STRUCTURAL ANALYSIS REPORT

For

ME5040 (LTE 6C/FN/2RRH)

MUNJOY HILL
211 Cumberland Avenue
Portland, ME 04101

Antennas Mounted on Building Façade and on Ballast Frames; Equipment Room in Basement

Prepared for:

EMPIRE telecom

at&t

Dated: November 6, 2017

Prepared by:

HUDSON Design Group LLC

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SCOPE OF WORK:

Hudson Design Group LLC (HDG) has been authorized by AT&T to conduct a structural evaluation of the structure that will support the existing AT&T equipment located in the areas depicted in the latest HDG's construction drawings.

This report represents this office's findings, conclusions and recommendations pertaining to the support of AT&T's proposed equipment.

This office conducted an on-site visual survey of the above areas on October 27, 2017. Attendees included Manuel Tejada (HDG – Field Technician).

CONCLUSION SUMMARY:

Building plans prepared by Leasure, Tuttle, Lee dated 03/23/1967 were obtained for our use. A limited visual survey of the structure was completed in or near the areas of the proposed work.

Based on our evaluation, we have determined that the existing structure **IS CAPABLE** of supporting the proposed equipment loading for the RRH ballast sleds and Gamma sector antennas.

Based on our evaluation, we have determined that the existing structure **IS NOT CAPABLE** of supporting the proposed equipment loading for the Alpha and Beta sector antennas. HDG recommends the following modifications:

- **Replace the existing ballast sleds in Alpha and Beta sectors and install new custom steel frames.**

HDG did not perform a condition assessment of the entire roof, but did perform an inspection of the existing roof members and structural columns below the area where the proposed equipment is located.

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APPURTENANCE/EQUIPMENT CONFIGURATION:

(3) 7750 Antennas (57"x11"x5" Wt. = 35 lbs. /ea.)

(2) AM-X-CD-16-65-00T-RET Antennas (72"x11.8"x5.9" – Wt. = 48.5 lbs. /ea.)

(1) AM-X-CD-14-65-00T-RET Antenna (48"x11.8"x5.9" - Wt. = 36.5 lbs.)

(3) QS66512-2 Antennas (72"x12"x9.6" - Wt. = 48 lbs. /ea.)

(6) RRUS-11 RRH's (19.69"x16.97"x7.17" – Wt. = 50.7 lbs. /ea.)

(3) Squid Surge Arrestors (Wt. = 32.8 lbs. /ea.)

(6) Powerwave LGP21401 TMAs (14.4"x9.0"x2.7" – Wt. = 19 lbs. /ea.)

(6) RRUS-32 RRH's (26.7"x12.1"x6.7") (Wt. = 77 lbs. /ea.)

(3) 800-10965 Antennas (78.7"x20"x6.9" – Wt. = 44.3 lbs. ea.)

(3) RRUS-11 RRH's (19.7"x17.0"x7.2" – Wt. = 50.7 lbs. /ea.)

(3) RRUS-32 B66 RRH's (27.2"x12.1"x7.0" – Wt. = 60 lbs. /ea.)

(3) B14 4478 RRH's (15.0"x13.2"x7.4" – Wt. = 60 lbs. /ea.)

(3) Squid Surge Arrestors (24"x9.7"ø Wt. = 32.8 lbs. /each)

*Proposed loading shown in bold.

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DESIGN CRITERIA:

1. International Building Code (IBC) 2009, and ASCE 7-05 (Minimum Design Loads for Buildings and Other Structures).

   Wind Analysis:

Reference Wind Speed:	100 mph	(FIG 6-1C; ASCE 7-05)
Category:	B	(Section 6.5.6.3; ASCE 7-05)

   Roof:

Ground Snow, P_g:	60 psf	(FIG 7-1; ASCE 7-05)
Importance Factor, I:	1.0	(Category II)
Exposure Factor, Ce:	1.0	(Partially Exposed)
Thermal Factor, Ct:	1.0	(Typical Structure)
Flat Roof Snow Load:	**42 psf**	**(P_f=0.7*Ce*Ct*I*P_g)**

2. EIA/TIA -222- G Structural Standards for Steel Antenna Towers and Antenna Supporting Structures

City/Town:	Portland
County:	Cumberland
Wind Load:	100 mph
Nominal Ice Thickness:	1 inch

3. Approximate height above grade to the center of the Antennas:

   160'-0"+/- (Alpha & Beta)
   155'-0"+/- (Gamma)

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EXISTING ROOF CONSTRUCTION:

The existing roof construction is assumed to consist of a roofing membrane over rigid insulation over reinforced concrete slab supported by reinforced concrete beams and columns.

ANTENNA SUPPORT RECOMMENDATIONS:

- The new Alpha and Beta sector antennas are proposed to be mounted on new pipe masts installed to new custom steel frames secured to the existing roof with epoxy anchors.
- The new Gamma sector antenna is proposed to be mounted on the existing pipe mast secured to the existing building façade with epoxy anchors.

RRH/SURGE ARRESTOR SUPPORT RECOMMENDATIONS:

The new RRH's are proposed to be mounted on the existing non-penetrating ballast frames located on the roof.

Limitations and assumptions:

1. Reference the latest HDG construction drawings for all the equipment locations details.
2. Mount all equipment per manufacturer's specifications.
3. All structural members and their connections are assumed to be in good condition and are free from defects with no deterioration to its member capacities.
4. All antennas, coax cables and waveguide cables are assumed to be properly installed and supported as per the manufacturer requirements.
5. HDG is not responsible for any modifications completed prior to and hereafter which HDG was not directly involved.
6. If field conditions differ from what is assumed in this report, then the engineer of record is to be notified as soon as possible.
7. A condition assessment of the existing structure was not part of the scope of work.

FIELD PHOTOS:

Photo 1: Sample photo illustrating the existing Alpha sector antennas.

Photo 2: Sample photo illustrating the existing Beta sector antennas.

Photo 3: Sample photo illustrating the existing Gamma sector antennas.

Photo 4: Sample photo illustrating the existing Gamma sector RRH's.

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Alpha & Beta Sector
Antenna Calculations
(Existing Conditions)

Date: 10/31/2017
Project Name: Munjoy Hill
Project Number: ME5040
Designed By: BD **Checked By:** MSC

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2.6.5.2 Velocity Pressure Coeff:

$K_z = 2.01\ (z/z_g)^{2/\alpha}$

z=	160	(ft)
z_g=	1200	(ft)
α=	7.0	

K_z= 1.130

Kzmin ≤ Kz ≤ 2.01

Table 2-4

Exposure	Z_g	α	K_{zmin}	K_e
B	1200 ft	7.0	0.70	0.9
C	900 ft	9.5	0.85	1.0
D	700 ft	11.5	1.03	1.1

2.6.6.4 Topographic Factor:

Table 2-5

Topo. Category	K_t	f
2	0.43	1.25
3	0.53	2.0
4	0.72	1.5

$K_{zt} = [1+(K_e K_t/K_h)]^2$

$K_h = e^{(f*z/H)}$

K_{zt}= #DIV/0!

K_h=	#DIV/0!	
K_e=	0	(from Table 2-4)
K_t=	0	(from Table 2-5)
f=	0	(from Table 2-5)
z=	160	
H=	0	(Ht. of the crest above surrounding terrain)
K_{zt}=	1.00	

(If Category 1 then K_{zt} =1.0)

Category= 1

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Project Name: Munjoy Hill
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2.6.7 Gust Effect Factor

2.6.7.1 Self Supporting Lattice Structures

Gh = 1.0 Latticed Structures > 600 ft

Gh = 0.85 Latticed Structures 450 ft or less

Gh = 0.85 + 0.15 [h/150 - 3.0] h= ht. of structure

h=	170	Gh=	0.85
2.6.7.2 Guyed Masts		Gh=	0.85
2.6.7.3 Pole Structures		Gh=	1.1
2.6.9 Appurtenances		Gh=	1.0

2.6.7.4 Structures Supported on Other Structures
(Cantilivered tubular or latticed spines, pole, structures on buildings (ht. : width ratio > 5)

Gh=	1.35	Gh=	1.35

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2.6.9.2 Design Wind Force on Appurtenances

$$F = q_z * G_h * (EPA)_A$$

$$q_z = 0.00256 * K_z * K_{zt} * K_d * V_{max}^2 * I$$

K_z=	1.130
K_{zt}=	1.0
K_d=	0.95
V_{max}=	100
I=	1.0

q_z= 27.49

Table 2-2

Structure Type	Wind Direction Probability Factor, Kd
Latticed structures with triangular, square or rectangular cross sections	0.85
Tubular pole structures, latticed structures with other cross sections, appurtenances	0.95

Determine Cf:

If lattice Structure See Manual

If Tubular Pole Structure, Use Corrected Value from Table 2.7 Below

C mph.ft	Round	18 Sided	16 Sided	12 Sided	8 Sided
< 32 (Subcritical)	1.2	1.2	1.2	1.2	1.2
32 to 64 (Transitional)	$38.4/C^{1.0}$	$25.8/C^{0.885}$	$12.6/C^{0.678}$	$2.99/C^{0.263}$	1.2
> 64 (Supercritical)	0.6	0.65	0.75	1	1.2

$$C = (I * K_{zt} * K_z)^{0.5} * V * D$$

D = Outside diameter for rounds: 0.25 feet

C= 26.58 **Cf=** 1.2

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Determine Ca:

Table 2-8

Force Coefficients (Ca) for Appurtenances				
Member Type		Aspect Ratio ≤ 2.5	Aspect Ratio = 7	Aspect Ratio ≥ 25
		Ca	Ca	Ca
Flat		1.2	1.4	2.0
Round	C < 32 (Subcritical)	0.7	0.8	1.2
	32 ≤ C ≤ 64 (Transitional)	$3.76/(C^{0.485})$	$3.37/(C^{0.415})$	$38.4/(C^{1.0})$
	C > 64 (Supercritical)	0.5	0.6	0.6

Aspect Ratio is the overall length/width ratio in the plane normal to the wind direction.
(Aspect ratio is independent of the spacing between support points of a linear appurtenance, and the section length considered to have uniform wind load).

Note: Linear interpolation may be used for aspect ratios other than those shown.

Appurtenances	Height	Width	Depth	Flat Area	Aspect Ratio	Ca	Force (lbs)
7750	57.0	11.0	5.0	**4.35**	5.18	1.32	**213**
AM-X-CD-16-65-00T-RET	72.0	11.8	5.9	**5.90**	6.10	1.36	**298**
800-10965	78.7	20.0	6.9	**10.93**	3.94	1.26	**513**
QS66512-2	72	12	9.6	**6.00**	6.00	1.36	**302**
RRU-11	19.7	17.0	7.2	**2.33**	1.16	1.20	**104**
B14 4478	15.0	13.2	7.4	**1.38**	1.14	1.20	**61**
RRUS-32 B66	27.2	12.1	7.0	**2.29**	2.25	1.20	**102**
Squid Surge Arrestor	24	9.7	9.7	**1.62**	2.47	1.20	**72**

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Calculate Total Ballast Required for Ballast Mount

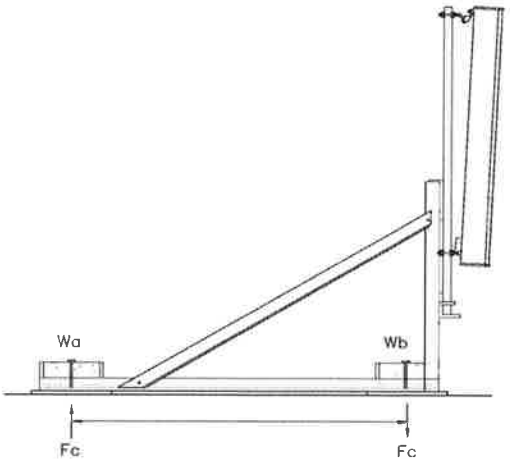
WIND FORCES

F antennas = at 7.5 ft. 1325 lbs.

F RRH/SURGE/FIBER BOX 337 lbs.

Antenna Height = 7.5 ft

RRH/Surge/Fiber Box= 4 ft



Length = 7.92 ft

Overturning at Ballast **FS =** 1.5

Moment = 16928.25 lbs.-ft

Hold Down Force = 2137.41 lbs. Per Side

Wa Ballast

Equipment

Frame =	150	lbs.

Total Ballast Required Wa= **1987.41** lbs.

Blocks Required Wa = 53 Assumed 38lbs Block (4"x8"x16" Solid)

Wb Ballast

Equipment

Frame	300	lbs.
4 Antennas	164	lbs.
RRH's	171	lbs.
Surge Arrestor/Box	33	lbs.
Total =	668	lbs.

Total Ballast Required Wb = **1469.41** lbs.

Blocks Required Wb= 39 Assumed 38lbs Block (4"x8"x16" Solid)

Footprint area under ballast frame= 58.4 sq. ft.

Area Load= 73.87 psf > 30 psf Therefore, N.G.!

Total weight of frame and equipment= 4314 lbs.

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Alpha & Beta Sector
Antenna Calculations
(Proposed Calculations)

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2.6.5.2 Velocity Pressure Coeff:

$K_z = 2.01\ (z/z_g)^{2/\alpha}$

K_z=	1.130

z=	160	(ft)
z_g=	1200	(ft)
α=	7.0	

Kzmin ≤ Kz ≤ 2.01

Table 2-4

Exposure	Z_g	α	K_{zmin}	K_e
B	1200 ft	7.0	0.70	0.9
C	900 ft	9.5	0.85	1.0
D	700 ft	11.5	1.03	1.1

2.6.6.4 Topographic Factor:

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$K_h = e^{(f*z/H)}$

K_{zt}=	#DIV/0!

(If Category 1 then K_{zt} =1.0)

Category=	1

K_h=	#DIV/0!	
K_e=	0	(from Table 2-4)
K_t=	0	(from Table 2-5)
f=	0	(from Table 2-5)
z=	160	
H=	0	(Ht. of the crest above surrounding terrain)
K_{zt}=	1.00	

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Gh = 0.85 + 0.15 [h/150 - 3.0] h= ht. of structure

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2.6.7.3 Pole Structures		Gh=	1.1
2.6.9 Appurtenances		Gh=	1.0

2.6.7.4 Structures Supported on Other Structures
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Gh=	1.35	Gh=	1.35

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2.6.9.2 Design Wind Force on Appurtenances

$$F = qz*Gh*(EPA)_A$$

$$q_z = 0.00256*K_z*K_{zt}*K_d*V_{max}^2*I$$

K_z=	1.130
K_{zt}=	1.0
K_d=	0.95
V_{max}=	100
I=	1.0

q_z=	27.49

Table 2-2

Structure Type	Wind Direction Probability Factor, Kd
Latticed structures with triangular, square or rectangular cross sections	0.85
Tubular pole structures, latticed structures with other cross sections, appurtenances	0.95

Determine Cf:

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If Tubular Pole Structure, Use Corrected Value from Table 2.7 Below

C mph.ft	Round	18 Sided	16 Sided	12 Sided	8 Sided
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32 to 64 (Transitional)	$38.4/C^{1.0}$	$25.8/C^{0.885}$	$12.6/C^{0.678}$	$2.99/C^{0.263}$	1.2
> 64 (Supercritical)	0.6	0.65	0.75	1	1.2

$$C = (I*K_{zt}*K_z)^{0.5}*V*D$$

D = Outside diameter for rounds: 0.25 feet

C=	26.58

Cf= 1.2

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Determine Ca:

Table 2-8

Force Coefficients (Ca) for Appurtenances				
Member Type		Aspect Ratio ≤ 2.5	Aspect Ratio = 7	Aspect Ratio ≥ 25
		Ca	Ca	Ca
Flat		1.2	1.4	2.0
Round	C < 32 (Subcritical)	0.7	0.8	1.2
	32 ≤ C ≤ 64 (Transitional)	$3.76/(C^{0.485})$	$3.37/(C^{0.415})$	$38.4/(C^{1.0})$
	C > 64 (Supercritical)	0.5	0.6	0.6

Aspect Ratio is the overall length/width ratio in the plane normal to the wind direction.
(Aspect ratio is independent of the spacing between support points of a linear appurtenance, and the section length considered to have uniform wind load).

Note: Linear interpolation may be used for aspect ratios other than those shown.

Appurtenances	Height	Width	Depth	Flat Area	Aspect Ratio	Ca	Force (lbs)
7750	57.0	11.0	5.0	4.35	5.18	1.32	**213**
7750 (Side)	57.0	5.0	11.0	1.98	11.40	1.55	**114**
AM-X-CD-16-65-00T-RET	72.0	11.8	5.9	5.90	6.10	1.36	**298**
AM-X-CD-16-65-00T-RET (Side)	72.0	5.9	11.8	2.95	12.20	1.57	**172**
800-10965	78.7	20.0	6.9	10.93	3.94	1.26	**513**
800-10965 (Side)	78.7	6.9	20.0	3.77	11.41	1.55	**216**
QS66512-2	72	12	9.6	6.00	6.00	1.36	**302**
QS66512-2 (Side)	72	9.6	12	4.80	7.50	1.42	**252**
RRU-11	19.7	17.0	7.2	2.33	1.16	1.20	**104**
RRU-11 (Side)	19.7	7.2	17.0	0.99	2.74	1.21	**44**
B14 4478	15.0	13.2	7.4	1.38	1.14	1.20	**61**
B14 4478 (Side)	15.0	7.4	13.2	0.77	2.03	1.20	**34**
RRUS-32 B66	27.2	12.1	7.0	2.29	2.25	1.20	**102**
RRUS-32 B66 (Side)	27.2	7.0	12.1	1.32	3.89	1.26	**62**
Squid Surge Arrestor	24	9.7	9.7	1.62	2.47	1.20	**72**

Date: 11/2/2017
Project Name: Munjoy Hill
Project Number: ME5040
Designed By: BD **Checked By:** MSC

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ICE WEIGHT CALCULATIONS

Thickness of ice (in): 0.75
* Density of ice used = 56 PCF

7750 Antenna
Weight of ice based on total radial SF area:

Depth (in):	5.0	
height (in):	57.0	
Width (in):	11.0	
Total weight of ice on object:		47 lbs
Weight of object:	35 lbs	
Combined weight of ice and object:		82 lbs

AM-X-CD-16-65-00T-RET Antenna
Weight of ice based on total radial SF area:

Depth (in):	5.9	
height (in):	72.0	
Width (in):	11.8	
Total weight of ice on object:		65 lbs
Weight of object:	36.5 lbs	
Combined weight of ice and object:		102 lbs

800-10965 Antenna
Weight of ice based on total radial SF area:

Depth (in):	6.9	
height (in):	78.7	
Width (in):	20.0	
Total weight of ice on objec.		110 lbs
Weight of object:	44.3 lbs	
Combined weight of ice and object:		154 lbs

QS66512-2
Weight of ice based on total radial SF area:

Depth (in):	9.6	
height (in):	72.0	
Width (in):	12.0	
Total weight of ice on object:		81 lbs
Weight of object:	48 lbs	
Combined weight of ice and object:		129 lbs

RRUS-11
Weight of ice based on total radial SF area:

Depth (in):	7.2	
height (in):	19.7	
Width (in):	17.0	
Total weight of ice on object:		29 lbs
Weight of object:	50.7 lbs	
Combined weight of ice and object:		80 lbs

RRUS-32 B66
Weight of ice based on total radial SF area:

Depth (in):	7.0	
height (in):	27.2	
Width (in):	12.1	
Total weight of ice on object:		29 lbs
Weight of object:	60 lbs	
Combined weight of ice and object:		89 lbs

B14 4478
Weight of ice based on total radial SF area:

Depth (in):	7.4	
height (in):	15.0	
Width (in):	13.2	
Total weight of ice on object:		20 lbs
Weight of object:	60 lbs	
Combined weight of ice and object:		80 lbs

Squid Surge Arrestor
Weight of ice based on total radial SF area:

Depth (in):	9.7	
height (in):	24.0	
Width (in):	9.7	
Total weight of ice on object:		27 lbs
Weight of object:	32.8 lbs	
Combined weight of ice and object:		60 lbs

L 4x4x3/8
Weight of ice based on total radial SF area:

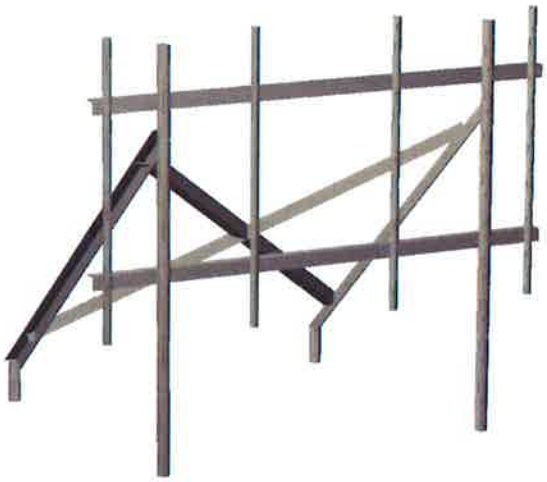
Depth (in):	4	
height (in):	12	
Width (in):	4	
Per foot weight of ice on object:		5 lbs/ft

2" pipe
Per foot weight of ice:

diameter (in):	2.375	
Per foot weight of ice on object:		2 lbs/ft

3" pipe
Per foot weight of ice:

diameter (in):	3.5	
Per foot weight of ice on object:		3 lbs/ft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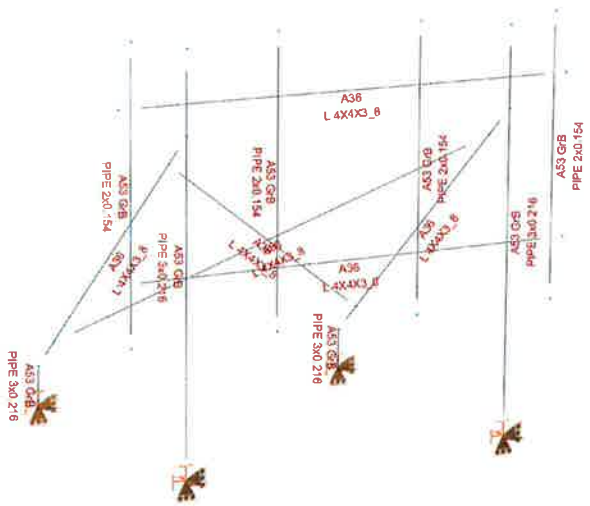
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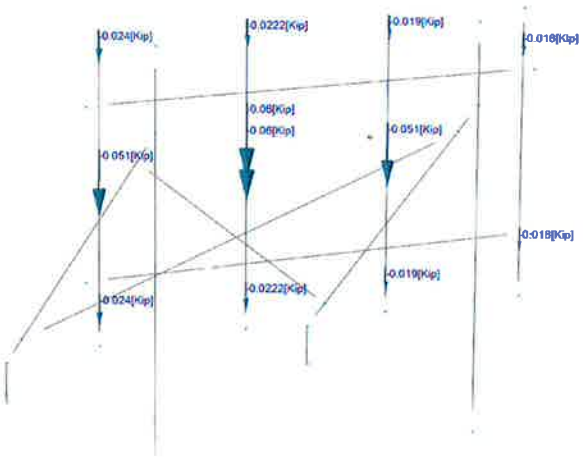
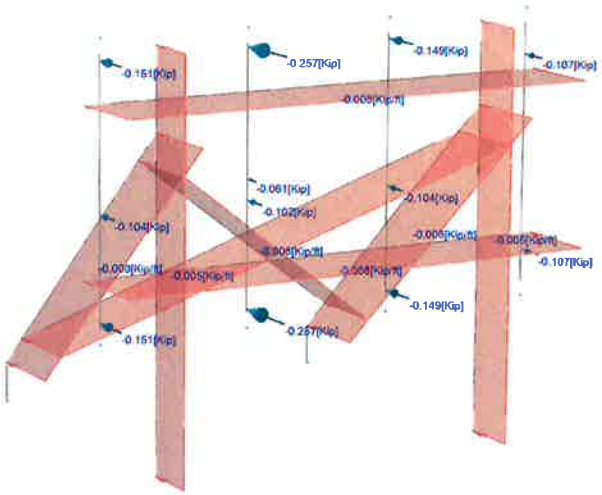
Loads

Concentrated user loads - Members



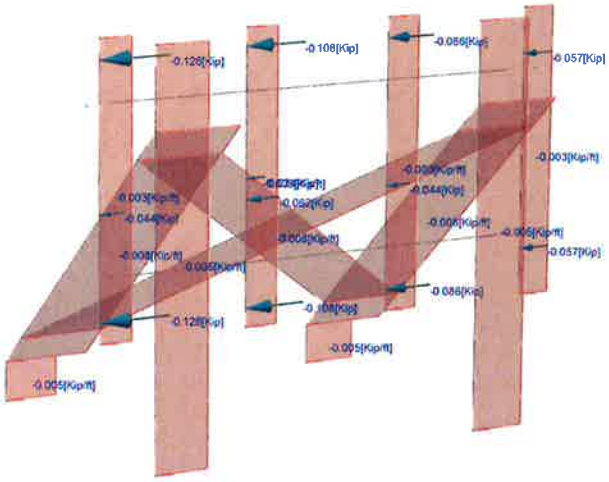
Loads

Distributed user loads - Members
Concentrated user loads - Members



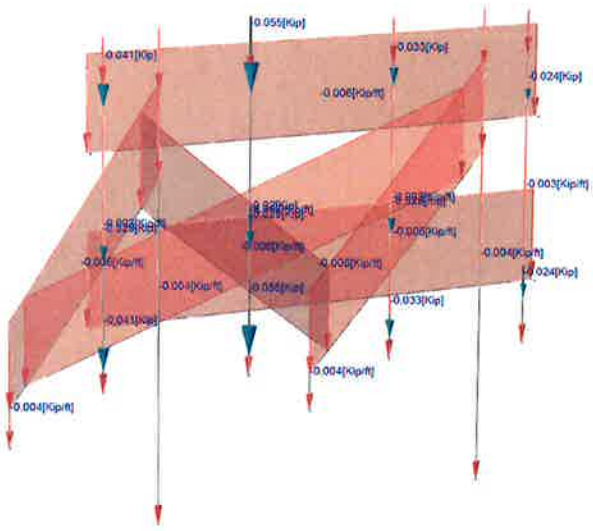
Loads

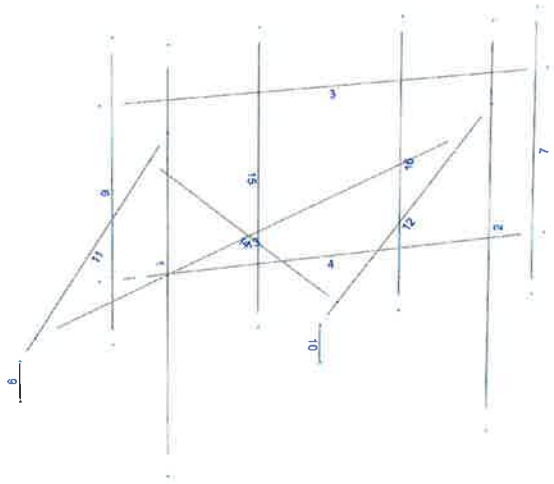
- Distributed user loads - Members
- Concentrated user loads - Members



Loads

- Distributed user loads - Members
- Concentrated user loads - Members




3
7
9
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2
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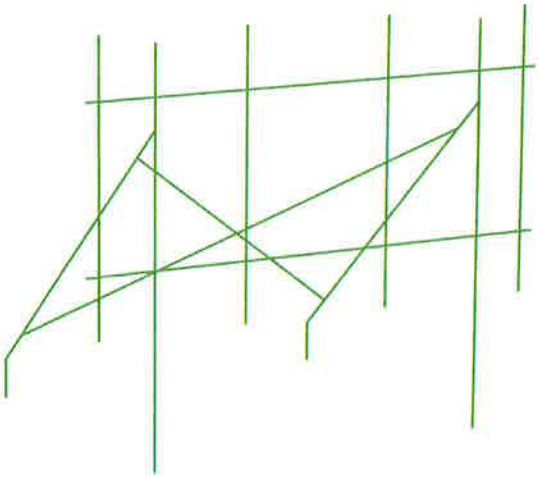
8


Y
X
Z

Design status

- Not designed
- Error on design
- Design O.K.
- With warnings



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Current Date: 11/2/2017 2:18 PM
Units system: English
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Steel Code Check

Report: Summary - For all selected load conditions

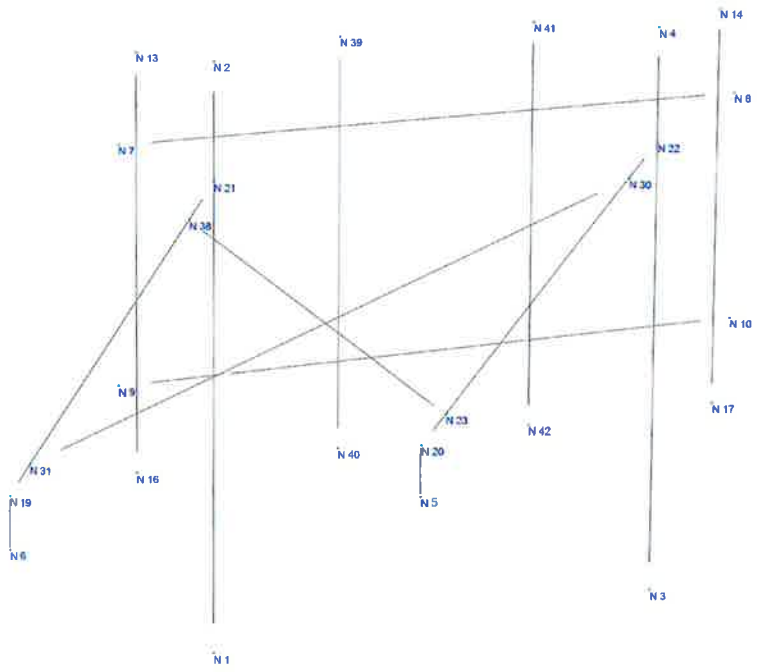
Load conditions to be included in design :

D1=1.4DL
D2=1.2DL+1.6IL
D3=1.2DL+0.8WL1
D4=1.2DL+0.8WL2
D5=1.2DL+1.6WL1
D6=1.2DL+1.6WL2
D7=1.2DL+IL+1.6WL1
D8=1.2DL+IL+1.6WL2
D9=0.9DL+1.6WL1
D10=0.9DL+1.6WL2

Description	Section	Member	Ctrl Eq.	Ratio	Status	Reference
	L 4X4X3_8	3	D1 at 15.18%	0.09	OK	
			D10 at 15.18%	0.12	OK	
			D2 at 15.18%	0.17	OK	
			D3 at 15.18%	0.17	OK	
			D4 at 15.18%	0.11	OK	
			D5 at 33.93%	0.27	OK	
			D6 at 15.18%	0.14	OK	
			D7 at 15.18%	**0.32**	**OK**	Eq. H2-1
			D8 at 15.18%	0.20	OK	
			D9 at 33.93%	0.27	OK	
		4	D1 at 15.18%	0.09	OK	
			D10 at 15.18%	0.18	OK	
			D2 at 15.18%	0.16	OK	
			D3 at 15.18%	0.13	OK	
			D4 at 15.18%	0.14	OK	
			D5 at 15.18%	0.26	OK	
			D6 at 15.18%	0.20	OK	
			D7 at 15.18%	**0.27**	**OK**	Eq. H3-8
			D8 at 15.18%	0.25	OK	Eq. H2-1
			D9 at 15.18%	0.26	OK	
		11	D1 at 47.92%	0.07	OK	
			D10 at 10.42%	**0.38**	**OK**	Eq. H2-1
			D2 at 47.92%	0.11	OK	
			D3 at 41.67%	0.09	OK	
			D4 at 10.42%	0.18	OK	
			D5 at 10.42%	0.14	OK	
			D6 at 10.42%	0.38	OK	
			D7 at 37.50%	0.14	OK	
			D8 at 10.42%	0.37	OK	
			D9 at 10.42%	0.14	OK	
		12	D1 at 47.92%	0.07	OK	
			D10 at 10.42%	0.34	OK	
			D2 at 47.92%	0.11	OK	
			D3 at 41.67%	0.07	OK	
			D4 at 10.42%	0.18	OK	
			D5 at 10.42%	0.11	OK	

		D6 at 10.42%	0.35	OK	
		D7 at 37.50%	0.11	OK	
		D8 at 10.42%	**0.36**	**OK**	Eq. H2-1
		D9 at 10.42%	0.11	OK	
	13	D1 at 50.00%	0.08	OK	
		D10 at 53.13%	0.10	OK	
		D2 at 50.00%	0.12	OK	Eq. H2-1
		D3 at 56.25%	0.03	OK	
		D4 at 50.00%	0.09	OK	
		D5 at 78.13%	0.02	OK	
		D6 at 53.13%	0.12	OK	
		D7 at 62.50%	0.04	OK	
		D8 at 50.00%	**0.15**	**OK**	Eq. H2-1
		D9 at 75.00%	0.02	OK	
	14	D1 at 46.88%	0.08	OK	
		D10 at 46.88%	0.08	OK	
		D2 at 46.88%	0.12	OK	
		D3 at 43.75%	0.03	OK	
		D4 at 46.88%	0.08	OK	
		D5 at 21.88%	0.02	OK	
		D6 at 46.88%	0.10	OK	
		D7 at 37.50%	0.04	OK	
		D8 at 46.88%	**0.13**	**OK**	Eq. H2-1
		D9 at 25.00%	0.02	OK	
PIPE 2x0.154	**6**	D1 at 77.08%	0.02	OK	
		D10 at 20.83%	0.16	OK	
		D2 at 77.08%	0.03	OK	
		D3 at 22.92%	0.10	OK	
		D4 at 20.83%	0.08	OK	
		D5 at 22.92%	0.20	OK	
		D6 at 20.83%	0.16	OK	
		D7 at 22.92%	**0.20**	**OK**	Eq. H1-1b
		D8 at 20.83%	0.16	OK	
		D9 at 22.92%	0.20	OK	
	7	D1 at 77.08%	0.01	OK	
		D10 at 22.92%	0.03	OK	
		D2 at 22.92%	0.01	OK	
		D3 at 77.08%	0.03	OK	
		D4 at 22.92%	0.02	OK	
		D5 at 77.08%	0.05	OK	
		D6 at 22.92%	0.03	OK	
		D7 at 77.08%	**0.05**	**OK**	Eq. H1-1b
		D8 at 22.92%	0.03	OK	Eq. H1-1b
		D9 at 20.83%	0.05	OK	
	15	D1 at 22.92%	0.06	OK	
		D10 at 77.08%	0.17	OK	
		D2 at 22.92%	0.11	OK	
		D3 at 77.08%	0.24	OK	
		D4 at 77.08%	0.12	OK	
		D5 at 22.92%	0.44	OK	
		D6 at 77.08%	0.18	OK	
		D7 at 77.08%	**0.46**	**OK**	Eq. H1-1b
		D8 at 77.08%	0.22	OK	
		D9 at 22.92%	0.43	OK	
	16	D1 at 77.08%	0.05	OK	
		D10 at 20.83%	0.11	OK	
		D2 at 77.08%	0.09	OK	
		D3 at 77.08%	0.16	OK	

		D4 at 20.83%	0.06	OK	
		D5 at 22.92%	0.29	OK	
		D6 at 20.83%	0.11	OK	
		D7 at 77.08%	**0.31**	**OK**	Eq. H1-1b
		D8 at 20.83%	0.11	OK	
		D9 at 22.92%	0.28	OK	
PIPE 3x0.216	**1**	D1 at 85.94%	0.04	OK	
		D10 at 0.00%	0.26	OK	
		D2 at 85.94%	0.07	OK	
		D3 at 48.44%	0.17	OK	
		D4 at 0.00%	0.14	OK	
		D5 at 48.44%	0.31	OK	
		D6 at 0.00%	0.27	OK	
		D7 at 48.44%	**0.33**	**OK**	Eq. H1-1b
		D8 at 0.00%	0.28	OK	Eq. H1-1b
		D9 at 48.44%	0.31	OK	
	2	D1 at 85.94%	0.04	OK	
		D10 at 0.00%	0.25	OK	
		D2 at 85.94%	0.06	OK	
		D3 at 48.44%	0.12	OK	
		D4 at 0.00%	0.13	OK	
		D5 at 48.44%	0.23	OK	
		D6 at 0.00%	0.25	OK	
		D7 at 48.44%	0.24	OK	Eq. H1-1b
		D8 at 0.00%	**0.25**	**OK**	Eq. H1-1b
		D9 at 48.44%	0.22	OK	
	9	D1 at 100.00%	0.02	OK	
		D10 at 100.00%	**0.53**	**OK**	Eq. H1-1b
		D2 at 100.00%	0.04	OK	
		D3 at 100.00%	0.24	OK	
		D4 at 100.00%	0.26	OK	
		D5 at 100.00%	0.48	OK	
		D6 at 100.00%	0.53	OK	
		D7 at 100.00%	0.48	OK	
		D8 at 100.00%	0.52	OK	
		D9 at 100.00%	0.49	OK	
	10	D1 at 100.00%	0.02	OK	
		D10 at 100.00%	0.56	OK	
		D2 at 100.00%	0.04	OK	Eq. H1-1b
		D3 at 100.00%	0.17	OK	
		D4 at 100.00%	0.29	OK	
		D5 at 100.00%	0.36	OK	
		D6 at 100.00%	0.56	OK	
		D7 at 100.00%	0.35	OK	
		D8 at 100.00%	**0.57**	**OK**	Eq. H1-1b
		D9 at 100.00%	0.36	OK	


N 14
N 41
N 4
N 39
N 13
N 2
N 8
N 7
N 22
N 21
N 30
N 38
N 10
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N 17
N 23
N 42
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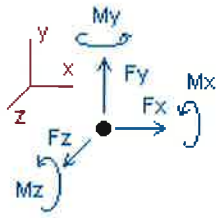
Analysis result

Reactions



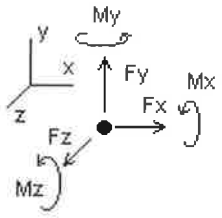
Direction of positive forces and moments

	Forces [Kip]			Moments [Kip*ft]		
Node	**FX**	**FY**	**FZ**	**MX**	**MY**	**MZ**
Condition **D1=1.4DL**						
1	0.01303	0.83913	-0.00345	-0.00634	-0.00552	-0.01959
3	-0.01741	0.66426	-0.00329	-0.00667	0.00671	0.02730
5	0.08707	0.16358	-0.00060	-0.00060	-0.00043	-0.08755
6	-0.08269	0.17055	0.00735	0.00735	0.00042	0.08318
SUM	0.00000	1.83751	0.00000	-0.00627	0.00119	0.00333
Condition **D2=1.2DL+1.6IL**						
1	0.02184	1.49672	-0.00531	-0.00908	-0.00924	-0.03264
3	-0.03152	1.15855	-0.00505	-0.00986	0.01200	0.04957
5	0.13758	0.25248	-0.00357	-0.00357	-0.00066	-0.13834
6	-0.12790	0.26778	0.01392	0.01392	0.00066	0.12865
SUM	0.00000	3.17553	0.00000	-0.00859	0.00275	0.00724
Condition **D3=1.2DL+0.8WL1**						
1	0.01938	0.02529	0.22952	0.51570	-0.07960	-0.02777
3	-0.01776	0.08521	0.15579	0.34728	0.10568	0.01793
5	0.00783	0.62563	0.62659	0.62659	0.00020	-0.00760
6	-0.00945	0.83888	0.87031	0.87031	-0.00015	0.00928
SUM	0.00000	1.57501	1.88221	2.35988	0.02612	-0.00816
Condition **D4=1.2DL+0.8WL2**						
1	0.19758	0.80998	-0.00361	0.00306	0.01581	-0.48812
3	0.17252	0.47881	-0.00198	-0.01267	0.02144	-0.44894
5	0.48541	-0.39278	-0.61382	-0.61382	0.00034	-0.48302
6	0.33950	0.67900	0.61941	0.61941	0.00109	-0.33625
SUM	1.19501	1.57501	0.00000	-0.00402	0.03869	-1.75633

Condition **D5=1.2DL+1.6WL1**						
1	0.02759	-0.66867	0.46200	1.03683	-0.15448	-0.03875
3	-0.02059	-0.39894	0.31440	0.70028	0.20561	0.01247
5	-0.05897	1.11106	1.25370	1.25370	0.00077	0.05984
6	0.05197	1.53157	1.73433	1.73433	-0.00067	-0.05273
SUM	0.00000	1.57501	3.76443	4.72514	0.05122	-0.01917
Condition **D6=1.2DL+1.6WL2**						
1	0.38399	0.90070	-0.00427	0.01156	0.03635	-0.95944
3	0.35996	0.38825	-0.00113	-0.01962	0.03714	-0.92128
5	0.89620	-0.92577	-1.22713	-1.22713	0.00105	-0.89099
6	0.74988	1.21183	1.23252	1.23252	0.00182	-0.74380
SUM	2.39003	1.57501	0.00000	-0.00267	0.07636	-3.51551
Condition **D7=1.2DL+IL+1.6WL1**						
1	0.03425	-0.18276	0.46053	1.03456	-0.15730	-0.04865
3	-0.03096	-0.03069	0.31301	0.69770	0.20951	0.02882
5	-0.01962	1.18122	1.25179	1.25179	0.00058	0.02029
6	0.01633	1.60757	1.73910	1.73910	-0.00048	-0.01689
SUM	0.00000	2.57534	3.76443	4.72314	0.05231	-0.01643
Condition **D8=1.2DL+IL+1.6WL2**						
1	0.39065	1.38662	-0.00574	0.00928	0.03353	-0.96934
3	0.34959	0.75650	-0.00252	-0.02221	0.04104	-0.90492
5	0.93554	-0.85560	-1.22904	-1.22904	0.00087	-0.93055
6	0.71425	1.28782	1.23729	1.23729	0.00201	-0.70795
SUM	2.39003	2.57534	0.00000	-0.00467	0.07744	-3.51277
Condition **D9=0.9DL+1.6WL1**						
1	0.02480	-0.84849	0.46274	1.03819	-0.15330	-0.03455
3	-0.01686	-0.54128	0.31511	0.70171	0.20417	0.00662
5	-0.07762	1.07600	1.25382	1.25382	0.00086	0.07861
6	0.06969	1.49502	1.73276	1.73276	-0.00076	-0.07056
SUM	0.00000	1.18126	3.76443	4.72649	0.05097	-0.01989
Condition **D10=0.9DL+1.6WL2**						
1	0.38119	0.72089	-0.00353	0.01292	0.03753	-0.95524
3	0.36369	0.24591	-0.00042	-0.01819	0.03570	-0.92713
5	0.87754	-0.96082	-1.22700	-1.22700	0.00115	-0.87223
6	0.76760	1.17528	1.23095	1.23095	0.00173	-0.76162
SUM	2.39003	1.18126	0.00000	-0.00132	0.07610	-3.51623

Envelope for nodal reactions

Note.- **Ic** is the controlling load condition



Direction of positive forces and moments

Envelope of nodal reactions for :

D1=1.4DL
D2=1.2DL+1.6IL
D3=1.2DL+0.8WL1
D4=1.2DL+0.8WL2
D5=1.2DL+1.6WL1
D6=1.2DL+1.6WL2
D7=1.2DL+IL+1.6WL1
D8=1.2DL+IL+1.6WL2
D9=0.9DL+1.6WL1
D10=0.9DL+1.6WL2

		Forces						Moments					
Node		**Fx** [Kip]	**Ic**	**Fy** [Kip]	**Ic**	**Fz** [Kip]	**Ic**	**Mx** [Kip*ft]	**Ic**	**My** [Kip*ft]	**Ic**	**Mz** [Kip*ft]	**Ic**
1	Max	0.391	D8	1.497	D2	0.463	D9	1.03819	D9	0.03753	D10	-0.01959	D1
	Min	0.013	D1	-0.848	D9	-0.006	D8	-0.00908	D2	-0.15730	D7	-0.96934	D8
3	Max	0.364	D10	1.159	D2	0.315	D9	0.70171	D9	0.20951	D7	0.04957	D2
	Min	-0.032	D2	-0.541	D9	-0.005	D2	-0.02221	D8	0.00671	D1	-0.92713	D10
5	Max	0.936	D8	1.181	D7	1.254	D9	1.25382	D9	0.00115	D10	0.07861	D9
	Min	-0.078	D9	-0.961	D10	-1.229	D8	-1.22904	D8	-0.00066	D2	-0.93055	D8
6	Max	0.768	D10	1.608	D7	1.739	D7	1.73910	D7	0.00201	D8	0.12865	D2
	Min	-0.128	D2	0.171	D1	0.007	D1	0.00735	D1	-0.00076	D9	-0.76162	D10

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Gamma Sector Calculations

Date: 10/31/2017
Project Name: Munjoy Hill
Project Number: ME5040
Designed By: BD **Checked By:** MSC

HUDSON Design Group LLC

2.6.5.2 Velocity Pressure Coeff:

$K_z = 2.01 (z/z_g)^{2/\alpha}$

z=	155 (ft)
z_g=	1200 (ft)
α=	7.0

K_z= 1.120

Kzmin ≤ Kz ≤ 2.01

Table 2-4

Exposure	Z_g	α	K_{zmin}	K_e
B	1200 ft	7.0	0.70	0.9
C	900 ft	9.5	0.85	1.0
D	700 ft	11.5	1.03	1.1

2.6.6.4 Topographic Factor:

Table 2-5

Topo. Category	K_t	f
2	0.43	1.25
3	0.53	2.0
4	0.72	1.5

$K_{zt} = [1+(K_e K_t/K_h)]^2$

$K_h = e^{(f*z/H)}$

K_{zt}= #DIV/0!

K_h=	#DIV/0!
K_e=	0 (from Table 2-4)
K_t=	0 (from Table 2-5)
f=	0 (from Table 2-5)
z=	155
H=	0 (Ht. of the crest above surrounding terrain)
K_{zt}=	1.00

(If Category 1 then K_{zt} =1.0)

Category= **1**

Date: 10/31/2017
Project Name: Munjoy Hill
Project Number: ME5040
Designed By: BD Checked By: MSC

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2.6.7 Gust Effect Factor

2.6.7.1 Self Supporting Lattice Structures

Gh = 1.0 Latticed Structures > 600 ft

Gh = 0.85 Latticed Structures 450 ft or less

Gh = 0.85 + 0.15 [h/150 - 3.0] h= ht. of structure

h=	170	Gh=	0.85
2.6.7.2 Guyed Masts		Gh=	0.85
2.6.7.3 Pole Structures		Gh=	1.1
2.6.9 Appurtenances		Gh=	1.0

2.6.7.4 Structures Supported on Other Structures
(Cantilivered tubular or latticed spines, pole, structures on buildings (ht. : width ratio > 5)

Gh=	1.35	**Gh=**	**1.35**

Date: 10/31/2017
Project Name: Munjoy Hill
Project Number: ME5040
Designed By: BD Checked By: MSC

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2.6.9.2 Design Wind Force on Appurtenances

$$F = qz*Gh*(EPA)_A$$

$$q_z = 0.00256*K_z*K_{zt}*K_d*V_{max}^2*I$$

K_z=	1.120
K_{zt}=	1.0
K_d=	0.95
V_{max}=	100
I=	1.0

q_z= 27.24

Table 2-2

Structure Type	Wind Direction Probability Factor, Kd
Latticed structures with triangular, square or rectangular cross sections	0.85
Tubular pole structures, latticed structures with other cross sections, appurtenances	0.95

Determine Cf:

If lattice Structure See Manual

If Tubular Pole Structure, Use Corrected Value from Table 2.7 Below

C mph.ft	Round	18 Sided	16 Sided	12 Sided	8 Sided
< 32 (Subcritical)	1.2	1.2	1.2	1.2	1.2
32 to 64 (Transitional)	$38.4/C^{1.0}$	$25.8/C^{0.885}$	$12.6/C^{0.678}$	$2.99/C^{0.263}$	1.2
> 64 (Supercritical)	0.6	0.65	0.75	1	1.2

$$C = (I*K_{zt}*K_z)^{0.5}*V*D$$

D = Outside diameter for rounds: 0.25 feet

C= 26.46 **Cf=** 1.2

Date: 10/31/2017
Project Name: Munjoy Hill
Project Number: ME5040
Designed By: BD Checked By: MSC

HUDSON Design Group LLC

Determine Ca:

Table 2-8

Force Coefficients (Ca) for Appurtenances				
Member Type		Aspect Ratio ≤ 2.5	Aspect Ratio = 7	Aspect Ratio ≥ 25
		Ca	Ca	Ca
Flat		1.2	1.4	2.0
Round	C < 32 (Subcritical)	0.7	0.8	1.2
	32 ≤ C ≤ 64 (Transitional)	$3.76/(C^{0.485})$	$3.37/(C^{0.415})$	$38.4/(C^{1.0})$
	C > 64 (Supercritical)	0.5	0.6	0.6

Aspect Ratio is the overall length/width ratio in the plane normal to the wind direction.
(Aspect ratio is independent of the spacing between support points of a linear appurtenance, and the section length considered to have uniform wind load).

Note: Linear interpolation may be used for aspect ratios other than those shown.

Appurtenances	Height	Width	Depth	Flat Area	Aspect Ratio	Ca	Force (lbs)
7750	57.0	11.0	5.0	4.35	5.18	1.32	**211**
QS66512-2	72	12	9.6	6.00	6.00	1.36	**299**
800-10965	78.7	20.0	6.9	10.93	3.94	1.26	**508**
AM-X-CD-16-65-00T-RET	72.0	11.8	5.9	5.90	6.10	1.36	**295**
RRU-11	19.7	17.0	7.2	2.33	1.16	1.20	**103**
B14 4478	15.0	13.2	7.4	1.38	1.14	1.20	**61**
RRUS-32 B66	27.2	12.1	7.0	2.29	2.25	1.20	**101**
Squid Surge Arrestor	24	9.7	9.7	1.62	2.47	1.20	**71**

Date: 10/31/2017
Site Name: Munjoy Hill
Site Number: ME5040
Done by: BD **Checked by:** MSC

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CHECK CONNECTION CAPACITY (Worse Case)

Reference: Hilti Volume 2: Anchor Fastening Technical Guide

Epoxy Type =	HIT-HY20	(Assumed)
Anchor Diameter =	3/8	in. (Assumed)
Embedment Depth =	2	in. (Min.) (Assumed)

Allowable Tensile Load =

F_{Tall} = 657 lbs.

Allowable Shear Load =

F_{Vall}= 790 lbs.

WIND FORCES

Reaction **F =** 508 lbs.

GRAVITY LOADS

Ice and Equipment 156 lbs.

No. of Supports = 2
No. of Anchors / Support = 2

Tension Design Load / Anchor =

f_t= 127.00 lbs. < 657 lbs. **Therefore, OK !**

Shear Design Load / Anchor=

f_v= 39.00 lbs. < 790 lbs. **Therefore, OK !**

CHECK COMBINED TENSION AND SHEAR

f_t / F_T	+	f_v / F_V	≤	1.0			
0.193	+	0.049	=	0.243	<	1.0	**Therefore, OK !**

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RRH Frame Calculations

Date: 10/31/2017
Project Name: Munjoy Hill
Project Number: ME5040
Designed By: BD **Checked By:** MSC

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2.6.5.2 Velocity Pressure Coeff:

$K_z = 2.01 (z/z_g)^{2/\alpha}$

z=	157 (ft)
z_g=	1200 (ft)
α=	7.0

K_z= 1.124

$Kzmin \leq Kz \leq 2.01$

Table 2-4

Exposure	Z_g	α	K_{zmin}	K_e
B	1200 ft	7.0	0.70	0.9
C	900 ft	9.5	0.85	1.0
D	700 ft	11.5	1.03	1.1

2.6.6.4 Topographic Factor:

Table 2-5

Topo. Category	K_t	f
2	0.43	1.25
3	0.53	2.0
4	0.72	1.5

$K_{zt} = [1+(K_e K_t/K_h)]^2$

$K_h = e^{(f*z/H)}$

K_{zt}= #DIV/0!

K_h=	#DIV/0!
K_e=	0 (from Table 2-4)
K_t=	0 (from Table 2-5)
f=	0 (from Table 2-5)
z=	157
H=	0 (Ht. of the crest above surrounding terrain)
K_{zt}=	1.00

(If Category 1 then K_{zt} =1.0)

Category= 1

Date: 10/31/2017
Project Name: Munjoy Hill
Project Number: ME5040
Designed By: BD Checked By: MSC

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2.6.7 Gust Effect Factor

2.6.7.1 Self Supporting Lattice Structures

Gh = 1.0 Latticed Structures > 600 ft

Gh = 0.85 Latticed Structures 450 ft or less

Gh = 0.85 + 0.15 [h/150 - 3.0] h= ht. of structure

h=	170	Gh=	0.85

2.6.7.2 Guyed Masts Gh= 0.85

2.6.7.3 Pole Structures Gh= 1.1

2.6.9 Appurtenances Gh= 1.0

2.6.7.4 Structures Supported on Other Structures
(Cantilivered tubular or latticed spines, pole, structures on buildings (ht. : width ratio > 5)

Gh=	1.35	**Gh=**	**1.35**

Date: 10/31/2017
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2.6.9.2 Design Wind Force on Appurtenances

$$F = q_z * G_h * (EPA)_A$$

$$q_z = 0.00256 * K_z * K_{zt} * K_d * V_{max}^2 * I$$

K_z=	1.124
K_{zt}=	1.0
K_d=	0.95
V_{max}=	100
I=	1.0

q_z= 27.34

Table 2-2

Structure Type	Wind Direction Probability Factor, Kd
Latticed structures with triangular, square or rectangular cross sections	0.85
Tubular pole structures, latticed structures with other cross sections, appurtenances	0.95

Determine Cf:

If lattice Structure See Manual

If Tubular Pole Structure, Use Corrected Value from Table 2.7 Below

C mph.ft	Round	18 Sided	16 Sided	12 Sided	8 Sided
< 32 (Subcritical)	1.2	1.2	1.2	1.2	1.2
32 to 64 (Transitional)	$38.4/C^{1.0}$	$25.8/C^{0.885}$	$12.6/C^{0.678}$	$2.99/C^{0.263}$	1.2
> 64 (Supercritical)	0.6	0.65	0.75	1	1.2

$$C = (I * K_{zt} * K_z)^{0.5} * V * D$$

D = Outside diameter for rounds: 0.25 feet

C= 26.51 **Cf=** 1.2

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Determine Ca:

Table 2-8

Force Coefficients (Ca) for Appurtenances				
Member Type		Aspect Ratio ≤ 2.5	Aspect Ratio = 7	Aspect Ratio ≥ 25
		Ca	Ca	Ca
Flat		1.2	1.4	2.0
Round	C < 32 (Subcritical)	0.7	0.8	1.2
	32 ≤ C ≤ 64 (Transitional)	$3.76/(C^{0.485})$	$3.37/(C^{0.415})$	$38.4/(C^{-1.0})$
	C > 64 (Supercritical)	0.5	0.6	0.6

Aspect Ratio is the overall length/width ratio in the plane normal to the wind direction.
(Aspect ratio is independent of the spacing between support points of a linear appurtenance, and the section length considered to have uniform wind load).

Note: Linear interpolation may be used for aspect ratios other than those shown.

Appurtenances	Height	Width	Depth	Flat Area	Aspect Ratio	Ca	Force (lbs)
RRU-11	19.7	17.0	7.2	2.33	1.16	1.20	**103**
B14 4478	15.0	13.2	7.4	1.38	1.14	1.20	**61**
RRUS-32 B66	27.2	12.1	7.0	2.29	2.25	1.20	**101**
Squid Surge Arrestor	24	9.7	9.7	1.62	2.47	1.20	**72**

Date: 10/31/2017
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Project Number: ME5040
Designed By: BD **Checked By:** MSC

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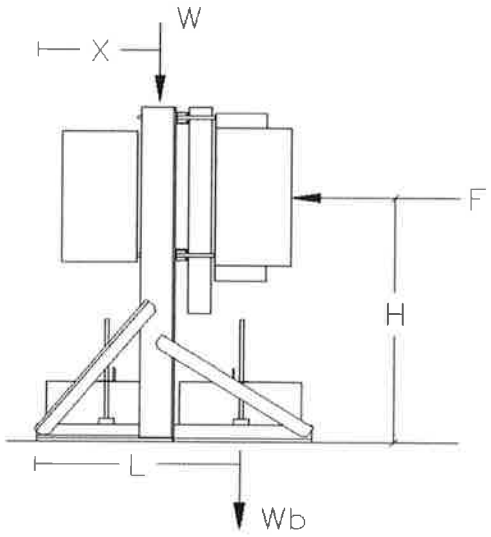
Calculate Total Ballast Required for Ballast Mount

Assume (2) RRH's as projected area



Force (F) =	204	lbs.
Height (H) =	2.75	ft
Weight (W) =	384	lbs.
Frame Width/2 (X) =	1.3	ft
Length (L) =	2.2	ft
Ballast (Wb) =	TBD	
Safety Factor (SF) =	1.5	

Overturning at Ballast

$\Sigma M = 0 = (F * H) - (W * X) - (Wb * L)$ ---> $Wb = [(F*H*SF-W*X)/L] =$ **156 lbs.**

Determine Number of Blocks Required

(assume 4"x8"x16" solid blocks @ 38 lbs. each)

Number of Blocks Required = 3 BLOCKS PER SIDE

-Total Weight of Fully Loaded Frame = 498 lbs.

-Footprint Area Under Ballast Frame = 10.5 sqft.

-Distributed Load Under Ballast Frame = 47 psf