WESTERN™
UTILITY / TELECOM, INC.

Structural Calculations with Foundation Design

For A:

35' Tall, Concealment Antenna / Light Pole

Located At:

Various Puyallup, WA Nodes

PIERCE **County**

Prepared for:

Mastec Network Solutions

8-Sep-21

Dated:
September 8, 2021

Western UT Project No.: 21-0267

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Table of Contents

8-Sep-21

PROFESSIONAL ENGINEER SEAL

I hereby certify that this structural design report was prepared by me, or under my direct supervision, and that I am a duly licensed Professional Engineer under the laws of the State of Washington.

Loading, Codes, and Materials

Design Loading:

Antenna(s):	(1) - 12" Ø x 60" Tall Antenna/Radio Shroud, Wt. = 165 lbs., C.L. @ 32.5' ± AGL
Other:	(1) - Nokia 5G Antennas/RRHs in Top Shroud, Wt. = 35 lbs., C.L. @ 31.7' ± AGL
	(1) - 9" Tall x 30" Long Cobra Head Luminaire, Wt. = 45 lbs., C.L. @ 30' ± AGL
	(1) - 2 7/8" OD x 14' (Max.) Long Luminaire Arm, Wt. = 85 lbs. C.L. @ 27.5' ± AGL
	(1) - Nokia B12/B14 Micro RRH, Wt. = 77 lbs. C.L. @ 17.7' ± AGL
	(1) - Nokia B25/B66 Micro RRH, Wt. = 66 lbs. C.L. @ 12' ± AGL
	(1) - CCI Twin RRU PSU, Wt. = 34 lbs. C.L. @ 6' ± AGL
	(1) - Base Cover, Wt. = 66 lbs. C.L. @ 0.33' ± AGL

Design Criteria:

Basic Wind Speed (V): 97 mph (3-Second Gust) Per ANSI/TIA-222-H & 2018 IBC, Section 1609.1.1, Exc. 5

Risk Category:	II	*Per Table 2-1*
Exposure Category:	C	*Per Section 2.6.5.1*
Topographic Category:	1	*Per Section 2.6.6.2*

(V_{AASHTO}): 97 mph (3-Second Gust) Per 2015 AASHTO LRFD LTS-1 w/2017 Interims

Ice: Not required for this structure per Annex B

Seismic: Per 2018 IBC Section 1613 ASCE 7-16 Sections 15.1.3 & 12.8

Standards and Design Codes:

Industry Standards:	ANSI/TIA 222-H & 2018 IBC
Concrete:	ACI 318-14
Steel:	AISC "Steel Construction Manual", 15th Edition
Welding:	ANSI/AWS D1.1-15
Soil:	Per 2018 IBC, Table1806.2, Class 5 Material

Materials:

Pole Shaft:	ASTM A53/A500 Gr. B/API 5L Gr. B (Min. Fy = 35 ksi)
Baseplate:	ASTM A36
Ports:	ASTM A500 Gr. B (Rect.)
Plates:	ASTM A36
Welds:	E70XX Electrodes
Structural Bolts:	ASTM F3125 A325
Anchor Bolts:	ASTM F1554 Gr. 55
Rebar:	ASTM A615 Gr. 60

Coatings:

Galvanizing: ASTM A123

Wind Loading Calculations: Monopole Shaft

Reference: ANSI/TIA-222-H, Section 2.6.11.6

V =	97	mph (3-Second Gust Basic Wind Speed)
G_H =	1.10	Gust Response Factor - 1.10 for Poles
K_d =	0.95	Wind Direction Probability Factor
K_e =	1.00	Ground Elevation Factor
	II	:Risk Category
	C	:Exposure Category
	1	:Topographic Category

Velocity Pressure, $q_z = 0.00256 * K_z * K_{zt} * K_e * K_d * V^2$ ***Where:***

K_z = Velocity Pressure Exposure Coefficient, Section 2.6.5.2 and Table 2-4
K_{zt} = Topographic Factor, Section 2.6.6.2, Table 2-4 and 2-5
K_e = Ground Elevation Factor, Section 2.6.8
K_d = Wind Direction Probability Factor, Table 2-2
V = Basic Wind Speed, 3-Second Gust, mph

Section Wind Force, $F_{ST} = q_z * G_H * (EPA)_S$ ***Where:***

$(EPA)_s = C_f A_P$

Shaft Section Properties					Section Area				Wind Pressure							Wind Loading					
Average Section Elevation (Feet AGL)	Section Width (Point-to-Point) (inches)	Monopole Shaft Wall Thickness (inches)	Section Height (feet)	Section Elevation At Base (Feet)	Gross Section Area (Square Feet)	(mph - feet)	Force Coefficient	Effective Section Area (Square Feet)	Velocity Pressure Coefficient	Topographic Factor	Wind Direction Probability Factor	Ground Elevation Factor	Velocity Pressure (psf)	Gust Effect Factor	Applied Wind Pressure (psf)	Factored Section Base Wind Shear (kips)	Section Base Wind Moment (Foot-kips)	Factored Section Base Wind Moment (Foot-kips)	Factored Section Base Seismic Shear (kips)	Section Base Seismic Moment (Foot-kips)	Section Weight (kips)
Z	D_P	T_W	H	Z_{Base}	A_P	C	C_F	EPA_S	K_Z	K_{Zt}	K_d	K_e	q_Z	G_H	$q_Z G_H$	F_{ST}	F_{ST} * Z	F_{ST}*Z	W_T*C_s	W_T*C_s*Z	W_T
1.74	20.00	0.250	2.89	0.29	4.8	149.0	0.60	2.89	0.85	1.00	0.95	1.00	19.5	1.10	21.4	0.062	0.09	0.09	0.10	0.15	0.153
4.63	20.00	0.250	2.89	3.18	4.82	149.0	0.60	2.89	0.85	1.00	0.95	1.00	19.5	1.10	21.4	0.062	0.27	0.27	0.10	0.45	0.153
7.52	20.00	0.250	2.89	6.08	4.82	149.0	0.60	2.89	0.85	1.00	0.95	1.00	19.5	1.10	21.4	0.062	0.45	0.45	0.10	0.75	0.153
10.41	20.00	0.250	2.89	8.97	4.82	149.0	0.60	2.89	0.85	1.00	0.95	1.00	19.5	1.10	21.4	0.062	0.63	0.63	0.10	1.05	0.153
13.31	20.00	0.250	2.89	11.9	4.82	149.0	0.60	2.89	0.85	1.00	0.95	1.00	19.5	1.10	21.4	0.062	0.81	0.81	0.10	1.35	0.153
16.20	20.00	0.250	2.89	14.8	4.82	150.2	0.60	2.89	0.86	1.00	0.95	1.00	19.7	1.10	21.7	0.063	1.00	1.00	0.10	1.64	0.153
19.09	20.00	0.250	2.89	17.6	4.82	152.8	0.60	2.89	0.89	1.00	0.95	1.00	20.4	1.10	22.5	0.065	1.22	1.22	0.10	1.94	0.153
21.98	20.00	0.250	2.89	20.5	4.82	155.1	0.60	2.89	0.92	1.00	0.95	1.00	21.1	1.10	23.2	0.067	1.45	1.45	0.10	2.24	0.153
24.88	20.00	0.250	2.89	23.4	4.82	157.1	0.60	2.89	0.94	1.00	0.95	1.00	21.6	1.10	23.8	0.069	1.69	1.69	0.10	2.54	0.153
27.77	20.00	0.250	2.89	26.3	4.82	158.9	0.60	2.89	0.97	1.00	0.95	1.00	22.1	1.10	24.3	0.070	1.93	1.93	0.10	2.84	0.153
30.66	20.00	0.250	2.89	29.2	4.82	160.6	0.60	2.89	0.99	1.00	0.95	1.00	22.6	1.10	24.8	0.072	2.18	2.18	0.10	3.14	0.153
33.55	20.00	0.250	2.89	32.1	4.82	162.1	0.60	2.89	1.01	1.00	0.95	1.00	23.0	1.10	25.3	0.073	2.44	2.44	0.10	3.44	0.153
															Loading Summations:	**0.788**	**14.15**	**14.15**	**1.24**	**21.53**	**1.83**

Overall Length of Pole = 34.71 feet

Base Elevation of Pole = 0.29 feet (AGL)

Top of Steel Elevation = 35.00 feet (AGL)

Wind Loading Calculations - Sectorized Antennas and Mounts:

Description	CL Elevation (feet)	Offset from Shaft C.L. (in.)	Quantity Per Sector	Weight (lbs)	Height (inches)	Width (inches)	Depth (inches)	Shielding Factor K_a	C_a Calc (Normal)	C_a Calc (Transverse)	$(EPA)_N$ (ft^2)	$(EPA)_T$ (ft^2)	$(EPA)_A$ (ft^2)		Unfactored Wind Pressure (psf)	Factored Loads: Factored V_{wind} (kips)	Factored Wind Torque (ft-kips)	Factored M_{wind} (ft-kips)	$V_{seismic}$ (kips)	Factored Seismic Torque (ft-kips)	Factored $M_{seismic}$ (ft-kips)	Factored Total Wt (kips)
Shear, Moment, and Weight Summations:																0.00	0.00	0.00	0.00	0.00	0.00	0.00

Wind Loading Calculations - Miscellaneous Appurtenances:

Description	CL Elevation (feet)	Offset from Shaft C.L. (in.)	Quantity	Weight (lbs)	Shape Round (R) or Flat (F)	Height (inches)	Width (inches)	Area Factor	A_A (ft^2)	Aspect Ratio (Height / Width)	C	C_a	C_aA_A (ft^2)	ΣC_aA_A (ft^2)	Factored Wind Pressure (psf)	Factored Loads: Factored V_{wind} (kips)	Factored Wind Torque (ft-kips)	Factored M_{wind} (ft-kips)	$V_{seismic}$ (kips)	Factored Seismic Torque (ft-kips)	Factored $M_{seismic}$ (ft-kips)	Factored Total Wt (kips)
12" Ø x 60" Tall Antenna/Radio Shro	32.5	0.0	1	165.0	R	60.0	20.0	1.00	8.33	3.00	162	0.51	4.26	4.26	22.9	0.097	0.00	3.16	0.11	0.00	3.63	0.20
Nokia 5G Antennas/RRHs in Top Sh	31.7	0.0	1	35.0	R	24.0	20.0	0.00	3.33	1.20	161	0.50	1.67	0.00	22.7	0.000	0.00	0.00	0.02	0.00	0.75	0.04
9" Tall x 30" Long Cobra Head Lumi	30.0	186.0	1	45.0	F	9.0	30.0	1.00	1.88	3.33	N/A	1.24	2.32	2.32	22.5	0.052	0.81	1.56	0.03	0.47	0.91	0.05
2 7/8" OD x 14' (Max.) Long Luminai	27.5	96.9	1	85.0	R	2.9	168.0	1.00	3.35	58.43	1334	0.60	2.01	2.01	22.1	0.044	0.36	1.22	0.06	0.46	1.58	0.10
Nokia B12/B14 Micro RRH	17.7	0.0	1	77.0	F	22.1	12.1	0.00	1.86	1.82	N/A	1.20	2.23	0.00	20.1	0.000	0.00	0.00	0.05	0.00	0.92	0.09
Nokia B25/B66 Micro RRH	12.0	0.0	1	66.0	F	22.0	12.1	0.00	1.85	1.82	N/A	1.20	2.22	0.00	19.5	0.000	0.00	0.00	0.04	0.00	0.54	0.08
CCI Twin RRU PSU	6.0	0.0	1	34.0	F	14.0	8.4	0.00	0.82	1.67	N/A	1.20	0.98	0.00	19.5	0.000	0.00	0.00	0.02	0.00	0.14	0.04
Base Cover	0.3	0.0	1	66.0	F	9.0	22.0	1.00	1.38	2.44	N/A	1.20	1.65	1.65	19.5	0.032	0.00	0.01	0.04	0.00	0.01	0.08
Shear, Moment, and Weight Summations:																0.23	1.17	5.96	0.39	0.94	8.49	0.69

Wind Loading Summary - Factored Base Reactions:

For Load Combination: 1.2D + 1.0W$_o$:

Design Base Moment, M$_{base}$ = 20.2 ft-kips : $M_{Shaft} + M_{appurtenance} + M_{P\Delta}$

Design Base Shear, V$_{base}$ = 1.01 kips : $V_{Shaft} + V_{Appurtenance}$

Design Base Torsion, T$_{base}$ = 1.17 kips : $T_{Shaft} + T_{Appurtenance}$

Design Base Weight, WT$_{base}$ = 2.89 kips : $Wt_{Shaft} + Wt_{Appurtenance}$

Seismic Loading Summary - Factored Base Reactions:

For Load Combination: 1.2D + 1.0E$_V$ + 1.0 E$_h$:

Design Base Moment, M$_{base}$ = 30.03 ft-kips : $M_{Shaft} + M_{appurtenance} + M_{P\Delta}$

Design Base Shear, V$_{base}$ = 1.63 kips : $V_{Shaft} + V_{Appurtenance}$

Design Base Torsion, T$_{base}$ = 0.94 ft-kips : $T_{Shaft} + T_{Appurtenance}$

Design Base Weight, WT$_{base}$ = 3.37 kips : $Wt_{Shaft} + Wt_{Appurtenance}$

Wind and Ice Loading Calculations: Monopole Shaft

Reference: ANSI/TIA-222-H, Section 2.6.9.6

V_i =	30.0	mph (3-Second Gust Basic Wind Speed)
G_H =	1.10	Gust Response Factor - 1.10 for Poles
K_d =	0.95	Wind Direction Probability Factor
K_e =	1.00	Ground Elevation Factor
I_{ice} =	1.00	Importance Factor, t_i
t_i =	0.5	Base Ice Thickness, in.
	II	:Classification of Structure
	C	:Exposure Category
	1	:Topographic Category

Velocity Pressure, $q_z = 0.00256 * K_z * K_{zt} * K_e * K_d * V^2$ ***Where:***

See Page 2 for Variable Descriptions

Section Wind Force, $F_{ST} = q_z * G_H * (EPA)_S$ ***Where:***

$(EPA)_s = C_f A_P$

Excalated Ice Thickness, $t_{iz} = t_i * I_{ice} * K_{iz} * (K_{zt})^{0.35}$ ***Where:***

$K_{iz} = (z / 33)^{0.10}$

Shaft Section Properties					Section Area			Escalated Ice Thickness				Wind Pressure			Wind Loading				
Average Section Elevation (Feet)	Section Pipe Diameter (inches)	Monopole Shaft Wall Thickness (inches)	Section Height (feet)	Section Elevation At Base (Feet)	Gross Section Area (Square Feet)	Force Coefficient	Effective Section Area (Square Feet)	Height Escalation Factor	Topographic Factor	Importance Factor Ice Thickness (Inches)	Escalated Ice Thickness (Inches)	Velocity Pressure (psf)	Gust Effect Factor	Applied Wind Pressure (psf)	Section Base Wind Shear (kips)	Factored Section Base Wind Shear (kips)	Section Base Wind Moment (Foot-kips)	Factored Section Base Wind Moment (Foot-kips)	Section Weight (kips)
Z	D_P	T_W	H	Z_{Base}	A_P	C_F	EPA_S	K_{iz}	K_{Zt}	I_{ice}	t_{iz}	q_Z	G_H	$q_Z G_H$	F_{ST}	$1.6*F_{ST}$	$F_{ST}*Z$	$1.6*F_{ST}*Z$	W_T
1.74	20.0	0.250	2.9	0.3	4.8	1.20	6.2	0.74	1.00	1.00	0.74	1.18	1.10	1.30	0.008	0.013	0.01	0.02	0.21
4.63	20.0	0.250	2.9	3.2	4.8	1.20	6.3	0.82	1.00	1.00	0.82	1.45	1.10	1.60	0.010	0.016	0.04	0.07	0.21
7.52	20.0	0.250	2.9	6.1	4.8	1.20	6.3	0.86	1.00	1.00	0.86	1.61	1.10	1.77	0.011	0.018	0.08	0.13	0.22
10.41	20.0	0.250	2.9	9.0	4.8	1.20	6.3	0.89	1.00	1.00	0.89	1.72	1.10	1.89	0.012	0.019	0.12	0.19	0.22
13.31	20.0	0.250	2.9	11.9	4.8	1.20	6.3	0.91	1.00	1.00	0.91	1.81	1.10	1.99	0.013	0.020	0.16	0.26	0.22
16.20	20.0	0.250	2.9	14.8	4.8	1.20	6.3	0.93	1.00	1.00	0.93	1.89	1.10	2.08	0.013	0.021	0.21	0.33	0.22
19.09	20.0	0.250	2.9	17.6	4.8	1.20	6.3	0.95	1.00	1.00	0.95	1.95	1.10	2.15	0.014	0.022	0.3	0.4	0.22
21.98	20.0	0.250	2.9	20.5	4.8	1.20	6.3	0.96	1.00	1.00	0.96	2.01	1.10	2.22	0.014	0.022	0.3	0.5	0.22
24.88	20.0	0.250	2.9	23.4	4.82	1.20	6.3	0.97	1.00	1.00	0.97	2.07	1.10	2.3	0.014	0.023	0.4	0.6	0.22
27.77	20.0	0.250	2.9	26.3	4.82	1.20	6.4	0.98	1.00	1.00	0.98	2.12	1.10	2.3	0.015	0.024	0.4	0.6	0.23
30.66	20.0	0.250	2.9	29.2	4.82	1.20	6.4	0.99	1.00	1.00	0.99	2.16	1.10	2.4	0.015	0.024	0.5	0.7	0.23
33.55	20.0	0.250	2.9	32.1	4.82	1.20	6.4	1.00	1.00	1.00	1.00	2.20	1.10	2.4	0.015	0.025	0.5	0.8	0.23
														Loading Summations:	**0.15**	**0.25**	**2.9**	**4.7**	**2.65**

Overall Height of Steel =	**34.71**	**feet**	**Deflection at Top of Pole =**	**0.19**	**inches**
Base Elevation of Pole =	**0.29**	**feet (AGL)**	**Sway at Top of Pole =**	**0.03**	**degrees**
Top of Steel Elevation =	**35.00**	**feet (AGL)**	**Moment Due to P-Δ Effects =**	**0.03**	**ft-kips**

Wind and Ice Loading Calculations - Sectorized Antennas and Mounts:

Description	CL Elevation (feet)	Offset from Shaft C.L. (in.)	Quantity Per Sector	Weight (lbs)	Height (inches)	Width (inches)	Depth (inches)	Shielding Factor K_a	Escalated Ice Thickness (Inches)	C_a Calc (Normal)	C_a Calc (Transverse)	$(EPA)_N$ (ft^2)	$(EPA)_T$ (ft^2)	$(EPA)_A$ (ft^2)	Wind Pressure (psf)	Factored Loads: Factored $V_{wind\text{-}No\ Ice}$ (kips)	Factored Wind Torque (ft-kips)	Factored $M_{wind\text{-}No\ Ice}$ (ft-kips)	Factored Total $Wt_{No\ Ice}$ (kips)
Shear, Moment, and Weight Summations:																0.00	0.00	0.0	0.00

Wind and Ice Loading Calculations - Miscellaneous Appurtenances:

Description	CL Elevation (feet)	Offset from Shaft C.L. (in.)	Quantity	Weight (lbs)	Shape Round (R) or Flat (F)	Height (inches)	Width (inches)	Area Factor	A_A (ft^2)	Aspect Ratio (Height / Width)	C	C_a	C_aA_A (ft^2)	ΣC_aA_A (ft^2)	Wind Pressure (psf)	Factored Loads: Factored $V_{wind\text{-}No\ Ice}$ (kips)	Factored Wind Torque (ft-kips)	Factored $M_{wind\text{-}No\ Ice}$ (ft-kips)	Factored Total $Wt_{No\ Ice}$ (kips)
12" Ø x 60" Tall Antenna/Radio Shrou	32.5	0.0	1	259	R	61	21.00	1.00	8.9	2.9	162	0.51	4.55	4.5	2.41	0.02	0.00	0.57	0.31
Nokia 5G Antennas/RRHs in Top Shro	31.7	0.0	1	81	R	25	21.0	0.00	3.64	1.19	161	0.50	1.82	0.00	2.39	0.00	0.00	0.00	0.10
9" Tall x 30" Long Cobra Head Lumina	30.0	186.0	1	86	F	10	30.99	1.00	2.15	0.32	N/A	1.24	2.7	3	2.4	0.01	1.87	0.3	0.10
2 7/8" OD x 14' (Max.) Long Luminaire	27.5	96.9	1	121	R	4	168.98	1.00	4.53	0.02	1334	0.60	2.7	3	2.3	0.01	0.98	0.3	0.15
Nokia B12/B14 Micro RRH	17.7	0.0	1	94	F	23	13.07	0.00	2.09	1.76	N/A	1.20	2.5	0	2.1	0.00	0.00	0.0	0.11
Nokia B25/B66 Micro RRH	12.0	0.0	1	81	F	23	13.00	0.00	2.07	1.76	N/A	1.20	2.5	0	2.0	0.00	0.00	0.0	0.10
CCI Twin RRU PSU	6.0	0.0	1	42	F	15	9.24	0.00	0.95	1.61	N/A	1.20	1.1	0	2.0	0.00	0.00	0.0	0.05
Base Cover	0.3	0.0	1	84.7	F	10	22.63	1.00	1.51	0.43	N/A	1.20	1.8	2	2.0	0.01	0.00	0.0	0.10
Shear, Moment, and Weight Summations:																0.04	2.85	1.15	1.02

Wind Loading Summary - Base Reactions:

For Load Combination: 1.2D + 1.0D $_i$ + 1.0W $_i$:

Design Base Moment, M $_{pole}$ = 5.9 ft-kips : $M_{Shaft} + M_{appurtenance} + M_{P\Delta}$

Design Base Shear, V $_{pole}$ = 0.29 kips : $V_{Shaft} + V_{Appurtenance}$

Design Base Torsion, T $_{base}$ = 1.15 ft-kips : $T_{Shaft} + T_{Appurtenance}$

Design Base Weight, WT $_{pole}$ = 4.2 kips : $Wt_{Shaft} + Wt_{Appurtenance}$

Wind Loading Calculations: Monopole Shaft

Reference: AASHTO LRFD-LTS-1, 2015 (w/ 2017 Interim Revs), Sec. 3

$V_{(ult)}$ =	97	mph (3-Second Gust)
G =	1.14	Gust Effect Factor, Section 3.8.6, Min. Value = 1.14
K_d =	0.95	Wind Direction Probability Factor
I =	1	Importance Factor
	II	:Risk Category
	C	:Exposure Category
	1	:Topographic Category
C_v =	1.0	:Wind Drag Coefficient (= 0.8 for the Extreme Limit State and 1.0 otherwise), Section 3.8.7

Design Wind Pressure, $P_z = 0.00256 * K_z * K_d * G * V^2$ Where:

K_z = Velocity Pressure Exposure Coefficient, Section 3.8.4 and Eqn. 3.8.4-1
K_d = Wind Direction Probability Factor, Table 3.8.5-1
V = Basic Wind Speed, 3-Second Gust, mph

Section Wind Force, $F_{ST} = P_Z * (EPA)_S$ Where:

$(EPA)_s = C_d A_P$
C_d = Drag Coefficient, Section 3.8.7

Shaft Section Properties					Section Area				Wind Pressure							Wind Loading				
Average Section Elevation (Feet)	Section Pipe Diameter (inches)	Monopole Shaft Wall Thickness (inches)	Section Height (feet)	Section Elevation At Base (Feet)	Gross Section Area (Square Feet)	(mph - feet)	Drag Coefficient	Effective Section Area (Square Feet)	Velocity Pressure Coefficient		Wind Direction Probability Factor	Importance Factor	Velocity Pressure (psf)	Gust Effect Factor	Applied Wind Pressure (psf)	Section Base Wind Shear (kips)	Factored Section Base Wind Shear (kips)	Section Base Wind Moment (Foot-kips)	Factored Section Base Wind Moment (Foot-kips)	Section Weight (kips)
Z	D_P	T_W	H	Z_{Base}	A_P	Cv*V*d	C_d	EPA_S	K_Z		K_d	I	P_Z	G	P_ZG	F_{ST}	$1.0*F_{ST}$	$F_{ST}*Z$	$1.0*F_{ST}*Z$	W_T
1.74	20.00	0.250	2.89	0.29	4.82	161.7	0.45	2.17	0.85		0.95	1.00	19.5	1.14	22.2	0.048	0.048	0.07	0.07	0.15
4.63	20.00	0.250	2.89	3.18	4.82	161.7	0.45	2.17	0.85		0.95	1.00	19.5	1.14	22.2	0.048	0.048	0.21	0.21	0.15
7.52	20.00	0.250	2.89	6.1	4.82	161.7	0.45	2.17	0.85		0.95	1.00	19.5	1.14	22.2	0.048	0.048	0.35	0.35	0.15
10.41	20.00	0.250	2.89	9.0	4.82	161.7	0.45	2.17	0.85		0.95	1.00	19.5	1.14	22.2	0.048	0.048	0.49	0.49	0.15
13.31	20.00	0.250	2.89	11.9	4.82	161.7	0.45	2.17	0.85		0.95	1.00	19.5	1.14	22.2	0.048	0.048	0.63	0.63	0.15
16.20	20.00	0.250	2.89	14.8	4.82	161.7	0.45	2.17	0.86		0.95	1.00	19.7	1.14	22.5	0.049	0.049	0.78	0.78	0.15
19.09	20.00	0.250	2.89	17.6	4.82	161.7	0.45	2.17	0.89		0.95	1.00	20.4	1.14	23.3	0.051	0.051	0.95	0.95	0.15
21.98	20.00	0.250	2.89	20.5	4.82	161.7	0.45	2.17	0.92		0.95	1.00	21.1	1.14	24.0	0.052	0.052	1.13	1.13	0.15
24.88	20.00	0.250	2.89	23.4	4.82	161.7	0.45	2.17	0.94		0.95	1.00	21.6	1.14	24.6	0.053	0.053	1.31	1.31	0.15
27.77	20.00	0.250	2.89	26.3	4.82	161.7	0.45	2.17	0.97		0.95	1.00	22.1	1.14	25.2	0.055	0.055	1.50	1.50	0.15
30.66	20.00	0.250	2.89	29.2	4.82	161.7	0.45	2.17	0.99		0.95	1.00	22.6	1.14	25.7	0.056	0.056	1.70	1.70	0.15
33.55	20.00	0.250	2.89	32.1	4.82	161.7	0.45	2.17	1.01		0.95	1.00	23.0	1.14	26.2	0.057	0.057	1.89	1.89	0.15
															Loading Summations:	**0.61**	**0.61**	**11.00**	**11.00**	**1.83**

Overall Length of Pole =	**34.71**	**feet**	**Deflection at Top of Pole =**	**0.54**	**inches**
Base Elevation of Pole =	**0.29**	**feet (AGL)**	**Sway at Top of Pole =**	**0.07**	**degrees**
Top of Steel Elevation =	**35.00**	**feet (AGL)**	**Moment Due to P-Δ Effects =**	**0.05**	**ft-kips**

Wind Loading Calculations - Sectorized Antennas and Mounts:

Description	CL Elevation (feet)	Offset from Shaft C.L. (in.)	Quantity Per Sector	Weight (lbs)	Height (inches)	Width (inches)	Depth (inches)	Shielding Factor K_a	C_a Calc (Normal)	C_a Calc (Transverse)	$(EPA)_N$ (ft^2)	$(EPA)_T$ (ft^2)	$(EPA)_A$ (ft^2)		Wind Pressure (psf)	Factored Loads: Factored V_{wind} (kips)	Factored Loads: Factored Torque (ft-kips)	Factored Loads: Factored M_{wind} (ft-kips)	Factored Loads: Factored Total Wt (kips)
Shear, Moment, and Weight Summations:																0.00	0.00	0.00	0.00

Wind Loading Calculations - Miscellaneous Appurtenances:

Description	CL Elevation (feet)	Offset from Shaft C.L. (in.)	Quantity	Weight (lbs)	Shape Round (R) or Flat (F)	Height (inches)	Width (inches)	Area Factor	A_A (ft^2)	Aspect Ratio (Height / Width)	C_vVd	Wind Drag Coefficient, C_d	C_dA_A (ft^2)	ΣC_aA_A (ft^2)	Wind Pressure (psf)	Factored Loads: Factored V_{wind} (kips)	Factored Loads: Factored Torque (ft-kips)	Factored Loads: Factored M_{wind} (ft-kips)	Factored Loads: Factored Total Wt (kips)
12" Ø x 60" Tall Antenna/Radio Shroud	32.5	0.0	1	165	R	60.0	20.0	1.00	8.33	3.00	162	0.45	3.75	3.75	26.1	0.10	0.02	3.18	0.20
Nokia 5G Antennas/RRHs in Top Shroud	31.7	0.0	1	35	R	24.0	20.0	0.00	3.33	1.20	162	0.45	1.50	0.00	25.9	0.00	0.00	0.00	0.04
9" Tall x 30" Long Cobra Head Luminaire	30.0	186.0	1	45	F	9.0	30.0	1.00	1.88	3.33	N/A	1.20	2.25	2.25	25.6	0.06	0.89	1.73	0.05
2 7/8" OD x 14' (Max.) Long Luminaire Arm	27.5	96.9	1	85	R	2.9	168.0	1.00	3.35	58.43	1358	0.45	1.51	1.51	25.2	0.04	0.31	1.04	0.10
Nokia B12/B14 Micro RRH	17.7	0.0	1	77	F	22.1	12.1	0.00	1.86	1.82	N/A	1.19	2.21	0.00	22.9	0.00	0.00	0.00	0.09
Nokia B25/B66 Micro RRH	12.0	0.0	1	66	F	22.0	12.1	0.00	1.85	1.82	N/A	1.19	2.20	0.00	22.2	0.00	0.00	0.00	0.08
CCI Twin RRU PSU	6.0	0.0	1	34	F	14.0	8.4	0.00	0.82	1.67	N/A	1.19	0.97	0.00	22.2	0.00	0.00	0.00	0.04
Base Cover	0.3	0.0	1	66	F	9.0	22.0	1.00	1.38	2.44	N/A	1.20	1.65	1.65	22.2	0.04	0.01	0.01	0.08
Shear, Moment, and Weight Summations:																0.23	1.23	5.96	0.69

Wind Loading Summary - Factored Base Reactions:

Design Base Moment, M_{AASHTO} = 17.01 ft-kips

Design Base Shear, V_{AASHTO} = 0.84 kips

Design Base Torsion, T_{AASHTO} = 1.23 ft-kips

Design Base Weight, WT_{AASHTO} = 2.89 kips

Stress Check - Monopole Shaft / Access Ports

Access Port Information:

Port Width =	6.0	in.	Number of Ports =	1	
Port Height =	12.0	in.			
C.L. Port =	25.0	in. (Above Base Plate)			

Monopole Shaft Information:

Pole Diameter @ Port, D =	20.00	in.	Wall Slenderness Ratio, λ = D/t =	86.0	
Design Wall Thickness, t =	0.2325	in.	Plastic Design Slenderness Ratio, λ_p =	59.2	
Yield Stress, F_Y =	35.0	ksi	Limiting Slenderness Ratio, λ_{Max} =	400	
Distance to Extreme Fiber, C =	10.00	in.	Effective Section Modulus, S_{eff} =	70.35	in^3
Effective Yield Stress, F'_Y =	35.0	ksi	Effective Radius of Gyration, R_{eff} =	4.20	in.

MP Shaft Section Properties at Access Ports:

Nominal Pipe Section:			***Reinforced Radio Port:***	***X - X Axis:***		***Y - Y Axis:***	
Mast Area, $A_{Nominal}$ =	14.44	in^2	Mast Area, A_{Reinf} =	9.03	in^2	9.03	in^2
Mom Of Inertia, $I_{Nominal}$ =	703.5	in^4	Mom Of Inertia, I_{Reinf} =	159.61	in^4	340.68	in^4
Port Yield Stress, F_Y =	46	ksi	Dist. to Extreme Fiber, C_x =	7.87	in.	8.00	in.

Design Flexural Strength:

			Effective Section Modulus, S_{eff} =	20.0	in^3
Compact Slenderness Ratio, λ_p =	59.2		**Section Is Non-Compact**		
Noncompact Slenderness Ratio, λ_r =	256		Nominal Flexural Strength, M_n =	**76.48**	ft-kips
Factored Moment, M_{BP} =	**30.0**	**ft-kips**	**Design Flexural Strength, $\phi_b M_n$ =**	**68.8**	***ft-kips (OK)***

Design Compressive Strength:

			Nominal Compressive Strength, $P_n = F'_Y * A_{Nominal}$ =	316	kips
Factored Weight, Wt_{BP} =	**3.37**	**kips**	**Design Compressive Strength, $\phi_c P_n$ =**	**284**	***kips (OK)***

Design Shear Strength:

F_{nv} =	21.0	ksi	Nominal Shear Strength, $V_n = F_{nv} * A_{Nominal}$ =	94.82	kips
Factored Shear, V_{BP} =	**1.63**	**kips**	**Design Shear Strength, $\phi_v V_n$ =**	**85.34**	***kips (OK)***

Design Torsional Strength:

F_{nt} =	21.00	ksi			
C_t =	142.63		Nominal Torsional Strength, Tn = Fnt * Ct =	**250**	ft-kips
Factored Torsion, T_{BP} =	**1.17**	**ft-kips**	**Design Torsional Strength, $\phi_t T_n$ =**	**237.13**	***kips (OK)***

Combined Flexure and Axial Force Check: (Section 4.8.2)

$$|P_u / \phi_c P_n| + |M_u / \phi_b M_n| + [\,|V_u / \phi_v V_n| + |T_u / \phi_r T_n|\,]^2 = \mathbf{0.45} \quad \mathbf{< 1.00\ OK}$$

Summary - Access Ports

Monopole Shaft:

USE: 20" OD x 0.25" wall, A53/A500 Gr B/API 5L Gr. B (Min. Fy = 35ksi) Monopole Shaft

Access Ports:

(1) - 6" x 12" Reinforced Access Port, C.L. @ 25'-0" ± AGL
(1) - 12" x 56" Unreinforced Access Port, C.L. @ 17'-8" ± AGL
(1) - 12" x 56" Unreinforced Access Port, C.L.'s @ 12'- 0" ± AGL
(1) - 12" x 42" Unreinforced Access Port, C.L.'s @ 6'- 0" ± AGL
(1) - 12" x 14" Unreinforced Access Port, C.L.'s @ 1'- 11" ± AGL

Stress Check - Monopole Shaft @ Base

Monopole Shaft Information:

Pole Diameter @ Base, D_{Base} =	20.00	in.	Mast Area, $A_{Nominal}$ =	14.44	in^2
Nominal Wall Thickness, t =	0.2500	in.	Mom Of Inertia, $I_{Nominal}$ =	703.5	in^4
Distance to Extreme Fiber, C =	10.00	in.	Section Modulus, $S_{Modulus}$ =	70.3	in^3
Yield Stress, F_Y =	35.0	ksi	Plastic Section Modulus, $Z_{Modulus}$ =	90.9	in^3
Wall Slenderness Ratio, λ = D/t or b/t=	80.0		Average Radius of Gyration, $R_{Gyration}$ =	6.98	in.

AASHTO LRFD

Design Flexural Strength: Section 5.8

Compact Slenderness Ratio, λ_p =	58.0	**Section Is Non-Compact**	ϕ_b =	0.9	
Noncompact Slenderness Ratio, λ_r =	257				
Limiting Slenderness Ratio, λ_{Max} =	373	**(OK)**			
Nominal Flexural Strength, M_n =	248.0	ft-kips	Base Moment, M_{AASHTO} =	17.01	ft-kips
			Design Flexural Strength, $\phi_b M_n$ =	223.2	**ft-kips (OK)**

Design Compressive Strength: Section 5.10

Compact Slenderness Ratio, λ_p =	91		ϕ_c =	0.9	
kL/r (k = 2.1) =	125.3		Q =	1.000	
Euler's Buckling Stress = F_e =	18.23	ksi			
Critical Buckling Stress = F_{cr} =	15.67	ksi			
Nominal Compressive Strength = $P_n = F_{cr}$*A_g =	226.2	kips	Base Weight, Wt_{Base} =	2.89	kips
			Design Compressive Strength = $\phi_c P_n = F_{cr}$*A_g =	203.6	**kips (OK)**

Design Shear Strength: Section 5.11.2

Nominal Shear Stress Capacity = F_{nv} =	21.0	ksi	ϕ_v =	0.9	
Shear Area = A_v =	7.22	in^2			
Nominal Shear Strength = V_n =	151.6	kips	Applied Shear Load, V_{AASHTO} =	0.84	kips
			Design Shear Strength = $\phi_v V_n = F_{nv}$ * A_v =	136.4	**kips (OK)**

Design Torsion Strength: Section 5.11.3

Torsional Constant, C_t =	153.1	in	ϕ_t =	0.95	
Nominal Torsion Stress Capacity , F_{nt} =	21.00	ksi			
Nominal Torsion Strength, $T_n = F_{nt}$ * C_t =	267.9	kip-ft	Applied Torsion Load, T_{AASHTO} =	1.23	ft-kips
			Design Torsion Strength, $\phi_t T_n = F_{nt}$ * C_t =	254.5	**ft-kips (OK)**

Combined Force Interaction: Section 5.12.1

Mom Of Inertia @ T.O. Pole, I_T =	703.49	in^4	Mom Of Inertia @ B.O. Pole, I_B =	703.49	in^4
Factored Vertical Load, P_T =	0.69	kips	Factored Weight, D_P =	2.20	kips
$P_{equivalent} = (I_B/I_T)^{1/3}$*$P_T$ + 0.38*D_p =	1.52	kips	$P_{Euler\ bottom} = \pi^2$*E*$I_B/(k$*$L)^2$ =	263.20	kips
Coefficient for Amplification, B = B_2 =	1	≥ 1.0			

$P_u / \phi_c P_n + B$*$M_u / \phi_b M_n + [\ |V_u / \phi_v V_n| + |T_u / \phi_r T_n|\ ]^2$ = 0.09 **(OK)**

USE: 20" OD x 0.25" wall, A53/A500 Gr B/API 5L Gr. B (Min. Fy = 35ksi) Monopole Shaft

Anchor Bolt & Base Plate Data:

No. of Anchor Bolts, n =	4		Yield Strength, F_{y_AB} =	55.0	ksi	A.B. Gross Area, A_g =	1.77	in^2
AB Diameter, D_{AB} =	1.50	in.	Tensile Strength, F_{u_AB} =	75.0	ksi	A.B. Tensile Stress Area, A_n =	1.41	in^2
AB Circle, D_{BC} =	25.0	in.	Base Plate Width, W_{BP} =	23.0	in.	A.B. Plastic Modulus, Z_{ar} =	0.47	in^3
AB Length, L_{AB} =	72.0	in.	Pole Diameter, D_{pole} =	20.00	in.	Dist. Btwn Concr. & Lvl'g Nut, l_{ar} =	1.50	in.

Anchor Bolt Design Per ANSI/TIA 222-H, Section 4.9.9

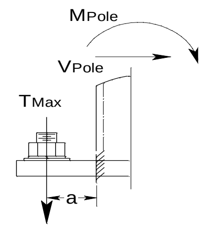
Factored Base Reactions:

αM_{pole} = 30.03 ft-kips

αV_{pole} = 1.63 kips

αT_{pole} = 0.94 ft-kips

αWt_{pole} = 3.37 kips



Section A-A

Factored Compressive Force per bolt:

$P_{uc} = [4 * \alpha M_{Pole} / (n * D_{B.C.})] + \alpha Wt_{pole} / n$ = 15.3 kips

Factored Tensile Force per bolt:

$P_{ut} = [4 * \alpha M_{Pole} / (n * D_{B.C.})] - \alpha Wt_{pole} / n$ = 13.6 kips

Factored Shear Force per bolt:

$V_u = \alpha V_{pole} / n + \alpha T_{pole} / ((n * D_{BC}) / 2)$ = 0.63 kips

Anchor Bolt Moment

$M_{u\_ab} = 0.65 * V_u * l_{ar}$ = 0.62 in-kips

Design Anchor Bolt Strengths:

Design Tensile Strength, $\phi_t R_{nt\_AB} = \phi_t * F_{u\_AB} * A_n$ = 79.3 kips — $\phi_t = \phi_v$ = 0.75

Design Compressive Strength, $\phi_c R_{nc\_AB} = \phi_c * F_{y\_AB} * A_n$ = 77.6 kips — ϕ_c = 1.00

Design Shear Rupture Strength, $\phi_v R_{nv\_AB} = \phi_v * 0.5 * F_{u\_AB} * A_g$ = 49.7 kips

Design Shear Yield Strength, $\phi_c R_{nvc\_AB} = \phi_c * 0.6 * F_{y\_AB} * A_n/2$ = 23.3 kips

Design Flexural Strength, $\phi_f M_{n\_AB} = \phi_f * F_{y\_AB} * Z$ = 23.13 in-kips — ϕ_f = 0.90

Combined Shear & Tension Interaction Check: ***Anchor Rod Moment Interaction Equations N/A***

$[|P_{ut} / Ø_t R_{nt\_AB}|]^2 + [V_u / Ø_v R_{nv\_AB}]^2$ = 0.03 < 1.00 - (OK)

$|P_{uc} / Ø_c R_{nc\_AB}| + [V_u / Ø_c R_{nvc\_AB}]^2$ = 0.20 < 1.00 - (OK)

Base Plate Design Per ANSI/TIA 222-H, Section 4.7

Factored Base Plate Loading:

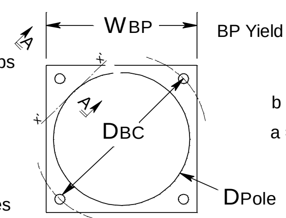
BP Bending, $M_{Plate} = P_{ut} * a$ = 33.9 in.-kips

Design Base Plate Bending Strength,

$\phi F_{B\_BP} = 0.90 * F_{y\_BP}$ = 32.4 ksi

Minimum Base Plate thickness:

$t_{min} = [4 * M_{plate} / (b * \phi F_{B\_BP})]^{1/2}$ = 0.578 inches



BP Yield Strength, F_{y_BP} = 36.0 ksi

b = length of x'-x' = 12.5 in.

a = $(D_{BC} - D_{Pole})/2$ = 2.5 in.

Failure across x'-x', modeled as fixed-end cantilevered beam.

Use: (4) - 1.5" Ø x 72" Long, Grade 55 Anchor Bolts on a 25" Ø B.C. — **Structural Usage = 19.7%**

Use: 1.25" Thick by 23" Square, Grade 36 Base Plate — **Structural Usage = 68.0%**

Base Plate-to-Pole Shaft weld Design:

Minimum weld size per ANSI/AWS d1.1, Table 5.8, Low-Hydrogen process = 1/8 inch

Upper Weld Size, w_t = 0.313 in. — Weld Tensile Strength, F_{weld} = 70.0 ksi (E70XX)

Lower Weld Size, w_b = 0.188 in. — Design Weld Strength, ϕF_w = 31.5 ksi

Distance to Centroid of Upper Weld, $L_{tw} = D_{pole}/2 + w_t/3$ = 10.10 inches

Distance to Centroid of Lower Weld, $L_{bw} = D_{pole}/2 - w_t/3$ = 9.94 inches

Section Modulus of Upper Weld, $S_{tw} = 0.707 * w_t * \pi * L_{tw}^2$ = 70.9 $in.^3$

Section Modulus of Lower Weld, $S_{lw} = 0.707 * w_b * \pi * L_{bw}^2$ = 41.1 $in.^3$

Total Weld Area, A_{weld} = 22.3 $in.^2$

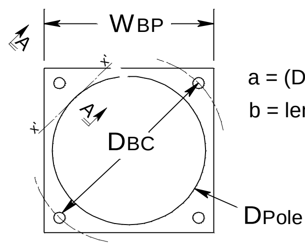
Required Weld Strength, $f_w = M_{pole}/\Sigma S_w + Wt_{pole}/A_{weld}$ = 3.37 ksi (OK)

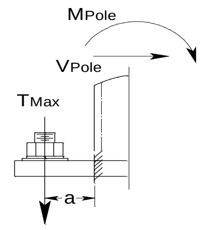
Use: Socketed Pole into Base Plate with 5/16" Upper Fillet Weld with 3/16" Lower fillet weld

Anchor Bolt & Base Plate Analysis with Code Result:

Anchor Bolt & Base Plate Data:

No. of Anchor Bolts, n =	4		Weld Tensile Strength, F_{weld} =	70.0	ksi (E70XX)
AB Diameter, D_{AB} =	1.50	in.	Upper Weld Size, w_t =	0.313	in.
AB Circle, D_{BC} =	25.0	in.	Lower Weld Size, w_b =	0.188	in.
AB Length, L_{AB} =	72.0	in.			
Yield Strength, F_{y_AB} =	55.0	ksi			
Tensile Strength, F_{u_AB} =	75.0	ksi	a = $(D_{BC} - D_{Pole})/2$ =	2.5	in.
A.B. Gross Area, A_g =	1.77	in^2	b = length of x'-x' =	12.5	in.
Base Plate Width, W_{BP} =	23.0	in.			
BP Yield Strength, F_{y_BP} =	36.0	ksi			
Pole Diameter, D_{pole} =	20.00	in.			





Section A-A

AASHTO LTS-6, Section 5.16.3

Maximum Base Reactions:

αM_{pole} =	17.01	ft-kips	αT_{pole} =	1.23	ft-kips
αV_{pole} =	1.63	kips	αWt_{pole} =	2.89	kips

Maximum Tensile Stress per bolt:

$\alpha f_t = \{[4 * \alpha M_{Pole} / (n * D_{B.C.})] - \alpha Wt_{pole} / n\}$ = 7.4 kips

Maximum Shear Stress per bolt:

$\alpha f_v = (\alpha V_{pole} + 2 * \alpha T_{pole} / D_{BC}) / n$ = 0.70 kips

Design Anchor Bolt Tensile Stress:

ϕ_t = 0.75 $\phi_t F_{t\_AB} = 0.75 * F_{u\_AB} * A_n$ = 74.6 kips

Design Anchor Bolt Shear Stress:

ϕ_v = 0.75 $\phi_v F_{v\_AB} = 0.75 * 0.4 * F_{u\_AB} * A_g$ = 39.8 kips

Combined Shear & Tension Interaction Check:

$[(\alpha f_v / F_{v\_AB})^2 + (\alpha f_t / F_{t\_AB})^2]$ = 0.01 < 1.00 - (OK)

Base Plate:

Factored Base Plate Loading:

BP Bending, $M_{Plate} = \alpha f_t * a$ = 18.6 kips

Design Base Plate Bending Stress:

$\phi F_{b\_AB} = 0.9 * F_{y\_AB}$ = 32.4 in.-kips

Minimum Base Plate thickness:

ϕ = 0.90 $t_{min}=[4 * M_{Plate}/(b * \phi F_{B\_BP})]^{1/2}$ = 0.428 inches

Use: (4) - 1.5" Ø Grade 55 Anchor Bolts on a 25" Ø B.C. **Structural Usage = 1.0%**

Use: 1.25" Thick by 23" Square, Grade 36 Base Plate **Structural Usage = 34%**

Base Plate-to-Pole Shaft weld Design:

Minimum weld size per ANSI/AWS d1.1, Table 5.8, Low-Hydrogen process =	1/8	inch
Design Weld Strength, ϕF_w =	31.5	ksi
Distance to Centroid of Upper Weld, $L_{tw} = D_{pole}/2 + w_t/3$ =	10.10	inches
Distance to Centroid of Lower Weld, $L_{bw} = D_{pole}/2 - w_t/3$ =	9.94	inches
Section Modulus of Lower Weld, $S_{lw} = 0.707 * w_h * \pi * L_{hw}^2$ =	41.1	$in.^3$
Section Modulus of Upper Weld, $S_{tw} = 0.707 * w_t * \pi * L_{tw}^2$ =	70.9	$in.^3$

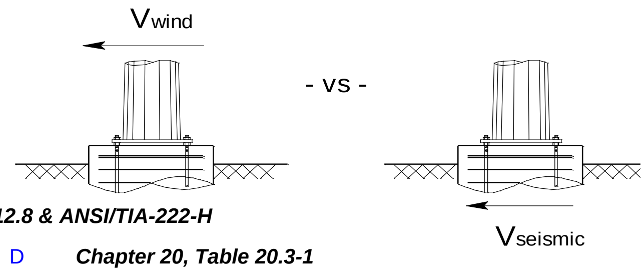
Total Weld Area, A_{weld} = 22.3 $in.^2$

Required Weld Strength, $f_w = M_{pole}/\Sigma S_w + Wt_{pole}/A_{weld}$ = 1.95 ksi (OK)

Use: Socketed Pole into Base Plate with 5/16" Upper Fillet Weld with 3/16" Lower fillet weld

Seismic Base Shear Calculations

Factored Base Reactions from Wind Loading:



M_{base} =	20.2	ft-kips
V_{base} =	1.01	kips
Wt_{base} =	2.89	kips

Seismic Parameters :

Per 2018 IBC Section 1613, ASCE 7-16 Sections 15.1.3 & 12.8 & ANSI/TIA-222-H

Site Classification =	D	***Chapter 20, Table 20.3-1***
Short-Period Spectral Acceleration, S_s =	1.270	g
1-Second Period Spectral Acceleration, S_1 =	0.437	g

Seismic Shear Factors:

I =	1.00	***Table 1.5-2*** Location:
R =	1.50	***Table 15.4-2***
T_L =	6	s, ***Annex B Fig. B-19***
F_a =	1.20	Values for S_1, S_s, F_a, and F_v obtained from ASCE 7 online Hazard Tool based on ASCE 7-16
F_v =	1.85	(Based on the location indicated above).

Seismic Design Classifications:

Occupancy Category:	I	***I - IV, Table 1-1***
Seismic Design Category:	D	***A - F, Section 11.6***

Seismic Base Shear (Nominal Value) Sec. 2.7.7.1

$V = C_s * W$ =		**1.63**	**kips**
$C_s = S_{DS} / (R / I)$ =	0.677		
$S_{DS} = (2 / 3) * S_{MS}$ =	1.016		
$S_{MS} = S_S * F_a$ =	1.524		

Seismic Base Shear (Need Not Exceed Value) Sec. 2.7.7.1 & Sec. 2.7.7.1.3.3

$V = C_s * W$ =		**4.18**	**kips**
$C_s \leq S_{D1} / [T * (R / I)]$ (for $T \leq T_L$), $\leq S_{D1} * T_L * I / (T^2 * R)$ (for $T > T_L$) (for $S_1 \leq 0.2g$, x 1.5)	1.737		
$S_{D1} = (2 / 3) * S_{M1}$ =	0.539		
$S_{M1} = S_1 * F_v$ =	0.808		
$T = 1 / f_1 = 1 / (1 / (2\pi) * (3 * E * I_{avg} * g / (L_p * (W_u + 0.236 * W_L)))^{1/2})$ =	0.31	Seconds	

E =	29000	ksi	W_u=	0.275	kips
$I_{avg} = (I_{top}+I_{bot})/2$ =	703.49	in^4	W_L =	2.130	kips
L_p=	420	in	W_t =	2.41	kips
g =	386	in/s^2			

Seismic Base Shear (Minimum Value) Sec. 2.7.7.1

$V = C_s * W$ =		**0.11**	**kips**
$C_s = 0.044 * S_{DS} * I$ =	0.045	**≥ 0.03**	

Seismic Base Shear (Minimum Value, S_1 ≥ 0.6g) Sec. 2.7.7.1

$V = C_s * W$ =		**0.56**	**kips**
$C_s = 0.8 * S_1 / (R / I)]$ =	0.233		

Vertical Seismic Load Effect Sec. 2.7.6

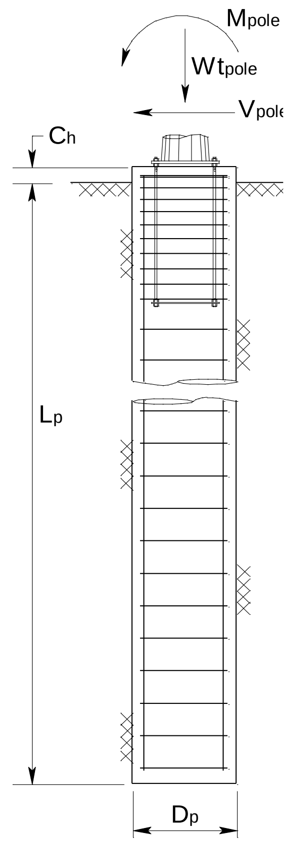
Total Seismic Vertical Load Effect = $E_v = 0.2*S_{DS} * W$ =	**0.49**	***kips***
Total Seismic Shear =	***1.63***	***kips***
Total Wind Shear =	***1.01***	***kips***

Design Base Shear is Governed by Seismic Loading

Drilled Pier Foundation Design

Factored Monopole Base Reactions:

αM_{base} = Overturning Moment =	30.0	ft-kips
αV_{base} = Base Shear =	1.63	kips
αWt_{base} = Base Weight =	3.37	kips



Design Basis:

1. Ref. 2018 IBC Section 1807.3.2.1, Nonconstrained Condition

2. ACI 318-14 - Requirements for Reinforced Concrete.

3. Soil Design Values: Per 2018 IBC, Table1806.2, Class 5 Material

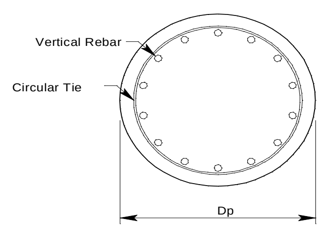
Soil Characteristics:

Based on 2018 IBC Soil Classification for Type:	5	(1 - 5)
ϕR_p = Lateral Bearing Strength at 1' below grade =	150	psf/ft
d_{negl} = Depth of soil below grade neglected =	0.00	ft.

Drilled Pier Characteristics:

Minimum Diameter:

D_{templ} = OD of AB Template =	27.4	in.
S_b = Minimum AB and Rebar Separation =	0.75	in.
Concrete Cover = C_{cover} =	3.00	in.
$D_{p\_min} = D_{templ} + 2*(S_b + d_b + d_{ties} + C_{cover})$=	37.9	in.
Use D_p = Pier Diameter =	**42.0**	**in.**



Minimum Length/Depth:

C_h = Pier Projection AGL =	0.00	ft.
$S_1 = 2 * \phi R_p * (L_p - d_{negl}) / 3$ =	700	psf; Where $(L_p - d_{negl}) \leq 12$ ft.
$A = 2.34*V_{pole} / (S_1*D_p)$ =	1.56	
$L_{p\_min} = A/2 * [1 + (1 + 4.36*h/A)^{½}] + d_{negl}$ =	6.42	ft.
Use: L_p = Below Grade Pier Length =	**7.00**	**ft.**
L_{tot} = Total Length of Pier =	7.00	ft.
Total Volume of Concrete Required =	2.5	cu. yds.

Drilled Pier Foundation Design

Reinforcement:

Vertical Reinforcement Parameters:

Vertical Bar Size =	8		Tie Bar Size =	4	
Qty of Vertical Bars =	10		f'_c =	4.0	ksi
d_b = Diameter of Bar =	1.00	in.	f_y =	60.0	ksi

A_s = Total Area of Vert. Bars = 7.85 sq. in.

Pier Moment Capacity: Verify $M_{ult} \le ØM_n$

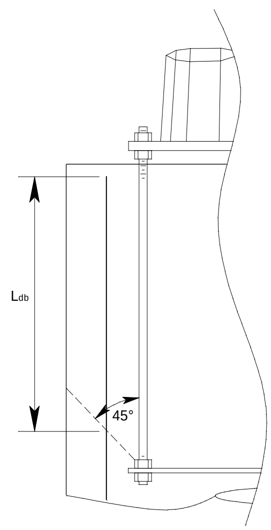
$M_{ult} = 1.3*[M_{pole}+V_{pole}*(L_p/3+d_{negl})]=$ 44.0 ft-kips

$ØM_n =$ 613 ft-kips (OK)

$A_{smin} = 4*M_{ult} / Ø*f_y*N*D_p =$ 0.0931 sq. in.

$\rho_{prov} = A_s / (\pi/4 * D_p^2) =$ 0.0057

$\rho_{min} =$ 0.0050 (OK)



Vertical Bar Development Length:

$L_{db} = [0.04*d_b*f_y / f'_c{}^{½}] * M_{ult} / ØM_n =$ 2.72 in.

$L_{db\_prov'd} =$ 54.5 in. (OK)

Shear Reinforcement:

Factored Shear, $V_u = 1.4 * V_{pole} =$ 1.42 kips

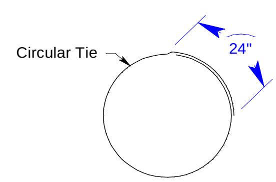
Horizontal Tie Shear Capacity, V_s = 134.4 kips ACI 318 Equation 22.5.10.5.3

Concrete Shear Capacity, V_c = 171.4 kips ACI 318 Table 22.5.5.1

Total Shear Capacity, $ØV_c + ØV_s$ = 229 kips (OK)

D_{tie} = Diameter of Tie = 36 " Ø

Reinforcement Summary:



Vertical Bars: 10 - #8 x 6.5 ft. Long A615 Gr. 60 Deformed Vertical Bars
Spaced evenly (approx. 10.4" o.c.) within Horizontal Ties

Horizontal Ties: 14 - #4 Horizontal Ties , 36 in. Diameter, with 24 in. lap
Spaced at 6" o.c. along the anchor bolts and 12" o.c. in remainder of pier

Rebar Weights:	Vertical Bars =	174	pounds
	Horizontal Ties =	108	pounds
	Horizontal Tie Length =	11' - 6"	