HF ANTENNA INSTALLATION

The tasks associated with shore station antenna installations such as design, survey, construction and site preparation are normally accomplished under the supervision of the NAVELEX FTA and the NAVFAC EFD as directed by NAVELEX and NAVFAC. Individual shore station personnel may assist in the planning and actual installation by coordinating activities or otherwise ensuring an installation of benefit to the government.

A site survey conducted prior to determining the general suitability of a site establishes the location of property lines and access points, develops data concerning topography and soil conditions, and establishes an accurate base line from which antenna azimuths can be determined. The data obtained from this survey, together with the antenna drawings and specifications constitute the basis for developing site preparation, construction, and antenna installation plans.

7.1 REFERENCE BASE LINE

The azimuthal accuracy of HF directional antennas is normally required to be within one-tenth of a degree. Since the base line established during the site survey, or later during site development, is used as a reference point for determining azimuths, it is essential that the base line markers be protected from movement or loss during construction activity. These markers should be of a permanent nature as specified in NAVFAC DM-5 — "Civil Engineering."

When additional antennas are to be installed in an existing antenna park, the original base line markers should be used as a point of reference. If the original markers cannot be located, a new base line must be established by solar observation, or, in the northern hemisphere, by observation of Polaris. Usually, at least six observations are required to ensure adequate base line accuracy. When the base line has been established, record its position on the site plan, and retain all significant notes and calculations.

Once the base line is established, lay out and mark the antenna foundation and anchor points. When several antennas are to be installed close together these markers must be identified appropriately as to a particular antenna. The positions marked for poles or towers that affect the accuracy of the antenna bearing should be rechecked at least once.

7.2 FOUNDATIONS

Foundations for antenna supporting structures are designed and constructed in accordance with NAVFAC DM-2 — "Structural Engineering" and NAVDOCKS DM-7 — "Soil Mechanics, Foundations, and Earth Structures," and as defined by NAVFAC.

Foundation requirements can be determined only after the soil design characteristics have been ascertained by field observation, boring, sampling, and analysis as specified in NAVDOCKS DM-7. The data thus obtained are considered in conjunction with the type of supporting structure and the stresses resulting from such factors as wind and ice loading, temperature changes and other weather conditions that affect structural stability.

7.3 CONCRETE CONSTRUCTION

The concrete work for antenna structure foundations is usually done by a contractor in conformance with NAVFAC Specification 13Y — "Concrete Construction, " or in accordance with other standards designated by NAVFAC.

7.3.1 Concrete Tests

If the local cement, aggregate, or concrete is of unknown quality, sample test cylinders of the mix are required before construction commences. In most cases, field testing of the concrete mix is not practical, and the services of a laboratory will be needed. Where concrete tests are necessary, they should be conducted in accordance with the American Society for Testing Materials (ASTM), specifications No. C31 and C39, or with other specifications furnished by NAVFAC.

When construction is started, slump tests of the concrete are required to ensure correct consistency (the ratio of water to cement) of the mix as it is being placed. The correct amount of water is determined at the time of mixing according to the weight of the portland cement. As water is added, the slump increases and the mix will pour more easily; however, the ultimate strength of concrete is decreased if more than the correct proportion is used. Frequent slump measurements aid in achieving a consistent quality of concrete and provide a means of eliminating inferior quality mixes. Many of the companies who supply pre-mixed concrete use a form of quality certification which is intended to serve as a guarantee of each delivery of pre-mixed concrete. The acceptability of such certifications should be checked with the nearest NAVFAC field activity or with a local government office. An acceptable certification can eliminate or reduce the need for on-site testing, thereby expediting construction progress.

7.3.2 Concrete Forming

The elevation of antenna foundations is particularly important in the construction and installation of HF antennas that have multiple supports separated by considerable distances. Tower and foundation specifications usually provide for a maximum tolerance of ±1/2-inch if adjustment may be made by grouting.

The following general procedures should be followed to assure correct forming of concrete structure foundations and anchors:

a. Tie Wires. Where reinforcing steel is to be placed in the forms, use tie wires to hold the reinforcements and forms in position.

b. Anchor Positioning. Position the forms and pour concrete anchors so that the front face of the anchor will be poured against undisturbed earth if possible. Anchor shafts are to be positioned directly in line with the tower at the specified design angle.

c. Attachment Points. Eye bolts or similar hardware to aid in rigging, tower erection and maintenance should be placed in the concrete form by setting them in a template that will ensure correct position and alignment.

d. Placing Concrete. Place the concrete as near as possible to its final position. It should be distributed in layers and worked into place by spading or vibrating to eliminate voids and stone pockets. Ensure that all reinforcing steel is well embedded in the concrete, and bring only enough fine mix to the surface to produce the finish desired.

e. Filling Voids. After the forms have been stripped from the formed concrete, fill all voids and tie wire break pockets with cement mortar.

f. Backfill. Backfill materials are selected and placed in accordance with specifications provided by NAVFAC. Place backfill around completed foundations and anchors in well tamped layers. Avoid using rocks, muck, sod, and light-weight materials. After backfilling, grade the area to prevent erosion and to eliminate water collection spots.

7.4 ANTENNA TOWERS

Towers are usually provided and installed by the antenna manufacturer, or by a contractor experienced in structural rigging. The task of assembling, erecting, and guying steel towers should not be undertaken by inexperienced personnel.

To facilitate expeditious procurement of standard, commercially manufactured steel radio towers of 300 feet or less in height, towers that meet the specification and design requirements of Electronic Industries Association (EIA) Standard RS-222 may be used. NAVFAC must be consulted, on an individual project basis, for installation criteria on towers over 300 feet high. Also, NAVFAC should be consulted for adequate tower and foundation design criteria, and for review of other heights of towers and antenna types. Steel materials used in towers must conform to the requirements in NAVFAC DM-2 or as further defined by NAVFAC.

7.4.1 Guyed Towers

The most commonly used guyed towers are fabricated from steel in untapered sections 10 to 20 feet long. These constant dimension sections are erected one above the other to form the desired height. Structural stability for this type of tower is provided by attaching guywires from the tower to ground anchors.

Base supports for guyed towers vary according to the type of tower to be installed. Three commonly used base-types are the tapered tower base, the pivoted tower base, and the composite base. All three are shown in figure 7-1. A tapered tower base concentrates the load from multiple tower legs to a small area on the foundation. The pivoted base is used primarily on lightweight structures for ease of tower erection. A composite base is generally used with heavier towers since it affords much more supporting strength than the other two types.

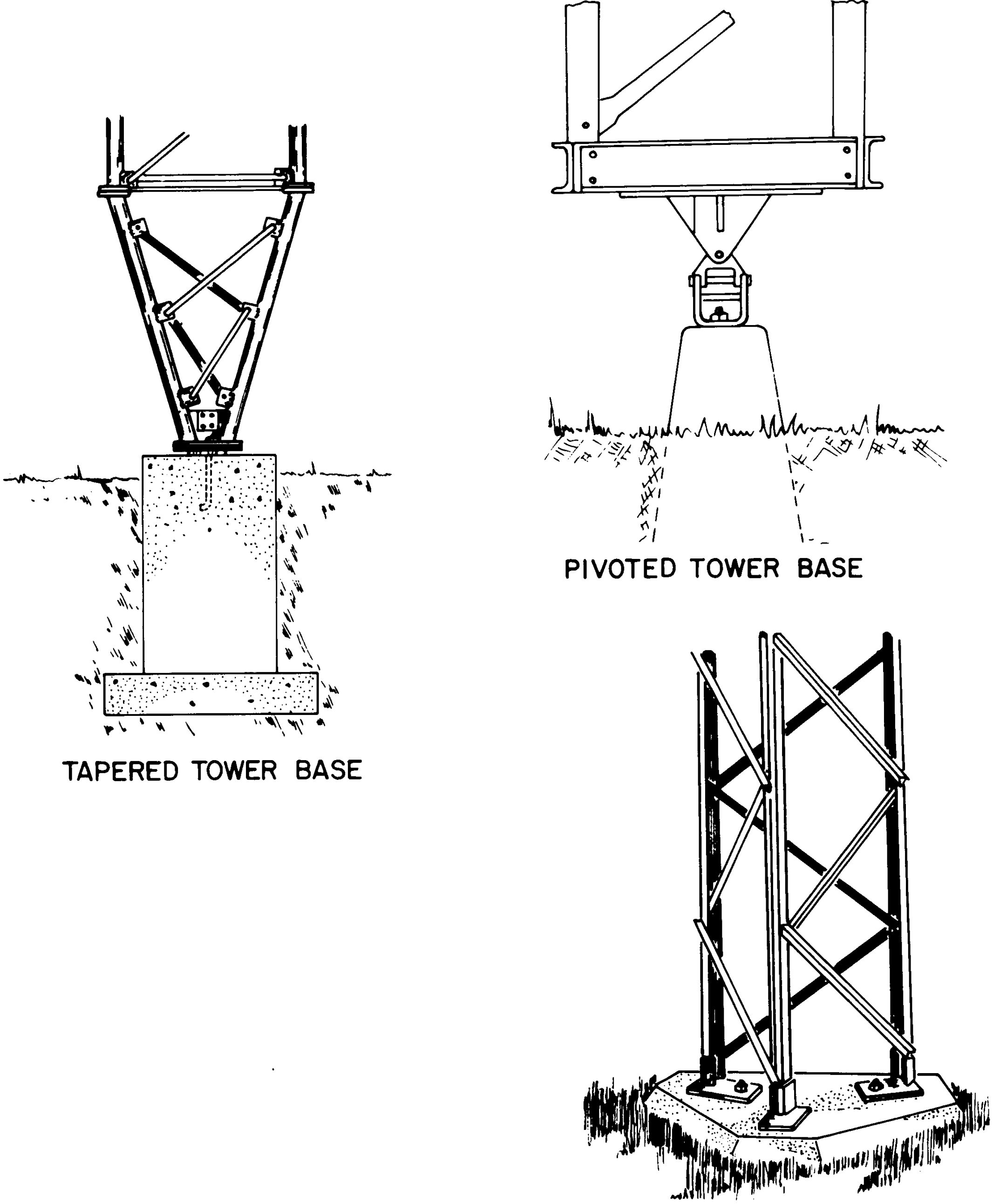


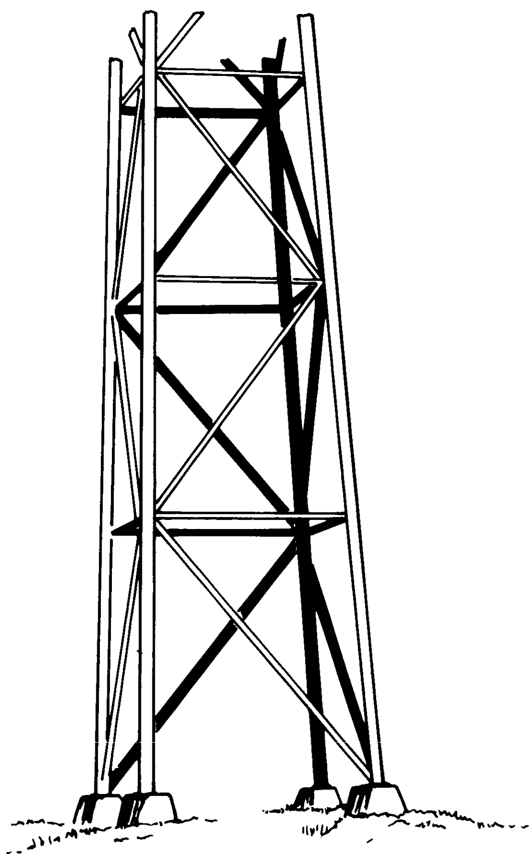
Figure 7-1. Base Supports for Guyed Towers

Sections for lightweight towers are usually preassembled prior to delivery in order to expedite final tower assembly whereas heavier weight towers must be assembled completely in the field.

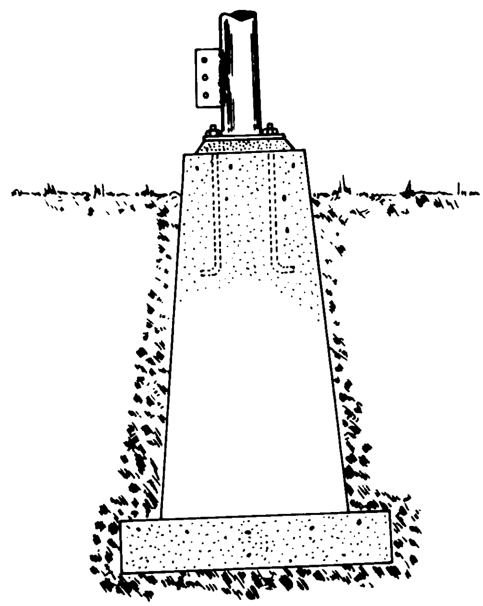
Tower bracing should include diagonal bracing and horizontal struts in the plane of each tower face, for the full tower height. Procedures to be followed and engineering requirements for effective bracing are contained in NAVFAC DM-2.

7.4.2 Freestanding Towers

Freestanding, or self-supporting, steel antenna towers are characterized by heavier construction than guyed towers and by a shape that tapers in toward the top from a wide base. Freestanding towers exert much greater weight-bearing pressure on foundations than most guyed towers; consequently, deeper foundations are required (because of the greater size, weight, and spread of tower legs) to provide sufficient resistance to uplift. Each leg of a freestanding tower must be supported by an individual foundation. Figure 7-2 shows a typical individual foundation for a freestanding tower and figure 7-3 illustrates a foundation plan for a triangular steel freestanding tower. Bracing and material specifications for these towers are the same as for guyed towers.



SQUARE SELF-SUPPORTING TOWER



SELF-SUPPORTING TOWER BASE

Figure 7-2. Square Self-Supporting Tower and Base

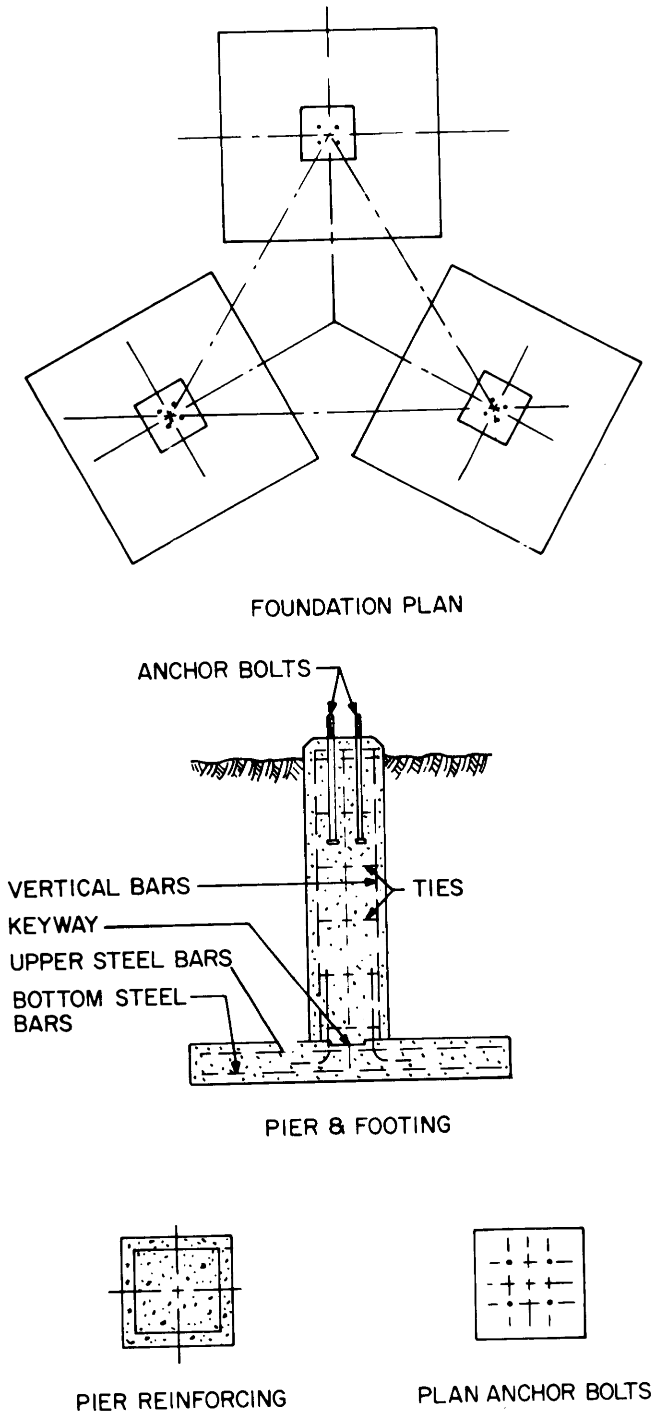


Figure 7-3. Triangular Tower Foundation

7.4.3 Tower Assembly

Advance planning for tower assembly and erection is essential to completion of the project safely and correctly. Both the installation plan and the manufacturer's instructions should be studied to gain a complete understanding of the tower assembly and erection methods to be employed. The following general procedures and practices should be observed for the assembly and erection of towers:

a. Ground Assembly. Assemble the tower sections on well-leveled supports in order to avoid building in twists or other deviations. Any such deviations in one section will be magnified by the number of sections in the complete assembly.

b. General Preservation. Check all surface areas for proper preservation. Cover all holes and dents in galvanized materials with zinc chromate or other acceptable preservatives to prevent deterioration.

c. Bolts and Hardware. If any bolts or other hardware must be provided from on-site material ensure that they meet the specifications of NAVFAC DM-2.

d. Tightening Bolts. When high-strength bolts are used in tower assembly, place a hardened steel washer under the nut or bolt head, whichever is to be turned. Care must be exercised not to exceed the maximum torque limit of the bolt. Maximum torque values of several different sizes and types of bolts commonly used in antenna towers are listed in table 7-1.

Table 7-1. Bolt Torques (Foot Pounds)

Size	Mild Steel	High-Strength Steel	Aluminum 24 ST-4	Stainless Steel 18-8
3/8" - 16----	17	----	12	30
1/2" - 13----	38	105	26	43
5/8" - 11----	84	205	60	92
3/4" - 10----	105	370	82	128
7/8" - 9-----	160	530	184	194
1" - 8-----	236	850	---	---
1-1/8"-7-----	340	1100	---	---
1-1/4"-7-----	432	1800	---	---

7.4.4 Erection of Guyed Towers

The safety precautions for steel erection set forth in NAVSO P-2455, "Safety Precautions for Shore Activities," are to be observed at all times during the erection of antenna towers. The following paragraphs of this section present methods that have been successfully used to erect guyed towers. The most practical method for any particular tower will be determined by the size, weight, and construction characteristics of the tower and by the hoisting equipment available.

a. Davit Method. Lightweight guyed towers are frequently erected with a davit hoist which is anchored to the previously erected section, providing a pivoted hoisting arm. The davit arm is swung away from the tower in hoisting the added section, and swung centrally over the tower in depositing the section prior to bolting up the splice plates. Figure 7-4 shows a ground assembled unit being hoisted for connection to a previously erected tower section. A snatch block secured to the tower base transmits the hoisting line to a source of power or hand winch. A tag line secured to the base of the section being hoisted avoids possible contact with the erected portion of the tower.

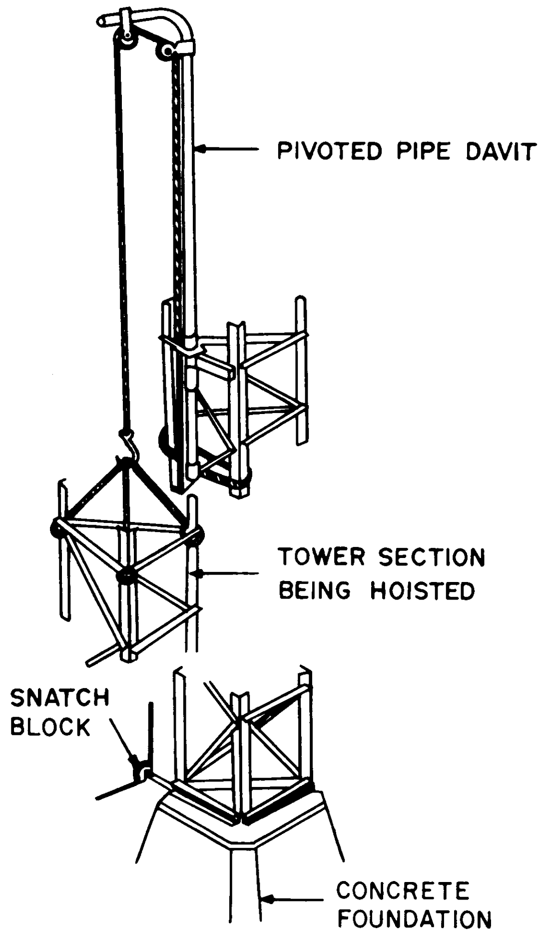


Figure 7-4. Typical Davit Installation

b. Gin Pole Method. Light triangular guyed towers furnished with a pivoted base may be completely assembled on the ground and then raised to a vertical position with the aid of a gin pole. Figure 7-5 illustrates the lower section of a tower which has an attached pivoted base in a horizontal position preparatory to hoisting. The thrust sling shown counteracts the thrust on the base foundation from hoisting operations. Rigging operations and location of personnel essential to the raising of a pivoted base tower are detailed in Figures 7-6 and 7-7. Light towers in lengths of approximately 80 feet may be raised with a single attachment of the winch line. However, longer towers frequently are too flexible for a single attachment, and, in this case, a hoisting sling furnished with a snatch block allows for two points of attachment. The gin pole is mounted close to a concrete tower base and is provided with a top sheave to take the winch line. Permanent guys attached to the tower at three elevations are handled by personnel during hoisting operations as shown in figure 7-6. Temporary rope guys provided with snatch blocks anchored to dead men furnish the necessary lateral stability. As the mast approaches a vertical position the permanent guys are fastened to the guy anchors installed prior to erection.

c. Auxiliary Mast Method. Guyed towers of heavier construction require erection equipment of greater rigidity than the light davit previously described. A mast or gin

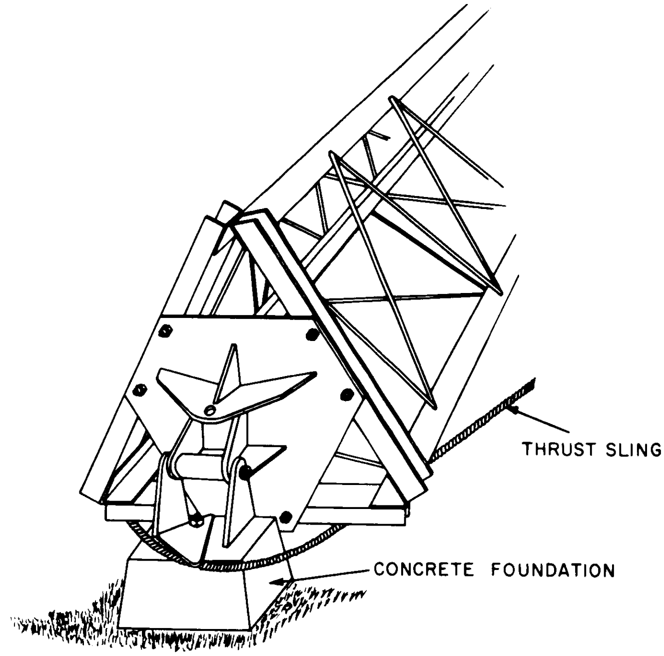


Figure 7-5. Pivoted Tower Hoisting Preparation

pole furnished with a swiveled "T" head is shown in figure 7-8. At the top of the mast and at right angles to it, is a revolving pin-supported head with the hoist line running over two separated sheaves. Tower sections are completely bolted on the ground, hoisted by the rig to the right elevation, kept away from the completed structure by means of a tag line, and then swung into place. After each new section is securely bolted, the mast is relocated and the process repeated until the full height is reached.

d. Hand Assembly. Erection without a davit or gin pole may be accomplished by assembly of individual members piece by piece as the tower is erected. The assembler climbs inside the tower and works with the lower half of his body inside the previously assembled construction. He then builds the web of the tower section around him as he progresses upward. As each member is bolted in place the assembler should tighten all connections immediately so that at no time is he standing on or being supported by any loose member.

Frequently, temporary guying is required in the erection of guyed towers. Such guying is often necessary where several sections are erected before the elevation of the permanent guy level is reached. Requirements for temporary and permanent guying are presented in paragraph 7.6.

7.4.5 Erection of Self-Supporting (Freestanding) Towers

Erection of self-supporting towers is most effectively accomplished with a mobile crane if the height of the tower is within the height range of the crane. For high towers, the lower portion may be erected with a crane and the upper section handled with the basket boom rig illustrated in figure 7-9. The pole for the basket boom is supported at the top and bottom by guys attached to the column struts by reeved blocks. This is a flexible

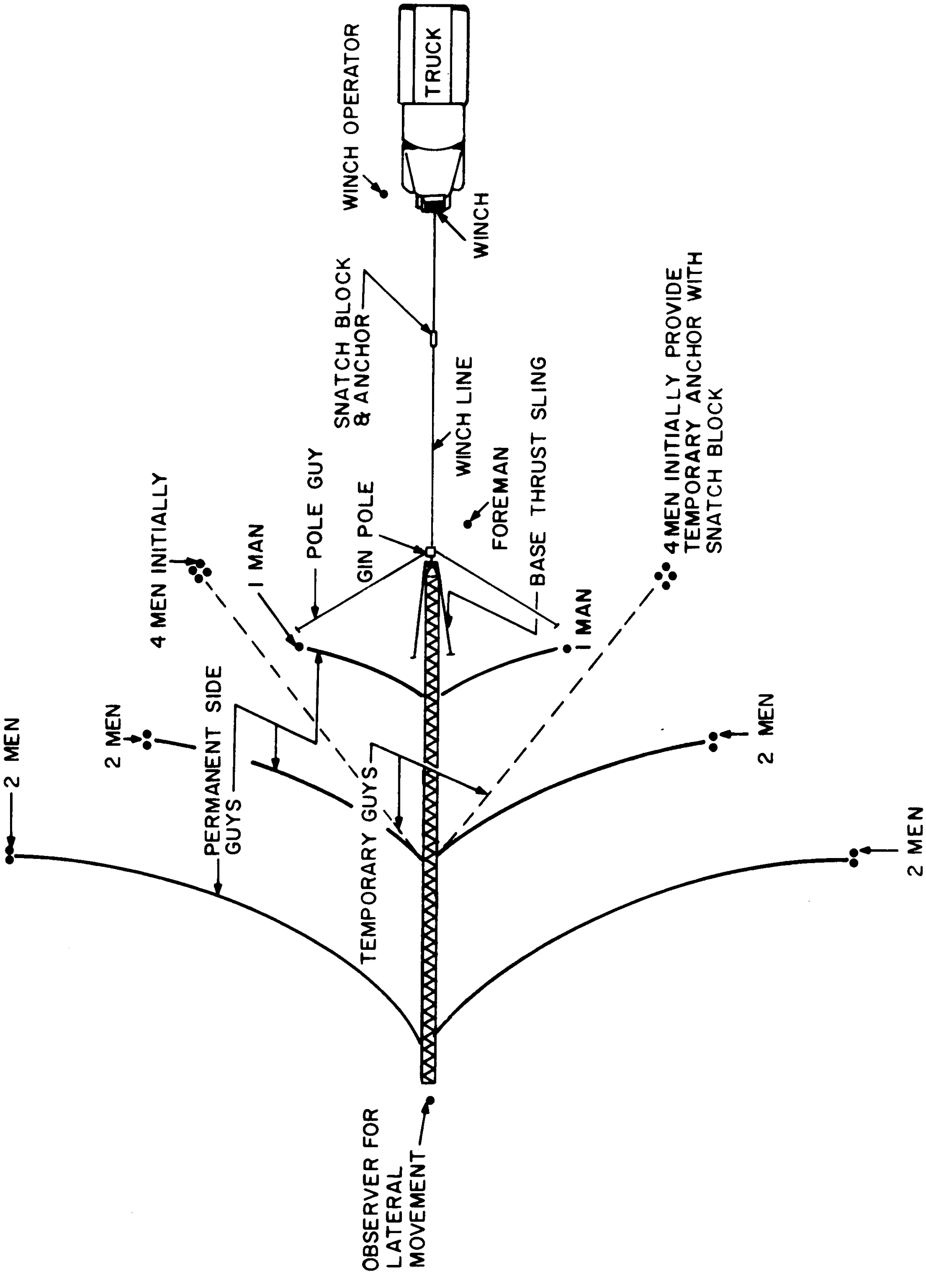


Figure 7-6. Erection Plan for Pivoted Tower

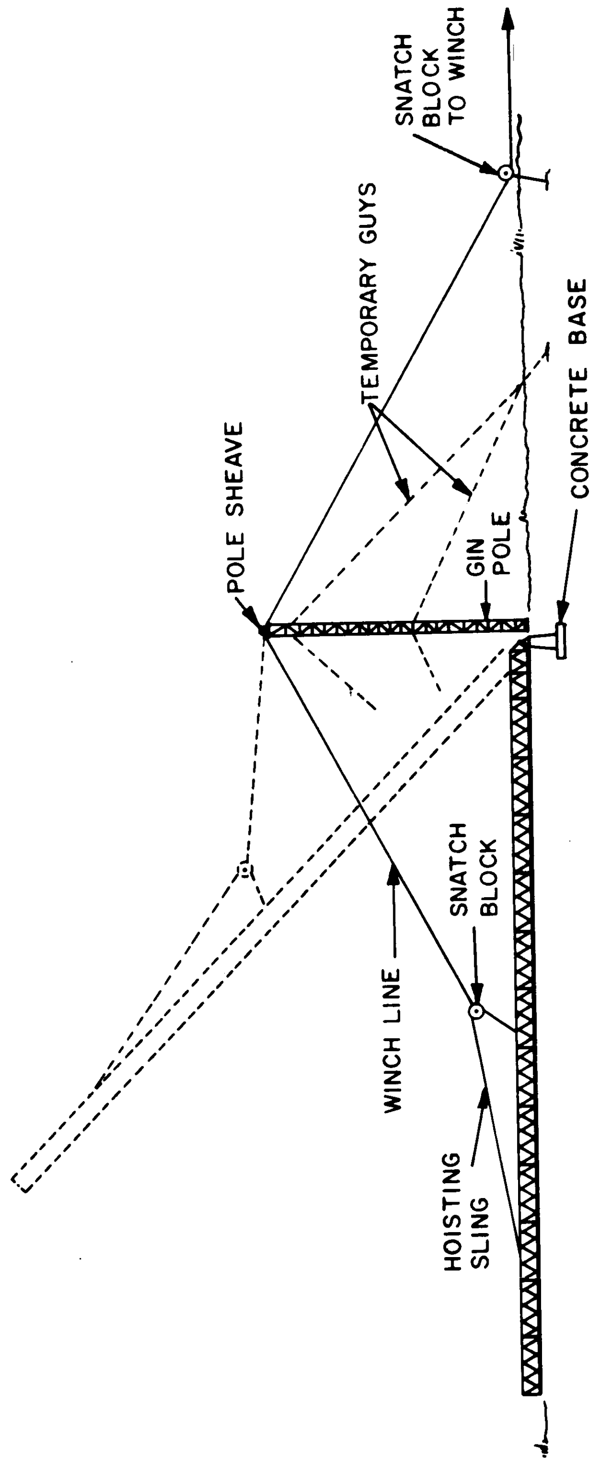


Figure 7-7. Erection of Pivoted Guyed Tower

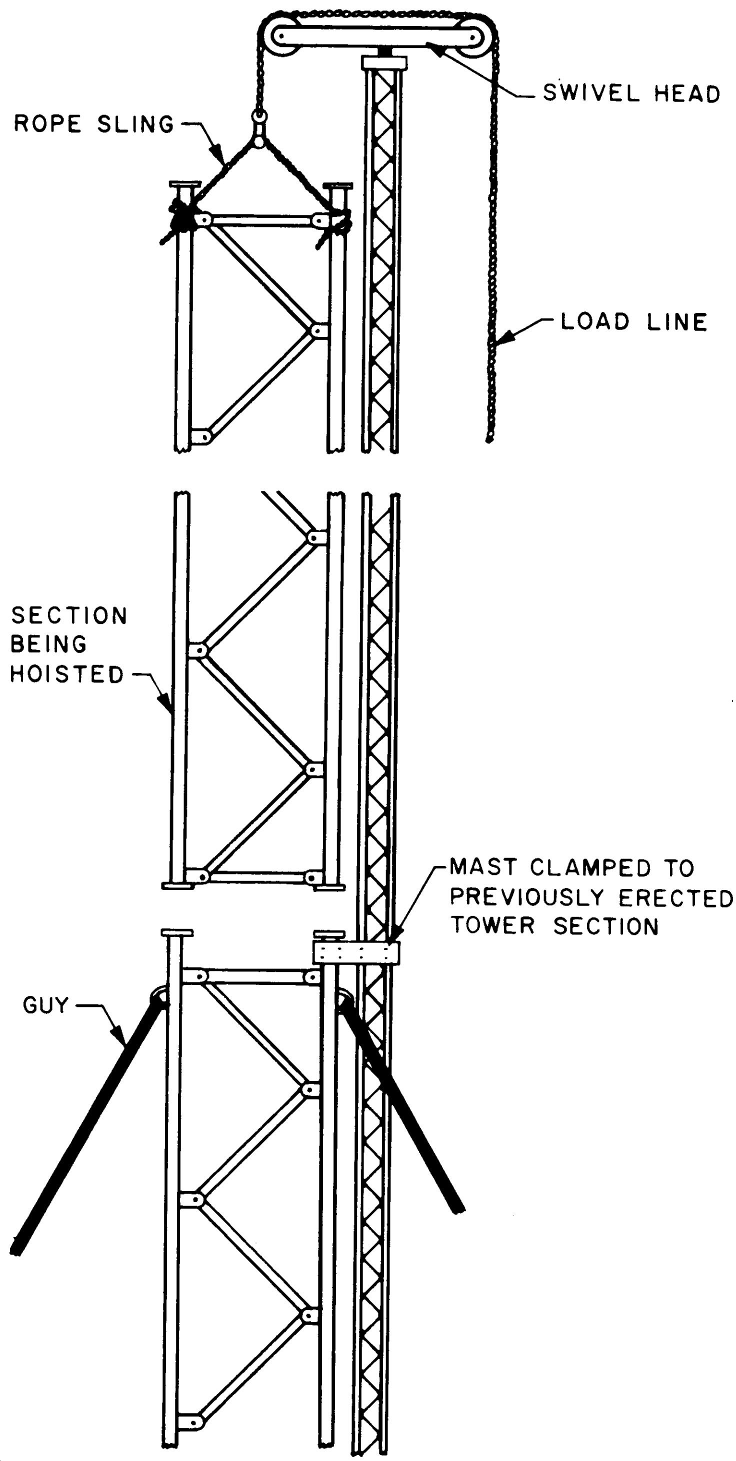


Figure 7-8. Tower Erection with Auxiliary Mast

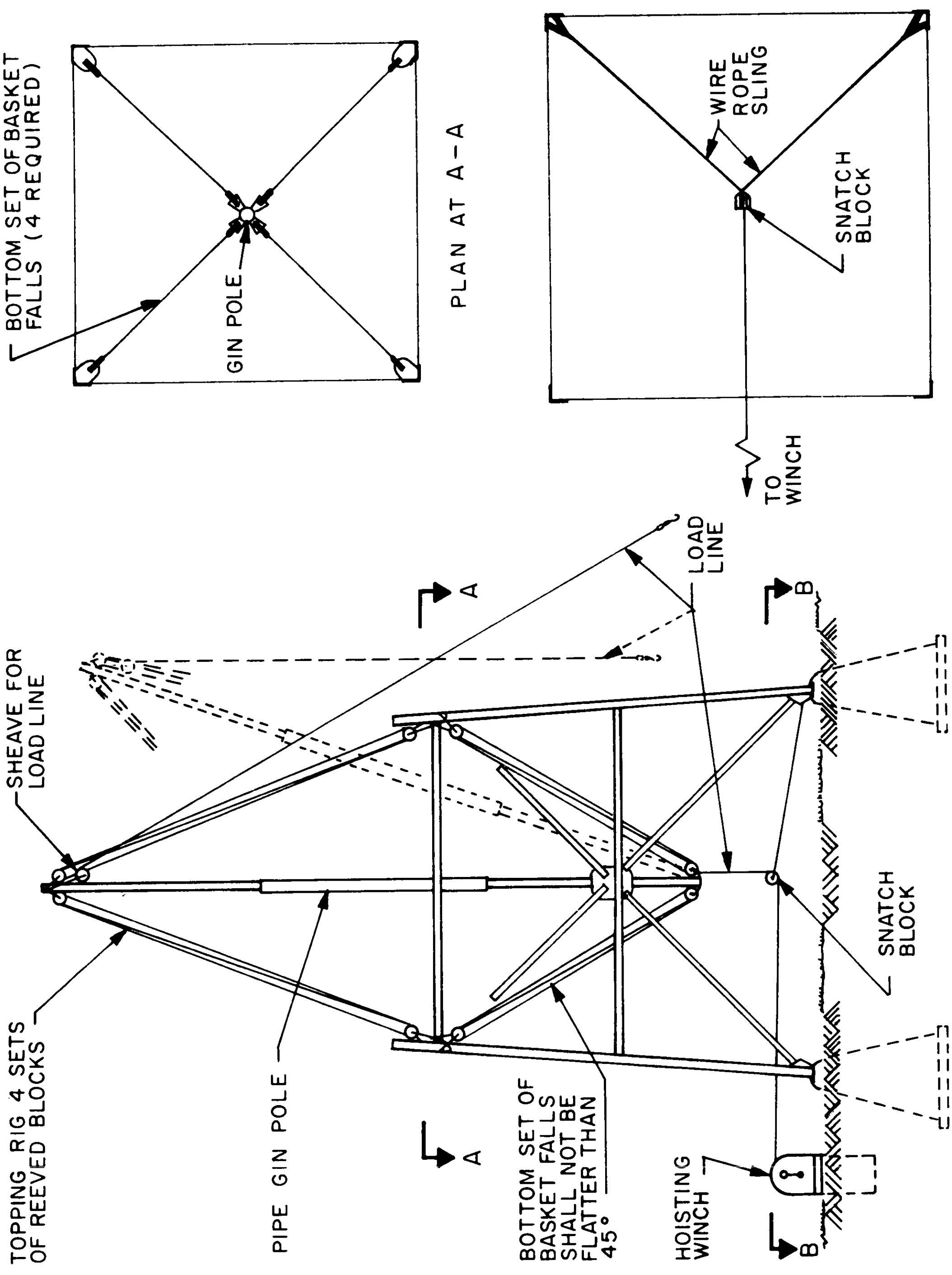


Figure 7-9. Basket Boom for Erecting Self-Supporting Towers

arrangement which facilitates erection by allowing the pole to be moved quickly to any work location. Where cross obstructions hinder hoisting, the pole can be placed at an angle to raise material outside the structure. When erection of the structure has reached a height at which the gin pole is no longer useful, the pole must be lifted to a new position at a higher level.

7.5 WOOD ANTENNA POLES

Wood poles used as HF antenna supports will vary in size according to the characteristics of the antenna; e.g., antenna height above ground and length, size, and weight of the antenna wire. The selection of wood poles for antenna supports is based on species, length and class of pole, and type of wood treatment. Poles selected are cut and prepared under the specifications of the American Standards Association (ASA), and are treated in accordance with the specifications of the American Wood Preserving Association Standards (AWPA). Where special requirements are anticipated, or when there is a conflict between specifications and requirements, NAVFAC must be consulted.

7.5.1 Wood Pole Characteristics

Wood antenna poles are characterized by classes ranging from 1, which has the greatest transverse breaking stress, to 10 which has the lowest. Typical pole sizes and breaking loads for the classes acceptable for antenna uses are given in table 7-2.

Table 7-2. Transverse Breaking Loads Of Poles

Class	Transverse Breaking Load (Pounds)	Typical Minimum Dimensions for Southern Pine Creosoted Poles, Top Circumference (Inches)
1	4700	27
2	3700	25
3	3000	23
4	2400	21
5	1900	19

All wood poles used as antenna supports are required to meet the following requirements:

a. Standard Poles. Poles must be either Douglas Fir or Southern Pine and are to conform to ASA specification 0.51.

b. Roof. Poles must be cut at the top to form a one-way roof with a 15° slope.

c. Steps. Standard hook pole steps, 5/8-inch in diameter and 10 inches long are required. Hook steps should be installed so that the first step is approximately 3 feet above ground, and all others are 18 inches above each other. The steps are placed alternately on opposite sides of the pole.

d. Preservative Treatment. Poles must be treated to prevent decay and insect damage. Treatment consists of the Full Cell Pressure Process in accordance with AWPA Standards C1 and C4. The preservative to be used is a solution of creosote and coal tar. The creosote must meet the requirements of AWPA Standard P13. The creosote-coal tar solution must meet the requirements of AWPA Standard P12.

e. Final Retention. Final retention of the preservative must be at least 16 pounds per cubic foot for Douglas Fir, and 20 pounds per cubic foot for Southern Pine.

7.5.2 Preparation for Erecting Wood Poles

A truck-mounted power-driven auger may be used to dig the holes for wood antenna poles. The hole must be large enough to admit the pole freely and to permit the use of tampers when backfilling. The hole depth required to provide adequate strength for a pole is determined by total length of the pole, height of the pole above ground, and the soil conditions. A tabulation of hole depths required for average soil conditions is given in table 7-3. If soil conditions are such that the hole may cave in, shoring should be forced into the hole as the soil is removed. A barrel with the heads removed is a practical device to use for shoring.

All preliminary pole work such as drilling, roofing, and gaining is to be accomplished on the ground before the pole is erected and set in place.

Antenna pole erection is accomplished most practically by using a power-driven winch or derrick. In most cases, this equipment is truck-mounted, as is the auger used in drilling the hole. The actual technique to be used in raising the pole to the setting-in position with this power equipment depends upon the size and weight of the pole. The

Table 7-3. Pole Depth Setting Data (Feet)

Total Length	Height Above Ground	Depth Set
20	15.5	4.5
25	20	5
30	24	6
35	29	6
40	33.5	6.5
45	38	7
50	42.5	7.5
55	47.5	7.5
60	52	8
65	56.5	8.5
70	61	9
75	65.5	9.5
80	70	10
85	74.5	10.5
90	79	11
95	83.5	11.5
100	88	12
110	97	13

following methods of pole erection are commonly applied. Use the method that is best suited in consideration of pole size and weight, type of power equipment, and the number of personnel available.

a. Truck Derrick Method. One of the most satisfactory methods of erecting and setting a pole is with the use of a truck-mounted pole derrick. The truck is moved into position with the derrick centered over the hole; then the derrick supports are put into place. The winch line is fastened just above the balance point of the pole and the pole is slowly raised as shown in figure 7-10. The butt is then guided until it is centered over the hole. The pole should be raised until the winch hook is less than 1 foot from the sheave at the end of the derrick. If the pole is so tall that it cannot be raised sufficiently by the derrick, the truck should be moved slightly away from the hole and the butt of the pole should be set in the hole at an angle. Then the truck can be moved slowly back to its original position, and the pole can be lowered into place. Plumbing, backfilling, and tamping complete the job.

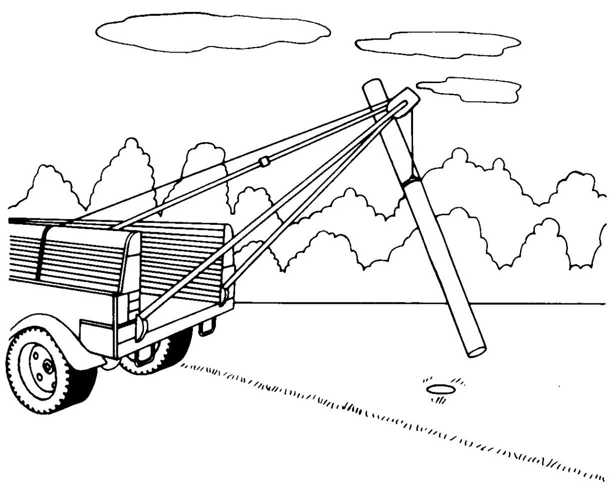


Figure 7-10. Pole Erection with a Truck Derrick

b. Gin Pole Method. The gin pole is an improvised derrick somewhat longer than half the length of the pole to be set. The gin pole is erected, as shown in figure 7-11, as close as possible to the hole in which the pole is to be set. The gin pole is guyed in four directions, pulley blocks are attached, and the pole is raised as in the pole derrick method. The butt is then guided into the hole, and the pole is set and plumbed. Backfilling and tamping can then be completed.

c. A-Frame Method. Figure 7-12 illustrates the use of an A-frame with a power winch for pole erection. The A-frame is constructed of two short poles or timbers that are bolted or lashed together. A power winch on a truck is used as the pulling force for pole erection. The purpose of the A-frame is to change the direction of the pulling force that is exerted on the pole during the initial raising. When this method is used, an inclined trench is dug into the pole hole, and a butting board is placed vertically in the hole. The pole is laid in the trench and the butt is pushed against the board. The necessary lines are rigged, including a line to a power winch on the truck, and the pole is raised by means of the winch. As the pole is raised, the guy lines are used to keep the pole steady. The A-frame is removed when the pole has been raised sufficiently so that the

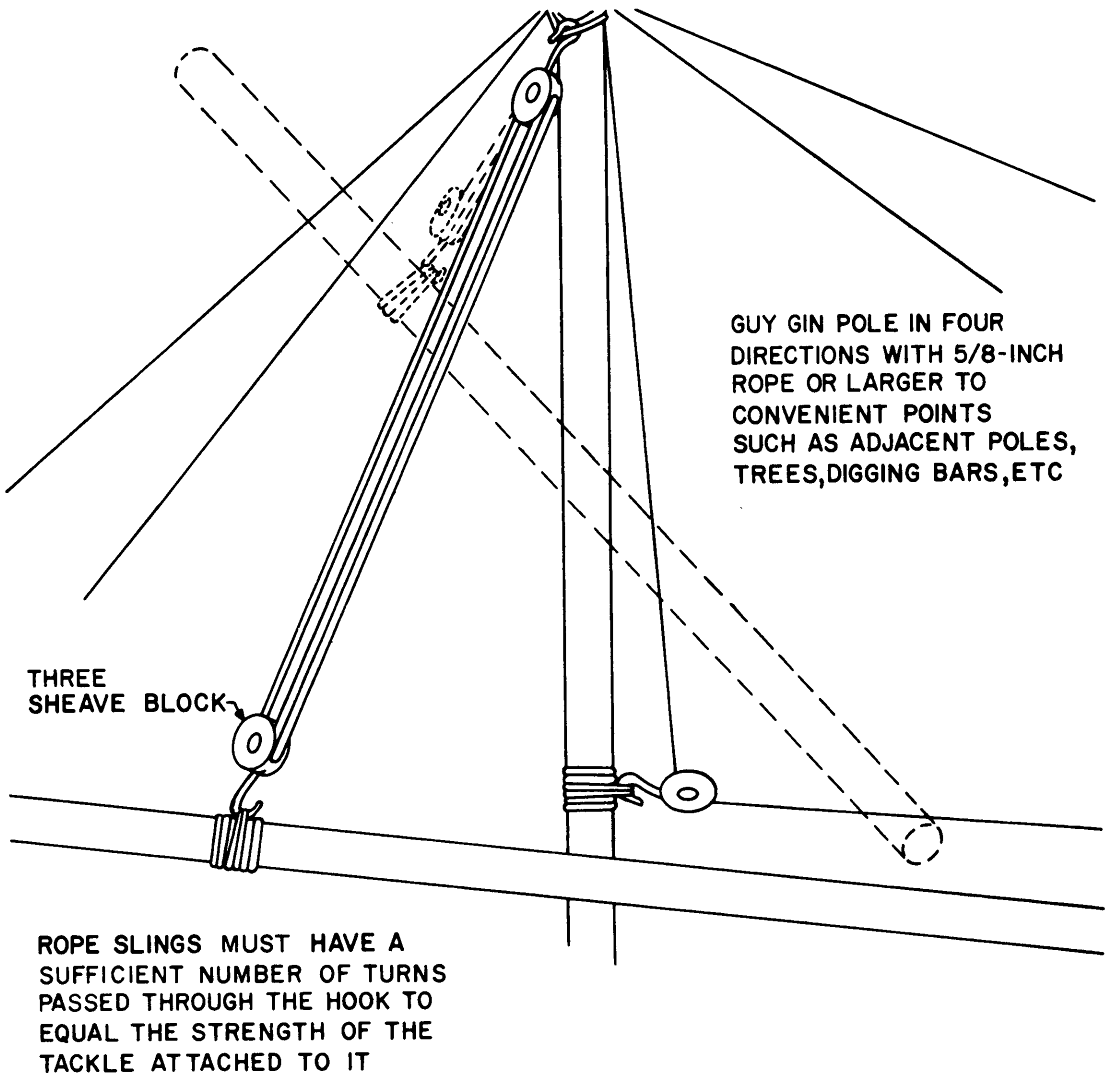


Figure 7-11. Pole Erection with a Gin Pole

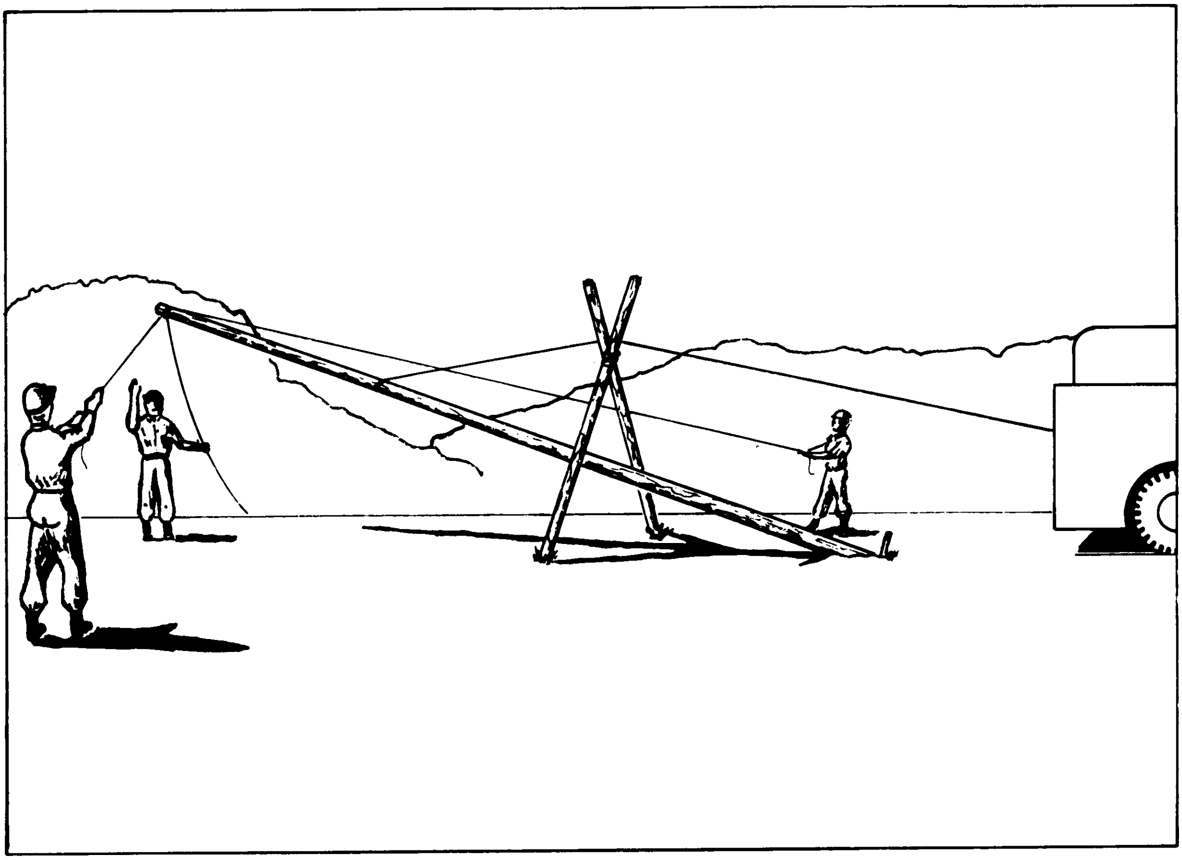


Figure 7-12. Pole Erection with an A-Frame

pulling line no longer touches it. The rear guy line is used to prevent the pole from falling in the direction of the truck as the pole is raised further to a vertical position. The butting board can then be removed and the pole can be plumbed. Backfilling and tamping complete the installation.

7.6 GUYING

Guying steel towers and wood antenna poles is done in two phases: temporary guying during the erection of the tower or pole, and permanent guying in conjunction with plumbing the structure.

Wood poles that are erected and set to their specified depth are reasonably self-supporting under normal wind conditions. However, high winds can move a pole from its vertical position. Therefore, wood antenna poles must be temporarily guyed during construction and installation, and then must be permanently guyed.

Temporary guying of steel towers is always necessary where more than one tower section is erected. Under no circumstances should the tower be advanced more than two sections without guying. Permanent guys are to be installed before the temporary ones are removed.

7.6.1 Guy Anchors

Guy anchors are selected by the antenna manufacturer or installing contractor in accordance with NAVDOCKS DM-7 and other specifications defined by NAVFAC. The antenna design and installation plans specify the anchor type, location, and hole depth required.

Anchor shafts, or rods, must project above grade sufficiently to keep all connecting guywire attachments free of vegetation and standing water. Shafts and connecting attachments should be thoroughly cleaned, and then coated with a petroleum preservative to retard effects of weather.

Soil conditions, anticipated wind and ice loading of the antenna, and the stresses placed on the guys by the wind loading and weight of the structure are determining factors in the selection of guy anchors. The following types of anchors are representative of those commonly used in antenna installations.

a. Screw Anchor. The screw anchor shown in figure 7-13 may be used for temporary guying and for anchoring guys for lightweight towers. This anchor is installed by screwing it into the ground in line with the direction the guy will take.

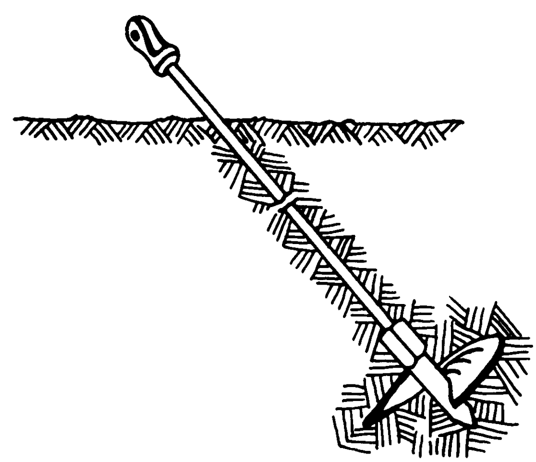


Figure 7-13. Typical Screw Anchor

b. Expansion Anchor. The expansion anchor shown in figure 7-14 is suitable for practically all guying applications where the soil is firm. This anchor is placed with its expanding plates in the closed position in an auger-drilled, inclined hole not less than 3 feet deep. The plates are expanded into the firm, undisturbed sides of the hole by striking the expanding bar at point B with a hammer and thereby forcing the sliding collar downward the distance D shown in figure 7-14. The anchor installation is completed by backfilling the hole with thoroughly tamped backfill.

c. Concrete Anchors. Poured-in-place concrete anchors are normally used for high stress applications, and where multiple guys are attached to a single anchorage.

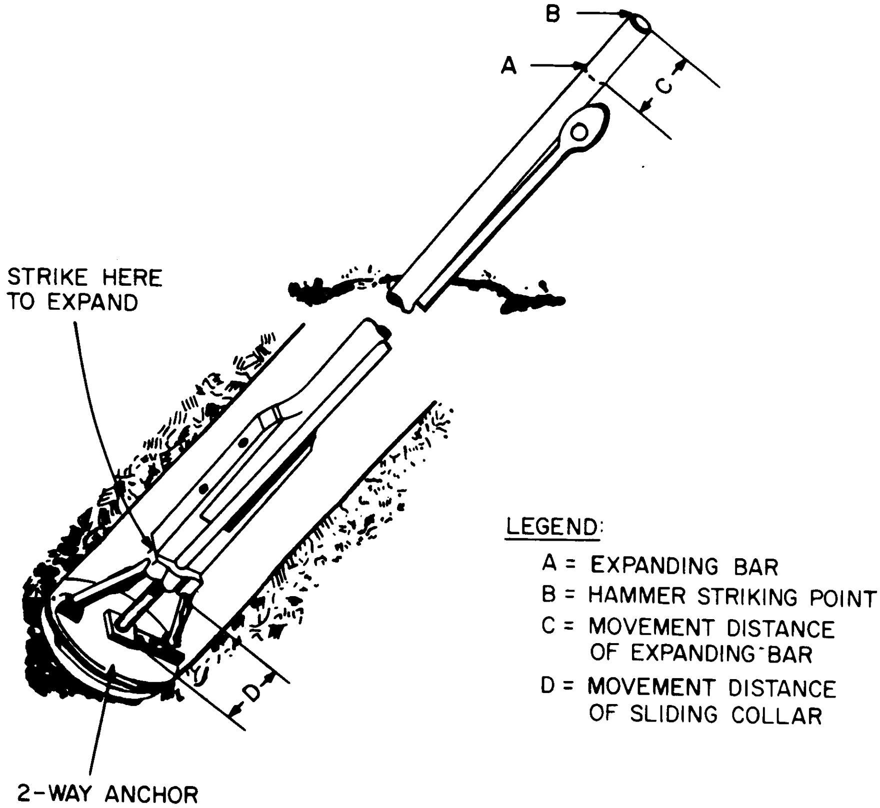


Figure 7-14. Expansion Anchor

7.6.2 Temporary Guying

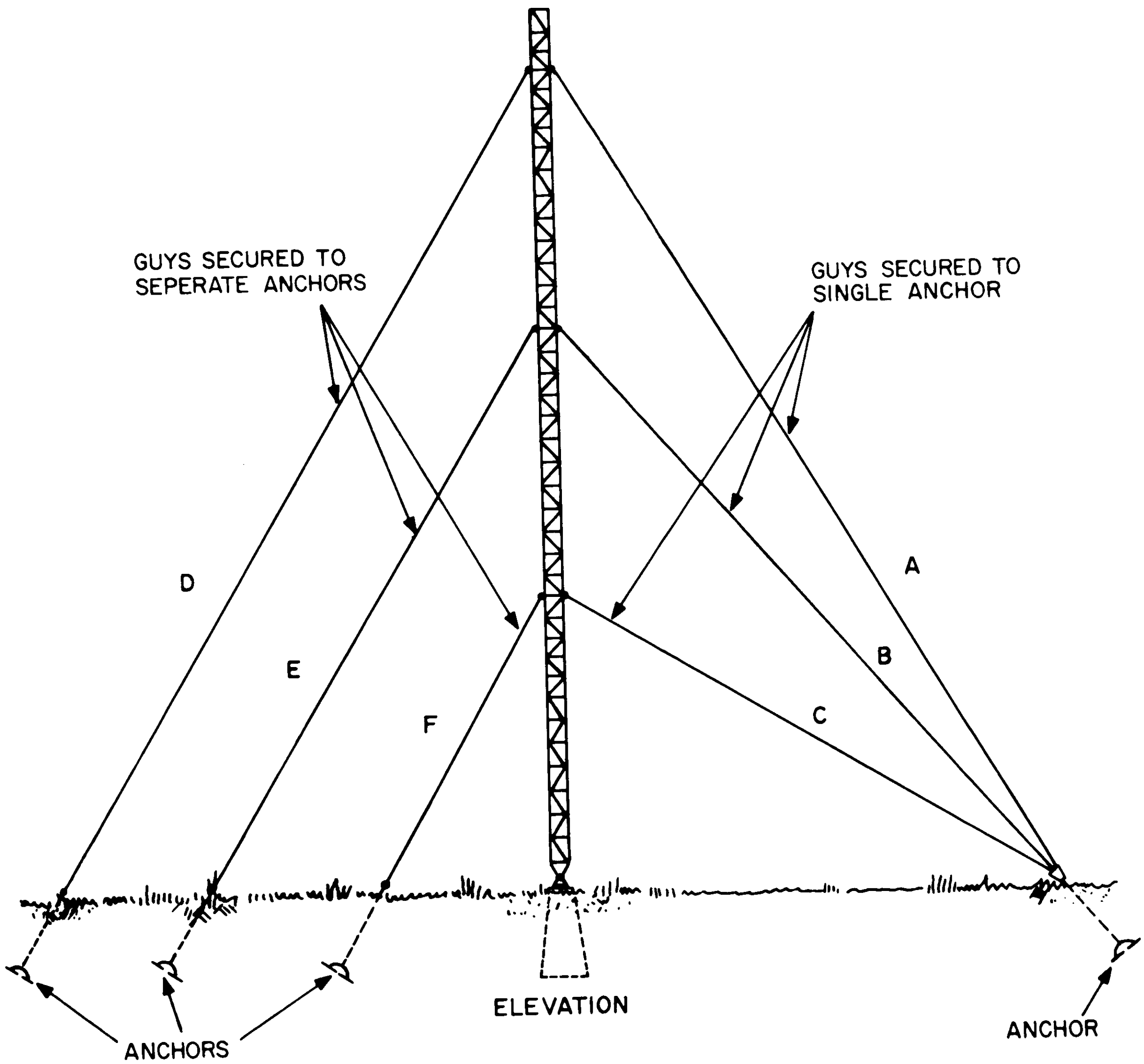
Several materials, including stranded wire, wire rope, and fiber rope are acceptable for temporary guying. New manila rope is the most suitable because of its strength and ease of handling. The size of guy material required is determined by the height and weight of the structure to be guyed and by weather conditions at the installation site.

Secure the temporary guys to the permanent guy anchors, to temporary-type anchors, or to any nearby structure that provides the required supporting strength. Leave the temporary guys in place until the structure is permanently guyed and plumbed.

7.6.3 Permanent Guying

Antenna structures are permanently guyed with steel cables or fiberglass guy sections to pre-positioned anchors in conformance with the installation plan.

Figure 7-15 illustrates two methods of guying triangular steel towers. Guys A, B, and C are secured to a single anchor, while guys D, E, and F are secured to individual anchors. Both arrangements are satisfactory; however, the anchor that terminates guys A, B, and C must be capable of withstanding much greater stresses than the



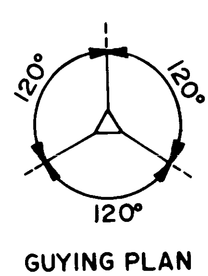


Figure 7-15. Tower Guying Arrangements

individual guy anchor arrangement. Triangular tower guys are arranged so that three guys are spaced 120° apart at each level of guying as shown in figure 7-15. Square towers require four guys spaced 90° apart at each guying level. The following general elevation requirements apply to guy attachments for towers.

a. Single-Guy Layer. The cable attachments are placed in position at approximately two-thirds the tower height.

b. Two-Guy Layers. For towers with two-guy layers, cable attachments are placed in positions at approximately 30 and 80 percent of the tower height.

c. Three-Guy Layers. For towers with three-guy layers, cable attachments are placed in positions at approximately 25, 55, and 85 percent of the tower height.

Permanent guying of wood poles that are set to the required depth in firm soil is done primarily to counteract stresses (as opposed to towers, where guys are used to provide vertical support). Locate wood pole guys 120° apart at each level of guying as specified in the installation plan, and as determined by pole height and anticipated stresses. Position guys on the pole so that a 45° angle is formed from the pole attachment point to the anchor.

7.6.4 Tower Guy Tension

Setting guy tension and plumbing a tower is done at the same time and only when wind forces are light. Guy tension adjustment and tower plumbing is done as follows:

a. Initial Tension. All guys should be adjusted gradually to the approximate tensions specified in the antenna installation details. If tensions are not specified, guy tension should be adjusted to 10 percent of the guystrand breaking strength as tabulated in table 7-4. (If fiberglass guys are installed, tensions must be set strictly in accordance with the manufacturer's specifications.) The tension on all guys is adjusted while ensuring that the tower is in a stable, vertical position.

b. Final Guy Tension. In one procedure used for final tensioning of tower guys the final tension is measured with a dynamometer as shown in figure 7-16. Carpenter stoppers or cable grips of the proper size designed for the lay of the wire must be selected for use in the tensioning operation. Any cable grip assembly which grips the wire by biting into the cable with gripping teeth could penetrate and damage the protective coating of guy cables and should not be used. In step A of figure 7-16, the coffing hoist is shown in series with a dynamometer to measure the tension. A turnbuckle is shown in position to receive the guy tail. In step B, an additional cable grip and hoist or tackle is attached above the cable grip shown in step A. The lower end of this tackle is provided with a second cable grip which is attached to the guy tail previously threaded through the turnbuckle. The second coffing hoist is operated until sufficient tension is applied to cause the reading on the series dynamometer to fall off. Step C shows the guy in final position, secured in place with clamps. With the tower properly plumbed to a vertical position, only one guy at a given level need be tested with the dynamometer.

On some installations, other procedures for tensioning guys may be necessary because of the type of guys and hardware supplied with the antenna. For example, preformed wire helical guy grips are sometimes used for attaching guywires to the adjusting turnbuckles. In such cases, the techniques used for guy assembly, connection of guywire to

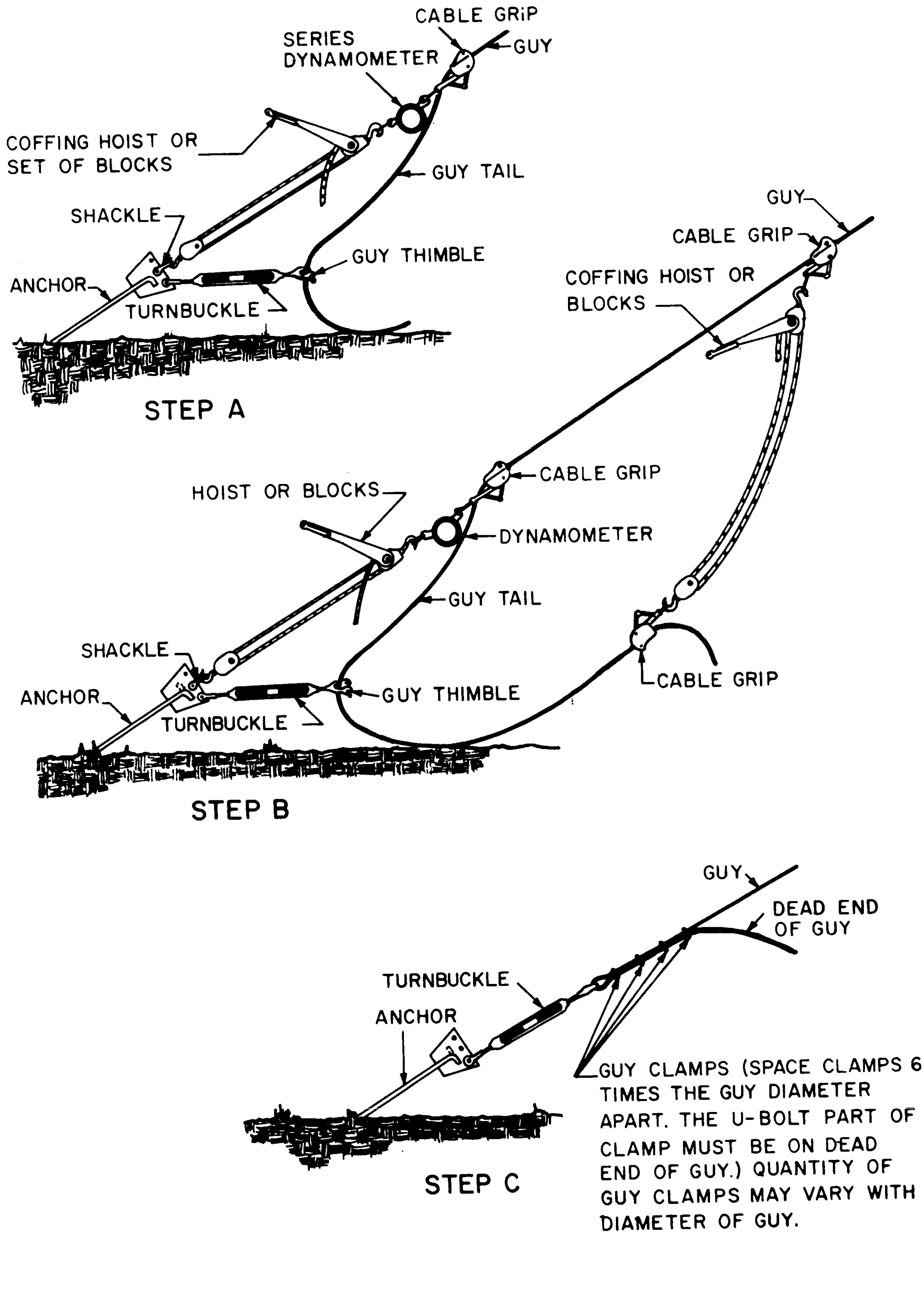


Figure 7-16. Final Tensioning of Guys

Table 7-4. Minimum Breaking Strength (Pounds) of Guystrand

Material	Diameter (Inches)	Wires	Utilities Grade	High Strength	Extra High Strength	Aluminum-Clad Steel Wire Copper-Clad Steel Wire
Steel	0.250	3	3, 150			
Do	0.250	7		4, 750	6, 650	
Do	0.3125	3	6, 500			
Do	0.3125	7		8, 000	11, 200	
Do	0.375	3	8, 500			
Do	0.375	7	11, 500	10, 800	15, 400	
Do	0.500	7	25, 000	18, 800	26, 900	
Do	0.500	19		19, 100	26, 700	
Do	0.625	19		28, 100	40, 200	
Do	0.750	19		40, 800	58, 300	
Aluminum-Clad Steel Wire	0.247	3#9				5, 715
Do	0.349	3#6				10, 280
Do	0.385	7#8				15, 930
Do	0.486	7#6				22, 730
Do	0.546	7#5				27, 030
Do	0.509	19#10				27, 190
Copper-Clad Steel Wire	0.237	7 x 0.079				6, 000
Do	0.360	7 x 0.120				14, 000
Do	0.432	7 x 0.144				20, 000

the anchor, and tension adjustments, must be determined from the detailed installation plan or the appropriate antenna technical manual.

Guys should be checked at least once annually to ensure structural stability, and they should be retensioned whenever the guy cable tension is found to be outside the limits specified in the appropriate technical manual or installation drawings.

c. Plumb Requirements. Antenna towers should be plumbed in accordance with Section 5 of the American Institute of Steel Construction (AISC) Standard Practice (5-149), which is quoted as follows:

> In the erection of structural steel for structures other than bridges and multi-story tier buildings, the individual pieces are considered plumb, level, and aligned if the error does not exceed 1.500 inches.

7.7 ANTENNA ASSEMBLY

HF antennas are assembled in accordance with the manufacturer's detailed plans and drawings, or as specified in NAVELEX standard plans (such as NAVELEX Drawing RW 66D295 for rhombic antennas). A bill of material included in the plans lists structural materials, antenna materials, hardware, and tools required for the complete antenna assembly.

Simple antennas intended for assembly in the field are usually assembled on the ground and then hoisted into position. In this case good work practices and strict attention to the detailed assembly instructions are the main requirements for correct assembly. Some other antennas, such as rhombics and similar curtain-type antennas are, essentially, constructed at the site. In such cases of wire antenna installation the breaking load of the type of wire being used has considerable effect on the measurements and installation of the wire elements.

The length of a wire suspended between supports must be adequate to allow for the sag that corresponds to the correct tension on the wire. Under static conditions, tension on antenna wires is adjusted to approximately 10 percent of their breaking strength without considering wind or ice load. This allows for a fairly generous sag which can compensate for a considerable change in temperature, without increasing the tension to a danger point in very cold periods.

An approximation for sag and tension is given by:

$$S = \frac{W\ell^2}{8T} \qquad (7\text{-}1)$$

$$T = \frac{W\ell^2}{8S} \qquad (7\text{-}2)$$

where
- S = sag in feet
- W = weight in pounds per foot
- ℓ = wire length in feet
- T = tension in pounds

Table 7-5 lists the diameters, breaking loads, and weights per 1,000 feet for various types of copper wire and copper-clad steel wire.

Table 7-5. Breaking Loads and Weights of Copper Wire and Copper-Clad Steel Wire

Material	Dia. (Inches)	Breaking Load (Pounds)	Weight/1000 ft (Pounds)
Solid Copper Wire:			
No. 4 Hard	0.204	1970	126.4
No. 6 Hard	0.162	1280	79.46
No. 8 Hard	0.128	826	49.98
Solid Copper-Clad Steel Wire:			
No. 4 - 40% HS	0.204	3541	115.8
No. 6 - 40% HS	0.162	2433	72.85
No. 8 - 40% HS	0.128	1660	45.81
No. 4 - 30% EHS	0.204	3934	115.8
No. 6 - 30% EHS	0.162	2680	72.85
No. 8 - 30% EHS	0.128	1815	45.81

NOTE 1. HS indicates high strength.
2. EHS indicates extra high strength.

The approximate length of a wire suspended between two points with a small sag in relation to the distance can be determined from the following formula (all dimensions are in feet):

$$\text{Wire length} = d\left[1 + \frac{2}{3}\left(\frac{2S}{d}\right)^2\right] \qquad (7\text{-}3)$$

where d = distance between suspension points
S = sag

Measuring, stretching and cutting wires to the correct length and sag can be simplified by temporarily attaching the wire on the supports at points close to the ground.

7.8 STRINGING TRANSMISSION LINES

Detailed physical and electrical characteristics, and installation requirements for open-wire and coaxial transmission lines are included in chapter 6. This section lists some details pertinent to suspending open-wire transmission lines above ground.

a. Wood Support Poles. The criteria for wood poles suitable for transmission line support is the same as specified for antenna poles in paragraph 7.5.

b. Positioning Poles. When supporting poles are set in place, all curvatures should be in the direction of the transmission line run, and each pole should appear to be perfectly straight when viewed along the line. Figure 7-17 shows the relation of the parts of a pole to its curvature.

c. Facing Poles. After the poles are set-in, turn them so that the cross-arm gains are positioned alternately gain-to-gain and back-to-back. Where the transmission line is on a slope, all gains should face up-grade.

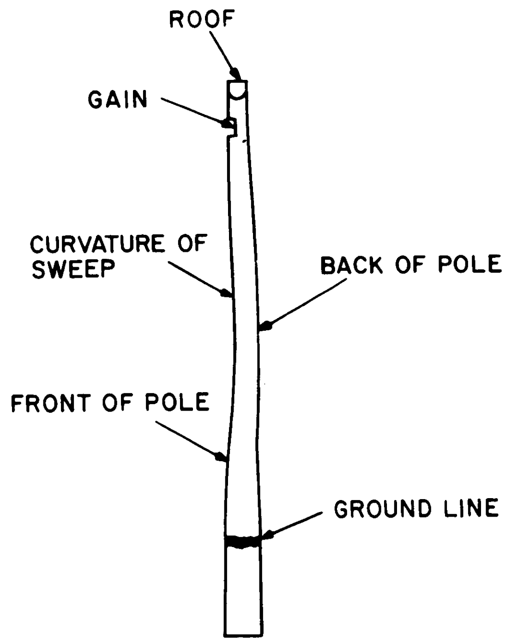


Figure 7-17. Relationship of Pole Parts to its Curvature

d. Line Tension. Set the transmission line tension to 10 percent of the conductor's breaking strength unless local conditions dictate otherwise. Unusual ice and wind loads, or extreme temperatures may require tension and sag adjustments. See table 7-5 for minimum breaking loads of copper wire and copper-clad steel wire.

7.9 POLE AND TOWER LIGHTING

Poles and towers which are a potential hazard to aircraft must be lighted at night by obstruction lights. A typical system consists of a double light fixture, a transfer relay, and a photoelectric control unit which automatically turns the light on at dusk and off at dawn. The double-fixture obstruction light is mounted directly onto the end of the power cable conduit and is located so that it extends above the pole or tower to be lighted. The transfer relay, mounted directly in the conduit run, automatically switches the power to the spare light in the event that the operating light fails. The photoelectric control unit is mounted directly onto the pole by means of lag screws, or is mounted with bolts to a crosspiece that is attached between the legs or braces of a tower. Figure 7-18 illustrates a typical obstruction lighting system.

The number of lights required for a tower depends upon the height of the tower. The FAA- and FCC-approved lighting systems for various tower heights are listed in table 7-6 and illustrated in figure 7-18.

Higher towers require lights of a higher brilliancy and either a rotating red beacon or a beacon flasher to cause the lights to flash on and off.

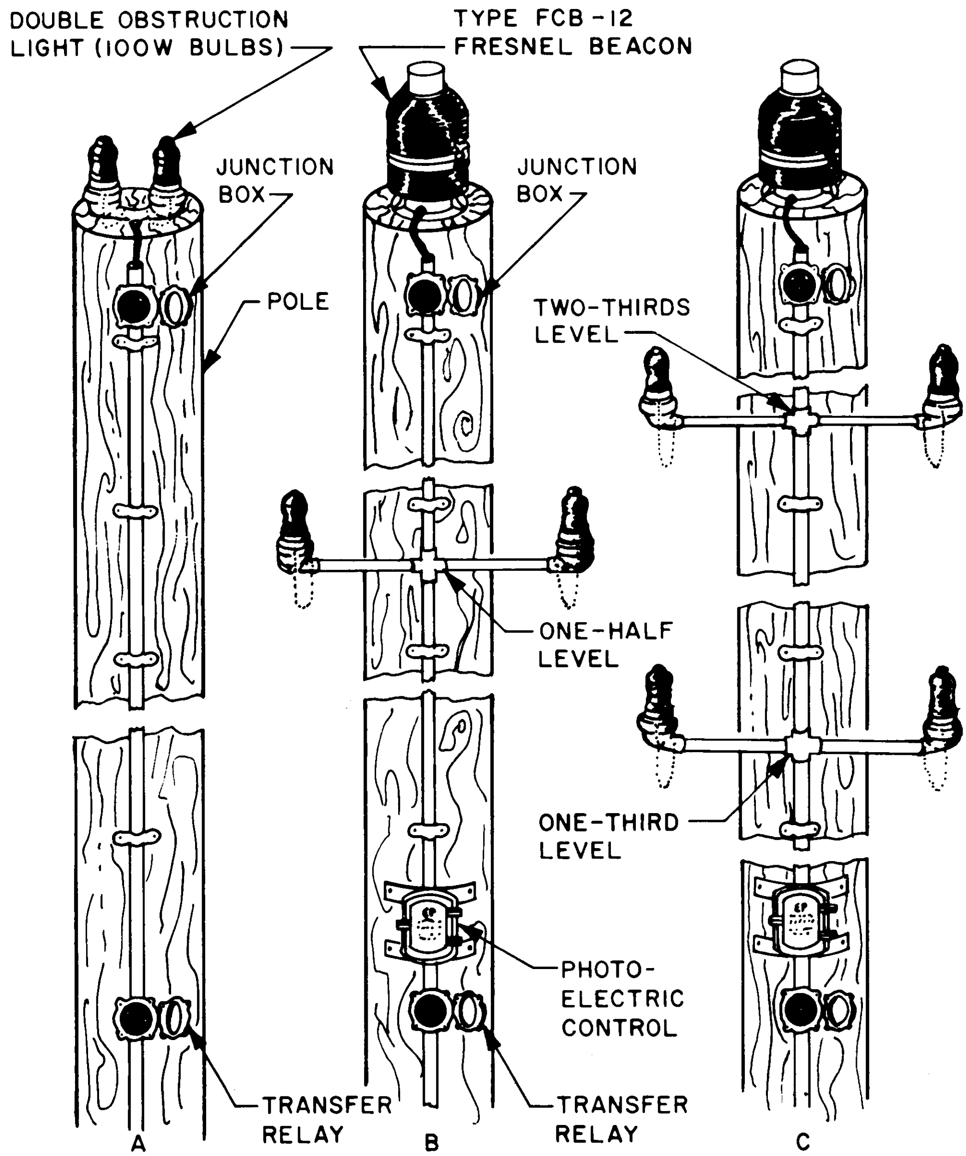


Figure 7-18. Typical FAA- and FCC-Approved Obstruction Lights

Table 7-6. FAA- and FCC-Approved Obstruction Lighting Systems

Tower Height (Feet)	FAA-Approved System Nomenclature	FCC-Approved System Nomenclature	Typical System Detail Figure 7-18
21-150	A-1	17.24	A
151-300	A-2	17.25	B
301-450	A-3	17.26	C