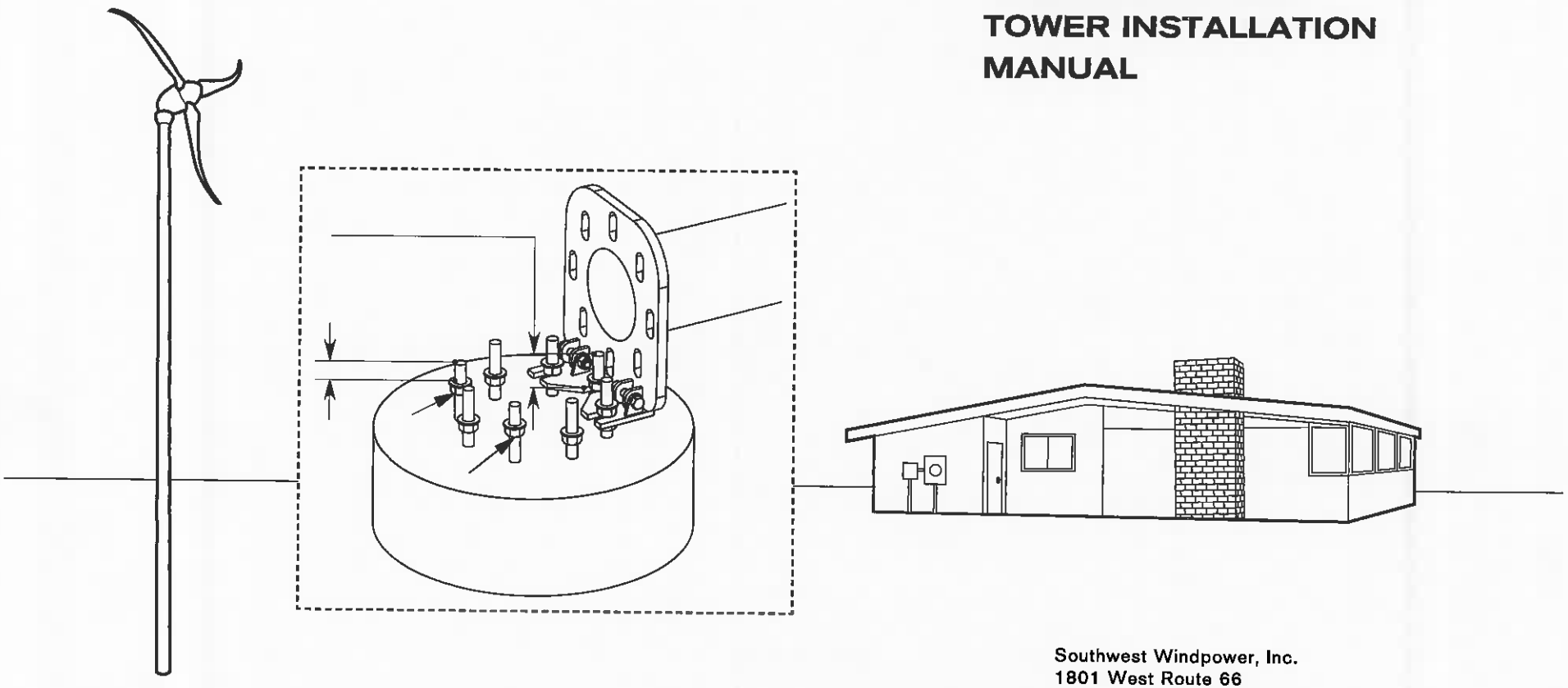
SKYSTREAM 3.7™

FOUNDATION AND TOWER INSTALLATION MANUAL



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MADE IN THE USA

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Skystream Foundation and
Tower Installation Manual
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IMPORTANT SAFETY INSTRUCTIONS

READ THESE INSTRUCTIONS IN THEIR ENTIRETY BEFORE INSTALLING.

1) SAVE THESE INSTRUCTIONS. This manual contains important instructions for constructing foundations, and raising, lowering and leveling towers that MUST be followed.
2) Read, Understand and Follow all warnings.
3) Read these instructions in their entirety before starting foundation construction and tower installation.
4) Install foundation and tower in accordance with National Electric Code, and all local building and zoning codes and requirements.
5) Obtain building and construction permits prior to starting construction.
6) Foundation concrete must be completely cured prior to installing tower (Minimum 2500 PSI, 28 day strength).
7) Skystream uses high voltage and is potentially dangerous. Follow all safety precautions at all times.
8) Follow proper grounding procedures for tower, foundation and windturbine.
9) Remain at a safe distance when raising and lowering tower. NEVER stand or walk under tower while it is being raised or lowered.
10) Be aware of overhead power lines.

In this manual

IMPORTANT: Please take note

TIP: Helpful information to ease the installation

Professional installation highly recommended

Warning: Risk of injury or death - proceed with extreme caution

One - Foundation Installation Introduction

This manual provides information for the construction of foundations for Southwest Windpower 33, 45 and 60 foot monopole towers.

- Two foundation configurations are presented for 33 foot tower – the pier and mat foundation.
- Two tower configurations are also presented for the 45 and 60 foot towers – a "pier and pad" configuration and a "pier" or "caisson" configuration.

Technical drawings and specifications are provided for all each foundation configuration. Because of the size and complexity of the foundations Southwest Windpower strongly recommends professional construction.

Please read and understand the entire installation manual before proceeding. Important information is provided regarding the positioning of the foundation "J" bolts, electrical conduit and tower grounding.

1-1 Foundation Bolt Kits and Template(s)

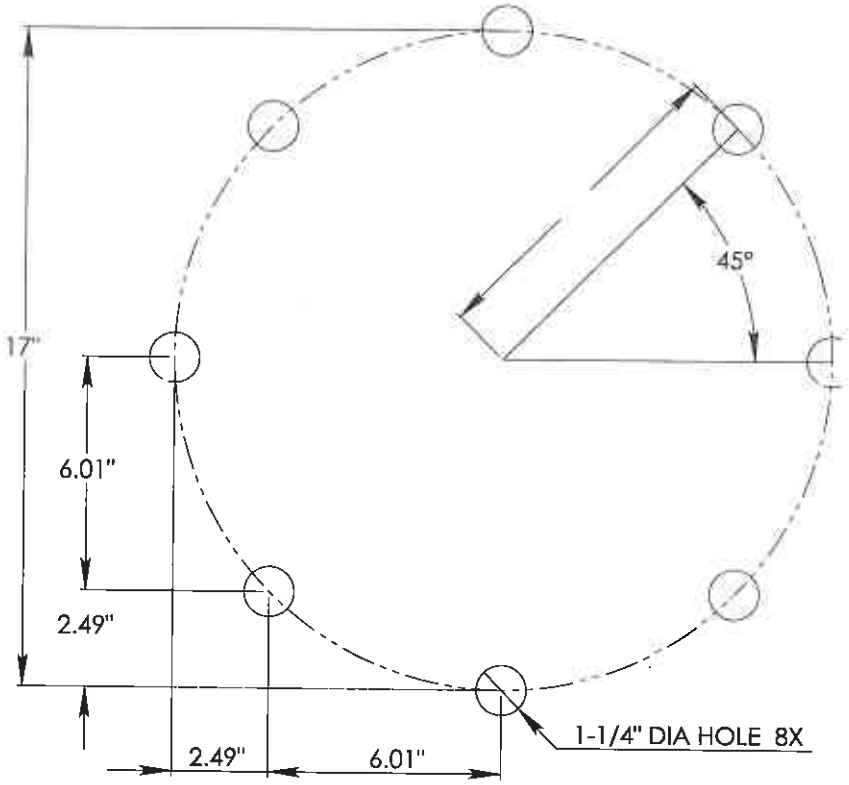
Two foundation bolt kits are available. The difference between the two kits is the length of the bolts. 42 inches long bolts are required for all foundations except the 33 ft. tower Mat foundation which uses 32 inch bolts. Each kit includes hot dip galvanized bolts, nuts and washers constructed of the appropriate steel alloys.

Two bolt pattern templates are provided with each bolt kit – the 17 inch bolt circle template is used to position the foundation "J" bolts for the 33 and 45 foot towers and the 19 inch bolt circle template is used to position the "J" bolts for the 60 foot tower. Representations of the templates are provided in **Fig. 1**.

A typical pier foundation

Two - 33 Foot Tower Pier Foundation

Technical drawings for the pier foundation are presented in **Figs. 2 and 3**. The pier diameter is 24 inches (61 cm) and the depth of the pier will vary from 5 to 11 feet (1.5 m to 3.35 m) depending on soil classification. Refer to **Fig. 4** to determine the soil classification.



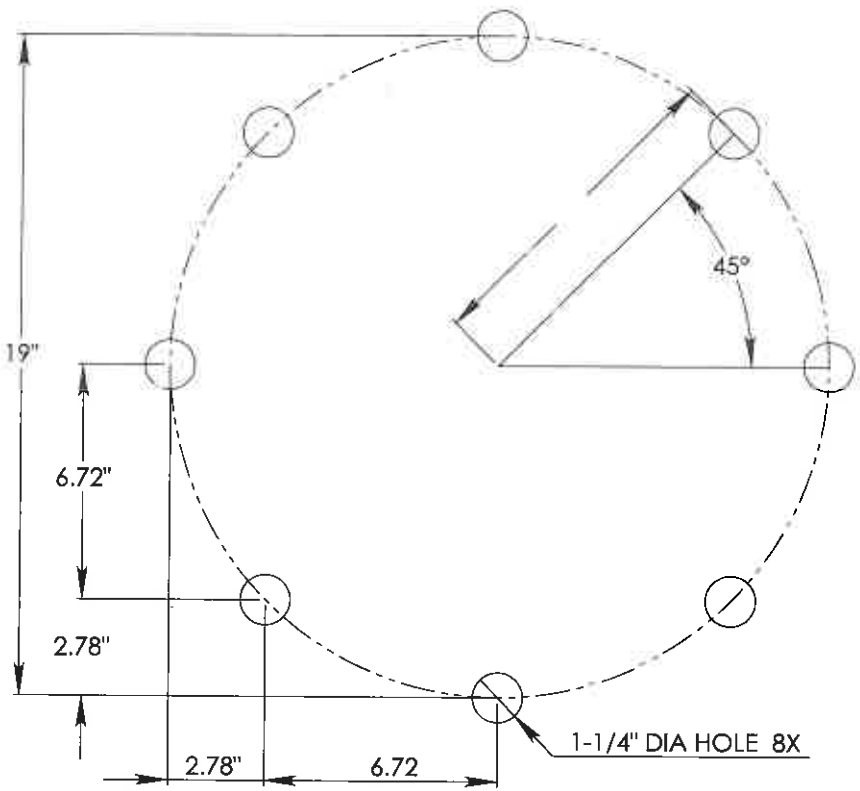


Fig. 1 Bolt template for 33' and 45' towers (17") and bolt template for 60' tower (19")

IMPORTANT: Be sure to use correct template for your tower.

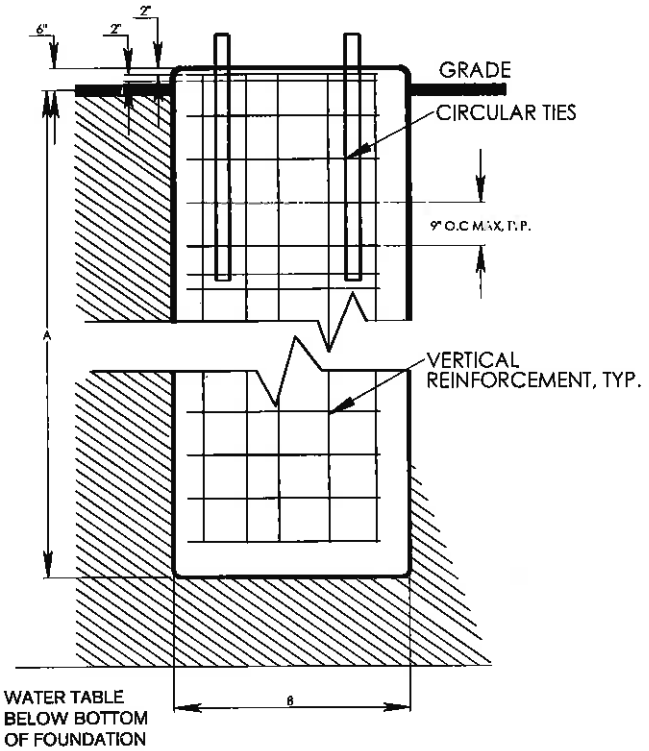


Fig. 2 Technical drawing for Pier Foundation 33 ft. Tower

TIP: Because special equipment is required to cut and bend the reinforcing bar it may be most economical to contract with a local concrete company to manufacture the reinforcement structure for the pier foundation.

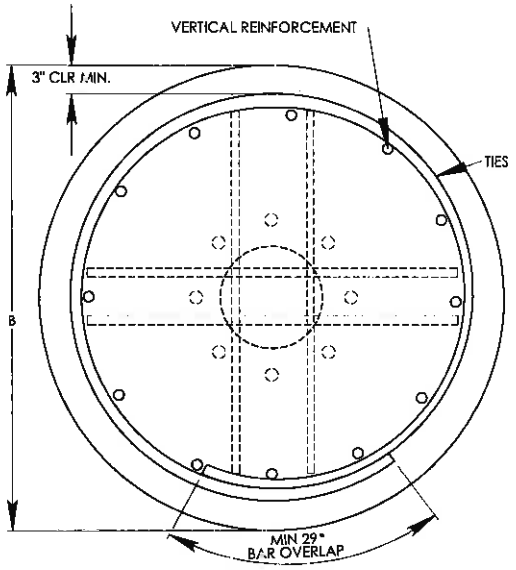


Fig. 3 Technical drawing for Pier Foundation 33 ft. Tower

Soil Classification		Allowable Soil Pressure		Design Loads at Tower Base*			Minimum Pier Dimensions**			Reinforcement	
		Lateral	Vertical	Shear (V)	Moment (M)	Vertical (P)	Depth (A)	Diameter (B)	Projection (C)	Vertical	Ties
		psf	psf	lbs.	ft-lbs	lbs	feet	inches	inches		
Class 1	Crystalline bedrock	1200	12,000	867	26,290	760	6 5	24	6	(8)-#6 (12)-#6	#4 @ 9" O.C. max
Class 2	Sedimintary and foliated rock	400	4000	867	26,290	760	8 7	24	6	(8)-#6 (12)-#6	#4 @ 9" O.C. max
Class 3	Sandy gravel and/or gravel (GW and GP)	200	3000	867	26,290	760	10 9	24	6	(8)-#6 (12)-#6	#4 @ 9" O.C. max
Class 4	Sand , sity sand, clayey sand, sity gravel and claye gravel (SW, SP, SM, SC, GM and GC)	150	2000	867	26,290	760	10	24	6	(12)-#6	#4 @ 9" O.C. max
Class 5	Clay, sand clay, sity clay, clayey sit, silt, and sandy silt (CL, ML, MH and CH)	100	1500	867	26,290	760	11 10	24 30	6	(12)-#6	#4 @ 9" O.C. max

* These Are the unfactored wind turbine extreme loads using a hub-height wind speed of 62.9m/s (140 mph), a wind shear of 0.20 and a tower drag coefficient of 0.28 [from pollamus, E.C., NASA CR 3809, 1984].

**installation of cirvular ties and anchor bols shall be in accordance with the drawings.

Fig. 4 Soil Chart 33 ft. Tower

2-1 Forming and Reinforcing Bar (33 ft. Tower Pier Foundation)

Position reinforcing bar per **Figs. 2** and **3.** Circular ties require a minimum overlap of 29 degrees (7 inches) and a minimum 3 inch clearance from the outside edge of the pier. Circular ties are #4 reinforcing bar with maximum 9 inch (23 cm) spacing. Vertical reinforcement bars are 12, #6 reinforcing bars equally spaced about circular ties. Forming is most easily accomplished using 24 inch (61 cm) sonotube. Forms must be removed before backfilling. The sonotube need not extend full depth of foundation if excavation is in solid undisturbed soil. See **Fig. 2.** Position 4, #6 cap bars as shown in **Fig. 2.**

2-2 "J" Bolts & Template (33 ft. Tower Pier Foundation)

Note: Take the time to prepare an accurate and strong template to position and secure the "J" bolts. This will save much time and difficult rework.

- Before pouring the foundation the "J" bolts **MUST** be **SECURELY** locked in position.
- Two paper templates are provided with the foundation bolt kits. Use the 17 Inch bolt circle template to position the "J" bolts for the 33 foot tower foundation.
- Use the paper template to construct a wood template.
- Two methods of framing the "J" bolts are presented in **Fig. 5.** The first method uses a single template while the second method utilizes two templates sandwiched between lengths of 2"x4" lumber. Regardless of the method be sure bolts are correctly positioned prior to pouring concrete.
- Fabricate a wood template by securing the paper template to the wood template material (3/4" plywood works well).
- Center punch the center position of each "J" bolt. Remove the paper template and drill a 1.25 inch (3.1 cm) mounting hole for each bolt. If possible compare the template to the tower base to assure bolts will be positioned correctly.
- Mount each of the "J" bolts to the wood template by using a pair of foundation nuts to clamp the template between the nuts.
- Adjust the "J" bolts so they extend 7 +/- 0.5 inches above the finished grade of the foundation. This dimension is very important for the proper operation of the tower hinge.
- Assure all bolts are vertical and parallel.

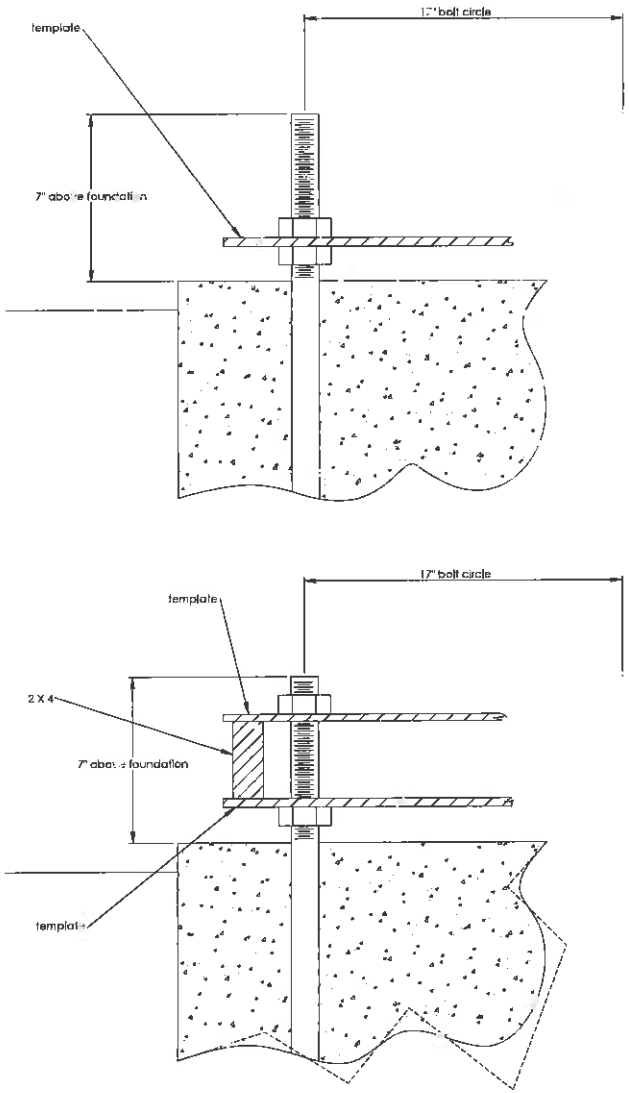


Fig. 5 "J" bolts and template (all towers)

2-3 Pier Foundation Specifications (33 ft. tower only):

Diameter	24 inches (61 cm)
Depth	Depends on soil conditions
Concrete	Minimum 2500 PSI, 28 day strength, 5% air entrapment
Pier Projection Above Grade	6 inches (16.24 cm)
Reinforcing Bar	ASTM A615 Grade 60
Circular Ties	#4 reinforcing bar, 17-18 inch (43 cm) diameter, 29 inch (73.6 cm) overlap
Vertical Reinforcement	12 equally spaced #6 reinforcing bar
Anchor "J" Bolts	42 inch (1 m) length, 1.25 inch (3.1 cm) diameter, 6 inch (16.24 cm) "J"
"J" Bolt Projection Above Foundation	7 +/- 0.5 inches

IMPORTANT: Do not exceed 7 +/- 0.5 inches dimension or bolts may interfere with hinge plate.

Three - MAT Foundation (33 ft. Tower only)

The MAT foundation is presented in **Fig. 6.** The foundation is a 6 foot by 6 foot (1.8 m x 1.8 m) square with a depth of 3 feet (.9 m). The MAT foundation is designed for an allowable vertical bearing pressure of 1,500 PSF (IBC Class 5 Soil per Table 1804.2).

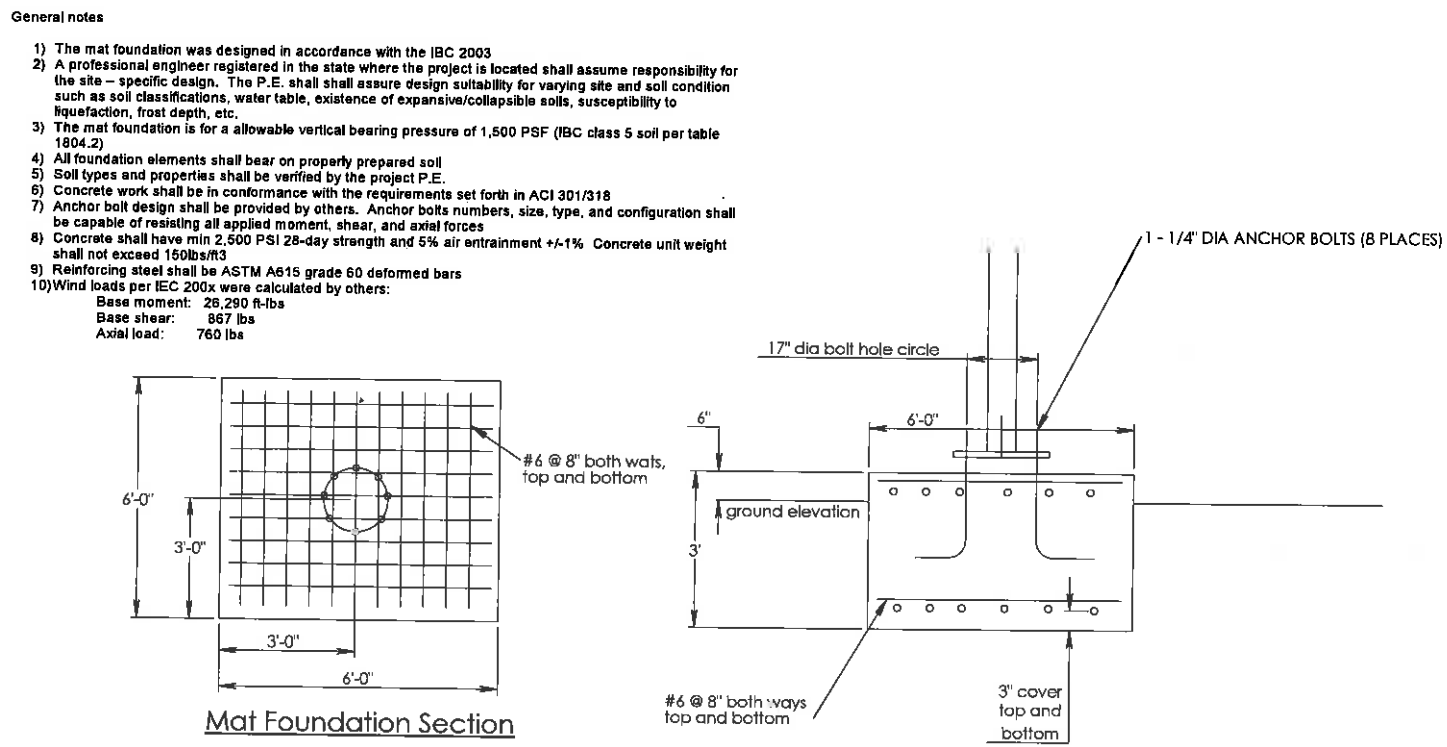


Fig. 6 Technical drawings for Mat Foundation

3-1 Reinforcing Bars (33 ft. Tower only)

Position reinforcing bar "mats" as indicated in **Fig. 6.** Reinforcing bar is #6 bar spaced at 8 inch (20.3 cm) intervals. Reinforcing bar mats positioned with minimum 3 inch (7.6 cm) concrete cover top and bottom.

3-2 "J" Bolts and Template (33 ft. Tower only)

> Note: Take the time to prepare an accurate and strong template to position and secure the "J" bolts. This will save much time and difficult rework.

- Before pouring the foundation the "J" bolts **MUST** be **SECURELY** locked in position.
- Two paper templates are provided with the foundation bolt kits. Use the 17 Inch bolt circle template to position the "J" bolts for the 33 foot tower foundation.
- Use the paper template to construct a wood template.
- Two methods of framing the "J" bolts are presented in **Fig. 5**. The first method uses a single template while the second method utilizes two templates sandwiched between 2"x4" lengths of lumber. Regardless of the method be sure bolts are correctly positioned prior to pouring concrete.
- Fabricate a wood template by securing the paper template to the wood template material.
- Center punch the center position of each "J" bolt. Remove the paper template and drill a 1.25 inch (3.1 cm) mounting hole for each bolt. If possible compare the template to the tower base to assure bolts will be positioned correctly.
- Mount each of the "J" bolts to the wood template by using a pair of foundation nuts to clamp the template between the nuts.
- Adjust the "J" bolts so they extend 7 +/- 0.5 inches above the finished grade of the foundation. This dimension is very important for the proper operation of the tower hinge.
- Assure all bolts are vertical and parallel to each other.

3-3 MAT Foundation Specifications (33 ft. Tower only)

Dimensions	6 feet x 6 feet x 3 feet (1.8 x 1.8 x .9 m) deep
Reinforcing Bar	ASTM A615 Grade 60
Anchor "J" Bolts	32 inch (81.3 cm) length, 1.25 (3.1 cm) diameter, 6 inch (16.24 cm) "J"
Concrete	Minimum 2500 PSI, 28 day strength, 5% Air Entrapment

Four - Electrical Conduit

Electrical conduit may be cast into the foundation such that the conduit continues below grade to electrical panel. Alternately wire may be routed between tower base plate and foundation. Refer to local building codes **BEFORE** pouring concrete.

Building codes typically require direct burial cables be buried to a minimum depth of 24 inches (61 cm) while cables in conduit may be buried at a depth of 18 inches (46 cm). Additionally, most codes prohibit embedding cables directly in concrete. Refer to local codes for conduit size and minimum depth requirements.

Five - Tower Installation Introduction

The following sections provide step by step directions for raising the Southwest Windpower 33 foot monopole tower (part number 3-CMBP-3043). The installation instructions assume availability of hinge plate and gin pole kits specifically designed for this application. The instructions also assume a foundation bolt kit was purchased and the correct fasteners are available.

Once the tower is raised the hinge plate and gin pole are removed. Many dealers will loan or rent these components so it is not necessary to purchase them. Contact Southwest Windpower or your Skysteam dealer for additional information.

Note: Detailed installation instructions are not provided for the 45 and 60 foot towers since raising these towers require specialized equipment and skills. This procedure is beyond the capability of most homeowners.

5-1 Required Tools & Equipment

The following tools and equipment are necessary to install the tower:

- Hinge Mounting Kit - Part Number 3-CMBP-3063 (there are two versions of hinge plate – see specific instructions for your hinge plate)
- Gin Pole Kit - Part Number 3-CMBP-3054 (there are three versions of gin pole – see specific instructions for your gin pole)
- 16 Flat Washers, 1 1/4" ID, galvanized SATM F436, (SWWP part number 3-HDWA-917)
- 20 Nuts, 1 1/4", galvanized, (SWWP part number 3-HDNT-908)
- Bubble level, (easier with two levels)
- Pair of 2" open end wrenches.
- Pair of adjustable wrenches to install hinge plates and gin pole, tape measure.

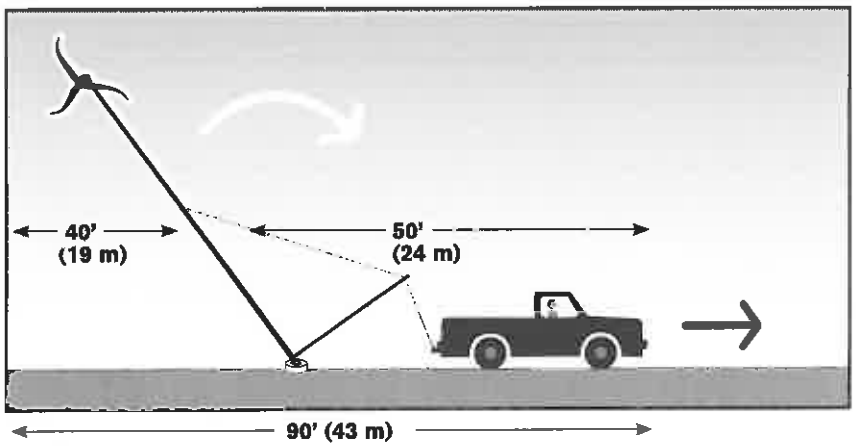


Fig. 7

TIP: Approximately 90 feet (43 meters) are required to raise the tower vertically into position. Forty feet (19 meters) are required on one side of the foundation for the tower and wind generator. An additional 50 feet (24 meters) are required on the other side of the foundation for the gin pole and pulling vehicle. See **Fig. 7**.

TIP: The 5" adjustment is temporary. The height of the hinge must be adjusted as described in latter instructions.

Six - Hinge Plate Installation Instructions

IMPORTANT: There are two versions of the Hinge Plate Kit – **Early and Later Versions** - refer to Figs. 8 and 9 to determine which kit you have and follow the directions for that kit.

6-1 Early Version Hinge Plate Kit Mounting Instructions:
(refer to **Fig. 8** and follow instructions below)

• Determine the three foundation bolts to be used to mount the hinge and install a nut on each bolt. The top of the nut should be 5 inches from the top of the bolt.

• Place a single nut on one of the foundation bolts. (Not one of the bolts used to secure the hinge plate.) This nut will later be used to ground the tower.

• Install a nut and washer on each of the eight foundation bolts. Leave a gap of approximately 7/8 inch between the nuts on the bolts for the hinge plate.

• Bolt the hinge to the tower base using the 7/8 inch nuts and bolts supplied with the hinge kit. Install the bolts from the "outside" to ease later removal of the bolts. Fully screw the nuts onto the bolts but do not over tighten since the bolts act as pivots.

• Using suitable lifting equipment, lift the tower (with hinge) and position the hinge slots between the nuts on the foundation bolts. Refer to **Fig. 8.**

• Adjust and tighten the nuts securing the hinge plate such that the top of the hinge plate is 4 1/4 inches from the top of the foundation bolts.

• Position the remaining nuts as shown in **Fig. 8.** The washers on the "A" and "B" nuts should be 2 1/4 inches from the top of the bolts. Position the remaining nuts lower than the "A" and "B" nuts – these nuts will be tightened after leveling the tower.

The tower, hinge plate and foundation should now appear as shown in **Fig. 8.**

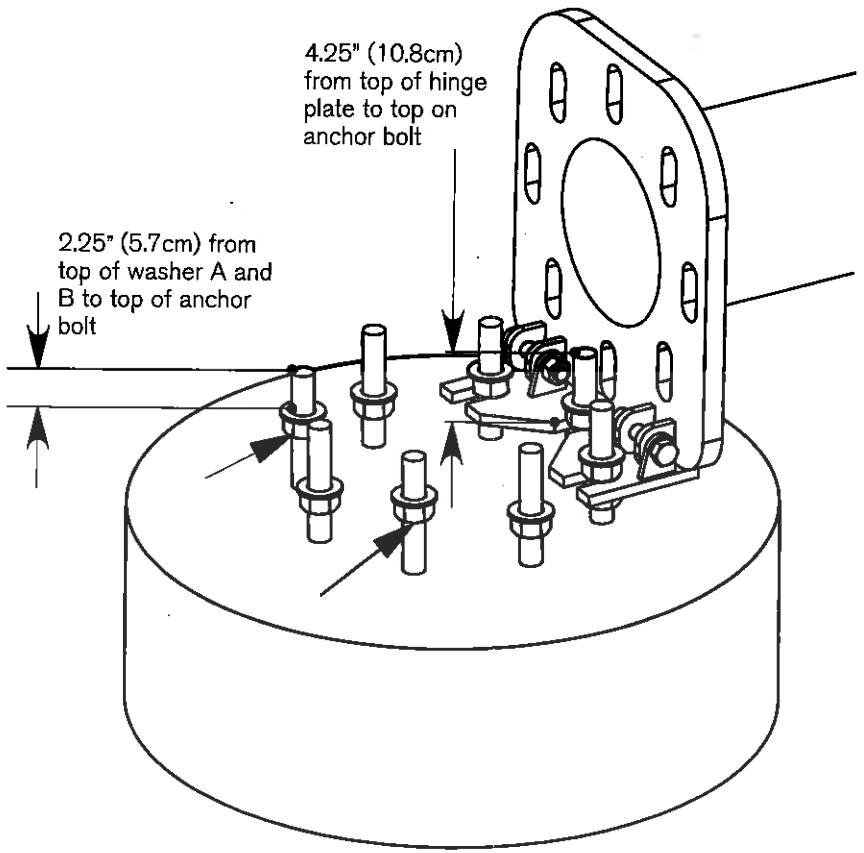


Fig. 8 Early Version hinge assembly and nut placement.

WARNING: The 4 1/4" height adjustment is VERY important to insure the foundation bolts will clear the slotted holes in the base plate allowing the tower to fully tilt into position.

6-2 Later Version Hinge Plate Kit Mounting Instructions:
(refer to **Fig. 9** and follow instructions below)

• Determine the three foundation bolts to be used to mount the hinge and place a nut on each of the bolts. Leave approximately 1 inch between the bottom of the nut and top of the foundation.

• Attach the hinge plate to the tower base as shown in **Fig. 9** using the clevis pins supplied with the hinge plate kit.

• Using suitable lifting equipment, lift the tower (with hinge) and position hinge slots fully onto the foundation bolts between the top of the foundation and the foundation nuts. Refer to **Fig. 9.**

• Place a single nut on one of the foundation bolts. (Not one of the bolts used to secure the hinge plate.) This nut will later be used to ground the tower.

• Install a nut on each of the five bolts NOT USED to secure the hinge to the foundation then place a washer on top of each of the eight foundation bolts.

• Adjust the five nuts on the bolts not securing the hinge plate such that the top of the washer is 3.1 +/- 0.25 inches from the top of bolt.

The tower, hinge plate and foundation should now appear as shown in **Fig. 9.**

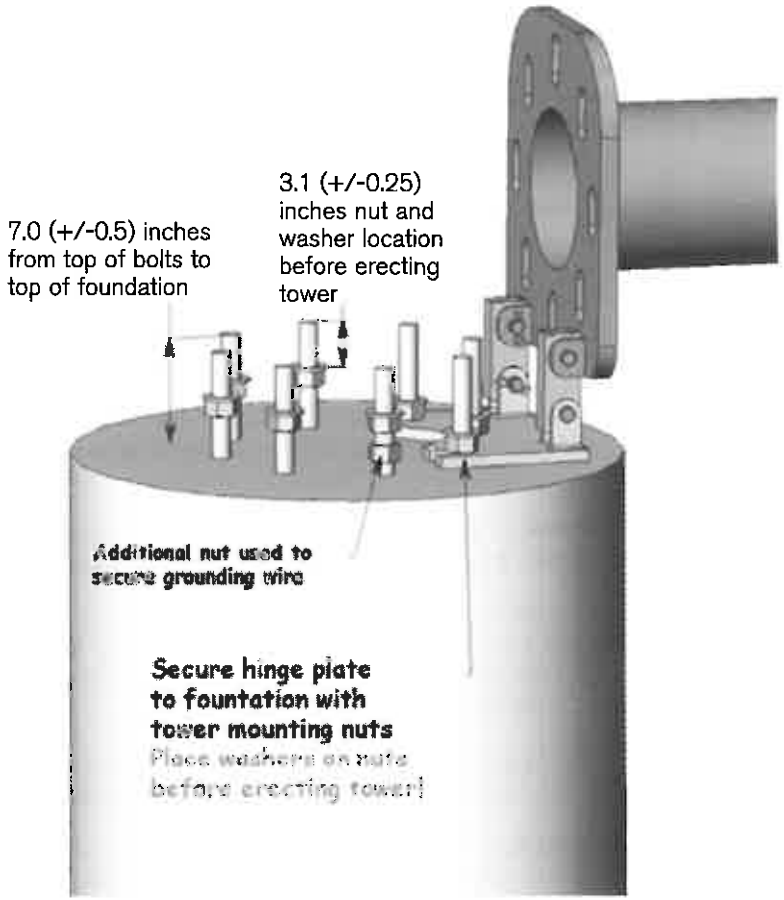


Fig. 9 Late Version hinge assembly and nut placement.

Seven - Gin Pole Installation Instructions

There are three versions of the Gin Pole Kit as shown below. The installation instructions for each kit differ slightly. Where required the directions indicate specific instructions for either the "A", "B" or "C" versions of the Gin Pole Kit.

TIP: The tower is now set to be raised. Southwest Windpower recommends raising the tower once without the wind turbine installed. This permits checking the proper operation and installation of the hinge and gin pole and also allows inexperienced installers an opportunity to practice raising the tower without risking damage to the wind turbine.

A

- two cables
- two shackles
- two M16 (metric 16 mm) bolts
- two M16 nuts
- three M24 (metric 24 mm) bolts
- three M24 nuts

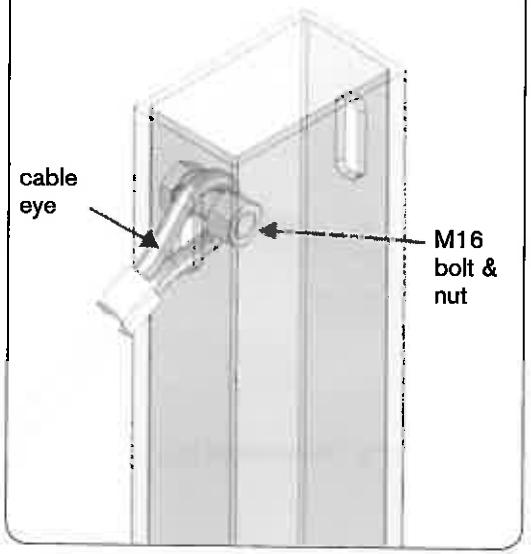


Fig. 10 Eary Version cable-gin pole assembly details

B

- gin pole
- two cables
- three shackles
- one M16 (metric 16 mm) bolt
- one M16 nut
- three M24 (metric 24 mm) bolts
- three M24 nuts

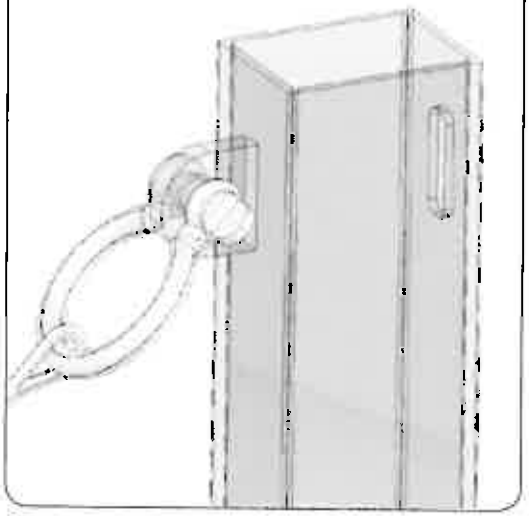


Fig. 11 Late Version cable-gin pole assembly details

C

- gin pole
- two cables
- four shackles
- three M24 (metric 24 mm) bolts
- three M24 nuts

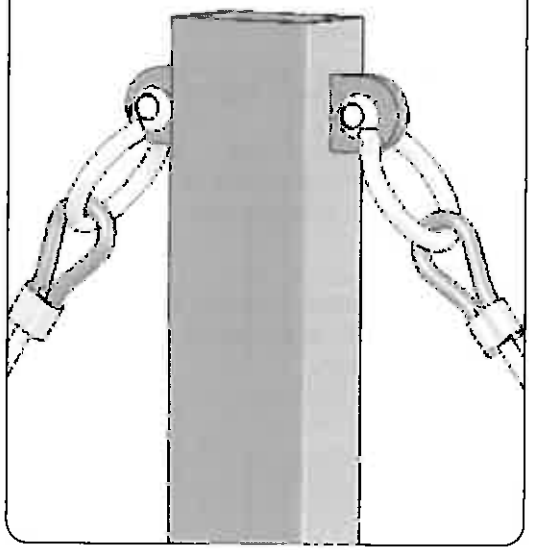


Fig. 12 Version "C" cable-gin pole assembly details

- Connect the gin pole to the tower base on the opposite side of the tower hinge. Use three 24 mm nuts and bolts. The nuts only need to be hand tight.

> **TIP:** Install 24 mm gin pole bolts from above so they can be removed after tower is tilted into position.

- "A" and "B" model gin poles – using a 16 mm nut and bolt connect one cable end to the gin pole as shown in **Fig 10**. Connect the other end of the cable to the welded tab on the tower using one of the supplied shackles.
- "C" model gin poles – connect the welded tab on the gin pole to the welded tab on the tower using a cable and two shackles.
- "A" model gin pole only – connect the second cable to the gin pole using a 16 mm nut and bolt as depicted in **Fig 10**.
- "B" and "C" model gin poles – connect the second cable to the welded tab on the gin pole using a shackle as shown in **Figs. 11 and 12**.
- All model gin poles – connect loose end of second cable to raising vehicle using one of supplied shackles.

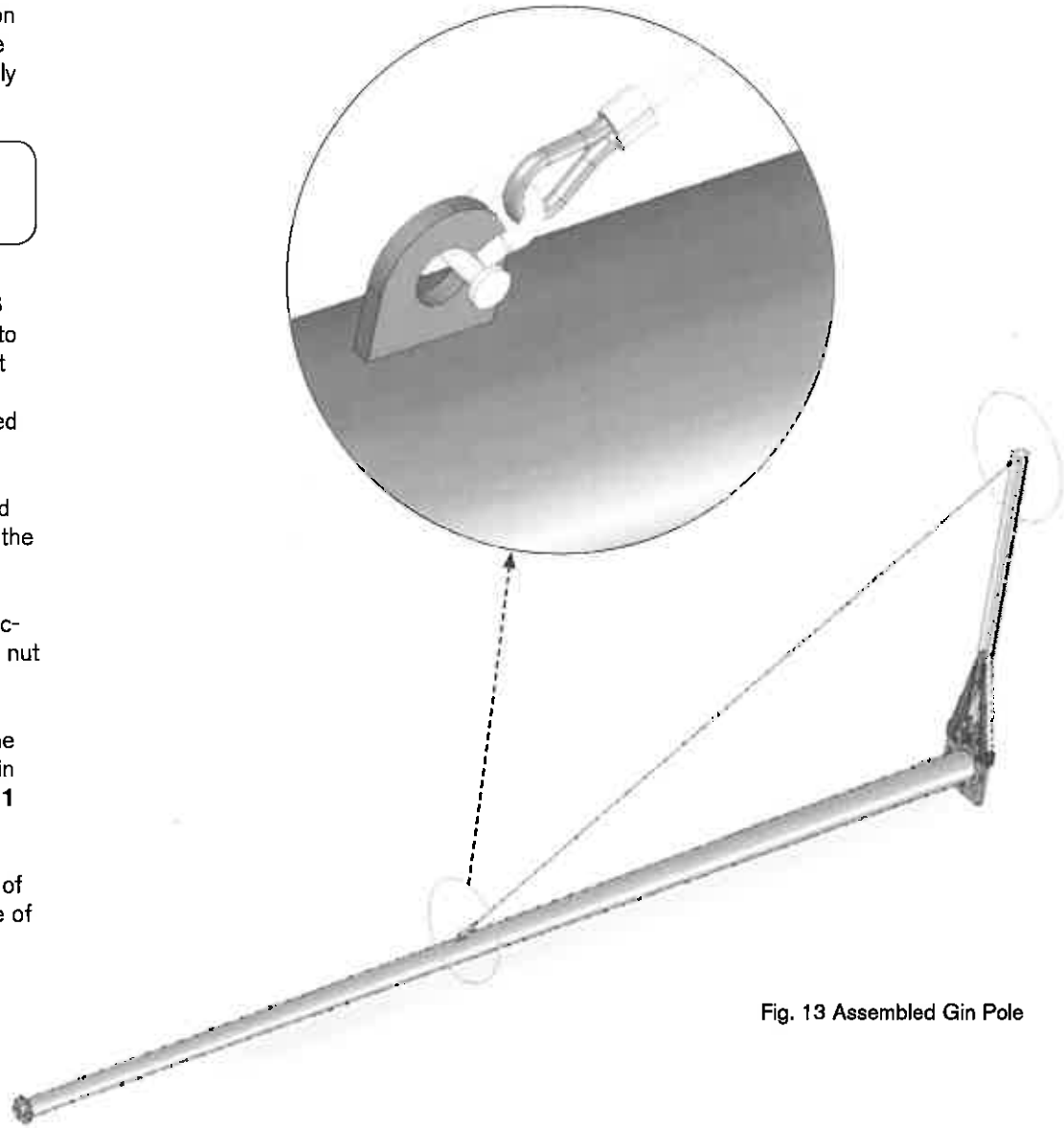


Fig. 13 Assembled Gin Pole

Eight - Raising the Tower

Refer to your Skystream Owner's Manual for directions on mounting Skystream on the tower. If you have not raised a tower before it is also recommended to first raise the tower without the turbine. Raising the tower without the turbine provides the opportunity to practice the procedure without risking damage to the turbine.

A minimum of three people are required to raise the tower.

- Position the remainder of tower mounting hardware and tools close to the tower foundation.
- Securely connect the gin pole cable to the raising vehicle.
- Very slowly, drive the vehicle away from the tower taking the "slack" out of the cable. Keep the vehicle inline with the tower while slowly raising the tower.

WARNING: Use extreme caution when raising the tower. Keep well away and to sides of tower and cable. Beware of overhead power lines.

- As the tower approaches vertical it will reach a "balance point". At this point two people can take over from the vehicle and use the gin pole to manually "lower" the tower into the full upright position. The goal is to prevent the tower from "falling" into the final vertical position after it passes the "balance point".
- With the tower vertical and resting on the foundation bolts, install the remaining nuts and washers and hand tighten the nuts. Note that the tower may be tilted away from the hinge and it may be necessary to lower the "hinge side" of the tower to fully thread the nuts on the foundation bolts.
- If the tower was raised without the wind turbine, refer to the Lowering the Tower section and follow the instructions. If the tower was raised with the wind turbine proceed to Leveling the Tower section.

Nine - Lowering the Tower

Lowering the tower is essentially the reverse of raising the tower. The same precautions should be observed, including positioning the hinge so the tower base plate clears the foundation bolts. As with raising the tower a minimum of three people are recommended.

WARNING: Use extreme caution when lowering the tower. Keep well away and to sides of tower and cable.

- Position suitable bracing support the top of the tower after it is lowered. The support should be located approximately 8 feet (2.5 m) from the top of the tower to clear the turbine blades.
- If not already in place, install the hinge plate by sliding the hinge between the lower and middle nuts on the foundation bolts. Slide the 7/8" diameter bolts that act as hinge pins through the hinge and tower foundation plate and snuggly tighten the 7/8" nuts.
- Securely tighten the 1 1/4" nuts that secure the hinge to the foundation bolts. Check the distance from the top of the hinge to the top of the foundation bolts is 4 1/4". Adjust if necessary. Refer to **Fig. 8**.
- Bolt the gin pole to the foundation plate and connect the cable from gin pole to the weldment on the tower.
- Connect the second cable to the gin pole and lowering vehicle.
- Position the vehicle so it is in line with the tower and there is approximately 1 foot (30 cm) of slack in the gin pole cable.
- Remove the remaining 1 1/4" nuts and washers from the foundation bolts.
- The lowering process is started by two people lifting the gin pole so that the tower starts to tilt and takes up the cable slack.
- Once the tower passes the balance point the the vehicle can then be used to fully lower the tower.

WARNING: Someone MUST be in the vehicle at all times to control lowering the tower. The "pulling" force the tower exerts greatly increases as the tower approaches the horizontal. In other words the tower is lowered using the vehicle brakes to slow the descent of the tower. During lowering keep the vehicle engine running to provide power brake assistance.

Ten - Leveling the Tower

Leveling the tower is most easily accomplished using only four of the eight foundation bolts. Once the tower is leveled the remaining bolts can be fully tightened to secure the tower.

Be aware that leveling the tower may require some trial and error adjustments – even though the base is level, the upper tower flange may be off level due to manufacturing tolerances.

To level the tower:

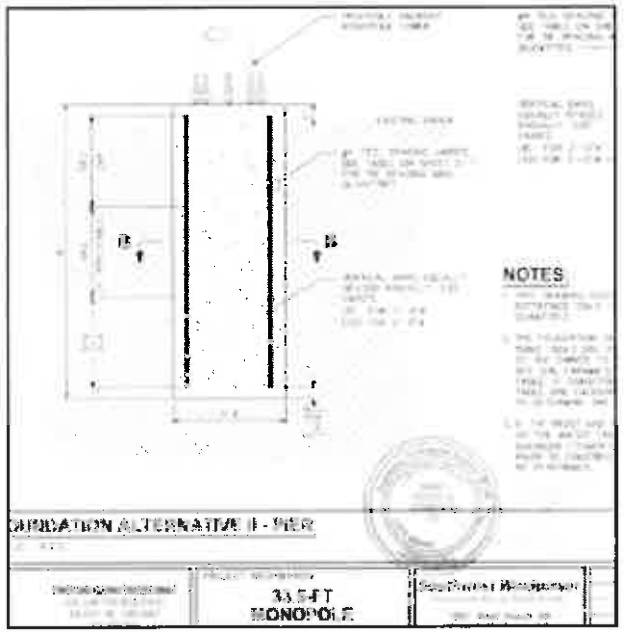
- Level the tower on a calm day to minimize movement of Skystream. Start by loosening all the upper foundation nuts about a full turn.
- Loosen and lower the four nuts on the "sides" of the foundation base plate. In other words the tower should be supported by the four "corner" nuts of the tower base plate. (refer to **Fig. 8**, Bolts A and B are "corner" bolts)
- Using two bubble levels set perpendicular to each other on the base plate adjust the foundation nuts until the tower is level. Magnetic bubble levels may make this process easier.
- Once the tower is level tighten all nuts and recheck level.

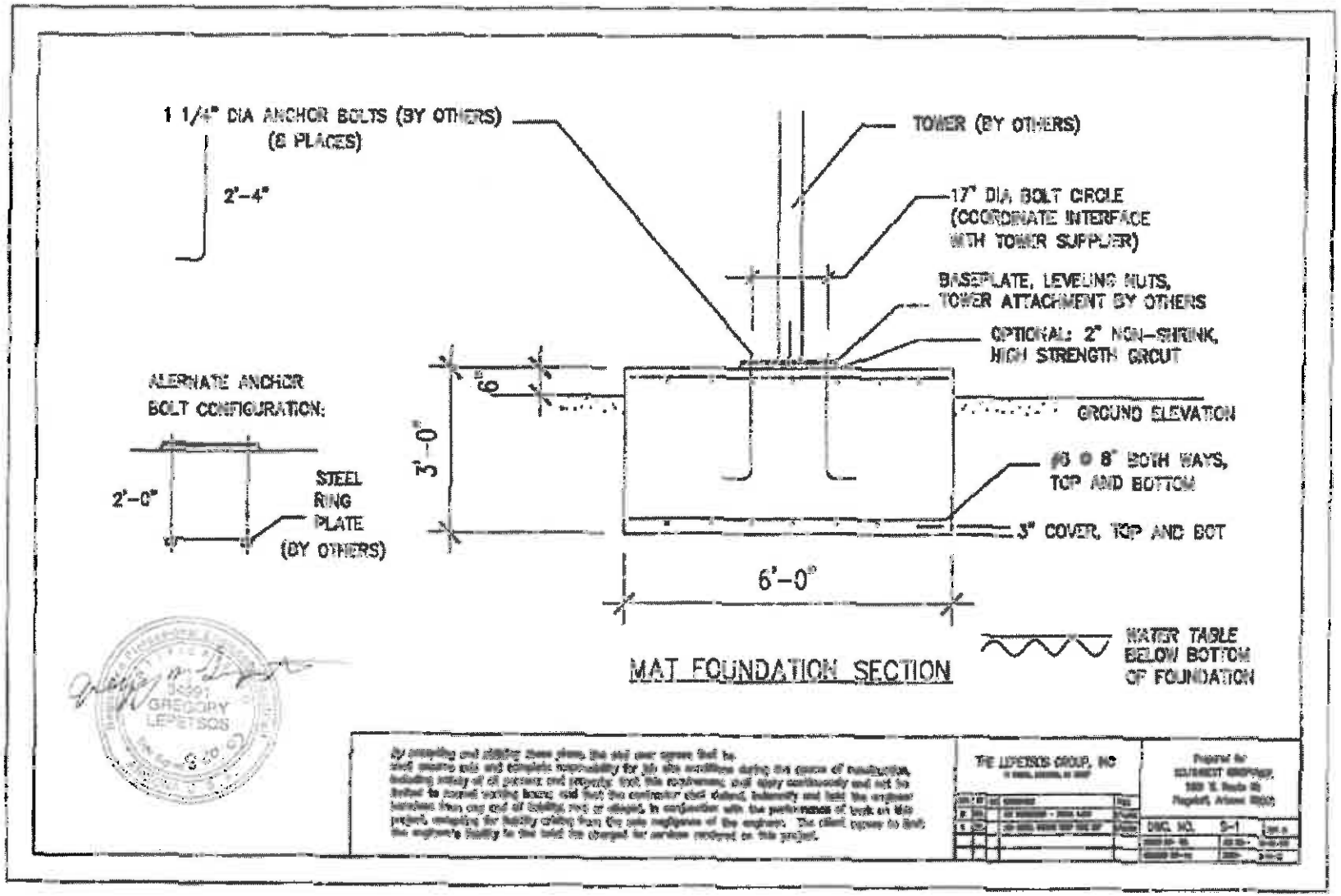
Observe the position of Skystream on calm days. If the wind turbine seems to favor a single position with no wind, the tower may require fine tuning even if it appears level using the bubble leveling technique.

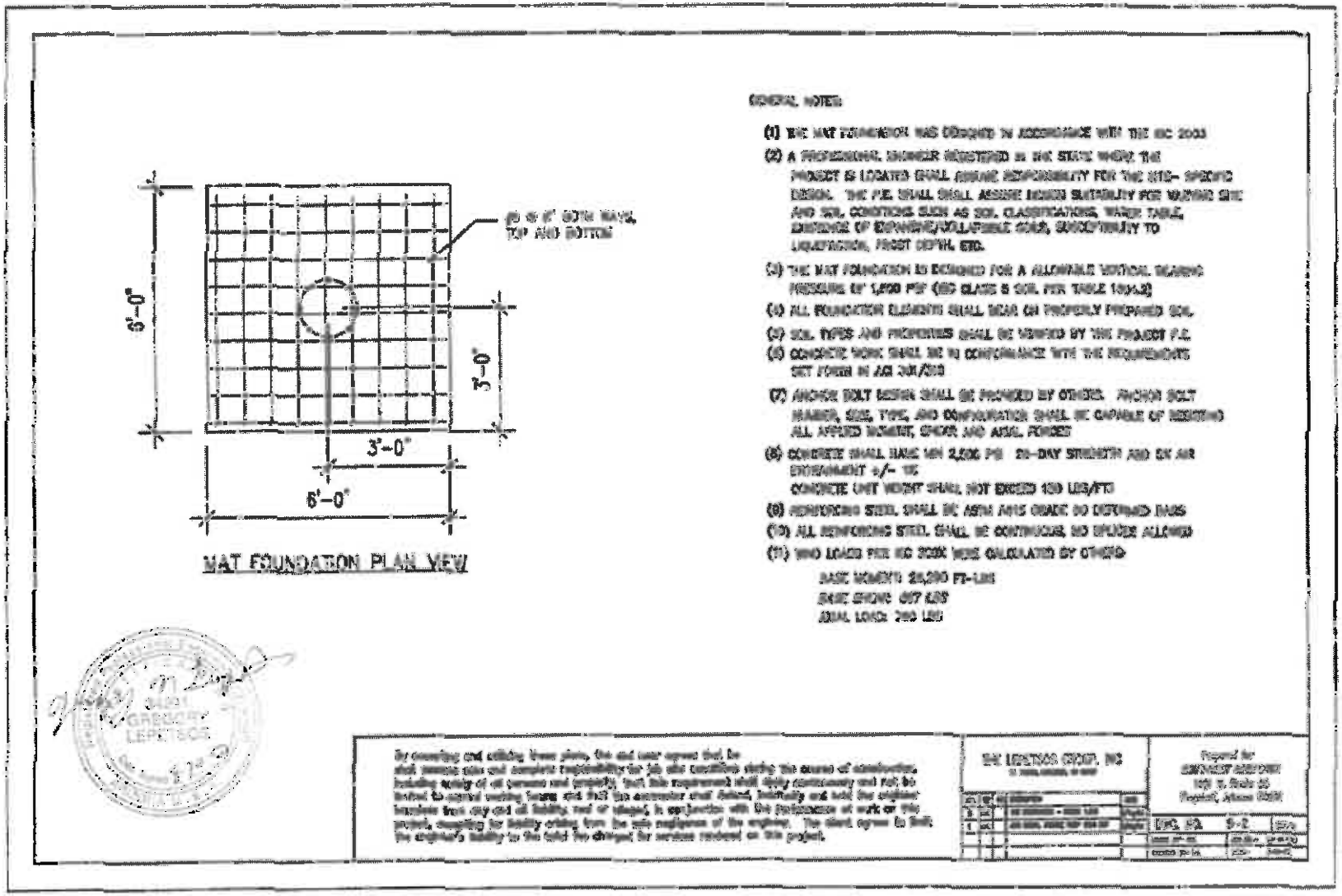
To fine tune the tower realize that the nose cone of the wind turbine will "point" in the direction of the tower low side. Therefore, to level the tower, slightly raise the side of the tower under the nose cone or lower the side of the tower opposite the nose cone. Make fine adjustments. Approximately one turn of a foundation nut equates to slightly more than 1/8" (6.4 mm) so even a half turn adjustment will make a difference.

Skystream 3.7 Foundation & Tower Installation Manual

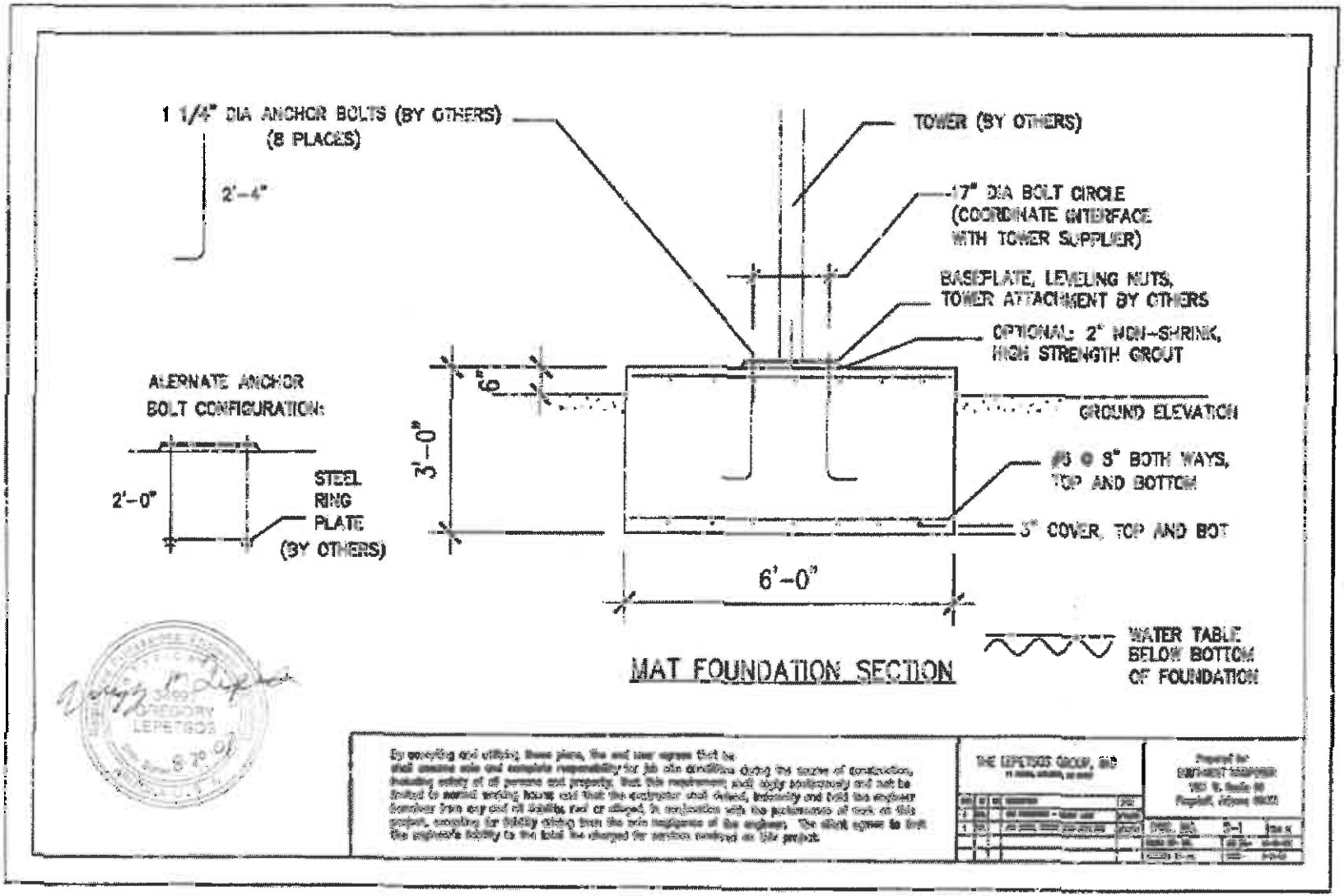
Appendix A: Professional Engineer Stamped Foundation Analysis & Drawings

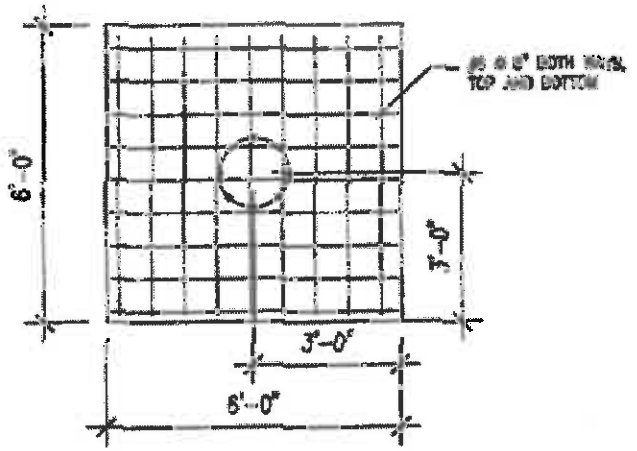



1 1/4" DIA ANCHOR BOLTS (BY OTHERS)
(8 PLACES)
2'-4"
TOWER (BY OTHERS)
17" DIA BOLT CIRCLE
(COORDINATE INTERFACE
WITH TOWER SUPPLIER)
BASEPLATE, LEVELING NUTS,
TOWER ATTACHMENT BY OTHERS
OPTIONAL: 2" NON-SHRINK,
HIGH STRENGTH GROUT
ALTERNATE ANCHOR
BOLT CONFIGURATION:
2'-0"
STEEL
RING
PLATE
(BY OTHERS)
6"
3'-0"
GROUND ELEVATION
#3 @ 8" BOTH WAYS,
TOP AND BOTTOM
3" COVER, TOP AND BOT
6'-0"
WATER TABLE
BELOW BOTTOM
OF FOUNDATION
MAT FOUNDATION SECTION
GREGORY
LEPETSOS
THE LEPETSOS GROUP, INC
DWG. NO. S-1



MAT FOUNDATION PLAN VIEW


1 1/4" DIA ANCHOR BOLTS (BY OTHERS)
(8 PLACES)
2'-4"
TOWER (BY OTHERS)
17" DIA BOLT CIRCLE
(COORDINATE INTERFACE
WITH TOWER SUPPLIER)
BASEPLATE, LEVELING NUTS,
TOWER ATTACHMENT BY OTHERS
OPTIONAL: 2" NON-SHRINK,
HIGH STRENGTH GROUT
ALTERNATE ANCHOR
BOLT CONFIGURATION:
2'-0"
STEEL
RING
PLATE
(BY OTHERS)
6"
3'-0"
GROUND ELEVATION
#5 @ 8" BOTH WAYS,
TOP AND BOTTOM
3" COVER, TOP AND BOT
6'-0"
WATER TABLE
BELOW BOTTOM
OF FOUNDATION
MAT FOUNDATION SECTION



MAT FOUNDATION PLAN VIEW

GENERAL NOTES:

(1) THE MAT FOUNDATION WAS DESIGNED IN ACCORDANCE WITH THE IBC 2009

(2) A PROFESSIONAL ENGINEER REGISTERED IN THE STATE WHERE THE PROJECT IS LOCATED SHALL ASSUME RESPONSIBILITY FOR THE SITE- SPECIFIC DESIGN. THE P.E. SHALL SHALL ASSUME DESIGN RESPONSIBILITY FOR WIND AND SOIL CONDITIONS SUCH AS SOIL CLASSIFICATIONS, WATER TABLE, EXISTENCE OF EXPANSIVE/COLLAPSIBLE SOILS, SUSCEPTIBILITY TO LIQUEFACTION, FROST DEPTH, ETC.

(3) THE MAT FOUNDATION IS DESIGNED FOR A ALLOWABLE VERTICAL BEARING PRESSURE OF 1,500 PSF (IBC CLASS 5 SOIL PER TABLE 1804.2)

(4) ALL FOUNDATION ELEMENTS SHALL BEAR ON PROPERLY PREPARED SOIL

(5) SOIL TYPES AND PROPERTIES SHALL BE VERIFIED BY THE PROJECT P.E.

(6) CONCRETE WORK SHALL BE IN CONFORMANCE WITH THE REQUIREMENTS SET FORTH IN ACI 301/318

(7) ANCHOR BOLT DESIGN SHALL BE PROVIDED BY OTHERS. ANCHOR BOLT NUMBER, SIZE, TYPE, AND CONFIGURATION SHALL BE CAPABLE OF RESISTING ALL APPLIED MOMENT, SHEAR AND AXIAL FORCES

(8) CONCRETE SHALL HAVE MIN 2,500 PSI 28-DAY STRENGTH AND BY AIR ENTRAINMENT +/- 3%
CONCRETE UNIT WEIGHT SHALL NOT EXCEED 150 LBS/FT3

(9) REINFORCING STEEL SHALL BE ASTM A615 GRADE 60 DEFORMED BARS

(10) ALL REINFORCING STEEL SHALL BE CONTINUOUS, NO SPLICES ALLOWED

(11) WIND LOADS PER IBC 2009 WERE CALCULATED BY OTHERS:
BASE MOMENT: 28,800 FT-LBS
BASE SHEAR: 867 LBS
AXIAL LOAD: 360 LBS

34881
GREGORY LEPETOS

By accepting and utilizing these plans, the end user agrees that he shall assume total and complete responsibility for job site conditions during the course of construction, including safety of all persons and property; that this requirement must apply continuously and not be limited to normal working hours; and that the contractor shall defend, indemnify and hold the engineer harmless from any and all liability real or alleged, in connection with the performance of work on this project, excepting for liability arising from the sole negligence of the engineer. The client agrees to limit the engineer's liability to the total fee charged for services rendered on this project.

THE LEPETOS GROUP, INC

Prepared for
SKYSTREAM WIND CORP.

Southwest Windpower

Renewable Energy Made Simple

ATTENTION

THE FOUNDATION DESIGNS ARE AVE IN ACCORDANCE WITH TIA/EIA-222-G-2005, STRUCTURAL STANDARD FOR ANTENNA SUPPORTING STRUCTURES AND ANTENNAS DATED JANUARY 2006, THE 2006 INTERNATIONAL BUILDING CODE (IBC 2006), AND ASCE 7-05, MINIMUM DESIGN LOADS FOR BUILDINGS AND OTHER STRUCTURES. THE FOUNDATION DESIGNS ARE FOR THE 33.5-FT DABR MONOPOLE BY VALMONT INDUSTRIES, INC. AND THE SKYSTREAM 3.7 WIND TURBINE BASED ON THE WIND ZONES DESCRIBED ON SHEET S-1 AND THE SOIL INFORMATION LISTED IN TABLE 1804.2 (IBC 2006) REFERENCED ON SHEET S-3. IT IS THE RESPONSIBILITY OF THE OWNER TO VERIFY BY GEOTECHNICAL INVESTIGATION THAT ACTUAL SITE SOIL PARAMETERS MEET OR EXCEED THOSE SHOWN IN THE REFERENCED TABLE. IF CONDITIONS OTHER THAN THOSE DESCRIBED IN THE REFERENCED TABLE ARE ENCOUNTERED A FOUNDATION ANALYSIS SHOULD BE PERFORMED TO DETERMINE THE STRUCTURAL ADEQUACY OF THE SUBSTRUCTURE.

INDEX OF SHEETS

NO	SHEET TITLE	REV	DATE
T-1	TITLE SHEET	0	06-25-07
S-1	CONTINENTAL UNITED STATES WIND SPEED MAP – ASCE 7-05	0	06-25-07
S-2	PROJECT NOTES	0	06-25-07
S-3	TABLE 1804.2 ALLOWABLE FOUNDATION AND LATERAL PRESSURE (IBC 2003)	0	06-25-07
S-4	TOWER REACTIONS	0	06-25-07
S-5	33.5-FT MONOPOLE FOUNDATION DIMENSIONS – PAD AND PIER	0	06-25-07
S-6	FOUNDATION ALTERNATIVE 1 – PAD AND PIER	0	06-25-07
S-7	33.5-FT MONOPOLE FOUNDATION DIMENSIONS – PIER	0	06-25-07
S-8	FOUNDATION ALTERNATIVE 2 – PIER	0	06-25-07

TOWER ENGINEERING PROFESSIONALS
[illegible]

PROJECT INFORMATION
33.5-FT MONOPOLE FOUNDATIONS

Southwest Windpower
Renewable Energy Made Simple
1801 West Route 66
Flagstaff, AZ 86001
Office: (928) 779-9463

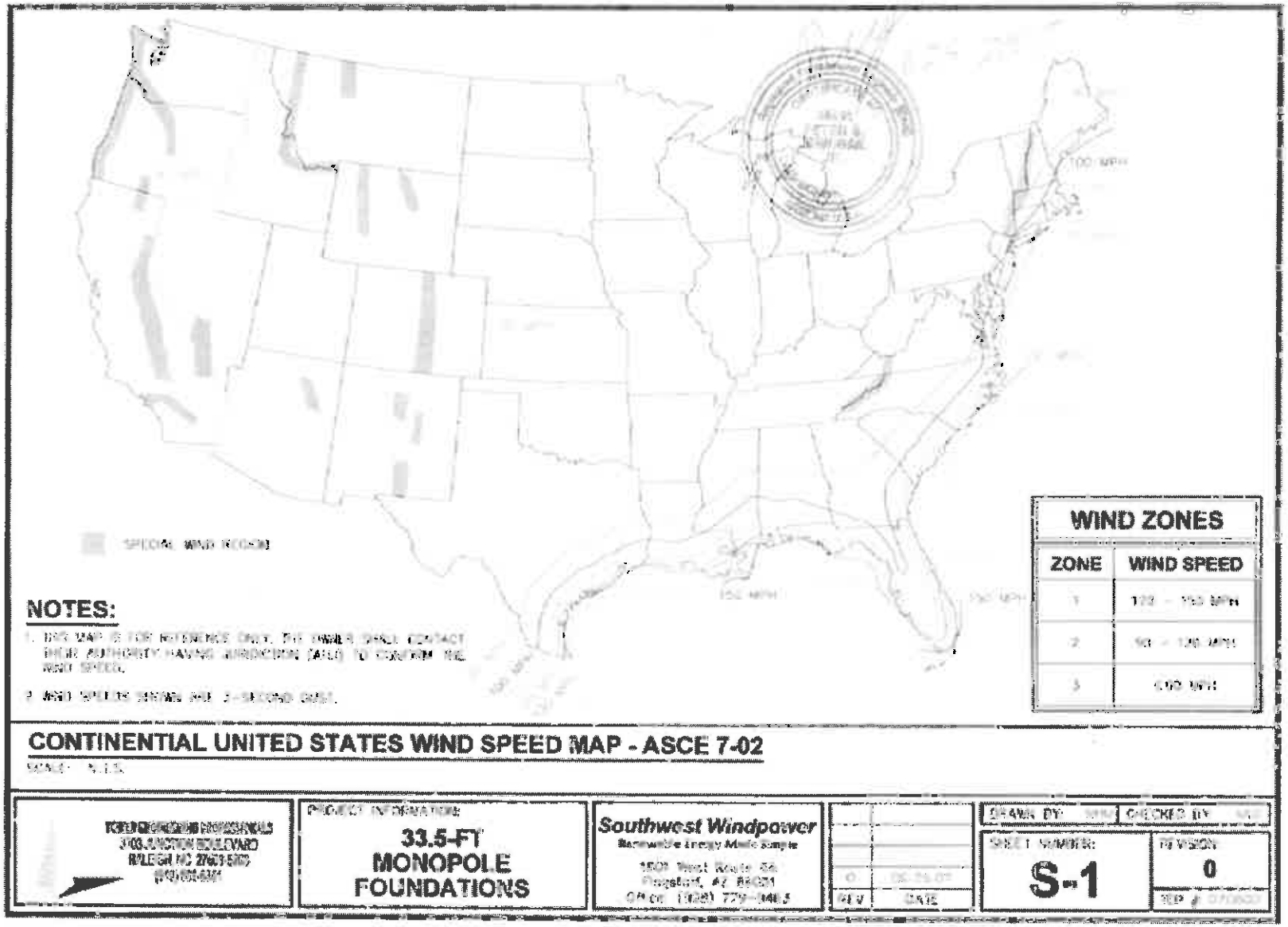
REV	DATE
0	06-25-07

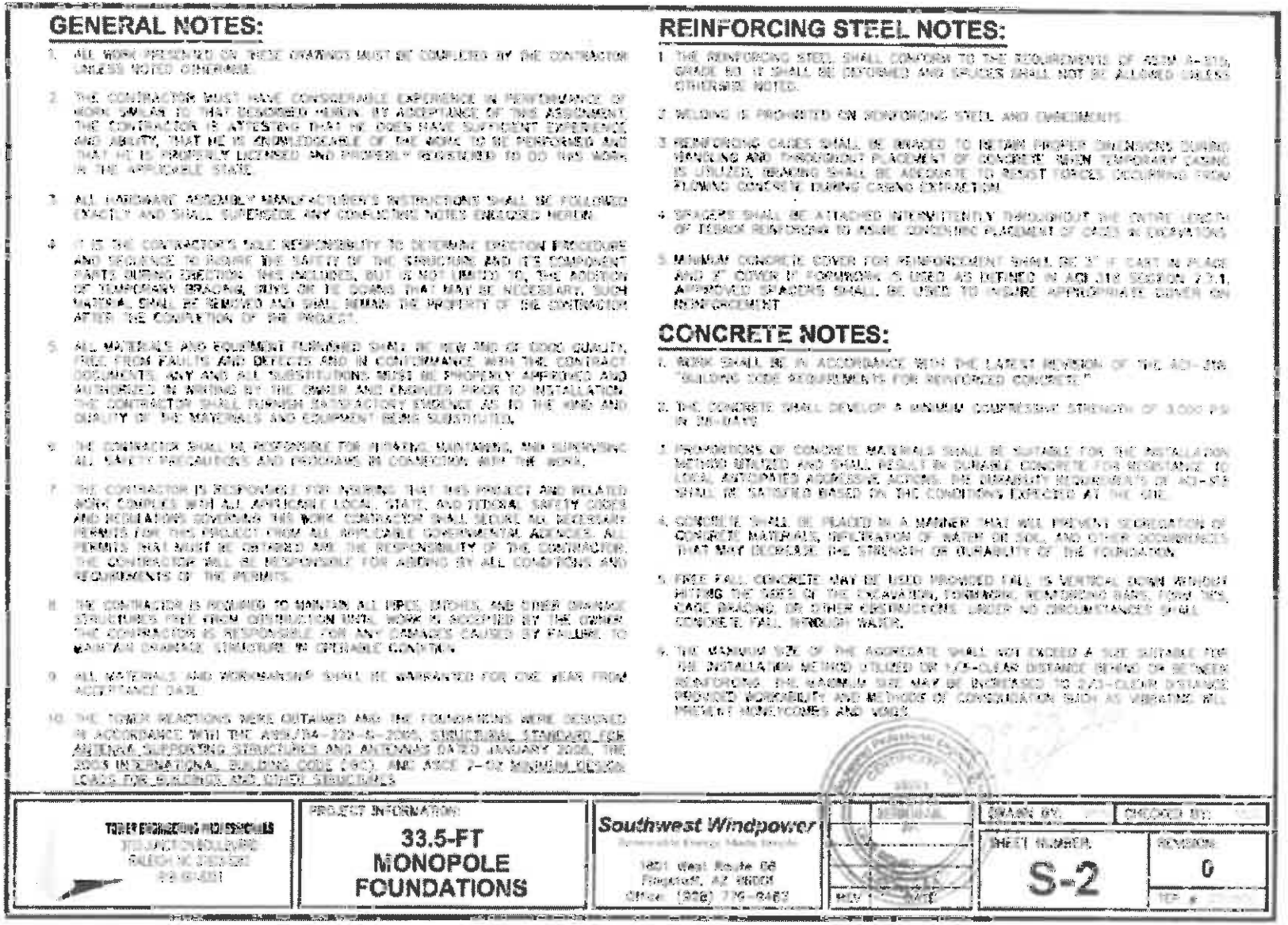
DRAWN BY: [illegible] CHECKED BY: [illegible]

SHEET NUMBER: T-1

REVISION: 0

TOP #: [illegible]


WIND ZONES
ZONE
WIND SPEED
NOTES:
CONTINENTIAL UNITED STATES WIND SPEED MAP - ASCE 7-02
33.5-FT
MONOPOLE
FOUNDATIONS
Southwest Windpower
S-1
0



GENERAL NOTES:

1. ALL WORK PRESENTED ON THESE DRAWINGS MUST BE COMPLETED BY THE CONTRACTOR UNLESS NOTED OTHERWISE.

2. THE CONTRACTOR MUST HAVE CONSIDERABLE EXPERIENCE IN PERFORMANCE OF WORK SIMILAR TO THAT DESCRIBED HEREIN. BY ACCEPTANCE OF THIS ASSIGNMENT, THE CONTRACTOR IS ATTESTING THAT HE DOES HAVE SUFFICIENT EXPERIENCE AND ABILITY, THAT HE IS KNOWLEDGEABLE OF THE WORK TO BE PERFORMED AND THAT HE IS PROPERLY LICENSED AND PROPERLY EQUIPPED TO DO THIS WORK IN THE APPLICABLE STATE.

3. ALL HARDWARE ASSEMBLY MANUFACTURER'S INSTRUCTIONS SHALL BE FOLLOWED EXACTLY AND SHALL SUPERSEDE ANY CONFLICTING NOTES ENCODED HEREIN.

4. IT IS THE CONTRACTOR'S SOLE RESPONSIBILITY TO DETERMINE ERECTION PROCEDURE AND SEQUENCE TO ENSURE THE SAFETY OF THE STRUCTURE AND ITS COMPONENT PARTS DURING ERECTION. THIS INCLUDES, BUT IS NOT LIMITED TO, THE ADDITION OF TEMPORARY BRACING, GUYS OR TIE DOWNS THAT MAY BE NECESSARY. SUCH MATERIALS SHALL BE REMOVED AND SHALL REMAIN THE PROPERTY OF THE CONTRACTOR AFTER THE COMPLETION OF THE PROJECT.

5. ALL MATERIALS AND EQUIPMENT FURNISHED SHALL BE NEW AND OF GOOD QUALITY, FREE FROM FAULTS AND DEFECTS AND IN CONFORMANCE WITH THE CONTRACT DOCUMENTS. ANY AND ALL SUBSTITUTIONS MUST BE PROPERLY APPROVED AND AUTHORIZED IN WRITING BY THE OWNER AND ENGINEER PRIOR TO INSTALLATION. THE CONTRACTOR SHALL FURNISH SATISFACTORY EVIDENCE AS TO THE KIND AND QUALITY OF THE MATERIALS AND EQUIPMENT BEING SUBSTITUTED.

6. THE CONTRACTOR SHALL BE RESPONSIBLE FOR ERECTION, MAINTENANCE, AND SUPERVISING ALL SAFETY PRECAUTIONS AND PROGRAMS IN CONNECTION WITH THE WORK.

7. THE CONTRACTOR IS RESPONSIBLE FOR ENSURING THAT THIS PROJECT AND RELATED WORK COMPLIES WITH ALL APPLICABLE LOCAL, STATE, AND FEDERAL SAFETY CODES AND REGULATIONS GOVERNING THE WORK. CONTRACTOR SHALL SECURE ALL NECESSARY PERMITS FOR THIS PROJECT FROM ALL APPLICABLE GOVERNMENTAL AGENCIES. ALL PERMITS THAT MUST BE OBTAINED ARE THE RESPONSIBILITY OF THE CONTRACTOR. THE CONTRACTOR WILL BE RESPONSIBLE FOR ADHERING TO ALL CONDITIONS AND REQUIREMENTS OF THE PERMITS.

8. THE CONTRACTOR IS REQUIRED TO MAINTAIN ALL PIPES, DITCHES, AND OTHER DRAINAGE STRUCTURES FREE FROM OBSTRUCTION UNTIL WORK IS ACCEPTED BY THE OWNER. THE CONTRACTOR IS RESPONSIBLE FOR ANY DAMAGES CAUSED BY FAILURE TO MAINTAIN DRAINAGE STRUCTURE IN OPERABLE CONDITION.

9. ALL MATERIALS AND WORKMANSHIP SHALL BE WARRANTED FOR ONE YEAR FROM ACCEPTANCE DATE.

10. THE TOWER REACTIONS WERE OUTLINED AND THE FOUNDATIONS WERE DESIGNED IN ACCORDANCE WITH THE ANSI/TIA-222-G-2005, STRUCTURAL STANDARD FOR ANTENNA SUPPORTING STRUCTURES AND ANTENNAS DATED JANUARY 2006, THE 2003 INTERNATIONAL BUILDING CODE (IBC), AND ASCE 7-05 MINIMUM DESIGN LOADS FOR BUILDINGS AND OTHER STRUCTURES.

REINFORCING STEEL NOTES:

1. THE REINFORCING STEEL SHALL CONFORM TO THE REQUIREMENTS OF ASTM A-615, GRADE 60. IT SHALL BE DEFORMED AND SPLICES SHALL NOT BE ALLOWED UNLESS OTHERWISE NOTED.

2. WELDING IS PROHIBITED ON REINFORCING STEEL AND EMBEDMENTS.

3. REINFORCING CAGES SHALL BE BRACED TO RETAIN PROPER ORIENTATION DURING HANDLING AND THROUGHOUT PLACEMENT OF CONCRETE. WHEN TEMPORARY CASING IS UTILIZED, BRACING SHALL BE ADEQUATE TO RESIST FORCES OCCURRING FROM FLOWING CONCRETE DURING CASING EXTRACTION.

4. SPACERS SHALL BE ATTACHED INTERMITTENTLY THROUGHOUT THE ENTIRE LENGTH OF TEDDER REINFORCING TO ASSURE CONCENTRIC PLACEMENT OF CAGE IN EXCAVATION.

5. MINIMUM CONCRETE COVER FOR REINFORCEMENT SHALL BE 3" IF CAST IN PLACE AND 2" COVER IF FORMWORK IS USED AS DEFINED IN ACI 318 SECTION 7.7.1. APPROVED SPACERS SHALL BE USED TO INSURE APPROPRIATE COVER ON REINFORCEMENT.

CONCRETE NOTES:

1. WORK SHALL BE IN ACCORDANCE WITH THE LATEST REVISION OF THE ACI-318 "BUILDING CODE REQUIREMENTS FOR REINFORCED CONCRETE."

2. THE CONCRETE SHALL DEVELOP A MINIMUM COMPRESSIVE STRENGTH OF 3,000 PSI IN 28 DAYS.

3. PROPORTIONS OF CONCRETE MATERIALS SHALL BE SUITABLE FOR THE INSTALLATION METHOD UTILIZED AND SHALL RESULT IN DURABLE CONCRETE FOR EXPOSURE TO LOCAL ANTICIPATED AGGRESSIVE AGENTS. THE MINIMUM REQUIREMENTS OF ACI-318 SHALL BE SATISFIED BASED ON THE CONDITIONS EXPOSED AT THE SITE.

4. CONCRETE SHALL BE PLACED IN A MANNER THAT WILL PREVENT SEGREGATION OF CONCRETE MATERIALS, DEFLECTION OF WATER OR STEEL, AND OTHER OCCURRENCES THAT MAY DECREASE THE STRENGTH OR DURABILITY OF THE FOUNDATION.

5. FREE FALL CONCRETE MAY BE USED PROVIDED FALL IS VERTICAL DOWN AUGER HITTING THE SIDES OF THE EXCAVATION, FORMWORK, REINFORCING BARS, FOUR TIES, CAGE BRACING OR OTHER OBSTRUCTIONS UNDER NO CIRCUMSTANCES SHALL CONCRETE FALL THROUGH WATER.

6. THE MAXIMUM SIZE OF THE AGGREGATE SHALL NOT EXCEED A SIZE SUITABLE FOR THE INSTALLATION METHOD UTILIZED OR 1/4 CLEAR DISTANCE BEHIND OR BETWEEN REINFORCING. THE MAXIMUM SIZE MAY BE INCREASED TO 2/3 CLEAR DISTANCE PROVIDED WORKABILITY AND METHODS OF CONSOLIDATION SUCH AS VIBRATING WILL PREVENT HONEYCOMBS AND VOIDS.

TOWER ENGINEERING PROFESSIONALS
P.O. BOX 1704
RALEIGH, NC 27602
919-661-6351

PROJECT INFORMATION:

33.5-FT MONOPOLE FOUNDATIONS

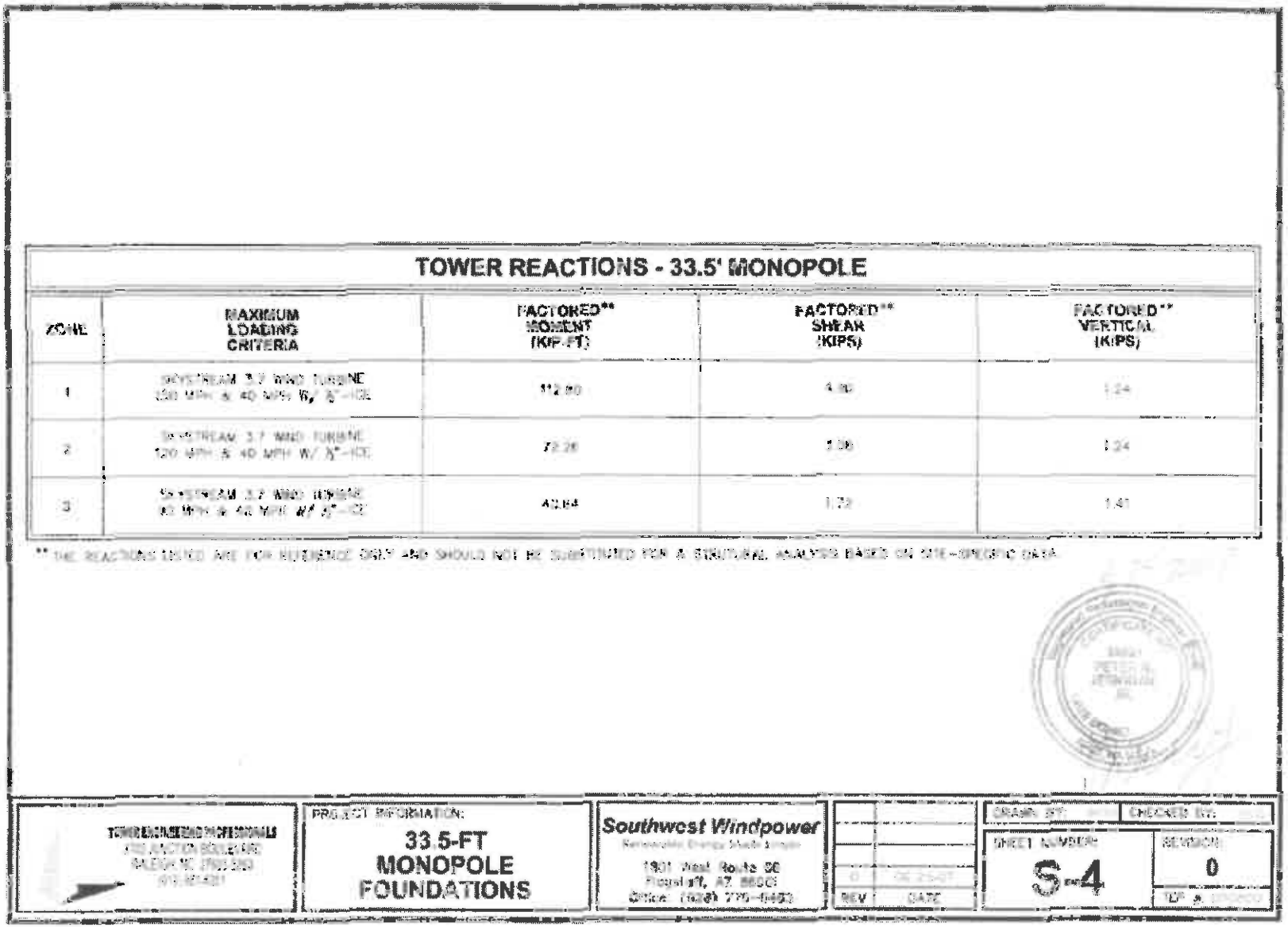
Southwest Windpower
1801 West Route 66
Flagstaff, AZ 86001
Office: (928) 779-9463

DESIGNED BY:	CHECKED BY:
DRAWN BY:	CHECKED BY:
SHEET NUMBER: S-2	REVISION: 0

TABLE 1804.2 ALLOWABLE FOUNDATION AND LATERAL PRESSURE (IBC 2003)

SOIL CLASS	DESCRIPTION	ALLOWABLE FOUNDATION PRESSURE (PSF)	LATERAL BEARING (PSF/FT BELOW NATURAL GRADE)	LATERAL SLIDING		ASSUMED UNIT WEIGHT W/O WATER	ASSUMED INTERNAL ANGLE OF FRICTION
				COEFF. OF FRICTION	RESISTANCE (PSF)		
1	CRYSTALLINE BEDROCK	12,000	1,200	0.70	–	140	0°
2	SEDIMENTARY AND FOLIATED ROCK	4,000	400	0.35	–	130	0°
3	SANDY GRAVEL AND/OR GRAVEL (GW AND GP)	3,000	200	0.35	–	125	32°
4	SAND, SILTY SAND, CLAYEY SAND, SILTY GRAVEL, AND CLAYEY GRAVEL (SW,SP,SM,SC,GM AND GC)	2,000	150	0.35	–	120	28°
5	CLAY, SANDY CLAY, SILTY CLAY, CLAYEY SILT, SILT AND SANDY SILT (CL, ML, MH AND CH)	1,500	100	–	130	90	0°

[illegible]	PROJECT INFORMATION: 33.5-FT MONOPOLE FOUNDATIONS	Southwest Windpower [illegible] 1801 West Route 66 Flagstaff, AZ 86001 Office: (928) 779-9463	REV. DATE	DRAWN BY: [illegible] CHECKED BY: [illegible] SHEET NUMBER: S-3	REVISION 0



TOWER REACTIONS - 33.5' MONOPOLE

ZONE	MAXIMUM LOADING CRITERIA	FACTORED** MOMENT (KIP-FT)	FACTORED** SHEAR (KIPS)	FACTORED** VERTICAL (KIPS)
1	SKYSTREAM 3.7 WIND TURBINE 120 MPH & 40 MPH W/ ½"-ICE	112.80	4.80	1.24
2	SKYSTREAM 3.7 WIND TURBINE 120 MPH & 40 MPH W/ ½"-ICE	72.28	3.08	1.24
3	SKYSTREAM 3.7 WIND TURBINE 90 MPH & 40 MPH W/ ½"-ICE	40.64	1.73	1.41

** THE REACTIONS LISTED ARE FOR REFERENCE ONLY AND SHOULD NOT BE SUBSTITUTED FOR A STRUCTURAL ANALYSIS BASED ON SITE-SPECIFIC DATA

TOWER ENGINEERING PROFESSIONALS
P.O. BOX 1704 BOILING SPRINGS
RALEIGH, NC 27603-1704
(919) 661-6351

PROJECT INFORMATION:
33.5-FT
MONOPOLE
FOUNDATIONS

Southwest Windpower
Renewable Energy Made Simple
1801 West Route 66
Flagstaff, AZ 86001
Office: (928) 779-9463

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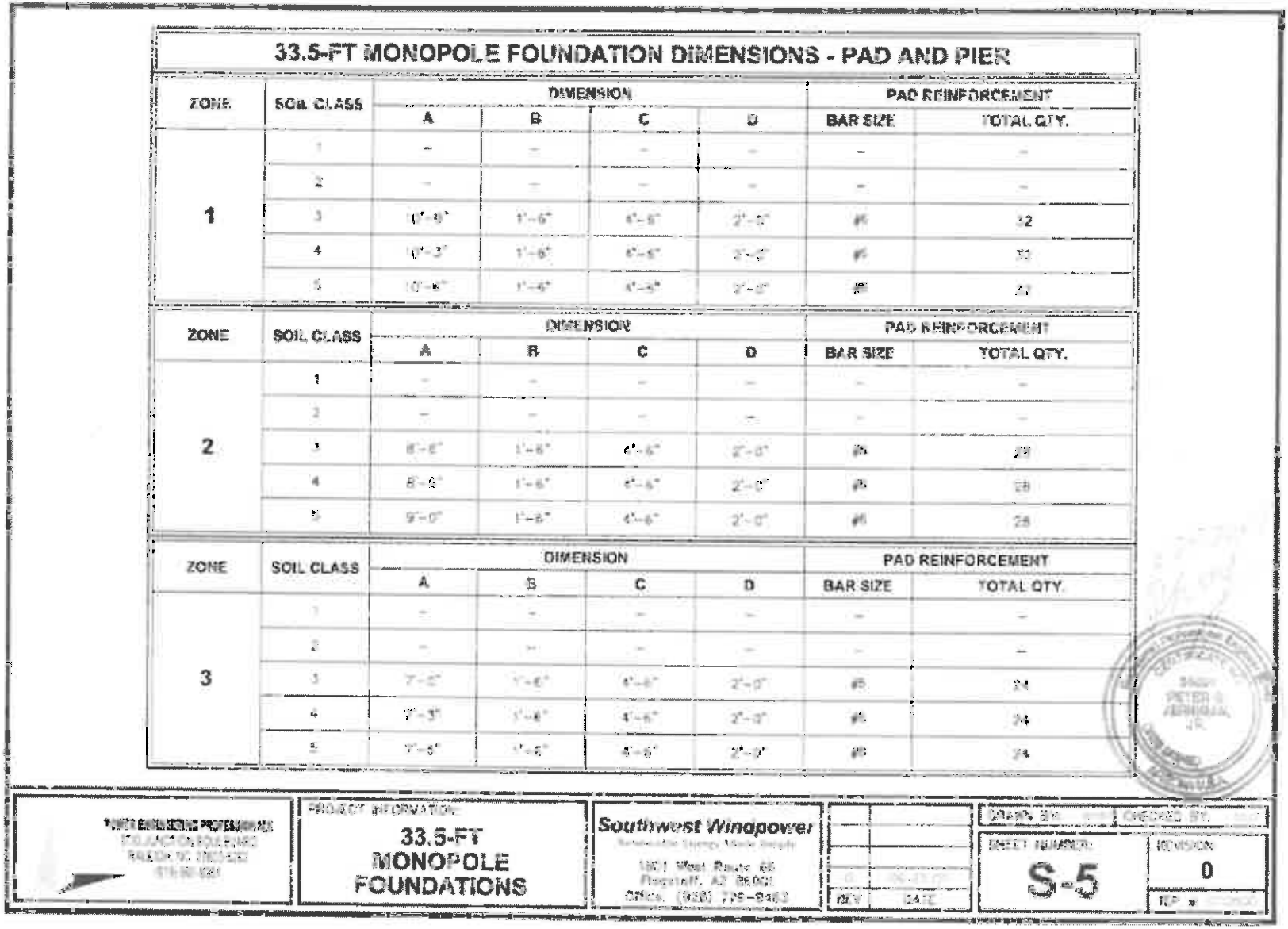
SHEET NUMBER: S-4

REVISION: 0



33.5-FT MONOPOLE FOUNDATION DIMENSIONS - PAD AND PIER

ZONE	SOIL CLASS	DIMENSION				PAD REINFORCEMENT	
		A	B	C	D	BAR SIZE	TOTAL QTY.
1	1	–	–	–	–	–	–
	2	–	–	–	–	–	–
	3	6'-6"	1'-6"	6'-6"	2'-0"	#6	32
	4	6'-3"	1'-6"	6'-6"	2'-0"	#6	31
	5	6'-0"	1'-6"	6'-6"	2'-0"	#6	30

ZONE	SOIL CLASS	DIMENSION				PAD REINFORCEMENT	
		A	B	C	D	BAR SIZE	TOTAL QTY.
2	1	–	–	–	–	–	–
	2	–	–	–	–	–	–
	3	5'-6"	1'-6"	6'-6"	2'-0"	#6	29
	4	5'-3"	1'-6"	6'-6"	2'-0"	#6	28
	5	5'-0"	1'-6"	6'-6"	2'-0"	#6	28

ZONE	SOIL CLASS	DIMENSION				PAD REINFORCEMENT	
		A	B	C	D	BAR SIZE	TOTAL QTY.
3	1	–	–	–	–	–	–
	2	–	–	–	–	–	–
	3	7'-0"	1'-6"	6'-6"	2'-0"	#6	34
	4	6'-9"	1'-6"	6'-6"	2'-0"	#6	34
	5	6'-6"	1'-6"	6'-6"	2'-0"	#6	34

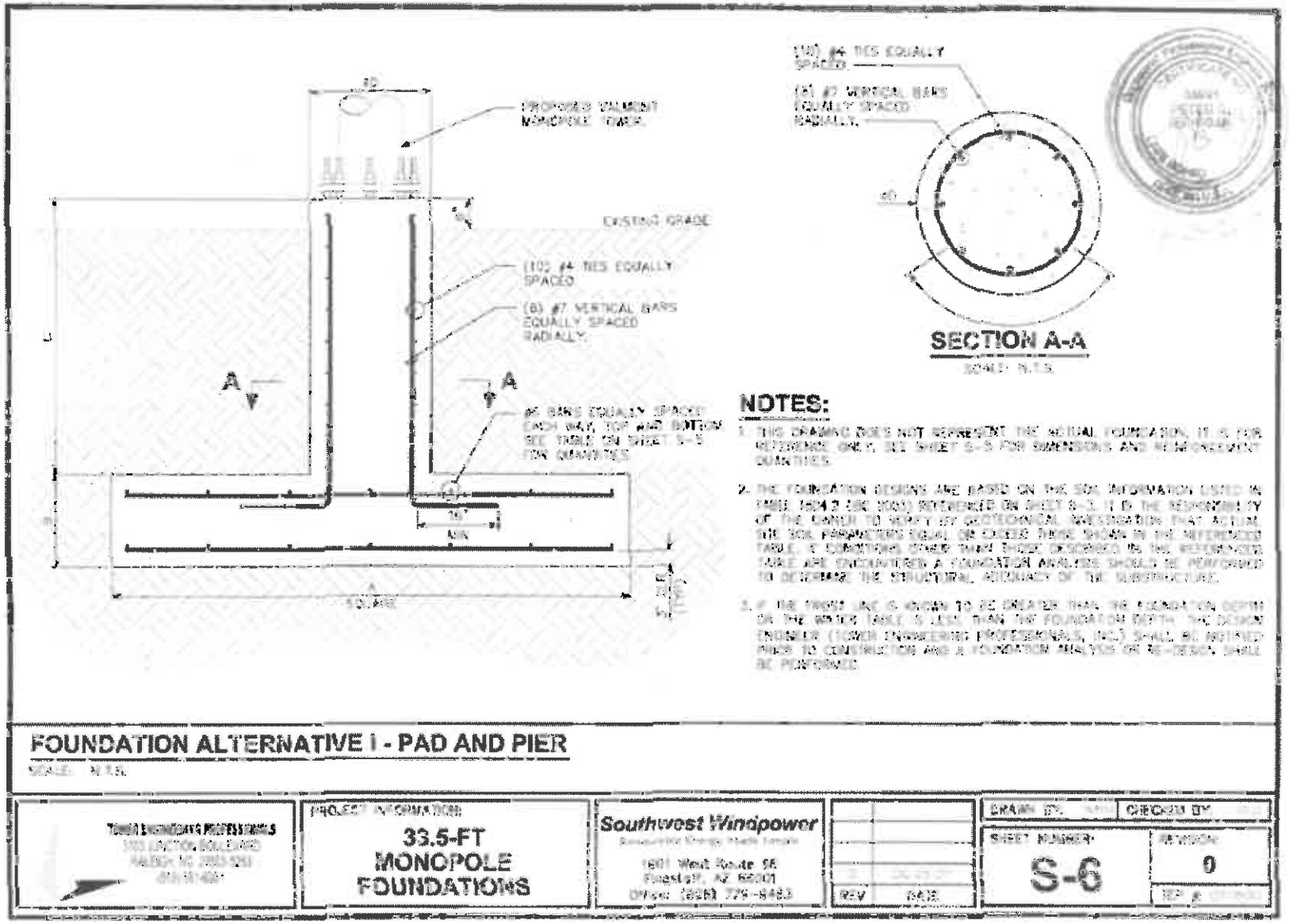
PROJECT INFORMATION

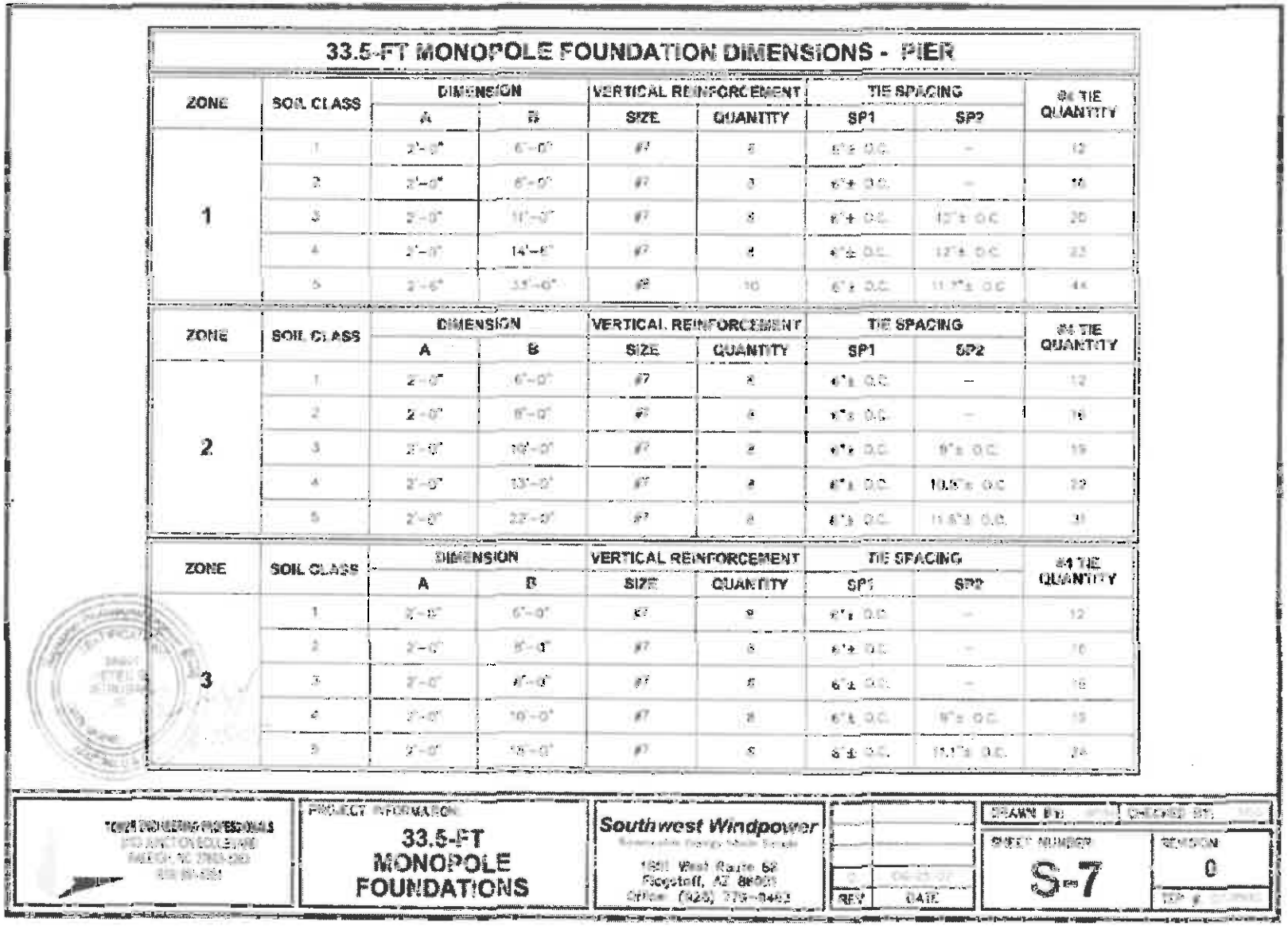
33.5-FT MONOPOLE FOUNDATIONS

Southwest Windpower

SHEET NUMBER: S-5

REVISION: 0


PROPOSED SKYMONT MONOPOLE TOWER
EXISTING GRADE
(10) #4 TIES EQUALLY SPACED
(8) #7 VERTICAL BARS EQUALLY SPACED RADIALLY
A
A
SQUARE
(10) #4 TIES EQUALLY SPACED
(8) #7 VERTICAL BARS EQUALLY SPACED RADIALLY
SECTION A-A
NOTES:
1. THIS DRAWING DOES NOT REPRESENT THE ACTUAL FOUNDATION, IT IS FOR REFERENCE ONLY. SEE SHEET S-5 FOR DIMENSIONS AND REINFORCEMENT QUANTITIES.
2. THE FOUNDATION DESIGNS ARE BASED ON THE SOIL INFORMATION LISTED IN TABLE 1 ON SHEET S-5. IT IS THE RESPONSIBILITY OF THE OWNER TO SUPPLY GEOTECHNICAL INVESTIGATION THAT ACTUAL SITE SOIL PARAMETERS EQUAL OR EXCEED THOSE SHOWN IN THE REFERENCED TABLE. IF CONDITIONS OTHER THAN THOSE DESCRIBED IN THE REFERENCED TABLE ARE ENCOUNTERED A FOUNDATION ANALYSIS SHOULD BE PERFORMED TO DETERMINE THE STRUCTURAL ADEQUACY OF THE SUBSTRUCTURE.
3. IF THE WATER LINE IS KNOWN TO BE GREATER THAN THE FOUNDATION DEPTH OR THE WATER TABLE IS LESS THAN THE FOUNDATION DEPTH, THE DESIGN ENGINEER (TOWER ENGINEERING PROFESSIONALS, INC.) SHALL BE NOTIFIED PRIOR TO CONSTRUCTION AND A FOUNDATION ANALYSIS OR RE-DESIGN SHALL BE PERFORMED.
FOUNDATION ALTERNATIVE I - PAD AND PIER
33.5-FT MONOPOLE FOUNDATIONS
Southwest Windpower
S-6
0



33.5-FT MONOPOLE FOUNDATION DIMENSIONS - PIER

ZONE	SOIL CLASS	DIMENSION		VERTICAL REINFORCEMENT		TIE SPACING		#4 TIE QUANTITY
		A	B	SIZE	QUANTITY	SP1	SP2	
1	1	2'-0"	6'-0"	#7	8	6"± O.C.	–	12
	2	2'-0"	8'-0"	#7	8	6"± O.C.	–	16
	3	2'-0"	11'-0"	#7	8	6"± O.C.	12"± O.C.	20
	4	2'-0"	14'-6"	#7	8	6"± O.C.	12"± O.C.	23
	5	2'-6"	33'-0"	#8	10	6"± O.C.	11.5"± O.C.	44

ZONE	SOIL CLASS	DIMENSION		VERTICAL REINFORCEMENT		TIE SPACING		#4 TIE QUANTITY
		A	B	SIZE	QUANTITY	SP1	SP2	
2	1	2'-0"	6'-0"	#7	8	6"± O.C.	–	12
	2	2'-0"	8'-0"	#7	8	6"± O.C.	–	16
	3	2'-0"	10'-0"	#7	8	6"± O.C.	9"± O.C.	19
	4	2'-0"	13'-0"	#7	8	6"± O.C.	10.5"± O.C.	22
	5	2'-0"	22'-0"	#7	8	6"± O.C.	11.5"± O.C.	31

ZONE	SOIL CLASS	DIMENSION		VERTICAL REINFORCEMENT		TIE SPACING		#4 TIE QUANTITY
		A	B	SIZE	QUANTITY	SP1	SP2	
3	1	2'-0"	6'-0"	#7	8	6"± O.C.	–	12
	2	2'-0"	8'-0"	#7	8	6"± O.C.	–	16
	3	2'-0"	9'-0"	#7	8	6"± O.C.	–	18
	4	2'-0"	10'-0"	#7	8	6"± O.C.	9"± O.C.	19
	5	2'-0"	15'-0"	#7	8	6"± O.C.	11.5"± O.C.	28

PROJECT INFORMATION

33.5-FT MONOPOLE FOUNDATIONS

Southwest Windpower

1801 West Route 66
Flagstaff, AZ 86001
Office: (928) 779-9463

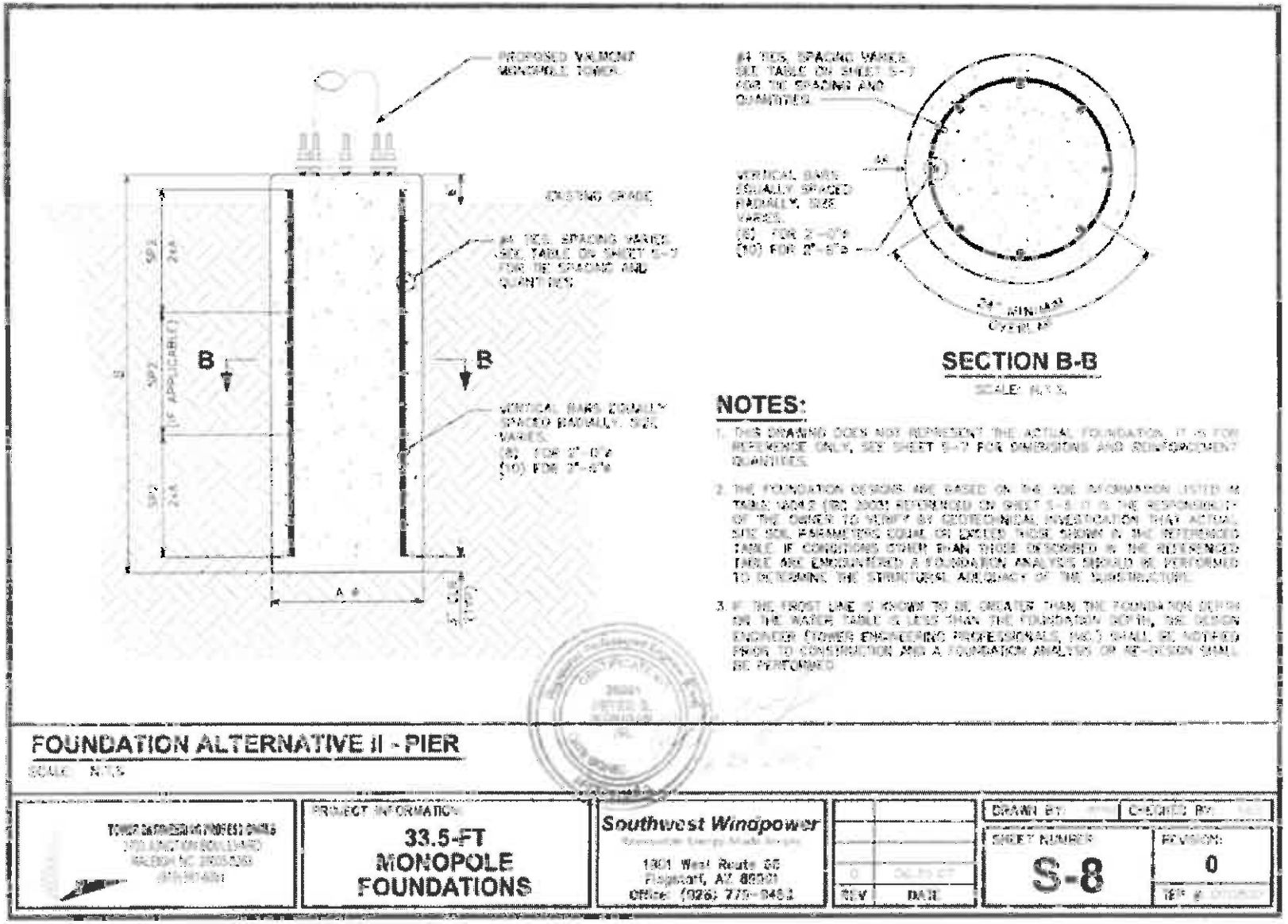
REV | DATE

DRAWN BY: | CHECKED BY:

SHEET NUMBER: S-7

REVISION: 0

Skystream 3.7™ Foundation and Tower Installation Manual: Appendix A: Pier Foundation for 33' Tower **33**


PROPOSED VAUGHT MONOPOLE TOWER
EXISTING GRADE
#4 TIES, SPACING VARIES SEE TABLE ON SHEET S-7 FOR TIE SPACING AND QUANTITIES
VERTICAL BARS EQUALLY SPACED RADIALLY, SEE NOTES FOR QUANTITIES
B
B
SPZ
SPZ (IF APPLICABLE)
SPZ
A ø
#4 TIES, SPACING VARIES SEE TABLE ON SHEET S-7 FOR TIE SPACING AND QUANTITIES
VERTICAL BARS EQUALLY SPACED RADIALLY, SEE NOTES FOR QUANTITIES
24" MINIMUM COVER
SECTION B-B
SCALE: N.T.S.
NOTES:
1. THIS DRAWING DOES NOT REPRESENT THE ACTUAL FOUNDATION. IT IS FOR REFERENCE ONLY. SEE SHEET S-7 FOR DIMENSIONS AND REINFORCEMENT QUANTITIES.
2. THE FOUNDATION DESIGNS ARE BASED ON THE SOIL INFORMATION LISTED IN TABLE ABOVE (SOIL PARAMETERS REFERENCED ON SHEET S-7). IT IS THE RESPONSIBILITY OF THE OWNER TO VERIFY BY GEOTECHNICAL INVESTIGATION THAT ACTUAL SITE SOIL PARAMETERS EQUAL OR EXCEED THOSE SHOWN IN THE REFERENCED TABLE. IF CONDITIONS OTHER THAN THOSE DESIGNED IN THE REFERENCED TABLE ARE ENCOUNTERED A FOUNDATION ANALYSIS SHOULD BE PERFORMED TO DETERMINE THE STRUCTURAL ADEQUACY OF THE SUPERSTRUCTURE.
3. IF THE FROST LINE IS KNOWN TO BE GREATER THAN THE FOUNDATION DEPTH OR THE WATER TABLE IS LESS THAN THE FOUNDATION DEPTH, THE DESIGN ENGINEER (TOWER ENGINEERING PROFESSIONALS, P.C.) SHALL BE NOTIFIED PRIOR TO CONSTRUCTION AND A FOUNDATION ANALYSIS OR RE-DESIGN SHALL BE PERFORMED.
FOUNDATION ALTERNATIVE II - PIER
SCALE: N.T.S.
PROJECT INFORMATION
33.5-FT MONOPOLE FOUNDATIONS
Southwest Windpower
1801 West Route 66
Flagstaff, AZ 86001
Office: (928) 779-9463
REV
DATE
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Southwest Windpower

Renewable Energy Made Simple

ATTENTION

THE FOUNDATION DESIGNS ARE ARE IN ACCORDANCE WITH THE ANSI/TIA-222-G-2005, STRUCTURAL STANDARD FOR ANTENNA SUPPORTING STRUCTURES AND ANTENNAS DATED JANUARY 2005, THE 2003 INTERNATIONAL BUILDING CODE (IBC 2003), AND ASCE 7-02, MINIMUM DESIGN LOADS FOR BUILDINGS AND OTHER STRUCTURES. THE FOUNDATION DESIGNS ARE FOR THE 45-FT AND 60-FT UNGUYED MONOPOLES BY VALMONT INDUSTRIES, INC. AUS US SPECIFICATION 3.2 WIND TURBINE BASED ON THE WIND ZONES DESCRIBED ON SHEET S-1 AND THE SOIL INFORMATION LISTED IN TABLE 1804.2 (IBC 2003) REFERENCED ON SHEET S-3. IT IS THE RESPONSIBILITY OF THE OWNER TO VERIFY BY GEOTECHNICAL INVESTIGATION THAT ACTUAL SITE SOIL PARAMETERS MEET OR EXCEED THOSE SHOWN IN THE REFERENCED TABLE. IF CONDITIONS OTHER THAN THOSE DESCRIBED IN THE REFERENCED TABLE ARE ENCOUNTERED A FOUNDATION ANALYSIS SHOULD BE PERFORMED TO DETERMINE THE STRUCTURAL ADEQUACY OF THE SUBSTRUCTURE.

INDEX OF SHEETS

TOWER ENGINEERING PROFESSIONALS

PROJECT INFORMATION:

45-FT AND 60-FT MONOPOLE FOUNDATIONS

Southwest Windpower

1801 West Route 66

Flagstaff, AZ 86001

Office: (928) 779-9463

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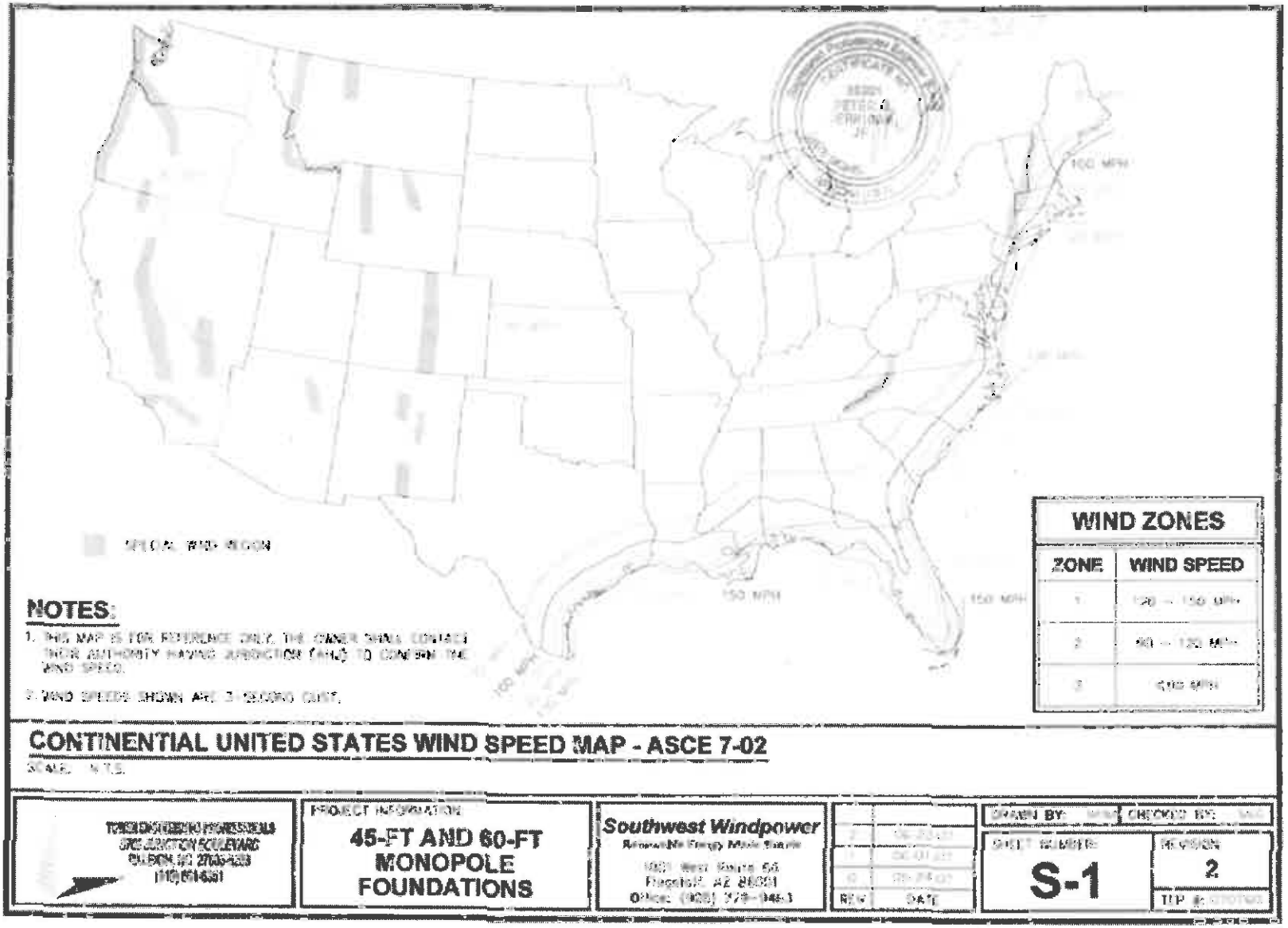
WIND ZONES
ZONE
WIND SPEED
NOTES:
CONTINENTIAL UNITED STATES WIND SPEED MAP - ASCE 7-02
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GENERAL NOTES:

1. ALL WORK PRESENTED ON THESE DRAWINGS MUST BE COMPLETED BY THE CONTRACTOR UNLESS NOTED OTHERWISE.
2. THE CONTRACTOR MUST HAVE CONSIDERABLE EXPERIENCE IN PERFORMANCE OF WORK SIMILAR TO THAT DESCRIBED HEREIN. BY ACCEPTANCE OF THIS ASSIGNMENT, THE CONTRACTOR IS ATTESTING THAT HE DOES HAVE SUFFICIENT EXPERIENCE AND ABILITY, THAT HE IS KNOWLEDGEABLE OF THE WORK TO BE PERFORMED AND THAT HE IS PROPERLY LICENSED AND PROPERLY REGISTERED TO DO THIS WORK IN THE APPLICABLE STATE.
3. ALL HARDWARE ASSEMBLY MANUFACTURER'S INSTRUCTIONS SHALL BE FOLLOWED EXACTLY AND SHALL SUPERCEDE ANY CONFLICTING NOTES ENCLOSED HEREIN.
4. IT IS THE CONTRACTOR'S SOLE RESPONSIBILITY TO DETERMINE ERECTION PROCEDURE AND SEQUENCE TO INSURE THE SAFETY OF THE STRUCTURE AND IT'S COMPONENT PARTS DURING ERECTION. THIS INCLUDES, BUT IS NOT LIMITED TO, THE ADDITION OF TEMPORARY BRACING, GUYS OR TIE DOWNS THAT MAY BE NECESSARY. SUCH MATERIAL SHALL BE REMOVED AND SHALL REMAIN THE PROPERTY OF THE CONTRACTOR AFTER THE COMPLETION OF THE PROJECT.
5. ALL MATERIALS AND EQUIPMENT FURNISHED SHALL BE NEW AND OF GOOD QUALITY, FREE FROM FAULTS AND DEFECTS AND IN CONFORMANCE WITH THE CONTRACT DOCUMENTS. ANY AND ALL SUBSTITUTIONS MUST BE PROPERLY APPROVED AND AUTHORIZED IN WRITING BY THE OWNER AND ENGINEER PRIOR TO INSTALLATION. THE CONTRACTOR SHALL FURNISH SATISFACTORY EVIDENCE AS TO THE KIND AND QUALITY OF THE MATERIALS AND EQUIPMENT BEING SUBSTITUTED.
6. THE CONTRACTOR SHALL BE RESPONSIBLE FOR INITIATING, MAINTAINING, AND SUPERVISING ALL SAFETY PRECAUTIONS AND PROGRAMS IN CONNECTION WITH THE WORK.
7. THE CONTRACTOR IS RESPONSIBLE FOR INSURING THAT THIS PROJECT AND RELATED WORK COMPLIES WITH ALL APPLICABLE LOCAL, STATE, AND FEDERAL SAFETY CODES AND REGULATIONS GOVERNING THIS WORK. CONTRACTOR SHALL SECURE ALL NECESSARY PERMITS FOR THIS PROJECT FROM ALL APPLICABLE GOVERNMENTAL AGENCIES. ALL PERMITS THAT MUST BE OBTAINED ARE THE RESPONSIBILITY OF THE CONTRACTOR. THE CONTRACTOR WILL BE RESPONSIBLE FOR ABIDING BY ALL CONDITIONS AND REQUIREMENTS OF THE PERMITS.
8. THE CONTRACTOR IS REQUIRED TO MAINTAIN ALL PIPES, DITCHES, AND OTHER DRAINAGE STRUCTURES FREE FROM OBSTRUCTION UNTIL WORK IS ACCEPTED BY THE OWNER. THE CONTRACTOR IS RESPONSIBLE FOR ANY DAMAGES CAUSED BY FAILURE TO MAINTAIN DRAINAGE STRUCTURE IN OPERABLE CONDITION.
9. ALL MATERIALS AND WORKMANSHIP SHALL BE WARRANTED FOR ONE YEAR FROM ACCEPTANCE DATE.
10. THE TOWER REACTIONS WERE OBTAINED AND THE FOUNDATIONS WERE DESIGNED IN ACCORDANCE WITH THE ANSI/TIA-222-G-2005, STRUCTURAL STANDARD FOR ANTENNA SUPPORTING STRUCTURES AND ANTENNAS DATED JANUARY 2006, THE 2003 INTERNATIONAL BUILDING CODE (IBC), AND ASCE 7-02 MINIMUM DESIGN LOADS FOR BUILDINGS AND OTHER STRUCTURES.

REINFORCING STEEL NOTES:

1. THE REINFORCING STEEL SHALL CONFORM TO THE REQUIREMENTS OF ASTM A-615, GRADE 60. IT SHALL BE DEFORMED AND SPLICES SHALL NOT BE ALLOWED UNLESS OTHERWISE NOTED.
2. WELDING IS PROHIBITED ON REINFORCING STEEL AND EMBEDMENTS.
3. REINFORCING CAGES SHALL BE BRACED TO RETAIN PROPER DIMENSIONS DURING HANDLING AND THROUGHOUT PLACEMENT OF CONCRETE. WHEN TEMPORARY CASING IS UTILIZED, BRACING SHALL BE ADEQUATE TO RESIST FORCES OCCURRING FROM FLOWING CONCRETE DURING CASING EXTRACTION.
4. SPACERS SHALL BE ATTACHED INTERMITTENTLY THROUGHOUT THE ENTIRE LENGTH OF REBAR REINFORCING TO INSURE CONCENTRIC PLACEMENT OF CAGES IN EXCAVATIONS.
5. MINIMUM CONCRETE COVER FOR REINFORCEMENT SHALL BE 3" UNLESS OTHERWISE NOTED. APPROVED SPACERS SHALL BE USED TO INSURE A 3" MINIMUM COVER ON REINFORCEMENT.

CONCRETE NOTES:

1. WORK SHALL BE IN ACCORDANCE WITH THE LATEST REVISION OF THE ACI-318, "BUILDING CODE REQUIREMENTS FOR REINFORCED CONCRETE."
2. THE CONCRETE SHALL DEVELOP A MINIMUM COMPRESSIVE STRENGTH OF 3,000 PSI IN 28-DAYS.
3. PROPORTIONS OF CONCRETE MATERIALS SHALL BE SUITABLE FOR THE INSTALLATION METHOD UTILIZED AND SHALL RESULT IN DURABLE CONCRETE FOR RESISTANCE TO LOCAL ANTICIPATED AGGRESSIVE ACTIONS. THE DURABILITY REQUIREMENTS OF ACI-318 SHALL BE SATISFIED BASED ON THE CONDITIONS EXPECTED AT THE SITE.
4. CONCRETE SHALL BE PLACED IN A MANNER THAT WILL PREVENT SEGREGATION OF CONCRETE MATERIALS, INFILTRATION OF WATER OR SOIL, AND OTHER OCCURRENCES THAT MAY DECREASE THE STRENGTH OR DURABILITY OF THE FOUNDATION.
5. FREE FALL CONCRETE MAY BE USED PROVIDED FALL IS VERTICAL DOWN WITHOUT HITTING THE SIDES OF THE EXCAVATION, FORMWORK, REINFORCING BARS, FORM TIES, CAGE BRACING, OR OTHER OBSTRUCTIONS. UNDER NO CIRCUMSTANCES SHALL CONCRETE FALL THROUGH WATER.
6. THE MAXIMUM SIZE OF THE AGGREGATE SHALL NOT EXCEED A SIZE SUITABLE FOR THE INSTALLATION METHOD UTILIZED OR 1/3-CLEAR DISTANCE BEHIND OR BETWEEN REINFORCING. THE MAXIMUM SIZE MAY BE INCREASED TO 2/3-CLEAR DISTANCE PROVIDED WORKABILITY AND METHODS OF CONSOLIDATION SUCH AS VIBRATING WILL PREVENT HONEYCOMBS AND VOIDS.

TOWER ENGINEERING PROFESSIONALS	PROJECT INFORMATION: 45-FT AND 60-FT MONOPOLE FOUNDATIONS	Southwest Windpower 1801 West Route 66 Flagstaff, AZ 86001 Office: (928) 779-9463	REV / DATE	DRAWN BY: / CHECKED BY: SHEET NUMBER: S-2 REVISION: 2 TEP #:

TABLE 1804.2 ALLOWABLE FOUNDATION AND LATERAL PRESSURE (IBC 2003)

SOIL CLASS	DESCRIPTION	ALLOWABLE FOUNDATION PRESSURE (PSF)	LATERAL BEARING (PSF/FT BELOW NATURAL GRADE)	LATERAL SLIDING		ASSUMED UNIT WEIGHT W/O WATER	ASSUMED INTERNAL ANGLE OF FRICTION
				COEFF. OF FRICTION	RESISTANCE (PSF)		
1	CRYSTALLINE BEDROCK	12,000	1,200	0.70	–	160	0°
2	SEDIMENTARY AND FOLIATED ROCK	4,000	400	0.35	–	120	0°
3	SANDY GRAVEL AND/OR GRAVEL (GW AND GP)	3,000	200	0.35	–	120	34°
4	SAND, SILTY SAND, CLAYEY SAND, SILTY GRAVEL, AND CLAYEY GRAVEL (SW, SP, SM, SC, GM AND GC)	2,000	150	0.25	–	100	30°
5	CLAY, SANDY CLAY, SILTY CLAY, CLAYEY SILT, SILT AND SANDY SILT (CL, ML, MH AND CH)	1,500	100	–	130	90	0°

PROJECT INFORMATION: 45-FT AND 60-FT MONOPOLE FOUNDATIONS	Southwest Windpower 1801 West Route 66 Flagstaff, AZ 86001 Office: (928) 779-9463	REV	DATE	DRAWN BY: CHECKED BY: SHEET NUMBER: S-3 REVISION: 2

TOWER REACTIONS - 45' MONOPOLE

ZONE	LOADING CRITERIA	FACTORED** MOMENT (KIP-FT)	FACTORED** SHEAR (KIPS)	FACTORED** VERTICAL (KIPS)
1	SKYSTREAM 3.7 WIND TURBINE 150 MPH @ 40 MPH W/ 3" ICE	169.60	5.21	1.35
2	SKYSTREAM 3.7 WIND TURBINE 120 MPH @ 40 MPH W/ 3" ICE	109.84	3.39	1.25
3	SKYSTREAM 3.7 WIND TURBINE 90 MPH @ 40 MPH W/ 3" ICE	61.38	1.89	1.14

TOWER REACTIONS - 60' MONOPOLE

ZONE	MAXIMUM LOADING CRITERIA	FACTORED** MOMENT (KIP-FT)	FACTORED** SHEAR (KIPS)	FACTORED** VERTICAL (KIPS)
1	SKYSTREAM 3.7 WIND TURBINE 150 MPH @ 40 MPH W/ 3" ICE	282.60	7.32	2.36
2	SKYSTREAM 3.7 WIND TURBINE 120 MPH @ 40 MPH W/ 3" ICE	181.44	4.68	2.36
3	SKYSTREAM 3.7 WIND TURBINE 90 MPH @ 40 MPH W/ 3" ICE	102.19	2.64	2.42

** THE REACTIONS LISTED ARE FOR REFERENCE ONLY AND SHOULD NOT BE SUBSTITUTED FOR A STRUCTURAL ANALYSIS BASED ON SITE-SPECIFIC DATA

TOWER ENGINEERING PROFESSIONALS 326 LAWRENCE BOULEVARD [illegible]	PROJECT INFORMATION: 45-FT AND 60-FT MONOPOLE FOUNDATIONS	Southwest Windpower [illegible] 1801 West Route 66 Flagstaff, AZ 86001 Office: (928) 779-9453	REV / DATE
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45-FT MONOPOLE FOUNDATION DIMENSIONS - PAD AND PIER

ZONE	SOIL CLASS	DIMENSION				PAD REINFORCEMENT	
		A	B	C	D	BAR SIZE	TOTAL QTY.
1	1	–	–	–	–	–	–
	2	–	–	–	–	–	–
	3	11'-3"	1'-6"	4'-6"	2'-6"	#6	36
	4	11'-9"	1'-6"	4'-6"	2'-6"	#6	36
	5	12'-0"	1'-6"	4'-6"	2'-6"	#6	36

ZONE	SOIL CLASS	DIMENSION				PAD REINFORCEMENT	
		A	B	C	D	BAR SIZE	TOTAL QTY.
2	1	–	–	–	–	–	–
	2	–	–	–	–	–	–
	3	9'-9"	1'-6"	4'-6"	2'-6"	#6	32
	4	10'-3"	1'-6"	4'-6"	2'-6"	#6	32
	5	10'-9"	1'-6"	4'-6"	2'-6"	#6	32

ZONE	SOIL CLASS	DIMENSION				PAD REINFORCEMENT	
		A	B	C	D	BAR SIZE	TOTAL QTY.
3	1	–	–	–	–	–	–
	2	–	–	–	–	–	–
	3	8'-0"	1'-6"	4'-6"	2'-6"	#6	28
	4	8'-3"	1'-6"	4'-6"	2'-6"	#6	28
	5	8'-6"	1'-6"	4'-6"	2'-6"	#6	28

TOWER ENGINEERING PROFESSIONALS

PROJECT INFORMATION

45-FT AND 60-FT MONOPOLE FOUNDATIONS

Southwest Windpower

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60-FT MONOPOLE FOUNDATION DIMENSIONS - PAD AND PIER

ZONE	SOIL CLASS	DIMENSION				PAD REINFORCEMENT	
		A	B	C	D	BAR SIZE	TOTAL QTY.
1	1	–	–	–	–	–	–
	2	–	–	–	–	–	–
	3	13'-3"	1'-6"	4'-6"	2'-6"	#6	40
	4	14'-0"	1'-6"	4'-6"	2'-6"	#6	40
	5	14'-3"	1'-6"	4'-6"	2'-6"	#6	40

ZONE	SOIL CLASS	DIMENSION				PAD REINFORCEMENT	
		A	B	C	D	BAR SIZE	TOTAL QTY.
2	1	–	–	–	–	–	–
	2	–	–	–	–	–	–
	3	11'-6"	1'-6"	4'-6"	2'-6"	#6	36
	4	12'-0"	1'-6"	4'-6"	2'-6"	#6	36
	5	12'-3"	1'-6"	4'-6"	2'-6"	#6	36

ZONE	SOIL CLASS	DIMENSION				PAD REINFORCEMENT	
		A	B	C	D	BAR SIZE	TOTAL QTY.
3	1	–	–	–	–	–	–
	2	–	–	–	–	–	–
	3	9'-6"	1'-6"	4'-6"	2'-6"	#6	32
	4	9'-9"	1'-6"	4'-6"	2'-6"	#6	32
	5	10'-0"	1'-6"	4'-6"	2'-6"	#6	32

PROJECT INFORMATION

45-FT AND 60-FT MONOPOLE FOUNDATIONS

Southwest Windpower

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Flagstaff, AZ 86001
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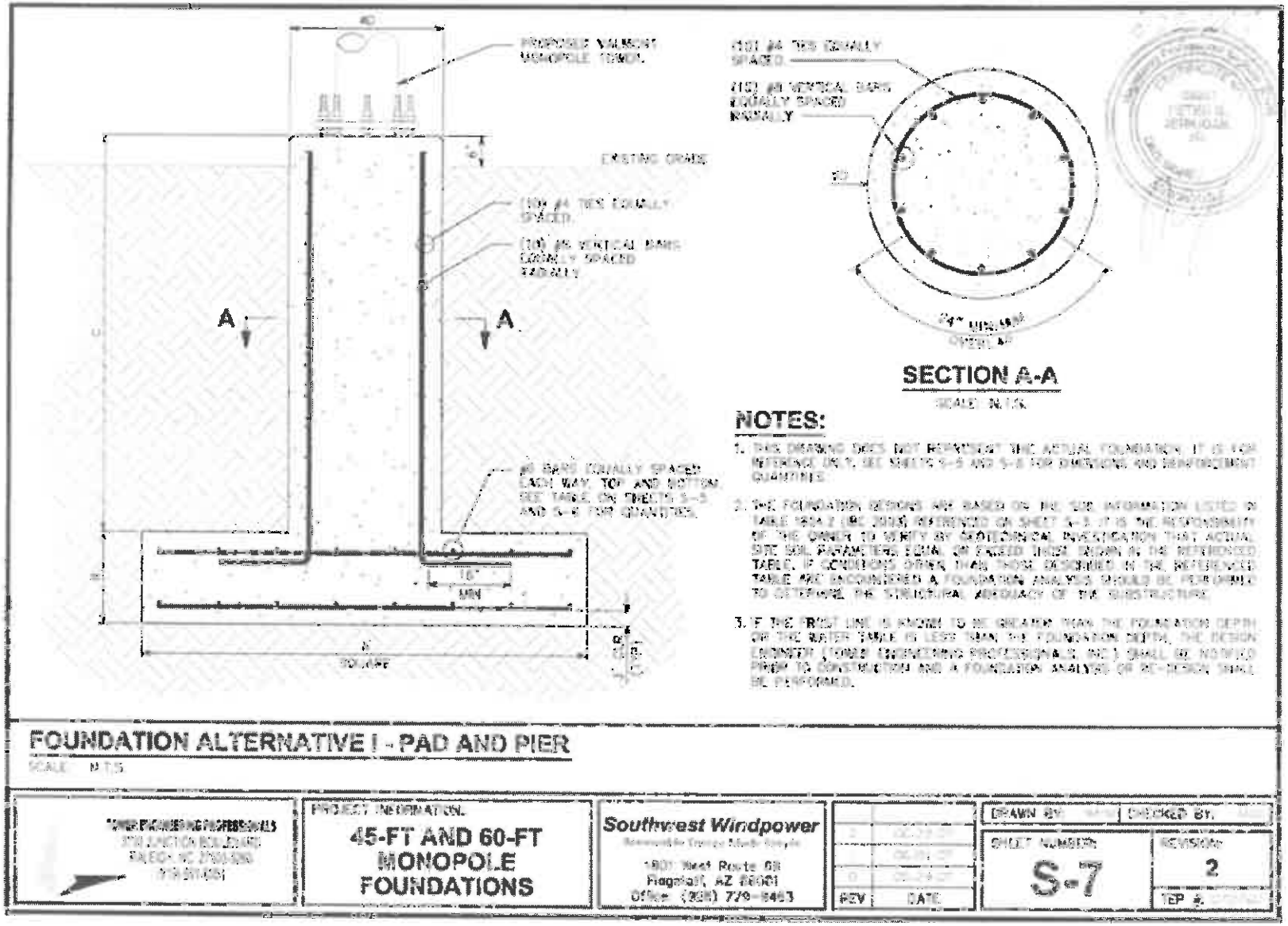
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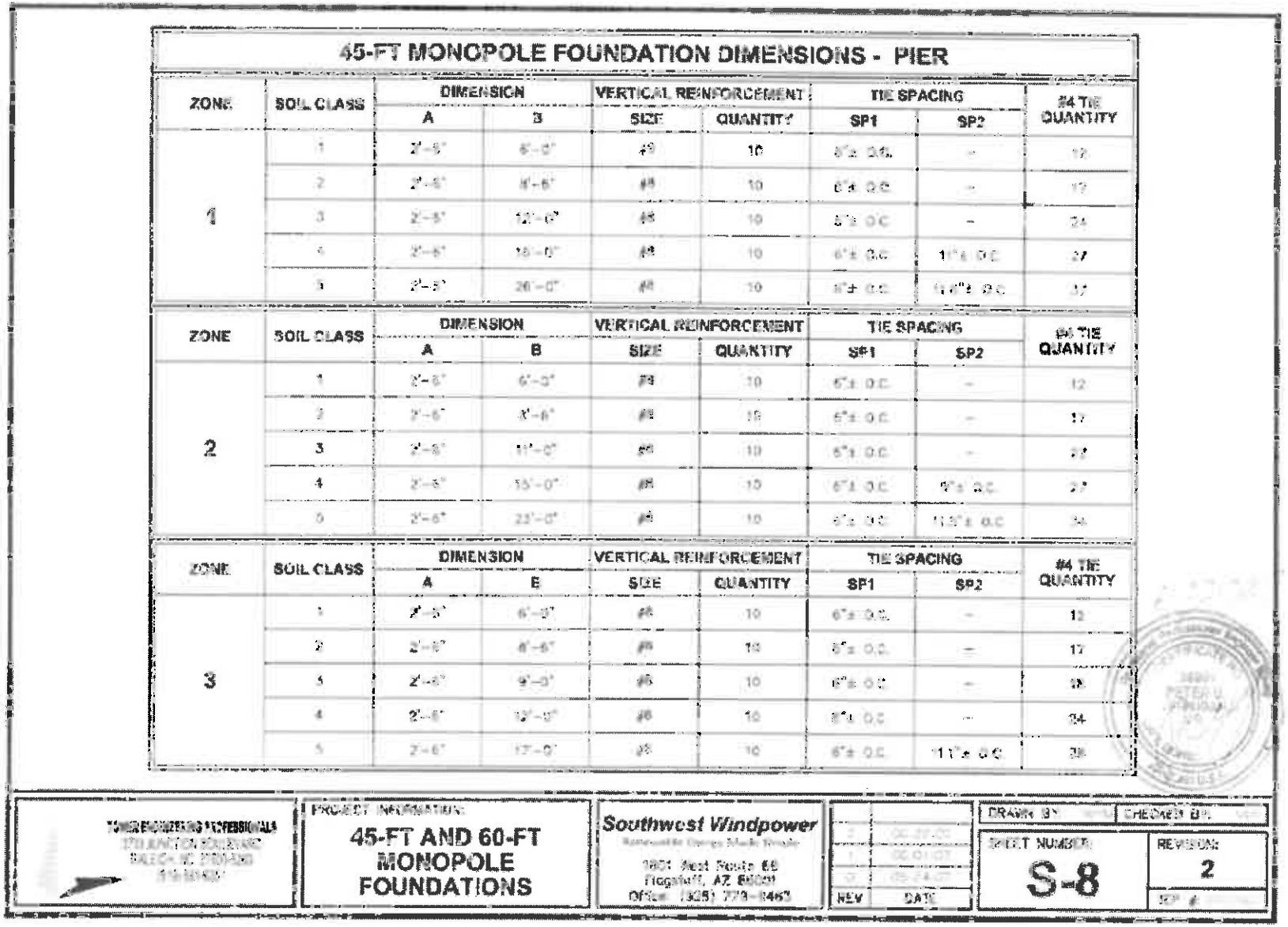

45-FT MONOPOLE FOUNDATION DIMENSIONS - PIER

ZONE	SOIL CLASS	DIMENSION		VERTICAL REINFORCEMENT		TIE SPACING		#4 TIE QUANTITY
		A	B	SIZE	QUANTITY	SP1	SP2	
1	1	2'-6"	6'-0"	#8	10	6"± O.C.	–	12
	2	2'-6"	8'-6"	#8	10	6"± O.C.	–	17
	3	2'-6"	12'-0"	#8	10	6"± O.C.	–	24
	4	2'-6"	16'-0"	#8	10	6"± O.C.	12"± O.C.	27
	5	2'-6"	20'-0"	#8	10	6"± O.C.	12"± O.C.	37

ZONE	SOIL CLASS	DIMENSION		VERTICAL REINFORCEMENT		TIE SPACING		#4 TIE QUANTITY
		A	B	SIZE	QUANTITY	SP1	SP2	
2	1	2'-6"	6'-0"	#8	10	6"± O.C.	–	12
	2	2'-6"	8'-6"	#8	10	6"± O.C.	–	17
	3	2'-6"	11'-0"	#8	10	6"± O.C.	–	22
	4	2'-6"	15'-0"	#8	10	6"± O.C.	12"± O.C.	27
	5	2'-6"	23'-0"	#8	10	6"± O.C.	12"± O.C.	36

ZONE	SOIL CLASS	DIMENSION		VERTICAL REINFORCEMENT		TIE SPACING		#4 TIE QUANTITY
		A	B	SIZE	QUANTITY	SP1	SP2	
3	1	2'-6"	6'-0"	#8	10	6"± O.C.	–	12
	2	2'-6"	8'-6"	#8	10	6"± O.C.	–	17
	3	2'-6"	9'-0"	#8	10	6"± O.C.	–	18
	4	2'-6"	12'-0"	#8	10	6"± O.C.	–	24
	5	2'-6"	17'-0"	#8	10	6"± O.C.	12"± O.C.	36

TOWER ENGINEERING PROFESSIONALS
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45-FT AND 60-FT MONOPOLE FOUNDATIONS
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60-FT MONOPOLE FOUNDATION DIMENSIONS - PIER

ZONE	SOIL CLASS	DIMENSION		VERTICAL REINFORCEMENT		TIE SPACING		#4 TIE QUANTITY
		A	B	SIZE	QUANTITY	SP1	SP2	
1	1	3'-0"	5'-0"	#8	14	6"± O.C.	–	19
	2	3'-0"	9'-0"	#8	14	6"± O.C.	–	19
	3	3'-0"	15'-0"	#8	14	6"± O.C.	–	24
	4	3'-0"	17'-0"	#8	14	6"± O.C.	–	24
	5	3'-0"	30'-0"	#8	14	6"± O.C.	12.5"± O.C.	44

ZONE	SOIL CLASS	DIMENSION		VERTICAL REINFORCEMENT		TIE SPACING		#4 TIE QUANTITY
		A	B	SIZE	QUANTITY	SP1	SP2	
2	1	2'-6"	5'-0"	#8	10	6"± O.C.	–	12
	2	2'-6"	8'-6"	#8	10	6"± O.C.	–	17
	3	2'-6"	12'-0"	#8	10	6"± O.C.	–	21
	4	2'-6"	16'-0"	#8	10	6"± O.C.	11"± O.C.	27
	5	2'-6"	28'-0"	#8	10	6"± O.C.	11.5"± O.C.	37

ZONE	SOIL CLASS	DIMENSION		VERTICAL REINFORCEMENT		TIE SPACING		#4 TIE QUANTITY
		A	B	SIZE	QUANTITY	SP1	SP2	
3	1	2'-6"	5'-0"	#8	10	6"± O.C.	–	12
	2	2'-6"	9'-6"	#8	10	6"± O.C.	–	17
	3	2'-6"	11'-0"	#8	10	6"± O.C.	–	22
	4	2'-6"	15'-0"	#8	10	6"± O.C.	9"± O.C.	27
	5	2'-6"	27'-0"	#8	10	6"± O.C.	11.5"± O.C.	34

TOWER ENGINEERING PROFESSIONALS

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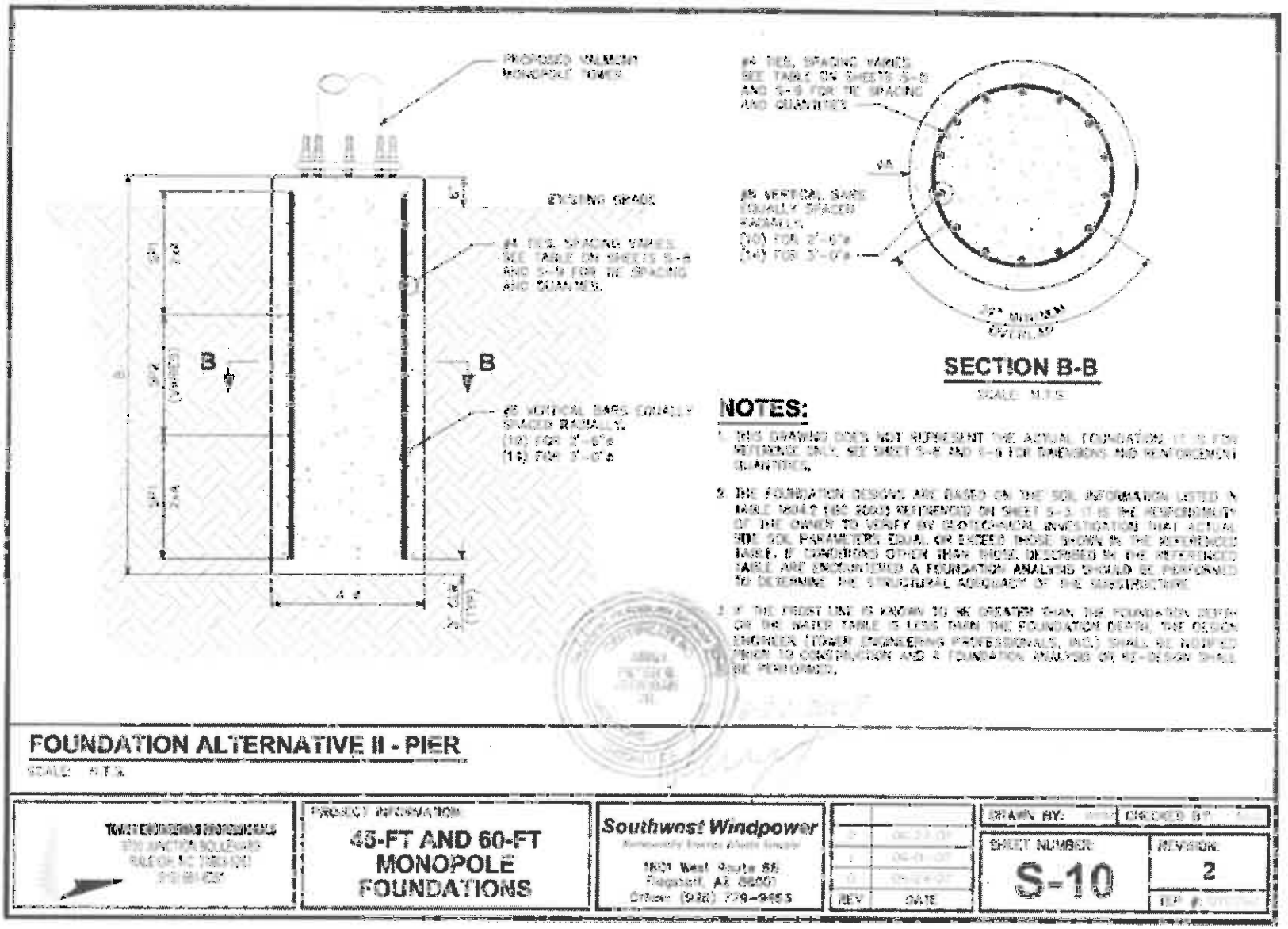
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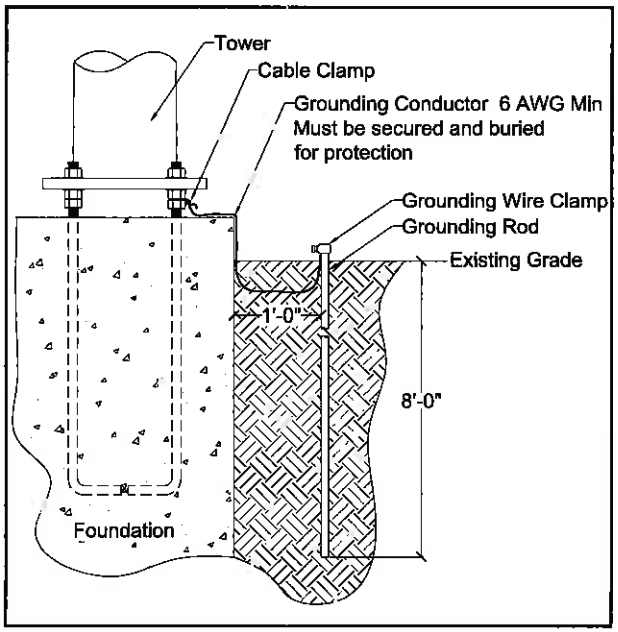
Skystream 3.7 Foundation & Tower Installation Manual

Appendix B: Tower Grounding

Skystream Monopole Towers



IMPORTANT SAFETY INSTRUCTIONS

READ THESE INSTRUCTIONS IN THEIR ENTIRETY BEFORE INSTALLING.

Professional installation
highly recommended

1) SAVE THESE INSTRUCTIONS. This manual contains important instructions for grounding your Skystream monopole tower.
2) Read these instructions in their entirety before beginning.
3) Do not start installation unless all required equipment and tools are on site.

In this guide

TIP: Helpful information to ease the installation

Professional installation
highly recommended

Warning: Risk of injury or death - proceed with extreme caution

One - Introduction

Even though the wind turbine is grounded at the service panel it must also be grounded at the tower base. Grounding the tower at its base may prevent electrical shocks, voltage surges and static charge build up. Proper tower grounding may also limit or minimize damage due to lightning strikes.

This document provides recommendations for grounding small wind turbine systems with rated line currents of less than 200A to achieve compliance with the 2005 USA National Electrical Code (NEC) as well as IEC (International Electrotechnical Commission) standard 60364-5-54 Selection and Erection of Electrical Equipment – Earthing Arrangements, Protective Conductors and Protective Bonding Conductors.

The grounding information contained in this document is provided as a reference. Please refer to the aforementioned NEC and IEC standards for complete detailed information. Local building codes and electrical standards may differ from the information presented here and have precedence over this document.

Two - Grounding Techniques

There are several tower grounding techniques compliant with NEC and IEC standards, this document presents two of the most common approaches:

- **Copper clad electrodes driven into the soil**
- **Electrodes encased in the concrete of the tower foundation**

2-1 Copper Clad Electrodes Driven Into the Soil

The figure 1 depicts a typical tower grounded using an electrode driven into the soil.

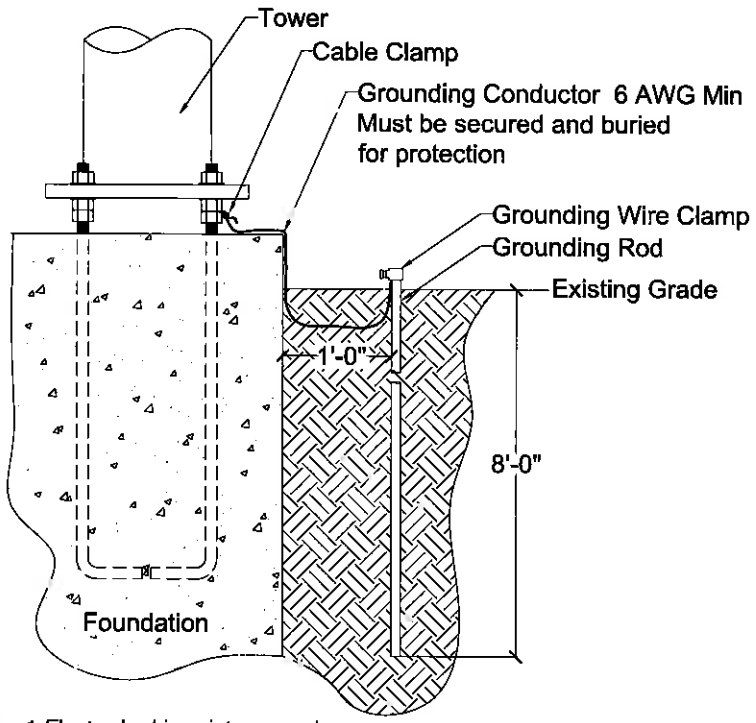


Fig. 1 Electrode driven into ground.

The tower may be grounded using a copper-clad electrode(s) of appro priate diameter and length. See the section entitled "Electrode resistance to ground" to determine the dimensions of the rod. The electrode shall be free from non-conductive coatings such as paint or enamel. Rod and pipe electrodes shall not be less than 8 ft (2.5 m) in length and shall consist of the following materials:

a) Electrodes of pipe or conduit (hollow electrodes) shall not be smaller than metric designator 21 (trade size 3/4) and, where of iron or steel, shall have the outer surface galvanized or otherwise metal-coated for corrosion protection.

b) Electrodes of rods of iron or steel shall be at least 15.87 mm (5/8 in) in diameter. Stainless steel rods less than 16 mm (5/8 in) in diameter, nonferrous rods, or their equivalent shall be listed* and shall not be less than 13 mm (1/2 in) in diameter.

Other grounding electrode types may be used as recommended in 2005 NEC section 250.52 and in accordance with the user's local electrical code authority.

*Be included in a list published by an organization (or marked as such) that is acceptable to the local authority having jurisdiction in the area. For example, UL/CSA listed in USA/Canada.

2-1-1 Grounding Electrode Installation

The following information is excerpted from the 2005 NEC article 250.53 (G). Refer to code for additional detailed information.

The electrode shall be installed such that at least 8 ft (2.44 m) of length is in contact with the soil. It shall be driven into undisturbed soil within 1 ft of the tower foundation. It shall be driven to a depth of not less than 8 ft (2.44 m) except that, where rock bottom is encountered, the electrode shall be driven at an oblique angle not to exceed 45 degrees from the vertical or, where rock bottom is encountered at an angle up to 45 degrees, the electrode shall be permitted to be buried in a trench that is at least 30 in (750 mm) deep. The upper end of the electrode shall be flush with or below ground level unless the aboveground end and grounding electrode conductor are protected against physical damage as specified below (quoted from 2005 NEC article 250.10):

a) In installations where they are not likely to be damaged.

b) Where enclosed in metal, wood, or equivalent protective covering.

2-1-2 Electrode Resistance to Ground

The resistance to earth of a single ground rod can be calculated using Dwight's equation:

$R = [r/(2\pi L)]x[\ln(4^L/R)-1]$, where r is the soil resistivity, L is the length of the rod buried inside the earth and R = radius of the rod; ln stands for the natural logarithm.

For calculating the resistance of the rod to ground, one must know the value of soil resistivity. This may be found in the local electrical code or building inspector's office/municipal office or by an actual soil resistivity test.

The resistance of a rod electrode to ground may be lowered by increasing the rod diameter, increasing the buried length of the rod or by treatment of the soil to reduce its resistivity.

If the single chosen electrode does not have a resistance to ground of 10 ohm or less, it shall be augmented by additional electrodes as necessary. The overall resistance of multiple rods to ground would roughly equal the resistance of a single rod to ground divided by the number of rods. Where multiple such electrodes are installed to meet the above requirement, they shall not be less than 6 ft (1.8 m) apart. The multiple rods must be bonded together using the grounding electrode conductor.

2-1-3 Grounding Electrode Conductor: Material, Size, Bonding to Electrode and Bonding to Tower

Material (Ref. 2005 NEC articles 250.62, 250.96(A).

The grounding electrode conductor shall be of copper, aluminum, or copper-clad aluminum. The material selected shall be resistant to any corrosive condition existing at the installation or shall be suitably protected against corrosion. The conductor shall be solid or stranded, insulated, covered or bare. Any non-conductive paint, enamel, or similar coating shall be removed at threads, contact points, and contact surfaces or be connected by means of fittings designed so as to make such removal unnecessary.

Note: Many local electrical standards do not permit the use of aluminum or copper-clad aluminum conductor and strictly require the use of copper conductors.

2-1-4 Conductor Size

(Ref. 2005 NEC article 250.66(A)):

Where the grounding electrode conductor is connected to rod, pipe or plate electrodes, that portion of the conductor that is the sole connection to the grounding electrode shall be a minimum of 6AWG copper wire or 4AWG aluminum wire.

2-1-5 Bonding the Grounding Electrode Conductor to the Earth Electrode

(Ref. 2005 NEC article 250.70):

The grounding or bonding conductor shall be connected to the grounding electrode by exothermic welding, listed lugs, listed pressure connectors, listed clamps, or other listed means. Connections depending on solder shall not be used. Ground clamps shall be listed (approved) for the materials of the grounding electrode and the grounding electrode conductor and, where used on pipe, rod or other buried electrodes, shall also be listed for direct soil burial.

2-1-6 Bonding the Grounding Electrode Conductor to the Tower

The grounding conductor may be connected to the tower by any one the following means:

2-1-6-1 Using a Tower Bolt/Nut Assembly

a) Pre-assemble the extra nut (supplied in the tower bolt kit) on one of the tower bolts containing nuts "A" or "B" as shown in fig. 2C of Skystream Foundation and Tower Installation Manual. Move the extra nut towards the bottom of the bolt so that it does not interfere with the nut to go on top of it.

b) Assemble the nut and washer on top as explained in the Installation Manual. Generously apply a listed "joint compound" to the sandwiching surfaces of the two nuts as well as to the tower bolt in question. The joint compound must be of the type to prevent corrosion between copper and galvanized steel.

c) Take one end of the grounding conductor and loop it once around the tower bolt containing the extra nut, between the upper and lower nut. Generously apply joint compound to the grounding conductor and cable clamp in the area of attachment. Secure the conductor with a cable clamp around the loop so that it just clears the tower nuts and keeps the loop snug around the tower bolt (see fig. 3). The cable clamp is required so that the ground wire does not slip out from between the nuts when the lower nut is tightened.

d) Ensure that surfaces of the lower and upper nuts facing each other are free of dirt and have very clean surfaces. If necessary, wash and clean these surfaces. This is essential for a good electrical connection between the ground conductor and the tower. Tighten the lower nut towards the upper nut applying sufficient torque (50 lb-ft or 68 N-m minimum) to securely clamp the grounding wire (see fig. 3).

e) Erect the tower and level it as required by adjusted any or all of the tower nuts. You may have to loosen the ground wire nut during this adjustment. After finished adjusting the tower level, re-tighten the lower nut to the suggested torque to make sure the ground wire is securely sandwiched and bound between the two nuts.

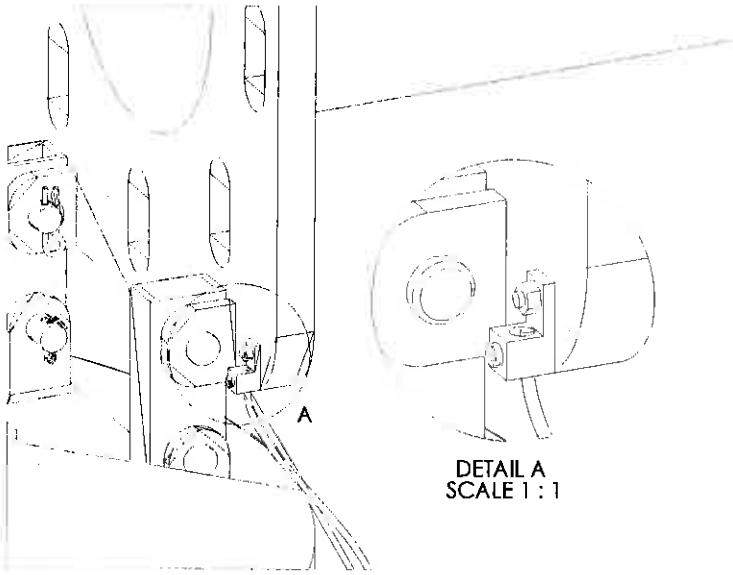


Fig. 2 Attaching the grounding wire to the tower base.

2-1-6-2 Using a Grounding Lug at Tower Base

Bond the grounding conductor to the tower base flange through a ground terminal lug attached to the tower base as shown in figure 2. Use a 1/4-20 x 1.75 in long stainless steel bolt through a hole in the tower base and a Nyloc stainless steel nut to fasten the ground lug to the underside of the tower base. The ground lug must be UL listed and must be type to that accommodates up to 1/ 0 AWG wire minimum.

2-1-6-3 Using Exothermic Welding

Bond the grounding conductor to the tower base flange by exother welding of the conductor to the base flange. Make exothermic welds strictly in accordance with the weld manufacturer's written recommendations.

Electrode conductor routing and placement / installation:

Ensure that the grounding conductor has no sharp bends in it. This is important to keep its inductance low. The grounding conductor may be buried or contained in a conduit as explained in 2005 NEC article 250.64.

2-2 Electrodes encased in the concrete of the tower foundation

(reference 2005 NEC article 250.52(A)(3))

A grounding electrode may also be encased in the concrete of the tower foundation. The electrode is located at the bottom of the foundation and connects to the tower mounting "J" bolts and to the tower base by means of a grounding conductor.

Because the grounding electrode will be encased in concrete it should be inspected and approved prior to pouring the foundation to avoid conflicts with local construction inspectors.

Two types of electrodes, their locations and their connection to the electrode grounding conductor are described below:

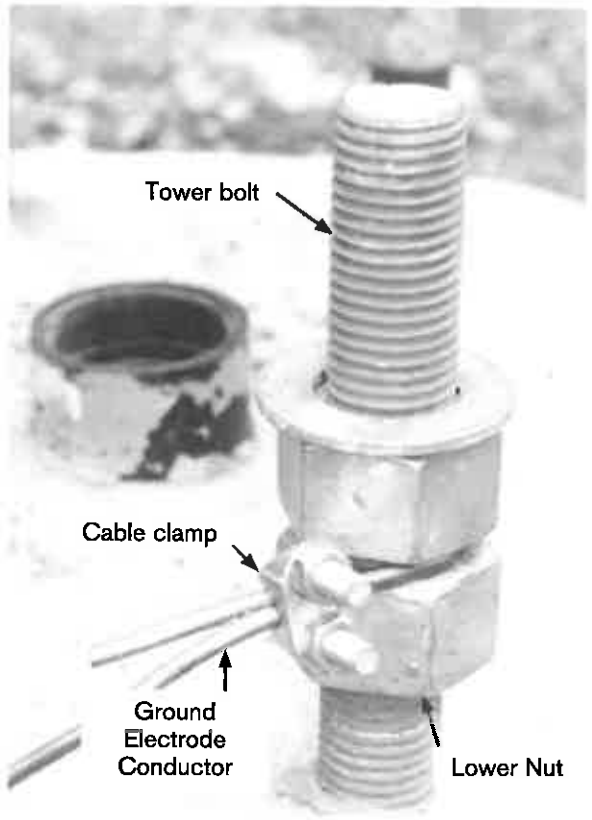
a) The Electrode must be at least 20 ft (6.0 m) of one or more (electrically connected by steel tie wires) bare or zinc galvanized steel or other electrically conductive coated steel reinforcing bars or rods of not less than 1/2 in (13 mm) in diameter, located near the bottom of the concrete foundation that is in direct contact with the earth. The electrode must be encased by at least 2 in (50 mm) of concrete as shown in figure 4. The reinforcing bars, if bare, must not be rusted at the time of installation to prevent bad electrical connection between bars and with the grounding electrode conductor. The reinforcing bars must be electrically connected to the anchor bolts either using the steel tie wires or using the grounding electrode conductor. The grounding electrode conductor must not be smaller than 4AWG copper and must be electrically bonded to the bottom reinforcing bars using listed/approved means that is suitable for concrete encasement. Sufficient extra length of the conductor must be available to bring it out of the foundation top and at least 18 in above the foundation top. It should then be bonded to the tower as described in section 1.5 of this document.

b) The Electrode must be least 20 ft (6.0 m) of bare copper conductor not smaller than 4AWG. The copper conductor, which may be in the

form of a coil, must lie at the bottom of the foundation with either a 2-in thick (maximum) tamped fill of earth covering the grounding coil or covered in concrete a maximum of 2 in above the soil at the bottom of the foundation. Sufficient extra length must be present in the copper conductor to bring it at least 18 inch above the foundation top where it should be bonded to the tower as described in section 1.5 of this document. On its way up, the copper conductor must also be bonded to the tower anchor bolts using a clamp listed or approved means that is suitable for concrete encasement and also suitable for connecting copper to steel. This listed clamp is generally tin plated and must be of the type to prevent direct contact between copper and steel to prevent corrosion.

2-3 Bolting Grounding Lug to Tower Base

An alternate method of attaching the electrode grounding conductor to the tower is to drill a hole thorough the base and utilize a commercially available lug as depicted in figure 2. To connect the grounding conductor to the tower base using this approach drill a 0.25 in (6 mm) hole through the tower base. After joining the grounding conductor to the listed lug according to the lug manufacturer's instructions, bolt the lug to the tower base with a stainless steel bolt and self locking nut. The listed lug is generally tin plated and prevents corrosion between the galvanized steel tower and the copper conductor.



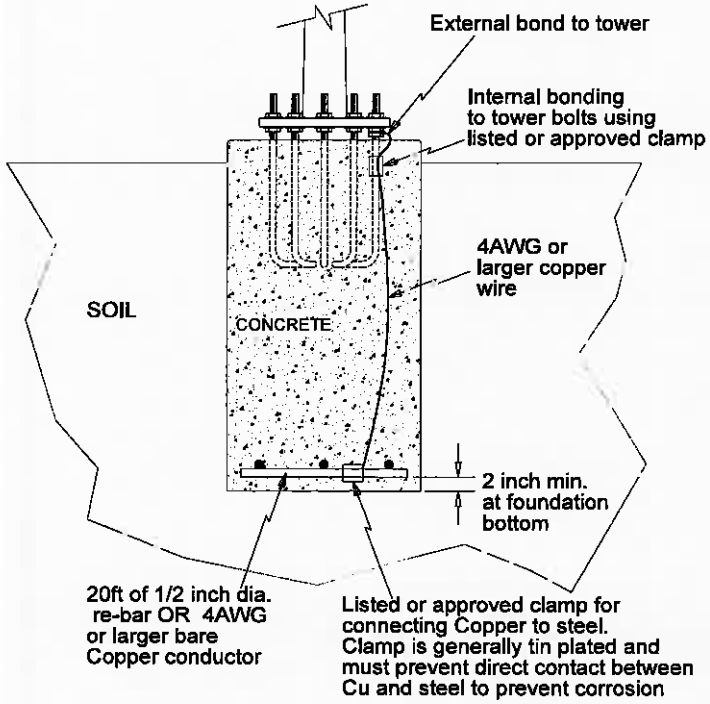


Fig. 4 Concrete encased electrode.

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