# Structural Design Calculations
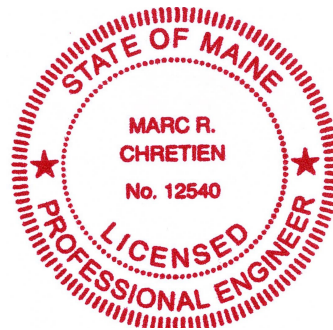
**Site No.:** 4DN2202A - Deering Pavilion
**Client:** J Lee Associates
**Date:** November 28, 2016

**Client:** J Lee Associates
**Project:** L2100
**Subject:** Structural Analysis,880 Forest Avenue, Portland, ME

**Advanced Engineering Group**
500 North Broadway
East Providence, RI 02914
Ph: 401-354-2403

**Sheet:** 1
**Date:** 11/28/16
**Calculated by:** MRC

**Synopsis:**

The proposed T-Mobile equipment installation will replacing three (3) existing EMS panel antennas with three (3) Ericsson AIR21 panel antennas.  As detailed on plans by this office, the antennas will be mounted to the existing mount pipes that are supported by the existing industry-standard wall mounts.

**Loads:**

Environmental Loads:

_Wind Load:_

| | | |
|---|---|---|
| Exposure category, | $EC := C$ | (ASCE 7-05 Sec 6.5.6.3) |
| Basic wind velocity, | $V_w := 98$    mph | (MSBC Table 1604.11) |
| Importance factor, | $I := 1$         (Category II) | (ASCE 7-05 Table 6-1) |
| Height of Equipment, | $Height := 110ft$ | |
| Exposure coefficient, | $K_z = 1.28$ | (ASCE 7-05 Table 6-3) |
| Velocity wind pressure, | $q_z := .00256 \cdot V_w{}^2 \cdot K_z \cdot I \cdot psf = 31.55 \cdot psf$ | (ASCE 7-05 6.5.10) |
| Flat Force coeff., | $C_f := 1.4$ | (ASCE 7-05 Fig. 6-21) |
|    Wind load pressure, | $WL_f := q_z \cdot C_f = 44.16 \cdot psf$ | (ASCE 7-05 Sec. 6.5.15) |
| Round Force coeff., | $C_r := 0.7$ | (ASCE 7-05 Fig. 6-21) |
|    Wind load pressure, | $WL_r := q_z \cdot C_r = 22.08 \cdot psf$ | (ASCE 7-05 Sec. 6.5.15) |
| Radial ice thickness, | $t_{ice} := 0.75 \cdot in$ | |
| Density of ice, | $\gamma_{ice} := 56 \cdot pcf$ | |

_Snow Load:_

| | | |
|---|---|---|
| Ground Snow Load | $p_g := 45psf$ | (ASCE 7-05 Fig. 7-1) |
| Exposure Factor | $C_e := 0.9$   (Fully Exposed, exposure "B") | (ASCE 7-05 Table 7-2) |
| Thermal Factor | $C_t := 1.0$ | (ASCE 7-05 Table 7-3) |
| Importance Factor | $I_s := 1.0$ | (ASCE 7-05 Table 7-4) |
| Roof Snow Load, | $p_f := 0.7 \cdot C_e \cdot C_t \cdot I_s \cdot p_g = 28.35 \cdot psf$ | (ASCE 7-05 Sec. 7.3) |

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**Sheet:** 2
**Date:** 11/28/16
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**Analysis:**

Equipment Loads:

Proposed Antenna Properties:

Width,  $w_{pant} := 12 \cdot in$

Depth,  $t_{pant} := 8 \cdot in$

Length,  $l_{pant} := 56 \cdot in$

Weight,  $W_{pant} := 91.5 \cdot lb$

Weight of ice:

Proposed Antenna:

$$W_{pant\_ice} := \left[ \left[ \left[ w_{pant} + \left( 2 \cdot t_{ice} \right) \right] \cdot \left[ t_{pant} + \left( 2 \cdot t_{ice} \right) \right] \cdot \left[ l_{pant} + \left( 2 \cdot t_{ice} \right) \right] \right] - w_{pant} \cdot t_{pant} \cdot l_{pant} \right] \cdot \gamma_{ice}$$

$$W_{pant\_ice} = 64.76 \, lb$$

Wind force on proposed antenna,  $P_{pa} := \left( \sqrt{w_{pant}^2 + t_{pant}^2} \cdot l_{pant} \right) \cdot WL_f = 247.7 \, lb$

Reactions acting on pipe,  $P_{pipe} := \dfrac{P_{pa}}{2} = 123.85 \, lb$

Moment on pipe,  $M_{pipe} := 568 \cdot ft \cdot lb$

See attached Enercalc output

Allowable moment,  $M_{allow} := 1.245 \cdot ft \cdot kip$

$$MomentCheck := \begin{vmatrix} \text{"OK"} & \text{if} & M_{allow} \geq M_{pipe} \\ \text{"NG"} & \text{otherwise} \end{vmatrix}$$
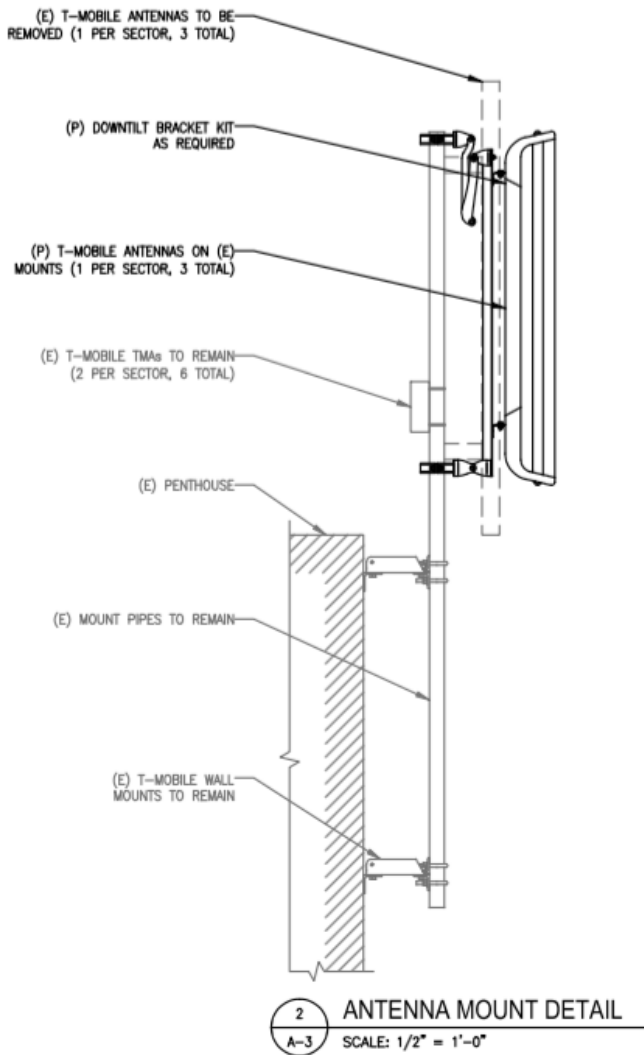
$MomentCheck = \text{"OK"}$

*Check Wall Mounts:*

Total wind load acting on mount,  $P_{tot} := P_{pa}$

$$P_{tot} = 247.7 \, lb$$

Weight of pipe, brackets,  $P_{misc} := 75 \cdot lb$

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Avenue, Portland, ME

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**Sheet:** 3
**Date:** 11/28/16
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Distance of antenna off wall,    $d_1 := 16 \cdot in$

Fig. 1 Antenna Mount (from CDs)



ANTENNA MOUNT DETAIL
SCALE: 1/2" = 1'-0"

Check Wall Mounts:

Wind force on proposed assembly,   $P_{tot} = 247.7\,lb$

Gravity load on assembly,   $P_g := W_{pant\_ice} + W_{pant} + P_{misc} = 231.26\,lb$

Bracket separation,  $d := 4 \cdot ft$

Number of bolts per bracket,    $n := 2$

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**Sheet:** 4
**Date:** 11/28/16
**Calculated by:** MRC

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Approximate tensile force on bolt,

$$T_{bolt} := \frac{\dfrac{P_g \cdot d_1 + P_{pipe} \cdot \left[ (d + 1.67 \cdot ft) + I_{pant} \right]}{d}}{n}$$

$$T_{bolt} = 198.57 \, lb$$

Allowable tensile capacity of 1/2" Hilti HIT HY 150,

$$T_{allow} := \frac{2725 \cdot lb}{4} = 681.25 \, lb$$

$$TensileCheck := \begin{cases} \text{"OK"} & \text{if } T_{allow} \geq T_{bolt} \\ \text{"NG"} & \text{otherwise} \end{cases}$$

TensileCheck = "OK"

**Conclusion:**

**Based on the results of the analysis, the proposed T-Mobile 2100 MHz equipment installation is structurally sound, as designed and depicted on plans by this office entitled "4DN2202A, Deering Pavilion", Rev 0, 11/22/16". The analysis was conducted in accordance with the Maine Uniform Building and Energy Code, and ASCE 7-05.**

References:

1. American Society of Civil Engineers (2005), Minimum Design Loads for Buildings and Other Structures (7-05), American Society of Civil Engineers, New York, NY
2. Maine Uniform Building and Energy Code.

500 North Broadway
East Providence, RI 02914
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Project Title: **Cantilevered Pipe Mount**
Engineer: **MRC**
Project Descr: **L2100**
Project ID: **4DN2201A**

**eg ADVANCED**
ENGINEERING GROUP, P.C.

## Steel Beam

Description :    Mount Pipe

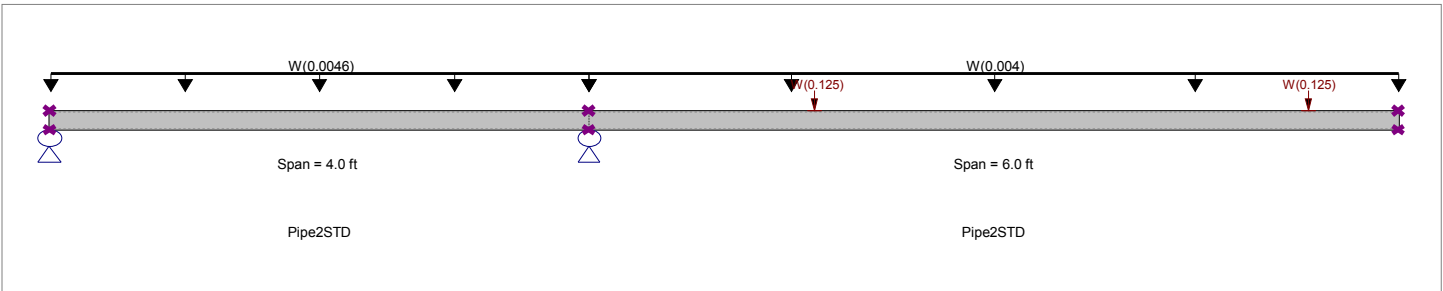## CODE REFERENCES

Calculations per AISC 360-05, IBC 2009, CBC 2010, ASCE 7-05
Load Combination Set : ASCE 7-05

### Material Properties

| | | | |
|---|---|---|---|
| Analysis Method: | Allowable Strength Design | Fy : Steel Yield | 35.0 ksi |
| Beam Bracing : | Completely Unbraced | E: Modulus : | 29,000.0 ksi |
| Bending Axis : | Major Axis Bending | | |



### Applied Loads

Service loads entered. Load Factors will be applied for calculations.

Beam self weight NOT internally calculated and added
Load for Span Number 1
   Uniform Load : W = 0.00460 k/ft, Tributary Width = 1.0 ft, (Wind)
Load for Span Number 2
   Uniform Load : W = 0.0040 k/ft, Tributary Width = 1.0 ft, (Wind)
   Point Load : W = 0.1250 k @ 1.670 ft, (Antenna)
   Point Load : W = 0.1250 k @ 5.330 ft, (Antenna)

### DESIGN SUMMARY

**Design OK**

| | | | | |
|---|---|---|---|---|
| Maximum Bending Stress Ratio = | **0.760** : 1 | Maximum Shear Stress Ratio = | **0.043** : 1 |
| Section used for this span | **Pipe2STD** | Section used for this span | **Pipe2STD** |
| Ma : Applied | 0.947 k-ft | Va : Applied | 0.2740 k |
| Mn / Omega : Allowable | 1.245 k-ft | Vn/Omega : Allowable | 6.413 k |
| Load Combination | +D+W+H | Load Combination | +D+W+H |
| Location of maximum on span | 4.000 ft | Location of maximum on span | 4.000 ft |
| Span # where maximum occurs | Span # 1 | Span # where maximum occurs | Span # 1 |

Maximum Deflection
| | | | |
|---|---|---|---|
| Max Downward Transient Deflection | 1.567 in | Ratio = | 91 >=90.0 |
| Max Upward Transient Deflection | -0.091 in | Ratio = | 524 >=90.0 |
| Max Downward Total Deflection | 1.575 in | Ratio = | 91 >=90.0 |
| Max Upward Total Deflection | -0.091 in | Ratio = | 525 >=90.0 |

### Maximum Forces & Stresses for Load Combinations

| Load Combination Segment Length | Span # | Max Stress Ratios M | V | Mmax + | Mmax - | Ma Max | Mnx | Mnx/Omega | Cb | Rm | Va Max | Vnx | Vnx/Omega |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| D Only | | | | | | | | | | | | | |
| Dsgn. L =    4.00 ft | 1 | | 0.000 | | | | 2.08 | 1.25 | 1.00 | 1.00 | -0.00 | 10.71 | 6.41 |
| Dsgn. L =    6.00 ft | 2 | | 0.000 | | | | 2.08 | 1.25 | 1.00 | 1.00 | -0.00 | 10.71 | 6.41 |
| +D+L+H | | | | | | | | | | | | | |
| Dsgn. L =    4.00 ft | 1 | | 0.000 | | | | 2.08 | 1.25 | 1.00 | 1.00 | -0.00 | 10.71 | 6.41 |
| Dsgn. L =    6.00 ft | 2 | | 0.000 | | | | 2.08 | 1.25 | 1.00 | 1.00 | -0.00 | 10.71 | 6.41 |
| +D+Lr+H | | | | | | | | | | | | | |
| Dsgn. L =    4.00 ft | 1 | | 0.000 | | | | 2.08 | 1.25 | 1.00 | 1.00 | -0.00 | 10.71 | 6.41 |
| Dsgn. L =    6.00 ft | 2 | | 0.000 | | | | 2.08 | 1.25 | 1.00 | 1.00 | -0.00 | 10.71 | 6.41 |
| +D+S+H | | | | | | | | | | | | | |
| Dsgn. L =    4.00 ft | 1 | | 0.000 | | | | 2.08 | 1.25 | 1.00 | 1.00 | -0.00 | 10.71 | 6.41 |
| Dsgn. L =    6.00 ft | 2 | | 0.000 | | | | 2.08 | 1.25 | 1.00 | 1.00 | -0.00 | 10.71 | 6.41 |
| +D+0.750Lr+0.750L+H | | | | | | | | | | | | | |
| Dsgn. L =    4.00 ft | 1 | | 0.000 | | | | 2.08 | 1.25 | 1.00 | 1.00 | -0.00 | 10.71 | 6.41 |
| Dsgn. L =    6.00 ft | 2 | | 0.000 | | | | 2.08 | 1.25 | 1.00 | 1.00 | -0.00 | 10.71 | 6.41 |
| +D+0.750L+0.750S+H | | | | | | | | | | | | | |
| Dsgn. L =    4.00 ft | 1 | | 0.000 | | | | 2.08 | 1.25 | 1.00 | 1.00 | -0.00 | 10.71 | 6.41 |
| Dsgn. L =    6.00 ft | 2 | | 0.000 | | | | 2.08 | 1.25 | 1.00 | 1.00 | -0.00 | 10.71 | 6.41 |
| +D+W+H | | | | | | | | | | | | | |
| Dsgn. L =    4.00 ft | 1 | 0.760 | 0.043 | | -0.95 | 0.95 | 2.08 | 1.25 | 1.69 | 1.00 | 0.27 | 10.71 | 6.41 |

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Project Title: **Cantilevered Pipe Mount**
Engineer: **MRC**
Project Descr: **L2100**

Project ID: **4DN2201A**

# ADVANCED
## ENGINEERING GROUP, P.C.

## Steel Beam

Description :   Mount Pipe

| Load Combination Segment Length | Span # | Max Stress Ratios M | V | Mmax + | Mmax - | Ma Max | Mnx | Mnx/Omega | Cb | Rm | Va Max | Vnx | Vnx/Omega |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Dsgn. L = 6.00 ft | 2 | 0.760 | 0.043 | | -0.95 | 0.95 | 2.08 | 1.25 | 1.00 | 1.00 | 0.27 | 10.71 | 6.41 |
| +D+0.70E+H | | | | | | | | | | | | | |
| Dsgn. L = 4.00 ft | 1 | | 0.000 | | | | 2.08 | 1.25 | 1.00 | 1.00 | -0.00 | 10.71 | 6.41 |
| Dsgn. L = 6.00 ft | 2 | | 0.000 | | | | 2.08 | 1.25 | 1.00 | 1.00 | -0.00 | 10.71 | 6.41 |
| +D+0.750Lr+0.750L+0.750W+H | | | | | | | | | | | | | |
| Dsgn. L = 4.00 ft | 1 | 0.570 | 0.032 | | -0.71 | 0.71 | 2.08 | 1.25 | 1.69 | 1.00 | 0.21 | 10.71 | 6.41 |
| Dsgn. L = 6.00 ft | 2 | 0.570 | 0.032 | | -0.71 | 0.71 | 2.08 | 1.25 | 1.00 | 1.00 | 0.21 | 10.71 | 6.41 |
| +D+0.750L+0.750S+0.750W+H | | | | | | | | | | | | | |
| Dsgn. L = 4.00 ft | 1 | 0.570 | 0.032 | | -0.71 | 0.71 | 2.08 | 1.25 | 1.69 | 1.00 | 0.21 | 10.71 | 6.41 |
| Dsgn. L = 6.00 ft | 2 | 0.570 | 0.032 | | -0.71 | 0.71 | 2.08 | 1.25 | 1.00 | 1.00 | 0.21 | 10.71 | 6.41 |
| +D+0.750Lr+0.750L+0.5250E+H | | | | | | | | | | | | | |
| Dsgn. L = 4.00 ft | 1 | | 0.000 | | | | 2.08 | 1.25 | 1.00 | 1.00 | -0.00 | 10.71 | 6.41 |
| Dsgn. L = 6.00 ft | 2 | | 0.000 | | | | 2.08 | 1.25 | 1.00 | 1.00 | -0.00 | 10.71 | 6.41 |
| +D+0.750L+0.750S+0.5250E+H | | | | | | | | | | | | | |
| Dsgn. L = 4.00 ft | 1 | | 0.000 | | | | 2.08 | 1.25 | 1.00 | 1.00 | -0.00 | 10.71 | 6.41 |
| Dsgn. L = 6.00 ft | 2 | | 0.000 | | | | 2.08 | 1.25 | 1.00 | 1.00 | -0.00 | 10.71 | 6.41 |
| +0.60D+W+H | | | | | | | | | | | | | |
| Dsgn. L = 4.00 ft | 1 | 0.760 | 0.043 | | -0.95 | 0.95 | 2.08 | 1.25 | 1.69 | 1.00 | 0.27 | 10.71 | 6.41 |
| Dsgn. L = 6.00 ft | 2 | 0.760 | 0.043 | | -0.95 | 0.95 | 2.08 | 1.25 | 1.00 | 1.00 | 0.27 | 10.71 | 6.41 |
| +0.60D+0.70E+H | | | | | | | | | | | | | |
| Dsgn. L = 4.00 ft | 1 | | 0.000 | | | | 2.08 | 1.25 | 1.00 | 1.00 | -0.00 | 10.71 | 6.41 |
| Dsgn. L = 6.00 ft | 2 | | 0.000 | | | | 2.08 | 1.25 | 1.00 | 1.00 | -0.00 | 10.71 | 6.41 |

## Overall Maximum Deflections

| Load Combination | Span | Max. "-" Defl | Location in Span | Load Combination | Max. "+" Defl | Location in Span |
|---|---|---|---|---|---|---|
| | 1 | 0.0000 | 0.000 | W Only | -0.0914 | 2.320 |
| W Only | 2 | 1.5750 | 6.000 | | 0.0000 | 2.320 |

## Vertical Reactions

Support notation : Far left is #1          Values in KIPS

| Load Combination | Support 1 | Support 2 | Support 3 |
|---|---|---|---|
| Overall MAXimum | -0.228 | 0.520 | |
| Overall MINimum | -0.171 | 0.390 | |
| D Only | | | |
| +D+L+H | | | |
| +D+Lr+H | | | |
| +D+S+H | | | |
| +D+0.750Lr+0.750L+H | | | |
| +D+0.750L+0.750S+H | | | |
| +D+W+H | -0.228 | 0.520 | |
| +D+0.70E+H | | | |
| +D+0.750Lr+0.750L+0.750W+H | -0.171 | 0.390 | |
| +D+0.750L+0.750S+0.750W+H | -0.171 | 0.390 | |
| +D+0.750Lr+0.750L+0.5250E+H | | | |
| +D+0.750L+0.750S+0.5250E+H | | | |
| +0.60D+W+H | -0.228 | 0.520 | |
| +0.60D+0.70E+H | | | |
| D Only | | | |
| Lr Only | | | |
| L Only | | | |
| S Only | | | |
| W Only | -0.228 | 0.520 | |
| E Only | | | |
| H Only | | | |

### ASCE 7 Windspeed    ASCE 7 Ground Snow Load    Related Resources    Sponsors    About ATC    Contact

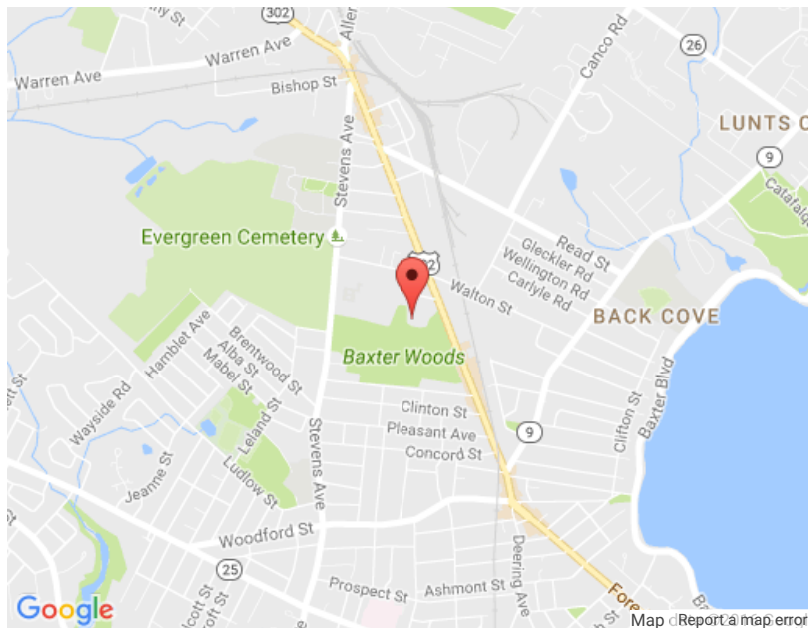# Search Results

**Query Date:** Mon Nov 28 2016
**Latitude:** 43.6781
**Longitude:** -70.2899

**ASCE 7-10 Windspeeds
(3-sec peak gust in mph\*):**

**Risk Category I:** 107
**Risk Category II:** 117
**Risk Category III-IV:** 126
**MRI\*\* 10-Year:** 76
**MRI\*\* 25-Year:** 86
**MRI\*\* 50-Year:** 91
**MRI\*\* 100-Year:** 97

**ASCE 7-05 Windspeed:**
  98 (3-sec peak gust in mph)
**ASCE 7-93 Windspeed:**
  83 (fastest mile in mph)



\*Miles per hour
\*\*Mean Recurrence Interval

Users should consult with local building officials
to determine if there are community-specific wind speed
requirements that govern.

 Print your results

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