



PennSummit Tubular, LLC

Wireless Monopole Installation Recommended Guidelines

Introduction

The following document is for use in assembling and erecting PennSummit's wireless tubular steel monopoles. The document contains recommendations and guidelines which have been collected from various sources and from PennSummit's extensive experience in manufacturing, providing, and assembling monopoles. The information is general and intended to be a helpful guide. The information is not comprehensive enough to cover all situations or the details of all installations. Special features required by the Owner may require unique installation methods. In this event, the contractor must be familiar with the Owner's specifications and the PennSummit structural drawings included with the delivery of the structure. Questions or concerns regarding the monopole or its component parts should be addressed to PennSummit.

PennSummit structural documents provided with the monopole do not indicate the method of construction. The contractor should not rely solely on these guidelines to determine the assembly and erection of the structure. It is the contractor's sole responsibility to determine erection procedure and sequence to insure the safety of the monopole and its component parts during installation and assembly.

The contractor shall supervise and direct the installation and shall be solely responsible for all construction means, methods, techniques, sequences, and procedures. Observation visits to the site by the Owner and/or PennSummit shall not include inspections of the construction procedures. Due to the varied methods used by contractors in actual field operation, PennSummit cannot be liable for damage occurring during assembly and erection.

The contractor shall be responsible for initiating, maintaining, and supervising all safety precautions and programs in connection with the work. The contractor is responsible to insure that the project and related work complies with all applicable local, state, and federal safety codes and regulations governing this work.

Site

The telecommunications site where the monopole is to be located should be prepared per the Owner's engineering plans and specifications. The efficient assembly and erection of a monopole will require a clear, level area. Any possible obstructions near the site such as overhead power lines or buildings should be noted and proper precautions taken during crane operation. Access to the site should be assessed for the foundation drill rig, erection crane, and truck delivering the monopole assembly. Assessment of whether the monopole can be assembled on the ground or vertically in the air should be accomplished. The contractor should review the site drawings provided by the Owner and the PennSummit structural drawings for any conflicting information.

Foundation

A typical monopole foundation includes a reinforced concrete caisson, pad and pier type foundation, or mat foundation. Foundation design is based on a site specific soils report provided by a geotechnical engineer hired by the Owner. Foundation drawings should include details showing depth, diameter, reinforcing steel, the location of the reinforcing steel, and the orientation of the anchor bolt cluster. A typical minimum diameter of 4'-0" is used for caisson or pier foundations, increasing by 6" or 12" increments as required by design. The availability and size of the foundation contractor's drill rig may also play a part in the size and type of foundation used. A minimum concrete compressive strength of 3000 psi is typically used. Reinforcing steel in the foundation is typically grade 60 as required for bending or minimum reinforcement. Monopole anchor bolts typically consist of 2 ¼" diameter #18J ASTM A615 Grade 75 jumbo rebar. The quantity of anchor bolts is determined by the loads to be transferred to the foundation from the monopole. The anchor bolts utilize a top and bottom steel template for orientation. Both templates are notched 180 degrees for orientation purposes.

The reinforced concrete for the foundation should be installed well ahead of the erection of the monopole. PennSummit recommends a 7 day minimum wait after concrete is poured for proper curing prior to setting the monopole on the anchor bolts. If a reduced time frame is required, contact PennSummit prior to setting the monopole. In designing and installing the foundation, consideration should be given to the need for underground antenna cable access as required by the Owner.

Upon arrival at the site, the templates and threaded portion of the anchor bolts should be checked for bending or other damage which might disturb the anchor bolt pattern. If the templates or threaded portion of the anchor bolts is damaged, contact PennSummit. Under no circumstances attempt to substitute wood or any other material for a damaged template. The threads of the anchor bolts should be checked with a 2 ¼" heavy hex galvanized nut to ensure the nut can be turned up or down the full length of the threaded portion of the anchor bolt. Measure the bolt circle of the templates and verify the bolt circle and quantity of anchor bolts shown on the foundation and template drawing.

The bottom template is secured with double 2 ¼" black heavy hex nuts on the bottom threaded 6" of each anchor bolt and is embedded in the foundation. The top 18" of each anchor bolt is galvanized and the top 14" of each anchor bolt is threaded. When placing the anchor bolt cluster in the reinforcing steel cage, the template notches should be oriented to face the equipment building or pad unless otherwise noted by the Owner or PennSummit. Do not weld the anchor bolts to the reinforcing steel cage. Care must be taken to place the anchor bolts vertically and not to disturb their orientation while placing concrete. The unused portion of the anchor bolt should be protected from concrete splatter during pouring. A popular means of accomplishing this utilizes duct tape. The projection of the anchor bolts above the foundation should be 12". After setting and proper curing, the top template may be discarded. The gap between the top of the foundation and the bottom of the base plate varies from 2 ½" to 4" as required for leveling the base plate. At least two threads of the anchor bolts should extend above the top heavy hex nuts.

Grout is not required or recommended by PennSummit. The monopole/foundation connection is designed to function without grout. Grout is not a required structural component and inhibits proper drainage and ventilation of the monopole. If the Owner chooses to grout the monopole base plate, provisions to vent the inside of the monopole and to prevent standing water inside or underneath the monopole should be made. If required, grouting should only be done after the Owner is satisfied with the monopole installation. Covering the leveling nuts with grout removes access to the only adjustment method for plumbing the structure. Corrosion due to standing water and moisture from grouting of the monopole will void the warranty.

Direct Burial Foundation

The Owner may specify the use of a direct burial foundation. The monopole in this application is directly embedded into the ground in place of utilizing a concrete foundation. The embedded portion of the monopole is coated with a two-part polyurethane coating for corrosion protection. An optional ground sleeve provides additional corrosion protection at grade level. Backfill around the embedded monopole tube section may consist of a lean concrete fill or grout. Prior to placing the embedded monopole tube section, the coating finish should be inspected and touched-up as needed. The embedded section should be supported while the backfill is placed. Temporary guys or the crane may be used for support. The base monopole tube section must be checked periodically for plumbness during installation. Once the backfill is placed, there is no adjustment for the monopole for plumb.

Handling and Unloading

When delivering the monopole to site special care should be taken during the loading, hauling, and unloading to prevent any damage to the monopole or its component parts. Slings for handling the monopole should be made of or covered with nylon or some other nonmetallic material to protect the finish. Do not roll the monopole tube sections off the delivery truck or drop the sections on the ground. The monopole should be handled in such a manner that no portion is dragged along the ground or any other object that could damage the monopole. A check of each monopole tube section identification marking and the required order of assembly at this stage is highly recommended. Contact PennSummit for monopole tube sections out of round due to mishandling during shipping.

Monopole tube sections should be unloaded at the proper location and aligned as required for installation. The lower tube section should be blocked at a point about eight feet below the upper end. Blocking should consist of hard wood lumber or other suitable materials placed outside the slip joint areas. Do not block with oak wood which will stain the galvanized finish. Blocking should maintain the true alignment of the assembled structure and should be used to prevent the section(s) from rolling. Care must be taken to avoid scratching, denting, or deforming the sections, particularly at the ends.

Identification

PennSummit structural drawings are provided with the monopole attached to the box of hardware accompanying the structure shipment. If the structural drawings are incomplete or missing, contact PennSummit. Each monopole tube section with the exception of the base tube section is marked with a weld bead above the slip joint. The base tube section is marked below the slip joint. Refer to Figure 1. The weld bead designates the structure number. The box of hardware accompanying the monopole is identified by the Owner's name, PennSummit job number, structure number, purchase order number, monopole height, and site name if available.

Erection

Erection of the monopole is performed by assembly on the ground and lifting the entire structure or by stacking - assembly vertically in the air. Assembly on the ground involves slip joint assembly, attachment of climbing devices, assembly and attachment of antenna mounting platforms or arms, antenna mounting, and installation of antenna cables on the ground prior to erecting the structure by crane. Assembly in the air involves erecting the monopole vertically section by section. Slip joint assembly is accomplished in the air. The antenna mounting platform or arms is assembled on the ground and erected with the appropriate tube section. Antenna cables are installed by winching the cables from the ground to the top of the monopole, cable by cable.

Monopole tube sections may be hoisted from a single point with a nylon or padded cable choker and maneuvered into position. The lifting crane must be attached to the monopole tube section, not to appurtenances such as step bolts, step bolt attachment clips, safety cable equipment lugs, or

the antenna mounting platform or arms. If lifting the entire assembly, lift above the center of gravity including the weight of all equipment mounted on the structure prior to erection. The higher the lifting point will result in more nearly vertical alignment of the assembly while suspended above the foundation or the mating male section. PennSummit provides 1 ½" diameter holes at 180 degrees apart, 2 inches below the top of each tube section with the exception of the top tube section. The holes may be utilized to hoist each section by crane to slip on the proceeding section.

The monopole tube section should not be rocked while lifting. Prior to lifting the structure, any slip joint assembly below the crane attachment point should be tethered together as a safety precaution against pulling apart during lifting. This may be accomplished by bolting a bar, plate, or angle across the slip joint using the 1" jacking nuts. A hook capable of supporting the entire weight of the tube section can be attached to any handhole openings in the section and connected to the crane attachment point. Care should be taken to operate the crane smoothly to avoid impact loads which may adversely affect the monopole or its component parts. Leveling nuts should be adjusted prior to installing the monopole. The nuts should be in a horizontal plane, turned down on the threading to provide enough room on the anchor bolts for the base plate thickness, the top nut and at least an inch of projection for possible adjustment. The leveling nuts may be adjusted by utilizing the top template prior to discarding to obtain a true horizontal plane. After the monopole is erected, proper plumbing of the pole can be accomplished by adjusting the heavy hex leveling nuts underneath the base plate.

The amount of room at the site and the size of the equipment available to the contractor will dictate the best method of construction. Where space near the foundation and lifting capabilities permit, PennSummit recommends assembling the monopole on the ground and erecting the structure as a unit. If the monopole is assembled vertically in the air, extra care may be needed to assure all slip joints are properly assembled as indicated below. ***The weight of the monopole tube sections should not be substituted for the jacking force required to make a slip joint. All jacking and assembly procedures, as detailed in this document, should be observed for either method of erection.***

Slip Joint Assembly

The PennSummit structural drawings indicate the proper amount of joint overlap required. The structural drawings list the design slip value +/- 10%. Overlap in the range of 10% less than the design value as well as 10% over the design value is acceptable. The target value is the design slip joint value.

The male tube section should be marked with chalk or non-permanent marker to indicate the proper overlap into the female tube section. Additional marks should be made at 2" increments, for 2" less than minimum overlap, and for 2" to 12" more than maximum overlap. The mark for proper overlap should be clearly distinguishable from the other overlap marks as shown in Figure 2. Mating surfaces should be clean. Prior to jacking, check the inside of the female slip joint for galvanizing build-up or other debris. Galvanizing build-up may form a wedge during slip joint assembly and may inhibit achieving proper joint overlap.

Shop installed jacking nuts are provided both above and below each slip joint. The jacking nuts are 1"-8 ASTM A563 heavy hex nuts. The jacking nuts are welded to the monopole tube shaft 180 degrees apart and consist of two pairs of nuts on each side of the tube section above and three pairs of nuts on each side of the tube section below the slip joint. Refer to Figure 1.

Several methods are available for jacking the monopole tube sections together depending on the monopole design, section sizes, and the availability of equipment. Hydraulic jacking devices are acceptable. Mechanical jacking devices such as ratchet chain hoists or similar devices are also acceptable.

Hydraulic jacking devices have proved to be very effective for making sound, high quality joints. These devices generally have a large capacity to insure proper seating of the tube sections even if the sections are slightly out of round or not aligned precisely. PennSummit recommends the use of hydraulic jacking devices for slip joint assembly. Jacking plates should be utilized to jack the monopole tube sections together for larger diameter monopoles greater than 12" in diameter, when large jacking forces are anticipated, when attempting to jack a stubborn slip joint, or when attempting to jack a monopole tube section out of round. Jacking plates consist of 'T' plates which have a pair of holes in the flange of the 'T' that allow them to be bolted to the jacking nuts on each side of the slip joint. Each pair of jacking nuts utilizes one jacking plate, thereby requiring four (4) jacking plate assemblies for a slip joint assembly. Each jacking plate has a hole in the web of the 'T' for attachment of the jacking device. Jacking plates are available for purchase from PennSummit. Refer to Figure 3.

Mechanical jacking devices consist of two ratchet chain hoists or similar devices attached on opposite sides of the monopole shaft. The devices may pull on cables secured to the monopole tube sections with a choker type hitch or attached to high strength 1" bolts installed in the jacking nuts. Equal forces should be applied by the two hoists simultaneously. If the jacking nuts are used, forces must be applied no more than 1 ½" from the surface of the monopole shaft and the forces must be distributed equally to all the jacking nuts at each joint. Although a common method of jacking monopoles, this technique should be limited to only the smallest monopoles. ***PennSummit recommends utilizing mechanical jacking devices on monopoles with a diameter 12" or less at the slip joint. Each mechanical jacking device should have a minimum capacity of 6 tons (12,000 lbs) each for a total jacking force of 24,000 lbs.***

The female tube section should be aligned and its large end slipped over the small end of the male tube section. The longitudinal weld seams must be aligned the full length of the monopole. The monopole tube sections should be worked up and down to help bring the sections together. Do not use any climbing step bolts, step bolt attachment clips, or any other attachment on the monopole not intended for jacking during the jacking process. The alignment and pulling force must be even and steady. The pulling will be facilitated by flexing the joint either by lifting the small end of the pole slightly, or by lifting the joint slightly. The slip joint should be pulled until the application of additional pulling pressure produces little or no movement. The minimum and maximum insertion should be within +/- 10% of the design slip joint per the provided PennSummit structural drawing. Caution should always be used when jacking the monopole tube sections together since the required jacking forces can be of a large magnitude. The contractor should stand a safe distance from the jacking devices and should keep hands away from the slip joint during joint assembly. The jacking forces should be applied until the joint is tight with no more than small gaps. Gaps should be smaller than ¼". Gaps are more likely at the bends of the monopole tube section and where the seam weld(s) is located.

Failure to meet the criteria established in this section may void PennSummit's warranty. The proper jacking force is not defined or limited by the capacity of the jacking system being utilized by the contractor until the applied force meets 90,000 lbs or 24,000 lbs for monopole diameters less than 12" in diameter.

Other methods may exist and be available to generate and apply the force needed to obtain a proper slip joint assembly. The contractor must judge the quality of the slip joint based on the overlap length which should be +/- 10% of the design slip length, applying a minimum of 24,000 lbs jacking force, lack of movement in the joint under the jacking force, and the absence of excessive gaps.

Lubricants applied to the slip joint may be used at the contractor's discretion. Care should be taken to not use a lubricant that will leak from the assembled slip joint and stain the galvanized finish. Soapy water may be utilized, however, a heavier lubricant like water soluble clear grease may prove to be more effective. The contractor will assume all responsibility for any stains to the monopole finish.

The above procedures for slip joint assembly should be followed whether the monopole is assembled on the ground or in the air. If upon completion of the slip joint assembly procedure, a slip joint does not meet all specified criteria herein, contact PennSummit prior to proceeding with erection. Under no circumstances erect a monopole without proper slip joint engagement unless written authorization from PennSummit has been received.

Flange Connections

An alternative to overlapping slip joint connections are flange joints. A flange joint utilizes a bolted butt flange to flange connection with high-strength structural bolts. Install the connection bolts to a snug tight condition per AISC requirements. The snug tight condition is defined as the tightness that exists when all plies in a joint are in firm contact. This may be attained by a few impacts of an impact wrench or the full effort of a man using an ordinary spud wrench. Tighten the bolts in a criss-cross alternating pattern.

Antenna Cable Installation

PennSummit provides J-hooks below all handholes inside the monopole and at the top of the monopole at the antenna mounting platform or arms for antenna cable hoisting grips. Do not use the J-hooks for winching antenna cables or hoisting equipment.

Ground Bar Installation

PennSummit provides ground lugs or ground nuts underneath most handholes for mounting ground bars and ground bar support angles for grounding the antenna cables. The ground lugs, or ground nuts, may be inside or outside the monopole, in the horizontal or vertical orientation, as requested or specified by the Owner. Ground bars, insulators, and various length lightning rods are available from PennSummit.

Climbing Equipment Installation

Climbing consists of galvanized ASTM A307 step bolts $\frac{3}{4}$ " dia. x 7 $\frac{1}{2}$ " long and a vertical safety cable system. The step bolts are attached by double galvanized $\frac{3}{4}$ "-10 hex head nuts to step bolt clips shop welded to the monopole tube sections. Screw one nut onto the step bolt as far as possible. Insert the other nut behind the step bolt clip on the tube section and screw the step bolt in until the step bolt touches the surface of the monopole shaft. Tighten the outer nut against the step bolt clip sufficiently to prevent the step bolt from loosening. Do not overtighten the step bolt to the extent of damaging the threads or step bolt clip. If the step bolt cannot be installed properly or there is excessive motion in the step bolt when inserted in the step bolt clip, contact PennSummit prior to climbing on the monopole.

The step bolts start approximately 12 ft above ground level and are placed approximately 25 $\frac{1}{2}$ " apart radially, approximately 12" to 18" apart vertically, and alternate progressing up the monopole. Working step bolts are included around handholes and at the top 6 ft of the monopole. Removable step bolts are available from PennSummit as requested or specified by the Owner.

The safety climb equipment manufacturer's instructions are provided with the monopole shipment to the contractor responsible for installing the safety climb equipment. The contractor must read and understand these instructions or have the instructions explained prior to installation. Read and follow the manufacturer's instructions for any related safety equipment such as a full body harness that is intended to be used with the safety climb equipment. The provided instructions must be

followed for proper installation, use, inspection, and maintenance of the safety climb equipment. Alterations, substitutions, or misuse of the safety climb equipment or failure to follow instructions may result in serious injury or death. The contractor must attach the identification tag provided by the safety climb manufacturer with the equipment to the monopole.

Install the safety climb cable system per the manufacturer's guidelines. Lugs for attachment of the safety cable bottom bracket and top bracket are located approximately 12 ft above the base plate and 1' below the top flange, respectively. Lugs for mounting safety cable stand-offs are located on the monopole tube sections at approximately 27 ft intervals. Mount the safety cable bottom bracket at the lug approximately 12 feet above the base plate. Mount the top safety cable bracket on the lug below the top of the monopole. Mount the appropriate number of safety cable stand-off brackets with rubber guides. All safety climb equipment should be bolted to the snug tight condition per AISC requirements. Install the safety cable per the manufacturer's instructions and insert the safety cable in the groove of the stand-off rubber guides. Periodic inspection of the safety climb cable for soundness and tautness is recommended.

Antenna Mounting Appurtenances

PennSummit provides a wide variety of antenna mounting appurtenances. Platforms and arms are available as top mounted or clamp-on for future installation on a monopole. Platforms of various sizes are available with full handrail or as low profile without handrail. Arms are available as curved, stiff, or T-arms. Antenna mounting appurtenances are as specified by the Owner. Microwave mounts, FAA light support mounts, GPS antenna mounts, and miscellaneous other mounts are available.

PennSummit structural drawings for the mounts are provided with the shipment of the monopole and are included with the monopole structural drawings. Assemble the mount per the provided structural drawings. Bolts should be tightened to the snug tight condition per AISC requirements. ***Do not climb on mounts that consist of arms (all non-platform mounts) during installation or maintenance of the antennas.***

Anchor Bolt Installation

After the monopole has been erected, the anchor bolt heavy hex nuts must be properly tightened to ensure that the structure will perform as designed. The top heavy hex nuts should be turned down as quickly as possible after placement on the leveling nuts. Below the monopole base plate, use 2 ¼" galvanized flat washers and galvanized heavy hex nuts as leveling nuts. Using a 2 ¼" galvanized flat and lock washer, a 2 ¼" galvanized heavy hex nut, and a 2 ¼" galvanized heavy hex lock nut above the base plate is recommended. The additional heavy hex lock nut discourages unauthorized loosening of the nuts. See Figure 3. Other methods include: 1) using a 2 ¼" galvanized flat and lock washer, and a 2 ¼" galvanized heavy hex nut with a galvanized heavy hex half lock nut; 2) using a 2 ¼" galvanized flat and lock washer, a single 2 ¼" galvanized full size heavy hex nut, and hammer and chisel or weld the anchor bolt threads. Two threads of the anchor bolts should always extend above the top nuts.

Before final tightening of the nuts the monopole should be measured for plumbness. Different techniques may be used to obtain the same objective which is to align the centerline of the monopole top with the centerline of the base plate. The maximum deviation of the monopole from a true vertical line should occur approximately in the middle of the structure. Plumbing the monopole does not mean leveling the base plate. The plumbing should be done on a calm day early in the morning when there is minimum heat effect from the sun and when there is no appreciable wind. The heat from the sun on one side of the structure can cause a visible bow to occur. Observations and calculations have indicated that the sweep in the monopole caused by thermal metal expansion can be as much as 2 ft in 100 ft, leaning away from the sun. To plumb the monopole, transits should be setup away from the monopole at 90 degrees to each other and at a distance

approximately equal to the height of the monopole. The transits should be plumbed, centered on the center line of the monopole at the base, then tilted upward to the top of the structure. Slightly loosen the heavy hex nuts above the base plate and adjust the heavy hex leveling nuts located under the base plate. The top of the monopole is moved by adjusting the anchor bolt nuts so that the top of the monopole is centered when viewed from each transit. **Note that a small amount of rotation of a leveling nut will represent a number of inches of movement at the top of the monopole. The taller the monopole the more sensitive the adjustment of the leveling nuts will be. Do not loosen the top heavy hex nuts more than one turn at a time or dramatic structure movement may occur. Keep hands and fingers away from loosened anchor bolt nuts as a shift in wind could cause the monopole to move pinching hands or fingers below loosened nuts and the base plate.** Where directions show raising one side of the base plate field conditions such as available thread may require the other side to be lowered. The final operation should be checking the monopole for plumb in two directions at 90 degrees and re-tightening all anchor bolt nuts top and bottom.

After the monopole is plumbed, snug up all the bottom anchor bolt leveling nuts until the washers are in firm contact with the bottom of the base plate. Do not over tighten the leveling nuts or the pole will be moved out of plumb. Bring all top anchor bolt nuts down to a snug tight condition on the top of the base plate. Fully tighten each top anchor bolt nut using the full effort of a single man on a four foot wrench - approximately 600 ft-lbs of torque. Anchor bolt nuts should be tightened in alternating fashion working diagonally back and forth until all nuts have been secured. Tighten the locking nuts in a similar fashion. Check all leveling nuts to ensure that they have not been loosened in the process. Any nuts which have been loosened should be tightened again. Re-check monopole for plumb and re-adjust if necessary.

Inspection

Once the monopole is totally assembled, the structure should be thoroughly inspected. Repair any damages to the galvanized surface of the monopole which may have occurred during shipping, unloading, jacking, or erection. This can be accomplished with hot stick or zinc rich paint for galvanized surfaces or touch-up paint for painted structures. Hot stick is recommended since it most nearly matches the original galvanizing. Zinc rich paints (95% zinc) are acceptable, however do not provide the same millage and protection as the original galvanizing.

Do not weld, cut, burn, or drill holes in the field on a monopole or its component parts unless written permission is received from PennSummit. The fumes from welding on a galvanized surface can be hazardous. Unauthorized welding, cutting, burning, or drilling will void the warranty.

Maintenance

Routine maintenance of the monopole installation is strongly recommended. If the monopole base plate is grouted, check for proper drainage and any signs of corrosion due to poor drainage at the base plate. The anchor bolt nuts should be checked and tightened if required. Grounding connections should be inspected for integrity. Prior to climbing, the safety climb cable should be inspected for soundness and tautness. Check the connection of the safety cable bottom bracket and tighten if required. Each step bolt should be verified for tightness during the initial climb of the monopole. Visually inspect each slip joint during the climb. Inspect the galvanized finish of the monopole for any signs of corrosion. Tighten any unused handhole covers. Check the connection of the top safety cable bracket on the lug below the top flange of the monopole. The bolted connection at the top of the monopole for the mount and any bolted connections in the mount should be checked and tightened if required. Antenna mounting pipe brackets should be periodically checked for plumbness and tightened. Check the connection of the lightning rod if applicable.

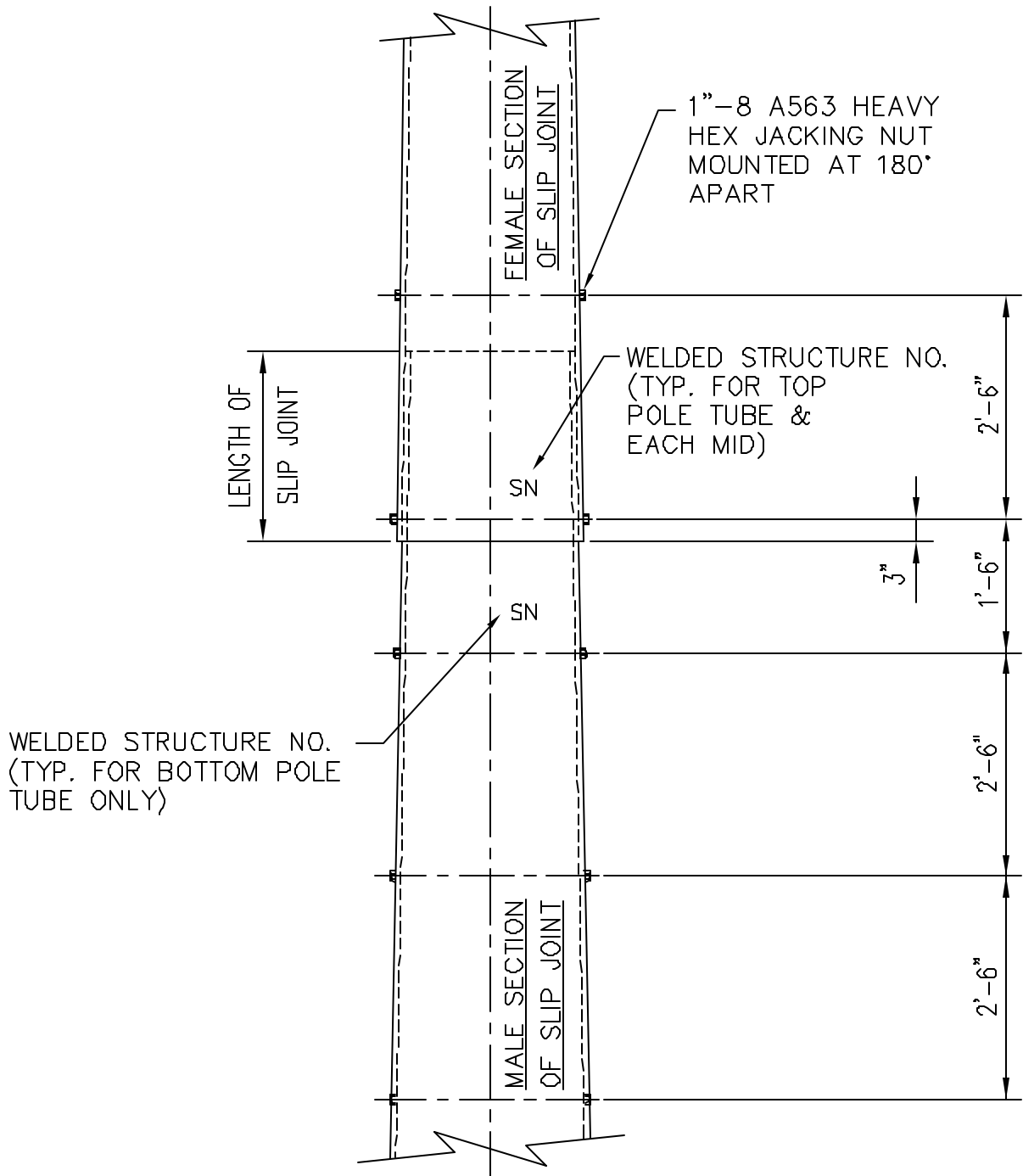
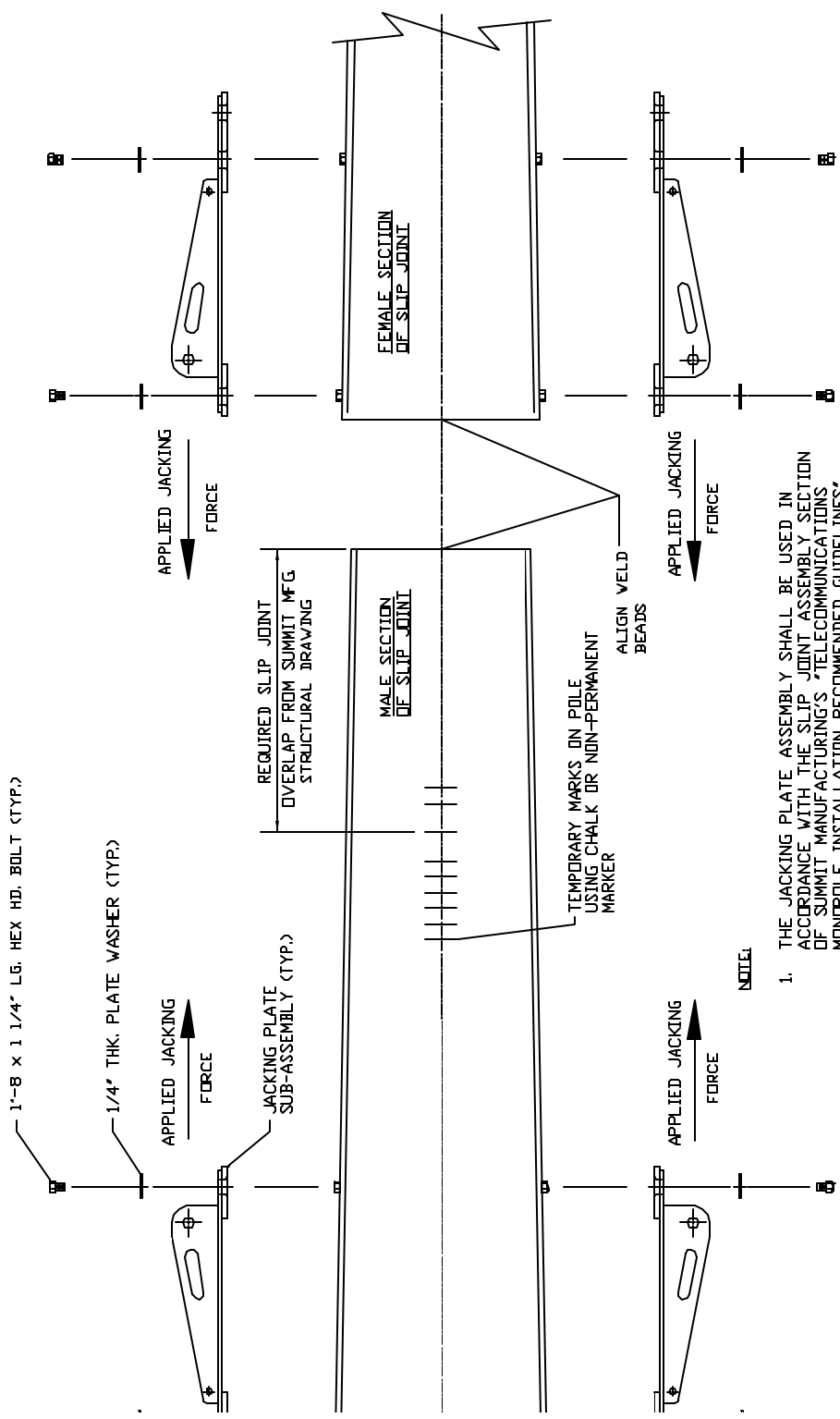


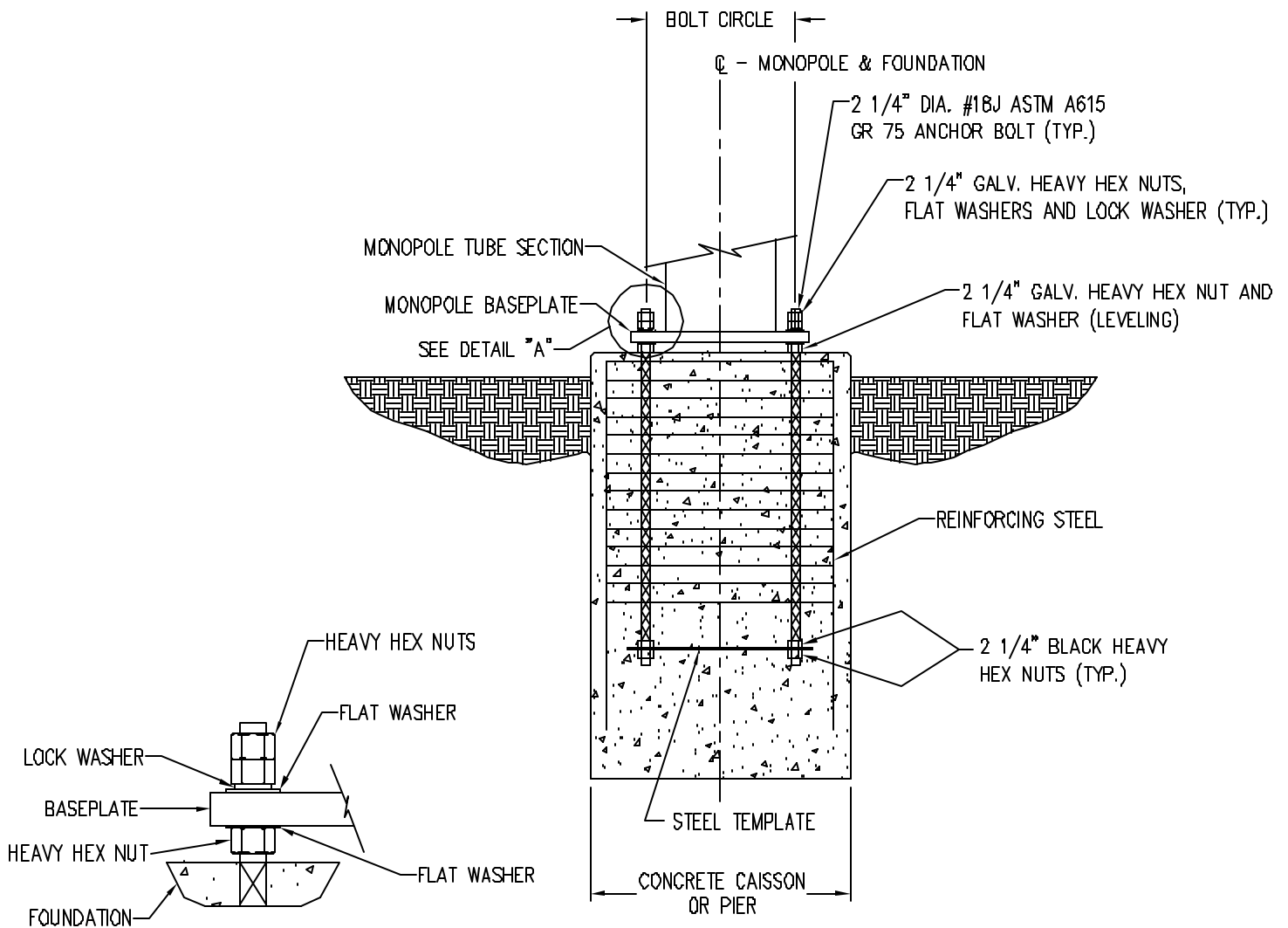
FIGURE 1



- NOTE:
1. THE JACKING PLATE ASSEMBLY SHALL BE USED IN ACCORDANCE WITH THE SLIP JOINT ASSEMBLY SECTION OF SUMMIT MANUFACTURING'S 'TELECOMMUNICATIONS MONOPOLE INSTALLATION RECOMMENDED GUIDELINES'.

PLAN - JACKING PLATE ASSEMBLY ON MONOPOLE

FIGURE 3



DETAIL "A"

FIGURE 4