Manatee County
Department of Public Works

Signalization Structure Design

Moccasin Wall Road from US 41 to West of I-75
Manatee County, FL

DESIGN NOTEBOOK

Cardno Project No. 00193012.01
Manatee County Project No. 6092560

April 2022

Manatee County
Department of Public Works

Signalization Structure Design

Moccasin Wall Road from US 41 to West of I-75
Manatee County, FL

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Table of Contents

CHRISTOPHER P. GAMACHE
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Section 1.0: Mast Arm Design

Mast Arm Design Narrative

Moccasin Wallow Rd., Manatee County, FL

Description

Mast arm designs are part of a larger Public Works Department project along Moccasin Wallow Road from US 41 to West of I-75. Mast arm designs were performed using FDOT Excel program "StandardMastArm" v1.5, dated 10/01/2021. Drilled shafts designs were performed using FDOT Mathcad program Drilled Shaft v1.1, dated 11/07/2018.

Specifications

The structural design shall be in accordance with the following:

FDOT Structures Design Guidelines, January 2021. (SDG)

FDOT Modifications to LRFD Specifications for Structural Supports for Highway Signs, Luminaires, and Traffic Signals, January 2021. (LRFDLTS-1)

AASHTO LRFD Bridge Design Specifications, 9th Ed., 2020. (LRFD)

AASHTO LRFD Specifications for Structural Supports for Highway Signs, Luminaires, and Traffic Signals, 1st Edition 2015 with 2017, 2019, & 2020 Interim Revisions. (LTS-1)

Design Method

The design of all components utilize the Load and Resistance Factor Design (LRFD) methodology in accordance with the FDOT Structures Manual.

Design Loads

Wind Load

In accordance with FDOT Structures Manual, Volume 1 Section 2.4 and Volume 3.

- Mast Arm Signal Structures: 700 year Extreme Event Limit State = 150 mph

2.4 WIND LOADS

2.4.1 Wind Loads on Completed Structures: WL and WS (LRFD 3.8)

A. Design Wind Speed

Use the design 3-second gust wind speed, V, from Table 2.4.1-1 in lieu of ***LRFD*** Figure 3.8.1.1.2-1.

Table 2.4.1-1 Design Wind Speed, V

County (Dist)	Design Wind Speed (mph)	County (Dist)	Design Wind Speed (mph)	County (Dist)	Design Wind Speed (mph)
Alachua (2)	130	Hardee (1)	150	Okaloosa (3)	150
Baker (2)	130	Hendry (1)	150	Okeechobee (1)	150
Bay (3)	150	Hernando (7)	150	Orange (5)	150
Bradford (2)	130	Highlands (1)	150	Osceola (5)	150
Brevard (5)	170	Hillsborough (7)	150	Palm Beach (4)	170
Broward (4)	170	Holmes (3)	150	Pasco (7)	150
Calhoun (3)	130	Indian River (4)	170	Pinellas (7)	150
Charlotte (1)	170	Jackson (3)	130	Polk (1)	150
Citrus (7)	150	Jefferson (3)	130	Putnam (2)	130
Clay (2)	130	Lafayette (2)	130	St. Johns (2)	150
Collier (1)	170	Lake (5)	150	St. Lucie (4)	170
Columbia (2)	130	Lee (1)	170	Santa Rosa (3)	150
DeSoto (1)	150	Leon (3)	130	Sarasota (1)	170
Dixie (2)	130	Levy (2)	150	Seminole (5)	150
Duval (2)	130	Liberty (3)	130	Sumter (5)	150
Escambia (3)	170	Madison (2)	130	Suwannee (2)	130
Flagler (5)	150	Manatee (1)	150	Taylor (2)	130
Franklin (3)	150	Marion (5)	150	Union (2)	130
Gadsden (3)	130	Martin (4)	170	Volusia (5)	150
Gilchrist (2)	130	Miami-Dade (6)	170	Wakulla (3)	130
Glades (1)	150	Monroe (6)	170	Walton (3)	150
Gulf (3)	150	Monroe Islands (6)[1]	180	Washington (3)	150
Hamilton (2)	130	Nassau (2)	130		

[1] For non-bridge structures use 170 mph or as modified by Vol. 3

Modification for Non-Conventional Projects:
See the RFP for possible supplemental requirements to ***SDG*** 2.4.1.A.

3 LOADS

3.8 Wind Load

Delete Table 3.8.1 and replace it with the following:

Structure Support Type	Interval (years)
• Overhead sign structures • Luminaire support structures >50' in height. • Mast Arm Signal Structures • Monotubes • High Mast Light Poles • ITS Camera Poles >50' in height • Bridge Aesthetic Lighting Structures	700
• Luminaire supports and other structures ≤ 50' in height. • Concrete and Steel Strain Poles	300
• Roadside sign structures	10

3.8.2 Basic Wind Speed (Rev. 01/21)

Delete the entire paragraph including Figures 3.8-1, 3.8-2, 3.8-3 and 3.8-4 and add the following:

For the 700 year Extreme Event Limit State, use the wind speeds (mph) shown in FDOT ***SDG*** *Table 2.4.1-1*

For the 300 year Extreme Event Limit State, use the wind speeds (mph) shown in FDOT ***SDG*** *Table 2.4.1-1* minus 10 mph.

For the 10 year Extreme Event Limit State, use a design wind speed of 110 mph for the entire state.

For the Service Limit State, use a design wind speed of 90 mph for the entire state.

For temporary ground signs, luminaires and span wire traffic signals, for both the Extreme Event and Service Limit States,

C 3.8

FDOT continues the past practice of determining wind speeds based on structure type.

Luminaire support structures shall include all support elements including all poles, arms, connections and anchorages for all high-mast lighting, roadway lighting, sign lighting, underdeck lighting, landscape lighting, and bridge aesthetic lighting.

Based on the ASD-LTS Specifications, the design life is:

- 10 years for ground signs.
- 25 years for conventional light poles and strain poles.
- 50 years for mast arms, high mast light poles and overhead sign structures.

C 3.8.2

Add the following:

FDOT ***SDG*** *Table 2.4.1-1* was derived from the ASCE 7-10 wind speed map.

To simplify the design process, FDOT has designated one wind speed per county for the 700 year and 300 year Extreme Event Limit States. To maintain consistency with past practice, a 110 mph design wind speed was chosen for the 10 year Extreme Event Limit State, and an 80 mph design wind speed was chosen for temporary ground sign supports.

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

NOTE:

1. Work this Index with Index 649-031.

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

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.

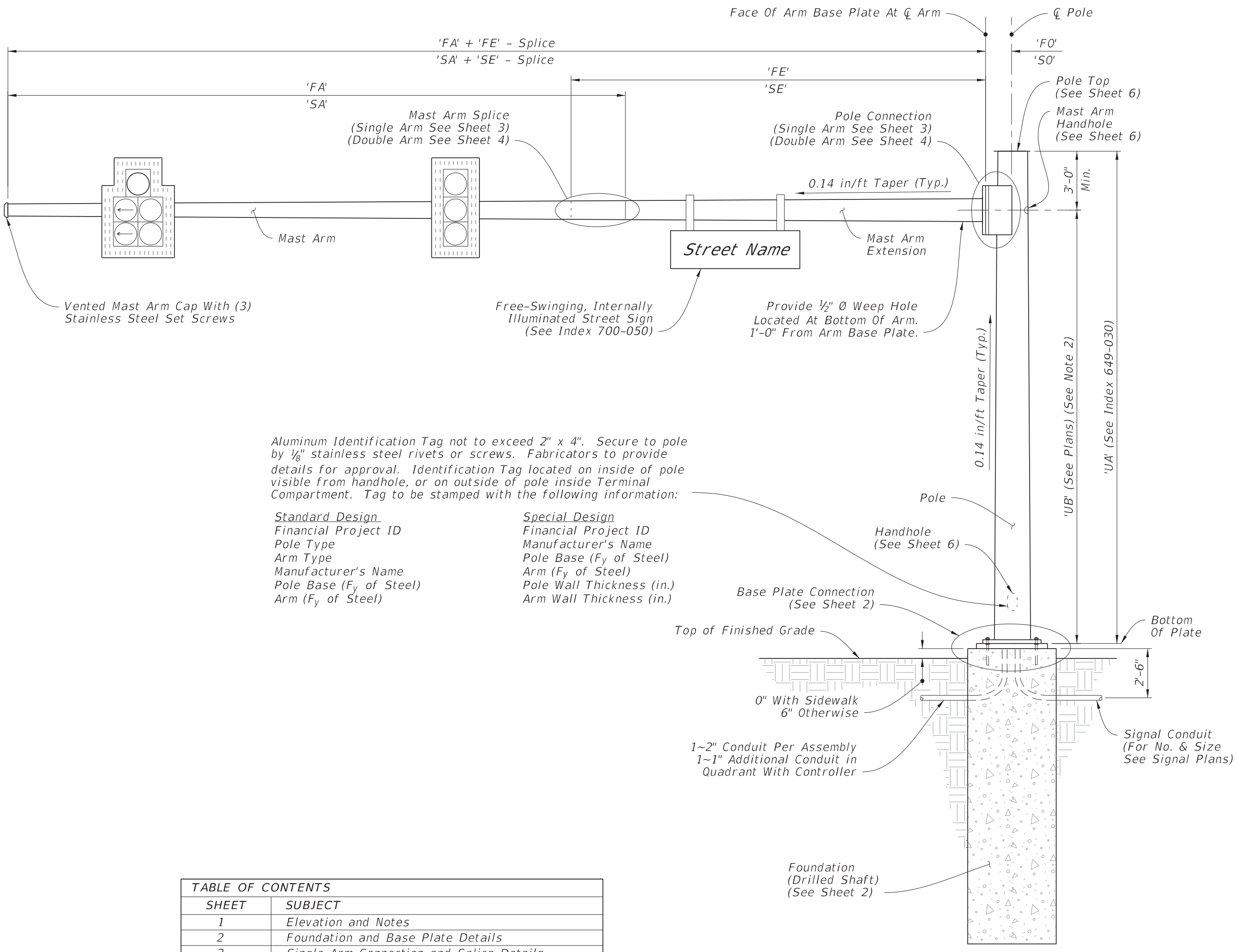
3. Details for Signal and Sign locations, Signal Head attachment, Sign attachment, Pedestrian Head attachment, and Foundation Conduit are not shown for simplicity.

4. Materials:
    - A. Poles, Mast Arms and Backing Rings:
        - a. Less than $\frac{3}{16}$": ASTM A1011 Grade 50, 55, 60 or 65
        - b. Greater than or equal to $\frac{3}{16}$": 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 $\frac{1}{16}$” prior to galvanizing.
            2. Anchor Bolts: Bolt diameter plus $\frac{1}{2}$” (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.



Aluminum Identification Tag not to exceed 2" x 4". Secure to pole by ⅛" stainless steel rivets or screws. Fabricators to provide details for approval. Identification Tag located on inside of pole visible from handhole, or on outside of pole inside Terminal Compartment. Tag to be stamped with the following information:

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

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

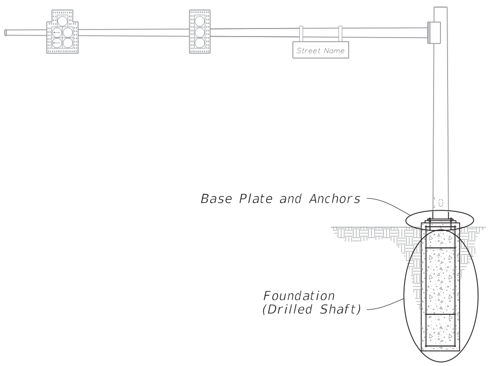
MAST ARM ASSEMBLY

TABLE OF CONTENTS

10/12/2020 8:22:07 AM

ELEVATION AND NOTES

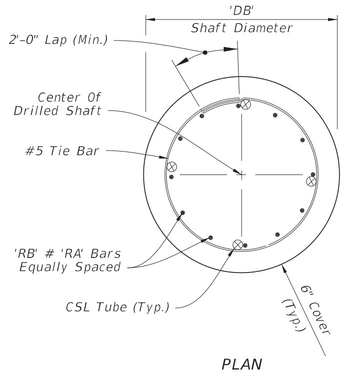
LAST REVISION	REVISION	DESCRIPTION:			INDEX	SHEET
11/01/18			FDOT FY 2021-22 STANDARD PLANS	MAST ARM ASSEMBLIES	649-031	1 of 6



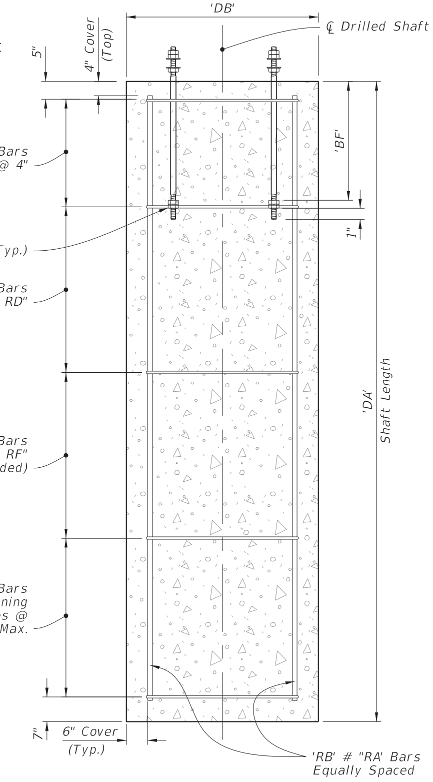
MAST ARM ASSEMBLY

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.

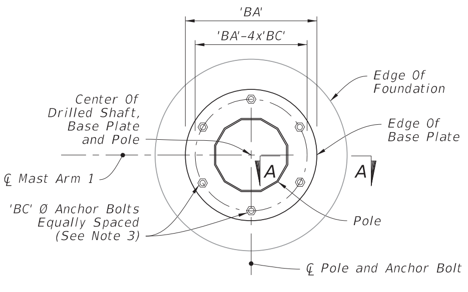


PLAN

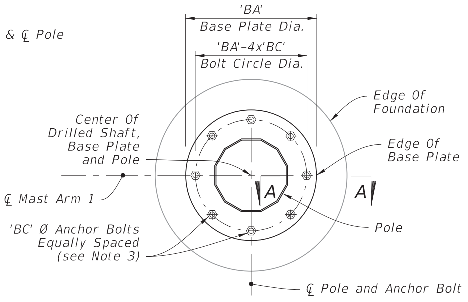


ELEVATION

FOUNDATION

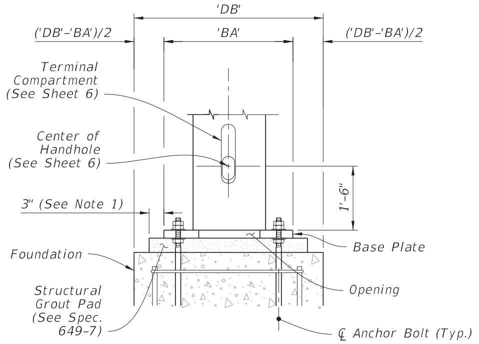


(6 Anchor Bolts)



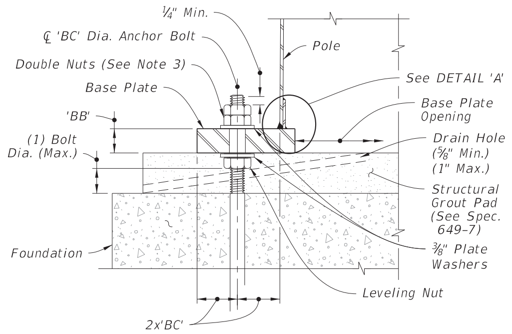
(8 Anchor Bolts)

PLAN

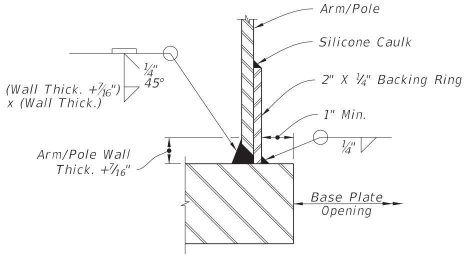


ELEVATION
(Back Face Shown)

BASE PLATE CONNECTION



SECTION A-A



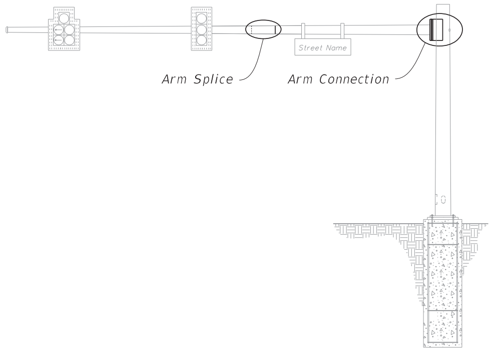
JOINT WELD DETAIL

DETAIL 'A'

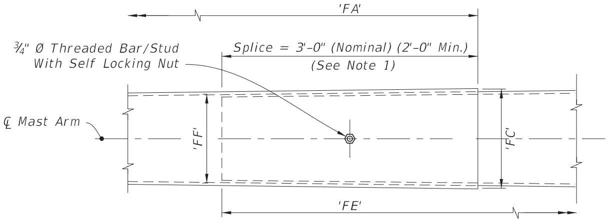
FOUNDATION AND BASE PLATE DETAILS

10/12/2020 8:22:11 AM

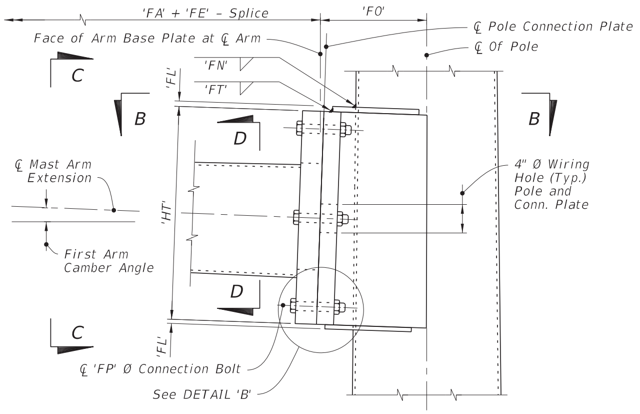
LAST REVISION	REVISION	DESCRIPTION:	FDOT	FY 2021-22 STANDARD PLANS	MAST ARM ASSEMBLIES	INDEX	SHEET
11/01/19						649-031	2 of 6



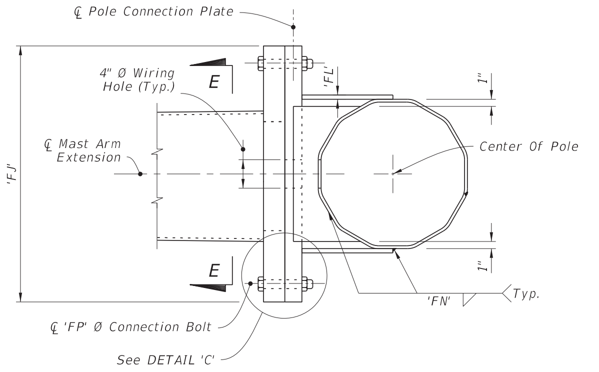
MAST ARM ASSEMBLY



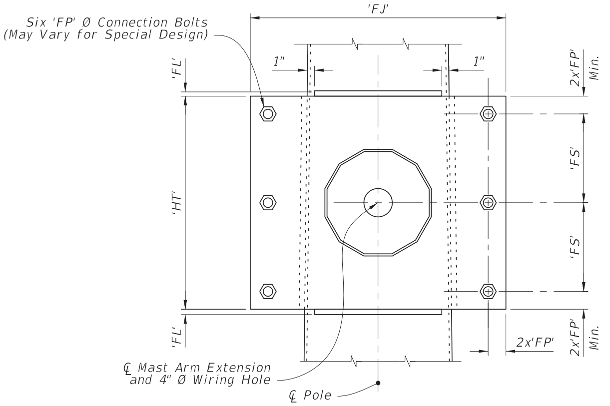
ARM SPLICE



SINGLE ARM CONNECTION



SECTION B-B



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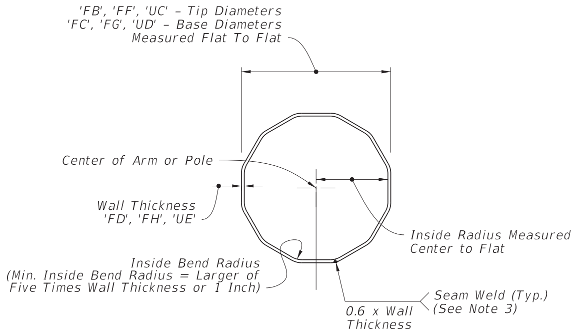
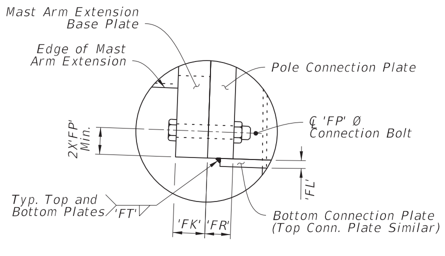
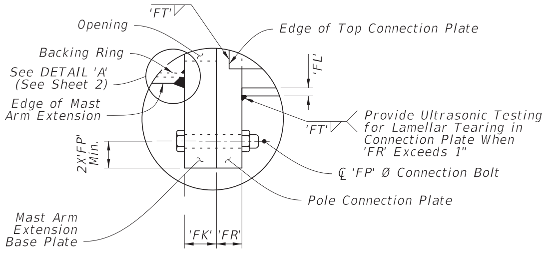


SECTION D-D



DETAIL 'B'



DETAIL 'C'

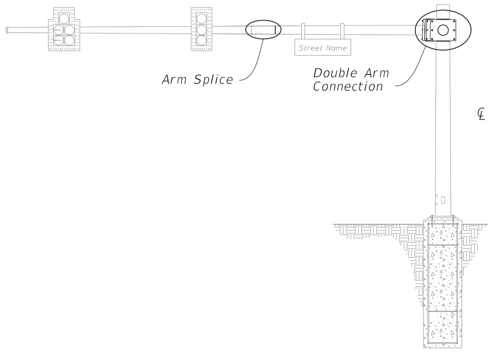
NOTE:

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).

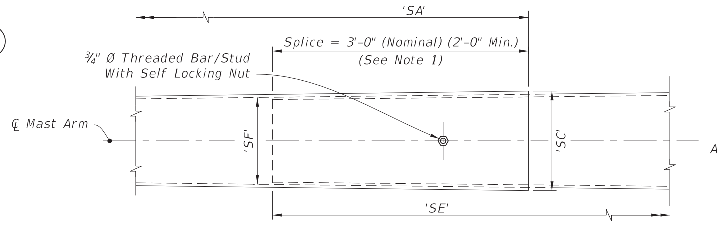
SINGLE ARM CONNECTIONS & SPLICE DETAILS

10/12/2020 8:22:17 AM

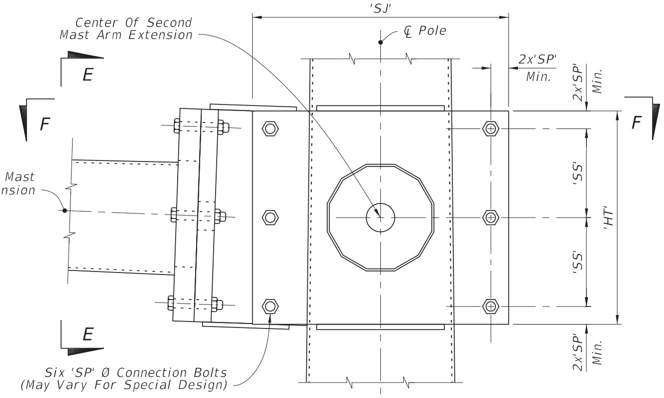
LAST REVISION	REVISION	DESCRIPTION:	FDOT	FY 2021-22 STANDARD PLANS	MAST ARM ASSEMBLIES	INDEX	SHEET
11/01/18						649-031	3 of 6



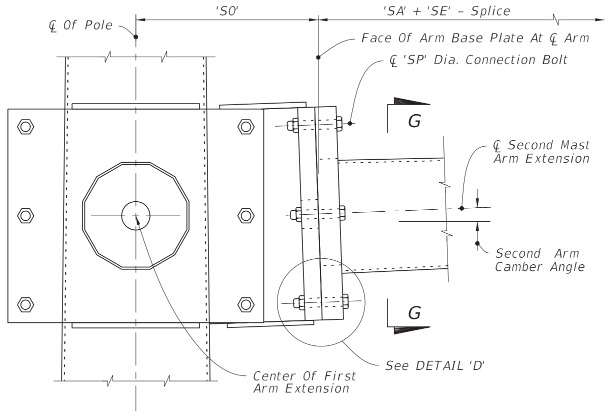
MAST ARM ASSEMBLY



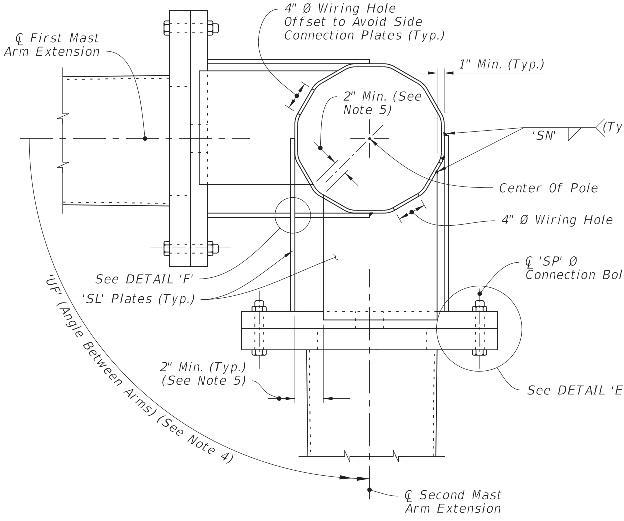
ARM SPLICE



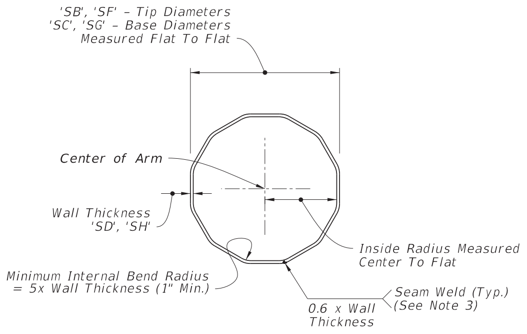
DOUBLE ARM CONNECTION



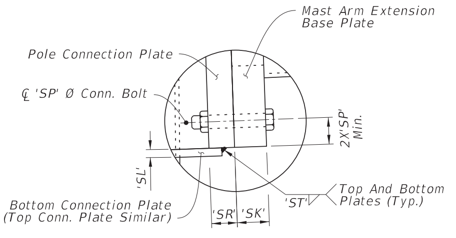
SECTION E-E



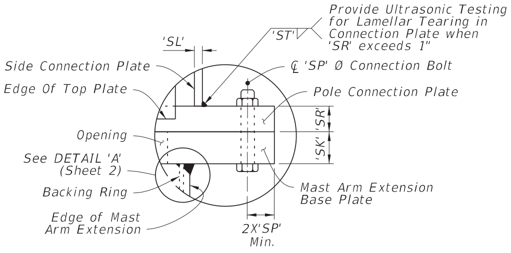
SECTION F-F



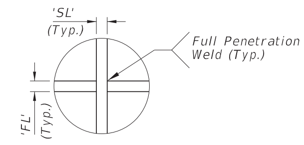
SECTION G-G



DETAIL 'D'



DETAIL 'E'



DETAIL 'F'

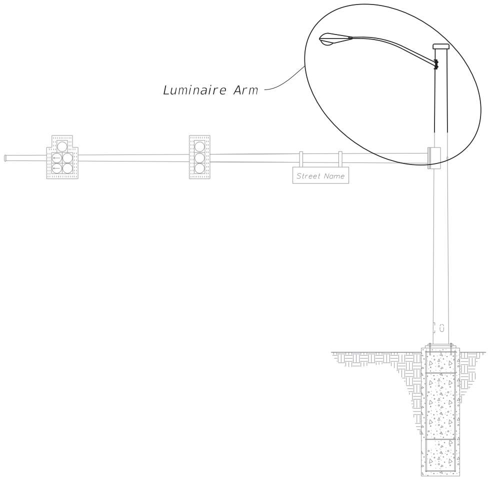
NOTE:

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.

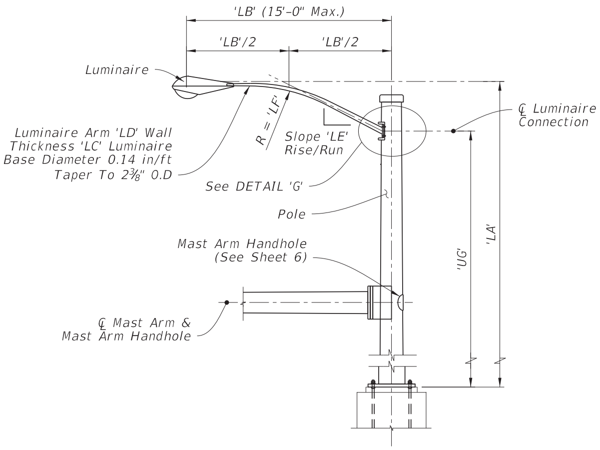
DOUBLE ARM CONNECTIONS & SPLICE DETAILS

10/12/2020 8:22:21 AM

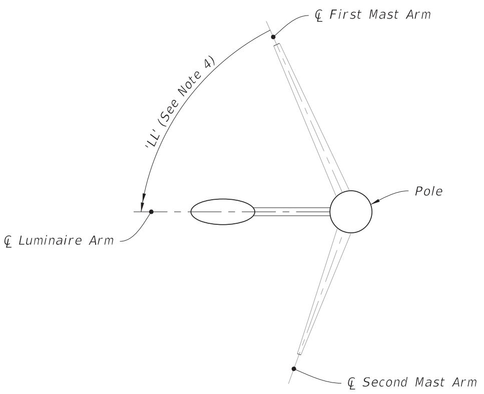
LAST REVISION	REVISION	DESCRIPTION:	FDOT	FY 2021-22 STANDARD PLANS	MAST ARM ASSEMBLIES	INDEX	SHEET
11/01/19						649-031	4 of 6



MAST ARM ASSEMBLY



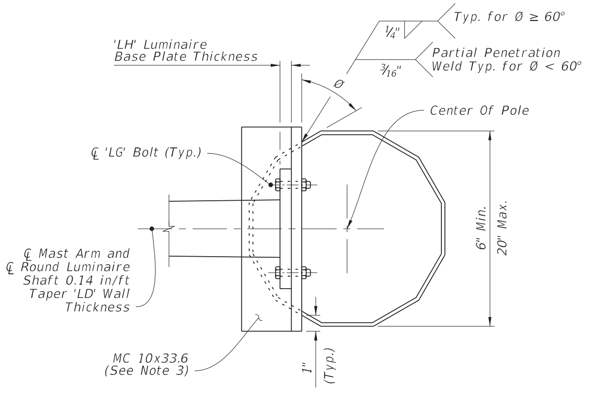
LUMINAIRE ELEVATION



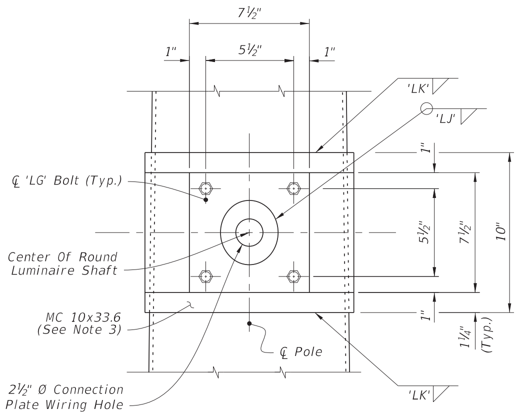
LUMINAIRE ORIENTATION

NOTES:

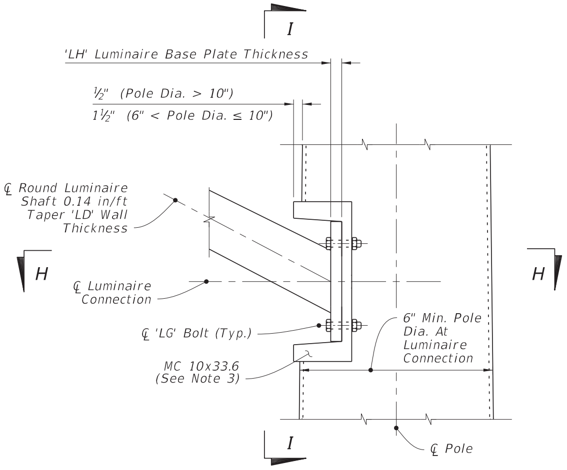
1. Galvanized steel luminaire type and luminaire length may be found in the Lighting Plans.
2. Align Luminaire Arm with Single Mast Arm or First Arm of Double Mast Arm unless indicated otherwise in the plans.
3. The fabricator may substitute a ½" thick bent plate with the same flange width, height, and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



SECTION H-H



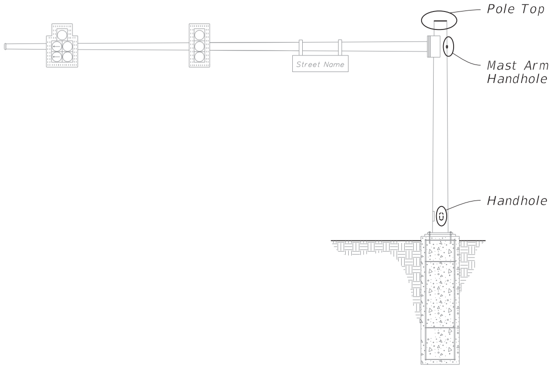
SECTION I-I



LUMINAIRE CONNECTION ELEVATION

DETAIL 'G'

LUMINAIRE ARM AND CONNECTION DETAILS



MAST ARM ASSEMBLY

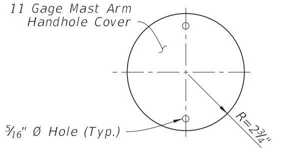
NOTES:

1. Handhole covers may be omitted when Terminal Compartment is provided.

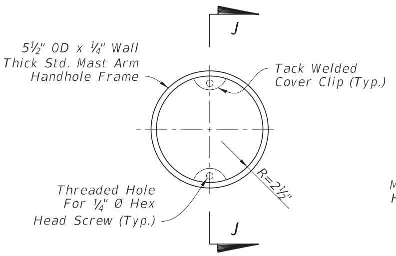
2. See Mast Arm Tabulation sheet to see if Terminal Compartment is required and for locations.

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.

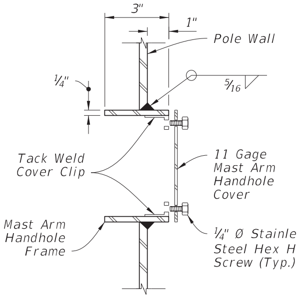
4. Any combination of Option 'a' or 'b' may be used, provided both lifting and wiring is accommodated.



COVER

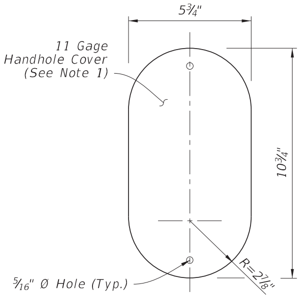


FRAME

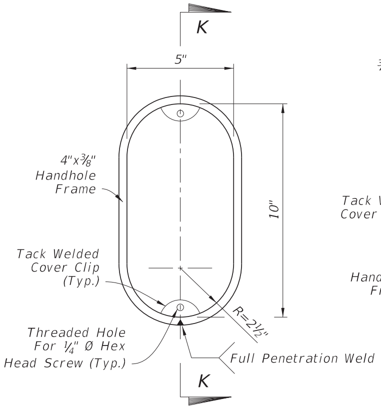


SECTION J-J

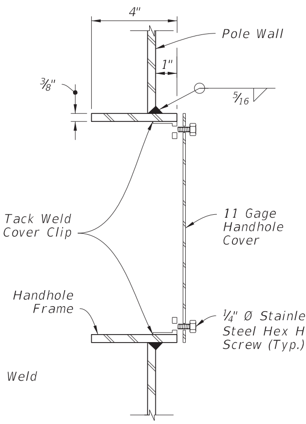
MAST ARM HANDHOLE



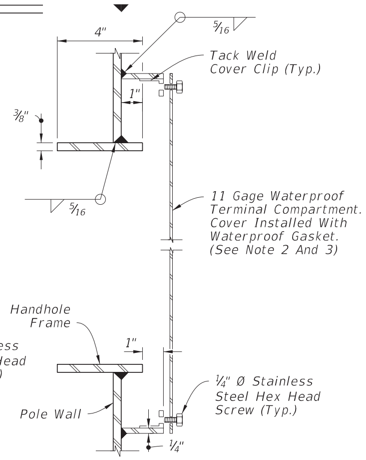
COVER



FRAME

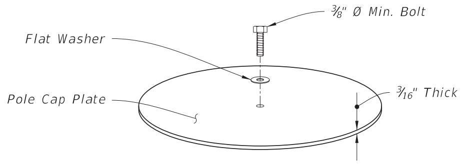


SECTION K-K
(Thru Handhole)

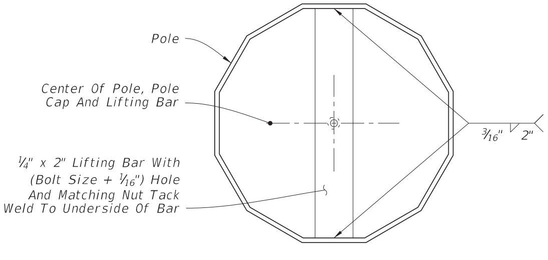


SECTION K-K
(Terminal Compartment)

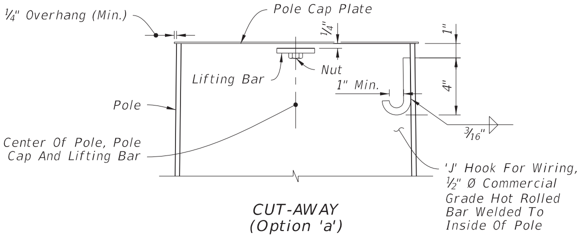
HANDHOLE



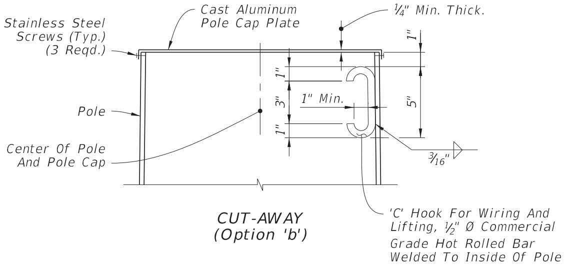
ISO VIEW
(Option 'a')



TOP VIEW
(Option 'a')



CUT-AWAY
(Option 'a')

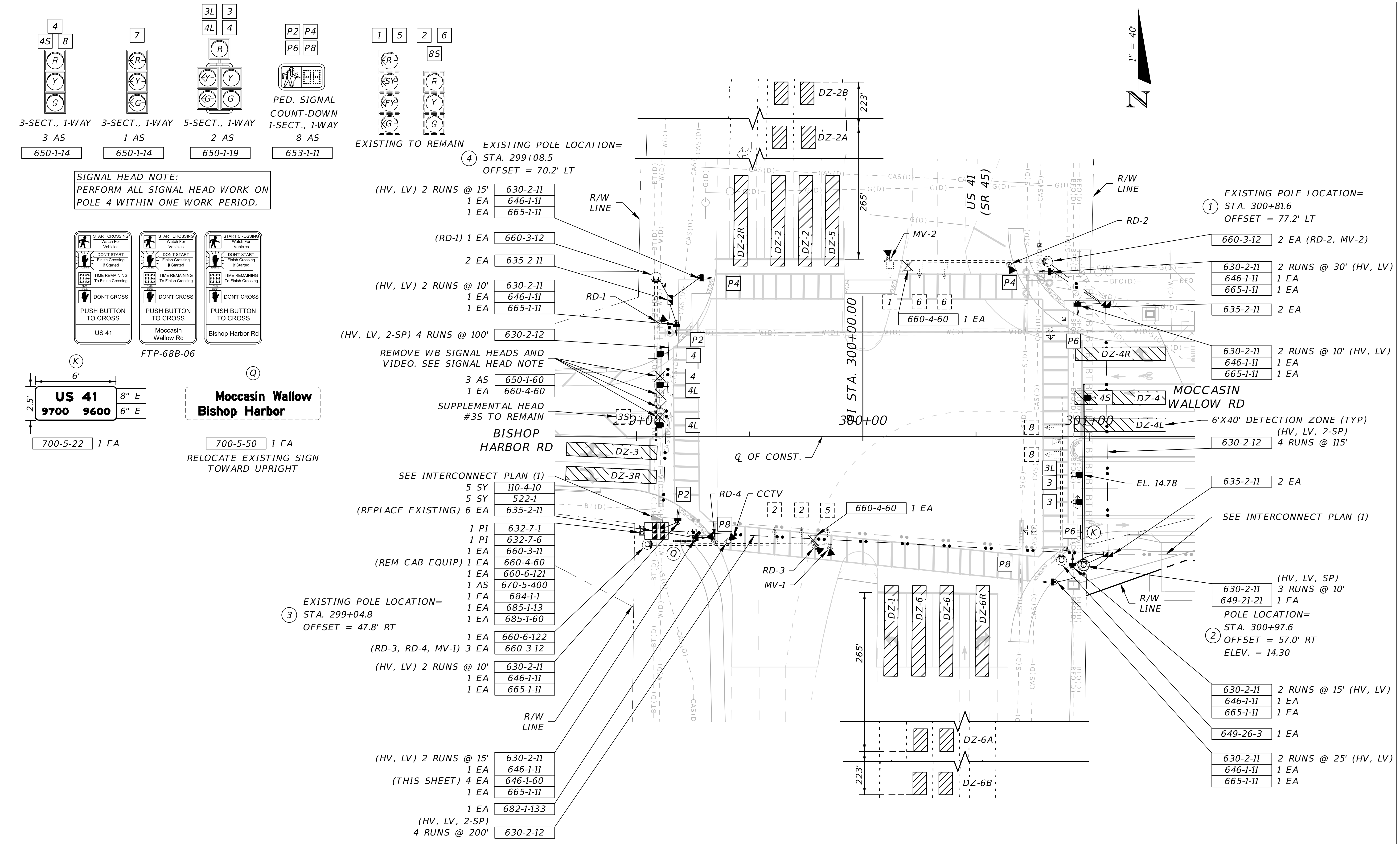


CUT-AWAY
(Option 'b')

POLE TOP

HANDHOLE AND POLE TOP DETAILS

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



SIGNAL HEAD NOTE:
PERFORM ALL SIGNAL HEAD WORK ON POLE 4 WITHIN ONE WORK PERIOD.

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REVISIONS

DATE	DESCRIPTION	DATE	DESCRIPTION
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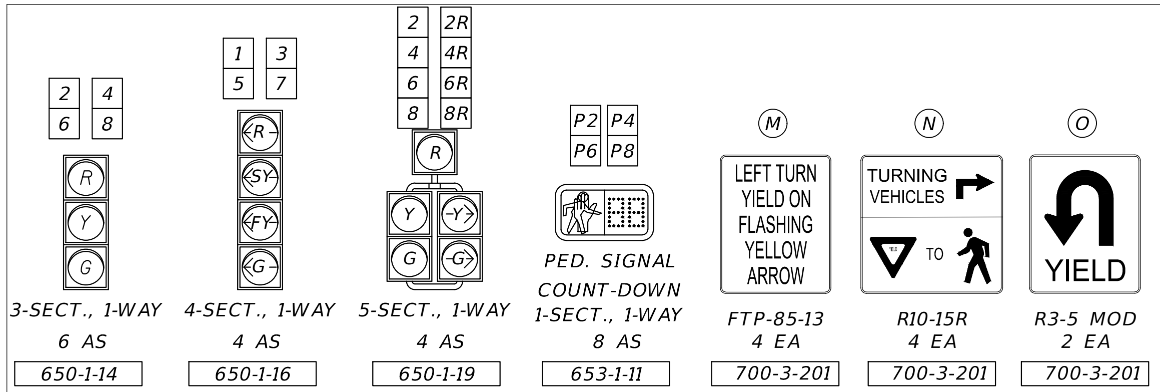
DAVID J. ALLEN, P.E.
P.E. LICENSE NUMBER 58540
CARDNO
3905 CRESCENT PARK DRIVE
RIVERVIEW, FLORIDA 33578
CERTIFICATE OF AUTHORIZATION 29915

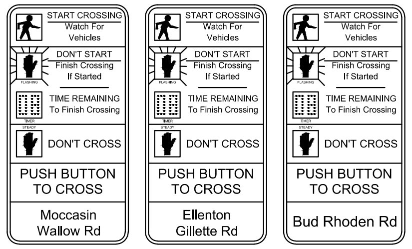
MANATEE COUNTY

ROAD NO.	PROJECT ID
MOCCASIN WALLOW RD	6092560

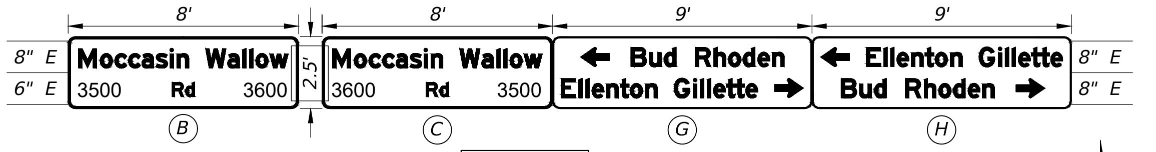
SIGNALIZATION PLAN (1)

SHEET NO.
T-10





FTP-68B-06



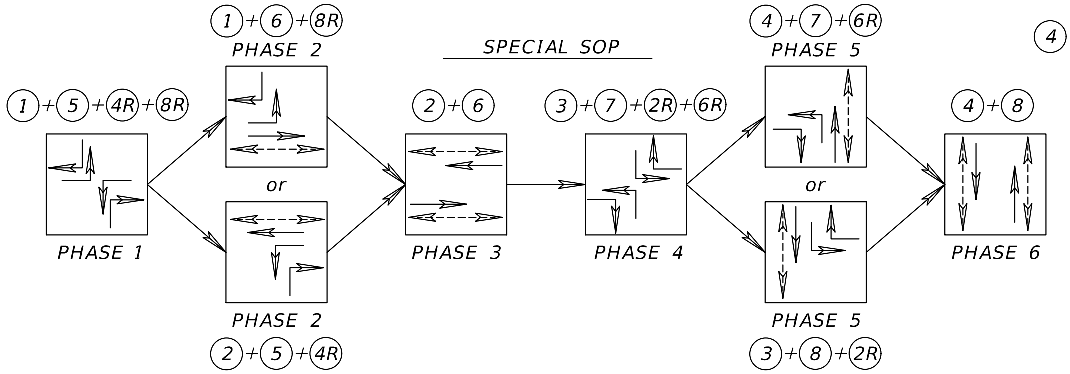
700-5-22 4 EA

CONTROLLER OPERATION

1. MAJOR STREET IS MOCCASIN WALLOW RD, MINOR STREET IS BUD RHODEN RD/ELLENTON GILLETTE RD.

NOTES:

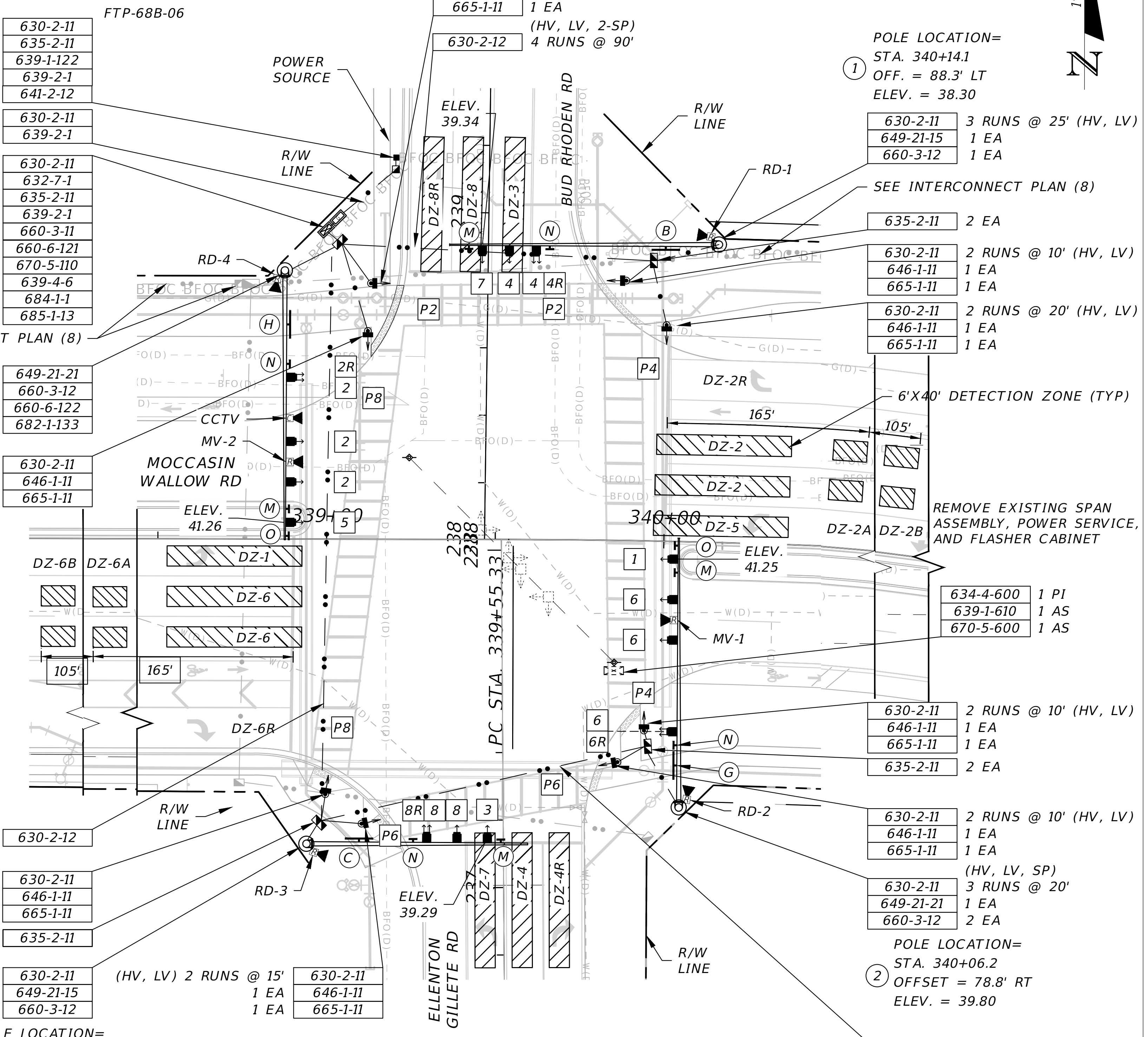
1. POSTED SPEED FOR MOCCASIN WALLOW ROAD IS 45 MPH. POSTED SPEED FOR 36TH AVENUE EAST IS 40 MPH AND ELLENTON GILLETTE ROAD IS 45 MPH.



DETECTOR ZONES			
ZONE LOCATION NO.	RADAR/ MVDS NO.	NO. OF DETECTION ZONES	DELAY TIME (SEC)
DZ-1	RD-4	1	0
DZ-2	RD-2	2	0
DZ-2R	RD-2	1	8
DZ-3	RD-1	1	0
DZ-4	RD-3	1	0
DZ-4R	RD-3	1	8
DZ-5	RD-2	1	0
DZ-6	RD-4	2	0
DZ-6R	RD-4	1	8
DZ-7	RD-3	1	0
DZ-8	RD-1	1	0
DZ-8R	RD-1	1	8
DZ-2A	MV-2	2	N/A
DZ-2B	MV-2	2	N/A
DZ-6A	MV-1	2	N/A
DZ-6B	MV-1	2	N/A

CONTROLLER TIMINGS									
TIMING FUNCTION									
MOVEMENT NUMBER		1	2	3	4	5	6	7	8
TIMING FUNCTION	MINIMUM GREEN	7	20		7	7	20		7
	EXTENSION	2.5	2.5		2.5	2.5	2.5		2.5
	MAXIMUM GREEN 1	12	30		20	12	30		20
	MAXIMUM GREEN 2								
	YELLOW CLEARANCE	4.8	4.8		4.0	4.8	4.8		4.0
	ALL RED	2.0	2.0		2.0	2.0	2.0		2.0
	PEDESTRIAN WALK		7		7		7		7
	PED. CLEARANCE		31		17		31		17
	RECALL		MIN				MIN		

TIMINGS ARE INITIAL AND MAY REQUIRE FIELD ADJUSTING AS DIRECTED BY PROJECT ENGINEER.



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REVISIONS			
DATE	DESCRIPTION	DATE	DESCRIPTION
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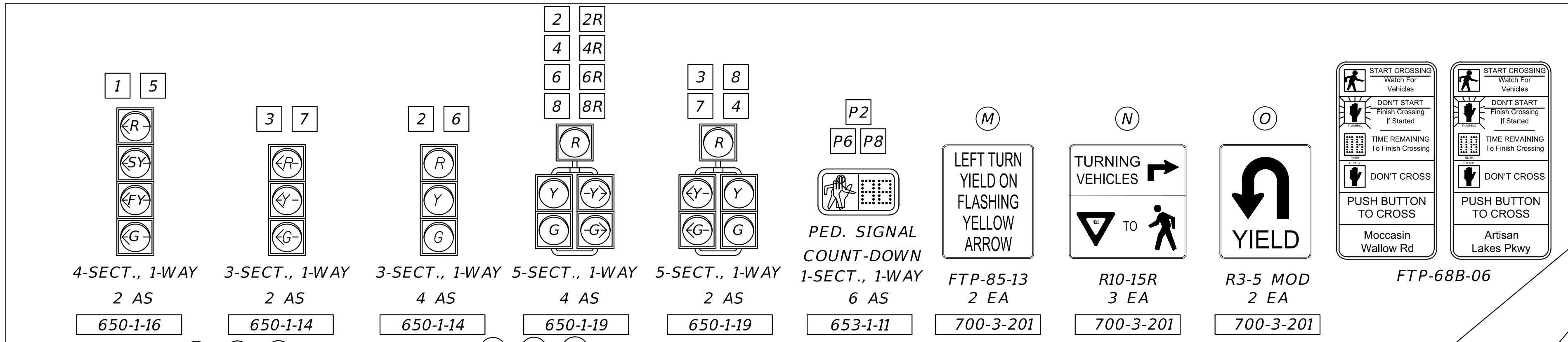
DAVID J. ALLEN, P.E.
P.E. LICENSE NUMBER 58540
CARDNO
3905 CRESCENT PARK DRIVE
RIVERVIEW, FLORIDA 33578
CERTIFICATE OF AUTHORIZATION 29915

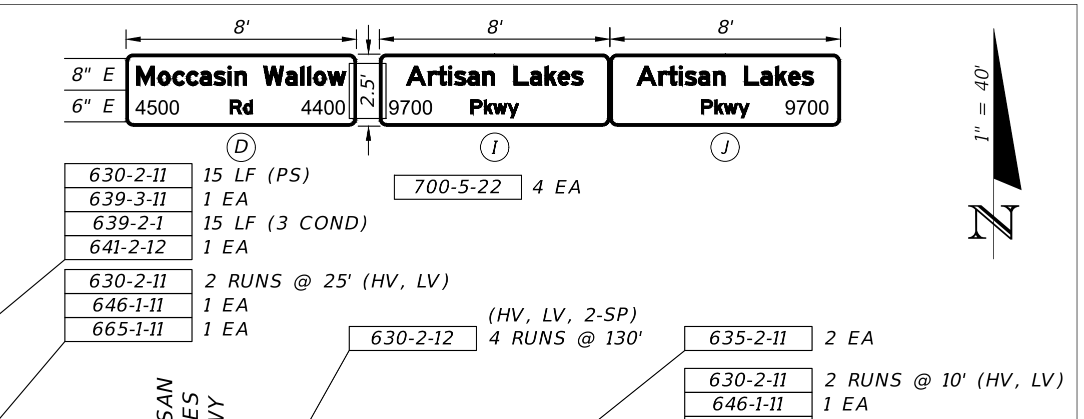
MANATEE COUNTY

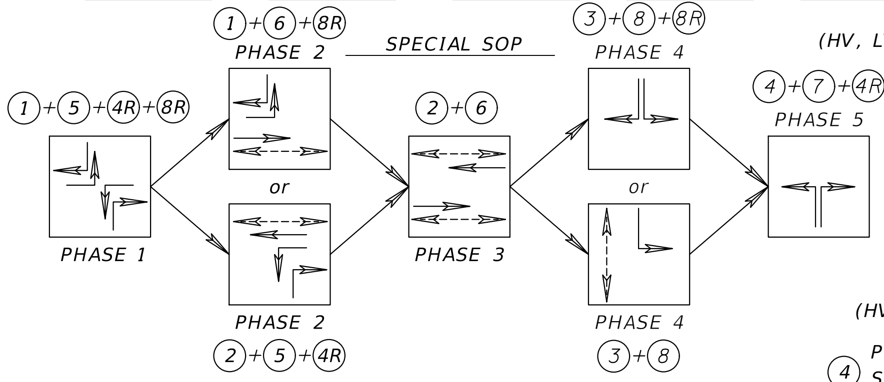
ROAD NO.	PROJECT ID
MOCCASIN WALLOW RD	6092560

SIGNALIZATION PLAN (4)

SHEET NO.
T-13







DETECTOR ZONES			
ZONE LOCATION NO.	RADAR/ MVDS NO.	NO. OF DETECTION ZONES	DELAY TIME (SEC)
DZ-1	RD-4	1	0
DZ-2	RD-2	2	0
DZ-3	RD-1	1	0
DZ-4	RD-3	1	0
DZ-4R	RD-3	1	8
DZ-5	RD-2	1	0
DZ-6	RD-4	2	0
DZ-7	RD-3	1	0
DZ-8	RD-1	1	0
DZ-8R	RD-1	1	8
DZ-2A	MV-2	2	N/A
DZ-2B	MV-2	2	N/A
DZ-6A	MV-1	2	N/A
DZ-6B	MV-1	2	N/A

CONTROLLER OPERATION

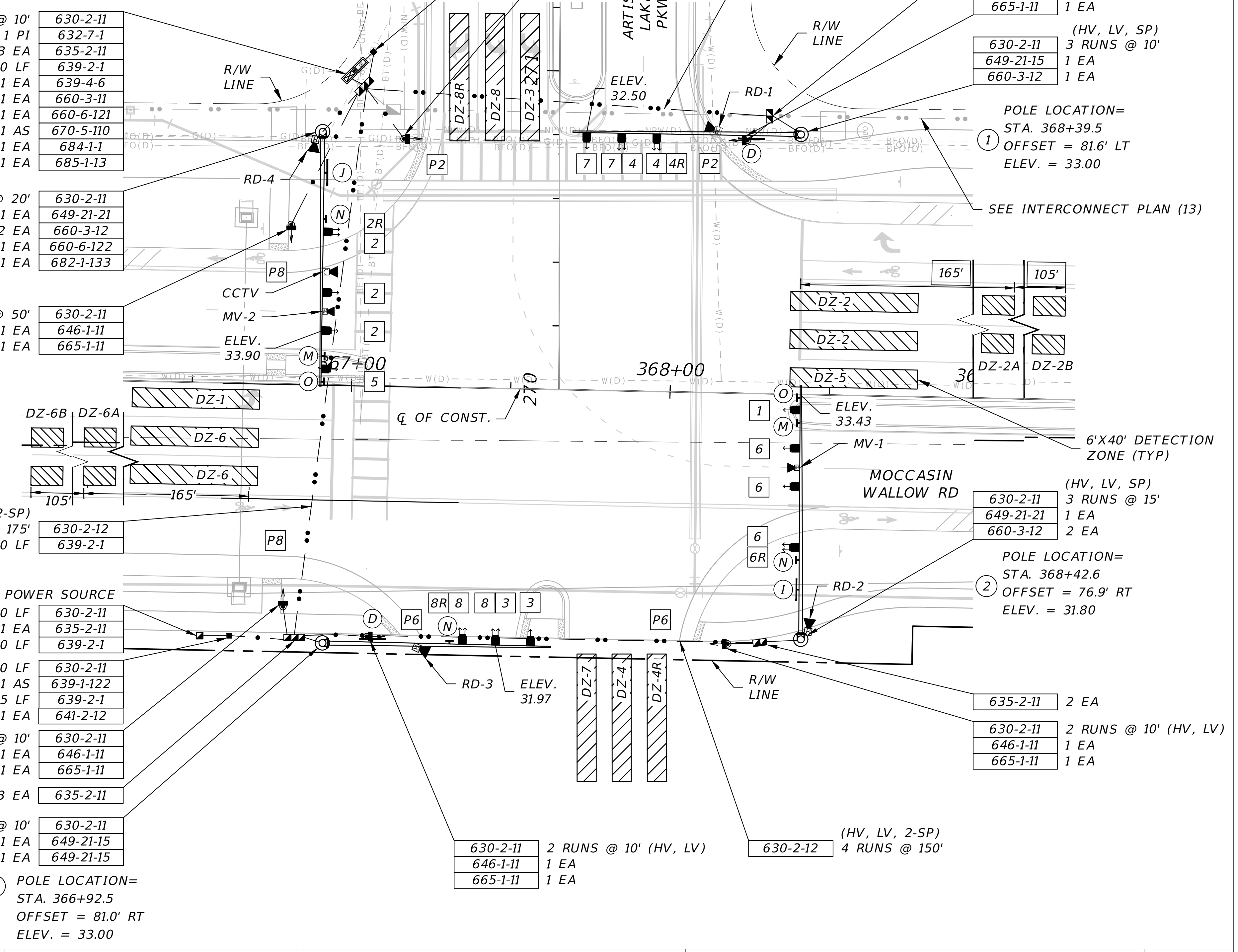
1. MAJOR STREET IS MOCCASIN WALLOW RD, MINOR STREET IS ARTISAN LAKES PARKWAY.

NOTES:

1. POSTED SPEED FOR MOCCASIN WALLOW ROAD IS 45 MPH. POSTED SPEED FOR ARTISAN LAKES PARKWAY IS 35 MPH.

CONTROLLER TIMINGS									
TIMING FUNCTION									
MOVEMENT NUMBER		1	2	3	4	5	6	7	8
TIMING FUNCTION	MINIMUM GREEN	7	20	7	7	7	20	7	7
	EXTENSION	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5
	MAXIMUM GREEN 1	12	30	20	20	12	30	20	20
	MAXIMUM GREEN 2								
	YELLOW CLEARANCE	4.8	4.8	4.0	4.0	4.8	4.8	4.0	4.0
	ALL RED	2.0	2.0	2.1	2.2	2.0	2.0	2.2	2.1
	PEDESTRIAN WALK		7				7		7
	PED. CLEARANCE		XX				XX		XX
	RECALL		MIN				MIN		

TIMINGS ARE INITIAL AND MAY REQUIRE FIELD ADJUSTING AS DIRECTED BY PROJECT ENGINEER.



REVISIONS			
DATE	DESCRIPTION	DATE	DESCRIPTION
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DAVID J. ALLEN, P.E.
P.E. LICENSE NUMBER 58540
CARDNO
3905 CRESCENT PARK DRIVE
RIVERVIEW, FLORIDA 33578
CERTIFICATE OF AUTHORIZATION 29915

MANATEE COUNTY

ROAD NO.	PROJECT ID
MOCCASIN WALLOW RD	6092560

SIGNALIZATION PLAN (6)

SHEET NO.
T-15

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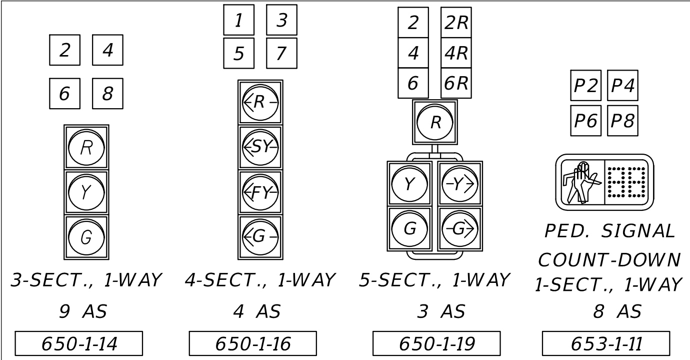
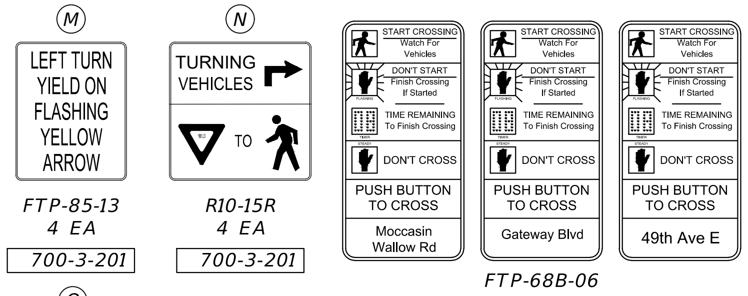
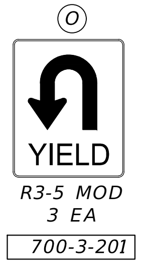
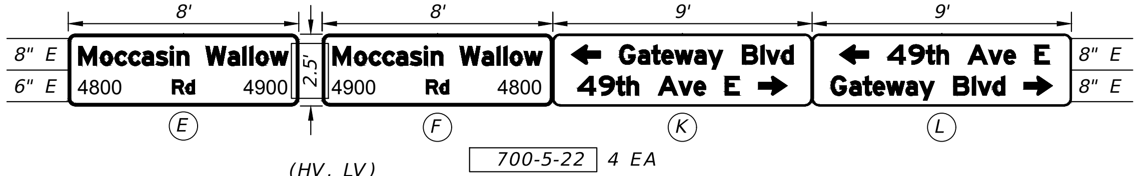






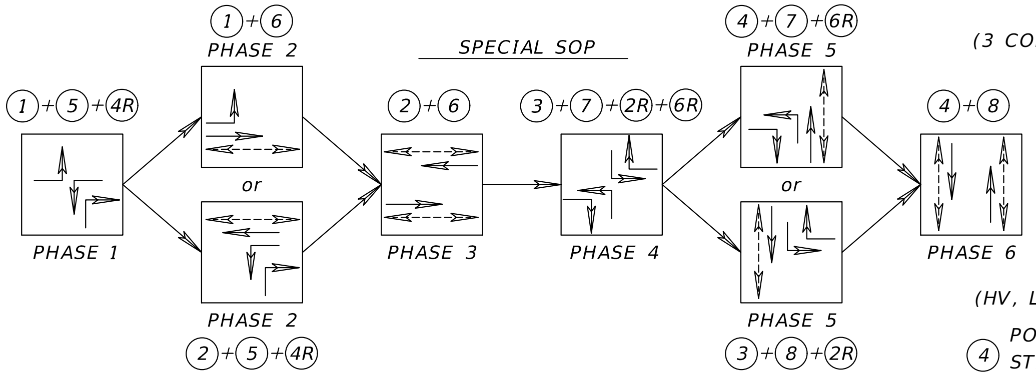


CONTROLLER OPERATION

1. MAJOR STREET IS MOCCASIN WALLOW RD, MINOR STREET IS GATEWAY BLVD/49TH AVE EAST.

NOTES:

1. POSTED SPEED FOR MOCCASIN WALLOW ROAD IS 45 MPH. POSTED SPEED FOR GATEWAY BLVD IS ASSUMED 35 MPH AND 35 FOR 49TH AVE EAST.

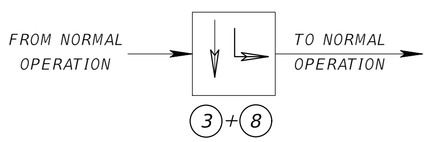


DETECTOR ZONES			
ZONE LOCATION NO.	RADAR/ MVDS NO.	NO. OF DETECTION ZONES	DELAY TIME (SEC)
DZ-1	RD-4	1	0
DZ-2	RD-2	2	0
DZ-2R	RD-2	1	8
DZ-3	RD-1	1	0
DZ-4	RD-3	1	0
DZ-4R	RD-3	1	8
DZ-5	RD-2	1	0
DZ-6	RD-4	2	0
DZ-6R	RD-4	1	8
DZ-7	RD-3	1	0
DZ-8	RD-1	1	0
DZ-2A	MV-2	2	N/A
DZ-2B	MV-2	2	N/A
DZ-6A	MV-1	2	N/A
DZ-6B	MV-1	2	N/A

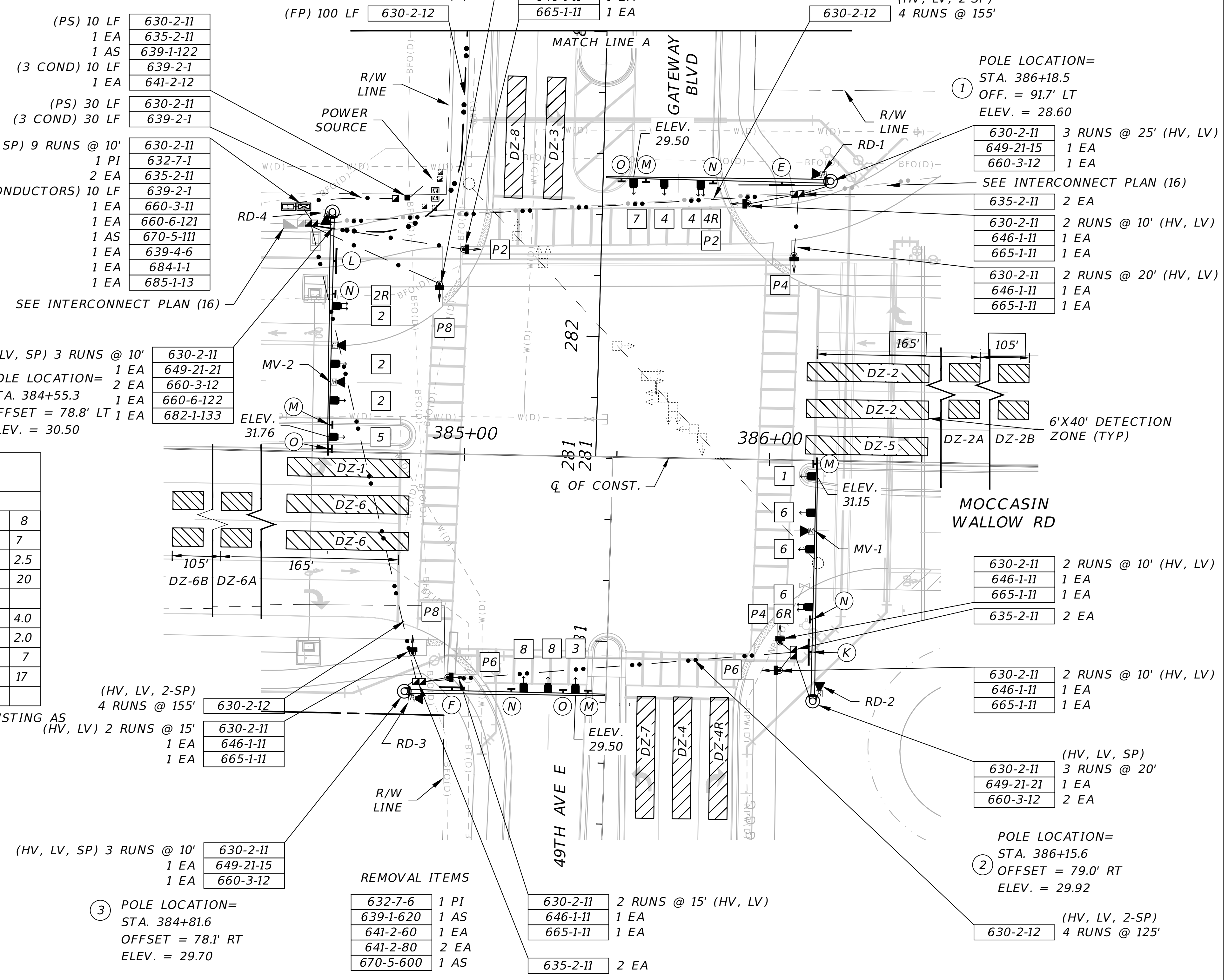
CONTROLLER TIMINGS									
TIMING FUNCTION									
MOVEMENT NUMBER		1	2	3	4	5	6	7	8
TIMING FUNCTION	MINIMUM GREEN	7	20		7	7	20		7
	EXTENSION	2.5	2.5		2.5	2.5	2.5		2.5
	MAXIMUM GREEN 1	12	30		20	12	30		20
	MAXIMUM GREEN 2								
	YELLOW CLEARANCE	4.8	4.8		4.0	4.8	4.8		4.0
	ALL RED	2.0	2.0		2.0	2.0	2.0		2.0
	PEDESTRIAN WALK		7		7		7		7
	PED. CLEARANCE		31		17		31		17
	RECALL		MIN				MIN		

TIMINGS ARE INITIAL AND MAY REQUIRE FIELD ADJUSTING AS DIRECTED BY PROJECT ENGINEER.

SPECIAL P.O.P.



DWELL 45 SECONDS
TIMINGS TO BE ADJUSTED BY THE COUNTY



REMOVAL ITEMS

632-7-6	1 PI
639-1-620	1 AS
641-2-60	1 EA
641-2-80	2 EA
670-5-600	1 AS

REVISIONS			
DATE	DESCRIPTION	DATE	DESCRIPTION
----	----		

DAVID J. ALLEN, P.E.
P.E. LICENSE NUMBER 58540
CARDNO
3905 CRESCENT PARK DRIVE
RIVERVIEW, FLORIDA 33578
CERTIFICATE OF AUTHORIZATION 29915

MANATEE COUNTY

ROAD NO.	PROJECT ID
MOCCASIN WALLOW RD	6092560

SIGNALIZATION PLAN (8)

SHEET NO.
T-17

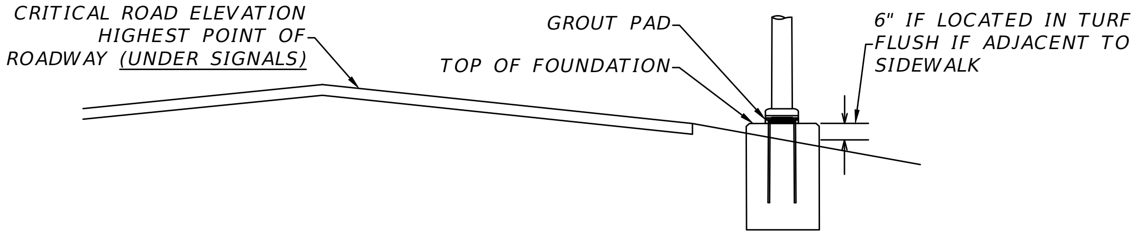
SPECIAL NOTES

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.

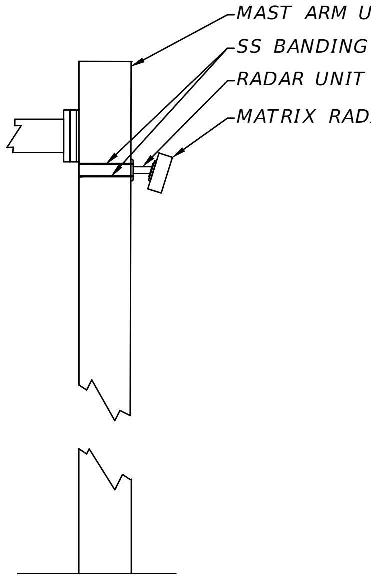
B. ANCHOR BOLT COVERS (ORNAMENTAL, NON-ORNAMENTAL, AND/OR PAINTED) SHALL BE GALVANIZED STEEL OR CAST ALUMINUM AND SHALL BE SECURED BY A MINIMUM OF TWO (2) THREADED FASTENERS. THE BOLT COVERS SHALL BE OF SUFFICIENT SIZE SO THAT THERE IS NO GAP BETWEEN ITSELF AND THE POLE SHAFT.

C. IT SHALL BE THE CONTRACTOR'S RESPONSIBILITY TO FIELD VERIFY ALL ELEVATIONS LISTED IN THE PLANS.

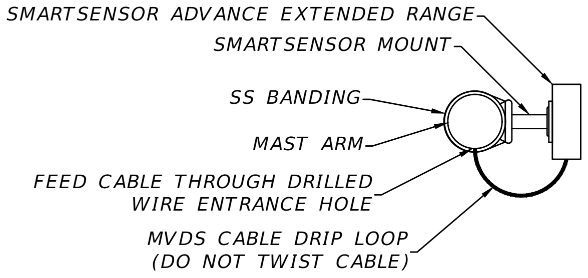
D. ALL MAST ARM POLES SHALL BE GALVANIZED, NON-PAINTED.



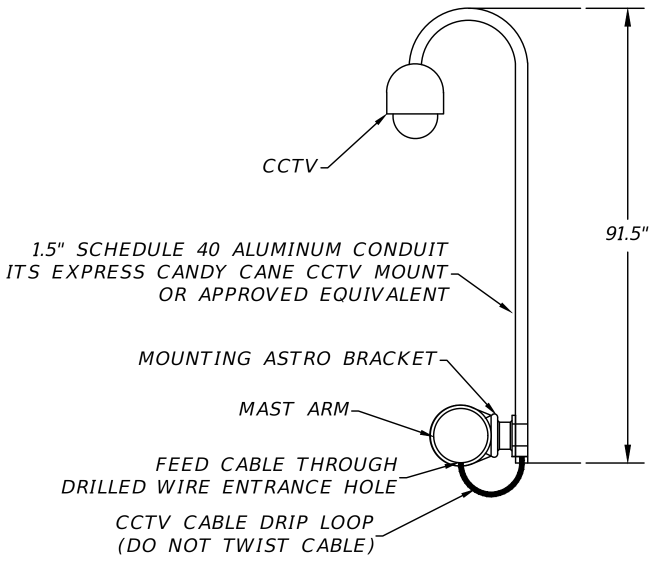
POLE FOUNDATION DETAIL



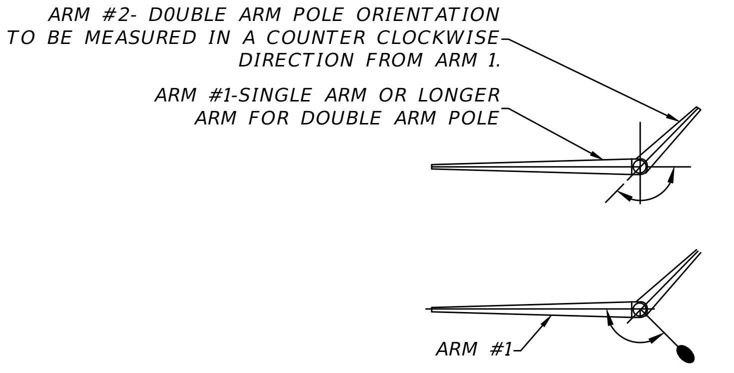
STOP BAR DETECTION
MVDS MOUNTING DETAIL



DILEMMA ZONE MVDS
MOUNTING DETAIL

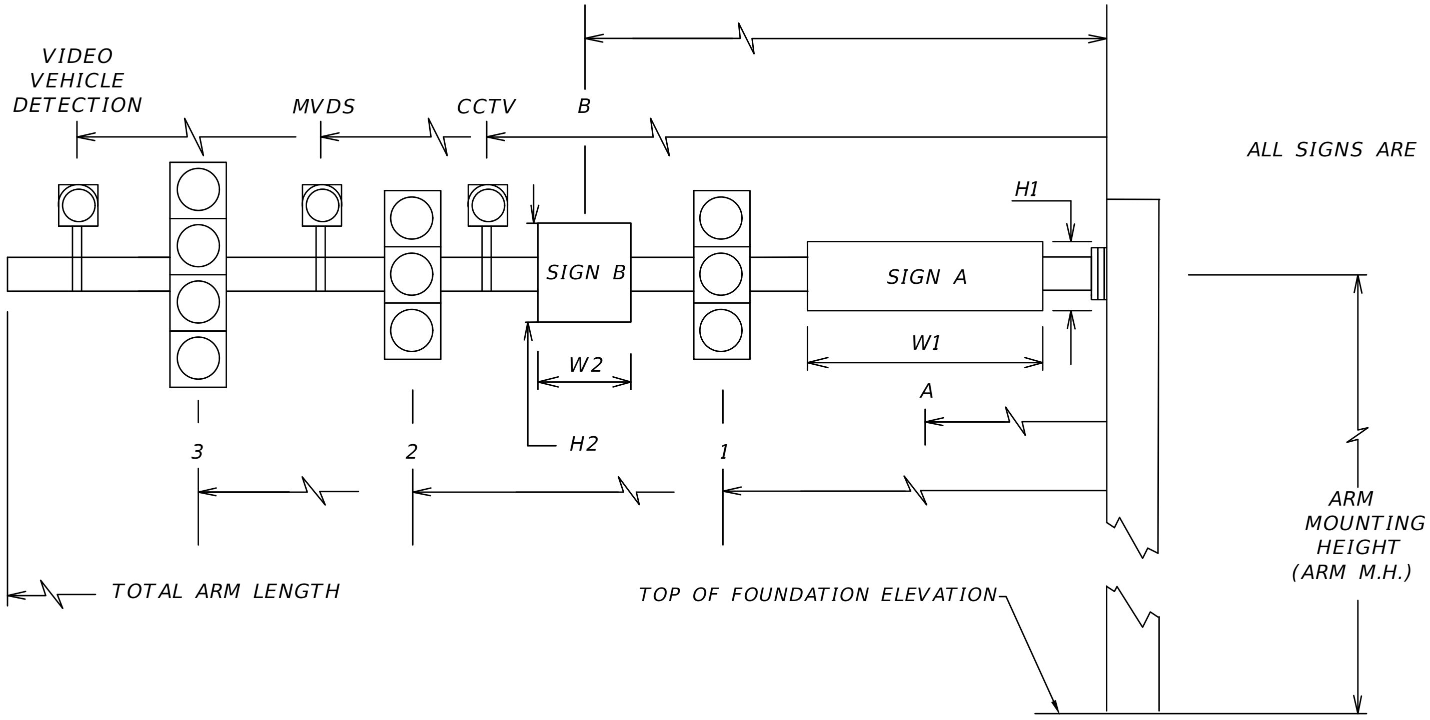


CCTV MOUNTING DETAIL



LUMINAIRE ROTATION TO BE
MEASURED IN A COUNTER
CLOCKWISE DIRECTION FROM ARM

ARM ORIENTATION DETAIL



ALL SIGNS ARE RIGIDLY MOUNTED TO MAST ARM

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

REVISIONS

DATE	DESCRIPTION	DATE	DESCRIPTION
----	----		

DAVID J. ALLEN, P.E.
P.E. LICENSE NUMBER 58540
CARDNO
3905 CRESCENT PARK DRIVE
RIVERVIEW, FLORIDA 33578
CERTIFICATE OF AUTHORIZATION 29915

MANATEE COUNTY

ROAD NO.	PROJECT ID
MOCCASIN WALLOW RD	6092560

MAST ARM TABULATION (1)

SHEET NO.
T-46

* DENOTES NUMBER OF SECTIONS IN SIGNAL HEAD ASSEMBLY

-- FIELD INSTALLATION DATA --

FDOT ID NO.	SHEET-POLE NO.	LOCATION BY STA.	TOP OF FOUND. ELEVATION	RDWY ARM NO.	CROWN ELEV.	SIGNAL DATA													TOTAL ARM LENGTH	ARM M.H.	ANGLE BETWEEN DUAL ARMS	SIGN DATA												CCTV OR MVDS DISTANCE			
						SIGNAL V/H	BACK PLATES Y/N	PED. SIGNAL Y/N	DISTANCE FROM POLE													DISTANCE FROM POLE / HEIGHT AND WIDTH OF SIGN															
									1	*	2	*	3	*	4	*	5	*				A	H1	W1	B	H2	W2	C	H3	W3	D	H4	W4	1	2	3	4
13M144	T-10-1	300+81.6 77.2 LT	N/A	1	N/A	V	Y	N	(44)	(3)	(55)	(3)	(68)	(4)					(70.5)	(22)	N/A	(10)	(2.5)	(6)										16	69		
13M144	T-10-2	300+97.6 57.0 RT	14.30	1	14.78	V	Y	N	26	3	38	5	75.5	3					78	21	N/A	13	2.5	6													
13M144	T-10-3	299+04.8 47.8 RT	N/A	1	N/A	V	Y	N	(54.5)	(3)	(66.5)	(3)	(78)	(3)					(80)	(23.5)	N/A	15	(2.5)	(10)										30	34	75	79
13M144	T-10-4	299+08.5 70.2 LT	N/A	1	N/A	V	Y	N	32	3	46	5	(60)	(3)	63.5	3			(70.5)	(23)	N/A	(10)	(2.5)	(6)										19			
---	T-13-1	340+14.1 88.3 LT	38.30	1	39.34	V	Y	N	52.5	5	60.5	3	68.5	4					78	22	N/A	14	2.5	8	48.5	2.5	2.5	72.5	3	2.5							
---	T-13-2	340+06.2 78.8 RT	39.80	1	41.25	V	Y	N	21	5	48	3	60	3	72	4			78	21	N/A	10.5	2.5	9	17	2.5	2.5	68	3	2.5	76	3	2.5	54			
---	T-13-3	338+94.2 90.3 RT	39.50	1	39.29	V	Y	N	34	5	43	3	52	4					64	22.00	N/A	14	2.5	8	30	2.5	2.5	56	3	2.5							
---	T-13-4	338+87.5 79.6 LT	39.80	1	41.26	V	Y	N	30	5	49	3	61	3	73	4			78	22	N/A	14.5	2.5	9	26	2.5	2.5	69	3	2.5	77	3	2.5	42	55		
---	T-15-1	368+39.5 81.6 LT	33.00	1	32.50	V	Y	N	44	5	55	5	66	3					70	XX	N/A	14	2.5	8										22			
---	T-15-2	368+42.6 76.9 RT	31.80	1	33.43	V	Y	N	27	5	46	3	58	3	70	4			78	XX	N/A	14	2.5	8	23	2.5	2.5	66	3	2.5	74	3	2.5	52			
---	T-15-3	366+92.5 81.0 RT	33.00	1	31.97	V	Y	N	42	5	53	5	64	3					70	XX	N/A	14	2.5	8	38	2.5	2.5							26			
---	T-15-4	366+89.4 79.4 LT	33.76	1	33.90	V	Y	N	30	5	49	3	61	3	73	4			78	XX	N/A	14	2.5	8	26	2.5	2.5	69	3	2.5	76	3	2.5	42	67		
---	T-17-1	386+18.5 91.7 LT	28.60	1	29.50	V	Y	N	41	5	53	3	63	4					72	22	N/A	14	2.5	8	37	2.5	2.5	59	3	2.5	67	3	2.5				
---	T-17-2	386+15.6 79.0 RT	29.92	1	31.15	V	Y	N	29	5	48	3	60	3	72	4			78	21	N/A	14.5	2.5	9	25	2.5	2.5	76	3	2.5				54			
---	T-17-3	384+81.63 78.1 RT	29.70	1	29.50	V	Y	N	37.5	3	45.5	3	54.5	4					64	22	N/A	14	2.5	8	33.5	2.5	2.5	50	3	2.5	58.5	3	2.5				
---	T-17-4	384+55.3 78.8 LT	30.50	1	31.76	V	Y	N	29	5	48	3	60	3	72	4			78	22	N/A	14.5	2.5	9	25	2.5	2.5	68	3	2.5	76	3	2.5	42	54		

(XX) = EXISTING MAST ARM AND ATTACHMENT VALUES. EXISTING MAST ARM DATA AS PER FDOT PROJECT ID 432661-1-52-01.

*** THE TABLE BELOW IS FOR DESIGN PURPOSES ONLY! THE CONTRACTOR SHALL NOT USE INFORMATION BELOW IN PLACEMENT OF THE SIGNALS AND/OR SIGNS. SEE INFORMATION IN THE TABLE LOCATED ABOVE FOR FIELD INSTALLATION.

* DENOTES NUMBER OF SECTIONS IN SIGNAL HEAD ASSEMBLY

-- MAST ARM DESIGN DATA --

FDOT ID NO.	SHEET-POLE NO.	LOCATION BY STA.	TOP OF FOUND. ELEVATION	RDWY ARM NO.	CROWN ELEV.	SIGNAL DATA													TOTAL ARM LENGTH	ARM M.H.	ANGLE BETWEEN DUAL ARMS	SIGN DATA												CCTV OR MVDS DISTANCE			
						SIGNAL V/H	BACK PLATES Y/N	PED. SIGNAL Y/N	DISTANCE FROM POLE													DISTANCE FROM POLE / HEIGHT AND WIDTH OF SIGN															
									1	*	2	*	3	*	4	*	5	*				A	H1	W1	B	H2	W2	C	H3	W3	D	H4	W4	1	2	3	4
13M144	T-10-1	300+81.6 77.2 LT	N/A	1	N/A	V	Y	N	(44)	(3)	(55)	(3)	(68)	(4)					(70.5)	(22)	N/A	(10)	(2.5)	(6)										16	69		
13M144	T-10-2	300+97.6 57.0 RT	14.30	1	14.78	V	Y	N	26	3	38	5	75.5	3					78	21	N/A	13	2.5	6													
13M144	T-10-3	299+04.8 47.8 RT	N/A	1	N/A	V	Y	N	(54.5)	(3)	(66.5)	(3)	(78)	(3)					(80)	(23.5)	N/A	15	(2.5)	(10)										30	34	75	79
13M144	T-10-4	299+08.5 70.2 LT	N/A	1	N/A	V	Y	N	32	3	46	5	(60)	(3)	63.5	3			(70.5)	(23)	N/A	(10)	(2.5)	(6)										19			
---	T-13-1	340+14.1 88.3 LT	38.30	1	39.34	V	Y	N	52.5	5	60.5	3	68.5	4					78	22	N/A	14	2.5	8	48.5	2.5	2.5	72.5	3	2.5							
---	T-13-2	340+06.2 78.8 RT	39.80	1	41.25	V	Y	N	21	5	48	3	60	3	72	4			78	21	N/A	10.5	2.5	9	17	2.5	2.5	68	3	2.5	76	3	2.5	54			
---	T-13-3	338+94.2 90.3 RT	39.50	1	39.29	V	Y	N	34	5	43	3	52	4					64	22	N/A	14	2.5	8	30	2.5	2.5	56	3	2.5							
---	T-13-4	338+87.5 79.6 LT	39.80	1	41.26	V	Y	N	30	5	49	3	61	3	73	4			78	22	N/A	14.5	2.5	9	26	2.5	2.5	69	3	2.5	77	3	2.5	42	55		
---	T-15-1	368+39.5 81.6 LT	33.00	1	32.50	V	Y	N	44	5	55	5	66	3					70	XX	N/A	14	2.5	8										22			
---	T-15-2	368+42.6 76.9 RT	31.80	1	33.43	V	Y	N	27	5	46	3	58	3	70	4			78	XX	N/A	14	2.5	8	23	2.5	2.5	66	3	2.5	74	3	2.5	52			
---	T-15-3	366+92.5 81.0 RT	33.00	1	31.97	V	Y	N	42	5	53	5	64	3					70	XX	N/A	14	2.5	8	38	2.5	2.5							26			
---	T-15-4	366+89.4 79.4 LT	33.76	1	33.90	V	Y	N	30	5	49	3	61	3	73	4			78	XX	N/A	14	2.5	8	26	2.5	2.5	69	3	2.5	76	3	2.5	42	67		
---	T-17-1	386+18.5 91.7 LT	28.60	1	29.50	V	Y	N	41	5	53	3	63	4					72	22	N/A	14	2.5	8	37	2.5	2.5	59	3	2.5	67	3	2.5				
---	T-17-2	386+15.6 79.0 RT	29.92	1	31.15	V	Y	N	29	5	48	3	60	3	72	4			78	21	N/A	14.5	2.5	9	25	2.5	2.5	76	3	2.5				54			
---	T-17-3	384+81.63 78.1 RT	29.70	1	29.50	V	Y	N	37.5	3	45.5	3	54.5	4					64	22	N/A	14	2.5	8	33.5	2.5	2.5	50	3	2.5	58.5	3	2.5				
---	T-17-4	384+55.3 78.8 LT	30.50	1	31.76	V	Y	N	29	5	48	3	60	3	72	4			78	22	N/A	14.5	2.5	9	25	2.5	2.5	68	3	2.5	76	3	2.5	42	54		

(XX) = EXISTING MAST ARM AND ATTACHMENT VALUES. EXISTING MAST ARM DATA AS PER FDOT PROJECT ID 432661-1-52-01.

REVISIONS

DATE	DESCRIPTION	DATE	DESCRIPTION
----	----		

DAVID J. ALLEN, P.E.
P.E. LICENSE NUMBER 58540
CARDNO
3905 CRESCENT PARK DRIVE
RIVERVIEW, FLORIDA 33578
CERTIFICATE OF AUTHORIZATION 29915

MANATEE COUNTY

ROAD NO.	PROJECT ID
MOCCASIN WALLOW RD	6092560

MAST ARM TABULATION (2)

SHEET NO.
T-47

STANDARD MAST ARM ASSEMBLIES DATA TABLE

Table Date 11-01-16

FDOT STRUCTURE ID NUMBER	SHEET-POLE NO.	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.)	
13M144	T-10-2	A78/S-P6/S-DS/16/4.5	A78/S	---	---	---	---	---	P6/S	24.0	21.0	DS/16/4.5
---	T-13-1	A78/S-P6/S-DS/25/5.0	A78/S	---	---	---	---	---	P6/S	---	22.0	DS/25/5.0
---	T-13-2	A78/S-P6/S/L-DS/25/5.0	A78/S	---	---	---	---	---	P6/S/L	---	22.0	DS/25/5.0
---	T-13-3	A70/S-P5/S-DS/25/5.0	A70/S	32.0	---	---	---	---	P5/S	24.0	21.0	DS/25/5.0
---	T-13-4	A78/S/H-P6/S-DS/20/5.0	A78/S/H	---	---	---	---	---	P6/S	---	22.0	DS/20/5.0
---	T-15-1	A70/S-P5/S-DS/25/5.0	A70/S	---	---	---	---	---	P5/S	---	22.0	DS/25/5.0
---	T-15-2	A78/S-P6/S-DS/25/5.0	A78/S	---	---	---	---	---	P6/S	24.0	21.0	DS/25/5.0
---	T-15-3	A70/S-P5/S-DS/25/5.0	A70/S	---	---	---	---	---	P5/S	23.0	20.0	DS/25/5.0
---	T-15-4	A78/S/H-P6/S-DS/25/5.0	A78/S/H	---	---	---	---	---	P6/S	24.0	21.0	DS/25/5.0
---	T-17-1	A78/S-P6/S-DS/25/5.0	A78/S	33.0	---	---	---	---	P6/S	---	22.0	DS/25/5.0
---	T-17-2	A78/S-P6/S-DS/25/5.0	A78/S	---	---	---	---	---	P6/S	---	22.0	DS/25/5.0
---	T-17-3	A70/S-P5/S-DS/20/5.0	A70/S	32.0	---	---	---	---	P5/S	24.0	21.0	DS/20/5.0
---	T-17-4	A78/S/H-P6/S-DS/25/5.0	A78/S/H	---	---	---	---	---	P6/S	---	22.0	DS/25/5.0

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 Index 649-030 and 649-031.

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

REVISIONS

DATE	DESCRIPTION	DATE	DESCRIPTION
----	----		

CHRISTOPHER P. GAMACHE, P.E.
P.E. LICENSE NUMBER 82122
CARDNO
380 PARK PLACE BLVD SUITE 300
CLEARWATER, FLORIDA 33759
CERTIFICATE OF AUTHORIZATION 29915

MANATEE COUNTY

ROAD NO.	PROJECT ID
MOCCASIN WALLOW RD	6092560

STANDARD MAST ARM ASSEMBLIES

SHEET NO.
T-48

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

Mast Arm Assembly Information

Wind Speed
○ 130 mph ● 150 mph ○ 170 mph

Signal Orientation
● Vertical
○ Horizontal

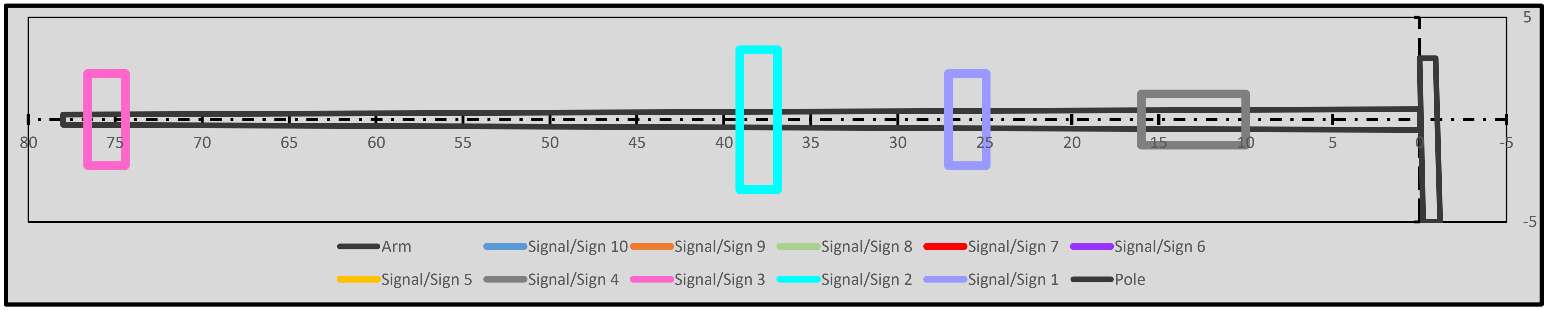
Back Plate Width
● 6.0 in.
○ 2.5 in.
○ 0 in.

Luminaire?
○ Yes
● No

Arm 1 Length
30
40
50
60
70
78

Arm 1 Length, Signal/Sign Location and Size

	Signal\Sign #10	Signal\Sign #9	Signal\Sign #8	Signal\Sign #7	Signal\Sign #6	Signal\Sign #5	Signal\Sign #4	Signal\Sign #3	Signal\Sign #2	Signal\Sign #1
Dist to Pole (ft.)	75	68	65	59	59	55	13	75.5	38	26
	● 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
Sign Width (in.)							72			
Sign Height (in.)							30			
Area (SF)	0.0	0.0	0.0	0.0	0.0	0.0	15.0	9.8	14.8	9.8
M_{wl}, (kip*ft)	0	0	0	0	0	0	13	49	38	17



Arm 1 Length (ft)	78	
Design Standard Index 17743	**Regular**	**Heavy Duty**
Dia. at Arm Base (in)	18	20
Wall Thickness (in)	0.3750	0.3750
Resistance ($M_r=\phi M_n$) (kip*ft)	422	512

Arm 1 Loads	**Regular**	**Heavy Duty**
1.1*Arm M_{dl} (kip*ft)	121	143
Arm M_{wl} (kip*ft)	120	141
1.1*Sign/Signal M_{dl} (kip*ft)	10	
Sign/Signal M_{wl} (kip*ft)	117	
Total Moment ($M_{extreme}$)	271	300

Mast Arm Assembly Designation

One Arm Assembly
A78/S-P6/S-DS/14/5

See separate calc for foundation

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.

Tube Wind Pressure (psf)	44.1

Fy (ksi)	50

Sign/Sig. Wind Pressure (psf)	67.0

short free-head pile in cohesionless soil using Broms method

$$\phi \cdot \frac{\gamma_{soil} \cdot b_{shaft} \cdot L_{shaft}^{3} \cdot K_p}{2} \geq M_u + P_u \cdot L_{shaft}$$

Arm Without Attachments: Dead Load Moment, Wind Load Moment and Moment Capacity at Base Connection

Total Arm Length (ft)	Regular							Heavy Duty						
	wall thk (in)	base dia (in)	S (in3)	Z (in3)	M_{dl} (kip*ft)	$M_{wl\ 130\ mph}$ (kip*ft)	$M_r=\phi M_n$ (kip*ft)	wall thk (in)	base dia (in)	S (in3)	Z (in3)	M_{dl} (kip*ft)	$M_{wl\ 130mph}$ (kip*ft)	$Mr=\phi Mn$ (kip*ft)
30	0.25	11	23	29	10	10	107	0.25	12	27	34	11	11	125
40	0.25	13	32	40	20	20	145	0.25	14	37	47	22	22	166
50	0.3125	14	46	58	36	33	215	0.3125	15	53	67	40	37	244
60	0.375	15	63	79	56	48	300	0.375	16	72	91	62	53	340
70	0.375	17	81	103	85	71	380	0.375	18	91	115	100	77	422
78	0.375	18	91	115	110	90	422	0.375	20	113	143	130	106	512

Drilled Shaft

Index 17743 Drilled Shaft Capacities						1 Arm Assembly Loads And Capacity Check					2 Arm Assembly Loads and Capacity Check				
DS Index #	ID	Length	Diameter	ϕM_n	ϕT_n	M_u+ P_u*L_{shaft}	T_u	Check Mom. & Min Dia.	Check Torsion	Check	M_u+ P_u*L_{shaft}	T_u	Check Mom. & Min Dia.	Check Torsion	Check
1	DS/20/5	20	5	1800	589	494.6	236.8	Okay	Okay	Okay	0.0	0.0	0	0	0
2	DS/18/5	18	5	1312	477	472.4		Okay	Okay	Okay	0.0		0	0	0
3	DS/16/5	16	5	922	377	450.2		Okay	Okay	Okay	0.0		0	0	0
4	DS/16/4.5	16	4.5	829	305	450.2		NoGood	Okay	NoGood	0.0		0	0	0
5	DS/14/5	14	5	617	289	428.0		Okay	Okay	Okay	0.0		0	0	0
6	DS/14/4.5	14	4.5	556	234	428.0		NoGood	NoGood	NoGood	0.0		0	0	0
7	DS/12/4.5	12	4.5	350	172	405.8		NoGood	NoGood	NoGood	0.0		0	0	0
8	DS/12/4	12	4	311	136	405.8		NoGood	NoGood	NoGood	0.0		0	0	0

Arm 1 Attachments: Extreme Event Dead Load Moment, Wind Load Moment at Base Connection

	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	Total		
Sign/Sig Mwl (kip*ft)	0.0	0.0	0.0	0.0	0.0	0.0	13.1	49.3	37.7	17.0	117.0		
Sign/Sig 1.1*Mdl (kip*ft)	0.0	0.0	0.0	0.0	0.0	0.0	0.9	4.2	3.3	1.4	9.8		
Arm 1 Mwl (kip*ft)											119.8	141.1	*Reg Arm / HD Arm*
Arm 1 1.1*Mdl (kip*ft)											121.0	143.0	*Reg Arm / HD Arm*
*Extreme Event Arm Moment (kip*ft)*											270.6	300.5	

Ensures anchor bolts fit inside rebar cage

Min Shaft Diameter
5

Required Drilled Shaft Index Number Required (see Table for size)		
Load Case	1 Arm DS Index #	2 Arm DS Index #
Drilled Shaft Index req'd for Overturning including Min. Diamter	5	0
Drilled Shaft Index req'd for Torsion	5	0
Drilled Shaft Controlling Load Case	**5**	**#N/A**

Pole Base Shears & Moments				
	Arm 1 Shear	Arm 1 Moment	Arm 2 Shear	Arm 2 Moment
dl att	N/A	9.8	N/A	0.0
dl arm	N/A	121.0	N/A	0.0
wl pole	2.6	52.9	0.0	0.0
wl att	3.3	72.7	0.0	0.0
wl arm	5.2	113.5	0.0	0.0
Tor wl att	N/A	117.0	N/A	0.0
Tor wl arm	N/A	119.8	N/A	0.0

assume a 37.5' pole wl with lum

Forces at Top of DS		
	One Arm	Two Arms
Moment dl	130.8	N/A
Moment wl	239.1	
Moment Total	272.5	0.0
Torsion	236.8	0.0
Shear	11.1	0.0
	Shaft 2-Arm Factor	*1.1*

used for OT & Torsion

Arm 2 Attachments: Extreme Event Dead Load Moment, Wind Load Moment at Base Connection

	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	Total	
Sign/Sig Mwl (kip*ft)	0.0	0.0	0.0	0.0	0.0	47.6	*24.2*	*40.2*	*15.0*	*7.8*	134.8	
Sign/Sig 1.1*Mdl (kip*ft)	0.0	0.0	0.0	0.0	0.0	4.2	*2.0*	*2.6*	*1.3*	*0.7*	10.8	
Arm 2 Mwl (kip*ft)											0.0	0.0
Arm 2 1.1*Mdl (kip*ft)											0.0	0.0
											0.0	0.0

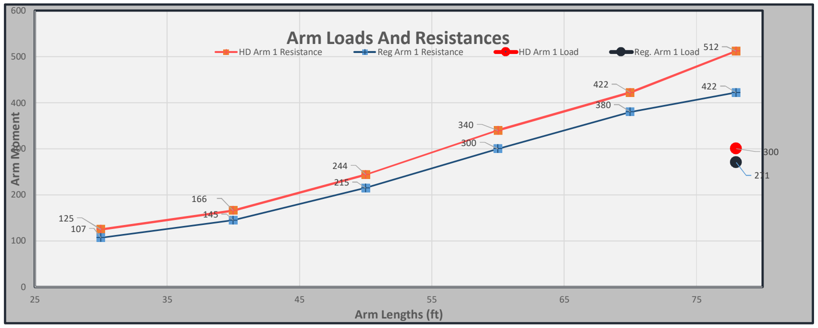
Pole ID			
Arm 1 Length	78	Arm 2 Length	0
	Pole ID	P6	

1 Arm Assembly	Use Regular Arm						
Design Arm Designation			**Pole Designation**			**Drilled Shaft**	
A78	/S		P6	/S		DS	
A78/S-			P6/S-			DS/14/5	
A78/S-P6/S-DS/14/5							

2 Arm Assembly	Use Regular Arm						
Design Arm Designation			**Pole Designation**			**Drilled Shaft**	
						DS	
-			-				

Assembly ID	A78/S-P6/S-DS/14/5	
	Arm 1	**Arm 2**
Arm Length(s)	78	0
Max Design CFI %	0.95	
Est. Regular Arm CFI	0.67	0.00
Est. HD Arm CFI	0.62	0.00

Note: Poles are designed to have a smaller CFI than Arms



Drilled Shaft Foundation for
Sign, Signal, and Lighting Support Structures v1.1

FDOT
State Structures Design Office

SUBJECT: Moccasin Wallow Road
Struct # T-10-2 LOCATION: Sta. 300+97.6, 57.0' RT

DESIGNED BY: MPR DATE: 12/2021
CHECKED BY: DATE: 12/2021

Program Changes

$SoilType :=$
- **Sand**
- Clay

$\phi_{soil} := 30 \cdot deg$ *soil friction angle (sand)*

$c_{soil} := 1.25 \cdot \frac{kip}{ft^2}$ *soil shear strength (clay)*

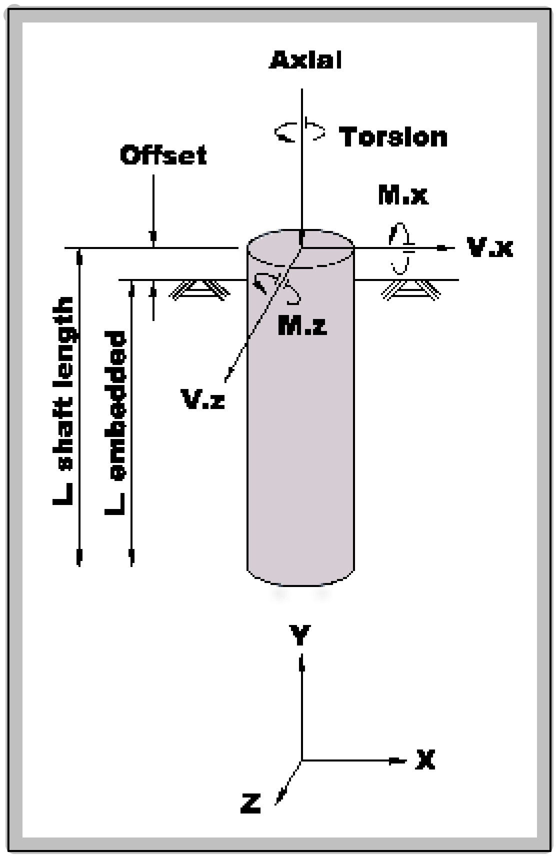
$N_{blows} := 15$ *number of blows per foot. If N< 5, contact the district geotech Engineer*

$\gamma_{soil} := 50 \cdot pcf$ *effective soil weight (typical design value = 45 ~ 50 pcf)*

Geometry

$b := 4.5 \cdot ft$ *shaft diameter, "DB"*

$Offset := 0.5 \cdot ft$ *groundline to top of foundation*



Applied Loads (Extreme I)

$M_x := 239.1 \cdot kip \cdot ft$ $V_x := 0 \cdot kip$ $Torsion := 236.8 \cdot kip \cdot ft$

$M_z := 130.8 \cdot kip \cdot ft$ $V_z := 11.1 \cdot kip$ $Axial := 4.0 \cdot kip$

$StructureType :=$
- Cantilever Overhead Sign Structure
- **Mast Arm Signal Structure**
- Concrete/Steel Strain Poles
- Ground Sign

$StructureType = 1$

$\phi_{ot} := if(StructureType = 3, 0.8, 0.6)$ $\phi_{ot} = 0.6$ *ϕ factor against overturning [SM Vol-3 13.6.1.1]*

$\phi_{tor} := if(StructureType = 0, 0.9, 1.0)$ $\phi_{tor} = 1$ *ϕ factor against torsion [SM Vol-3 13.6.1.1]*

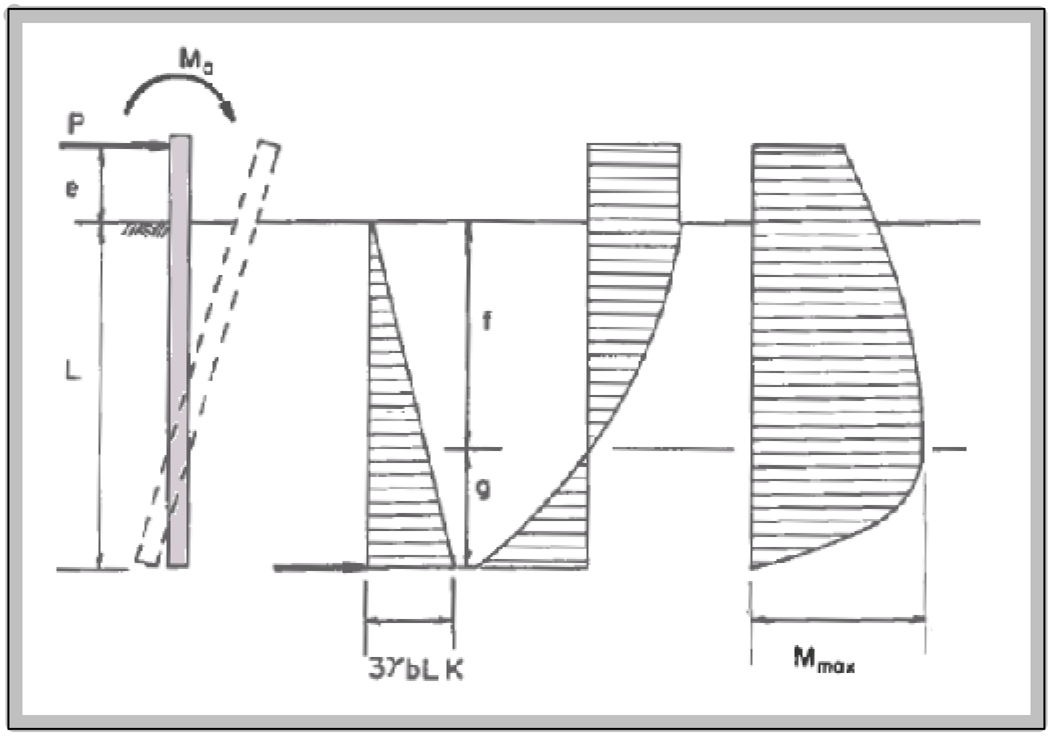
Shaft Depth Required to Resist Overturning

$M_u := \sqrt{M_x^{\,2} + M_z^{\,2}} = 272.5 \cdot \text{kip} \cdot \text{ft}$

$P_u := \sqrt{V_x^{\,2} + V_z^{\,2}} = 11.1 \cdot \text{kip}$

$T_u := \text{Torsion} = 236.8 \cdot \text{kip} \cdot \text{ft}$

*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.

$K_p := \tan\left(45 \cdot \text{deg} + \frac{\phi_{soil}}{2}\right)^2 = 3$ $\qquad e_{sand} := \text{Offset} = 0.5 \text{ ft}$

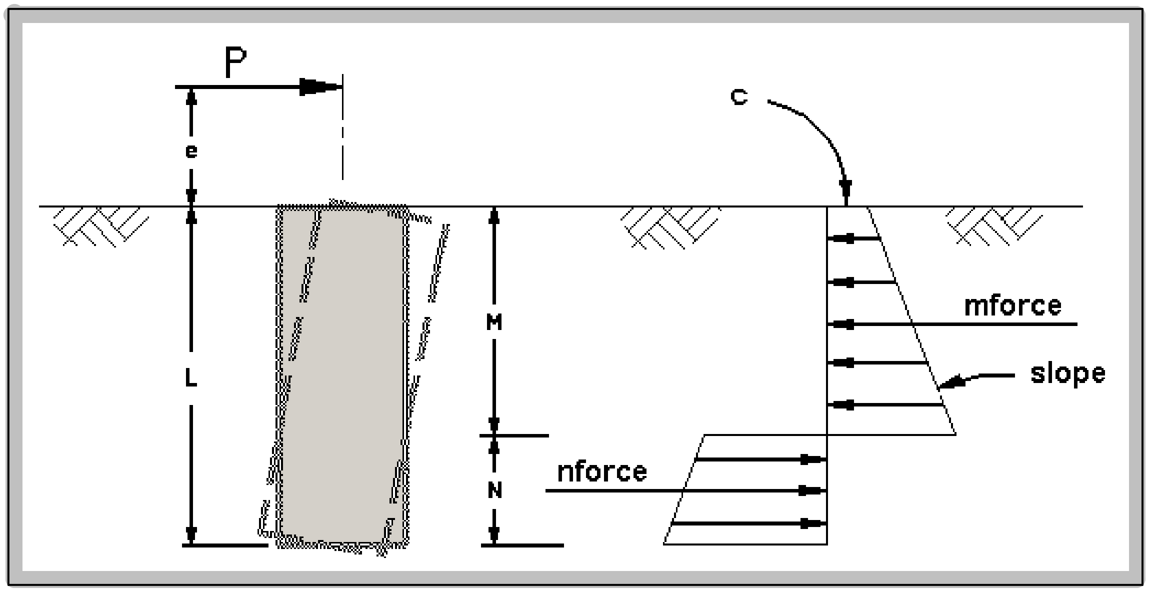
Guess value $\qquad L_{otSand} := 8 \cdot \text{ft}$

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

$L_{otSand} := \text{Find}\left(L_{otSand}\right) = 12.7 \text{ ft}$

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

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.

$c_{soil} := \text{if}\left(c_{soil} = 0\cdot ksf, 0.1\cdot ksf, c_{soil}\right) = 1.3\cdot ksf$

$Slope := 8\cdot\frac{c_{soil}}{3\cdot b} = 0.7\cdot\frac{kip}{ft^3}$ $\qquad e_{clay} := \frac{M_u}{P_u} + Offset = 25.1\ ft$

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

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

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

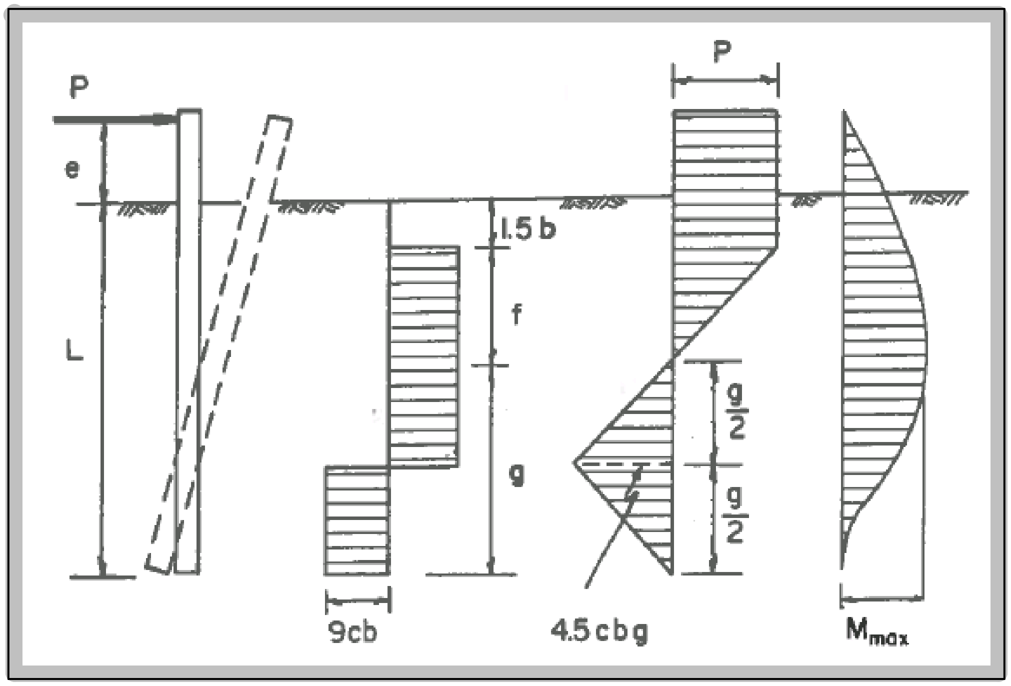
Guess value $\quad M := 4.0\cdot ft \qquad N := 4.0\cdot ft$

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

$\begin{pmatrix} M \\ N \end{pmatrix} := Find(M,N) \qquad L_{ot1Clay} := M + N = 10.8\ ft$

$L_{ot1Clay} := \text{ceil}\left(\frac{L_{ot1Clay}}{ft}\right)\cdot ft = 11\ ft$ $\qquad$ *(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.*

$$f := \frac{P_u}{\phi_{ot} \cdot 9 \cdot c_{soil} \cdot b} = 0.4\,ft$$

$$M_{max.clay} := P_u \cdot \left(e_{clay} + 1.5 \cdot b + 0.5 \cdot f\right) = 355 \cdot kip \cdot ft$$

$$g := \sqrt{\frac{M_{max.clay}}{2.25 \cdot \phi_{ot} \cdot c_{soil} \cdot b}} = 6.8\,ft$$

$$L_{ot2Clay} := \left(1.5 \cdot b + f + g\right) = 14\,ft$$

$$L_{ot2Clay} := ceil\left(\frac{L_{ot2Clay}}{ft}\right) \cdot ft = 14\,ft$$

(round up to next foot)

$$L_{otClay} := if\left(L_{ot1Clay} < 3 \cdot b, L_{ot1Clay}, L_{ot2Clay}\right) = 3.4$$

(If $L_{ot} < 3b$*, use Modified Broms method)*

$$L_{reqdOT} := if\left(SoilType = "Sand", L_{otSand}, L_{otClay}\right)$$

$L_{reqdOT} = 13\,ft$

required shaft embedment depth to resist overturning

Shaft Depth Required to Resist Torsion

*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.

$N_{blows} = 15$

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

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 $L_{torSand} := L_{reqdOT} = 13\,\text{ft}$

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

$L_{torSand} := \text{Find}(L_{torSand}) = 14.1\,\text{ft}$

$L_{torSand} := \text{ceil}\left(\frac{L_{torSand}}{\text{ft}}\right) \cdot \text{ft} = 15\,\text{ft}$ *(round up to next foot)*

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

$\text{CohesionFactor} := 0.55$

$f_{se} := \text{CohesionFactor} \cdot c_{soil} = 0.7 \cdot \text{ksf}$

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

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

$L_{torClay} := \text{Find}(L_{torClay}) = 12.3\,\text{ft}$

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

$L_{reqdTor} := \text{if}(\text{SoilType} = \text{"Sand"}, L_{torSand}, L_{torClay})$

$L_{reqdTor} = 15\,\text{ft}$ *required shaft embedment depth to resist torsion*

$L_{embedded} := \text{if}(L_{reqdTor} > L_{reqdOT}, L_{reqdTor}, L_{reqdOT}) = 4.6$

$L_{shaft.length} := L_{embedded} + \text{Offset}$

$L_{shaft.length} = 15.5\,\text{ft}$ *shaft length*

Maximum Moment in Shaft

short free-head pile in cohesionless soil using Broms method

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

$$M_{maxSand} := P_u \cdot (e_{sand} + f_{sand}) - \frac{P_u \cdot f_{sand}}{3} + M_u = 309.7 \cdot kip \cdot ft$$

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

$f_{mod} := Find(f_{mod}) = 2\ ft$

$$M_{modBroms} := P_u \cdot (e_{clay} + f_{mod}) - \frac{\phi_{ot} \cdot c_{soil} \cdot b \cdot f_{mod}^{\ 2}}{2} - \frac{\phi_{ot} \cdot b \cdot f_{mod}^{\ 3} \cdot Slope}{6} = 290.9 \cdot kip \cdot ft$$

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

$$M_{Broms} := P_u \cdot (e_{clay} + 1.5 \cdot b + 0.5 \cdot f) = 355 \cdot kip \cdot ft$$

$M_{maxClay} := if(L_{ot1Clay} < 3 \cdot b, M_{modBroms}, M_{Broms}) = 290.9 \cdot kip \cdot ft$ *(If* $L_{ot} < 3b$, *use Modified Broms method)*

$$M_{max} := if(SoilType = \text{"Sand"}, M_{maxSand}, M_{maxClay}) = 309.7 \cdot kip \cdot ft$$

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*

$Num_{bar} := 16$ *number of longitudinal bars, "RB"*

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

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

$A_{v.bar} := \mathbf{0.31} \cdot in^2$ *stirrup area* *SM Vol-3 13.6.2*

$d_{v.bar} := \mathbf{0.625} \cdot in$ *stirrup diameter*

$s_{v1} := \mathbf{4} \cdot in$ *stirrup spacing, depth = 0 ft-2 ft* *SM Vol-3 13.6.2*

$s_{v2} := 8 \cdot in$ *stirrup spacing, depth = 2 ft-depth.stir, "RD"*

$s_{v3} := 12 \cdot in$ *stirrup spacing, depth > depth.stir, "RF"*

$depth_{stir} := 9.083 \cdot ft$ *stirrup depth, see s.v2 and s.v3 above*

$b = 4.5\ ft$ *shaft diameter*

$$A_{req} := \min\left(0.135 \cdot \frac{\pi \cdot b^2}{4} \cdot \frac{f_c}{F_{y.rebar}}, 0.015 \cdot \frac{\pi \cdot b^2}{4}\right) = 20.6 \cdot in^2$$ *LRFD 5.7.4.2*

$A_{long} := Num_{bar} \cdot A_{long.bar} = 25 \cdot in^2$ *total area of longitudinal steel*

$CheckLongitudinalReinf := if\left(A_{long} \geq A_{req}, \text{"OK"}, \text{"No Good"}\right)$ $CheckLongitudinalReinf = \text{"OK"}$

$Dia_{bar.circle} := b - 2 \cdot Cover - 2 \cdot d_{v.bar} - d_{long.bar} = 39.3 \cdot in$

$Spacing_{vert.reinf} := Dia_{bar.circle} \cdot \frac{\pi}{Num_{bar}} = 7.7 \cdot in$ $Clearance_{vert.reinf} := Spacing_{vert.reinf} - d_{long.bar} = 6.31 \cdot in$

$CheckReinfClearSpacing := if\left(Clearance_{vert.reinf} \geq 6in, \text{"OK"}, \text{"No Good"}\right)$ $CheckReinfClearSpacing = \text{"OK"}$ *SDG 3.6.10*

Check Shear and Torsion

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

$V_u := \sqrt{V_x^2 + V_z^2} = 11.1 \cdot kip$

$T_u = 236.8 \cdot kip \cdot ft$

Effective shear depth

$D_r := b - 2 \cdot \left(Cover + d_{v.bar} + \frac{d_{long.bar}}{2}\right) = 3.3\ ft$ $\quad d_e := \frac{b}{2} + \frac{D_r}{\pi} = 3.3\ ft$ *LRFD C5.8.2.9-2*

$d_v := \max\left(0.9 \cdot d_e, 0.72 \cdot b\right) = 3.2\ ft$

Check Shear Strength

$V_c := 0.0316 \cdot (2.0) \cdot \sqrt{\frac{f_c}{ksi}} \cdot \left(\frac{b}{in}\right) \cdot \left(\frac{d_v}{in}\right) \cdot kip = 265.4 \cdot kip$ *LRFD Eqn 5.8.3.3-3* *LRFD 5.8.3.4.1* *ACI 11.3.3*

$V_s := \frac{A_{v.bar} \cdot F_{y.rebar} \cdot d_v}{\max\left(s_{v1}, s_{v2}, s_{v3}\right)} = 60.3 \cdot kip$ *LRFD Eqn 5.8.3.3-4*

$ShearRatio := \frac{V_u - \phi_v \cdot V_c}{\phi_v \cdot V_s} = -4.2$

$ShearRatio := \text{if}\left(ShearRatio \le 0, 0, ShearRatio\right) = 0$

Check Torsion Strength

$A_{cp} := \pi \cdot \left(\frac{b}{2}\right)^2 = 2290.2 \cdot in^2$ $\quad p_{cp} := 2 \cdot \pi \cdot \left(\frac{b}{2}\right) = 169.6 \cdot in$ *Area and perimeter of concrete cross-section*

$d_{oh} := b - 2 \cdot \left(Cover + \frac{d_{v.bar}}{2}\right) = 41.4 \cdot in$ $\quad p_h := \pi \cdot d_{oh} = 130 \cdot in$ *Diameter, perimeter and area enclosed by the centerline of the outermost closed transverse torsion reinforcement*

$A_{oh} := \pi \left(\frac{d_{oh}}{2}\right)^2 = 1.3 \times 10^3 \cdot in^2$ $\quad A_o := 0.85 \cdot A_{oh} = 1.1 \times 10^3 \cdot in^2$

$T_{n1} := \frac{2 \cdot A_o \cdot A_{v.bar} \cdot F_{y.rebar}}{s_{v1}} = 885.7 \cdot kip \cdot ft$ *LRFD Eqn 5.8.3.6.2-1*

$T_{n2} := \frac{2 \cdot A_o \cdot A_{v.bar} \cdot F_{y.rebar}}{s_{v2}} = 442.8 \cdot kip \cdot ft$ *LRFD 5.8.3.4.1*

$$T_{n3} := \frac{2 \cdot A_o \cdot A_{v.bar} \cdot F_{y.rebar}}{s_{v3}} = 295.2 \cdot \text{kip} \cdot \text{ft}$$

$\phi_v = 0.9$ $\qquad$ $T_u = 236.8 \cdot \text{kip} \cdot \text{ft}$ $\qquad$ $L_{reqdTor} = 15\,\text{ft}$

$$Tor2_{sand} := T_u - \text{if}\left[2\text{ft} > \text{Offset}, \left[\pi \cdot b \cdot (2 \cdot \text{ft} - \text{Offset}) \cdot \gamma_{soil} \cdot \left(\frac{2 \cdot \text{ft} - \text{Offset}}{2}\right) \cdot (\omega_{fdot}) \cdot \frac{b}{2}\right], 0 \cdot \text{kip} \cdot \text{ft}\right] = 234.1 \cdot \text{kip} \cdot \text{ft}$$

$$Tor3_{sand} := T_u - \text{if}\left[\text{depth}_{stir} > \text{Offset}, \left[\pi \cdot b \cdot (\text{depth}_{stir} - \text{Offset}) \cdot \gamma_{soil} \cdot \left(\frac{\text{depth}_{stir} - \text{Offset}}{2}\right) \cdot (\omega_{fdot}) \cdot \frac{b}{2}\right], 0 \cdot \text{kip} \cdot \text{ft}\right] = 148.9 \cdot \text{kip} \cdot \text{ft}$$

$$Tor2_{clay} := T_u - \text{if}\left[2\text{ft} - 1.5\text{ft} > \text{Offset}, \left[f_{se} \cdot (\pi \cdot b) \cdot (2.0 \cdot \text{ft} - \text{Offset} - 1.5 \cdot \text{ft}) \cdot \frac{b}{2}\right], 0 \cdot \text{kip} \cdot \text{ft}\right] = 236.8 \cdot \text{kip} \cdot \text{ft}$$

$$Tor3_{clay} := T_u - \text{if}\left[\text{depth}_{stir} - 1.5\text{ft} > \text{Offset}, \left[f_{se} \cdot (\pi \cdot b) \cdot (\text{depth}_{stir} - \text{Offset} - 1.5 \cdot \text{ft}) \cdot \frac{b}{2}\right], 0 \cdot \text{kip} \cdot \text{ft}\right] = 81.9 \cdot \text{kip} \cdot \text{ft}$$

$$Tor2 := \text{if}\left(\text{SoilType} = \text{"Sand"}, Tor2_{sand}, Tor2_{clay}\right) = 234.1 \cdot \text{kip} \cdot \text{ft}$$

$$Tor3 := \text{if}\left(\text{SoilType} = \text{"Sand"}, Tor3_{sand}, Tor3_{clay}\right) = 148.9 \cdot \text{kip} \cdot \text{ft}$$

$$\text{TorsionRatio}_{n1} := \frac{T_u}{\phi_{tor} \cdot T_{n1}} = 0.27$$

$$\text{TorsionRatio}_{n2} := \frac{Tor2}{\phi_{tor} \cdot T_{n2}} = 0.53$$

$$\text{TorsionRatio}_{n3} := \frac{Tor3}{\phi_{tor} \cdot T_{n3}} = 0.5$$

$$\text{TorsionRatio} := \max\left(\text{TorsionRatio}_{n1}, \text{TorsionRatio}_{n2}, \text{TorsionRatio}_{n3}\right) = 0.53$$

$$T_{cr} := 0.125 \sqrt{\frac{f_c}{\text{ksi}}} \cdot \left(\frac{A_{cp}^{\,2}}{p_{cp} \cdot \text{in}^3}\right) \cdot \text{kip} \cdot \text{in} = 644.1 \cdot \text{kip} \cdot \text{ft}$$

LRFD Eqn 5.8.2.1-4

$$\text{TorsionRatio} := \text{if}\left(T_u \le 0.25 \cdot \phi_{tor} \cdot T_{cr}, 0, \text{TorsionRatio}\right) = 0.5$$

LRFD Eqn 5.8.2.1-3

$\text{ShearRatio} = 0$

$$\text{CheckShearTorsion} := \text{if}\left(\text{ShearRatio} + \text{TorsionRatio} \le 1, \text{"OK"}, \text{"No Good"}\right)$$

CheckShearTorsion = "OK"

Check Maximum Spacing Transverse Reinforcement

$$v_u := \frac{V_u}{\phi_v \cdot b \cdot d_v} = 0.005874 \cdot \text{ksi} \qquad 0.125 \cdot f_c = 0.5 \cdot \text{ksi}$$

LRFD Eqn 5.8.2.9-1

$s_{max1} := \text{if}\left(0.8 \cdot d_v < 24 \cdot in, 0.8 d_v, 24 \cdot in\right) = 24 \cdot in$ LRFD Eqn 5.8.2.7-1

$s_{max2} := \text{if}\left(0.4 \cdot d_v < 12 \cdot in, 0.4 d_v, 12 \cdot in\right) = 12 \cdot in$ LRFD Eqn 5.8.2.7-2

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

$\max\left(s_{v1}, s_{v2}, s_{v3}\right) = 12 \cdot in$

$\text{CheckMaxSpacingTransvReinf} := \text{if}\left(\max\left(s_{v1}, s_{v2}, s_{v3}\right) \leq s_{max}, \text{"OK"}, \text{"No Good"}\right)$

$\text{CheckMaxSpacingTransvReinf} = \text{"OK"}$

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

LRFD 5.8.3.4.1

$M_u = 272.5 \cdot kip \cdot ft$

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

$$\text{LongReinf}_{shr.tor} := \frac{\frac{M_u}{\phi_v \cdot d_v} + \sqrt{\left(V_{temp}\right)^2 + \left(\frac{0.45 \cdot p_h \cdot T_u}{2 \cdot A_o \cdot \phi_v}\right)^2}}{F_{y.rebar}} = 2.9 \cdot in^2$$

$\text{Num}_{bar} \cdot A_{long.bar} = 25 \cdot in^2$

$\text{CheckLongReinf}_{shr.tor} := \text{if}\left(\text{Num}_{bar} \cdot A_{long.bar} \geq \text{LongReinf}_{shr.tor}, \text{"OK"}, \text{"No Good"}\right)$

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

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

Mast Arm Assembly Information

Wind Speed
○ 130 mph ● 150 mph ○ 170 mph

Signal Orientation
● Vertical
○ Horizontal

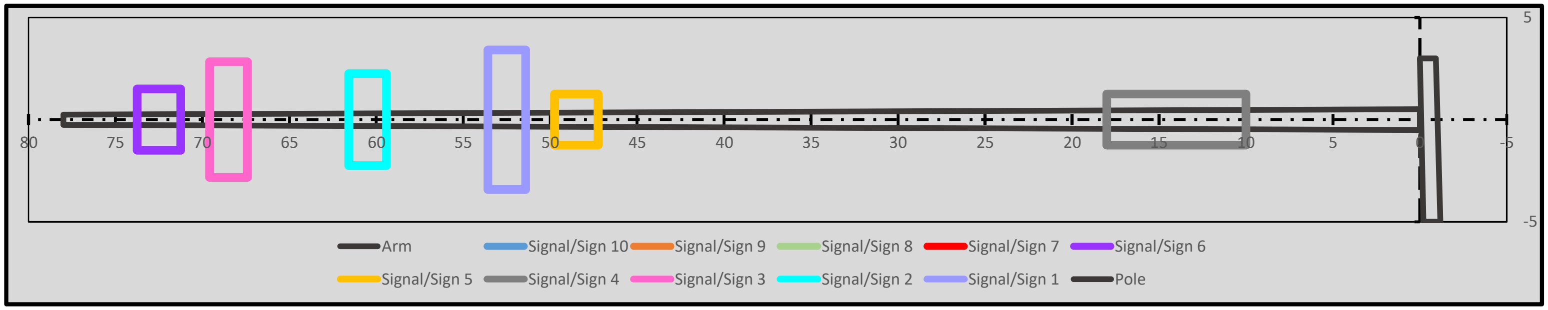
Back Plate Width
● 6.0 in.
○ 2.5 in.
○ 0 in.

Luminaire?
○ Yes
● No

Arm 1 Length
30
40
50
60
70
78

Arm 1 Length, Signal/Sign Location and Size

	Signal\Sign #10	Signal\Sign #9	Signal\Sign #8	Signal\Sign #7	Signal\Sign #6	Signal\Sign #5	Signal\Sign #4	Signal\Sign #3	Signal\Sign #2	Signal\Sign #1
Dist to Pole (ft.)	75	68	65	59	72.5	48.5	14	68.5	60.5	52.5
	● 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
Sign Width (in.)					30	30	96			
Sign Height (in.)					36	30	30			
Area (SF)	0.0	0.0	0.0	0.0	7.5	6.3	20.0	12.3	9.8	14.8
M_{wl}. (kip*ft)	0	0	0	0	36	20	19	56	40	52



Arm 1 Length (ft)	78	
Design Standard Index 17743	Regular	Heavy Duty
Dia. at Arm Base (in)	18	20
Wall Thickness (in)	0.3750	0.3750
Resistance (M_r=ϕM_n) (kip*ft)	422	512

Arm 1 Loads	Regular	Heavy Duty
1.1*Arm M_{dl} (kip*ft)	121	143
Arm M_{wl} (kip*ft)	120	141
1.1*Sign/Signal M_{dl} (kip*ft)	18	
Sign/Signal M_{wl} (kip*ft)	223	
Total Moment ($M_{extreme}$)	370	399

Mast Arm Assembly Designation

One Arm Assembly
A78/S-P6/S-DS/16/5

See separate calc
for foundation

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.

Tube Wind Pressure (psf)	44.1	**Fy (ksi)**	50	**Sign/Sig. Wind Pressure (psf)**	67.0

short free-head pile in cohesionless soil using Broms method

$$\phi \cdot \frac{\gamma_{soil} \cdot b_{shaft} \cdot L_{shaft}^{3} \cdot K_p}{2} \geq M_u + P_u \cdot L_{shaft}$$

Arm Without Attachments: Dead Load Moment, Wind Load Moment and Moment Capacity at Base Connection

	Regular							Heavy Duty						
Total Arm Length (ft)	**wall thk (in)**	**base dia (in)**	**S (in3)**	**Z (in3)**	**M_{dl} (kip*ft)**	**$M_{wl\ 130\ mph}$ (kip*ft)**	**$M_r=\phi M_n$ (kip*ft)**	**wall thk (in)**	**base dia (in)**	**S (in3)**	**Z (in3)**	**M_{dl} (kip*ft)**	**$M_{wl\ 130mph}$ (kip*ft)**	**Mr=ϕMn (kip*ft)**
30	0.25	11	23	29	10	10	107	0.25	12	27	34	11	11	125
40	0.25	13	32	40	20	20	145	0.25	14	37	47	22	22	166
50	0.3125	14	46	58	36	33	215	0.3125	15	53	67	40	37	244
60	0.375	15	63	79	56	48	300	0.375	16	72	91	62	53	340
70	0.375	17	81	103	85	71	380	0.375	18	91	115	100	77	422
78	0.375	18	91	115	110	90	422	0.375	20	113	143	130	106	512

Drilled Shaft

Index 17743 Drilled Shaft Capacities						1 Arm Assembly Loads And Capacity Check					2 Arm Assembly Loads and Capacity Check				
DS Index #	**ID**	**Length**	**Diameter**	**ϕM_n**	**ϕT_n**	**M_u+ P_u*L_{shaft}**	**T_u**	**Check Mom. & Min Dia.**	**Check Torsion**	**Check**	**M_u+ P_u*L_{shaft}**	**T_u**	**Check Mom. & Min Dia.**	**Check Torsion**	**Check**
1	DS/20/5	20	5	1800	589	554.6	343.2	Okay	Okay	Okay	0.0	0.0	0	0	0
2	DS/18/5	18	5	1312	477	529.5		Okay	Okay	Okay	0.0		0	0	0
3	DS/16/5	16	5	922	377	504.5		Okay	Okay	Okay	0.0		0	0	0
4	DS/16/4.5	16	4.5	829	305	504.5		NoGood	NoGood	NoGood	0.0		0	0	0
5	DS/14/5	14	5	617	289	479.4		Okay	NoGood	NoGood	0.0		0	0	0
6	DS/14/4.5	14	4.5	556	234	479.4		NoGood	NoGood	NoGood	0.0		0	0	0
7	DS/12/4.5	12	4.5	350	172	454.3		NoGood	NoGood	NoGood	0.0		0	0	0
8	DS/12/4	12	4	311	136	454.3		NoGood	NoGood	NoGood	0.0		0	0	0

Arm 1 Attachments: Extreme Event Dead Load Moment, Wind Load Moment at Base Connection

	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**	**Total**		
Sign/Sig Mwl (kip*ft)	0.0	0.0	0.0	0.0	36.4	20.3	18.8	56.3	39.5	52.1	223.4		
Sign/Sig 1.1*Mdl (kip*ft)	0.0	0.0	0.0	0.0	2.4	1.3	1.2	4.9	3.3	4.6	17.8		
Arm 1 Mwl (kip*ft)											119.8	141.1	*Reg Arm / HD Arm*
Arm 1 1.1*Mdl (kip*ft)											121.0	143.0	*Reg Arm / HD Arm*
										*Extreme Event Arm Moment (kip*ft)*	370.2	398.9	

Ensures anchor bolts fit inside rebar cage

Min Shaft Diameter
5

Required Drilled Shaft Index Number Required (see Table for size)

Load Case	**1 Arm DS Index #**	**2 Arm DS Index #**
Drilled Shaft Index req'd for Overturning including Min. Diamter	5	0
Drilled Shaft Index req'd for Torsion	3	0
Drilled Shaft Controlling Load Case	3	#N/A

Pole Base Shears & Moments

	Arm 1 Shear	**Arm 1 Moment**	**Arm 2 Shear**	**Arm 2 Moment**
dl att	N/A	17.8	N/A	0.0
dl arm	N/A	121.0	N/A	0.0
wl pole	2.6	52.9	0.0	0.0
wl att	4.7	104.0	0.0	0.0
wl arm	5.2	113.5	0.0	0.0
Tor wl att	N/A	223.4	N/A	0.0
Tor wl arm	N/A	119.8	N/A	0.0

assume a 37.5' pole wl with lum

Arm 2 Attachments: Extreme Event Dead Load Moment, Wind Load Moment at Base Connection

	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**	**Total**	
Sign/Sig Mwl (kip*ft)	0.0	0.0	0.0	0.0	0.0	47.6	*24.2*	*40.2*	*15.0*	*7.8*	134.8	
Sign/Sig 1.1*Mdl (kip*ft)	0.0	0.0	0.0	0.0	0.0	4.2	*2.0*	*2.6*	*1.3*	*0.7*	10.8	
Arm 2 Mwl (kip*ft)											0.0	0.0
Arm 2 1.1*Mdl (kip*ft)											0.0	0.0
											0.0	0.0

Forces at Top of DS

	One Arm	**Two Arms**
Moment dl	138.8	N/A
Moment wl	270.4	
Moment Total	304.0	0.0
Torsion	343.2	0.0
Shear	12.5	0.0
	Shaft 2-Arm Factor	*1.1*

used for OT & Torsion

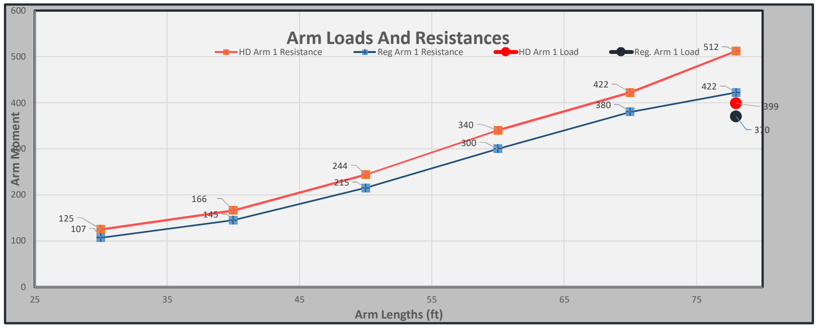
Pole ID			
Arm 1 Length	78	Arm 2 Length	0
	Pole ID	P6	

1 Arm Assembly	Use Regular Arm						
Design Arm Designation			**Pole Designation**			**Drilled Shaft**	
A78	/S		P6	/S		DS	
A78/S-			P6/S-			DS/16/5	
A78/S-P6/S-DS/16/5							

2 Arm Assembly	Use Regular Arm						
Design Arm Designation			**Pole Designation**			**Drilled Shaft**	
						DS	
-			-				

Assembly ID	A78/S-P6/S-DS/16/5	
	Arm 1	**Arm 2**
Arm Length(s)	78	0
Max Design CFI %	0.95	
Est. Regular Arm CFI	0.92	0.00
Est. HD Arm CFI	0.82	0.00

Note: Poles are designed to have a smaller CFI than Arms



Drilled Shaft Foundation for
Sign, Signal, and Lighting Support Structures v1.1

FDOT
State Structures Design Office

SUBJECT: Moccasin Wallow Road
Struct # T-13-1 LOCATION: Sta. 340+14.1, 88.3' LT

DESIGNED BY: MPR DATE: 12/2021
CHECKED BY: DATE: 12/2021

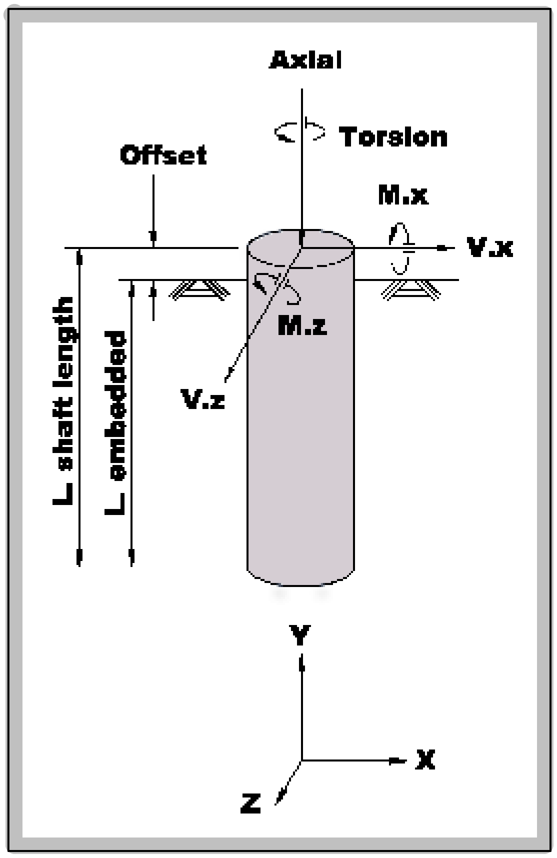
Program Changes

SoilType :=
- ● Sand
- Clay

$\phi_{soil} := 29 \cdot deg$	*soil friction angle (sand)*
$c_{soil} := 1.25 \cdot \frac{kip}{ft^2}$	*soil shear strength (clay)*
$N_{blows} := 11$	*number of blows per foot. If N< 5, contact the district geotech Engineer*
$\gamma_{soil} := 42.6 \cdot pcf$	*effective soil weight (typical design value = 45 ~ 50 pcf)*

Geometry

$b := 5 \cdot ft$	*shaft diameter, "DB"*
$Offset := 0.5 \cdot ft$	*groundline to top of foundation*



Applied Loads (Extreme I)

$M_x := 270.4 \cdot kip \cdot ft$ $V_x := 0 \cdot kip$ $Torsion := 343.2 \cdot kip \cdot ft$

$M_z := 138.8 \cdot kip \cdot ft$ $V_z := 12.5 \cdot kip$ $Axial := 4.0 \cdot kip$

StructureType :=
- Cantilever Overhead Sign Structure
- ● Mast Arm Signal Structure
- Concrete/Steel Strain Poles
- Ground Sign

$StructureType = 1$

$\phi_{ot} := if(StructureType = 3, 0.8, 0.6)$	$\phi_{ot} = 0.6$	*ϕ factor against overturning [SM Vol-3 13.6.1.1]*
$\phi_{tor} := if(StructureType = 0, 0.9, 1.0)$	$\phi_{tor} = 1$	*ϕ factor against torsion [SM Vol-3 13.6.1.1]*

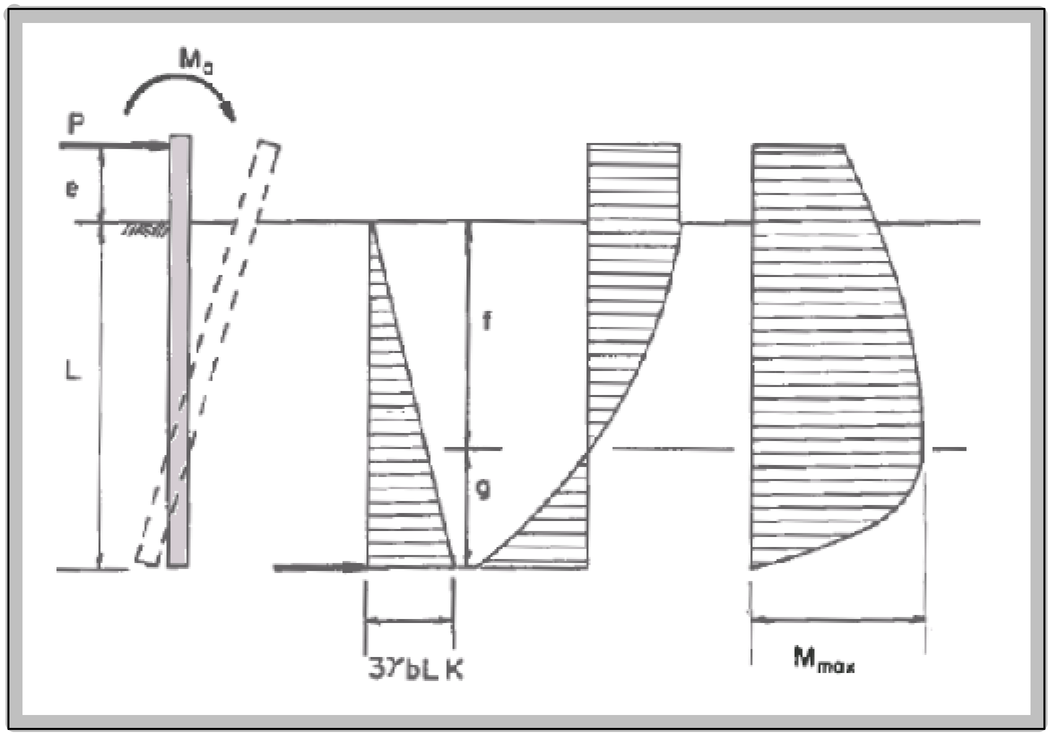
Shaft Depth Required to Resist Overturning

$$M_u := \sqrt{{M_x}^2 + {M_z}^2} = 303.9 \cdot \text{kip} \cdot \text{ft}$$

$$P_u := \sqrt{{V_x}^2 + {V_z}^2} = 12.5 \cdot \text{kip}$$

$$T_u := \text{Torsion} = 343.2 \cdot \text{kip} \cdot \text{ft}$$

*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.

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

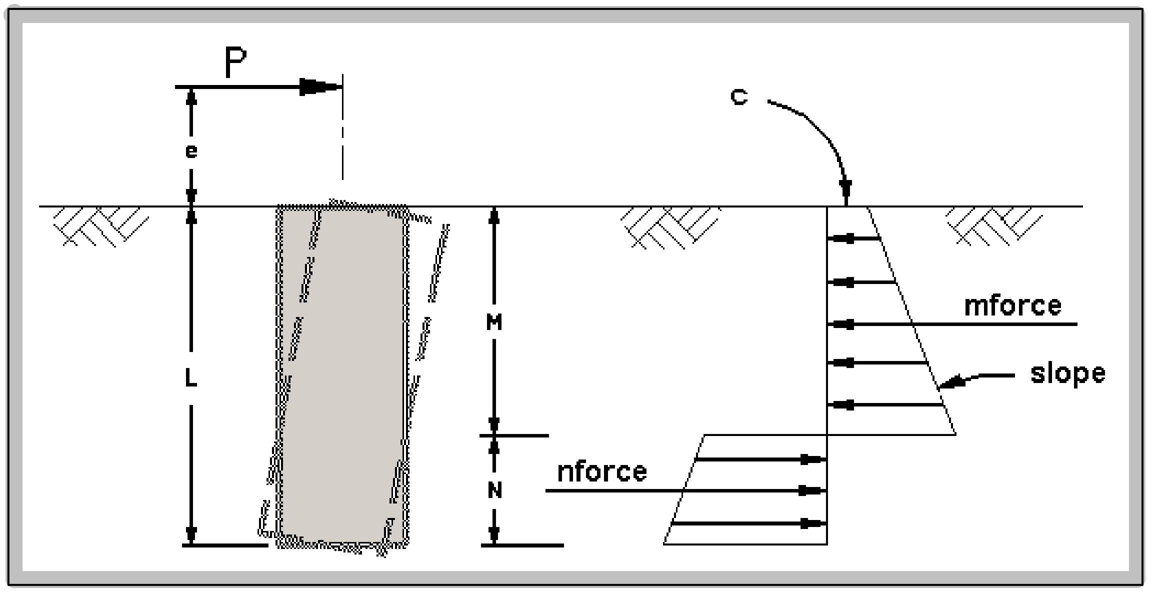
Guess value $L_{otSand} := 8 \cdot \text{ft}$

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

$L_{otSand} := \text{Find}\left(L_{otSand}\right) = 13.8\,\text{ft}$

$$L_{otSand} := \text{ceil}\left(\frac{L_{otSand}}{\text{ft}}\right) \cdot \text{ft} = 14\,\text{ft}$$ *(round up to next foot)*

*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.

$c_{soil} := \text{if}\left(c_{soil} = 0 \cdot ksf, 0.1 \cdot ksf, c_{soil}\right) = 1.3 \cdot ksf$

$\text{Slope} := 8 \cdot \frac{c_{soil}}{3 \cdot b} = 0.7 \cdot \frac{kip}{ft^3}$ $\qquad e_{clay} := \frac{M_u}{P_u} + \text{Offset} = 24.8\ ft$

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

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

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

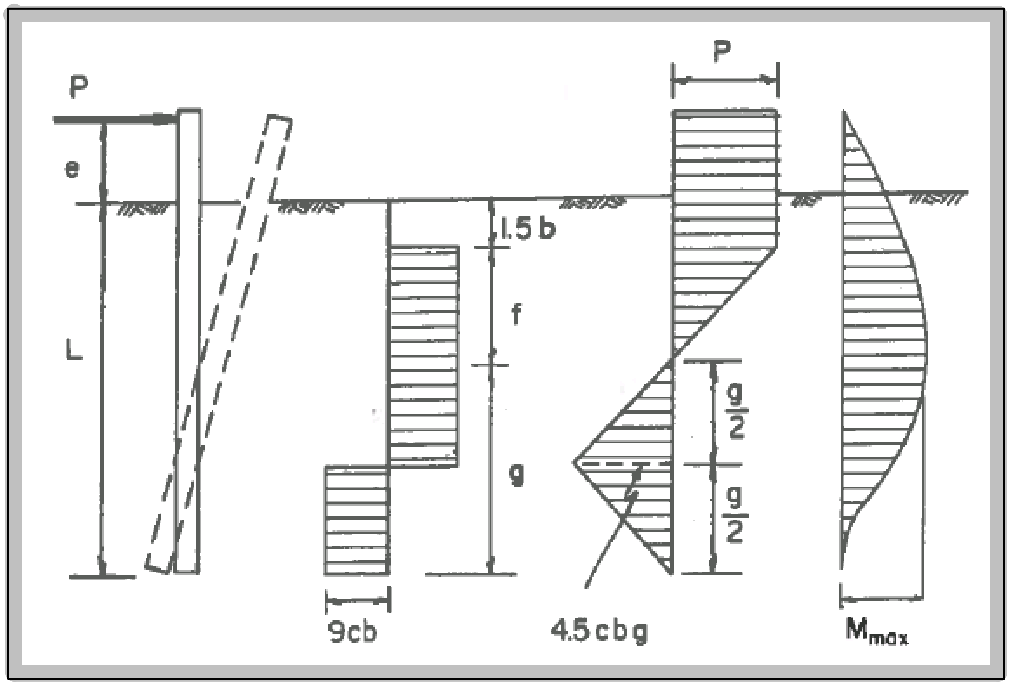
Guess value $\quad M := 4.0 \cdot ft \qquad N := 4.0 \cdot ft$

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

$\begin{pmatrix} M \\ N \end{pmatrix} := \text{Find}(M, N) \qquad L_{ot1Clay} := M + N = 11.2\ ft$

$L_{ot1Clay} := \text{ceil}\left(\frac{L_{ot1Clay}}{ft}\right) \cdot ft = 12\ ft$ $\qquad$ *(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.*

$$f := \frac{P_u}{\phi_{ot} \cdot 9 \cdot c_{soil} \cdot b} = 0.4\ ft$$

$$M_{max.clay} := P_u \cdot \left(e_{clay} + 1.5 \cdot b + 0.5 \cdot f\right) = 406.3 \cdot kip \cdot ft$$

$$g := \sqrt{\frac{M_{max.clay}}{2.25 \cdot \phi_{ot} \cdot c_{soil} \cdot b}} = 6.9\ ft$$

$$L_{ot2Clay} := \left(1.5 \cdot b + f + g\right) = 14.8\ ft$$

$$L_{ot2Clay} := ceil\left(\frac{L_{ot2Clay}}{ft}\right) \cdot ft = 15\ ft$$ *(round up to next foot)*

$$L_{otClay} := if\left(L_{ot1Clay} < 3 \cdot b, L_{ot1Clay}, L_{ot2Clay}\right) = 3.7$$ *(If* $L_{ot} < 3b$*, use Modified Broms method)*

$$L_{reqdOT} := if\left(SoilType = \text{"Sand"}, L_{otSand}, L_{otClay}\right)$$

$L_{reqdOT} = 14\ ft$ *required shaft embedment depth to resist overturning*

Shaft Depth Required to Resist Torsion

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.

$N_{blows} = 11$

$$\omega_{fdot} := \text{if}\left(N_{blows} < 5, 0, \text{if}\left(N_{blows} \geq 15, 1.5, 1.5 \cdot \frac{N_{blows}}{15}\right)\right) = 1.1$$

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 $L_{torSand} := L_{reqdOT} = 14\,\text{ft}$

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

$L_{torSand} := \text{Find}(L_{torSand}) = 19.3\,\text{ft}$

$L_{torSand} := \text{ceil}\left(\frac{L_{torSand}}{\text{ft}}\right) \cdot \text{ft} = 20\,\text{ft}$ *(round up to next foot)*

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

$\text{CohesionFactor} := 0.55$

$f_{se} := \text{CohesionFactor} \cdot c_{soil} = 0.7 \cdot \text{ksf}$

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

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

$L_{torClay} := \text{Find}(L_{torClay}) = 14.2\,\text{ft}$

$L_{torClay} := \text{ceil}\left(\frac{L_{torClay}}{\text{ft}}\right) \cdot \text{ft} = 15\,\text{ft}$ *(round up to next foot)*

$L_{reqdTor} := \text{if}(\text{SoilType} = \text{"Sand"}, L_{torSand}, L_{torClay})$

$L_{reqdTor} = 20\,\text{ft}$ *required shaft embedment depth to resist torsion*

$L_{embedded} := \text{if}(L_{reqdTor} > L_{reqdOT}, L_{reqdTor}, L_{reqdOT}) = 6.1$

$L_{shaft.length} := L_{embedded} + \text{Offset}$

$L_{shaft.length} = 20.5\,\text{ft}$ *shaft length*

Maximum Moment in Shaft

short free-head pile in cohesionless soil using Broms method

$$f_{sand} := \sqrt{\frac{2 \cdot P_u}{3 \cdot \gamma_{soil} \cdot b \cdot K_p \cdot \phi_{ot}}} = 4.8\ \mathrm{ft}$$

$$M_{maxSand} := P_u \cdot \left(e_{sand} + f_{sand}\right) - \frac{P_u \cdot f_{sand}}{3} + M_u = 349.8 \cdot \mathrm{kip} \cdot \mathrm{ft}$$

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

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

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

$$f_{mod} := \mathrm{Find}\left(f_{mod}\right) = 2.1\ \mathrm{ft}$$

$$M_{modBroms} := P_u \cdot \left(e_{clay} + f_{mod}\right) - \frac{\phi_{ot} \cdot c_{soil} \cdot b \cdot f_{mod}^{\ 2}}{2} - \frac{\phi_{ot} \cdot b \cdot f_{mod}^{\ 3} \cdot \mathrm{Slope}}{6} = 325.1 \cdot \mathrm{kip} \cdot \mathrm{ft}$$

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

$$M_{Broms} := P_u \cdot \left(e_{clay} + 1.5 \cdot b + 0.5 \cdot f\right) = 406.3 \cdot \mathrm{kip} \cdot \mathrm{ft}$$

$$M_{maxClay} := \mathrm{if}\left(L_{ot1Clay} < 3 \cdot b, M_{modBroms}, M_{Broms}\right) = 325.1 \cdot \mathrm{kip} \cdot \mathrm{ft}$$

(If $L_\alpha < 3b$, use Modified Broms method)

$$M_{max} := \mathrm{if}\left(\mathrm{SoilType} = \text{"Sand"}, M_{maxSand}, M_{maxClay}\right) = 349.8 \cdot \mathrm{kip} \cdot \mathrm{ft}$$

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*

$Num_{bar} := 18$ *number of longitudinal bars, "RB"*

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

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

$A_{v.bar} := \mathbf{0.31} \cdot in^2$ *stirrup area* *SM Vol-3 13.6.2*

$d_{v.bar} := \mathbf{0.625} \cdot in$ *stirrup diameter*

$s_{v1} := \mathbf{4} \cdot in$ *stirrup spacing, depth = 0 ft-2 ft* *SM Vol-3 13.6.2*

$s_{v2} := 8 \cdot in$ *stirrup spacing, depth = 2 ft-depth.stir, "RD"*

$s_{v3} := 12 \cdot in$ *stirrup spacing, depth > depth.stir, "RF"*

$depth_{stir} := 9.083 \cdot ft$ *stirrup depth, see s.v2 and s.v3 above*

$b = 5\,ft$ *shaft diameter*

$$A_{req} := \min\left(0.135 \cdot \frac{\pi \cdot b^2}{4} \cdot \frac{f_c}{F_{y.rebar}}, 0.015 \cdot \frac{\pi \cdot b^2}{4}\right) = 25.4 \cdot in^2$$ *LRFD 5.7.4.2*

$A_{long} := Num_{bar} \cdot A_{long.bar} = 28.1 \cdot in^2$ *total area of longitudinal steel*

$CheckLongitudinalReinf := if(A_{long} \geq A_{req}, \text{"OK"}, \text{"No Good"})$ $CheckLongitudinalReinf = \text{"OK"}$

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

$Spacing_{vert.reinf} := Dia_{bar.circle} \cdot \frac{\pi}{Num_{bar}} = 7.9 \cdot in$ $Clearance_{vert.reinf} := Spacing_{vert.reinf} - d_{long.bar} = 6.5 \cdot in$

$CheckReinfClearSpacing := if(Clearance_{vert.reinf} \geq 6in, \text{"OK"}, \text{"No Good"})$ $CheckReinfClearSpacing = \text{"OK"}$ *SDG 3.6.10*

Check Shear and Torsion

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

$$V_u := \sqrt{V_x^2 + V_z^2} = 12.5 \cdot \text{kip}$$

$$T_u = 343.2 \cdot \text{kip} \cdot \text{ft}$$

Effective shear depth

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

LRFD C5.8.2.9-2

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

Check Shear Strength

$$V_c := 0.0316 \cdot (2.0) \cdot \sqrt{\frac{f_c}{\text{ksi}}} \cdot \left(\frac{b}{\text{in}}\right) \cdot \left(\frac{d_v}{\text{in}}\right) \cdot \text{kip} = 327.6 \cdot \text{kip}$$

LRFD Eqn 5.8.3.3-3 *LRFD 5.8.3.4.1* *ACI 11.3.3*

$$V_s := \frac{A_{v.bar} \cdot F_{y.rebar} \cdot d_v}{\max\left(s_{v1}, s_{v2}, s_{v3}\right)} = 67 \cdot \text{kip}$$

LRFD Eqn 5.8.3.3-4

$$\text{ShearRatio} := \frac{V_u - \phi_v \cdot V_c}{\phi_v \cdot V_s} = -4.7$$

$$\text{ShearRatio} := \text{if}\left(\text{ShearRatio} \le 0, 0, \text{ShearRatio}\right) = 0$$

Check Torsion Strength

$$A_{cp} := \pi \cdot \left(\frac{b}{2}\right)^2 = 2827.4 \cdot \text{in}^2 \qquad p_{cp} := 2 \cdot \pi \cdot \left(\frac{b}{2}\right) = 188.5 \cdot \text{in}$$

Area and perimeter of concrete cross-section

$$d_{oh} := b - 2 \cdot \left(\text{Cover} + \frac{d_{v.bar}}{2} \right) = 47.4 \cdot \text{in} \qquad p_h := \pi \cdot d_{oh} = 148.8 \cdot \text{in}$$

Diameter, perimeter and area enclosed by the centerline of the outermost closed transverse torsion reinforcement

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

$$T_{n1} := \frac{2 \cdot A_o \cdot A_{v.bar} \cdot F_{y.rebar}}{s_{v1}} = 1.2 \times 10^3 \cdot \text{kip} \cdot \text{ft}$$

LRFD Eqn 5.8.3.6.2-1

$$T_{n2} := \frac{2 \cdot A_o \cdot A_{v.bar} \cdot F_{y.rebar}}{s_{v2}} = 580.6 \cdot \text{kip} \cdot \text{ft}$$

LRFD 5.8.3.4.1

$$T_{n3} := \frac{2 \cdot A_o \cdot A_{v.bar} \cdot F_{y.rebar}}{s_{v3}} = 387.1 \cdot kip \cdot ft$$

$\phi_v = 0.9$ $T_u = 343.2 \cdot kip \cdot ft$ $L_{reqdTor} = 20\,ft$

$$Tor2_{sand} := T_u - if\left[2ft > Offset, \left[\pi \cdot b \cdot (2 \cdot ft - Offset) \cdot \gamma_{soil} \cdot \left(\frac{2 \cdot ft - Offset}{2}\right) \cdot (\omega_{fdot}) \cdot \frac{b}{2}\right], 0 \cdot kip \cdot ft\right] = 341.1 \cdot kip \cdot ft$$

$$Tor3_{sand} := T_u - if\left[depth_{stir} > Offset, \left[\pi \cdot b \cdot (depth_{stir} - Offset) \cdot \gamma_{soil} \cdot \left(\frac{depth_{stir} - Offset}{2}\right) \cdot (\omega_{fdot}) \cdot \frac{b}{2}\right], 0 \cdot kip \cdot ft\right] = 275.4 \cdot kip \cdot ft$$

$$Tor2_{clay} := T_u - if\left[2ft - 1.5ft > Offset, \left[f_{se} \cdot (\pi \cdot b) \cdot (2.0 \cdot ft - Offset - 1.5 \cdot ft) \cdot \frac{b}{2}\right], 0 \cdot kip \cdot ft\right] = 343.2 \cdot kip \cdot ft$$

$$Tor3_{clay} := T_u - if\left[depth_{stir} - 1.5ft > Offset, \left[f_{se} \cdot (\pi \cdot b) \cdot (depth_{stir} - Offset - 1.5 \cdot ft) \cdot \frac{b}{2}\right], 0 \cdot kip \cdot ft\right] = 152 \cdot kip \cdot ft$$

$$Tor2 := if(SoilType = \text{"Sand"}, Tor2_{sand}, Tor2_{clay}) = 341.1 \cdot kip \cdot ft$$

$$Tor3 := if(SoilType = \text{"Sand"}, Tor3_{sand}, Tor3_{clay}) = 275.4 \cdot kip \cdot ft$$

$$TorsionRatio_{n1} := \frac{T_u}{\phi_{tor} \cdot T_{n1}} = 0.3$$

$$TorsionRatio_{n2} := \frac{Tor2}{\phi_{tor} \cdot T_{n2}} = 0.59$$

$$TorsionRatio_{n3} := \frac{Tor3}{\phi_{tor} \cdot T_{n3}} = 0.71$$

$$TorsionRatio := max(TorsionRatio_{n1}, TorsionRatio_{n2}, TorsionRatio_{n3}) = 0.71$$

$$T_{cr} := 0.125 \sqrt{\frac{f_c}{ksi}} \cdot \left(\frac{A_{cp}^{\ 2}}{p_{cp} \cdot in^3}\right) \cdot kip \cdot in = 883.6 \cdot kip \cdot ft$$ *LRFD Eqn 5.8.2.1-4*

$$TorsionRatio := if(T_u \le 0.25 \cdot \phi_{tor} \cdot T_{cr}, 0, TorsionRatio) = 0.7$$ *LRFD Eqn 5.8.2.1-3*

$ShearRatio = 0$

$$CheckShearTorsion := if(ShearRatio + TorsionRatio \le 1, \text{"OK"}, \text{"No Good"})$$

$CheckShearTorsion = \text{"OK"}$

Check Maximum Spacing Transverse Reinforcement

$$v_u := \frac{V_u}{\phi_v \cdot b \cdot d_v} = 0.005358 \cdot ksi$$ $0.125 \cdot f_c = 0.5 \cdot ksi$ *LRFD Eqn 5.8.2.9-1*

$s_{max1} := \text{if}\left(0.8 \cdot d_v < 24 \cdot in, 0.8 d_v, 24 \cdot in\right) = 24 \cdot in$ LRFD Eqn 5.8.2.7-1

$s_{max2} := \text{if}\left(0.4 \cdot d_v < 12 \cdot in, 0.4 d_v, 12 \cdot in\right) = 12 \cdot in$ LRFD Eqn 5.8.2.7-2

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

$\max\left(s_{v1}, s_{v2}, s_{v3}\right) = 12 \cdot in$

$\text{CheckMaxSpacingTransvReinf} := \text{if}\left(\max\left(s_{v1}, s_{v2}, s_{v3}\right) \le s_{max}, \text{"OK"}, \text{"No Good"}\right)$

$\text{CheckMaxSpacingTransvReinf} = \text{"OK"}$

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

LRFD 5.8.3.4.1

$M_u = 303.9 \cdot kip \cdot ft$

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

$$LongReinf_{shr.tor} := \frac{\dfrac{M_u}{\phi_v \cdot d_v} + \sqrt{\left(V_{temp}\right)^2 + \left(\dfrac{0.45 \cdot p_h \cdot T_u}{2 \cdot A_o \cdot \phi_v}\right)^2}}{F_{y.rebar}} = 3.3 \cdot in^2$$

$Num_{bar} \cdot A_{long.bar} = 28.1 \cdot in^2$

$CheckLongReinf_{shr.tor} := \text{if}\left(Num_{bar} \cdot A_{long.bar} \ge LongReinf_{shr.tor}, \text{"OK"}, \text{"No Good"}\right)$

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

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

Mast Arm Assembly Information

Wind Speed
○ 130 mph ● 150 mph ○ 170 mph

Signal Orientation
● Vertical
○ Horizontal

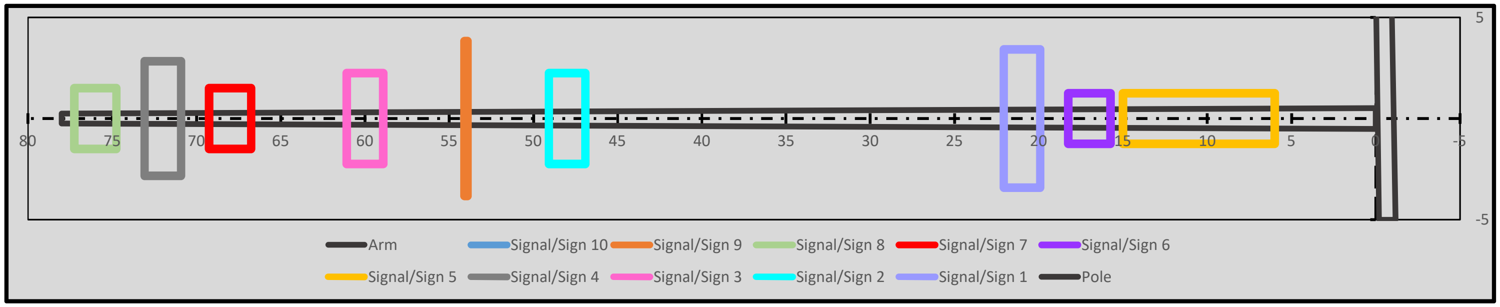
Back Plate Width
● 6.0 in.
○ 2.5 in.
○ 0 in.

Luminaire?
● Yes
○ No

Arm 1 Length
30
40
50
60
70
78

Arm 1 Length, Signal/Sign Location and Size

	Signal\Sign #10	Signal\Sign #9	Signal\Sign #8	Signal\Sign #7	Signal\Sign #6	Signal\Sign #5	Signal\Sign #4	Signal\Sign #3	Signal\Sign #2	Signal\Sign #1
Dist to Pole (ft.)	75	54	76	68	17	10.5	72	60	48	21
	● 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
Sign Width (in.)		2	30	30	30	108				
Sign Height (in.)		92	36	36	30	30				
Area (SF)	0.0	1.3	7.5	7.5	6.3	22.5	12.3	9.8	9.8	14.8
M_{wl}, (kip*ft)	0	5	38	34	7	16	59	39	31	21



Arm 1 Length (ft)	78	
Design Standard Index 17743	Regular	Heavy Duty
Dia. at Arm Base (in)	18	20
Wall Thickness (in)	0.3750	0.3750
Resistance ($M_r=\phi M_n$) (kip*ft)	422	512

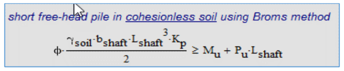
Arm 1 Loads	Regular	Heavy Duty
1.1*Arm M_{dl} (kip*ft)	121	143
Arm M_{wl} (kip*ft)	120	141
1.1*Sign/Signal M_{dl} (kip*ft)	19	
Sign/Signal M_{wl} (kip*ft)	250	
Total Moment ($M_{extreme}$)	396	424

Mast Arm Assembly Designation
One Arm Assembly A78/S-P6/S/L-DS/16/5

See separate calc
for foundation

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.

Tube Wind Pressure (psf)	44.1	**Fy (ksi)**	50	**Sign/Sig. Wind Pressure (psf)**	67.0



short free-head pile in cohesionless soil using Broms method

$$\phi \cdot \frac{\gamma_{soil} \cdot b_{shaft} \cdot L_{shaft}^{3} \cdot K_p}{2} \geq M_u + P_u \cdot L_{shaft}$$

Arm Without Attachments: Dead Load Moment, Wind Load Moment and Moment Capacity at Base Connection

	Regular							Heavy Duty						
Total Arm Length (ft)	**wall thk (in)**	**base dia (in)**	**S (in3)**	**Z (in3)**	**M_{dl} (kip*ft)**	**$M_{wl\ 130\ mph}$ (kip*ft)**	**$M_r=\phi M_n$ (kip*ft)**	**wall thk (in)**	**base dia (in)**	**S (in3)**	**Z (in3)**	**M_{dl} (kip*ft)**	**$M_{wl\ 130mph}$ (kip*ft)**	**Mr=ϕMn (kip*ft)**
30	0.25	11	23	29	10	10	107	0.25	12	27	34	11	11	125
40	0.25	13	32	40	20	20	145	0.25	14	37	47	22	22	166
50	0.3125	14	46	58	36	33	215	0.3125	15	53	67	40	37	244
60	0.375	15	63	79	56	48	300	0.375	16	72	91	62	53	340
70	0.375	17	81	103	85	71	380	0.375	18	91	115	100	77	422
78	0.375	18	91	115	110	90	422	0.375	20	113	143	130	106	512

Drilled Shaft

Index 17743 Drilled Shaft Capacities						1 Arm Assembly Loads And Capacity Check					2 Arm Assembly Loads and Capacity Check				
DS Index #	**ID**	**Length**	**Diameter**	**ϕM_n**	**ϕT_n**	**M_u+ P_u*L_{shaft}**	**T_u**	**Check Mom. & Min Dia.**	**Check Torsion**	**Check**	**M_u+ P_u*L_{shaft}**	**T_u**	**Check Mom. & Min Dia.**	**Check Torsion**	**Check**
1	DS/20/5	20	5	1800	589	611.3	370.3	Okay	Okay	Okay	0.0	0.0	0	0	0
2	DS/18/5	18	5	1312	477	583.5		Okay	Okay	Okay	0.0		0	0	0
3	DS/16/5	16	5	922	377	555.6		Okay	Okay	Okay	0.0		0	0	0
4	DS/16/4.5	16	4.5	829	305	555.6		NoGood	NoGood	NoGood	0.0		0	0	0
5	DS/14/5	14	5	617	289	527.7		Okay	NoGood	NoGood	0.0		0	0	0
6	DS/14/4.5	14	4.5	556	234	527.7		NoGood	NoGood	NoGood	0.0		0	0	0
7	DS/12/4.5	12	4.5	350	172	499.8		NoGood	NoGood	NoGood	0.0		0	0	0
8	DS/12/4	12	4	311	136	499.8		NoGood	NoGood	NoGood	0.0		0	0	0

Arm 1 Attachments: Extreme Event Dead Load Moment, Wind Load Moment at Base Connection

	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**	**Total**		
Sign/Sig Mwl (kip*ft)	0.0	4.6	38.2	34.2	7.1	15.8	59.2	39.2	31.3	20.8	250.5		
Sign/Sig 1.1*Mdl (kip*ft)	0.0	0.3	2.5	2.2	0.5	1.0	5.1	3.3	2.6	1.8	19.5		
Arm 1 Mwl (kip*ft)											119.8	141.1	*Reg Arm / HD Arm*
Arm 1 1.1*Mdl (kip*ft)											121.0	143.0	*Reg Arm / HD Arm*
										*Extreme Event Arm Moment (kip*ft)*	396.0	424.5	

Ensures anchor bolts fit inside rebar cage

Min Shaft Diameter
5

Arm 2 Attachments: Extreme Event Dead Load Moment, Wind Load Moment at Base Connection

	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**	**Total**	
Sign/Sig Mwl (kip*ft)	0.0	0.0	0.0	0.0	0.0	47.6	*24.2*	*40.2*	*15.0*	*7.8*	134.8	
Sign/Sig 1.1*Mdl (kip*ft)	0.0	0.0	0.0	0.0	0.0	4.2	*2.0*	*2.6*	*1.3*	*0.7*	10.8	
Arm 2 Mwl (kip*ft)											0.0	0.0
Arm 2 1.1*Mdl (kip*ft)											0.0	0.0
											0.0	0.0

Required Drilled Shaft Index Number Required (see Table for size)

Load Case	**1 Arm DS Index #**	**2 Arm DS Index #**
Drilled Shaft Index req'd for Overturning including Min. Diamter	5	0
Drilled Shaft Index req'd for Torsion	3	0
Drilled Shaft Controlling Load Case	**3**	**#N/A**

Pole Base Shears & Moments

	Arm 1 Shear	**Arm 1 Moment**	**Arm 2 Shear**	**Arm 2 Moment**	
dl att	N/A	19.5	N/A	0.0	
dl arm	N/A	121.0	N/A	0.0	
wl pole	2.6	52.9	0.0	0.0	*assume a 37.5' pole wl with lum*
wl att	6.1	135.0	0.0	0.0	
wl arm	5.2	113.5	0.0	0.0	
Tor wl att	N/A	250.5	N/A	0.0	
Tor wl arm	N/A	119.8	N/A	0.0	

Forces at Top of DS

	One Arm	Two Arms	
Moment dl	140.5	N/A	
Moment wl	301.4		
Moment Total	332.5	0.0	
Torsion	370.3	0.0	
Shear	13.9	0.0	
Shaft 2-Arm Factor	*1.1*		*used for OT & Torsion*

Pole ID

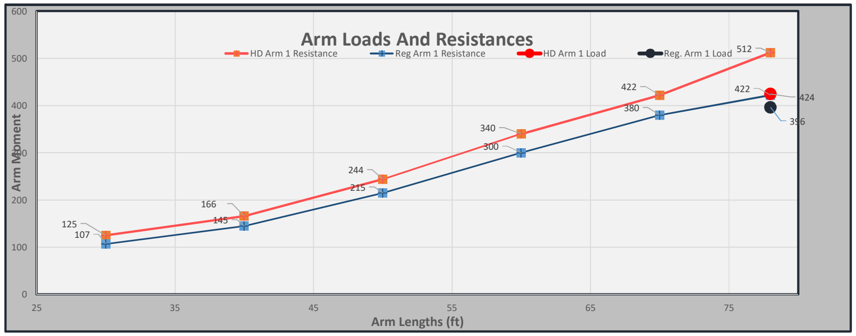
Arm 1 Length	78	Arm 2 Length	0
	Pole ID	P6	

1 Arm Assembly	Use Regular Arm						
Design Arm Designation			**Pole Designation**			**Drilled Shaft**	
A78	/S		P6	/S	/L	DS	
A78/S-			P6/S/L-			DS/16/5	
A78/S-P6/S/L-DS/16/5							

2 Arm Assembly	Use Regular Arm						
Design Arm Designation			**Pole Designation**			**Drilled Shaft**	
						DS	
-			-				

Assembly ID	A78/S-P6/S/L-DS/16/5	
	Arm 1	**Arm 2**
Arm Length(s)	78	0
Max Design CFI %	0.95	
Est. Regular Arm CFI	0.99	0.00
Est. HD Arm CFI	0.87	0.00

Note: Poles are designed to have a smaller CFI than Arms



Drilled Shaft Foundation for
Sign, Signal, and Lighting Support Structures v1.1

State Structures Design Office

SUBJECT: Moccasin Wallow Road
Struct # T-13-2 LOCATION: Sta. 340+06.2, 78.8' RT

DESIGNED BY: MPR DATE: 12/2021
CHECKED BY: DATE: 12/2021

Program Changes

SoilType :=
- Sand
- Clay

$\phi_{soil} := 29 \cdot deg$ *soil friction angle (sand)*

$c_{soil} := 1.25 \cdot \frac{kip}{ft^2}$ *soil shear strength (clay)*

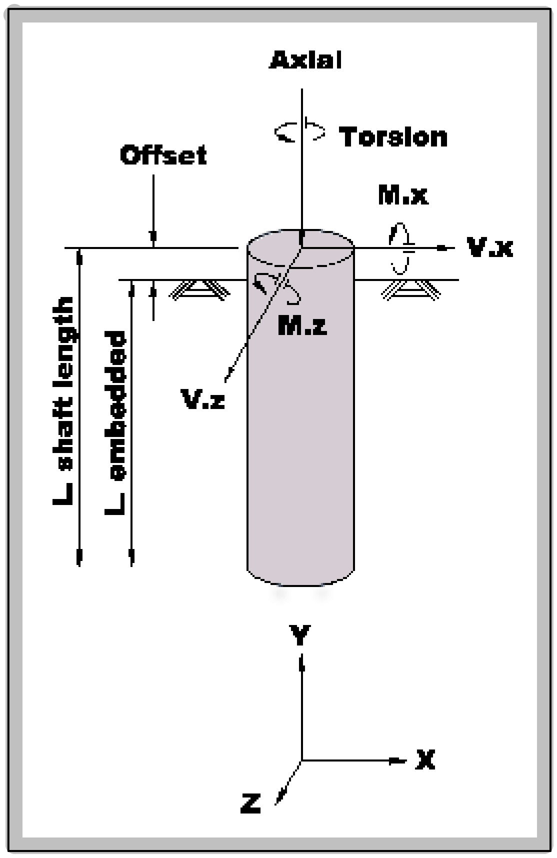
$N_{blows} := 8.5$ *number of blows per foot. If N< 5, contact the district geotech Engineer*

$\gamma_{soil} := 42.6 \cdot pcf$ *effective soil weight (typical design value = 45 ~ 50 pcf)*

Geometry

$b := 5 \cdot ft$ *shaft diameter, "DB"*

$Offset := 2 \cdot ft$ *groundline to top of foundation*



Applied Loads (Extreme I)

$M_x := 301.4 \cdot kip \cdot ft$ $V_x := 0 \cdot kip$ $Torsion := 370.3 \cdot kip \cdot ft$

$M_z := 140.5 \cdot kip \cdot ft$ $V_z := 13.9 \cdot kip$ $Axial := 4.0 \cdot kip$

StructureType :=
- Cantilever Overhead Sign Structure
- Mast Arm Signal Structure
- Concrete/Steel Strain Poles
- Ground Sign

$StructureType = 1$

$\phi_{ot} := if(StructureType = 3, 0.8, 0.6)$ $\phi_{ot} = 0.6$ *ϕ factor against overturning [SM Vol-3 13.6.1.1]*

$\phi_{tor} := if(StructureType = 0, 0.9, 1.0)$ $\phi_{tor} = 1$ *ϕ factor against torsion [SM Vol-3 13.6.1.1]*

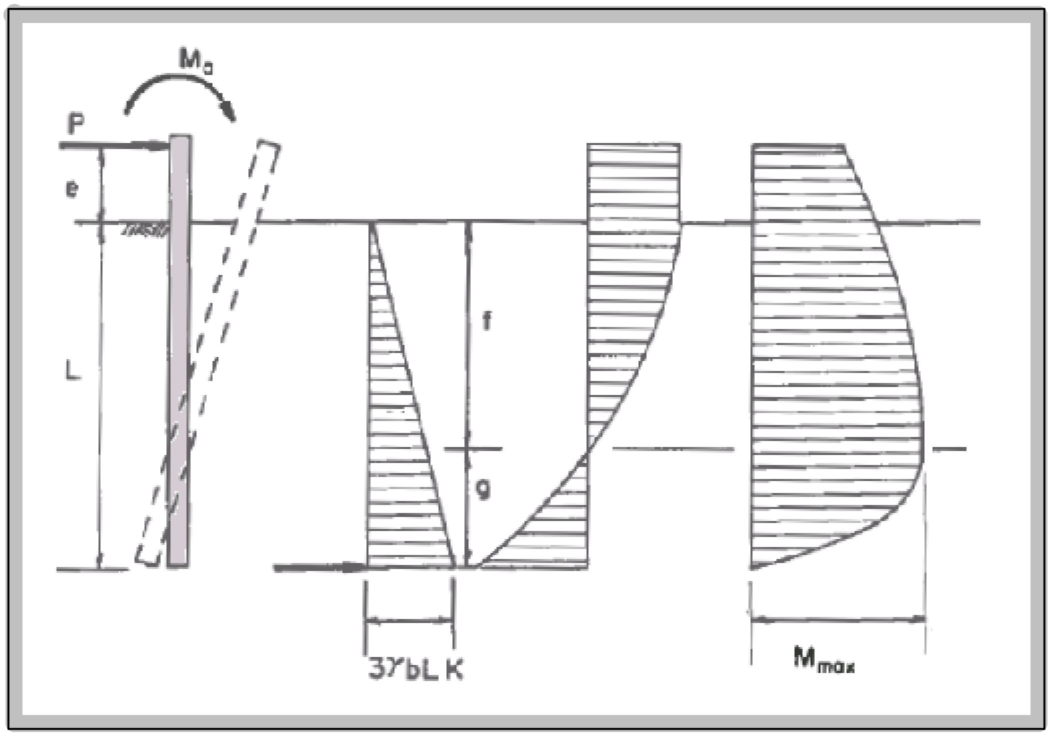
Shaft Depth Required to Resist Overturning

$$M_u := \sqrt{M_x^{\ 2} + M_z^{\ 2}} = 332.5 \cdot \text{kip} \cdot \text{ft}$$

$$P_u := \sqrt{V_x^{\ 2} + V_z^{\ 2}} = 13.9 \cdot \text{kip}$$

$$T_u := \text{Torsion} = 370.3 \cdot \text{kip} \cdot \text{ft}$$

*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.

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

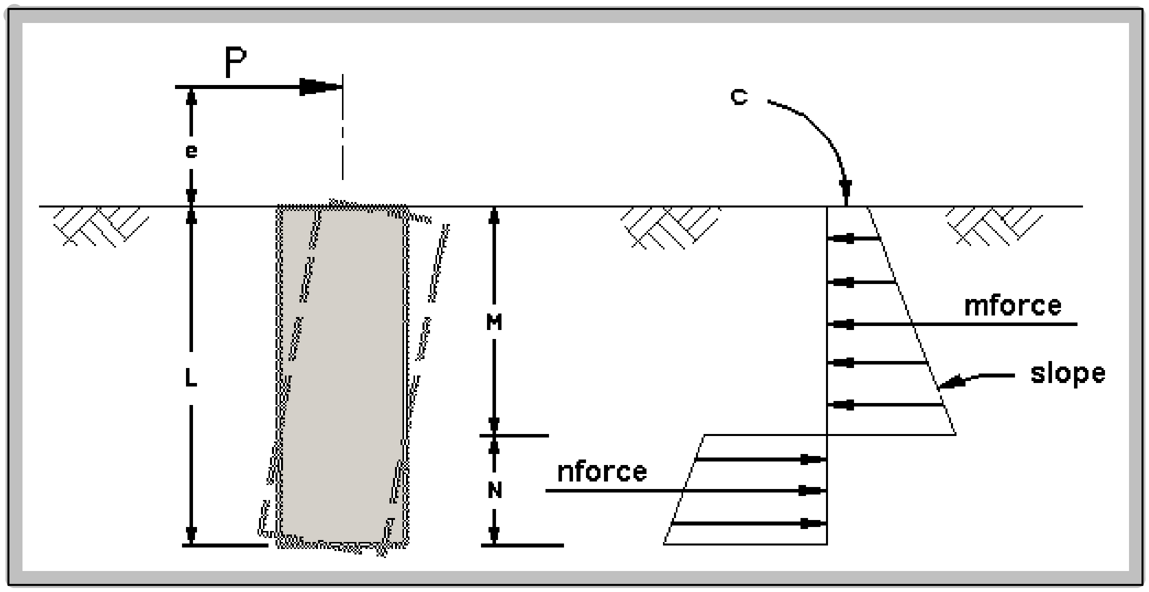
Guess value $L_{otSand} := 8 \cdot \text{ft}$

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

$$L_{otSand} := \text{Find}\left(L_{otSand}\right) = 14.5\,\text{ft}$$

$$L_{otSand} := \text{ceil}\left(\frac{L_{otSand}}{\text{ft}}\right) \cdot \text{ft} = 15\,\text{ft}$$ *(round up to next foot)*

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.

$c_{soil} := \text{if}\left(c_{soil} = 0 \cdot ksf, 0.1 \cdot ksf, c_{soil}\right) = 1.3 \cdot ksf$

$\text{Slope} := 8 \cdot \frac{c_{soil}}{3 \cdot b} = 0.7 \cdot \frac{kip}{ft^3}$ $\qquad$ $e_{clay} := \frac{M_u}{P_u} + \text{Offset} = 25.9\ ft$

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

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

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

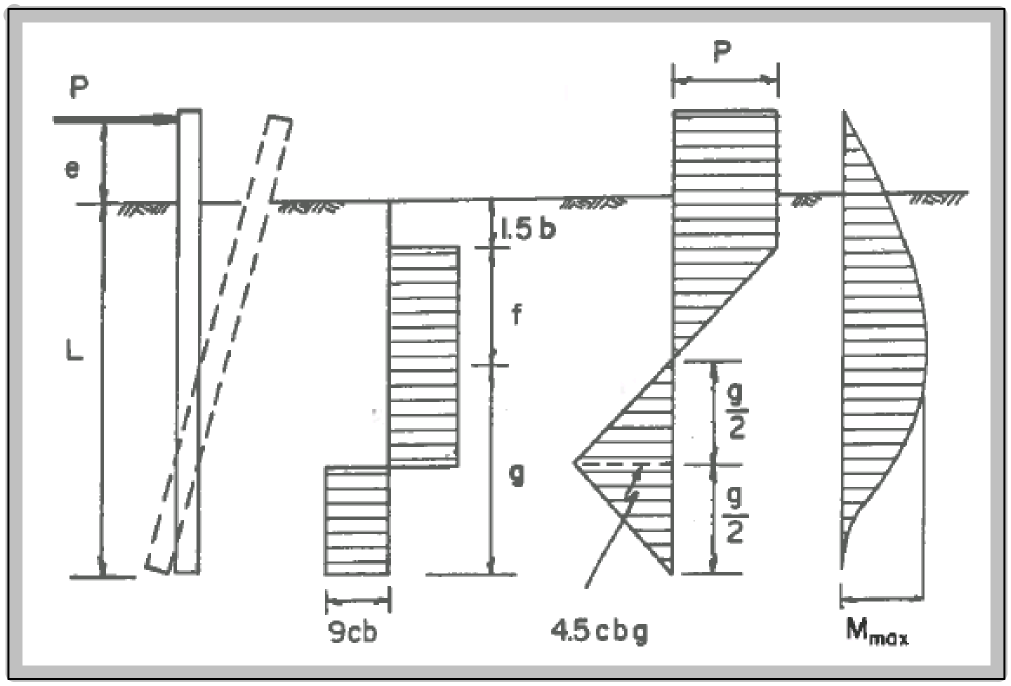
Guess value $\qquad M := 4.0 \cdot ft \qquad N := 4.0 \cdot ft$

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

$\begin{pmatrix} M \\ N \end{pmatrix} := \text{Find}(M,N) \qquad L_{ot1Clay} := M + N = 11.8\ ft$

$L_{ot1Clay} := \text{ceil}\left(\frac{L_{ot1Clay}}{ft}\right) \cdot ft = 12\ ft$ $\qquad$ *(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.*

$$f := \frac{P_u}{\phi_{ot} \cdot 9 \cdot c_{soil} \cdot b} = 0.4\,ft$$

$$M_{max.clay} := P_u \cdot \left(e_{clay} + 1.5 \cdot b + 0.5 \cdot f\right) = 467.5 \cdot kip \cdot ft$$

$$g := \sqrt{\frac{M_{max.clay}}{2.25 \cdot \phi_{ot} \cdot c_{soil} \cdot b}} = 7.4\,ft$$

$$L_{ot2Clay} := \left(1.5 \cdot b + f + g\right) = 15.4\,ft$$

$$L_{ot2Clay} := ceil\left(\frac{L_{ot2Clay}}{ft}\right) \cdot ft = 16\,ft$$ *(round up to next foot)*

$$L_{otClay} := if\left(L_{ot1Clay} < 3 \cdot b, L_{ot1Clay}, L_{ot2Clay}\right) = 3.7$$ *(If $L_{ot} < 3b$, use Modified Broms method)*

$$L_{reqdOT} := if\left(SoilType = \text{"Sand"}, L_{otSand}, L_{otClay}\right)$$

$L_{reqdOT} = 15\,ft$ *required shaft embedment depth to resist overturning*

Shaft Depth Required to Resist Torsion

*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.

$N_{blows} = 8.5$

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

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 $L_{torSand} := L_{reqdOT} = 15\,\text{ft}$

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

$L_{torSand} := \text{Find}(L_{torSand}) = 22.8\,\text{ft}$

$L_{torSand} := \text{ceil}\left(\frac{L_{torSand}}{\text{ft}}\right) \cdot \text{ft} = 23\,\text{ft}$ *(round up to next foot)*

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

$\text{CohesionFactor} := 0.55$

$f_{se} := \text{CohesionFactor} \cdot c_{soil} = 0.7 \cdot \text{ksf}$

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

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

$L_{torClay} := \text{Find}(L_{torClay}) = 15.2\,\text{ft}$

$L_{torClay} := \text{ceil}\left(\frac{L_{torClay}}{\text{ft}}\right) \cdot \text{ft} = 16\,\text{ft}$ *(round up to next foot)*

$L_{reqdTor} := \text{if}(\text{SoilType} = \text{"Sand"}, L_{torSand}, L_{torClay})$

$L_{reqdTor} = 23\,\text{ft}$ *required shaft embedment depth to resist torsion*

$L_{embedded} := \text{if}(L_{reqdTor} > L_{reqdOT}, L_{reqdTor}, L_{reqdOT}) = 7$

$L_{shaft.length} := L_{embedded} + \text{Offset}$

$L_{shaft.length} = 25\,\text{ft}$ *shaft length*

Maximum Moment in Shaft

short free-head pile in cohesionless soil using Broms method

$$f_{sand} := \sqrt{\frac{2 \cdot P_u}{3 \cdot \gamma_{soil} \cdot b \cdot K_p \cdot \phi_{ot}}} = 5\,ft$$

$$M_{maxSand} := P_u \cdot \left(e_{sand} + f_{sand}\right) - \frac{P_u \cdot f_{sand}}{3} + M_u = 406.8 \cdot kip \cdot ft$$

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

$$f_{mod} := Find\left(f_{mod}\right) = 2.3\,ft$$

$$M_{modBroms} := P_u \cdot \left(e_{clay} + f_{mod}\right) - \frac{\phi_{ot} \cdot c_{soil} \cdot b \cdot f_{mod}^{\ 2}}{2} - \frac{\phi_{ot} \cdot b \cdot f_{mod}^{\ 3} \cdot Slope}{6} = 378.3 \cdot kip \cdot ft$$

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

$$M_{Broms} := P_u \cdot \left(e_{clay} + 1.5 \cdot b + 0.5 \cdot f\right) = 467.5 \cdot kip \cdot ft$$

$$M_{maxClay} := if\left(L_{ot1Clay} < 3 \cdot b, M_{modBroms}, M_{Broms}\right) = 378.3 \cdot kip \cdot ft$$ *(If $L_{\alpha} < 3b$, use Modified Broms method)*

$$M_{max} := if\left(SoilType = \text{"Sand"}, M_{maxSand}, M_{maxClay}\right) = 406.8 \cdot kip \cdot ft$$

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*

$Num_{bar} := 18$ *number of longitudinal bars, "RB"*

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

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

$A_{v.bar} := 0.31 \cdot in^2$ *stirrup area* *SM Vol-3 13.6.2*

$d_{v.bar} := 0.625 \cdot in$ *stirrup diameter*

$s_{v1} := 4 \cdot in$ *stirrup spacing, depth = 0 ft-2 ft* *SM Vol-3 13.6.2*

$s_{v2} := 8 \cdot in$ *stirrup spacing, depth = 2 ft-depth.stir, "RD"*

$s_{v3} := 12 \cdot in$ *stirrup spacing, depth > depth.stir, "RF"*

$depth_{stir} := 9.083 \cdot ft$ *stirrup depth, see s.v2 and s.v3 above*

$b = 5\,ft$ *shaft diameter*

$$A_{req} := \min\left(0.135 \cdot \frac{\pi \cdot b^2}{4} \cdot \frac{f_c}{F_{y.rebar}}, 0.015 \cdot \frac{\pi \cdot b^2}{4}\right) = 25.4 \cdot in^2$$ *LRFD 5.7.4.2*

$A_{long} := Num_{bar} \cdot A_{long.bar} = 28.1 \cdot in^2$ *total area of longitudinal steel*

$CheckLongitudinalReinf := \text{if}\left(A_{long} \geq A_{req}, \text{"OK"}, \text{"No Good"}\right)$ $CheckLongitudinalReinf = \text{"OK"}$

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

$Spacing_{vert.reinf} := Dia_{bar.circle} \cdot \frac{\pi}{Num_{bar}} = 7.9 \cdot in$ $Clearance_{vert.reinf} := Spacing_{vert.reinf} - d_{long.bar} = 6.5 \cdot in$

$CheckReinfClearSpacing := \text{if}\left(Clearance_{vert.reinf} \geq 6in, \text{"OK"}, \text{"No Good"}\right)$ $CheckReinfClearSpacing = \text{"OK"}$ *SDG 3.6.10*

Check Shear and Torsion

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

$$V_u := \sqrt{V_x^{\,2} + V_z^{\,2}} = 13.9 \cdot \text{kip}$$

$$T_u = 370.3 \cdot \text{kip} \cdot \text{ft}$$

Effective shear depth

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

LRFD C5.8.2.9-2

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

Check Shear Strength

$$V_c := 0.0316 \cdot (2.0) \cdot \sqrt{\frac{f_c}{\text{ksi}}} \cdot \left(\frac{b}{\text{in}}\right) \cdot \left(\frac{d_v}{\text{in}}\right) \cdot \text{kip} = 327.6 \cdot \text{kip}$$

LRFD Eqn 5.8.3.3-3 *LRFD 5.8.3.4.1* *ACI 11.3.3*

$$V_s := \frac{A_{v.bar} \cdot F_{y.rebar} \cdot d_v}{\max\left(s_{v1}, s_{v2}, s_{v3}\right)} = 67 \cdot \text{kip}$$

LRFD Eqn 5.8.3.3-4

$$\text{ShearRatio} := \frac{V_u - \phi_v \cdot V_c}{\phi_v \cdot V_s} = -4.7$$

$$\text{ShearRatio} := \text{if}\left(\text{ShearRatio} \le 0, 0, \text{ShearRatio}\right) = 0$$

Check Torsion Strength

$$A_{cp} := \pi \cdot \left(\frac{b}{2}\right)^2 = 2827.4 \cdot \text{in}^2 \qquad p_{cp} := 2 \cdot \pi \cdot \left(\frac{b}{2}\right) = 188.5 \cdot \text{in}$$

Area and perimeter of concrete cross-section

$$d_{oh} := b - 2 \cdot \left(\text{Cover} + \frac{d_{v.bar}}{2}\right) = 47.4 \cdot \text{in} \qquad p_h := \pi \cdot d_{oh} = 148.8 \cdot \text{in}$$

Diameter, perimeter and area enclosed by the centerline of the outermost closed transverse torsion reinforcement

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

$$T_{n1} := \frac{2 \cdot A_o \cdot A_{v.bar} \cdot F_{y.rebar}}{s_{v1}} = 1.2 \times 10^3 \cdot \text{kip} \cdot \text{ft}$$

LRFD Eqn 5.8.3.6.2-1

$$T_{n2} := \frac{2 \cdot A_o \cdot A_{v.bar} \cdot F_{y.rebar}}{s_{v2}} = 580.6 \cdot \text{kip} \cdot \text{ft}$$

LRFD 5.8.3.4.1

$$T_{n3} := \frac{2 \cdot A_o \cdot A_{v.bar} \cdot F_{y.rebar}}{s_{v3}} = 387.1 \cdot kip \cdot ft$$

$\phi_v = 0.9$ $\quad$ $T_u = 370.3 \cdot kip \cdot ft$ $\quad$ $L_{reqdTor} = 23\,ft$

$$Tor2_{sand} := T_u - if\left[2ft > Offset, \left[\pi \cdot b \cdot (2 \cdot ft - Offset) \cdot \gamma_{soil} \cdot \left(\frac{2 \cdot ft - Offset}{2}\right) \cdot (\omega_{fdot}) \cdot \frac{b}{2}\right], 0 \cdot kip \cdot ft\right] = 370.3 \cdot kip \cdot ft$$

$$Tor3_{sand} := T_u - if\left[depth_{stir} > Offset, \left[\pi \cdot b \cdot (depth_{stir} - Offset) \cdot \gamma_{soil} \cdot \left(\frac{depth_{stir} - Offset}{2}\right) \cdot (\omega_{fdot}) \cdot \frac{b}{2}\right], 0 \cdot kip \cdot ft\right] = 334.6 \cdot kip \cdot ft$$

$$Tor2_{clay} := T_u - if\left[2ft - 1.5ft > Offset, \left[f_{se} \cdot (\pi \cdot b) \cdot (2.0 \cdot ft - Offset - 1.5 \cdot ft) \cdot \frac{b}{2}\right], 0 \cdot kip \cdot ft\right] = 370.3 \cdot kip \cdot ft$$

$$Tor3_{clay} := T_u - if\left[depth_{stir} - 1.5ft > Offset, \left[f_{se} \cdot (\pi \cdot b) \cdot (depth_{stir} - Offset - 1.5 \cdot ft) \cdot \frac{b}{2}\right], 0 \cdot kip \cdot ft\right] = 219.6 \cdot kip \cdot ft$$

$$Tor2 := if(SoilType = \text{"Sand"}, Tor2_{sand}, Tor2_{clay}) = 370.3 \cdot kip \cdot ft$$

$$Tor3 := if(SoilType = \text{"Sand"}, Tor3_{sand}, Tor3_{clay}) = 334.6 \cdot kip \cdot ft$$

$$TorsionRatio_{n1} := \frac{T_u}{\phi_{tor} \cdot T_{n1}} = 0.32$$

$$TorsionRatio_{n2} := \frac{Tor2}{\phi_{tor} \cdot T_{n2}} = 0.64$$

$$TorsionRatio_{n3} := \frac{Tor3}{\phi_{tor} \cdot T_{n3}} = 0.86$$

$$TorsionRatio := max(TorsionRatio_{n1}, TorsionRatio_{n2}, TorsionRatio_{n3}) = 0.86$$

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

LRFD Eqn 5.8.2.1-4

$$TorsionRatio := if(T_u \le 0.25 \cdot \phi_{tor} \cdot T_{cr}, 0, TorsionRatio) = 0.9$$

LRFD Eqn 5.8.2.1-3

$ShearRatio = 0$

$$CheckShearTorsion := if(ShearRatio + TorsionRatio \le 1, \text{"OK"}, \text{"No Good"})$$

$CheckShearTorsion = \text{"OK"}$

Check Maximum Spacing Transverse Reinforcement

$$v_u := \frac{V_u}{\phi_v \cdot b \cdot d_v} = 0.005959 \cdot ksi \qquad 0.125 \cdot f_c = 0.5 \cdot ksi$$

LRFD Eqn 5.8.2.9-1

$s_{max1} := \text{if}\left(0.8 \cdot d_v < 24 \cdot in, 0.8d_v, 24 \cdot in\right) = 24 \cdot in$ LRFD Eqn 5.8.2.7-1

$s_{max2} := \text{if}\left(0.4 \cdot d_v < 12 \cdot in, 0.4d_v, 12 \cdot in\right) = 12 \cdot in$ LRFD Eqn 5.8.2.7-2

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

$\max\left(s_{v1}, s_{v2}, s_{v3}\right) = 12 \cdot in$

$\text{CheckMaxSpacingTransvReinf} := \text{if}\left(\max\left(s_{v1}, s_{v2}, s_{v3}\right) \le s_{max}, \text{"OK"}, \text{"No Good"}\right)$

$\text{CheckMaxSpacingTransvReinf} = \text{"OK"}$

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

LRFD 5.8.3.4.1

$M_u = 332.5 \cdot kip \cdot ft$

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

$$\text{LongReinf}_{shr.tor} := \frac{\dfrac{M_u}{\phi_v \cdot d_v} + \sqrt{\left(V_{temp}\right)^2 + \left(\dfrac{0.45 \cdot p_h \cdot T_u}{2 \cdot A_o \cdot \phi_v}\right)^2}}{F_{y.rebar}} = 3.5 \cdot in^2$$

$\text{Num}_{bar} \cdot A_{long.bar} = 28.1 \cdot in^2$

$\text{CheckLongReinf}_{shr.tor} := \text{if}\left(\text{Num}_{bar} \cdot A_{long.bar} \ge \text{LongReinf}_{shr.tor}, \text{"OK"}, \text{"No Good"}\right)$

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

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

Mast Arm Assembly Information

Wind Speed
○ 130 mph ● 150 mph ○ 170 mph

Signal Orientation
● Vertical
○ Horizontal

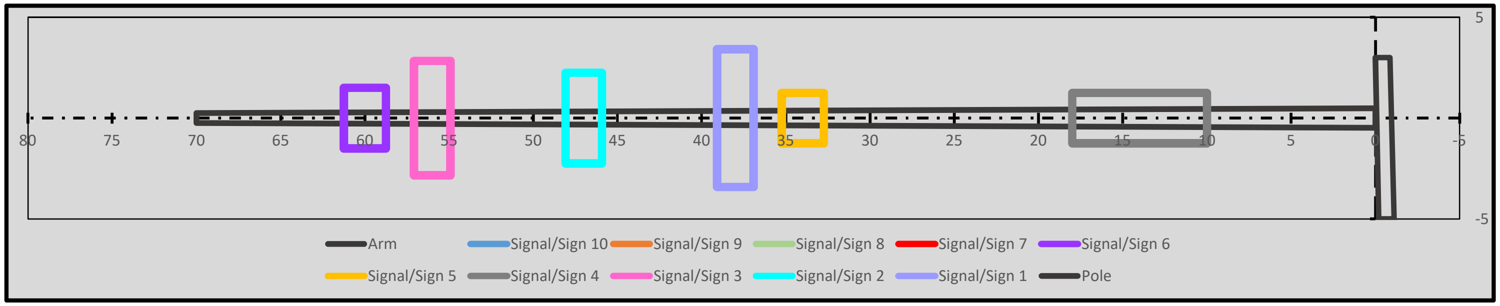
Back Plate Width
● 6.0 in.
○ 2.5 in.
○ 0 in.

Luminaire?
○ Yes
● No

Arm 1 Length
30
40
50
60
70
78

Arm 1 Length, Signal/Sign Location and Size

	Signal\Sign #10	Signal\Sign #9	Signal\Sign #8	Signal\Sign #7	Signal\Sign #6	Signal\Sign #5	Signal\Sign #4	Signal\Sign #3	Signal\Sign #2	Signal\Sign #1
Dist to Pole (ft.)	75	54	76	68	60	34	14	56	47	38
	● 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
Sign Width (in.)					30	30	96			
Sign Height (in.)					36	30	30			
Area (SF)	0.0	0.0	0.0	0.0	7.5	6.3	20.0	12.3	9.8	14.8
M_{wl}. (kip*ft)	0	0	0	0	30	14	19	46	31	38



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=ϕM_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)	14	
Sign/Signal M_{wl} (kip*ft)	178	
Total Moment ($M_{extreme}$)	293	307

Mast Arm Assembly Designation
One Arm Assembly A70/S-P5/S-DS/14/5

See separate calc
for foundation

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.

Tube Wind Pressure (psf)	44.1

Fy (ksi)	50

Sign/Sig. Wind Pressure (psf)	67.0

short free-head pile in cohesionless soil using Broms method

$$\phi \cdot \frac{\gamma_{soil} \cdot b_{shaft} \cdot L_{shaft}^{3} \cdot K_p}{2} \geq M_u + P_u \cdot L_{shaft}$$

Arm Without Attachments: Dead Load Moment, Wind Load Moment and Moment Capacity at Base Connection

Total Arm Length (ft)	Regular							Heavy Duty						
	wall thk (in)	base dia (in)	S (in3)	Z (in3)	M_{dl} (kip*ft)	$M_{wl\ 130\ mph}$ (kip*ft)	M_r=ϕM_n (kip*ft)	wall thk (in)	base dia (in)	S (in3)	Z (in3)	M_{dl} (kip*ft)	$M_{wl\ 130mph}$ (kip*ft)	Mr=ϕMn (kip*ft)
30	0.25	11	23	29	10	10	107	0.25	12	27	34	11	11	125
40	0.25	13	32	40	20	20	145	0.25	14	37	47	22	22	166
50	0.3125	14	46	58	36	33	215	0.3125	15	53	67	40	37	244
60	0.375	15	63	79	56	48	300	0.375	16	72	91	62	53	340
70	0.375	17	81	103	85	71	380	0.375	18	91	115	100	77	422
78	0.375	18	91	115	110	90	422	0.375	20	113	143	130	106	512

Drilled Shaft

Index 17743 Drilled Shaft Capacities						1 Arm Assembly Loads And Capacity Check					2 Arm Assembly Loads and Capacity Check				
DS Index #	ID	Length	Diameter	ϕM_n	ϕT_n	M_u+ P_u*L_{shaft}	T_u	Check Mom. & Min Dia.	Check Torsion	Check	M_u+ P_u*L_{shaft}	T_u	Check Mom. & Min Dia.	Check Torsion	Check
1	DS/20/5	20	5	1800	589	509.9	272.1	Okay	Okay	Okay	0.0	0.0	0	0	0
2	DS/18/5	18	5	1312	477	486.4		Okay	Okay	Okay	0.0		0	0	0
3	DS/16/5	16	5	922	377	463.0		Okay	Okay	Okay	0.0		0	0	0
4	DS/16/4.5	16	4.5	829	305	463.0		NoGood	Okay	NoGood	0.0		0	0	0
5	DS/14/5	14	5	617	289	439.5		Okay	Okay	Okay	0.0		0	0	0
6	DS/14/4.5	14	4.5	556	234	439.5		NoGood	NoGood	NoGood	0.0		0	0	0
7	DS/12/4.5	12	4.5	350	172	416.0		NoGood	NoGood	NoGood	0.0		0	0	0
8	DS/12/4	12	4	311	136	416.0		NoGood	NoGood	NoGood	0.0		0	0	0

Arm 1 Attachments: Extreme Event Dead Load Moment, Wind Load Moment at Base Connection

	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	Total		
Sign/Sig Mwl (kip*ft)	0.0	0.0	0.0	0.0	30.1	14.2	18.8	46.1	30.7	37.7	177.6		
Sign/Sig 1.1*Mdl (kip*ft)	0.0	0.0	0.0	0.0	2.0	0.9	1.2	4.0	2.6	3.3	14.1		
Arm 1 Mwl (kip*ft)											94.5	102.5	*Reg Arm / HD Arm*
Arm 1 1.1*Mdl (kip*ft)											93.5	110.0	*Reg Arm / HD Arm*
*Extreme Event Arm Moment (kip*ft)*											292.6	306.8	

Ensures anchor bolts fit inside rebar cage

Min Shaft Diameter
5

Required Drilled Shaft Index Number Required (see Table for size)		
Load Case	1 Arm DS Index #	2 Arm DS Index #
Drilled Shaft Index req'd for Overturning including Min. Diamter	5	0
Drilled Shaft Index req'd for Torsion	5	0
Drilled Shaft Controlling Load Case	5	#N/A

Pole Base Shears & Moments				
	Arm 1 Shear	Arm 1 Moment	Arm 2 Shear	Arm 2 Moment
dl att	N/A	14.1	N/A	0.0
dl arm	N/A	93.5	N/A	0.0
wl pole	2.6	52.9	0.0	0.0
wl att	4.7	104.0	0.0	0.0
wl arm	4.4	96.2	0.0	0.0
Tor wl att	N/A	177.6	N/A	0.0
Tor wl arm	N/A	94.5	N/A	0.0

assume a 37.5' pole wl with lum

Forces at Top of DS		
	One Arm	Two Arms
Moment dl	107.6	N/A
Moment wl	253.1	
Moment Total	275.0	0.0
Torsion	272.1	0.0
Shear	11.7	0.0
Shaft 2-Arm Factor	*1.1*	*used for OT & Torsion*

Pole ID			
Arm 1 Length	70	Arm 2 Length	0
	Pole ID	P5	

Arm 2 Attachments: Extreme Event Dead Load Moment, Wind Load Moment at Base Connection

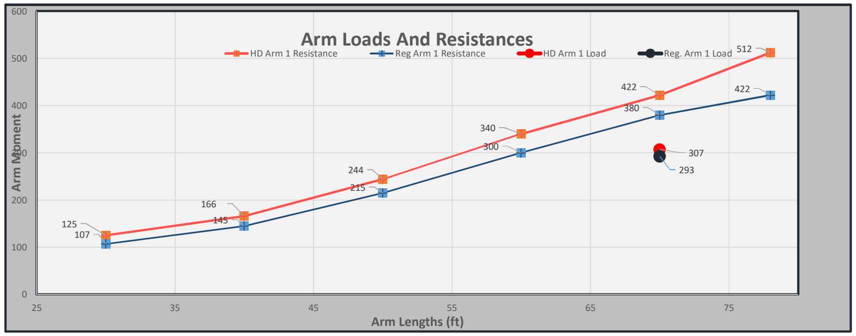
	Signal/ Sign 10	Signal/ Sign 9	Signal/ Sign 8	Signal/ Sign 7	Signal/ Sign 6	Signal/ Sign 5	Signal/ Sign 4	Signal/ Sign 3	Signal/ Sign 2	Signal/ Sign 1	Total	
Sign/Sig Mwl (kip*ft)	0.0	0.0	0.0	0.0	0.0	47.6	*24.2*	*40.2*	*15.0*	*7.8*	134.8	
Sign/Sig 1.1*Mdl (kip*ft)	0.0	0.0	0.0	0.0	0.0	4.2	*2.0*	*2.6*	*1.3*	*0.7*	10.8	
Arm 2 Mwl (kip*ft)											0.0	0.0
Arm 2 1.1*Mdl (kip*ft)											0.0	0.0
											0.0	0.0

1 Arm Assembly	Use Regular Arm						
Design Arm Designation			Pole Designation			Drilled Shaft	
A70	/S		P5	/S		DS	
A70/S-			P5/S-			DS/14/5	
A70/S-P5/S-DS/14/5							

2 Arm Assembly	Use Regular Arm						
Design Arm Designation			Pole Designation			Drilled Shaft	
						DS	
-			-				

Assembly ID	A70/S-P5/S-DS/14/5	
	Arm 1	Arm 2
Arm Length(s)	70	0
Max Design CFI %	0.95	
Est. Regular Arm CFI	0.81	0.00
Est. HD Arm CFI	0.77	0.00

Note: Poles are designed to have a smaller CFI than Arms



Drilled Shaft Foundation for
Sign, Signal, and Lighting Support Structures v1.1

State Structures Design Office

SUBJECT: Moccasin Wallow Road
Struct # T-13-3 LOCATION: Sta. 338+90.7, 90.3' RT

DESIGNED BY: MPR DATE: 12/2021
CHECKED BY: DATE: 12/2021

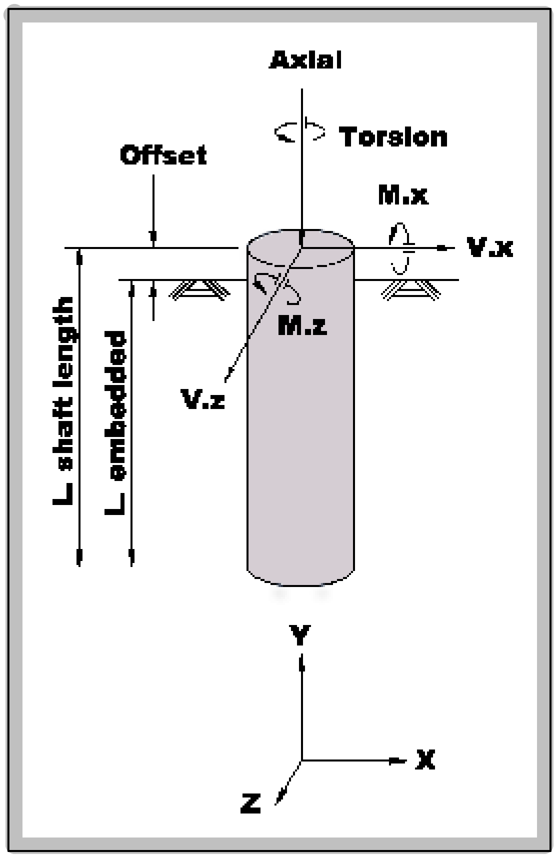
Program Changes

SoilType :=
- Sand
- Clay

$\phi_{soil} := 29 \cdot deg$	*soil friction angle (sand)*
$c_{soil} := 1.25 \cdot \frac{kip}{ft^2}$	*soil shear strength (clay)*
$N_{blows} := 8.5$	*number of blows per foot. If N< 5, contact the district geotech Engineer*
$\gamma_{soil} := 42.6 \cdot pcf$	*effective soil weight (typical design value = 45 ~ 50 pcf)*

Geometry

$b := 5 \cdot ft$	*shaft diameter, "DB"*
$Offset := 0.5 \cdot ft$	*groundline to top of foundation*



Applied Loads (Extreme I)

$M_x := 253.1 \cdot kip \cdot ft$ $V_x := 0 \cdot kip$ $Torsion := 272.1 \cdot kip \cdot ft$

$M_z := 107.6 \cdot kip \cdot ft$ $V_z := 11.7 \cdot kip$ $Axial := 4.0 \cdot kip$

StructureType :=
- Cantilever Overhead Sign Structure
- Mast Arm Signal Structure
- Concrete/Steel Strain Poles
- Ground Sign

$StructureType = 1$

$\phi_{ot} := if(StructureType = 3, 0.8, 0.6)$ $\phi_{ot} = 0.6$ *ϕ factor against overturning [SM Vol-3 13.6.1.1]*

$\phi_{tor} := if(StructureType = 0, 0.9, 1.0)$ $\phi_{tor} = 1$ *ϕ factor against torsion [SM Vol-3 13.6.1.1]*

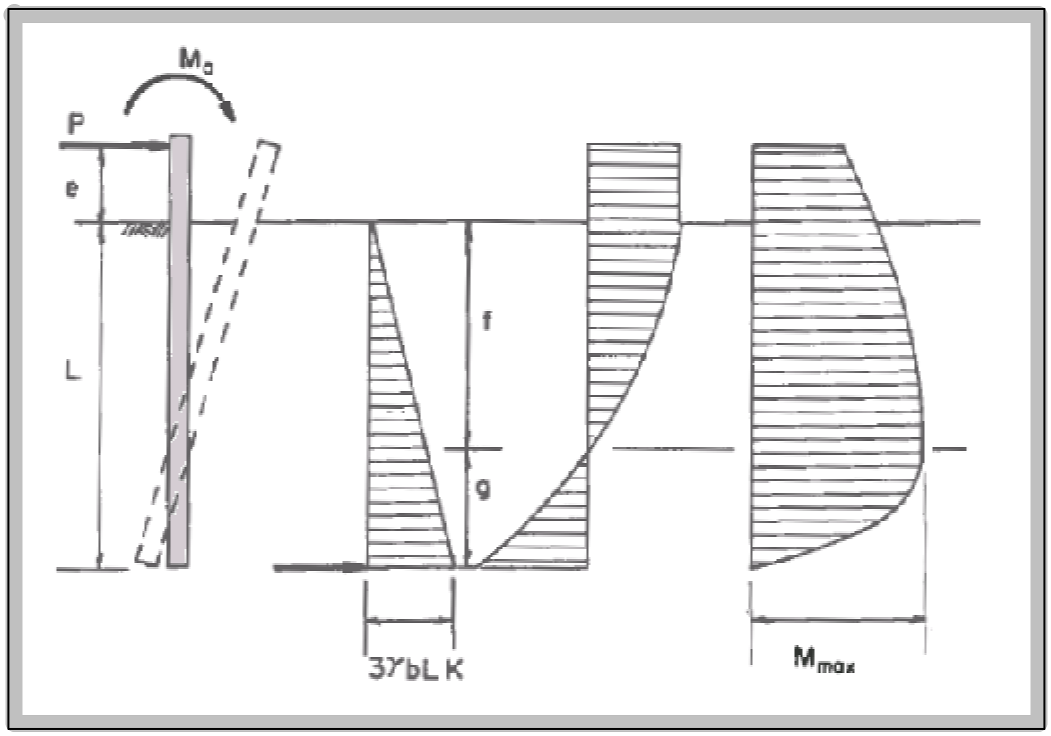
Shaft Depth Required to Resist Overturning

$$M_u := \sqrt{{M_x}^2 + {M_z}^2} = 275 \cdot kip \cdot ft$$

$$P_u := \sqrt{{V_x}^2 + {V_z}^2} = 11.7 \cdot kip$$

$$T_u := Torsion = 272.1 \cdot kip \cdot ft$$

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.

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

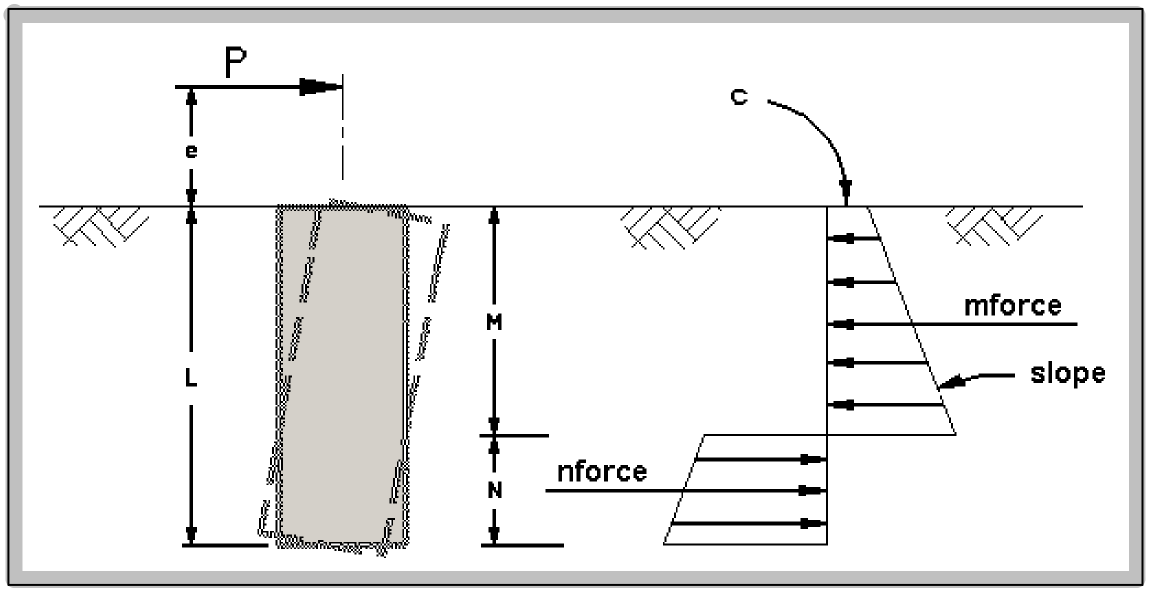
Guess value $L_{otSand} := 8 \cdot ft$

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

$$L_{otSand} := Find(L_{otSand}) = 13.3\,ft$$

$$L_{otSand} := ceil\left(\frac{L_{otSand}}{ft}\right) \cdot ft = 14\,ft$$ *(round up to next foot)*

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.

$c_{soil} := \text{if}\left(c_{soil} = 0 \cdot ksf, 0.1 \cdot ksf, c_{soil}\right) = 1.3 \cdot ksf$

$Slope := 8 \cdot \frac{c_{soil}}{3 \cdot b} = 0.7 \cdot \frac{kip}{ft^3}$ $\qquad e_{clay} := \frac{M_u}{P_u} + Offset = 24\,ft$

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

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

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

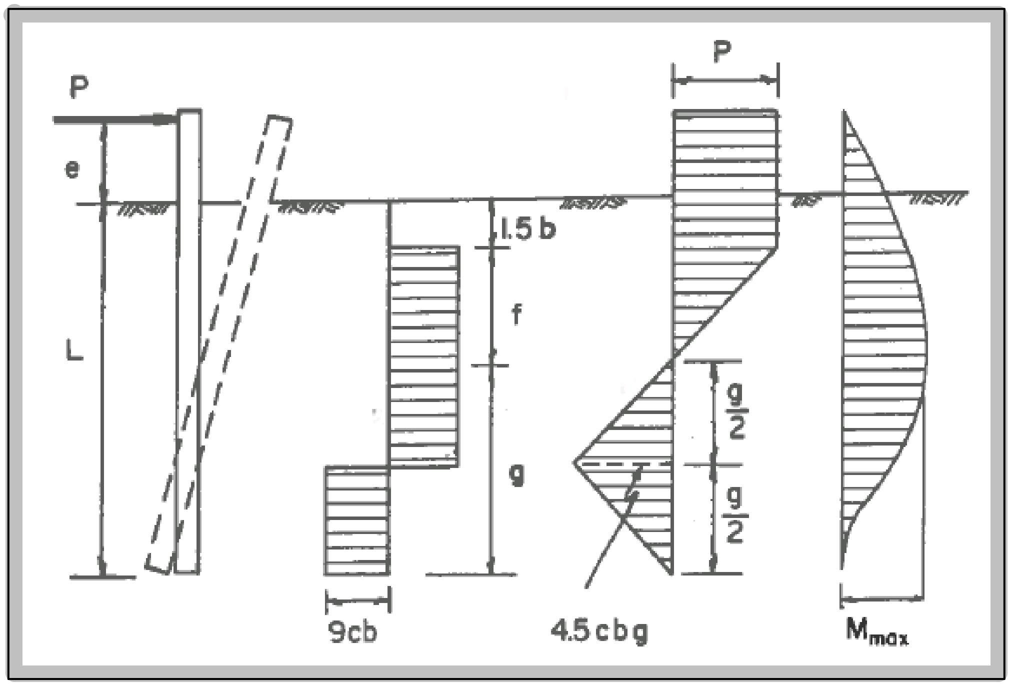
Guess value $\qquad M := 4.0 \cdot ft \qquad N := 4.0 \cdot ft$

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

$\begin{pmatrix} M \\ N \end{pmatrix} := \text{Find}(M,N) \qquad L_{ot1Clay} := M + N = 10.8\,ft$

$L_{ot1Clay} := \text{ceil}\left(\frac{L_{ot1Clay}}{ft}\right) \cdot ft = 11\,ft$ *(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.*

$$f := \frac{P_u}{\phi_{ot} \cdot 9 \cdot c_{soil} \cdot b} = 0.3\ \text{ft}$$

$$M_{max.clay} := P_u \cdot \left(e_{clay} + 1.5 \cdot b + 0.5 \cdot f\right) = 370.7 \cdot \text{kip} \cdot \text{ft}$$

$$g := \sqrt{\frac{M_{max.clay}}{2.25 \cdot \phi_{ot} \cdot c_{soil} \cdot b}} = 6.6\ \text{ft}$$

$$L_{ot2Clay} := \left(1.5 \cdot b + f + g\right) = 14.5\ \text{ft}$$

$$L_{ot2Clay} := \text{ceil}\left(\frac{L_{ot2Clay}}{\text{ft}}\right) \cdot \text{ft} = 15\ \text{ft}$$ *(round up to next foot)*

$$L_{otClay} := \text{if}\left(L_{ot1Clay} < 3 \cdot b, L_{ot1Clay}, L_{ot2Clay}\right) = 3.4$$ *(If L_{ot} < 3b, use Modified Broms method)*

$$L_{reqdOT} := \text{if}\left(\text{SoilType} = \text{"Sand"}, L_{otSand}, L_{otClay}\right)$$

$L_{reqdOT} = 14\ \text{ft}$ *required shaft embedment depth to resist overturning*

Shaft Depth Required to Resist Torsion

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.

$N_{blows} = 8.5$

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

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 $L_{torSand} := L_{reqdOT} = 14\,\text{ft}$

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

$L_{torSand} := \text{Find}(L_{torSand}) = 19.6\,\text{ft}$

$L_{torSand} := \text{ceil}\left(\frac{L_{torSand}}{\text{ft}}\right) \cdot \text{ft} = 20\,\text{ft}$ *(round up to next foot)*

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

$\text{CohesionFactor} := 0.55$

$f_{se} := \text{CohesionFactor} \cdot c_{soil} = 0.7 \cdot \text{ksf}$

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

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

$L_{torClay} := \text{Find}(L_{torClay}) = 11.6\,\text{ft}$

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

$L_{reqdTor} := \text{if}(\text{SoilType} = \text{"Sand"}, L_{torSand}, L_{torClay})$

$L_{reqdTor} = 20\,\text{ft}$ *required shaft embedment depth to resist torsion*

$L_{embedded} := \text{if}(L_{reqdTor} > L_{reqdOT}, L_{reqdTor}, L_{reqdOT}) = 6.1$

$L_{shaft.length} := L_{embedded} + \text{Offset}$

$L_{shaft.length} = 20.5\,\text{ft}$ *shaft length*

Maximum Moment in Shaft

short free-head pile in cohesionless soil using Broms method

$$f_{sand} := \sqrt{\frac{2 \cdot P_u}{3 \cdot \gamma_{soil} \cdot b \cdot K_p \cdot \phi_{ot}}} = 4.6\ ft$$

$$M_{maxSand} := P_u \cdot (e_{sand} + f_{sand}) - \frac{P_u \cdot f_{sand}}{3} + M_u = 316.8 \cdot kip \cdot ft$$

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

$f_{mod} := Find(f_{mod}) = 2\ ft$

$$M_{modBroms} := P_u \cdot (e_{clay} + f_{mod}) - \frac{\phi_{ot} \cdot c_{soil} \cdot b \cdot f_{mod}^{\ 2}}{2} - \frac{\phi_{ot} \cdot b \cdot f_{mod}^{\ 3} \cdot Slope}{6} = 294.1 \cdot kip \cdot ft$$

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

$$M_{Broms} := P_u \cdot (e_{clay} + 1.5 \cdot b + 0.5 \cdot f) = 370.7 \cdot kip \cdot ft$$

$M_{maxClay} := if(L_{ot1Clay} < 3 \cdot b, M_{modBroms}, M_{Broms}) = 294.1 \cdot kip \cdot ft$ *(If $L_{\alpha} < 3b$, use Modified Broms method)*

$$M_{max} := if(SoilType = "Sand", M_{maxSand}, M_{maxClay}) = 316.8 \cdot kip \cdot ft$$

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*

$Num_{bar} := 18$ *number of longitudinal bars, "RB"*

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

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

$A_{v.bar} := 0.31 \cdot in^2$ *stirrup area* *SM Vol-3 13.6.2*

$d_{v.bar} := 0.625 \cdot in$ *stirrup diameter*

$s_{v1} := 4 \cdot in$ *stirrup spacing, depth = 0 ft-2 ft* *SM Vol-3 13.6.2*

$s_{v2} := 8 \cdot in$ *stirrup spacing, depth = 2 ft-depth.stir, "RD"*

$s_{v3} := 12 \cdot in$ *stirrup spacing, depth > depth.stir, "RF"*

$depth_{stir} := 9.083 \cdot ft$ *stirrup depth, see s.v2 and s.v3 above*

$b = 5\,ft$ *shaft diameter*

$$A_{req} := \min\left(0.135 \cdot \frac{\pi \cdot b^2}{4} \cdot \frac{f_c}{F_{y.rebar}}, 0.015 \cdot \frac{\pi \cdot b^2}{4}\right) = 25.4 \cdot in^2$$ *LRFD 5.7.4.2*

$A_{long} := Num_{bar} \cdot A_{long.bar} = 28.1 \cdot in^2$ *total area of longitudinal steel*

$CheckLongitudinalReinf := if(A_{long} \ge A_{req}, \text{"OK"}, \text{"No Good"})$ $CheckLongitudinalReinf = \text{"OK"}$

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

$Spacing_{vert.reinf} := Dia_{bar.circle} \cdot \frac{\pi}{Num_{bar}} = 7.9 \cdot in$ $Clearance_{vert.reinf} := Spacing_{vert.reinf} - d_{long.bar} = 6.5 \cdot in$

$CheckReinfClearSpacing := if(Clearance_{vert.reinf} \ge 6in, \text{"OK"}, \text{"No Good"})$ $CheckReinfClearSpacing = \text{"OK"}$ *SDG 3.6.10*

Check Shear and Torsion

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

$V_u := \sqrt{V_x^2 + V_z^2} = 11.7 \cdot \text{kip}$

$T_u = 272.1 \cdot \text{kip} \cdot \text{ft}$

Effective shear depth

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

$d_v := \max(0.9 \cdot d_e, 0.72 \cdot b) = 3.6\ \text{ft}$

Check Shear Strength

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

$V_s := \frac{A_{v.bar} \cdot F_{y.rebar} \cdot d_v}{\max(s_{v1}, s_{v2}, s_{v3})} = 67 \cdot \text{kip}$ *LRFD Eqn 5.8.3.3-4*

$\text{ShearRatio} := \frac{V_u - \phi_v \cdot V_c}{\phi_v \cdot V_s} = -4.7$

$\text{ShearRatio} := \text{if}(\text{ShearRatio} \le 0, 0, \text{ShearRatio}) = 0$

Check Torsion Strength

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

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

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

$T_{n1} := \frac{2 \cdot A_o \cdot A_{v.bar} \cdot F_{y.rebar}}{s_{v1}} = 1.2 \times 10^3 \cdot \text{kip} \cdot \text{ft}$ *LRFD Eqn 5.8.3.6.2-1*

$T_{n2} := \frac{2 \cdot A_o \cdot A_{v.bar} \cdot F_{y.rebar}}{s_{v2}} = 580.6 \cdot \text{kip} \cdot \text{ft}$ *LRFD 5.8.3.4.1*

$T_{n3} := \dfrac{2 \cdot A_o \cdot A_{v.bar} \cdot F_{y.rebar}}{s_{v3}} = 387.1 \cdot kip \cdot ft$

$\phi_v = 0.9$ $\quad$ $T_u = 272.1 \cdot kip \cdot ft$ $\quad$ $L_{reqdTor} = 20\,ft$

$Tor2_{sand} := T_u - if\left[2ft > Offset, \left[\pi \cdot b \cdot (2 \cdot ft - Offset) \cdot \gamma_{soil} \cdot \left(\dfrac{2 \cdot ft - Offset}{2}\right) \cdot (\omega_{fdot}) \cdot \dfrac{b}{2}\right], 0 \cdot kip \cdot ft\right] = 270.5 \cdot kip \cdot ft$

$Tor3_{sand} := T_u - if\left[depth_{stir} > Offset, \left[\pi \cdot b \cdot (depth_{stir} - Offset) \cdot \gamma_{soil} \cdot \left(\dfrac{depth_{stir} - Offset}{2}\right) \cdot (\omega_{fdot}) \cdot \dfrac{b}{2}\right], 0 \cdot kip \cdot ft\right] = 219.7 \cdot kip \cdot ft$

$Tor2_{clay} := T_u - if\left[2ft - 1.5ft > Offset, \left[f_{se} \cdot (\pi \cdot b) \cdot (2.0 \cdot ft - Offset - 1.5 \cdot ft) \cdot \dfrac{b}{2}\right], 0 \cdot kip \cdot ft\right] = 272.1 \cdot kip \cdot ft$

$Tor3_{clay} := T_u - if\left[depth_{stir} - 1.5ft > Offset, \left[f_{se} \cdot (\pi \cdot b) \cdot (depth_{stir} - Offset - 1.5 \cdot ft) \cdot \dfrac{b}{2}\right], 0 \cdot kip \cdot ft\right] = 80.9 \cdot kip \cdot ft$

$Tor2 := if(SoilType = \text{"Sand"}, Tor2_{sand}, Tor2_{clay}) = 270.5 \cdot kip \cdot ft$

$Tor3 := if(SoilType = \text{"Sand"}, Tor3_{sand}, Tor3_{clay}) = 219.7 \cdot kip \cdot ft$

$TorsionRatio_{n1} := \dfrac{T_u}{\phi_{tor} \cdot T_{n1}} = 0.23$

$TorsionRatio_{n2} := \dfrac{Tor2}{\phi_{tor} \cdot T_{n2}} = 0.47$

$TorsionRatio_{n3} := \dfrac{Tor3}{\phi_{tor} \cdot T_{n3}} = 0.57$

$TorsionRatio := max(TorsionRatio_{n1}, TorsionRatio_{n2}, TorsionRatio_{n3}) = 0.57$

$T_{cr} := 0.125 \sqrt{\dfrac{f_c}{ksi}} \cdot \left(\dfrac{A_{cp}^{\,2}}{p_{cp} \cdot in^3}\right) \cdot kip \cdot in = 883.6 \cdot kip \cdot ft$ LRFD Eqn 5.8.2.1-4

$TorsionRatio := if(T_u \le 0.25 \cdot \phi_{tor} \cdot T_{cr}, 0, TorsionRatio) = 0.6$ LRFD Eqn 5.8.2.1-3

$ShearRatio = 0$

$CheckShearTorsion := if(ShearRatio + TorsionRatio \le 1, \text{"OK"}, \text{"No Good"})$

$CheckShearTorsion = \text{"OK"}$

Check Maximum Spacing Transverse Reinforcement

$v_u := \dfrac{V_u}{\phi_v \cdot b \cdot d_v} = 0.005015 \cdot ksi$ $\quad$ $0.125 \cdot f_c = 0.5 \cdot ksi$ LRFD Eqn 5.8.2.9-1

$s_{max1} := \text{if}\left(0.8 \cdot d_v < 24 \cdot in, 0.8d_v, 24 \cdot in\right) = 24 \cdot in$ LRFD Eqn 5.8.2.7-1

$s_{max2} := \text{if}\left(0.4 \cdot d_v < 12 \cdot in, 0.4d_v, 12 \cdot in\right) = 12 \cdot in$ LRFD Eqn 5.8.2.7-2

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

$\max\left(s_{v1}, s_{v2}, s_{v3}\right) = 12 \cdot in$

$\text{CheckMaxSpacingTransvReinf} := \text{if}\left(\max\left(s_{v1}, s_{v2}, s_{v3}\right) \le s_{max}, \text{"OK"}, \text{"No Good"}\right)$

$\text{CheckMaxSpacingTransvReinf} = \text{"OK"}$

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

LRFD 5.8.3.4.1

$M_u = 275 \cdot kip \cdot ft$

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

$$\text{LongReinf}_{shr.tor} := \frac{\dfrac{M_u}{\phi_v \cdot d_v} + \sqrt{\left(V_{temp}\right)^2 + \left(\dfrac{0.45 \cdot p_h \cdot T_u}{2 \cdot A_o \cdot \phi_v}\right)^2}}{F_{y.rebar}} = 2.8 \cdot in^2$$

$\text{Num}_{bar} \cdot A_{long.bar} = 28.1 \cdot in^2$

$\text{CheckLongReinf}_{shr.tor} := \text{if}\left(\text{Num}_{bar} \cdot A_{long.bar} \ge \text{LongReinf}_{shr.tor}, \text{"OK"}, \text{"No Good"}\right)$

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

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

Mast Arm Assembly Information

Wind Speed
○ 130 mph ● 150 mph ○ 170 mph

Signal Orientation
● Vertical
○ Horizontal

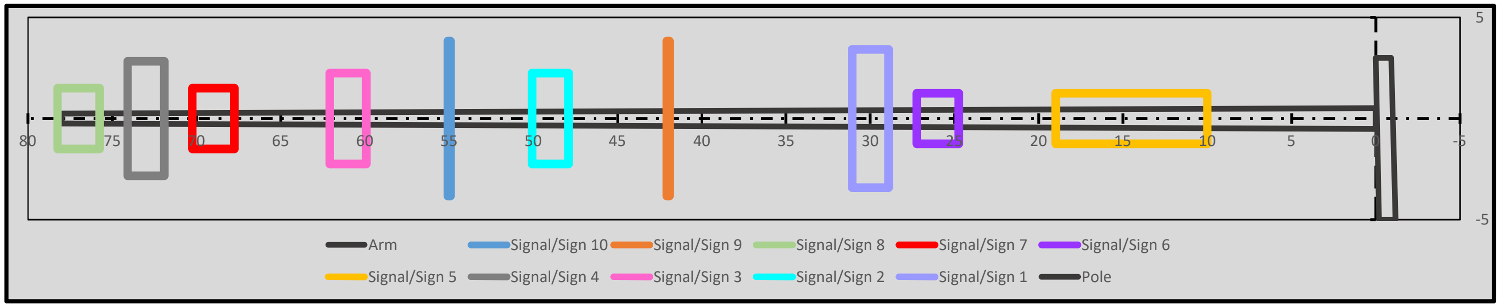
Back Plate Width
● 6.0 in.
○ 2.5 in.
○ 0 in.

Luminaire?
○ Yes
● No

Arm 1 Length
30
40
50
60
70
78

Arm 1 Length, Signal/Sign Location and Size

	Signal\Sign #10	Signal\Sign #9	Signal\Sign #8	Signal\Sign #7	Signal\Sign #6	Signal\Sign #5	Signal\Sign #4	Signal\Sign #3	Signal\Sign #2	Signal\Sign #1
Dist to Pole (ft.)	55	42	77	69	26	14.5	73	61	49	30
	○ 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
Sign Width (in.)	2	2	30	30	30	108				
Sign Height (in.)	92	92	36	36	30	30				
Area (SF)	1.3	1.3	7.5	7.5	6.3	22.5	12.3	9.8	9.8	14.8
M_{wl}. (kip*ft)	5	4	39	35	11	22	60	40	32	30



Arm 1 Length (ft)	78	
Design Standard Index 17743	Regular	Heavy Duty
Dia. at Arm Base (in)	18	20
Wall Thickness (in)	0.3750	0.3750
Resistance (M_r=ϕM_n) (kip*ft)	422	512

Arm 1 Loads	Regular	Heavy Duty
1.1*Arm M_{dl} (kip*ft)	121	143
Arm M_{wl} (kip*ft)	120	141
1.1*Sign/Signal M_{dl} (kip*ft)	21	
Sign/Signal M_{wl} (kip*ft)	276	
Total Moment ($M_{extreme}$)	421	449

Mast Arm Assembly Designation
One Arm Assembly **A78/S/H-P6/S-DS/18/5**

See separate calc for foundation

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.

Tube Wind Pressure (psf)	44.1

Fy (ksi)	50

Sign/Sig. Wind Pressure (psf)	67.0

short free-head pile in cohesionless soil using Broms method

$$\phi \cdot \frac{\gamma_{soil} \cdot b_{shaft} \cdot L_{shaft}{}^{3} \cdot K_p}{2} \geq M_u + P_u \cdot L_{shaft}$$

Arm Without Attachments: Dead Load Moment, Wind Load Moment and Moment Capacity at Base Connection

	Regular							Heavy Duty						
Total Arm Length (ft)	wall thk (in)	base dia (in)	S (in3)	Z (in3)	M_{dl} (kip*ft)	$M_{wl\ 130\ mph}$ (kip*ft)	M_r=ϕM_n (kip*ft)	wall thk (in)	base dia (in)	S (in3)	Z (in3)	M_{dl} (kip*ft)	$M_{wl\ 130mph}$ (kip*ft)	Mr=ϕMn (kip*ft)
30	0.25	11	23	29	10	10	107	0.25	12	27	34	11	11	125
40	0.25	13	32	40	20	20	145	0.25	14	37	47	22	22	166
50	0.3125	14	46	58	36	33	215	0.3125	15	53	67	40	37	244
60	0.375	15	63	79	56	48	300	0.375	16	72	91	62	53	340
70	0.375	17	81	103	85	71	380	0.375	18	91	115	100	77	422
78	0.375	18	91	115	110	90	422	0.375	20	113	143	130	106	512

Drilled Shaft

Index 17743 Drilled Shaft Capacities						1 Arm Assembly Loads And Capacity Check					2 Arm Assembly Loads and Capacity Check				
DS Index #	ID	Length	Diameter	ϕM_n	ϕT_n	M_u+ P_u*L_{shaft}	T_u	Check Mom. & Min Dia.	Check Torsion	Check	M_u+ P_u*L_{shaft}	T_u	Check Mom. & Min Dia.	Check Torsion	Check
1	DS/20/5	20	5	1800	589	657.5	395.8	Okay	Okay	Okay	0.0	0.0	0	0	0
2	DS/18/5	18	5	1312	477	628.3		Okay	Okay	Okay	0.0		0	0	0
3	DS/16/5	16	5	922	377	599.1		Okay	NoGood	NoGood	0.0		0	0	0
4	DS/16/4.5	16	4.5	829	305	599.1		NoGood	NoGood	NoGood	0.0		0	0	0
5	DS/14/5	14	5	617	289	569.9		Okay	NoGood	NoGood	0.0		0	0	0
6	DS/14/4.5	14	4.5	556	234	569.9		NoGood	NoGood	NoGood	0.0		0	0	0
7	DS/12/4.5	12	4.5	350	172	540.7		NoGood	NoGood	NoGood	0.0		0	0	0
8	DS/12/4	12	4	311	136	540.7		NoGood	NoGood	NoGood	0.0		0	0	0

Arm 1 Attachments: Extreme Event Dead Load Moment, Wind Load Moment at Base Connection

	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	Total		
Sign/Sig Mwl (kip*ft)	4.7	3.6	38.7	34.7	10.9	21.9	60.0	39.8	32.0	29.7	276.0		
Sign/Sig 1.1*Mdl (kip*ft)	0.3	0.2	2.5	2.3	0.7	1.4	5.2	3.4	2.7	2.6	21.4		
Arm 1 Mwl (kip*ft)											119.8	141.1	*Reg Arm / HD Arm*
Arm 1 1.1*Mdl (kip*ft)											121.0	143.0	*Reg Arm / HD Arm*
										*Extreme Event Arm Moment (kip*ft)*	420.7	448.9	

Ensures anchor bolts fit inside rebar cage	Min Shaft Diameter
	5

Required Drilled Shaft Index Number Required (see Table for size)		
Load Case	1 Arm DS Index #	2 Arm DS Index #
Drilled Shaft Index req'd for Overturning including Min. Diamter	5	0
Drilled Shaft Index req'd for Torsion	2	0
Drilled Shaft Controlling Load Case	2	#N/A

Pole Base Shears & Moments					
	Arm 1 Shear	Arm 1 Moment	Arm 2 Shear	Arm 2 Moment	
dl att	N/A	21.4	N/A	0.0	
dl arm	N/A	143.0	N/A	0.0	
wl pole	2.6	63.5	0.0	0.0	*assume a 37.5' pole wl with lum*
wl att	6.2	136.9	0.0	0.0	
wl arm	5.7	126.1	0.0	0.0	
Tor wl att	N/A	276.0	N/A	0.0	
Tor wl arm	N/A	119.8	N/A	0.0	

Forces at Top of DS			
	One Arm	Two Arms	
Moment dl	164.4	N/A	
Moment wl	326.5		
Moment Total	365.5	0.0	
Torsion	395.8	0.0	
Shear	14.6	0.0	
Shaft 2-Arm Factor	*1.1*		*used for OT & Torsion*

Pole ID			
Arm 1 Length	78	Arm 2 Length	0
	Pole ID	P6	

Arm 2 Attachments: Extreme Event Dead Load Moment, Wind Load Moment at Base Connection

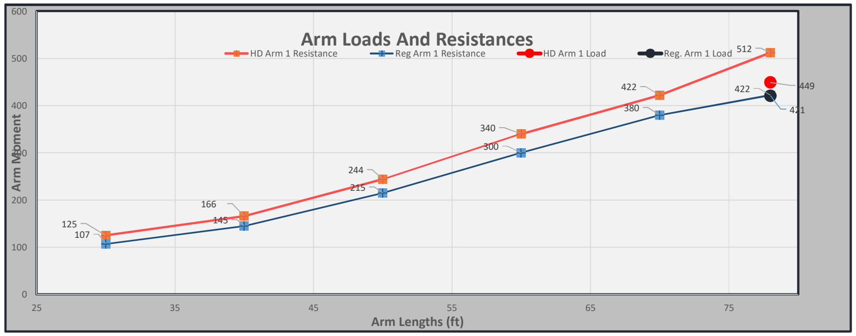
	Signal/ Sign 10	Signal/ Sign 9	Signal/ Sign 8	Signal/ Sign 7	Signal/ Sign 6	Signal/ Sign 5	Signal/ Sign 4	Signal/ Sign 3	Signal/ Sign 2	Signal/ Sign 1	Total	
Sign/Sig Mwl (kip*ft)	0.0	0.0	0.0	0.0	0.0	47.6	*24.2*	*40.2*	*15.0*	*7.8*	134.8	
Sign/Sig 1.1*Mdl (kip*ft)	0.0	0.0	0.0	0.0	0.0	4.2	*2.0*	*2.6*	*1.3*	*0.7*	10.8	
Arm 2 Mwl (kip*ft)											0.0	0.0
Arm 2 1.1*Mdl (kip*ft)											0.0	0.0
											0.0	0.0

1 Arm Assembly		Use Heavy Duty Arm					
Design Arm Designation			Pole Designation			Drilled Shaft	
A78	/S	/H	P6	/S		DS	
A78/S/H-			P6/S-			DS/18/5	
A78/S/H-P6/S-DS/18/5							

2 Arm Assembly		Use Regular Arm					
Design Arm Designation			Pole Designation			Drilled Shaft	
						DS	
-			-				

Assembly ID	A78/S/H-P6/S-DS/18/5	
	Arm 1	Arm 2
Arm Length(s)	78	0
Max Design CFI %	0.95	
Est. Regular Arm CFI	1.05	0.00
Est. HD Arm CFI	0.92	0.00

Note: Poles are designed to have a smaller CFI than Arms



Drilled Shaft Foundation for
Sign, Signal, and Lighting Support Structures v1.1

State Structures Design Office

SUBJECT: Moccasin Wallow Road
Struct # T-13-4 LOCATION: Sta. 338+87.5, 79.6' LT

DESIGNED BY: MPR DATE: 12/2021
CHECKED BY: DATE: 12/2021

Program Changes

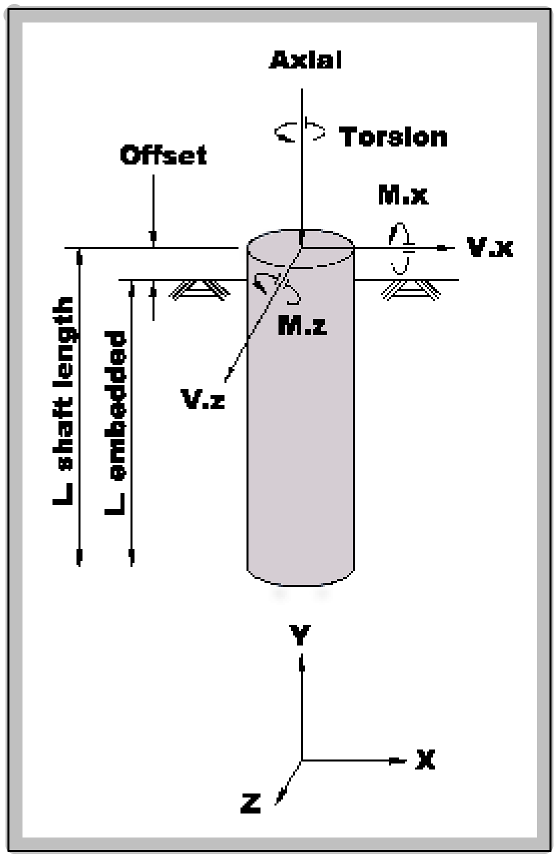
SoilType :=
- Sand
- Clay

$\phi_{soil} := 29 \cdot deg$ *soil friction angle (sand)*

$c_{soil} := 1.25 \cdot \frac{kip}{ft^2}$ *soil shear strength (clay)*

$N_{blows} := 10$ *number of blows per foot. If N< 5, contact the district geotech Engineer*

$\gamma_{soil} := 42.6 \cdot pcf$ *effective soil weight (typical design value = 45 ~ 50 pcf)*



Geometry

$b := 5 \cdot ft$ *shaft diameter, "DB"*

$Offset := 1 \cdot ft$ *groundline to top of foundation*

Applied Loads (Extreme I)

$M_x := 326.5 \cdot kip \cdot ft$ $V_x := 0 \cdot kip$ $Torsion := 395.8 \cdot kip \cdot ft$

$M_z := 164.4 \cdot kip \cdot ft$ $V_z := 14.6 \cdot kip$ $Axial := 4.0 \cdot kip$

StructureType :=
- Cantilever Overhead Sign Structure
- Mast Arm Signal Structure
- Concrete/Steel Strain Poles
- Ground Sign

$StructureType = 1$

$\phi_{ot} := if(StructureType = 3, 0.8, 0.6)$ $\phi_{ot} = 0.6$ *ϕ factor against overturning [SM Vol-3 13.6.1.1]*

$\phi_{tor} := if(StructureType = 0, 0.9, 1.0)$ $\phi_{tor} = 1$ *ϕ factor against torsion [SM Vol-3 13.6.1.1]*

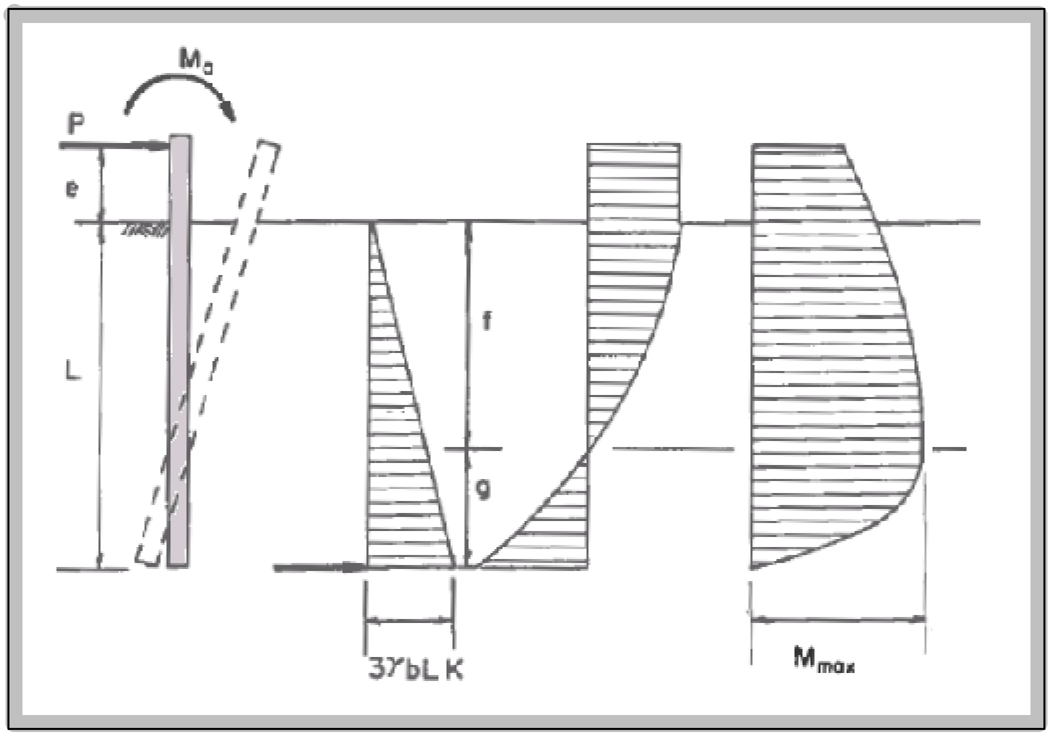
Shaft Depth Required to Resist Overturning

$$M_u := \sqrt{M_x^{\,2} + M_z^{\,2}} = 365.6 \cdot \text{kip} \cdot \text{ft}$$

$$P_u := \sqrt{V_x^{\,2} + V_z^{\,2}} = 14.6 \cdot \text{kip}$$

$$T_u := \text{Torsion} = 395.8 \cdot \text{kip} \cdot \text{ft}$$

*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.

$$K_p := \tan\left(45 \cdot \text{deg} + \frac{\phi_{soil}}{2}\right)^2 = 2.9 \qquad e_{sand} := \text{Offset} = 1\,\text{ft}$$

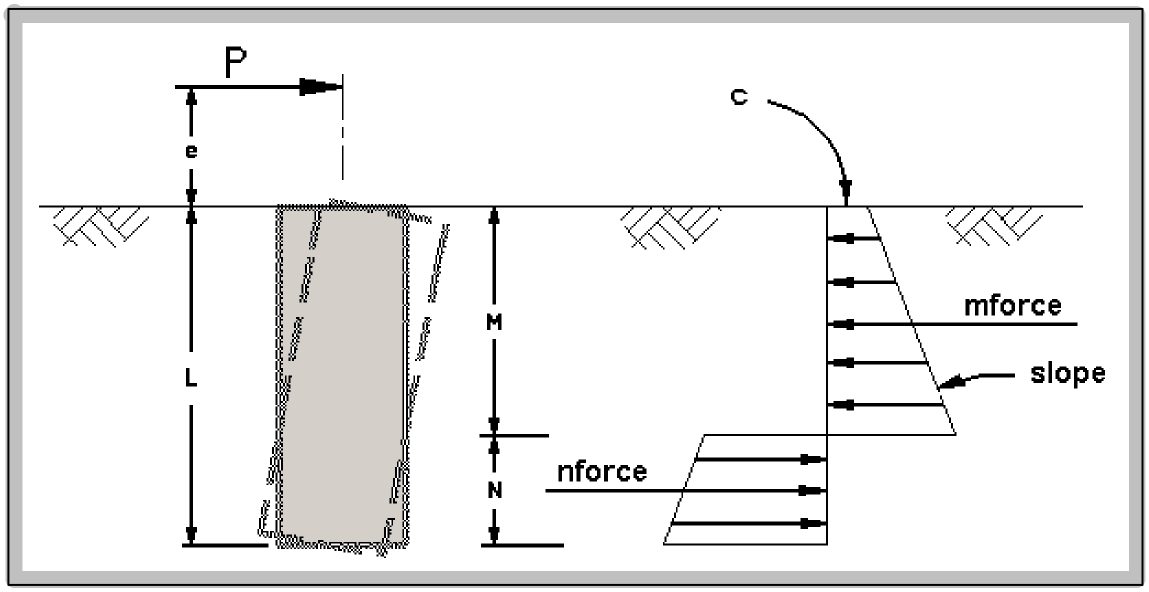
Guess value $L_{otSand} := 8 \cdot \text{ft}$

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

$$L_{otSand} := \text{Find}\left(L_{otSand}\right) = 14.8\,\text{ft}$$

$$L_{otSand} := \text{ceil}\left(\frac{L_{otSand}}{\text{ft}}\right) \cdot \text{ft} = 15\,\text{ft}$$ *(round up to next foot)*

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.

$c_{soil} := \text{if}\left(c_{soil} = 0\cdot ksf, 0.1\cdot ksf, c_{soil}\right) = 1.3\cdot ksf$

$Slope := 8\cdot\frac{c_{soil}}{3\cdot b} = 0.7\cdot\frac{kip}{ft^3}$ $\qquad e_{clay} := \frac{M_u}{P_u} + Offset = 26\,ft$

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

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

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

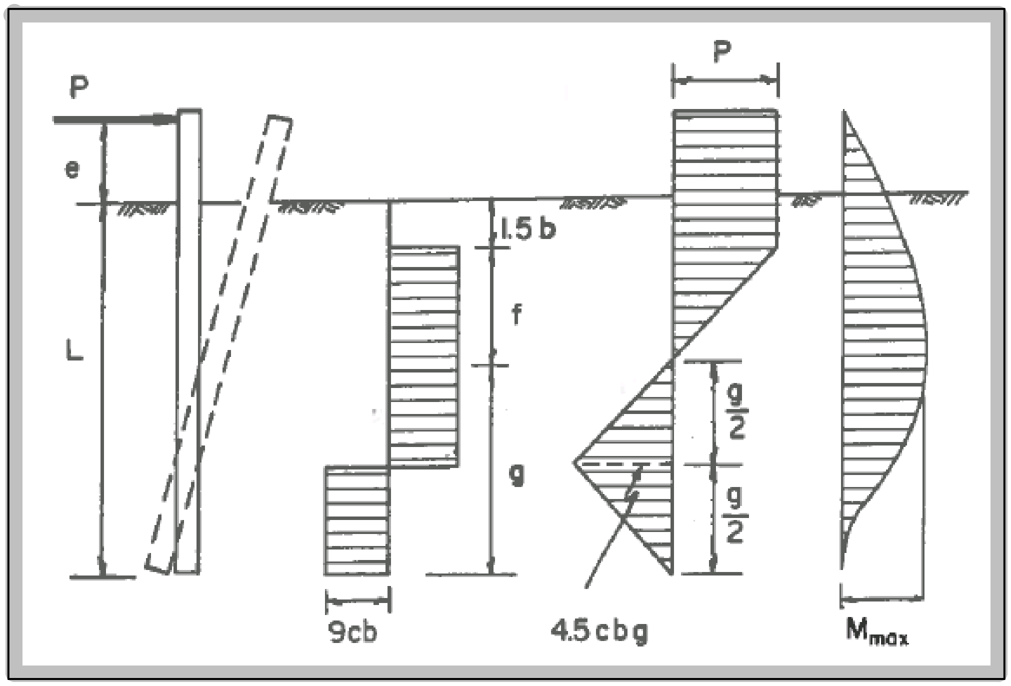
Guess value $\qquad M := 4.0\cdot ft \qquad N := 4.0\cdot ft$

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

$\begin{pmatrix} M \\ N \end{pmatrix} := \text{Find}(M,N) \qquad L_{ot1Clay} := M + N = 12.1\,ft$

$L_{ot1Clay} := \text{ceil}\left(\frac{L_{ot1Clay}}{ft}\right)\cdot ft = 13\,ft$ $\qquad$ *(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.*

$$f := \frac{P_u}{\phi_{ot} \cdot 9 \cdot c_{soil} \cdot b} = 0.4\ ft$$

$$M_{max.clay} := P_u \cdot \left(e_{clay} + 1.5 \cdot b + 0.5 \cdot f\right) = 492.8 \cdot kip \cdot ft$$

$$g := \sqrt{\frac{M_{max.clay}}{2.25 \cdot \phi_{ot} \cdot c_{soil} \cdot b}} = 7.6\ ft$$

$$L_{ot2Clay} := (1.5 \cdot b + f + g) = 15.6\ ft$$

$$L_{ot2Clay} := ceil\left(\frac{L_{ot2Clay}}{ft}\right) \cdot ft = 16\ ft$$ *(round up to next foot)*

$$L_{otClay} := if\left(L_{ot1Clay} < 3 \cdot b, L_{ot1Clay}, L_{ot2Clay}\right) = 4$$ *(If* $L_{ot} < 3b$*, use Modified Broms method)*

$$L_{reqdOT} := if\left(SoilType = "Sand", L_{otSand}, L_{otClay}\right)$$

$L_{reqdOT} = 15\ ft$ *required shaft embedment depth to resist overturning*

Shaft Depth Required to Resist Torsion

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.

$N_{blows} = 10$

$$\omega_{fdot} := \text{if}\left(N_{blows} < 5, 0, \text{if}\left(N_{blows} \geq 15, 1.5, 1.5 \cdot \frac{N_{blows}}{15}\right)\right) = 1$$

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 $L_{torSand} := L_{reqdOT} = 15\ \text{ft}$

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

$$L_{torSand} := \text{Find}\left(L_{torSand}\right) = 21.8\ \text{ft}$$

$$L_{torSand} := \text{ceil}\left(\frac{L_{torSand}}{\text{ft}}\right) \cdot \text{ft} = 22\ \text{ft}$$

(round up to next foot)

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

$\text{CohesionFactor} := 0.55$

$f_{se} := \text{CohesionFactor} \cdot c_{soil} = 0.7 \cdot \text{ksf}$

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

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

$$L_{torClay} := \text{Find}\left(L_{torClay}\right) = 16.2\ \text{ft}$$

$$L_{torClay} := \text{ceil}\left(\frac{L_{torClay}}{\text{ft}}\right) \cdot \text{ft} = 17\ \text{ft}$$

(round up to next foot)

$L_{reqdTor} := \text{if}\left(\text{SoilType} = \text{"Sand"}, L_{torSand}, L_{torClay}\right)$

$L_{reqdTor} = 22\ \text{ft}$

required shaft embedment depth to resist torsion

$L_{embedded} := \text{if}\left(L_{reqdTor} > L_{reqdOT}, L_{reqdTor}, L_{reqdOT}\right) = 6.7$

$L_{shaft.length} := L_{embedded} + \text{Offset}$

$L_{shaft.length} = 23\ \text{ft}$

shaft length

Maximum Moment in Shaft

short free-head pile in cohesionless soil using Broms method

$$f_{sand} := \sqrt{\frac{2 \cdot P_u}{3 \cdot \gamma_{soil} \cdot b \cdot K_p \cdot \phi_{ot}}} = 5.1\ ft$$

$$M_{maxSand} := P_u \cdot \left(e_{sand} + f_{sand}\right) - \frac{P_u \cdot f_{sand}}{3} + M_u = 430.2 \cdot kip \cdot ft$$

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

$$f_{mod} := Find\left(f_{mod}\right) = 2.4\ ft$$

$$M_{modBroms} := P_u \cdot \left(e_{clay} + f_{mod}\right) - \frac{\phi_{ot} \cdot c_{soil} \cdot b \cdot f_{mod}^{\ 2}}{2} - \frac{\phi_{ot} \cdot b \cdot f_{mod}^{\ 3} \cdot Slope}{6} = 399.8 \cdot kip \cdot ft$$

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

$$M_{Broms} := P_u \cdot \left(e_{clay} + 1.5 \cdot b + 0.5 \cdot f\right) = 492.8 \cdot kip \cdot ft$$

$$M_{maxClay} := if\left(L_{ot1Clay} < 3 \cdot b, M_{modBroms}, M_{Broms}\right) = 399.8 \cdot kip \cdot ft$$

(If L_{α} < 3b, use Modified Broms method)

$$M_{max} := if\left(SoilType = "Sand", M_{maxSand}, M_{maxClay}\right) = 430.2 \cdot kip \cdot ft$$

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*

$Num_{bar} := 18$ *number of longitudinal bars, "RB"*

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

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

$A_{v.bar} := 0.31 \cdot in^2$ *stirrup area* *SM Vol-3 13.6.2*

$d_{v.bar} := 0.625 \cdot in$ *stirrup diameter*

$s_{v1} := 4 \cdot in$ *stirrup spacing, depth = 0 ft-2 ft* *SM Vol-3 13.6.2*

$s_{v2} := 8 \cdot in$ *stirrup spacing, depth = 2 ft-depth.stir, "RD"*

$s_{v3} := 12 \cdot in$ *stirrup spacing, depth > depth.stir, "RF"*

$depth_{stir} := 9.083 \cdot ft$ *stirrup depth, see s.v2 and s.v3 above*

$b = 5\,ft$ *shaft diameter*

$$A_{req} := \min\left(0.135 \cdot \frac{\pi \cdot b^2}{4} \cdot \frac{f_c}{F_{y.rebar}}, 0.015 \cdot \frac{\pi \cdot b^2}{4}\right) = 25.4 \cdot in^2$$ *LRFD 5.7.4.2*

$A_{long} := Num_{bar} \cdot A_{long.bar} = 28.1 \cdot in^2$ *total area of longitudinal steel*

$CheckLongitudinalReinf := if(A_{long} \geq A_{req}, \text{"OK"}, \text{"No Good"})$ $CheckLongitudinalReinf = \text{"OK"}$

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

$Spacing_{vert.reinf} := Dia_{bar.circle} \cdot \frac{\pi}{Num_{bar}} = 7.9 \cdot in$ $Clearance_{vert.reinf} := Spacing_{vert.reinf} - d_{long.bar} = 6.5 \cdot in$

$CheckReinfClearSpacing := if(Clearance_{vert.reinf} \geq 6in, \text{"OK"}, \text{"No Good"})$ $CheckReinfClearSpacing = \text{"OK"}$ *SDG 3.6.10*

Check Shear and Torsion

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

$$V_u := \sqrt{V_x^2 + V_z^2} = 14.6 \cdot kip$$

$$T_u = 395.8 \cdot kip \cdot ft$$

Effective shear depth

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

LRFD C5.8.2.9-2

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

Check Shear Strength

$$V_c := 0.0316 \cdot (2.0) \cdot \sqrt{\frac{f_c}{ksi}} \cdot \left(\frac{b}{in}\right) \cdot \left(\frac{d_v}{in}\right) \cdot kip = 327.6 \cdot kip$$

LRFD Eqn 5.8.3.3-3 *LRFD 5.8.3.4.1* *ACI 11.3.3*

$$V_s := \frac{A_{v.bar} \cdot F_{y.rebar} \cdot d_v}{\max(s_{v1}, s_{v2}, s_{v3})} = 67 \cdot kip$$

LRFD Eqn 5.8.3.3-4

$$ShearRatio := \frac{V_u - \phi_v \cdot V_c}{\phi_v \cdot V_s} = -4.7$$

$$ShearRatio := if(ShearRatio \le 0, 0, ShearRatio) = 0$$

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

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

$$T_{n1} := \frac{2 \cdot A_o \cdot A_{v.bar} \cdot F_{y.rebar}}{s_{v1}} = 1.2 \times 10^3 \cdot kip \cdot ft$$

LRFD Eqn 5.8.3.6.2-1

$$T_{n2} := \frac{2 \cdot A_o \cdot A_{v.bar} \cdot F_{y.rebar}}{s_{v2}} = 580.6 \cdot kip \cdot ft$$

LRFD 5.8.3.4.1

$$T_{n3} := \frac{2 \cdot A_o \cdot A_{v.bar} \cdot F_{y.rebar}}{s_{v3}} = 387.1 \cdot kip \cdot ft$$

$\phi_v = 0.9$ $\qquad$ $T_u = 395.8 \cdot kip \cdot ft$ $\qquad$ $L_{reqdTor} = 22\,ft$

$$Tor2_{sand} := T_u - if\left[2ft > Offset, \left[\pi \cdot b \cdot (2 \cdot ft - Offset) \cdot \gamma_{soil} \cdot \left(\frac{2 \cdot ft - Offset}{2}\right) \cdot (\omega_{fdot}) \cdot \frac{b}{2}\right], 0 \cdot kip \cdot ft\right] = 395 \cdot kip \cdot ft$$

$$Tor3_{sand} := T_u - if\left[depth_{stir} > Offset, \left[\pi \cdot b \cdot (depth_{stir} - Offset) \cdot \gamma_{soil} \cdot \left(\frac{depth_{stir} - Offset}{2}\right) \cdot (\omega_{fdot}) \cdot \frac{b}{2}\right], 0 \cdot kip \cdot ft\right] = 341.2 \cdot kip \cdot ft$$

$$Tor2_{clay} := T_u - if\left[2ft - 1.5ft > Offset, \left[f_{se} \cdot (\pi \cdot b) \cdot (2.0 \cdot ft - Offset - 1.5 \cdot ft) \cdot \frac{b}{2}\right], 0 \cdot kip \cdot ft\right] = 395.8 \cdot kip \cdot ft$$

$$Tor3_{clay} := T_u - if\left[depth_{stir} - 1.5ft > Offset, \left[f_{se} \cdot (\pi \cdot b) \cdot (depth_{stir} - Offset - 1.5 \cdot ft) \cdot \frac{b}{2}\right], 0 \cdot kip \cdot ft\right] = 218.1 \cdot kip \cdot ft$$

$$Tor2 := if(SoilType = \text{"Sand"}, Tor2_{sand}, Tor2_{clay}) = 395 \cdot kip \cdot ft$$

$$Tor3 := if(SoilType = \text{"Sand"}, Tor3_{sand}, Tor3_{clay}) = 341.2 \cdot kip \cdot ft$$

$$TorsionRatio_{n1} := \frac{T_u}{\phi_{tor} \cdot T_{n1}} = 0.34$$

$$TorsionRatio_{n2} := \frac{Tor2}{\phi_{tor} \cdot T_{n2}} = 0.68$$

$$TorsionRatio_{n3} := \frac{Tor3}{\phi_{tor} \cdot T_{n3}} = 0.88$$

$$TorsionRatio := max(TorsionRatio_{n1}, TorsionRatio_{n2}, TorsionRatio_{n3}) = 0.88$$

$$T_{cr} := 0.125 \sqrt{\frac{f_c}{ksi}} \cdot \left(\frac{A_{cp}^{\,2}}{p_{cp} \cdot in^3}\right) \cdot kip \cdot in = 883.6 \cdot kip \cdot ft$$ LRFD Eqn 5.8.2.1-4

$$TorsionRatio := if(T_u \le 0.25 \cdot \phi_{tor} \cdot T_{cr}, 0, TorsionRatio) = 0.9$$ LRFD Eqn 5.8.2.1-3

$ShearRatio = 0$

$CheckShearTorsion := if(ShearRatio + TorsionRatio \le 1, \text{"OK"}, \text{"No Good"})$

$CheckShearTorsion = \text{"OK"}$

Check Maximum Spacing Transverse Reinforcement

$$v_u := \frac{V_u}{\phi_v \cdot b \cdot d_v} = 0.006259 \cdot ksi \qquad 0.125 \cdot f_c = 0.5 \cdot ksi$$ LRFD Eqn 5.8.2.9-1

$s_{max1} := \text{if}\left(0.8 \cdot d_v < 24 \cdot in, 0.8 d_v, 24 \cdot in\right) = 24 \cdot in$ LRFD Eqn 5.8.2.7-1

$s_{max2} := \text{if}\left(0.4 \cdot d_v < 12 \cdot in, 0.4 d_v, 12 \cdot in\right) = 12 \cdot in$ LRFD Eqn 5.8.2.7-2

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

$\max\left(s_{v1}, s_{v2}, s_{v3}\right) = 12 \cdot in$

$\text{CheckMaxSpacingTransvReinf} := \text{if}\left(\max\left(s_{v1}, s_{v2}, s_{v3}\right) \le s_{max}, \text{"OK"}, \text{"No Good"}\right)$

$\text{CheckMaxSpacingTransvReinf} = \text{"OK"}$

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

LRFD 5.8.3.4.1

$M_u = 365.6 \cdot kip \cdot ft$

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

$$\text{LongReinf}_{shr.tor} := \frac{\dfrac{M_u}{\phi_v \cdot d_v} + \sqrt{\left(V_{temp}\right)^2 + \left(\dfrac{0.45 \cdot p_h \cdot T_u}{2 \cdot A_o \cdot \phi_v}\right)^2}}{F_{y.rebar}} = 3.8 \cdot in^2$$

$\text{Num}_{bar} \cdot A_{long.bar} = 28.1 \cdot in^2$

$\text{CheckLongReinf}_{shr.tor} := \text{if}\left(\text{Num}_{bar} \cdot A_{long.bar} \ge \text{LongReinf}_{shr.tor}, \text{"OK"}, \text{"No Good"}\right)$

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

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

Mast Arm Assembly Information

Wind Speed
○ 130 mph ● 150 mph ○ 170 mph

Signal Orientation
● Vertical
○ Horizontal

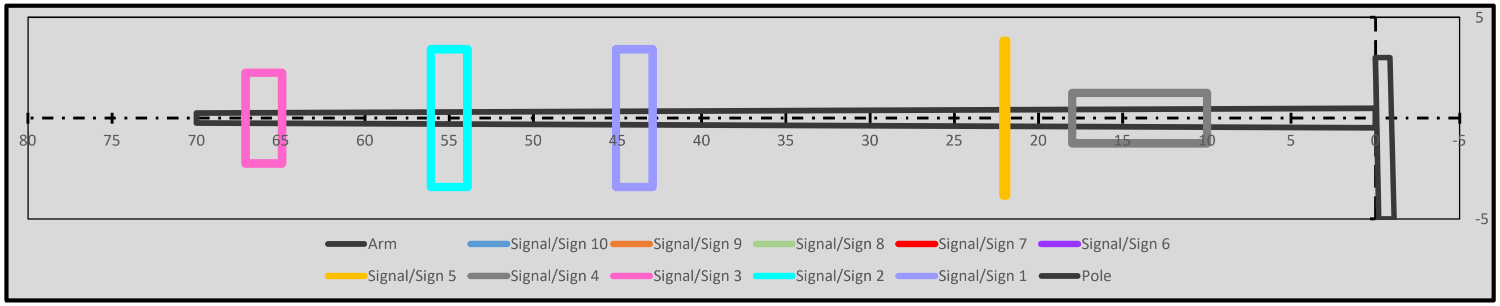
Back Plate Width
● 6.0 in.
○ 2.5 in.
○ 0 in.

Luminaire?
○ Yes
● No

Arm 1 Length
30
40
50
60
70
78

Arm 1 Length, Signal/Sign Location and Size

	Signal\Sign #10	Signal\Sign #9	Signal\Sign #8	Signal\Sign #7	Signal\Sign #6	Signal\Sign #5	Signal\Sign #4	Signal\Sign #3	Signal\Sign #2	Signal\Sign #1
Dist to Pole (ft.)	55	42	77	69	22	22	14	66	55	44
	● 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
Sign Width (in.)						2	96			
Sign Height (in.)						92	30			
Area (SF)	0.0	0.0	0.0	0.0	0.0	1.3	20.0	9.8	14.8	14.8
M_{wl} (kip*ft)	0	0	0	0	0	2	19	43	55	44



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=ϕM_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)	14	
Sign/Signal M_{wl} (kip*ft)	162	
Total Moment ($M_{extreme}$)	278	292

Mast Arm Assembly Designation

One Arm Assembly
A70/S-P5/S-DS/14/5

See separate calc
for foundation

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.

Tube Wind Pressure (psf)	44.1

Fy (ksi)	50

Sign/Sig. Wind Pressure (psf)	67.0

short free-head pile in cohesionless soil using Broms method

$$\phi \cdot \frac{\gamma_{soil} \cdot b_{shaft} \cdot L_{shaft}^{3} \cdot K_p}{2} \geq M_u + P_u \cdot L_{shaft}$$

Arm Without Attachments: Dead Load Moment, Wind Load Moment and Moment Capacity at Base Connection

Total Arm Length (ft)	**Regular**							**Heavy Duty**						
	wall thk (in)	**base dia (in)**	**S (in3)**	**Z (in3)**	**M_{dl} (kip*ft)**	**$M_{wl\ 130\ mph}$ (kip*ft)**	**M_r=ϕM_n (kip*ft)**	**wall thk (in)**	**base dia (in)**	**S (in3)**	**Z (in3)**	**M_{dl} (kip*ft)**	**$M_{wl\ 130mph}$ (kip*ft)**	**Mr=ϕMn (kip*ft)**
30	0.25	11	23	29	10	10	107	0.25	12	27	34	11	11	125
40	0.25	13	32	40	20	20	145	0.25	14	37	47	22	22	166
50	0.3125	14	46	58	36	33	215	0.3125	15	53	67	40	37	244
60	0.375	15	63	79	56	48	300	0.375	16	72	91	62	53	340
70	0.375	17	81	103	85	71	380	0.375	18	91	115	100	77	422
78	0.375	18	91	115	110	90	422	0.375	20	113	143	130	106	512

Drilled Shaft

Index 17743 Drilled Shaft Capacities						**1 Arm Assembly Loads And Capacity Check**					**2 Arm Assembly Loads and Capacity Check**				
DS Index #	**ID**	**Length**	**Diameter**	**ϕM_n**	**ϕT_n**	**M_u+ P_u*L_{shaft}**	**T_u**	**Check Mom. & Min Dia.**	**Check Torsion**	**Check**	**M_u+ P_u*L_{shaft}**	**T_u**	**Check Mom. & Min Dia.**	**Check Torsion**	**Check**
1	DS/20/5	20	5	1800	589	483.0	256.4	Okay	Okay	Okay	0.0	0.0	0	0	0
2	DS/18/5	18	5	1312	477	460.9		Okay	Okay	Okay	0.0		0	0	0
3	DS/16/5	16	5	922	377	438.7		Okay	Okay	Okay	0.0		0	0	0
4	DS/16/4.5	16	4.5	829	305	438.7		NoGood	Okay	NoGood	0.0		0	0	0
5	DS/14/5	14	5	617	289	416.6		Okay	Okay	Okay	0.0		0	0	0
6	DS/14/4.5	14	4.5	556	234	416.6		NoGood	NoGood	NoGood	0.0		0	0	0
7	DS/12/4.5	12	4.5	350	172	394.4		NoGood	NoGood	NoGood	0.0		0	0	0
8	DS/12/4	12	4	311	136	394.4		NoGood	NoGood	NoGood	0.0		0	0	0

Arm 1 Attachments: Extreme Event Dead Load Moment, Wind Load Moment at Base Connection

	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**	**Total**		
Sign/Sig Mwl (kip*ft)	0.0	0.0	0.0	0.0	0.0	1.9	18.8	43.1	54.5	43.6	161.9		
Sign/Sig 1.1*Mdl (kip*ft)	0.0	0.0	0.0	0.0	0.0	0.1	1.2	3.6	4.8	3.9	13.7		
Arm 1 Mwl (kip*ft)											94.5	102.5	*Reg Arm / HD Arm*
Arm 1 1.1*Mdl (kip*ft)											93.5	110.0	*Reg Arm / HD Arm*
										*Extreme Event Arm Moment (kip*ft)*	277.9	292.4	

Ensures anchor bolts fit inside rebar cage

Min Shaft Diameter
5

Required Drilled Shaft Index Number Required (see Table for size)

Load Case	**1 Arm DS Index #**	**2 Arm DS Index #**
Drilled Shaft Index req'd for Overturning including Min. Diamter	5	0
Drilled Shaft Index req'd for Torsion	5	0
Drilled Shaft Controlling Load Case	**5**	**#N/A**

Pole Base Shears & Moments

	Arm 1 Shear	**Arm 1 Moment**	**Arm 2 Shear**	**Arm 2 Moment**	
dl att	N/A	13.7	N/A	0.0	
dl arm	N/A	93.5	N/A	0.0	
wl pole	2.6	52.9	0.0	0.0	*assume a 37.5' pole wl with lum*
wl att	4.1	89.4	0.0	0.0	
wl arm	4.4	96.2	0.0	0.0	
Tor wl att	N/A	161.9	N/A	0.0	
Tor wl arm	N/A	94.5	N/A	0.0	

Forces at Top of DS

	One Arm	Two Arms	
Moment dl	107.2	N/A	
Moment wl	238.5		
Moment Total	261.4	0.0	
Torsion	256.4	0.0	
Shear	11.1	0.0	
Shaft 2-Arm Factor	*1.1*		*used for OT & Torsion*

Pole ID			
Arm 1 Length	70	Arm 2 Length	0
	Pole ID	P5	

Arm 2 Attachments: Extreme Event Dead Load Moment, Wind Load Moment at Base Connection

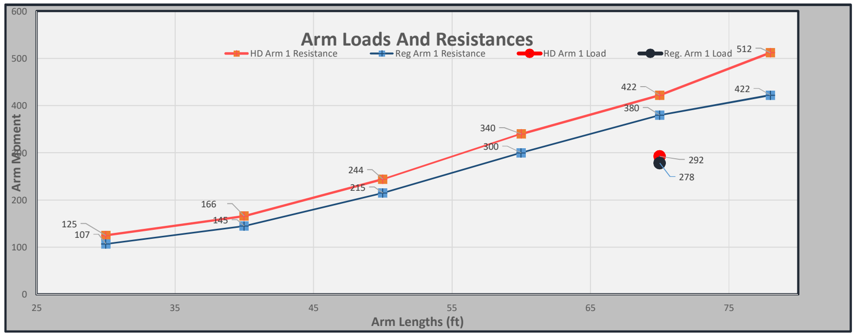
	Signal/ Sign 10	**Signal/ Sign 9**	**Signal/ Sign 8**	**Signal/ Sign 7**	**Signal/ Sign 6**	**Signal/ Sign 5**	**Signal/ Sign 4**	**Signal/ Sign 3**	**Signal/ Sign 2**	**Signal/ Sign 1**	**Total**	
Sign/Sig Mwl (kip*ft)	0.0	0.0	0.0	0.0	0.0	47.6	*24.2*	*40.2*	*15.0*	*7.8*	134.8	
Sign/Sig 1.1*Mdl (kip*ft)	0.0	0.0	0.0	0.0	0.0	4.2	*2.0*	*2.6*	*1.3*	*0.7*	10.8	
Arm 2 Mwl (kip*ft)											0.0	0.0
Arm 2 1.1*Mdl (kip*ft)											0.0	0.0
											0.0	0.0

1 Arm Assembly		Use Regular Arm				
Design Arm Designation			**Pole Designation**			**Drilled Shaft**
A70	/S		P5	/S		DS
A70/S-			P5/S-			DS/14/5
A70/S-P5/S-DS/14/5						

2 Arm Assembly		Use Regular Arm				
Design Arm Designation			**Pole Designation**			**Drilled Shaft**
						DS
-			-			

Assembly ID	A70/S-P5/S-DS/14/5	
	Arm 1	**Arm 2**
Arm Length(s)	70	0
Max Design CFI %	0.95	
Est. Regular Arm CFI	0.77	0.00
Est. HD Arm CFI	0.73	0.00

Note: Poles are designed to have a smaller CFI than Arms



Drilled Shaft Foundation for
Sign, Signal, and Lighting Support Structures v1.1

State Structures Design Office

SUBJECT: Moccasin Wallow Road
Struct # T-15-1 LOCATION: Sta. 368+39.5, 81.6' LT

DESIGNED BY: MPR DATE: 12/2021
CHECKED BY: DATE: 12/2021

Program Changes

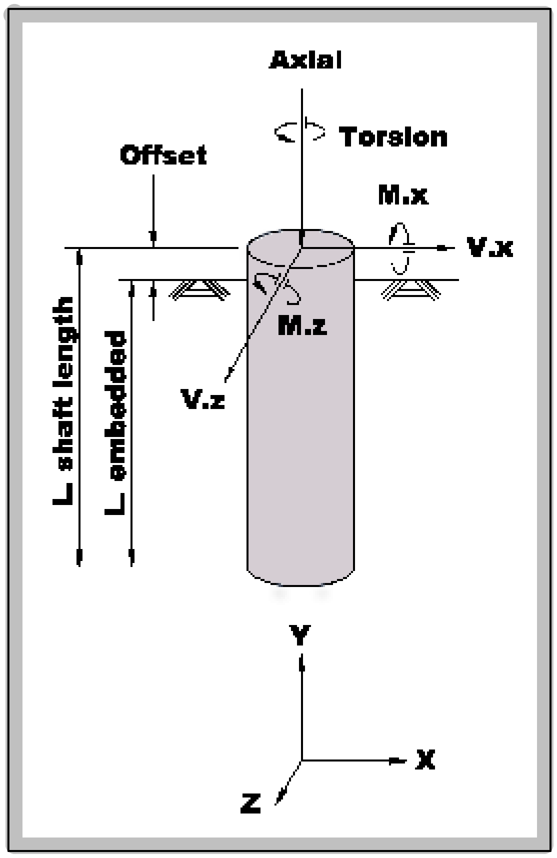
SoilType :=
Sand
Clay

$\phi_{soil} := 29 \cdot deg$ *soil friction angle (sand)*

$c_{soil} := 1.25 \cdot \frac{kip}{ft^2}$ *soil shear strength (clay)*

$N_{blows} := 8.5$ *number of blows per foot. If N< 5, contact the district geotech Engineer*

$\gamma_{soil} := 42.6 \cdot pcf$ *effective soil weight (typical design value = 45 ~ 50 pcf)*



Geometry

$b := 5 \cdot ft$ *shaft diameter, "DB"*

$Offset := 0.5 \cdot ft$ *groundline to top of foundation*

Applied Loads (Extreme I)

$M_x := 238.5 \cdot kip \cdot ft$ $V_x := 0 \cdot kip$ $Torsion := 256.4 \cdot kip \cdot ft$

$M_z := 107.2 \cdot kip \cdot ft$ $V_z := 11.1 \cdot kip$ $Axial := 4.0 \cdot kip$

StructureType :=
Cantilever Overhead Sign Structure
Mast Arm Signal Structure
Concrete/Steel Strain Poles
Ground Sign

StructureType = 1

$\phi_{ot} := if(StructureType = 3, 0.8, 0.6)$ $\phi_{ot} = 0.6$ *ϕ factor against overturning [SM Vol-3 13.6.1.1]*

$\phi_{tor} := if(StructureType = 0, 0.9, 1.0)$ $\phi_{tor} = 1$ *ϕ factor against torsion [SM Vol-3 13.6.1.1]*

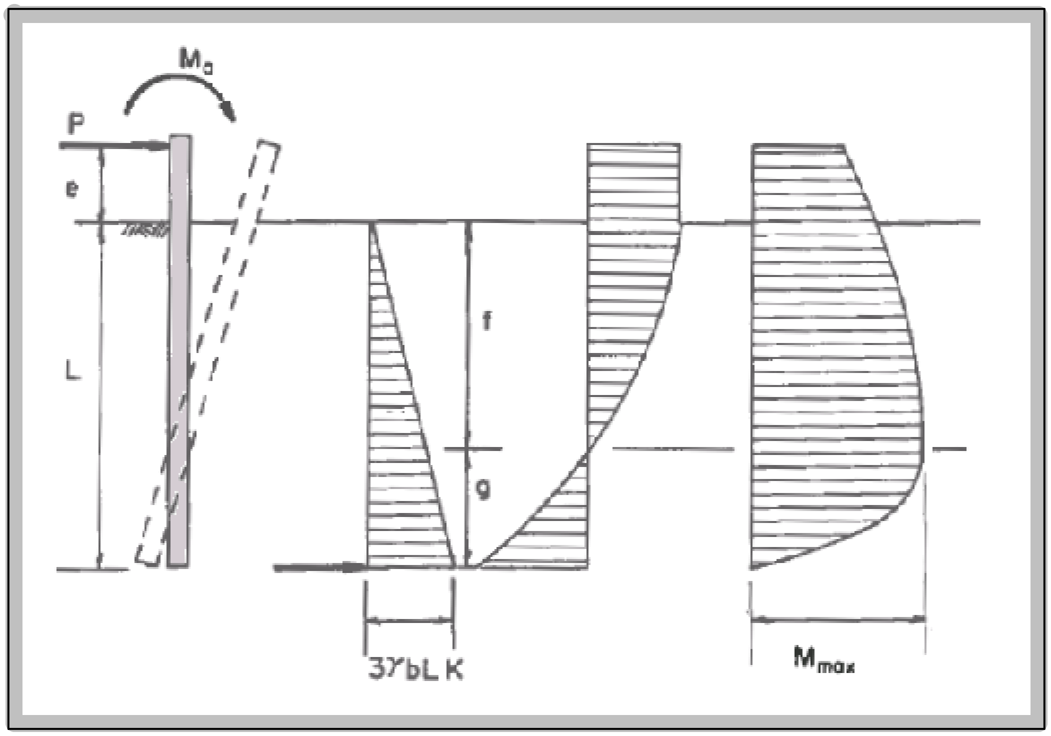
Shaft Depth Required to Resist Overturning

$M_u := \sqrt{M_x^{\ 2} + M_z^{\ 2}} = 261.5 \cdot kip \cdot ft$

$P_u := \sqrt{V_x^{\ 2} + V_z^{\ 2}} = 11.1 \cdot kip$

$T_u := Torsion = 256.4 \cdot kip \cdot ft$

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.

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

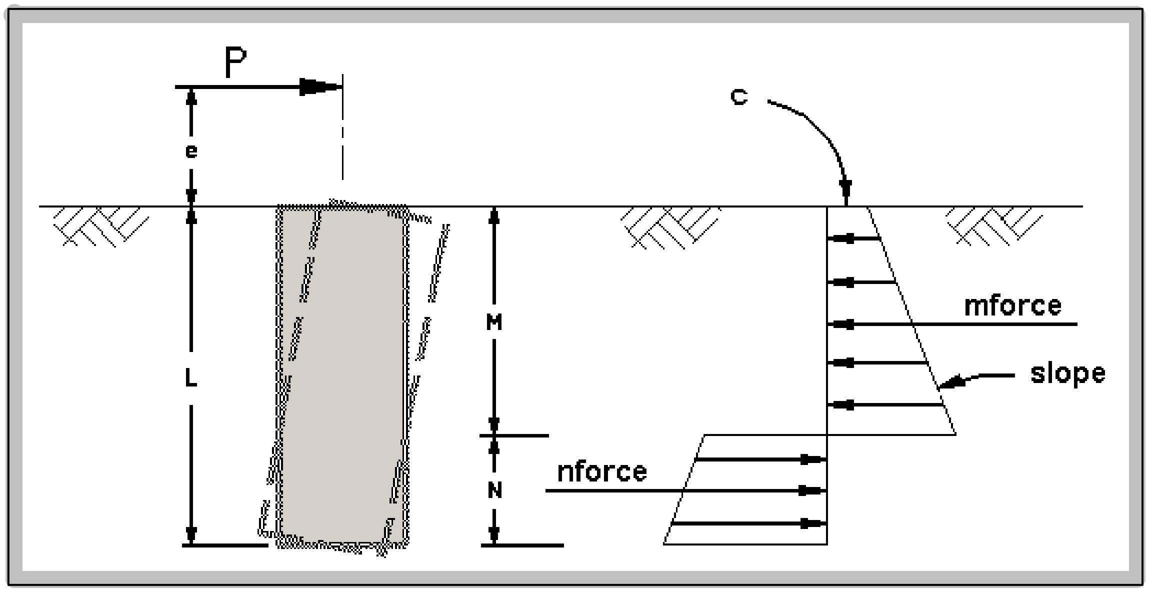
Guess value $\qquad L_{otSand} := 8 \cdot ft$

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

$L_{otSand} := Find\left(L_{otSand}\right) = 13.1\ ft$

$L_{otSand} := ceil\left(\dfrac{L_{otSand}}{ft}\right) \cdot ft = 14\ ft$ $\qquad$ *(round up to next foot)*

*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.

$c_{soil} := \text{if}\left(c_{soil} = 0 \cdot ksf, 0.1 \cdot ksf, c_{soil}\right) = 1.3 \cdot ksf$

$Slope := 8 \cdot \frac{c_{soil}}{3 \cdot b} = 0.7 \cdot \frac{kip}{ft^3}$

$e_{clay} := \frac{M_u}{P_u} + Offset = 24.1\ ft$

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

$mforce(M) := \left(2 \cdot c_{soil} + M \cdot Slope\right) \cdot M \cdot \frac{b}{2}$

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

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

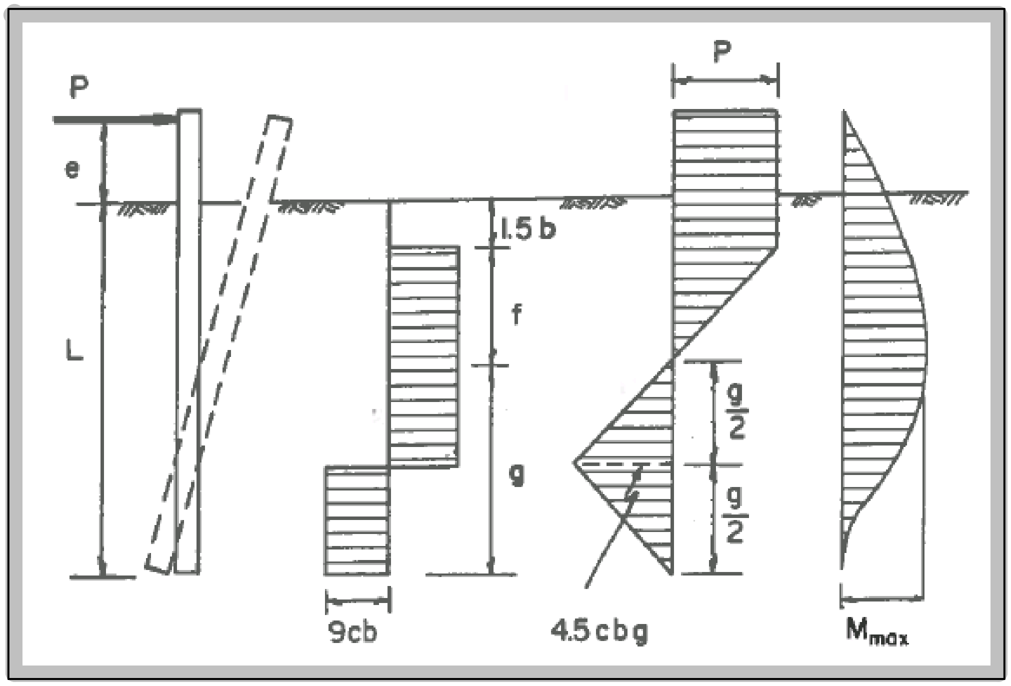
Guess value $M := 4.0 \cdot ft$ $N := 4.0 \cdot ft$

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

$\begin{pmatrix} M \\ N \end{pmatrix} := \text{Find}(M, N)$ $L_{ot1Clay} := M + N = 10.5\ ft$

$L_{ot1Clay} := \text{ceil}\left(\frac{L_{ot1Clay}}{ft}\right) \cdot ft = 11\ ft$ *(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.*

$$f := \frac{P_u}{\phi_{ot} \cdot 9 \cdot c_{soil} \cdot b} = 0.3\ \text{ft}$$

$$M_{max.clay} := P_u \cdot \left(e_{clay} + 1.5 \cdot b + 0.5 \cdot f\right) = 352.1 \cdot \text{kip} \cdot \text{ft}$$

$$g := \sqrt{\frac{M_{max.clay}}{2.25 \cdot \phi_{ot} \cdot c_{soil} \cdot b}} = 6.5\ \text{ft}$$

$$L_{ot2Clay} := \left(1.5 \cdot b + f + g\right) = 14.3\ \text{ft}$$

$$L_{ot2Clay} := \text{ceil}\left(\frac{L_{ot2Clay}}{\text{ft}}\right) \cdot \text{ft} = 15\ \text{ft}$$ *(round up to next foot)*

$$L_{otClay} := \text{if}\left(L_{ot1Clay} < 3 \cdot b, L_{ot1Clay}, L_{ot2Clay}\right) = 3.4$$ *(If L_{ot} < 3b, use Modified Broms method)*

$$L_{reqdOT} := \text{if}\left(\text{SoilType} = \text{"Sand"}, L_{otSand}, L_{otClay}\right)$$

$L_{reqdOT} = 14\ \text{ft}$ *required shaft embedment depth to resist overturning*

Shaft Depth Required to Resist Torsion

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.

$N_{blows} = 8.5$

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

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 $L_{torSand} := L_{reqdOT} = 14\,\text{ft}$

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

$$L_{torSand} := \text{Find}(L_{torSand}) = 19\,\text{ft}$$

$$L_{torSand} := \text{ceil}\left(\frac{L_{torSand}}{\text{ft}}\right) \cdot \text{ft} = 19\,\text{ft}$$

(round up to next foot)

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

$\text{CohesionFactor} := 0.55$

$f_{se} := \text{CohesionFactor} \cdot c_{soil} = 0.7 \cdot \text{ksf}$

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

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

$$L_{torClay} := \text{Find}(L_{torClay}) = 11\,\text{ft}$$

$$L_{torClay} := \text{ceil}\left(\frac{L_{torClay}}{\text{ft}}\right) \cdot \text{ft} = 11\,\text{ft}$$

(round up to next foot)

$L_{reqdTor} := \text{if}(\text{SoilType} = \text{"Sand"}, L_{torSand}, L_{torClay})$

$L_{reqdTor} = 19\,\text{ft}$

required shaft embedment depth to resist torsion

$L_{embedded} := \text{if}(L_{reqdTor} > L_{reqdOT}, L_{reqdTor}, L_{reqdOT}) = 5.8$

$L_{shaft.length} := L_{embedded} + \text{Offset}$

$L_{shaft.length} = 19.5\,\text{ft}$

shaft length

Maximum Moment in Shaft

short free-head pile in cohesionless soil using Broms method

$$f_{sand} := \sqrt{\frac{2\cdot P_u}{3\cdot\gamma_{soil}\cdot b\cdot K_p\cdot\phi_{ot}}} = 4.5\ \text{ft}$$

$$M_{maxSand} := P_u\cdot\left(e_{sand} + f_{sand}\right) - \frac{P_u\cdot f_{sand}}{3} + M_u = 300.2\cdot\text{kip}\cdot\text{ft}$$

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

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

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

$$f_{mod} := \text{Find}\left(f_{mod}\right) = 1.9\ \text{ft}$$

$$M_{modBroms} := P_u\cdot\left(e_{clay} + f_{mod}\right) - \frac{\phi_{ot}\cdot c_{soil}\cdot b\cdot f_{mod}^{\,2}}{2} - \frac{\phi_{ot}\cdot b\cdot f_{mod}^{\,3}\cdot\text{Slope}}{6} = 279.1\cdot\text{kip}\cdot\text{ft}$$

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

$$M_{Broms} := P_u\cdot\left(e_{clay} + 1.5\cdot b + 0.5\cdot f\right) = 352.1\cdot\text{kip}\cdot\text{ft}$$

$$M_{maxClay} := \text{if}\left(L_{ot1Clay} < 3\cdot b, M_{modBroms}, M_{Broms}\right) = 279.1\cdot\text{kip}\cdot\text{ft}$$ *(If $L_{\alpha} < 3b$, use Modified Broms method)*

$$M_{max} := \text{if}\left(\text{SoilType} = \text{"Sand"}, M_{maxSand}, M_{maxClay}\right) = 300.2\cdot\text{kip}\cdot\text{ft}$$

Minimum Reinforcing and Spacing

$F_{y.rebar} := \mathbf{60} \cdot \text{ksi}$	*reinforcing yield strength*	
$f_c := \mathbf{4.0} \cdot \text{ksi}$	*concrete strength* *Spec 346-3*	
$\text{Cover} := \mathbf{6} \cdot \text{in}$	*cover* *SDG Table 1.4.2-1*	
$\text{Num}_{bar} := 18$	*number of longitudinal bars, "RB"*	
$A_{long.bar} := \mathbf{1.56} \cdot \text{in}^2$	*longitudinal bar area*	
$d_{long.bar} := \mathbf{1.41} \cdot \text{in}$	*longitudinal bar diameter*	
$A_{v.bar} := \mathbf{0.31} \cdot \text{in}^2$	*stirrup area*	*SM Vol-3 13.6.2*
$d_{v.bar} := \mathbf{0.625} \cdot \text{in}$	*stirrup diameter*	
$s_{v1} := \mathbf{4} \cdot \text{in}$	*stirrup spacing, depth = 0 ft-2 ft*	*SM Vol-3 13.6.2*
$s_{v2} := 8 \cdot \text{in}$	*stirrup spacing, depth = 2 ft-depth.stir, "RD"*	
$s_{v3} := 12 \cdot \text{in}$	*stirrup spacing, depth > depth.stir, "RF"*	
$\text{depth}_{stir} := 9.083 \cdot \text{ft}$	*stirrup depth, see s.v2 and s.v3 above*	
$b = 5\,\text{ft}$	*shaft diameter*	

$$A_{req} := \min\left(0.135 \cdot \frac{\pi \cdot b^2}{4} \cdot \frac{f_c}{F_{y.rebar}}, 0.015 \cdot \frac{\pi \cdot b^2}{4}\right) = 25.4 \cdot \text{in}^2$$ *LRFD 5.7.4.2*

$A_{long} := \text{Num}_{bar} \cdot A_{long.bar} = 28.1 \cdot \text{in}^2$ *total area of longitudinal steel*

$\text{CheckLongitudinalReinf} := \text{if}\left(A_{long} \geq A_{req}, \text{"OK"}, \text{"No Good"}\right)$ $\text{CheckLongitudinalReinf} = \text{"OK"}$

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

$\text{Spacing}_{vert.reinf} := \text{Dia}_{bar.circle} \cdot \frac{\pi}{\text{Num}_{bar}} = 7.9 \cdot \text{in}$ $\text{Clearance}_{vert.reinf} := \text{Spacing}_{vert.reinf} - d_{long.bar} = 6.5 \cdot \text{in}$

$\text{CheckReinfClearSpacing} := \text{if}\left(\text{Clearance}_{vert.reinf} \geq 6\text{in}, \text{"OK"}, \text{"No Good"}\right)$ $\text{CheckReinfClearSpacing} = \text{"OK"}$ *SDG 3.6.10*

Check Shear and Torsion

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

$$V_u := \sqrt{V_x^2 + V_z^2} = 11.1 \cdot kip$$

$$T_u = 256.4 \cdot kip \cdot ft$$

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

$$V_c := 0.0316 \cdot (2.0) \cdot \sqrt{\frac{f_c}{ksi}} \cdot \left(\frac{b}{in}\right) \cdot \left(\frac{d_v}{in}\right) \cdot kip = 327.6 \cdot kip$$

LRFD Eqn 5.8.3.3-3 *LRFD 5.8.3.4.1* *ACI 11.3.3*

$$V_s := \frac{A_{v.bar} \cdot F_{y.rebar} \cdot d_v}{\max\left(s_{v1}, s_{v2}, s_{v3}\right)} = 67 \cdot kip$$

LRFD Eqn 5.8.3.3-4

$$ShearRatio := \frac{V_u - \phi_v \cdot V_c}{\phi_v \cdot V_s} = -4.7$$

$$ShearRatio := if\left(ShearRatio \le 0, 0, ShearRatio\right) = 0$$

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

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

$$T_{n1} := \frac{2 \cdot A_o \cdot A_{v.bar} \cdot F_{y.rebar}}{s_{v1}} = 1.2 \times 10^3 \cdot kip \cdot ft$$

LRFD Eqn 5.8.3.6.2-1

$$T_{n2} := \frac{2 \cdot A_o \cdot A_{v.bar} \cdot F_{y.rebar}}{s_{v2}} = 580.6 \cdot kip \cdot ft$$

LRFD 5.8.3.4.1

$$T_{n3} := \frac{2 \cdot A_o \cdot A_{v.bar} \cdot F_{y.rebar}}{s_{v3}} = 387.1 \cdot kip \cdot ft$$

$\phi_v = 0.9$ $\qquad$ $T_u = 256.4 \cdot kip \cdot ft$ $\qquad$ $L_{reqdTor} = 19\,ft$

$$Tor2_{sand} := T_u - if\left[2ft > Offset, \left[\pi \cdot b \cdot (2 \cdot ft - Offset) \cdot \gamma_{soil} \cdot \left(\frac{2 \cdot ft - Offset}{2}\right) \cdot (\omega_{fdot}) \cdot \frac{b}{2}\right], 0 \cdot kip \cdot ft\right] = 254.8 \cdot kip \cdot ft$$

$$Tor3_{sand} := T_u - if\left[depth_{stir} > Offset, \left[\pi \cdot b \cdot (depth_{stir} - Offset) \cdot \gamma_{soil} \cdot \left(\frac{depth_{stir} - Offset}{2}\right) \cdot (\omega_{fdot}) \cdot \frac{b}{2}\right], 0 \cdot kip \cdot ft\right] = 204 \cdot kip \cdot ft$$

$$Tor2_{clay} := T_u - if\left[2ft - 1.5ft > Offset, \left[f_{se} \cdot (\pi \cdot b) \cdot (2.0 \cdot ft - Offset - 1.5 \cdot ft) \cdot \frac{b}{2}\right], 0 \cdot kip \cdot ft\right] = 256.4 \cdot kip \cdot ft$$

$$Tor3_{clay} := T_u - if\left[depth_{stir} - 1.5ft > Offset, \left[f_{se} \cdot (\pi \cdot b) \cdot (depth_{stir} - Offset - 1.5 \cdot ft) \cdot \frac{b}{2}\right], 0 \cdot kip \cdot ft\right] = 65.2 \cdot kip \cdot ft$$

$$Tor2 := if(SoilType = \text{"Sand"}, Tor2_{sand}, Tor2_{clay}) = 254.8 \cdot kip \cdot ft$$

$$Tor3 := if(SoilType = \text{"Sand"}, Tor3_{sand}, Tor3_{clay}) = 204 \cdot kip \cdot ft$$

$$TorsionRatio_{n1} := \frac{T_u}{\phi_{tor} \cdot T_{n1}} = 0.22$$

$$TorsionRatio_{n2} := \frac{Tor2}{\phi_{tor} \cdot T_{n2}} = 0.44$$

$$TorsionRatio_{n3} := \frac{Tor3}{\phi_{tor} \cdot T_{n3}} = 0.53$$

$$TorsionRatio := max(TorsionRatio_{n1}, TorsionRatio_{n2}, TorsionRatio_{n3}) = 0.53$$

$$T_{cr} := 0.125 \sqrt{\frac{f_c}{ksi}} \cdot \left(\frac{A_{cp}^{\,2}}{p_{cp} \cdot in^3}\right) \cdot kip \cdot in = 883.6 \cdot kip \cdot ft$$ *LRFD Eqn 5.8.2.1-4*

$$TorsionRatio := if(T_u \le 0.25 \cdot \phi_{tor} \cdot T_{cr}, 0, TorsionRatio) = 0.5$$ *LRFD Eqn 5.8.2.1-3*

$ShearRatio = 0$

$$CheckShearTorsion := if(ShearRatio + TorsionRatio \le 1, \text{"OK"}, \text{"No Good"})$$

$CheckShearTorsion = \text{"OK"}$

Check Maximum Spacing Transverse Reinforcement

$$v_u := \frac{V_u}{\phi_v \cdot b \cdot d_v} = 0.004758 \cdot ksi \qquad 0.125 \cdot f_c = 0.5 \cdot ksi$$ *LRFD Eqn 5.8.2.9-1*

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

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

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

$\max\left(s_{v1}, s_{v2}, s_{v3}\right) = 12 \cdot \text{in}$

$\text{CheckMaxSpacingTransvReinf} := \text{if}\left(\max\left(s_{v1}, s_{v2}, s_{v3}\right) \le s_{max}, \text{"OK"}, \text{"No Good"}\right)$

$\text{CheckMaxSpacingTransvReinf} = \text{"OK"}$

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

LRFD 5.8.3.4.1

$M_u = 261.5 \cdot \text{kip} \cdot \text{ft}$

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

$$\text{LongReinf}_{shr.tor} := \frac{\dfrac{M_u}{\phi_v \cdot d_v} + \sqrt{\left(V_{temp}\right)^2 + \left(\dfrac{0.45 \cdot p_h \cdot T_u}{2 \cdot A_o \cdot \phi_v}\right)^2}}{F_{y.rebar}} = 2.6 \cdot \text{in}^2$$

$\text{Num}_{bar} \cdot A_{long.bar} = 28.1 \cdot \text{in}^2$

$\text{CheckLongReinf}_{shr.tor} := \text{if}\left(\text{Num}_{bar} \cdot A_{long.bar} \ge \text{LongReinf}_{shr.tor}, \text{"OK"}, \text{"No Good"}\right)$

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

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

Mast Arm Assembly Information

Wind Speed
○ 130 mph ● 150 mph ○ 170 mph

Signal Orientation
● Vertical
○ Horizontal

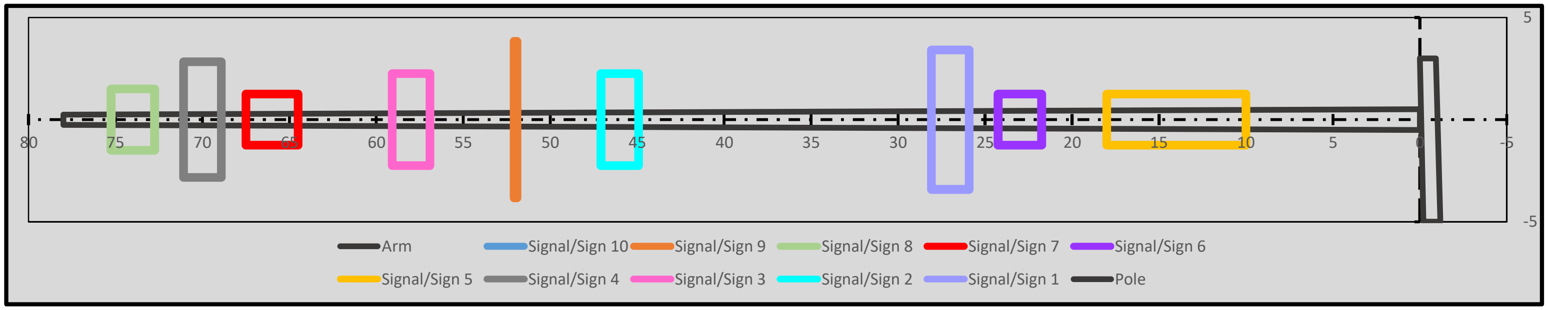
Back Plate Width
● 6.0 in.
○ 2.5 in.
○ 0 in.

Luminaire?
○ Yes
● No

Arm 1 Length
30
40
50
60
70
78

Arm 1 Length, Signal/Sign Location and Size

	Signal\Sign #10	Signal\Sign #9	Signal\Sign #8	Signal\Sign #7	Signal\Sign #6	Signal\Sign #5	Signal\Sign #4	Signal\Sign #3	Signal\Sign #2	Signal\Sign #1
Dist to Pole (ft.)	55	52	74	66	23	14	70	58	46	27
	● 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
Sign Width (in.)		2	30	36	30	96				
Sign Height (in.)		92	36	30	30	30				
Area (SF)	0.0	1.3	7.5	7.5	6.3	20.0	12.3	9.8	9.8	14.8
M_{wl}. (kip*ft)	0	4	37	33	10	19	58	38	30	27



Arm 1 Length (ft)	78	
Design Standard Index 17743	**Regular**	**Heavy Duty**
Dia. at Arm Base (in)	18	20
Wall Thickness (in)	0.3750	0.3750
Resistance (M_r=ϕM_n) (kip*ft)	422	512

Arm 1 Loads	Regular	Heavy Duty
1.1*Arm M_{dl} (kip*ft)	121	143
Arm M_{wl} (kip*ft)	120	141
1.1*Sign/Signal M_{dl} (kip*ft)	20	
Sign/Signal M_{wl} (kip*ft)	255	
Total Moment ($M_{extreme}$)	401	429

Mast Arm Assembly Designation

One Arm Assembly
A78/S-P6/S-DS/16/5

See separate calc
for foundation

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.

Tube Wind Pressure (psf)	44.1	**Fy (ksi)**	50	**Sign/Sig. Wind Pressure (psf)**	67.0

short free-head pile in cohesionless soil using Broms method

$$\phi \cdot \frac{\gamma_{soil} \cdot b_{shaft} \cdot L_{shaft}{}^{3} \cdot K_p}{2} \geq M_u + P_u \cdot L_{shaft}$$

Arm Without Attachments: Dead Load Moment, Wind Load Moment and Moment Capacity at Base Connection

Total Arm Length (ft)	**Regular**							**Heavy Duty**						
	wall thk (in)	**base dia (in)**	**S (in3)**	**Z (in3)**	**M_{dl} (kip*ft)**	**$M_{wl\ 130\ mph}$ (kip*ft)**	**M_r=ϕM_n (kip*ft)**	**wall thk (in)**	**base dia (in)**	**S (in3)**	**Z (in3)**	**M_{dl} (kip*ft)**	**$M_{wl\ 130mph}$ (kip*ft)**	**Mr=ϕMn (kip*ft)**
30	0.25	11	23	29	10	10	107	0.25	12	27	34	11	11	125
40	0.25	13	32	40	20	20	145	0.25	14	37	47	22	22	166
50	0.3125	14	46	58	36	33	215	0.3125	15	53	67	40	37	244
60	0.375	15	63	79	56	48	300	0.375	16	72	91	62	53	340
70	0.375	17	81	103	85	71	380	0.375	18	91	115	100	77	422
78	0.375	18	91	115	110	90	422	0.375	20	113	143	130	106	512

Drilled Shaft

Index 17743 Drilled Shaft Capacities						**1 Arm Assembly Loads And Capacity Check**					**2 Arm Assembly Loads and Capacity Check**				
DS Index #	**ID**	**Length**	**Diameter**	**ϕM_n**	**ϕT_n**	**M_u+ P_u*L_{shaft}**	**T_u**	**Check Mom. & Min Dia.**	**Check Torsion**	**Check**	**M_u+ P_u*L_{shaft}**	**T_u**	**Check Mom. & Min Dia.**	**Check Torsion**	**Check**
1	DS/20/5	20	5	1800	589	604.8	375.2	Okay	Okay	Okay	0.0	0.0	0	0	0
2	DS/18/5	18	5	1312	477	577.3		Okay	Okay	Okay	0.0		0	0	0
3	DS/16/5	16	5	922	377	549.7		Okay	Okay	Okay	0.0		0	0	0
4	DS/16/4.5	16	4.5	829	305	549.7		NoGood	NoGood	NoGood	0.0		0	0	0
5	DS/14/5	14	5	617	289	522.2		Okay	NoGood	NoGood	0.0		0	0	0
6	DS/14/4.5	14	4.5	556	234	522.2		NoGood	NoGood	NoGood	0.0		0	0	0
7	DS/12/4.5	12	4.5	350	172	494.6		NoGood	NoGood	NoGood	0.0		0	0	0
8	DS/12/4	12	4	311	136	494.6		NoGood	NoGood	NoGood	0.0		0	0	0

Arm 1 Attachments: Extreme Event Dead Load Moment, Wind Load Moment at Base Connection

	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**	**Total**		
Sign/Sig Mwl (kip*ft)	0.0	4.5	37.2	33.2	9.6	18.8	57.6	37.9	30.0	26.8	255.4		
Sign/Sig 1.1*Mdl (kip*ft)	0.0	0.3	2.4	2.2	0.6	1.2	5.0	3.2	2.5	2.4	19.9		
Arm 1 Mwl (kip*ft)											119.8	141.1	*Reg Arm / HD Arm*
Arm 1 1.1*Mdl (kip*ft)											121.0	143.0	*Reg Arm / HD Arm*
*Extreme Event Arm Moment (kip*ft)*											400.8	429.2	

Ensures anchor bolts fit inside rebar cage	**Min Shaft Diameter**
	5

Required Drilled Shaft Index Number Required (see Table for size)		
Load Case	**1 Arm DS Index #**	**2 Arm DS Index #**
Drilled Shaft Index req'd for Overturning including Min. Diamter	5	0
Drilled Shaft Index req'd for Torsion	3	0
Drilled Shaft Controlling Load Case	3	#N/A

Pole Base Shears & Moments				
	Arm 1 Shear	**Arm 1 Moment**	**Arm 2 Shear**	**Arm 2 Moment**
dl att	N/A	19.9	N/A	0.0
dl arm	N/A	121.0	N/A	0.0
wl pole	2.6	52.9	0.0	0.0
wl att	6.0	131.3	0.0	0.0
wl arm	5.2	113.5	0.0	0.0
Tor wl att	N/A	255.4	N/A	0.0
Tor wl arm	N/A	119.8	N/A	0.0

assume a 37.5' pole wl with lum

Arm 2 Attachments: Extreme Event Dead Load Moment, Wind Load Moment at Base Connection

	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**	**Total**	
Sign/Sig Mwl (kip*ft)	0.0	0.0	0.0	0.0	0.0	47.6	*24.2*	*40.2*	*15.0*	*7.8*	134.8	
Sign/Sig 1.1*Mdl (kip*ft)	0.0	0.0	0.0	0.0	0.0	4.2	*2.0*	*2.6*	*1.3*	*0.7*	10.8	
Arm 2 Mwl (kip*ft)											0.0	0.0
Arm 2 1.1*Mdl (kip*ft)											0.0	0.0
											0.0	0.0

Forces at Top of DS		
	One Arm	Two Arms
Moment dl	140.9	N/A
Moment wl	297.7	
Moment Total	329.4	0.0
Torsion	375.2	0.0
Shear	13.8	0.0
Shaft 2-Arm Factor	*1.1*	*used for OT & Torsion*

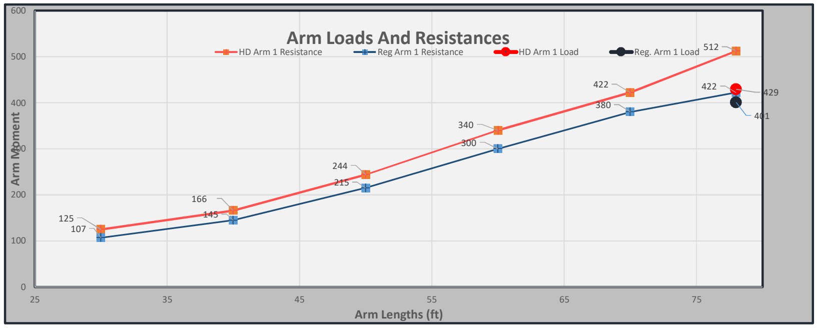
Pole ID			
Arm 1 Length	78	Arm 2 Length	0
	Pole ID	P6	

1 Arm Assembly	Use Regular Arm					
Design Arm Designation			**Pole Designation**		**Drilled Shaft**	
A78	/S		P6	/S	DS	
A78/S-			P6/S-		DS/16/5	
A78/S-P6/S-DS/16/5						

2 Arm Assembly	Use Regular Arm					
Design Arm Designation			**Pole Designation**		**Drilled Shaft**	
					DS	
-			-			

Assembly ID	A78/S-P6/S-DS/16/5	
	Arm 1	**Arm 2**
Arm Length(s)	78	0
Max Design CFI %	0.95	
Est. Regular Arm CFI	1.00	0.00
Est. HD Arm CFI	0.88	0.00

Note: Poles are designed to have a smaller CFI than Arms



Drilled Shaft Foundation for
Sign, Signal, and Lighting Support Structures v1.1

FDOT
State Structures Design Office

SUBJECT: Moccasin Wallow Road
Struct # T-15-2 LOCATION: Sta. 368+42.6, 76.9' RT

DESIGNED BY: MPR DATE: 12/2021
CHECKED BY: DATE: 12/2021

Program Changes

SoilType :=
● Sand
○ Clay

$\phi_{soil} := 29 \cdot deg$ *soil friction angle (sand)*

$c_{soil} := 1.25 \cdot \frac{kip}{ft^2}$ *soil shear strength (clay)*

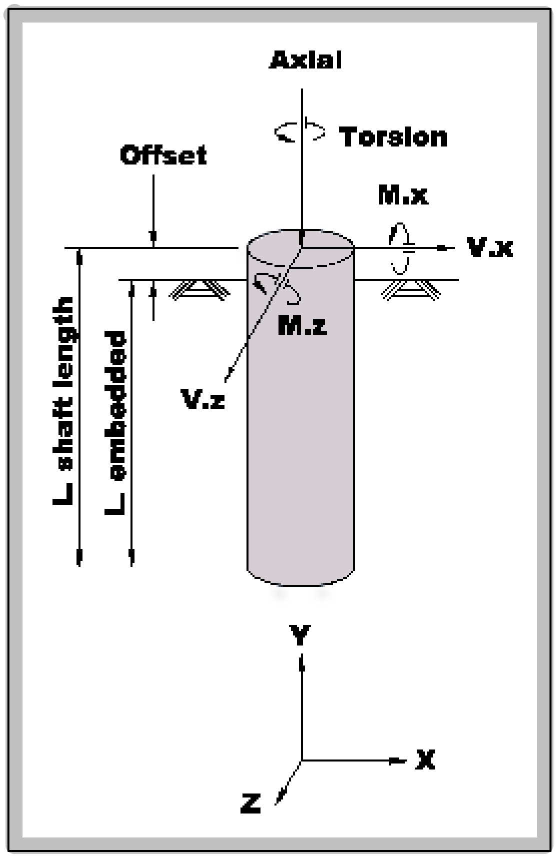
$N_{blows} := 9$ *number of blows per foot. If N< 5, contact the district geotech Engineer*

$\gamma_{soil} := 42.6 \cdot pcf$ *effective soil weight (typical design value = 45 ~ 50 pcf)*

Geometry

$b := 5 \cdot ft$ *shaft diameter, "DB"*

$Offset := 0.5 \cdot ft$ *groundline to top of foundation*



Applied Loads (Extreme I)

$M_x := 297.7 \cdot kip \cdot ft$ $V_x := 0 \cdot kip$ $Torsion := 375.2 \cdot kip \cdot ft$

$M_z := 140.9 \cdot kip \cdot ft$ $V_z := 13.8 \cdot kip$ $Axial := 4.0 \cdot kip$

StructureType :=
○ Cantilever Overhead Sign Structure
● Mast Arm Signal Structure
○ Concrete/Steel Strain Poles
○ Ground Sign

$StructureType = 1$

$\phi_{ot} := if(StructureType = 3, 0.8, 0.6)$ $\phi_{ot} = 0.6$ *ϕ factor against overturning [SM Vol-3 13.6.1.1]*

$\phi_{tor} := if(StructureType = 0, 0.9, 1.0)$ $\phi_{tor} = 1$ *ϕ factor against torsion [SM Vol-3 13.6.1.1]*

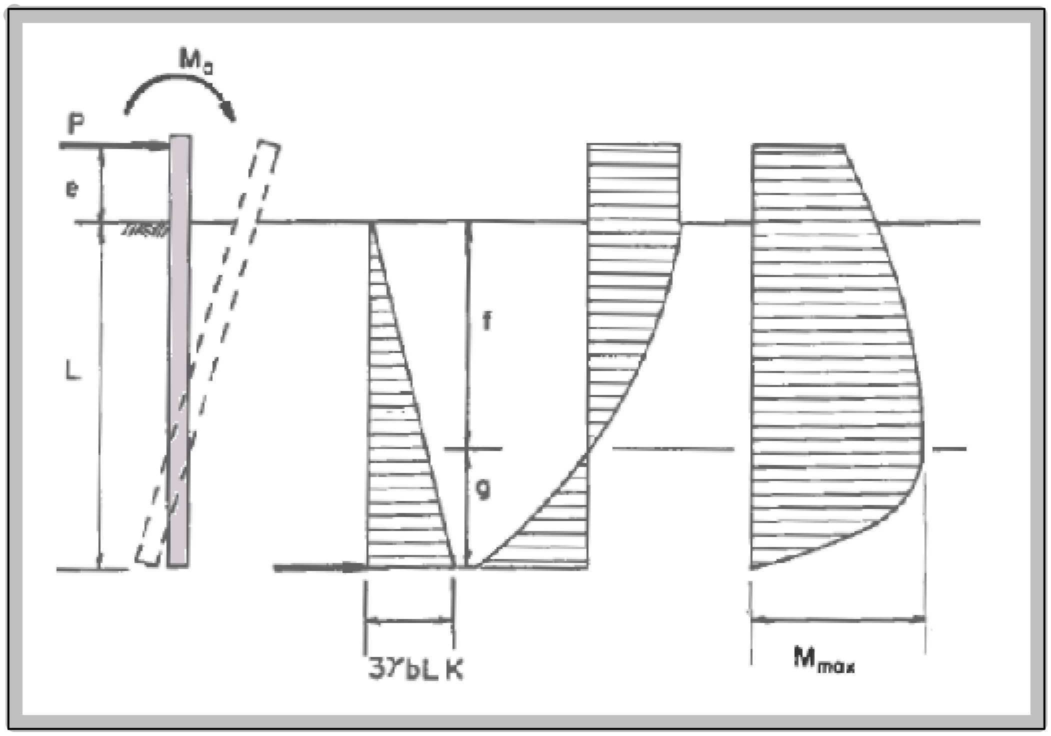
Shaft Depth Required to Resist Overturning

$$M_u := \sqrt{{M_x}^2 + {M_z}^2} = 329.4 \cdot \text{kip} \cdot \text{ft}$$

$$P_u := \sqrt{{V_x}^2 + {V_z}^2} = 13.8 \cdot \text{kip}$$

$$T_u := \text{Torsion} = 375.2 \cdot \text{kip} \cdot \text{ft}$$

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.

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

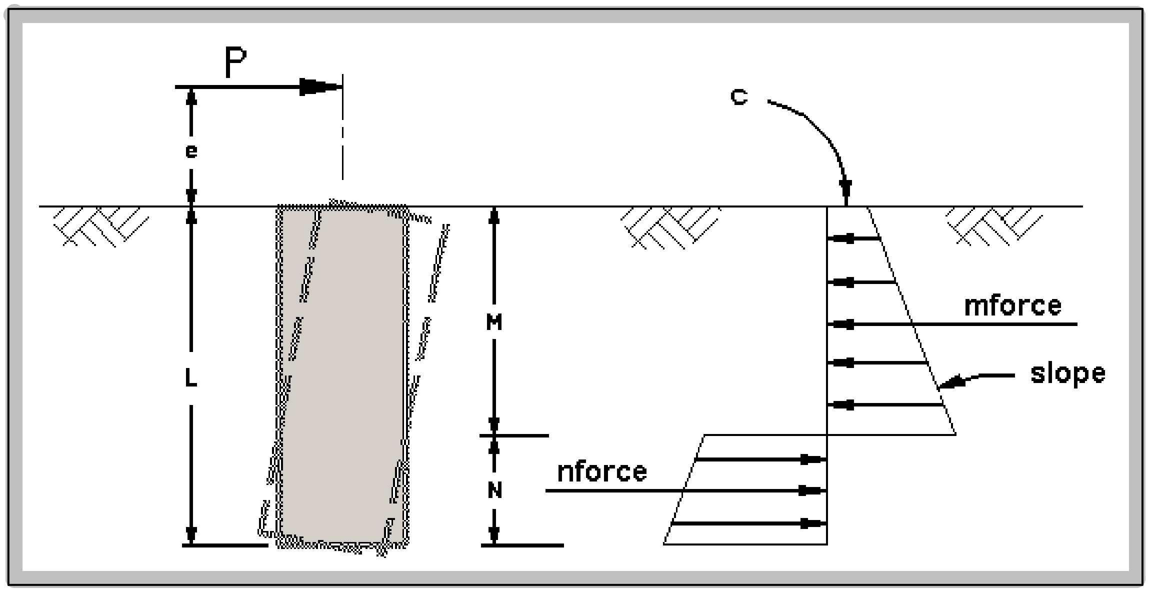
Guess value $L_{otSand} := 8 \cdot \text{ft}$

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

$$L_{otSand} := \text{Find}\left(L_{otSand}\right) = 14.3\ \text{ft}$$

$$L_{otSand} := \text{ceil}\left(\frac{L_{otSand}}{\text{ft}}\right) \cdot \text{ft} = 15\ \text{ft}$$ *(round up to next foot)*

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.

$c_{soil} := \text{if}\left(c_{soil} = 0\cdot ksf, 0.1\cdot ksf, c_{soil}\right) = 1.3\cdot ksf$

$Slope := 8\cdot\frac{c_{soil}}{3\cdot b} = 0.7\cdot\frac{kip}{ft^3}$ $e_{clay} := \frac{M_u}{P_u} + Offset = 24.4\,ft$

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

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

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

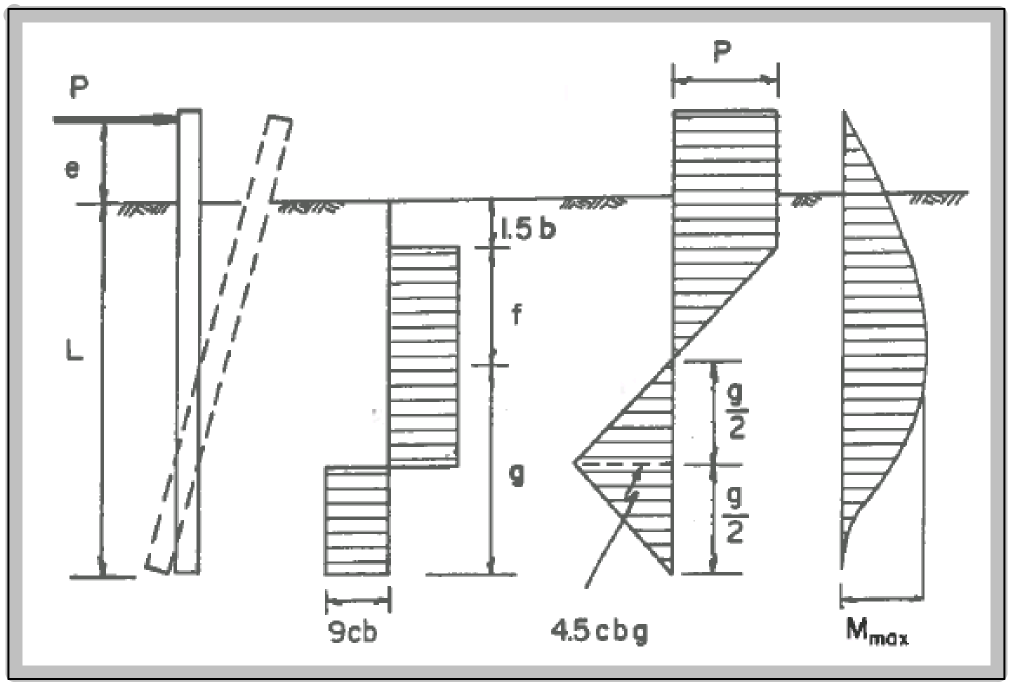
Guess value $M := 4.0\cdot ft$ $N := 4.0\cdot ft$

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

$\begin{pmatrix} M \\ N \end{pmatrix} := Find(M,N)$ $L_{ot1Clay} := M + N = 11.6\,ft$

$L_{ot1Clay} := ceil\left(\frac{L_{ot1Clay}}{ft}\right)\cdot ft = 12\,ft$ *(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.*

$$f := \frac{P_u}{\phi_{ot} \cdot 9 \cdot c_{soil} \cdot b} = 0.4\ ft$$

$$M_{max.clay} := P_u \cdot \left(e_{clay} + 1.5 \cdot b + 0.5 \cdot f\right) = 442.6 \cdot kip \cdot ft$$

$$g := \sqrt{\frac{M_{max.clay}}{2.25 \cdot \phi_{ot} \cdot c_{soil} \cdot b}} = 7.2\ ft$$

$$L_{ot2Clay} := (1.5 \cdot b + f + g) = 15.2\ ft$$

$$L_{ot2Clay} := ceil\left(\frac{L_{ot2Clay}}{ft}\right) \cdot ft = 16\ ft$$ *(round up to next foot)*

$$L_{otClay} := if\left(L_{ot1Clay} < 3 \cdot b, L_{ot1Clay}, L_{ot2Clay}\right) = 3.7$$ *(If $L_{ot} < 3b$, use Modified Broms method)*

$$L_{reqdOT} := if\left(SoilType = "Sand", L_{otSand}, L_{otClay}\right)$$

$L_{reqdOT} = 15\ ft$ *required shaft embedment depth to resist overturning*

Shaft Depth Required to Resist Torsion

*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.

$N_{blows} = 9$

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

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 $L_{torSand} := L_{reqdOT} = 15\ \text{ft}$

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

$L_{torSand} := \text{Find}(L_{torSand}) = 22.3\ \text{ft}$

$L_{torSand} := \text{ceil}\left(\frac{L_{torSand}}{\text{ft}}\right) \cdot \text{ft} = 23\ \text{ft}$ *(round up to next foot)*

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

$\text{CohesionFactor} := 0.55$

$f_{se} := \text{CohesionFactor} \cdot c_{soil} = 0.7 \cdot \text{ksf}$

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

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

$L_{torClay} := \text{Find}(L_{torClay}) = 15.4\ \text{ft}$

$L_{torClay} := \text{ceil}\left(\frac{L_{torClay}}{\text{ft}}\right) \cdot \text{ft} = 16\ \text{ft}$ *(round up to next foot)*

$L_{reqdTor} := \text{if}(\text{SoilType} = \text{"Sand"}, L_{torSand}, L_{torClay})$

$L_{reqdTor} = 23\ \text{ft}$ *required shaft embedment depth to resist torsion*

$L_{embedded} := \text{if}(L_{reqdTor} > L_{reqdOT}, L_{reqdTor}, L_{reqdOT}) = 7$

$L_{shaft.length} := L_{embedded} + \text{Offset}$

$L_{shaft.length} = 23.5\ \text{ft}$ *shaft length*

Maximum Moment in Shaft

short free-head pile in cohesionless soil using Broms method

$$f_{sand} := \sqrt{\frac{2\cdot P_u}{3\cdot\gamma_{soil}\cdot b\cdot K_p\cdot\phi_{ot}}} = 5\,ft$$

$$M_{maxSand} := P_u\cdot\left(e_{sand} + f_{sand}\right) - \frac{P_u\cdot f_{sand}}{3} + M_u = 382.2\cdot kip\cdot ft$$

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

$f_{mod} := Find\left(f_{mod}\right) = 2.3\,ft$

$$M_{modBroms} := P_u\cdot\left(e_{clay} + f_{mod}\right) - \frac{\phi_{ot}\cdot c_{soil}\cdot b\cdot f_{mod}^{\ 2}}{2} - \frac{\phi_{ot}\cdot b\cdot f_{mod}^{\ 3}\cdot Slope}{6} = 354\cdot kip\cdot ft$$

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

$$M_{Broms} := P_u\cdot\left(e_{clay} + 1.5\cdot b + 0.5\cdot f\right) = 442.6\cdot kip\cdot ft$$

$M_{maxClay} := if\left(L_{ot1Clay} < 3\cdot b, M_{modBroms}, M_{Broms}\right) = 354\cdot kip\cdot ft$ *(If $L_{\alpha} < 3b$, use Modified Broms method)*

$$M_{max} := if\left(SoilType = \text{"Sand"}, M_{maxSand}, M_{maxClay}\right) = 382.2\cdot kip\cdot ft$$

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*

$Num_{bar} := 18$ *number of longitudinal bars, "RB"*

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

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

$A_{v.bar} := \mathbf{0.31} \cdot in^2$ *stirrup area* *SM Vol-3 13.6.2*

$d_{v.bar} := \mathbf{0.625} \cdot in$ *stirrup diameter*

$s_{v1} := \mathbf{4} \cdot in$ *stirrup spacing, depth = 0 ft-2 ft* *SM Vol-3 13.6.2*

$s_{v2} := 8 \cdot in$ *stirrup spacing, depth = 2 ft-depth.stir, "RD"*

$s_{v3} := 12 \cdot in$ *stirrup spacing, depth > depth.stir, "RF"*

$depth_{stir} := 9.083 \cdot ft$ *stirrup depth, see s.v2 and s.v3 above*

$b = 5\,ft$ *shaft diameter*

$$A_{req} := \min\left(0.135 \cdot \frac{\pi \cdot b^2}{4} \cdot \frac{f_c}{F_{y.rebar}}, 0.015 \cdot \frac{\pi \cdot b^2}{4}\right) = 25.4 \cdot in^2$$ *LRFD 5.7.4.2*

$A_{long} := Num_{bar} \cdot A_{long.bar} = 28.1 \cdot in^2$ *total area of longitudinal steel*

$CheckLongitudinalReinf := if(A_{long} \geq A_{req}, \text{"OK"}, \text{"No Good"})$ $CheckLongitudinalReinf = \text{"OK"}$

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

$Spacing_{vert.reinf} := Dia_{bar.circle} \cdot \frac{\pi}{Num_{bar}} = 7.9 \cdot in$ $Clearance_{vert.reinf} := Spacing_{vert.reinf} - d_{long.bar} = 6.5 \cdot in$

$CheckReinfClearSpacing := if(Clearance_{vert.reinf} \geq 6in, \text{"OK"}, \text{"No Good"})$ $CheckReinfClearSpacing = \text{"OK"}$ *SDG 3.6.10*

Check Shear and Torsion

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

$V_u := \sqrt{V_x^{\,2} + V_z^{\,2}} = 13.8 \cdot \text{kip}$

$T_u = 375.2 \cdot \text{kip} \cdot \text{ft}$

Effective shear depth

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

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

Check Shear Strength

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

$V_s := \frac{A_{v.bar} \cdot F_{y.rebar} \cdot d_v}{\max\left(s_{v1}, s_{v2}, s_{v3}\right)} = 67 \cdot \text{kip}$ *LRFD Eqn 5.8.3.3-4*

$\text{ShearRatio} := \frac{V_u - \phi_v \cdot V_c}{\phi_v \cdot V_s} = -4.7$

$\text{ShearRatio} := \text{if}\left(\text{ShearRatio} \le 0, 0, \text{ShearRatio}\right) = 0$

Check Torsion Strength

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

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

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

$T_{n1} := \frac{2 \cdot A_o \cdot A_{v.bar} \cdot F_{y.rebar}}{s_{v1}} = 1.2 \times 10^3 \cdot \text{kip} \cdot \text{ft}$ *LRFD Eqn 5.8.3.6.2-1*

$T_{n2} := \frac{2 \cdot A_o \cdot A_{v.bar} \cdot F_{y.rebar}}{s_{v2}} = 580.6 \cdot \text{kip} \cdot \text{ft}$ *LRFD 5.8.3.4.1*

$$T_{n3} := \frac{2 \cdot A_o \cdot A_{v.bar} \cdot F_{y.rebar}}{s_{v3}} = 387.1 \cdot kip \cdot ft$$

$\phi_v = 0.9$ $T_u = 375.2 \cdot kip \cdot ft$ $L_{reqdTor} = 23\ ft$

$$Tor2_{sand} := T_u - if\left[2ft > Offset, \left[\pi \cdot b \cdot (2 \cdot ft - Offset) \cdot \gamma_{soil} \cdot \left(\frac{2 \cdot ft - Offset}{2}\right) \cdot (\omega_{fdot}) \cdot \frac{b}{2}\right], 0 \cdot kip \cdot ft\right] = 373.5 \cdot kip \cdot ft$$

$$Tor3_{sand} := T_u - if\left[depth_{stir} > Offset, \left[\pi \cdot b \cdot (depth_{stir} - Offset) \cdot \gamma_{soil} \cdot \left(\frac{depth_{stir} - Offset}{2}\right) \cdot (\omega_{fdot}) \cdot \frac{b}{2}\right], 0 \cdot kip \cdot ft\right] = 319.7 \cdot kip \cdot ft$$

$$Tor2_{clay} := T_u - if\left[2ft - 1.5ft > Offset, \left[f_{se} \cdot (\pi \cdot b) \cdot (2.0 \cdot ft - Offset - 1.5 \cdot ft) \cdot \frac{b}{2}\right], 0 \cdot kip \cdot ft\right] = 375.2 \cdot kip \cdot ft$$

$$Tor3_{clay} := T_u - if\left[depth_{stir} - 1.5ft > Offset, \left[f_{se} \cdot (\pi \cdot b) \cdot (depth_{stir} - Offset - 1.5 \cdot ft) \cdot \frac{b}{2}\right], 0 \cdot kip \cdot ft\right] = 184 \cdot kip \cdot ft$$

$$Tor2 := if(SoilType = \text{"Sand"}, Tor2_{sand}, Tor2_{clay}) = 373.5 \cdot kip \cdot ft$$

$$Tor3 := if(SoilType = \text{"Sand"}, Tor3_{sand}, Tor3_{clay}) = 319.7 \cdot kip \cdot ft$$

$$TorsionRatio_{n1} := \frac{T_u}{\phi_{tor} \cdot T_{n1}} = 0.32$$

$$TorsionRatio_{n2} := \frac{Tor2}{\phi_{tor} \cdot T_{n2}} = 0.64$$

$$TorsionRatio_{n3} := \frac{Tor3}{\phi_{tor} \cdot T_{n3}} = 0.83$$

$$TorsionRatio := max(TorsionRatio_{n1}, TorsionRatio_{n2}, TorsionRatio_{n3}) = 0.83$$

$$T_{cr} := 0.125 \sqrt{\frac{f_c}{ksi}} \cdot \left(\frac{A_{cp}^{\ 2}}{p_{cp} \cdot in^3}\right) \cdot kip \cdot in = 883.6 \cdot kip \cdot ft$$ *LRFD Eqn 5.8.2.1-4*

$$TorsionRatio := if(T_u \le 0.25 \cdot \phi_{tor} \cdot T_{cr}, 0, TorsionRatio) = 0.8$$ *LRFD Eqn 5.8.2.1-3*

$ShearRatio = 0$

$$CheckShearTorsion := if(ShearRatio + TorsionRatio \le 1, \text{"OK"}, \text{"No Good"})$$

$CheckShearTorsion = \text{"OK"}$

Check Maximum Spacing Transverse Reinforcement

$$v_u := \frac{V_u}{\phi_v \cdot b \cdot d_v} = 0.005916 \cdot ksi$$ $0.125 \cdot f_c = 0.5 \cdot ksi$ *LRFD Eqn 5.8.2.9-1*

$s_{max1} := \text{if}\left(0.8 \cdot d_v < 24 \cdot in, 0.8d_v, 24 \cdot in\right) = 24 \cdot in$ LRFD Eqn 5.8.2.7-1

$s_{max2} := \text{if}\left(0.4 \cdot d_v < 12 \cdot in, 0.4d_v, 12 \cdot in\right) = 12 \cdot in$ LRFD Eqn 5.8.2.7-2

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

$\max\left(s_{v1}, s_{v2}, s_{v3}\right) = 12 \cdot in$

$\text{CheckMaxSpacingTransvReinf} := \text{if}\left(\max\left(s_{v1}, s_{v2}, s_{v3}\right) \le s_{max}, \text{"OK"}, \text{"No Good"}\right)$

$\text{CheckMaxSpacingTransvReinf} = \text{"OK"}$

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

LRFD 5.8.3.4.1

$M_u = 329.4 \cdot kip \cdot ft$

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

$$LongReinf_{shr.tor} := \frac{\frac{M_u}{\phi_v \cdot d_v} + \sqrt{\left(V_{temp}\right)^2 + \left(\frac{0.45 \cdot p_h \cdot T_u}{2 \cdot A_o \cdot \phi_v}\right)^2}}{F_{y.rebar}} = 3.6 \cdot in^2$$

$Num_{bar} \cdot A_{long.bar} = 28.1 \cdot in^2$

$CheckLongReinf_{shr.tor} := \text{if}\left(Num_{bar} \cdot A_{long.bar} \ge LongReinf_{shr.tor}, \text{"OK"}, \text{"No Good"}\right)$

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

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

Mast Arm Assembly Information

Wind Speed
○ 130 mph ● 150 mph ○ 170 mph

Signal Orientation
● Vertical
○ Horizontal

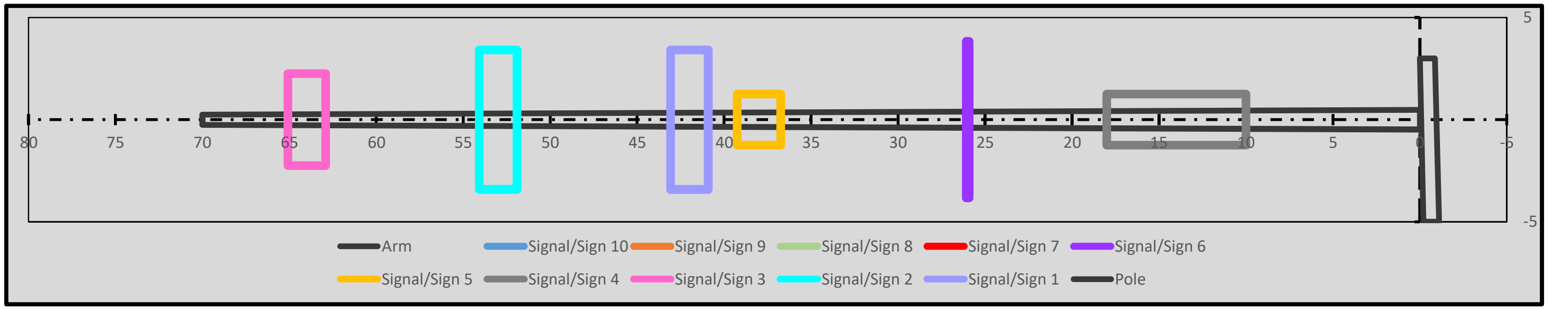
Back Plate Width
● 6.0 in.
○ 2.5 in.
○ 0 in.

Luminaire?
○ Yes
● No

Arm 1 Length
30
40
50
60
70
78

Arm 1 Length, Signal/Sign Location and Size

	Signal\Sign #10	Signal\Sign #9	Signal\Sign #8	Signal\Sign #7	Signal\Sign #6	Signal\Sign #5	Signal\Sign #4	Signal\Sign #3	Signal\Sign #2	Signal\Sign #1
Dist to Pole (ft.)	55	52	74	66	26	38	14	64	53	42
	● 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
Sign Width (in.)					2	30	96			
Sign Height (in.)					92	30	30			
Area (SF)	0.0	0.0	0.0	0.0	1.3	6.3	20.0	9.8	14.8	14.8
M_{wl}. (kip*ft)	0	0	0	0	2	16	19	42	53	42



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=ϕM_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)	14	
Sign/Signal M_{wl} (kip*ft)	173	
Total Moment ($M_{extreme}$)	288	303

Mast Arm Assembly Designation

One Arm Assembly
A70/S-P5/S-DS/14/5

See separate calc for foundation

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.

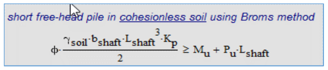
Arm to pole connection is at 22 ft.

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

Tube Wind Pressure (psf)	44.1

Fy (ksi)	50

Sign/Sig. Wind Pressure (psf)	67.0



short free-head pile in cohesionless soil using Broms method

$$\phi \cdot \frac{\gamma_{soil} \cdot b_{shaft} \cdot L_{shaft}^{3} \cdot K_p}{2} \geq M_u + P_u \cdot L_{shaft}$$

Arm Without Attachments: Dead Load Moment, Wind Load Moment and Moment Capacity at Base Connection

Total Arm Length (ft)	Regular							Heavy Duty						
	wall thk (in)	base dia (in)	S (in3)	Z (in3)	M_{dl} (kip*ft)	$M_{wl\ 130\ mph}$ (kip*ft)	M_r=ϕM_n (kip*ft)	wall thk (in)	base dia (in)	S (in3)	Z (in3)	M_{dl} (kip*ft)	$M_{wl\ 130mph}$ (kip*ft)	Mr=ϕMn (kip*ft)
30	0.25	11	23	29	10	10	107	0.25	12	27	34	11	11	125
40	0.25	13	32	40	20	20	145	0.25	14	37	47	22	22	166
50	0.3125	14	46	58	36	33	215	0.3125	15	53	67	40	37	244
60	0.375	15	63	79	56	48	300	0.375	16	72	91	62	53	340
70	0.375	17	81	103	85	71	380	0.375	18	91	115	100	77	422
78	0.375	18	91	115	110	90	422	0.375	20	113	143	130	106	512

Drilled Shaft

Index 17743 Drilled Shaft Capacities						1 Arm Assembly Loads And Capacity Check					2 Arm Assembly Loads and Capacity Check				
DS Index #	ID	Length	Diameter	ϕM_n	ϕT_n	M_u+ P_u*L_{shaft}	T_u	Check Mom. & Min Dia.	Check Torsion	Check	M_u+ P_u*L_{shaft}	T_u	Check Mom. & Min Dia.	Check Torsion	Check
1	DS/20/5	20	5	1800	589	500.1	267.4	Okay	Okay	Okay	0.0	0.0	0	0	0
2	DS/18/5	18	5	1312	477	477.1		Okay	Okay	Okay	0.0		0	0	0
3	DS/16/5	16	5	922	377	454.1		Okay	Okay	Okay	0.0		0	0	0
4	DS/16/4.5	16	4.5	829	305	454.1		NoGood	Okay	NoGood	0.0		0	0	0
5	DS/14/5	14	5	617	289	431.1		Okay	Okay	Okay	0.0		0	0	0
6	DS/14/4.5	14	4.5	556	234	431.1		NoGood	NoGood	NoGood	0.0		0	0	0
7	DS/12/4.5	12	4.5	350	172	408.1		NoGood	NoGood	NoGood	0.0		0	0	0
8	DS/12/4	12	4	311	136	408.1		NoGood	NoGood	NoGood	0.0		0	0	0

Arm 1 Attachments: Extreme Event Dead Load Moment, Wind Load Moment at Base Connection

	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	Total		
Sign/Sig Mwl (kip*ft)	0.0	0.0	0.0	0.0	2.2	15.9	18.8	41.8	52.6	41.6	172.9		
Sign/Sig 1.1*Mdl (kip*ft)	0.0	0.0	0.0	0.0	0.1	1.0	1.2	3.5	4.7	3.7	14.3		
Arm 1 Mwl (kip*ft)											94.5	102.5	*Reg Arm / HD Arm*
Arm 1 1.1*Mdl (kip*ft)											93.5	110.0	*Reg Arm / HD Arm*
*Extreme Event Arm Moment (kip*ft)*											288.3	302.7	

Ensures anchor bolts fit inside rebar cage

Min Shaft Diameter
5

Required Drilled Shaft Index Number Required (see Table for size)

Load Case	1 Arm DS Index #	2 Arm DS Index #
Drilled Shaft Index req'd for Overturning including Min. Diamter	5	0
Drilled Shaft Index req'd for Torsion	5	0
Drilled Shaft Controlling Load Case	**5**	**#N/A**

Pole Base Shears & Moments

	Arm 1 Shear	Arm 1 Moment	Arm 2 Shear	Arm 2 Moment	
dl att	N/A	14.3	N/A	0.0	
dl arm	N/A	93.5	N/A	0.0	
wl pole	2.6	52.9	0.0	0.0	*assume a 37.5' pole wl with lum*
wl att	4.5	98.6	0.0	0.0	
wl arm	4.4	96.2	0.0	0.0	
Tor wl att	N/A	172.9	N/A	0.0	
Tor wl arm	N/A	94.5	N/A	0.0	

Arm 2 Attachments: Extreme Event Dead Load Moment, Wind Load Moment at Base Connection

	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	Total	
Sign/Sig Mwl (kip*ft)	0.0	0.0	0.0	0.0	0.0	47.6	*24.2*	*40.2*	*15.0*	*7.8*	134.8	
Sign/Sig 1.1*Mdl (kip*ft)	0.0	0.0	0.0	0.0	0.0	4.2	*2.0*	*2.6*	*1.3*	*0.7*	10.8	
Arm 2 Mwl (kip*ft)											0.0	0.0
Arm 2 1.1*Mdl (kip*ft)											0.0	0.0
											0.0	0.0

Forces at Top of DS		
	One Arm	Two Arms
Moment dl	107.8	N/A
Moment wl	247.7	
Moment Total	270.1	0.0
Torsion	267.4	0.0
Shear	11.5	0.0
Shaft 2-Arm Factor	*1.1*	*used for OT & Torsion*

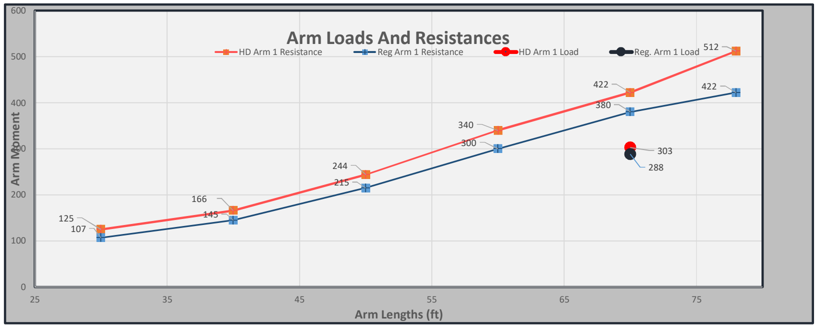
Pole ID			
Arm 1 Length	70	Arm 2 Length	0
	Pole ID	P5	

1 Arm Assembly	Use Regular Arm						
Design Arm Designation			**Pole Designation**			**Drilled Shaft**	
A70	/S		P5	/S		DS	
A70/S-			P5/S-			DS/14/5	
A70/S-P5/S-DS/14/5							

2 Arm Assembly	Use Regular Arm						
Design Arm Designation			**Pole Designation**			**Drilled Shaft**	
						DS	
-			-				

Assembly ID	A70/S-P5/S-DS/14/5	
	Arm 1	**Arm 2**
Arm Length(s)	70	0
Max Design CFI %	0.95	
Est. Regular Arm CFI	0.80	0.00
Est. HD Arm CFI	0.75	0.00

Note: Poles are designed to have a smaller CFI than Arms



Drilled Shaft Foundation for
Sign, Signal, and Lighting Support Structures v1.1

State Structures Design Office

SUBJECT: Moccasin Wallow Road
Struct # T-15-3 LOCATION: Sta. 366+92.5, 81.0' RT

DESIGNED BY: MPR DATE: 12/2021
CHECKED BY: DATE: 12/2021

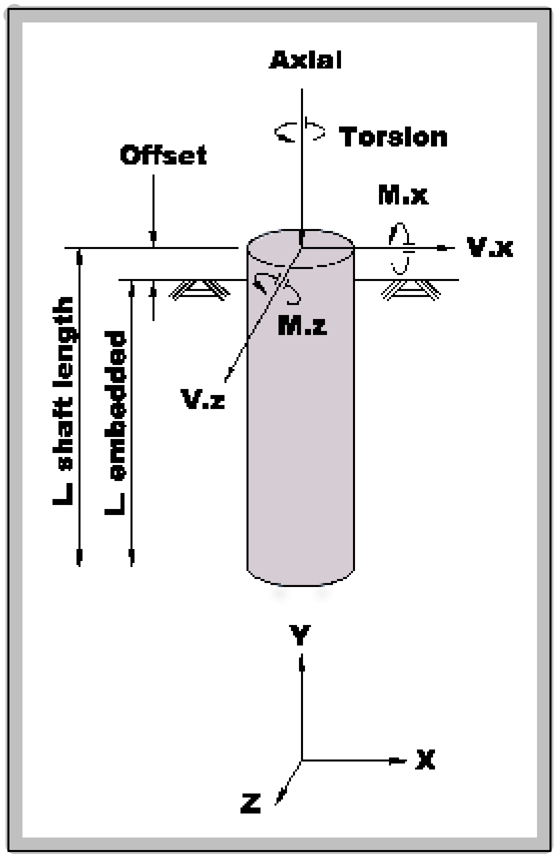
Program Changes

SoilType :=
- **Sand**
- Clay

$\phi_{soil} := 29\cdot deg$	*soil friction angle (sand)*
$c_{soil} := 1.25\cdot\frac{kip}{ft^2}$	*soil shear strength (clay)*
$N_{blows} := 8$	*number of blows per foot. If N< 5, contact the district geotech Engineer*
$\gamma_{soil} := 42.6\cdot pcf$	*effective soil weight (typical design value = 45 ~ 50 pcf)*

Geometry

$b := 5\cdot ft$	*shaft diameter, "DB"*
$Offset := 0.5\cdot ft$	*groundline to top of foundation*



Applied Loads (Extreme I)

$M_x := 247.7\cdot kip\cdot ft$ $V_x := 0\cdot kip$ $Torsion := 267.4\cdot kip\cdot ft$

$M_z := 107.8\cdot kip\cdot ft$ $V_z := 11.5\cdot kip$ $Axial := 4.0\cdot kip$

StructureType :=
- Cantilever Overhead Sign Structure
- **Mast Arm Signal Structure**
- Concrete/Steel Strain Poles
- Ground Sign

$StructureType = 1$

$\phi_{ot} := if(StructureType = 3, 0.8, 0.6)$	$\phi_{ot} = 0.6$	*ϕ factor against overturning [SM Vol-3 13.6.1.1]*
$\phi_{tor} := if(StructureType = 0, 0.9, 1.0)$	$\phi_{tor} = 1$	*ϕ factor against torsion [SM Vol-3 13.6.1.1]*

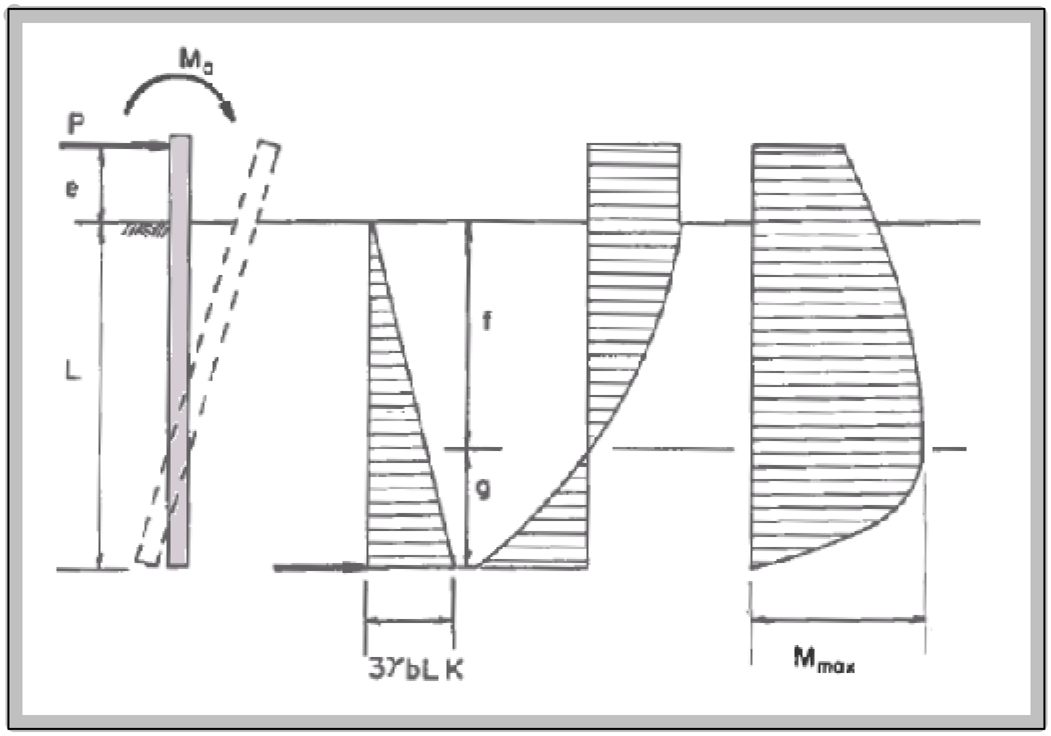
Shaft Depth Required to Resist Overturning

$M_u := \sqrt{M_x^{\,2} + M_z^{\,2}} = 270.1 \cdot kip \cdot ft$

$P_u := \sqrt{V_x^{\,2} + V_z^{\,2}} = 11.5 \cdot kip$

$T_u := Torsion = 267.4 \cdot kip \cdot ft$

*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.

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

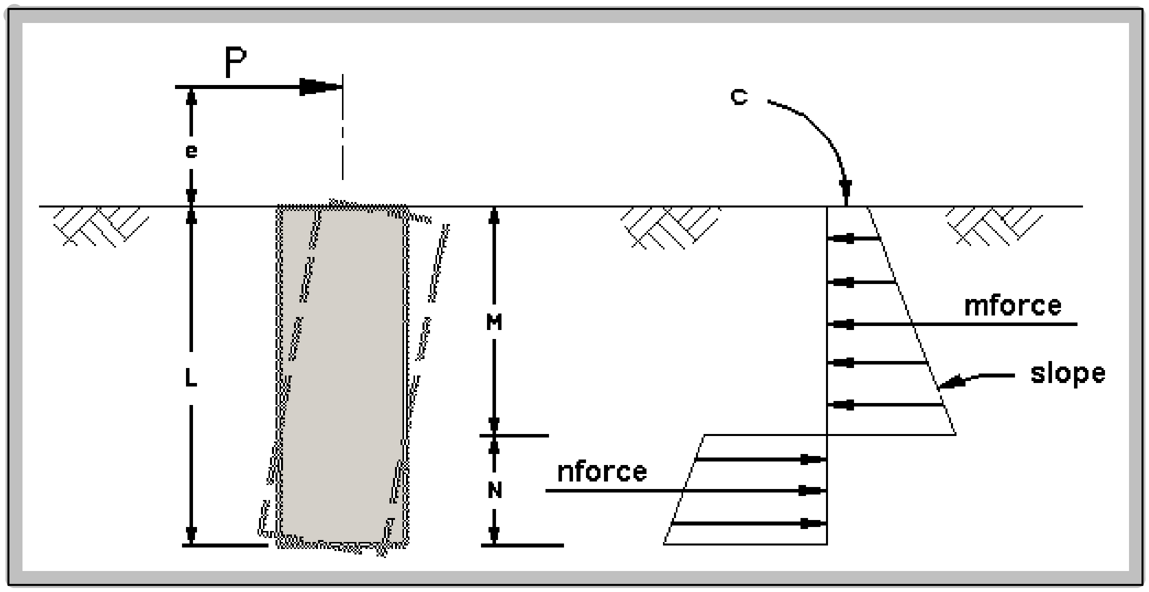
Guess value $\qquad L_{otSand} := 8 \cdot ft$

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

$L_{otSand} := Find(L_{otSand}) = 13.2\ ft$

$L_{otSand} := ceil\left(\frac{L_{otSand}}{ft}\right) \cdot ft = 14\ ft$ $\qquad$ *(round up to next foot)*

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.

$c_{soil} := \text{if}\left(c_{soil} = 0 \cdot ksf, 0.1 \cdot ksf, c_{soil}\right) = 1.3 \cdot ksf$

$Slope := 8 \cdot \frac{c_{soil}}{3 \cdot b} = 0.7 \cdot \frac{kip}{ft^3}$ $\qquad e_{clay} := \frac{M_u}{P_u} + Offset = 24\,ft$

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

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

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

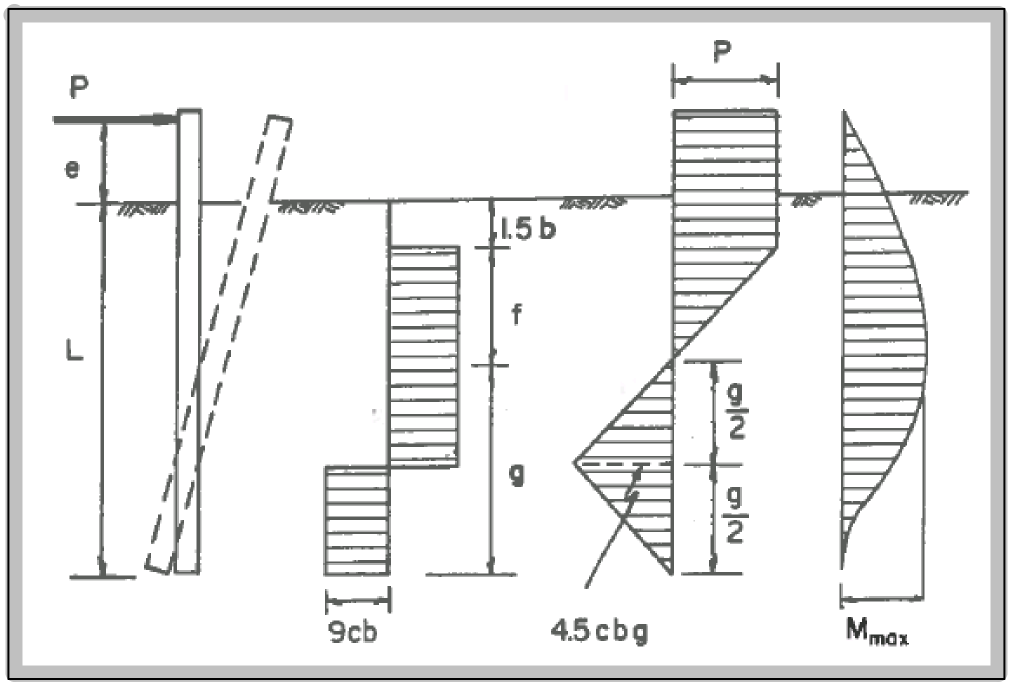
Guess value $\quad M := 4.0 \cdot ft \qquad N := 4.0 \cdot ft$

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

$\begin{pmatrix} M \\ N \end{pmatrix} := \text{Find}(M, N) \qquad L_{ot1Clay} := M + N = 10.7\,ft$

$L_{ot1Clay} := \text{ceil}\left(\frac{L_{ot1Clay}}{ft}\right) \cdot ft = 11\,ft$ $\qquad$ *(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.*

$$f := \frac{P_u}{\phi_{ot} \cdot 9 \cdot c_{soil} \cdot b} = 0.3 \, ft$$

$$M_{max.clay} := P_u \cdot \left(e_{clay} + 1.5 \cdot b + 0.5 \cdot f\right) = 364.1 \cdot kip \cdot ft$$

$$g := \sqrt{\frac{M_{max.clay}}{2.25 \cdot \phi_{ot} \cdot c_{soil} \cdot b}} = 6.6 \, ft$$

$$L_{ot2Clay} := \left(1.5 \cdot b + f + g\right) = 14.4 \, ft$$

$$L_{ot2Clay} := \text{ceil}\left(\frac{L_{ot2Clay}}{ft}\right) \cdot ft = 15 \, ft$$ *(round up to next foot)*

$$L_{otClay} := \text{if}\left(L_{ot1Clay} < 3 \cdot b, L_{ot1Clay}, L_{ot2Clay}\right) = 3.4$$ *(If $L_{ot} < 3b$, use Modified Broms method)*

$$L_{reqdOT} := \text{if}\left(\text{SoilType} = \text{"Sand"}, L_{otSand}, L_{otClay}\right)$$

$L_{reqdOT} = 14 \, ft$ *required shaft embedment depth to resist overturning*

Shaft Depth Required to Resist Torsion

*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.

$N_{blows} = 8$

$$\omega_{fdot} := \mathrm{if}\left(N_{blows} < 5, 0, \mathrm{if}\left(N_{blows} \geq 15, 1.5, 1.5 \cdot \frac{N_{blows}}{15}\right)\right) = 0.8$$

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 $L_{torSand} := L_{reqdOT} = 14\,\mathrm{ft}$

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

$$L_{torSand} := \mathrm{Find}(L_{torSand}) = 20\,\mathrm{ft}$$

$$L_{torSand} := \mathrm{ceil}\left(\frac{L_{torSand}}{\mathrm{ft}}\right) \cdot \mathrm{ft} = 20\,\mathrm{ft}$$

(round up to next foot)

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

$CohesionFactor := 0.55$

$f_{se} := CohesionFactor \cdot c_{soil} = 0.7 \cdot \mathrm{ksf}$

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

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

$$L_{torClay} := \mathrm{Find}(L_{torClay}) = 11.4\,\mathrm{ft}$$

$$L_{torClay} := \mathrm{ceil}\left(\frac{L_{torClay}}{\mathrm{ft}}\right) \cdot \mathrm{ft} = 12\,\mathrm{ft}$$

(round up to next foot)

$L_{reqdTor} := \mathrm{if}(SoilType = \text{"Sand"}, L_{torSand}, L_{torClay})$

$L_{reqdTor} = 20\,\mathrm{ft}$

required shaft embedment depth to resist torsion

$L_{embedded} := \mathrm{if}(L_{reqdTor} > L_{reqdOT}, L_{reqdTor}, L_{reqdOT}) = 6.1$

$L_{shaft.length} := L_{embedded} + Offset$

$L_{shaft.length} = 20.5\,\mathrm{ft}$

shaft length

Maximum Moment in Shaft

short free-head pile in cohesionless soil using Broms method

$$f_{sand} := \sqrt{\frac{2 \cdot P_u}{3 \cdot \gamma_{soil} \cdot b \cdot K_p \cdot \phi_{ot}}} = 4.6\ \text{ft}$$

$$M_{maxSand} := P_u \cdot \left(e_{sand} + f_{sand}\right) - \frac{P_u \cdot f_{sand}}{3} + M_u = 310.9 \cdot \text{kip} \cdot \text{ft}$$

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

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

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

$f_{mod} := \text{Find}\left(f_{mod}\right) = 2\ \text{ft}$

$$M_{modBroms} := P_u \cdot \left(e_{clay} + f_{mod}\right) - \frac{\phi_{ot} \cdot c_{soil} \cdot b \cdot f_{mod}^{\ 2}}{2} - \frac{\phi_{ot} \cdot b \cdot f_{mod}^{\ 3} \cdot \text{Slope}}{6} = 288.7 \cdot \text{kip} \cdot \text{ft}$$

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

$$M_{Broms} := P_u \cdot \left(e_{clay} + 1.5 \cdot b + 0.5 \cdot f\right) = 364.1 \cdot \text{kip} \cdot \text{ft}$$

$M_{maxClay} := \text{if}\left(L_{ot1Clay} < 3 \cdot b, M_{modBroms}, M_{Broms}\right) = 288.7 \cdot \text{kip} \cdot \text{ft}$ *(If $L_{\alpha} < 3b$, use Modified Broms method)*

$$M_{max} := \text{if}\left(\text{SoilType} = \text{"Sand"}, M_{maxSand}, M_{maxClay}\right) = 310.9 \cdot \text{kip} \cdot \text{ft}$$

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*

$Num_{bar} := 18$ *number of longitudinal bars, "RB"*

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

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

$A_{v.bar} := 0.31 \cdot in^2$ *stirrup area* *SM Vol-3 13.6.2*

$d_{v.bar} := 0.625 \cdot in$ *stirrup diameter*

$s_{v1} := 4 \cdot in$ *stirrup spacing, depth = 0 ft-2 ft* *SM Vol-3 13.6.2*

$s_{v2} := 8 \cdot in$ *stirrup spacing, depth = 2 ft-depth.stir, "RD"*

$s_{v3} := 12 \cdot in$ *stirrup spacing, depth > depth.stir, "RF"*

$depth_{stir} := 9.083 \cdot ft$ *stirrup depth, see s.v2 and s.v3 above*

$b = 5\,ft$ *shaft diameter*

$$A_{req} := \min\left(0.135 \cdot \frac{\pi \cdot b^2}{4} \cdot \frac{f_c}{F_{y.rebar}}, 0.015 \cdot \frac{\pi \cdot b^2}{4}\right) = 25.4 \cdot in^2$$ *LRFD 5.7.4.2*

$A_{long} := Num_{bar} \cdot A_{long.bar} = 28.1 \cdot in^2$ *total area of longitudinal steel*

$CheckLongitudinalReinf := if\left(A_{long} \geq A_{req}, "OK", "No\ Good"\right)$ $CheckLongitudinalReinf = "OK"$

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

$Spacing_{vert.reinf} := Dia_{bar.circle} \cdot \frac{\pi}{Num_{bar}} = 7.9 \cdot in$ $Clearance_{vert.reinf} := Spacing_{vert.reinf} - d_{long.bar} = 6.5 \cdot in$

$CheckReinfClearSpacing := if\left(Clearance_{vert.reinf} \geq 6in, "OK", "No\ Good"\right)$ $CheckReinfClearSpacing = "OK"$ *SDG 3.6.10*

Check Shear and Torsion

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

$$V_u := \sqrt{V_x^2 + V_z^2} = 11.5 \cdot kip$$

$$T_u = 267.4 \cdot kip \cdot ft$$

Effective shear depth

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

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

$$V_c := 0.0316 \cdot (2.0) \cdot \sqrt{\frac{f_c}{ksi}} \cdot \left(\frac{b}{in}\right) \cdot \left(\frac{d_v}{in}\right) \cdot kip = 327.6 \cdot kip$$

LRFD Eqn 5.8.3.3-3 *LRFD 5.8.3.4.1* *ACI 11.3.3*

$$V_s := \frac{A_{v.bar} \cdot F_{y.rebar} \cdot d_v}{\max\left(s_{v1}, s_{v2}, s_{v3}\right)} = 67 \cdot kip$$

LRFD Eqn 5.8.3.3-4

$$ShearRatio := \frac{V_u - \phi_v \cdot V_c}{\phi_v \cdot V_s} = -4.7$$

$$ShearRatio := if\left(ShearRatio \le 0, 0, ShearRatio\right) = 0$$

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

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

$$T_{n1} := \frac{2 \cdot A_o \cdot A_{v.bar} \cdot F_{y.rebar}}{s_{v1}} = 1.2 \times 10^3 \cdot kip \cdot ft$$

LRFD Eqn 5.8.3.6.2-1

$$T_{n2} := \frac{2 \cdot A_o \cdot A_{v.bar} \cdot F_{y.rebar}}{s_{v2}} = 580.6 \cdot kip \cdot ft$$

LRFD 5.8.3.4.1

$$T_{n3} := \frac{2 \cdot A_o \cdot A_{v.bar} \cdot F_{y.rebar}}{s_{v3}} = 387.1 \cdot kip \cdot ft$$

$\phi_v = 0.9$ $T_u = 267.4 \cdot kip \cdot ft$ $L_{reqdTor} = 20\,ft$

$$Tor2_{sand} := T_u - if\left[2ft > Offset, \left[\pi \cdot b \cdot (2 \cdot ft - Offset) \cdot \gamma_{soil} \cdot \left(\frac{2 \cdot ft - Offset}{2}\right) \cdot (\omega_{fdot}) \cdot \frac{b}{2}\right], 0 \cdot kip \cdot ft\right] = 265.9 \cdot kip \cdot ft$$

$$Tor3_{sand} := T_u - if\left[depth_{stir} > Offset, \left[\pi \cdot b \cdot (depth_{stir} - Offset) \cdot \gamma_{soil} \cdot \left(\frac{depth_{stir} - Offset}{2}\right) \cdot (\omega_{fdot}) \cdot \frac{b}{2}\right], 0 \cdot kip \cdot ft\right] = 218.1 \cdot kip \cdot ft$$

$$Tor2_{clay} := T_u - if\left[2ft - 1.5ft > Offset, \left[f_{se} \cdot (\pi \cdot b) \cdot (2.0 \cdot ft - Offset - 1.5 \cdot ft) \cdot \frac{b}{2}\right], 0 \cdot kip \cdot ft\right] = 267.4 \cdot kip \cdot ft$$

$$Tor3_{clay} := T_u - if\left[depth_{stir} - 1.5ft > Offset, \left[f_{se} \cdot (\pi \cdot b) \cdot (depth_{stir} - Offset - 1.5 \cdot ft) \cdot \frac{b}{2}\right], 0 \cdot kip \cdot ft\right] = 76.2 \cdot kip \cdot ft$$

$$Tor2 := if(SoilType = \text{"Sand"}, Tor2_{sand}, Tor2_{clay}) = 265.9 \cdot kip \cdot ft$$

$$Tor3 := if(SoilType = \text{"Sand"}, Tor3_{sand}, Tor3_{clay}) = 218.1 \cdot kip \cdot ft$$

$$TorsionRatio_{n1} := \frac{T_u}{\phi_{tor} \cdot T_{n1}} = 0.23$$

$$TorsionRatio_{n2} := \frac{Tor2}{\phi_{tor} \cdot T_{n2}} = 0.46$$

$$TorsionRatio_{n3} := \frac{Tor3}{\phi_{tor} \cdot T_{n3}} = 0.56$$

$$TorsionRatio := max(TorsionRatio_{n1}, TorsionRatio_{n2}, TorsionRatio_{n3}) = 0.56$$

$$T_{cr} := 0.125 \sqrt{\frac{f_c}{ksi}} \cdot \left(\frac{A_{cp}^{\;2}}{p_{cp} \cdot in^3}\right) \cdot kip \cdot in = 883.6 \cdot kip \cdot ft$$ LRFD Eqn 5.8.2.1-4

$$TorsionRatio := if(T_u \le 0.25 \cdot \phi_{tor} \cdot T_{cr}, 0, TorsionRatio) = 0.6$$ LRFD Eqn 5.8.2.1-3

$ShearRatio = 0$

$$CheckShearTorsion := if(ShearRatio + TorsionRatio \le 1, \text{"OK"}, \text{"No Good"})$$

$CheckShearTorsion = \text{"OK"}$

Check Maximum Spacing Transverse Reinforcement

$$v_u := \frac{V_u}{\phi_v \cdot b \cdot d_v} = 0.00493 \cdot ksi$$ $0.125 \cdot f_c = 0.5 \cdot ksi$ LRFD Eqn 5.8.2.9-1

$s_{max1} := \text{if}\left(0.8\cdot d_v < 24\cdot in, 0.8d_v, 24\cdot in\right) = 24\cdot in$ LRFD Eqn 5.8.2.7-1

$s_{max2} := \text{if}\left(0.4\cdot d_v < 12\cdot in, 0.4d_v, 12\cdot in\right) = 12\cdot in$ LRFD Eqn 5.8.2.7-2

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

$\max\left(s_{v1}, s_{v2}, s_{v3}\right) = 12\cdot in$

$\text{CheckMaxSpacingTransvReinf} := \text{if}\left(\max\left(s_{v1}, s_{v2}, s_{v3}\right) \le s_{max}, \text{"OK"}, \text{"No Good"}\right)$

$\text{CheckMaxSpacingTransvReinf} = \text{"OK"}$

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

LRFD 5.8.3.4.1

$M_u = 270.1\cdot kip\cdot ft$

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

$$\text{LongReinf}_{shr.tor} := \frac{\frac{M_u}{\phi_v\cdot d_v} + \sqrt{\left(V_{temp}\right)^2 + \left(\frac{0.45\cdot p_h\cdot T_u}{2\cdot A_o\cdot \phi_v}\right)^2}}{F_{y.rebar}} = 2.7\cdot in^2$$

$\text{Num}_{bar}\cdot A_{long.bar} = 28.1\cdot in^2$

$\text{CheckLongReinf}_{shr.tor} := \text{if}\left(\text{Num}_{bar}\cdot A_{long.bar} \ge \text{LongReinf}_{shr.tor}, \text{"OK"}, \text{"No Good"}\right)$

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

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

Mast Arm Assembly Information

Wind Speed
○ 130 mph ● 150 mph ○ 170 mph

Signal Orientation
● Vertical
○ Horizontal

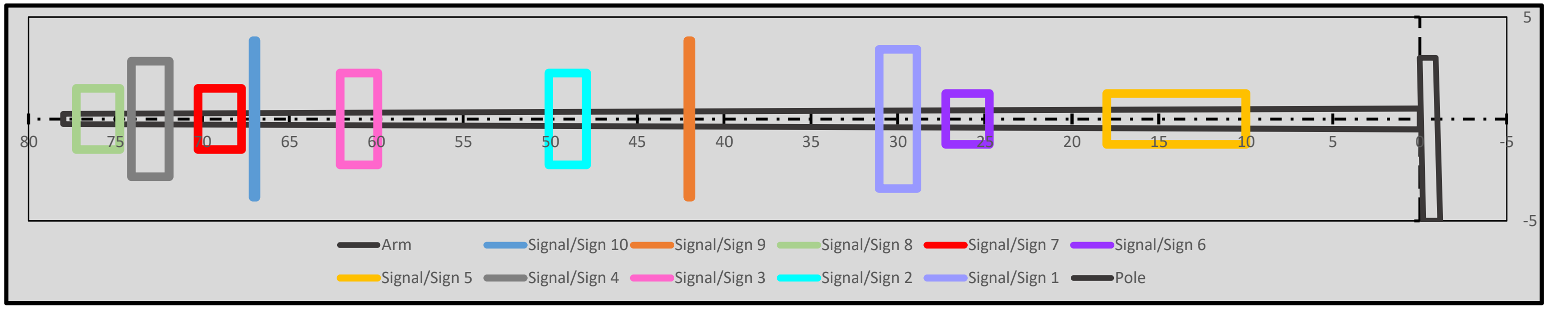
Back Plate Width
● 6.0 in.
○ 2.5 in.
○ 0 in.

Luminaire?
○ Yes
● No

Arm 1 Length
30
40
50
60
70
78

Arm 1 Length, Signal/Sign Location and Size

	Signal\Sign #10	Signal\Sign #9	Signal\Sign #8	Signal\Sign #7	Signal\Sign #6	Signal\Sign #5	Signal\Sign #4	Signal\Sign #3	Signal\Sign #2	Signal\Sign #1
Dist to Pole (ft.)	67	42	76	69	26	14	73	61	49	30
	○ 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
Sign Width (in.)	2	2	30	30	30	96				
Sign Height (in.)	92	92	36	36	30	30				
Area (SF)	1.3	1.3	7.5	7.5	6.3	20.0	12.3	9.8	9.8	14.8
M_{wl}. (kip*ft)	6	4	38	35	11	19	60	40	32	30



Arm 1 Length (ft)	78	
Design Standard Index 17743	Regular	Heavy Duty
Dia. at Arm Base (in)	18	20
Wall Thickness (in)	0.3750	0.3750
Resistance ($M_r=\phi M_n$) (kip*ft)	422	512

Arm 1 Loads	Regular	Heavy Duty
1.1*Arm M_{dl} (kip*ft)	121	143
Arm M_{wl} (kip*ft)	120	141
1.1*Sign/Signal M_{dl} (kip*ft)	21	
Sign/Signal M_{wl} (kip*ft)	273	
Total Moment ($M_{extreme}$)	418	446

Mast Arm Assembly Designation
One Arm Assembly **A78/S/H-P6/S-DS/18/5**

See separate calc
for foundation

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.

Tube Wind Pressure (psf)	44.1

Fy (ksi)	50

Sign/Sig. Wind Pressure (psf)	67.0

short free-head pile in cohesionless soil using Broms method

$$\phi \cdot \frac{\gamma_{soil} \cdot b_{shaft} \cdot L_{shaft}{}^{3} \cdot K_p}{2} \geq M_u + P_u \cdot L_{shaft}$$

Arm Without Attachments: Dead Load Moment, Wind Load Moment and Moment Capacity at Base Connection

	Regular							Heavy Duty						
Total Arm Length (ft)	wall thk (in)	base dia (in)	S (in3)	Z (in3)	M_{dl} (kip*ft)	$M_{wl\ 130\ mph}$ (kip*ft)	M_r=ϕM_n (kip*ft)	wall thk (in)	base dia (in)	S (in3)	Z (in3)	M_{dl} (kip*ft)	$M_{wl\ 130mph}$ (kip*ft)	Mr=ϕMn (kip*ft)
30	0.25	11	23	29	10	10	107	0.25	12	27	34	11	11	125
40	0.25	13	32	40	20	20	145	0.25	14	37	47	22	22	166
50	0.3125	14	46	58	36	33	215	0.3125	15	53	67	40	37	244
60	0.375	15	63	79	56	48	300	0.375	16	72	91	62	53	340
70	0.375	17	81	103	85	71	380	0.375	18	91	115	100	77	422
78	0.375	18	91	115	110	90	422	0.375	20	113	143	130	106	512

Drilled Shaft

Index 17743 Drilled Shaft Capacities						1 Arm Assembly Loads And Capacity Check					2 Arm Assembly Loads and Capacity Check				
DS Index #	ID	Length	Diameter	ϕM_n	ϕT_n	M_u+ P_u*L_{shaft}	T_u	Check Mom. & Min Dia.	Check Torsion	Check	M_u+ P_u*L_{shaft}	T_u	Check Mom. & Min Dia.	Check Torsion	Check
1	DS/20/5	20	5	1800	589	650.8	393.2	Okay	Okay	Okay	0.0	0.0	0	0	0
2	DS/18/5	18	5	1312	477	621.9		Okay	Okay	Okay	0.0		0	0	0
3	DS/16/5	16	5	922	377	593.1		Okay	NoGood	NoGood	0.0		0	0	0
4	DS/16/4.5	16	4.5	829	305	593.1		NoGood	NoGood	NoGood	0.0		0	0	0
5	DS/14/5	14	5	617	289	564.2		Okay	NoGood	NoGood	0.0		0	0	0
6	DS/14/4.5	14	4.5	556	234	564.2		NoGood	NoGood	NoGood	0.0		0	0	0
7	DS/12/4.5	12	4.5	350	172	535.4		NoGood	NoGood	NoGood	0.0		0	0	0
8	DS/12/4	12	4	311	136	535.4		NoGood	NoGood	NoGood	0.0		0	0	0

Arm 1 Attachments: Extreme Event Dead Load Moment, Wind Load Moment at Base Connection

	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	Total		
Sign/Sig Mwl (kip*ft)	5.7	3.6	38.2	34.7	10.9	18.8	60.0	39.8	32.0	29.7	273.4		
Sign/Sig 1.1*Mdl (kip*ft)	0.4	0.2	2.5	2.3	0.7	1.2	5.2	3.4	2.7	2.6	21.3		
Arm 1 Mwl (kip*ft)											119.8	141.1	*Reg Arm / HD Arm*
Arm 1 1.1*Mdl (kip*ft)											121.0	143.0	*Reg Arm / HD Arm*
										*Extreme Event Arm Moment (kip*ft)*	418.2	446.4	

Ensures anchor bolts fit inside rebar cage

Min Shaft Diameter
5

Required Drilled Shaft Index Number Required (see Table for size)

Load Case	1 Arm DS Index #	2 Arm DS Index #
Drilled Shaft Index req'd for Overturning including Min. Diamter	5	0
Drilled Shaft Index req'd for Torsion	2	0
Drilled Shaft Controlling Load Case	2	#N/A

Pole Base Shears & Moments

	Arm 1 Shear	Arm 1 Moment	Arm 2 Shear	Arm 2 Moment
dl att	N/A	21.3	N/A	0.0
dl arm	N/A	143.0	N/A	0.0
wl pole	2.6	63.5	0.0	0.0
wl att	6.1	133.2	0.0	0.0
wl arm	5.7	126.1	0.0	0.0
Tor wl att	N/A	273.4	N/A	0.0
Tor wl arm	N/A	119.8	N/A	0.0

assume a 37.5' pole wl with lum

Arm 2 Attachments: Extreme Event Dead Load Moment, Wind Load Moment at Base Connection

	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	Total	
Sign/Sig Mwl (kip*ft)	0.0	0.0	0.0	0.0	0.0	47.6	*24.2*	*40.2*	*15.0*	*7.8*	134.8	
Sign/Sig 1.1*Mdl (kip*ft)	0.0	0.0	0.0	0.0	0.0	4.2	*2.0*	*2.6*	*1.3*	*0.7*	10.8	
Arm 2 Mwl (kip*ft)											0.0	0.0
Arm 2 1.1*Mdl (kip*ft)											0.0	0.0
											0.0	0.0

Forces at Top of DS

	One Arm	Two Arms
Moment dl	164.3	N/A
Moment wl	322.8	
Moment Total	362.2	0.0
Torsion	393.2	0.0
Shear	14.4	0.0
	Shaft 2-Arm Factor	*1.1*

used for OT & Torsion

Pole ID			
Arm 1 Length	78	Arm 2 Length	0
	Pole ID	P6	

1 Arm Assembly	Use Heavy Duty Arm

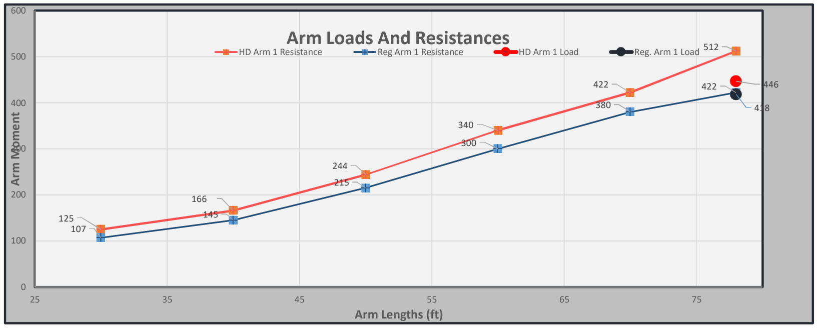
Design Arm Designation			Pole Designation			Drilled Shaft	
A78	/S	/H	P6	/S		DS	
A78/S/H-			P6/S-			DS/18/5	
A78/S/H-P6/S-DS/18/5							

2 Arm Assembly	Use Regular Arm

Design Arm Designation			Pole Designation			Drilled Shaft	
						DS	
-			-				

Assembly ID	A78/S/H-P6/S-DS/18/5	
	Arm 1	Arm 2
Arm Length(s)	78	0
Max Design CFI %	0.95	
Est. Regular Arm CFI	1.04	0.00
Est. HD Arm CFI	0.92	0.00

Note: Poles are designed to have a smaller CFI than Arms



Drilled Shaft Foundation for
Sign, Signal, and Lighting Support Structures v1.1

FDOT
State Structures Design Office

SUBJECT: Moccasin Wallow Road
Struct # T-15-4 LOCATION: Sta. 366+89.4, 79.4' LT

DESIGNED BY: MPR DATE: 12/2021
CHECKED BY: DATE: 12/2021

Program Changes

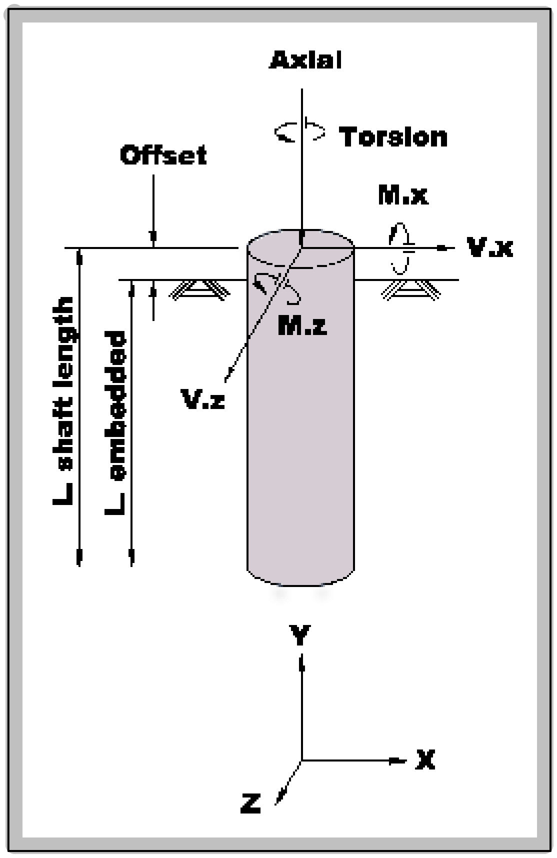
SoilType :=
- Sand
- Clay

$\phi_{soil} := 29 \cdot deg$ *soil friction angle (sand)*

$c_{soil} := 1.25 \cdot \frac{kip}{ft^2}$ *soil shear strength (clay)*

$N_{blows} := 9$ *number of blows per foot. If N< 5, contact the district geotech Engineer*

$\gamma_{soil} := 42.6 \cdot pcf$ *effective soil weight (typical design value = 45 ~ 50 pcf)*



Geometry

$b := 5 \cdot ft$ *shaft diameter, "DB"*

$Offset := 0.5 \cdot ft$ *groundline to top of foundation*

Applied Loads (Extreme I)

$M_x := 322.8 \cdot kip \cdot ft$ $V_x := 0 \cdot kip$ $Torsion := 393.2 \cdot kip \cdot ft$

$M_z := 164.3 \cdot kip \cdot ft$ $V_z := 14.4 \cdot kip$ $Axial := 4.0 \cdot kip$

StructureType :=
- Cantilever Overhead Sign Structure
- Mast Arm Signal Structure
- Concrete/Steel Strain Poles
- Ground Sign

$StructureType = 1$

$\phi_{ot} := if(StructureType = 3, 0.8, 0.6)$ $\phi_{ot} = 0.6$ *ϕ factor against overturning [SM Vol-3 13.6.1.1]*

$\phi_{tor} := if(StructureType = 0, 0.9, 1.0)$ $\phi_{tor} = 1$ *ϕ factor against torsion [SM Vol-3 13.6.1.1]*

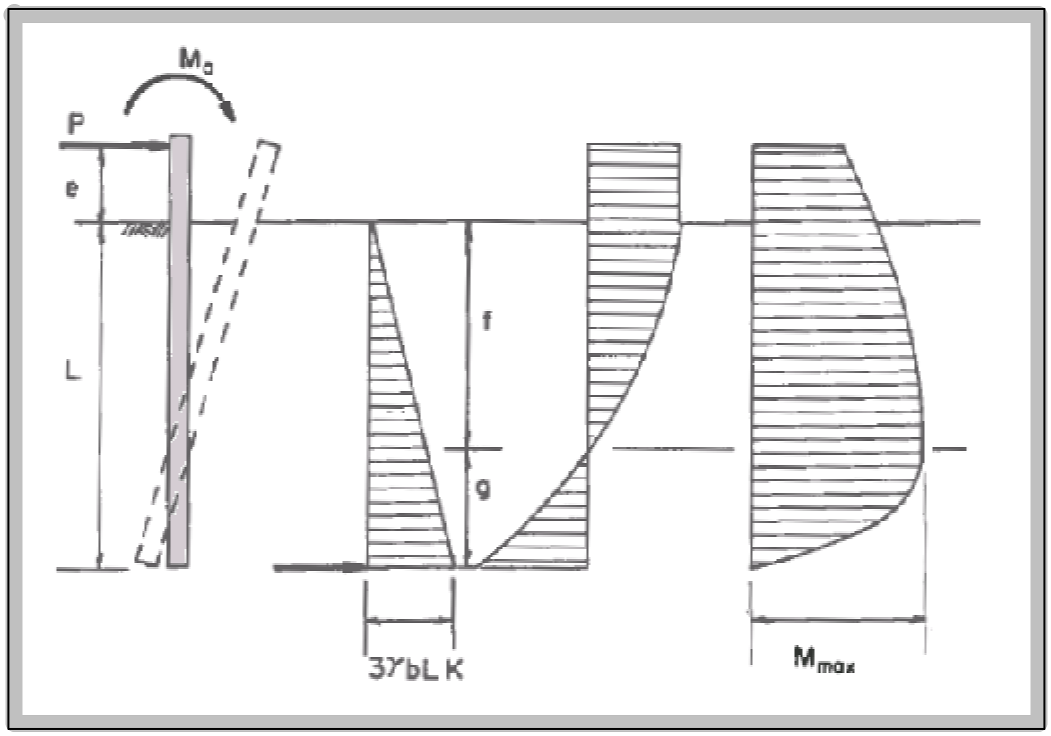
Shaft Depth Required to Resist Overturning

$M_u := \sqrt{M_x^{\,2} + M_z^{\,2}} = 362.2 \cdot kip \cdot ft$

$P_u := \sqrt{V_x^{\,2} + V_z^{\,2}} = 14.4 \cdot kip$

$T_u := Torsion = 393.2 \cdot kip \cdot ft$

*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.

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

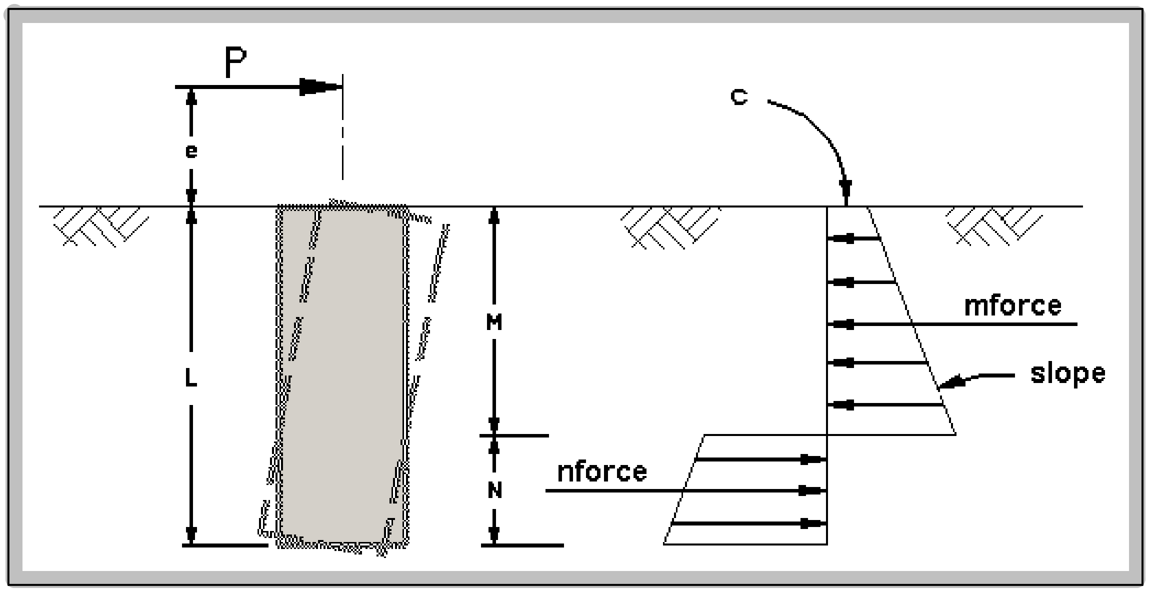
Guess value $\qquad L_{otSand} := 8 \cdot ft$

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

$L_{otSand} := Find\left(L_{otSand}\right) = 14.7\ ft$

$L_{otSand} := ceil\left(\frac{L_{otSand}}{ft}\right) \cdot ft = 15\ ft$ $\qquad$ *(round up to next foot)*

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.

$c_{soil} := \text{if}\left(c_{soil} = 0 \cdot ksf, 0.1 \cdot ksf, c_{soil}\right) = 1.3 \cdot ksf$

$\text{Slope} := 8 \cdot \frac{c_{soil}}{3 \cdot b} = 0.7 \cdot \frac{kip}{ft^3}$ $\qquad e_{clay} := \frac{M_u}{P_u} + \text{Offset} = 25.7\ ft$

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

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

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

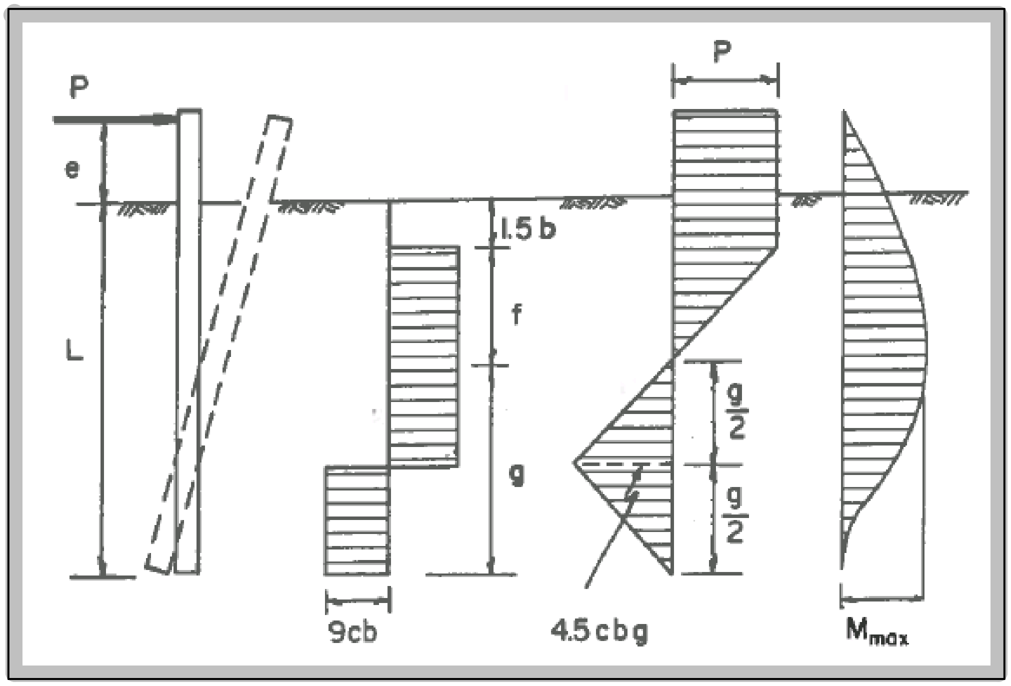
Guess value $\qquad M := 4.0 \cdot ft \qquad N := 4.0 \cdot ft$

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

$\begin{pmatrix} M \\ N \end{pmatrix} := \text{Find}(M, N) \qquad L_{ot1Clay} := M + N = 12.0\ ft$

$L_{ot1Clay} := \text{ceil}\left(\frac{L_{ot1Clay}}{ft}\right) \cdot ft = 12\ ft$ $\qquad$ *(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.*

$$f := \frac{P_u}{\phi_{ot} \cdot 9 \cdot c_{soil} \cdot b} = 0.4\ ft$$

$$M_{max.clay} := P_u \cdot \left(e_{clay} + 1.5 \cdot b + 0.5 \cdot f\right) = 480.5 \cdot kip \cdot ft$$

$$g := \sqrt{\frac{M_{max.clay}}{2.25 \cdot \phi_{ot} \cdot c_{soil} \cdot b}} = 7.5\ ft$$

$$L_{ot2Clay} := \left(1.5 \cdot b + f + g\right) = 15.5\ ft$$

$$L_{ot2Clay} := ceil\left(\frac{L_{ot2Clay}}{ft}\right) \cdot ft = 16\ ft$$ *(round up to next foot)*

$$L_{otClay} := if\left(L_{ot1Clay} < 3 \cdot b, L_{ot1Clay}, L_{ot2Clay}\right) = 3.7$$ *(If L_{ot} < 3b, use Modified Broms method)*

$$L_{reqdOT} := if\left(SoilType = \text{"Sand"}, L_{otSand}, L_{otClay}\right)$$

$L_{reqdOT} = 15\ ft$ *required shaft embedment depth to resist overturning*

Shaft Depth Required to Resist Torsion

*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.

$N_{blows} = 9$

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

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 $L_{torSand} := L_{reqdOT} = 15\,\text{ft}$

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

$L_{torSand} := \text{Find}(L_{torSand}) = 22.9\,\text{ft}$

$L_{torSand} := \text{ceil}\left(\frac{L_{torSand}}{\text{ft}}\right) \cdot \text{ft} = 23\,\text{ft}$ *(round up to next foot)*

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

$\text{CohesionFactor} := 0.55$

$f_{se} := \text{CohesionFactor} \cdot c_{soil} = 0.7 \cdot \text{ksf}$

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

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

$L_{torClay} := \text{Find}(L_{torClay}) = 16.1\,\text{ft}$

$L_{torClay} := \text{ceil}\left(\frac{L_{torClay}}{\text{ft}}\right) \cdot \text{ft} = 17\,\text{ft}$ *(round up to next foot)*

$L_{reqdTor} := \text{if}(\text{SoilType} = \text{"Sand"}, L_{torSand}, L_{torClay})$

$L_{reqdTor} = 23\,\text{ft}$ *required shaft embedment depth to resist torsion*

$L_{embedded} := \text{if}(L_{reqdTor} > L_{reqdOT}, L_{reqdTor}, L_{reqdOT}) = 7$

$L_{shaft.length} := L_{embedded} + \text{Offset}$

$L_{shaft.length} = 23.5\,\text{ft}$ *shaft length*

Maximum Moment in Shaft

short free-head pile in cohesionless soil using Broms method

$$f_{sand} := \sqrt{\frac{2 \cdot P_u}{3 \cdot \gamma_{soil} \cdot b \cdot K_p \cdot \phi_{ot}}} = 5.1 \text{ ft}$$

$$M_{maxSand} := P_u \cdot (e_{sand} + f_{sand}) - \frac{P_u \cdot f_{sand}}{3} + M_u = 418.4 \cdot \text{kip} \cdot \text{ft}$$

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

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

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

$f_{mod} := \text{Find}(f_{mod}) = 2.4 \text{ ft}$

$$M_{modBroms} := P_u \cdot (e_{clay} + f_{mod}) - \frac{\phi_{ot} \cdot c_{soil} \cdot b \cdot f_{mod}^2}{2} - \frac{\phi_{ot} \cdot b \cdot f_{mod}^3 \cdot Slope}{6} = 388.6 \cdot \text{kip} \cdot \text{ft}$$

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

$$M_{Broms} := P_u \cdot (e_{clay} + 1.5 \cdot b + 0.5 \cdot f) = 480.5 \cdot \text{kip} \cdot \text{ft}$$

$$M_{maxClay} := \text{if}(L_{ot1Clay} < 3 \cdot b, M_{modBroms}, M_{Broms}) = 388.6 \cdot \text{kip} \cdot \text{ft}$$

(If $L_\alpha < 3b$, use Modified Broms method)

$$M_{max} := \text{if}(SoilType = \text{"Sand"}, M_{maxSand}, M_{maxClay}) = 418.4 \cdot \text{kip} \cdot \text{ft}$$

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*

$Num_{bar} := 18$ *number of longitudinal bars, "RB"*

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

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

$A_{v.bar} := \mathbf{0.31} \cdot in^2$ *stirrup area* *SM Vol-3 13.6.2*

$d_{v.bar} := \mathbf{0.625} \cdot in$ *stirrup diameter*

$s_{v1} := \mathbf{4} \cdot in$ *stirrup spacing, depth = 0 ft-2 ft* *SM Vol-3 13.6.2*

$s_{v2} := 8 \cdot in$ *stirrup spacing, depth = 2 ft-depth.stir, "RD"*

$s_{v3} := 12 \cdot in$ *stirrup spacing, depth > depth.stir, "RF"*

$depth_{stir} := 9.083 \cdot ft$ *stirrup depth, see s.v2 and s.v3 above*

$b = 5\,ft$ *shaft diameter*

$$A_{req} := \min\left(0.135 \cdot \frac{\pi \cdot b^2}{4} \cdot \frac{f_c}{F_{y.rebar}}, 0.015 \cdot \frac{\pi \cdot b^2}{4}\right) = 25.4 \cdot in^2$$ *LRFD 5.7.4.2*

$A_{long} := Num_{bar} \cdot A_{long.bar} = 28.1 \cdot in^2$ *total area of longitudinal steel*

$CheckLongitudinalReinf := if\left(A_{long} \ge A_{req}, \text{"OK"}, \text{"No Good"}\right)$ $CheckLongitudinalReinf = \text{"OK"}$

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

$Spacing_{vert.reinf} := Dia_{bar.circle} \cdot \frac{\pi}{Num_{bar}} = 7.9 \cdot in$ $Clearance_{vert.reinf} := Spacing_{vert.reinf} - d_{long.bar} = 6.5 \cdot in$

$CheckReinfClearSpacing := if\left(Clearance_{vert.reinf} \ge 6in, \text{"OK"}, \text{"No Good"}\right)$ $CheckReinfClearSpacing = \text{"OK"}$ *SDG 3.6.10*

Check Shear and Torsion

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

$V_u := \sqrt{V_x^2 + V_z^2} = 14.4 \cdot \text{kip}$

$T_u = 393.2 \cdot \text{kip} \cdot \text{ft}$

Effective shear depth

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

$d_v := \max(0.9 \cdot d_e, 0.72 \cdot b) = 3.6\ \text{ft}$

Check Shear Strength

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

$V_s := \frac{A_{v.bar} \cdot F_{y.rebar} \cdot d_v}{\max(s_{v1}, s_{v2}, s_{v3})} = 67 \cdot \text{kip}$ *LRFD Eqn 5.8.3.3-4*

$\text{ShearRatio} := \frac{V_u - \phi_v \cdot V_c}{\phi_v \cdot V_s} = -4.7$

$\text{ShearRatio} := \text{if}(\text{ShearRatio} \le 0, 0, \text{ShearRatio}) = 0$

Check Torsion Strength

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

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

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

$T_{n1} := \frac{2 \cdot A_o \cdot A_{v.bar} \cdot F_{y.rebar}}{s_{v1}} = 1.2 \times 10^3 \cdot \text{kip} \cdot \text{ft}$ *LRFD Eqn 5.8.3.6.2-1*

$T_{n2} := \frac{2 \cdot A_o \cdot A_{v.bar} \cdot F_{y.rebar}}{s_{v2}} = 580.6 \cdot \text{kip} \cdot \text{ft}$ *LRFD 5.8.3.4.1*

$$T_{n3} := \frac{2 \cdot A_o \cdot A_{v.bar} \cdot F_{y.rebar}}{s_{v3}} = 387.1 \cdot kip \cdot ft$$

$\phi_v = 0.9$ $T_u = 393.2 \cdot kip \cdot ft$ $L_{reqdTor} = 23\,ft$

$$Tor2_{sand} := T_u - if\left[2ft > Offset, \left[\pi \cdot b \cdot (2 \cdot ft - Offset) \cdot \gamma_{soil} \cdot \left(\frac{2 \cdot ft - Offset}{2}\right) \cdot (\omega_{fdot}) \cdot \frac{b}{2}\right], 0 \cdot kip \cdot ft\right] = 391.5 \cdot kip \cdot ft$$

$$Tor3_{sand} := T_u - if\left[depth_{stir} > Offset, \left[\pi \cdot b \cdot (depth_{stir} - Offset) \cdot \gamma_{soil} \cdot \left(\frac{depth_{stir} - Offset}{2}\right) \cdot (\omega_{fdot}) \cdot \frac{b}{2}\right], 0 \cdot kip \cdot ft\right] = 337.7 \cdot kip \cdot ft$$

$$Tor2_{clay} := T_u - if\left[2ft - 1.5ft > Offset, \left[f_{se} \cdot (\pi \cdot b) \cdot (2.0 \cdot ft - Offset - 1.5 \cdot ft) \cdot \frac{b}{2}\right], 0 \cdot kip \cdot ft\right] = 393.2 \cdot kip \cdot ft$$

$$Tor3_{clay} := T_u - if\left[depth_{stir} - 1.5ft > Offset, \left[f_{se} \cdot (\pi \cdot b) \cdot (depth_{stir} - Offset - 1.5 \cdot ft) \cdot \frac{b}{2}\right], 0 \cdot kip \cdot ft\right] = 202 \cdot kip \cdot ft$$

$$Tor2 := if(SoilType = \text{"Sand"}, Tor2_{sand}, Tor2_{clay}) = 391.5 \cdot kip \cdot ft$$

$$Tor3 := if(SoilType = \text{"Sand"}, Tor3_{sand}, Tor3_{clay}) = 337.7 \cdot kip \cdot ft$$

$$TorsionRatio_{n1} := \frac{T_u}{\phi_{tor} \cdot T_{n1}} = 0.34$$

$$TorsionRatio_{n2} := \frac{Tor2}{\phi_{tor} \cdot T_{n2}} = 0.67$$

$$TorsionRatio_{n3} := \frac{Tor3}{\phi_{tor} \cdot T_{n3}} = 0.87$$

$$TorsionRatio := max(TorsionRatio_{n1}, TorsionRatio_{n2}, TorsionRatio_{n3}) = 0.87$$

$$T_{cr} := 0.125 \sqrt{\frac{f_c}{ksi}} \cdot \left(\frac{A_{cp}^{\ 2}}{p_{cp} \cdot in^3}\right) \cdot kip \cdot in = 883.6 \cdot kip \cdot ft$$ LRFD Eqn 5.8.2.1-4

$$TorsionRatio := if(T_u \le 0.25 \cdot \phi_{tor} \cdot T_{cr}, 0, TorsionRatio) = 0.9$$ LRFD Eqn 5.8.2.1-3

$ShearRatio = 0$

$$CheckShearTorsion := if(ShearRatio + TorsionRatio \le 1, \text{"OK"}, \text{"No Good"})$$

$CheckShearTorsion = \text{"OK"}$

Check Maximum Spacing Transverse Reinforcement

$$v_u := \frac{V_u}{\phi_v \cdot b \cdot d_v} = 0.006173 \cdot ksi$$ $0.125 \cdot f_c = 0.5 \cdot ksi$ LRFD Eqn 5.8.2.9-1

$s_{max1} := \mathrm{if}\left(0.8 \cdot d_v < 24 \cdot in, 0.8 d_v, 24 \cdot in\right) = 24 \cdot in$ LRFD Eqn 5.8.2.7-1

$s_{max2} := \mathrm{if}\left(0.4 \cdot d_v < 12 \cdot in, 0.4 d_v, 12 \cdot in\right) = 12 \cdot in$ LRFD Eqn 5.8.2.7-2

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

$\max\left(s_{v1}, s_{v2}, s_{v3}\right) = 12 \cdot in$

$CheckMaxSpacingTransvReinf := \mathrm{if}\left(\max\left(s_{v1}, s_{v2}, s_{v3}\right) \le s_{max}, \text{"OK"}, \text{"No Good"}\right)$

$CheckMaxSpacingTransvReinf = \text{"OK"}$

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

LRFD 5.8.3.4.1

$M_u = 362.2 \cdot kip \cdot ft$

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

$$LongReinf_{shr.tor} := \frac{\dfrac{M_u}{\phi_v \cdot d_v} + \sqrt{\left(V_{temp}\right)^2 + \left(\dfrac{0.45 \cdot p_h \cdot T_u}{2 \cdot A_o \cdot \phi_v}\right)^2}}{F_{y.rebar}} = 3.8 \cdot in^2$$

$Num_{bar} \cdot A_{long.bar} = 28.1 \cdot in^2$

$CheckLongReinf_{shr.tor} := \mathrm{if}\left(Num_{bar} \cdot A_{long.bar} \ge LongReinf_{shr.tor}, \text{"OK"}, \text{"No Good"}\right)$

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

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

Mast Arm Assembly Information

Wind Speed
○ 130 mph ● 150 mph ○ 170 mph

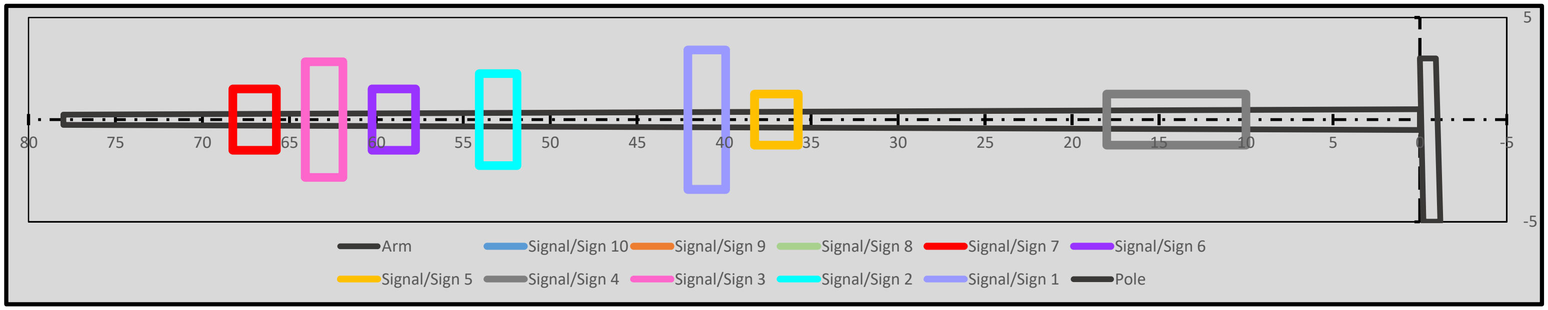
Signal Orientation
● Vertical
○ Horizontal

Back Plate Width
● 6.0 in.
○ 2.5 in.
○ 0 in.

Luminaire?
○ Yes
● No

Arm 1 Length
30
40
50
60
70
78

	Arm 1 Length, Signal/Sign Location and Size									
	Signal\Sign #10	Signal\Sign #9	Signal\Sign #8	Signal\Sign #7	Signal\Sign #6	Signal\Sign #5	Signal\Sign #4	Signal\Sign #3	Signal\Sign #2	Signal\Sign #1
Dist to Pole (ft.)	67	42	76	67	59	37	14	63	53	41
	● 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
Sign Width (in.)				30	30	30	96			
Sign Height (in.)				36	36	30	30			
Area (SF)	0.0	0.0	0.0	7.5	7.5	6.3	20.0	12.3	9.8	14.8
M_{wl} (kip*ft)	0	0	0	34	30	15	19	52	35	41



Arm 1 Length (ft)	78	
Design Standard Index 17743	**Regular**	**Heavy Duty**
Dia. at Arm Base (in)	18	20
Wall Thickness (in)	0.3750	0.3750
Resistance ($M_r=\phi M_n$) (kip*ft)	422	512

Arm 1 Loads	Regular	Heavy Duty
1.1*Arm M_{dl} (kip*ft)	121	143
Arm M_{wl} (kip*ft)	120	141
1.1*Sign/Signal M_{dl} (kip*ft)	17	
Sign/Signal M_{wl} (kip*ft)	225	
Total Moment ($M_{extreme}$)	371	400

Mast Arm Assembly Designation

One Arm Assembly
A78/S-P6/S-DS/16/5

See separate calc
for foundation

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.

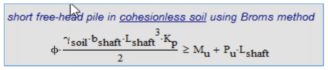
Arm to pole connection is at 22 ft.

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

Tube Wind Pressure (psf)	44.1

Fy (ksi)	50

Sign/Sig. Wind Pressure (psf)	67.0


short free-head pile in cohesionless soil using Broms method

$$\phi \cdot \frac{\gamma_{soil} \cdot b_{shaft} \cdot L_{shaft}^{3} \cdot K_p}{2} \geq M_u + P_u \cdot L_{shaft}$$

Arm Without Attachments: Dead Load Moment, Wind Load Moment and Moment Capacity at Base Connection

Total Arm Length (ft)	Regular							Heavy Duty						
	wall thk (in)	base dia (in)	S (in3)	Z (in3)	M_{dl} (kip*ft)	$M_{wl\ 130\ mph}$ (kip*ft)	$M_r=\phi M_n$ (kip*ft)	wall thk (in)	base dia (in)	S (in3)	Z (in3)	M_{dl} (kip*ft)	$M_{wl\ 130mph}$ (kip*ft)	$Mr=\phi Mn$ (kip*ft)
30	0.25	11	23	29	10	10	107	0.25	12	27	34	11	11	125
40	0.25	13	32	40	20	20	145	0.25	14	37	47	22	22	166
50	0.3125	14	46	58	36	33	215	0.3125	15	53	67	40	37	244
60	0.375	15	63	79	56	48	300	0.375	16	72	91	62	53	340
70	0.375	17	81	103	85	71	380	0.375	18	91	115	100	77	422
78	0.375	18	91	115	110	90	422	0.375	20	113	143	130	106	512

Drilled Shaft

Index 17743 Drilled Shaft Capacities						1 Arm Assembly Loads And Capacity Check					2 Arm Assembly Loads and Capacity Check				
DS Index #	ID	Length	Diameter	ϕM_n	ϕT_n	M_u+ P_u*L_{shaft}	T_u	Check Mom. & Min Dia.	Check Torsion	Check	M_u+ P_u*L_{shaft}	T_u	Check Mom. & Min Dia.	Check Torsion	Check
1	DS/20/5	20	5	1800	589	574.4	344.4	Okay	Okay	Okay	0.0	0.0	0	0	0
2	DS/18/5	18	5	1312	477	548.3		Okay	Okay	Okay	0.0		0	0	0
3	DS/16/5	16	5	922	377	522.2		Okay	Okay	Okay	0.0		0	0	0
4	DS/16/4.5	16	4.5	829	305	522.2		NoGood	NoGood	NoGood	0.0		0	0	0
5	DS/14/5	14	5	617	289	496.1		Okay	NoGood	NoGood	0.0		0	0	0
6	DS/14/4.5	14	4.5	556	234	496.1		NoGood	NoGood	NoGood	0.0		0	0	0
7	DS/12/4.5	12	4.5	350	172	470.1		NoGood	NoGood	NoGood	0.0		0	0	0
8	DS/12/4	12	4	311	136	470.1		NoGood	NoGood	NoGood	0.0		0	0	0

Arm 1 Attachments: Extreme Event Dead Load Moment, Wind Load Moment at Base Connection

	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	Total		
Sign/Sig Mwl (kip*ft)	0.0	0.0	0.0	33.7	29.6	15.5	18.8	51.8	34.6	40.7	224.6		
Sign/Sig 1.1*Mdl (kip*ft)	0.0	0.0	0.0	2.2	1.9	1.0	1.2	4.5	2.9	3.6	17.4		
Arm 1 Mwl (kip*ft)											119.8	141.1	*Reg Arm / HD Arm*
Arm 1 1.1*Mdl (kip*ft)											121.0	143.0	*Reg Arm / HD Arm*
*Extreme Event Arm Moment (kip*ft)*											371.2	399.9	

Ensures anchor bolts fit inside rebar cage

Min Shaft Diameter
5

Required Drilled Shaft Index Number Required (see Table for size)		
Load Case	1 Arm DS Index #	2 Arm DS Index #
Drilled Shaft Index req'd for Overturning including Min. Diamter	5	0
Drilled Shaft Index req'd for Torsion	3	0
Drilled Shaft Controlling Load Case	**3**	**#N/A**

Pole Base Shears & Moments				
	Arm 1 Shear	Arm 1 Moment	Arm 2 Shear	Arm 2 Moment
dl att	N/A	17.4	N/A	0.0
dl arm	N/A	121.0	N/A	0.0
wl pole	2.6	52.9	0.0	0.0
wl att	5.2	115.1	0.0	0.0
wl arm	5.2	113.5	0.0	0.0
Tor wl att	N/A	224.6	N/A	0.0
Tor wl arm	N/A	119.8	N/A	0.0

assume a 37.5' pole wl with lum

Arm 2 Attachments: Extreme Event Dead Load Moment, Wind Load Moment at Base Connection

	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	Total	
Sign/Sig Mwl (kip*ft)	0.0	0.0	0.0	0.0	0.0	47.6	*24.2*	*40.2*	*15.0*	*7.8*	134.8	
Sign/Sig 1.1*Mdl (kip*ft)	0.0	0.0	0.0	0.0	0.0	4.2	*2.0*	*2.6*	*1.3*	*0.7*	10.8	
Arm 2 Mwl (kip*ft)											0.0	0.0
Arm 2 1.1*Mdl (kip*ft)											0.0	0.0
											0.0	0.0

Forces at Top of DS		
	One Arm	Two Arms
Moment dl	138.4	N/A
Moment wl	281.5	
Moment Total	313.7	0.0
Torsion	344.4	0.0
Shear	13.0	0.0
	Shaft 2-Arm Factor	*1.1*

used for OT & Torsion

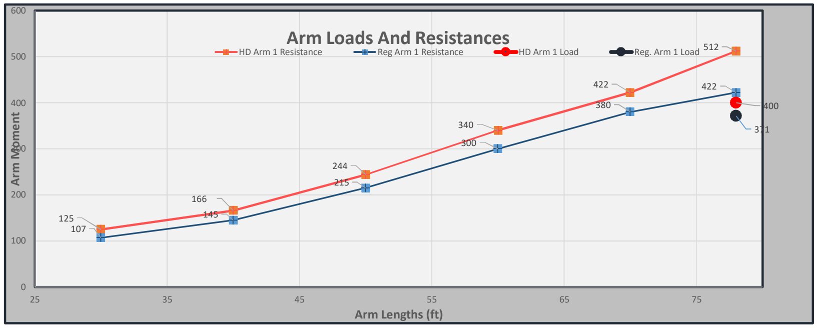
Pole ID			
Arm 1 Length	78	Arm 2 Length	0
	Pole ID	P6	

1 Arm Assembly		Use Regular Arm					
Design Arm Designation			**Pole Designation**			**Drilled Shaft**	
A78	/S		P6	/S		DS	
A78/S-			P6/S-			DS/16/5	
A78/S-P6/S-DS/16/5							

2 Arm Assembly		Use Regular Arm					
Design Arm Designation			**Pole Designation**			**Drilled Shaft**	
						DS	
-			-				

Assembly ID	A78/S-P6/S-DS/16/5	
	Arm 1	Arm 2
Arm Length(s)	78	0
Max Design CFI %	0.95	
Est. Regular Arm CFI	0.93	0.00
Est. HD Arm CFI	0.82	0.00

Note: Poles are designed to have a smaller CFI than Arms



Drilled Shaft Foundation for
Sign, Signal, and Lighting Support Structures v1.1

State Structures Design Office

SUBJECT: Moccasin Wallow Road
Struct # T-17-1 LOCATION: Sta. 386+18.5, 91.7' LT

DESIGNED BY: MPR DATE: 12/2021
CHECKED BY: DATE: 12/2021

Program Changes

SoilType :=
Sand
Clay

$\phi_{soil} := 29 \cdot deg$ *soil friction angle (sand)*

$c_{soil} := 1.25 \cdot \frac{kip}{ft^2}$ *soil shear strength (clay)*

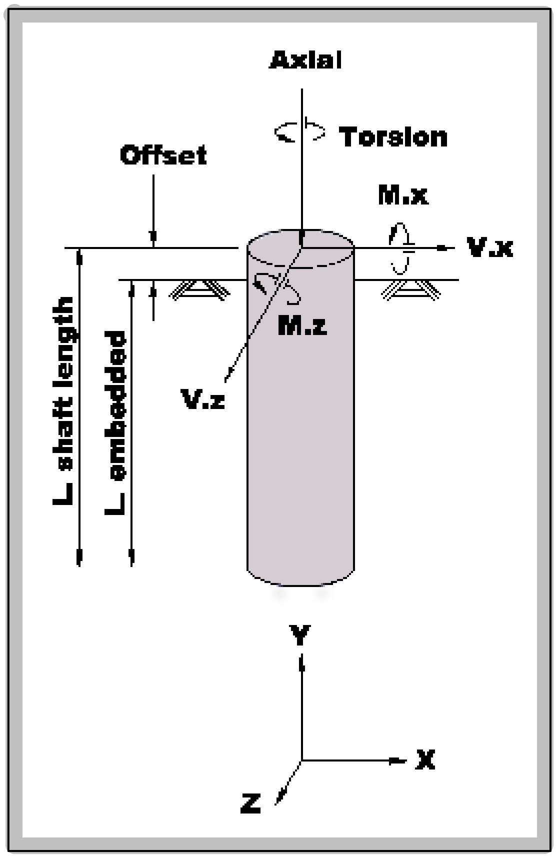
$N_{blows} := 8$ *number of blows per foot. If N< 5, contact the district geotech Engineer*

$\gamma_{soil} := 42.6 \cdot pcf$ *effective soil weight (typical design value = 45 ~ 50 pcf)*

Geometry

$b := 5 \cdot ft$ *shaft diameter, "DB"*

$Offset := 0.5 \cdot ft$ *groundline to top of foundation*



Applied Loads (Extreme I)

$M_x := 281.5 \cdot kip \cdot ft$ $V_x := 0 \cdot kip$ $Torsion := 344.4 \cdot kip \cdot ft$

$M_z := 138.4 \cdot kip \cdot ft$ $V_z := 13.0 \cdot kip$ $Axial := 4.0 \cdot kip$

StructureType :=
Cantilever Overhead Sign Structure
Mast Arm Signal Structure
Concrete/Steel Strain Poles
Ground Sign

StructureType = 1

$\phi_{ot} := if(StructureType = 3, 0.8, 0.6)$ $\phi_{ot} = 0.6$ *ϕ factor against overturning [SM Vol-3 13.6.1.1]*

$\phi_{tor} := if(StructureType = 0, 0.9, 1.0)$ $\phi_{tor} = 1$ *ϕ factor against torsion [SM Vol-3 13.6.1.1]*

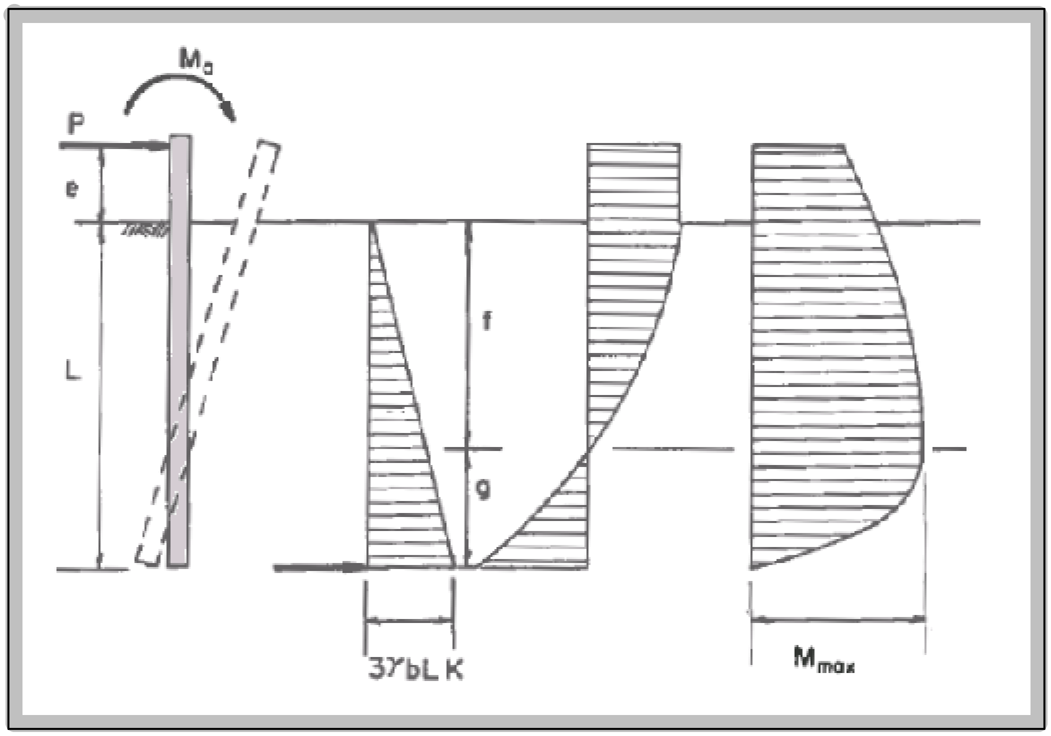
Shaft Depth Required to Resist Overturning

$$M_u := \sqrt{{M_x}^2 + {M_z}^2} = 313.7 \cdot kip \cdot ft$$

$$P_u := \sqrt{{V_x}^2 + {V_z}^2} = 13 \cdot kip$$

$$T_u := Torsion = 344.4 \cdot kip \cdot ft$$

*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.

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

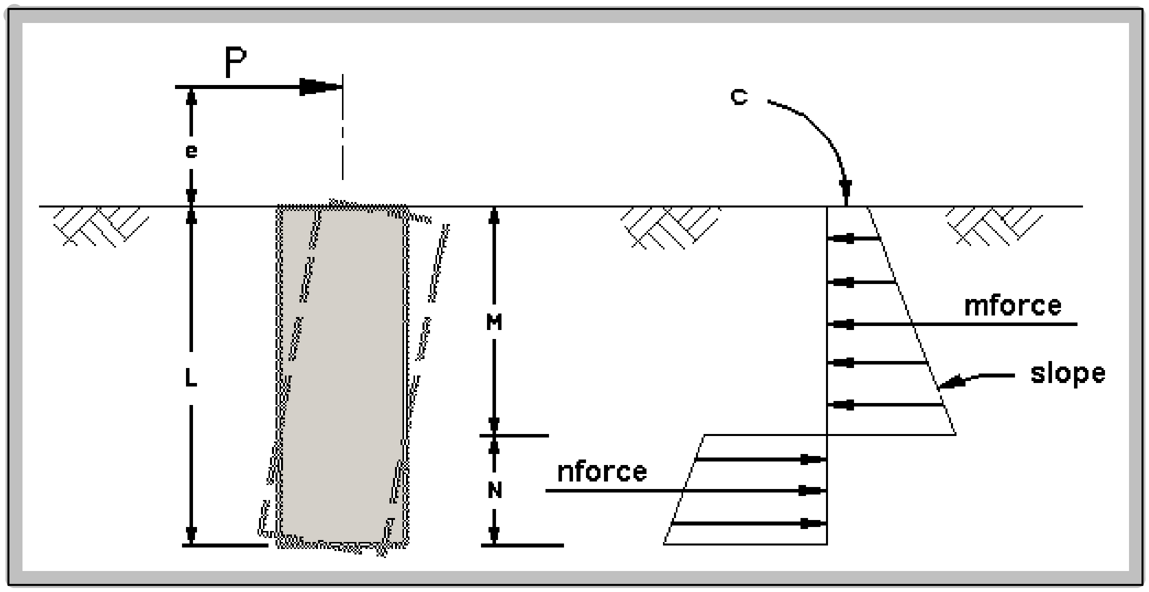
Guess value $L_{otSand} := 8 \cdot ft$

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

$$L_{otSand} := Find\left(L_{otSand}\right) = 14\,ft$$

$$L_{otSand} := ceil\left(\frac{L_{otSand}}{ft}\right) \cdot ft = 14\,ft$$ *(round up to next foot)*

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.

$c_{soil} := \text{if}\left(c_{soil} = 0\cdot ksf, 0.1\cdot ksf, c_{soil}\right) = 1.3\cdot ksf$

$Slope := 8\cdot\frac{c_{soil}}{3\cdot b} = 0.7\cdot\frac{kip}{ft^3}$ $\qquad e_{clay} := \frac{M_u}{P_u} + Offset = 24.6\,ft$

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

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

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

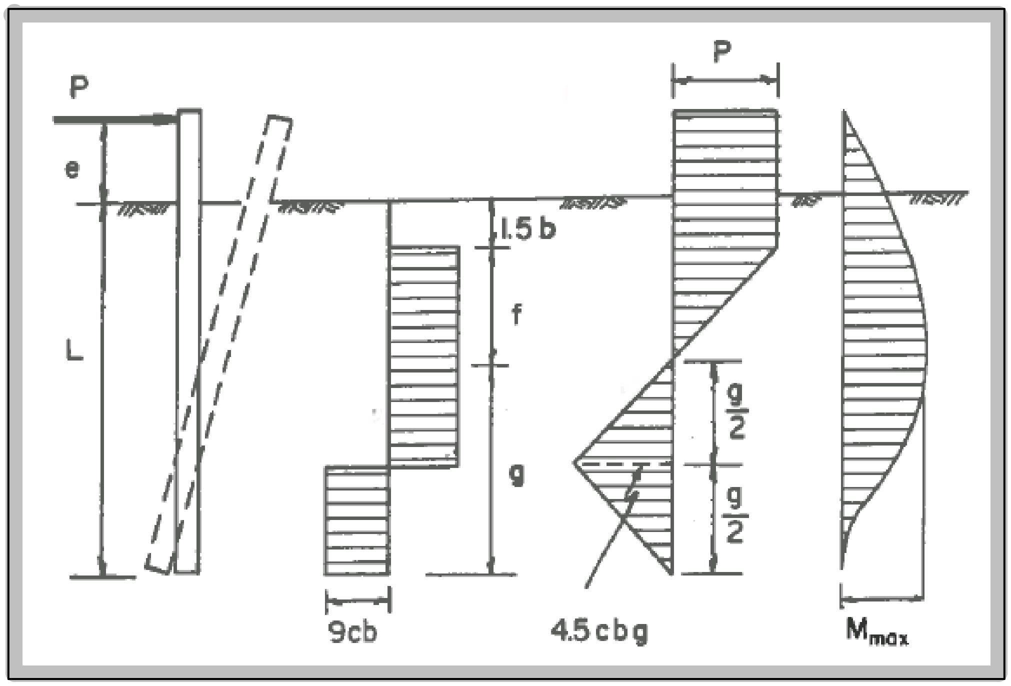
Guess value $\qquad M := 4.0\cdot ft \qquad N := 4.0\cdot ft$

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

$\begin{pmatrix} M \\ N \end{pmatrix} := Find(M,N) \qquad L_{ot1Clay} := M + N = 11.3\,ft$

$L_{ot1Clay} := ceil\left(\frac{L_{ot1Clay}}{ft}\right)\cdot ft = 12\,ft$ $\qquad$ *(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.*

$$f := \frac{P_u}{\phi_{ot} \cdot 9 \cdot c_{soil} \cdot b} = 0.4\ ft$$

$$M_{max.clay} := P_u \cdot \left(e_{clay} + 1.5 \cdot b + 0.5 \cdot f\right) = 420.2 \cdot kip \cdot ft$$

$$g := \sqrt{\frac{M_{max.clay}}{2.25 \cdot \phi_{ot} \cdot c_{soil} \cdot b}} = 7.1\ ft$$

$$L_{ot2Clay} := (1.5 \cdot b + f + g) = 14.9\ ft$$

$$L_{ot2Clay} := ceil\left(\frac{L_{ot2Clay}}{ft}\right) \cdot ft = 15\ ft$$ *(round up to next foot)*

$$L_{otClay} := if\left(L_{ot1Clay} < 3 \cdot b, L_{ot1Clay}, L_{ot2Clay}\right) = 3.7$$ *(If $L_{ot} < 3b$, use Modified Broms method)*

$$L_{reqdOT} := if\left(SoilType = "Sand", L_{otSand}, L_{otClay}\right)$$

$L_{reqdOT} = 14\ ft$ *required shaft embedment depth to resist overturning*

Shaft Depth Required to Resist Torsion

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.*

$N_{blows} = 8$

$$\omega_{fdot} := \text{if}\left(N_{blows} < 5, 0, \text{if}\left(N_{blows} \geq 15, 1.5, 1.5 \cdot \frac{N_{blows}}{15}\right)\right) = 0.8$$

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 $L_{torSand} := L_{reqdOT} = 14\,\text{ft}$

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

$L_{torSand} := \text{Find}(L_{torSand}) = 22.7\,\text{ft}$

$L_{torSand} := \text{ceil}\left(\frac{L_{torSand}}{\text{ft}}\right) \cdot \text{ft} = 23\,\text{ft}$ *(round up to next foot)*

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

$\text{CohesionFactor} := 0.55$

$f_{se} := \text{CohesionFactor} \cdot c_{soil} = 0.7 \cdot \text{ksf}$

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

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

$L_{torClay} := \text{Find}(L_{torClay}) = 14.3\,\text{ft}$

$L_{torClay} := \text{ceil}\left(\frac{L_{torClay}}{\text{ft}}\right) \cdot \text{ft} = 15\,\text{ft}$ *(round up to next foot)*

$L_{reqdTor} := \text{if}(\text{SoilType} = \text{"Sand"}, L_{torSand}, L_{torClay})$

$L_{reqdTor} = 23\,\text{ft}$ *required shaft embedment depth to resist torsion*

$L_{embedded} := \text{if}(L_{reqdTor} > L_{reqdOT}, L_{reqdTor}, L_{reqdOT}) = 7$

$L_{shaft.length} := L_{embedded} + \text{Offset}$

$L_{shaft.length} = 23.5\,\text{ft}$ *shaft length*

Maximum Moment in Shaft

short free-head pile in cohesionless soil using Broms method

$$f_{sand} := \sqrt{\frac{2 \cdot P_u}{3 \cdot \gamma_{soil} \cdot b \cdot K_p \cdot \phi_{ot}}} = 4.9\ ft$$

$$M_{maxSand} := P_u \cdot \left(e_{sand} + f_{sand}\right) - \frac{P_u \cdot f_{sand}}{3} + M_u = 362.2 \cdot kip \cdot ft$$

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

$$f_{mod} := Find\left(f_{mod}\right) = 2.2\ ft$$

$$M_{modBroms} := P_u \cdot \left(e_{clay} + f_{mod}\right) - \frac{\phi_{ot} \cdot c_{soil} \cdot b \cdot f_{mod}^{\ 2}}{2} - \frac{\phi_{ot} \cdot b \cdot f_{mod}^{\ 3} \cdot Slope}{6} = 336.2 \cdot kip \cdot ft$$

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

$$M_{Broms} := P_u \cdot \left(e_{clay} + 1.5 \cdot b + 0.5 \cdot f\right) = 420.2 \cdot kip \cdot ft$$

$M_{maxClay} := if\left(L_{ot1Clay} < 3 \cdot b, M_{modBroms}, M_{Broms}\right) = 336.2 \cdot kip \cdot ft$ *(If $L_{\alpha} < 3b$, use Modified Broms method)*

$$M_{max} := if\left(SoilType = \text{"Sand"}, M_{maxSand}, M_{maxClay}\right) = 362.2 \cdot kip \cdot ft$$

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

$Num_{bar} := 18$ number of longitudinal bars, "RB"

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

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

$A_{v.bar} := 0.31 \cdot in^2$ stirrup area SM Vol-3 13.6.2

$d_{v.bar} := 0.625 \cdot in$ stirrup diameter

$s_{v1} := 4 \cdot in$ stirrup spacing, depth = 0 ft-2 ft SM Vol-3 13.6.2

$s_{v2} := 8 \cdot in$ stirrup spacing, depth = 2 ft-depth.stir, "RD"

$s_{v3} := 12 \cdot in$ stirrup spacing, depth > depth.stir, "RF"

$depth_{stir} := 9.083 \cdot ft$ stirrup depth, see s.v2 and s.v3 above

$b = 5\,ft$ shaft diameter

$$A_{req} := \min\left(0.135 \cdot \frac{\pi \cdot b^2}{4} \cdot \frac{f_c}{F_{y.rebar}}, 0.015 \cdot \frac{\pi \cdot b^2}{4}\right) = 25.4 \cdot in^2$$ LRFD 5.7.4.2

$A_{long} := Num_{bar} \cdot A_{long.bar} = 28.1 \cdot in^2$ total area of longitudinal steel

$CheckLongitudinalReinf := if(A_{long} \geq A_{req}, "OK", "No Good")$ $CheckLongitudinalReinf = "OK"$

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

$Spacing_{vert.reinf} := Dia_{bar.circle} \cdot \frac{\pi}{Num_{bar}} = 7.9 \cdot in$ $Clearance_{vert.reinf} := Spacing_{vert.reinf} - d_{long.bar} = 6.5 \cdot in$

$CheckReinfClearSpacing := if(Clearance_{vert.reinf} \geq 6in, "OK", "No Good")$ $CheckReinfClearSpacing = "OK"$ SDG 3.6.10

Check Shear and Torsion

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

$$V_u := \sqrt{V_x^2 + V_z^2} = 13 \cdot kip$$

$$T_u = 344.4 \cdot kip \cdot ft$$

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

$$V_c := 0.0316 \cdot (2.0) \cdot \sqrt{\frac{f_c}{ksi}} \cdot \left(\frac{b}{in}\right) \cdot \left(\frac{d_v}{in}\right) \cdot kip = 327.6 \cdot kip$$

LRFD Eqn 5.8.3.3-3 LRFD 5.8.3.4.1 ACI 11.3.3

$$V_s := \frac{A_{v.bar} \cdot F_{y.rebar} \cdot d_v}{\max(s_{v1}, s_{v2}, s_{v3})} = 67 \cdot kip$$

LRFD Eqn 5.8.3.3-4

$$ShearRatio := \frac{V_u - \phi_v \cdot V_c}{\phi_v \cdot V_s} = -4.7$$

$$ShearRatio := if(ShearRatio \le 0, 0, ShearRatio) = 0$$

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

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

$$T_{n1} := \frac{2 \cdot A_o \cdot A_{v.bar} \cdot F_{y.rebar}}{s_{v1}} = 1.2 \times 10^3 \cdot kip \cdot ft$$

LRFD Eqn 5.8.3.6.2-1

$$T_{n2} := \frac{2 \cdot A_o \cdot A_{v.bar} \cdot F_{y.rebar}}{s_{v2}} = 580.6 \cdot kip \cdot ft$$

LRFD 5.8.3.4.1

$$T_{n3} := \frac{2 \cdot A_o \cdot A_{v.bar} \cdot F_{y.rebar}}{s_{v3}} = 387.1 \cdot kip \cdot ft$$

$\phi_v = 0.9$ $\quad T_u = 344.4 \cdot kip \cdot ft$ $\quad L_{reqdTor} = 23\ ft$

$$Tor2_{sand} := T_u - if\left[2ft > Offset, \left[\pi \cdot b \cdot (2 \cdot ft - Offset) \cdot \gamma_{soil} \cdot \left(\frac{2 \cdot ft - Offset}{2}\right) \cdot (\omega_{fdot}) \cdot \frac{b}{2}\right], 0 \cdot kip \cdot ft\right] = 342.9 \cdot kip \cdot ft$$

$$Tor3_{sand} := T_u - if\left[depth_{stir} > Offset, \left[\pi \cdot b \cdot (depth_{stir} - Offset) \cdot \gamma_{soil} \cdot \left(\frac{depth_{stir} - Offset}{2}\right) \cdot (\omega_{fdot}) \cdot \frac{b}{2}\right], 0 \cdot kip \cdot ft\right] = 295.1 \cdot kip \cdot ft$$

$$Tor2_{clay} := T_u - if\left[2ft - 1.5ft > Offset, \left[f_{se} \cdot (\pi \cdot b) \cdot (2.0 \cdot ft - Offset - 1.5 \cdot ft) \cdot \frac{b}{2}\right], 0 \cdot kip \cdot ft\right] = 344.4 \cdot kip \cdot ft$$

$$Tor3_{clay} := T_u - if\left[depth_{stir} - 1.5ft > Offset, \left[f_{se} \cdot (\pi \cdot b) \cdot (depth_{stir} - Offset - 1.5 \cdot ft) \cdot \frac{b}{2}\right], 0 \cdot kip \cdot ft\right] = 153.2 \cdot kip \cdot ft$$

$$Tor2 := if(SoilType = \text{"Sand"}, Tor2_{sand}, Tor2_{clay}) = 342.9 \cdot kip \cdot ft$$

$$Tor3 := if(SoilType = \text{"Sand"}, Tor3_{sand}, Tor3_{clay}) = 295.1 \cdot kip \cdot ft$$

$$TorsionRatio_{n1} := \frac{T_u}{\phi_{tor} \cdot T_{n1}} = 0.3$$

$$TorsionRatio_{n2} := \frac{Tor2}{\phi_{tor} \cdot T_{n2}} = 0.59$$

$$TorsionRatio_{n3} := \frac{Tor3}{\phi_{tor} \cdot T_{n3}} = 0.76$$

$$TorsionRatio := max(TorsionRatio_{n1}, TorsionRatio_{n2}, TorsionRatio_{n3}) = 0.76$$

$$T_{cr} := 0.125 \sqrt{\frac{f_c}{ksi}} \cdot \left(\frac{A_{cp}^{\ 2}}{p_{cp} \cdot in^3}\right) \cdot kip \cdot in = 883.6 \cdot kip \cdot ft$$ *LRFD Eqn 5.8.2.1-4*

$$TorsionRatio := if(T_u \le 0.25 \cdot \phi_{tor} \cdot T_{cr}, 0, TorsionRatio) = 0.8$$ *LRFD Eqn 5.8.2.1-3*

$ShearRatio = 0$

$CheckShearTorsion := if(ShearRatio + TorsionRatio \le 1, \text{"OK"}, \text{"No Good"})$

$CheckShearTorsion = \text{"OK"}$

Check Maximum Spacing Transverse Reinforcement

$$v_u := \frac{V_u}{\phi_v \cdot b \cdot d_v} = 0.005573 \cdot ksi$$ $\quad 0.125 \cdot f_c = 0.5 \cdot ksi$ *LRFD Eqn 5.8.2.9-1*

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

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

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

$max\left(s_{v1}, s_{v2}, s_{v3}\right) = 12 \cdot in$

$CheckMaxSpacingTransvReinf := if\left(max\left(s_{v1}, s_{v2}, s_{v3}\right) \le s_{max}, "OK", "No Good"\right)$

CheckMaxSpacingTransvReinf = "OK"

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

LRFD 5.8.3.4.1

$M_u = 313.7 \cdot kip \cdot ft$

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

$$LongReinf_{shr.tor} := \frac{\frac{M_u}{\phi_v \cdot d_v} + \sqrt{\left(V_{temp}\right)^2 + \left(\frac{0.45 \cdot p_h \cdot T_u}{2 \cdot A_o \cdot \phi_v}\right)^2}}{F_{y.rebar}} = 3.3 \cdot in^2$$

$Num_{bar} \cdot A_{long.bar} = 28.1 \cdot in^2$

$CheckLongReinf_{shr.tor} := if\left(Num_{bar} \cdot A_{long.bar} \ge LongReinf_{shr.tor}, "OK", "No Good"\right)$

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

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

Mast Arm Assembly Information

Wind Speed
○ 130 mph ● 150 mph ○ 170 mph

Signal Orientation
● Vertical
○ Horizontal

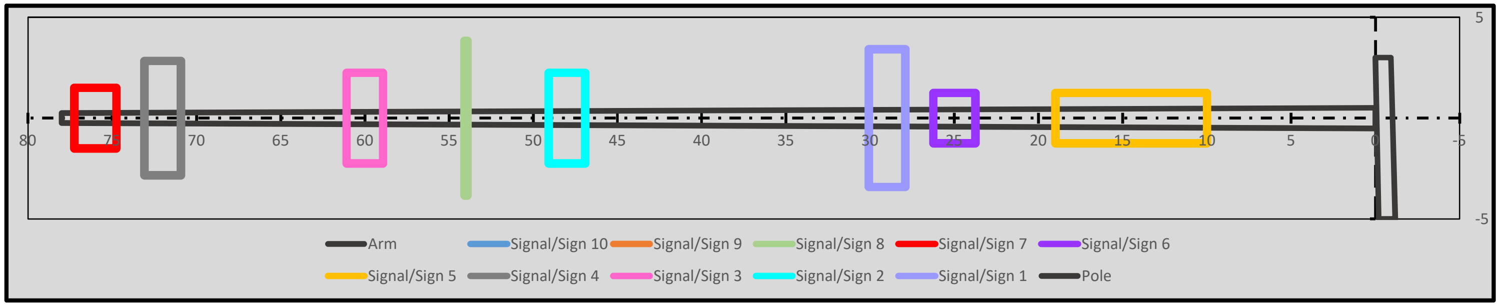
Back Plate Width
● 6.0 in.
○ 2.5 in.
○ 0 in.

Luminaire?
○ Yes
● No

Arm 1 Length
30
40
50
60
70
78

Arm 1 Length, Signal/Sign Location and Size

	Signal\Sign #10	Signal\Sign #9	Signal\Sign #8	Signal\Sign #7	Signal\Sign #6	Signal\Sign #5	Signal\Sign #4	Signal\Sign #3	Signal\Sign #2	Signal\Sign #1
Dist to Pole (ft.)	67	42	54	76	25	14.5	72	60	48	29
	● 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
Sign Width (in.)			2	30	30	108				
Sign Height (in.)			92	36	30	30				
Area (SF)	0.0	0.0	1.3	7.5	6.3	22.5	12.3	9.8	9.8	14.8
M_{wl}, (kip*ft)	0	0	5	38	10	22	59	39	31	29



Arm 1 Length (ft)	78	
Design Standard Index 17743	Regular	Heavy Duty
Dia. at Arm Base (in)	18	20
Wall Thickness (in)	0.3750	0.3750
Resistance (M_r=ϕM_n) (kip*ft)	422	512

Arm 1 Loads	Regular	Heavy Duty
1.1*Arm M_{dl} (kip*ft)	121	143
Arm M_{wl} (kip*ft)	120	141
1.1*Sign/Signal M_{dl} (kip*ft)	19	
Sign/Signal M_{wl} (kip*ft)	234	
Total Moment ($M_{extreme}$)	380	409

Mast Arm Assembly Designation
One Arm Assembly A78/S-P6/S-DS/16/5

See separate calc for foundation

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.

Tube Wind Pressure (psf)	44.1

Fy (ksi)	50

Sign/Sig. Wind Pressure (psf)	67.0

short free-head pile in cohesionless soil using Broms method

$$\phi \cdot \frac{\gamma_{soil} \cdot b_{shaft} \cdot L_{shaft}^{3} \cdot K_p}{2} \geq M_u + P_u \cdot L_{shaft}$$

Arm Without Attachments: Dead Load Moment, Wind Load Moment and Moment Capacity at Base Connection

	Regular							Heavy Duty						
Total Arm Length (ft)	wall thk (in)	base dia (in)	S (in3)	Z (in3)	M_{dl} (kip*ft)	$M_{wl\ 130\ mph}$ (kip*ft)	$M_r=\phi M_n$ (kip*ft)	wall thk (in)	base dia (in)	S (in3)	Z (in3)	M_{dl} (kip*ft)	$M_{wl\ 130mph}$ (kip*ft)	Mr=ϕMn (kip*ft)
30	0.25	11	23	29	10	10	107	0.25	12	27	34	11	11	125
40	0.25	13	32	40	20	20	145	0.25	14	37	47	22	22	166
50	0.3125	14	46	58	36	33	215	0.3125	15	53	67	40	37	244
60	0.375	15	63	79	56	48	300	0.375	16	72	91	62	53	340
70	0.375	17	81	103	85	71	380	0.375	18	91	115	100	77	422
78	0.375	18	91	115	110	90	422	0.375	20	113	143	130	106	512

Drilled Shaft

Index 17743 Drilled Shaft Capacities						1 Arm Assembly Loads And Capacity Check					2 Arm Assembly Loads and Capacity Check				
DS Index #	ID	Length	Diameter	ϕM_n	ϕT_n	M_u+ P_u*L_{shaft}	T_u	Check Mom. & Min Dia.	Check Torsion	Check	M_u+ P_u*L_{shaft}	T_u	Check Mom. & Min Dia.	Check Torsion	Check
1	DS/20/5	20	5	1800	589	590.9	353.4	Okay	Okay	Okay	0.0	0.0	0	0	0
2	DS/18/5	18	5	1312	477	564.0		Okay	Okay	Okay	0.0		0	0	0
3	DS/16/5	16	5	922	377	537.2		Okay	Okay	Okay	0.0		0	0	0
4	DS/16/4.5	16	4.5	829	305	537.2		NoGood	NoGood	NoGood	0.0		0	0	0
5	DS/14/5	14	5	617	289	510.3		Okay	NoGood	NoGood	0.0		0	0	0
6	DS/14/4.5	14	4.5	556	234	510.3		NoGood	NoGood	NoGood	0.0		0	0	0
7	DS/12/4.5	12	4.5	350	172	483.4		NoGood	NoGood	NoGood	0.0		0	0	0
8	DS/12/4	12	4	311	136	483.4		NoGood	NoGood	NoGood	0.0		0	0	0

Arm 1 Attachments: Extreme Event Dead Load Moment, Wind Load Moment at Base Connection

	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	Total		
Sign/Sig Mwl (kip*ft)	0.0	0.0	4.6	38.2	10.5	21.9	59.2	39.2	31.3	28.8	233.6		
Sign/Sig 1.1*Mdl (kip*ft)	0.0	0.0	0.3	2.5	0.7	1.4	5.1	3.3	2.6	2.6	18.6		
Arm 1 Mwl (kip*ft)											119.8	141.1	*Reg Arm / HD Arm*
Arm 1 1.1*Mdl (kip*ft)											121.0	143.0	*Reg Arm / HD Arm*
										*Extreme Event Arm Moment (kip*ft)*	380.0	408.6	

Ensures anchor bolts fit inside rebar cage

Min Shaft Diameter
5

Required Drilled Shaft Index Number Required (see Table for size)		
Load Case	1 Arm DS Index #	2 Arm DS Index #
Drilled Shaft Index req'd for Overturning including Min. Diamter	5	0
Drilled Shaft Index req'd for Torsion	3	0
Drilled Shaft Controlling Load Case	3	#N/A

Pole Base Shears & Moments				
	Arm 1 Shear	Arm 1 Moment	Arm 2 Shear	Arm 2 Moment
dl att	N/A	18.6	N/A	0.0
dl arm	N/A	121.0	N/A	0.0
wl pole	2.6	52.9	0.0	0.0
wl att	5.6	123.9	0.0	0.0
wl arm	5.2	113.5	0.0	0.0
Tor wl att	N/A	233.6	N/A	0.0
Tor wl arm	N/A	119.8	N/A	0.0

assume a 37.5' pole wl with lum

Forces at Top of DS		
	One Arm	Two Arms
Moment dl	139.6	N/A
Moment wl	290.3	
Moment Total	322.2	0.0
Torsion	353.4	0.0
Shear	13.4	0.0
Shaft 2-Arm Factor	*1.1*	*used for OT & Torsion*

Arm 2 Attachments: Extreme Event Dead Load Moment, Wind Load Moment at Base Connection

	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	Total	
Sign/Sig Mwl (kip*ft)	0.0	0.0	0.0	0.0	0.0	47.6	*24.2*	*40.2*	*15.0*	*7.8*	134.8	
Sign/Sig 1.1*Mdl (kip*ft)	0.0	0.0	0.0	0.0	0.0	4.2	*2.0*	*2.6*	*1.3*	*0.7*	10.8	
Arm 2 Mwl (kip*ft)											0.0	0.0
Arm 2 1.1*Mdl (kip*ft)											0.0	0.0
											0.0	0.0

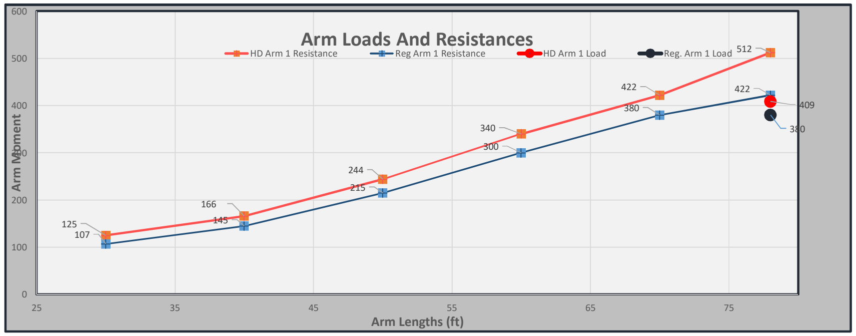
Pole ID			
Arm 1 Length	78	Arm 2 Length	0
	Pole ID	P6	

1 Arm Assembly	Use Regular Arm							
Design Arm Designation			Pole Designation			Drilled Shaft	
A78	/S		P6	/S		DS	
A78/S-			P6/S-			DS/16/5	
A78/S-P6/S-DS/16/5							

2 Arm Assembly	Use Regular Arm						
Design Arm Designation			Pole Designation			Drilled Shaft	
						DS	
-			-				

Assembly ID	A78/S-P6/S-DS/16/5	
	Arm 1	Arm 2
Arm Length(s)	78	0
Max Design CFI %	0.95	
Est. Regular Arm CFI	0.95	0.00
Est. HD Arm CFI	0.84	0.00

Note: Poles are designed to have a smaller CFI than Arms



Drilled Shaft Foundation for
Sign, Signal, and Lighting Support Structures v1.1

FDOT
State Structures Design Office

SUBJECT: Moccasin Wallow Road
Struct # T-17-2 LOCATION: Sta. 386+15.6, 79.0' LT

DESIGNED BY: MPR DATE: 12/2021
CHECKED BY: DATE: 12/2021

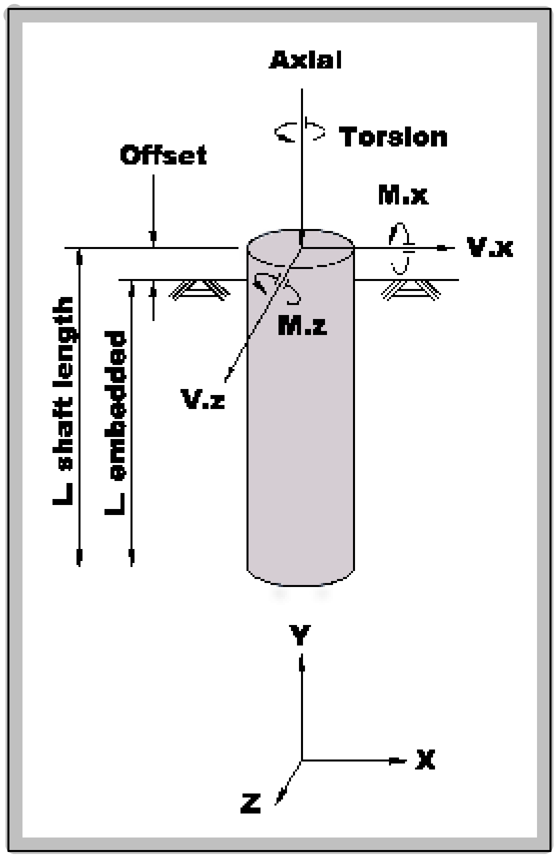
Program Changes

SoilType :=
- Sand
- Clay

$\phi_{soil} := 29 \cdot deg$	*soil friction angle (sand)*
$c_{soil} := 1.25 \cdot \frac{kip}{ft^2}$	*soil shear strength (clay)*
$N_{blows} := 10$	*number of blows per foot. If N< 5, contact the district geotech Engineer*
$\gamma_{soil} := 42.6 \cdot pcf$	*effective soil weight (typical design value = 45 ~ 50 pcf)*

Geometry

$b := 5 \cdot ft$	*shaft diameter, "DB"*
$Offset := 1 \cdot ft$	*groundline to top of foundation*



Applied Loads (Extreme I)

$M_x := 290.3 \cdot kip \cdot ft$ $V_x := 0 \cdot kip$ $Torsion := 353.4 \cdot kip \cdot ft$

$M_z := 139.6 \cdot kip \cdot ft$ $V_z := 13.4 \cdot kip$ $Axial := 4.0 \cdot kip$

StructureType :=
- Cantilever Overhead Sign Structure
- Mast Arm Signal Structure
- Concrete/Steel Strain Poles
- Ground Sign

$StructureType = 1$

$\phi_{ot} := if(StructureType = 3, 0.8, 0.6)$ $\phi_{ot} = 0.6$ *ϕ factor against overturning [SM Vol-3 13.6.1.1]*

$\phi_{tor} := if(StructureType = 0, 0.9, 1.0)$ $\phi_{tor} = 1$ *ϕ factor against torsion [SM Vol-3 13.6.1.1]*

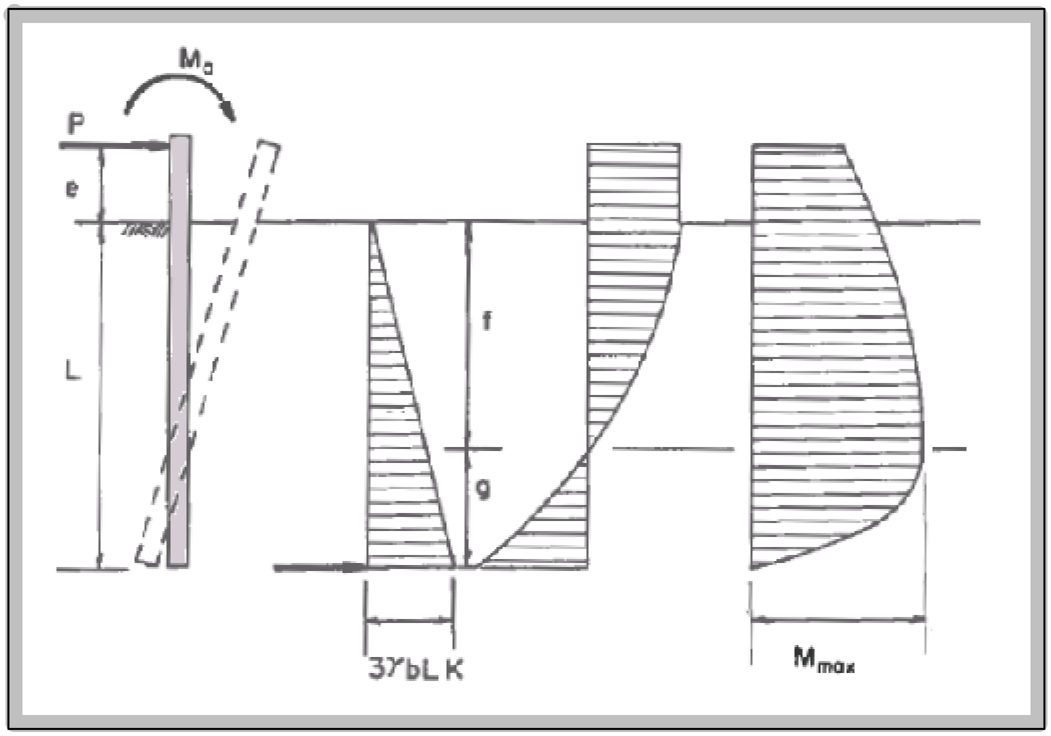
Shaft Depth Required to Resist Overturning

$$M_u := \sqrt{{M_x}^2 + {M_z}^2} = 322.1\cdot\text{kip}\cdot\text{ft}$$

$$P_u := \sqrt{{V_x}^2 + {V_z}^2} = 13.4\cdot\text{kip}$$

$$T_u := \text{Torsion} = 353.4\cdot\text{kip}\cdot\text{ft}$$

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.

$$K_p := \tan\left(45\cdot\text{deg} + \frac{\phi_{soil}}{2}\right)^2 = 2.9 \qquad e_{sand} := \text{Offset} = 1\,\text{ft}$$

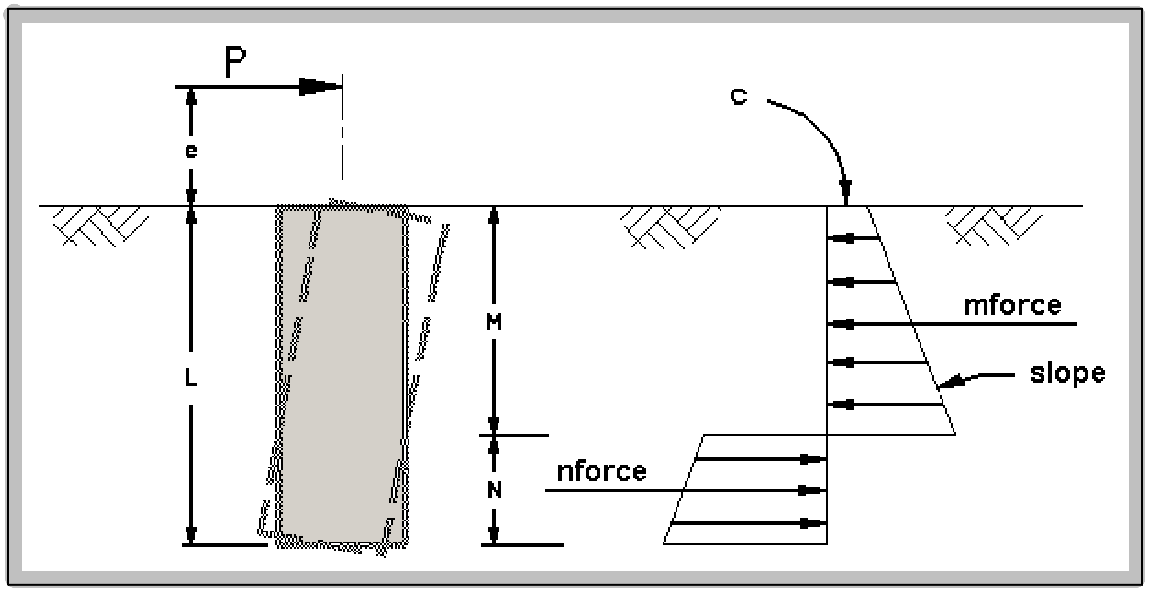
Guess value $\quad L_{otSand} := 8\cdot\text{ft}$

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

$$L_{otSand} := \text{Find}\left(L_{otSand}\right) = 14.2\,\text{ft}$$

$$L_{otSand} := \text{ceil}\left(\frac{L_{otSand}}{\text{ft}}\right)\cdot\text{ft} = 15\,\text{ft}$$ *(round up to next foot)*

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.

$c_{soil} := \text{if}\left(c_{soil} = 0 \cdot ksf, 0.1 \cdot ksf, c_{soil}\right) = 1.3 \cdot ksf$

$Slope := 8 \cdot \dfrac{c_{soil}}{3 \cdot b} = 0.7 \cdot \dfrac{kip}{ft^3}$ $\qquad e_{clay} := \dfrac{M_u}{P_u} + Offset = 25\,ft$

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

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

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

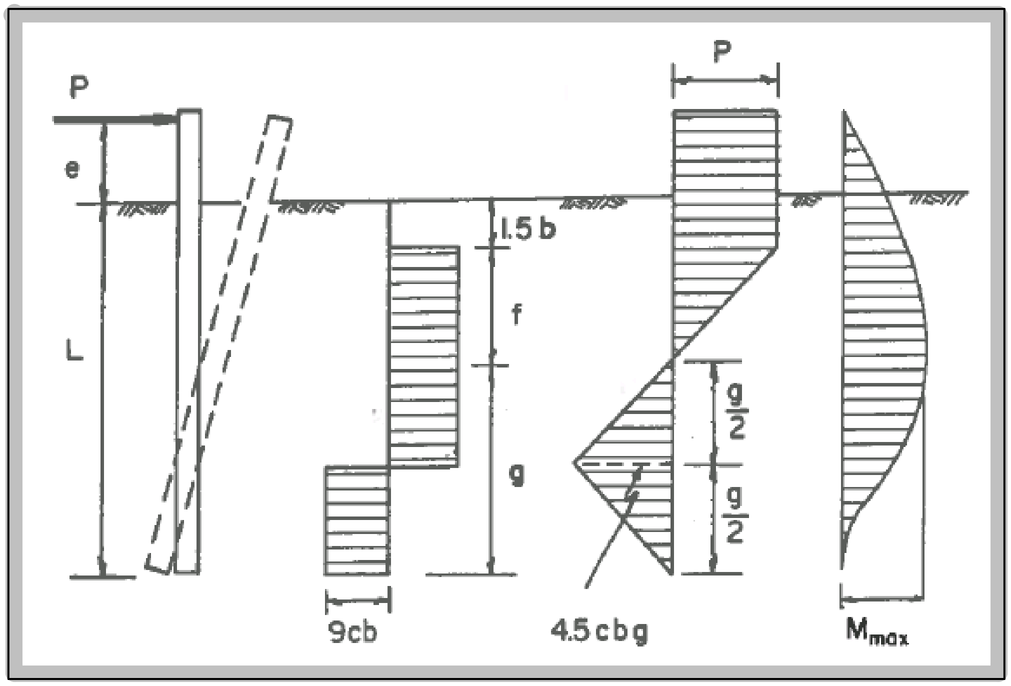
Guess value $\quad M := 4.0 \cdot ft \qquad N := 4.0 \cdot ft$

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

$\begin{pmatrix} M \\ N \end{pmatrix} := \text{Find}(M,N) \qquad L_{ot1Clay} := M + N = 11.5\,ft$

$L_{ot1Clay} := \text{ceil}\left(\dfrac{L_{ot1Clay}}{ft}\right) \cdot ft = 12\,ft$ $\quad$ *(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.*

$$f := \frac{P_u}{\phi_{ot} \cdot 9 \cdot c_{soil} \cdot b} = 0.4\,ft$$

$$M_{max.clay} := P_u \cdot \left(e_{clay} + 1.5 \cdot b + 0.5 \cdot f\right) = 438.7 \cdot kip \cdot ft$$

$$g := \sqrt{\frac{M_{max.clay}}{2.25 \cdot \phi_{ot} \cdot c_{soil} \cdot b}} = 7.2\,ft$$

$$L_{ot2Clay} := (1.5 \cdot b + f + g) = 15.1\,ft$$

$$L_{ot2Clay} := ceil\left(\frac{L_{ot2Clay}}{ft}\right) \cdot ft = 16\,ft$$ *(round up to next foot)*

$$L_{otClay} := if\left(L_{ot1Clay} < 3 \cdot b, L_{ot1Clay}, L_{ot2Clay}\right) = 3.7$$ *(If $L_{ot} < 3b$, use Modified Broms method)*

$$L_{reqdOT} := if\left(SoilType = "Sand", L_{otSand}, L_{otClay}\right)$$

$L_{reqdOT} = 15\,ft$ *required shaft embedment depth to resist overturning*

Shaft Depth Required to Resist Torsion

*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.

$N_{blows} = 10$

$$\omega_{fdot} := \text{if}\left(N_{blows} < 5, 0, \text{if}\left(N_{blows} \geq 15, 1.5, 1.5 \cdot \frac{N_{blows}}{15}\right)\right) = 1$$

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 $L_{torSand} := L_{reqdOT} = 15\,\text{ft}$

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

$L_{torSand} := \text{Find}(L_{torSand}) = 20.6\,\text{ft}$

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

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

$\text{CohesionFactor} := 0.55$

$f_{se} := \text{CohesionFactor} \cdot c_{soil} = 0.7 \cdot \text{ksf}$

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

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

$L_{torClay} := \text{Find}(L_{torClay}) = 14.6\,\text{ft}$

$L_{torClay} := \text{ceil}\left(\frac{L_{torClay}}{\text{ft}}\right) \cdot \text{ft} = 15\,\text{ft}$ *(round up to next foot)*

$L_{reqdTor} := \text{if}(\text{SoilType} = \text{"Sand"}, L_{torSand}, L_{torClay})$

$L_{reqdTor} = 21\,\text{ft}$ *required shaft embedment depth to resist torsion*

$L_{embedded} := \text{if}(L_{reqdTor} > L_{reqdOT}, L_{reqdTor}, L_{reqdOT}) = 6.4$

$L_{shaft.length} := L_{embedded} + \text{Offset}$

$L_{shaft.length} = 22\,\text{ft}$ *shaft length*

Maximum Moment in Shaft

short free-head pile in cohesionless soil using Broms method

$$f_{sand} := \sqrt{\frac{2 \cdot P_u}{3 \cdot \gamma_{soil} \cdot b \cdot K_p \cdot \phi_{ot}}} = 4.9\ ft$$

$$M_{maxSand} := P_u \cdot \left(e_{sand} + f_{sand}\right) - \frac{P_u \cdot f_{sand}}{3} + M_u = 379.5 \cdot kip \cdot ft$$

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

$$f_{mod} := Find\left(f_{mod}\right) = 2.2\ ft$$

$$M_{modBroms} := P_u \cdot \left(e_{clay} + f_{mod}\right) - \frac{\phi_{ot} \cdot c_{soil} \cdot b \cdot f_{mod}^{\ 2}}{2} - \frac{\phi_{ot} \cdot b \cdot f_{mod}^{\ 3} \cdot Slope}{6} = 352.4 \cdot kip \cdot ft$$

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

$$M_{Broms} := P_u \cdot \left(e_{clay} + 1.5 \cdot b + 0.5 \cdot f\right) = 438.7 \cdot kip \cdot ft$$

$$M_{maxClay} := if\left(L_{ot1Clay} < 3 \cdot b, M_{modBroms}, M_{Broms}\right) = 352.4 \cdot kip \cdot ft$$ *(If L_{α} < 3b, use Modified Broms method)*

$$M_{max} := if\left(SoilType = \text{"Sand"}, M_{maxSand}, M_{maxClay}\right) = 379.5 \cdot kip \cdot ft$$

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

$Num_{bar} := 18$ *number of longitudinal bars, "RB"*

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

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

$A_{v.bar} := 0.31 \cdot in^2$ *stirrup area* SM Vol-3 13.6.2

$d_{v.bar} := 0.625 \cdot in$ *stirrup diameter*

$s_{v1} := 4 \cdot in$ *stirrup spacing, depth = 0 ft-2 ft* SM Vol-3 13.6.2

$s_{v2} := 8 \cdot in$ *stirrup spacing, depth = 2 ft-depth.stir, "RD"*

$s_{v3} := 12 \cdot in$ *stirrup spacing, depth > depth.stir, "RF"*

$depth_{stir} := 9.083 \cdot ft$ *stirrup depth, see s.v2 and s.v3 above*

$b = 5\,ft$ *shaft diameter*

$$A_{req} := \min\left(0.135 \cdot \frac{\pi \cdot b^2}{4} \cdot \frac{f_c}{F_{y.rebar}}, 0.015 \cdot \frac{\pi \cdot b^2}{4}\right) = 25.4 \cdot in^2$$ LRFD 5.7.4.2

$A_{long} := Num_{bar} \cdot A_{long.bar} = 28.1 \cdot in^2$ *total area of longitudinal steel*

$CheckLongitudinalReinf := if(A_{long} \geq A_{req}, "OK", "No\ Good")$ $CheckLongitudinalReinf = "OK"$

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

$Spacing_{vert.reinf} := Dia_{bar.circle} \cdot \frac{\pi}{Num_{bar}} = 7.9 \cdot in$ $Clearance_{vert.reinf} := Spacing_{vert.reinf} - d_{long.bar} = 6.5 \cdot in$

$CheckReinfClearSpacing := if(Clearance_{vert.reinf} \geq 6in, "OK", "No\ Good")$ $CheckReinfClearSpacing = "OK"$ SDG 3.6.10

Check Shear and Torsion

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

$$V_u := \sqrt{V_x^{\,2} + V_z^{\,2}} = 13.4 \cdot \text{kip}$$

$$T_u = 353.4 \cdot \text{kip} \cdot \text{ft}$$

Effective shear depth

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

LRFD C5.8.2.9-2

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

Check Shear Strength

$$V_c := 0.0316 \cdot (2.0) \cdot \sqrt{\frac{f_c}{\text{ksi}}} \cdot \left(\frac{b}{\text{in}}\right) \cdot \left(\frac{d_v}{\text{in}}\right) \cdot \text{kip} = 327.6 \cdot \text{kip}$$

LRFD Eqn 5.8.3.3-3 *LRFD 5.8.3.4.1* *ACI 11.3.3*

$$V_s := \frac{A_{v.bar} \cdot F_{y.rebar} \cdot d_v}{\max\left(s_{v1}, s_{v2}, s_{v3}\right)} = 67 \cdot \text{kip}$$

LRFD Eqn 5.8.3.3-4

$$\text{ShearRatio} := \frac{V_u - \phi_v \cdot V_c}{\phi_v \cdot V_s} = -4.7$$

$$\text{ShearRatio} := \text{if}\left(\text{ShearRatio} \le 0, 0, \text{ShearRatio}\right) = 0$$

Check Torsion Strength

$$A_{cp} := \pi \cdot \left(\frac{b}{2}\right)^2 = 2827.4 \cdot \text{in}^2 \qquad p_{cp} := 2 \cdot \pi \cdot \left(\frac{b}{2}\right) = 188.5 \cdot \text{in}$$

Area and perimeter of concrete cross-section

$$d_{oh} := b - 2 \cdot \left(\text{Cover} + \frac{d_{v.bar}}{2} \right) = 47.4 \cdot \text{in} \qquad p_h := \pi \cdot d_{oh} = 148.8 \cdot \text{in}$$

Diameter, perimeter and area enclosed by the centerline of the outermost closed transverse torsion reinforcement

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

$$T_{n1} := \frac{2 \cdot A_o \cdot A_{v.bar} \cdot F_{y.rebar}}{s_{v1}} = 1.2 \times 10^3 \cdot \text{kip} \cdot \text{ft}$$

LRFD Eqn 5.8.3.6.2-1

$$T_{n2} := \frac{2 \cdot A_o \cdot A_{v.bar} \cdot F_{y.rebar}}{s_{v2}} = 580.6 \cdot \text{kip} \cdot \text{ft}$$

LRFD 5.8.3.4.1

$$T_{n3} := \frac{2 \cdot A_o \cdot A_{v.bar} \cdot F_{y.rebar}}{s_{v3}} = 387.1 \cdot kip \cdot ft$$

$\phi_v = 0.9$ $\qquad T_u = 353.4 \cdot kip \cdot ft$ $\qquad L_{reqdTor} = 21\ ft$

$$Tor2_{sand} := T_u - if\left[2ft > Offset, \left[\pi \cdot b \cdot (2 \cdot ft - Offset) \cdot \gamma_{soil} \cdot \left(\frac{2 \cdot ft - Offset}{2}\right) \cdot (\omega_{fdot}) \cdot \frac{b}{2}\right], 0 \cdot kip \cdot ft\right] = 352.6 \cdot kip \cdot ft$$

$$Tor3_{sand} := T_u - if\left[depth_{stir} > Offset, \left[\pi \cdot b \cdot (depth_{stir} - Offset) \cdot \gamma_{soil} \cdot \left(\frac{depth_{stir} - Offset}{2}\right) \cdot (\omega_{fdot}) \cdot \frac{b}{2}\right], 0 \cdot kip \cdot ft\right] = 298.8 \cdot kip \cdot ft$$

$$Tor2_{clay} := T_u - if\left[2ft - 1.5ft > Offset, \left[f_{se} \cdot (\pi \cdot b) \cdot (2.0 \cdot ft - Offset - 1.5 \cdot ft) \cdot \frac{b}{2}\right], 0 \cdot kip \cdot ft\right] = 353.4 \cdot kip \cdot ft$$

$$Tor3_{clay} := T_u - if\left[depth_{stir} - 1.5ft > Offset, \left[f_{se} \cdot (\pi \cdot b) \cdot (depth_{stir} - Offset - 1.5 \cdot ft) \cdot \frac{b}{2}\right], 0 \cdot kip \cdot ft\right] = 175.7 \cdot kip \cdot ft$$

$$Tor2 := if(SoilType = \text{"Sand"}, Tor2_{sand}, Tor2_{clay}) = 352.6 \cdot kip \cdot ft$$

$$Tor3 := if(SoilType = \text{"Sand"}, Tor3_{sand}, Tor3_{clay}) = 298.8 \cdot kip \cdot ft$$

$$TorsionRatio_{n1} := \frac{T_u}{\phi_{tor} \cdot T_{n1}} = 0.3$$

$$TorsionRatio_{n2} := \frac{Tor2}{\phi_{tor} \cdot T_{n2}} = 0.61$$

$$TorsionRatio_{n3} := \frac{Tor3}{\phi_{tor} \cdot T_{n3}} = 0.77$$

$$TorsionRatio := max(TorsionRatio_{n1}, TorsionRatio_{n2}, TorsionRatio_{n3}) = 0.77$$

$$T_{cr} := 0.125\sqrt{\frac{f_c}{ksi}} \cdot \left(\frac{A_{cp}{}^2}{p_{cp} \cdot in^3}\right) \cdot kip \cdot in = 883.6 \cdot kip \cdot ft$$ *LRFD Eqn 5.8.2.1-4*

$$TorsionRatio := if(T_u \le 0.25 \cdot \phi_{tor} \cdot T_{cr}, 0, TorsionRatio) = 0.8$$ *LRFD Eqn 5.8.2.1-3*

$ShearRatio = 0$

$$CheckShearTorsion := if(ShearRatio + TorsionRatio \le 1, \text{"OK"}, \text{"No Good"})$$

$CheckShearTorsion = \text{"OK"}$

Check Maximum Spacing Transverse Reinforcement

$$v_u := \frac{V_u}{\phi_v \cdot b \cdot d_v} = 0.005744 \cdot ksi$$ $\qquad 0.125 \cdot f_c = 0.5 \cdot ksi$ *LRFD Eqn 5.8.2.9-1*

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

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

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

$\max\left(s_{v1}, s_{v2}, s_{v3}\right) = 12 \cdot in$

$\text{CheckMaxSpacingTransvReinf} := \text{if}\left(\max\left(s_{v1}, s_{v2}, s_{v3}\right) \le s_{max}, \text{"OK"}, \text{"No Good"}\right)$

$\text{CheckMaxSpacingTransvReinf} = \text{"OK"}$

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

LRFD 5.8.3.4.1

$M_u = 322.1 \cdot kip \cdot ft$

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

$$\text{LongReinf}_{shr.tor} := \frac{\frac{M_u}{\phi_v \cdot d_v} + \sqrt{\left(V_{temp}\right)^2 + \left(\frac{0.45 \cdot p_h \cdot T_u}{2 \cdot A_o \cdot \phi_v}\right)^2}}{F_{y.rebar}} = 3.4 \cdot in^2$$

$\text{Num}_{bar} \cdot A_{long.bar} = 28.1 \cdot in^2$

$\text{CheckLongReinf}_{shr.tor} := \text{if}\left(\text{Num}_{bar} \cdot A_{long.bar} \ge \text{LongReinf}_{shr.tor}, \text{"OK"}, \text{"No Good"}\right)$

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

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

Mast Arm Assembly Information

Wind Speed
○ 130 mph ● 150 mph ○ 170 mph

Signal Orientation
● Vertical
○ Horizontal

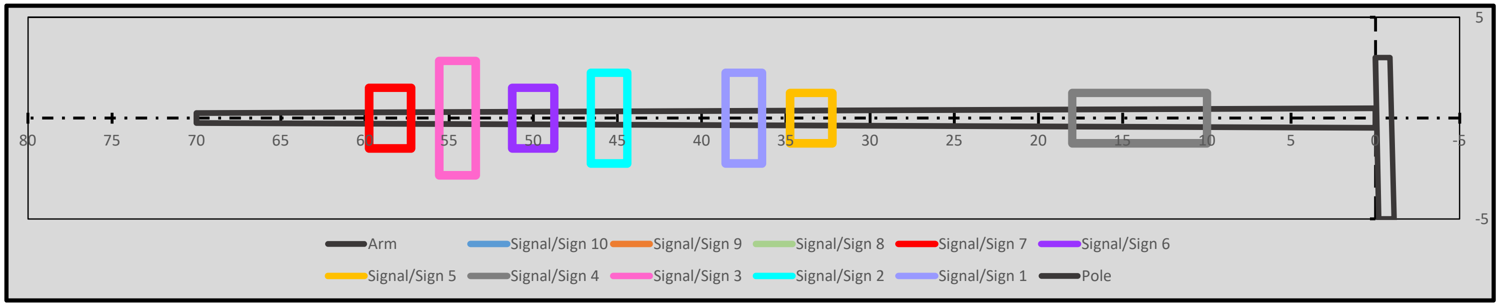
Back Plate Width
● 6.0 in.
○ 2.5 in.
○ 0 in.

Luminaire?
○ Yes
● No

Arm 1 Length
30
40
50
60
70
78

Arm 1 Length, Signal/Sign Location and Size

	Signal\Sign #10	Signal\Sign #9	Signal\Sign #8	Signal\Sign #7	Signal\Sign #6	Signal\Sign #5	Signal\Sign #4	Signal\Sign #3	Signal\Sign #2	Signal\Sign #1
Dist to Pole (ft.)	67	42	54	58.5	50	33.5	14	54.5	45.5	37.5
	● 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
Sign Width (in.)				30	30	30	96			
Sign Height (in.)				36	36	30	30			
Area (SF)	0.0	0.0	0.0	7.5	7.5	6.3	20.0	12.3	9.8	9.8
M_{wl}, (kip*ft)	0	0	0	29	25	14	19	45	30	24



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)	14	
Sign/Signal M_{wl} (kip*ft)	186	
Total Moment ($M_{extreme}$)	301	315

Mast Arm Assembly Designation

One Arm Assembly
A70/S-P5/S-DS/14/5

See separate calc for foundation

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.

Tube Wind Pressure (psf)	44.1

Fy (ksi)	50

Sign/Sig. Wind Pressure (psf)	67.0

short free-head pile in cohesionless soil using Broms method

$$\phi \cdot \frac{\gamma_{soil} \cdot b_{shaft} \cdot L_{shaft}^{3} \cdot K_p}{2} \geq M_u + P_u \cdot L_{shaft}$$

Arm Without Attachments: Dead Load Moment, Wind Load Moment and Moment Capacity at Base Connection

	Regular							Heavy Duty						
Total Arm Length (ft)	wall thk (in)	base dia (in)	S (in3)	Z (in3)	M_{dl} (kip*ft)	$M_{wl\ 130\ mph}$ (kip*ft)	M_r=φM_n (kip*ft)	wall thk (in)	base dia (in)	S (in3)	Z (in3)	M_{dl} (kip*ft)	$M_{wl\ 130mph}$ (kip*ft)	Mr=φMn (kip*ft)
30	0.25	11	23	29	10	10	107	0.25	12	27	34	11	11	125
40	0.25	13	32	40	20	20	145	0.25	14	37	47	22	22	166
50	0.3125	14	46	58	36	33	215	0.3125	15	53	67	40	37	244
60	0.375	15	63	79	56	48	300	0.375	16	72	91	62	53	340
70	0.375	17	81	103	85	71	380	0.375	18	91	115	100	77	422
78	0.375	18	91	115	110	90	422	0.375	20	113	143	130	106	512

Drilled Shaft

Index 17743 Drilled Shaft Capacities						1 Arm Assembly Loads And Capacity Check					2 Arm Assembly Loads and Capacity Check				
DS Index #	ID	Length	Diameter	φM_n	φT_n	M_u+ P_u*L_{shaft}	T_u	Check Mom. & Min Dia.	Check Torsion	Check	M_u+ P_u*L_{shaft}	T_u	Check Mom. & Min Dia.	Check Torsion	Check
1	DS/20/5	20	5	1800	589	516.6	280.8	Okay	Okay	Okay	0.0	0.0	0	0	0
2	DS/18/5	18	5	1312	477	492.8		Okay	Okay	Okay	0.0		0	0	0
3	DS/16/5	16	5	922	377	468.9		Okay	Okay	Okay	0.0		0	0	0
4	DS/16/4.5	16	4.5	829	305	468.9		NoGood	Okay	NoGood	0.0		0	0	0
5	DS/14/5	14	5	617	289	445.1		Okay	Okay	Okay	0.0		0	0	0
6	DS/14/4.5	14	4.5	556	234	445.1		NoGood	NoGood	NoGood	0.0		0	0	0
7	DS/12/4.5	12	4.5	350	172	421.3		NoGood	NoGood	NoGood	0.0		0	0	0
8	DS/12/4	12	4	311	136	421.3		NoGood	NoGood	NoGood	0.0		0	0	0

Arm 1 Attachments: Extreme Event Dead Load Moment, Wind Load Moment at Base Connection

	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	Total		
Sign/Sig Mwl (kip*ft)	0.0	0.0	0.0	29.4	25.1	14.0	18.8	44.8	29.7	24.5	186.3		
Sign/Sig 1.1*Mdl (kip*ft)	0.0	0.0	0.0	1.9	1.7	0.9	1.2	3.9	2.5	2.1	14.2		
Arm 1 Mwl (kip*ft)											94.5	102.5	*Reg Arm / HD Arm*
Arm 1 1.1*Mdl (kip*ft)											93.5	110.0	*Reg Arm / HD Arm*
*Extreme Event Arm Moment (kip*ft)*											300.8	314.9	

Ensures anchor bolts fit inside rebar cage

Min Shaft Diameter
5

Arm 2 Attachments: Extreme Event Dead Load Moment, Wind Load Moment at Base Connection

	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	Total	
Sign/Sig Mwl (kip*ft)	0.0	0.0	0.0	0.0	0.0	47.6	*24.2*	*40.2*	*15.0*	*7.8*	134.8	
Sign/Sig 1.1*Mdl (kip*ft)	0.0	0.0	0.0	0.0	0.0	4.2	*2.0*	*2.6*	*1.3*	*0.7*	10.8	
Arm 2 Mwl (kip*ft)											0.0	0.0
Arm 2 1.1*Mdl (kip*ft)											0.0	0.0
											0.0	0.0

Required Drilled Shaft Index Number Required (see Table for size)

Load Case	1 Arm DS Index #	2 Arm DS Index #
Drilled Shaft Index req'd for Overturning including Min. Diamter	5	0
Drilled Shaft Index req'd for Torsion	5	0
Drilled Shaft Controlling Load Case	5	#N/A

Pole Base Shears & Moments

	Arm 1 Shear	Arm 1 Moment	Arm 2 Shear	Arm 2 Moment	
dl att	N/A	14.2	N/A	0.0	
dl arm	N/A	93.5	N/A	0.0	
wl pole	2.6	52.9	0.0	0.0	*assume a 37.5' pole wl with lum*
wl att	4.9	107.6	0.0	0.0	
wl arm	4.4	96.2	0.0	0.0	
Tor wl att	N/A	186.3	N/A	0.0	
Tor wl arm	N/A	94.5	N/A	0.0	

Forces at Top of DS

	One Arm	Two Arms	
Moment dl	107.7	N/A	
Moment wl	256.7		
Moment Total	278.4	0.0	
Torsion	280.8	0.0	
Shear	11.9	0.0	
Shaft 2-Arm Factor	*1.1*		*used for OT & Torsion*

Pole ID

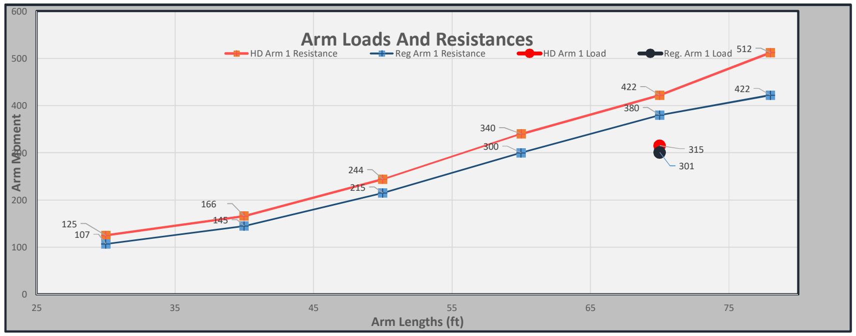
Arm 1 Length	70	Arm 2 Length	0
	Pole ID	P5	

1 Arm Assembly	Use Regular Arm						
Design Arm Designation			**Pole Designation**			**Drilled Shaft**	
A70	/S		P5	/S		DS	
A70/S-			P5/S-			DS/14/5	
A70/S-P5/S-DS/14/5							

2 Arm Assembly	Use Regular Arm						
Design Arm Designation			**Pole Designation**			**Drilled Shaft**	
						DS	
-			-				

Assembly ID	A70/S-P5/S-DS/14/5	
	Arm 1	Arm 2
Arm Length(s)	70	0
Max Design CFI %	0.95	
Est. Regular Arm CFI	0.83	0.00
Est. HD Arm CFI	0.79	0.00

Note: Poles are designed to have a smaller CFI than Arms



Drilled Shaft Foundation for
Sign, Signal, and Lighting Support Structures v1.1

State Structures Design Office

SUBJECT: Moccasin Wallow Road
Struct # T-17-3 LOCATION: Sta. 384+81.6, 78.1' RT

DESIGNED BY: MPR DATE: 12/2021
CHECKED BY: DATE: 12/2021

Program Changes

SoilType :=
- Sand
- Clay

$\phi_{soil} := 29 \cdot deg$ *soil friction angle (sand)*

$c_{soil} := 1.25 \cdot \frac{kip}{ft^2}$ *soil shear strength (clay)*

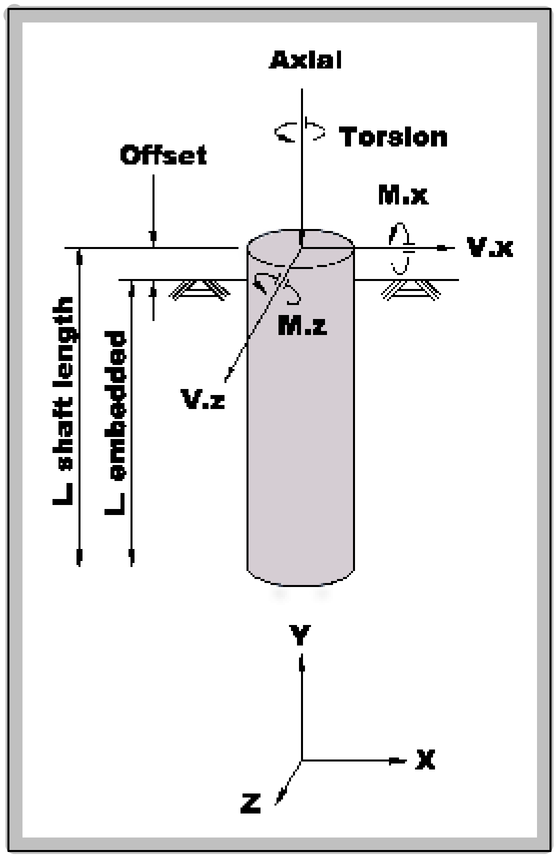
$N_{blows} := 10$ *number of blows per foot. If N< 5, contact the district geotech Engineer*

$\gamma_{soil} := 42.6 \cdot pcf$ *effective soil weight (typical design value = 45 ~ 50 pcf)*

Geometry

$b := 5 \cdot ft$ *shaft diameter, "DB"*

$Offset := 0.5 \cdot ft$ *groundline to top of foundation*



Applied Loads (Extreme I)

$M_x := 256.7 \cdot kip \cdot ft$ $V_x := 0 \cdot kip$ $Torsion := 280.8 \cdot kip \cdot ft$

$M_z := 107.7 \cdot kip \cdot ft$ $V_z := 11.9 \cdot kip$ $Axial := 4.0 \cdot kip$

StructureType :=
- Cantilever Overhead Sign Structure
- Mast Arm Signal Structure
- Concrete/Steel Strain Poles
- Ground Sign

$StructureType = 1$

$\phi_{ot} := if(StructureType = 3, 0.8, 0.6)$ $\phi_{ot} = 0.6$ *ϕ factor against overturning [SM Vol-3 13.6.1.1]*

$\phi_{tor} := if(StructureType = 0, 0.9, 1.0)$ $\phi_{tor} = 1$ *ϕ factor against torsion [SM Vol-3 13.6.1.1]*

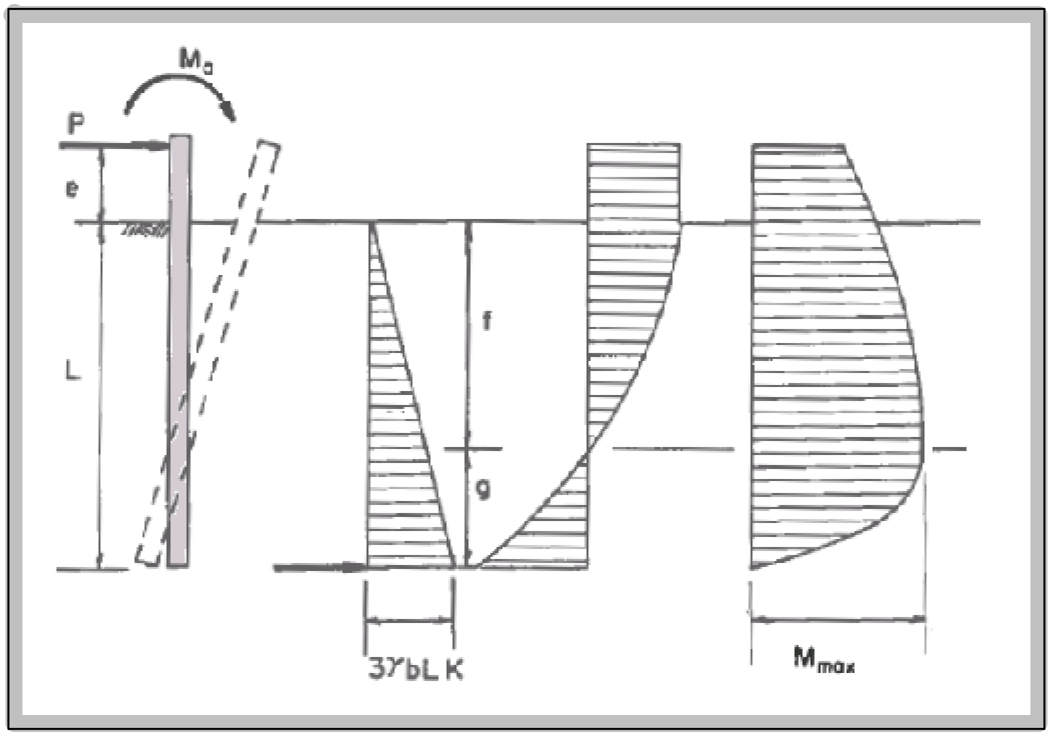
Shaft Depth Required to Resist Overturning

$$M_u := \sqrt{M_x^{\,2} + M_z^{\,2}} = 278.4 \cdot \text{kip} \cdot \text{ft}$$

$$P_u := \sqrt{V_x^{\,2} + V_z^{\,2}} = 11.9 \cdot \text{kip}$$

$$T_u := \text{Torsion} = 280.8 \cdot \text{kip} \cdot \text{ft}$$

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.

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

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

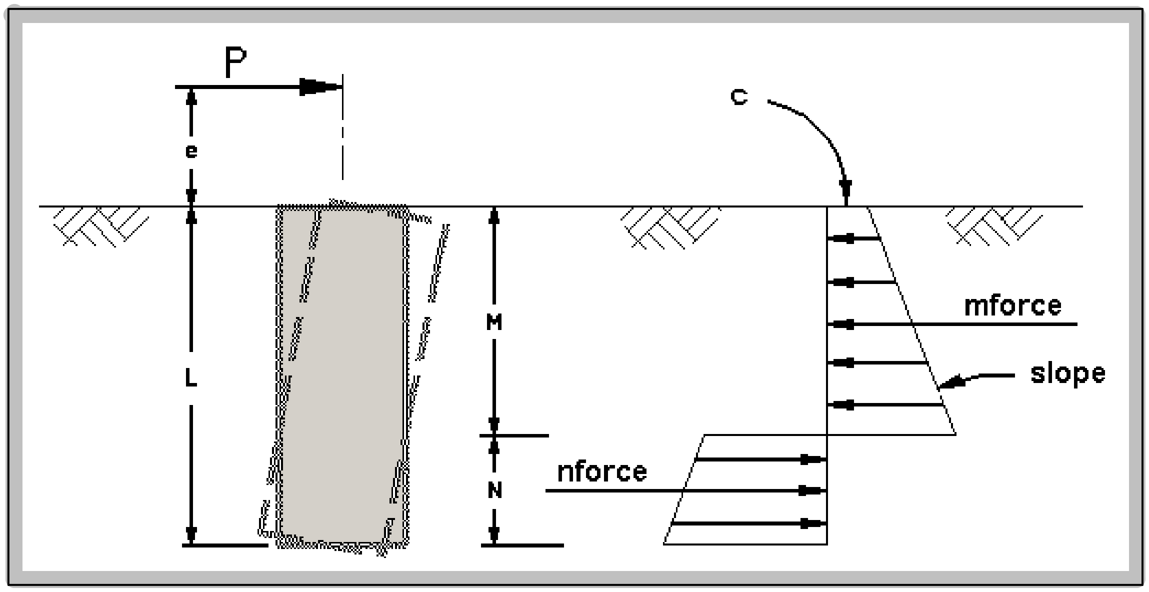
Given $P_u \cdot \left(e_{sand} + L_{otSand}\right) + M_u = \phi_{ot} \cdot \left[\left(3 \cdot \gamma_{soil} \cdot b \cdot L_{otSand} \cdot K_p\right) \cdot \left(\frac{1}{2} \cdot L_{otSand}\right) \cdot \left(\frac{1}{3} \cdot L_{otSand}\right)\right]$

$$L_{otSand} := \text{Find}\left(L_{otSand}\right) = 13.4\ \text{ft}$$

$$L_{otSand} := \text{ceil}\left(\frac{L_{otSand}}{\text{ft}}\right) \cdot \text{ft} = 14\ \text{ft}$$

(round up to next foot)

*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.

$c_{soil} := \text{if}\left(c_{soil} = 0 \cdot ksf, 0.1 \cdot ksf, c_{soil}\right) = 1.3 \cdot ksf$

$Slope := 8 \cdot \frac{c_{soil}}{3 \cdot b} = 0.7 \cdot \frac{kip}{ft^3}$ $\qquad e_{clay} := \frac{M_u}{P_u} + Offset = 23.9\ ft$

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

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

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

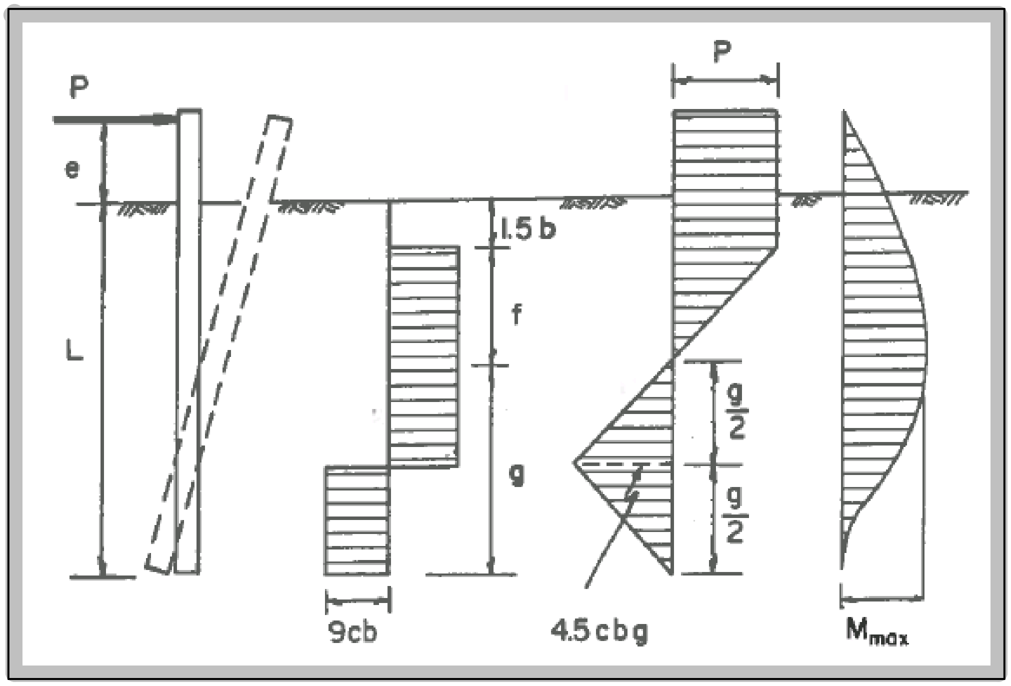
Guess value $\qquad M := 4.0 \cdot ft \qquad N := 4.0 \cdot ft$

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

$\begin{pmatrix} M \\ N \end{pmatrix} := \text{Find}(M,N) \qquad L_{ot1Clay} := M + N = 10.8\ ft$

$L_{ot1Clay} := \text{ceil}\left(\frac{L_{ot1Clay}}{ft}\right) \cdot ft = 11\ ft$ $\qquad$ *(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.*

$$f := \frac{P_u}{\phi_{ot} \cdot 9 \cdot c_{soil} \cdot b} = 0.4\ ft$$

$$M_{max.clay} := P_u \cdot \left(e_{clay} + 1.5 \cdot b + 0.5 \cdot f\right) = 375.7 \cdot kip \cdot ft$$

$$g := \sqrt{\frac{M_{max.clay}}{2.25 \cdot \phi_{ot} \cdot c_{soil} \cdot b}} = 6.7\ ft$$

$$L_{ot2Clay} := \left(1.5 \cdot b + f + g\right) = 14.5\ ft$$

$$L_{ot2Clay} := ceil\left(\frac{L_{ot2Clay}}{ft}\right) \cdot ft = 15\ ft$$ *(round up to next foot)*

$$L_{otClay} := if\left(L_{ot1Clay} < 3 \cdot b, L_{ot1Clay}, L_{ot2Clay}\right) = 3.4$$ *(If* $L_{ot} < 3b$*, use Modified Broms method)*

$$L_{reqdOT} := if\left(SoilType = \text{"Sand"}, L_{otSand}, L_{otClay}\right)$$

$L_{reqdOT} = 14\ ft$ *required shaft embedment depth to resist overturning*

Shaft Depth Required to Resist Torsion

*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.

$N_{blows} = 10$

$\omega_{fdot} := \text{if}\left(N_{blows} < 5, 0, \text{if}\left(N_{blows} \geq 15, 1.5, 1.5 \cdot \frac{N_{blows}}{15}\right)\right) = 1$

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 $L_{torSand} := L_{reqdOT} = 14\,\text{ft}$

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

$L_{torSand} := \text{Find}(L_{torSand}) = 18.3\,\text{ft}$

$L_{torSand} := \text{ceil}\left(\frac{L_{torSand}}{\text{ft}}\right) \cdot \text{ft} = 19\,\text{ft}$ *(round up to next foot)*

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

$\text{CohesionFactor} := 0.55$

$f_{se} := \text{CohesionFactor} \cdot c_{soil} = 0.7 \cdot \text{ksf}$

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

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

$L_{torClay} := \text{Find}(L_{torClay}) = 11.9\,\text{ft}$

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

$L_{reqdTor} := \text{if}(\text{SoilType} = \text{"Sand"}, L_{torSand}, L_{torClay})$

$L_{reqdTor} = 19\,\text{ft}$ *required shaft embedment depth to resist torsion*

$L_{embedded} := \text{if}(L_{reqdTor} > L_{reqdOT}, L_{reqdTor}, L_{reqdOT}) = 5.8$

$L_{shaft.length} := L_{embedded} + \text{Offset}$

$L_{shaft.length} = 19.5\,\text{ft}$ *shaft length*

Maximum Moment in Shaft

short free-head pile in cohesionless soil using Broms method

$$f_{sand} := \sqrt{\frac{2 \cdot P_u}{3 \cdot \gamma_{soil} \cdot b \cdot K_p \cdot \phi_{ot}}} = 4.6\ ft$$

$$M_{maxSand} := P_u \cdot \left(e_{sand} + f_{sand}\right) - \frac{P_u \cdot f_{sand}}{3} + M_u = 321.1 \cdot kip \cdot ft$$

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

$$f_{mod} := Find\left(f_{mod}\right) = 2.1\ ft$$

$$M_{modBroms} := P_u \cdot \left(e_{clay} + f_{mod}\right) - \frac{\phi_{ot} \cdot c_{soil} \cdot b \cdot f_{mod}^{\ 2}}{2} - \frac{\phi_{ot} \cdot b \cdot f_{mod}^{\ 3} \cdot Slope}{6} = 298 \cdot kip \cdot ft$$

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

$$M_{Broms} := P_u \cdot \left(e_{clay} + 1.5 \cdot b + 0.5 \cdot f\right) = 375.7 \cdot kip \cdot ft$$

$$M_{maxClay} := if\left(L_{ot1Clay} < 3 \cdot b, M_{modBroms}, M_{Broms}\right) = 298 \cdot kip \cdot ft$$

(If $L_{\alpha} < 3b$, use Modified Broms method)

$$M_{max} := if\left(SoilType = \text{"Sand"}, M_{maxSand}, M_{maxClay}\right) = 321.1 \cdot kip \cdot ft$$

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*

$Num_{bar} := 18$ *number of longitudinal bars, "RB"*

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

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

$A_{v.bar} := \mathbf{0.31} \cdot in^2$ *stirrup area* *SM Vol-3 13.6.2*

$d_{v.bar} := \mathbf{0.625} \cdot in$ *stirrup diameter*

$s_{v1} := \mathbf{4} \cdot in$ *stirrup spacing, depth = 0 ft-2 ft* *SM Vol-3 13.6.2*

$s_{v2} := 8 \cdot in$ *stirrup spacing, depth = 2 ft-depth.stir, "RD"*

$s_{v3} := 12 \cdot in$ *stirrup spacing, depth > depth.stir, "RF"*

$depth_{stir} := 9.083 \cdot ft$ *stirrup depth, see s.v2 and s.v3 above*

$b = 5\,ft$ *shaft diameter*

$$A_{req} := \min\left(0.135 \cdot \frac{\pi \cdot b^2}{4} \cdot \frac{f_c}{F_{y.rebar}}, 0.015 \cdot \frac{\pi \cdot b^2}{4}\right) = 25.4 \cdot in^2$$ *LRFD 5.7.4.2*

$A_{long} := Num_{bar} \cdot A_{long.bar} = 28.1 \cdot in^2$ *total area of longitudinal steel*

$CheckLongitudinalReinf := if\left(A_{long} \ge A_{req}, \text{"OK"}, \text{"No Good"}\right)$ $CheckLongitudinalReinf = \text{"OK"}$

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

$Spacing_{vert.reinf} := Dia_{bar.circle} \cdot \frac{\pi}{Num_{bar}} = 7.9 \cdot in$ $Clearance_{vert.reinf} := Spacing_{vert.reinf} - d_{long.bar} = 6.5 \cdot in$

$CheckReinfClearSpacing := if\left(Clearance_{vert.reinf} \ge 6in, \text{"OK"}, \text{"No Good"}\right)$ $CheckReinfClearSpacing = \text{"OK"}$ *SDG 3.6.10*

Check Shear and Torsion

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

$$V_u := \sqrt{V_x^2 + V_z^2} = 11.9 \cdot kip$$

$$T_u = 280.8 \cdot kip \cdot ft$$

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

$$V_c := 0.0316 \cdot (2.0) \cdot \sqrt{\frac{f_c}{ksi}} \cdot \left(\frac{b}{in}\right) \cdot \left(\frac{d_v}{in}\right) \cdot kip = 327.6 \cdot kip$$

LRFD Eqn 5.8.3.3-3 *LRFD 5.8.3.4.1* *ACI 11.3.3*

$$V_s := \frac{A_{v.bar} \cdot F_{y.rebar} \cdot d_v}{\max(s_{v1}, s_{v2}, s_{v3})} = 67 \cdot kip$$

LRFD Eqn 5.8.3.3-4

$$ShearRatio := \frac{V_u - \phi_v \cdot V_c}{\phi_v \cdot V_s} = -4.7$$

$$ShearRatio := if(ShearRatio \le 0, 0, ShearRatio) = 0$$

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

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

$$T_{n1} := \frac{2 \cdot A_o \cdot A_{v.bar} \cdot F_{y.rebar}}{s_{v1}} = 1.2 \times 10^3 \cdot kip \cdot ft$$

LRFD Eqn 5.8.3.6.2-1

$$T_{n2} := \frac{2 \cdot A_o \cdot A_{v.bar} \cdot F_{y.rebar}}{s_{v2}} = 580.6 \cdot kip \cdot ft$$

LRFD 5.8.3.4.1

$$T_{n3} := \frac{2 \cdot A_o \cdot A_{v.bar} \cdot F_{y.rebar}}{s_{v3}} = 387.1 \cdot kip \cdot ft$$

$\phi_v = 0.9$ $\qquad$ $T_u = 280.8 \cdot kip \cdot ft$ $\qquad$ $L_{reqdTor} = 19\,ft$

$$Tor2_{sand} := T_u - if\left[2ft > Offset, \left[\pi \cdot b \cdot (2 \cdot ft - Offset) \cdot \gamma_{soil} \cdot \left(\frac{2 \cdot ft - Offset}{2}\right) \cdot (\omega_{fdot}) \cdot \frac{b}{2}\right], 0 \cdot kip \cdot ft\right] = 278.9 \cdot kip \cdot ft$$

$$Tor3_{sand} := T_u - if\left[depth_{stir} > Offset, \left[\pi \cdot b \cdot (depth_{stir} - Offset) \cdot \gamma_{soil} \cdot \left(\frac{depth_{stir} - Offset}{2}\right) \cdot (\omega_{fdot}) \cdot \frac{b}{2}\right], 0 \cdot kip \cdot ft\right] = 219.2 \cdot kip \cdot ft$$

$$Tor2_{clay} := T_u - if\left[2ft - 1.5ft > Offset, \left[f_{se} \cdot (\pi \cdot b) \cdot (2.0 \cdot ft - Offset - 1.5 \cdot ft) \cdot \frac{b}{2}\right], 0 \cdot kip \cdot ft\right] = 280.8 \cdot kip \cdot ft$$

$$Tor3_{clay} := T_u - if\left[depth_{stir} - 1.5ft > Offset, \left[f_{se} \cdot (\pi \cdot b) \cdot (depth_{stir} - Offset - 1.5 \cdot ft) \cdot \frac{b}{2}\right], 0 \cdot kip \cdot ft\right] = 89.6 \cdot kip \cdot ft$$

$$Tor2 := if(SoilType = \text{"Sand"}, Tor2_{sand}, Tor2_{clay}) = 278.9 \cdot kip \cdot ft$$

$$Tor3 := if(SoilType = \text{"Sand"}, Tor3_{sand}, Tor3_{clay}) = 219.2 \cdot kip \cdot ft$$

$$TorsionRatio_{n1} := \frac{T_u}{\phi_{tor} \cdot T_{n1}} = 0.24$$

$$TorsionRatio_{n2} := \frac{Tor2}{\phi_{tor} \cdot T_{n2}} = 0.48$$

$$TorsionRatio_{n3} := \frac{Tor3}{\phi_{tor} \cdot T_{n3}} = 0.57$$

$$TorsionRatio := max(TorsionRatio_{n1}, TorsionRatio_{n2}, TorsionRatio_{n3}) = 0.57$$

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

LRFD Eqn 5.8.2.1-4

$$TorsionRatio := if(T_u \le 0.25 \cdot \phi_{tor} \cdot T_{cr}, 0, TorsionRatio) = 0.6$$

LRFD Eqn 5.8.2.1-3

$ShearRatio = 0$

$CheckShearTorsion := if(ShearRatio + TorsionRatio \le 1, \text{"OK"}, \text{"No Good"})$

$CheckShearTorsion = \text{"OK"}$

Check Maximum Spacing Transverse Reinforcement

$v_u := \frac{V_u}{\phi_v \cdot b \cdot d_v} = 0.005101 \cdot ksi$ $\qquad$ $0.125 \cdot f_c = 0.5 \cdot ksi$

LRFD Eqn 5.8.2.9-1

$s_{max1} := \text{if}\left(0.8 \cdot d_v < 24 \cdot in, 0.8 d_v, 24 \cdot in\right) = 24 \cdot in$ LRFD Eqn 5.8.2.7-1

$s_{max2} := \text{if}\left(0.4 \cdot d_v < 12 \cdot in, 0.4 d_v, 12 \cdot in\right) = 12 \cdot in$ LRFD Eqn 5.8.2.7-2

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

$\max\left(s_{v1}, s_{v2}, s_{v3}\right) = 12 \cdot in$

$\text{CheckMaxSpacingTransvReinf} := \text{if}\left(\max\left(s_{v1}, s_{v2}, s_{v3}\right) \le s_{max}, \text{"OK"}, \text{"No Good"}\right)$

$\text{CheckMaxSpacingTransvReinf} = \text{"OK"}$

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

LRFD 5.8.3.4.1

$M_u = 278.4 \cdot kip \cdot ft$

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

$$\text{LongReinf}_{shr.tor} := \frac{\dfrac{M_u}{\phi_v \cdot d_v} + \sqrt{\left(V_{temp}\right)^2 + \left(\dfrac{0.45 \cdot p_h \cdot T_u}{2 \cdot A_o \cdot \phi_v}\right)^2}}{F_{y.rebar}} = 2.8 \cdot in^2$$

$\text{Num}_{bar} \cdot A_{long.bar} = 28.1 \cdot in^2$

$\text{CheckLongReinf}_{shr.tor} := \text{if}\left(\text{Num}_{bar} \cdot A_{long.bar} \ge \text{LongReinf}_{shr.tor}, \text{"OK"}, \text{"No Good"}\right)$

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

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

Mast Arm Assembly Information

Wind Speed
○ 130 mph ● 150 mph ○ 170 mph

Signal Orientation
● Vertical
○ Horizontal

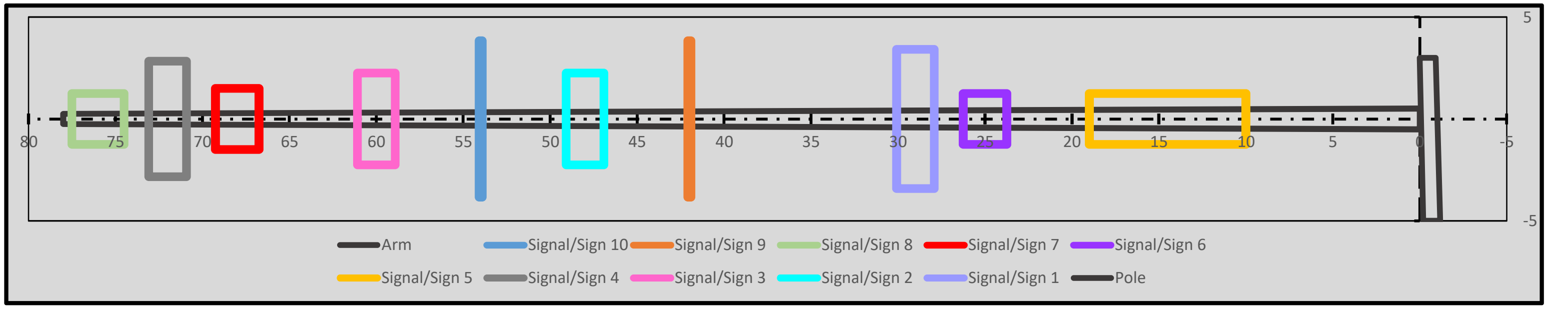
Back Plate Width
● 6.0 in.
○ 2.5 in.
○ 0 in.

Luminaire?
○ Yes
● No

Arm 1 Length
30
40
50
60
70
78

Arm 1 Length, Signal/Sign Location and Size

	Signal\Sign #10	Signal\Sign #9	Signal\Sign #8	Signal\Sign #7	Signal\Sign #6	Signal\Sign #5	Signal\Sign #4	Signal\Sign #3	Signal\Sign #2	Signal\Sign #1
Dist to Pole (ft.)	54	42	76	68	25	14.5	72	60	48	29
	○ 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
Sign Width (in.)	2	2	36	30	30	108				
Sign Height (in.)	92	92	30	36	30	30				
Area (SF)	1.3	1.3	7.5	7.5	6.3	22.5	12.3	9.8	9.8	14.8
M_{wl}. (kip*ft)	5	4	38	34	10	22	59	39	31	29



Arm 1 Length (ft)	78	
Design Standard Index 17743	Regular	Heavy Duty
Dia. at Arm Base (in)	18	20
Wall Thickness (in)	0.3750	0.3750
Resistance (M_r=ϕM_n) (kip*ft)	422	512

Arm 1 Loads	Regular	Heavy Duty
1.1*Arm M_{dl} (kip*ft)	121	143
Arm M_{wl} (kip*ft)	120	141
1.1*Sign/Signal M_{dl} (kip*ft)	21	
Sign/Signal M_{wl} (kip*ft)	271	
Total Moment ($M_{extreme}$)	416	444

Mast Arm Assembly Designation

One Arm Assembly
A78/S/H-P6/S-DS/18/5

See separate calc
for foundation

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.

Tube Wind Pressure (psf)	44.1

Fy (ksi)	50

Sign/Sig. Wind Pressure (psf)	67.0

short free-head pile in cohesionless soil using Broms method

$$\phi \cdot \frac{\gamma_{soil} \cdot b_{shaft} \cdot L_{shaft}^{3} \cdot K_p}{2} \geq M_u + P_u \cdot L_{shaft}$$

Arm Without Attachments: Dead Load Moment, Wind Load Moment and Moment Capacity at Base Connection

	Regular							Heavy Duty						
Total Arm Length (ft)	wall thk (in)	base dia (in)	S (in3)	Z (in3)	M_{dl} (kip*ft)	$M_{wl\ 130\ mph}$ (kip*ft)	M_r=ϕM_n (kip*ft)	wall thk (in)	base dia (in)	S (in3)	Z (in3)	M_{dl} (kip*ft)	$M_{wl\ 130mph}$ (kip*ft)	Mr=ϕMn (kip*ft)
30	0.25	11	23	29	10	10	107	0.25	12	27	34	11	11	125
40	0.25	13	32	40	20	20	145	0.25	14	37	47	22	22	166
50	0.3125	14	46	58	36	33	215	0.3125	15	53	67	40	37	244
60	0.375	15	63	79	56	48	300	0.375	16	72	91	62	53	340
70	0.375	17	81	103	85	71	380	0.375	18	91	115	100	77	422
78	0.375	18	91	115	110	90	422	0.375	20	113	143	130	106	512

Drilled Shaft

Index 17743 Drilled Shaft Capacities						1 Arm Assembly Loads And Capacity Check					2 Arm Assembly Loads and Capacity Check				
DS Index #	ID	Length	Diameter	ϕM_n	ϕT_n	M_u+ P_u*L_{shaft}	T_u	Check Mom. & Min Dia.	Check Torsion	Check	M_u+ P_u*L_{shaft}	T_u	Check Mom. & Min Dia.	Check Torsion	Check
1	DS/20/5	20	5	1800	589	657.4	391.2	Okay	Okay	Okay	0.0	0.0	0	0	0
2	DS/18/5	18	5	1312	477	628.2		Okay	Okay	Okay	0.0		0	0	0
3	DS/16/5	16	5	922	377	599.0		Okay	NoGood	NoGood	0.0		0	0	0
4	DS/16/4.5	16	4.5	829	305	599.0		NoGood	NoGood	NoGood	0.0		0	0	0
5	DS/14/5	14	5	617	289	569.8		Okay	NoGood	NoGood	0.0		0	0	0
6	DS/14/4.5	14	4.5	556	234	569.8		NoGood	NoGood	NoGood	0.0		0	0	0
7	DS/12/4.5	12	4.5	350	172	540.6		NoGood	NoGood	NoGood	0.0		0	0	0
8	DS/12/4	12	4	311	136	540.6		NoGood	NoGood	NoGood	0.0		0	0	0

Arm 1 Attachments: Extreme Event Dead Load Moment, Wind Load Moment at Base Connection

	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	Total		
Sign/Sig Mwl (kip*ft)	4.6	3.6	38.2	34.2	10.5	21.9	59.2	39.2	31.3	28.8	271.4		
Sign/Sig 1.1*Mdl (kip*ft)	0.3	0.2	2.5	2.2	0.7	1.4	5.1	3.3	2.6	2.6	21.1		
Arm 1 Mwl (kip*ft)											119.8	141.1	*Reg Arm / HD Arm*
Arm 1 1.1*Mdl (kip*ft)											121.0	143.0	*Reg Arm / HD Arm*
*Extreme Event Arm Moment (kip*ft)*											416.2	444.4	

Ensures anchor bolts fit inside rebar cage

Min Shaft Diameter
5

Required Drilled Shaft Index Number Required (see Table for size)

Load Case	1 Arm DS Index #	2 Arm DS Index #
Drilled Shaft Index req'd for Overturning including Min. Diamter	5	0
Drilled Shaft Index req'd for Torsion	2	0
Drilled Shaft Controlling Load Case	**2**	**#N/A**

Pole Base Shears & Moments

	Arm 1 Shear	Arm 1 Moment	Arm 2 Shear	Arm 2 Moment
dl att	N/A	21.1	N/A	0.0
dl arm	N/A	143.0	N/A	0.0
wl pole	2.6	63.5	0.0	0.0
wl att	6.2	136.9	0.0	0.0
wl arm	5.7	126.1	0.0	0.0
Tor wl att	N/A	271.4	N/A	0.0
Tor wl arm	N/A	119.8	N/A	0.0

assume a 37.5' pole wl with lum

Forces at Top of DS

	One Arm	Two Arms
Moment dl	164.1	N/A
Moment wl	326.5	
Moment Total	365.4	0.0
Torsion	391.2	0.0
Shear	14.6	0.0
	Shaft 2-Arm Factor	*1.1*

used for OT & Torsion

Arm 2 Attachments: Extreme Event Dead Load Moment, Wind Load Moment at Base Connection

	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	Total	
Sign/Sig Mwl (kip*ft)	0.0	0.0	0.0	0.0	0.0	47.6	*24.2*	*40.2*	*15.0*	*7.8*	134.8	
Sign/Sig 1.1*Mdl (kip*ft)	0.0	0.0	0.0	0.0	0.0	4.2	*2.0*	*2.6*	*1.3*	*0.7*	10.8	
Arm 2 Mwl (kip*ft)											0.0	0.0
Arm 2 1.1*Mdl (kip*ft)											0.0	0.0
											0.0	0.0

Pole ID

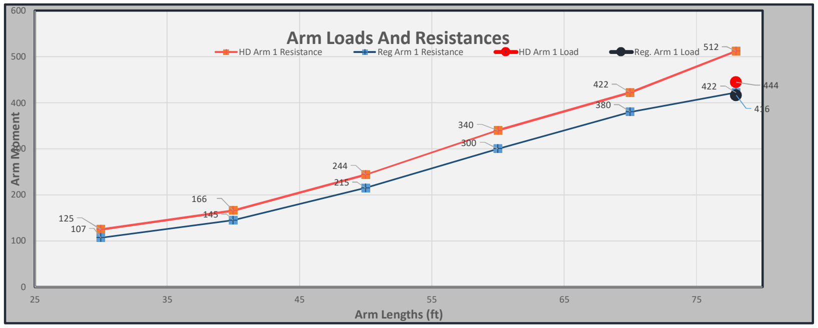
Arm 1 Length	78	Arm 2 Length	0
	Pole ID	P6	

1 Arm Assembly	Use Heavy Duty Arm						
Design Arm Designation			**Pole Designation**			**Drilled Shaft**	
A78	/S	/H	P6	/S		DS	
A78/S/H-			P6/S-			DS/18/5	
A78/S/H-P6/S-DS/18/5							

2 Arm Assembly	Use Regular Arm						
Design Arm Designation			**Pole Designation**			**Drilled Shaft**	
						DS	
-			-				

Assembly ID	A78/S/H-P6/S-DS/18/5	
	Arm 1	**Arm 2**
Arm Length(s)	78	0
Max Design CFI %	0.95	
Est. Regular Arm CFI	1.04	0.00
Est. HD Arm CFI	0.91	0.00

Note: Poles are designed to have a smaller CFI than Arms



Drilled Shaft Foundation for Sign, Signal, and Lighting Support Structures v1.1

FDOT
State Structures Design Office

SUBJECT: Moccasin Wallow Road
Struct # T-17-4 LOCATION: Sta. 384+81.6, 78.1' RT

DESIGNED BY: MPR DATE: 12/2021
CHECKED BY: DATE: 12/2021

Program Changes

$\mathrm{SoilType} :=$
- [✓ Sand]
- Clay

$\phi_{soil} := 29 \cdot deg$ *soil friction angle (sand)*

$c_{soil} := 1.25 \cdot \frac{kip}{ft^2}$ *soil shear strength (clay)*

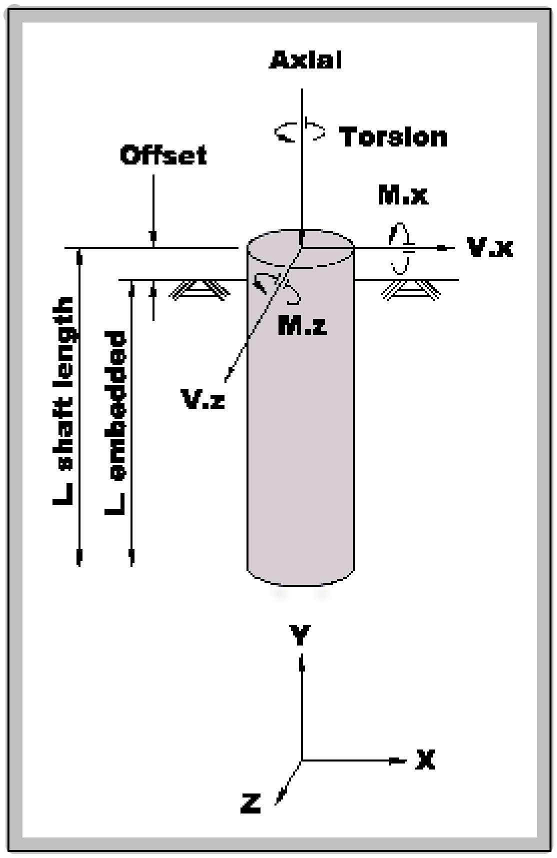
$N_{blows} := 9$ *number of blows per foot. If N< 5, contact the district geotech Engineer*

$\gamma_{soil} := 42.6 \cdot pcf$ *effective soil weight (typical design value = 45 ~ 50 pcf)*

Geometry

$b := 5 \cdot ft$ *shaft diameter, "DB"*

$\mathrm{Offset} := 0.5 \cdot ft$ *groundline to top of foundation*



Applied Loads (Extreme I)

$M_x := 326.5 \cdot kip \cdot ft$ $V_x := 0 \cdot kip$ $\mathrm{Torsion} := 391.2 \cdot kip \cdot ft$

$M_z := 164.1 \cdot kip \cdot ft$ $V_z := 14.6 \cdot kip$ $\mathrm{Axial} := 4.0 \cdot kip$

$\mathrm{StructureType} :=$
- Cantilever Overhead Sign Structure
- [✓ Mast Arm Signal Structure]
- Concrete/Steel Strain Poles
- Ground Sign

$\mathrm{StructureType} = 1$

$\phi_{ot} := \mathrm{if}(\mathrm{StructureType} = 3, 0.8, 0.6)$ $\phi_{ot} = 0.6$ *ϕ factor against overturning [SM Vol-3 13.6.1.1]*

$\phi_{tor} := \mathrm{if}(\mathrm{StructureType} = 0, 0.9, 1.0)$ $\phi_{tor} = 1$ *ϕ factor against torsion [SM Vol-3 13.6.1.1]*

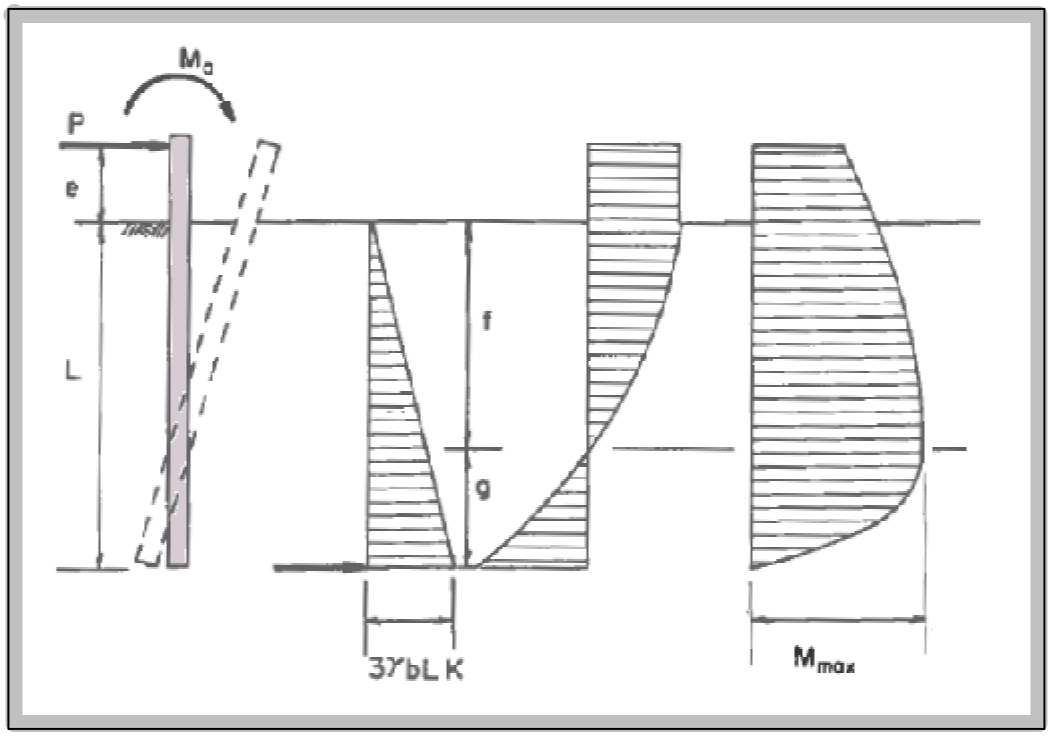
Shaft Depth Required to Resist Overturning

$M_u := \sqrt{M_x^{\,2} + M_z^{\,2}} = 365.4 \cdot \text{kip} \cdot \text{ft}$

$P_u := \sqrt{V_x^{\,2} + V_z^{\,2}} = 14.6 \cdot \text{kip}$

$T_u := \text{Torsion} = 391.2 \cdot \text{kip} \cdot \text{ft}$

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.

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

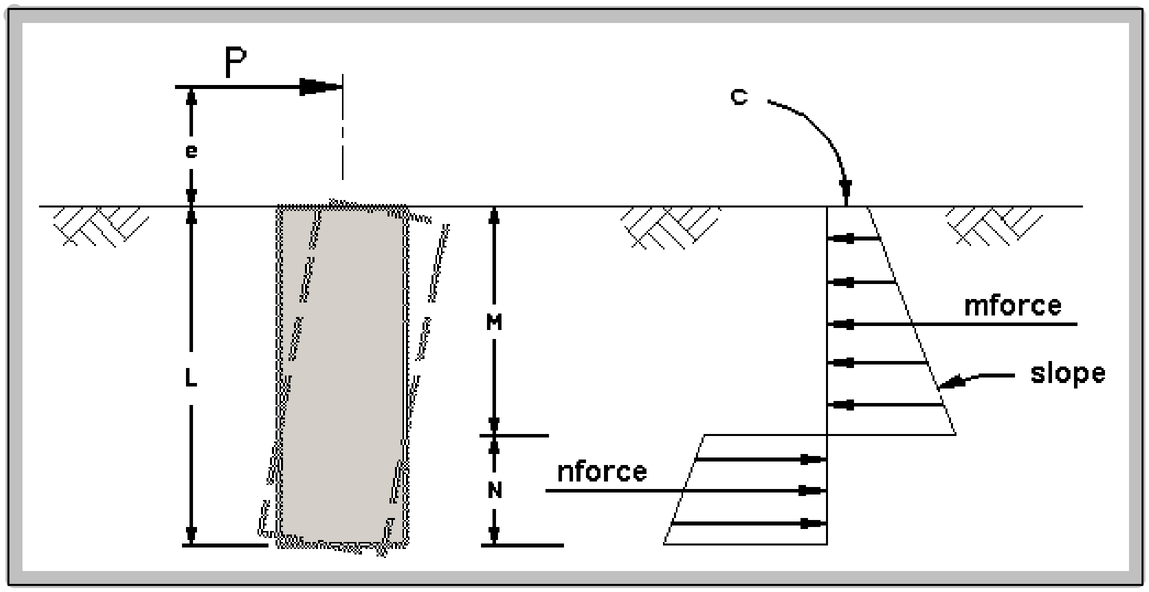
Guess value $\qquad L_{otSand} := 8 \cdot \text{ft}$

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

$L_{otSand} := \text{Find}\left(L_{otSand}\right) = 14.7\ \text{ft}$

$L_{otSand} := \text{ceil}\left(\dfrac{L_{otSand}}{\text{ft}}\right) \cdot \text{ft} = 15\ \text{ft}$ $\qquad$ *(round up to next foot)*

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.

$c_{soil} := \text{if}\left(c_{soil} = 0\cdot ksf, 0.1\cdot ksf, c_{soil}\right) = 1.3\cdot ksf$

$Slope := 8\cdot\frac{c_{soil}}{3\cdot b} = 0.7\cdot\frac{kip}{ft^3}$ $\qquad e_{clay} := \frac{M_u}{P_u} + Offset = 25.5\ ft$

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

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

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

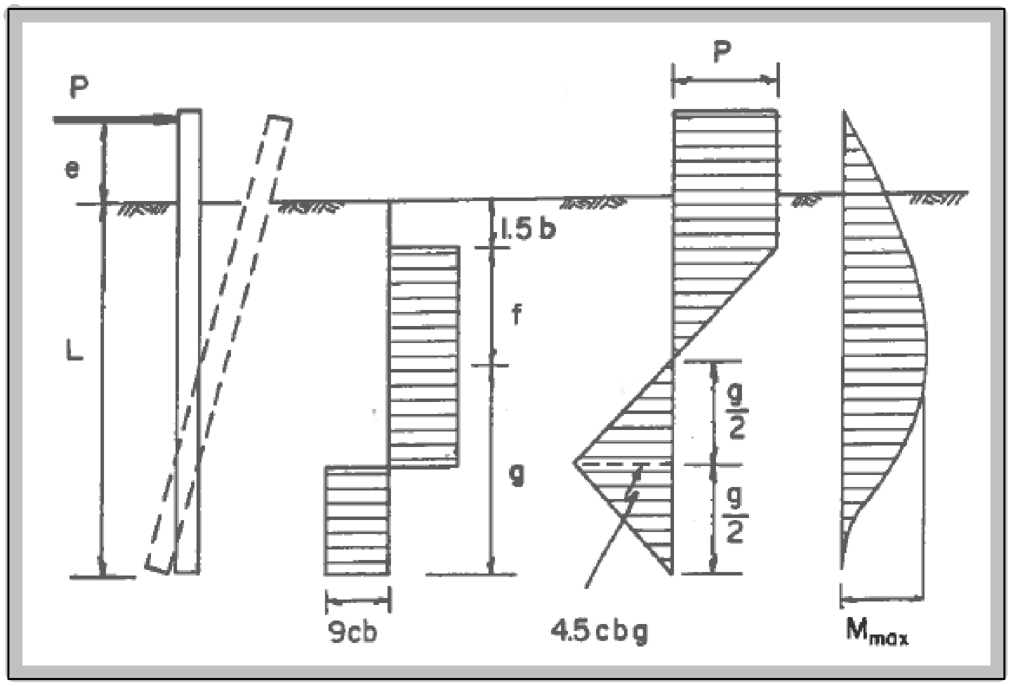
Guess value $\qquad M := 4.0\cdot ft \qquad N := 4.0\cdot ft$

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

$\begin{pmatrix} M \\ N \end{pmatrix} := Find(M,N) \qquad L_{ot1Clay} := M + N = 12.0\ ft$

$L_{ot1Clay} := ceil\left(\frac{L_{ot1Clay}}{ft}\right)\cdot ft = 13\ ft$ $\qquad$ *(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.*

$$f := \frac{P_u}{\phi_{ot} \cdot 9 \cdot c_{soil} \cdot b} = 0.4\ \text{ft}$$

$$M_{max.clay} := P_u \cdot \left(e_{clay} + 1.5 \cdot b + 0.5 \cdot f\right) = 485.4 \cdot \text{kip} \cdot \text{ft}$$

$$g := \sqrt{\frac{M_{max.clay}}{2.25 \cdot \phi_{ot} \cdot c_{soil} \cdot b}} = 7.6\ \text{ft}$$

$$L_{ot2Clay} := \left(1.5 \cdot b + f + g\right) = 15.5\ \text{ft}$$

$$L_{ot2Clay} := \text{ceil}\left(\frac{L_{ot2Clay}}{\text{ft}}\right) \cdot \text{ft} = 16\ \text{ft}$$ *(round up to next foot)*

$$L_{otClay} := \text{if}\left(L_{ot1Clay} < 3 \cdot b, L_{ot1Clay}, L_{ot2Clay}\right) = 4$$ *(If $L_{ot} < 3b$, use Modified Broms method)*

$$L_{reqdOT} := \text{if}\left(\text{SoilType} = \text{"Sand"}, L_{otSand}, L_{otClay}\right)$$

$L_{reqdOT} = 15\ \text{ft}$ *required shaft embedment depth to resist overturning*

Shaft Depth Required to Resist Torsion

*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.

$N_{blows} = 9$

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

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 $L_{torSand} := L_{reqdOT} = 15\,\text{ft}$

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

$$L_{torSand} := \text{Find}(L_{torSand}) = 22.8\,\text{ft}$$

$$L_{torSand} := \text{ceil}\left(\frac{L_{torSand}}{\text{ft}}\right) \cdot \text{ft} = 23\,\text{ft}$$

(round up to next foot)

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

$\text{CohesionFactor} := 0.55$

$f_{se} := \text{CohesionFactor} \cdot c_{soil} = 0.7 \cdot \text{ksf}$

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

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

$$L_{torClay} := \text{Find}(L_{torClay}) = 16\,\text{ft}$$

$$L_{torClay} := \text{ceil}\left(\frac{L_{torClay}}{\text{ft}}\right) \cdot \text{ft} = 16\,\text{ft}$$

(round up to next foot)

$L_{reqdTor} := \text{if}(\text{SoilType} = \text{"Sand"}, L_{torSand}, L_{torClay})$

$L_{reqdTor} = 23\,\text{ft}$

required shaft embedment depth to resist torsion

$L_{embedded} := \text{if}(L_{reqdTor} > L_{reqdOT}, L_{reqdTor}, L_{reqdOT}) = 7$

$L_{shaft.length} := L_{embedded} + \text{Offset}$

$L_{shaft.length} = 23.5\,\text{ft}$

shaft length

Maximum Moment in Shaft

short free-head pile in cohesionless soil using Broms method

$$f_{sand} := \sqrt{\frac{2 \cdot P_u}{3 \cdot \gamma_{soil} \cdot b \cdot K_p \cdot \phi_{ot}}} = 5.1\ ft$$

$$M_{maxSand} := P_u \cdot \left(e_{sand} + f_{sand}\right) - \frac{P_u \cdot f_{sand}}{3} + M_u = 422.8 \cdot kip \cdot ft$$

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

$$f_{mod} := Find\left(f_{mod}\right) = 2.4\ ft$$

$$M_{modBroms} := P_u \cdot \left(e_{clay} + f_{mod}\right) - \frac{\phi_{ot} \cdot c_{soil} \cdot b \cdot f_{mod}^{\ 2}}{2} - \frac{\phi_{ot} \cdot b \cdot f_{mod}^{\ 3} \cdot Slope}{6} = 392.4 \cdot kip \cdot ft$$

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

$$M_{Broms} := P_u \cdot \left(e_{clay} + 1.5 \cdot b + 0.5 \cdot f\right) = 485.4 \cdot kip \cdot ft$$

$M_{maxClay} := if\left(L_{ot1Clay} < 3 \cdot b, M_{modBroms}, M_{Broms}\right) = 392.4 \cdot kip \cdot ft$ *(If $L_{\alpha} < 3b$, use Modified Broms method)*

$$M_{max} := if\left(SoilType = \text{"Sand"}, M_{maxSand}, M_{maxClay}\right) = 422.8 \cdot kip \cdot ft$$

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*

$Num_{bar} := 18$ *number of longitudinal bars, "RB"*

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

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

$A_{v.bar} := \mathbf{0.31} \cdot in^2$ *stirrup area* *SM Vol-3 13.6.2*

$d_{v.bar} := \mathbf{0.625} \cdot in$ *stirrup diameter*

$s_{v1} := \mathbf{4} \cdot in$ *stirrup spacing, depth = 0 ft-2 ft* *SM Vol-3 13.6.2*

$s_{v2} := 8 \cdot in$ *stirrup spacing, depth = 2 ft-depth.stir, "RD"*

$s_{v3} := 12 \cdot in$ *stirrup spacing, depth > depth.stir, "RF"*

$depth_{stir} := 9.083 \cdot ft$ *stirrup depth, see s.v2 and s.v3 above*

$b = 5\,ft$ *shaft diameter*

$$A_{req} := \min\left(0.135 \cdot \frac{\pi \cdot b^2}{4} \cdot \frac{f_c}{F_{y.rebar}}, 0.015 \cdot \frac{\pi \cdot b^2}{4}\right) = 25.4 \cdot in^2$$ *LRFD 5.7.4.2*

$A_{long} := Num_{bar} \cdot A_{long.bar} = 28.1 \cdot in^2$ *total area of longitudinal steel*

$CheckLongitudinalReinf := if\left(A_{long} \geq A_{req}, \text{"OK"}, \text{"No Good"}\right)$ $CheckLongitudinalReinf = \text{"OK"}$

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

$Spacing_{vert.reinf} := Dia_{bar.circle} \cdot \frac{\pi}{Num_{bar}} = 7.9 \cdot in$ $Clearance_{vert.reinf} := Spacing_{vert.reinf} - d_{long.bar} = 6.5 \cdot in$

$CheckReinfClearSpacing := if\left(Clearance_{vert.reinf} \geq 6in, \text{"OK"}, \text{"No Good"}\right)$ $CheckReinfClearSpacing = \text{"OK"}$ *SDG 3.6.10*

Check Shear and Torsion

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

$$V_u := \sqrt{{V_x}^2 + {V_z}^2} = 14.6 \cdot \text{kip}$$

$$T_u = 391.2 \cdot \text{kip} \cdot \text{ft}$$

Effective shear depth

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

LRFD C5.8.2.9-2

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

Check Shear Strength

$$V_c := 0.0316 \cdot (2.0) \cdot \sqrt{\frac{f_c}{\text{ksi}}} \cdot \left(\frac{b}{\text{in}}\right) \cdot \left(\frac{d_v}{\text{in}}\right) \cdot \text{kip} = 327.6 \cdot \text{kip}$$

LRFD Eqn 5.8.3.3-3 *LRFD 5.8.3.4.1* *ACI 11.3.3*

$$V_s := \frac{A_{v.bar} \cdot F_{y.rebar} \cdot d_v}{\max\left(s_{v1}, s_{v2}, s_{v3}\right)} = 67 \cdot \text{kip}$$

LRFD Eqn 5.8.3.3-4

$$\text{ShearRatio} := \frac{V_u - \phi_v \cdot V_c}{\phi_v \cdot V_s} = -4.7$$

$$\text{ShearRatio} := \text{if}\left(\text{ShearRatio} \le 0, 0, \text{ShearRatio}\right) = 0$$

Check Torsion Strength

$$A_{cp} := \pi \cdot \left(\frac{b}{2}\right)^2 = 2827.4 \cdot \text{in}^2 \qquad p_{cp} := 2 \cdot \pi \cdot \left(\frac{b}{2}\right) = 188.5 \cdot \text{in}$$

Area and perimeter of concrete cross-section

$$d_{oh} := b - 2 \cdot \left(\text{Cover} + \frac{d_{v.bar}}{2}\right) = 47.4 \cdot \text{in} \qquad p_h := \pi \cdot d_{oh} = 148.8 \cdot \text{in}$$

Diameter, perimeter and area enclosed by the centerline of the outermost closed transverse torsion reinforcement

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

$$T_{n1} := \frac{2 \cdot A_o \cdot A_{v.bar} \cdot F_{y.rebar}}{s_{v1}} = 1.2 \times 10^3 \cdot \text{kip} \cdot \text{ft}$$

LRFD Eqn 5.8.3.6.2-1

$$T_{n2} := \frac{2 \cdot A_o \cdot A_{v.bar} \cdot F_{y.rebar}}{s_{v2}} = 580.6 \cdot \text{kip} \cdot \text{ft}$$

LRFD 5.8.3.4.1

$$T_{n3} := \frac{2\cdot A_o\cdot A_{v.bar}\cdot F_{y.rebar}}{s_{v3}} = 387.1\cdot kip\cdot ft$$

$\phi_v = 0.9$ $\quad T_u = 391.2\cdot kip\cdot ft$ $\quad L_{reqdTor} = 23\ ft$

$$Tor2_{sand} := T_u - if\left[2ft > Offset, \left[\pi\cdot b\cdot(2\cdot ft - Offset)\cdot\gamma_{soil}\cdot\left(\frac{2\cdot ft - Offset}{2}\right)\cdot(\omega_{fdot})\cdot\frac{b}{2}\right], 0\cdot kip\cdot ft\right] = 389.5\cdot kip\cdot ft$$

$$Tor3_{sand} := T_u - if\left[depth_{stir} > Offset, \left[\pi\cdot b\cdot(depth_{stir} - Offset)\cdot\gamma_{soil}\cdot\left(\frac{depth_{stir} - Offset}{2}\right)\cdot(\omega_{fdot})\cdot\frac{b}{2}\right], 0\cdot kip\cdot ft\right] = 335.7\cdot kip\cdot ft$$

$$Tor2_{clay} := T_u - if\left[2ft - 1.5ft > Offset, \left[f_{se}\cdot(\pi\cdot b)\cdot(2.0\cdot ft - Offset - 1.5\cdot ft)\cdot\frac{b}{2}\right], 0\cdot kip\cdot ft\right] = 391.2\cdot kip\cdot ft$$

$$Tor3_{clay} := T_u - if\left[depth_{stir} - 1.5ft > Offset, \left[f_{se}\cdot(\pi\cdot b)\cdot(depth_{stir} - Offset - 1.5\cdot ft)\cdot\frac{b}{2}\right], 0\cdot kip\cdot ft\right] = 200\cdot kip\cdot ft$$

$$Tor2 := if(SoilType = \text{"Sand"}, Tor2_{sand}, Tor2_{clay}) = 389.5\cdot kip\cdot ft$$

$$Tor3 := if(SoilType = \text{"Sand"}, Tor3_{sand}, Tor3_{clay}) = 335.7\cdot kip\cdot ft$$

$$TorsionRatio_{n1} := \frac{T_u}{\phi_{tor}\cdot T_{n1}} = 0.34$$

$$TorsionRatio_{n2} := \frac{Tor2}{\phi_{tor}\cdot T_{n2}} = 0.67$$

$$TorsionRatio_{n3} := \frac{Tor3}{\phi_{tor}\cdot T_{n3}} = 0.87$$

$$TorsionRatio := max(TorsionRatio_{n1}, TorsionRatio_{n2}, TorsionRatio_{n3}) = 0.87$$

$$T_{cr} := 0.125\sqrt{\frac{f_c}{ksi}}\cdot\left(\frac{A_{cp}{}^2}{p_{cp}\cdot in^3}\right)\cdot kip\cdot in = 883.6\cdot kip\cdot ft$$ *LRFD Eqn 5.8.2.1-4*

$$TorsionRatio := if(T_u \le 0.25\cdot\phi_{tor}\cdot T_{cr}, 0, TorsionRatio) = 0.9$$ *LRFD Eqn 5.8.2.1-3*

$ShearRatio = 0$

$$CheckShearTorsion := if(ShearRatio + TorsionRatio \le 1, \text{"OK"}, \text{"No Good"})$$

$CheckShearTorsion = \text{"OK"}$

Check Maximum Spacing Transverse Reinforcement

$$v_u := \frac{V_u}{\phi_v\cdot b\cdot d_v} = 0.006259\cdot ksi \qquad 0.125\cdot f_c = 0.5\cdot ksi$$ *LRFD Eqn 5.8.2.9-1*

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

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

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

$\max\left(s_{v1}, s_{v2}, s_{v3}\right) = 12\cdot in$

$\text{CheckMaxSpacingTransvReinf} := \text{if}\left(\max\left(s_{v1}, s_{v2}, s_{v3}\right) \le s_{max}, \text{"OK"}, \text{"No Good"}\right)$

$\text{CheckMaxSpacingTransvReinf} = \text{"OK"}$

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

LRFD 5.8.3.4.1

$M_u = 365.4\cdot kip\cdot ft$

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

$$\text{LongReinf}_{shr.tor} := \frac{\dfrac{M_u}{\phi_v\cdot d_v} + \sqrt{\left(V_{temp}\right)^2 + \left(\dfrac{0.45\cdot p_h\cdot T_u}{2\cdot A_o\cdot \phi_v}\right)^2}}{F_{y.rebar}} = 3.8\cdot in^2$$

$\text{Num}_{bar}\cdot A_{long.bar} = 28.1\cdot in^2$

$\text{CheckLongReinf}_{shr.tor} := \text{if}\left(\text{Num}_{bar}\cdot A_{long.bar} \ge \text{LongReinf}_{shr.tor}, \text{"OK"}, \text{"No Good"}\right)$

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

Structure ID	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.)	
T-10-2	A78/S-P6/S-DS/16/4.5	A78/S	-	-	-	-	-	P6/S	24.0	21.0	DS/16/4.5
T-13-1	A78/S-P6/S-DS/25/5	A78/S	-	-	-	-	-	P6/S	-	22.0	DS/25/5
T-13-2	A78/S-P6/S/L-DS/25/5	A78/S	-	-	-	-	-	P6/S/L	-	22.0	DS/25/5
T-13-3	A70/S-P5/S-DS/25/5	A70/S	32	-	-	-	-	P5/S	24.0	21.0	DS/25/5
T-13-4	A78/S/H-P6/S-DS/20/5	A78/S/H	-	-	-	-	-	P6/S	-	22.0	DS/20/5
T-15-1	A70/S-P5/S-DS/25/5	A70/S	-	-	-	-	-	P5/S	-	22.0	DS/25/5
T-15-2	A78/S-P6/S-DS/25/5	A78/S	-	-	-	-	-	P6/S	24.0	21.0	DS/25/5
T-15-3	A70/S-P5/S-DS/25/5	A70/S	-	-	-	-	-	P5/S	23.0	20.0	DS/25/5
T-15-4	A78/S/H-P6/S-DS/25/5	A78/S/H	-	-	-	-	-	P6/S	24.0	21.0	DS/25/5
T-17-1	A78/S-P6/S-DS/25/5	A78/S	33	-	-	-	-	P6/S	-	22.0	DS/25/5
T-17-2	A78/S-P6/S-DS/25/5	A78/S	-	-	-	-	-	P6/S	-	22.0	DS/25/5
T-17-3	A70/S-P5/S-DS/20/5	A70/S	32	-	-	-	-	P5/S	24.0	21.0	DS/20/5
T-17-4	A78/S/H-P6/S-DS/25/5	A78/S/H	-	-	-	-	-	P6/S	-	22.0	DS/25/5

FAA/SAA = FA/SA - (Stardard Total Arm Length - Actual Total Arm Length)

UAA (with luminaire) = Luminaire Mounting Height - 1.0 ft

UAA (without luminaire) = UB + 3.0 ft

Structure ID	*First Arm*		*Second Arm*				*Pole*			
	Total (ft.)	*FA (ft.)*	*FAA (ft.)*	*Total (ft.)*	*SA (ft.)*	*SAA (ft.)*	*Found EL*	*Road EL*	*UB (ft.)*	*UAA (ft.)*
T-10-2	78.0	78.0	-	-	-	-	14.30	14.78	21.0	24.0
T-13-1	78.0	78.0	-	-	-	-	38.30	39.40	22.0	-
T-13-2	78.0	78.0	-	-	-	-	39.80	41.25	22.0	-
T-13-3	64.0	70.0	32	-	-	-	39.50	39.29	21.0	24.0
T-13-4	78.0	78.0	-	-	-	-	39.80	41.26	22.0	-
T-15-1	70.0	70.0	-	-	-	-	33.00	34.44	22.0	-
T-15-2	78.0	78.0	-	-	-	-	33.40	33.30	21.0	24.0
T-15-3	70.0	70.0	-	-	-	-	34.20	33.79	20.0	23.0
T-15-4	78.0	78.0	-	-	-	-	33.76	33.90	21.0	24.0
T-17-1	72.0	78.0	33	-	-	-	28.60	29.50	22.0	-
T-17-2	78.0	78.0	-	-	-	-	29.92	31.15	22.0	-
T-17-3	64.0	70.0	32	-	-	-	29.70	29.50	21.0	24.0
T-17-4	78.0	78.0	-	-	-	-	30.50	31.76	22.0	-

Section 2.0: MVDS Concrete Pole Design

DVMS Design Narrative

Moccasin Wallow Rd., Manatee County, FL

Description

Mast arm designs are part of a larger Public Works Department project along Moccasin Wallow Road from US 41 to West of I-75.

Specifications

The structural design shall be in accordance with the following:

FDOT Structures Design Guidelines, January 2021. (SDG)

FDOT Modifications to LRFD Specifications for Structural Supports for Highway Signs, Luminaires, and Traffic Signals, January 2021. (LRFDLTS-1)

AASHTO LRFD Bridge Design Specifications, 9th Ed., 2020. (LRFD)

AASHTO LRFD Specifications for Structural Supports for Highway Signs, Luminaires, and Traffic Signals, 1st Edition 2015 with 2017, 2019, & 2020 Interim Revisions. (LTS-1)

Design Method

The design of all components utilize the Load and Resistance Factor Design (LRFD) methodology in accordance with the FDOT Structures Manual.

Design Loads

Wind Load

In accordance with FDOT Structures Manual, Volume 1 Section 2.4 and Volume 3.

- MVDS Concrete Pole: 300 year Extreme Event Limit State = 140 mph

2.4 WIND LOADS

2.4.1 Wind Loads on Completed Structures: WL and WS (LRFD 3.8)

A. Design Wind Speed

Use the design 3-second gust wind speed, V, from Table 2.4.1-1 in lieu of ***LRFD*** Figure 3.8.1.1.2-1.

Table 2.4.1-1 Design Wind Speed, V

County (Dist)	Design Wind Speed (mph)	County (Dist)	Design Wind Speed (mph)	County (Dist)	Design Wind Speed (mph)
Alachua (2)	130	Hardee (1)	150	Okaloosa (3)	150
Baker (2)	130	Hendry (1)	150	Okeechobee (1)	150
Bay (3)	150	Hernando (7)	150	Orange (5)	150
Bradford (2)	130	Highlands (1)	150	Osceola (5)	150
Brevard (5)	170	Hillsborough (7)	150	Palm Beach (4)	170
Broward (4)	170	Holmes (3)	150	Pasco (7)	150
Calhoun (3)	130	Indian River (4)	170	Pinellas (7)	150
Charlotte (1)	170	Jackson (3)	130	Polk (1)	150
Citrus (7)	150	Jefferson (3)	130	Putnam (2)	130
Clay (2)	130	Lafayette (2)	130	St. Johns (2)	150
Collier (1)	170	Lake (5)	150	St. Lucie (4)	170
Columbia (2)	130	Lee (1)	170	Santa Rosa (3)	150
DeSoto (1)	150	Leon (3)	130	Sarasota (1)	170
Dixie (2)	130	Levy (2)	150	Seminole (5)	150
Duval (2)	130	Liberty (3)	130	Sumter (5)	150
Escambia (3)	170	Madison (2)	130	Suwannee (2)	130
Flagler (5)	150	Manatee (1)	150	Taylor (2)	130
Franklin (3)	150	Marion (5)	150	Union (2)	130
Gadsden (3)	130	Martin (4)	170	Volusia (5)	150
Gilchrist (2)	130	Miami-Dade (6)	170	Wakulla (3)	130
Glades (1)	150	Monroe (6)	170	Walton (3)	150
Gulf (3)	150	Monroe Islands (6)[1]	180	Washington (3)	150
Hamilton (2)	130	Nassau (2)	130		

[1] For non-bridge structures use 170 mph or as modified by Vol. 3

Modification for Non-Conventional Projects:

See the RFP for possible supplemental requirements to ***SDG*** 2.4.1.A.

3 LOADS

3.8 Wind Load

Delete Table 3.8.1 and replace it with the following:

Structure Support Type	Interval (years)
• Overhead sign structures • Luminaire support structures >50' in height. • Mast Arm Signal Structures • Monotubes • High Mast Light Poles • ITS Camera Poles >50' in height • Bridge Aesthetic Lighting Structures	700
• Luminaire supports and other structures ≤ 50' in height. • Concrete and Steel Strain Poles	300
• Roadside sign structures	10

C 3.8

FDOT continues the past practice of determining wind speeds based on structure type.

Luminaire support structures shall include all support elements including all poles, arms, connections and anchorages for all high-mast lighting, roadway lighting, sign lighting, underdeck lighting, landscape lighting, and bridge aesthetic lighting.

Based on the ASD-LTS Specifications, the design life is:

- 10 years for ground signs.
- 25 years for conventional light poles and strain poles.
- 50 years for mast arms, high mast light poles and overhead sign structures.

3.8.2 Basic Wind Speed (Rev. 01/21)

Delete the entire paragraph including Figures 3.8-1, 3.8-2, 3.8-3 and 3.8-4 and add the following:

For the 700 year Extreme Event Limit State, use the wind speeds (mph) shown in FDOT ***SDG*** *Table 2.4.1-1*

For the 300 year Extreme Event Limit State, use the wind speeds (mph) shown in FDOT ***SDG*** *Table 2.4.1-1* minus 10 mph.

For the 10 year Extreme Event Limit State, use a design wind speed of 110 mph for the entire state.

For the Service Limit State, use a design wind speed of 90 mph for the entire state.

For temporary ground signs, luminaires and span wire traffic signals, for both the Extreme Event and Service Limit States,

C 3.8.2

Add the following:

FDOT ***SDG*** *Table 2.4.1-1* was derived from the ASCE 7-10 wind speed map.

To simplify the design process, FDOT has designated one wind speed per county for the 700 year and 300 year Extreme Event Limit States. To maintain consistency with past practice, a 110 mph design wind speed was chosen for the 10 year Extreme Event Limit State, and an 80 mph design wind speed was chosen for temporary ground sign supports.

GENERAL NOTES:

1. Work these Index drawings with the Strain Pole Schedule in the Plans.

2. Shop Drawings: This Index is considered fully detailed and no shop drawings are necessary. Submit shop drawings for minor modifications not detailed in the plans.

3. Materials:

A. Concrete:	Class V Special with 4 ksi minimum strength at transfer or Class VI with 6.5 ksi minimum strength at transfer
B. Prestress Strands & Spiral Reinforcing:	Specification 641
C. Hand and coupler cover plates:	Non-corrosive material
D. Screws:	Round headed, chrome plated

4. Fabrication:
    - A. Pole Taper for pole width, strands, reinforcing and void: 0.081 in/ft per face.
    - B. Concrete Cover: 1" minimum
    - C. Spiral Reinforcing: As shown, plus one turn for splices and two turns at both the tip and butt ends of the pole.
    - D. The design dimensions for Front Face (FF) and Back Face (BF) of the poles may vary transversely from the section shown by ± ¼" to assist with removal from forms. Balance addition and subtraction of the face widths to maintain section areas shown.
    - E. Tie ground wires to the interior of reinforcing steel to prevent displacement during concreting operations.
    - F. Cut the tip end of the prestressed strand first or simultaneously with the butt end.
    - G. Provide cover plates and screws for hand hole and couplers. Attach cover plates to the poles using lead anchors or embedded threaded inserts.
    - H. Provide Aluminum Identification Tags on the poles with the following information:
        - a. Financial Project ID.
        - b. Pole Manufacturer
        - c. Standard Pole Type Number
        - d. Pole Length (L)

5. Support locations are for strand release, storage, lifting and transport. Keep BF oriented downward until final erection.

6. Pick-up and support locations shown may vary within a tolerance of ±3".

7. Two point attachment: provide an eye bolt hole for the messenger wire.

8. Tether Wire: When required, field-drill the eyebolt hole prior to installation

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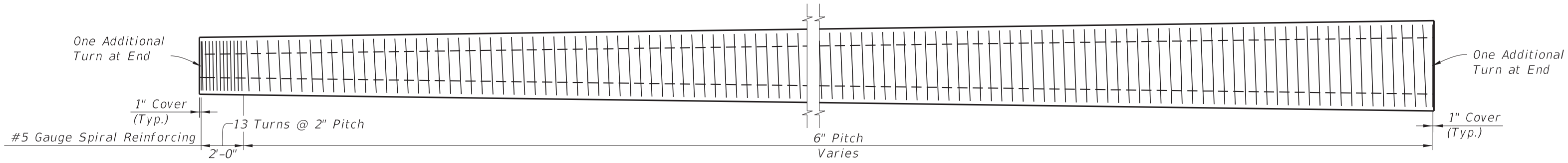
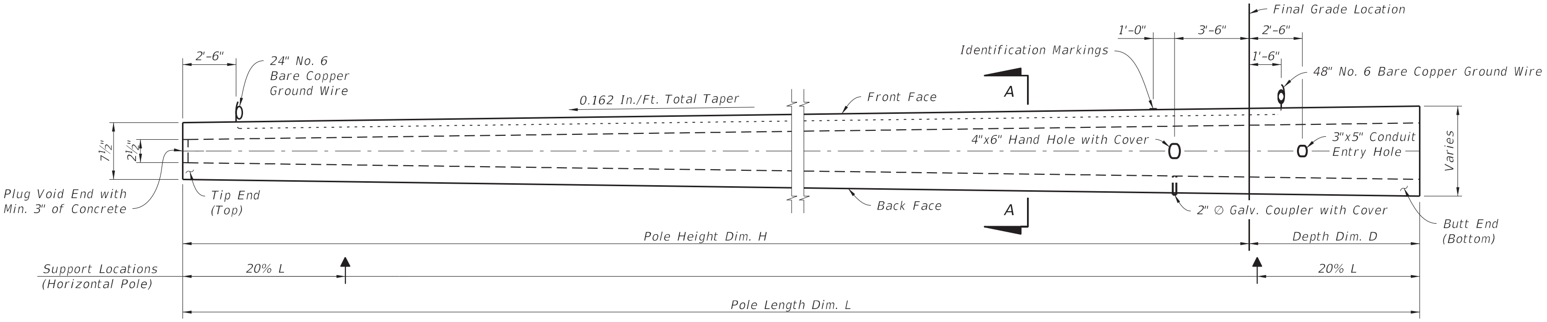
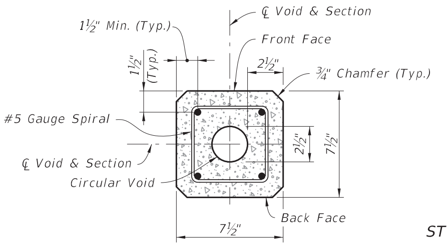
LAST REVISION	REVISION	DESCRIPTION:	FDOT	FY 2021-22 STANDARD PLANS	CONCRETE POLES	INDEX	SHEET
11/01/20						641-010	1 of 8



SPIRAL REINFORCING ELEVATION
(Strands, Holes, and Fixtures Not Shown)



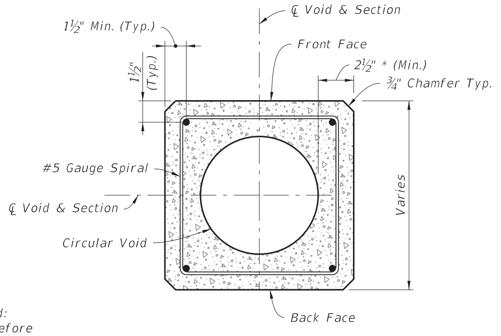
POLE ELEVATION
(Strands and Reinforcing Not Shown)



TIP END SECTION (TOP)

STRAND LEGEND

● - Prestressed Strand:
0.5 in. ~ 31 kips Before
Transfer (4 strands total)



SECTION A-A
(Typical Square Section)

NOTES:

Strands shown are continuous from Tip End to Butt End.

Elevation view scale is exaggerated vertically for clarity.

For final erection, tilt pole upright with single point attachment located a distance 33.3% L from Tip End.

* Dimension may vary from 2½" to 3¾" to accommodate smaller radius of optional stepped (PVC) void. The void diameter shall not be less than 2½".

POLE TYPE P-III

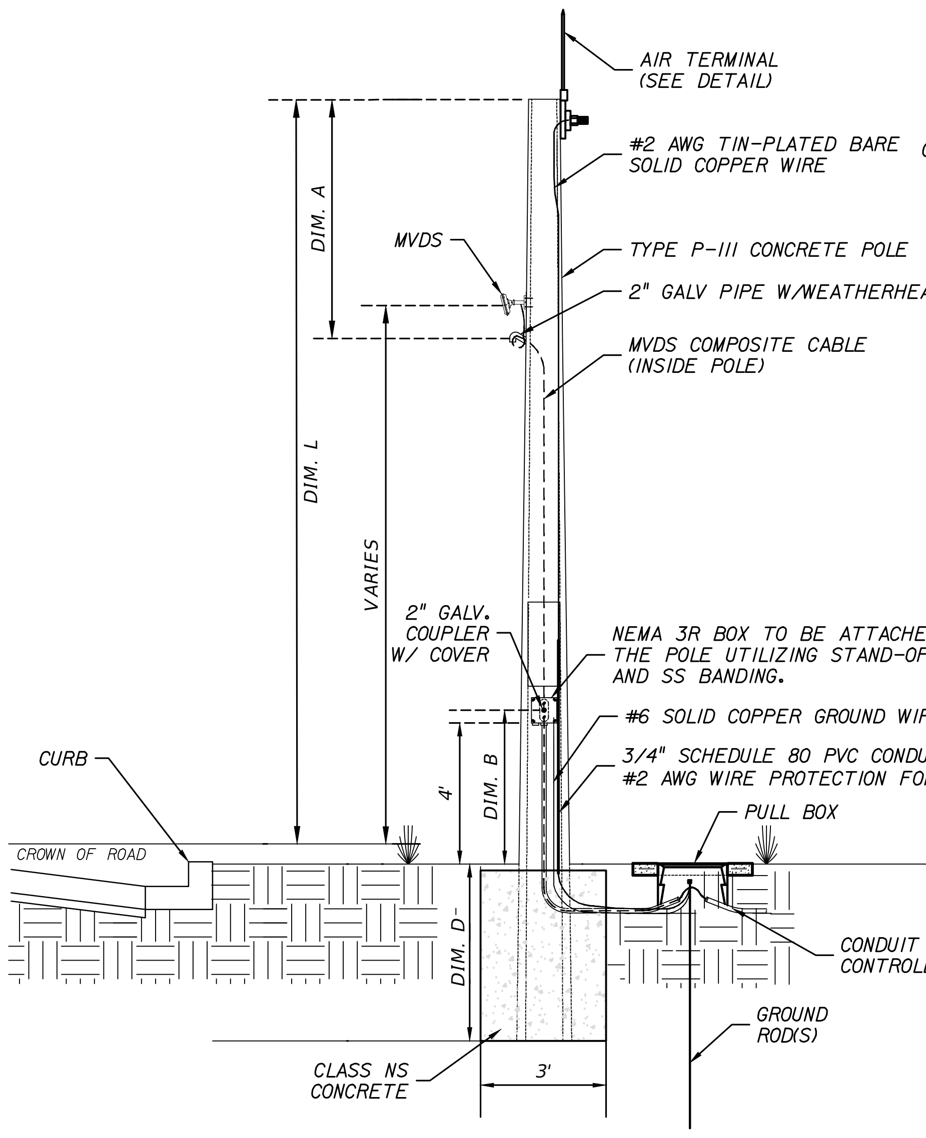
LAST REVISION	REVISION	DESCRIPTION:	FDOT	FY 2021-22 STANDARD PLANS	CONCRETE POLES	INDEX	SHEET
11/01/17						641-010	3 of 8

NOTES:

1. WORK THIS SHEET WITH FDOT STANDARD PLAN INDEX 641-010.
2. THE NEMA 3R BOX AND MOUNTING ARMS FOR THE MVDS SHALL BE ATTACHED TO THE POLE USING 3/4" STAINLESS STEEL BANDING.
3. INSTALL GROUNDING FOR THE MVDS SITE AS PER SECTION 620 OF THE FDOT STANDARD SPECIFICATIONS FOR ROAD AND BRIDGE CONSTRUCTION. ACHIEVE A GROUND RESISTANCE OF 5 OHMS OR LESS AS DESCRIBED FOR ITS POLES/STRUCTURES WITH ELECTRONIC EQUIPMENT. FOLLOW PROCEDURES FOR TESTING AND DOCUMENTATION. THE MAIN POLE GROUND ROD ASSEMBLY SHALL BE LOCATED IN THE NEAREST PULL BOX FOR MAINTENANCE ACCESS.
4. THE CONTRACTOR SHALL CONFIRM MANUFACTURER RECOMMENDATIONS FOR ALL EQUIPMENT AND MOUNTING HEIGHT DIMENSIONS PRIOR TO INSTALLATION.
5. THE CONTRACTOR SHALL INTEGRATE THE MVDS INTO THE COUNTY'S EXISTING ATMS SYSTEM AND CALIBRATE THE MVDS UNITS IN THE PRESENCE OF COUNTY STAFF.

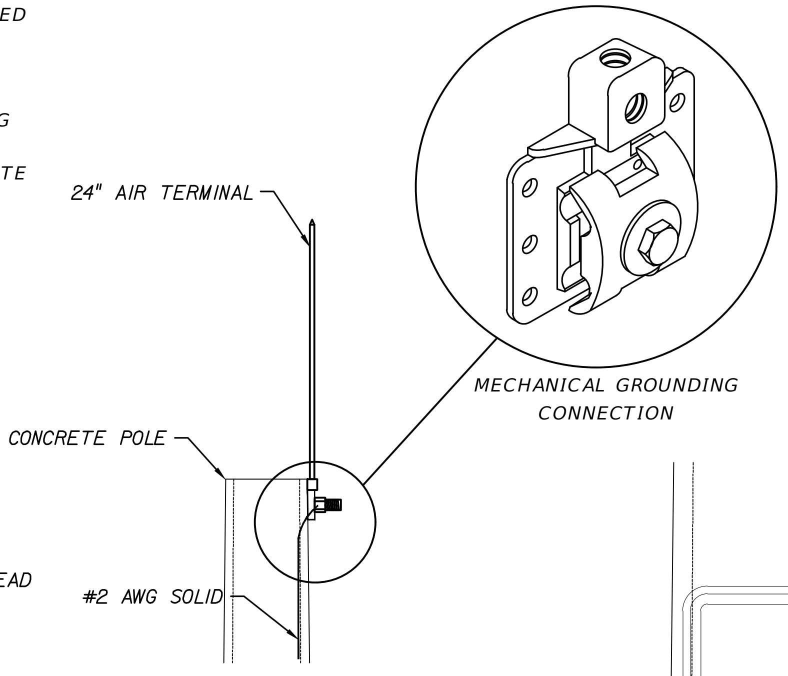
MVDS POLE VARIABLES

MVDS STATION	DIM. A (FT)	DIM. B (FT)	DIM. D (FT)	DIM. L (FT)	LOCATION
310+07	6	4.5	10	36	2' BEHIND SHARED USE PATH
334+41	6	4.5	10	36	3.5' BEHIND SHARED USE PATH
395+00	6	4.5	10	36	2' FRONT OF SHARED USE PATH



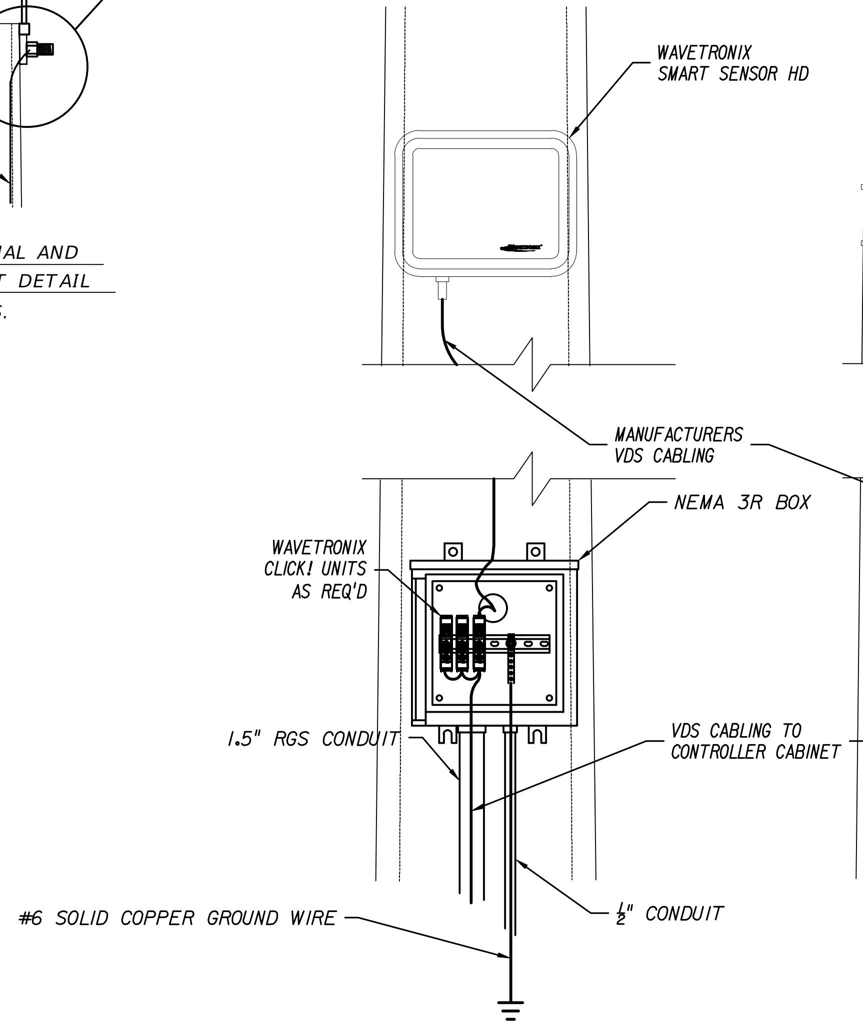
MVDS POLE DETAIL

N.T.S.



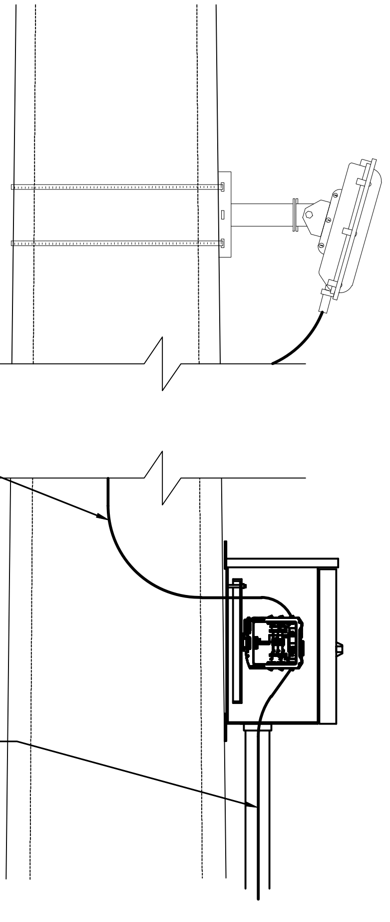
AIR TERMINAL AND ATTACHMENT DETAIL

N.T.S.



FRONT VIEW

N.T.S.



SIDE VIEW

N.T.S.

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

REVISIONS			
DATE	DESCRIPTION	DATE	DESCRIPTION
----	----		

CHRISTOPHER P. GAMACHE, P.E.
P.E. LICENSE NUMBER 82122
CARDNO
380 PARK PLACE BLVD SUITE 300
CLEARWATER, FLORIDA 33759
CERTIFICATE OF AUTHORIZATION 29915

MANATEE COUNTY

ROAD NO.	PROJECT ID
MOCCASIN WALLOW RD	6092560

MVDS DETAILS

SHEET NO.
T-49

Christopher Gamache 12/22/2021 3:59:31 PM C:\Users\christopher.gamache\OneDrive - Cardno\Desktop\MVDSDET01.dwg

Concrete MVDS Pole 3

(Poles 1 & 2 similar)

Location: 395+00

This Mathcad determines required embedment depth for a pre-cast, pre-stressed concrete pole. Design for Extreme Event Limit State.

References:
2020-21 FDOT Standard Plans Index 641-010
FDOT Structures Manual, January 2019
AASHTO LRFD Specifications for Structural Supports for Highway Signs, Luminaires, and Traffic Signals, First Edition 2015 (LTS-1)
AASHTO LRFD Bridge Design Specifications, Eight Edition (LRFD)

Geometry

Pole Type P-111, FDOT Standard Plans Index 641-010

Pole length (includes buried depth) $L_{pole} := 48 \cdot ft$

Buried depth $depth_{buried} := 10ft$

Pole length (minus buried depth) $H_{pole} := L_{pole} - depth_{buried} = 38\ ft$

Wall thickness at pole tip $t_{wall\_tip} := 2.50in$

Wall thickness at pole butt $t_{wall\_butt} := 2.50in$

Width at pole tip $dia_{tip} := 7.5in$

Pole taper $taper_{pole} := 0.162 \cdot \frac{in}{ft}$

Minimum void taper given step option $taper_{void} := 0.162 \cdot \frac{in}{ft}$

Strand taper $taper_{strand} := taper_{pole}$

Diameter of void at pole tip $dia_{void.tip} := dia_{tip} - 2 \cdot t_{wall\_tip} = 2.5 \cdot in$

Number of sections (must be even) $\#sections := 50$

Mounted Camera Properties

Camera properties are used to calculate the axial force, wind load moment, and drag due to the camera.

Area of camera (EPA) $A_{camera} := 1.17ft^2$ *Index 641-020 SPI*

Weight of camera $Weight_{camera} := 50lbf$

Drag coefficient $C_{d.camera} := 1.0$

Width of camera arm $Width_{camera} := 1.17ft$

Height and Exposure Factor (K_z)

[ref. LTS-1, 3.8.4]

The segment number

$$ns := 1 .. \#sections$$

Maximum Fill height measured from natural ground

$$FillHeight := 0ft$$

The y distance to the CG of each pole segment

$$y_{segment_{ns}} := H_{pole} - \frac{(ns)\cdot 2 - 1}{2\cdot\#sections}\cdot H_{pole}$$

$$y_{segment_0} := H_{pole}$$

$$z_{ns} := if\left[\left(y_{segment_{ns}} + FillHeight\right) < 15\cdot ft, 15\cdot ft, \left(y_{segment_{ns}} + FillHeight\right)\right]$$

$$z_0 := if\left[\left(y_{segment_0} + FillHeight\right) < 15\cdot ft, 15\cdot ft, \left(y_{segment_0} + FillHeight\right)\right]$$

The height and exposure factor that varies with height above the ground depending on the local exposure conditions. (Assumes Exposure C with zg=900 ft.)

[ref. LTS-1, 3.8.4-1]

$$K_{z_{ns}} := 2.0\cdot\left(\frac{z_{ns}}{900ft}\right)^{\frac{2}{9.5}}$$

$$K_{z_0} := 2.0\cdot\left(\frac{z_0}{900ft}\right)^{\frac{2}{9.5}}$$

$$\max\left(K_z\right) = 1.03$$

Importance Factor (I_r) and Gust Effect Factor (G) and Unmodified Wind Pressure

Interval 300 years for Luminaire supports and other structures less than 50' in height. FDOT Str. Manual Vol. 3, 3.8 Wind Load

Wind speed $WindSpeed := 140mph$ *Manatee County Design Wind Speed minus 10 mph, per Vol. 3* *[ref. FDOT SDG Vol. 3, 3.8.2, & Vol. 1 Table 2.4.1-1]*

Directionality Factor (for square pole) $K_d := 0.90$ *[ref. LTS-1, Table 3.8.5-1]*

Gust Effect Factor $G := 1.14$ *[ref. LTS-1, 3.8.6]*

Wind pressure (Kz and Cd not included) *[ref. LTS-1, 3.8.1-1]*

$$Pressure := (0.00256\cdot psf)\cdot K_d\cdot G\cdot\left(\frac{WindSpeed}{mph}\right)^2 = 51.48\cdot psf$$

Total Forces and Applied Loads to the Pole

Axial forces due to camera dead load $N_{camera} := Weight_{camera} = 0.05 \cdot kip$

Forces due to wind load on the camera $Force_{camera} := \left(A_{camera} \cdot C_{d.camera}\right) \cdot Pressure \cdot K_{z_1} = 0.06 \cdot kip$

Shear forces due to wind load on the camera $V_{camera} := Force_{camera} = 0.06 \cdot kip$

Upright Bare Steel Section Properties, Axial Force

Pole forces are assumed to act at the CG of each segment and a sectional analysis is performed at the end of each segment. Therefore, the pole has 1 more section than segment, where nx *is the section number* ns *is the segment number. Section properties are calculated for each section location and will be used for axial, bending, and shear stress calculations.*

Section number $nx := 0 .. \#sections$

$$dist_{wind.section_n} := \frac{n}{\#sections} \cdot \left(H_{pole}\right)$$

Height of each section

$$y_{section_{nx}} := H_{pole} - H_{pole} \cdot \left(\frac{nx}{\#sections}\right)$$

Wind Load Shear and Moments on Bare Pole

Each segment on the pole may have a different height and exposure factor K_z, coefficient of drag C_d, *and diameter, therefore forces on each segment are different. Note: the average diameter is used to calculate the wind loading.*

Average Diameter

$$d_{ns} := \frac{dia_{section_{ns-1}} + dia_{section_{ns}}}{2}$$

Coefficient of Drag $C_{d_{ns}} := 1.25$ *Square* *[ref. LTS-1, Table 3.8.7-1]*

$C_{d_0} := C_{d_1}$

$\max\left(C_d\right) = 1.25$

$\min\left(C_d\right) = 1.25$

Maximum Segment Force

$$SegmentForce_{ns} := \frac{\left(H_{pole}\right)}{\#sections} \cdot d_{ns} \cdot Pressure \cdot C_{d_{ns}} \cdot K_{z_{ns}}$$

$\max(SegmentForce) = 0.05 \cdot kip$

Pole Moments and Shears at each section

Note: $y_{segment}$ *and* $y_{section}$ *are the distances measured from the base to the centroid of the each pole segment and each pole cross section respectively. Segment 0 and Section 0 are at the top of the pole.*

Pole Moment

$$M_{x.pole_{ns}} := \sum_{p=1}^{ns} \left[SegmentForce_p \cdot \left(y_{segment_p} - y_{section_{ns}}\right)\right]$$

$$\max\left(M_{x.pole}\right) = 36.4 \cdot kip \cdot ft$$

Pole Shear

$$V_{pole_{ns}} := \sum_{p=1}^{ns} SegmentForce_p$$

$$\max\left(V_{pole}\right) = 2.1 \cdot kip$$

Pole Axial Load

$$N_{pole_{ns}} := CummulativeWeight_{ns}$$

$$\max\left(N_{pole}\right) = 3.5 \cdot kip$$

Total Forces at a Section (bare pole plus camera)

All forces (camera and pole) are combined and calculated per segment.

$$M_{x_{nx}} := M_{x.pole_{nx}} + V_{camera} \cdot \left[\left(H_{pole} - 2 \cdot ft\right) - y_{section_{nx}}\right]$$

$$M_{z_{nx}} := 0.2 \cdot M_{x.pole_{nx}}$$

$$V_{z_{nx}} := V_{pole_{nx}} + V_{camera}$$

$$V_{x_{nx}} := 0.2 \cdot V_{pole_{nx}}$$

$$N_{total_{nx}} := N_{pole_{nx}} + N_{camera}$$

Total Loads at a Section

Total Shear Load

$$V_{T_{nx}} := \sqrt{\left(V_{x_{nx}}\right)^2 + \left(V_{z_{nx}}\right)^2}$$

$$\max\left(V_T\right) = 2.2 \cdot kip$$

Total Moment

$$M_{T_{nx}} := \sqrt{\left(M_{x_{nx}}\right)^2 + \left(M_{z_{nx}}\right)^2}$$

$$\max\left(M_T\right) = 39.28 \cdot kip \cdot ft$$

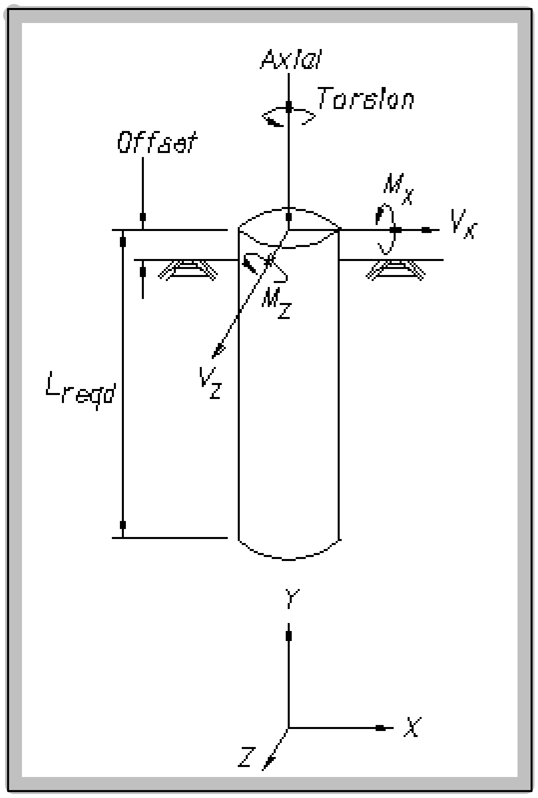
Foundation Analysis

$SoilType := 1$ *0 - clay*
1 - sand

$SoilWeight := 42.6\cdot pcf$ $ShaftDiameter := 3.0\cdot ft$ $Offset := 0\cdot ft$
(saturated weight)

$SoilFrictionAngle := 29\cdot deg$ *(sand)* $SoilShearStrength := 3\cdot \frac{kip}{ft^2}$ *(clay)*

$SF_{ot} := 2$ *(safety factor against overturning)*



Shaft Depth Required to Resist Overturning

$\gamma_{soil} := SoilWeight$ $b := ShaftDiameter$

$\phi_{soil} := SoilFrictionAngle$ $c_{soil} := SoilShearStrength$

$\max(M_T) = 39.28\cdot kip\cdot ft$ $M_{total} := SF_{ot}\cdot \max(M_T) = 78.56\cdot kip\cdot ft$

$\max(V_T) = 2.2\cdot kip$ $P_{total} := SF_{ot}\cdot(\max(V_T))$

Pole Embedment Depth

short free-head pile in cohesionless soil using Broms method

$K_p := \tan\left(45\cdot deg + \frac{\phi_{soil}}{2}\right)^2 = 2.88$ $e_{sand} := Offset = 0$

Guess value $L_{Sand} := depth_{buried} = 10\,ft$

Given $\frac{\gamma_{soil}\cdot b\cdot L_{Sand}{}^3\cdot K_p}{2} - P_{total}\cdot(e_{sand} + L_{Sand}) - M_{total} = 0\cdot kip\cdot ft$

$Temp := Find(L_{Sand}) = 8.57\,ft$ $L_{otSand} := \max(Temp + Offset) = 8.57\,ft$

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

short free-head pile in cohesive soil using Modified Broms method for L < 3b

$\text{Slope} := 8\cdot\dfrac{c_{soil}}{3\cdot b} = 2.67\cdot\dfrac{kip}{ft^{3}}$ $\qquad e_{clay} := \dfrac{M_{total}}{P_{total}} + \text{Offset} = 18.04\ ft$

$$\text{mforce}(M) := \left(2\cdot c_{soil} + M\cdot \text{Slope}\right)\cdot M\cdot\frac{b}{2}$$

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

$$\text{mmoment}(M,N) := \left[e_{clay} + \frac{M}{3}\cdot\frac{2\cdot\left(M\cdot\text{Slope} + c_{soil}\right) + c_{soil}}{M\cdot\text{Slope} + 2\cdot c_{soil}}\right]\cdot\left[\left(2\cdot c_{soil} + M\cdot\text{Slope}\right)\cdot M\cdot\frac{b}{2}\right]$$

$$\text{nmoment}(M,N) := \left[e_{clay} + M + \frac{N}{3}\cdot\frac{2\cdot\left(N\cdot\text{Slope} + M\cdot\text{Slope} + c_{soil}\right) + \left(M\cdot\text{Slope} + c_{soil}\right)}{\text{Slope}\cdot(2\cdot M + N) + 2\cdot c_{soil}}\right]\cdot\left[\left[\text{Slope}\cdot(2\cdot M + N) + 2\cdot c_{soil}\right]\cdot N\cdot\frac{b}{2}\right]$$

Guess value $\qquad M := 4\cdot ft \qquad N := 4\cdot ft$

Given $\qquad P_{total} + \text{nforce}(M,N) = \text{mforce}(M)$

$\qquad \text{mmoment}(M,N) = \text{nmoment}(M,N)$

$\begin{pmatrix} M_m \\ N_n \end{pmatrix} := \text{Find}(M,N) = \begin{pmatrix} 2.65 \\ 1.34 \end{pmatrix} ft$ $\qquad L_{ot1Clay} := \max\left(M_m + N_n + \text{Offset}\right) = 3.99\ ft$

(round up to next foot) $\qquad L_{ot1Clay} := \text{ceil}\left(\dfrac{L_{ot1Clay}}{ft}\right)\cdot ft = 4\ ft$

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

$f_{clay} := \dfrac{P_{total}}{9\cdot c_{soil}\cdot b} = 0.05\ ft$ $\qquad M_{maxtemp} := P_{total}\cdot\left(e_{clay} + 1.5\cdot b + 0.5\cdot f_{clay}\right) = 98.28\cdot kip\cdot ft$

$$g := \sqrt{\frac{M_{maxtemp}}{2.25\cdot c_{soil}\cdot b}} = 2.2\ ft$$

$$L_{ot2Clay} := \max\left(1.5\cdot b + f_{clay} + g + \text{Offset}\right) = 6.76\ ft$$

(round up to next foot) $\qquad L_{ot2Clay} := \text{ceil}\left(\dfrac{L_{ot2Clay}}{ft}\right)\cdot ft = 7\ ft$

$L_{otClay} := \left|\begin{array}{ll} L_{ot1Clay} & \text{if } L_{ot1Clay} - \text{Offset} < 3\cdot b \\ L_{ot2Clay} & \text{otherwise} \end{array}\right.$ $\qquad L_{otClay} = 4\ ft$

(If $L_{ot} < 3*b$, *use Modified Broms method)*

$$\text{Length}_{Shaft} := \left|\begin{array}{ll} L_{otSand} & \text{if SoilType} = 1 \\ L_{otClay} & \text{otherwise} \end{array}\right.$$

$$\boxed{\text{Length}_{Shaft} = 9\ ft}$$

Section 3.0: Cantilever Sign Structure

Cantilever Sign Design Narrative

Moccasin Wallow Rd., Manatee County, FL

Description

Mast arm designs are part of a larger Public Works Department project along Moccasin Wallow Road from US 41 to West of I-75. For this project, an existing cantilever overhead sign is being relocated to a new drilled shaft foundation. The foundation for the existing cantilever overhead sign design was performed using FDOT Mathcad program "Cantilever Overhead Sign" v1.5, dated 10/01/2021.

Specifications

The structural design shall be in accordance with the following:

FDOT Structures Design Guidelines, January 2021. (SDG)

FDOT Modifications to LRFD Specifications for Structural Supports for Highway Signs, Luminaires, and Traffic Signals, January 2021. (LRFDLTS-1)

AASHTO LRFD Bridge Design Specifications, 9th Ed., 2020. (LRFD)

AASHTO LRFD Specifications for Structural Supports for Highway Signs, Luminaires, and Traffic Signals, 1st Edition 2015 with 2017, 2019, & 2020 Interim Revisions. (LTS-1)

Design Method

The design of all components utilize the Load and Resistance Factor Design (LRFD) methodology in accordance with the FDOT Structures Manual.

Design Loads

Wind Load

In accordance with FDOT Structures Manual, Volume 1 Section 2.4 and Volume 3.

- Overhead Sign Structures: 700 year Extreme Event Limit State = 150 mph

2.4 WIND LOADS

2.4.1 Wind Loads on Completed Structures: WL and WS (LRFD 3.8)

A. Design Wind Speed

Use the design 3-second gust wind speed, V, from Table 2.4.1-1 in lieu of ***LRFD*** Figure 3.8.1.1.2-1.

Table 2.4.1-1 Design Wind Speed, V

County (Dist)	Design Wind Speed (mph)	County (Dist)	Design Wind Speed (mph)	County (Dist)	Design Wind Speed (mph)
Alachua (2)	130	Hardee (1)	150	Okaloosa (3)	150
Baker (2)	130	Hendry (1)	150	Okeechobee (1)	150
Bay (3)	150	Hernando (7)	150	Orange (5)	150
Bradford (2)	130	Highlands (1)	150	Osceola (5)	150
Brevard (5)	170	Hillsborough (7)	150	Palm Beach (4)	170
Broward (4)	170	Holmes (3)	150	Pasco (7)	150
Calhoun (3)	130	Indian River (4)	170	Pinellas (7)	150
Charlotte (1)	170	Jackson (3)	130	Polk (1)	150
Citrus (7)	150	Jefferson (3)	130	Putnam (2)	130
Clay (2)	130	Lafayette (2)	130	St. Johns (2)	150
Collier (1)	170	Lake (5)	150	St. Lucie (4)	170
Columbia (2)	130	Lee (1)	170	Santa Rosa (3)	150
DeSoto (1)	150	Leon (3)	130	Sarasota (1)	170
Dixie (2)	130	Levy (2)	150	Seminole (5)	150
Duval (2)	130	Liberty (3)	130	Sumter (5)	150
Escambia (3)	170	Madison (2)	130	Suwannee (2)	130
Flagler (5)	150	Manatee (1)	150	Taylor (2)	130
Franklin (3)	150	Marion (5)	150	Union (2)	130
Gadsden (3)	130	Martin (4)	170	Volusia (5)	150
Gilchrist (2)	130	Miami-Dade (6)	170	Wakulla (3)	130
Glades (1)	150	Monroe (6)	170	Walton (3)	150
Gulf (3)	150	Monroe Islands (6)[1]	180	Washington (3)	150
Hamilton (2)	130	Nassau (2)	130		

[1] For non-bridge structures use 170 mph or as modified by Vol. 3

Modification for Non-Conventional Projects:

See the RFP for possible supplemental requirements to ***SDG*** 2.4.1.A.

3 LOADS

3.8 Wind Load

Delete Table 3.8.1 and replace it with the following:

Structure Support Type	Interval (years)
• Overhead sign structures • Luminaire support structures >50' in height. • Mast Arm Signal Structures • Monotubes • High Mast Light Poles • ITS Camera Poles >50' in height • Bridge Aesthetic Lighting Structures	700
• Luminaire supports and other structures ≤ 50' in height. • Concrete and Steel Strain Poles	300
• Roadside sign structures	10

C 3.8

FDOT continues the past practice of determining wind speeds based on structure type.

Luminaire support structures shall include all support elements including all poles, arms, connections and anchorages for all high-mast lighting, roadway lighting, sign lighting, underdeck lighting, landscape lighting, and bridge aesthetic lighting.

Based on the ASD-LTS Specifications, the design life is:

- 10 years for ground signs.
- 25 years for conventional light poles and strain poles.
- 50 years for mast arms, high mast light poles and overhead sign structures.

3.8.2 Basic Wind Speed (Rev. 01/21)

Delete the entire paragraph including Figures 3.8-1, 3.8-2, 3.8-3 and 3.8-4 and add the following:

For the 700 year Extreme Event Limit State, use the wind speeds (mph) shown in FDOT ***SDG*** *Table 2.4.1-1*

For the 300 year Extreme Event Limit State, use the wind speeds (mph) shown in FDOT ***SDG*** *Table 2.4.1-1* minus 10 mph.

For the 10 year Extreme Event Limit State, use a design wind speed of 110 mph for the entire state.

For the Service Limit State, use a design wind speed of 90 mph for the entire state.

For temporary ground signs, luminaires and span wire traffic signals, for both the Extreme Event and Service Limit States,

C 3.8.2

Add the following:

FDOT ***SDG*** *Table 2.4.1-1* was derived from the ASCE 7-10 wind speed map.

To simplify the design process, FDOT has designated one wind speed per county for the 700 year and 300 year Extreme Event Limit States. To maintain consistency with past practice, a 110 mph design wind speed was chosen for the 10 year Extreme Event Limit State, and an 80 mph design wind speed was chosen for temporary ground sign supports.

NOTES:

1. Work this Index in conjunction with CANTILEVER SIGN STRUCTURE DATA TABLES in the Plans and Index 11300.

2. Handholes are required at pole base for DMS Structures. Refer to Index 18300 for Handhole Details.

3. <u>Shop Drawings are required.</u>

   Obtain Shop Drawing approval prior to fabrication. Include the following:
   A. Upright Pipe height ('A'). Verify dimension in the field prior to submittal.
   B. Foundation elevations: Ensure minimum vertical clearances of the sign panel over the roadway.
   C. Height of the foundation above adjacent ground.
   D. Anchor bolt orientation with respect to centerline of truss and the direction of traffic.
   E. Chord Splices
   F. Handholes at pole base (when required).

4. <u>Materials:</u>

   A. Sign Structure:
      a. Upright and Chords (Steel Pipe): API-5L-X42, 42 ksi yield or ASTM A500, Grade B (Min.)
      b. Steel Angles and Structural Plates and Bars: ASTM A709 Grade 36
      c. Weld Material: E70XX
   B. Bolts, Nuts and Washers:
      a. High Strength Bolts: ASTM A325 Type 1
      b. Nuts: ASTM A563 Grade DH Heavy-Hex
      c. Washers: ASTM F436 Type 1, one under turned element
   C. Anchor Bolts, Nuts and Washers
      a. Anchor Bolts: ASTM F1554 Grade 55
      b. Nuts: ASTM A563 Grade A Heavy-Hex (5 per bolt)
      c. Plate Washers: ASTM A36 (2 per bolt)
   D. Concrete:
      a. Spread Footing Concrete: Class IV
      b. Drilled Shaft concrete: Class IV (Drilled Shaft)
   E. Reinforcing Steel: Specification Section 415

5. <u>Fabrication:</u>

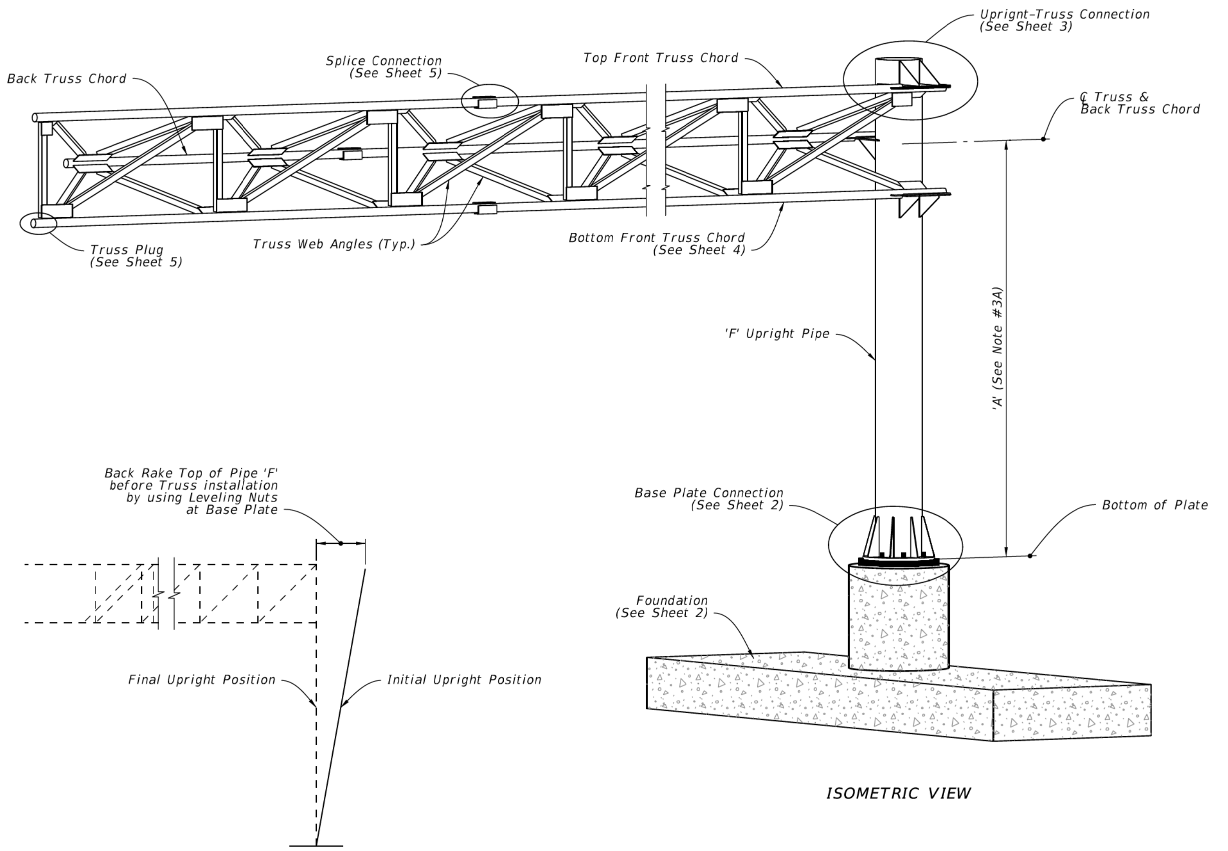
   A. Welding: Specification Section 460-6.4
   B. Chord Splices: "SD" Panel from upright is the closest panel in which a chord splice may be used. See Plans for CANTILEVER SIGN STRUCTURE DATA TABLE. Minimum splice spacing is two truss panel lengths apart.
   C. Upright splices: Not allowed
   D. Structural bolt hole diameters: Bolt diameter plus 1/16"
   E. Anchor bolt hole diameters: Bolt diameter plus ½"
   F. Hot Dip Galvanize after fabrication.
   G. Shop assemble the entire structure after galvanizing to validate/document alignment and clearance for bolted connections as well as contact between connecting plates. Take remedial action, if necessary, prior to shipment.
   H. Disassemble, as necessary, and secure components for shipment.

6. <u>Coatings:</u>

   A. Bolts, Nuts and Washers: ASTM F2329
   B. All other steel, including Plate Washers, hot dip galvanize: ASTM A123

7. <u>Construction:</u>

   A. Construct foundation in accordance with Specification Section 455, except payment is included in the cost of the structure.
   B. Prior to erection, record the as-built anchor locations and submit to the Engineer.
   C. Place backfill above spread footings prior to installation of the sign panels. Do not remove or reduce backfill without prior approval of the Engineer.
   D. Tighten nuts and bolts in accordance with Specification Section 700. Split-Lock Washers are not permitted.
   E. Install Aluminum Sign Panels as shown on the Elevation drawing.
   F. Place structural grout pad with drain between top of foundation and bottom of baseplate in accordance with Specification Section 649-7.



ISOMETRIC VIEW

CAMBER DIAGRAM

CANTILEVER SIGN ASSEMBLY

11/30/2015 2:18:51 PM

LAST REVISION 01/01/16

REVISION

DESCRIPTION:

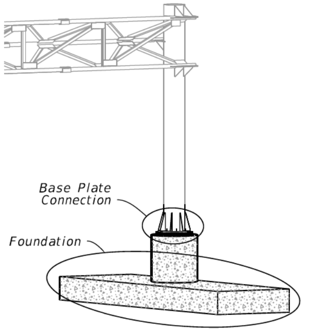
FDOT

FY 2016-17
DESIGN STANDARDS

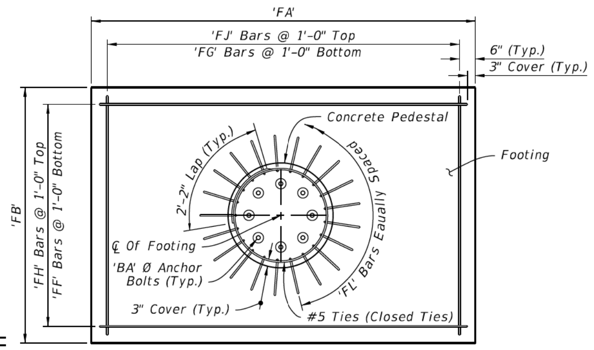
CANTILEVER SIGN STRUCTURE

INDEX NO. 11310

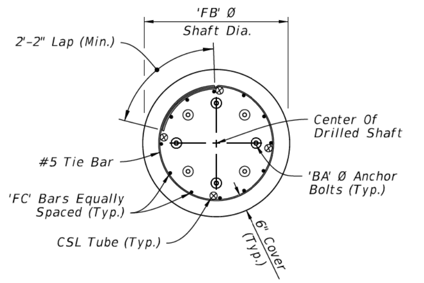
SHEET NO. 1 of 5



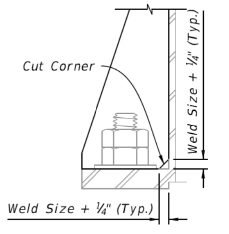
CANTILEVER ASSEMBLY



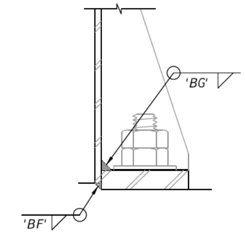
PLAN



PLAN



DETAIL 'A'



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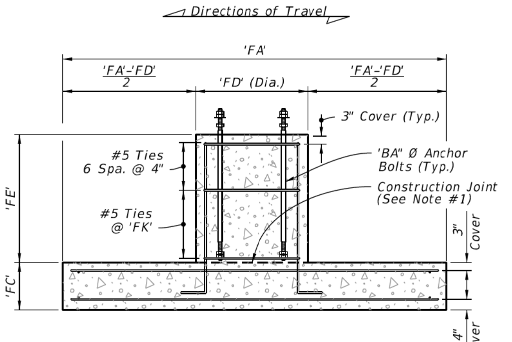
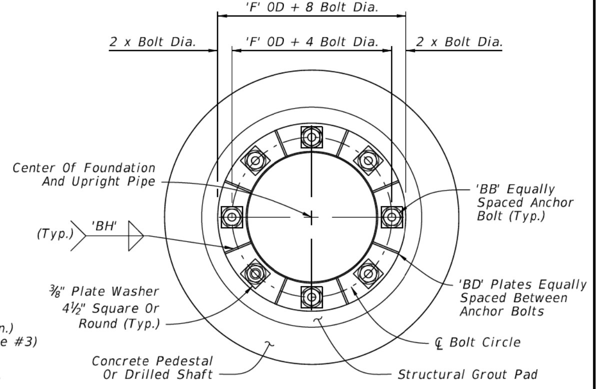


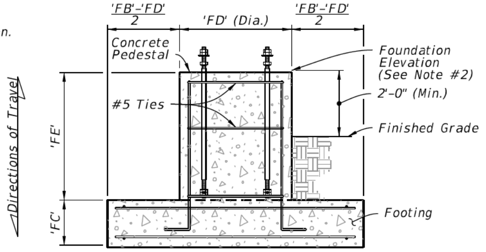
SIDE ELEVATION



PLAN

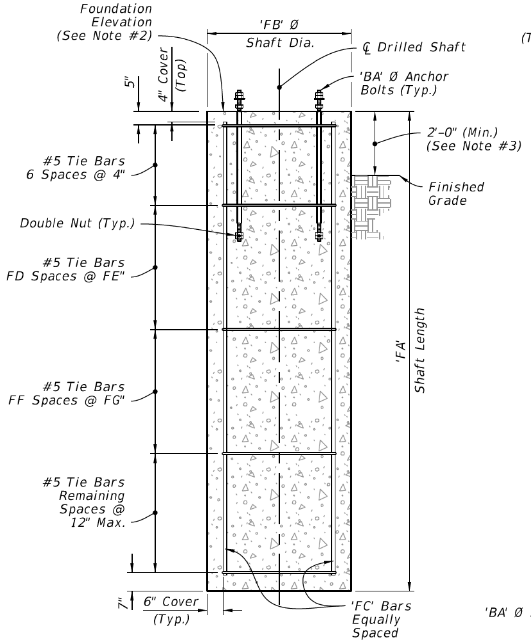
NOTES:

1. Construction joint allowed, roughen surface to ¼" minimum amplitude prior to pour.
2. See Traffic Plans for elevation at top of Foundation.
3. Install Drilled Shaft with a 2'-0" minimum from top elevation of the drill shaft to the finished grade, unless specified otherwise in the plans.
4. Structural Grout Pad dimension may be modified to be less than 3" where the footprint of the Structural Grout Pad does not provide adequate clearance for accessibility considerations.
5. Wrap fillet weld around the stiffner termination on the tube wall.



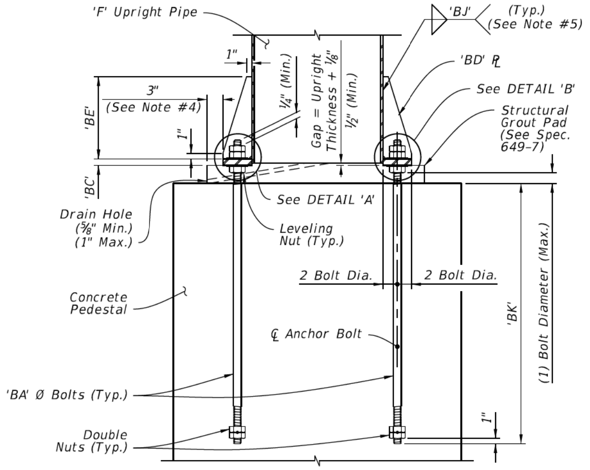
FRONT ELEVATION

FOOTING AND PEDESTAL



ELEVATION

DRILLED SHAFT
(Alternate Foundation)



ELEVATION

FOUNDATION

BASE PLATE CONNECTION

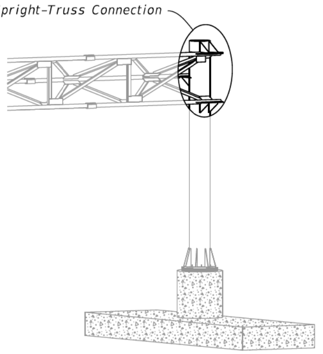
LAST REVISION 01/01/16
REVISION
DESCRIPTION:

FDOT
FY 2016-17
DESIGN STANDARDS

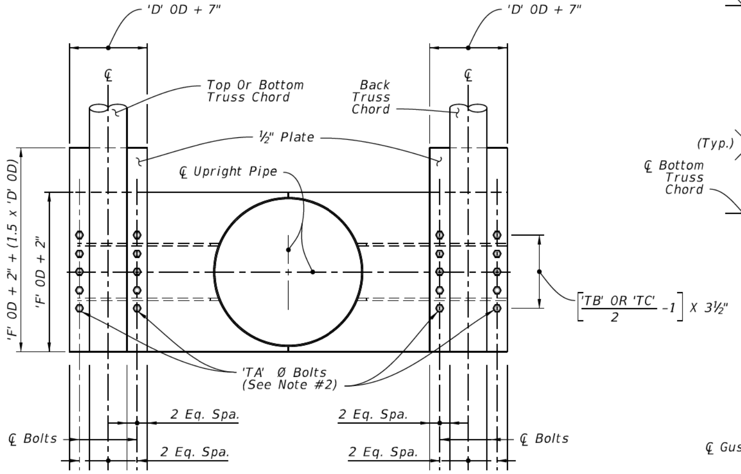
CANTILEVER SIGN STRUCTURE

INDEX NO. 11310
SHEET NO. 2 of 5

11/30/2015 2:18:53 PM

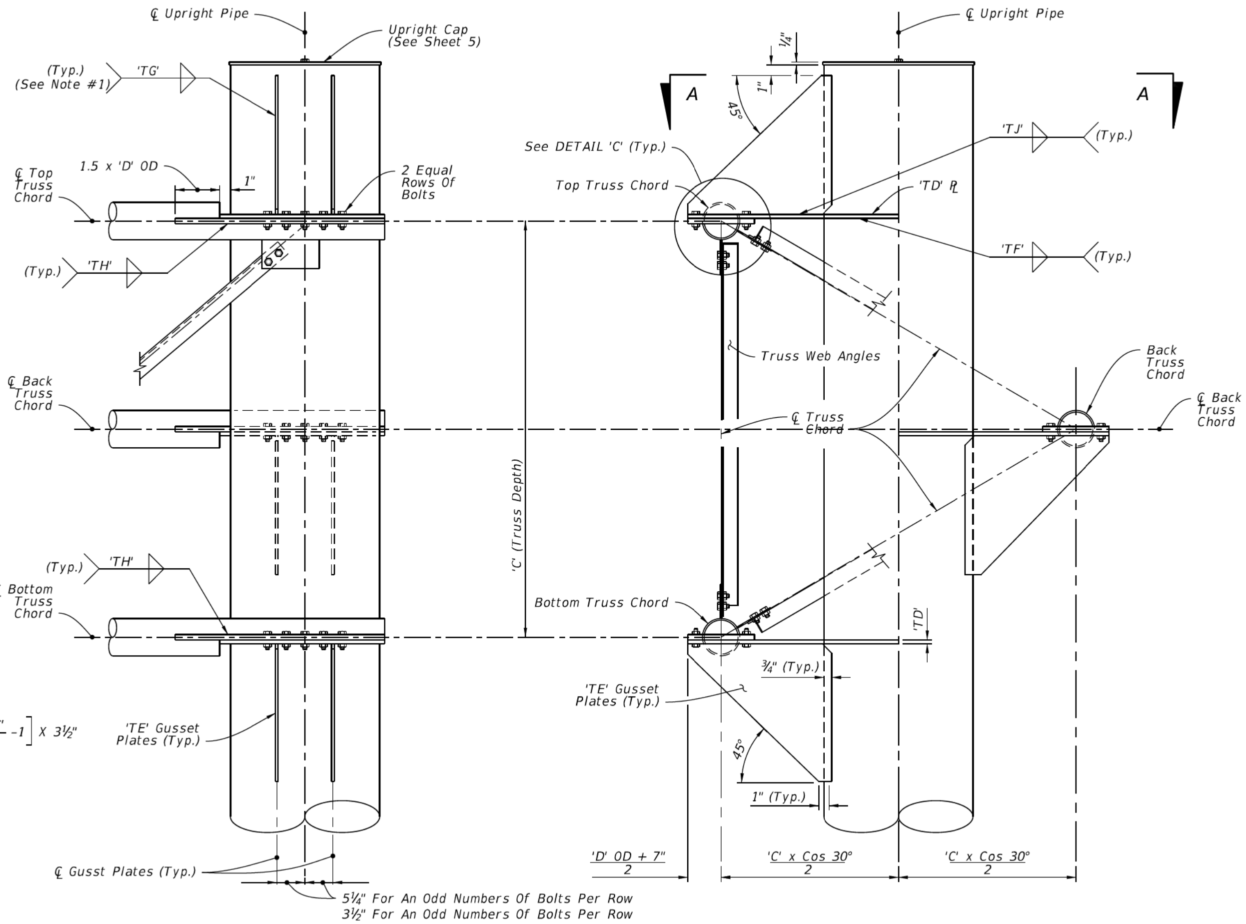


CANTILEVER ASSEMBLY



SECTION A-A

(With Gusset Plates And Web Angles Omitted For Clarity)

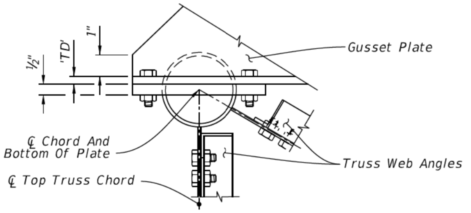


FRONT ELEVATION

SIDE ELEVATION

UPRIGHT-TRUSS CONNECTION DETAIL

(Web Members From Back Truss Chord Omitted For Clarity)



DETAIL 'C'

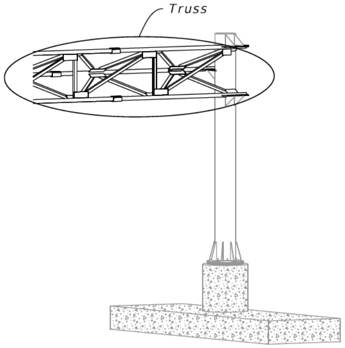
NOTES:

1. Wrap fillet weld around the stiffner termination on the tube wall.

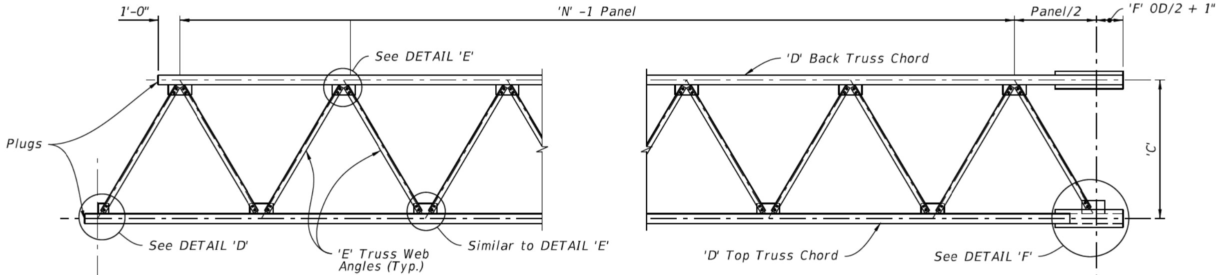
2. Truss Chord Bolts:
   A. Top and Bottom: Install 'TC' hex head bolts.
   B. Back: Install 'TB' hex head bolts.

7:03:01 AM
4/19/2016

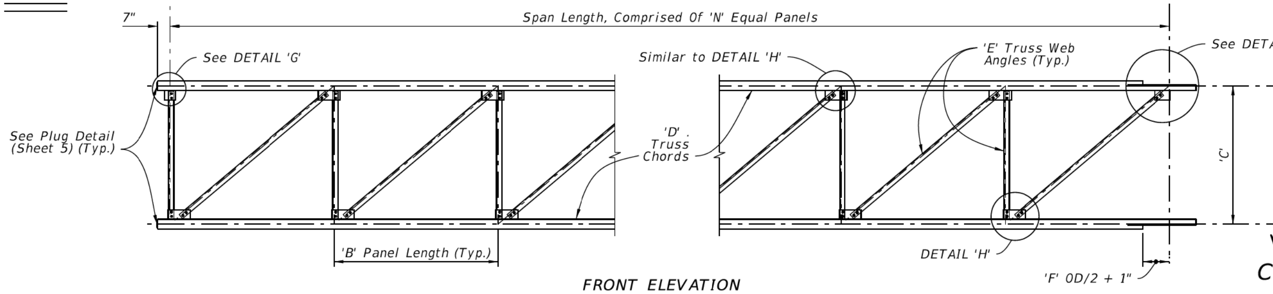
LAST REVISION 01/01/16	REVISION	DESCRIPTION:	FDOT FY 2016-17 DESIGN STANDARDS	CANTILEVER SIGN STRUCTURE	INDEX NO. 11310	SHEET NO. 3 of 5



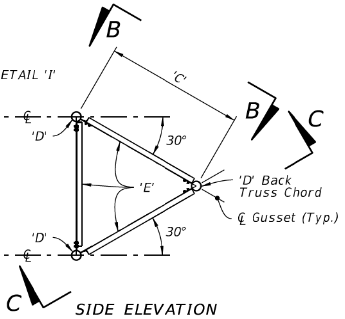
CANTILEVER ASSEMBLY



Section B-B (Section C-C Similar)
(See Note #1)



FRONT ELEVATION
(See Note #2)



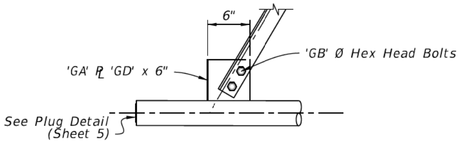
SIDE ELEVATION

TRUSS

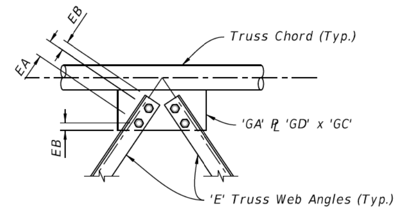
TRUSS NOTES:

1. Out-of-plane members are not shown for clarity.
2. Back truss chord and attached angles are not shown for clarity.
3. Wrap fillet weld around plate termination on the tube wall.
4. Chord Splices not shown.

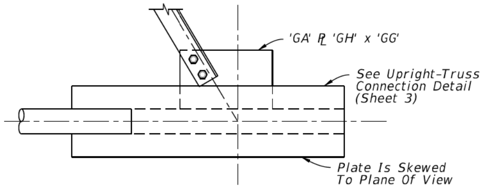
Bolt Size	Distance	
	EA	EB
1" Ø	3½"	1¾"
⅞" Ø	3"	1½"
¾" Ø	2½"	1¼"
⅝" Ø	2¼"	1⅛"



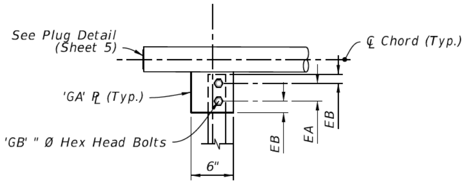
DETAIL 'D'



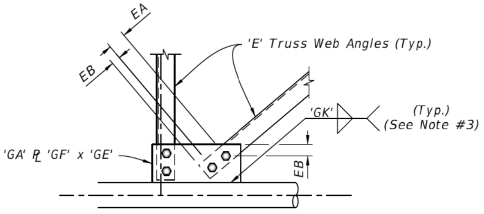
DETAIL 'E'



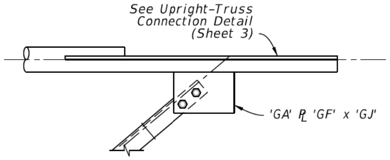
DETAIL 'F'



DETAIL 'G'



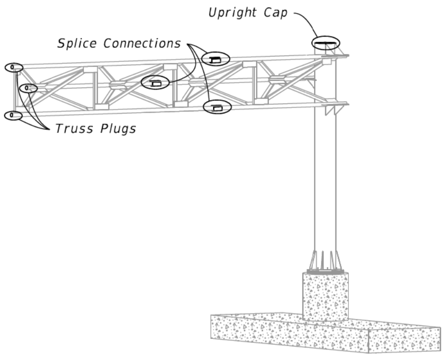
DETAIL 'H'



DETAIL 'I'

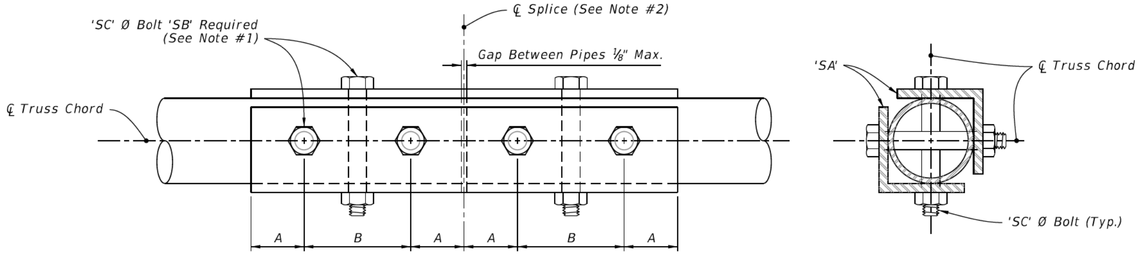
4/19/2016 7:03:03 AM

LAST REVISION	REVISION	DESCRIPTION:	FDOT FY 2016-17 DESIGN STANDARDS	CANTILEVER SIGN STRUCTURE	INDEX NO.	SHEET NO.
01/01/16					11310	4 of 5



CANTILEVER ASSEMBLY

Bolt Size	Distance	
	A	B
1" Ø	1¾"	3½"
⅞" Ø	1½"	3"
¾" Ø	1¼"	2½"



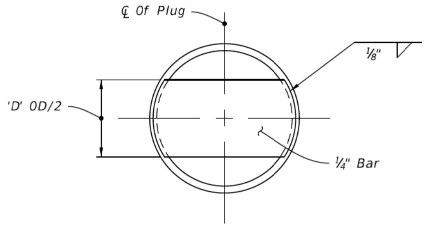
FRONT ELEVATION

SIDE ELEVATION

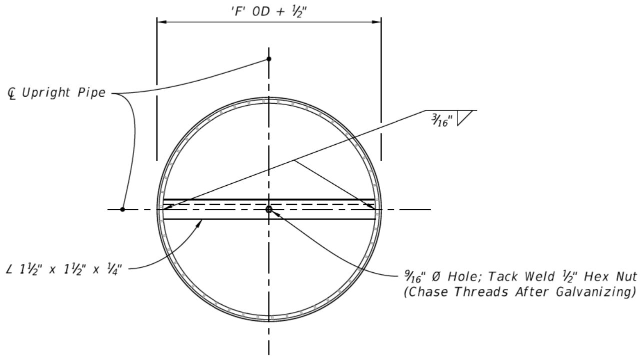
SPLICE CONNECTION DETAIL

SPLICE CONNECTION NOTES:

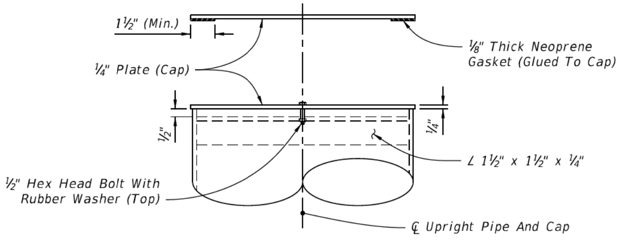
1. Only 6 bolts are shown in detail for clarity. (One Half Each Side Of Splice)
2. Splices are not allowed for truses less than or equal to 40', Splice optional for trusses greater than 40'.



TRUSS PLUG DETAIL



PLAN

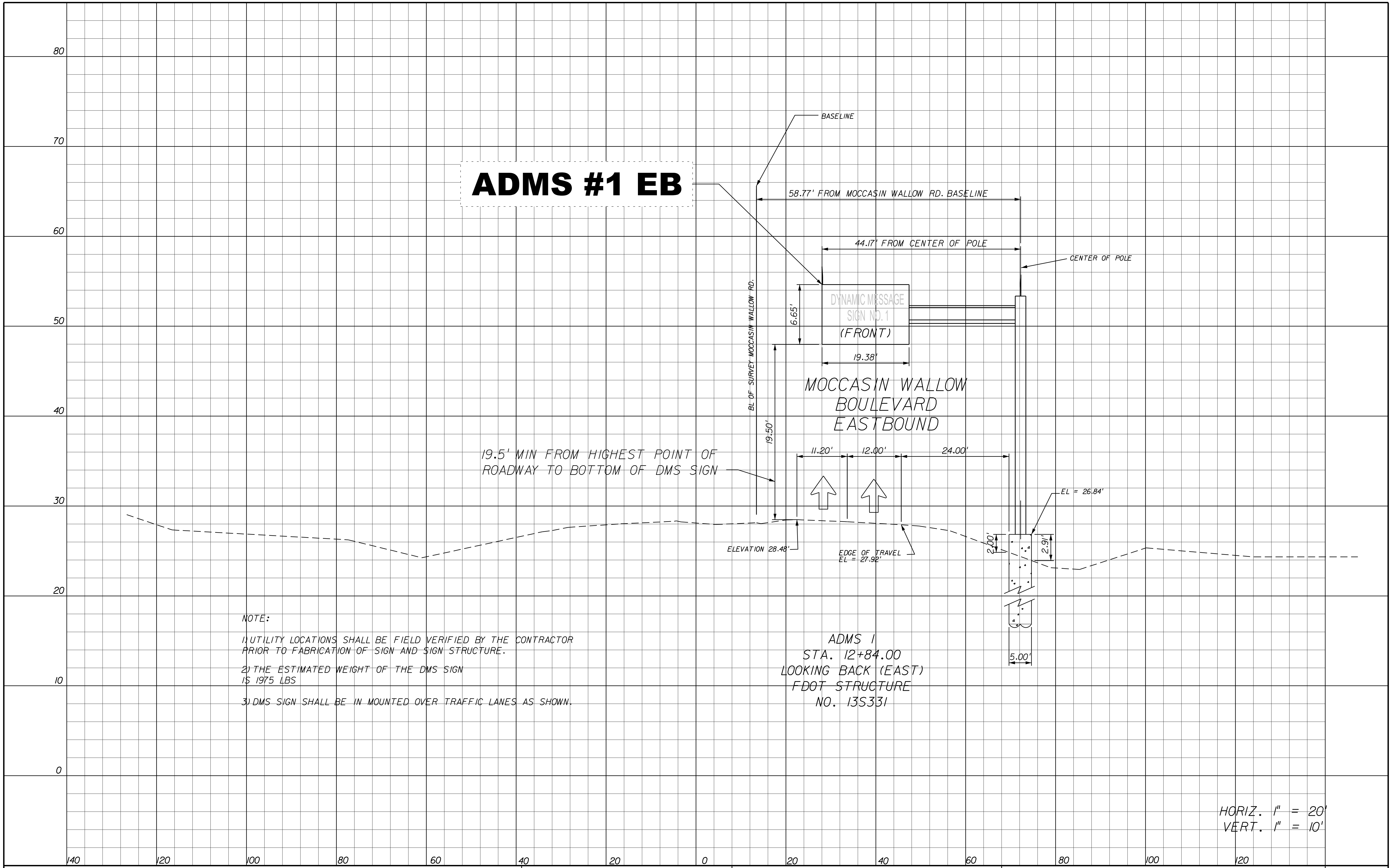


ELEVATION

UPRIGHT CAP DETAIL

11/30/2015 2:18:56 PM

LAST REVISION	REVISION	DESCRIPTION:			INDEX NO.	SHEET NO.
01/01/16			FDOT FY 2016-17 DESIGN STANDARDS	CANTILEVER SIGN STRUCTURE	11310	5 of 5



NOTE:

1) UTILITY LOCATIONS SHALL BE FIELD VERIFIED BY THE CONTRACTOR PRIOR TO FABRICATION OF SIGN AND SIGN STRUCTURE.

2) THE ESTIMATED WEIGHT OF THE DMS SIGN IS 1975 LBS

3) DMS SIGN SHALL BE IN MOUNTED OVER TRAFFIC LANES AS SHOWN.

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

REVISIONS

DATE	DESCRIPTION	DATE	DESCRIPTION

PHUC H. DUONG, P.E.
P.E. NO.: 63835
GANNETT FLEMING
9119 CORPORATE LAKE DR., SUITE 150
TAMPA, FLORIDA 33634
CERTIFICATE OF AUTHORIZATION No. 5564

STATE OF FLORIDA
DEPARTMENT OF TRANSPORTATION

ROAD NO.	COUNTY	FINANCIAL PROJECT ID
SR-93A	MANATEE	434026-1-52-01

DMS CROSS SECTIONS

SHEET NO.
S-10

kpollard 9/12/2018 11:26:22 AM S:\CF_TOPS\062478 GFPDC -FDOT 7 E7R00 DB\Project Working\As Builts\43402615201\ITS - DMS\SSXSIT

CANTILEVER SIGN STRUCTURES DATA TABLE

Table Date 07-01-14

SIGN NO.	STATION	DIMENSIONS				PANELS	MEMBER SIZES			BACKRAKE
		A	B		C	N	D (CHORD)	E (WEB)	F (UPRIGHT)	G
		ft	ft	in	in	#	O. D. x Wall Thk. (in)	Angle (in)	O. D. x Wall Thk. (in)	in
ADMS-1	12+84.00/58.77	24.465	8	8-3/4	60	5	5.56 x 0.375	3 x 3 x 5/16	24.00 x 0.750	5.6878

NOTES [Notes Date 7-01-13]:
1.Work these Data Tables with Index 11310.
2.Design Wind Speed = 130 mph.
3.Upright wall thickness given is a minimum dimension.

FOUNDATION NOTES [Notes Date 7-01-12]:
1.Design based on Borings taken XX-XX-17
sealed by H2R CORP.
2.Assumptions and Values used in design:
Soil Type Non-Cohesive
Soil Layer Thickness = 25 ft.
Soil Friction Angle = 31 deg.
Soil Weight = 48.6 pcf
Design Water Table is 0 ft. below surface

CANTILEVER SIGN STRUCTURES DATA TABLE (CONT.)

Table Date 01-01-11

SIGN NO.	GUSSET PLATES																	TRUSS CONNECTION									SPLICE			
	GA	GB	GC		GD		GE		GF		GG		GH		GJ		GK	TA	TB	TC	TD	TE	TF	TG	TH	TJ	SA	SB	SC	SD
	in	in	ft	in	ft	in	ft	in	ft	in	ft	in	ft	in	ft	in	in	in	#	#	in	in	in	in	in	in	Angle (in)	#	in	#
ADMS-1	3/4	3/4	1	5		6-1/2	1	2-1/4		5-1/2		7-1/2		5		11-3/4	3/16	7/8	6	6	1/2	1/2	1/4	3/16	3/16	3/16	5 x 5 x 1/2	4	7/8	3

CANTILEVER SIGN STRUCTURES DATA TABLE (CONT.)

Table Date 07-01-15

SIGN NO.	BASE CONNECTION										ANCHOR		FOOTING - DRILLED SHAFT								
	BA	BB	BC	BD	BE		BF	BG	BH	BJ	BK		FA		FB		FC	FD	FE	FF	FG
	in	#	in	in	ft	in	in	in	in	in	ft	in	ft	in	ft	in	# / Size	#	in	#	in
ADMS-1	2	12	1-1/2	1/2	2	3	5/16	5/16	5/16	3/16	3	4	21	0	5	0	19 / 11	7	4	31	6

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

REVISIONS

DATE	DESCRIPTION	DATE	DESCRIPTION

EOR: DEREK M. GIL, P.E.
P.E. LICENSE NUMBER 54798
ELEMENT ENGINEERING GROUP
1713 E. 9th AVENUE
TAMPA, FL 33605
CERTIFICATE OF AUTHORIZATION 26921

STATE OF FLORIDA
DEPARTMENT OF TRANSPORTATION

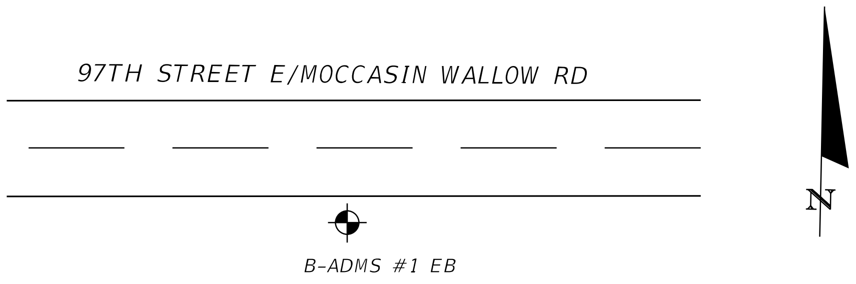
ROAD NO.	COUNTY	FINANCIAL PROJECT ID
SR-93A	MANATEE	434026-1-52-01

CANTILEVER SIGN STRUCTURE DATA TABLE

SHEET NO.
S-13

RECOMMENDED SOIL PARAMETERS

BORING NUMBER	SOIL LAYER DEPTHS (feet)		SATURATED UNIT WEIGHT (pcf)	SUBMERGED UNIT WEIGHT (pcf)	INTERNAL ANGLE OF FRICTION Φ (degrees)	COHESION (tsf)	SHEAR STRENGTH OF LIMESTONE (tsf)
	from	to					
B-ADMS #1 EB	0.0	-17.0	111.0	48.6	30	-	-
	-17.0	-25.0	114.0	51.6	33	-	-
	-25.0	-40.0	114.0	51.6	-	0.48	0.008
	-40.0	-45.0	120.0	57.6	-	5.99	0.001



BORING LOCATION PLAN

LEGEND

▨ SP or SP-SM, Sand or slightly silty sand

▦ Limestone Soft

▨ SC, Clayey Sand

▨ CL or CH, Sandy Clay

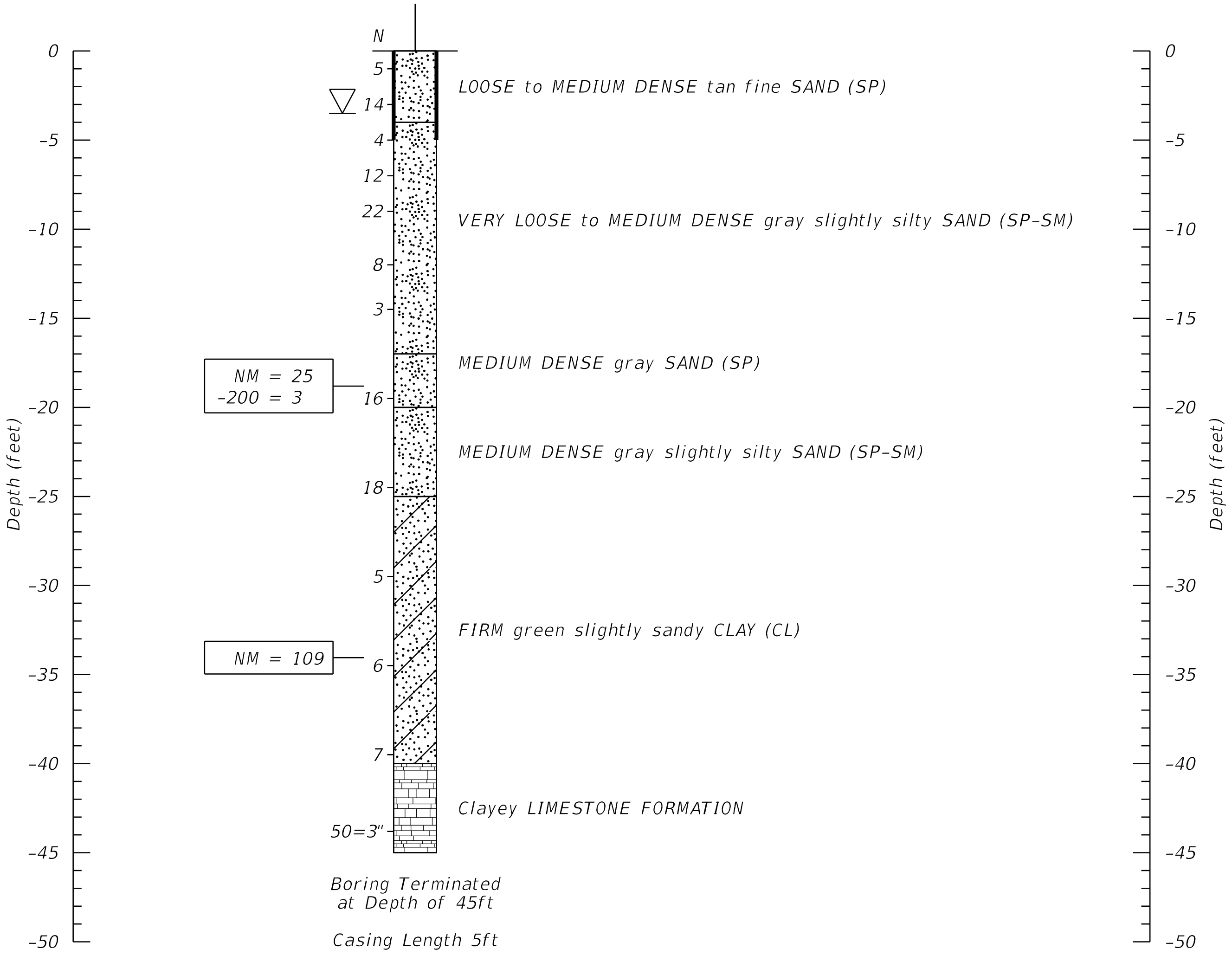
▨ SM, Silty Sand

▽ = Groundwater Table

▯ = Casing used

NM = % Natural Moisture Content
-200 = % Passing -200 Sieve
LL = % Liquid Limit
PI = % Plasticity Index
ORG = % Organic Content

BOR # B-ADMS #1 EB
LOCATION 12+83, 57'RT CL MOCCASIN WALLOW RD
DATE 4/21/2017
DRILLER T. CARNEY
HAMMER AUTOMATIC
RIG CME 75



B1BORING01

GENERAL NOTES

DRILL AND PENETRATION TESTING WERE PERFORMED IN ACCORDANCE WITH ASTM D 1586. NUMBER TO THE LEFT OF BORING INDICATES BLOWS OF 1⅜" I.D., 2" O.D. SPLIT-SPOON FOR 12" PENETRATION (UNLESS OTHERWISE NOTED) WITH A 140 LB HAMMER DROPPED 30 INCHES.

THE BORING LOGS SHOWN REPRESENT SUBSURFACE CONDITIONS WITHIN THE BOREHOLE AT THE TIME OF DRILLING. NO WARRANTY AS TO THE SUBSURFACE CONDITION, STRATA DEPTH OR SOIL CONSISTENCY BETWEEN OR OUTSIDE BORING LOCATIONS IS EXPRESSED OR IMPLIED BY THIS DRAWING.

REFER TO GEOTECHNICAL REPORT BY H2R CORP FOR DETAILED BORING INFORMATION.

GRANULAR MATERIALS-

Relative Density	Safety Hammer SPT N-Value (Blow/Foot)	Automatic Hammer SPT N-Value (Blow/Foot)
Very Loose	Less than 4	Less than 3
Loose	4 - 10	3 - 8
Medium Dense	10 - 30	8 - 24
Dense	30 - 50	24 - 40
Very Dense	Greater than 50	Greater than 40

SILTS AND CLAYS-

Consistency	Safety Hammer SPT N-Value (Blow/Foot)	Automatic Hammer SPT N-Value (Blow/Foot)
Very Soft	Less than 2	Less than 1
Soft	2 - 4	1 - 3
Firm	4 - 8	3 - 6
Stiff	8 - 15	6 - 12
Very Stiff	15 - 30	12 - 24
Hard	Greater than 30	Greater than 24

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

REVISIONS

DATE	BY	DESCRIPTION	DATE	BY	DESCRIPTION

H2R CORP
3921 76TH AVENUE NORTH
PINELLAS PARK, FLORIDA 33781
CERTIFICATE OF AUTHORIZATION 31828
Daniel C. Hart, P.E.
P.E. NO. 55438

DRAWN BY: TEJ
CHECKED BY: SD
DESIGNED BY: DCH
CHECKED BY: SD

STATE OF FLORIDA
DEPARTMENT OF TRANSPORTATION

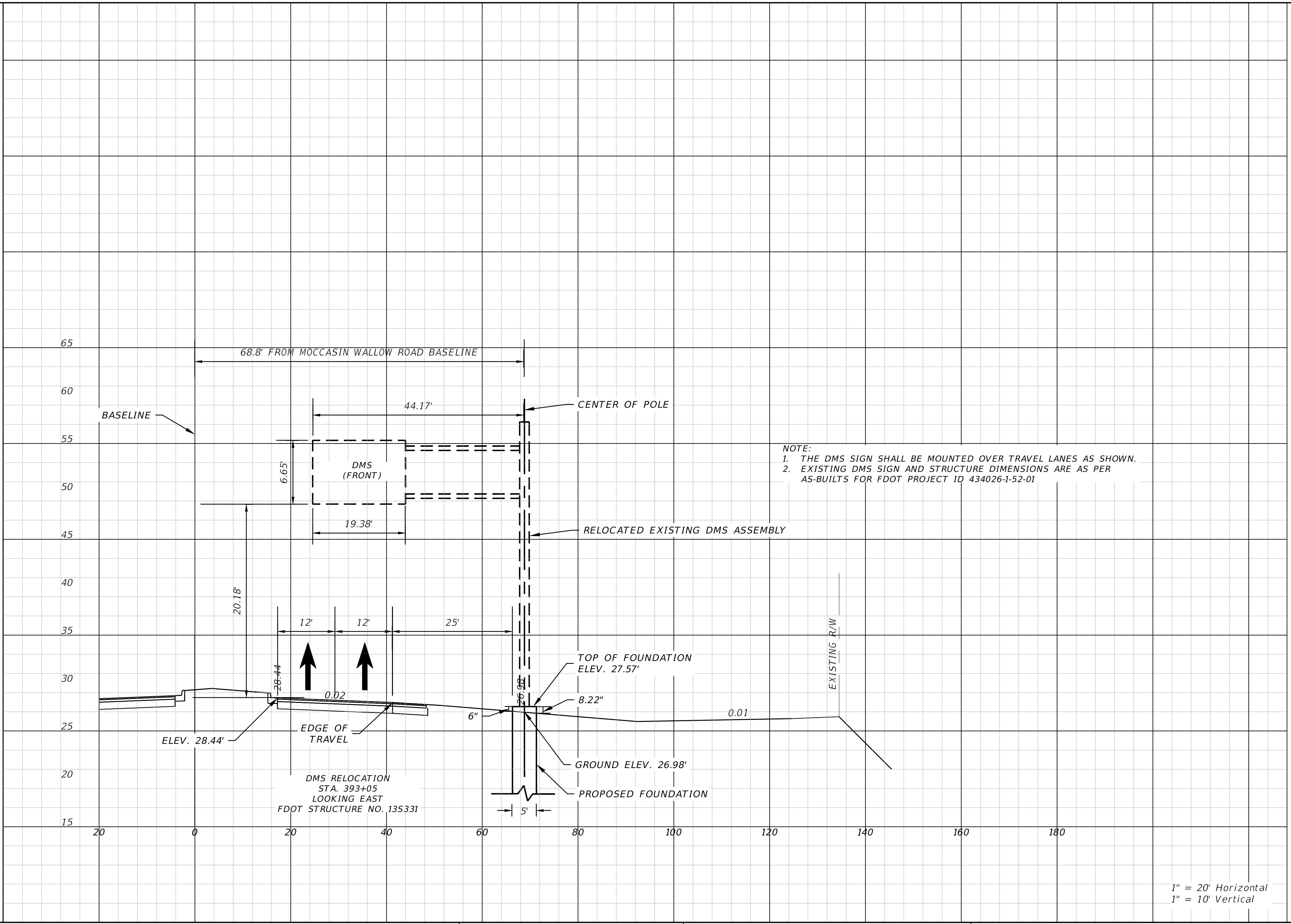
ROAD NO.	COUNTY	FINANCIAL PROJECT ID
SR-93A	MANATEE	434026-1-52-01

SHEET TITLE: REPORT OF CORE BORINGS

PROJECT NAME: I-75 MANATEE COUNTY ITS - GFPDC

REF. DWG. NO.

SHEET NO. S-17



NOTE:
1. THE DMS SIGN SHALL BE MOUNTED OVER TRAVEL LANES AS SHOWN.
2. EXISTING DMS SIGN AND STRUCTURE DIMENSIONS ARE AS PER AS-BUILTS FOR FDOT PROJECT ID 434026-1-52-01

1" = 20' Horizontal
1" = 10' Vertical

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REVISIONS

DATE	DESCRIPTION	DATE	DESCRIPTION
----	----		

DAVID J. ALLEN, P.E.
P.E. LICENSE NUMBER 58540
CARDNO
3905 CRESCENT PARK DRIVE
RIVERVIEW, FLORIDA 33578
CERTIFICATE OF AUTHORIZATION 29915

MANATEE COUNTY

ROAD NO.	FINANCIAL PROJECT ID
MOCCASIN WALLOW RD	6092560

XS_DMS - DMS CROSS SECTION

SHEET NO.

Howard Holley 12/20/2021 3:27:46 PM C:\Projects\Moccasin Wallow\dwg\00000000000\Signals\XS_DMS.dwg

CANTILEVER SIGN STRUCTURES DATA TABLE

Table Date 07-01-14

SIGN NO.	STATION	DIMENSIONS				PANELS	MEMBER SIZES			BACKRAKE
		A	B		C	N	D (CHORD)	E (WEB)	F (UPRIGHT)	G
		ft	ft	in	in	#	O. D. x Wall Thk. (in)	Angle (in)	O. D. x Wall Thk. (in)	in

NOTES [Notes Date 7-01-13]:
1. Work these Data Tables with Index 700-040.
2. Design Wind Speed = 150 mph.
3. Relocate existing DMS sign to new foundation.

FOUNDATION NOTES [Notes Date 7-01-12]:
1. Design based on Borings taken 4/21/2017 sealed by H2R Corp.
2. Assumptions and Values used in design:
Soil Type Non-Cohesive
Soil Layer Thickness = 25 ft.
Soil Friction Angle = 31 deg.
Soil Weight = 48.6 pcf
Design Water Table is 0 ft. below surface

CANTILEVER SIGN STRUCTURES DATA TABLE (CONT.)

Table Date 01-01-11

SIGN NO.	GUSSET PLATES																	TRUSS CONNECTION									SPLICE			
	GA	GB	GC		GD		GE		GF		GG		GH		GJ		GK	TA	TB	TC	TD	TE	TF	TG	TH	TJ	SA	SB	SC	SD
	in	in	ft	in	ft	in	ft	in	ft	in	ft	in	ft	in	ft	in	in	in	#	#	in	in	in	in	in	in	Angle (in)	#	in	#

CANTILEVER SIGN STRUCTURES DATA TABLE (CONT.)

Table Date 07-01-15

SIGN NO.	BASE CONNECTION										ANCHOR		FOOTING - DRILLED SHAFT								
	BA	BB	BC	BD	BE		BF	BG	BH	BJ	BK		FA		FB		FC	FD	FE	FF	FG
	in	#	in	in	ft	in	in	in	in	in	ft	in	ft	in	ft	in	# / Size	#	in	#	in
13S331	2	12	2	1/2	2	3-1/4	5/16	5/16	5/16	5/16	3	4	24	0	5	0	19 / 11	7	4	31	6

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REVISIONS

DATE	DESCRIPTION	DATE	DESCRIPTION
----	----		

CHRISTOPHER P. GAMACHE, P.E.
P.E. LICENSE NUMBER 82122
CARDNO
380 PARK PLACE BLVD SUITE 300
CLEARWATER, FLORIDA 33759
CERTIFICATE OF AUTHORIZATION 29915

MANATEE COUNTY

ROAD NO.	PROJECT ID
MOCCASIN WALLOW RD	6092560

CANTILEVER SIGN STRUCTURE DATA TABLE

SHEET NO.
T-48

Cantilever Overhead Sign Program LRFD v1.5

State Structures Design Office

User manual including Program Changes

Design Specifications & References:

[LTS] - AASHTO LRFD Specifications for Structural Supports for Highway Signs, Luminaires and Traffic Signals
[AASHTO] - AASHTO LRFD Bridge Design Specifications
[SMn] - FDOT Structures Manual n=1: Structures Design Guidelines; n=3: FDOT Modifications to LRFD Specifications for Structural Supports for Highway Signs, Luminaires and Traffic Signals (LRFD LTS).
[Index] - FDOT Standard Plans
[AISC] - Steel Construction Manual

➔ Reference:C:\Users\christopher.gamache\OneDrive - Cardno\Desktop\OverheadSign-CantileverV1.5\LRFD Equation Module.xmcd(R)

Data Files Folder

Change Folder

C:\Users\christopher.gamache\OneDrive - Cardno\Desktop\OverheadSign-CantileverV1.5\Data\

Open Existing Data File (optional)

Ex1 - Static Sign Panels with Drilled Shaft.dat
Ex2 - Static Sign Panels with Spread Footing.dat
Ex3 - Static Sign Panels Front and Back.dat
Ex4 - Walk-In DMS.dat
Ex5 - Walk-In DMS with Walkway.dat
Ex6 - Front-Access DMS with Static Signs.dat
Moccasin Wallow Rd.dat

Refresh List

Open File

Project Data

Project Name	Moccasin Wall Rd from US 41 to West of I-75		
Project No.	6092560		
Designed by	CPG	Date	12 / 2021
Checked by	TRH	Date	12 / 2021

Sign Structure Data

Sign Name	393+05
Station/Offset	393+05 / 68.8' RT

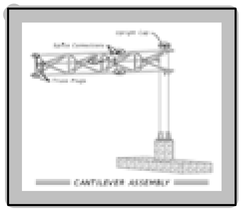
Material Properties Data

Upright and Chords: ASTM A500, Web Angles: ASTM A709 Grade 36

Fy of Upright	42	ksi	Fu of Upright	58	ksi
Fy of Web	36	ksi	Fu of Web	58	ksi
Fy of Chord	42	ksi	Fu of Chord	58	ksi

Truss Data

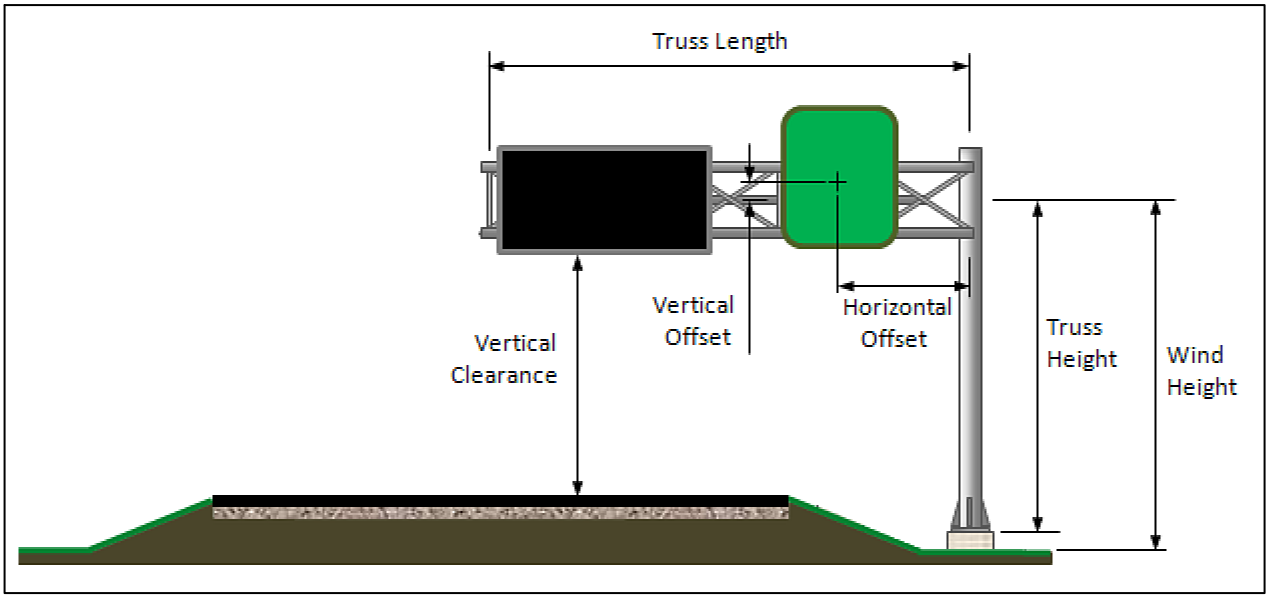
Truss Length	44.17	ft
Truss Height	24.465	ft
No. of Truss Panels	5	
Vert. Truss Depth	5	ft



Standard Plans and Instructions Index 700-040

Wind Load Data

Design Wind Speed	150	mph
Wind Height	30	ft
Vertical Clearance	20.18	ft



Load Data

Reset Load Data

Sign Panels

Show Panels 11-20

Sign Panel Number	Panel Length (ft)	Panel Height (ft)	Horizontal Offset (ft)	Vertical Offset* (ft)	Back-side Mounted?	Panel Weight (psf)
1					☐	
2					☐	
3					☐	
4					☐	
5					☐	
6					☐	
7					☐	
8					☐	
9					☐	
10					☐	

DMS Panels

DMS Panel Number	Panel Length (ft)	Panel Height (ft)	Panel Depth (ft)	Horizontal Offset (ft)	Vertical Offset* (ft)	Panel Weight (psf)
1	19.38	6.65	1.25	34.48	0	15.32
2						
3						

Walkways

Walkway Number	Walkway Length (ft)	Walkway Width (ft)	Number of Hangers	Horizontal Offset (ft)	Vertical Offset* (ft)	Walkway Weight (plf)
1						
2						

Attachments

Attachment Number	Projected Area (sq. ft)	Drag Coeff., C_d	Attached to Which Chord Member? (Top / Bottom / Back)	Horizontal Offset (ft)	Attachment Weight (lb)
1					
2					
3					

** Vertical offsets are input as negative values when element centroid is below the truss centerline.*

▶ Member Data

Member Properties

Chord Size

3.50" O.D. Pipe, 0.216" Wall
4.00" O.D. Pipe, 0.226" Wall
4.50" O.D. Pipe, 0.237" Wall
4.50" O.D. Pipe, 0.337" Wall
5.563" O.D. Pipe, 0.258" Wall
[✓ 5.563" O.D. Pipe, 0.375" Wall]
6.625" O.D. Pipe, 0.432" Wall
8.625" O.D. Pipe, 0.500" Wall
CUSTOM

Design Properties

Outside Diameter (D)	5.56	in
Wall Thickness (t)	0.349	in
Area (A)	5.72	in^2
Moment of Inertia (I)	19.5	in^4
Radius of Gyration (r)	1.85	in
Torsional Constant (J)	39	in^4
Nominal Weight	20.8	plf

Web Size

Angle 2-1/2" x 2-1/2" x 1/4"
Angle 3" x 3" x 1/4"
[✓ Angle 3" x 3" x 5/16"]
Angle 3-1/2" x 3-1/2" x 5/16"
Angle 3-1/2" x 3-1/2" x 3/8"
Angle 4" x 4" x 3/8"
Angle 4" x 4" x 1/2"
Angle 5" x 5" x 1/2"
CUSTOM

Design Properties

Leg Length (b)	3	in
Leg Thickness (t)	0.313	in
Area (A)	1.78	in^2
Dist. to Centroid ($\bar{x}$)	0.86	in
X Moment of Inertia (I_x)	1.5	in^4
X Rad. of Gyration (r_x)	0.918	in
Z Rad. of Gyration (r_z)	0.583	in
Nominal Weight	6.1	plf

Upright Size

12.75" O.D. Pipe, 0.375" Wall
14" O.D. Pipe, 0.375" Wall
16" O.D. Pipe, 0.375" Wall
18" O.D. Pipe, 0.438" Wall
20" O.D. Pipe, 0.500" Wall
24" O.D. Pipe, 0.375" Wall
24" O.D. Pipe, 0.562" Wall
[✓ 24" O.D. Pipe, 0.750" Wall]
30" O.D. Pipe, 0.500" Wall
30" O.D. Pipe, 0.625" Wall
30" O.D. Pipe, 0.750" Wall

Design Properties

Outside Diameter (D)	24	in
Wall Thickness (t)	0.75	in
Area (A)	54.8	in^2
Moment of Inertia (I)	3705	in^4
Radius of Gyration (r)	8.22	in
Torsional Constant (J)	7411	in^4
Nominal Weight	186.4	plf

Connection Data

Splice

Splice Bolt Diameter
- 3/4"
- [✓ 7/8"]
- 1"

Number of Splice Bolts
- [✓ 4]
- 6
- 8

Gusset Plates

Min. Gusset Bolt Diameter
- 5/8"
- [✓ 3/4"]
- 7/8"
- 1"
- 1-1/4"

Min. Gusset Plate Thickness
- 3/8"
- 1/2"
- 5/8"
- [✓ 3/4"]
- 7/8"
- 1"

Truss Connections

Truss Bolt Diameter
- [✓ 7/8"]
- 1"

Number of Truss Back Bolts
- [✓ 6]
- 8
- 10
- 12

Number of Truss Front Bolts
- [✓ 6]
- 8
- 10
- 12

Min. Horizontal Plate Thickness
- [✓ 1/2"]
- 5/8"
- 3/4"
- 7/8"
- 1"

Min. Vertical Plate Thickness
- [✓ 1/2"]
- 5/8"
- 3/4"
- 7/8"
- 1"

Base Connection

Anchor Bolt Diameter
- 1"
- 1-1/2"
- 1-3/4"
- [✓ 2"]
- 2-1/4"
- 2-1/2"

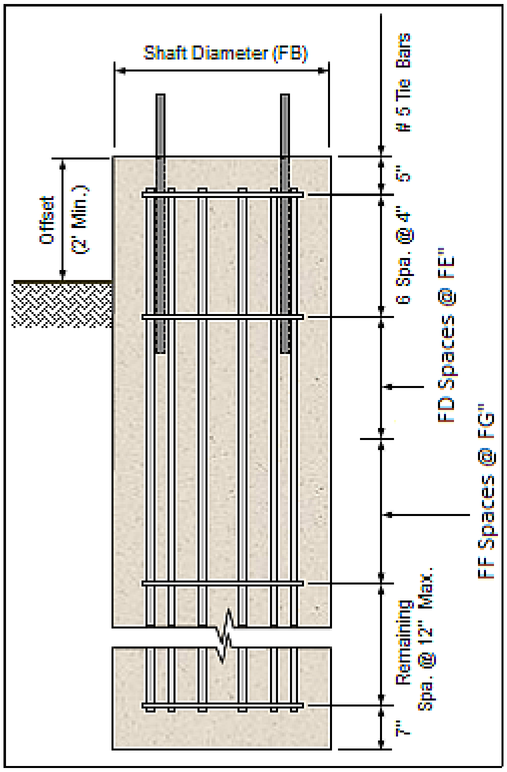
Number of Anchor Bolts
- 8
- 10
- [✓ 12]

Min. Base Plate Thickness
- 1"
- 1-1/4"
- [✓ 1-1/2"]
- 1-3/4"
- 2"

Min. Stiffener Plate Thickness
- 3/8"
- [✓ 1/2"]
- 5/8"
- 3/4"
- 7/8"
- 1"

Foundation Data

Foundation Type [✓ Drilled Shaft] Spread Footing None



Drilled Shaft Data

Soil Type [✓ Sand] Clay

Soil Density, γ_{soil} 48.6 pcf
Typical Design Value 45-50 pcf

Friction Angle, ϕ 31 deg

SPT Number (N_{blows}) 10

Shear Strength, *c* ksf

Shaft Diameter (FB) 5 ft

Ground to Top of Shaft Offset 1 ft

First Set Stirrups:

Number of Stirrup Spaces (FD) 7

Stirrup Spacing (FE) 4 in

Second Set Stirrups:

Number of Stirrup Spaces (FF) 31

Stirrup Spacing (FG) 6 in

Stirrup Bar Size [✓ #5 Stirrup] #6 Stirrup

Spread Footing Data

Factored Bearing Resistance $\varphi_b \cdot q_n$ psf

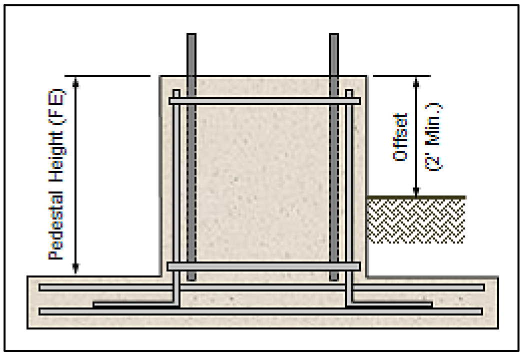
Soil Density (Ground Cover) pcf

Coeff. of Passive Pressure

Coeff. Friction between Slab and Soil

Pedestal Height (FE) ft

Ground to Top of Pedestal Offset ft



☐ Cross Slope Present run/rise

▶ Save Data

Save Data File (optional)

☑ Use current input file

File Name Moccasin Wallow Rd.dat Save Data

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

▶ Data Initialization

▶ Geometry Check Calculations

Preliminary Geometry Checks

$\text{CheckL}_{\text{TrussPanel}} = \text{"OK"}$ $L_{\text{TrussPanel}} = 8.83\,\text{ft}$ OK if $L_{\text{TrussPanel}} \le 12\cdot\text{ft}$

$\text{CheckClr}_{\text{Web}} = \text{"OK"}$ *Check for Web members interfere with upright.*

$\text{CheckClr}_{\text{GusPlate}} = \text{"OK"}$ $D_{\text{Horz}} - \left(d_{\text{Upright}} + d_{\text{Chord}}\right) = 1.87\,\text{ft}$ OK if > $18\cdot\text{in}$

$\text{CheckLayout}_{\text{Sign}} = \text{"OK"}$ *Check that panels fit on the chord members.*

$\text{CheckOverlap}_{\text{Panel}} = \text{"OK"}$ *Check that panels do not overlap.*

$\text{Check}_{\text{DMS}} = \text{"OK"}$ *For DMS, checks vertical depth and span-to-depth ratio*

Member Slenderness Checks

$\text{CheckSlenderness}_{\text{Chord}} = \text{"OK"}$ $\text{KLr}_{\text{Chord}} = 57.3$

$\text{CheckSlenderness}_{\text{Web}} = \text{"OK"}$ $\text{KLr}_{\text{Web}} = 197.86$

$\text{Check}_{\text{Classification.chord}} = \text{"OK"}$ $\text{SectionClassification}_{\text{.local.buckling.chord}} = \text{"Compact"}$

$\text{Check}_{\text{Classification.web}} = \text{"OK"}$ $\text{SectionClassification}_{\text{.local.buckling.web}} = \text{"Compact"}$

▶ 3D Model Data and Wireframe Diagram

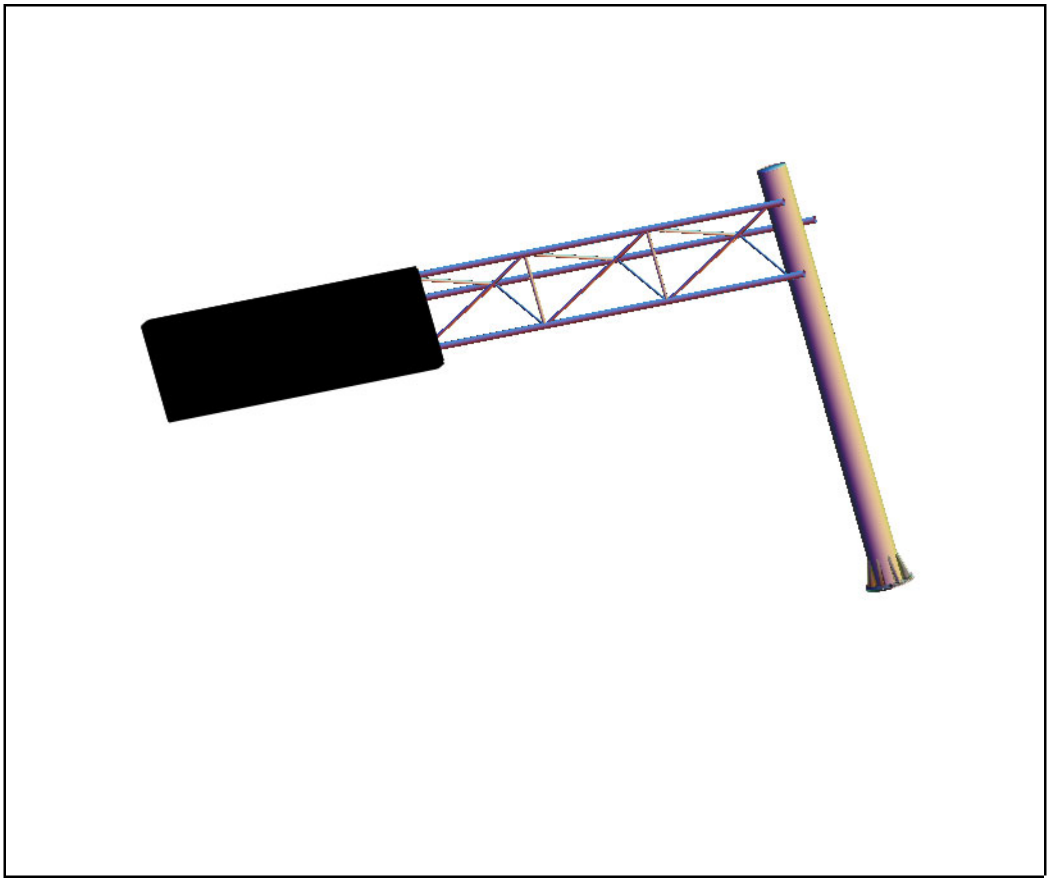
▶ Design Forces

▶ Fatigue Forces

▶ Total Forces

▶ Truss Diagram Data

Truss Diagram



Note: Use your mouse and keyboard to zoom in, zoom out or rotate the 3D plot above.
(See "Rotating, Spinning, or Zooming a 3D Plot" in Mathcad Help for instructions.)

3D Structural Analysis

Run Analysis

Note: A new analysis MUST be run after any change in program input.

▶ PC-SAP Output Data and Design Check Calculations

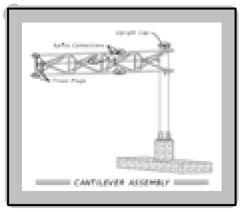
▶ Maximum Reactions and Results Output

ProjectName = "Moccasin Wall Rd from US 41 to West of I-75"

SignName = "393+05"

SignStation = "393+05 / 68.8' RT"

v_{wind} = 150·mph



Standard Plans and Instructions Index 700-040

Results

Sign Structure Geometry

(A) H_{Truss} = 24.46 ft

(B) NumberOfTrussPanels = "5 @ 8' 10" (Total_Length = 44.17 ft.)"

(C) VerticalTrussDepth = 60.00·in

HorizontalTrussDepth = 51.96·in

Sign Structure Members

(D) ChordMember = "5.563" O.D. Pipe, 0.375" Wall"

(E) WebMember = "Angle 3" x 3" x 5/16""

(F) UprightMember = "24" O.D. Pipe, 0.750" Wall"

CFI_{Chord} = "0.524 OK"

CFI_{Web} = "0.583 OK"

$CFI_{Upright}$ = "0.484 OK"

Additional Design Checks

$Check_{SignHangers}$ = "OK"

$CheckDeflection_{Upright}$ = "OK"

$CheckRotation_{Upright}$ = "OK"

MaxDeflection = 0.92·in

MaxRotation = 0.3·deg

ΔLimit := 2.5%·H_{Truss} = 7.34·in

RotLimit := 1.67·deg

Max. Reactions at Base of Upright

M_{Long} = 374.7·kip·ft

V_{Long} = 15.4·kip

M_{Trans} = 245.3·kip·ft

V_{Trans} = 2.9·kip

Axial = 13.4·kip

Torq = 443.3·kip·ft

(G) BackRake = 5.75·in

▶ Splice Calculations

▶ Gusset Plate Calculations

▶ Truss Connection Calculations

▶ Base Plate Calculations and Anchor Bolt Design

▶ Connection Output

Connection Values

Note: All truss bolted connections use A325 bolts, and upright anchor bolts are ASTM F1554.
All welds are sized assuming E70xx electrodes.

Splice Connection

(SA) $Size_{Angle}$ = "Angle 5" x 5" x 1/2""

(SB) $\#Bolts_{Reqd.in.Splice}$ = "4"

(SC) $d_{BoltReqd.for.Splice}$ = "7/8" Dia."

(SD) $N_{Panel.Where.1st.Splice.Allowed}$ = "3 (from upright)"

$CheckBolt_{Splice}$ = "OK"

Gusset Plates

(GA) t_{Gus} = "3/4""

(GB) $d_{Bolt.Gus}$ = "3/4" Dia."

(GC) $L_{Back.Chord.Gus}$ = "1' 5-1/4""

(GD) $H_{Back.Chord.Gus}$ = "6-1/2""

(GE) $L_{Front.Chord.Gus}$ = "1' 2-1/2""

(GF) $H_{Front.Chord.Gus}$ = "5-1/2""

(GG) $L_{Back.Truss.End.Plate}$ = "10""

(GH) $H_{Back.Truss.End.Plate}$ = "6-1/4""

(GJ) $L_{Front.Truss.End.Plate}$ = "11-3/4""

(GK) $Weld_{Gusset.to.Chord}$ = "3/16""

$CheckThickness_{Gusset}$ = "OK"

Truss Connections

(TA) $d_{Required}$ = "7/8" Dia."

(TB) $\#Bolts_{Reqd.Back.Chord.Connection}$ = "6"

(TC) $\#Bolts_{Reqd.Front.Chord.Connection}$ = "6"

(TD) $t_{Horz.Connec.Plate}$ = "1/2""

(TE) $t_{Vert.Connec.Plate}$ = "1/2""

(TF) $Weld_{Horz.PL.to.Upright}$ = "1/4""

(TG) $Weld_{Vert.PL.to.Upright}$ = "5/16""

(TH) $Weld_{Chord.to.Connec.PL}$ = "3/16""

(TJ) $Weld_{Vert.PL.to.Horz.PL}$ = "3/16""

Additional Truss Connection Checks

$\text{CheckBolt}_{\text{TrussBack}} = \text{"OK"}$

$\text{CheckBolt}_{\text{TrussFront}} = \text{"OK"}$

$\text{CheckThickness}_{\text{Horz.Plate}} = \text{"OK"}$

$\text{CheckThickness}_{\text{Vert.Plate}} = \text{"OK"}$

$\text{CheckThickness}_{\text{Connec.Plate}} = \text{"OK"}$

$\text{CheckThickness}_{\text{Horz.Vert}} = \text{"OK"}$

$\text{CheckStress}_{\text{Horz.Plate}} = \text{"OK"}$

$\text{CheckStress}_{\text{Vert.Plate}} = \text{"OK"}$

$\text{CheckBending}_{\text{Upright}} = \text{"OK"}$

$\text{D/C}_{\text{bolt.truss.back}} = 0.70$

$\text{D/C}_{\text{bolt.truss.front}} = 0.07$

Base Connection

(BA) $\text{D}_{\text{Anchor}} = \text{"2" Dia."}$

(BB) $\text{\#AnchorBoltsReqd} = \text{"12"}$

(BC) $\text{t}_{\text{Base.Plate}} = \text{"2""}$

(BD) $\text{t}_{\text{Stiffener.Plate}} = \text{"1/2""}$

(BE) $\text{H}_{\text{Stiffener.Plate}} = \text{"2' 3-1/4""}$

(BF) $\text{Weld}_{\text{Inside.Base.PL}} = \text{"5/16""}$

(BG) $\text{Weld}_{\text{Outside.Base.PL}} = \text{"5/16""}$

(BH) $\text{Weld}_{\text{Stiffener.to.Base}} = \text{"5/16""}$

(BJ) $\text{Weld}_{\text{Stiffener.to.Upright}} = \text{"5/16""}$

Additional Base Connection Check

$\text{CheckThickenss}_{\text{Stiffener}} = \text{"OK"}$

$\text{CheckWeldSizeLimit}_{\text{BaseUpright.in}} = \text{"OK"}$

$\text{CheckWeldSizeLimit}_{\text{BaseUpright.out}} = \text{"OK"}$

$\text{CheckWeldSizeLimit}_{\text{StiffBase}} = \text{"OK"}$

$\text{CheckWeldSizeLimit}_{\text{StiffUpright}} = \text{"OK"}$

$\text{CheckSpacing}_{\text{Stiffener}} = \text{"OK"}$

▶ Fatigue Calculations

Fatigue Design Checks

Base Connection

$CheckFatigue_{Upright}$ = "OK (1.6 ksi < 7 ksi)"

$CheckFatigue_{Base}$ = "OK (0.92 ksi < 10 ksi)"

$CheckFatique_{Anchor.Bolt}$ = "OK (0.16 ksi < 7 ksi)"

Chord Member and Connections

$CheckFatigue_{Chord.Truss}$ = "OK (2.09 ksi < 4.5 ksi)"

$CheckFatigue_{Chord.Splice}$ = "OK (1.16 ksi < 7 ksi)"

$CheckFatigue_{Chord.Slot}$ = "OK (2.09 ksi < 2.6 ksi)"

$CheckFatigue_{Half.Chord}$ = "OK (1.26 ksi < 2.6 ksi)"

$CheckFatigue_{Truss.Bolts}$ = "OK (0.25 ksi < 7 ksi)"

Gusset Plates

$CheckFatigue_{Back.Plates}$ = "OK (0.03 ksi < 1.2 ksi)"

$CheckFatigue_{Back.End.Plates}$ = "OK (0.12 ksi < 1.2 ksi)"

$CheckFatigue_{Front.Plates}$ = "OK (0.03 ksi < 1.2 ksi)"

$CheckFatigue_{Front.End.Plate}$ = "OK (0.09 ksi < 1.2 ksi)"

$CheckFatigue_{Front.Tip.Plate}$ = "OK (0.02 ksi < 1.2 ksi)"

Web Members

$CheckFatigue_{Web}$ = "OK (1.04 ksi < 7 ksi)"

▶ Drilled Shaft Calculations

▶ Spread Footing Calculations

▶ Anchor Bolt Embedment and Breakout Strength

Drilled Shaft Design

$\text{ReinfClearSpacing} = 6.1 \cdot \text{in}$ *should be > 6 inches*

Drilled Shaft Design Checks

$\text{Check}_{\text{MassConcrete}} = \text{"OK"}$

$\text{Check}_{\text{Long.Reinf.Spacing}} = \text{"OK"}$

$\text{Check}_{\text{Capacity.Long.Reinf}} = \text{"OK"}$

$\text{Check}_{\text{Comb.Shear.Torsion}} = \text{"OK"}$

$\text{Check}_{\text{Max.Stirrup.Spacing}} = \text{"OK"}$

$\text{Check}_{\text{StirrupSpacing}} = \text{"OK"}$

Drilled Shaft Dimensions/Reinforcing

(FA) $L_{\text{Drilled.Shaft}} = 24.0\,\text{ft}$

(FB) $D_{\text{Drilled.Shaft}} = 5.0\,\text{ft}$

(FC) LongitudinalReinforcement = "19 No. 11 bars evenly spaced"

(FD) $\#\text{Spaces}_{\text{Stirrup}} = 7$

(FE) $\text{Spacing}_{\text{Shear.Stirrup}} = 4.00 \cdot \text{in}$

(FF) $\#\text{Spaces}_{\text{Stirrupb}} = 31$

(FG) $\text{Spacing}_{\text{Shear.Stirrupb}} = 6.00 \cdot \text{in}$

$\text{Size}_{\text{Stirup}} = \text{"5"}$

Spread Footing Design

Spread Footing Design Checks

$\text{Check}_{\text{Footing.Design}} = \text{"n/a"}$

$\text{Check}_{\text{Pedestal.Height}} = \text{"n/a"}$

Spread Footing Dimensions/Reinforcing

(FA) $L_{\text{Slab}} = \text{"n/a"}$

(FB) $W_{\text{Slab}} = \text{"n/a"}$

(FC) $t_{\text{Slab}} = \text{"n/a"}$

(FD) $D_{\text{Pedestal}} = 0.0\,\text{ft}$

(FE) $H_{\text{Pedestal}} = \text{"n/a"}$

(FF) $\text{LongitudinalRebar}_{\text{Bot}} = \text{"n/a"}$

(FG) $\text{TransverseRebarar}_{\text{Bot}} = \text{"n/a"}$

(FH) $\text{LongitudinalRebar}_{\text{Top}} = \text{"n/a"}$

(FJ) $\text{TransverselRebar}_{\text{Top}} = \text{"n/a"}$

(FK) StirrupBars = "n/a"

(FL) VerticalBars = "n/a"

Anchor Bolt Design

Anchor Bolt Length

(BK) $L_{Anchor.Bolt.Embed} = 40 \cdot in$

Additional Anchor Bolt Checks

$Check_{Anchor.Bolt.Capacity} =$ "OK"

$D/C_{anchor.bolt} = 0.6$

$Check_{Concrete.Breakout} =$ "OK"

$Check_{clear.bar.to.bolt} =$ "OK" $Spacing_{clear.bar.to.bolt} = 4.1 \cdot in$ *should be >= 2 inches*

$Spacing_{ClearFooting} =$ "n/a" $\cdot in$

▶ MicroStation Data

Create Micro Station Text File

☑ Use same name as current data file

File Name Moccasin Wallow Rd.txt

Create MicroStation File

MicroStation Table Directions

1. Open the text menu and select "TableData" on the menu. This sets the text font for correct placement in the table.
2. Open the key-in dialog box and type in “include” and then add the full path to the text file.
3. Place the text using the text node provided in the Table. Some minor adjustment may be necessary to center the text.

▶ Check All

CheckAll_Results = "1 check is not OK"

Checks_Not_OK =

	0
0	"CheckFatigue.Chord.Splice - OK "

Section 4.0: Geotechnical Information

UNIVERSAL
ENGINEERING SCIENCES

GEOTECHNICAL EXPLORATION
PROPOSED MAST ARM STRUCTURES
MOCCASIN WALLOW ROAD
PALMETTO, MANATEE COUNTY; FL

UES PROJECT NO.:1130.1800187.0000
UES REPORT NO.: 14602

Prepared For:

Cardno
380 Park Place Boulevard, Suite 300
Clearwater, FL 333759

Prepared By:

Universal Engineering Sciences, Inc.
1748 Independence Boulevard, Ste. B-1
Sarasota, FL 34234
(941) 358-7410

January 16, 2020

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- Tampa
- Tifton
- West Palm Beach

January 16, 2020

Cardno
380 Park Place Boulevard, Suite 300
Clearwater, FL 333759

Attn: Mr. Hamid R. Faraji, PE

Reference: <u>**GEOTECHNICAL EXPLORATION**</u>
Proposed Mast Arm Structures
Moccasin Wallow Road
Palmetto, Manatee County; FL
UES Project No.:1130.1800187.0000
UES Report No.: 14602

Dear Mr. Faraji:

Universal Engineering Sciences, Inc. (UES) has completed the subsurface exploration for the above referenced project. The scope of our exploration was planned in conjunction with and authorized by you.

This report contains the results of our exploration, an engineering interpretation of these results with respect to the project characteristics described to us, and recommendations to aid in foundation design, and site preparation.

We appreciate the opportunity to have worked with you on this project and look forward to a continued association. Please do not hesitate to contact us if you should have any questions, or if we may further assist you as your plans proceed.

Respectfully submitted,

UNIVERSAL ENGINEERING SCIENCES, INC.
Certificate of Authorization Number 549

ROBERT GOMEZ
LICENSE
No. 58348

Digitally signed by Robert Gomez
DN: cn=Robert Gomez, o, ou, email=rgomez@universalengineering.com, c=US
Date: 2020.01.17 10:38:14 -05'00'
Adobe Acrobat version: 11.0.23

Yudelsy Alvarez
Project Engineer

Robert Gomez, P.E. #58348
Branch Manager

RG/YA:

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TABLE OF CONTENTS

SECTION **PAGE**

LIST OF APPENDICES

1.0 INTRODUCTION

1.1 GENERAL

In this report, we present the results of the subsurface exploration of the proposed mast arm structures. A general location plan of the project appears in Appendix A: Site Location Plan. We have divided this report into the following sections:

- SCOPE OF SERVICES - Defines what we did
- FINDINGS - Describes what we encountered
- RECOMMENDATIONS - Describes what we encourage you to do
- LIMITATIONS - Describes the restrictions inherent in this report
- APPENDICES - Presents support materials referenced in this report.

2.0 SCOPE OF SERVICES

2.1 PROJECT DESCRIPTION

The project consists of the construction of mast arms structures within three (3) intersections along Moccasin Wallow Road in Palmetto, FL. A site plan showing the pole locations was provided to us.

Our recommendations are based upon the above considerations. If any of this information is incorrect or if you anticipate any changes, inform Universal Engineering Sciences so that we may review our recommendations.

2.2 PURPOSE

The purposes of this exploration were:

- To explore the general subsurface conditions at the site;

- To interpret and review the subsurface conditions with respect to the proposed construction; and

- To provide geotechnical engineering recommendations for foundation design, and site preparation.

Recommendations concerning other soil related considerations were beyond the scope of our exploration. This report presents an evaluation of site conditions on the basis of traditional geotechnical procedures for site characterization. Our work did not address the potential for surface expression of deep geological conditions, such as sinkhole development related to karst activity. The recovered samples were not examined, either visually or analytically, for chemical composition or environmental hazards. Universal Engineering Sciences would be pleased to perform these services, if you desire.

2.3 FIELD EXPLORATION

The subsurface conditions were explored by drilling and sampling eleven (11) Standard Penetration Test (SPT) borings within the intersection areas to a depth of 40 feet below existing grades.

We performed the Standard Penetration Test using our truck mounted drill rig utilizing mud rotary procedures according to the procedures of ASTM D-1586, with continuous sampling performed above a depth of 10 feet, to detect slight variations in the soil profile at shallow depths, and then at five-foot intervals thereafter. The basic procedure for the Standard Penetration Test is as follows: A standard split-barrel sampler is driven into the soil by a 140-pound hammer falling 30 inches. The number of blows required to drive the sampler 1-foot, after seating 6 inches, is designated the penetration resistance, or N-value; this value is an index to soil strength and consistency.

The boring locations were located by our drill crew based on the site plan and existing site conditions. The test boring locations are shown on the attached Boring Location Plan in Appendix A as B-1 through B-11.

2.4 LABORATORY INVESTIGATION

The soil samples recovered from the soil test borings were returned to our laboratory and then an engineer visually examined and reviewed the field descriptions. We selected representative soil samples for laboratory testing consisting of ten (10) wash 200 determinations and moisture content tests.

We performed these tests to aid in classifying the soils and to help evaluate the general engineering characteristics of the site soils. See Appendix A: Boring Logs and Description of Testing Procedures for further data and explanations. Jar samples of the soils will be held in our laboratory for your inspection for sixty days unless we are notified otherwise.

3.0 FINDINGS

3.1 SURFACE CONDITIONS

A Universal Engineering Sciences representative performed a visual site observation of the subject property to gain a "hands-on" familiarity of the project area. The overall existing roadways are relatively level and generally elevated above surrounding grade and consist of ditches along the roadside for drainage.

3.2 SOIL SURVEY-PUBLISHED INFORMATION

The “Soil Survey of Manatee County, Florida”, published by the published by the United States Department of Agriculture (USDA) - Soil Conservation Service (SCS), was reviewed for general near-surface soil information prior to development within the general project vicinity. The USDA, SCS primary soil mapping groups within the proposed project area, and some characteristics and properties are summarized below. The location of these groups can be observed on the SCS Soil Survey Map provided in the Appendix A.

EauGallie (Soil Group No. 20): Under natural conditions, this soil group consists of fine sands from the surface to a depth of about 42 inches, sandy clay loam from 42 to 50 inches, and fine sand from 50 to 65 inches below grade. Based on the soil survey, the water table is from 6 to 18 inches below grade.

Felda (Soil Group No. 22): Under natural conditions, this soil group consists of fine sands from the surface to a depth of about 35 inches, fine sandy loam from 35 to 43 inches, and extremely paragravelly fine sand from 43 to 80 inches below grade. Based on the soil survey, the water table is from the ground surface to 12 inches below grade.

Floridana-Immokalee-Okeelanta (Soil Group No. 26): Under natural conditions, this soil group consists of fine sand and **muck** from the surface to a depth of about 20 inches, fine sand from 20 inches to 36 inches; sandy clay loam from 36 to 63 inches, and fine sand from 63 to 80 inches below grade. Based on the soil survey, the water table is at the ground surface.

Palmetto (soil Group No. 38): Under natural conditions, this soil group consists of sand from the surface to a depth of 45 inches, sandy clay loam from 45 to 64 inches, and loamy sand from 64 to 68 inches below grade. Based on the soil survey, the water table is at the ground surface.

Tavares (soil Group No. 45): This soil group consists of fine sand from the surface to a depth of about 80 inches below grade. Based on the soil survey, the water table is from 42 to 72 inches below grade, under natural conditions.

Wabasso (Soil Group No. 48): Under natural conditions, this soil group consists of fine sands from the surface to a depth of about 37 inches, sandy clay loam from 37 to 65 inches, and fine sand from 65 to 80 inches below grade. Based on the soil survey, the water table is from 6 to 18 inches below grade.

3.3 SUBSURFACE CONDITIONS

The boring locations and detailed subsurface conditions are illustrated in Appendix A: Boring Location Plan and Boring Logs. The classifications and descriptions shown on the logs are generally based upon visual characterizations of the recovered soil samples. Also, see Appendix A: Soils Classification Chart, for further explanation of the symbols and placement of data on the Boring Logs. The following table summarizes the soil conditions encountered.

TABLE 1
General Soil Profile

Typical depth (ft)		**Soil Descriptions**
From	**To**	
B-1 – B-4: Moccasin Wallow Rd and 36th Ave Intersection		
0	2	Fine sand with silt [SP-SM]
2	6	Fine sand [SP]
6	8	Loose to medium dense fine sand with trace silt [SP]
8	12	Loose fine sand with trace silt [SP]
12	17	Medium dense to loose fine sand [SP]
17	32	Very dense clayey sand, and stiff to very hard clay [SC, CL/CH]
32	40*	Very hard clay [CL/CH]
B-5 – B-7: Moccasin Wallow Rd and Artisian Lakes Pkwy Intersection		
0	4	Very loose to loose fine sand, and fine sand with silt and roots [SP, SP-SM]
4	8	Medium dense fine sand, and clayey sand [SP, SC]
8	17	Very loose to loose fine sand, and clayey sand [SP, SC]
17	22	Very loose clayey sand, and medium stiff clay [SC, CL]
22	40*	Very hard clay [CL]
B-8 – B-11 Moccasin Wallow Rd and Gateway Blvd Intersection		
0	4	Fine sand with silt [SP-SM]
4	6	Fine sand, and fine sand with silt [SP, SP-SM]
6	12	Loose to medium dense fine sand with trace silt [SP]
12	17	Loose to medium dense silty clayey sand with shell, phosphates, and limestone fragments [SC-SM]
17	22	Loose silty clayey sand with shell, phosphates, and limestone fragments, and still clay [SC-SM, CL]
22	32	Loose clayey sand, and stiff to very hard clay [SC, CL]
32	40*	Very hard clay [CL]
*	**Termination Depth of Deepest Boring**	
[ ]	**Bracketed Text Indicates: Unified Soil Classification**	

Variations in the depth, thickness and consistency of the aforementioned soil strata occurred at the individual test boring locations. We encountered groundwater at depths ranging from 3.5 to 6 feet below existing grade at the time of our investigation. The variations in the measured water levels are attributed to the variation in the ground surface elevation at this site as well as the soil type encountered.

Shallow clayey soils were encountered in the soil borings. These soils may be moisture sensitive and difficult to compact if encountered during construction.

Very dense cemented sands and very hard cemented clays (rock-like material) were encountered in the borings below a depth of 22 feet with N-values of more than 50 blows per foot. This soil may vary across the site in depth and consistency, and may be difficult to excavate.

4.0 RECOMMENDATIONS

4.1 GENERAL

The following recommendations are made based upon a review of the attached soil test data, our understanding of the proposed construction, and experience with similar projects and subsurface conditions. If the assumed structural loadings, building locations, building sizes, or grading plans change or are different from those discussed previously, we request the opportunity to review and possibly amend our recommendations with respect to those changes.

Additionally, if subsurface conditions are encountered during construction which was not encountered in the borings, report those conditions immediately to us for observation and recommendations.

In this section of the report, we present our detailed recommendations for groundwater control, building foundations, and site preparation.

4.2 GROUNDWATER CONSIDERATIONS

The groundwater table will fluctuate seasonally depending upon local rainfall and tidal fluctuation. Temporary dewatering may be required for deeper excavations, such as large foundation elements, elevator pits and utility trenches. Surface drainage and dewatering measures may be required during site preparation procedures such as proof-compacting of the existing soils, and fill placement particularly if construction proceeds during the wet season. Further, we recommend that the groundwater table be maintained 18 to 24 inches below earthwork and compaction surfaces.

We recommend sufficient quantities of fill be placed in the building and pavement areas to mitigate the effect of groundwater on shallow excavations, such as foundations. Further, we recommend the bottom of the base course used in pavement construction be maintained at least 18 inches above the seasonal high water levels.

Temporary dewatering may be required during site preparation, especially if construction proceeds during the wet season or periods of heavy rainfall. Temporary dewatering may also be required for deeper excavations, such as utility trenches, the backfilling of the drainfield area and other excavations. We recommend that the contract documents provide for determining the groundwater level just prior to construction and for any dewatering measures which might be required. We recommend that the groundwater table be maintained at least 24 inches below all earthwork and compaction surfaces.

4.3 SOIL DESIGN PARAMETERS

Based on the SPT test results and soils encountered with the borings along the evaluated roads, soil design parameters of angle of internal friction, earth pressure coefficient, unit weights, cohesion, shear modulus, and bearing pressure were estimated and are presented in Table 2 below.

Table 2

Estimated Soil Design Parameter

Typical Depth		Effective Unit Weight (pcf)	Saturated Unit Weight (pcf)	Dry Unit Weight (pcf)	Friction Angle (psf)	Cohesion (psf)	Recommended Earth Pressure Coefficients			Allowable Bearing Pressure (Ksf)	Shear Modulus (psf)
From	To						At Rest K_O	Active K_A	Passive K_P		
B-1 – B-4: Moccasin Wallow Rd and 36th Ave Intersection											
0	6	42.6*	105	100	29	0	0.52	0.34	2.88	1.5	86,400
6	12	47.6	110	105	30	0	0.50	0.33	3.00	2.0	259,200
12	22	42.6	105	100	29	0	0.52	0.34	2.88	2.5	86,400
22	32	57.6	120	115	0	1,250	1.00	1.00	1.00	3.0	72,000
32	40	62.6	125	120	0	6,250	1.00	1.00	1.00	4.0	308,571
B-5 – B-7: Moccasin Wallow Rd and Artisian Lakes Pkwy Intersection											
0	4	42.6*	105	100	29	0	0.52	0.34	2.88	1,5	86,400
4	8	47.6	110	105	30	0	0.50	0.33	3.00	2.0	259,200
8	17	42.6	105	100	29	0	0.52	0.34	2.88	2.5	86,400
17	22	52.6	115	110	0	750	1.00	1.00	1.00	3.0	72,000
22	40	57.6	62.6	125	120	6,250	1.00	1.00	1.00	4.0	308,571
B-8 – B-11 Moccasin Wallow Rd and Gateway Blvd Intersection											
0	6	42.6*	105	100	29	0	0.52	0.34	2.88	1.5	86,400
6	8	47.6	110	105	30	0	0.50	0.33	3.00	2.0	259,200
8	17	42.6	105	100	29	0	0.52	0.34	2.88	2.5	86,400
17	32	57.6	120	115	0	1,250	1.00	1.00	1.00	3.0	72,000
32	40	62.6	125	120	0	6,250	1.00	1.00	1.00	4.0	308,571

4.4 DRILLED SHAFTS FOR MAST ARM STRUCTURES

The finished grade elevations of the mast arm footings are assumed to be at the existing ground surface. The shaft tips are recommended to be embedded a minimum depth below the ground surface following the site preparation recommendations. The estimated allowable resistance values were based on static analysis, as determined during the field exploration and laboratory testing. Geotechnical information to aid in mast arms foundation design, for the specific boring locations, is shown at the above table.

4.4.1 Drilled Shaft Installation

The previously recommended allowable pile resistance values are estimates based on anticipated installation techniques, the subsurface conditions at the site, and our experience in the area. Significant movement of a pile may be necessary to develop the full shear strength of the soil. The magnitude of this movement may not be compatible with the desired structural “fixity”, and allowable deflection may become the governing criterion for capacity rather than the ultimate shear strength of the soil. This is particularly true for piles subjected to uplift. Based on our experience, the previously recommended capacities should result in deflections tolerable to the proposed self supported cell tower.

Installation of the drilled shafts must also be monitored by a representative from UES. The auger teeth used to install the drilled shafts should have cutting teeth in good condition to prevent soil from being smeared on the shaft sidewalls. All production shafts should contain at least the neat-line volume of concrete calculated for the length of shaft installed.

Groundwater was encountered at the boring locations at depths ranging from 3.5 to 6 feet below existing ground surface, therefore depending on the design depth of the drilled shafts, and the rainfall variations, water may be encountered during the placement of the drilled shafts. Water in the bottom of the drilled shafts should be removed by pumping. Due to possible presence of groundwater, a temporary steel casing should be installed along the entire length of the shaft during drilling operations. Once the drilled shaft has been advanced to its designed depth the bottom of the shaft should be evaluated by a representative of UES to verify the proper diameter and that the bottom of the shaft is free of loose soil. The steel reinforcing cage should be installed upon the satisfactory evaluation of the drilled shaft excavation. The concrete should then be placed as soon as practicable to reduce the deterioration of the supporting soils due to sidewall caving and groundwater intrusion.

If the contractor elects to install the drilled shafts by ‘wet’ or ‘slurry’ methods a temporary casing may be needed in conjunction with the slurry. The slurry level should be at least a minimum of 5 feet or one shaft diameter, whichever is greater, above the groundwater level. The pH, specific gravity, and sand content of the drilling slurry should be periodically tested during the placement of the shafts. A significant change in any of these parameters during the drilling of the shafts may indicate excess soil migration into the slurry, which may settle on the bottom of the excavation and consequently result in a reduction of the allowable end bearing capacity of the drilled shafts.

We recommend a thorough testing program for the concrete placed in drilled shafts. During concrete placement the concrete may be allowed to fall freely through the open area in the reinforcing steel cage as long as the concrete is not allowed to strike the rebar or the casing prior to reaching the bottom of the shaft. If the shafts are advanced utilizing the ‘wet’ method the concrete should be placed using a tremie pipe which should be placed about 1 shaft diameter above the bottom of the shaft. The bottom of the tremie pipe must be below the concrete during placement. Qualified personnel should be present to cast compressive representative test specimens of the concrete being placed in the drilled shafts. We recommend that at least two sets of specimens, four specimens per set, be cast per day and that at least one set of specimens be cast for every 50 cubic yards of concrete placed. Batching tickets should reference the mix approved in the specifications and show batching times. The concrete mix shall have a slump of 6 to 8 inches. Admixtures, such as super plasticizer, may be needed to achieve this specified slump. The protective steel casing should be extracted as the concrete is being placed, however a head of concrete should be maintained above the bottom of the shaft casing to prevent soil and water intrusions into the shaft.

Buried obstructions such as debris or boulders can prevent shaft installation. If drilled shafts stop short of their design depths, it may be necessary to make backhoe explorations or one or more exploratory borings to evaluate the condition. Based on the findings, it may be necessary to add shafts. Likewise, it is possible that longer shafts may be required in some areas. Therefore, the contract documents should contain provisions for adding or deducting shaft length or installing additional shafts.

4.5 CONSTRUCTION RELATED SERVICES

We recommend the owner retain Universal Engineering Sciences to perform construction materials tests and observations on this project. Field tests and observations include verification of foundation and pavement subgrades by monitoring proof-rolling operations and performing quality assurance tests on the placement of compacted structural fill and pavement courses.

The geotechnical engineering design does not end with the advertisement of the construction documents. The design is an on-going process throughout construction. Because of our familiarity with the site conditions and the intent of the engineering design, we are most qualified to address problems that might arise during construction in a timely and cost-effective manner.

5.0 LIMITATIONS

This report has been prepared in order to aid the architect/engineer in the design of the proposed mast arm structures. The scope of services provided was limited to the specific project and locations described herein. The description of the project's design parameters represents our understanding of significant aspects relevant to soil and foundation characteristics.

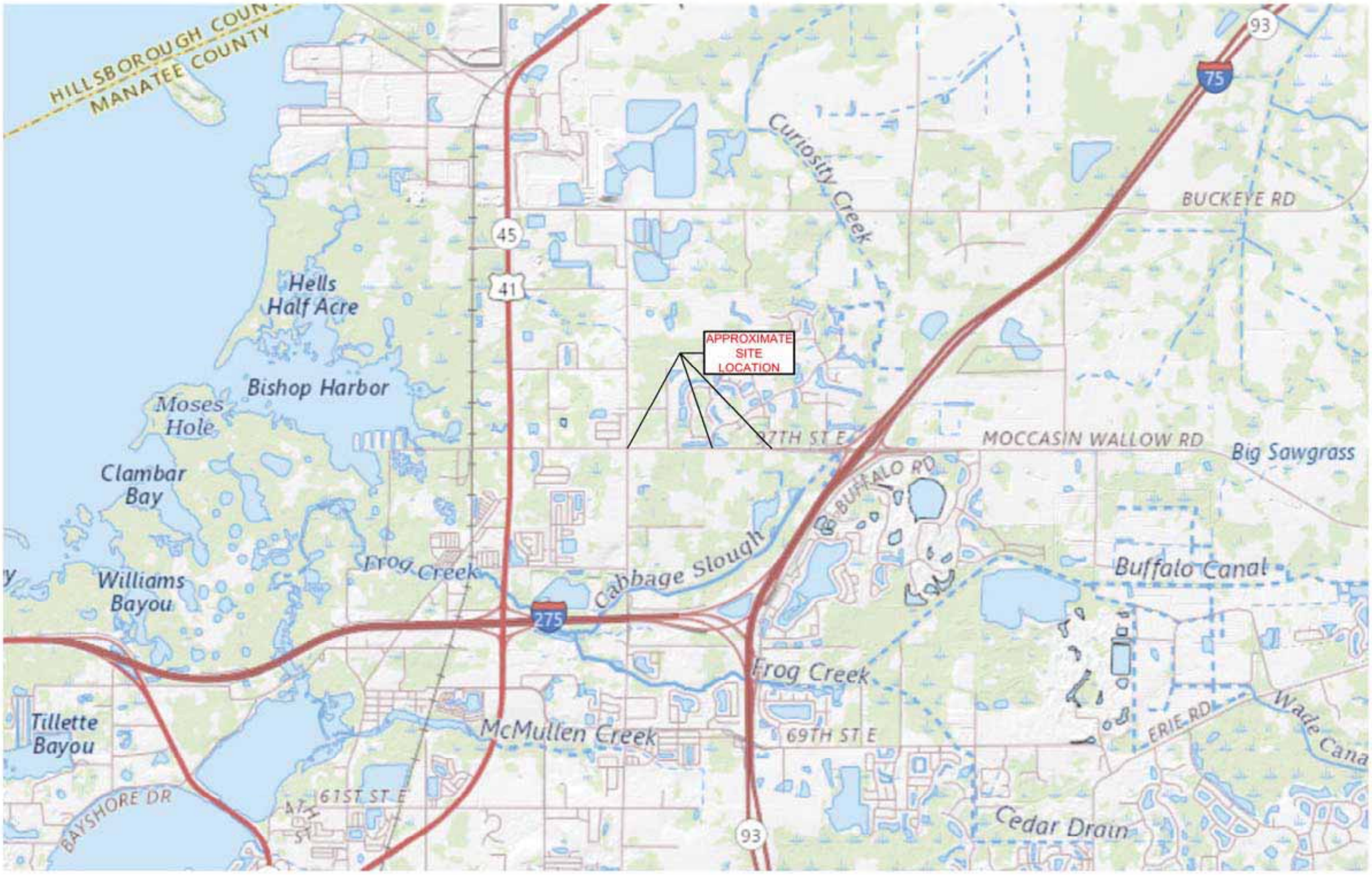
The recommendations submitted in this report are based upon the data obtained from the limited number of soil borings performed at the locations indicated on the Boring Location Plan and from other information as referenced. This report does not reflect any variations which may occur between the boring locations or unexplored areas of the site. This report should not be used for estimating such items as cut and fill quantities.

Borings for a typical geotechnical report are widely spaced and generally not sufficient for reliably detecting the presence of isolated, anomalous surface or subsurface conditions, or reliably estimating unsuitable or suitable material quantities. Accordingly, UES does not recommend relying on our boring information to negate presence of anomalous materials or for estimation of material quantities unless our contracted services ***specifically*** include sufficient exploration for such purpose(s) and within the report we so state that the level of exploration provided should be sufficient to detect such anomalous conditions or estimate such quantities. Therefore, UES will not be responsible for any extrapolation or use of our data by others beyond the purpose(s) for which it is applicable or intended.

All users of this report are cautioned that there was no requirement for Universal to attempt to locate any man-made buried objects or identify any other potentially hazardous conditions that may exist at the site during the course of this exploration. Therefore no attempt was made by Universal to locate or identify such concerns. Universal cannot be responsible for any buried man-made objects or environmental hazards which may be subsequently encountered during construction that are not discussed within the text of this report. We can provide this service if requested.

For a further description of the scope and limitations of this report please review the document attached within Appendix B "Important Information About Your Geotechnical Engineering Report" prepared by ASFE, an association of firms practicing in the geosciences.

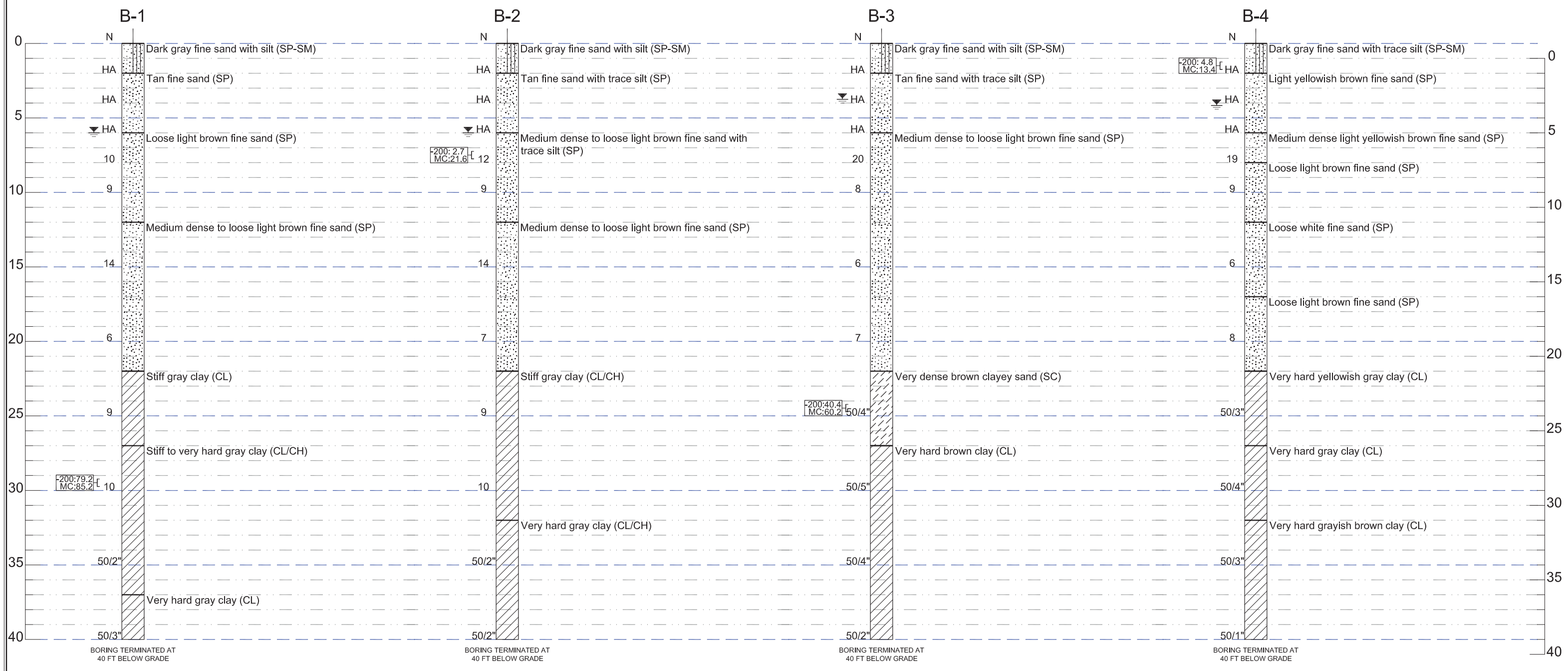
APPENDIX A



APPROXIMATE SITE LOCATION

N

A-1	**SITE LOCATION PLAN**	PROPOSED CIRCLE K 4219 MOCCASIN WALLOW ROAD PALMETTO, FL		DRAWN FOR	THOMAS ENGINEERING	UNIVERSAL ENGINEERING SCIENCES 1748 INDEPENDENCE BLVD. SARASOTA, FL. 941-358-7410
				DRILLED BY	NP / CL	
				DRAWN BY	R.L.D	
	OBTAINED FROM YAHOO MAPS 2018	PROJECT NO: 1130.1900375.0000	REPORT NO: 14404	DRAWING DATE	12/30/2019	
				SCALE	NOT TO SCALE	

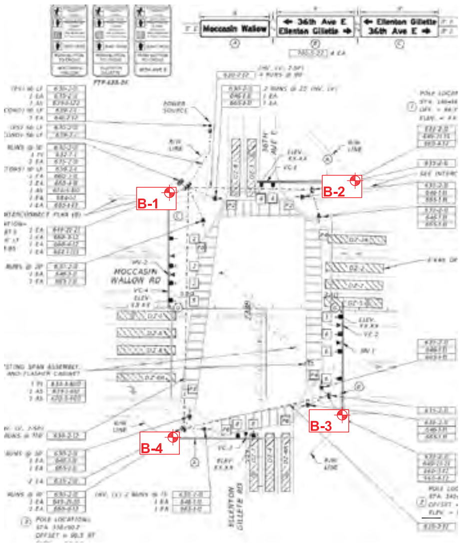


LEGEND

[SP]	UNIFIED SOIL CLASSIFICATION SYSTEM GROUP SYMBOL (ASTM D2487) .BASED ON VISUAL OBSERVATION AND LABORATORY TEST.
N	STANDARD PENETRATION RESISTANCE (N-VALUE) IN BLOWS PER FOOT (ASTM D1586)
HA	HAND AUGER
▼	GROUND WATER LEVEL MEASURED ON DATE DRILLED
▽	SEASONAL HIGH WATER LEVEL
GNE	GROUNDWATER LEVEL NOT ENCOUNTERD
◁— (%)	LOSS OF CIRCULATION (%)
-200	FINES PASSING NO. 200 U.S. STANDARD SIEVE (%)
WOH	WEIGHT OF HAMMER
50/1"	50 BLOWS FOR 1 INCH
OC	ORGANIC CONTENT (%)
MC	NATURAL MOISTURE CONTENT (%)
PL	PLASTICITY INDEX (%)
LL	LIQUID LIMIT (%)
NP	NON PLASTIC
UCS	UNCONFINED COMPRESSION STRENGTH

CORRELATION OF STANDARD PENETRATION RESISTANCE WITH RELATIVE DENSITY AND CONSISTENCY OF SOIL

COARSE-GRAINED SOILS-SANDS		FINES - CLAY AND SILT	
CONSISTENCY DESIGNATION	SPT N(BLOWS/FT)	CONSISTENCY DESIGNATION	SPT N(BLOWS/FT)
VERY LOOSE	0-4	VERY SOFT	0-1
LOOSE	5-10	SOFT	2-3
MEDIUM DENSE	11-30	MEDIUM STIFF	4-7
DENSE	31-50	STIFF	8-15
VERY DENSE	>50	VERY STIFF	16-31
		HARD	32-50
		VERY HARD	>50



N

LEGEND

APPROXIMATE LOCATION

⊕ SPT BORING

UNIVERSAL
ENGINEERING SCIENCES
1748 INDEPENDENCE BLVD.
SARASOTA, FL.
941-358-7410

DRAWN FOR	CARDNO
DRILLED BY	NP / CL
DRAWN BY	R.L.D
DRAWING DATE	12/30/2019
SCALE	NOT TO SCALE

PROJECT NO: 1130.1800187.0000

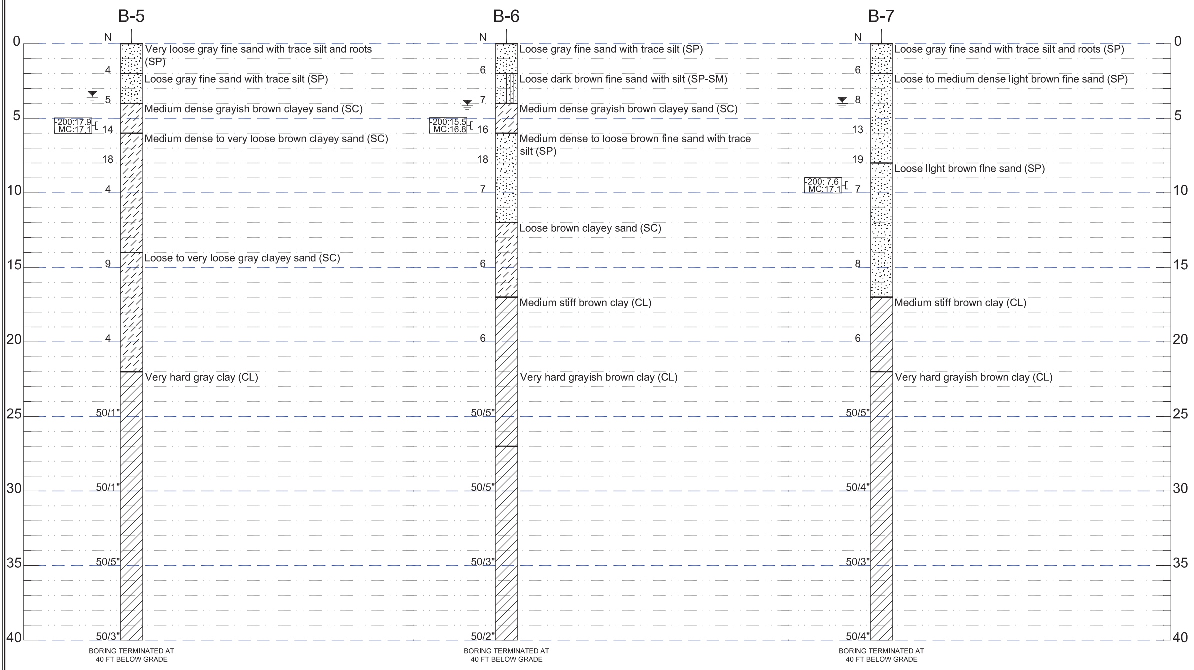
REPORT NO: 14602

PROPOSED MAST ARMS
MOCCASIN WALLOW ROAD
PALMETTO, FL

SOIL BORING PROFILES

ALL SOIL BORING TEST ARE APPROXIMATE. SUBSURFACE VARIATIONS BETWEEN BORINGS SHOULD BE ANTICIPATED

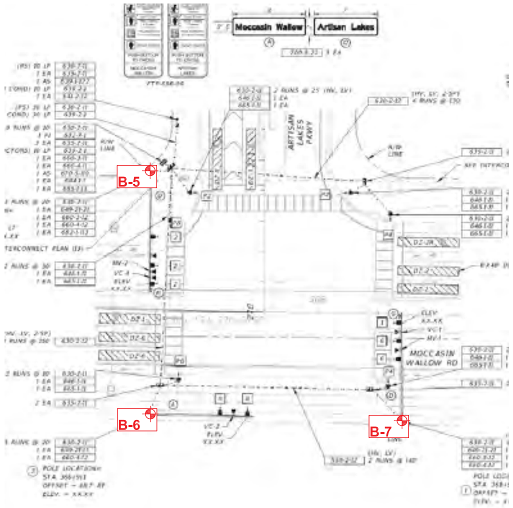
A-4.0



LEGEND

[SP] UNIFIED SOIL CLASSIFICATION SYSTEM GROUP SYMBOL (ASTM D2487) .BASED ON VISUAL OBSERVATION AND LABORATORY TEST.
N STANDARD PENETRATION RESISTANCE (N-VALUE) IN BLOWS PER FOOT (ASTM D1586)
HA HAND AUGER
▼ GROUND WATER LEVEL MEASURED ON DATE DRILLED
▽ SEASONAL HIGH WATER LEVEL
GNE GROUNDWATER LEVEL NOT ENCOUNTERD
◁– (%) LOSS OF CIRCULATION (%)
-200 FINES PASSING NO. 200 U.S. STANDARD SIEVE (%)
WOH WEIGHT OF HAMMER
50/1" 50 BLOWS FOR 1 INCH
OC ORGANIC CONTENT (%)
MC NATURAL MOISTURE CONTENT (%)
PL PLASTICITY INDEX (%)
LL LIQUID LIMIT (%)
NP NON PLASTIC
UCS UNCONFINED COMPRESSION STRENGTH

CORRELATION OF STANDARD PENETRATION RESISTANCE WITH RELATIVE DENSITY AND CONSISTENCY OF SOIL			
COARSE-GRAINED SOILS-SANDS		FINES - CLAY AND SILT	
CONSISTENCY DESIGNATION	SPT N(BLOWS/FT)	CONSISTENCY DESIGNATION	SPT N(BLOWS/FT)
VERY LOOSE	0-4	VERY SOFT	0-1
LOOSE	5-10	SOFT	2-3
MEDIUM DENSE	11-30	MEDIUM STIFF	4-7
DENSE	31-50	STIFF	8-15
VERY DENSE	>50	VERY STIFF	16-31
		HARD	32-50
		VERY HARD	>50



N

LEGEND

APPROXIMATE LOCATION
⊕ SPT BORING

UNIVERSAL
ENGINEERING SCIENCES
1748 INDEPENDENCE BLVD.
SARASOTA, FL.
941-358-7410

DRAWN FOR	CARDNO
DRILLED BY	NP / CL
DRAWN BY	R.L.D
DRAWING DATE	12/30/2019
SCALE	NOT TO SCALE

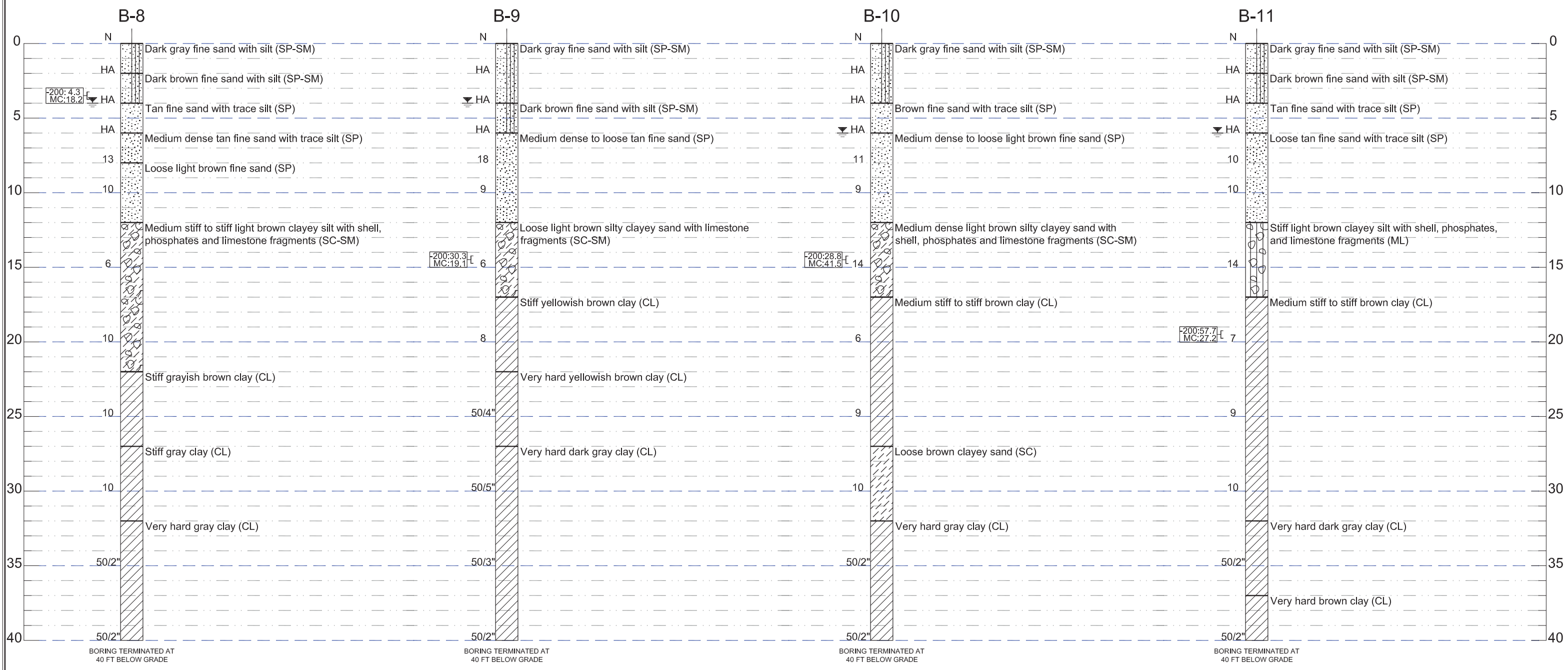
PROJECT NO: 1130.1800187.0000
REPORT NO: 14602

PROPOSED MAST ARMS
MOCCASIN WALLOW ROAD
PALMETTO, FL

SOIL BORING PROFILES

ALL SOIL BORING TEST ARE APPROXIMATE. SUBSURFACE VARIATIONS BETWEEN BORINGS SHOULD BE ANTICIPATED

A-4.1



LEGEND

[SP]	UNIFIED SOIL CLASSIFICATION SYSTEM GROUP SYMBOL (ASTM D2487) .BASED ON VISUAL OBSERVATION AND LABORATORY TEST.
N	STANDARD PENETRATION RESISTANCE (N-VALUE) IN BLOWS PER FOOT (ASTM D1586)
HA	HAND AUGER
▼	GROUND WATER LEVEL MEASURED ON DATE DRILLED
▽	SEASONAL HIGH WATER LEVEL
GNE	GROUNDWATER LEVEL NOT ENCOUNTERD
◁– (%)	LOSS OF CIRCULATION (%)
-200	FINES PASSING NO. 200 U.S. STANDARD SIEVE (%)
WOH	WEIGHT OF HAMMER
50/1"	50 BLOWS FOR 1 INCH
OC	ORGANIC CONTENT (%)
MC	NATURAL MOISTURE CONTENT (%)
PL	PLASTICITY INDEX (%)
LL	LIQUID LIMIT (%)
NP	NON PLASTIC
UCS	UNCONFINED COMPRESSION STRENGTH

CORRELATION OF STANDARD PENETRATION RESISTANCE WITH RELATIVE DENSITY AND CONSISTENCY OF SOIL

COARSE-GRAINED SOILS-SANDS		FINES - CLAY AND SILT	
CONSISTENCY DESIGNATION	SPT N(BLOWS/FT)	CONSISTENCY DESIGNATION	SPT N(BLOWS/FT)
VERY LOOSE	0-4	VERY SOFT	0-1
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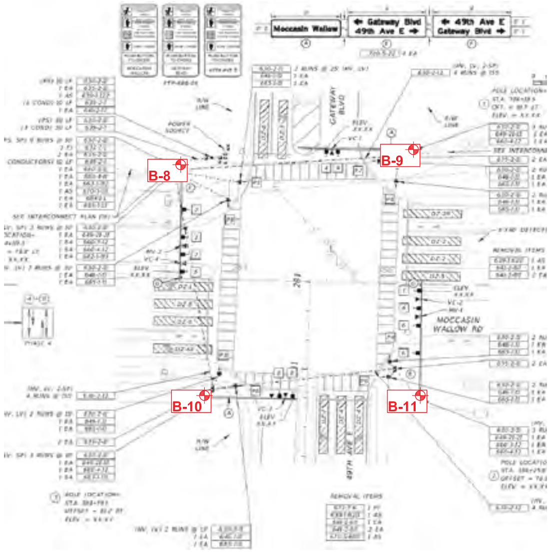
MEDIUM DENSE	11-30	MEDIUM STIFF	4-7
DENSE	31-50	STIFF	8-15
VERY DENSE	>50	VERY STIFF	16-31
		HARD	32-50
		VERY HARD	>50



LEGEND

APPROXIMATE LOCATION

⌖ SPT BORING

SOIL BORING PROFILES

ALL SOIL BORING TEST ARE APPROXIMATE. SUBSURFACE VARIATIONS BETWEEN BORINGS SHOULD BE ANTICIPATED

PROPOSED MAST ARMS
MOCCASIN WALLOW ROAD
PALMETTO, FL

PROJECT NO: 1130.1800187.0000
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UNIVERSAL
ENGINEERING SCIENCES
1748 INDEPENDENCE BLVD.
SARASOTA, FL.
941-358-7410

A-4.2

UNIVERSAL ENGINEERING SCIENCES
9802 Palm River Road
Tampa, Florida 33619

(813) 740-8506

SOIL CLASSIFICATION CHART

TERMS DESCRIBING CONSISTENCY OR CONDITION

COARSE-GRAINED SOILS (major portions retained on No 200 sieve): includes (1) clean gravel and sands and (2) silty or clayey gravels and sands. Condition is rated according to relative density as determined by laboratory tests or standard penetration resistance tests

Descriptive Terms	Relative Density	SPT Blow Count
Very loose	0 to 15 %	< 4
Loose	15 to 35 %	4 to 10
Medium dense	35 to 65 %	10 to 30
Dense	65 to 85 %	30 to 50
Very dense	85 to 100 %	> 50

FINE-GRAINED SOILS (major portions passing on No. 200 sieve): includes (1) inorganic and organic silts and clays, (2) gravelly, sandy, or silty clays, and (3) clayey silts. Consistency is rated according to shearing strength, as indicated by penetrometer readings, SPT blow count, or unconfined compression tests

Descriptive Terms	Unconfined Compressive Strength kPa	SPT Blow Count
Very soft	< 25	< 2
Soft	25 to 50	2 to 4
Medium stiff	50 to 100	4 to 8
Stiff	100 to 200	8 to 15
Very stiff	200 to 400	15 to 30
Hard	> 400	> 30

GENERAL NOTES

1. Classifications are based on the United Soil Classification System and include consistency, moisture, and color Field descriptions have been modified to reflect results of laboratory tests where deemed appropriate

2 Surface elevations are based on topographic maps and estimated locations

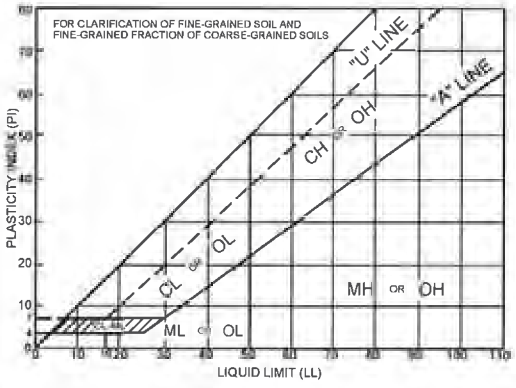
3. Descriptions on these boring logs apply only at the specific boring locations and at the time the borings were made They are not guaranteed to be representative of subsurface conditions at other locations or times

SOIL SYMBOLS

▩ FILL
▨ TOPSOIL
■ ASPHALT
▩ CONCRETE
□ SAND
▥ SAND W/ SILT
▨ [illegible]
▥ SILTY SAND
▩ CLAYEY SAND
▨ PEAT
▥ SILT LOW PLASTIC
▥ SILT HIGH PLASTIC
▤ ORGANIC SILT
▩ CLAY LOW PLASTIC
□ CLAY HIGH PLASTIC
▩ LIMESTONE HIGHLY WEATHERED
▦ LIMESTONE
□ DOLOMITE

OTHER SYMBOLS

▼ Measured Water Table Level
▽ Estimated Seasonal High Water Table

Major Divisions			Group Symbols	Typical Names	Laboratory Classification Criteria			
Coarse-Grained soils (More than half the material is larger than No 200 sieve size)	Gravels (More than half of coarse fraction is larger than No 4 sieve size)	Clean gravel (Little or no fines)	GW	Well-graded gravels, gravel-sand mixtures, little or no fines	Determine percentages of sand and gravel from grain size curve, Depending on percentage of fines (fraction smaller than No 200 sieve) coarse-grained soils are classified as follows:	Less than 5 percent — GW, GP, SW, SP More than 12 percent — GM, GC, SM, SC 5 to 12 percent — Borderline cases requiring dual symbols*	$C_u = \frac{D_{60}}{D_{10}}$ greater than 4; $C_c = \frac{(D_{30})^2}{D_{10} \times D_{60}}$ between 1 and 3	
			GP	Poorly-graded gravels, gravel-sand mixtures, little or no fines			Not meeting all gradation requirements for GW	
		Gravel with fines (Appreciable amount of fines)	GM	Silty gravels, gravel-sand-silt mixtures			Atterberg limits below "A" line or P I less than 4	Above "A" line with P I between 4 and 7 are border-line cases requiring use of dual symbols
			GC	Clayey gravels, gravel-sand-silt mixtures			Atterberg limits above "A" line or P I greater than 7	
	Sands (More than half of coarse fraction is smaller than No 4 sieve size)	Clean sands (Little or no fines)	SW	Well-graded sands, gravelly sands, little or no fines			$C_u = \frac{D_{60}}{D_{10}}$ greater than 6; $C_c = \frac{(D_{30})^2}{D_{10} \times D_{60}}$ between 1 and 3	
			SP	Poorly-graded sands, gravelly sands, little or no fines			Not meeting all gradation requirements for SW	
		Sands with fines (Appreciable amount of fines)	SM	Silty sands, sand-silt mixtures			Atterberg limits below "A" line or P I less than 4	Above "A" line with P I between 4 and 7 are border-line cases requiring use of dual symbols
			SC	Clayey sands, sand-clay mixtures			Atterberg limits above "A" line or P I greater than 7	
Fine-Grained soils (More than half the material is smaller than No 200 sieve size)	Silts and Clays (Liquid limit less than 50)		ML	Inorganic silts and very fine sands, rock floor, silty or clayey fine sands or clayey silts with slight plasticity	 Plasticity Chart			
			CL	Inorganic clays of low to medium plasticity, gravelly clays, sandy clays, silty clays, lean clays				
			OL	Organic silts and organic silty clays of low plasticity				
	Silts and Clays (Liquid limit greater than 50)		MH	Inorganic silts, micaceous or disto-maceous fine sandy or silty soils, organic silts				
			CH	Inorganic clays of high plasticity, fat clays				
			OH	Organic clays of medium to high plasticity, organic silts				
	Highly Organic Soils		Pt	Peat and other highly organic soils				

Material	Particle Size	
	Sieve sizes	mm
Silt or clay	< #200	< 0 074
Sand		
Fine	#200 to #40	0 074 to 0 42
Medium	#40 to #10	0 42 to 2 00
Coarse	#10 to #4	2 00 to 4 76

Material	Particle Size	
	Sieve	mm
Gravel		
Fine	#4 to 3/4 in	4 76 to 19 1
Coarse	3/4 in to 3 in	19 1 to 76 2
Cobble	3 in to 12 in	76 2 to 304 8
Boulders	12 in to 36 in	304 8 to 914 4

* When the percent passing a No 200 sieve is between 5% and 12%, a dual symbol is used to denote the soil For example; SP-SC, poorly-graded sand with clay content between 5% and 12%

APPENDIX B

Important Information about This
Geotechnical-Engineering Report

Subsurface problems are a principal cause of construction delays, cost overruns, claims, and disputes.

While you cannot eliminate all such risks, you can manage them. The following information is provided to help.

The Geoprofessional Business Association (GBA) has prepared this advisory to help you – assumedly a client representative – interpret and apply this geotechnical-engineering report as effectively as possible. In that way, clients can benefit from a lowered exposure to the subsurface problems that, for decades, have been a principal cause of construction delays, cost overruns, claims, and disputes. If you have questions or want more information about any of the issues discussed below, contact your GBA-member geotechnical engineer. Active involvement in the Geoprofessional Business Association exposes geotechnical engineers to a wide array of risk-confrontation techniques that can be of genuine benefit for everyone involved with a construction project.

Geotechnical-Engineering Services Are Performed for Specific Purposes, Persons, and Projects

Geotechnical engineers structure their services to meet the specific needs of their clients. A geotechnical-engineering study conducted for a given civil engineer will not likely meet the needs of a civil-works constructor or even a different civil engineer. Because each geotechnical-engineering study is unique, each geotechnical-engineering report is unique, prepared *solely* for the client. *Those who rely on a geotechnical-engineering report prepared for a different client can be seriously misled.* No one except authorized client representatives should rely on this geotechnical-engineering report without first conferring with the geotechnical engineer who prepared it. *And no one – not even you – should apply this report for any purpose or project except the one originally contemplated.*

Read this Report in Full

Costly problems have occurred because those relying on a geotechnical-engineering report did not read it *in its entirety*. Do not rely on an executive summary. Do not read selected elements only. *Read this report in full.*

You Need to Inform Your Geotechnical Engineer about Change

Your geotechnical engineer considered unique, project-specific factors when designing the study behind this report and developing the confirmation-dependent recommendations the report conveys. A few typical factors include:

- the client's goals, objectives, budget, schedule, and risk-management preferences;
- the general nature of the structure involved, its size, configuration, and performance criteria;
- the structure's location and orientation on the site; and
- other planned or existing site improvements, such as retaining walls, access roads, parking lots, and underground utilities.

Typical changes that could erode the reliability of this report include those that affect:

- the site's size or shape;
- the function of the proposed structure, as when it's changed from a parking garage to an office building, or from a light-industrial plant to a refrigerated warehouse;
- the elevation, configuration, location, orientation, or weight of the proposed structure;
- the composition of the design team; or
- project ownership.

As a general rule, *always* inform your geotechnical engineer of project changes – even minor ones – and request an assessment of their impact. *The geotechnical engineer who prepared this report cannot accept responsibility or liability for problems that arise because the geotechnical engineer was not informed about developments the engineer otherwise would have considered.*

This Report May Not Be Reliable

Do not rely on this report if your geotechnical engineer prepared it:

- for a different client;
- for a different project;
- for a different site (that may or may not include all or a portion of the original site); or
- before important events occurred at the site or adjacent to it; e.g., man-made events like construction or environmental remediation, or natural events like floods, droughts, earthquakes, or groundwater fluctuations.

Note, too, that it could be unwise to rely on a geotechnical-engineering report whose reliability may have been affected by the passage of time, because of factors like changed subsurface conditions; new or modified codes, standards, or regulations; or new techniques or tools. *If your geotechnical engineer has not indicated an "apply-by" date on the report, ask what it should be*, and, in general, *if you are the least bit uncertain* about the continued reliability of this report, contact your geotechnical engineer before applying it. A minor amount of additional testing or analysis – if any is required at all – could prevent major problems.

Most of the "Findings" Related in This Report Are Professional Opinions

Before construction begins, geotechnical engineers explore a site's subsurface through various sampling and testing procedures. *Geotechnical engineers can observe actual subsurface conditions only at those specific locations where sampling and testing were performed.* The data derived from that sampling and testing were reviewed by your geotechnical engineer, who then applied professional judgment to form opinions about subsurface conditions throughout the site. Actual sitewide-subsurface conditions may differ – maybe significantly – from those indicated in this report. Confront that risk by retaining your geotechnical engineer to serve on the design team from project start to project finish, so the individual can provide informed guidance quickly, whenever needed.

This Report's Recommendations Are Confirmation-Dependent

The recommendations included in this report – including any options or alternatives – are confirmation-dependent. In other words, *they are not final*, because the geotechnical engineer who developed them relied heavily on judgment and opinion to do so. Your geotechnical engineer can finalize the recommendations *only after observing actual subsurface conditions* revealed during construction. If through observation your geotechnical engineer confirms that the conditions assumed to exist actually do exist, the recommendations can be relied upon, assuming no other changes have occurred. *The geotechnical engineer who prepared this report cannot assume responsibility or liability for confirmation-dependent recommendations if you fail to retain that engineer to perform construction observation.*

This Report Could Be Misinterpreted

Other design professionals' misinterpretation of geotechnical-engineering reports has resulted in costly problems. Confront that risk by having your geotechnical engineer serve as a full-time member of the design team, to:

- confer with other design-team members,
- help develop specifications,
- review pertinent elements of other design professionals' plans and specifications, and
- be on hand quickly whenever geotechnical-engineering guidance is needed.

You should also confront the risk of constructors misinterpreting this report. Do so by retaining your geotechnical engineer to participate in prebid and preconstruction conferences and to perform construction observation.

Give Constructors a Complete Report and Guidance

Some owners and design professionals mistakenly believe they can shift unanticipated-subsurface-conditions liability to constructors by limiting the information they provide for bid preparation. To help prevent the costly, contentious problems this practice has caused, include the complete geotechnical-engineering report, along with any attachments or appendices, with your contract documents, *but be certain to note conspicuously that you've included the material for informational purposes only.* To avoid misunderstanding, you may also want to note that "informational purposes" means constructors have no right to rely on the interpretations, opinions, conclusions, or recommendations in the report, but they may rely on the factual data relative to the specific times, locations, and depths/elevations referenced. Be certain that constructors know they may learn about specific project requirements, including options selected from the report, *only* from the design drawings and specifications. Remind constructors that they may perform their own studies if they want to, and *be sure to allow enough time* to permit them to do so. Only then might you be in a position to give constructors the information available to you, while requiring them to at least share some of the financial responsibilities stemming from unanticipated conditions. Conducting prebid and preconstruction conferences can also be valuable in this respect.

Read Responsibility Provisions Closely

Some client representatives, design professionals, and constructors do not realize that geotechnical engineering is far less exact than other engineering disciplines. That lack of understanding has nurtured unrealistic expectations that have resulted in disappointments, delays, cost overruns, claims, and disputes. To confront that risk, geotechnical engineers commonly include explanatory provisions in their reports. Sometimes labeled "limitations," many of these provisions indicate where geotechnical engineers' responsibilities begin and end, to help others recognize their own responsibilities and risks. *Read these provisions closely.* Ask questions. Your geotechnical engineer should respond fully and frankly.

Geoenvironmental Concerns Are Not Covered

The personnel, equipment, and techniques used to perform an environmental study – e.g., a "phase-one" or "phase-two" environmental site assessment – differ significantly from those used to perform a geotechnical-engineering study. For that reason, a geotechnical-engineering report does not usually relate any environmental findings, conclusions, or recommendations; e.g., about the likelihood of encountering underground storage tanks or regulated contaminants. *Unanticipated subsurface environmental problems have led to project failures.* If you have not yet obtained your own environmental information, ask your geotechnical consultant for risk-management guidance. As a general rule, *do not rely on an environmental report prepared for a different client, site, or project, or that is more than six months old.*

Obtain Professional Assistance to Deal with Moisture Infiltration and Mold

While your geotechnical engineer may have addressed groundwater, water infiltration, or similar issues in this report, none of the engineer's services were designed, conducted, or intended to prevent uncontrolled migration of moisture – including water vapor – from the soil through building slabs and walls and into the building interior, where it can cause mold growth and material-performance deficiencies. Accordingly, ***proper implementation of the geotechnical engineer's recommendations will not of itself be sufficient to prevent moisture infiltration.*** Confront the risk of moisture infiltration by including building-envelope or mold specialists on the design team. ***Geotechnical engineers are not building-envelope or mold specialists.***

GEOPROFESSIONAL
BUSINESS
ASSOCIATION

Telephone: 301/565-2733
e-mail: info@geoprofessional.org   www.geoprofessional.org

CONSTRAINTS AND RESTRICTIONS

WARRANTY

Universal Engineering Sciences has prepared this report for our client for his exclusive use, in accordance with generally accepted soil and foundation engineering practices, and makes no other warranty either expressed or implied as to the professional advice provided in the report.

UNANTICIPATED SOIL CONDITIONS

The analysis and recommendations submitted in this report are based upon the data obtained from soil borings performed at the locations indicated on the Boring Location Plan. This report does not reflect any variations which may occur between these borings.

The nature and extent of variations between borings may not become known until construction begins. If variations appear, we may have to re-evaluate our recommendations after performing on-site observations and noting the characteristics of any variations.

CHANGED CONDITIONS

We recommend that the specifications for the project require that the contractor immediately notify Universal Engineering Sciences, as well as the owner, when subsurface conditions are encountered that are different from those present in this report.

No claim by the contractor for any conditions differing from those anticipated in the plans, specifications, and those found in this report, should be allowed unless the contractor notifies the owner and Universal Engineering Sciences of such changed conditions. Further, we recommend that all foundation work and site improvements be observed by a representative of Universal Engineering Sciences to monitor field conditions and changes, to verify design assumptions and to evaluate and recommend any appropriate modifications to this report.

MISINTERPRETATION OF SOIL ENGINEERING REPORT

Universal Engineering Sciences is responsible for the conclusions and opinions contained within this report based upon the data relating only to the specific project and location discussed herein. If the conclusions or recommendations based upon the data presented are made by others, those conclusions or recommendations are not the responsibility of Universal Engineering Sciences.

CHANGED STRUCTURE OR LOCATION

This report was prepared in order to aid in the evaluation of this project and to assist the architect or engineer in the design of this project. If any changes in the design or location of the structure as outlined in this report are planned, or if any structures are included or added that are not discussed in the report, the conclusions and recommendations contained in this report shall not be considered valid unless the changes are reviewed and the conclusions modified or approved by Universal Engineering Sciences.

USE OF REPORT BY BIDDERS

Bidders who are examining the report prior to submission of a bid are cautioned that this report was prepared as an aid to the designers of the project and it may affect actual construction operations.

Bidders are urged to make their own soil borings, test pits, test caissons or other explorations to determine those conditions that may affect construction operations. Universal Engineering Sciences cannot be responsible for any interpretations made from this report or the attached boring logs with regard to their adequacy in reflecting subsurface conditions which will affect construction operations.

STRATA CHANGES

Strata changes are indicated by a definite line on the boring logs which accompany this report. However, the actual change in the ground may be more gradual. Where changes occur between soil samples, the location of the change must necessarily be estimated using all available information and may not be shown at the exact depth.

OBSERVATIONS DURING DRILLING

Attempts are made to detect and/or identify occurrences during drilling and sampling, such as: water level, boulders, zones of lost circulation, relative ease or resistance to drilling progress, unusual sample recovery, variation of driving resistance, obstructions, etc.; however, lack of mention does not preclude their presence.

WATER LEVELS

Water level readings have been made in the drill holes during drilling and they indicate normally occurring conditions. Water levels may not have been stabilized at the last reading. This data has been reviewed and interpretations made in this report. However, it must be noted that fluctuations in the level of the groundwater may occur due to variations in rainfall, temperature, tides, and other factors not evident at the time measurements were made and reported. Since the probability of such variations is anticipated, design drawings and specifications should accommodate such possibilities and construction planning should be based upon such assumptions of variations.

LOCATION OF BURIED OBJECTS

All users of this report are cautioned that there was no requirement for Universal Engineering Sciences to attempt to locate any man-made buried objects during the course of this exploration and that no attempt was made by Universal Engineering Sciences to locate any such buried objects. Universal Engineering Sciences cannot be responsible for any buried man-made objects which are subsequently encountered during construction that are not discussed within the text of this report.

TIME

This report reflects the soil conditions at the time of exploration. If the report is not used in a reasonable amount of time, significant changes to the site may occur and additional reviews may be required.

Universal Engineering Sciences, Inc.
GENERAL CONDITIONS

SECTION 1: RESPONSIBILITIES

1.1 *Universal Engineering Sciences, Inc*, ("UES"), has the responsibility for providing the services described under the Scope of Services section. The work is to be performed according to accepted standards of care and is to be completed in a timely manner. The term "UES" as used herein includes all of *Universal Engineering Sciences, Inc's* agents, employees, professional staff, and subcontractors.

1.2 The Client or a duly authorized representative is responsible for providing UES with a clear understanding of the project nature and scope. The Client shall supply UES with sufficient and adequate information, including, but not limited to, maps, site plans, reports, surveys and designs, to allow UES to properly complete the specified services. The Client shall also communicate changes in the nature and scope of the project as soon as possible during performance of the work so that the changes can be incorporated into the work product.

1.3 The Client acknowledges that UES's responsibilities in providing the services described under the Scope of Services section is limited to those services described therein, and the Client hereby assumes any collateral or affiliated duties necessitated by or for those services. Such duties may include, but are not limited to, reporting requirements imposed by any third party such as federal, state, or local entities, the provision of any required notices to any third party, or the securing of necessary permits or permissions from any third parties required for UES's provision of the services so described, unless otherwise agreed upon by both parties.

1.4 Universal will not be responsible for scheduling our services and will not be responsible for tests or inspections that are not performed due to a failure to schedule our services on the project or any resulting damages.

1.5 **PURSUANT TO FLORIDA STATUTES §558.0035, ANY INDIVIDUAL EMPLOYEE OR AGENT OF UES MAY NOT BE HELD INDIVIDUALLY LIABLE FOR NEGLIGENCE.**

SECTION 2: STANDARD OF CARE

2.1 Services performed by UES under this Agreement will be conducted in a manner consistent with the level of care and skill ordinarily exercised by members of UES's profession practicing contemporaneously under similar conditions in the locality of the project. No other warranty, express or implied, is made.

2.2 The Client recognizes that subsurface conditions may vary from those observed at locations where borings, surveys, or other explorations are made, and that site conditions may change with time. Data, interpretations, and recommendations by UES will be based solely on information available to UES at the time of service. UES is responsible for those data, interpretations, and recommendations, but will not be responsible for other parties' interpretations or use of the information developed.

2.3 Execution of this document by UES is not a representation that UES has visited the site, become generally familiar with local conditions under which the services are to be performed, or correlated personal observations with the requirements of the Scope of Services. It is the Client's responsibility to provide UES with all information necessary for UES to provide the services described under the Scope of Services, and the Client assumes all liability for information not provided to UES that may affect the quality or sufficiency of the services so described.

2.4 Should UES be retained to provide threshold inspection services under Florida Statutes §553.79, Client acknowledges that UES's services thereunder do not constitute a guarantee that the construction in question has been properly designed or constructed, and UES's services do not replace any of the obligations or liabilities associated with any architect, contractor, or structural engineer. Therefore it is explicitly agreed that the Client will not hold UES responsible for the proper performance of service by any architect, contractor, structural engineer or any other entity associated with the project.

SECTION 3: SITE ACCESS AND SITE CONDITIONS

3.1 Client will grant or obtain free access to the site for all equipment and personnel necessary for UES to perform the work set forth in this Agreement. The Client will notify any and all possessors of the project site that Client has granted UES free access to the site. UES will take reasonable precautions to minimize damage to the site, but it is understood by Client that, in the normal course of work, some damage may occur, and the correction of such damage is not part of this Agreement unless so specified in the Proposal.

3.2 The Client is responsible for the accuracy of locations for all subterranean structures and utilities. UES will take reasonable precautions to avoid known subterranean structures, and the Client waives any claim against UES, and agrees to defend, indemnify, and hold UES harmless from any claim or liability for injury or loss, including costs of defense, arising from damage done to subterranean structures and utilities not identified or accurately located. In addition, Client agrees to compensate UES for any time spent or expenses incurred by UES in defense of any such claim with compensation to be based upon UES's prevailing fee schedule and expense reimbursement policy.

SECTION 4: SAMPLE OWNERSHIP AND DISPOSAL

4.1 Soil or water samples obtained from the project during performance of the work shall remain the property of the Client.

4.2 UES will dispose of or return to Client all remaining soils and rock samples 60 days after submission of report covering those samples. Further storage or transfer of samples can be made at Client's expense upon Client's prior written request.

4.3 Samples which are contaminated by petroleum products or other chemical waste will be returned to Client for treatment or disposal, consistent with all appropriate federal, state, or local regulations.

SECTION 5: BILLING AND PAYMENT

5.1 UES will submit invoices to Client monthly or upon completion of services. Invoices will show charges for different personnel and expense classifications.

5.2 Payment is due 30 days after presentation of invoice and is past due 31 days from invoice date. Client agrees to pay a finance charge of one and one-half percent (1 ½ %) per month, or the maximum rate allowed by law, on past due accounts.

5.3 If UES incurs any expenses to collect overdue billings on invoices, the sums paid by UES for reasonable attorneys' fees, court costs, UES's time, UES's expenses, and interest will be due and owing by the Client.

SECTION 6: OWNERSHIP AND USE OF DOCUMENTS

6.1 All reports, boring logs, field data, field notes, laboratory test data, calculations, estimates, and other documents prepared by UES, as instruments of service, shall remain the property of UES.

6.2 Client agrees that all reports and other work furnished to the Client or his agents, which are not paid for, will be returned upon demand and will not be used by the Client for any purpose.

6.3 UES will retain all pertinent records relating to the services performed for a period of five years following submission of the report, during which period the records will be made available to the Client at all reasonable times.

6.4 All reports, boring logs, field data, field notes, laboratory test data, calculations, estimates, and other documents prepared by UES, are prepared for the sole and exclusive use of Client, and may not be given to any other party or used or relied upon by any such party without the express written consent of UES.

SECTION 7: DISCOVERY OF UNANTICIPATED HAZARDOUS MATERIALS

7.1 Client warrants that a reasonable effort has been made to inform UES of known or suspected hazardous materials on or near the project site.

7.2 Under this agreement, the term hazardous materials include hazardous materials (40 CFR 172.01), hazardous wastes (40 CFR 261.2), hazardous substances (40 CFR 300.6), petroleum products, polychlorinated biphenyls, and asbestos.

7.3 Hazardous materials may exist at a site where there is no reason to believe they could or should be present. UES and Client agree that the discovery of unanticipated hazardous materials constitutes a changed condition mandating a renegotiation of the scope of work. UES and Client also agree that the discovery of unanticipated hazardous materials may make it necessary for UES to take immediate measures to protect health and safety. Client agrees to compensate UES for any equipment decontamination or other costs incident to the discovery of unanticipated hazardous waste.

7.4 UES agrees to notify Client when unanticipated hazardous materials or suspected hazardous materials are encountered. Client agrees to make any disclosures required by law to the appropriate governing agencies. Client also agrees to hold UES harmless for any and all consequences of disclosures made by UES which are required by governing law. In the event the project site is not owned by Client, Client recognizes that it is the Client's responsibility to inform the property owner of the discovery of unanticipated hazardous materials or suspected hazardous materials.

7.5 Notwithstanding any other provision of the Agreement, Client waives any claim against UES, and to the maximum extent permitted by law, agrees to defend, indemnify, and save UES harmless from any claim, liability, and/or defense costs for injury or loss arising from UES's discovery of unanticipated hazardous materials or suspected hazardous materials including any costs created by delay of the project and any cost associated with possible reduction of the property's value. Client will be responsible for ultimate disposal of any samples secured by UES which are found to be contaminated.

SECTION 8: RISK ALLOCATION

8.1 Client agrees that UES's liability for any damage on account of any breach of contract, error, omission or other professional negligence will be limited to a sum not to exceed $50,000 or UES's fee, whichever is greater. If Client prefers to have higher limits on contractual or professional liability, UES agrees to increase the limits up to a maximum of $1,000,000.00 upon Client's written request at the time of accepting our proposal provided that Client agrees to pay an additional consideration of four percent of the total fee, or $400.00, whichever is greater. The additional charge for the higher liability limits is because of the greater risk assumed and is not strictly a charge for additional professional liability insurance.

SECTION 9: INSURANCE

9.1 UES represents and warrants that it and its agents, staff and consultants employed by it, is and are protected by worker's compensation insurance and that UES has such coverage under public liability and property damage insurance policies which UES deems to be adequate. Certificates for all such policies of insurance shall be provided to Client upon request in writing. Within the limits and conditions of such insurance, UES agrees to indemnify and save Client harmless from and against loss, damage, or liability arising from negligent acts by UES, its agents, staff, and consultants employed by it. UES shall not be responsible for any loss, damage or liability beyond the amounts, limits, and conditions of such insurance or the limits described in Section 8, whichever is less. The Client agrees to defend, indemnify and save UES harmless for loss, damage or liability arising from acts by Client, Client's agent, staff, and other UESs employed by Client.

SECTION 10: DISPUTE RESOLUTION

10.1 All claims, disputes, and other matters in controversy between UES and Client arising out of or in any way related to this Agreement will be submitted to alternative dispute resolution (ADR) such as mediation or arbitration, before and as a condition precedent to other remedies provided by law, including the commencement of litigation.

10.2 If a dispute arises related to the services provided under this Agreement and that dispute requires litigation instead of ADR as provided above, then:

  (a) the claim will be brought and tried in judicial jurisdiction of the court of the county where UES's principal place of business is located and Client waives the right to remove the action to any other county or judicial jurisdiction, and

  (b) The prevailing party will be entitled to recovery of all reasonable costs incurred, including staff time, court costs, attorneys' fees, and other claim related expenses.

SECTION 11: TERMINATION

11.1 This agreement may be terminated by either party upon seven (7) days written notice in the event of substantial failure by the other party to perform in accordance with the terms hereof. Such termination shall not be effective if that substantial failure has been remedied before expiration of the period specified in the written notice. In the event of termination, UES shall be paid for services performed to the termination notice date plus reasonable termination expenses.

11.2 In the event of termination, or suspension for more than three (3) months, prior to completion of all reports contemplated by the Agreement, UES may complete such analyses and records as are necessary to complete its files and may also complete a report on the services performed to the date of notice of termination or suspension. The expense of termination or suspension shall include all direct costs of UES in completing such analyses, records and reports.

SECTION 12: ASSIGNS

12.1 Neither the Client nor UES may delegate, assign, sublet or transfer their duties or interest in this Agreement without the written consent of the other party.

SECTION 13. GOVERNING LAW AND SURVIVAL

13.1 The laws of the State of Florida will govern the validity of these Terms, their interpretation and performance.

13.2 If any of the provisions contained in this Agreement are held illegal, invalid, or unenforceable, the enforceability of the remaining provisions will not be impaired. Limitations of liability and indemnities will survive termination of this Agreement for any cause.

SECTION 14. INTEGRATION CLAUSE

14.1 This Agreement represents and contains the entire and only agreement and understanding among the parties with respect to the subject matter of this Agreement, and supersedes any and all prior and contemporaneous oral and written agreements, understandings, representations, inducements, promises, warranties, and conditions among the parties. No agreement, understanding, representation, inducement, promise, warranty, or condition of any kind with respect to the subject matter of this Agreement shall be relied upon by the parties unless expressly incorporated herein.

14.2 This Agreement may not be amended or modified except by an agreement in writing signed by the party against whom the enforcement of any modification or amendment is sought.