Knee braces are installed prior to setting each of the candelabra arms, which will be bolted onto the tabs (above and below the level of the crane hook) on the main tower. Between the knee braces you can see the two-person elevator, without which it takes an hour or more to climb the 950 ft to this level. The pulleys near the top of the photo are for the elevator hoist cable.

All photos and drawings: Stainless LLC

Good Morning, Miami!

BY THOMAS J. HOENNINGER, P.E.

Multiple television and radio antennas broadcast from high atop a new steel tower in Miami.

THE NEW AGE OF BROADCAST TV, especially the recent switch to digital transmission and high-definition TV (HDTV), has brought many changes to the broadcast industry. Changes in wind loading due to antenna and cabling replacement—or even just removal of analog equipment—can significantly affect existing towers. In addition, the telecommunications industry is also going through significant changes with the revision to its antenna supporting structure design standard, ANSI/TIA-222.

ANSI/TIA-222-G was adopted by ANSI and TIA (Telecommunications Industry Association) in 2005 and, with some exceptions, basically follows ASCE7 on the loading side and AISC and ACI on the design side. ANSI/TIA 222-G is now recognized as the telecommunication antenna supporting structure design standard by the International Code Council and is incorporated into the International Building Code (IBC).

The following are major changes included in ANSI/TIA 222-G:

- ➜ Three-second gust basic wind speed
- ➜ Mandatory ice loading (in certain regions)
- ➜ Pattern wind loading
- ➜ Load and Resistance Factor Design (LRFD)
- ➜ Rigging plan reviews and rigging tower effects

Candelabra

One tower project in Miami was affected by all these changes. The physical condition of WPLG's previous tower and HDTV's structural impact led to the decision to replace the station's existing tower. However, before going ahead with the replacement project, WPLG evaluated collocation opportunities that resulted in WSVN TV, WLYF FM, and many wireless tenants collocating on the new tower, which was completed in June.

Because multiple TV stations were planning to be installed on the new tower, a candelabra design was chosen to allow for all the stations to have their antennas located at approximately the same height. The candelabra design is basically three supporting structures that project out horizontally more than 40 ft at tower top to provide the 50-ft horizontal separation required between these antennas.

The overall height of the new structure is 1,042 ft, with the top of candelabra steel at 951 ft. The tower is also equipped with a two-person elevator, a climbing ladder with safety cable device, and an FAA-approved obstruction lighting system. In all, 510 tons of structural steel was used.

The ANSI/TIA 222-G design parameters used for the new tower were:

- ➜ Reliability Class II
- ➜ Exposure Category C
- ➜ 150-mph three-second gust basic wind speed (no ice loading)
- ➜ Topographic Category 1 (no wind speed-up effect)
- ➜ 0.05 earthquake spectral response acceleration at short periods (earthquake loading did not govern)

A 12-ft face, triangular cross-section tower was selected due to the high wind speed, candelabra design, and elevator. This tower design consists of standard components, including those used in the candelabara. The components were selected and arranged to resist the internal forces resulting from a rigorous structural analysis of various loading conditions.

Also investigated were second-order effects that required a balanced design between mast and guys. A five-guy-level design was selected. The first four guy levels have three guy assemblies per level oriented at 120° from each other. The top guy level has six guy assemblies attached to the candelabra structure to provide torsional resistance due to the uneven loading on each apex of the candelabra. The guy assemblies were supplied in accordance with ASTM A586 GR2 with a threaded take-up at the anchor end to allow for final tensioning.

The tower mast uses 30-ft long sections assembled on the ground consisting of ASTM A572 GR 50 round bar vertical members (with additional mechanical requirements), 7-ft 6-in.-high bracing bays of ASTM A36 K-braced double-angle diagonals, and double-angle horizontals.

Erection

A significant amount of engineering labor was spent on evaluating the tower due to erection loads.

Thomas J. Hoenninger, P.E. is the vice president of engineering/chief engineer with Stainless LLC.

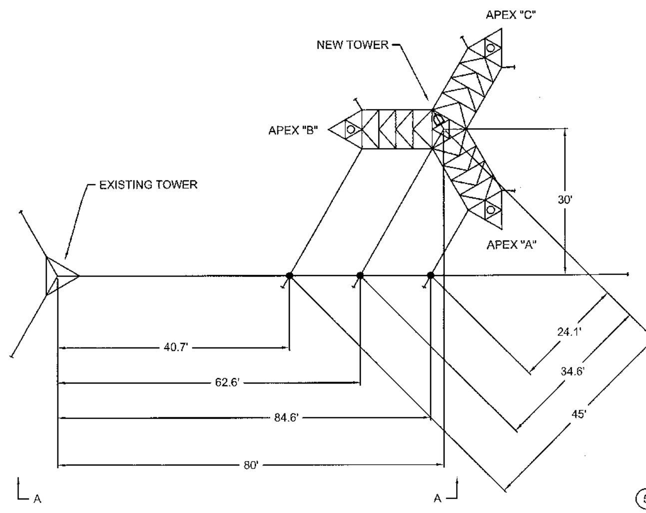
The yellow gin pole attached to the tower provides the ability to lift successive sections of the tower into place. Here it has been jumped into the "high" position. A tag line maintains clearance between the tower and the loads as they are being lifted.

Rigging supports were built into the base and anchor foundations to facilitate erection. A rigging plan was developed by the erector and was reviewed by the engineer of record (EOR). The main rigging equipment/lines were checked to ensure adequate safety factors were maintained. The effects of the rigging loads imposed on the tower were also analyzed. After completion and approval of the engineering rigging plan review, erection commenced in the following sequence:

1. The first few tower sections were assembled together on the ground and lifted in place by a crane.
2. Temporary guys were installed to stabilize the tower since the base section tapers to a point allowing rotation.
3. The crane lifted the gin pole which was then attached to the tower. Lifting operations with a gin pole include a load line, gin pole jump line, and tag line. The tag line maintains clearance of the load away from the tower during the lifting process. On this tower an inverted trolley tag line was used.
4. The gin pole was positioned (jumped) into the high position to be ready to lift and install tower sections. After each section was lifted and installed on the tower, the gin pole was jumped again. This procedure was repeated until the section that contained the first permanent guy level was lifted and installed.
5. The guy assemblies were lifted and connected to the tower in each of the three directions.
6. The guy assemblies were then pulled out and connected to the anchor foundations. (Pulling out and attachment to the anchor foundations must be performed at the same time in all three directions to minimize unbalanced loading on the tower.) During this process it was important for the erection crew to watch the top tower section for lateral movement to maintain balanced loading and vertical alignment.
7. The gin pole jumping and tower section installation were repeated until the second guy level height was reached and the guy assemblies installed. Then the entire process was repeated until tower top was reached.
8. Temporary guys were installed near tower top. They were not required for the main mast erection unless more than three sections above a permanent guy level would have been left freestanding overnight.
9. The falsework and additional temporary guys were installed. This erection sequence was the same as for erecting tower sections. The falsework provided height above the candelabra structure level to install the candelabra outriggers and antennas.
10. The gin pole was again jumped in the high position.
11. The crane support assembly interface was then lifted and installed.
12. The crane was lifted and installed on the support assembly.
13. The knee braces of the candelabra were then installed.
14. Each candelabra arm structure was assembled on the ground, lifted, and installed.
15. The knee braces were then attached.
16. The antenna interface support assemblies and antennas were lifted and installed.
17. The crane and falsework were removed from the tower with the gin pole.
18. The gin pole was lowered below the candelabra. The candelabra was designed to allow clearance for the gin pole to pass through the completed candelabra structure.
19. The tower was rigged below the candelabra level and the gin pole was removed from the tower and lowered to the ground.
20. The tower was then derigged.

One set of guy lines from the new tower had to be threaded through the guy lines from the existing tower, further complicated design and erection.

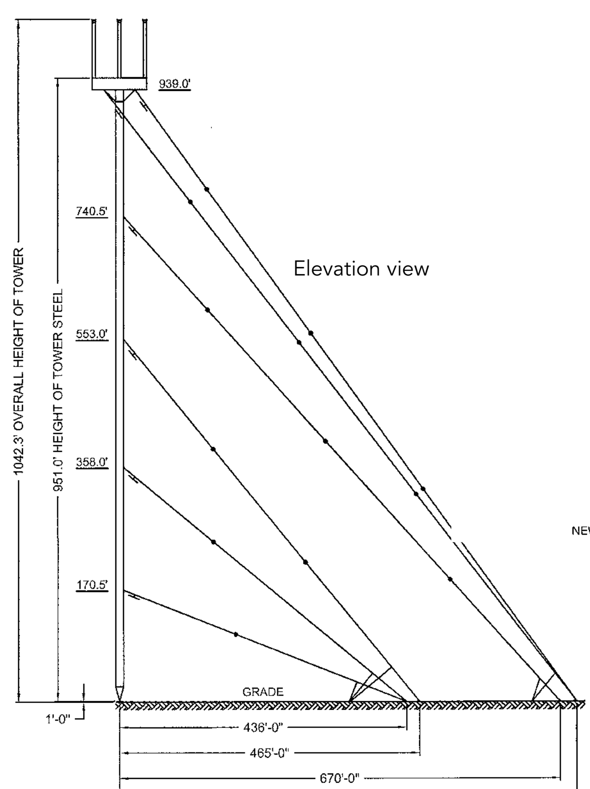
Each candelabra arm is assembled on the ground, then lifted and bolted into place. Here the top of steel is at 951 ft.



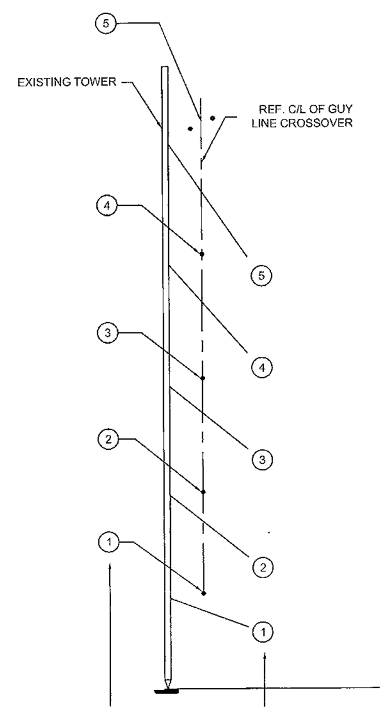
Plan view

Too Close for Comfort

The close proximity of the new tower to the existing tower created an amplified degree of difficulty for both the tower design and erection. In one direction the guy wires from the new tower, which ranged from 1⅞ in. to 2⅝ in. in diameter, were required to be weaved through the existing tower guy wires. At each guy level the tag line was first weaved between the existing guy levels above and below the elevation of the guy level on the new tower. The tag line was very light, so it was walked out to the guy anchor of the existing tower and weaved through the appropriate guy levels and then walked back to the correct position. The load line was then trolley attached to the tag line, lowered, and weaved through the existing tower guy levels. The tower end of the new guy assembly was attached to the load line and lifted. The lift was controlled by adjusting the tension on the inverted trolley tag line. This maintained the proper location of the lifted guy assembly through the existing guy levels. When it reached the guy attachment level it was positioned and connected to the tower. In the other two directions the guy assemblies were lifted and attached to the guy attachment connection on the tower using normal lifting procedures. Then all three guy assemblies were pulled out to each anchor simultaneously to minimize lateral load on the tower mast. **MSC**



Elevation view



Section "A" - "A"

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