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Date: 08/15/17

STAINLESS

A BUSINESS OF FDH VELOCITEL

# REPORT T063301

DATE: 03/15/2016

RIGOROUS ANALYSIS FOR A

230' ROHN SELF-SUPPORTING TOWER

PORTLAND, ME

PREPARED BY: PCC

CHECKED BY: AP

APPROVED: DDA

STATE OF MAINE
DENNIS D. ABEL
No. 10199
LICENSED
PROFESSIONAL ENGINEER

03-22-2016

| Date | Pages | Remarks |
|---|---|---|

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STATE OF MAINE
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03-22-2016

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## A. AUTHORIZATION/PURPOSE

As authorized by Brain Ross of Structure Consulting Group and Dick Man of Nanepashemet Project Management, Inc., a structural analysis was performed to investigate the adequacy of a 230' height ROHN self-supporting tower in Portland, Maine to support specified equipment.

## B. TOWER HISTORY

The tower was originally designed and furnished in 1977 by ROHN. The design standard and original design wind speed are unavailable.

The tower was analyzed by ROHN Products, Radian Communication Services in 2007, ROHN File number 08117EH, Radian Job Number 060-3713. The analysis report indicated that the following bracing members were replaced by higher capacity members.

- Replaced existing tower diagonal bracing members with new, large size members at the following bays:

| Location | No. of bays |
|---|---|
| 220' – 230' | 2 |
| 180' – 200' | 3 |
| 160' – 180' | 3 |
| 120' – 140' | 2 |

The proposed equipment and recommended modifications of Stainless Report T063300 Revision B, dated 01/22/2016, are assumed to be installed for the purpose of this analysis. The modification works are shown on Stainless Design Drawings dated 1/28/2016 and listed below:

- Installed additional horizontal sub-bracing at the midpoints of the following bays:

| Location | No. of bays |
|---|---|
| 140.0' – 150.0' | 1 |
| 120.0' – 130.0' | 1 |
| 100.0' – 110.0' | 1 |
| 60.0' – 80.0' | 2 |

- Replaced existing diagonal bracing members with new, higher capacity members at the following bays:

| Location | No. of bays |
|---|---|
| 100.0' – 160.0' | 6 |
| 40.0' – 60.0' | 1 |
| 20.0' – 40.0' | 1 |

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- Replaced existing secondary horizontal bracing members with new, higher capacity members at the following locations:

| Location | No. of levels |
|---|---|
| 10.0' | 1 |

Stainless has no record of any other modifications to the tower or its foundations.

## C. CONDITIONS INVESTIGATED

The analysis was performed for the tower supporting specified equipment based upon the following sources:

- Stainless Proposal P16_T063300_001 and P16_T063300A, dated 02/01/2016.
- Stainless Report T063300 Revision B, dated 01/22/2016.
- An analysis report by ROHN Products of Radian Communication Services, Radian Job No 060-3713, dated 04/25/2007.
- Tower original elevation drawing, no date.
- Tower foundation erection drawing, drawing No. C-770254, dated 04/11/1977.
- Tower mapping report by Stainless, Job Number T063300, dated 10/09/2015, for the existing equipment on tower and tower cross section.
- Email from Dick Man of Nanepashemet Project Management, Inc. to Jon Marcusse of Stainless, dated 08/12/2015, with details of proposed equipment.
- T-Mobile Construction Design package, Site No: 4PB-1288-A, by Chappell Engineering Associates, LLC, dated 03/30/2015, for the proposed equipment.
- Email from Dick Man of Nanepashemet Project Management, Inc. to Changfei Chen of Stainless, dated 11/20/2015, with details of proposed equipment.
- Verizon Wireless Construction Drawings, Site name: Portland_10_ME, Location Code: 381332, dated 09/28/2015, with details of proposed equipment.
- Emails from Craig Clark of Sinclair Broadcast Group to Jon Marcusse of Stainless dated 07/23/2015 and 11/25/2015, with proposed dishes information.
- Stainless tower mapping received 12/11/2015.
- Stainless Design Drawings dated 1/28/2016.

1. One beacon on tower top.
2. One abandoned rotating mount on tower top.
3. One (1) ENG antenna at the 230' level, fed by one (1) 7/8" line and one (1) 3/4" control cable.
4. One (1) ENG antenna at the 230' level, fed by one (1) 1-5/8" line and one (1) 3/4" control cable.
5. One (1) 8' dish with radome at the 225' level, azimuth 330 degrees, fed by one (1) EW63 cable.

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6. One (1) 8' grid dish at the 223' level, azimuth 20 degrees at the 223' level, fed by one (1) 7/8" line.
7. Two (2) PAR8-68 dish antennas at the 220' level, azimuth 330 degrees and 235 degrees respectively, fed by one (1) EW63 cable to each. **(Proposed)**
8. One (1) 8' dish with radome at the 190' level, azimuth 235 degrees, fed by one (1) EW63 cable.
9. One (1) 8' grid dish at the 178' level, azimuth 210 degrees, fed by one (1) 7/8" line.
10. One (1) 12' whip antenna on a standoff mount at the 165' level, fed by one (1) 3/8" line.
11. Six (6) Cellmax BDHH/6520/E0-8 panel antennas, three (3) Andrew LNX-6515DS-VTM panel antennas, nine (9) RRUS-11 units, and one (1) Radio Waves SP2-5.2 dish with 189.11 degrees azimuth on three (3) sector frame mounts at the 157' level, fed by twelve (12) 1-5/8" lines and three (3) 7/8" hybrid cables and one (1) 0.405" OD cable. **(Proposed)**
12. Six (6) panel antennas on three sector frame mounts at the 150' level, fed by six (6) 1-5/8" lines.
13. Six (6) Amphenol HT4C6318R000G panel antennas, six (6) Commscope HBXX-6516DS-A2M panel antennas, three (3) ALU B13 RRH4x30-4R units, three (3) ALU RRH2x60-AWS units, three (3) ALU B25 RRH4x30-4R units and two (2) DB-B1-6C-12AB-0Z Junction boxes on three (3) sector frame mounts at the 130' level, fed by two (2) 1-5/8" hybrid cables. **(Proposed)**
14. One (1) panel type antenna at the 125' level, fed by one (1) 3/8" diameter RG cable.
15. One (1) 4' Yagi antenna at the 120' level, fed by one (1) 1/4" line.
16. Two (2) obstruction lights at the 115' level.
17. One (1) 6' dish with radome at the 102', azimuth 332 degrees, fed by one (1) EW63 cable. (This dish and line will be removed and will included in the analysis)
18. One (1) ENG receiver antenna at the 100' level, fed by one (1) 7/8" line and one (1) 3/8" control cable.
19. One (1) 6' dish with radome at the 95' level, fed by one (1) EW63 cable.
20. One (1) dipole antenna on standoff mount at the 90' level, fed by one (1) 7/8" line.
21. One (1) low band VFH antenna at the 85' level, fed by one (1) 1/4" line. (Not in use and not included in the analysis)
22. One (1) 4' solid dish antenna at the 82' level, azimuth 140 degrees, fed by one (1) 7/8" line.
23. One (1) Yagi antenna at the 30' level, fed by one (1) 1/2" line.
24. One (1) waveguide rack to 150' level.
25. One (1) 1" conduit to tower top.
26. One (1) inside climbing ladder with safety for the full height of the tower.
27. One (1) waveguide ladder to the 130' level **(Proposed)**
28. One (1) waveguide ladder to the 157' level **(Proposed)**
29. One (1) 1" conduit to the 220' level **(Proposed)**

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The locations of the existing transmission lines are based upon Stainless Report T063300 Revision B, dated 01/22/2016. The locations of all transmission lines are shown on page A-2 of this Report. Deviating from this appurtenance arrangement may invalidate the results presented in this Report.

The azimuths of the tower legs were based upon a partial original design sheet showing the azimuth of Leg A with respect to true north. The tower leg azimuths are 57, 117 and 297 degrees for the A, B and C legs respectively.

Tower leg, diagonal and horizontal bracing member capacities are based on an analysis report by ROHN Products of Radian Communication Services, Radian Job No 060-3713, dated 04/25/2007.

All unused antennas and lines shall be removed prior to installation of the proposed equipment, and have not been included in the analysis.

## D. LOADS AND STRESSES

The analysis was performed using the following design parameters in accordance with IBC 2009 and ANSI/TIA 222-G-2005, Structural Standard for Antenna Supporting Structures and Antennas, effective 2005, including Addenda G-1 and G-2 dated 2007 and 2009 respectively:

- Structure Classification II
- 117 mph ultimate design wind speed with no ice
- 40 mph nominal design wind speed with 1" design ice thickness
- Exposure Category C
- Topographic Category 1
- 0.32 earthquake spectral response acceleration at short periods ($S_s$)
- Earthquake Site Class D

The wind loading used is 117 mph ultimate design wind speed (wind load factor =1.0) with no ice as determined per ASCE 7-10, Minimum Design Loads for Buildings and Other Structures, and 40 mph with 1" design ice thickness as determined per ANSI/TIA 222-G. The ANSI/TIA 222-G code refers to ASCE 7-05, under which a nominal design wind speed of 98 mph (with a wind load factor =1.6) with no ice is prescribed for the tower. The ultimate design wind speed of 117 mph is equivalent to a nominal design wind speed of approximately 98 mph.

The wind speed with no ice as determined per ASCE 7-10 represents the latest state of the art research and findings in the field of wind loading for hurricane prone regions of the US. The TIA Committee has approved the revised references which use statistical analysis of wind climatic data, and form the basis of the wind speed methodology of ASCE 7-10. It is anticipated that the next revision of the TIA code will incorporate ASCE 7-10.

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The ultimate design wind speed was converted to a nominal design wind speed for use with ANSI/TIA 222-G based upon the following formula:

$$V_{asd} = V_{ult} * (0.6)^{1/2}$$
$$= 117 * (0.6)^{1/2}$$
$$= 90.7 \text{ mph, use } 91 \text{ mph}$$

Seismic effects need not be considered as the value of Ss is less than 1.0 per Section 2.7.3 of ANSI/TIA 222-G. Load and resistance factors used to evaluate the adequacy of the structure were in accordance with ANSI/TIA 222-G.

## E. METHOD OF ANALYSIS

The analysis was performed using tnxTower, a computerized program which idealizes the tower as a structure consisting of finite elements, and subjected to simultaneous transverse (wind) and axial (dead and ice) loads.

## F. RESULTS

The results of the analysis show the following ratings:

| LOCATION | SPAN | RATING % |
|---|---|---|
| Leg compression | 220' to 230' | 11 |
| | 200' to 220' | 42 |
| | 180' to 200' | 81 |
| | 160' to 180' | 101 |
| | 140' to 160' | 93 |
| | 120' to 140' | 94 |
| | 100' to 120' | 105 |
| | 80' to 100' | 103 |
| | 60' to 80' | 97 |
| | 40' to 60' | 85 |
| | 20' to 40' | 95 |
| | 0' to 20' | 105 |
| Leg tension | 220' to 230' | 3 |
| | 200' to 220' | 25 |
| | 180' to 200' | 40 |
| | 160' to 180' | 60 |
| | 140' to 160' | 50 |
| | 120' to 140' | 56 |
| | 100' to 120' | 73 |
| | 80' to 100' | 81 |

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| | | |
|---|---|---|
| Leg tension | 60' to 80' | 75 |
| | 40' to 60' | 68 |
| | 20' to 40' | 75 |
| | 0' to 20' | 105 |
| Diagonals | 220' to 230' | 43 |
| | 200' to 220' | 81 |
| | 180' to 200' | 93 |
| | 160' to 180' | 98 |
| | 140' to 160' | 86 |
| | 120' to 140' | 100 |
| | 100' to 120' | 105 |
| | 80' to 100' | 99 |
| | 60' to 80' | 103 |
| | 40' to 60' | 65 |
| | 20' to 40' | 71 |
| | 0' to 20' | 75 |
| Horizontals | 220' to 230' | 9 |
| | 200' to 220' | 20 |
| | 40' to 60' | 72 |
| | 20' to 40' | 96 |
| | 0' to 20' | 61 |
| Secondary Bracing Members | 40' to 60' | 102 |
| | 20' to 40' | 82 |
| | 0' to 20' | 59 |
| Foundations | Compression | 104 |
| | Uplift | 105 |

Ratings of up to 105% are considered acceptable due to tolerances in calculating the applied loads on the tower as well as member design capacities.

The tower twist and sway at the elevations of the various dishes under a service wind speed of 60 mph are as follows:

| Dish | Elevation, ft. | Sway, degrees | Twist, degrees |
|---|---|---|---|
| 8' dish/radome | 225' | 0.28 | 0.07 |
| 8' grid dish | 223' | 0.28 | 0.07 |
| (2) 8' dishes | 220' | 0.28 | 0.07 |
| 8' dish/radome | 190' | 0.25 | 0.04 |
| 8' grid dish | 178' | 0.24 | 0.03 |
| SP2-5.2 dish | 157' | 0.20 | 0.02 |
| 6' dish/radome | 95' | 0.11 | 0.01 |
| 4' standard | 82' | 0.09 | 0.01 |

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## G. CONCLUSIONS AND RECOMMENDATIONS

Based on the preceding results, the following conclusions may be drawn:

1. The tower, with equipment as specified in Section C and all tower modifications per Stainless Design Drawings dated 1/28/2016 installed, is adequate to achieve an ultimate design wind speed of 117 mph with no ice, and a nominal design wind speed of 40 mph with 1" design ice thickness in accordance with IBC 2009 and ANSI/TIA 222-G and the analysis parameters of Section D.

## H. PROVISIONS OF ANALYSIS

The analysis performed and the conclusions contained herein are based on the assumption that the tower has been properly installed and maintained, including, but not limited to the following:

1. Proper alignment and plumbness.
2. Correct bolt tightness.
3. No significant deterioration or damage to any component.

Furthermore, the information and conclusions contained in this Report were determined by application of the current "state-of-the-arts" engineering and analysis procedures and formulae, and Stainless assumes no obligations to revise any of the information or conclusions contained in this Report in the event that such engineering and analysis procedures and formulae are hereafter modified or revised. In addition, under no circumstances will Stainless have any obligation or responsibility whatsoever for or on account of consequential or incidental damages sustained by any person, firm or organization as a result of any information or conclusions contained in the Report, and the maximum liability of Stainless, if any, pursuant to this Report shall be limited to the total funds actually received by Stainless for preparation of this Report.

Customer has requested Stainless to prepare and submit to Customer an engineering analysis with respect to the Subject Tower and has further requested Stainless to make appropriate recommendations regarding suggested structural modifications and changes to the Subject Tower. In making such request of Stainless, Customer has informed Stainless that Customer will make a determination as to whether or not to implement any of the changes or modifications which may be suggested by Stainless and that Customer will have any such changes or modifications made by riggers, erectors and other subcontractors of Customer's choice.

Customer hereby agrees and acknowledges that Stainless shall have no liability whatsoever to Customer or to others for any work or services performed by any persons other than Stainless in connection with the implementation of any structural changes or modifications

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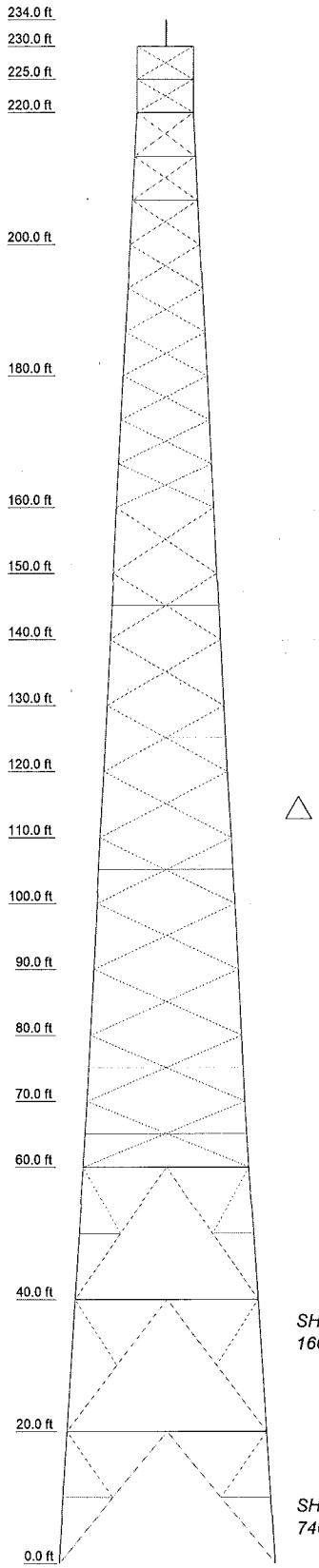
recommended by Stainless including but not limited to any services rendered for Customer or for others by riggers, erectors or other subcontractors. Customer acknowledges and agrees that any riggers, erectors or subcontractors retained or employed by Customer shall be solely responsible to Customer and to others for the quality of work performed by them and that Stainless shall have no liability or responsibility whatsoever as a result of any negligence or breach of contract by any such rigger, erector or subcontractor.

| Section | T18 | T17 | T16 | T15 | T14 | T13 | T12 | T11 | T10 | T9 | T8 | T7 | T6 | T5 | T4 | T3 | T2 | T1 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Legs | PIPE6.0E.H | | | PIPE5.0E.H | | | PIPE5.0STD | | | PIPE4.0E.H | | PIPE3.5E.H | | PIPE3.0STD | PIPE2.5E.H. | | A | |
| Leg Grade | A572-50 | | | | | | | | | | | | | | | | | |
| Diagonals | PIPE3.0STD | | | L4x4x1/4 | | | | D | C | L3x3x1/2 | L3x3x3/8 | L3x3x5/16 | L3x3x1/4 | L3x3x3/16 | L2 1/2x2 1/2x3/16 | L2x2x3/16 | B | |
| Diagonal Grade | A500-50 | | | | | | | | | | | A36 | | | | | | |
| Top Girts | PIPE3.0STD | PIPE2.5STD | | | | | N.A. | | | | | | | | | L2x2x3/16 | | E |
| Horizontals | | | | | | | | N.A. | | | | | | | | L2x2x3/16 | | N.A. |
| Sec. Horizontals | | N.A. | | G | F | | N.A. | | F | N.A. | 2L2x2x1/4 | 2L2x2x1/4 | | | N.A. | | | |
| Red. Horizontals | PIPE2.0STD | | P1.5"ODx0.1875 | | | | | | | | | N.A. | | | | | | |
| Red. Diagonals | | PIPE2.0STD | PIPE1.5STD | | | | | | | | | N.A. | | | | | | |
| Red. Hips | | P1.5"ODx0.1875 | | | | | | | | | | N.A. | | | | | | |
| Inner Bracing | | L2x2x3/16 | | | | | | | | | | N.A. | | | | | | |
| Face Width (ft) 32.625 | 30.13 | 27.63 | 24.96 | 23.87 | 22.78 | 21.825 | 20.87 | 19.785 | 18.7 | 17.7 | 16.7 | 15.68 | 14.66 | 12.6 | 10.56 | | 8.54 | |
| # Panels @ (ft) | | 3 @ 20 | | | | | | 10 @ 10 | | | | | | | 9 @ 6.66667 | | 2 @ 5 | |
| Weight (lb) 34810.8 | 4503.4 | 4176.5 | 3848.0 | 2586.4 | 2245.5 | 1944.7 | 1610.3 | 2132.2 | 1416.9 | 2017.4 | 1359.5 | 1429.9 | 962.1 | 1572.4 | 1291.5 | 1264.8 | 326.4 | 319.8 |




## DESIGNED APPURTENANCE LOADING

| TYPE | ELEVATION | TYPE | |
|---|---|---|---|
| Beacon, misc on top | 230 | 6 panel antenna on Sector Frames | |
| ENG antenna | 230 | Proposed Verizon Equipment | |
| ENG antenna | 230 | Panel type antenna | |
| 8' dish | 225 | Yagi antenna | 120 |
| 8' grid dish | 223 | OB light | 115 |
| 8' dish (prop) | 220 | ENG Receive antenna | 100 |
| 8' dish (prop) | 220 | 6' dish with radome | 95 |
| 8' dish radome | 190 | Dipole antenna | 90 |
| 8' grid dish | 178 | 4' dish | 82 |
| 12' whip antenna | 165 | Rest Platform | 80 |
| Proposed T-Mobile Equipment (w/dish) | 157 | Yagi antenna | 30 |

## SYMBOL LIST

| MARK | SIZE | MARK | SIZE |
|---|---|---|---|
| A | PIPE2.5STD | E | L2 1/2x2 1/2x3/16 |
| B | L1 3/4x1 3/4x1/8 | F | 2L2 1/2x2 1/2x1/4 |
| C | L3 1/2x3 1/2x5/16 | G | 2L2 1/2x2 1/2x3/8 |
| D | L3 1/2x3 1/2x3/8 | | |

## MATERIAL STRENGTH

| GRADE | Fy | Fu | GRADE | Fy | Fu |
|---|---|---|---|---|---|
| A572-50 | 50 ksi | 65 ksi | A500-50 | 50 ksi | 62 ksi |
| A36 | 36 ksi | 58 ksi | | | |

## TOWER DESIGN NOTES

1. Tower designed for Exposure C to the TIA-222-G Standard.
2. Tower designed for a 91 mph basic wind in accordance with the TIA-222-G Standard.
3. Tower is also designed for a 40 mph basic wind with 1.00 in ice. Ice is considered to increase in thickness with height.
4. Deflections are based upon a 60 mph wind.
5. Tower Structure Class II.
6. Topographic Category 1 with Crest Height of 0.00 ft

*ALL REACTIONS ARE FACTORED*

*MAX. CORNER REACTIONS AT BASE:*
*DOWN: 346150 lb*
*SHEAR: 44545 lb*

*UPLIFT: -285327 lb*
*SHEAR: 38350 lb*

*AXIAL 229796 lb*

*SHEAR 16690 lb* — *MOMENT 2214998 lb-ft*

*TORQUE 8481 lb-ft*
*40 mph WIND - 1.0000 in ICE*

*AXIAL 71807 lb*

*SHEAR 74625 lb* — *MOMENT 9119125 lb-ft*

*TORQUE 40854 lb-ft*
*REACTIONS - 91 mph WIND*

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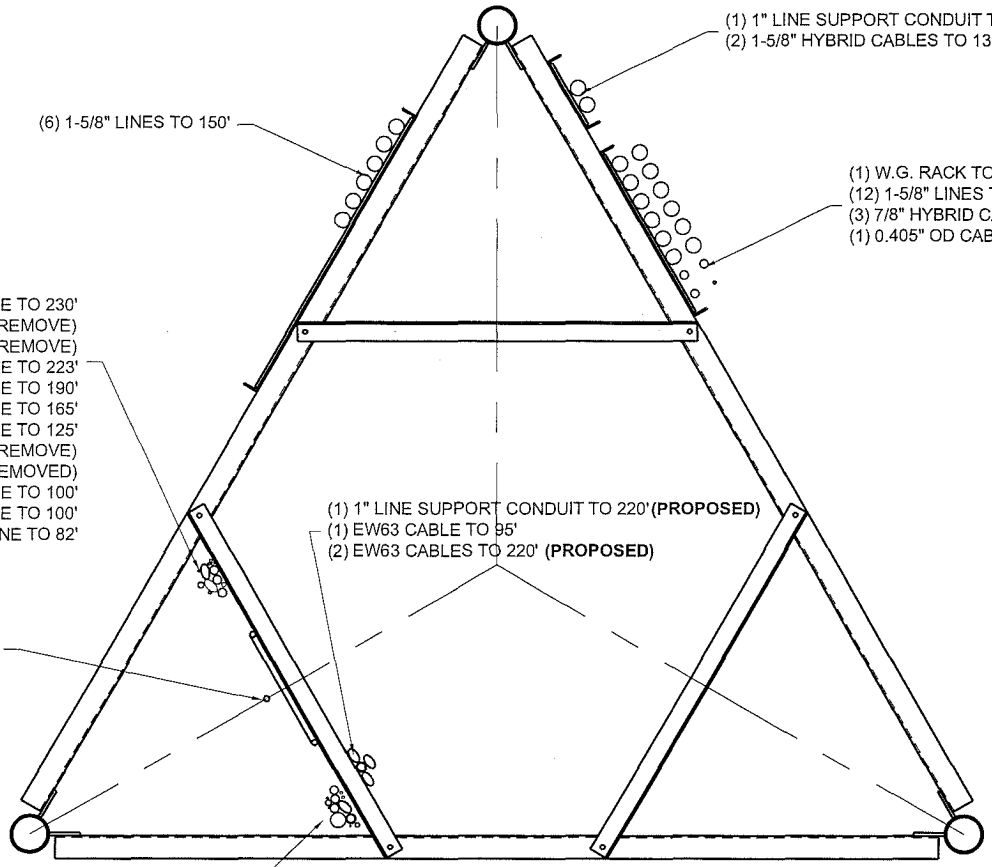
Stainless
100 West Main Street
Lansdale, PA 19446
Phone: (215)631-1400
FAX: (215)631-1425
Tower Engineers


| | |
|---|---|
| Job: | T063301; PORTLAND, ME |
| Project: | 230-ft ROHN SELF SUPPORTING TOWER, PASSING STRUCTURAL ANALYSIS |
| Client: | STRUCTURE CONSULTING GROUP/NPM, INC |
| Drawn by: | Changfei Chen |
| App'd: | |
| Code: | TIA-222-G |
| Date: | 03/22/16 |
| Scale: | NTS |
| Path: | K:\T063301\eng\tnxtower\T063301_PASSING_ANALYSIS.eri |
| Dwg No. | E-1 |




**TYPICAL CROSS SECTION**

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| REV | BY | DATE | REVISION DESCRIPTION | D.CK | DATE | E.CK | DATE |
|---|---|---|---|---|---|---|---|
| A | PCC | 12/4/2015 | ADD PROPOSED WAVEGUIDE RACK AND LINES TO 130' | | | | |

PREPARED BY: PCC 03/15/2016
CHECKED BY:
ENGINEER REVIEW:
PROJECT NUMBER:
DRAWING NUMBER:

STAINLESS
A Business of TOWER ENGINEERS
100 West Main Street, Suite 400
Lansdale, PA 19446

LINEAR APPURTENANCES
PORTLAND, ME

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