Investigation of the February 1, 2014 Collapse of a Telecommunication Tower at the Summit Park Community in Clarksburg, WV

U.S. Department of Labor
Occupational Safety and Health Administration
Directorate of Construction

July 2014
Investigation of the February 1, 2014 Collapse of a Telecommunication Tower at the Summit Park Community in Clarksburg, WV

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Attachment A – Selected Pages of the Related Industry Standards.

Attachment B – Evaluation of the Capacity of the Horizontal Braces as the Anchorage for the Personal Fall Arrest System.

This report was prepared by
Mohammad Ayub, P.E., S.E.
Scott Jin, Ph.D., P.E.
Office of Engineering Services
Directorate of Construction
Introduction

On February 1, 2014, at approximately 11:37 a.m., a 340'-high guyed telecommunication tower (cell tower), suddenly collapsed during upgrading/construction activities. Four employees were working on the tower removing its diagonals. In the process, no temporary supports were installed. As a result of the tower’s collapse, two employees were killed and two others were badly injured. The cell tower fell onto the guy wires of an adjacent smaller cell tower and caused it to collapse, killing a firefighter while he was rescuing the injured employees on the ground. The collapse of the smaller tower is not covered in this investigation.

The Occupational Safety and Health Administration’s (OSHA) Regional Administrator, Region III, asked the Directorate of Construction (DOC) in OSHA’s National Office in Washington, DC, to provide technical assistance in a causal determination and to provide engineering assistance to the OSHA Charleston Area Office in its investigation. A civil engineer from the DOC visited the incident site from February 5–7 to inspect the collapsed tower, examine the failed pieces, and discuss the sequence of events with representatives of the tower’s owner.

DOC reviewed the following documents:

- Photographs of the incident taken by the OSHA Charleston Area Office.
- Notes and records (27 pages) from the West Virginia State Police (WVSP).
- Taped records of four witness interviews conducted by WVSP.
- Photographs of the incident taken by WVSP.
- Inspection report on Despard Tower 1, prepared by FDH Engineering, Inc., April 2013.
- Original design of Despard Tower 1, certified by Thomas W. Schepke, PE, UNR-ROHN, October 1990.

The Project

The project was to upgrade and modify an existing 340' guyed cell tower by replacing diagonals, adding angle leg reinforcements, and replacing guy wires (See Figure 1). The tower was located at the Summit Park Community, Harrison County, West Virginia. The site name was Despard (Tower 1). The site number was WV08612-A-02. The site address was 9141 Murphy’s Run Road, Clarksburg, West Virginia.
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The triangular tower was originally designed by UNR-ROHN of Peoria, IL in 1990 and was assembled with pre-fabricated ROHN 80 sections. SBA Network Services, Inc. (SBA) of Boca Raton, FL was the owner of the tower and the associated site. SBA retained FDH Engineering, Inc. (FDH) of Raleigh, NC as the structural engineer of record (SER) to provide engineering services to upgrade and modify the tower. FDH inspected the tower in April 2013, performed structural analysis of the tower and made recommendations in June 2013. FDH prepared modification drawings in August 2013.

FDH retained SNS Communication Specialists, Inc. (SNS) of Bokoshe, OK as the contractor (erector) to perform the required modifications to the tower. SNS started to mobilize equipment...
and materials at the site on January 27, 2014. SNS started the construction work by placing new
guy wires on the ground and prepared to replace diagonals on the tower as identified by FDH.

The Incident

February 1, 2014, the day of the incident, was the first day SNS began construction activities on
the tower. SNS had a foreman and five employees at the site. Three employees, one on each
face of the tower, started to remove the existing diagonals from the tower legs at approximately
70' from the ground and progressed upward. The fourth employee was bringing the removed
diagonals from the tower down to the ground and to the welder (the fifth employee) at the
workstation approximately 50' away from the tower base. Based on the actual hole distance of
the removed diagonals, the welder would cut new steel angle pieces, drill holes at its ends, paint
and take pictures before sending them up as replacements.

The old diagonals were removed without installing any temporary supports to offset the loss of
strength of the tower. The tower suddenly collapsed at approximately 11:37 a.m. At the time of
the collapse, two old pipe diagonals and one old steel angle diagonal were identified at the
workstation (Figure 2). One old pipe diagonal was located on the passageway near the tower
(Figure 3). Another old diagonal that was wrapped with a rope remained in place on the way
down from the tower (Figure 4). Thus, a total of five old diagonals were recovered at the site
away from the tower. In addition, SBA safety personnel also recovered eight used (old)
connecting bolts from the work bags of the injured employees. It is believed that these bolts
were used to connect the diagonals at the lugs of the tower legs.

![Figure 2](image-url)  Two old pipe diagonals and one old steel angle diagonal were found at the workstation.
Figure 3. The fourth round diagonal, removed earlier from the tower, was found on the passageway near the tower.

Figure 4. The fifth round diagonal, still fastened to a rope, was found on the way down from the tower.
Observations of the Collapsed Tower

From observations of the collapsed tower, it appeared that the top 190' of the tower dropped nearly vertically to the ground. This portion of the tower then tilted and fell towards the northwest direction (see Figures 5, 6 and 7). The bottom 150' of the tower folded back-and-forth in the southwest and northeast directions like a folding ladder (Figures 8 through 12). In Figure 8, the bottom of the tower shifted only approximately 2' from its original position during the collapse. In Figure 12, the top of the lower portion of the tower, at approximately 150' from the base, fell to the ground within a 10' radius of the concrete foundation.

From the above description, it is believed that the top 190' of the tower was essentially intact before the collapse. The day of the incident was the first day the contractor did work on the tower. The contractor had removed five diagonals from the tower and disabled six diagonals (see explanations in Pages 13 and 14) without providing any temporary bracings to the tower between 70' to 80' from its base. This improper construction procedure would significantly increase the unbraced length and decrease the compressive capacity of the tower legs in this 10' length. As a result, the tower was subject to bending or folding at approximately 75' due to the existing vertical loads. The bending and folding of the tower proceeded downward to the base and upward to approximately 150'. Perhaps due to the lesser vertical loads and the effect of the upper guy wires, the bending and folding of the tower stopped at 150'. Thus, it is believed that the inadequate construction procedures initiated the collapse of the tower.

Figure 5. The upper portion of the collapsed tower, approximately from 150' to 190' above the ground (looking northeast).
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Figure 6. The upper portion of the collapsed tower, approximately from 175' to 240' above the ground (looking northeast).

Figure 7. The upper portion of the collapsed tower, approximately from 220' to the top of the tower at 340' above the ground (looking northeast).
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Figure 8. The lower portion of the folded and collapsed tower at its northwest end. Note that the 150' mark of the tower is at the lower-left corner of the photo and the base of the tower is at the lower-middle of the photo (WVSP Photo 5920, looking east).

Figure 9. The lower portion of the folded and collapsed tower at its southeast end (WVSP Photo 5924, looking northeast).
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Figure 10. The lower portion of the folded and collapsed tower at its southeast end (WVSP Photo 5864, looking southwest).

Figure 11. The lower portion of the folded and collapsed tower at the middle of the collapsed pile (WVSP Photo 5868, looking southwest).
Analysis

The guyed tower was a tall and slender structure designed primarily to support the axial compressive loads or the gravity loads arising from its own weight and the weights of antennas, dishes, coaxes, ice, etc., that were mounted or fell on it. The tower must be properly plumbed by the guy wires to minimize any flexural stresses. The bottom of the tower is usually pin connected to its foundation to eliminate any flexural stresses. All lateral forces from wind, earthquake, etc. applied to the tower were resisted by a series of pre-tensioned guy wires at different elevations.

The strength of a compressive member is determined by its unbraced length. It is, therefore, critical that the tower legs remain braced to maintain its capacity to carry the loads. The bracings must be placed in two different horizontal directions to ensure stability of the tower legs. The axial compressive capacity of a member is inversely proportional to the square of its unbraced length. In other words, if the unbraced length of the tower legs is doubled, the compressive capacity will be reduced to 25% of its original capacity.

In Figure 1, the tower in this project was constructed with seventeen sections of ROHN 80. Each section was 20' in length. The bottom section had a 5' tapered base. Except for the twelfth section, from 220' to 240' above ground, the tower was double braced to support the torque arm, while the remaining sixteen sections were single braced as shown in Figure 13. From this figure,
the tower was triangular in shape. Each tower leg consisted of 2" diameter steel pipes. They were 41" apart. The unbraced length of the tower leg was approximately 4'-10" for the single-braced section and 2'-5" for the double-braced section.

Figure 13. ROHN Standard 80 Series guyed tower section (modified from ROHN Products LLC, Product Catalog No. 3, Page 155, 2013).
In Figure 14, at each welded lug of the tower leg, there was one bolt connecting two diagonals. One diagonal had two holes for connection, one at each end. Thus, removing one bolt would disable two diagonals, although they would still be connected to the tower at the other ends. Figure 15 shows a disabled diagonal still attached to the collapsed tower.

Figure 14. Welded lug of the tower leg; one bolt connects two diagonals.

Figure 15. A diagonal disabled by being unbolted from the lug. It is still attached to the tower.
Removing bolts at each end of one diagonal would separate the diagonal completely from the tower but this would also disable two adjacent diagonals. For simplicity, three faces of the triangular tower are laid out in one plane as shown in the upper portion of Figure 16. In this figure, when eight bolts were removed, it produced six disabled diagonals (in dash lines) and five separated diagonals (in red lines). It should be noted that the numbers of removed bolts, disabled diagonals, and separated diagonals were consistent with the collections from the incident site.

Principles of structural mechanics require that a column be laterally braced in two principal directions. When the unbraced lengths in the two directions are not equal, the longer unbraced length governs, if the sectional properties of the column are same in these two directions. Thus, from the configurations and explanations in Figure 16, the unbraced length of each tower leg was estimated to be 9'-8" for leg A, and 14'-6" for legs B and C.
Based on the unbraced length of 14'-6" and the section properties of the leg at a height of 70' above ground, the ultimate compressive capacity of leg B or C was calculated to be 6.78 kips per leg, disregarding any factor of safety. The vertical loads, including the weight of the tower above, the half weight of the guy wires and the vertical components of the tensile force in guy wires were computed to be 8.82 kips per leg. The actual vertical load was greater than the ultimate compressive capacity of the leg. Thus, the tower legs B and C failed as the diagonals were removed without installing any temporary supports. As a result, the tower collapsed. It should be noted that the above vertical load computations did not include the weight of antennas, dishes, coaxes, ice, etc.

**Discussion**

One of the recognized industry standards for “Installation, Alteration and Maintenance of Antenna Supporting Structures and Antennas” is ANSI/TIA -1019-A-2012. The industry standard requires that:

- Proposed activities shall be classified in accord with the Table 2-1 of the standard (Section 2.2).
- For Class II, III and IV construction, a written rigging plan shall be established showing the construction sequence, and “procedures for the removal or reinforcing of structural members” (Section 2.2.2, and Annex D).
- A qualified engineer shall be involved in establishing such a written plan (Section 2.2.1).
- Temporary member capable of supporting the loading condition shall be provided when removing a structural member, such as a diagonal (Section 2.7.1).

(It should be noted that a copy of the above mentioned sections is included in Attachment A.)

The contractor was engaged in removal of diagonals. ANSI/TIA-1019-2012 identifies diagonals as structural members; see Section 2.7.1 of the standard. Removal of a structural member falls under Class IV of Table 2-1 which establishes a minimum level of responsibility to a “qualified person with qualified engineer.” Section 2.2 of the standard requires that a written rigging plan be established. Section 2.2.1 further states that for Class III and IV construction, a qualified person shall coordinate the involvement of a qualified engineer when establishing rigging plans.

The contractor violated the industry standard ANSI/TIA-1019-A-2012 in that:

1. No written rigging plan was established showing the manner, sequence and number of diagonal to be removed at a time.
2. No qualified engineer was involved in establishing any rigging plan.
3. No temporary supports were provided when removing structural members.

Another industry standard is ANSI/TIA-222-G-2005 entitled “Structural Standard for Antenna Supporting Structures and Antennas”. Section 16.0 of the standard states that “Rigging and
temporary supports such as temporary guys, braces, false work, cribbing or other elements required for erection/modification shall be determined, documented, furnished and installed by the erector accounting for the loads imposed on the structure due to the proposed construction methods.” The contractor violated this standard by not providing any temporary supports while removing diagonals from the tower.

It should be noted that the Contact Drawing N-2, Contractor Qualification Note 1, requires that “All repairs shall be performed by a tower contractor with a minimum 5 years experience in tower erection and retrofit and with working knowledge of the ANSI/TIA-222-G.” In addition, Contractor Qualification Note 4, requires that “All construction to be in accordance with the ANSI/TIA-1019-A Standard.”

Figure 17 shows that the snap hook from one of the injured employees was attached and anchored to a horizontal bracing member of the tower. The horizontal bracing was a steel pipe with 1½" O.D. x 16 GA in size and 2'-10" in span (ROHN Commercial Products, Drawing No. C681228 R5, 1981). The maximum vertical load at the mid span, based on the plastic flexural capacity of the pipe, was estimated to be approximately 600 pounds (see Attachment B). OSHA standard 1926.502(d)(15) requires that “Anchorages used for attachment of personal fall arrest equipment shall be ... capable of supporting at least 5,000 pounds (22.4 kN) per employee attached, or shall be designed, installed, and used as follows: (i) as part of a complete personal fall arrest system which maintains a safety factor of at least two; and...”

Figure 17. The snap hook from one of the injured employees was anchored to a horizontal bracing member of the tower (WVSP Photo 5969).
Figure 17 also shows that the other end of the snap hook was connected to a shock-absorbing lanyard, which was typically capable of limiting the maximum fall arrest force to approximately 900 pounds. With the minimum required safety factor of two, the anchorage for the shock-absorbing lanyard must be capable of supporting a vertical load of at least 1,800 pounds without failure. But, the horizontal bracing member had a vertical load capacity of 600 pounds, much less than the required anchorage capacity. Thus, the contractor did not comply with OSHA standard 1926.502(d)(15).

From the witness accounts and the climatological data from the Harrison/Marion Regional Airport, at the time of the collapse, there was no measurable wind at the incident site. Therefore, wind was not a causal factor of the tower collapse.

Conclusions

1. The cause of the cell tower collapse was the simultaneous removal of multiple diagonals from different faces of the tower compromising the load carrying capacity of the tower legs. No temporary supports were provided prior to the diagonal removing process.

2. The contractor did not comply with the industry standard – ANSI/TIA-1019-A, Section 2.2. Rigging Plans and Section 2.7. Temporary Supports, when removing diagonals from the tower:
   • No written rigging plan was established showing the manner, sequence and number of diagonal to be removed at a time.
   • No qualified engineer was involved in establishing any rigging plan.
   • No temporary supports were provided when removing structural members.

   In addition, the contractor did not comply with the industry standard – ANSI/TIA222-G, Section 16.0 Installation; by not providing any temporary supports while removing diagonals from the tower.

   Thus, the contractor violated Occupational Safety and Health Act of 1970, Section 5(a)(1).

3. One of the personal fall arrest systems used by the employees was anchored to a horizontal bracing member of the tower. A shock-absorbing lanyard was used in this system. Under this condition, the maximum fall arrest force was limited to approximately 900 pounds. The minimum required anchorage capacity would need to have been approximately 1,800 pounds to achieve a safety factor of two. However, the horizontal bracing member had a capacity of 600 pounds less than the required anchorage capacity. Thus, the contractor did not comply with OSHA standard 1926.502(d)(15).

4. Wind was not a causal factor of the tower collapse.
ATTACHMENT A

SELECTED PAGES OF THE RELATED INDUSTRY STANDARDS
TIA STANDARD

Standard for Installation, Alteration and Maintenance of Antenna Supporting Structures and Antennas

TIA-1019-A  September 2012
2. CONSTRUCTION CONSIDERATIONS

2.1. Scope
This section describes the considerations and processes to investigate strength and stability when installing, removing or altering antenna supporting structures or antennas and when adding or removing appurtenances and construction equipment.

2.2. Rigging Plans
All construction shall be classified in accordance with Table 2-1 based on the scope of the proposed construction work.

Proposed activities shall be outlined in a written rigging plan prior to implementation of Class II, III and IV construction.

The minimum level of responsibility for establishing a rigging plan is specified in Table 2-1.

2.2.1. Rigging Plan Requirements
An onsite Competent Rigger shall be identified for all classes of construction for identifying hazards and for authorizing prompt corrective measures as required. For Class III and IV Construction, a Qualified Person shall coordinate the involvement of a Qualified Engineer as required (i.e. satisfying Sections 2.7 Temporary Supports, Section 4 Supporting Structure Loading, etc.) when establishing rigging plans. A Qualified Engineer shall perform the analysis of structures and/or components for Class IV Construction.

2.2.2. Rigging Plan Considerations
The rigging plan shall consider the following in accordance with this Standard as applicable:
   a) Operational and non-operational construction loads (refer to Section 4.3).
   b) Construction equipment.
   c) Supporting structure.
   d) Construction sequence and duration.
   e) Required load testing and field monitoring.

Note: Refer to Annex D for a rigging plan template.

2.3. Construction Equipment

2.3.1. General Considerations
The effects on the structure from heel (base) blocks, crown (top) blocks and other similar connection devices that apply horizontal and vertical forces to the structure shall be considered.
2.6.3. Hoist Mechanisms


2.6.4. Capstan Hoists

Anchorage of capstan hoists shall be in accordance with Section 2.6.1. Capstan hoists shall not be used to raise or lower personnel or to lift loads directly over personnel.

The operator shall be properly trained on the operation of the capstan hoist. The number of wraps of rope on the capstan drum shall be consistent with the magnitude of the lift load and manufacturer’s recommendation. The number of wraps on the drum shall be limited to prevent the rope from riding over the end of the drum. Precautions shall be taken to prevent entanglement of other lines with the capstan rope. A rope splice shall not be in contact with the capstan drum.

2.7. Temporary Supports

The potential for partial or complete collapse of a structure may exist when constructing, dismantling or altering structural components of a structure. A procedure defining critical steps in the process shall be provided and followed by the rigging crew during all phases of the work. Such a procedure shall take into consideration temporary reinforcing of members to support the structure while structural components are disconnected or altered and the potential of guy slippage. The procedure shall account for the loading conditions in Section 4.

2.7.1. Structural Members

Temporary members capable of supporting the loading conditions in Section 4 shall be provided when removing a structural member, such as a diagonal, horizontal or vertical member, refer to Figures 2-2 a, b, c, & d, except when a structural analysis indicates otherwise and is documented in the rigging plan.

2.7.2. Guy Replacement

Temporary guys capable of supporting the loading conditions referenced in Section 4 are required when replacing existing guys, refer to Figure 2-3, except when a structural analysis indicates otherwise and is documented in the rigging plan. Vertical alignment, reduction of initial guy tensions, local structure forces and eccentric connections at guy anchors shall be considered in the rigging plan. The strength requirements of temporary guys shall comply with Section 2.7.5.

2.7.3. Guy Anchorage Inspection, Replacement or Alteration

Temporary supports shall be considered throughout foundation inspection, replacement or alteration activities. Temporary supports shall meet the loading conditions of Section 4. When inspection of an anchorage determines degradation of the anchor may be significant, the use of temporary supports shall be considered.
<table>
<thead>
<tr>
<th>Class</th>
<th>Description</th>
<th>Minimum Level of Responsibility</th>
</tr>
</thead>
<tbody>
<tr>
<td>I</td>
<td>The scope of work does not affect the integrity of the structure and the proposed rigging loads are minor in comparison to the strength of the structure, but not exceeding rigging forces greater than 650 lbs.</td>
<td>Competent Rigger</td>
</tr>
<tr>
<td>II</td>
<td>The scope of work involves the removal or the addition of appurtenances, mounts, platforms, etc. that involve minor rigging loads in comparison to the strength of the structure, but not exceeding rigging forces greater than 1,000 lbs.</td>
<td>Competent Rigger</td>
</tr>
<tr>
<td>III</td>
<td>Rigging plans that involve work outside the scope of Class I, II or IV construction.</td>
<td>Qualified Person</td>
</tr>
<tr>
<td>IV</td>
<td>The scope of work involves custom or infrequent construction methods, removal of structural members or unique appurtenances, special engineered lifts, and unique situations.</td>
<td>Qualified Person with Qualified Engineer</td>
</tr>
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</table>
ANNEX D: RIGGING PLANS (NORMATIVE)

D1. Scope
The intent of this annex is to provide information required to develop a Rigging Plan.
A rigging plan is intended to ensure that the proper procedures, equipment and rigging is used for each operation and to ensure that the supporting structure can support the rigging loads.
A rigging plan may be very detailed and complex or very simple, depending on the type of job and the type of equipment necessary to complete the job.

D2. Rigging Plan
The following data shall be considered when completing a Rigging Plan:

A. General
   1. Scope of work
   2. Construction sequence
   3. Duration of construction
   4. Monitoring requirements
   5. Rigging plan classification
   6. Gross loads to be lifted
   7. Height of lift
   8. Operational and non-operational wind loadings
   9. Load lifting restrictions

B. Gin Poles
   1. Vertical or tilted position
   2. Gin pole identification number
   3. Load chart reference number
   4. Maximum cantilever required
   5. Maximum load line positioning angle
   6. Load line size and number of parts

C. Basket and Bridle Attachments
   1. Sling size, type, angle and connection details to the structure and to the gin pole

D. Jumping of a Gin Pole
   1. Jump line size and number of parts
   2. Block sizes and connection details
   3. Gin pole attachment details
   4. Track details and connections to the structure

E. Hoists
   1. Load chart indicating line pull based on number of layers on the drum
   2. Hoist line pull required
   3. Cable sizes and breaking strengths
   4. Hoist anchorage details
   5. End connection efficiencies
6. Distance and orientation from tower base

F. Base Blocks
   1. Block size and capacity
   2. Sling size and applicable rigging hardware
   3. Attachment details to the structure, foundation or other support

G. Crown Blocks
   1. Block size and capacity
   2. Sling size and applicable rigging hardware
   3. Attachment details to the structure

H. Tag Lines
   1. Straight or trolley
   2. Size and type of tag line
   3. Tag angle restrictions

I. Cranes
   1. Main
   2. Tailing
   3. Pedestal
   4. Chicago boom

J. Supporting Structure
   1. Condition assessment
   2. Temporary guys
   3. Reinforcement to support the rigging loads
   4. Procedures for the removal or reinforcing of structural members
   5. Procedures for guy replacement
   6. Procedures for guy tensioning
   7. Guy slippage considerations

K. Miscellaneous
   1. Headache ball
   2. Condition of appurtenances to be removed
   3. Interference with climbing facilities
   4. Field welding and cutting procedures
D3. Rigging Plan Templates

The type of rigging plan created must be applicable to the proposed construction and/or maintenance and be classified in accordance with Section 2.2.

D3.1. General Data

The following template is intended to be generic and modified for site-specific applications:

<table>
<thead>
<tr>
<th>Rigging Plan</th>
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<tbody>
<tr>
<td><strong>Site Information</strong></td>
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<td>Pole</td>
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<tr>
<td><strong>Type of Work</strong></td>
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<td>Installation of New Structure</td>
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<td>Add or Remove TX Lines</td>
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<td>Replace Structural Members</td>
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<td>Change Guys</td>
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<td><strong>Construction Sequence</strong></td>
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<td>Construction Duration</td>
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Field Monitoring
TIA STANDARD

Structural Standard for Antenna Supporting Structures and Antennas

EFFECTIVE JANUARY 1, 2006

TIA-222-G
(Revision of TIA/EIA-222-F)

August 2005

TELECOMMUNICATIONS INDUSTRY ASSOCIATION

Representing the telecommunications industry in association with the Electronic Industries Alliance

Electronic Industries Alliance
15.7 Modification of Existing Structures

15.7.1 Design
Modifications to existing structures shall be based on a rigorous structural analysis. A design document shall be prepared indicating the proposed reinforcement of existing members and/or connections and all proposed additional members.

Prior to implementation of the changed conditions and/or modifications, the data designated on the design document requiring verification shall be validated.

16.0 INSTALLATION

Rigging and temporary supports such as temporary guys, braces, false work, cribbing or other elements required for the erection/modification shall be determined, documented, furnished and installed by the erector accounting for the loads imposed on the structure due to the proposed construction method.
PROJECT DESCRIPTION:
MODIFICATION DRAWINGS
FOR A 340' GUYED TOWER

SITE NAME:
DESPARD (TOWER 1)

SITE NUMBER:
WV08612-A-02

SITE ADDRESS:
9141 MURPHY ROAD
CLARKSBURG, WV 26301

COORDINATES:
LATITUDE: 39.2981°
LONGITUDE: -80.2996°
GENERAL NOTES:

1. ALL WORK SHALL BE DONE IN ACCORDANCE WITH ALL APPLICABLE FEDERAL, STATE, AND LOCAL LAWS AND ORDINANCES. IT IS THE CONTRACTOR'S RESPONSIBILITY TO OBTAIN ALL PERMITS NECESSARY TO COMPLETE THE PROJECT AND ADEQUATE CONSENT OF ALL CONDITIONS.

2. THE CONTRACTOR SHALL BE RESPONSIBLE FOR VOUCHER OF ALL Dimensions, Elevations and existing Conditions at the Site and any other data such as reports, specifications, or contracts. The owner reserves the right to make changes at any time during the construction period. The owner shall not be responsible for any losses or damages incurred by the contractor due to such changes.

3. INCOMPLETE, READY, OR OTHERWISE DEFICIENT, REPORTS TO THE CONTRACTOR FOR ENGINEERING APPROVAL.

4. IT IS THE CONTRACTOR'S SOLE RESPONSIBILITY TO DETERMINE THAT THE STRUCTURE AND ITS COMPONENT PARTS ARE CORRECTLY ERected AND/OR FIELD INSPECTIONS TAKEN. THIS INCLUDES, BUT IS NOT LIMITED TO, THE ACCURACY OF ALL INFORMATION RELATING TO THE STRUCTURE AND THAT MAY BE NECESSARY. SUCH MATERIAL IS NOT TO BE REMOVED AFTER THE COMPLETION OF THE PROJECT.

5. CONTRACTOR SHALL PROPERLY REMOVE ANY & ALL DEBRIS FROM THE SITE AND RESTORE AS BEFORE AS POSSIBLE TO PREVENT CONSTRUCTION CONSEQUENCES.

CONTRACTOR QUALIFICATION NOTES:

1. ALL WORKS SHALL BE PERFORMED BY A TOWNE CONTRACTOR. THE TOWNE CONTRACTOR IS AUCTIONED FOR THE WORK OF INSTALLING STRUCTURAL STEEL AND WELDING.

2. CONTRACTOR IS RESPONSIBLE FOR ALL CONSTRUCTION METHODS AND SERVICES. TOWNE CONTRACTOR SHALL PROVIDE TO THE CONTRACTOR A COMPLETE BILL OF LADING CONFORMING TO THE REQUIREMENTS OF THE AGREEMENT. ANY CHANGES TO THIS AGREEMENT SHALL BE MADE IN A WRITTEN FORM.

3. ALL SUBMITTAL INFORMATION MUST BE SENT TO TOWNE ENGINEERING, INC., 6351 MURPHY ROAD, FAIRFAX, VA 22033. ALL SUBMISSIONS MUST BE MADE IN A FORM CONFORMING TO THE REQUIREMENTS OF THE AGREEMENT. ANY CHANGES TO THIS AGREEMENT SHALL BE MADE IN A WRITTEN FORM.

4. ALL WORKS SHALL BE PERFORMED IN ACCORDANCE WITH THE 2017 IBC.

STEEL:

1. ALL STRUCTURAL STEEL SHALL BE FABRICATED AND ERECTED IN ACCORDANCE WITH THE LATEST ACCESS AND STEEL SPECIFICATIONS.

2. ALL STEEL, ANGLE, 7/8" ANGLE, AND 3/4" ANGLE, SHALL BE STEEL 4725-0-10 (1-1/4"") UNLESS OTHERWISE SPECIFIED.

3. ALL STEEL ANGLES USED FOR BRACING SHALL BE STEEL 4725-01-10 (1-1/4"") UNLESS OTHERWISE SPECIFIED.

4. ALL V-BOLTS SHALL BE MADE OF STEEL 4725-01-10 (1-1/4"") UNLESS OTHERWISE SPECIFIED.

5. ALL STEEL PLATES SHALL BE STEEL 4725-01-10 (1-1/4"") UNLESS OTHERWISE SPECIFIED.

6. ALL DUMMY BOLTS SHALL BE STEEL 4725-01-10 (1-1/4"") UNLESS OTHERWISE SPECIFIED.

ANGLE WELDING:

1. ALL WELDING TO THE EXISTING TOWER SHALL BE PERFORMED BY CERTIFIED WELDERS. ALL WELDING PROCEDURES SHALL CONFORM TO THE AMERICAN NATIONAL STANDARDS INSTITUTE AND THE AMERICAN WELDING SOCIETY. ALL WELDING PROCEDURES SHALL CONFORM TO THE AMERICAN NATIONAL STANDARDS INSTITUTE AND THE AMERICAN WELDING SOCIETY.

2. CONTRACTOR SHALL COMPLETE WITHIN ONE (1) HOUR OF THE RECEPTION OF THE SPECIFICATIONS ALL REPAIRS TO THE EXISTING TOWER. ALL REPAIRS SHALL BE PERFORMED IN ACCORDANCE WITH THE 2017 IBC.

3. ALL WORKS SHALL BE PERFORMED BY A TOWNE CONTRACTOR. THE TOWNE CONTRACTOR IS RESPONSIBLE FOR ALL CONSTRUCTION METHODS AND SERVICES. TOWNE CONTRACTOR SHALL PROVIDE TO THE CONTRACTOR A COMPLETE BILL OF LADING CONFORMING TO THE REQUIREMENTS OF THE AGREEMENT. ANY CHANGES TO THIS AGREEMENT SHALL BE MADE IN A WRITTEN FORM.

COAX LAYOUT:

1. CONTRACTOR TO INSTALL COAXIAL CABLE IN THE REQUIRED AREA.

2. CONTRACTOR SHALL PROVIDE ALL NECESSARY INSULATION AND INSTALLATION.

3. CONTRACTOR SHALL PROVIDE ALL NECESSARY INSULATION AND INSTALLATION.

4. CONTRACTOR SHALL PROVIDE ALL NECESSARY INSULATION AND INSTALLATION.

5. CONTRACTOR SHALL PROVIDE ALL NECESSARY INSULATION AND INSTALLATION.
ATTACHMENT B

EVALUATION OF THE CAPACITY OF THE HORIZONTAL BRACES AS THE ANCHORAGE FOR THE PERSONAL FALL ARREST SYSTEM
Evaluation of the capacity of the horizontal braces as the anchorage for the personal fall arrest system.

From: Rohn Drawing No. C681228 Rs. (Page B-3)
UNR-ROHN Original Design Drawing No. D900798 (Page B-4)
Alro Steel Tubing & Pipe, Page No. 7-17 (Page B-5)

The size of the horizontal brace was steel tube TS 1½" OD x 16 gauge with OD = 1.50 in., I.D. = 1.37 in. and the span length = 2'-10" = 34".

From AISC (2011), Page 17-39, the gross plastic section modulus $(Z)$

$$Z = \frac{(GD)^3}{6} - \frac{(ID)^3}{6} = \frac{(1.50)^3}{6} - \frac{(1.37)^3}{6} = 0.5525 \text{ in}^3 - 0.4286 \text{ in}^3$$

$$= 0.1239 \text{ in}^3 \div 0.134 \text{ in}^3$$

From AISC (2011), Page 3-215, for simple beam—concentrated load at center

$$M_{max} = P_{max} \times \frac{L}{4}$$

From AISC (2011), Page 16.1-4-7, Yielding

$$M_n = F_y Z_x$$

Assuming $M_n = M_{max}$, $Z_x = Z$. Thus, $F_y Z = P_{max} \times \frac{L}{4}$

The vertical load capacity $(P_{max})$ of the horizontal bracing member is

$$P_{max} = F_y \frac{Z}{L} = \frac{4 \times 35 \text{ ksi} \times 0.1239 \text{ in}^3}{34 \text{ in.}} = 0.552 \text{ kips} = 552 \text{ pounds, say 600 pounds}$$

From Papers B-6 and B-7, the maximum fall arrest force for a 6 ft long shock absorbing lanyard was approximately 900 pounds. With the minimum required safety factor of 2, the anchorage for the shock-absorbing lanyard must be capable of supporting a vertical load of at least 1,800 pounds.

$$900 \text{ pounds} \times 2 \text{ (Factor of Safety)} = 1,800 \text{ pounds} > 600 \text{ pounds. NO GOOD.}$$

B-2
# TOWER SECTION SCHEDULE

<table>
<thead>
<tr>
<th>SECTION</th>
<th>LEGS</th>
<th>FLANGE BOLTS</th>
<th>STEP BOLTS</th>
<th>BRACES</th>
<th>BRACE BOLTS</th>
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<tr>
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**GENERAL NOTES:**

1. ALL NUTS ARE PROVIDED FOR ALL TOWER BOLTS.
2. FOR LEG FABRICATION, SEE DRAWING NUMBER C680019 AND C680020.
3. FOR BRACE FABRICATION, SEE DRAWING NUMBER C680079.
4. FABRICATION DRAWINGS ARE FOR SHOP USE ONLY.

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**R3 REVISION:**

- **R3 REDRAWN:**
  - **Date:** 12-8-81
  - **Drawing:** C681228 R3

**R4 REVISION:**

- **R4 REVISION:**
  - **Date:** 1-31-90
  - **Drawing:** C681228 R4

**MODEL NO. 90 TOWER STANDARD SECTIONS**

**Scale:**

- **Drawn By:** AEG 12-8-81
- **Checked By:** EWP 12-22-81
- **Approved By:** G.R. 12-22-81
### E.R.W. (ELECTRIC RESISTANCE WELD)  
#### COLD DRAWN SEAMLESS (CDS)  
#### D.O.M. (DRAWN-OVER-MANDREL)  
#### HOT FINISHED SEAMLESS (HFS)

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<th>Wall Thickness (Dec-In)</th>
<th>Inside Diameter (ID)</th>
<th>Weight (lbs./ft)</th>
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<th>CDS</th>
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Drawn over Mandrel (DOM) tubing is defined by 3 different dimensions:  
- Inside Diameter (ID)  
- Outside Diameter (OD)  
- Wall Thickness  

When ordering, only 2 of the 3 tolerances must be defined. Alro Steel purchases DOM tubing, for general inventory, to the outside diameter and inside diameter.  

If you do not see a size listed, please contact your Alro representative.
EZ-Stop™ Shock Absorbing Lanyard

Model: 1246011
6 ft. (1.8m) web single-leg with snap hooks at each end.

PRODUCT HIGHLIGHTS
- 6 ft. (1.8m) single-leg lanyard
- Extremely compact and lightweight
- Exclusive Hi-10™ Vechian™ energy absorption system
- Repel™ webbing
- User friendly self-locking snap hooks at each end
- Built-in reflective materials
- Impact indicator
- Protected labels, equipped with i-Safe™

**Energy Absorber Class**
- 5 ft. (1.5m) Free Fall/MAF 300 lbs (4 kJ)

**Harness Connector Hook Type**
- Snap Hook

**Overview**

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<tr>
<td>Product Types</td>
<td>Shock Absorbing Lanyard</td>
</tr>
</tbody>
</table>

BUILD A FALL PROTECTION SOLUTION

A typical Personal Fall Arrest System (PFAS) incorporates three components often described as the ABC's of fall protection: The anchorage/anchor connector, body support and connecting device. Don't forget about "D" either, the descent, rescue and retrieval of a fallen worker.

http://www.capitalsafety.com/en-us/Pages/ProductDetails.aspx?prodId=840

7/8/2014
Potential Fall Arrest Forces

The following provides general information on fall arrest forces that could occur in free-falls at different distances.

**Non-shock absorbing** web lanyard with 220 pound steel weight
*(Data shown to reinforce the importance of using shock-absorbing lanyards)*

<table>
<thead>
<tr>
<th>Distance of Drop</th>
<th>Average Force</th>
</tr>
</thead>
<tbody>
<tr>
<td>6 inches</td>
<td>1100 pounds</td>
</tr>
<tr>
<td>3 feet</td>
<td>2500 pounds</td>
</tr>
<tr>
<td>4 feet</td>
<td>3200 pounds</td>
</tr>
<tr>
<td>5 feet</td>
<td>3800 pounds</td>
</tr>
<tr>
<td>6 feet</td>
<td>4000 pounds</td>
</tr>
</tbody>
</table>

**Miller Shock absorbing** web lanyard with 220 pound steel weight

<table>
<thead>
<tr>
<th>Distance of Drop</th>
<th>Average Force</th>
<th>Extension</th>
</tr>
</thead>
<tbody>
<tr>
<td>3 feet</td>
<td>820 pounds</td>
<td>21 inches</td>
</tr>
<tr>
<td>4 feet</td>
<td>810 pounds</td>
<td>22 inches</td>
</tr>
<tr>
<td>5 feet</td>
<td>822 pounds</td>
<td>28 inches</td>
</tr>
<tr>
<td>6 feet</td>
<td>872 pounds</td>
<td>33 inches</td>
</tr>
<tr>
<td>7 feet</td>
<td>877 pounds</td>
<td>38 inches</td>
</tr>
<tr>
<td>9 feet</td>
<td>1315 pounds</td>
<td>41 inches</td>
</tr>
<tr>
<td>10 feet</td>
<td>1654 pounds</td>
<td>42 inches</td>
</tr>
<tr>
<td>11.5 feet</td>
<td>2332 pounds</td>
<td>42 inches</td>
</tr>
</tbody>
</table>

Chuck Ziegler
Manager Technical Support