B GUYED TOWERS
FOUNDATIONS AND ANCHORS

CONTENTS **PAGE**

1. GENERAL

1.01 This section outlines details of foundations and anchors for B Guyed Towers, including soil bearing requirements and provisions for electrical grounding. It also provides data as to maximum guy tensions and foundation loads.

1.02 This section is reissued to delete concrete design information which is now provided in Section AG25.130. Since this reissue covers a general revision, arrows ordinarily used to indicate changes have been omitted.

1.03 Local or state laws may require the approval of foundation and anchor designs by a professional engineer duly registered and licensed to practice in that state. To facilitate checking the designs, the loads imposed by the towers are tabulated in Part 5.

1.04 A permit to erect and operate a radio system is required by the Federal Communications Commission. Local regulations may also require construction permits. All required permits should be obtained before starting foundation construction.

1.05 The foundation and anchor designs shown in this section assume soil adequate to withstand a pressure of 4000 pounds per square foot. In locations where the soil is not capable of satisfactorily bearing this load, soil stabilization or foundations and anchors specifically designed to meet local conditions will be required. If there is any doubt concerning the adequacy of the bearing characteristics of the soil at a proposed tower location, actual bearing characteristics of the soil should be determined by suitable tests performed by specialists in soil mechanics.

1.06 In some localities, bedrock may be encountered before reaching the required depth for the foundation or anchors. Since rock excavation is comparatively expensive, economies may be realized by using specially designed concrete structures anchored in the bedrock. The type, depth, and number of anchors required are dependent upon the type, stratification, inclination of the rift, etc, of the rock. The cross section of a typical foundation in rock is shown in Fig. 1.

1.07 Foundations for the towers are designed to include anchor bolts furnished as part of the B Guyed Tower Anchor. Steel wire mesh, usually supplied by the contractor, is required in the foundation but not in the anchors.

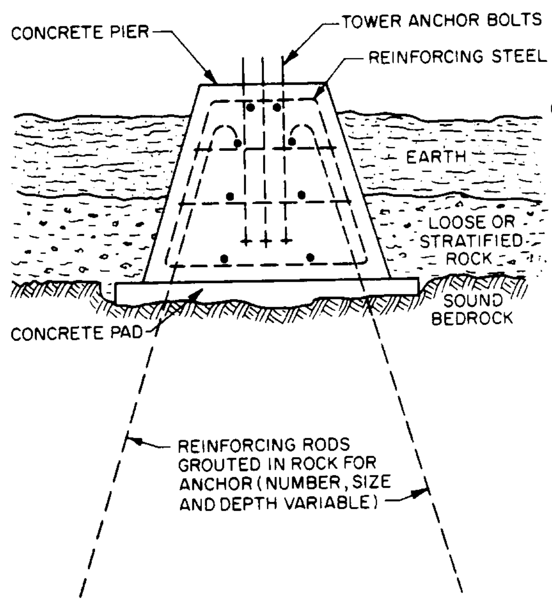


Fig. 1 — Typical Foundation in Rock

1.08 To avoid damage from lightning, the foundation and the anchors should be protected (as outlined in Part 4) with the B Guyed Tower Ground.

1.09 General information regarding concrete characteristics, forming, testing, reinforcing and related subjects is provided in Section AG25.130.

1.10 The approximate quantities of concrete required for foundations and anchors of B Guyed Towers are provided in Table A. Quantities given are based on a frost line of 2-1/2 feet. (See 2.01)

TABLE A

TOTAL CONCRETE REQUIREMENTS FOR FOUNDATIONS & ANCHORS

TOWER HEIGHT (feet)	QUANTITY OF CONCRETE (cubic yards)
80	14.7
100-160	19.9
180-200	24.4
220-300	35.1

2. FOUNDATION DETAILS

2.01 The B Guyed Tower rests upon a single concrete pier or foundation block as shown in Fig. 2. Dimensions of the blocks for each height tower are indicated. The three sizes require 2-3/8, 3-7/10 and 5-1/3 cubic yards of concrete, respectively, based on a maximum frost depth of 2-1/2 feet. Where it is known that frost depth will exceed 2-1/2 feet, the length of the pier should be increased by pouring additional concrete so that there will be at least 1 foot of concrete below the frost line.

2.02 All sizes of the B Tower employ the same size base shoe, and require the same spacing of anchor bolts on each pier. Details of the base shoe are shown in Fig. 3. The base of the tower is equipped with a socket which fits over the large rounded steel pin in the middle of the base shoe. Four 3/4 by 18 inch bolts are used to secure the base shoe to the foundation. (The bolts are component parts of the B Guyed Tower Anchor.)

2.03 Excavations which must remain open overnight should be adequately barricaded or covered to prevent children or animals from falling into them. Excavations should also be protected from flowing surface water in the event of rain. Extraneous materials (paper, rubbish, etc.), should be removed before concrete is poured. The volume of excavation required for a foundation is shown in Table B.

TABLE B

EXCAVATION REQUIRED FOR FOUNDATION

80 foot tower	2-1/10 cubic yards
100 to 200 foot towers	3-1/4 cubic yards
220 to 300 foot towers	4-2/3 cubic yards

Note: These quantities are based upon excavations with perpendicular sides.

2.04 Aside from the anchor bolts which are furnished as part of the B Guyed Tower Anchor, the only steel required with these foundations is a piece of 6- by 6-inch 10 gauge wire mesh, which is usually furnished by the foundation contractor. Foundations of 80-foot towers require a piece of mesh 5-1/2 by 5-1/2 feet; foundations of 100- to 200-foot towers require a piece of mesh 6-1/2 by 6-1/2 feet; and higher towers require a piece of mesh 7-1/2 by 7-1/2 feet. Note that the foundation extends only 6 inches above ground. Formwork will be required for the above-grade portion of the pier, but need not extend below grade more than a few inches. Since the tower rests on what is essentially a ball and socket joint, the foundation may be oriented for maximum convenience without regard to the orientation of the anchors.

2.05 The center of the anchor bolt group should coincide with the center of the foundation as shown in Fig. 2. Anchor bolts should extend at least 4 but not more than 5 inches above the finished grade of the pier. These bolts should be placed in strict accordance with the dimensions shown in Fig. 2, so no difficulty will be encountered when the base shoe is installed. All sizes of the tower employ 3/4- by 18-inch bolts, each equipped with two nuts. Anchor bolts should be wired to the reinforcing mesh to prevent possible

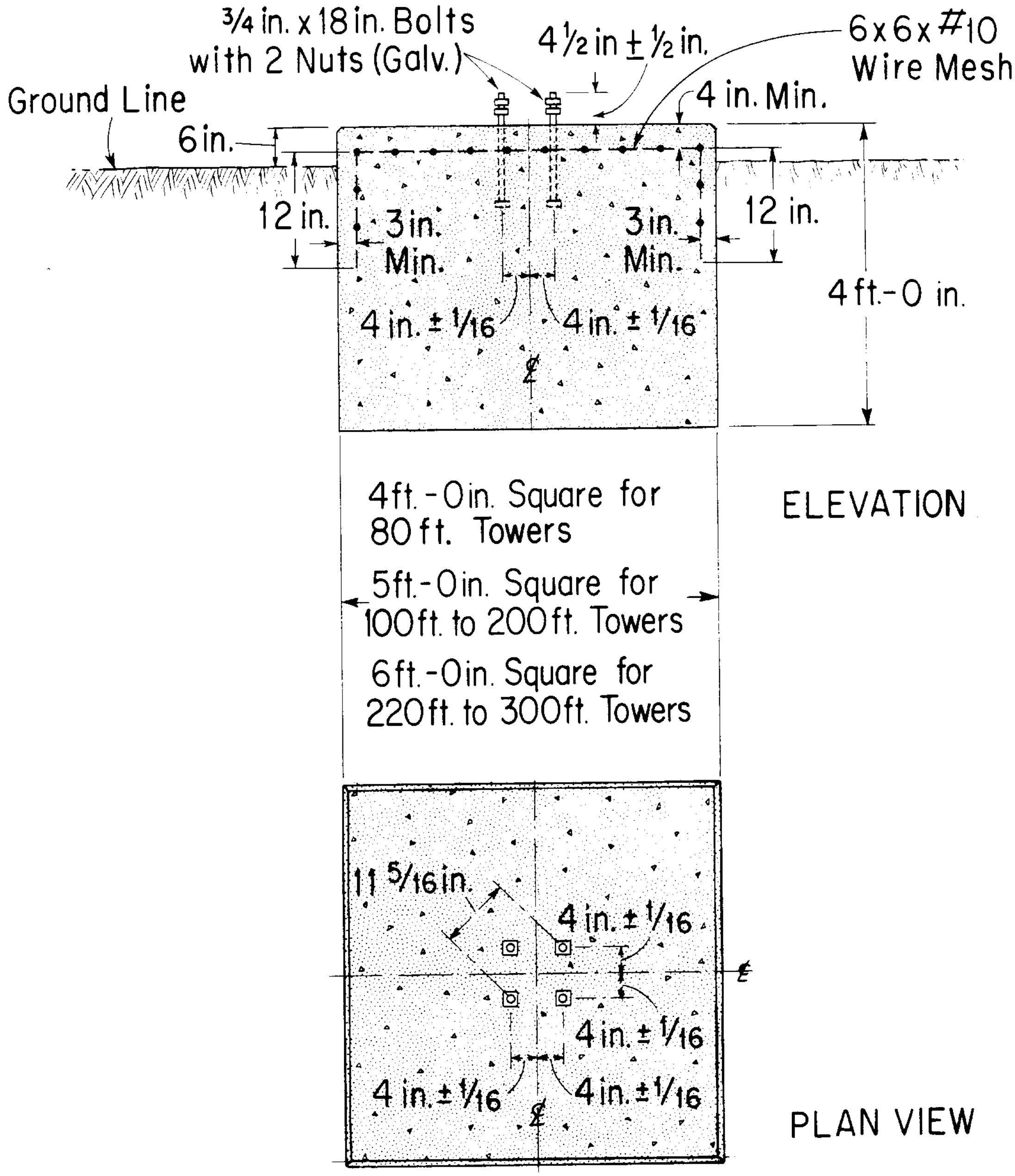


Fig. 2 — Foundation Pier

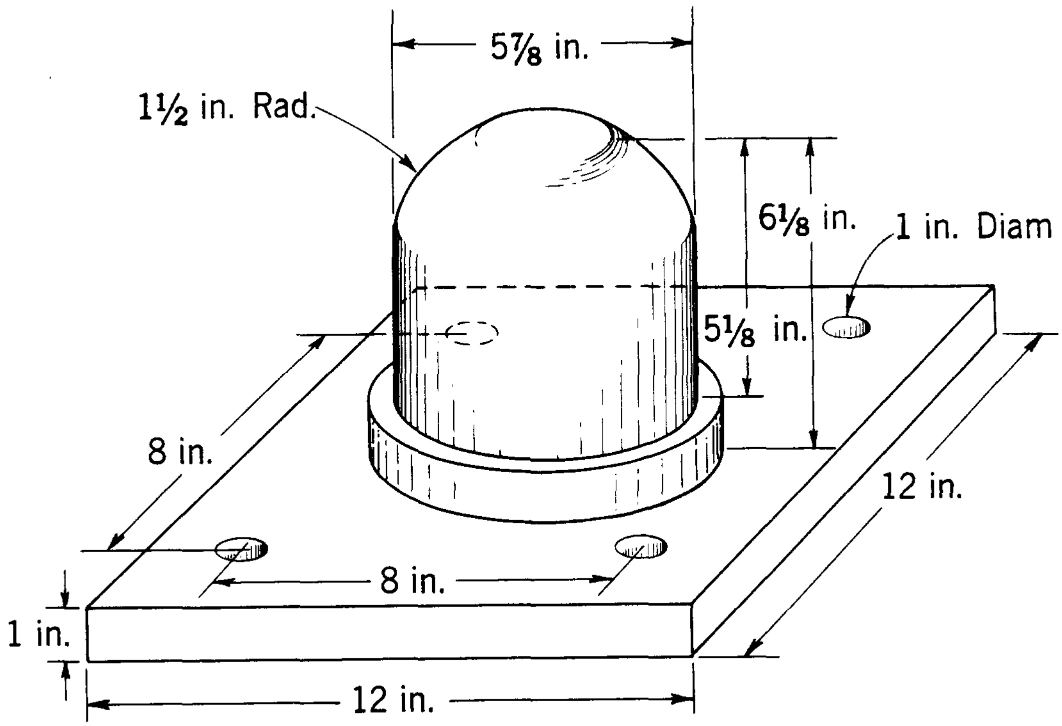


Fig. 3 — Base Shoe

internal arcing in the finished pier in the event of a lightning stroke. Care should be exercised to ensure that the bolts are not pulled out of alignment in doing this. The bolts should be plumb to within 1/16-inch of true vertical.

3. ANCHORS

3.01 The B Guyed Tower is guyed in three directions with guy anchors spaced 120 degrees apart. Each guy is attached to a separate guy rod, although two or three rods may be embedded in the same concrete anchor. Block anchors should be located so as to provide a lead-to-height ratio of 1 (45 degree angle) for the top set of six guys. For 100- to 200-foot towers, a second set of three guys is also attached to the same anchors. Towers of 220-foot height or greater require three levels of guying and two rings of anchors; both top and middle guys are installed at a 45 degree angle. The general layout is shown in Fig. 4. Because of the blind sectors (Section AG25.200), the orientation of the guy anchors must be selected carefully to permit transmission in the required directions.

3.02 Anchors for the B Guyed Tower consist of rectangular blocks of concrete equipped with the necessary anchor rods. Five varieties of anchors are used with B Guyed Towers. These have been designated asTypes I, II, III, IV, and V, and are illustrated in Figs. 5, 6, 7, 8, and 9. The Type I anchor is used only with the 80-foot tower. The Type II anchor is used only with 100- to 160-foot towers inclusive. Type III anchor is used only with 180- and 200-foot towers. Types IV and V are both required for towers 220 feet high and larger.

3.03 Table C lists the number and types of concrete anchors required for the various sizes of towers. Local conditions may indicate the need for other sizes or types of anchors, in which case special engineering will be required.

TABLE C
NUMBER AND TYPE OF ANCHORS

TOWER HEIGHT (feet)	TYPE OF ANCHOR				
	I	II	III	IV	V
80	3	0	0	0	0
100-160	0	3	0	0	0
180-200	0	0	3	0	0
220-300	0	0	0	3	3

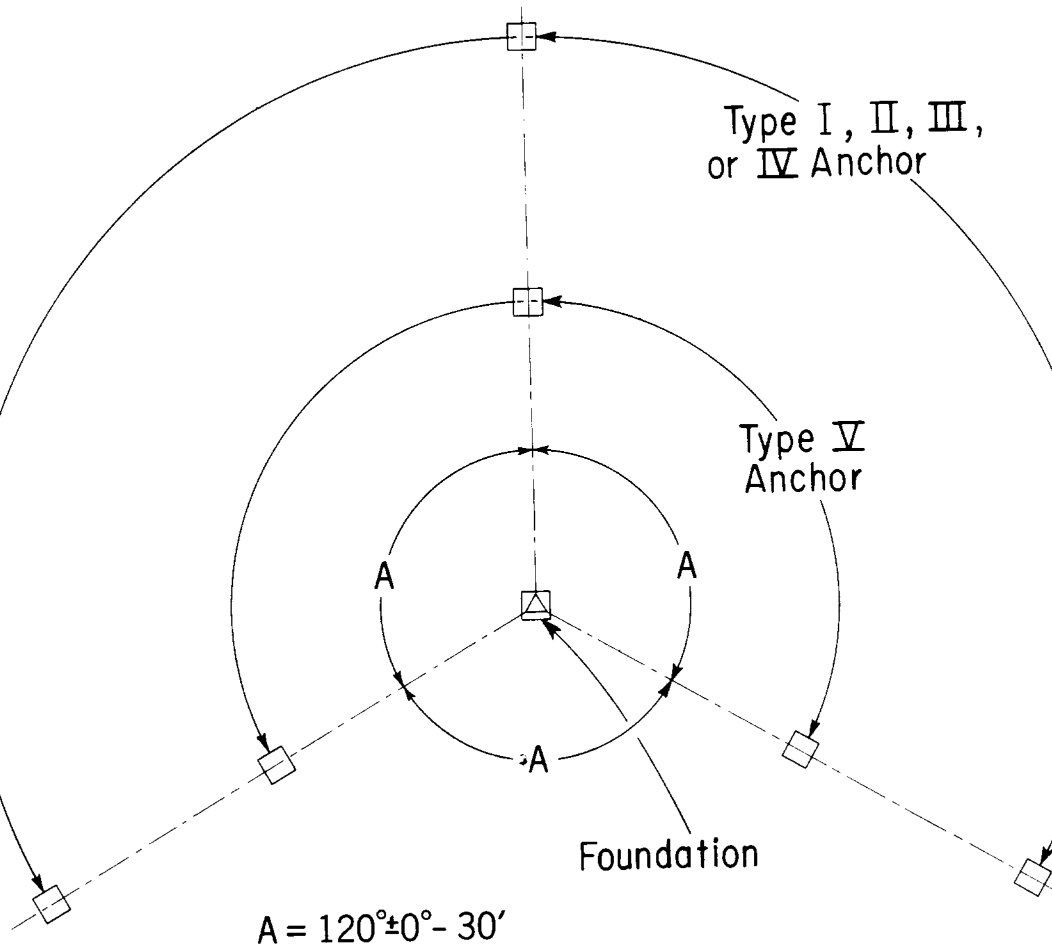


Fig. 4 — Anchor Layout

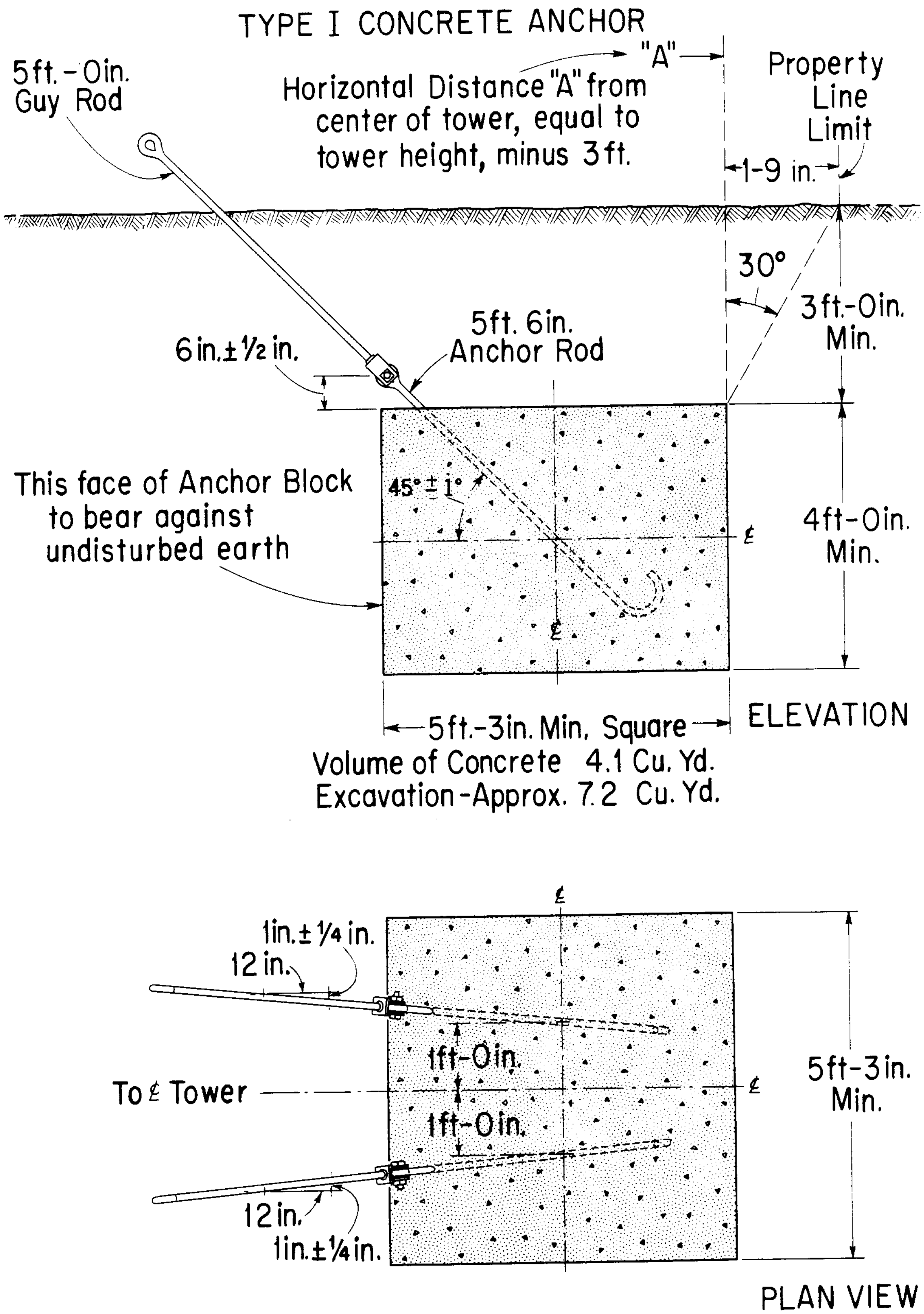
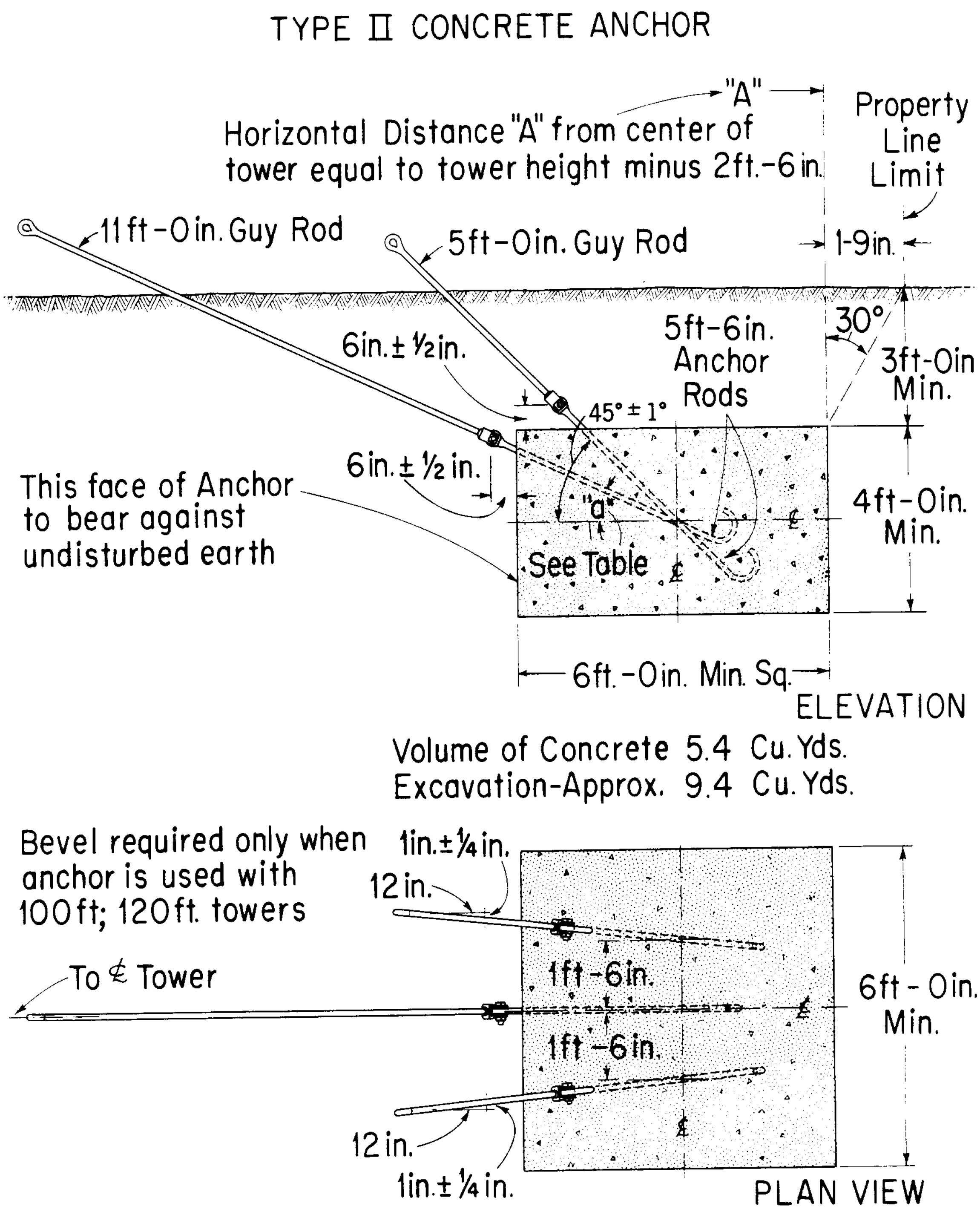


Fig. 5 — Anchor Used with 80 foot Tower

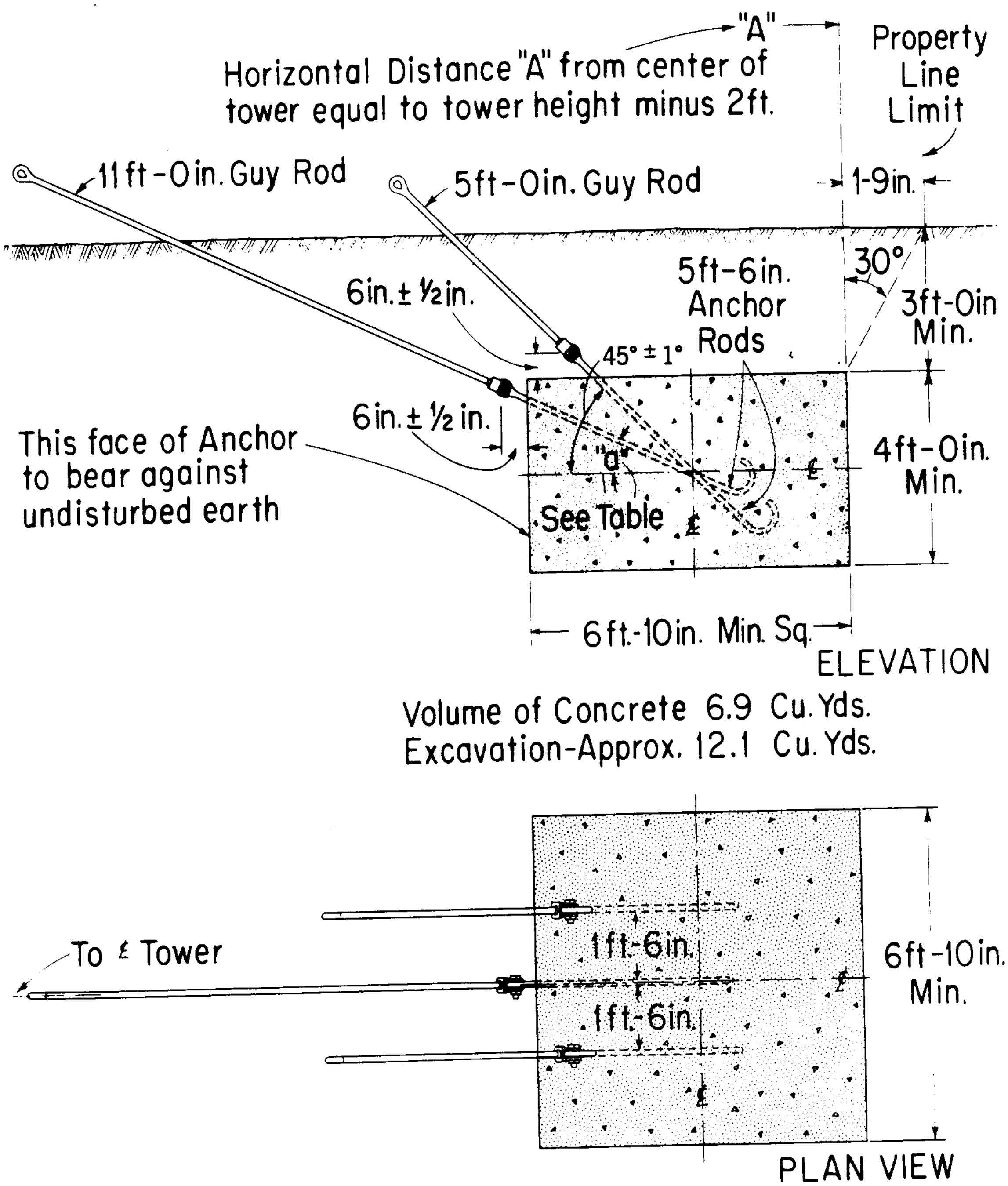


TABLE

Tower Height (Feet)	100	120	140	160
Angle "a" (Degrees) ±1°	26	30	26	23

Fig. 6 — Anchor Used with 100-160 foot Towers

TYPE III CONCRETE ANCHOR



TABLE

Tower Height (Feet)	180	200
Angle "a" (Degrees) ±1°	26	24

Fig. 7 — Anchor Used with 180-200 foot Towers

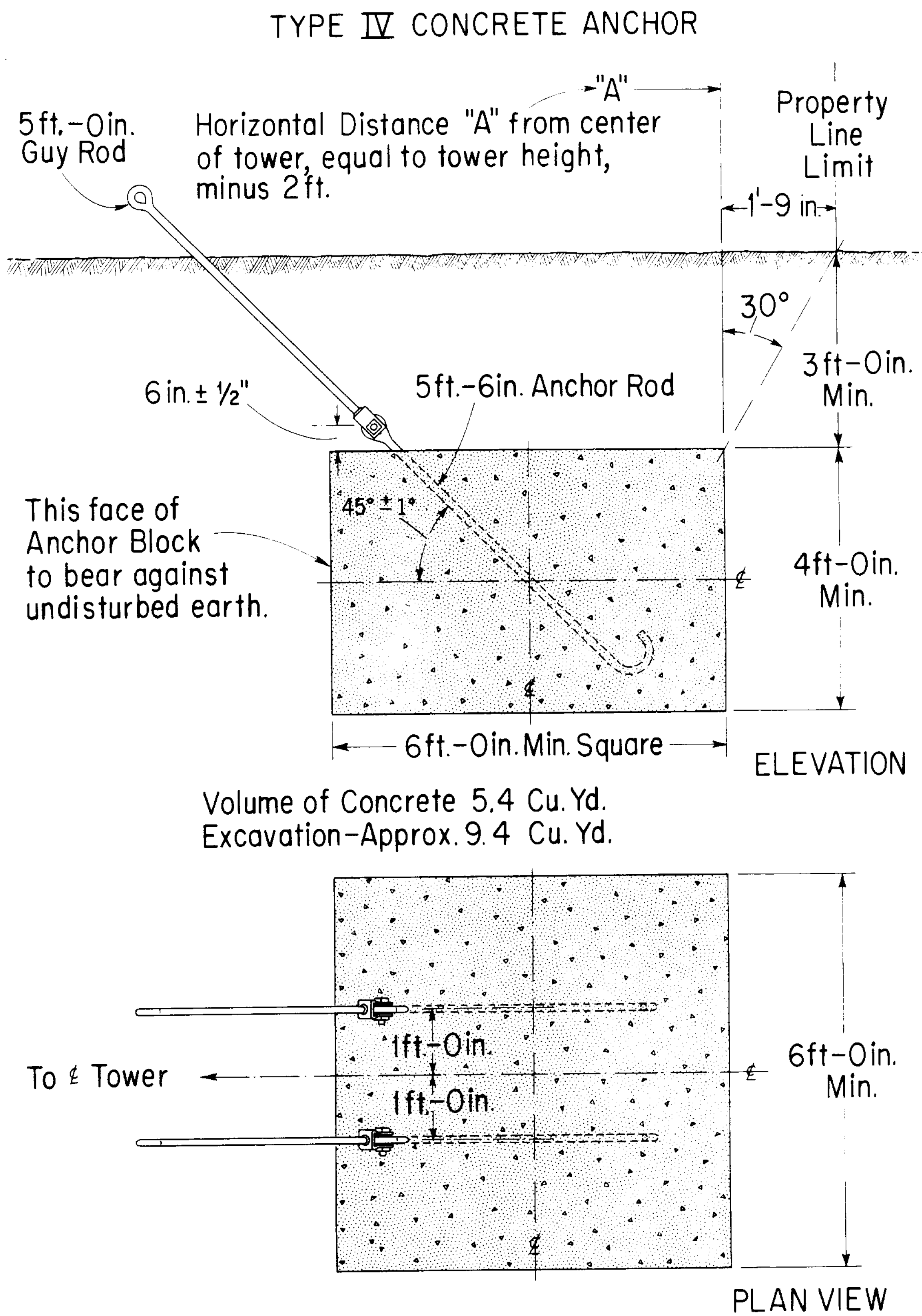
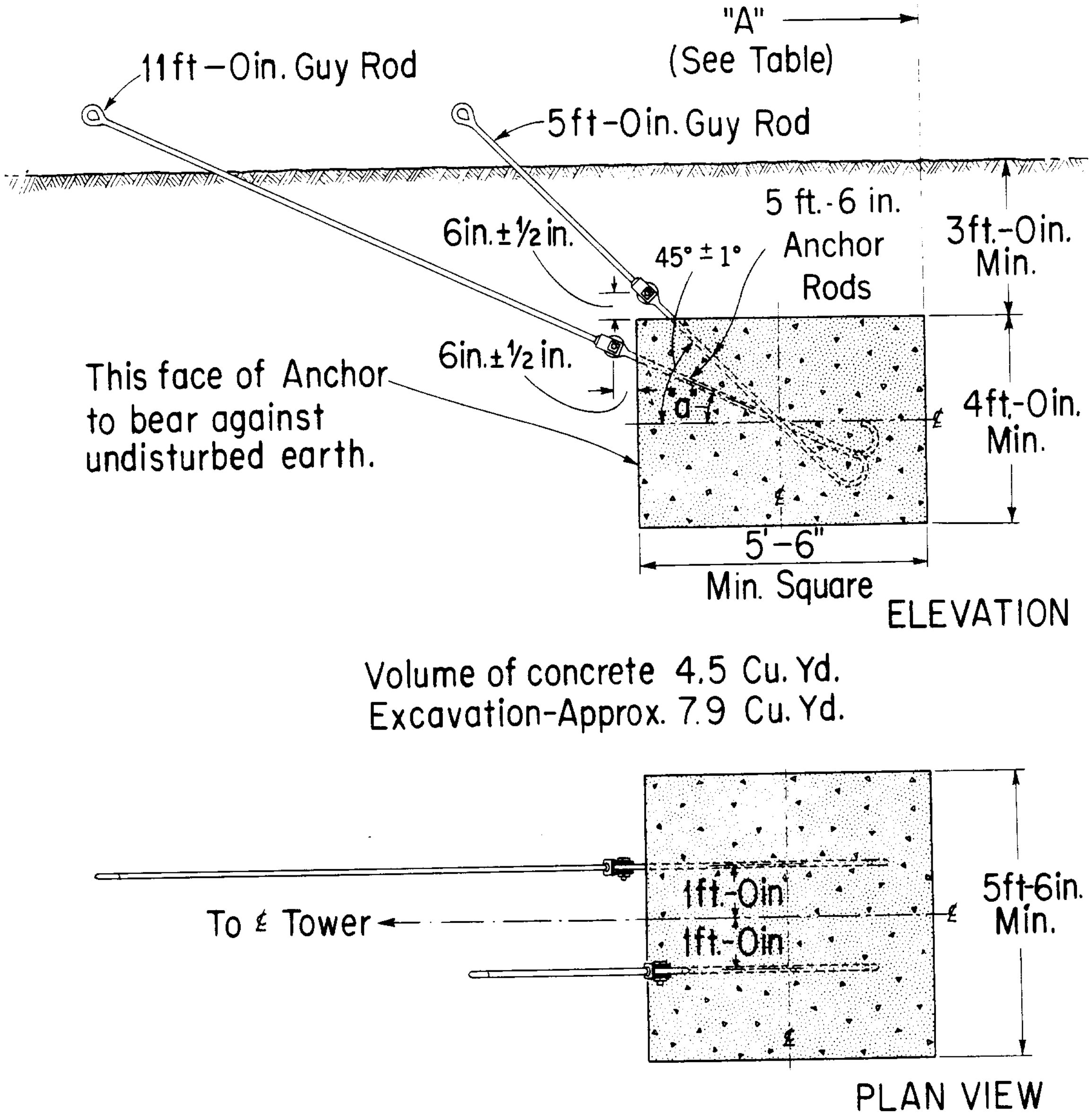


Fig. 8 — Outer Anchor Used with 220-300 foot Towers

TYPE V CONCRETE ANCHOR



TABLE

Tower Height (feet)	220	240	260	280	300
Horizontal Distance "A" from center of Tower (feet)	131	151	171	191	191
Angle "a" (Degrees) ± 1°	27	24	27	25	25

Fig. 9 — Inner Anchor Used with 220-300 foot Towers

3.04 The distance "A" (see Figs. 5 through 9) ***from the back face of the anchors is shown*** for the particular case of ***flat ground.*** If the tentative location of an anchor at distance "A" as shown is at a lower elevation than the location chosen for the foundation, horizontal distance "A" should be increased by the amount of difference in elevation so as to maintain a 45° angle for the upper guys. Conversely, if the tentative location of an anchor is higher in elevation than the spot chosen for the foundation, distance "A" should be reduced by the difference in elevation. If the ground slope exceeds 3 per cent, the wind load which will cause the tower to exceed the twist and deflection limits of 1/2 degree and 1/4 degree (with the equipment specified in AG25.200) may be less than 20 lbs/ft² (i.e., a lower wind velocity).

3.05 One B Guyed Tower Anchor is required for each B Guyed Tower. In addition to four anchor bolts, this unit includes the quantities of guy rods and anchor rods indicated in Table D. Since the quantity of different size and type rods varies with the height of the tower, it is necessary to order the B Guyed Tower Anchor according to tower height.

TABLE D

TOWER HEIGHT (feet)	GUY RODS		ANCHOR RODS
	11 FEET	5 FEET	
80	0	6	6
100-200	3	6	9
220-300	3	9	12

Note that the total number of guy rods is always the same as the number of anchor rods. As may be seen in Figs. 5 through 9, the 5-foot guy rods are always used with guys installed at a 45° angle (that is, all top guys, and on towers with three levels of guying, also the middle guys). All guy rods, regardless of length, engage the eye of an anchor rod with a 1-inch bolt passing through the clevis of the guy rod.

3.06 Anchor rods should be installed at the angles shown (±1 degree) in Figs. 5 through 9. Although no reinforcing is required in these anchors, it may be found expedient to drive a few short lengths of reinforcing rods into the sides and bottom of the excavations to support the anchor rods in place during the pouring operation. These supplemental rods will not affect the strength capabilities of the anchors. No formwork is required as a general rule, although it may be necessary to shore the sides of excavation to prevent cave-in. The approximate volume of excavation required for anchors is indicated in Table E.

TABLE E

TOWER HEIGHT (feet)	TOTAL VOLUME OF EXCAVATION* (cubic yards)
80	21.6
100-160	28.2
180-200	36.3
220-300	51.9

**Note:* Quantities are based upon vertical walls for all excavations. If dug by machine, the actual quantity of earth removed will generally be in excess of the quantities shown. No slope should be permitted on that part of the wall which abuts the front face of the anchor.

3.07 Guy rods should not be attached to anchor rods until the concrete has set. A sloping trench should be dug to accommodate the guy rods when they are placed. The trench should be deep and long enough so that the guy rod is free to pull into line with its tensioned guy without bending. These trenches should be left open until the guys are installed to make sure that each guy rod forms a straight line between its attachment point on the tower and the anchor rod.

4. GROUNDING

4.01 All towers should be grounded to prevent possible damage to their foundations or anchors. Grounding facilities should be installed at the same time the foundations and anchors are installed. The B Guyed Tower Ground contains materials which are furnished to electrically ground these towers and their guys. This ground is not furnished with the tower, but must be ordered separately. Since the quantity of material varies with the number of anchors and guys, and these in turn are a function of the tower height, it is necessary to specify the height of the tower as a part of the ordering information. Normally, a lightning rod is required only when lighting facilities are installed on the tower.

4.02 Sufficient wire is provided to ground the tower, but not to connect the tower grounding system to the station grounding system. This connection should normally be made, but since the distance between the tower ground and the station grounding system will vary for each installation, the length of wire required for this connection should be included in the wire ordered for the station grounding system. In some cases, the distance involved, and electrical considerations may indicate that interconnection of the two systems is not necessary.

4.03 The general principle of protecting a buried concrete structure against lightning which may enter through steel extending above ground, is to equalize the potential inside and outside the concrete mass, in order to prevent arcing. In the specific case of anchors and foundations for the B Guyed Tower, (as shown in Fig. 10 and 11) grounding is accomplished by placing two ground rods alongside each mass of concrete, and connecting them to the anchor rods and tower base, respectively. To obtain maximum protection, the two ground rods are placed on opposite sides of the concrete block.

4.04 In protecting the foundation, as shown in Fig. 10, the ground rods are placed within 12 inches or less of the midpoint of opposite sides and driven to a depth of about 5½ feet. Connectors are used to join the tail of each ground rod to a length of No. 2 AWG bare copper wire. About 7 feet of wire should be left above ground to make the connection to the tower. Each copper wire is secured to the tower under a grooved washer which is held by a ½-inch machine bolt supplied as part of the grounding kit. Two 9/16-inch diameter holes are provided for this purpose in each channel at the base of the tower. About an inch of wire should extend beyond the edge of the washer. The connection should be painted over with black pitch, or a similar waterproofing after the connection has been tightened to avoid loss of galvanizing which would otherwise take place.

4.05 As shown in Fig. 11, each anchor is protected with two ground rods connected to the guy rods by a length of No. 2 AWG bare copper wire. Ground rods should be installed after the concrete has been poured and set, but before the excavations are backfilled. The ground rods are 5 feet long and when installed to a depth of 8 feet, their tops will be about 3 feet below grade. While the excavations are open, it will be relatively easy to gouge a channel in the two sides of the excavation which are to receive the ground rods. The channel need be no more than 6 to 10 inches deep and about 6 inches wide to permit room to drive the rod. Since the tail of the ground rod is about 12 inches long, the connection to the No. 2 copper wire can be made outside the channel. The tail of the ground rod should be connected to a length of wire which is long enough to reach the ground rod on the opposite side of the anchor, and also permit connection to all guy rods associated with the anchor. Connectors are provided to join the ends of the wire to the tail of each ground rod and a clamp is provided to secure the wire to each guy rod. The clamps should be positioned so that they will be at least 6 inches below grade. Excavations may be backfilled after all connections are tightened, but care should be exercised to ensure that connections are not broken or damaged in this process.

5. FOUNDATION LOADS AND GUY TENSIONS

5.01 When the tower is loaded with a full complement of reflectors and/or antennas, and subjected to wind load of 40 pounds per square foot, the foundation will be subjected to certain loading. The approximate loads transmitted to the foundation under these conditions are indicated in Table G.

TABLE G

FOUNDATION LOADS

TOWER HEIGHT (feet)	FOUNDATION LOAD (pounds)	TOWER HEIGHT (feet)	FOUNDATION LOAD (pounds)
80	25,200	200	45,500
100	32,000	220	60,000
120	33,000	240	62,000
140	33,500	260	64,000
160	34,500	280	66,000
180	45,000	300	68,000

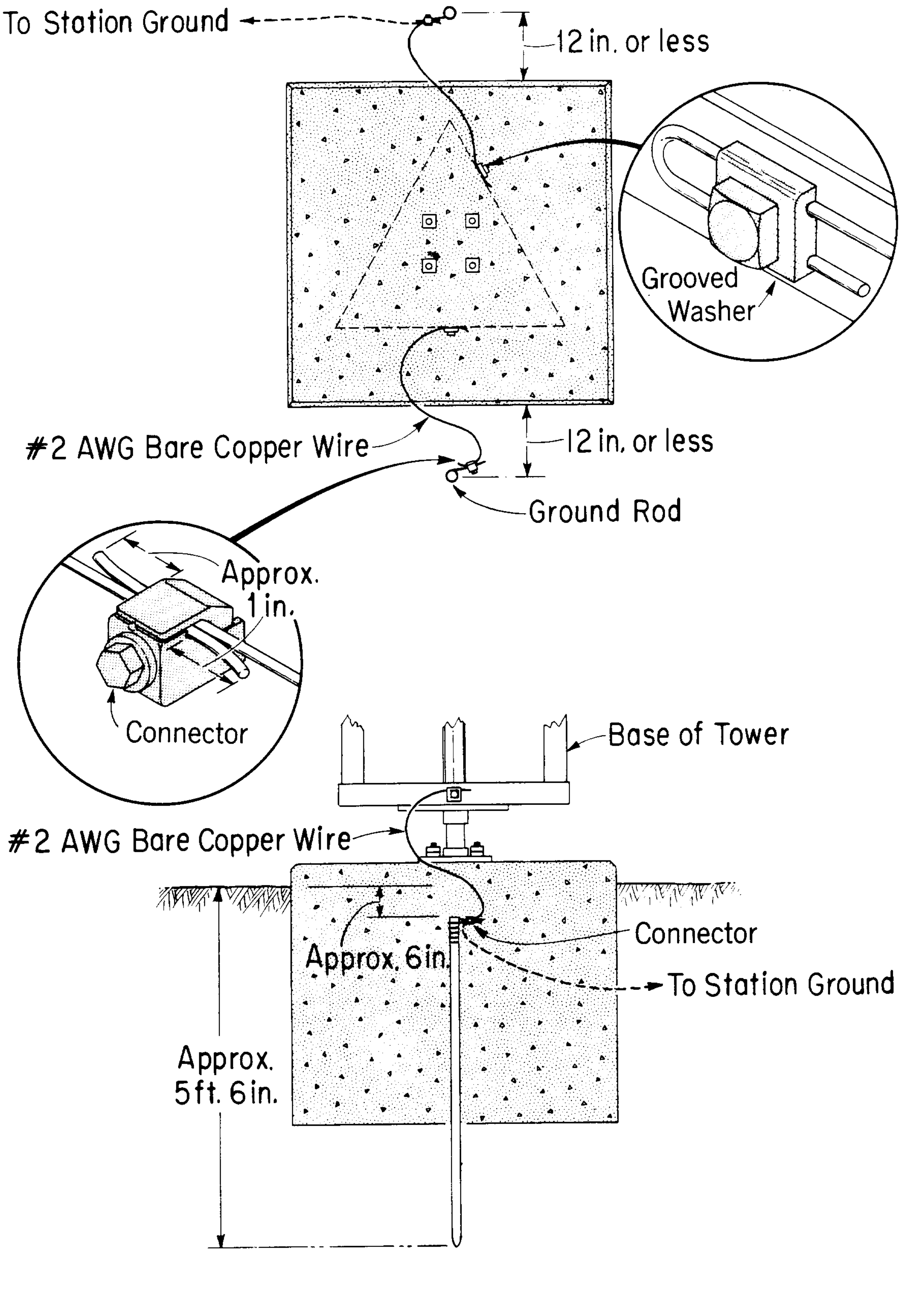


Fig. 10 — Grounding at Foundation

5.02 In addition to the above forces, there is a horizontal force (shear) of approximately 2400 pounds acting at the base of the tower. This force has also been taken into account in designing the foundation. The tower is capable of transmitting greater loads than those tabulated in Table G since the structure is designed with a safety factor. Foundations have, therefore, been designed to withstand loads one and one-half times greater than those shown. Only three sizes of foundations are used, and each size is used for a number of different tower heights. It follows, of course, that foundations which are adequate for a 300-foot tower are

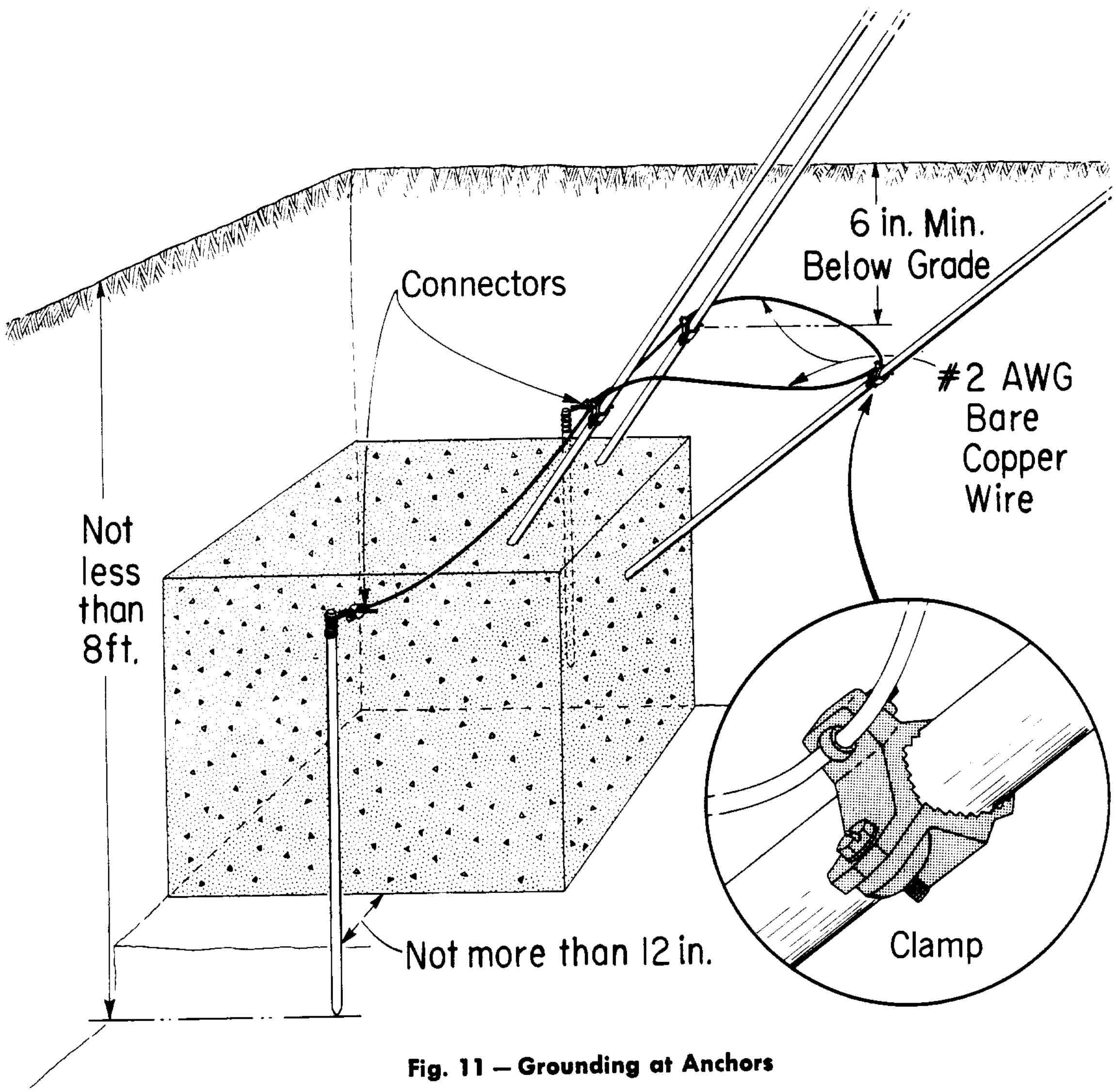


Fig. 11 — Grounding at Anchors

somewhat more than adequate for a 220-foot tower.

5.03 Maximum guy tensions under design loading are indicated in Table H.

TABLE H

MAXIMUM GUY TENSIONS

TOWER HEIGHT (feet)	UPPER GUYS (pounds)	MIDDLE GUYS (pounds)	LOWER GUYS (pounds)
80	10,000	—	—
100 to 160	10,000	—	7,600
180 to 200	12,000	—	11,000
220 to 300	12,700	11,000	12,700

5.04 The maximum guy tensions are based upon a design wind pressure of 40 pounds per square foot with the tower fully equipped. Anchor designs are based upon a safety factor of 2 for the vertical component of the guy tensions, assuming concrete weighs 140 pounds per cubic foot and earth weighs 100 pounds per cubic foot, and that the shape of engaged earth will be an inverted frustum of a pyramid with the sides inclined 30° from vertical. No specific safety factor is employed for the horizontal component since the vertical component design requirements are always controlling for the soil conditions assumed and the anchor configurations used. Section AG25.300 provides methods for determining horizontal and vertical components of guy tensions.