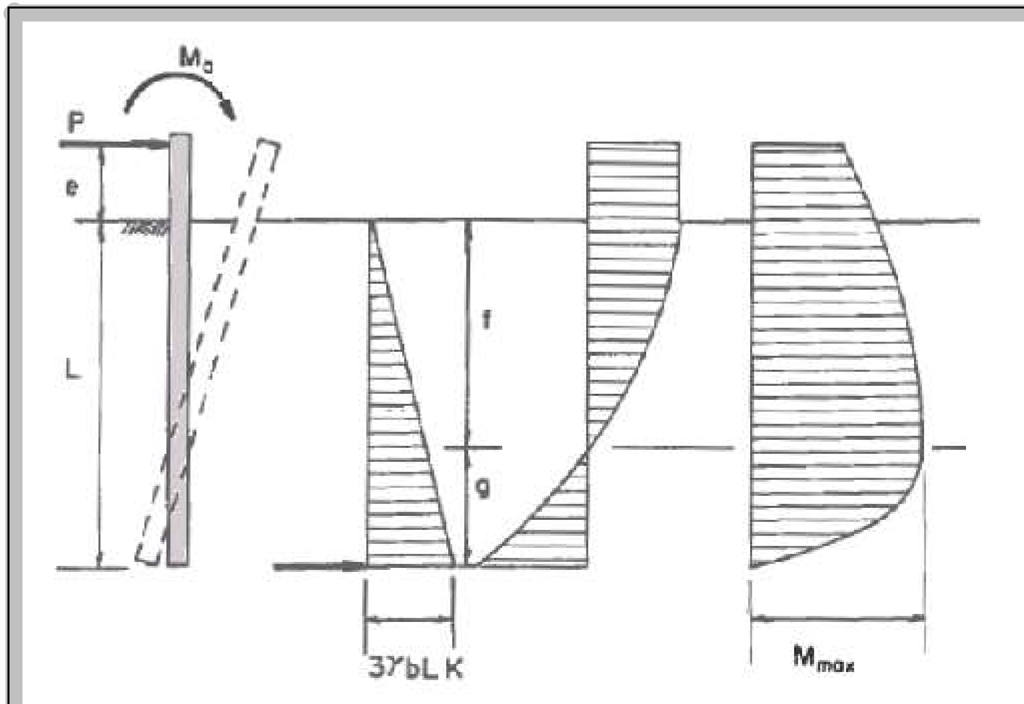
$\phi_{ot} := 0.6$ **SM V3 13.6** Offset = 0.5·ft *vertical distance between top of foundation and ground line*

$$M_u := \sqrt{\left(M_{x.polebase_{LoadCaseOT}}\right)^2 + \left(M_{z.polebase_{LoadCaseOT}}\right)^2} = 288.6 \cdot kip \cdot ft$$

$$P_u := \sqrt{\left(V_{x.polebase_{LoadCaseOT}}\right)^2 + \left(V_{z.polebase_{LoadCaseOT}}\right)^2} = 8.65 \cdot kip$$

$$T_u := M_{y.polebase_{LoadCaseT}} = 421.5 \cdot kip \cdot ft$$

short free-head pile in ***cohesionless soil*** *using Broms method*



Deflection, load, shear and moment diagram for a short pile in cohesionless soil that is unrestrained against rotation.

$K_p := \tan\left(45 \cdot deg + \frac{\phi_{soil}}{2}\right)^2 = 2.9$ $e_{sand} := Offset = 0.5\,ft$

Guess value $L_{otSand} := 8 \cdot ft$

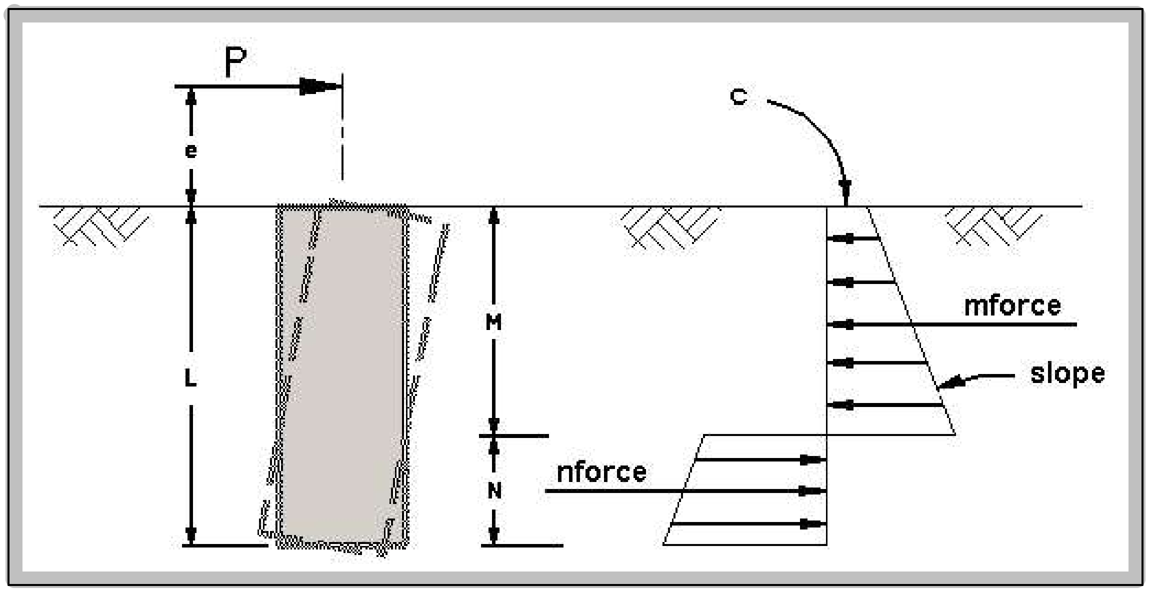
Given $P_u \cdot \left(e_{sand} + L_{otSand}\right) + M_u = \phi_{ot} \cdot \left[\left(3 \cdot \gamma_{soil} \cdot b \cdot L_{otSand} \cdot K_p\right) \cdot \left(\frac{1}{2} \cdot L_{otSand}\right) \cdot \left(\frac{1}{3} \cdot L_{otSand}\right)\right]$

$L_{otSand} := Find\left(L_{otSand}\right) = 13\,ft$

$L_{otSand} := ceil\left(\frac{L_{otSand}}{ft}\right) \cdot ft = 13\ ft$ *(round up to next foot)*

$$D/C_{otSand} := \frac{M_u + P_u \cdot (e_{sand} + L_{otSand})}{\frac{(\phi_{ot}) \cdot \gamma_{soil} \cdot b \cdot L_{otSand}^3 \cdot K_p}{2}} = 0.99$$

short free-head pile in cohesive soil using Modified Broms method for L < 3b (see reference file for derivation)



Deflection, load, shear and moment diagram for a short pile in cohesive soil that is unrestrained against rotation.

$c_{soil} := if[(c_{soil} = 0 \cdot ksf), 0.1 \cdot ksf, c_{soil}] = 2 \cdot ksf$ $c_{soil} = 2000 \cdot psf$

$Slope := 8 \cdot \frac{c_{soil}}{3 \cdot b} = 1.1 \cdot \frac{kip}{ft^3}$ $e_{clay} := \frac{M_u}{P_u} + Offset = 33.9\ ft$

$nforce(M,N) := [Slope \cdot (2 \cdot M + N) + 2 \cdot c_{soil}] \cdot N \cdot \frac{b}{2}$ $mforce(M) := (2 \cdot c_{soil} + M \cdot Slope) \cdot M \cdot \frac{b}{2}$

$$m\_arm(M) := e_{clay} + \frac{M}{3} \cdot \frac{2 \cdot (M \cdot Slope + c_{soil}) + c_{soil}}{M \cdot Slope + 2 \cdot c_{soil}}$$

$$n\_arm(M,N) := e_{clay} + M + \frac{N}{3} \cdot \frac{2 \cdot (N \cdot Slope + M \cdot Slope + c_{soil}) + (M \cdot Slope + c_{soil})}{Slope \cdot (2 \cdot M + N) + 2 \cdot c_{soil}}$$

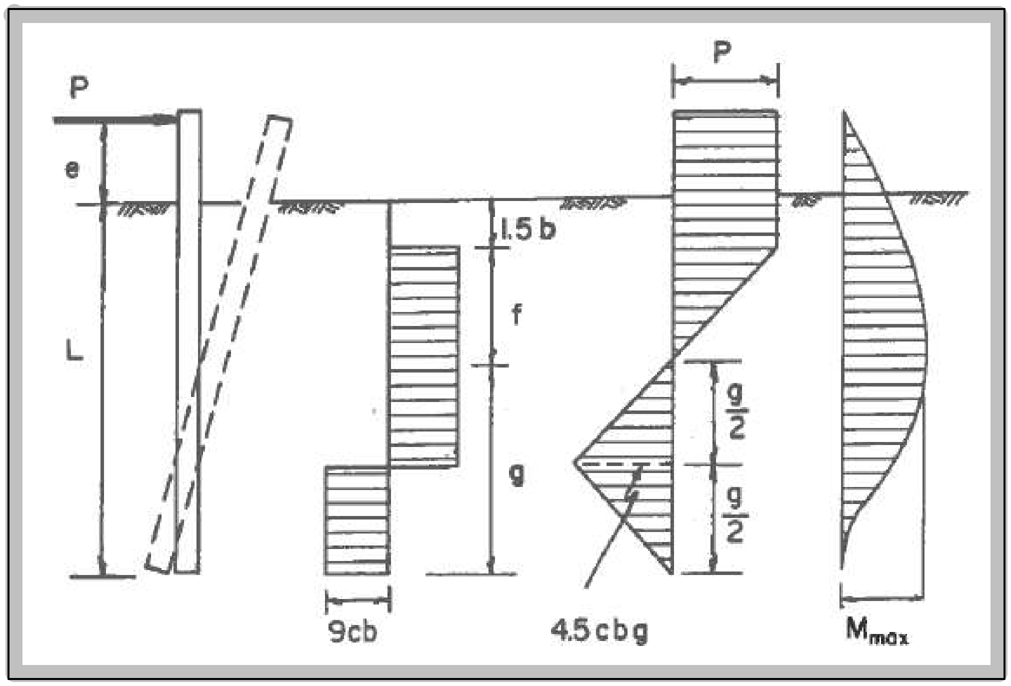
Guess value $M := 4.0 \cdot ft$ $N := 4.0 \cdot ft$

Given $P_u + \phi_{ot} \cdot nforce(M,N) = \phi_{ot} \cdot mforce(M)$ $mforce(M) \cdot m\_arm(M) = nforce(M,N) \cdot n\_arm(M,N)$

$\begin{pmatrix} M \\ N \end{pmatrix} := Find(M,N)$ $L_{ot1Clay} := M + N = 8.8\ ft$

$L_{ot1Clay} := ceil\left(\frac{L_{ot1Clay}}{ft}\right) \cdot ft = 9\ ft$ *(round up to next foot)*

short free-head pile in ***cohesive soil*** *using Regular Broms method for L > 3b*



Deflection, load, shear and moment diagram for a short pile in cohesive soil that is unrestrained against rotation.

$M_{max.clay}$ *equation is derived from the integration of the upper part of the shear diagram to the point of zero shear.*

$$f := \frac{P_u}{\phi_{ot} \cdot 9 \cdot c_{soil} \cdot b} = 0.2\ ft$$

$$M_{max.clay} := P_u \cdot (e_{clay} + 1.5 \cdot b + 0.5 \cdot f) = 358.5 \cdot kip \cdot ft$$

$$g := \sqrt{\frac{M_{max.clay}}{2.25 \cdot \phi_{ot} \cdot c_{soil} \cdot b}} = 5.2\ ft$$

$$L_{ot2Clay} := (1.5 \cdot b + f + g) = 12.8\ ft$$

$L_{ot2Clay} := ceil\left(\frac{L_{ot2Clay}}{ft}\right) \cdot ft = 13\ ft$ *(round up to next foot)*

$L_{otClay} := if\left[(L_{ot1Clay} < 3 \cdot b), L_{ot1Clay}, L_{ot2Clay}\right] = 2.7$ *(If $L_{ot} < 3b$, use Modified Broms method)*

$$L_{reqdOT} := if\left[(SoilType = 0), L_{otSand}, L_{otClay}\right]$$

$L_{reqdOT} = 13\ ft$ *required shaft embedment depth to resist overturning*

Shaft Depth Required to Resist Torsion

$\phi_{tor} := 1.0$ **SM V3 13.6**

*short free-head pile in **cohesionless soil***

NOTE: ω_{fdot} is based upon concrete soil interaction. This torsion methodology is not to be used with permanent casing.

$N_{blows} = 12$

$\omega_{fdot} := \text{if}\left[(N_{blows} < 5), 0, \text{if}\left[(N_{blows} \geq 15), 1.5, 1.5 \cdot \frac{N_{blows}}{15}\right]\right] = 1.2$

load transfer ratio, If 5<N<15, ω_{fdot} is reduced by a factor of $\frac{N_{blows}}{15}$ **SM Vol-3 13.6**

Guess value $L_{torSand} := L_{reqdOT} = 13\,ft$

Given $T_u = \phi_{tor} \cdot \left[(\pi \cdot b \cdot L_{torSand}) \cdot \left(\gamma_{soil} \cdot \frac{L_{torSand}}{2}\right) \cdot (\omega_{fdot}) \cdot \frac{b}{2}\right]$

$L_{torSand} := \text{Find}(L_{torSand}) = 20.4\,ft$

$L_{torSand} := \text{ceil}\left(\frac{L_{torSand}}{ft}\right) \cdot ft = 21\,ft$ *(round up to next foot)*

*short free-head pile in **cohesive soil***

$\text{CohesionFactor} := 0.55$

$f_{se} := \text{CohesionFactor} \cdot c_{soil} = 1.1 \cdot ksf$

Guess value $L_{torClay} := L_{reqdOT}$

Given $T_u = \phi_{tor} \cdot \left[f_{se} \cdot (\pi \cdot b) \cdot (L_{torClay} - 1.5 \cdot ft) \cdot \frac{b}{2}\right]$

$L_{torClay} := \text{Find}(L_{torClay}) = 11.3\,ft$

$L_{torClay} := \text{ceil}\left(\frac{L_{torClay}}{ft}\right) \cdot ft = 12\,ft$ *(round up to next foot)*

$\text{SoilType} = 0$ *0 - Sand* *1 - Clay*

$L_{reqdTor} := \text{if}[(\text{SoilType} = 0), L_{torSand}, L_{torClay}]$ $L_{reqdTor} = 21\,ft$ *required shaft embedment depth to resist torsion*

$L_{embedded} := \text{if}[(L_{reqdTor} > L_{reqdOT}), L_{reqdTor}, L_{reqdOT}] = 21 \cdot ft$

$L_{shaft} := L_{embedded} + \text{Offset}$ $L_{shaft} = 21.5\,ft$ *shaft length*

Maximum Moment in Shaft

short free-head pile in cohesionless soil using Broms method

$f_{sand} := \sqrt{\frac{2 \cdot P_u}{3 \cdot \gamma_{soil} \cdot b \cdot K_p \cdot \phi_{ot}}} = 3.9\,ft$

$$M_{maxSand} := P_u \cdot (e_{sand} + f_{sand}) - \frac{P_u \cdot f_{sand}}{3} + M_u = 315.6 \cdot kip \cdot ft$$

*short free-head pile in **cohesive soil** using Modified Broms method for L < 3b (see reference file for derivation)*

Guess value $f_{mod} := 4.0 \cdot ft$

Given $P_u = \frac{f_{mod} \cdot b}{2} \cdot (2\phi_{ot} \cdot c_{soil} + \phi_{ot} \cdot f_{mod} \cdot Slope)$

$f_{mod} := Find(f_{mod}) = 1.1\, ft$

$$M_{modBroms} := P_u \cdot (e_{clay} + f_{mod}) - \frac{\phi_{ot} \cdot c_{soil} \cdot b \cdot f_{mod}^2}{2} - \frac{\phi_{ot} \cdot b \cdot f_{mod}^3 \cdot Slope}{6} = 298.1 \cdot kip \cdot ft$$

*short free-head pile in **cohesive soil** using Regular Broms method for L > 3b*

$$M_{Broms} := P_u \cdot (e_{clay} + 1.5 \cdot b + 0.5 \cdot f) = 358.5 \cdot kip \cdot ft$$

$M_{maxClay} := if[(L_{ot1Clay} < 3 \cdot b), M_{modBroms}, M_{Broms}] = 298.1 \cdot kip \cdot ft$ *(If L_{ot} < 3b, use Modified Broms method)*

$M_{max} := if[(SoilType = 0), M_{maxSand}, M_{maxClay}] = 315.6 \cdot kip \cdot ft$

Minimum Reinforcing and Spacing

$F_{y.rebar} := 60 \cdot ksi$ *reinforcing yield strength*

$f_c := 4.0 \cdot ksi$ *concrete strength* ***Spec 346-3***

$Cover := 6 \cdot in$ *cover* ***SDG Table 1.4.2-1***

$A_{long.bar} := 1.56 \cdot in^2$ *longitudinal bar area*

$d_{long.bar} := 1.41 \cdot in$ *longitudinal bar diameter*

$A_{v.bar} := if(StirrupBarSize = 5, 0.31 \cdot in^2, 0.44 \cdot in^2) = 0.31 \cdot in^2$ *stirrup area* ***SM V3 13.6.2***

$d_{v.bar} := if(StirrupBarSize = 5, 0.625 \cdot in, 0.75 \cdot in) = 0.625 \cdot in$ *stirrup diameter*

SM V3 13.6.2

$$s_v := \begin{pmatrix} 4 \cdot in \\ s_{v_1} \\ s_{v_2} \\ 12 \cdot in \end{pmatrix} = \begin{pmatrix} 4 \\ 8 \\ 0 \\ 12 \end{pmatrix} \cdot in \quad \begin{pmatrix} \text{"Stirrups A"} \\ \text{"Stirrups B"} \\ \text{"Stirrups C"} \\ \text{"Stirrups D"} \end{pmatrix}$$

stirrup spacing defined in Index 649-031, depth = 0 ft-2 ft
stirrup spacing, depth = 2 ft-depth.stir
stirrup spacing, depth > depth.stir
stirrup spacing, depth > depth.stirA

$$\#Spaces_{vbar} := \begin{pmatrix} 6 \\ NumSpacesStirrupsB \\ NumSpacesStirrupsC \\ 1 \end{pmatrix} = \begin{pmatrix} 6 \\ 10 \\ 0 \\ 1 \end{pmatrix} \qquad \begin{pmatrix} \text{"Stirrups A"} \\ \text{"Stirrups B"} \\ \text{"Stirrups C"} \\ \text{"Stirrups D"} \end{pmatrix}$$

$$s_v = \begin{pmatrix} 4 \\ 8 \\ 0 \\ 12 \end{pmatrix} \cdot in \qquad \#Spaces_{vbar} = \begin{pmatrix} 6 \\ 10 \\ 0 \\ 1 \end{pmatrix}$$

$$\#Spaces_{vbar_2} := if\left[\#Spaces_{vbar_2} = 0, floor\left[\frac{L_{shaft} - 5 \cdot in - \sum_{i=0}^{1} \left(s_{v_i} \cdot \#Spaces_{vbar_i}\right)}{s_{v_3}}\right], \#Spaces_{vbar_2}\right] = 12$$

$$\#Spaces_{vbar_3} := floor\left[\frac{L_{shaft} - 5 \cdot in - \sum_{i=0}^{2} \left(s_{v_i} \cdot \#Spaces_{vbar_i}\right)}{s_{v_3}}\right] = 12$$

$$L_{shaft} = 21.5\,ft \qquad \sum_{i=0}^{3} \left(s_{v_i} \cdot \#Spaces_{vbar_i}\right) = 20.7\,ft$$

$b = 5\,ft$ *shaft diameter*

$$\#LongBars_{reqd_1} := \frac{0.01}{A_{long.bar}} \cdot \frac{\pi \cdot b^2}{4} = 18.1$$

LRFD 5.7.4.2

$$\#LongBars_{reqd_2} := \frac{0.135}{A_{long.bar} \cdot F_{y.rebar}} \cdot \left(\frac{\pi \cdot b^2}{4} \cdot f_c\right) = 16.3$$

$$\#LongBars_{prov} := ceil\left(max\left(\#LongBars_{reqd_1}, \#LongBars_{reqd_2}\right)\right) = 19$$

number of longitudinal bars

Use 18

$$Dia_{bar.circle} := b - 2 \cdot Cover - 2 \cdot d_{v.bar} - d_{long.bar} = 45.3 \cdot in$$

$$Spacing_{vert.reinf} := Dia_{bar.circle} \cdot \frac{\pi}{\#LongBars_{prov}} = 7.5 \cdot in \qquad Clearance_{vert.reinf} := Spacing_{vert.reinf} - d_{long.bar} = 6.09 \cdot in$$

$$CheckReinfClearSpacing := if\left(Clearance_{vert.reinf} \ge 6in, \text{"OK"}, \text{"No Good"}\right)$$

CheckReinfClearSpacing = "OK"

SDG 3.6.10

Check Shear and Torsion

$\phi_v := 0.90$ *Shear Resistance Factor* *LRFD 5.5.4.2.1*

$$V_u := \sqrt{\left(V_{x.polebase_{LoadCaseOT}}\right)^2 + \left(V_{z.polebase_{LoadCaseOT}}\right)^2} = 8.6 \cdot kip$$

$T_u = 421.5 \cdot kip \cdot ft$

Effective shear depth

$$D_r := b - 2 \cdot \left(Cover + d_{v.bar} + \frac{d_{long.bar}}{2}\right) = 3.8\,ft \qquad d_e := \frac{b}{2} + \frac{D_r}{\pi} = 3.7\,ft$$ *LRFD C5.8.2.9-2*

$d_v := \max(0.9 \cdot d_e, 0.72 \cdot b) = 3.6\,ft$

Check Shear Strength

$$V_c := 0.0316 \cdot (2.0) \cdot \sqrt{f_c \cdot ksi} \cdot (d_v) \cdot b = 327.6 \cdot kip$$ *LRFD Eqn 5.8.3.3-3* *LRFD 5.8.3.4.1* *ACI 11.3.3*

$$V_s := \frac{A_{v.bar} \cdot F_{y.rebar} \cdot d_v}{\max\left(s_{v_0}, s_{v_1}, s_{v_2}\right)} = 100.4 \cdot kip$$ *LRFD Eqn 5.8.3.3-4*

$$D/C_{shear} := \max\left(\begin{pmatrix} \frac{V_u - \phi_v \cdot V_c}{\phi_v \cdot V_s} \\ 0 \end{pmatrix}\right) = 0$$

Check Torsion Strength

$$A_{cp} := \pi \cdot \left(\frac{b}{2}\right)^2 = 2827.4 \cdot in^2 \qquad p_{cp} := 2 \cdot \pi \cdot \left(\frac{b}{2}\right) = 188.5 \cdot in$$ *Area and perimeter of concrete cross-section*

$$d_{oh} := b - 2 \cdot \left(Cover + \frac{d_{v.bar}}{2}\right) = 47.4 \cdot in \qquad p_h := \pi \cdot d_{oh} = 148.8 \cdot in$$ *Diameter, perimeter and area enclosed by the centerline of the outermost closed transverse torsion reinforcement*

$$A_{oh} := \pi \left(\frac{d_{oh}}{2}\right)^2 = 1.8 \times 10^3 \cdot in^2 \qquad A_o := 0.85 \cdot A_{oh} = 1.5 \times 10^3 \cdot in^2$$

$$T_{n.torsion_0} := \frac{2 \cdot A_o \cdot A_{v.bar} \cdot F_{y.rebar}}{s_{v_0}} = 1161.2 \cdot kip \cdot ft$$ *LRFD Eqn 5.8.3.6.2-1*

$$T_{n.torsion_1} := \frac{2 \cdot A_o \cdot A_{v.bar} \cdot F_{y.rebar}}{s_{v_1}} = 580.6 \cdot kip \cdot ft$$ *LRFD 5.8.3.4.1*

$$T_{n.torsion_2} := T_{n.torsion_1} \text{ on error } \frac{2 \cdot A_o \cdot A_{v.bar} \cdot F_{y.rebar}}{s_{v_2}} = 580.6 \cdot kip \cdot ft$$

$\phi_v = 0.9$ $T_u = 421.5 \cdot kip \cdot ft$ $L_{reqdTor} = 21\,ft$

$$depth_{stir} := \left| \begin{array}{l} \text{for } i \in 0..1 \\ \quad depth_i \leftarrow \sum_{j=0}^{i} \left(s_{v_j} \cdot \#Spaces_{vbar_j}\right) \\ depth \end{array} \right.$$

$$depth_{stir} = \begin{pmatrix} 2 \\ 8.7 \end{pmatrix} ft$$

$$T_{u.section_0} := T_u$$

$$T_{u.sand_1} := T_u - if\left[\left(depth_{stir_0} > Offset\right), \left[\pi \cdot b \cdot \left(depth_{stir_0} - Offset\right) \cdot \gamma_{soil} \cdot \left(\frac{depth_{stir_0} - Offset}{2}\right) \cdot \left(\omega_{fdot}\right) \cdot \frac{b}{2}\right], 0 \cdot kip \cdot ft\right] = 419.2 \cdot kip \cdot ft$$

$$T_{u.sand_2} := T_u - if\left[\left(depth_{stir_1} > Offset\right), \left[\pi \cdot b \cdot \left(depth_{stir_1} - Offset\right) \cdot \gamma_{soil} \cdot \left(\frac{depth_{stir_1} - Offset}{2}\right) \cdot \left(\omega_{fdot}\right) \cdot \frac{b}{2}\right], 0 \cdot kip \cdot ft\right] = 353.9 \cdot kip \cdot ft$$

$$T_{u.clay_1} := T_u - if\left[\left(depth_{stir_0} - 1.5ft > Offset\right), \left[f_{se} \cdot (\pi \cdot b) \cdot \left(depth_{stir_0} - Offset - 1.5 \cdot ft\right) \cdot \frac{b}{2}\right], 0 \cdot kip \cdot ft\right] = 421.5 \cdot kip \cdot ft$$

$$T_{u.clay_2} := T_u - if\left[\left(depth_{stir_1} - 1.5ft > Offset\right), \left[f_{se} \cdot (\pi \cdot b) \cdot \left(depth_{stir_1} - Offset - 1.5 \cdot ft\right) \cdot \frac{b}{2}\right], 0 \cdot kip \cdot ft\right] = 133.5 \cdot kip \cdot ft$$

$$T_{u.section_1} := if\left[(SoilType = 0), T_{u.sand_1}, T_{u.clay_1}\right] = 419.2 \cdot kip \cdot ft$$

$$T_{u.section_2} := if\left[(SoilType = 0), T_{u.sand_2}, T_{u.clay_2}\right] = 353.9 \cdot kip \cdot ft$$

$$T_{u.section} = \begin{pmatrix} 421.5 \\ 419.2 \\ 353.9 \end{pmatrix} \cdot kip \cdot ft \qquad T_{n.torsion} = \begin{pmatrix} 1161.2 \\ 580.6 \\ 580.6 \end{pmatrix} \cdot kip \cdot ft$$

$$D/C_{torsion} := \frac{T_{u.section}}{\phi_{tor} \cdot T_{n.torsion}} = \begin{pmatrix} 0.36 \\ 0.72 \\ 0.61 \end{pmatrix} \qquad D/C_{max.torsion} := max\left(D/C_{torsion}\right) = 0.72$$

$$T_{cr} := 0.125 \sqrt{\frac{f_c}{ksi}} \cdot \left(\frac{A_{cp}^{\ 2}}{p_{cp} \cdot in^3}\right) \cdot kip \cdot in = 883.6 \cdot kip \cdot ft$$

LRFD Eqn 5.8.2.1-4

$$T_u = 421.5 \cdot kip \cdot ft \qquad 0.25 \cdot \phi_{tor} \cdot T_{cr} = 220.9 \cdot kip \cdot ft$$

$$D/C_{torsion.max} := if\left[\left(T_u \le 0.25 \cdot \phi_{tor} \cdot T_{cr}\right), 0, max\left(D/C_{torsion}\right)\right] = 0.722$$

LRFD Eqn 5.8.2.1-3

$$D/C_{shear} = 0.000 \qquad D/C_{torsion.max} = 0.722$$

$$CheckD/C_{shear.and.torsion} := if\left[\left(D/C_{shear} + D/C_{torsion.max} \le 1\right), \text{"OK"}, \text{"No Good"}\right]$$

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

Check Maximum Spacing Transverse Reinforcement

$v_u := \dfrac{V_u}{\phi_v \cdot b \cdot d_v} = 0.0037 \cdot ksi$ $0.125 \cdot f_c = 0.5 \cdot ksi$ ***LRFD Eqn 5.8.2.9-1***

$s_{max1} := if\left[\left(0.8 \cdot d_v < 24 \cdot in\right), 0.8d_v, 24 \cdot in\right] = 24 \cdot in$ ***LRFD Eqn 5.8.2.7-1***

$s_{max2} := if\left[\left(0.4 \cdot d_v < 12 \cdot in\right), 0.4d_v, 12 \cdot in\right] = 12 \cdot in$ ***LRFD Eqn 5.8.2.7-2***

$s_{max} := if\left[\left(v_u < 0.125 \cdot f_c\right), s_{max1}, s_{max2}\right] = 24 \cdot in$

$max\left(s_v\right) = 12 \cdot in$

$CheckMaxSpacingTransvReinf := if\left[\left(max\left(s_v\right) \le s_{max}\right), "OK", "No\ Good"\right]$ $CheckMaxSpacingTransvReinf = "OK"$

Check Longitudinal Reinforcement for Combined Shear and Torsion ***LRFD Eqn 5.8.3.6.3-1***

LRFD 5.8.3.4.1

$M_u = 288.6 \cdot kip \cdot ft$

$V_{temp} := if\left(\dfrac{V_u}{\phi_v} - 0.5 \cdot V_s > 0 \cdot kip, \dfrac{V_u}{\phi_v} - 0.5 \cdot V_s, 0 \cdot kip\right) = 0 \cdot kip$

$$LongReinf_{shr.tor} := \frac{\dfrac{M_u}{\phi_v \cdot d_v} + \sqrt{\left(V_{temp}\right)^2 + \left(\dfrac{0.45 \cdot p_h \cdot T_u}{2 \cdot A_o \cdot \phi_v}\right)^2}}{F_{y.rebar}} = 3.58 \cdot in^2$$

$\#LongBars_{prov} \cdot A_{long.bar} = 29.6 \cdot in^2$

$CheckLongReinf_{shr.tor} := if\left[\left(\#LongBars_{prov} \cdot A_{long.bar} \ge LongReinf_{shr.tor}\right), "OK", "No\ Good"\right]$ $CheckLongReinf_{shr.tor} = "OK"$

Anchor Bolt Embedment

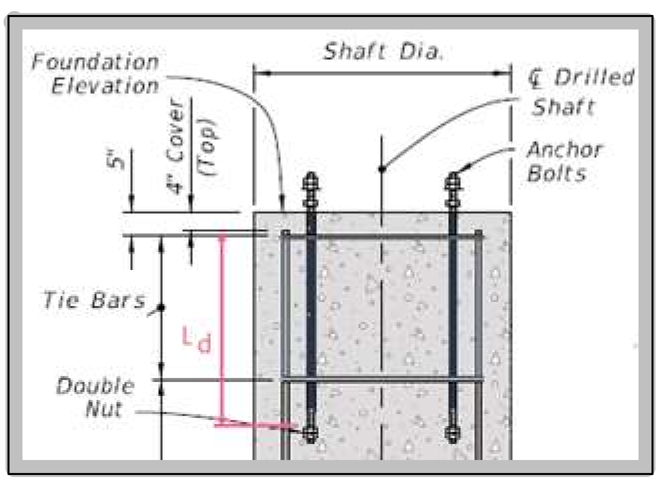
$T_{u.anchor} = 45.2 \cdot kip$ *tension force in anchor*

$Dia_{bar.circle} = 45.3 \cdot in$

$Dia_{anchor.circle} := Diameter_{boltcircle.pole} = 32 \cdot in$

center-to-center distance

$Dist_{bar.to.bolt} := \dfrac{Dia_{bar.circle} - Dia_{anchor.circle}}{2} = 6.7 \cdot in$



$$Num_{bars.per.anchor} := \min\left(\frac{\#LongBars_{prov}}{\#AnchorBolts}, 3\right) = 2.4$$

Use a maximum of three rebar per anchor bolt (conservative)

$$\phi := 0.9$$

$$Num_{bars.reqd.per.anchor} := \frac{T_{u.anchor}}{A_{long.bar}\cdot(\phi\cdot F_{y.rebar})}\cdot\frac{Dia_{anchor.circle}}{Dia_{bar.circle}} = 0.38$$

$$AreaRatio := \min\left(\frac{Num_{bars.reqd.per.anchor}}{Num_{bars.per.anchor}}, 1\right) = 0.16$$

2015 AASHTO Development Length of Deformed Bars in Tension ***5.11.2.1***

$$Cover = 6\cdot in$$

c_b = *the smaller of the distance from center of bar or wire being developed to the nearest concrete surface and one half the center-to-center spacing of the bars or wires being developed*

$$c_b := \min\left(\begin{pmatrix} Cover + d_{v.bar} + \frac{d_{long.bar}}{2} \\ \frac{Spacing_{vert.reinf}}{2} \end{pmatrix}\right) = 3.7\cdot in$$

$k_{tr} := 0\cdot in$ *assume no transverse bars:*

$$\lambda_{rc} := \min\left[\begin{bmatrix} 1.0 \\ \max\left(\begin{pmatrix} 0.4 \\ \frac{d_{long.bar}}{c_b + k_{tr}} \end{pmatrix}\right) \end{bmatrix}\right] = 0.4$$

LRFD Eqn 5.11.2.1.3-1

$$L_{d.bar} := \max\left(\begin{pmatrix} 12\cdot in \\ \lambda_{rc}\cdot 2.4\cdot d_{long.bar}\cdot\frac{F_{y.rebar}}{\sqrt{f_c\cdot ksi}} \end{pmatrix}\right) = 40.6\cdot in$$

tension development length ***LRFD Eqn 5.11.2.1.1-2***

$$SpacingFactor := \max\left[\begin{pmatrix} 0.5 \\ Num_{bars.per.anchor}\cdot 0.5 - 0.5 \end{pmatrix}\right] = 0.7$$

$$L_{embedment.added} := \sqrt{(Clearance_{vert.reinf}\cdot SpacingFactor)^2 + Dist_{bar.to.bolt}^{\;2}} = 7.9\cdot in$$

$$L_{embedment.anchor} := \max\left[\begin{bmatrix} L_{d.bar}\cdot(AreaRatio) + 12\cdot in + L_{embedment.added} \\ 20\cdot d_{anchorbolt} \end{bmatrix}\right] = 40\cdot in$$

Note: $20d_{anchor.bolt}$ *minimum embedment is in LTS,3rd Ed. 1994, Section 3, 1.3.4 and still a good rule of thumb.*

$$L_{anchor.bolt.exposed} := \max\left(\begin{pmatrix} 8\cdot in \\ 2\cdot d_{anchorbolt} + t_{baseplate.pole} + 2\cdot d_{anchorbolt} + 2\cdot in \end{pmatrix}\right) = 12.5\cdot in$$

$L_{anchor.bolt} := Ceil(L_{embedment.anchor} + L_{anchor.bolt.exposed}, in) = 53 \cdot in$ $L_{anchor.bolt} = 53 \cdot in$

Anchor Bolt Shear Break-Out Strength

References:
ACI 318-05 Appendix D.
FDOT/University of Florida Report BD545 RPWO #54,
Anchor Embedment Requirements for Signal/Sign Structures, July 2007.

$\#AnchorBolts = 8$ *number of anchor bolts*

$d_{anchorbolt} = 2 \cdot in$ *anchor bolt diameter*

$Diameter_{boltcircle.pole} = 32 \cdot in$ *anchor bolt circle diameter*

$L_{embedment.anchor} = 40 \cdot in$ *anchor bolt embedment*

$b = 60 \cdot in$ *shaft diameter*

$$r_b := \frac{Dia_{anchor.circle}}{2} = 16 \cdot in$$

$$r := \frac{b}{2} = 30 \cdot in$$

$$c_{a1} := \frac{\sqrt{r_b^2 + 3.25 \cdot (r^2 - r_b^2)} - r_b}{3.25} = 10 \cdot in$$

adjusted cover
UF Report Eqn 3-2

$$L_e := \min\left(\begin{pmatrix} 8 \cdot d_{anchorbolt} \\ L_{embedment.anchor} \end{pmatrix}\right) = 16 \cdot in$$

load bearing length of anchor for shear
ACI D.6.2.2

$$V_b := 13 \cdot \left(\frac{L_e}{d_{anchorbolt}}\right)^{0.2} \cdot \sqrt{\frac{d_{anchorbolt}}{in}} \cdot \sqrt{\frac{f_c}{psi}} \left(\frac{c_{a1}}{in}\right)^{1.5} \cdot lbf = 55.6 \cdot kip$$

shear break-out strength (single anchor)
UF Report Eqn 2-11

$$A_{bolt.sector} := \frac{(360 \cdot deg)}{\#AnchorBolts} = 45 \cdot deg$$

UF Report Fig 3-7

$$\alpha_{cone} := 2\, asin\left[\frac{(1.5 \cdot c_{a1})}{r}\right] = 59.9 \cdot deg$$

$OverlapTest := if(A_{bolt.sector} \le \alpha_{cone}, \text{"Overlap of Failure Cones"}, \text{"No Overlap of Failure Cones"}) = \text{"Overlap of Failure Cones"}$

$$chord := 2 \cdot r \cdot \sin\left(\frac{A_{bolt.sector}}{2}\right) = 23 \cdot in$$

UF Report Fig 3-7

$A_{Vco} := 4.5 \cdot c_{a1}^{2} = 449.1 \cdot in^{2}$

projected concrete failure area (single anchor)

ACI Eqn D-23

$A_{Vc} := chord \cdot 1.5 \cdot c_{a1} = 344.1 \cdot in^{2}$

projected concrete failure area (group)

ACI D.6.2.1

$A_{Vc} := if\left[\left(A_{Vc} > A_{Vco}\right), A_{Vco}, A_{Vc}\right] = 344.1 \cdot in^{2}$

$\psi_{ecV} := \mathbf{1.0}$ *eccentric load modifier* ***ACI D.6.2.5***

$\psi_{edV} := \mathbf{1.0}$ *edge effect modifier* ***ACI D.6.2.6***

$\psi_{cV} := \mathbf{1.0}$ *cracked section modifier* ***ACI D.6.2.7*** *(stirrup spacing <= 4")*

$\psi_{hV} := \mathbf{1.0}$ *member thickness modifier* ***ACI D.6.2.8***

$\phi_{breakout} := \mathbf{0.75}$ *strength reduction factor* ***ACI D.4.4.c.i*** *(shear breakout, condition A)*

$V_{cbg} := \#AnchorBolts \cdot \left(\dfrac{A_{Vc}}{A_{Vco}}\right) \cdot (\psi_{ecV} \cdot \psi_{edV} \cdot \psi_{cV} \cdot \psi_{hV}) \cdot V_b = 341.1 \cdot kip$ *concrete breakout strength - shear*

ACI Eqn D-22 *Shear force ⊥ to edge*

$V_{cbg\_parallel} := 2 \cdot V_{cbg} = 682.1 \cdot kip$ ***ACI D.6.2.1.c*** *Shear force ∥ to edge*

$T_{n.breakout} := V_{cbg\_parallel} \cdot r_b = 909.5 \cdot kip \cdot ft$ *concrete breakout strength - torsion*

$\phi_{breakout} \cdot T_{n.breakout} = 682.1 \cdot kip \cdot ft$

$T_u = 421.5 \cdot kip \cdot ft$

BreakoutTest := if[($\phi_{breakout} \cdot T_{n.breakout} \geq T_u$), "OK" , "No Good"]

BreakoutTest = "OK"

OverlapDesign := if[($A_{bolt.sector} \leq \alpha_{cone}$), "Based on Overlap of Failure Cones" , "Based on No Overlap of Failure Cones"]

OverlapDesign = "Based on Overlap of Failure Cones"

Clearance Between Vertical Reinforcement and Anchor Bolt Nut

$Dist_{bar.to.bolt} = 6.7 \cdot in$ *center-to-center distance*

$d_{anchor.nut} := 1.85 \cdot d_{anchorbolt} = 3.7 \cdot in$ *use an .to account for anchor nut*

$Clearance_{bar.to.nut} := Dist_{bar.to.bolt} - \left(\dfrac{d_{anchor.nut} + d_{long.bar}}{2}\right) = 4.1 \cdot in$

CheckAnchorageClearance := if[($Clearance_{bar.to.nut} \geq 2 \cdot in$), "OK" , "No Good, increase shaft diameter"]

CheckAnchorageClearance = "OK"

CSL tubes can be relocated plus/minus 2 inches from planned position (see Specifications)

$d_{csl.tube} := 2 \cdot in$

$Clearance_{csl.to.nut} := Dist_{bar.to.bolt} + 0.5 \cdot d_{long.bar} - d_{csl.tube} - 0.5 \cdot d_{anchor.nut} = 3.5 \cdot in$

Draw Drilled Shaft Section with Reinforcement

$$fDrawStirrups(spacing, \#spaces, inix, iniy) := \left| \begin{array}{l} coord_{0,0} \leftarrow inix \\ coord_{0,1} \leftarrow iniy \\ \text{for } i \in 1..\#spaces \\ \quad \left| \begin{array}{l} coord_{i,0} \leftarrow coord_{0,0} \\ coord_{i,1} \leftarrow coord_{i-1,1} - spacing \end{array} \right. \\ index \leftarrow 1 \\ \text{for } i \in \#spaces + 1..2 \cdot \#spaces + 1 \\ \quad \left| \begin{array}{l} coord_{i,0} \leftarrow b - inix \\ coord_{i,1} \leftarrow coord_{i-index,1} \\ index \leftarrow index + 2 \end{array} \right. \\ coord_{2 \cdot \#spaces+2,0} \leftarrow inix \\ coord_{2 \cdot \#spaces+2,1} \leftarrow iniy \\ coord \end{array} \right.$$

$$StirrupsA := fDrawStirrups\left(s_{v_0}, \#Spaces_{vbar_0}, Cover, Offset - 5 \cdot in\right)$$

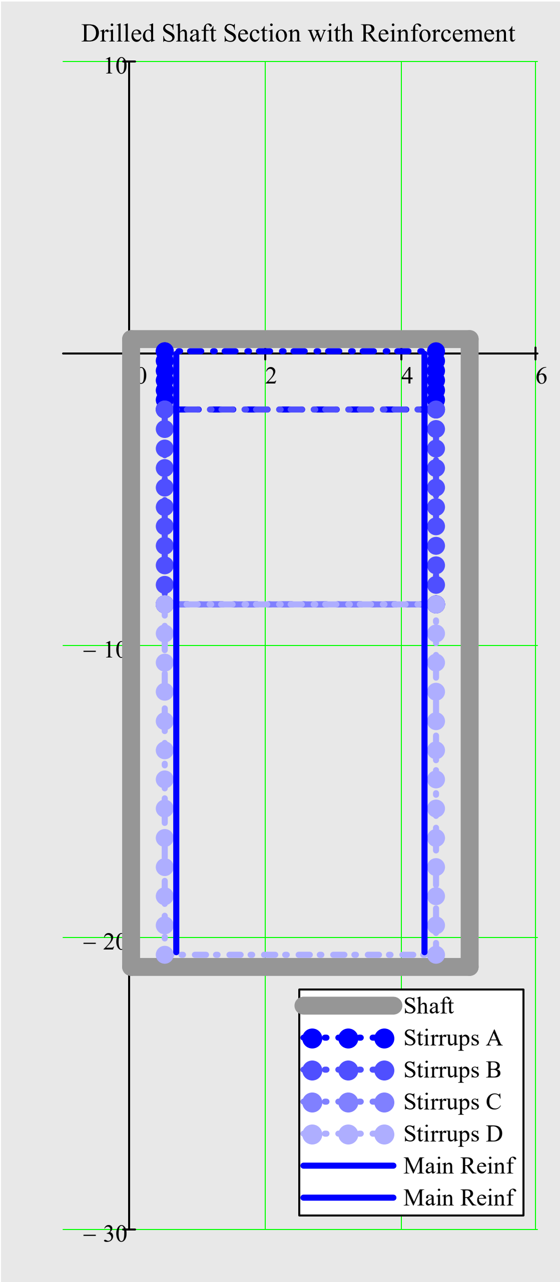
$$StirrupsB := fDrawStirrups\left(s_{v_1}, \#Spaces_{vbar_1}, Cover, \min\left(StirrupsA^{\langle 1 \rangle}\right)\right)$$

$$StirrupsC := fDrawStirrups\left(s_{v_2}, \#Spaces_{vbar_2}, Cover, \min\left(StirrupsB^{\langle 1 \rangle}\right)\right)$$

$$StirrupsD := \left| \begin{array}{l} coord \leftarrow \begin{pmatrix} Cover & \min(StirrupsC) \\ b - Cover & \min(StirrupsC) \end{pmatrix} \\ coord \leftarrow fDrawStirrups\left(s_{v_3}, \#Spaces_{vbar_3}, Cover, \min\left(StirrupsC^{\langle 1 \rangle}\right)\right) \text{ if } \min(StirrupsC) > -L_{shaft} + Cover + 6 \cdot in \\ coord \end{array} \right.$$

$$Shaft := \begin{pmatrix} 0 \cdot in & Offset \\ b & Offset \\ b & -L_{shaft} + Offset \\ 0 \cdot in & -L_{shaft} + Offset \\ 0 \cdot in & Offset \end{pmatrix} = \begin{pmatrix} 0 & 0.5 \\ 5 & 0.5 \\ 5 & -21 \\ 0 & -21 \\ 0 & 0.5 \end{pmatrix} ft$$

$$Rebar := \begin{bmatrix} (Cover + 2 \cdot in) & -Cover + Offset & (b - Cover - 2 \cdot in) \\ (Cover + 2 \cdot in) & \left(-L_{shaft} + Cover + Offset\right) & (b - Cover - 2 \cdot in) \end{bmatrix} = \begin{pmatrix} 8 & 1.1 \times 10^{-15} & 52 \\ 8 & -246 & 52 \end{pmatrix} \cdot in$$



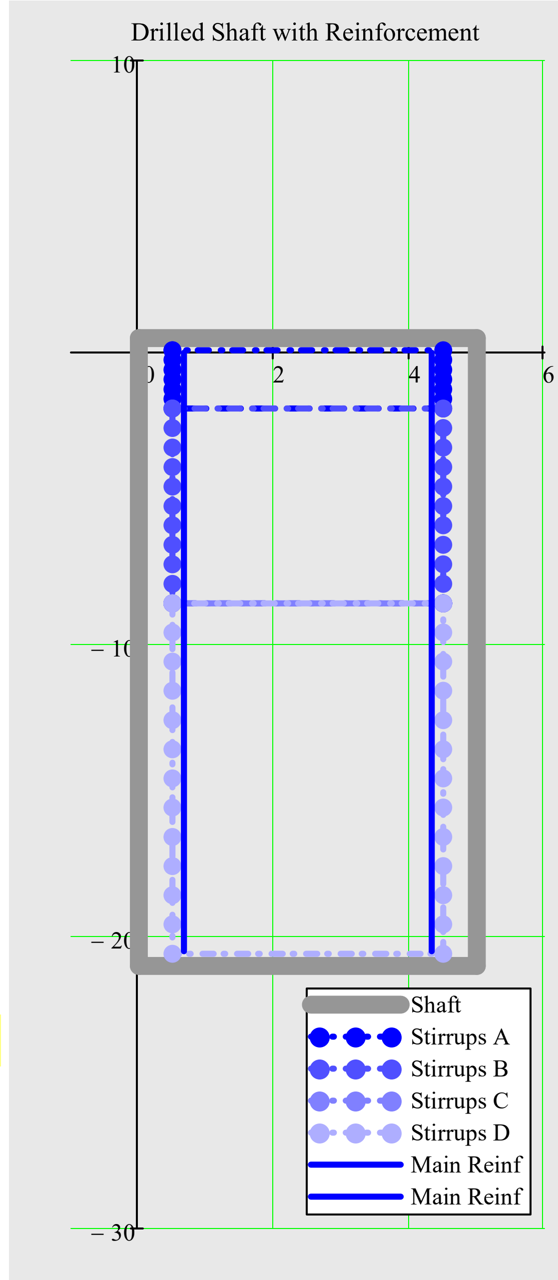
$s_v = \begin{pmatrix} 4 \\ 8 \\ 0 \\ 12 \end{pmatrix} \cdot in$ *stirrup spacing*

$\#Spaces_{vbar} = \begin{pmatrix} 6 \\ 10 \\ 12 \\ 12 \end{pmatrix}$ *number of stirrup spaces*

Analyze Foundation

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

$L_{shaft} = 21.5\ ft$ $s_v = \begin{pmatrix} 4 \\ 8 \\ 0 \\ 12 \end{pmatrix} \cdot in$ $\#Spaces_{vbar} = \begin{pmatrix} 6 \\ 10 \\ 12 \\ 12 \end{pmatrix}$



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 $s_{v_0} = 4 \cdot in$ @ $\#Spaces_{vbar_0} = 6$: $D/C_{torsion_0} = 0.4$

Stirrups 'RC' ($s_{v_1} = 8 \cdot in$) @ 'RD' ($\#Spaces_{vbar_1} = 10$): $D/C_{torsion_1} = 0.7$

Stirrups 'RE' ($s_{v_2} = 0 \cdot in$) @ 'RF' ($\#Spaces_{vbar_2} = 12$): $D/C_{torsion_2} = 0.6$

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

Use 22 ft

$Offset = 0.5\ ft$

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

$Dia_{bar.circle} = 45.3 \cdot in$

'DA'= $L_{shaft} = 21.5\ ft$ (struck through)

'DB'= $Diameter_{shaft} = 5 \cdot ft$

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

$L_{anchor.bolt} = 53 \cdot in$

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

'RB'= $\#LongBars_{prov} = 19$

Page 16 of the Mathcad sheets in this documentation shows required total number of longitudinal rebar is 18.1. Provide 18 to match FDOT Standard Plans Index 649-030 typical drilled shaft longitudinal reinforcement. This reinforcement is considered to be the 1% requirement per FDOT Modifications to LRFDLTS-1 provision 13.6.2 (within 1%), which is considered to typically be a conservative flexural design. Meets Eq. 5.6.4.2-3 of the AASHTO LRFD Bridge Design Specifications.

$\#Spaces_{vbar_0} = 6$

$s_{v_0} = 4 \cdot in$

'RC'= $\#Spaces_{vbar_1} = 10$

'RD'= $s_{v_1} = 8 \cdot in$

'RE'= $\#Spaces_{vbar_2} = 12$

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

$\#Spaces_{vbar_3} = 12$

$s_{v_3} = 12 \cdot in$

IX. Fatigue Analysis

InputDataFile = "A70D-A70D-P6D-DS185.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

$Check_{galloping.arm1} = "OK"$ $f_{galloping.arm1} = 5.8 \cdot ksi$ $CAFT_{fullpengroove.weld.arm1} = 7 \cdot ksi$

$Check_{galloping.arm2} = "OK"$ $f_{galloping.arm2} = 6.8 \cdot ksi$ $CAFT_{fullpengroove.weld.arm2} = 7 \cdot ksi$

$Check_{galloping.pole} = "OK"$ $f_{galloping.pole} = 2.5 \cdot ksi$ $CAFT_{fullpengroove.weld.pole} = 4.5 \cdot ksi$

$Check_{nwg.arm1} = "OK"$ $f_{nwg.arm1} = 3.6 \cdot ksi$ $CAFT_{fullpengroove.weld.arm1} = 7 \cdot ksi$

$Check_{nwg.arm2} = "OK"$ $f_{nwg.arm2} = 3.7 \cdot ksi$ $CAFT_{fullpengroove.weld.arm2} = 7 \cdot ksi$

$Check_{nwg.pole} = "OK"$ $f_{nwg.pole} = 1.2 \cdot ksi$ $CAFT_{fullpengroove.weld.pole} = 4.5 \cdot ksi$

$$CheckK1Values = \begin{pmatrix} \text{"K1 is outside of 2\% of K1 thresholds"} \\ \text{"K1 is outside of 2\% of K1 thresholds"} \\ \text{"K1 is outside of 2\% of K1 thresholds"} \end{pmatrix} \quad \begin{pmatrix} K_{I.arm1} \\ K_{I.arm2} \\ K_{I.pole} \end{pmatrix} = \begin{pmatrix} 3.781 \\ 3.781 \\ 8.768 \end{pmatrix} \quad \begin{pmatrix} \text{"Arm 1 Base Weld"} \\ \text{"Arm 2 Base Weld"} \\ \text{"Upright Base Weld"} \end{pmatrix}$$

A325 Connection Bolts

$$Check_{g.conn.bolt} = \begin{pmatrix} \text{"OK"} \\ \text{"OK"} \end{pmatrix} \quad f_{t.g.bolt} = \begin{pmatrix} 5.2 \\ 5.8 \end{pmatrix} \cdot ksi$$

$$CAFT_{conn.bolt} = 16 \cdot ksi$$

$$Check_{nwg.conn.bolt} = \begin{pmatrix} \text{"OK"} \\ \text{"OK"} \end{pmatrix} \quad f_{t.nwg.bolt} = \begin{pmatrix} 3.2 \\ 3.2 \end{pmatrix} \cdot ksi$$

Anchor Bolts

$Check_{g.anchor} = "OK"$ $f_{t.g.anchor} = 2.4 \cdot ksi$ $CAFT_{anchor.bolts} = 7 \cdot ksi$

$Check_{nwg.anchor} = "OK"$ $f_{t.nwg.anchor} = 1.3 \cdot ksi$

Save Data File (optional)

☑ Use current input file

File Name A70D-A70D-P6D-DS185.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 = "A70D-A70D-P6D-DS185.dat"

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

Subject = "Erie Rd and SR 62 Improvements" **DesignedBy** = "RT" **PoleLocation** = "106+71.00/52.5 RT"

ProjectNo = "850-6094060" **CheckedBy** = "" **Date** = "5 / 27 / 2021"

ExistingMastArm = "No"

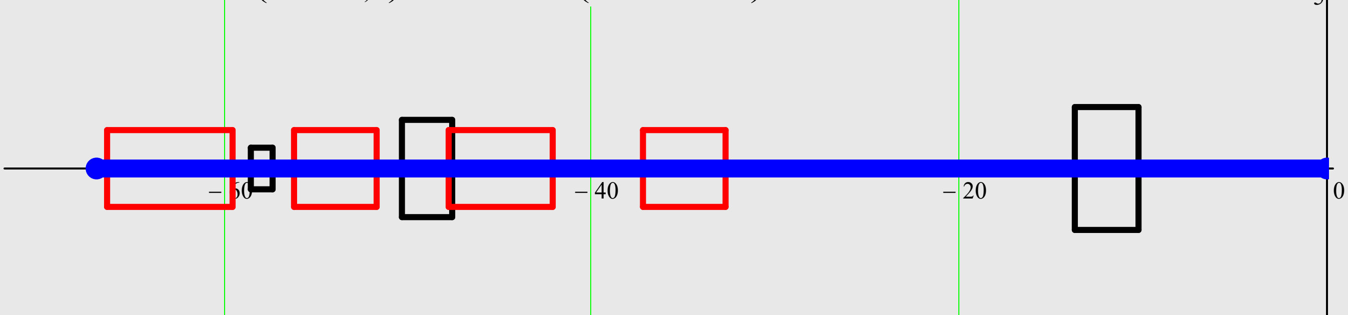
For FDOT Mast Arm Support Structures, $\max(CFI) \le 0.95$ ***(See Structures Manual Volume3)***

1st Mast Arm

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

Arm 1: Locations of Signs and Signals

$\#Signals_{arm1} = 4$ $\begin{pmatrix} \text{"Dist(ft)"} \\ \text{"\# Heads)"} \end{pmatrix}$ $Signals_{arm1}^{T} = \begin{pmatrix} 35 & 45 & 54 & 63 \\ 3 & 4 & 3 & 5 \end{pmatrix}$



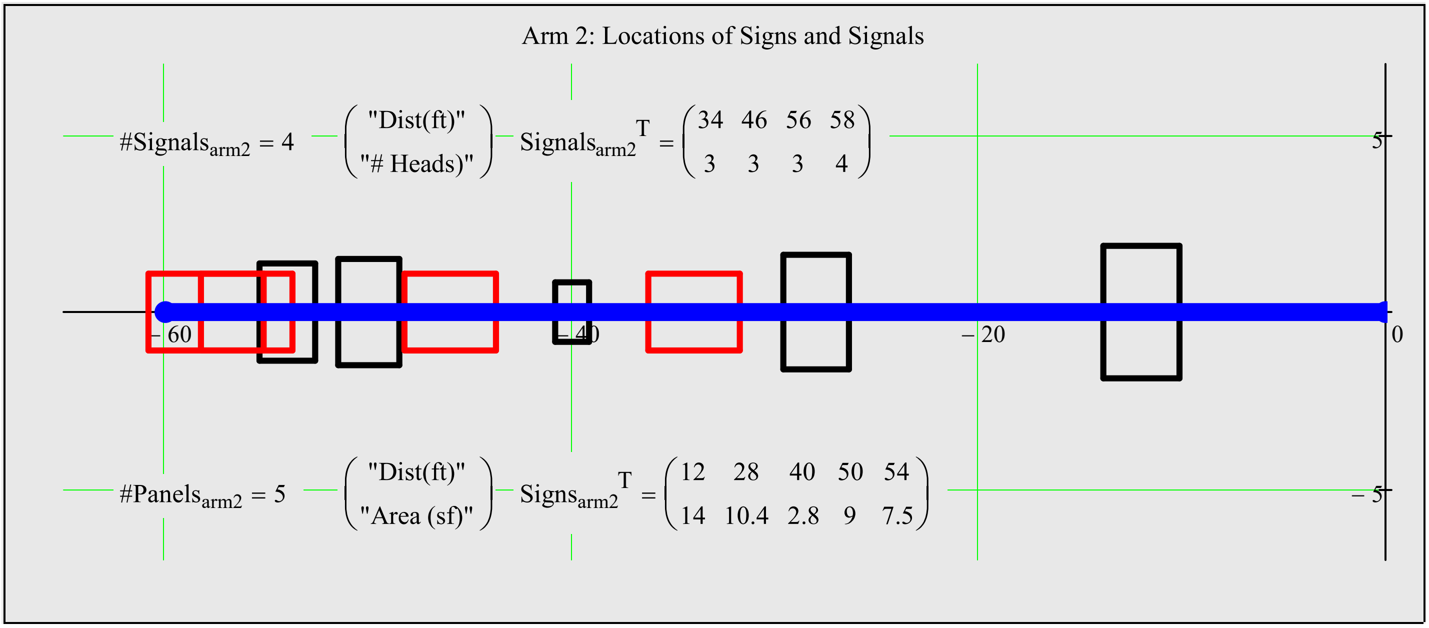
$\#Panels_{arm1} = 3$ $\begin{pmatrix} \text{"Dist(ft)"} \\ \text{"Area (sf)"} \end{pmatrix}$ $Signs_{arm1}^{T} = \begin{pmatrix} 12 & 49 & 58 \\ 12 & 7.5 & 1.4 \end{pmatrix}$

$\max(CFI_{arm1}) = 0.77$ $L_{total.arm1} = 67\,ft$ $L_{splice.provided.arm1} = 3 \cdot ft$ $\max(\Delta_{arm1}) = 14.4 \cdot in$

'FA'= 'FE'= $L_{fabricated.arm1} = \begin{pmatrix} 35 \\ 35 \end{pmatrix} \cdot ft$ 'FC'= 'FG'= $Diameter_{base.arm1} = \begin{pmatrix} 13.04 \\ 17.00 \end{pmatrix} \cdot in$

'FB'= 'FF'= $Diameter_{tip.arm1} = \begin{pmatrix} 8.14 \\ 12.10 \end{pmatrix} \cdot in$ 'FD'= 'FH'= $t_{wall.arm1} = \begin{pmatrix} 0.250 \\ 0.375 \end{pmatrix} \cdot in$

2nd Mast Arm



$\#Signals_{arm2} = 4$ — $\begin{pmatrix} \text{"Dist(ft)"} \\ \text{"\# Heads)"} \end{pmatrix}$ — $Signals_{arm2}^{T} = \begin{pmatrix} 34 & 46 & 56 & 58 \\ 3 & 3 & 3 & 4 \end{pmatrix}$

$\#Panels_{arm2} = 5$ — $\begin{pmatrix} \text{"Dist(ft)"} \\ \text{"Area (sf)"} \end{pmatrix}$ — $Signs_{arm2}^{T} = \begin{pmatrix} 12 & 28 & 40 & 50 & 54 \\ 14 & 10.4 & 2.8 & 9 & 7.5 \end{pmatrix}$

$max(CFI_{arm2}) = 0.81$ $L_{total.arm2} = 60\,ft$ $L_{splice.provided.arm2} = 3 \cdot ft$ $max(\Delta_{arm2}) = 10.1 \cdot in$

'SA'= 'SE'= $L_{fabricated.arm2} = \begin{pmatrix} 28 \\ 35 \end{pmatrix} \cdot ft$

'SC'= 'SG'= $Diameter_{base.arm2} = \begin{pmatrix} 13.04 \\ 17.00 \end{pmatrix} \cdot in$

'UF'= $\alpha = 90 \cdot deg$ **(Angle Between Arms)**

'SB'= 'SF'= $Diameter_{tip.arm2} = \begin{pmatrix} 9.12 \\ 12.10 \end{pmatrix} \cdot in$

'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)*

$$\begin{pmatrix} CFI_{base.lumarm} \\ CSR_{bolt.lum} \\ D/C_{baseplate.lum} \\ D/C_{conn.plate.lum} \end{pmatrix} = \begin{pmatrix} 0.00 \\ 7.17 \times 10^{-9} \\ 0.00 \\ 0.00 \end{pmatrix}$$

'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

$max(CFI_{pole}) = 0.50$ $Check_{deflection} = \text{"OK"}$ $Check_{slope} = \text{"OK"}$

'UA'= $Y_{pole} = 23.25 \cdot ft$

'UB'= $Y_{arm.conn} = 20.25 \cdot ft$

'UC'= $Diameter_{tip.pole} = 20.8 \cdot in$

'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

$D/C_{ht.conn.plate} = 0.75$

'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'= $t_{conn.plate_0} = 2.5 \cdot in$

$$\begin{pmatrix} D/C_{t.baseplate.arm_0} \\ CFI_{t.vert.plate_0} \\ CSR_{bolt.conn_0} \end{pmatrix} = \begin{pmatrix} 0.83 \\ 0.52 \\ 0.31 \end{pmatrix}$$

'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

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

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

$\#Bolts_{conn_1} = 6$

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

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

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

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

$$\begin{pmatrix} D/C_{t.baseplate.arm_1} \\ CFI_{t.vert.plate_1} \\ CSR_{bolt.conn_1} \end{pmatrix} = \begin{pmatrix} 0.83 \\ 0.54 \\ 0.31 \end{pmatrix}$$

'SK'= $t_{baseplate.arm_1} = 3 \cdot in$

'SR'= $t_{conn.plate_1} = 2.5 \cdot in$

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

'SS'= $Spacing_{bolts.conn_1} = 12 \cdot in$

'SN'= $w_{vertical.plate_1} = \frac{3}{8} \cdot in$

'ST'= $w_{conn.plate_1} = \frac{3}{8} \cdot in$

Pole Base Plate

$CSR_{anchor} = 0.38$

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

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

$CheckCSR_{anchorbolt} = "OK"$

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

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

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

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

$L_{anchor.bolt} = 53 \cdot in$

Foundation

$D/C_{torsion.max} = 0.72$

$CheckD/C_{shear.and.torsion}$ = "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 = 0.5 ft

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

$Dia_{bar.circle} = 45.3 \cdot in$

'DA'= $L_{shaft} = 21.5 \cdot ft$ ~~21.5~~ Use 22 ft

'DB'= $Diameter_{shaft} = 5 \cdot ft$

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

'RB'= $\#LongBars_{prov} = 19$ ~~19~~ Use 18

'RC'= $\#Spaces_{vbar_1} = 10$

'RD'= $s_{v_1} = 8 \cdot in$

'RE'= $\#Spaces_{vbar_2} = 12$

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

Fatigue

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

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

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

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

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

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

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

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

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

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

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

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

$\begin{pmatrix} K_{I.arm1} \\ K_{I.arm2} \\ K_{I.pole} \end{pmatrix} = \begin{pmatrix} 3.781 \\ 3.781 \\ 8.768 \end{pmatrix}$ $\begin{pmatrix} \text{"Arm 1 Base Weld"} \\ \text{"Arm 2 Base Weld"} \\ \text{"Upright Base Weld"} \end{pmatrix}$

WRITEPRN to Line 1-2-3 for Mast Arm Data Table

Mast Arm Tip Deflection

Compare Mast Arm deflection of each arm to a proposed camber

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

$Deflection_{arm1} := Slope_x \cdot L_{total.arm1} + max(\Delta_{arm1}) = 18.6 \cdot in$

$CamberArm1_{upward} := sin(Camber_{arm1}) \cdot L_{total.arm1} = 28.1 \cdot in$

$Deflection_{arm2} := [Slope_z \cdot L_{total.arm2} \cdot (sin(\alpha))] + Slope_x \cdot L_{total.arm2} \cdot cos(\alpha) + max(\Delta_{arm2}) = 13.6 \cdot in$

$CamberArm2_{upward} := sin(Camber_{arm2}) \cdot L_{total.arm2} = 25.1 \cdot in$

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

$\alpha = 90 \cdot deg$ $\alpha := if[(\alpha > 180 \cdot deg), (360 \cdot deg - \alpha), \alpha]$

$Offset_{conn_0} = 23 \cdot in$ $b_{conn.plate_0} = 36 \cdot in$ $h_{conn.plate} = 30 \cdot in$ $\alpha = 90 \cdot deg$

$Offset_{conn_1} = 23 \cdot in$ $b_{conn.plate_1} = 36 \cdot in$

$$x1 := Offset_{conn_0} - t_{conn.plate_0} - h_{conn.plate} \cdot \frac{\sin(Camber_{arm1})}{2} = 20 \cdot in \qquad y1 := \frac{b_{conn.plate_0}}{2} = 18 \cdot in$$

$$x2 := \left(Offset_{conn_1} - t_{conn.plate_1} - h_{conn.plate} \cdot \frac{\sin(Camber_{arm2})}{2}\right) \cdot \cos(\alpha) + \frac{b_{conn.plate_1}}{2} \cdot \sin(\alpha) = 18 \cdot in$$

$$y2 := \left(Offset_{conn_1} - t_{conn.plate_1} - h_{conn.plate} \cdot \frac{\sin(Camber_{arm2})}{2}\right) \cdot \sin(\alpha) - \frac{b_{conn.plate_1}}{2} \cdot \cos(\alpha) = 20 \cdot in$$

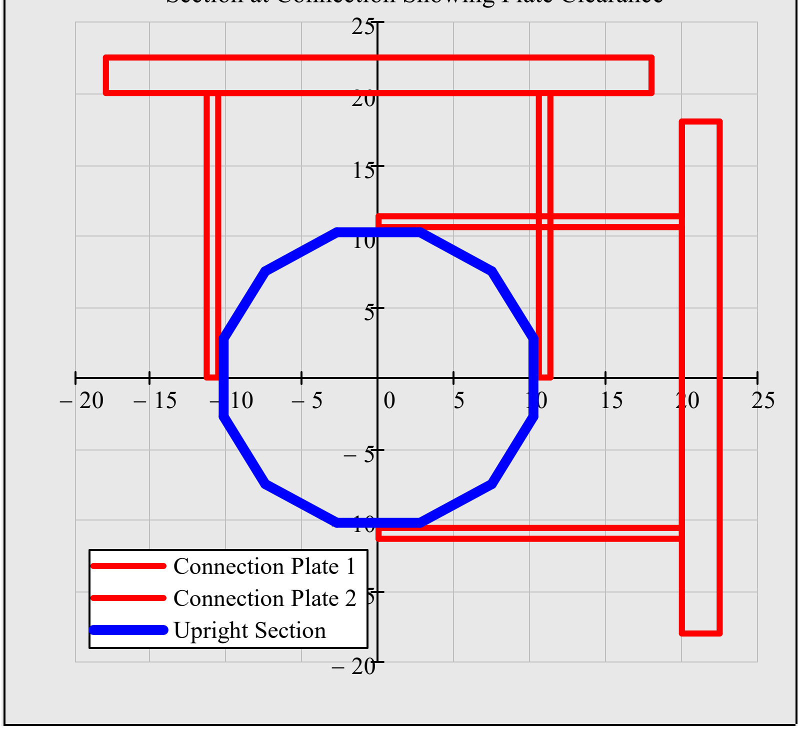
$$Clearance_{plate.to.plate} := if\left[(x1 > x2) \cdot (y2 > y1), \sqrt{(x1 - x2)^2 + (y1 - y2)^2}, 0 \cdot in\right] = 2.8 \cdot in$$

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

Coordinates for Drawings

Plan View - Connection Plate Clearance for Two Arm Connections

Section at Connection Showing Plate Clearance



$Clearance_{plate.to.plate} = 2.8 \cdot in$

$Diameter_{conn.pole} = 21.2 \cdot in$

'FR'= $t_{conn.plate_0} = 2.5 \cdot in$

'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'= $t_{conn.plate_1} = 2.5 \cdot in$

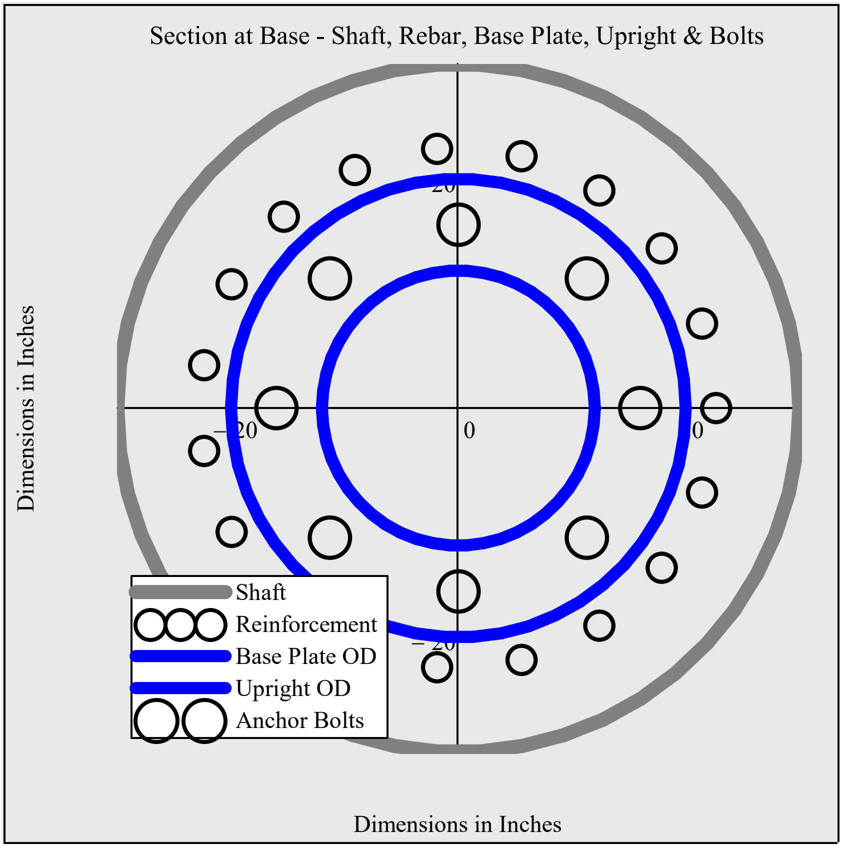
'SJ'= $b_{conn.plate_1} = 36 \cdot in$

'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'= $Diameter_{shaft} = 60 \cdot in$

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

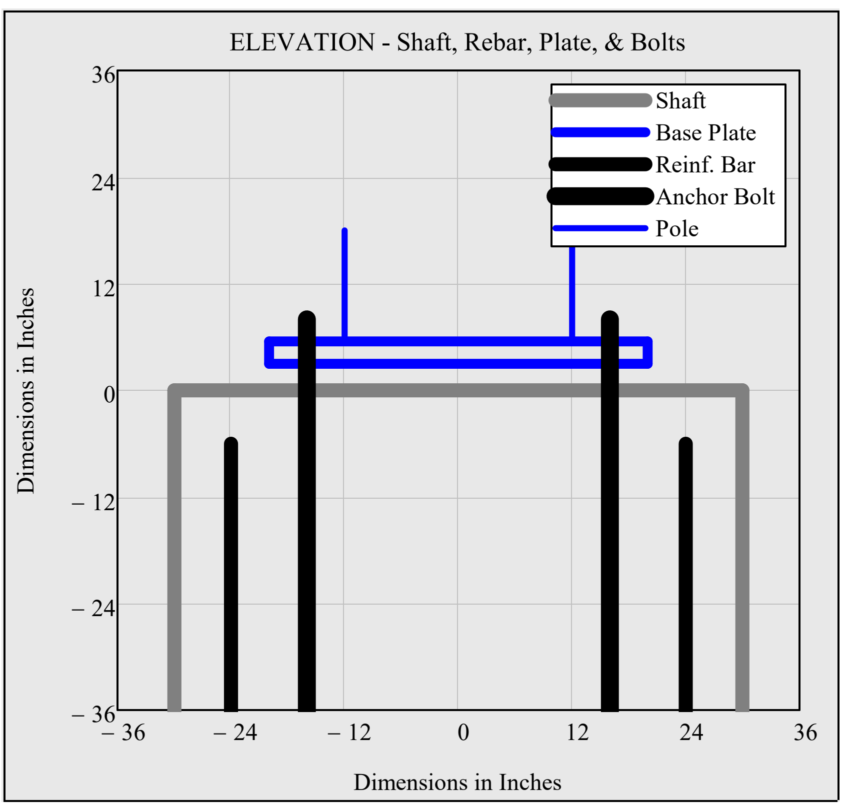
$Dia_{bar.circle} = 45.3 \cdot in$

$\#AnchorBolts = 8$

$\#LongBars_{prov} = 19$

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

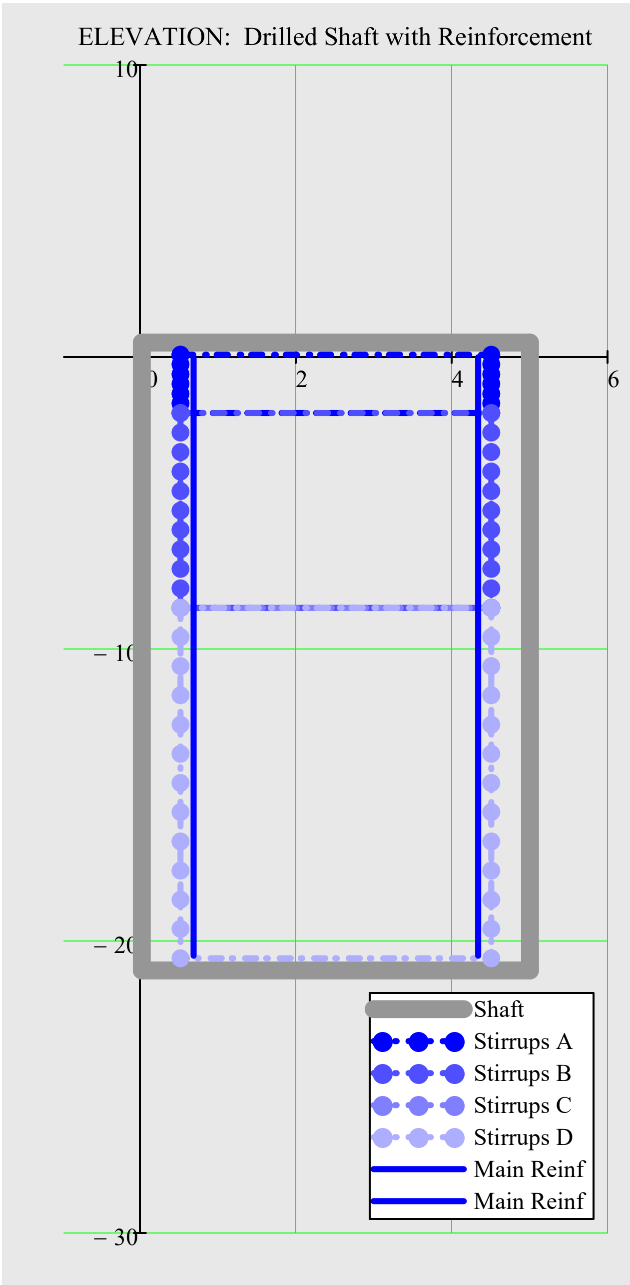
'BB'= $t_{baseplate.pole} = 2.5 \cdot in$

'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*

$$\#Spaces_{vbar} = \begin{pmatrix} 6 \\ 10 \\ 12 \\ 12 \end{pmatrix}$$ *number of stirrup spaces*

Erie Rd. and SR 62 Improvements

HDR Project Number: 10151274

Miscellaneous Structures

1.7 Geotechnical Information

For: Manatee County Public Works

Geotechnical Engineering Report

SR-62 and Erie Road
Parrish, Manatee County, Florida
January 3, 2019
Terracon Project No. HC185059

Prepared for:
Manatee County Public Works
Bradenton, Florida

Prepared by:
Terracon Consultants, Inc.
Sarasota, Florida

January 3, 2019

Manatee County Public Works
1022 26th Avenue East
Bradenton, Florida 34206

Attn: Mr. Michael Sturm, P.E.
P: (941) 708-7450
E: Michael.Sturm@mymanatee.com

Re: Geotechnical Engineering Report
SR-62 and Erie Road
Parrish, Manatee County, Florida
Terracon Project No. HC185059

Dear Mr. Sturm:

We have completed the Geotechnical Engineering services for the above referenced project. This study was performed in general accordance with Terracon Proposal No. PHC185059 dated October 11, 2018 and authorized by Purchase Order Work Assignment No. W1900036 dated October 30, 2018. This report presents the findings of the subsurface exploration and provides geotechnical recommendations concerning earthwork and the design and construction of pavements and signal pole foundations for the proposed project.

We appreciate the opportunity to be of service to you on this project. If you have any questions concerning this report or if we may be of further service, please contact us.

Sincerely,
Terracon Consultants, Inc.

James M. Jackson, P.E.
Department Manager
FL License No. 77733

Douglas S. Dunkelberger, P.E.
Principal
FL License No. 33317

REPORT TOPICS

Note: This report was originally delivered in a web-based format. **Orange Bold** text in the report indicates a referenced section heading. The PDF version also includes hyperlinks which direct the reader to that section and clicking on the ***GeoReport*** logo will bring you back to this page. For more interactive features, please view your project online at client.terracon.com.

ATTACHMENTS

Note: Refer to each individual Attachment for a listing of contents.

REPORT SUMMARY

Topic [1]	Overview Statement [2]
Project Description	The project includes widening Erie Road from US-301 to approximately 500 feet west of US-301 and extending Erie Road east of US-301 to connect with State Road 62 (approximately 1,300 linear feet). New mast arm signal poles are also planned for the intersection of Erie Road and US-301.
Geotechnical Characterization	In general, the borings found loose to dense poorly graded fine sand with varying amounts of silt from the surface to a depth of about 18 feet below the ground surface (bgs) followed by varying layers of loose to medium dense clayey sand and sand with silt to the maximum borehole termination depth of 30 feet bgs. The estimated Seasonal High Groundwater Level (SHGWL) is +39 ½ feet-NAVD.
Earthwork	Remove topsoil and other large vegetative matter from the planned pavement areas. Densify the existing sandy soils for support of the proposed pavements.
Deep Foundations	Recommended soil parameters for design of drilled shafts are provided on the **Report of Core Borings** exhibit.
Pavements	With subgrade prepared as noted in **Earthwork**. Asphalt: ■ 3" Asphaltic Concrete (AC) over 10" aggregate base and 12" of stabilized subgrade
General Comments	This section contains important information about the limitations of this geotechnical engineering report.

1. If the reader is reviewing this report as a pdf, the topics above can be used to access the appropriate section of the report by simply clicking on the topic itself.
2. This summary is for convenience only. It should be used in conjunction with the entire report for design purposes.

Geotechnical Engineering Report

SR-62 and Erie Road

Parrish, Manatee County, Florida

Terracon Project No. HC185059

January 3, 2019

INTRODUCTION

This report presents the results of our subsurface exploration and geotechnical engineering services performed for the proposed Erie Road extension in Parrish, Manatee County, Florida. The purpose of these services is to provide information and geotechnical engineering recommendations relative to:

- Subsurface soil conditions
- Site preparation and earthwork
- Groundwater conditions
- Geotechnical parameters for drilled shaft design (by others)
- Pavement design and construction

The geotechnical engineering Scope of Services for this project included the advancement of 18 test borings to depths ranging from approximately 10 to 30 feet below existing site grades.

Maps showing the site and boring locations are shown in the **Site Location** and **Exploration Plan** sections, respectively. The results of the laboratory testing performed on soil samples obtained from the site during the field exploration are included on the boring logs in the **Exploration Results** section.

SITE CONDITIONS

The following description of site conditions is derived from our site visit in association with the field exploration and our review of publicly available geologic and topographic maps.

Item	Description
Parcel Information	The project is located at SR-62 and Erie Road in Parrish, Manatee County, Florida. See **Site Location**
Existing Improvements	Erie Road, west of US-301, currently consists of a 2-lane, asphalt-paved road with unpaved shoulders. The planned extension of Erie Road, east of US-301, is currently undeveloped pasture land.
Current Ground Cover	Most of the site is covered with short grasses except for the western portion of Erie Road which is covered with asphalt pavement and unpaved shoulders.
Existing Topography	Based on information provided by Mr. Jim Gatch of ZNS Engineering, the site is relatively level with ground surface elevations ranging from about +42 to +44 feet-NAVD.

Item	Description
Prior Land Use	Review of historical aerial photographs (ref. Google Earth) indicate the western portion of Erie Road has been in-place from at least 1995 to the present day. The eastern portion of the site, east of US-301, appears to have been a citrus grove from at least 1995 until 2010 when the grove appears to have been abandoned. The trees appear to have been removed by 2012 and the site remains generally unchanged to the present day.
Surficial Soil Conditions	Review of the Soil Survey for Manatee County, Florida issued April 1983 indicates the site is mapped with Soil Unit 36, Orlando fine sand, moderately wet, 0 to 2 percent slopes. The typical soil profile consists of fine sand to a depth of 80 inches or more. Under natural (pre-development) conditions, the seasonal high groundwater level (SHGWL) is reported to be between 40 and 72 inches bgs.

We also collected photographs at the time of our field exploration program. Representative photos are provided in our **Photography Log**.

PROJECT DESCRIPTION

Our initial understanding of the project was provided in our proposal and was discussed during project planning. A period of collaboration has transpired since the project was initiated, and our final understanding of the project conditions is as follows:

Item	Description
Information Provided	The following information was provided to us by Mr. Michael Sturm, P.E. of Manatee County Public Works and Mr. Jason Starr, P.E. of HDR Engineering.
Project Description	The project includes widening Erie Road from US-301 to approximately 500 feet west of US-301 and extending Erie Road east of US-301 to connect with State Road 62 (approximately 1,300 linear feet). New mast arm signal poles are also planned for the intersection of Erie Road and US-301.
Proposed Structures	The project includes up to three mast arm signal poles located at the northeast, southeast, and southwest corners of Erie Road and US-301. The new signal poles are to be supported on drilled shaft foundations (to be designed by others). We have assumed the mast arm foundation will be designed assuming the most aggressive corrosion conditions.
Maximum Loads	Structural loads for the new mast arm foundation were not provided.
Grading/Slopes	We expect site grading fill thicknesses to be moderate (up to 5 feet in thickness).

Item	Description
Pavements[1]	Based on information from the Florida Department of Transportation (FDOT) Transportation Data and Analytics Office (provided by Mr. Jason Starr, P.E. of HDR) we understand SR-62 has an Average Annual Daily Traffic (AADT) of 3,000. Historically, the AADT peaked in 2014 at 3,400 (1,700 per lane). Additionally, the Average Daily Truck Traffic (ADTT) is 816 (24%) for SR-62 (408 per lane). Based on this information, the following traffic data was utilized: ■ Autos/light trucks: 1,292 vehicles per day per lane ■ Light delivery and trash collection vehicles: 355 vehicles per day per lane ■ Tractor-trailer trucks: 53 vehicles per day per lane The pavement design period is 20 years.

1. The distribution of truck traffic is based on Table 6.9 of Pavement Analysis and Design by Yang H. Huang (2004) and indicates 87% single-unit trucks and 13% multiple-unit trucks for a Rural Major Collector.

GEOTECHNICAL CHARACTERIZATION

We have developed a general characterization of the subsurface conditions based upon our review of the subsurface exploration, laboratory data, geologic setting and our understanding of the project. This characterization, termed GeoModel, forms the basis of our geotechnical calculations and evaluation of site preparation and foundation options. Conditions encountered at each exploration point are indicated on the individual logs. The individual logs can be found in the **Exploration Results** section and the GeoModel can be found in the **Figures** section of this report.

As part of our analyses, we identified the following model layers within the subsurface profile. For a more detailed view of the model layer depths at each boring location, refer to the GeoModel.

Model Layer	Layer Name	General Description
1	**Sand with silt**	Poorly graded SAND with silt, sometimes with sand-sized phosphate grains (A-3, A-2-4, SP, SP-SM)
2	**Clayey sand**	Clayey SAND (A-2-6, SC)
3	**Sandy clay**	Clayey sand to sandy CLAY (A-6, SC)
4	**Silty sand**	Silty SAND (A-2-4, SM)

Groundwater

Three shallow piezometers were installed along the planned Erie Road alignment to collect stabilized groundwater levels. Groundwater level measurements were made in the piezometers on a weekly basis during the month of December 2018 and are summarized in the table below:

Piezometer No.	Ground Surface Elevation (feet-NAVD)[1]	Elevation of Groundwater (feet-NAVD)			
		12-7-18	12-12-18	12-17-18	12-26-18
PZ-1	+42.7	+36.8	+37.8	+38.3	+39.4
PZ-2	+43.6	+37.7	+37.6	+37.9	+39.5
PZ-3	+43.0	+37.9	+36.8	+37.1	+38.7

1. Ground surface elevations were provided by ZNS Engineering.

As presented herein, the SHGWL is the highest sustained groundwater elevation during a typical (normal or average rainfall amount) wet season and not the peak groundwater elevation immediately following a major storm event. Therefore, the SHGWL referred to in this report is an average, high value and not necessarily a peak (upper bound) value. The SHGWL generally occurs at the end of the wet season, which the Southwest Florida Water Management District (SWFWMD) identifies as the four months of mid-May through October.

The best and most accurate method of determining the SHGWL is to obtain real-time site-specific groundwater data through an entire hydro period (dry and wet seasons) during a year with normal rainfall. However, due to the project's design schedule, this was not feasible. Therefore, our SHGWL estimates are based on the stabilized groundwater measurement made in December 2018 and an adjustment factor derived from published rainfall and groundwater data.

The groundwater levels in surficial aquifer well ROMP 39, which is located approximately 10 miles east of the site, were considered. The historical groundwater measurements reported for the well show that the groundwater levels peak in the month of August. In general, the groundwater level falls about 1 ½ feet from August to December, during a normal hydro-period. Additionally, the real-time data for the well suggests that the groundwater levels for December 2018 are about ½ feet higher than the typical average for this time of year.

The well data discussed above suggests that the groundwater measurements made in December 2018 for this study are likely on the order of about 2 feet below the normal (i.e. average rainfall) year SHGWL. Therefore, we estimate the SHGWL to be at an elevation of about +40 feet-NAVD (3 feet bgs).

Our estimated SHGWL is generally consistent with the Soil Survey.

GEOTECHNICAL OVERVIEW

In general, the borings found loose to dense poorly graded fine sand with varying amounts of silt from the surface to a depth of about 18 feet bgs followed by varying layers of loose to medium dense clayey sand, sandy clay, and sand with silt to the maximum borehole termination depth of 30 feet bgs. These materials are generally suitable for construction of the proposed roadway and associated structures following completion of the recommendations in the **Earthwork** section of this report.

The **Pavements** section addresses the design of pavement systems.

The **General Comments** section provides an understanding of the report limitations.

EARTHWORK

Earthwork is anticipated to include clearing and grubbing, excavations, and fill placement. The following sections provide recommendations for use in the preparation of specifications for the work. Recommendations include critical quality criteria, as necessary, to render the site in the state considered in our geotechnical engineering evaluation for foundations, floor slabs, and pavements.

Site Preparation

Earthwork operations should begin with the stripping of any surficial organic soils (topsoil) from the planned roadway areas. Tree removal should include roots down to finger sized roots and topsoil should be removed from the construction areas. Wet or dry material should either be removed, or moisture conditioned and re-compacted. After stripping and grubbing, the exposed surface should be proof-rolled to aid in locating loose or soft areas. Proof-rolling should be performed with a vibratory roller with a minimum static weight of 20,000 pounds. The roller should make a minimum of eight overlapping passes over all areas of the site, the latter four passes at right angles to previous passes. The soils should be compacted sufficiently to obtain a minimum compaction. Unstable soil (pumping) should be removed or moisture conditioned and compacted in place prior to placing fill.

Fill Material Types

Engineered fill should meet the following material property requirements:

Fill Type [1]	AASHTO Classification	Acceptable Location for Placement
Select [1]	A-3 and A-2-4 (fines content < 15 percent, maximum particle size < 2 inches, organic content < 3 percent)	All locations and elevations

1. GeoModel Layer 1 and 2 soils at this site appear to meet this criterion. Soils with fines content > 12 percent may retain moisture and be difficult to compact and achieve specified density and stability. These soils may need to be maintained dry of optimum to properly compact.

Fill Compaction Requirements

Engineered fill should meet the following compaction requirements:

Item	Description
Fill Lift Thickness	12 inches or less in loose thickness when heavy vibratory compaction equipment is used. Maximum particle size should not exceed 2 inches in a 12-inch lift. 4 to 6 inches in loose thickness when hand-guided equipment (i.e. jumping jack or plate compactor) is used. Maximum particle size should not exceed 1 inch in a 4- to 6-inch lift.
Minimum Compaction Requirements [1]	At least 100 percent of the maximum dry density as determined by the standard Proctor Test (AASHTO T-99).
Moisture Content [2]	Within ±3 percent of optimum moisture content as determined by the Modified Proctor test, at the time of placement and compaction.
Minimum Testing Frequency	At least one field density test per 500 linear feet of roadway.

1. The moisture content and compaction should be measured for each lift of engineered fill during placement. Should the results of the in-place density tests indicate the specified moisture or compaction limits have not been met, the area represented by the test should be reworked and retested as required until the specified moisture and compaction requirements are achieved.
2. Specifically, moisture levels should be maintained low enough to allow for satisfactory compaction to be achieved without the fill material pumping.

Utility Trench Backfill

All trench excavations should be made with sufficient working space to permit construction including backfill placement and compaction. Backfill for utility trenches located beneath pavements should be compacted to at least 98% of the maximum dry density as determined by the Modified Proctor Test (AASHTO T-180) per the Manatee County Utility Design Standards (June 2015). Utility trenches located outside of pavement areas should be compacted to at least 95% of the Modified Proctor maximum dry density.

Earthwork Construction Considerations

Excavations are anticipated to be accomplished with conventional construction equipment. The site should be graded to prevent ponding of surface water on the prepared subgrades or in excavations. Water collecting over, or adjacent to, construction areas should be removed. If the subgrade desiccates, saturates, or is disturbed, the affected material should be removed, or the materials should be scarified, moisture conditioned, and re-compacted.

The groundwater table will affect excavation efforts, especially for storm drain or utility construction. A temporary dewatering system consisting of well points or sumps with pumps will be necessary to achieve the recommended compaction in excavation trenches.

As a minimum, excavations should be performed in accordance with OSHA 29 CFR, Part 1926, Subpart P, "Excavations" and its appendices, and in accordance with any applicable local, and/or state regulations.

Construction site safety is the sole responsibility of the contractor who controls the means, methods, and sequencing of construction operations. Under no circumstances shall the information provided herein be interpreted to mean Terracon is assuming responsibility for construction site safety, or the contractor's activities; such responsibility shall neither be implied nor inferred.

Construction Observation and Testing

The earthwork efforts should be monitored under the direction of the Geotechnical Engineer. Monitoring should include documentation of adequate removal of vegetation and top soil, proof-rolling and mitigation of areas delineated by the proof-roll to require mitigation.

Each lift of compacted fill should be tested, evaluated, and reworked as necessary until approved by the Geotechnical Engineer prior to placement of additional lifts.

If unanticipated conditions are encountered, the Geotechnical Engineer should prescribe mitigation options.

In addition to the documentation of the essential parameters necessary for construction, the continuation of the Geotechnical Engineer into the construction phase of the project provides the continuity to maintain the Geotechnical Engineer's evaluation of subsurface conditions, including assessing variations and associated design changes.

DEEP FOUNDATIONS

Drilled Shaft Design Parameters

Soil design parameters are provided below in the tables on the **Report of Core Borings** exhibit for the design of drilled shaft foundations. The soil parameters were based on empirical correlations (ref: Florida Department of Transportation Soils and Foundations Handbook, 2017) with average SPT blow counts (N-Values) for the different soil strata. Lateral earth pressure coefficients were based on the estimated friction angles. It is our understanding that the pole foundations will be drilled shafts designed by others. The pole foundations should be designed using the soil parameters provided on the exhibit.

PAVEMENTS

General Pavement Comments

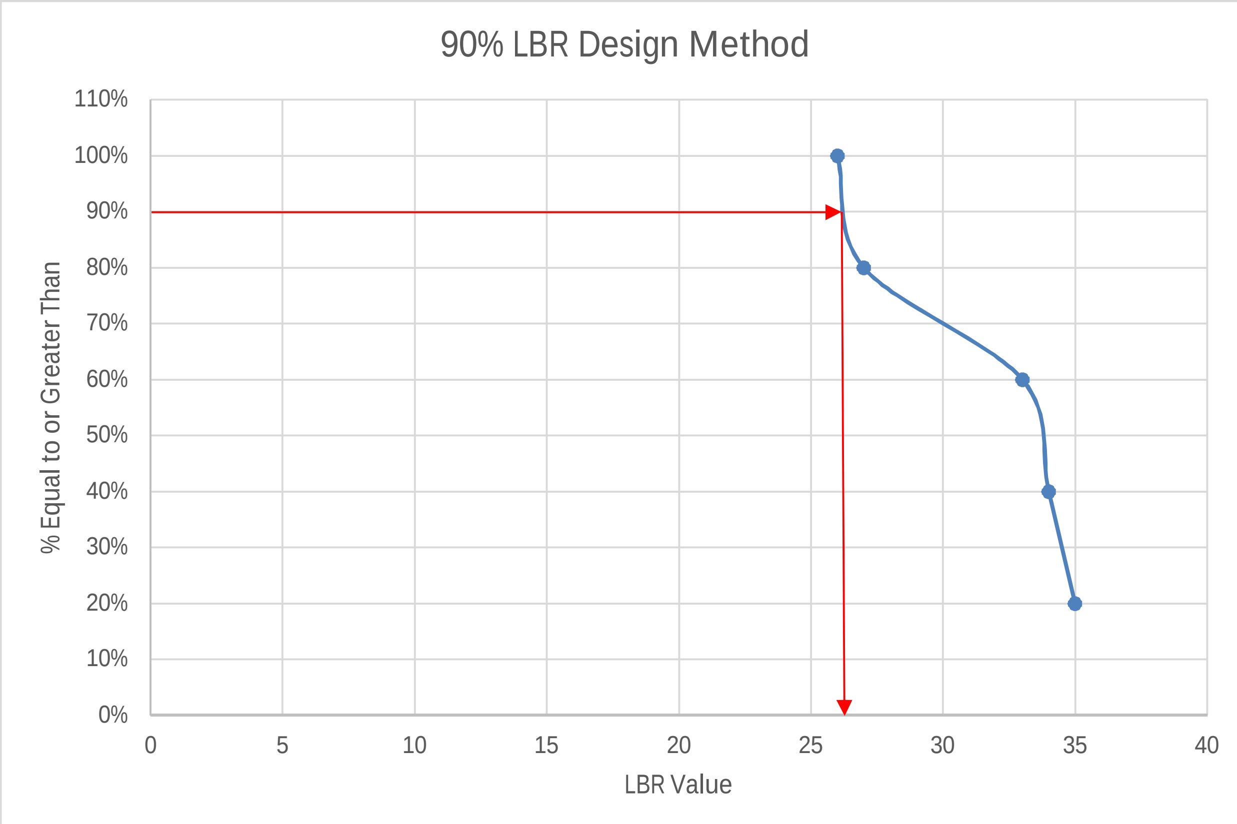
Pavement designs are provided for the traffic conditions and pavement life conditions as noted in **Project Description** and in the following sections of this report. A critical aspect of pavement performance is site preparation. Pavement designs, noted in this section, must be applied to the site, which has been prepared as recommended in the **Site Preparation** section.

Roadway Embankments

The design LBR value was determined according to the Florida Department of Transportation (FDOT) Soils and Foundations Handbook (2017) Section 8.1.2. The LBR values corresponding to moisture contents at 2% above and 2% below the moisture content at the maximum LBR value were averaged to determine a limiting LBR value (+/- 2% of Optimum Method) and are presented in the following table:

+/-2% of Optimum Moisture Method Calculation			
Test No.	**Maximum LBR**	**LBR at Moisture Contents (of Optimum LBR)**	
		-2%	**+2%**
RB-4	27	22.3	26.8
RB-7	26	21.9	7.6
RB-9	35	25.9	11.3
RB-11	34	28.9	6.0
RB-14	33	19.0	28.4
Mean LBR Value	31	23.6	16.0
		Average = 20	

The maximum LBR values were also sorted into ascending order and the percentage of values that were equal to or greater than each LBR vale were calculated. The percentages were plotted versus the maximum LBR values and the LBR value corresponding to 90% is the design value (see chart below) according the Soils and Foundations Handbook 90% Method.



Per the FDOT guidelines, the final design LBR value is taken as the lower of the values determined by each of these two methods. Therefore, we recommend that pavement designs include a limiting LBR value of 20, as determined by the 2% Method, for the existing embankment soils. This corresponds to a Resilient Modulus (M_R) of about 7,500 pounds per square inch (psi) per Table 5.1 of the FDOT Flexible Pavement Design Manual (2018).

Pavement Design Parameters

The design of the recommended pavement section has been based on the traffic data provided in the **Project Description** section and the FDOT Flexible Pavement Design Manual (2018). The following design parameters were used:

Design Criteria	Value
Design Life	20 years
Estimated Growth Factor Percentage	2.66%
Estimated ESAL	4,183,342

1. See Exhibit A for ESAL calculation

The following design parameters were based on the FDOT Flexible Pavement Design Manual (2018)

Pavement Thickness Design Parameters	
Input Parameter	**Value**
Reliability	85%
Asphalt Layer Coefficient	0.44
Aggregate Base Layer Coefficient (LBR = 100)	0.18
Subgrade Layer Coefficient (LBR = 60)	0.09

The recommended subgrade resilient modulus is 7,500 psi as provided in the above **Roadway Embankments** section.

Based on the estimated traffic data and the listed design parameters, the minimum required Structural Number of 4.20 was calculated for Erie Road based on Table A.3A of the FDOT Flexible Pavement Design Manual (2018).

Pavement Section Thicknesses

As a minimum, we suggest the following pavement section:

Typical Pavement Section (inches)		
Asphalt Concrete Surface Course	**Limerock, or Crushed Concrete Base Course**	**Stabilized Subbase Course**
3	10	12

The above recommended pavement section provides a Structural Number of 4.20 which equals the minimum required Structural Number of 4.20.

Asphalt Concrete Design Recommendations

The following items are applicable to asphalt concrete pavement sections.

- Terracon recommends a minimum separation of 36 inches between the bottom of the base course and the seasonal high-water table.

- Natural or fill subgrade soils to a depth of 18 inches below the base should be relatively clean sands with AASHTO Classifications of A-3 and A-2-4 but with a maximum of 15% fines. The natural soils generally satisfy this requirement.
- Stabilized subgrade soils (also identified as stabilized subbase) should be stabilized to a minimum Limerock Bearing Ratio (LBR; Florida Method of Test Designation FM 5-515) value of 60, per Manatee County requirements. Based on the results of the LBR tests, the existing sandy soils will need to be stabilized with an aggregate admixture to meet the minimum LBR value.
- The stabilized subgrade course should be compacted to at least 98 percent of the Modified Proctor maximum dry density (AASHTO T-180 or ASTM D-1557). Any underlying, newly-placed subgrade fill should also be compacted to a minimum of 98 percent of the Modified Proctor maximum dry density.
- Limerock base material from an approved FDOT source should have a minimum LBR value of 100 and be compacted to a minimum of 98 percent of the maximum dry density as determined by the Modified Proctor test. Limerock should be placed in uniform lifts not to exceed 6 inches of loose thickness. Recycled limerock is not a suitable substitute for virgin limerock for base courses but may be used as a granular stabilizing admixture.
- Crushed (recycled) concrete base should meet the current FDOT Specification 911 for recycled materials.
- Asphalt should be compacted to the requirements shown in Table 334-7 of the FDOT Specifications. Asphalt surface courses should be Type SP according to FDOT requirements.
- For a two-lane road with AADT and speed limit greater than 3,000 and 35 miles per hour (mph), respectively, FDOT requires use of a friction course.
- To verify thicknesses, after placement and compaction of the pavement courses, core the wearing surface to evaluate material thickness and composition at a minimum frequency shown in the most current FDOT specifications.

Pavement Drainage

Pavements should be sloped to provide rapid drainage of surface water. Water allowed to pond on or adjacent to the pavements could saturate the subgrade and contribute to premature pavement deterioration. In addition, the pavement subgrade should be graded to provide positive drainage within the granular base section. The subgrade and the pavement surface should have a minimum ¼ inch per foot slope to promote drainage. Appropriate sub-drainage or connection to a suitable daylight outlet should be provided to remove water from the base layer.

Pavement Maintenance

The pavement sections provided in this report represent minimum recommended thicknesses and, as such, periodic maintenance should be anticipated. Therefore, preventive maintenance should be planned and provided for through an on-going pavement management program. Maintenance activities are intended to slow the rate of pavement deterioration, and to preserve the pavement investment. Maintenance consists of both localized maintenance (e.g., crack and joint sealing and patching) and global maintenance (e.g., surface sealing). Preventive maintenance is usually the priority when implementing a pavement maintenance program. Additional engineering observation is recommended to determine the type and extent of a cost-effective program. Even with periodic maintenance, some movements and related cracking may still occur, and repairs may be required.

GENERAL COMMENTS

Our analysis and opinions are based upon our understanding of the project, the geotechnical conditions in the area, and the data obtained from our site exploration. Natural variations will occur between exploration point locations or due to the modifying effects of construction or weather. The nature and extent of such variations may not become evident until during or after construction. Terracon should be retained as the Geotechnical Engineer, where noted in this report, to provide observation and testing services during pertinent construction phases. If variations appear, we can provide further evaluation and supplemental recommendations. If variations are noted in the absence of our observation and testing services on-site, we should be immediately notified so that we can provide evaluation and supplemental recommendations.

Our Scope of Services does not include either specifically or by implication any environmental or biological (e.g., mold, fungi, bacteria) assessment of the site or identification or prevention of pollutants, hazardous materials or conditions. If the owner is concerned about the potential for such contamination or pollution, other studies should be undertaken.

Our services and any correspondence or collaboration through this system are intended for the sole benefit and exclusive use of our client for specific application to the project discussed and are accomplished in accordance with generally accepted geotechnical engineering practices with no third-party beneficiaries intended. Any third-party access to services or correspondence is solely for information purposes to support the services provided by Terracon to our client. Reliance upon the services and any work product is limited to our client and is not intended for third parties. Any use or reliance of the provided information by third parties is done solely at their own risk. No warranties, either express or implied, are intended or made.

Site characteristics as provided are for design purposes and not to estimate excavation cost. Any use of our report in that regard is done at the sole risk of the excavating cost estimator as there may be variations on the site that are not apparent in the data that could significantly impact excavation cost. Any parties charged with estimating excavation costs should seek their own site characterization for specific purposes to obtain the specific level of detail necessary for costing. Site safety, and cost estimating including, excavation support, and dewatering requirements/design are the responsibility of others. If changes in the nature, design, or location of the project are planned, our conclusions and recommendations shall not be considered valid unless we review the changes and either verify or modify our conclusions in writing.

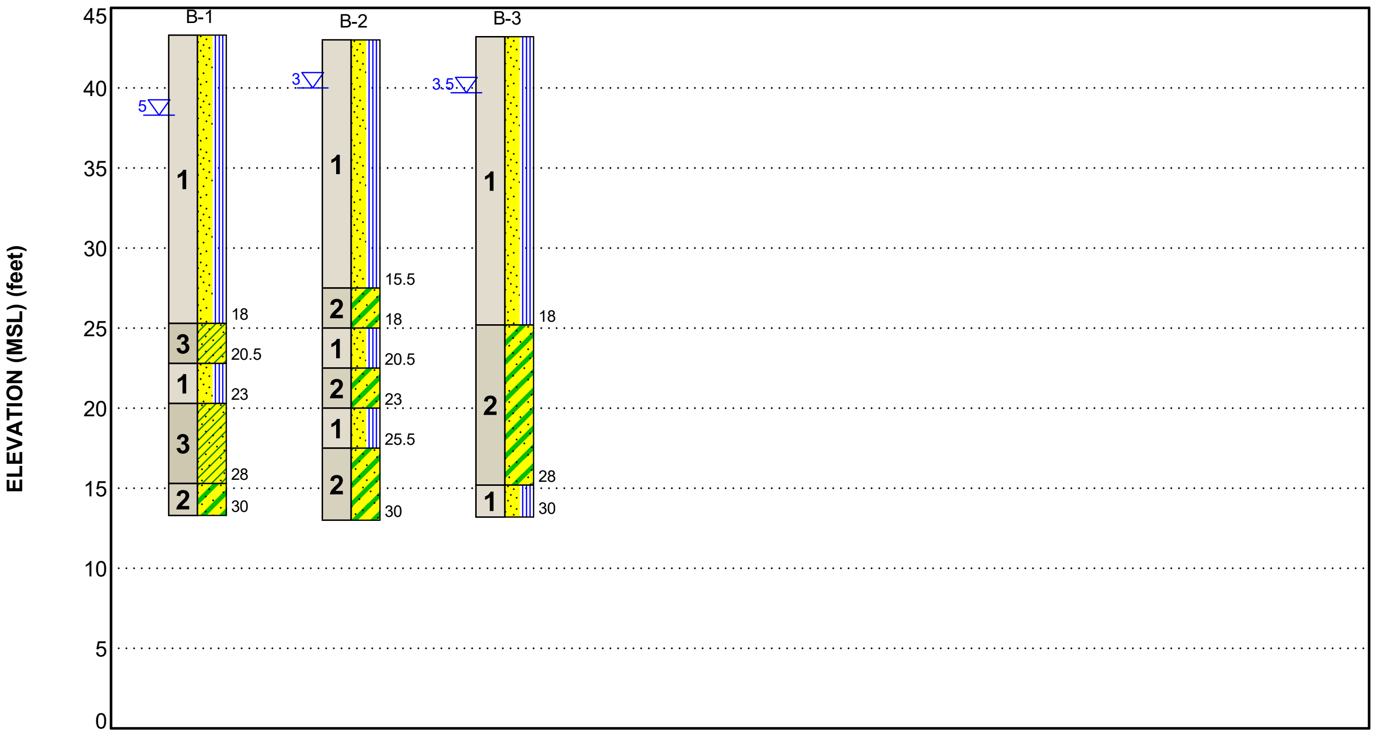
FIGURES

Contents:

GEOMODEL

SR 62 & Erie Road - Signal Poles ■ Parrish, FL
1/3/2019 ■ Terracon Project No. HC185059

Terracon GeoReport



This is not a cross section. This is intended to display the Geotechnical Model only. See individual logs for more detailed conditions.

Model Layer	Layer Name	General Description
1	Sand with silt	Poorly graded sand with silt (A-3, A-2-4, SP, SP-SM))
2	Clayey sand	Clayey sand (A-2-6, SC)
3	Sandy clay	Clayey sand to sandy clay (A-6, SC)
4	Silty sand	Silty sand (A-2-4, SM)

LEGEND

Poorly-graded Sand with Silt

Sandy Lean Clay

Clayey Sand

First Water Observation

Second Water Observation

Final Water Observation

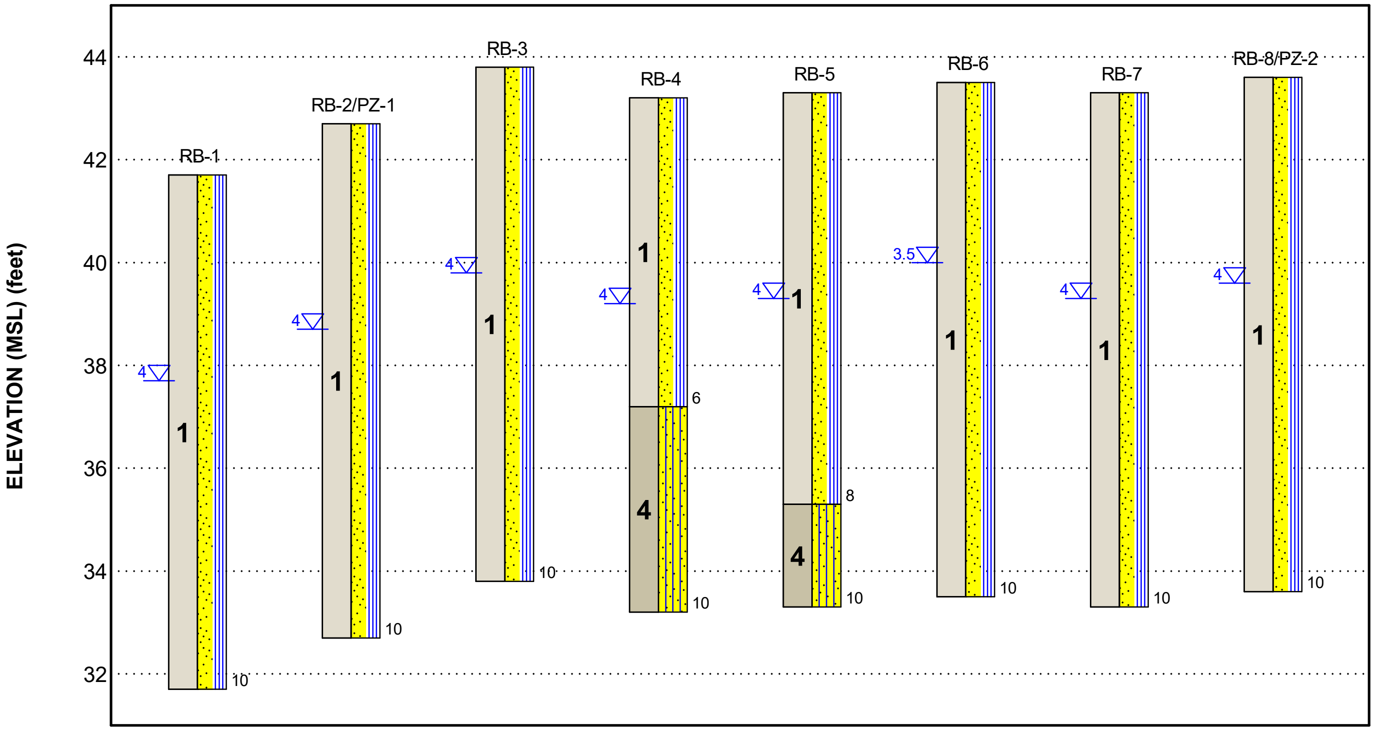
Groundwater levels are temporal. The levels shown are representative of the date and time of our exploration. Significant changes are possible over time. Water levels shown are as measured during and/or after drilling. In some cases, boring advancement methods mask the presence/absence of groundwater. See individual logs for details.

NOTES:
Layering shown on this figure has been developed by the geotechnical engineer for purposes of modeling the subsurface conditions as required for the subsequent geotechnical engineering for this project. Numbers adjacent to soil column indicate depth below ground surface.

GEOMODEL

SR 62 & Erie Road - Signal Poles ■ Parrish, FL
1/3/2019 ■ Terracon Project No. HC185059

Terracon GeoReport



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LEGEND

Poorly-graded Sand with Silt

Silty Sand

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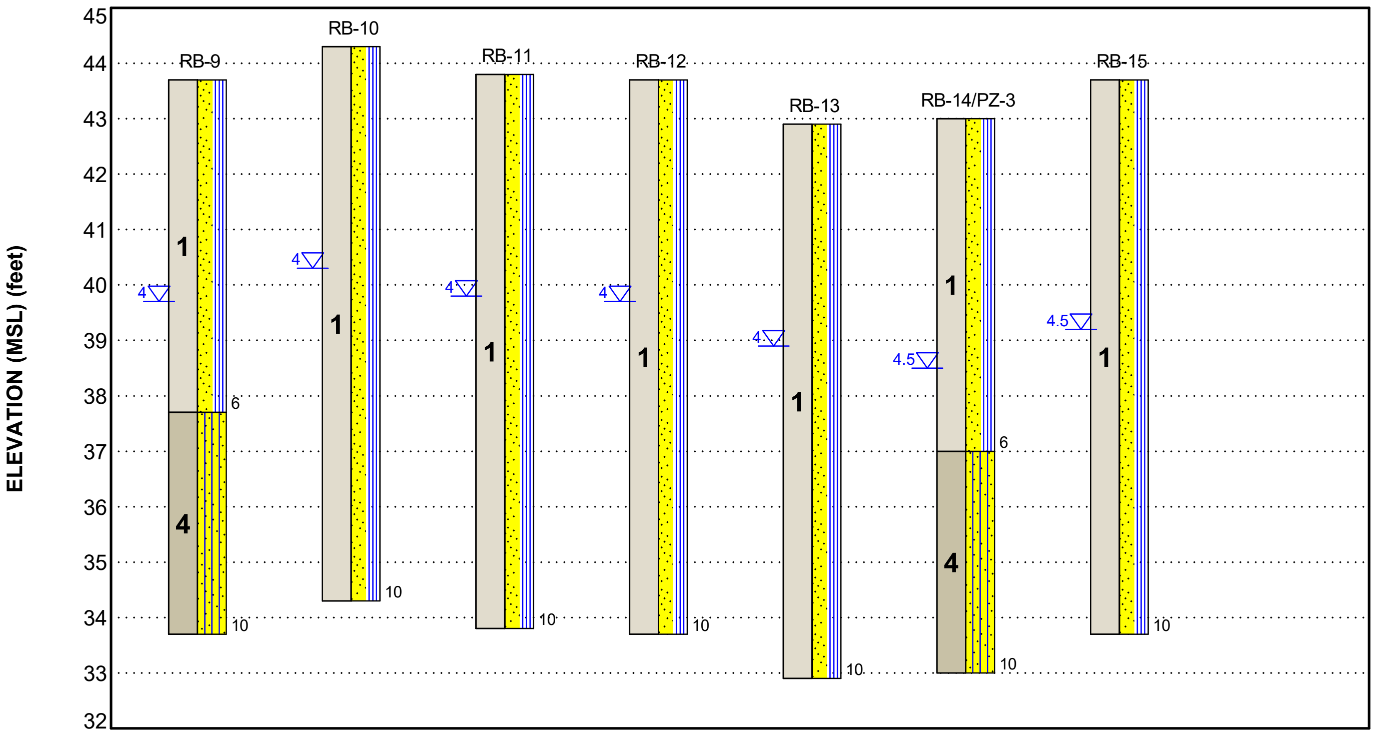
1/3/2019 ■ Terracon Project No. HC185059

Terracon GeoReport



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LEGEND

Poorly-graded Sand with Silt

Silty Sand

First Water Observation

Second Water Observation

Final Water Observation

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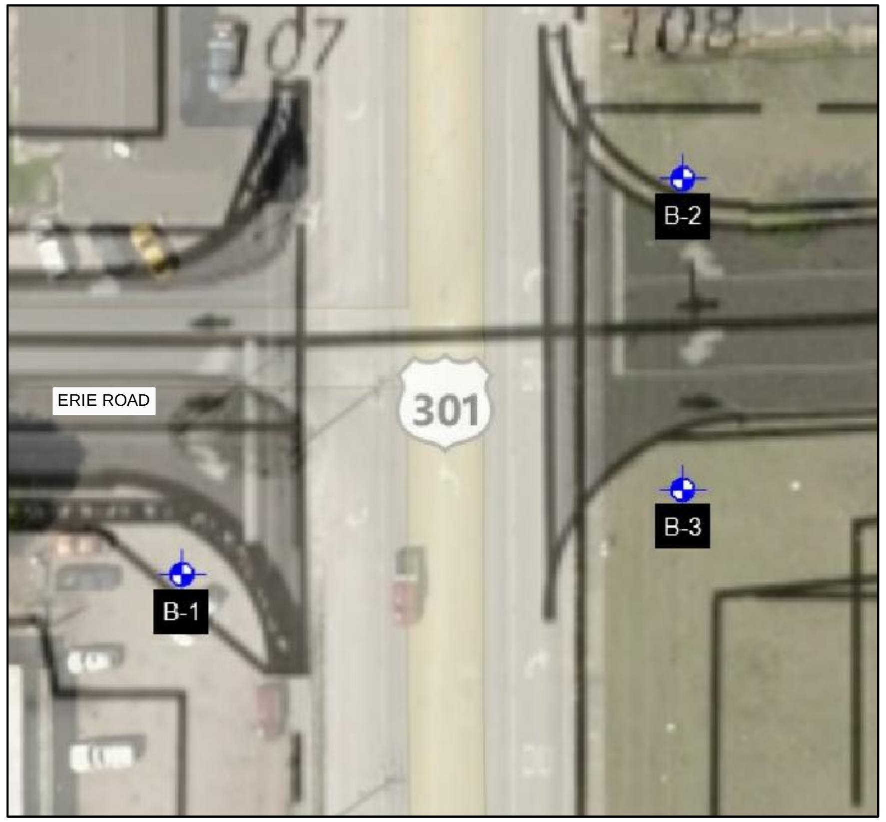
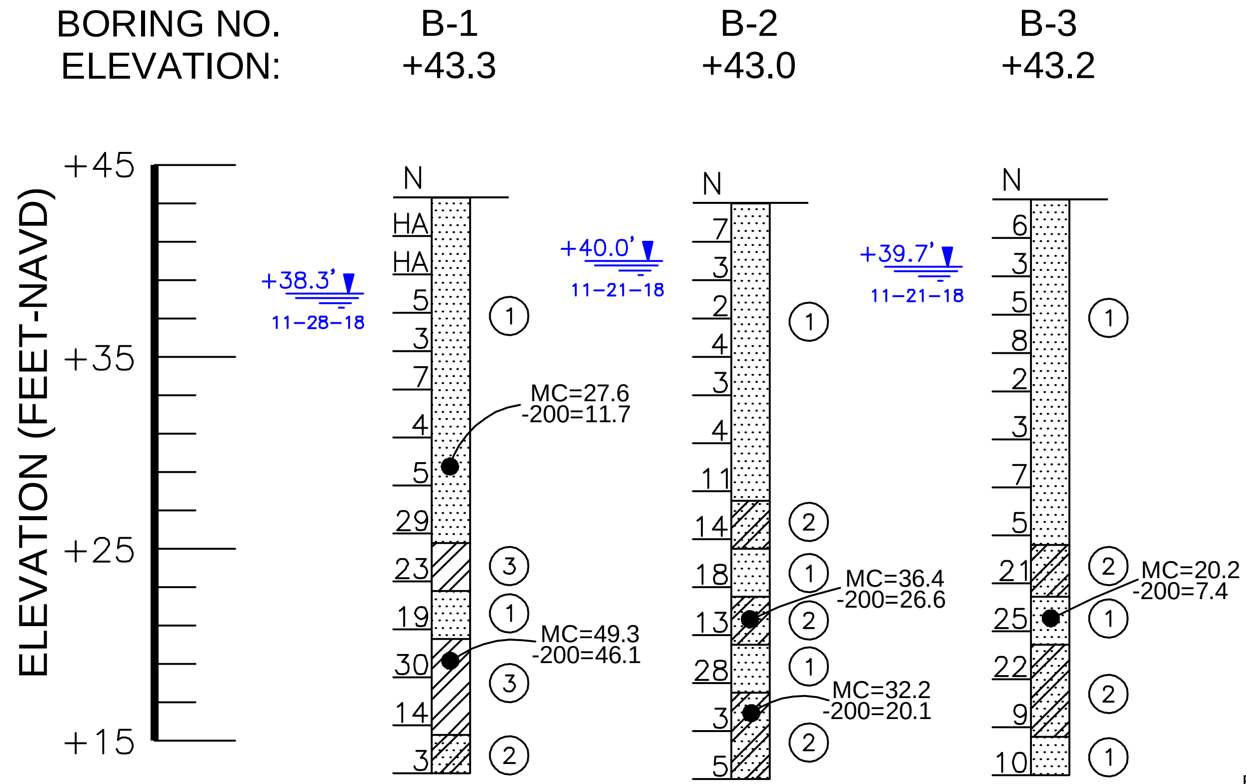


SOURCE: HDR

SCALE IN FEET (50 0 25 50)

LEGEND

APPROXIMATE LOCATION OF STANDARD PENETRATION TEST BORING (B-1)



GENERAL LEGEND

(1) Brown to gray SAND with silt, sometimes with sand-sized phosphate grains (A-3, SP, SP-SM)

(2) Dark gray, gray, and tan clayey SAND (A-2-6, SC)

(3) Gray clayey SANd to sandy CLAY (A-6, SC)

N – Standard penetration resistance in blows per foot unless otherwise noted

SP – Unified Soil Classification System Group Symbol (ASTM D 2487)

+38.3' 11-28-18 – Elevation of groundwater (feet-NAVD) & date measured

MC – Moisture Content (%)

-200 – Amount Finer Than The U.S. Standard No. 200 Sieve (%)

STANDARD PENETRATION TEST DATA

SPOON INSIDE DIA.	1.375 inch
SPOON OUTSIDE DIA.	2.00 inches
AVG. HAMMER DROP	30 inches
HAMMER WEIGHT	140 pounds

ENGINEERING CLASSIFICATION (AUTOMATIC HAMMER)

GRANULAR MATERIALS

Relative Density	SPT BLOW-COUNTS
Very Loose	Less than 2
Loose	3 - 8
Medium Dense	8 - 24
Dense	24 - 40
Very Dense	Greater than 40

SILTS AND CLAYS

Consistency	SPT BLOW-COUNTS
Very Soft	Less than 1
Soft	1 - 3
Firm	3 - 6
Stiff	6 - 12
Very Stiff	12 - 24
Hard	Greater than 24

SUMMARY OF FOUNDATION DESIGN PARAMETERS FOR B-1

Depth (feet)	Soil Type	Unit Weight (pcf)		Angle of Internal Friction (degrees)	Effective Cohesion (psf)	Earth Pressure Coefficients		Soil Modulus, k (pci)
		Moist	Submerged			Ka	Kp	
0 to 18	SAND	105	43	29	0	0.347	2.88	11
18 to 20.5	CLAY	125	63	0	3,100	1.00	1.00	-
20.5 to 23	SAND	115	53	34	0	0.283	3.54	65
23 to 28	CLAY	125	63	0	2,900	1.00	1.00	-
28 to 30	SAND	105	43	23	0	0.438	2.28	7

SUMMARY OF FOUNDATION DESIGN PARAMETERS FOR B-2

Depth (feet)	Soil Type	Unit Weight (pcf)		Angle of Internal Friction (degrees)	Effective Cohesion (psf)	Earth Pressure Coefficients		Soil Modulus, k (pci)
		Moist	Submerged			Ka	Kp	
0 to 13	SAND	105	43	28	0	0.361	2.77	11
13 to 25.5	SAND	115	53	32	0	0.307	3.25	55
25.5 to 30	SAND	105	43	23	0	0.438	2.28	11

SUMMARY OF FOUNDATION DESIGN PARAMETERS FOR B-3

Depth (feet)	Soil Type	Unit Weight (pcf)		Angle of Internal Friction (degrees)	Effective Cohesion (psf)	Earth Pressure Coefficients		Soil Modulus, k (pci)
		Moist	Submerged			Ka	Kp	
0 to 18	SAND	105	43	29	0	0.347	2.88	11
18 to 30	SAND	115	53	29	0	0.347	2.88	55

NOTES

(1) Borings were drilled on November 21 and 28, 2018 using a BR 2500 drilling rig equipped with an automatic hammer.

(2) Strata boundaries are approximate and represent soil strata at each test hole location only. Soil transitions may be more gradual than implied.

(3) Groundwater elevations shown on the subsurface profiles represent the groundwater levels on the dates shown. Groundwater level fluctuations should be anticipated throughout the year.

(4) Elevations were provided by the project surveyor, ZNS Engineering.

JAMES M. JACKSON, P.E
FL LICENSE NO. 77733

Project Mngr:	JMJ	Project No.	HC185059
Drawn By:	JMJ	Scale:	AS-SHOWN
Checked By:	SNP	File No.	1
Approved By:	DSD	Date:	12-21-18

Terracon
Consulting Engineers and Scientists
8260 VICO COURT, UNIT B SARASOTA, FL 34240
PH. (941) 379-0621 FAX. (941) 379-5061

REPORT OF CORE BORINGS
GEOTECHNICAL ENGINEERING REPORT
ERIE ROAD AT SR-62
MANATEE COUNTY, FLORIDA

EXHIBIT 1

AASHTO 1993 ESAL Calculator for Flexible Pavements

Vehicle Description	Traffic Volume: Quantity in the Design Lane	Days per Week	Weeks per Year	Analysis Period (years)	Axle Load and Type: Axle 1 (kips)		Axle 2 (kips)		Axle 3 (kips)		Gross Weight (pounds)	Equivalency Factors: Axle 1	Axle 2	Axle 3	ESAL's
Passenger car	**646**	**7**	**52**	**20**	2	S	2	S			4,000	0.0002	0.0002	0	2,440
Pick-up truck or van	**646**	**7**	**52**	**20**	2	S	4	S			6,000	0.0002	0.003	0	19,522
Recreational vehicle					4	S	4	S			8,000	0.003	0.003	0	0
School bus					6	S	14	S			20,000	0.013	0.388	0	0
TARC bus					8	S	14	S			22,000	0.041	0.388	0	0
Greyhound MC-12 bus					13.4	S	18.4	S	6	S	37,800	0.3355	1.094	0.013	0
Package delivery truck	**215**	**6**	**52**	**20**	4	S	14	S			18,000	0.003	0.388	0	680,882
Beverage delivery truck	**20**	**6**	**52**	**20**	6	S	12	S	12	S	30,000	0.013	0.213	0.213	71,105
Garbage/dumpster truck	**50**	**6**	**52**	**20**	20	S	35	T			55,000	1.47	1.245	0	1,099,515
Concrete truck (full)	**20**	**6**	**52**	**20**	20	S	48	R			68,000	1.47	1.069	0	411,286
Dump truck (full)	**50**	**6**	**52**	**20**	20	S	48	R			68,000	1.47	1.069	0	1,028,228
Semi-tractor (no trailer)					8	S	2	T			10,000	0.041	0	0	0
Semi-tractor trailer (empty)					8	S	8	T	6	T	22,000	0.041	0.004	0.001	0
Semi-tractor trailer	**53**	**5**	**52**	**20**	12	S	34	T	34	T	80,000	0.213	1.11	1.11	870,365
User Defined											0	0	0	0	0
User Defined											0	0	0	0	0
Vehicle type H10					4	S	16	S			20,000	0.003	0.645	0	0
Vehicle type H15					6	S	24	S			30,000	0.013	2.89	0	0
Vehicle type H20					8	S	32	S			40,000	0.041	8.8	0	0
Vehicle type 3					16	S	34	T			50,000	0.645	1.11	0	0
Vehicle type HS15					6	S	24	S	24	S	54,000	0.013	2.89	2.89	0
Vehicle type HS20					8	S	32	S	32	S	72,000	0.041	8.8	8.8	0
Vehicle type 3S2					10	S	31	T	31	T	72,000	0.102	0.791	0.791	0

Terminal Serviceability, r_t	**2.5**
Assumed Structural Number, SN	**4**
Traffic Growth Rate, %/yr	**2.66**

Summary:		
Total AASHTO ESAL's		**4,183,342**
	Superpave	**ESAL Class 3**
Traffic Category	**C**	

Project: Erie Road   Location: Manatee County, FL

Job No.: HC185059   Date: 12/19/2018

ATTACHMENTS

EXPLORATION AND TESTING PROCEDURES

Field Exploration

Number of Borings	Boring Depth (feet)	Planned Location
3	30	Planned signal pole locations
15	10	Planned roadway alignment

Boring Layout and Elevations: Unless otherwise noted, Terracon personnel provided the boring layout. Coordinates were obtained with a handheld GPS unit (estimated horizontal accuracy of about ±10 feet) and elevations were provided by ZNS Engineering.

Subsurface Exploration Procedures: We advanced the borings with a truck-mounted rotary drill rig using mud rotary procedures. Five samples were obtained in the upper 10 feet of each boring and at intervals of 2.5 feet thereafter. In the split-barrel sampling procedure, a standard 2-inch outer diameter split-barrel sampling spoon was driven into the ground by a 140-pound automatic hammer falling a distance of 30 inches. The number of blows required to advance the sampling spoon the last 12 inches of a normal 18-inch penetration is recorded as the Standard Penetration Test (SPT) resistance value. The SPT resistance values, also referred to as N-values, are indicated on the boring logs at the test depths. We observed and recorded groundwater levels during drilling and sampling. For safety purposes, all borings were backfilled with cement grout after their completion.

The sampling depths, penetration distances, and other sampling information was recorded on the field boring logs. The samples were placed in appropriate containers and taken to our soil laboratory for testing and classification by a Geotechnical Engineer. Our exploration team prepared field boring logs as part of the drilling operations. These field logs included visual classifications of the materials encountered during drilling and our interpretation of the subsurface conditions between samples. Final boring logs were prepared from the field logs. The final boring logs represent the Geotechnical Engineer's interpretation of the field logs and include modifications based on observations and tests of the samples in our laboratory.

Laboratory Testing

The project engineer reviewed the field data and assigned laboratory tests to understand the engineering properties of the various soil strata, as necessary, for this project. Procedural standards noted below are for reference to methodology in general. In some cases, variations to methods were applied because of local practice or professional judgment. Standards noted below include reference to other, related standards. Such references are not necessarily applicable to describe the specific test performed.

- ASTM D2216 Standard Test Methods for Laboratory Determination of Water (Moisture) Content of Soil and Rock by Mass
- ASTM D422 Standard Test Method for Particle-Size Analysis of Soils

The laboratory testing program also included examination of soil samples by an engineer. Based on the material's texture, we described and classified the soil samples in accordance with the American Association of State Highway and Transportation Officials (AASHTO) soil classification system and the Unified Soil Classification System (USCS).

PHOTOGRAPHY LOG

	
East end of the site.	West end of the site near US-301.

SITE LOCATION AND EXPLORATION PLANS

Contents:

Note: All attachments are one page unless noted above.

SITE LOCATION

SR-62 and Erie Road ■ Parrish, Manatee County, Florida

January 3, 2019 ■ Terracon Project No. HC185059

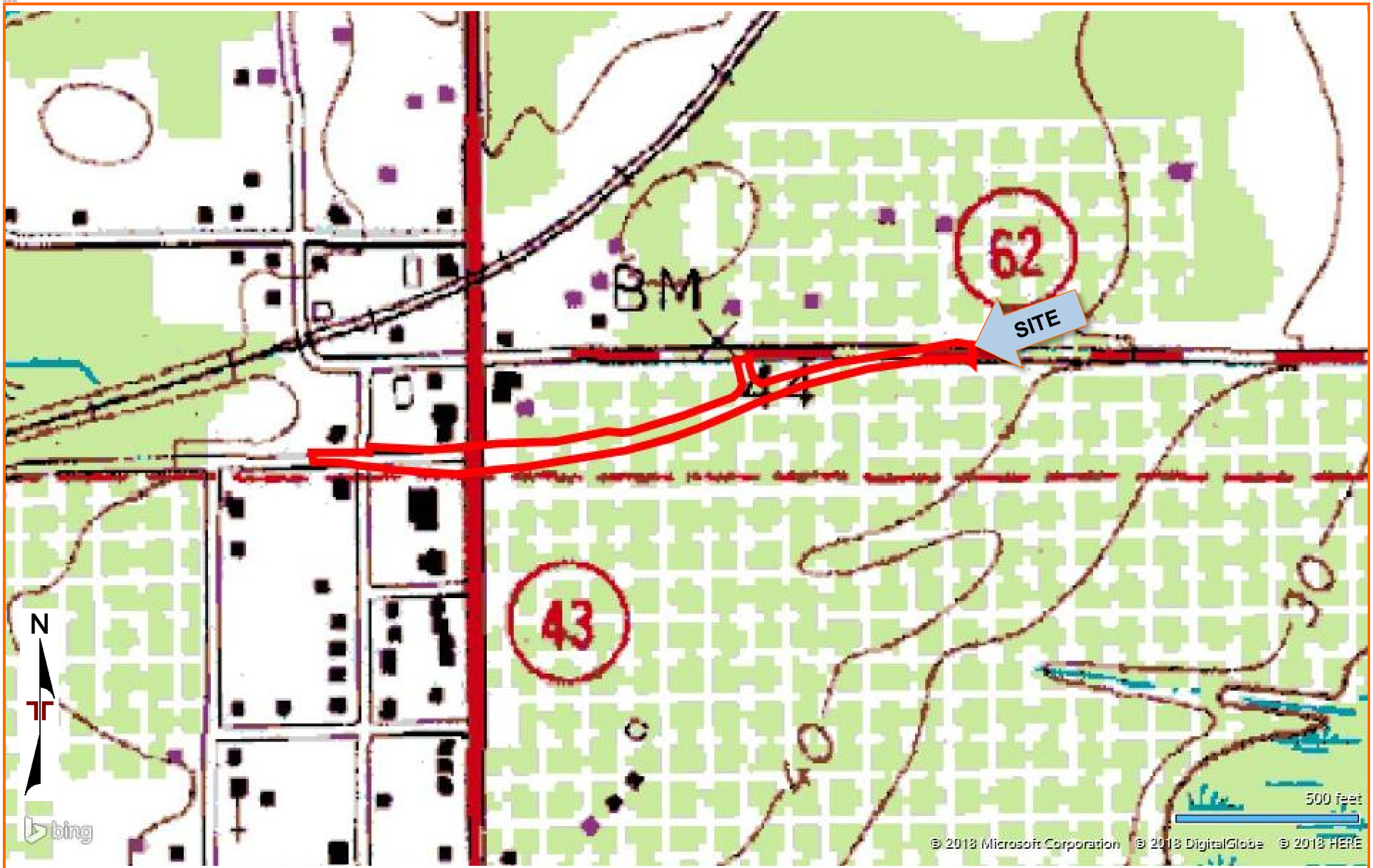


DIAGRAM IS FOR GENERAL LOCATION ONLY, AND IS NOT INTENDED FOR CONSTRUCTION PURPOSES

MAP PROVIDED BY MICROSOFT BING MAPS

EXPLORATION PLAN
SR-62 and Erie Road ▪ Parrish, Manatee County, Florida
January 3, 2019 ▪ Terracon Project No. HC185059

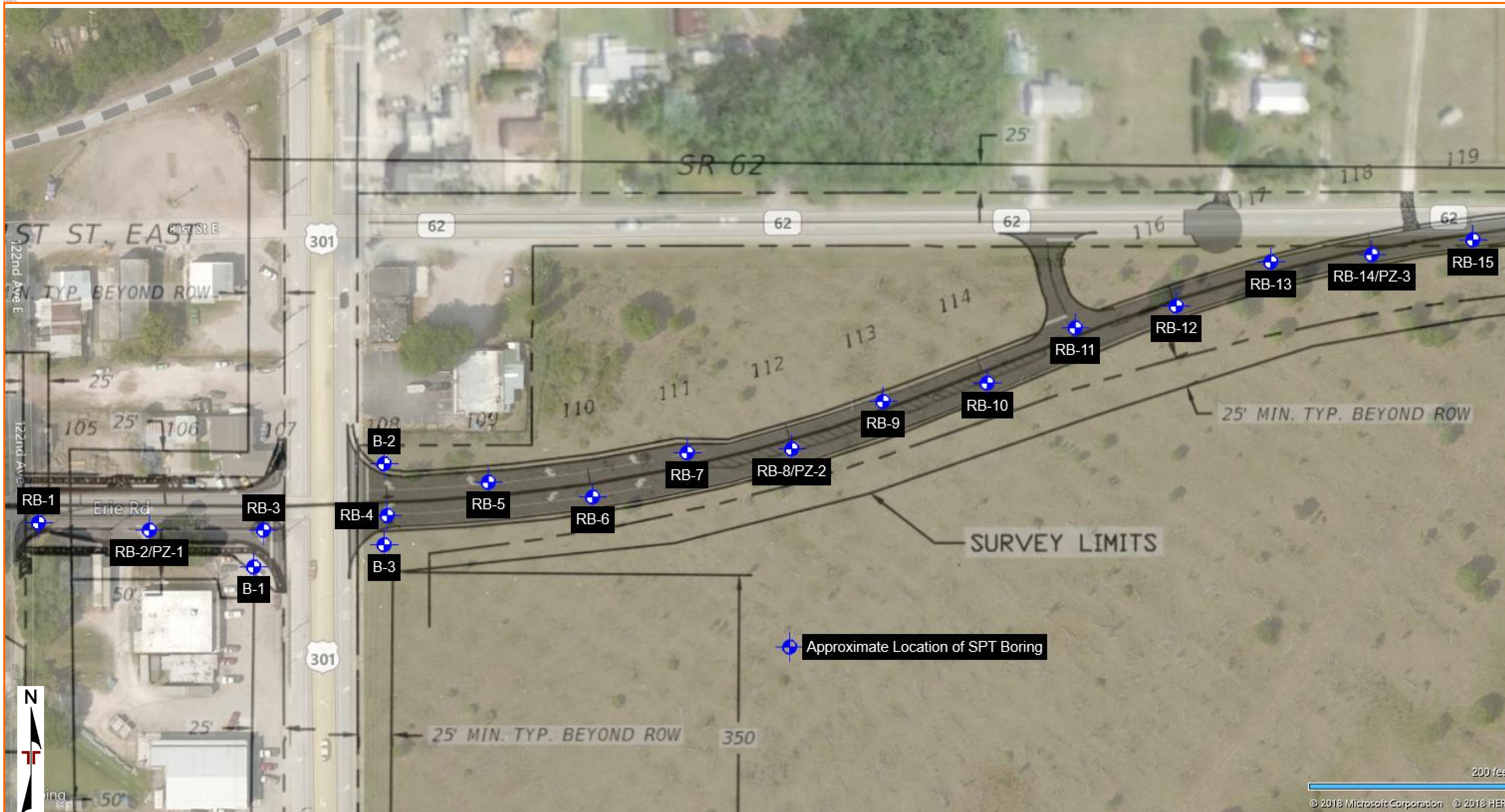


DIAGRAM IS FOR GENERAL LOCATION ONLY, AND IS NOT INTENDED FOR CONSTRUCTION PURPOSES

MAP PROVIDED BY MICROSOFT BING MAPS

EXPLORATION RESULTS

Contents:

Note: All attachments are one page unless noted above.

BORING LOG NO. RB-1

PROJECT: SR 62 & Erie Road - Signal Poles

CLIENT: Manatee County Government Bradenton, FL

SITE: SR 62 Parrish, FL

LOCATION See Exploration Plan

Latitude: 27.587° Longitude: -82.4264°

MODEL LAYER	DEPTH	DESCRIPTION	DEPTH (Ft.)	WATER LEVEL OBSERVATIONS	SAMPLE TYPE	FIELD TEST RESULTS	WATER CONTENT (%)	PERCENT FINES
1		**POORLY GRADED SAND WITH SILT (A-3) (SP-SM)**, fine grained, brown to gray, loose to medium dense					12	7
				▽ (4')				
			5			2-3-4-5 N=7		
						5-7-12-11 N=19		
						5-8-9-9 N=17		
	10.0		10					
		Boring Terminated at 10 Feet						

Stratification lines are approximate. In-situ, the transition may be gradual.

Hammer Type: Automatic

Advancement Method:
Hand auger to 4 feet then mud rotary

Abandonment Method:
Boring backfilled with cement grout upon completion.

See Exploration and Testing Procedures for a description of field and laboratory procedures used and additional data (If any).

See Supporting Information for explanation of symbols and abbreviations.

Elevations were provided by others.

Notes:

A-3: AASHTO Group Classification

WATER LEVEL OBSERVATIONS

▽ *At 4' while sampling*

Terracon
8260 Vico Ct, Unit B
Sarasota, FL

Boring Started: 11-28-2018	Boring Completed: 11-28-2018
Drill Rig: BR-2500	Driller: MC
Project No.: HC185059	

BORING LOG NO. RB-2/PZ-1

PROJECT: SR 62 & Erie Road - Signal Poles

CLIENT: Manatee County Government Bradenton, FL

SITE: SR 62 Parrish, FL

MODEL LAYER	GRAPHIC LOG	LOCATION See Exploration Plan Latitude: 27.5869° Longitude: -82.426° DEPTH	DEPTH (Ft.)	WATER LEVEL OBSERVATIONS	SAMPLE TYPE	FIELD TEST RESULTS	WATER CONTENT (%)	PERCENT FINES
1		**POORLY GRADED SAND WITH SILT (A-3, A-2-4) (SP-SM)**, fine grained, light brown to gray, loose to medium dense					20	12
			4	▽				
			5			2-3-4-3 N=7		
						3-3-4-3 N=7		
		10.0				3-6-10-10 N=16		
		Boring Terminated at 10 Feet	10					

Stratification lines are approximate. In-situ, the transition may be gradual.

Hammer Type: Automatic

Advancement Method:
Hand auger to 4 feet then mud rotary

Abandonment Method:
Boring backfilled with cement grout upon completion.

See Exploration and Testing Procedures for a description of field and laboratory procedures used and additional data (If any).

See Supporting Information for explanation of symbols and abbreviations.

Elevations were provided by others.

Notes:
A-3: AASHTO Group Classification

WATER LEVEL OBSERVATIONS

▽ *At 4' while sampling*

Terracon
8260 Vico Ct, Unit B
Sarasota, FL

Boring Started: 11-28-2018	Boring Completed: 11-28-2018
Drill Rig: BR-2500	Driller: MC
Project No.: HC185059	

BORING LOG NO. RB-3

PROJECT: SR 62 & Erie Road - Signal Poles

CLIENT: Manatee County Government Bradenton, FL

SITE: SR 62 Parrish, FL

LOCATION See Exploration Plan

Latitude: 27.5869° Longitude: -82.4257°

MODEL LAYER	GRAPHIC LOG	DEPTH	DEPTH (Ft.)	WATER LEVEL OBSERVATIONS	SAMPLE TYPE	FIELD TEST RESULTS	WATER CONTENT (%)	PERCENT FINES
1		**POORLY GRADED SAND WITH SILT (A-3) (SP-SM)**, fine grained, light brown to gray, loose to medium dense						
			4	▽				
			5			2-2-3-2 N=5	21	7
						1-2-3-5 N=5		
						2-4-6-4 N=10		
		10.0	10					
		Boring Terminated at 10 Feet						

Stratification lines are approximate. In-situ, the transition may be gradual.

Hammer Type: Automatic

Advancement Method:
Hand auger to 4 feet then mud rotary

Abandonment Method:
Boring backfilled with cement grout upon completion.

See Exploration and Testing Procedures for a description of field and laboratory procedures used and additional data (If any).

See Supporting Information for explanation of symbols and abbreviations.

Elevations were provided by others.

Notes:

A-3: AASHTO Group Classification

WATER LEVEL OBSERVATIONS

▽ *At 4' while sampling*

Terracon
8260 Vico Ct, Unit B
Sarasota, FL

Boring Started: 11-28-2018	Boring Completed: 11-28-2018
Drill Rig: BR-2500	Driller: MC
Project No.: HC185059	

BORING LOG NO. RB-4

PROJECT: SR 62 & Erie Road - Signal Poles

CLIENT: Manatee County Government Bradenton, FL

SITE: SR 62 Parrish, FL

LOCATION See Exploration Plan

Latitude: 27.587° Longitude: -82.4253°

MODEL LAYER	DEPTH	DESCRIPTION	DEPTH (Ft.)	WATER LEVEL OBSERVATIONS	SAMPLE TYPE	FIELD TEST RESULTS	WATER CONTENT (%)	PERCENT FINES
1		**POORLY GRADED SAND WITH SILT (A-3) (SP-SM)**, fine grained, brown to gray, very loose to loose			X	3-3-2-2 N=5		
					X	2-1-1-1 N=2		
	6.0		5	▽	X	2-1-1-1 N=2		
4		**SILTY SAND (A-2-4) (SM)**, fine grained, gray, loose to medium dense			X	2-2-3-4 N=5	21	14
	10.0		10		X	4-4-7-8 N=11		
		Boring Terminated at 10 Feet						

Stratification lines are approximate. In-situ, the transition may be gradual.

Hammer Type: Automatic

Advancement Method:
Mud rotary

Abandonment Method:
Boring backfilled with cement grout upon completion.

See Exploration and Testing Procedures for a description of field and laboratory procedures used and additional data (If any).

See Supporting Information for explanation of symbols and abbreviations.

Elevations were provided by others.

Notes:

A-3: AASHTO Group Classification

WATER LEVEL OBSERVATIONS

▽ *At 4' while sampling*

Terracon
8260 Vico Ct, Unit B
Sarasota, FL

Boring Started: 11-21-2018	Boring Completed: 11-21-2018
Drill Rig: BR-2500	Driller: MC
Project No.: HC185059	

BORING LOG NO. RB-5

PROJECT: SR 62 & Erie Road - Signal Poles

CLIENT: Manatee County Government Bradenton, FL

SITE: SR 62 Parrish, FL

LOCATION See Exploration Plan

Latitude: 27.5871° Longitude: -82.425°

MODEL LAYER	DEPTH	DESCRIPTION	DEPTH (Ft.)	WATER LEVEL OBSERVATIONS	SAMPLE TYPE	FIELD TEST RESULTS	WATER CONTENT (%)	PERCENT FINES
1		**POORLY GRADED SAND WITH SILT (A-3) (SP-SM)**, fine grained, brown to gray, very loose to loose				4-3-1-1 N=4		
						1-2-1-1 N=3		
				▽ (at 4')				
			5			1-1-1-1 N=2		
	8.0					3-4-5-6 N=9		
4	10.0	**SILTY SAND (A-2-4) (SM)**, fine grained, gray, medium dense				4-5-5-7 N=10	20	13
		Boring Terminated at 10 Feet	10					

Stratification lines are approximate. In-situ, the transition may be gradual.

Hammer Type: Automatic

Advancement Method:
Mud rotary

Abandonment Method:
Boring backfilled with cement grout upon completion.

See Exploration and Testing Procedures for a description of field and laboratory procedures used and additional data (If any).

See Supporting Information for explanation of symbols and abbreviations.

Elevations were provided by others.

Notes:

A-3: AASHTO Group Classification

WATER LEVEL OBSERVATIONS

▽ *At 4' while sampling*

Terracon
8260 Vico Ct, Unit B
Sarasota, FL

Boring Started: 11-21-2018	Boring Completed: 11-21-2018
Drill Rig: BR-2500	Driller: MC
Project No.: HC185059	

BORING LOG NO. RB-6

PROJECT: SR 62 & Erie Road - Signal Poles

CLIENT: Manatee County Government Bradenton, FL

SITE: SR 62 Parrish, FL

LOCATION See Exploration Plan

Latitude: 27.587° Longitude: -82.4247°

MODEL LAYER	GRAPHIC LOG	DEPTH	DEPTH (Ft.)	WATER LEVEL OBSERVATIONS	SAMPLE TYPE	FIELD TEST RESULTS	WATER CONTENT (%)	PERCENT FINES
1		**POORLY GRADED SAND WITH SILT (A-3) (SP-SM)**, fine grained, brown to gray, very loose to medium dense				3-3-2-2 N=5	5	7
				▽		2-1-2-1 N=3		
			5			2-1-1-2 N=2		
						4-4-4-4 N=8		
						2-5-5-2 N=10		
		10.0	10					
		Boring Terminated at 10 Feet						

Stratification lines are approximate. In-situ, the transition may be gradual.

Hammer Type: Automatic

Advancement Method:
Mud rotary

Abandonment Method:
Boring backfilled with cement grout upon completion.

See Exploration and Testing Procedures for a description of field and laboratory procedures used and additional data (If any).

See Supporting Information for explanation of symbols and abbreviations.

Elevations were provided by others.

Notes:

A-3: AASHTO Group Classification

WATER LEVEL OBSERVATIONS

▽ *At 3.5' while sampling*

Terracon
8260 Vico Ct, Unit B
Sarasota, FL

Boring Started: 11-21-2018	Boring Completed: 11-21-2018
Drill Rig: BR-2500	Driller: MC
Project No.: HC185059	

BORING LOG NO. RB-7

PROJECT: SR 62 & Erie Road - Signal Poles

CLIENT: Manatee County Government Bradenton, FL

SITE: SR 62 Parrish, FL

LOCATION See Exploration Plan

Latitude: 27.5871° Longitude: -82.4244°

MODEL LAYER	GRAPHIC LOG	DEPTH	DEPTH (Ft.)	WATER LEVEL OBSERVATIONS	SAMPLE TYPE	FIELD TEST RESULTS	WATER CONTENT (%)	PERCENT FINES
1		**POORLY GRADED SAND WITH SILT (A-3) (SP-SM)**, fine grained, brown, very loose to medium dense			X	1-1-1-1 N=2		
				▽	X	4-1-2-1 N=3	19	8
			5		X	6-3-4-2 N=7		
					X	4-4-4-3 N=8		
		10.0	10		X	2-3-3-4 N=6		
		Boring Terminated at 10 Feet						

Stratification lines are approximate. In-situ, the transition may be gradual.

Hammer Type: Automatic

Advancement Method:
Mud rotary

Abandonment Method:
Boring backfilled with cement grout upon completion.

See Exploration and Testing Procedures for a description of field and laboratory procedures used and additional data (If any).

See Supporting Information for explanation of symbols and abbreviations.

Elevations were provided by others.

Notes:

A-3: AASHTO Group Classification

WATER LEVEL OBSERVATIONS

▽ *At 4' while sampling*

Terracon
8260 Vico Ct, Unit B
Sarasota, FL

Boring Started: 11-21-2018	Boring Completed: 11-21-2018
Drill Rig: BR-2500	Driller: MC
Project No.: HC185059	

BORING LOG NO. RB-8/PZ-2

PROJECT: SR 62 & Erie Road - Signal Poles

CLIENT: Manatee County Government
Bradenton, FL

SITE: SR 62
Parrish, FL

LOCATION See Exploration Plan

Latitude: 27.5872° Longitude: -82.4241°

MODEL LAYER	GRAPHIC LOG	DEPTH	DEPTH (Ft.)	WATER LEVEL OBSERVATIONS	SAMPLE TYPE	FIELD TEST RESULTS	WATER CONTENT (%)	PERCENT FINES
1		**POORLY GRADED SAND WITH SILT (A-3, A-2-4) (SP-SM)**, fine grained, brown to gray, loose				2-2-3-2 N=5		
						2-1-2-3 N=3		
			5	▽ (at 4')		2-2-2-2 N=4	23	11
						2-2-4-7 N=6		
		10.0	10			2-2-5-7 N=7		
		Boring Terminated at 10 Feet						

Stratification lines are approximate. In-situ, the transition may be gradual.

Hammer Type: Automatic

Advancement Method:
Mud rotary

Abandonment Method:
Boring backfilled with cement grout upon completion.

See Exploration and Testing Procedures for a description of field and laboratory procedures used and additional data (If any).

See Supporting Information for explanation of symbols and abbreviations.

Elevations were provided by others.

Notes:

A-3: AASHTO Group Classification

WATER LEVEL OBSERVATIONS

▽ *At 4' while sampling*

Terracon
8260 Vico Ct, Unit B
Sarasota, FL

Boring Started: 11-27-2018	Boring Completed: 11-27-2018
Drill Rig: BR-2500	Driller: MC
Project No.: HC185059	

BORING LOG NO. RB-9

PROJECT: SR 62 & Erie Road - Signal Poles

CLIENT: Manatee County Government
Bradenton, FL

SITE: SR 62
Parrish, FL

LOCATION See Exploration Plan

Latitude: 27.5873° Longitude: -82.4238°

MODEL LAYER	GRAPHIC LOG	DEPTH	DEPTH (Ft.)	WATER LEVEL OBSERVATIONS	SAMPLE TYPE	FIELD TEST RESULTS	WATER CONTENT (%)	PERCENT FINES
1		**POORLY GRADED SAND WITH SILT (A-3) (SP-SM)**, fine grained, brown to light brown, very loose to loose				2-2-2-3 N=4		
						2-2-2-2 N=4		
			5	▽		2-1-2-1 N=3		
		6.0						
4		**SILTY SAND (A-2-4) (SM)**, fine grained, light brown, loose to medium dense				5-8-5-4 N=13	18	16
						2-4-5-7 N=9		
		10.0	10					
		Boring Terminated at 10 Feet						

Stratification lines are approximate. In-situ, the transition may be gradual.

Hammer Type: Automatic

Advancement Method:
Mud rotary

Abandonment Method:
Boring backfilled with cement grout upon completion.

See Exploration and Testing Procedures for a description of field and laboratory procedures used and additional data (If any).

See Supporting Information for explanation of symbols and abbreviations.

Elevations were provided by others.

Notes:

A-3: AASHTO Group Classification

WATER LEVEL OBSERVATIONS

▽ *At 4' while sampling*

Terracon
8260 Vico Ct, Unit B
Sarasota, FL

Boring Started: 11-27-2018	Boring Completed: 11-27-2018
Drill Rig: BR-2500	Driller: MC
Project No.: HC185059	

BORING LOG NO. RB-10

PROJECT: SR 62 & Erie Road - Signal Poles

CLIENT: Manatee County Government
Bradenton, FL

SITE: SR 62
Parrish, FL

LOCATION See Exploration Plan

Latitude: 27.5873° Longitude: -82.4235°

MODEL LAYER	GRAPHIC LOG	DEPTH	DEPTH (Ft.)	WATER LEVEL OBSERVATIONS	SAMPLE TYPE	FIELD TEST RESULTS	WATER CONTENT (%)	PERCENT FINES
1		**POORLY GRADED SAND WITH SILT (A-3) (SP-SM)**, fine grained, brown, very loose to medium dense				2-1-1-2 N=2		
						2-2-2-2 N=4		
			5	▽ (at 4')		2-1-2-1 N=3		
						2-4-5-7 N=9		
		10.0	10			2-2-4-6 N=6	20	9
		Boring Terminated at 10 Feet						

Stratification lines are approximate. In-situ, the transition may be gradual.

Hammer Type: Automatic

Advancement Method:
Mud rotary

Abandonment Method:
Boring backfilled with cement grout upon completion.

See Exploration and Testing Procedures for a description of field and laboratory procedures used and additional data (If any).

See Supporting Information for explanation of symbols and abbreviations.

Elevations were provided by others.

Notes:
A-3: AASHTO Group Classification

WATER LEVEL OBSERVATIONS

▽ *At 4' while sampling*

Terracon
8260 Vico Ct, Unit B
Sarasota, FL

Boring Started: 11-27-2018	Boring Completed: 11-27-2018
Drill Rig: BR-2500	Driller: MC
Project No.: HC185059	

BORING LOG NO. RB-11

PROJECT: SR 62 & Erie Road - Signal Poles

CLIENT: Manatee County Government Bradenton, FL

SITE: SR 62 Parrish, FL

LOCATION See Exploration Plan

Latitude: 27.5875° Longitude: -82.4232°

MODEL LAYER	DEPTH	DEPTH (Ft.)	WATER LEVEL OBSERVATIONS	SAMPLE TYPE	FIELD TEST RESULTS	WATER CONTENT (%)	PERCENT FINES
1	**POORLY GRADED SAND WITH SILT (A-3, A-2-4) (SP-SM)**, fine grained, dark brown to brown, loose to medium dense				1-2-1-2 N=3	5	12
					2-4-3-4 N=7		
			▽ (at 4')		2-4-7-6 N=11		
		5			2-5-4-4 N=9		
	10.0				2-2-1-2 N=3		
	Boring Terminated at 10 Feet	10					

Stratification lines are approximate. In-situ, the transition may be gradual.

Hammer Type: Automatic

Advancement Method:
Mud rotary

Abandonment Method:
Boring backfilled with cement grout upon completion.

See Exploration and Testing Procedures for a description of field and laboratory procedures used and additional data (If any).

See Supporting Information for explanation of symbols and abbreviations.

Elevations were provided by others.

Notes:

A-3: AASHTO Group Classification

WATER LEVEL OBSERVATIONS

▽ *At 4' while sampling*

Terracon

8260 Vico Ct, Unit B
Sarasota, FL

Boring Started: 11-27-2018	Boring Completed: 11-27-2018
Drill Rig: BR-2500	Driller: MC
Project No.: HC185059	

BORING LOG NO. RB-12

PROJECT: SR 62 & Erie Road - Signal Poles

CLIENT: Manatee County Government
Bradenton, FL

SITE: SR 62
Parrish, FL

LOCATION See Exploration Plan

Latitude: 27.5875° Longitude: -82.4229°

MODEL LAYER	GRAPHIC LOG	DEPTH	DEPTH (Ft.)	WATER LEVEL OBSERVATIONS	SAMPLE TYPE	FIELD TEST RESULTS	WATER CONTENT (%)	PERCENT FINES
1		**POORLY GRADED SAND WITH SILT (A-3) (SP-SM)**, fine grained, dark brown to brown, very loose to medium dense				2-2-2-2 N=4		
						2-1-1-1 N=2	7	7
			5	▽		1-2-1-1 N=3		
						4-6-4-5 N=10		
		10.0	10			3-4-6-5 N=10		
		Boring Terminated at 10 Feet						

Stratification lines are approximate. In-situ, the transition may be gradual.

Hammer Type: Automatic

Advancement Method:
Mud rotary

Abandonment Method:
Boring backfilled with cement grout upon completion.

See Exploration and Testing Procedures for a description of field and laboratory procedures used and additional data (If any).

See Supporting Information for explanation of symbols and abbreviations.

Elevations were provided by others.

Notes:

A-3: AASHTO Group Classification

WATER LEVEL OBSERVATIONS

▽ *At 4' while sampling*

Terracon

8260 Vico Ct, Unit B
Sarasota, FL

Boring Started: 11-27-2018	Boring Completed: 11-27-2018
Drill Rig: BR-2500	Driller: MC
Project No.: HC185059	

BORING LOG NO. RB-13

PROJECT: SR 62 & Erie Road - Signal Poles

CLIENT: Manatee County Government
Bradenton, FL

SITE: SR 62
Parrish, FL

LOCATION See Exploration Plan

Latitude: 27.5877° Longitude: -82.4226°

MODEL LAYER	GRAPHIC LOG	DEPTH	DEPTH (Ft.)	WATER LEVEL OBSERVATIONS	SAMPLE TYPE	FIELD TEST RESULTS	WATER CONTENT (%)	PERCENT FINES
1		**POORLY GRADED SAND WITH SILT (A-3) (SP-SM)**, fine grained, brown, very loose to medium dense				3-4-4-3 N=8		
						2-2-2-2 N=4		
				▽ (4')				
			5			1-WOH/12-1 N=1	25	9
						5-8-12-14 N=20		
		10.0				4-6-12-11 N=18		
		Boring Terminated at 10 Feet	10					

Stratification lines are approximate. In-situ, the transition may be gradual.

Hammer Type: Automatic

Advancement Method:
Mud rotary

Abandonment Method:
Boring backfilled with cement grout upon completion.

See Exploration and Testing Procedures for a description of field and laboratory procedures used and additional data (If any).

See Supporting Information for explanation of symbols and abbreviations.

Elevations were provided by others.

Notes:

A-3: AASHTO Group Classification

WATER LEVEL OBSERVATIONS

▽ *At 4' while sampling*

Terracon
8260 Vico Ct, Unit B
Sarasota, FL

Boring Started: 11-28-2018	Boring Completed: 11-28-2018
Drill Rig: BR-2500	Driller: MC
Project No.: HC185059	

BORING LOG NO. RB-14/PZ-3

PROJECT: SR 62 & Erie Road - Signal Poles

CLIENT: Manatee County Government Bradenton, FL

SITE: SR 62 Parrish, FL

LOCATION See Exploration Plan

Latitude: 27.5877° Longitude: -82.4223°

MODEL LAYER	GRAPHIC LOG	DEPTH	DEPTH (Ft.)	WATER LEVEL OBSERVATIONS	SAMPLE TYPE	FIELD TEST RESULTS	WATER CONTENT (%)	PERCENT FINES
1		**POORLY GRADED SAND WITH SILT (A-3) (SP-SM)**, fine grained, brown, loose				2-2-2-2 N=4		
						2-2-2-3 N=4		
		6.0	5	▽		2-2-2-3 N=4		
4		**SILTY SAND (A-2-4) (SM)**, fine grained, brown, medium dense				2-2-10-15 N=12	18	16
		10.0	10			5-6-9-9 N=15		
		Boring Terminated at 10 Feet						

Stratification lines are approximate. In-situ, the transition may be gradual.

Hammer Type: Automatic

Advancement Method:
Mud rotary

Abandonment Method:
Boring backfilled with cement grout upon completion.

See Exploration and Testing Procedures for a description of field and laboratory procedures used and additional data (If any).

See Supporting Information for explanation of symbols and abbreviations.

Elevations were provided by others.

Notes:

WATER LEVEL OBSERVATIONS

▽ *At 4.5' while sampling*

Terracon
8260 Vico Ct, Unit B
Sarasota, FL

Boring Started: 11-28-2018	Boring Completed: 11-28-2018
Drill Rig: BR-2500	Driller: MC
Project No.: HC185059	

BORING LOG NO. RB-15

PROJECT: SR 62 & Erie Road - Signal Poles

CLIENT: Manatee County Government, Bradenton, FL

SITE: SR 62, Parrish, FL

LOCATION See Exploration Plan

Latitude: 27.5877° Longitude: -82.422°

MODEL LAYER	GRAPHIC LOG	DEPTH	DEPTH (Ft.)	WATER LEVEL OBSERVATIONS	SAMPLE TYPE	FIELD TEST RESULTS	WATER CONTENT (%)	PERCENT FINES
1		**POORLY GRADED SAND WITH SILT (A-3) (SP-SM)**, fine grained, brown to gray, very loose to medium dense				4-3-3-3 N=6		
						2-1-1-2 N=2		
			5	▽		2-2-2-2 N=4		
						4-8-8-7 N=16		
		10.0				3-4-6-6 N=10	20	11
		Boring Terminated at 10 Feet	10					

Stratification lines are approximate. In-situ, the transition may be gradual.

Hammer Type: Automatic

Advancement Method:
Mud rotary

Abandonment Method:
Boring backfilled with cement grout upon completion.

See Exploration and Testing Procedures for a description of field and laboratory procedures used and additional data (If any).

See Supporting Information for explanation of symbols and abbreviations.

Elevations were provided by others.

Notes:

WATER LEVEL OBSERVATIONS

▽ *At 4.5' while sampling*

Terracon
8260 Vico Ct, Unit B
Sarasota, FL

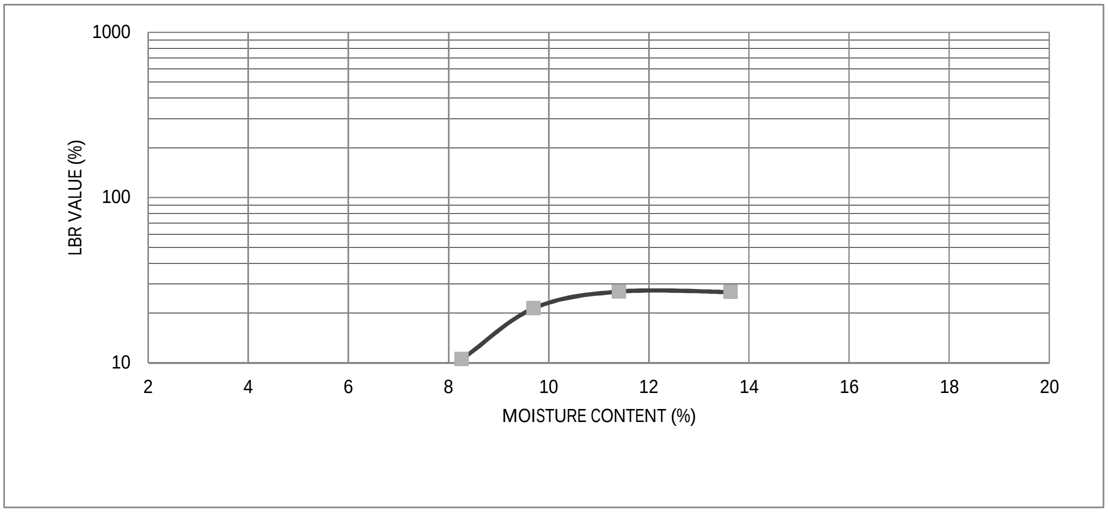
Boring Started: 11-28-2018	Boring Completed: 11-28-2018
Drill Rig: BR-2500	Driller: MC
Project No.: HC185059	

LIMEROCK BEARING RATIO TEST RESULTS
(FM5-515)

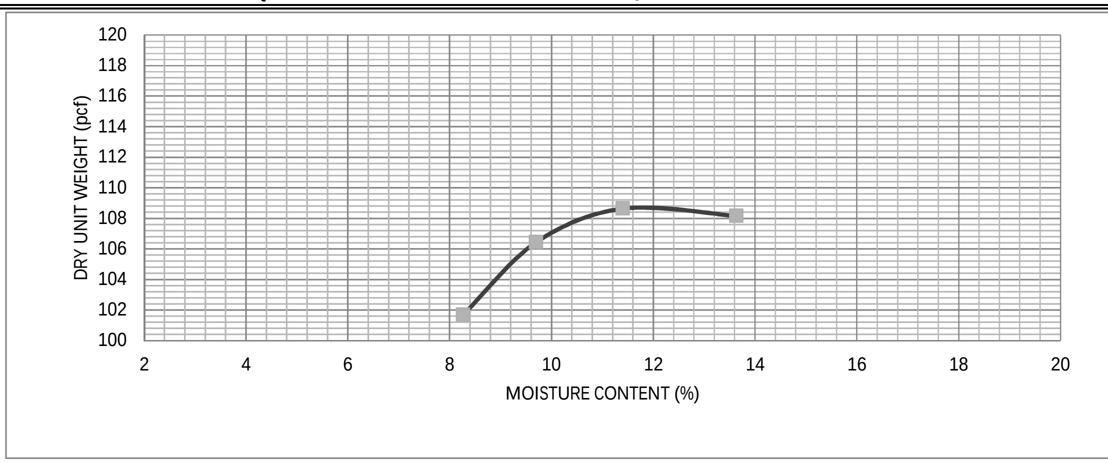
TESTED FOR: Manatee County Public Works
SAMPLE NO.: LBR-1
TESTED BY: D. Richards
DATE TESTED: November 19, 2018

PROJECT: Erie Road
PROJECT NO: HC185059
%<#4: 100.0%
WASH 200: 7.7%

SAMPLE LOCATION: RB-4
SOIL DESCRIPTION: Brown to gray sand with silt and trace roots



PROJECT LBR REQUIREMENT: **N/A** LBR VALUE: **27**



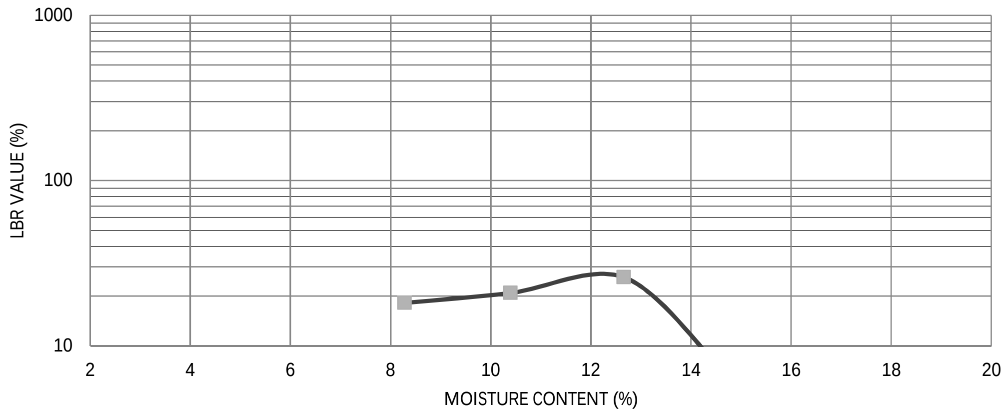
OPT MOISTURE: **12.0** MAX DENSITY: **108.7**

LIMEROCK BEARING RATIO TEST RESULTS
(FM5-515)

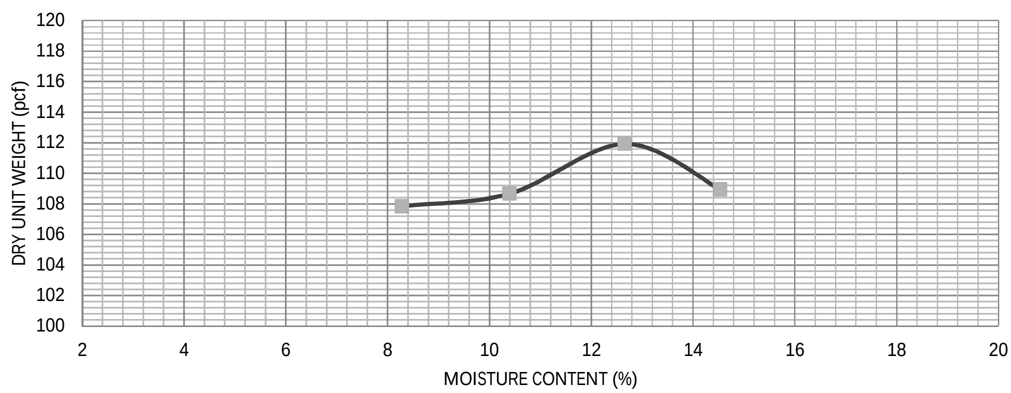
TESTED FOR:	Manatee County Public Works	**PROJECT:**	Erie Road
SAMPLE NO.:	LBR-2	**PROJECT NO:**	HC185059
TESTED BY:	D. Richards	**%<#4:**	100.0%
DATE TESTED:	November 19, 2018	**WASH 200:**	8.8%

SAMPLE LOCATION: RB-7

SOIL DESCRIPTION: Gray sand with silt and trace roots



PROJECT LBR REQUIREMENT: **N/A** LBR VALUE: **26**



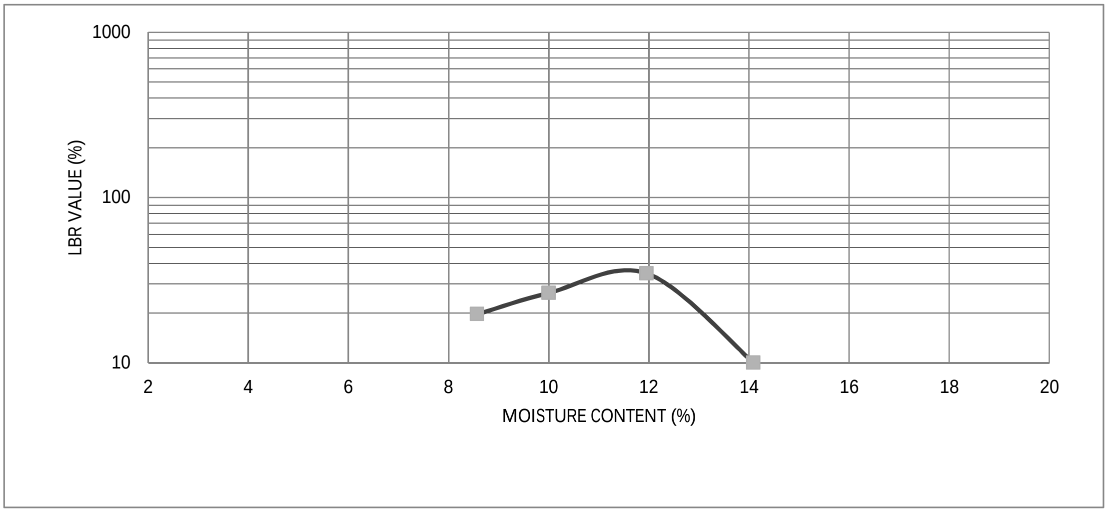
OPT MOISTURE: **12.9** MAX DENSITY: **111.9**

LIMEROCK BEARING RATIO TEST RESULTS
(FM5-515)

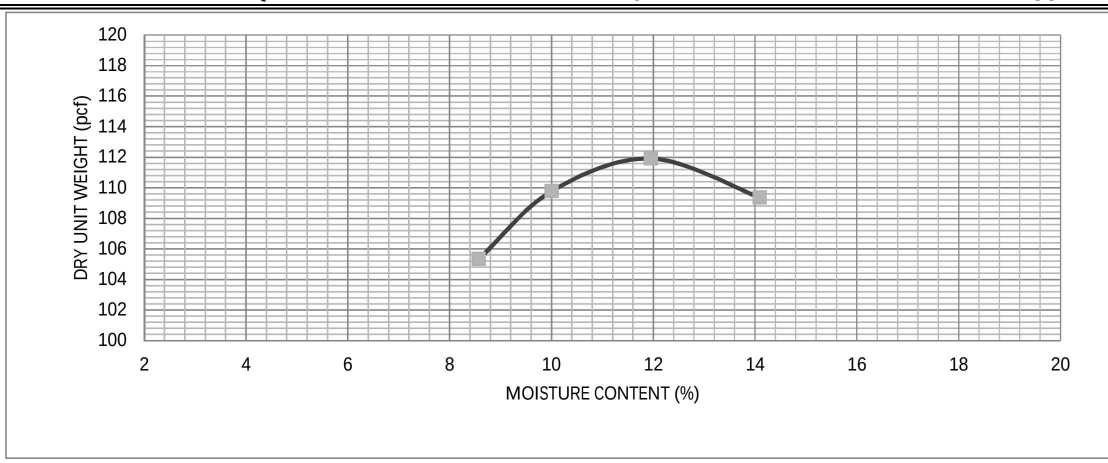
TESTED FOR: Manatee County Public Works
SAMPLE NO.: LBR-3
TESTED BY: D. Richards
DATE TESTED: November 19, 2018

PROJECT: Erie Road
PROJECT NO: HC185059
%<#4: 100.0%
WASH 200: 8.4%

SAMPLE LOCATION: RB-9
SOIL DESCRIPTION: Brown to gray sand with silt and trace roots



PROJECT LBR REQUIREMENT: **N/A** LBR VALUE: **35**



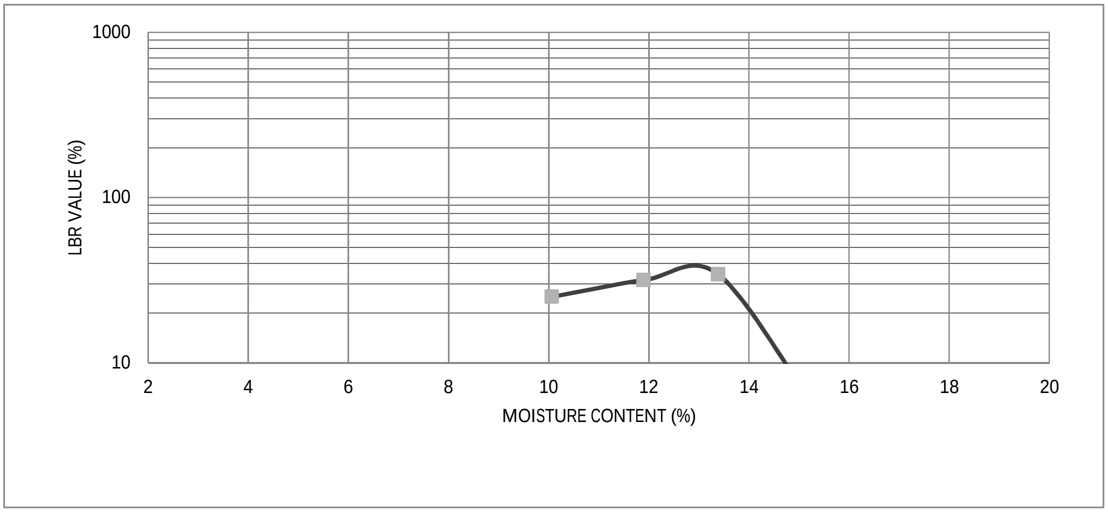
OPT MOISTURE: **11.9** MAX DENSITY: **111.9**

LIMEROCK BEARING RATIO TEST RESULTS
(FM5-515)

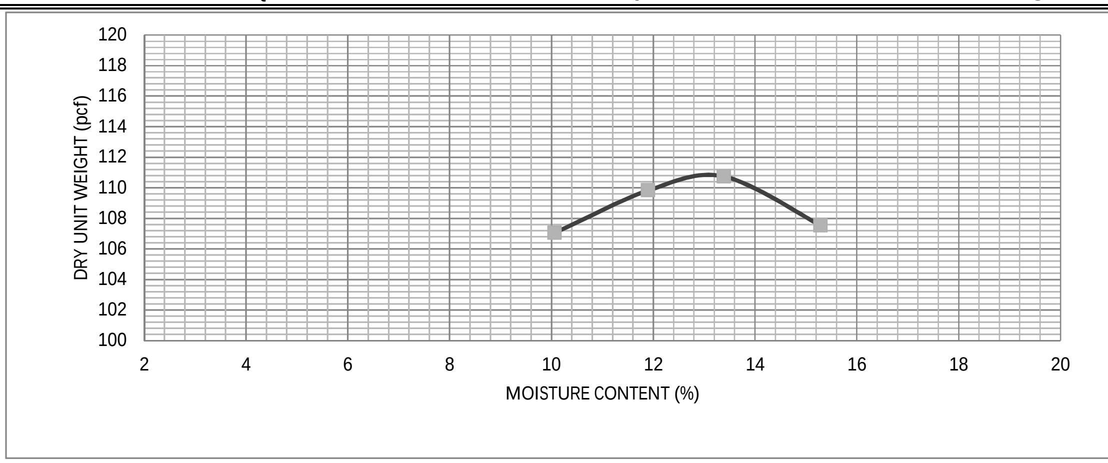
TESTED FOR: Manatee County Public Works
SAMPLE NO.: LBR-4
TESTED BY: D. Richards
DATE TESTED: November 21, 2018

PROJECT: Erie Road
PROJECT NO: HC185059
%<#4: 100.0%
WASH 200: 9.9%

SAMPLE LOCATION: RB-11
SOIL DESCRIPTION: Gray sand with silt and trace roots



PROJECT LBR REQUIREMENT: **N/A** LBR VALUE: **34**



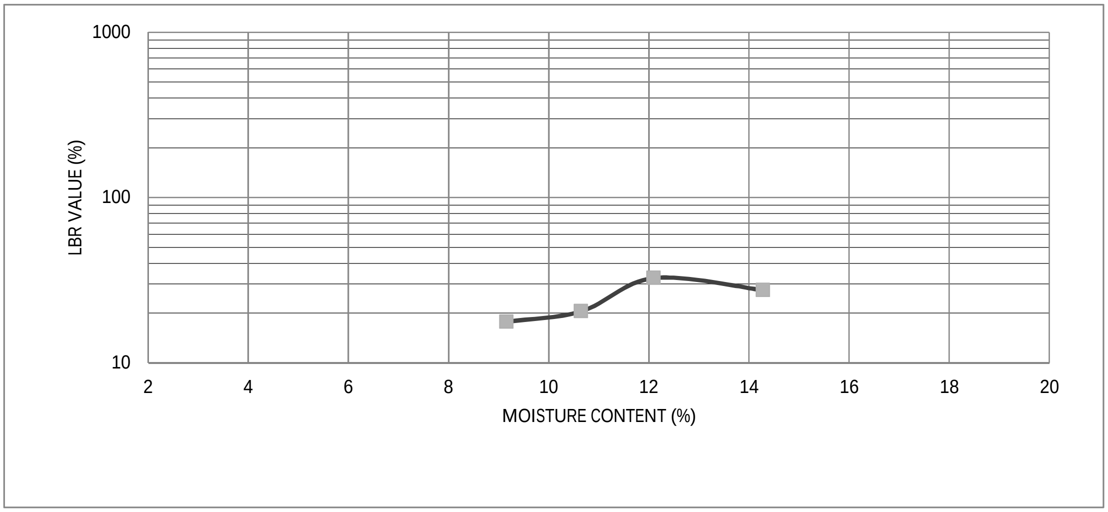
OPT MOISTURE: **13.2** MAX DENSITY: **110.7**

LIMEROCK BEARING RATIO TEST RESULTS
(FM5-515)

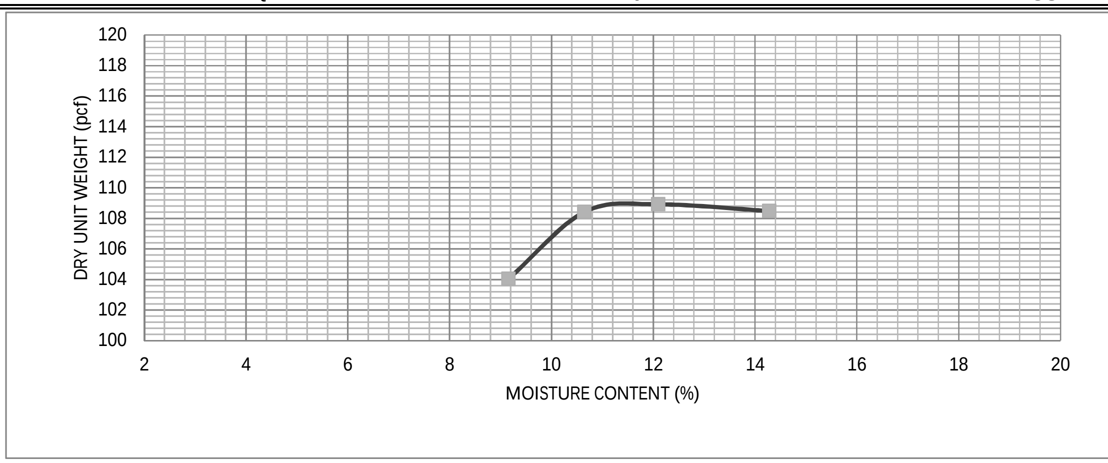
TESTED FOR: Manatee County Public Works
SAMPLE NO.: LBR-5
TESTED BY: D. Richards
DATE TESTED: November 19, 2018

PROJECT: Erie Road
PROJECT NO: HC185059
%<#4: 100.0%
WASH 200: 10.2%

SAMPLE LOCATION: RB-14
SOIL DESCRIPTION: Gray sand with silt and trace roots



PROJECT LBR REQUIREMENT: **N/A** LBR VALUE: **33**



OPT MOISTURE: **11.9** MAX DENSITY: **109.0**

SUPPORTING INFORMATION

Contents:

Note: All attachments are one page unless noted above.

GENERAL NOTES

DESCRIPTION OF SYMBOLS AND ABBREVIATIONS

SAMPLING

Auger Cuttings	Rock Core
Grab Sample	No Recovery
Shelby Tube	Standard Penetration Test

WATER LEVEL

- **Water Initially Encountered**
- **Water Level After a Specified Period of Time**
- **Water Level After a Specified Period of Time**

Water levels indicated on the soil boring logs are the levels measured in the borehole at the times indicated. Groundwater level variations will occur over time. In low permeability soils, accurate determination of groundwater levels is not possible with short term water level observations.

FIELD TESTS

(HP)	**Hand Penetrometer**
(T)	**Torvane**
(DCP)	**Dynamic Cone Penetrometer**
(PID)	**Photo-Ionization Detector**
(OVA)	**Organic Vapor Analyzer**

DESCRIPTIVE SOIL CLASSIFICATION

Soil classification is based on the Unified Soil Classification System. Coarse Grained Soils have more than 50% of their dry weight retained on a #200 sieve; their principal descriptors are: boulders, cobbles, gravel or sand. Fine Grained Soils have less than 50% of their dry weight retained on a #200 sieve; they are principally described as clays if they are plastic, and silts if they are slightly plastic or non-plastic. Major constituents may be added as modifiers and minor constituents may be added according to the relative proportions based on grain size. In addition to gradation, coarse-grained soils are defined on the basis of their in-place relative density and fine-grained soils on the basis of their consistency.

LOCATION AND ELEVATION NOTES

Unless otherwise noted, Latitude and Longitude are approximately determined using a hand-held GPS device. The accuracy of such devices is variable. Surface elevation data annotated with +/- indicates that no actual topographical survey was conducted to confirm the surface elevation. Instead, the surface elevation was approximately determined from topographic maps of the area.

STRENGTH TERMS

RELATIVE DENSITY OF COARSE-GRAINED SOILS (More than 50% retained on No. 200 sieve.) Density determined by Standard Penetration Resistance		**CONSISTENCY OF FINE-GRAINED SOILS** (50% or more passing the No. 200 sieve.) Consistency determined by laboratory shear strength testing, field visual-manual procedures or standard penetration resistance		
Descriptive Term (Density)	**Automatic Hammer SPT N-Value (Blows/Ft.)**	**Descriptive Term (Consistency)**	**Unconfined Compressive Strength Qu, (psf)**	**Automatic Hammer SPT N-Value (Blows/Ft.)**
Very Loose	< 3	Very Soft	less than 500	< 1
Loose	3 - 8	Soft	500 to 1,000	1 - 3
Medium Dense	8 - 24	Medium Stiff	1,000 to 2,000	3 - 6
Dense	24 - 40	Stiff	2,000 to 4,000	6 - 12
Very Dense	> 40	Very Stiff	4,000 to 8,000	12 - 24
		Hard	> 8,000	> 24

RELATIVE PROPORTIONS OF SAND AND GRAVEL

Descriptive Term(s) of other constituents	Percent of Dry Weight
Trace	< 15
With	15 - 29
Modifier	> 30

GRAIN SIZE TERMINOLOGY

Major Component of Sample	Particle Size
Boulders	Over 12 in. (300 mm)
Cobbles	12 in. to 3 in. (300mm to 75mm)
Gravel	3 in. to #4 sieve (75mm to 4.75 mm)
Sand	#4 to #200 sieve (4.75mm to 0.075mm
Silt or Clay	Passing #200 sieve (0.075mm)

RELATIVE PROPORTIONS OF FINES

Descriptive Term(s) of other constituents	Percent of Dry Weight
Trace	< 5
With	5 - 12
Modifier	> 12

PLASTICITY DESCRIPTION

Term	Plasticity Index
Non-plastic	0
Low	1 - 10
Medium	11 - 30
High	> 30

Terracon

UNIFIED SOIL CLASSIFICATION SYSTEM

Terracon GeoReport

Criteria for Assigning Group Symbols and Group Names Using Laboratory Tests [A]				Soil Classification: Group Symbol	Soil Classification: Group Name [B]
Coarse-Grained Soils: More than 50% retained on No. 200 sieve	**Gravels:** More than 50% of coarse fraction retained on No. 4 sieve	**Clean Gravels:** Less than 5% fines [C]	Cu ³ 4 and 1 £ Cc £ 3 [E]	GW	Well-graded gravel [F]
			Cu < 4 and/or [Cc<1 or Cc>3.0] [E]	GP	Poorly graded gravel [F]
		Gravels with Fines: More than 12% fines [C]	Fines classify as ML or MH	GM	Silty gravel [F, G, H]
			Fines classify as CL or CH	GC	Clayey gravel [F, G, H]
	Sands: 50% or more of coarse fraction passes No. 4 sieve	**Clean Sands:** Less than 5% fines [D]	Cu ³ 6 and 1 £ Cc £ 3 [E]	SW	Well-graded sand [I]
			Cu < 6 and/or [Cc<1 or Cc>3.0] [E]	SP	Poorly graded sand [I]
		Sands with Fines: More than 12% fines [D]	Fines classify as ML or MH	SM	Silty sand [G, H, I]
			Fines classify as CL or CH	SC	Clayey sand [G, H, I]
Fine-Grained Soils: 50% or more passes the No. 200 sieve	**Silts and Clays:** Liquid limit less than 50	**Inorganic:**	PI > 7 and plots on or above "A" line [J]	CL	Lean clay [K, L, M]
			PI < 4 or plots below "A" line [J]	ML	Silt [K, L, M]
		Organic:	Liquid limit - oven dried / Liquid limit - not dried < 0.75	OL	Organic clay [K, L, M, N]
					Organic silt [K, L, M, O]
	Silts and Clays: Liquid limit 50 or more	**Inorganic:**	PI plots on or above "A" line	CH	Fat clay [K, L, M]
			PI plots below "A" line	MH	Elastic Silt [K, L, M]
		Organic:	Liquid limit - oven dried / Liquid limit - not dried < 0.75	OH	Organic clay [K, L, M, P]
					Organic silt [K, L, M, Q]
Highly organic soils:	Primarily organic matter, dark in color, and organic odor			PT	Peat

[A] Based on the material passing the 3-inch (75-mm) sieve.

[B] If field sample contained cobbles or boulders, or both, add "with cobbles or boulders, or both" to group name.

[C] Gravels with 5 to 12% fines require dual symbols: GW-GM well-graded gravel with silt, GW-GC well-graded gravel with clay, GP-GM poorly graded gravel with silt, GP-GC poorly graded gravel with clay.

[D] Sands with 5 to 12% fines require dual symbols: SW-SM well-graded sand with silt, SW-SC well-graded sand with clay, SP-SM poorly graded sand with silt, SP-SC poorly graded sand with clay.

[E] $Cu = D_{60}/D_{10}$ $\quad Cc = \frac{(D_{30})^2}{D_{10} \times D_{60}}$

[F] If soil contains ³ 15% sand, add "with sand" to group name.

[G] If fines classify as CL-ML, use dual symbol GC-GM, or SC-SM.

[H] If fines are organic, add "with organic fines" to group name.

[I] If soil contains ³ 15% gravel, add "with gravel" to group name.

[J] If Atterberg limits plot in shaded area, soil is a CL-ML, silty clay.

[K] If soil contains 15 to 29% plus No. 200, add "with sand" or "with gravel," whichever is predominant.

[L] If soil contains ³ 30% plus No. 200 predominantly sand, add "sandy" to group name.

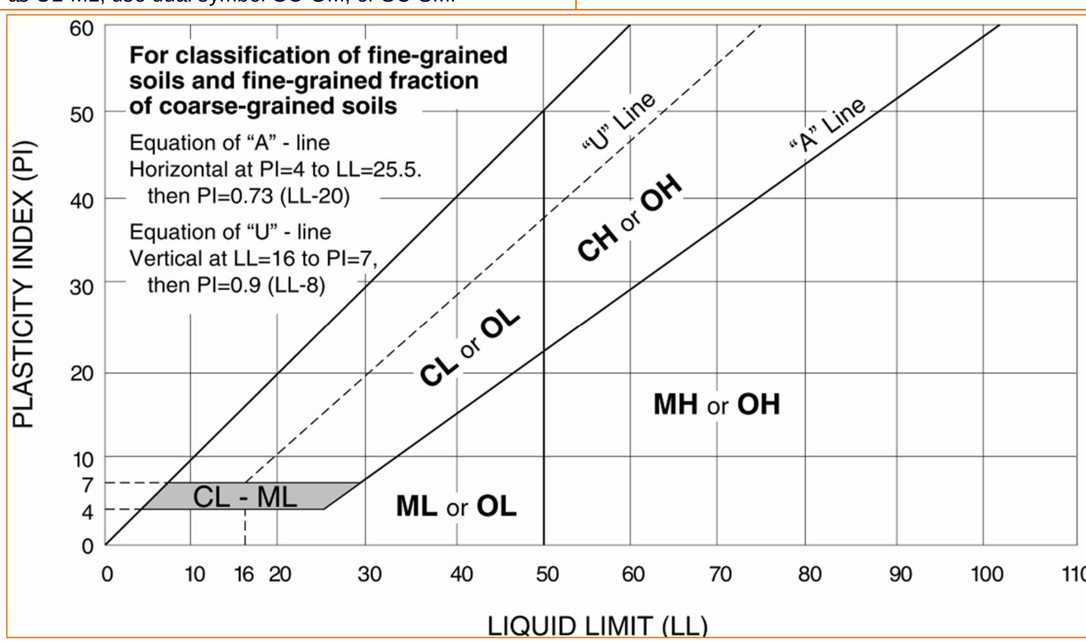
[M] If soil contains ³ 30% plus No. 200, predominantly gravel, add "gravelly" to group name.

[N] PI ³ 4 and plots on or above "A" line.

[O] PI < 4 or plots below "A" line.

[P] PI plots on or above "A" line.

[Q] PI plots below "A" line.



Erie Rd. and SR 62 Improvements

HDR Project Number: 10151274

Miscellaneous Structures

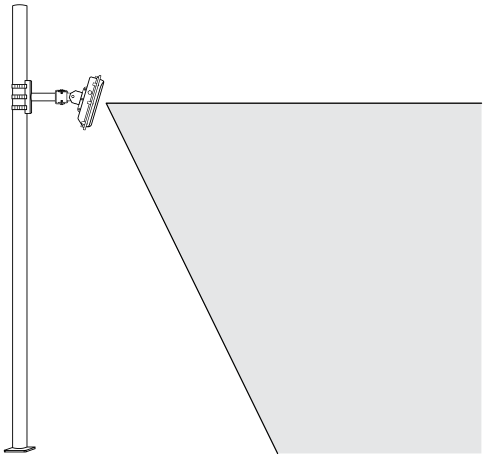
1.8 MVDS Product Data

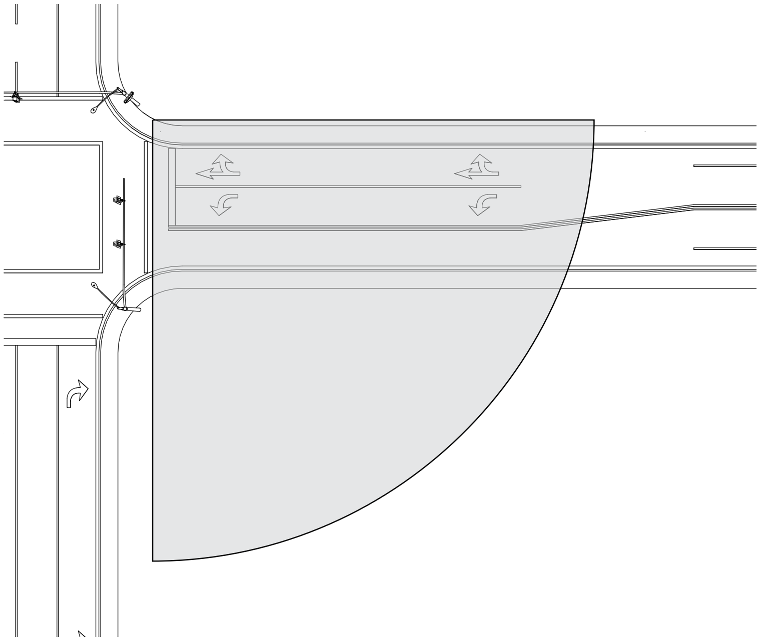
For: Manatee County Public Works

16–beam stop bar sensor

The SmartSensor Matrix is a first-of-its-kind stop bar presence detector designed for use at signalized intersections to detect vehicles with the reliability of radar and with all the advantages of non-intrusive detection.

- Matrix of 16 radars for two-dimensional coverage
- Tracks vehicles through a 90 degree field of view that extends out 140 ft. (42.7 m)
- Includes Radar Vision technology to detect and track in two dimensions
- Reports real-time presence of both moving and stopped vehicles
- Standard detector-rack contact-closure interface
- Easy to install and operate
- Supports curved and angled lanes
- Compatible with Click 65x all-in-one cabinet interface device
- Automated manufacturing process
- Patented auto-configuration process
- Patented Digital Wave Radar II technology
- Remote accessible for traffic monitoring and sensor management
- Flash upgradable
- Robust to changing temperature, light and weather conditions





Technical specifications

Measured quantities

- Per-vehicle range, speed
- Dynamic stop-bar ETA tracking, adjusted as vehicles change speeds
- Dynamic density (a measure of instantaneous roadway efficiency)
- Number of simultaneous vehicle detections: 25
- Logic filters for zone output
- Combinational logic applied to zone outputs for alert output
- Channel output from multiple alerts
- Latched channel output controlled by alerts and timer
- Delay and extend settings used for channel outputs
- Number of channels: 8
- Detection data available via serial communications
- Pulse channel outputs for intersection arrival-time information

Detectable area

- Maximum mounting distance from center of lanes: 50 ft. (15.2 m)
- Maximum mounting height: 40 ft. (12.2 m)
- Detection area: 50 to 600 ft. (15.2 m to 182.8 m)
- Percentage of vehicles detected before 400 ft. (121.9 m): large vehicles 95%; all motor vehicles 90%

Performance

- Detection accuracy: large vehicles 98%; all motor vehicles 95%
- Range accuracy: ±10 ft. (3 m) for 90% of measurements
- Speed accuracy: ±5 mph (8 kph) for 90% of measurements
- ETA accuracy: ±1 sec. for 85% of measurements

Performance maintenance

- No cleaning or adjustment necessary
- No battery replacement necessary
- Mean time between failures: 10 years (estimated based on manufacturing techniques

Physical properties

- Weight: 3.8 lbs. (1.7 kg)
- Physical dimensions: 13.2 in. × 10.6 in. × 3.8 in. (33.5 cm x 26.9 cm x 9.7 cm)
- Resistant to corrosion, fungus, moisture deterioration and ultraviolet rays
- Enclosure: Lexan polycarbonate
- Outdoor weatherable: UL 746C
- Watertight by NEMA 250 standard
- NEMA 250 compliant for:
  - External icing (clause 5.6)
  - Hose down (clause 5.7)
  - 4X corrosion protection (clause 5.10)
  - Gasket (clause 5.14)
- Withstands 5-ft. (1.5-m) drop
- Connector: MIL-C-26482
- Rotational backplate for 360° of roll

Electrical

- Power consumption: 3.2 W @ 12 VDC
- Supply voltage: 10–28 VDC
- Onboard surge protection

Communication ports

- Two half-duplex RS-485 COM ports support:
  - Dedicated detection communications
  - Configuration, verification, or traffic display without disrupting detection communications
- Firmware upgradability over any COM port

Ordering information

SmartSensor Advance
SS-200V

Retrofitted SmartSensor Advance
SS-200-001

Accessories

102-0416/102-0451 – Click 650/656 cabinet interface device

CLK-112/114 – Click 112/114 rack cards

SS-704-xxx/705 – SmartSensor 6-conductor cable

SS-708-xxx/707 – SmartSensor 8-conductor cable (for retrofitted sensor)

SS-611 – SmartSensor mount

SS-B01-0003/0005/0008 – Intersection preassembled backplate – AC

SS-B01-0004/0006 – Intersection preassembled backplate – DC

SS-B02-0002/0003 – Intersection preassembled 19-inch rack

SS-710 – Sensor cable junction box

Contact us

801.734.7200
sales@wavetronix.com
www.wavetronix.com

Technical specifications

Sensor outputs

- Real-time presence data across a 140-ft. (42.7-m) range
- Maximum number of zones: 16
- Maximum number of channels: 16
- User-selectable zone to channel mapping
- AND logic triggers the channel when all the selected zones are active
- OR logic used to combine multiple zones to a channel output
- Channel output extend and delay functionality
- Algorithms mitigate detections from wrong way or cross traffic
- Fail-safe mode for contact closure outputs if communication is lost

Detectable area

- Detection range: 6 to 140 ft. (1.8 to 42.7 m)
- Field of view: 90º
- Flexible lane configuration support including:
  - Up to 10 lanes
  - Curved lanes
  - Islands and medians

System hardware

- A complete SmartSensor Matrix system includes the following hardware:
  - A SmartSensor Matrix corner radar for each approach
  - Either a preassembled backplate or a cabinet interface device (the Click 600, 650 or 656)
  - Contact closure input file cards (if using a preassembled backplate or Click 600): 2 or 4 channel, compatible with industry standard detector racks

Maintenance

- No cleaning or adjustment necessary
- No battery replacement necessary
- Recalibration is not necessary
- Mean time between failures: 10 years (estimated based on manufacturing techniques)

Physical properties

- Weight: 4.2 lbs. (1.9 kg)
- Physical dimensions: 13.2 in. × 10.6 in. × 3.3 in. (33.5 cm x 26.9 cm x 8.4 cm)
- Resistant to corrosion, fungus, moisture deterioration, and ultraviolet rays
- Enclosure: Lexan EXL polycarbonate
- Outdoor weatherable: UL 746C
- Watertight by NEMA 250 standard
- NEMA 250 compliant for:
  - External icing (clause 5.6)
  - Hose down (clause 5.7)
  - 4X corrosion protection (clause 5.10)
  - Gasket (clause 5.14)
- Withstands 5-ft. (1.5-m) drop
- Connector: MIL-C-26482
- Rotational backplate for 360º of roll

Electrical

- Power consumption: 9 W
- Supply voltage: 10–28 VDC
- Onboard surge protection

Communication ports

- Two half-duplex RS-485 COM ports support:
  - Dedicated detection communications
  - Configuration, verification or traffic display without disrupting detection communications
- Firmware upgradability over any COM port
- User configurable:
  - Response delay
  - Push port

Ordering information

SmartSensor Matrix
SS-225

Accessories

102-0416/102-0451 – Click 650/656

CLK-112/114 – Click 112/114

SS-704-xxx/705 – SmartSensor 6-conductor Cable

SS-611 – SmartSensor Mount

SS-B01-0003/0005/0008 – Intersection Preassembled Backplate – AC

SS-B01-0004/0006 – Intersection Preassembled Backplate – DC

SS-B02-0002/0003 – Intersection Preassembled 19-inch Rack

SS-710 – Sensor Cable Junction Box

Contact us

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Technical specifications

Measured quantities

- Per-lane interval data: volume, average speed, occupancy, classification counts, 85th percentile speed, average headway, average gap, speed bin counts, direction counts
- Classification bins: 8
- Interval speed bins: 15
- Per-vehicle data: speed, length, class, lane assignment, range
- Presence data in 22 lanes

Detectable area

- Number of lanes: up to 22
- Detection range: 6 to 250 ft. (1.8 m to 76.2 m)
- Any lane spacing is supported
- Detection over barriers is supported

Performance

- Per-direction volume accuracy:
  - Typical: 98%–99%
  - Minimum: 95%
- Per-lane volume accuracy:
  - Typical: 98%–99%
  - Minimum: 90%
- Minimum separation between two vehicles: 5.5 ft. (1.67 m)
- Per-direction average speed accuracy: ±3 mph (5 kph)
- Per-lane average speed accuracy: ±3 mph (5 kph)
- Percentage of vehicles generating per-vehicle-speed measurements:
  - Typical: 98%
  - Minimum: 95%
- Per-vehicle speed measurement accuracy: ±3mph (5 kph) for 90% of measurements
- Method of speed measurement: dual radar speed trap
- Per-direction occupancy accuracy: ±10%
- Per-lane occupancy accuracy: ±20%
- Classification accuracy:
  - Typical: 90%
  - Minimum: 80%

Performance maintenance

- No cleaning or adjustment necessary
- No battery replacement necessary
- No recalibration necessary
- Mean time between failures: 10 years (estimated based on manufacturing techniques)

Physical properties

- Weight: 4.2 lbs. (1.9 kg)
- Physical dimensions: 13.2 in. × 10.6 in. × 3.3 in. (33.5 cm x 26.9 cm x 8.4 cm)
- Resistant to corrosion, fungus, moisture deterioration, and ultraviolet rays
- Enclosure: Lexan polycarbonate
- Outdoor weatherable: UL 746C, IP66 rated
- Watertight by NEMA 250 standard
- NEMA 250 compliant for:
  - External icing (clause 5.6)
  - Hose down (clause 5.7)
  - 4X corrosion protection (clause 5.10)
  - Gasket (clause 5.14)
- Withstands 5-ft. (1.5-m) drop
- Housing withstands wind loads exceeding 120 mph
- Connector: MIL-DTL-26482

Power

- Power consumption: 7.6 W
- Supply voltage: 10–28 VDC

Communication ports

- Com ports:
  - Full-duplex RS-232 with RTS/CTS
  - Half-duplex RS-485
- Firmware upgradability over any com port

Ordering information

SmartSensor HD
101-0415

Retrofitted SmartSensor HD
101-0416

SmartSensor HD with Rotating Backplate
101-0403

Accessories

CLK-201/202 – Click 201/202

CLK-200 – Click 200

CLK-112/114 – Click 112/114

SS-706-xxx/707 – SmartSensor 8-conductor Cable

SS-611 – SmartSensor Mount

Contact us

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www.wavetronix.com

Erie Rd. and SR 62 Improvements

HDR Project Number: 10151274

Miscellaneous Structures

1.9 Structure ID Number

For: Manatee County Public Works

c:\pwworking\east01\d2112484\Flagsheet_1.5_MastArms

MEMORANDUM

Districts 1 & 7 Structures Maintenance Office
2916 Leslie Road, Tampa, FL. 33619-2263
(813) 975-7570 • Fax: (813) 975-7595

DATE: April 29, 2020

TO: Michael Oates, P.E.; Senior Traffic Engineer; HDR

FROM: Katharine Sampson, E.I., Senior Engineer Trainee- Structures Project Manager.

COPIES: Tara Rodrigues, P.E., Engineering Section Manager; Nico Antona, DBi; Vicki Griswold Hitch, DBi; Traffic Signal Mast Arm File

SUBJECT: **Request for Traffic Signal Mast Arm/Steel Pole Number Assignment**

Your request for a Traffic Signal Mast Arm/Steel Pole Number Assignment has been granted as follows:

Traffic Signal Mast Arm/Steel Pole Project Information

FINANCIAL PROJECT ID: **N/A** OWNER: **State** **(Ex: State, County, City Name, Other [specify])**
EOR name; Design firm, address: **Michael Oates, P.E.; HDR; 4830 W. Kennedy Blvd, Suite 400, Tampa, FL 33609**

YEAR BUILT - PROPOSED: **2021** OR ACTUAL: _____ (if already built)
(Year Built (Proposed or Actual) pertains to the New Traffic Signal Mast Arm Structure)

Traffic Signal Mast Arm/Steel Pole Character Description (please check):

OCTAGON: **X** SQUARE: _____ ROUND: _____ OTHER: _____

HORIZONTAL CLEARANCE: **7.00ft Min.** MANUFACTURED BY: **Unknown**

VERTICAL CLEARANCE: **17.5ft Min.**

Traffic Signal Mast Arm Location

COUNTY: **Manatee** SECTION/SUBSECTION: **13020000** **(Refer to SLD's)** M.P.: **11.175** (At the center of the intersection)

NAME OF HIGHER RANKED ROUTE: **US 301/SR 43** **(Primary Route, example: I-75/SR 93)** NAME OF LOWER RANKED ROUTE: **SR 62** **(Secondary Route, example: Main Street)**

RANKING #: 2

THE ROUTE RANKING IS LISTED IN ORDER BELOW

1. Interstate Highway
2. U.S. Numbered Highway
3. State Highway
4. County Highway
5. City Street
6. Federal Lands Road
7. State Lands Road
8. Other

NOTE: ONLY ONE (1) NUMBER WILL BE ISSUED PER INTERSECTION

RANKING #: 3

FUNCTIONAL CLASSIFICATION OF INVENTORY ROUTE
CODE: **02** (see options below)
Code Description
Rural
01 Principal Arterial – Interstate
02 Principal Arterial – Other
06 Minor Arterial
07 Major Collector
08 Minor Collector
09 Local
Urban
11 Principal Arterial – Interstate
12 Principal Arterial – Other Freeways or Expressways
14 Other Principal Arterial
16 Minor Arterial
17 Collector
19 Local

Federal Aid ___ ***Non-Federal Aid X
******If Functional Classification=08, 09,or19 = Non-Federal Aid***

EXISTING TRAFFIC SIGNAL MAST ARM/STEEL POLE NUMBER TO BE REPLACED: **N/A**
NEW TRAFFIC SIGNAL MAST ARM/STEEL POLE NUMBER ASSIGNED: **13M178**