Investigation of the May 28, 2013 failure of gin pole rigging at a cell tower in Georgetown, MS

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Report Prepared by Mohammad Ayub, P.E., S.E. Office of Engineering Services Directorate of Construction

Contributions to this report made by Dinesh Shah, P.E., Office of Engineering Services, Directorate of Construction Dan Crane, Salt Lake Technical Center John Sauls, P.E., Safety Engineer, Jackson Area Office, MS

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The Background

On May 28, 2013, a construction incident occurred at the site of Verizon Wireless cell tower in Georgetown, MS. The 300 ft. high cell tower was being equipped with a gin pole to replace the old antennas with new ones. While the gin pole, approximately 40 ft. tall was being raised, the rigging of the gin pole block suddenly failed, killing two workers located on the tower.

The Occupational Safety and Health Administration's (OSHA) Regional Administrator, Region IV, requested the Directorate of Construction (DOC), OSHA National Office in Washington, DC to provide technical assistance in a causal determination, and engineering assistance to the Jackson, MS, OSHA Area Office in its investigation. A structural engineer from the DOC arrived at the site a few days later to inspect the incident site, and observe the failures.

Construction documents of the original towers were obtained from the original designer. Photos were taken at the incident site. Pieces of the fallen equipment were examined in the Jackson Area Office. The following is our report.

The project

Verizon Wireless decided to replace their existing antennas on the top of a 300 ft. high cell tower in Georgetown, MS. Verizon leases space on the tower owned by SBA Communications of Beverly, MA (SBA) which owns more than 20,000 similar cell towers around the country. The tower was originally designed by Sabre Communications Corporation of Sioux City, Iowa in 1999. The replacement of antennas is a common practice among wireless providers as new technologies emerge and when the area of coverage needs to be increased.

Verizon Wireless retained a consultant, CLS Group of Edmond, OK (CLS) to prepare construction documents, and to process permits, leasing and other regulatory approvals. CLS prepared documents to remove existing Omni antennas and associated lines, install six new antennas at a height of 295', install new pieces of telecommunications equipment, and install new utility lines to serve the new equipment. CLS prepared 11 drawings, and they were issued for construction in January 2012. The drawings were signed and sealed by a professional

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engineer. CLS did not take responsibility for the method and means of construction, a standard practice in the industry.

SBA retained a structural consultant, FDH Engineering of Raleigh, NC, to determine whether the existing tower could support the loads of the six new antennas and other associated equipment. FDH in its report of November 2, 2011, confirmed that the existing tower could support all new loads of Verizon antennas. The FDH report was signed and sealed by a registered professional engineer.

Verizon retained Andrews, a CommScope Company, to remove the old antennas and install new antennas and associated pieces of equipment. Andrews in turn hired a subcontractor Byrd Telcom (Byrd) to perform the work. Loyd Earl Byrd established Byrd and has been in business for six months. He quit his former company Circle B when a partner retired. Byrd retained several individuals to perform the work. These individuals brought their own hand tools, but the major tools and parts were furnished by Byrd. The individuals retained by Byrd were:

1. Randy Davidson (Randy)

Randy claimed to be the construction manager of the project and that he was appointed by Byrd, but Byrd denied it. Randy also said that he was not in charge of the site, though he claimed to be the construction manager. In fact, he said that no one was in charge at the site on the day of the incident after the previous foreman quit her job, the weekend before. Everyone worked in a group and consulted with one another. Randy has extensive experience in tower work, and has been involved in 30 to 40 projects involving gin poles. In all his gin pole projects, he had used chokers around the two tower legs, with a shackle at the center to support the hook and the load. He never used a carabiner to support any load block in the tower business, as was done in this case. Randy did not climb up the tower to examine the rigging. He only knew about the use of a carabiner after the incident.

2. John Davidson (John)

John is Randy's brother and calls himself a "tower hand." John said that no one person was in charge at the site but people were working together on the day of the incident. John had a leading role at the site as he and Johnny Martone (killed in the incident) had

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climbed up the tower before the incident to rig the carabiner, hook and the block for the jump line at the top of one of the legs of the tower. He said that Byrd furnished a few carabiners, and he used the one that looked new. John placed the carabiner in one of the four holes of the pad plate at the very top of a leg of the tower, and the carabiner went in smoothly. The wider part was at the top while the narrower part was at the bottom. The hook was placed in the narrower part without any difficulty. He had worked on projects involving gin poles at least half a dozen times in the past. In one of his projects he had used a carabiner.

- 3. Johnny Martone (killed during the incident)
- 4. Michael Castelli (killed during the incident)He had the least experience of them all, approximately six months in the tower business.
- 5. Michael Shane Callender

The day of the incident was his first day on the job. He operated the winch. He had extensive experience in the tower business. He witnessed the incident. He did not know of the carabiner until after the incident. In his experience, a choker with a shackle should be used to rig the jump line block. He had never seen a carabiner used in the manner as it was used here.

6. Allen Martin

Worked as a spotter and witnessed the incident.

7. Wilton Grimes

Started work on the day of the incident. Specific duties unknown.

The incident

On Thursday, May 23, 2013, the work began at the site with Ms. Claudia as the foreman. There were at least five persons on the job site, John Davidson, Johnny Martone, Michael Castelli,

Allen Martin aka BJ, and Ms. Claudia. They assembled the antennas and placed other equipment in a logical order for the next working day, and most importantly rigged the jump line block at the top of the tower, see fig. 1.



Fig. 1 – Rigging elevation

John Davidson and Johnny Martone climbed up the tower and hooked a carabiner in one of the holes of the tower leg's topmost plate. These plates are used to connect the lower and upper segments of the tower together, and are provided with four holes. The carabiner was placed in a manner so that the narrower part was pointing downwards to where the hook was placed. The hook was attached to a block where a synthetic rope was placed to pull the jump line wire rope. This is based on the testimony of John Davidson who rigged the carabiner and the block along with Johnny Martone. John testified that there was plenty of free movement of the hook, and there was no bind.

During the next four days, Friday to Monday, there was no work. The next Tuesday morning, May 28, 2013, at least seven people showed up for work at different times. Ms. Claudia did not come as she had quit her job with Byrd Telecom, the weekend before. Three new persons, Randy Davidson, Shane Callendar, and Wilton Grimes arrived at the site. Randy Davidson was the most experienced and claimed to be the construction manager, though this was contested by Byrd Telecom. Randy arrived late, so the work had already started at approximately 11:00 A.M. The gin pole was already lined up near the base of the tower, which was then assembled, and ready to climb. John Davidson and Johnny Martone climbed up the tower to replace the jump line synthetic rope installed the previous Thursday with the wire rope cable on the block. Everything reportedly went smoothly. Shortly thereafter, John climbed down to act as a point man to guide the gin pole to ensure that it did not entangle with any wires, cable or equipment, etc. during the ascent of the gin pole.

Meanwhile, Randy was assisting the crew in rigging the gin pole so that the gin pole could ascend vertically. After three or four attempts, the gin pole was satisfactorily rigged, and the "jumping" of the gin pole began in earnest by the winch, see fig. 2. As stated earlier, John Davidson was directing the winch man to raise the gin pole as he was keeping pace with the tip of the gin pole, and according to testimony obtained by OSHA, the gin pole was ascending without any hitch. As it reached approximately half way up, Randy Davidson took leave from the site, and left.

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Fig. 2 – The winch truck

John Davidson was gradually climbing up and keeping pace with the tip of the gin pole to guide it and to keep it clear of any obstruction along the height of the tower while standing on the face of the tower next to the face on which the gin pole was being raised. John, however, needed assistance and called Michael Castelli who was somewhere on the lower section of the tower to come up to give him a hand. Michael was situated on the same face as the gin pole, and was directly under the gin pole. Michael was slow to respond to John's request to come up for unknown reasons. John then finally called Johnny who was still at the top of the tower to come down to assist him. John remained on the adjoining face of the tower. Johnny began to descend, at John's request, but on the same face of the tower where the gin pole was being raised, see sketch below. He had hardly descended a few sections, when the jump line rigging failed at the top with the hook and the block hurled down, decapitating Johnny, see fig. 3.



Fig. 3 – The hook and the block of jump line

Michael was fatally struck with the falling gin pole. Both were thrown on to the ground. The gin pole came down in one piece at the foot of the tower, see fig. 4, 5 and 6. The time of the incident was 2:10 P.M..

Panic ensued at the site, and everyone jumped into their vehicles and left the site except Shane Callendar who called 911 and remained at the site. Randy Davidson was contacted and he soon returned to the site, along with others.



Fig. 4 – Plan view of gin pole and workers after the incident



Fig. 5 - A view of the gin pole from the top of the tower



Fig. 6 - A view of the gin pole from the top of the tower

<u>Analysis</u>

The tower consisted of a triangular shape, each side 36 inches wide, on centers, see fig. 9. Each leg consisted of various sizes of high strength steel solid round shapes with diameters ranging from $1 \frac{3}{4}$ " to $1 \frac{1}{2}$ ". The diagonal and horizontal members were also solid rounds $1 \frac{1}{4}$ "-1" diameter, and 7/8" diameter respectively. The tower was guyed at three locations, and additionally was provided with torque stabilizers at two locations, see fig. 7. See fig. 8 for guy wire supports.

The structural design of the original tower, and its ability to support the new loads during the replacement of antennas were generally determined to be adequate, see fig. 9.



Fig. 7 – Two torque stabilizers at the tower



Fig. 8 – Anchorage of the guy wires



Fig. 9 – Original drawing of the tower

Byrd provided the gin pole but its manufacturer is unknown. From the field measurements of the gin pole taken at the site on June 11, 2013, see fig. 10, 11, 12 and 13, the weights of both sections of the gin pole and the rooster head, see fig. 14, were calculated to be approximately 1,500 pounds. Adding the weight of the wire ropes, hook and the block, the total weight could have been approximately 1,700 pounds. The load on the carabiner was calculated to be approximately in the range of 3,300 to 3,400 pounds.





Fig. 10 – Gin pole

Fig. 11 – Gin pole



Fig. 12 – Field notes of measurements of the gin pole



Fig. 13 – Field measurements of the gin pole



Fig. 14 – Rooster head attached to the gin pole

It is believed that the carabiner used at the site was manufactured by PenSafe Inc. of Canada; model Number C 775, see fig. 15. The carabiner has been load-tested by the manufacturer to support a tensile load of 3,600 pounds, and a side load of 3,600 pounds. Using a factor of safety of 2.75, the failure load would be approximately 10,000 pounds. A couple of days after the incident, several photographs were taken of the failed carabiner stuck in the hole of the pad plate, see fig. 16, 17 and 18. The carabiner was taken out and examined, see fig. 19.

Specifications

- C775 Kwiklock Carabiner
- Cold Formed Steel
- 100% proof loaded to 3,600 lbs (16kN)
- Min tensile strength 10,000 lbs (45kN)
- Min gate strength 3,600 lbs (16kN)
- Min side load strength 3,600 lbs (16kN)
- Minor axis Strength 3.600 lbs (16kN)
- Gate marked "3.6m GATE"
- Captive Bar Available
- For Locksafe (Triple action) C777
 Certified To:
- ANSI/ASSE Z359.12-2009
- CSA Z259.12-11
- NFPA 1983-2006
- Meets Or Exceeds:
- · EN362-2004



Fig. 15 - Carabiner manufacturer's specifications



Fig. 16 – View of the failed carabiner



Fig. 17 – View of the failed carabiner Also see three tower legs.



Fig. 18 – Fracture of the carabiner at the hole drilled for captive bar



Fig. 19 - Close-up view of failed carabiner

In our analysis, we considered the following:

<u>First</u>, we examined whether the 13/16" (0.8125") hole in the plate with a clear edge distance of 0.92" would allow for a carabiner to be inserted which has a diameter of 0.78" at its thickest part. It appeared that would be possible. If the narrower part of the carabiner was placed under the plate, there would still be space left to place the $1\frac{1}{2}$ " thick hook, see fig. 20, 21 and 22.



Fig. 20 – Failed carabiner and the hook

Fig. 21 – Failed carabiner under the hook



Fig. 22 – Another view of failed carabiner at the hook

<u>Second</u>, we examined whether the configuration of the failed carabiner stuck in the plate, as observed after the incident, was the original position in which the carabiner was rigged on the previous Thursday with the hook and the block. It was determined that this was not likely due to the geometry of the carabiner and the hook. The hook was 1½" thick, and 1" wide. The narrow part of the carabiner does not lend itself to accommodate the hook in the position in which the failed carabiner was found. John Davidson stated in OSHA's interview that Johnny Martone and he placed the hook in the narrow part of the carabiner which was below the plate. Further, he said that the hook went in without any difficulty. Therefore, the position in which the carabiner was found was the result of the incident.

Third, we examined how high or low the carabiner could be placed in the 13/16" hole, and whether it could freely move up and down, and move horizontally over the diagonal edge of the plate. It was determined that the carabiner could move freely if the hole in the steel plate was smooth, as it was supposed to be. There was testimony from John Davidson who said that the carabiner went in smoothly, and that the movements were without any bind or hitch. The person who climbed up the tower and took the failed carabiner out of the hole also said in a telephone interview with OSHA that she took out the carabiner without any special effort or without using any tool. The hole in the plate was 13/16" (0.8125"), and the maximum diameter of the carabiner was 0.78" providing some room for movement, see fig. 23 and 24, for the measurements taken by OSHA's Salt Lake City Laboratory (SLTC). For the hook to be placed in the lower part of the carabiner, the minimum space required below the steel plate was required to be 1 7/8 to 2". The available space was 2 ½". By the force of gravity, the carabiner would eventually be located, see fig. 25 and 26, giving ample space for the hook to be placed, see discussion later on the new carabiner.



Fig. 23 - SLTC Photo of carabiner remnant showing dimensional measurements



The body diameter of the Kwiklock hasp was measured directly and used as the calibration for this photo. The plate diameter measurement was made at the location of the front holes, but is offset in this photo for clarity. The hasp extends 1.28" out on the left and 1.41" on the right as shown in the photo



Fig. 24 – SLTC Photo of carabiner remnant showing dimensional measurements

Fig. 25 – Top plate where carabiner was placed





<u>Fourth</u>, we examined how the carabiner would support the load of the gin pole, wire rope, etc. It was estimated that the carabiner would be subjected to a direct tensile load of approximately 3,600 pounds, well within the failure load of the carabiner, if used properly. Carabiners are always used in a configuration where the line of application of the load coincide with the line of support of the carabiner, subjecting the carabiner to direct tension, and preventing any flexural moment of the carabiner's body, see fig. 27 below of the manner in which carabiners are tested longitudinally. However, in this instance, the line of application of the load was at the center of the hook, but the support was where the carabiner touched the steel plate either in the 13/16" hole or the top part of the plate. If the support is not concentric to the application of the load, the

⁽Drawing by Sabre Communicatons)

carabiner will be subject to flexural loads, for which the carabiner is not designed. When the workers placed the carabiner in the plate hole, they did not realize that it was a misuse of the carabiner. They only considered the tensile load capacity which is much greater than the load placed on the block, but they failed to take into account that the support was a few inches away from the hook and the block.



Ref: ANSI/ASSEZ 359.12-2009 American National Standrad

Fig. 27 – Tensile testing of carabiner

For our investigation, DOC purchased a carabiner model No. C775 (ANSI/ASSE Z359.12-09) from the manufacturer in Canada. This model was almost identical to the carabiner (ANSI/ASSE Z359.1-07) used in the incident. The C775 was placed in a 13/16" hole drilled in a 5/8" wood piece to simulate the actual site conditions. The hole was drilled to the dimensions indicated in the drawing provided by the tower manufacturer, including edge distances. The C775 went into the hole with little difficulty, and it soon became apparent that the narrower part of the carabiner would have to be placed below the steel plate for the hook to be placed inside the carabiner. Also, the wider part of the carabiner allowed the carabiner to move freely in a horizontal angular direction. This validated the testimony given by John Davidson. See fig. 28 through 35.



Fig. 28 – Top view of the carabiner



Fig. 29 – New carabiner



Fig. 30 – New carabiner showing space To accommodate hook



Fig. 31 – New carabiner showing an easy fit in the 13/16" hole



Fig. 32 – Carabiner showing its free horizontal movement



Fig. 33 – The hook inside the carabiner





Fig. 34 Another view of the hook inside carabiner Fig. 35 Another view of the hook

Initially, it is believed that the carabiner supported the load through its contact with the inside surface of the hole in the plate. This subjected the carabiner to a flexural moment greater than its ultimate capacity, resulting in a permanent deformation, and the formation of a plastic hinge in the top portion of the horizontal portion of the carabiner. Immediately thereafter, the carabiner's top portion came into contact with the top surface of the plate, and supported the load at two locations, see fig. 28. It is believed that the line of application of the load almost coincided with the edge of the plate where the carabiner rested which could explain why the carabiner did not fall apart during the initial jumping of the gin pole. Johnny Martone might have been able to notice, if he was attentive, that the carabiner was becoming deformed under the load, but he did not convey any such message to John Davidson. Two gouges and a deep impression of the carabiner could be seen on the top surface of the plate, see fig. 36 and 37, indicating the contact of the carabiner with the plate. There were two weak points in the body of the carabiner, one at the nose (adjacent to the gate opening) due to its reduced cross-sectional area, and one in the body of the carabiner where a hole was drilled for the captive bar, (for the fractured surfaces, see fig. 36. Initially, the nose was subjected to a direct tension plus a horizontal force weakening it considerably because the nose is not designed for bi-axial forces, see fig. 37.

It must be noted here that the center of gravity of the gin pole would have coincided with the cable used for jumping the gin pole, offsetting from the center of the face of the tower. The tower was 36" wide, and the gin pole was 18" wide, but the block was located very near the leg

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of the tower. So, the offset between the center of the gin pole and the center of the tower face was estimated to be approximately 12-16". The point man, John Davidson, was trying to pull the gin pole towards the center of the face of the tower, thus applying additional side load to the hook and the carabiner, contributing to the failure of the carabiner.

One possible scenario of the failure is the formation of another plastic hinge in the top portion of the carabiner at the edge of the steel plate; thereafter the failure occurred. The carabiner began to rotate in a counter-clockwise direction. The next failure occurred at the other weaker location, where the hole was drilled for the captive bar in the vertical leg of the carabiner. As soon as the failure at the hole location occurred, the hook came off the broken carabiner, further pushing the remainder of the carabiner up the hole in the plate where it became lodged, as it was found after the incident.



Fig. 36 – View of the top plate showing deep indentation in the steel plate



Fig. 37 – Carabiner showing failure near its gate

Conclusion

- The failure occurred because the jump line block was rigged by using a carabiner which was subjected to considerable flexural loads. Carabiners are designed for loading in either the longitudinal or transverse axes with direct tension only.
- 2. The carabiner was used in a manner not recommended by the manufacturer, and contrary to the standard industry practice.
- 3. The carabiner was clearly marked with a stamp Z359.1 (07). The ANSI/ASSE standard Z359.1 (07) states that "the requirements of this standard do not address the construction industry.....", and still the carabiner, not meant for construction, was used to hoist the gin pole at the site.
- 4. The contractor deviated from the standard practice of rigging the jump line block by using chokers on the two tower legs and using a shackle at the center of the face of the tower to hang the block.
- 5. Wind was not the causal factor.