

CHAPTER 4

HORIZONTAL CONTROL MONUMENTS

4-1. Selection of Monument Type Based on Local Site Conditions. Types of monuments to be used for horizontal control are a function of the order of accuracy of the survey, of the intended use of the data collected, and of the location provided. The various monuments that should be used to provide horizontal control only are identified in Table 4-1. The site selection criteria have previously been discussed in paragraph 3-1. If higher order accuracy other than that illustrated in Table 4-1 is desired, then a Type A rod mark should be used. High precision engineering and deformation studies require extremely stable monuments, i.e, instrument pedestals and force-centering devices. Other rod type monuments in this manual may also be used for horizontal control as well as vertical control.

4-2. Construction and Installation Procedures. Construction details for rod marks have been previously discussed in paragraphs 3-2a. through 3-2g. Instrument pedestals shall be

Table 4-1

Site Conditions and Monument Types for Horizontal Control

<u>Site Conditions</u>	<u>Order of Accuracy</u>			
	<u>High</u>	<u>1</u>	<u>2</u>	<u>3</u>
Rock outcrops, large boulders, bedrock concrete structures (more than 5 years old)	C	C	C	C
Granular soils (sand and gravel)	G	G	G	F,G
Glaciated soils (till)	G	G	G	F,G
Fine-grained soils (silts and clays with high bearing strengths)	G	G	G	F,G
Fine-grained soils (silts and clays with low bearing strengths)	G	G	G	G
Construction fill (disturbed earth)	G	G	G	G
Permafrost	E	E	D	G
Marsh	A,B	A,B	A,B	A,B
Subsidence area	A,B	A,B	A,B	A,B

constructed as shown in Figure 4-1. The centering device should be constructed as outlined in Figures 4-2 and 4-3 and should have a protective cover. It is recommended that soil and/or geotechnical specialists be consulted prior to construction of instrument pedestals. All USACE survey disks and access covers shall be stamped using 3.17-millimeter (1/8-inch) steel dies. All stampings shall deform the disk surface by a minimum of 1 millimeter (0.039 inch).

a. Pedestal in Soil. For a monument pedestal in soil (Figure 4-1a), a 1.2-meter (4-foot) square concrete footing shall be constructed below the frost line. The thickness of the footing will be 0.6 meter (2 feet). A 25.4-centimeter (10-inch)-diameter steel pipe pedestal filled with concrete will be attached to the footing with five #4 ribbed rebars placed on 10-centimeter (4-inch) centers embedded in the footing and pedestal for a minimum of 50 centimeters (20 inches). A centering device as shown in Figures 4-2 and 4-3 shall be placed in the center of the pedestal. A protective cover and casing of 45.7-centimeter (18-inch)-diameter steel pipe shall be placed over the pedestal and extended from the top of the footing to approximately 1.22 meters (4 feet) above the ground surface.

b. Pedestal on Rock. For a control monument on rock, the construction is similar to the construction for a control monument in soil as illustrated in Figure 4-1b. All fractured and weathered material shall be removed from the rock. Then the rebars shall be epoxy grouted into the top of sound rock with five #4 ribbed rebars on 10-centimeter (4-inch) centers. The rebar shall be epoxy grouted into the rock for a minimum distance of 50 centimeters (20 inches) and should extend into the bottom of the pedestal at least 25 centimeters (10 inches). The protective covering, casing, pedestal, and centering device will be constructed in the same manner as a control monument in soil.

c. Centering Devices. The forced centering device shown in Figure 4-2 shall be installed in the top center of the instrument pedestal. The bottom of the centering device shall be embedded 5.7 centimeters (2.25 inches) in the concrete. The forced centering device shown in Figure 4-3 attaches to the base of the instrument and forces the instrument to center on the pedestal device.

d. Structure Insert. A structure insert is grouted in the existing concrete structure at selected locations (Figure 4-4). The top surface is rounded to provide a point for precise leveling. The center is tapped and threaded to fit a standard prism 5/8-inch by 11-inch thread. A 5/8-inch brass plug or bolt should be screwed into the threads when not in use. The insert shall be made from 1-1/4-inch hex stainless steel stock. The structure insert is illustrated in Figure 4-4.

4-3. Naming Horizontal Control Monuments. Intelligible names should be assigned as primary identifiers of horizontal control

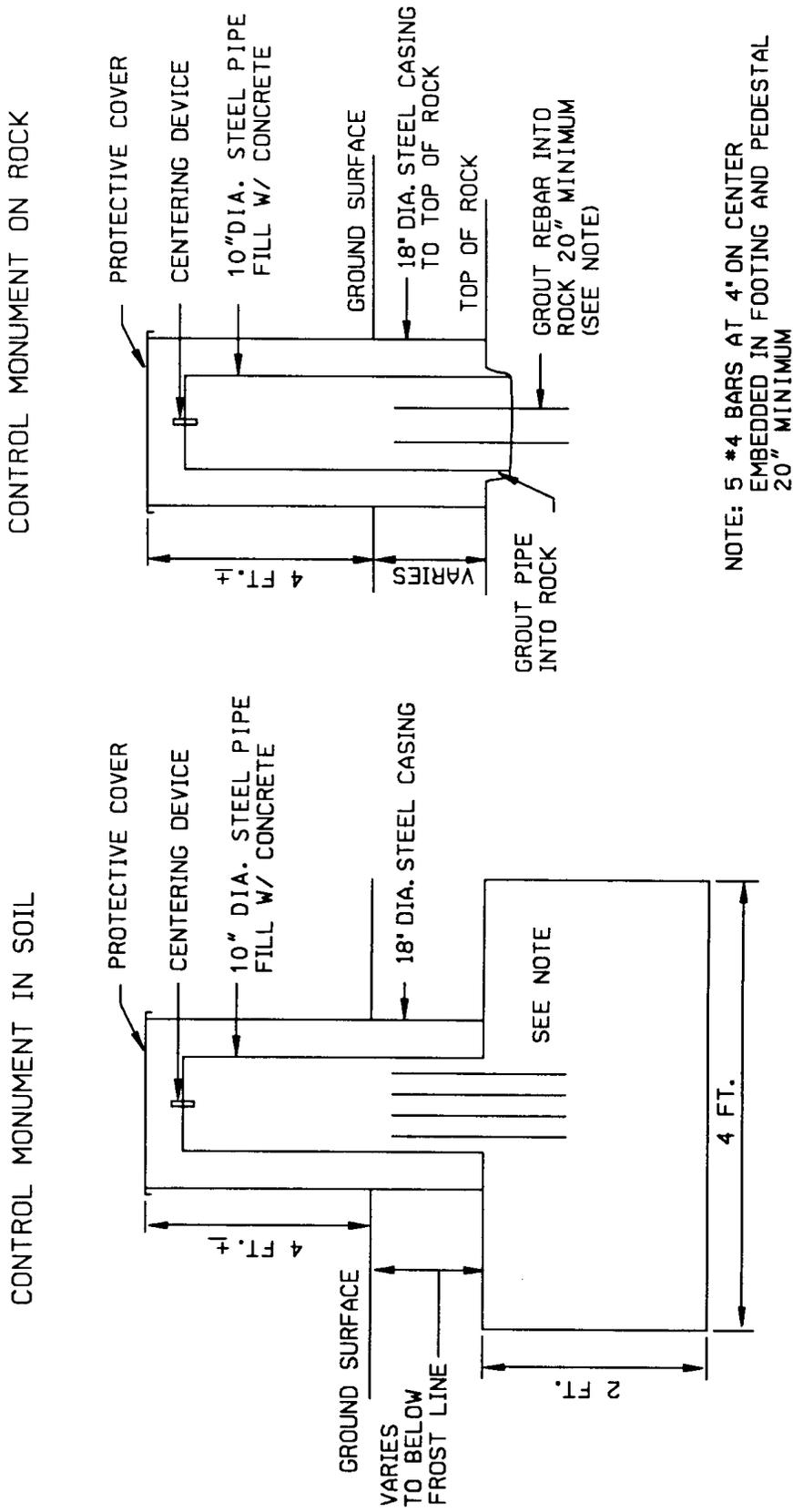


Figure 4-1. Instrument pedestal

NOTES:

1. DIMENSIONS ARE IN INCHES
2. TOLERANCE ON .xx ± .01,
.xxx ± .005
3. TO BE MADE FROM B21 ALLOY -
2" ROUND STOCK
4. FOR ASSEMBLY - USE 1/4-20
UNC-2A, 1/4" LONG SET SCREW

5. ALL MACHINE SURFACES ARE
 $\sqrt{.32}$

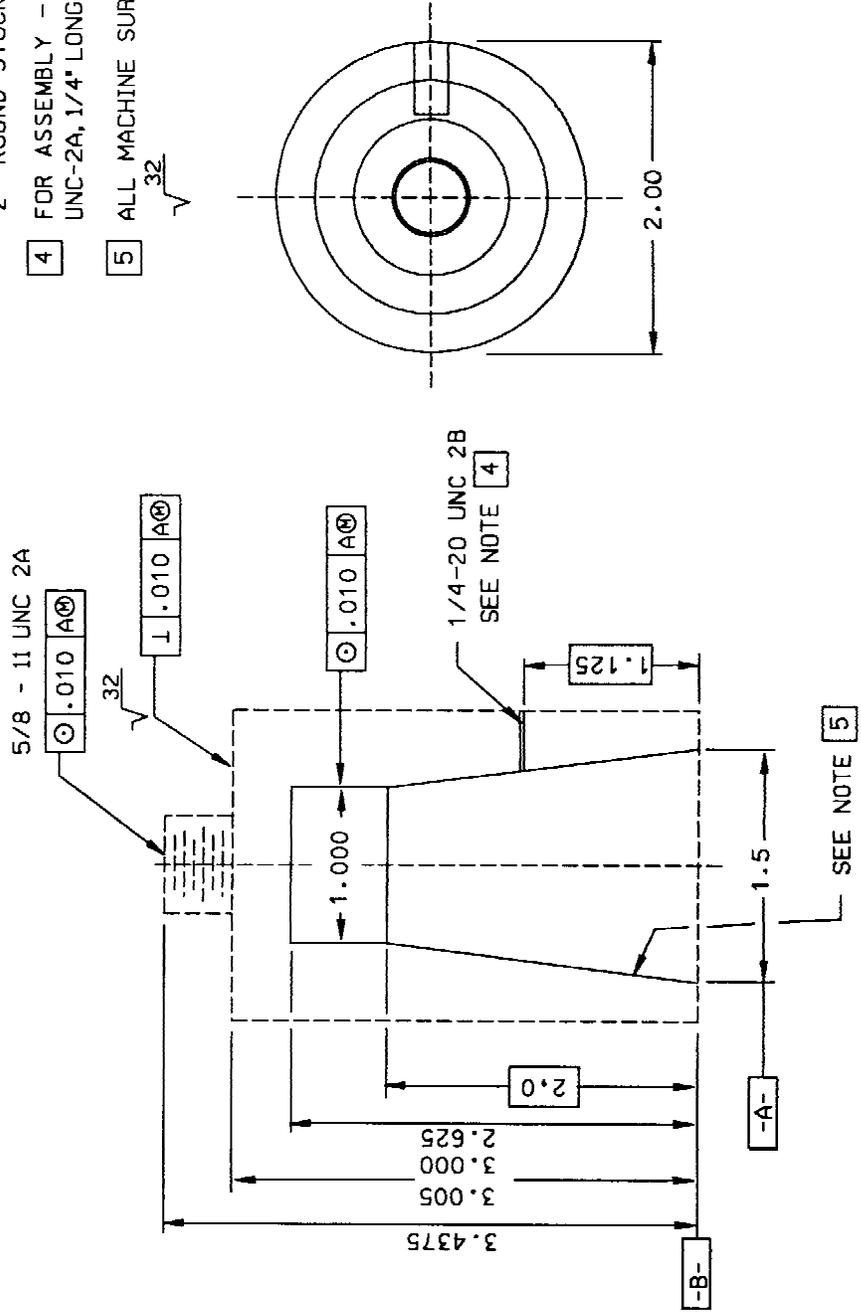


Figure 4-3. Instrument forced centering device

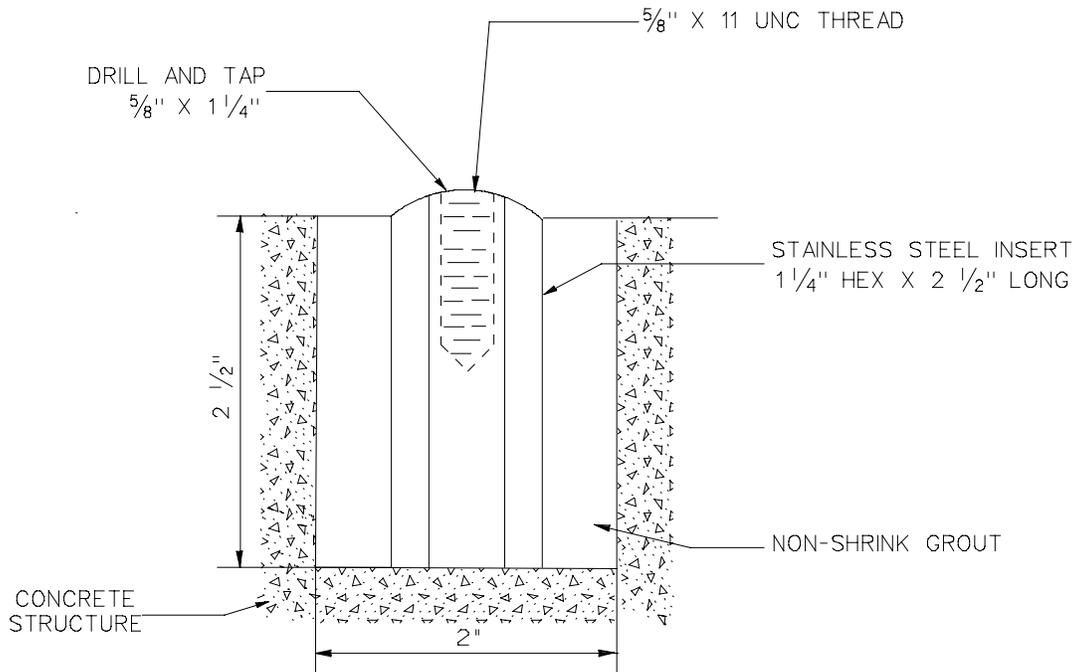


Figure 4-4. Structure insert

points. A properly chosen station name should in itself be descriptive and/or indicative of the general location of the respective horizontal control point.

a. Maximum Character Length. The name of a monumented horizontal control point should be concise, being limited in length to a maximum of 30 characters.

b. Monumented Point. In addition to the "year mark set" another date is associated with every survey point whether it is a monumented horizontal control point or an unmonumented recoverable landmark. This additional information, referred to as the "year established," is the year in which observations were first performed for the purpose of determining the position of the horizontal control point. The "year established" should also reflect the year in which the original description of that control point was prepared. The "year established" and "year-mark-set" of a monumented horizontal control point are often identical. Additional information on network design, geometry, and connections is located in a separate engineering manual that is currently in preparation.

c. Unmonumented Point. Another type of horizontal control point is an unmonumented recoverable landmark such as a flagpole or church spire. The name of a horizontal control point of this type must be sufficiently descriptive in order to identify the respective landmark (frequently a specific feature of the landmark). For this reason, the name of this type of control point is usually lengthy. The length of a station name, including all imbedded blanks, should be limited to 30 characters. The same limit applies to the name or designation of a reference mark (RM) or azimuth mark (AZ MK). Accordingly, the name of every horizontal control point, as well as the name or designation of an RM or AZ MK, should be abbreviated so that it does not exceed 30 characters.

d. Abbreviating Lengthy Names. When a lengthy name of a horizontal control point is contracted to the 30-character limit, the abbreviation and/or editing of the station name should be accomplished with due regard to the following fact. The names of reference and azimuth marks should be formed by appending the symbols RM 1, RM 2, ..., RM 13, etc., and AZ MK (possibly AZ MK 2, AZ MK 3, etc.) to the station name of the control point. For this reason, the name of a horizontal control point that has peripheral reference marks and/or azimuth marks may have to be further contracted to 24 characters (possibly less). This contraction is necessary to allow the reference and azimuth mark names to conform to the 30-character limit. The abbreviation "ECC." (for eccentric) should never be stamped on a disk. Each standard disk utilized to mark a horizontal control point should be stamped with the station name, year set, and organization (District) designated on the marker. Each recorded station, which is re-marked, should be stamped with the original name of the station, the original date of establishment, and the year in which it is reset. All information imprinted on any disk used for station and reference marks should be stamped with 3.17-millimeter (1/8-inch) dies.

4-4. Reference and Azimuth Marks. Reference and azimuth marks should be constructed similar to their respective control monuments. Type F and Type G monuments (Figures 3-7 and 3-8) may be used as reference and azimuth monuments. However, these types of marks need only extend a minimum of 91 centimeters (3 feet) below natural ground. In areas having permafrost, marks should be anchored about 60 centimeters (2 feet) in the permafrost. Reference marks and azimuth marks should be identified by standard USACE disk markers with an arrow as the survey point symbol created by stamping a "V" on either end of the line indicating the center. The markers are set in such a way that the arrow points toward the respective horizontal control point. Three reference marks should be established for first- and second-order control networks in the immediate vicinity (less than 30 meters (100 feet)) of a monumented horizontal control point. The reference marks may be natural landmarks or manmade monuments. In addition, if a well-defined permanent object (natural or manmade) is not available, one azimuth mark shall be established for

first- and second-order control networks not less than 0.4 kilometer (0.25 mile) away when feasible. This will provide an azimuth reference point that is visible from ground level at the horizontal control point. Azimuth and reference marks are not required for third-order networks or when adjacent control points have intervisibility and are not closer than 0.4 kilometer (0.25 mile). Vertical and horizontal control type monuments may be used for reference and azimuth marks.

a. Naming Reference Marks. The originally established reference marks of a horizontal control point should be assigned sequential numbers (for example, NO 1, NO 2, etc). Any subsequently established reference mark should be assigned the next unused number in the sequence, even if one or more of the previously established reference marks may have been destroyed. The standard practice is to stamp the name of the horizontal control point to which a reference mark refers above the arrow (station designation) that appears in the center of the disk marker. The number of the reference mark, NO 1, NO 2, etc., is stamped immediately below the arrow. The year in which the reference mark was set is stamped in the block marked "year." The name or designation of a reference mark (RM) must not exceed 30 characters in length. It should normally consist of the name of the horizontal control point to which the respective RM belongs with the symbol RM 1, RM 2, ..., RM 13, etc., appended for reference marks NO 1, NO 2, ..., NO 13, etc. No additional information should be added to the name of an RM, except when the numbering system described above has not been followed, or when two or more reference marks associated with a horizontal control point have identical names. In this case, the "year mark set" should be further appended to make the respective names unique (for example, KELLEY RM 1974 and KELLEY RM 1975, if the RM set in 1975 has not been stamped "NO 2"). Considering that the total length of RM name must not exceed 30 characters, the name of the horizontal control point must itself be limited to 24 characters to allow for any appended symbols (RM 1, RM 2, etc.). The name of the horizontal control point must be taken as it appears on the disk, except for possible further abbreviation and/or editing that may be required. If old reference marks are found to be in poor condition, they should be destroyed and reset. The new reference mark should be numbered with the next consecutive unused number, regardless of the existence or absence of any of the reference marks.

b. Naming Azimuth Marks. The same procedures used to name reference monuments shall be used for azimuth marks. If more than one azimuth mark is involved, a number should be assigned and stamped on the azimuth disk marker. Symbols such as AZ MK should be appended to the control point designation when only one azimuth mark is present. Symbols such as AZ MK 2, AZ MK 3, etc., should be appended when two or more azimuth marks are installed. The complete designation station name plus AZ MK 2, etc., shall not exceed the 30-character limit.

c. Other Agency Monuments. Occasionally, an existing monumented survey point of another agency may be used for a reference mark or, more frequently, for an azimuth mark. Such a survey point must be treated as a control point. If it can be positioned, or if its geodetic position is available from other sources, this data should be provided in the description; otherwise, give its name or designation.

4.5 Three-Dimensional Monuments. With the increasing use of space system measurement techniques, such as the Navstar Global Positioning System (GPS), it is important that station markers be stable in all three dimensions (Three-Dimensional Monuments). When selecting sites for high precision primary networks or for deformation monitoring, it is recommended that soil and geotechnical specialists be consulted. The type monument best suited for a given condition will depend on factors previously discussed. To meet the requirements of permanent and stable monumentation, the three-dimensional monuments should be metal disks set in rock outcrops or large masses of concrete, Type C (Figure 3-3), and deep-driven rod monuments, Types A and B (Figures 3-1 and 3-2). The name or designation of individual monuments used for both horizontal and vertical control networks of third order or better should be limited to 25 characters. Neither the "year established" nor the "year mark set" should appear as a part of the station name. Designation criteria for vertical control monuments, as outlined in paragraph 3-3, should also be used for all three-dimensional monuments.

4-6. Marks of Other Organizations. If a satisfactory horizontal control monument of another organization is found at the project site in good condition, it may be used without alteration as the station mark of a new USACE Survey Monument. Reference marks and azimuth marks should be placed, as necessary, to bring the station installation up to the requirements of this manual. In case the existing mark of the other organization is not in good condition for a station mark, a new station mark should be established in the vicinity, and the mark of the other organization should be used as an extra reference mark. The stamping of additional marks should be done as indicated in this manual. Care should be taken not to displace a mark of another organization in horizontal position, or even in vertical position if there is a possibility that it could be used as a bench mark. The mark should not be altered without permission from the organization that established it.

4-7. Witness Posts. In order to aid in preservation and to serve as a means of easy recovery of monuments being established, a witness post should be set adjacent to the monument or near one of the reference marks at each station. This post should be 1.8 meters (6 feet) in length and be set to a minimum of 1 meter (3 feet) above the ground surface. The post should have the standard witness post sign attached (Figure 3-11). Witness posts will be set for monuments of third-order accuracy and above, established along public highways, in rural districts, along the

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rights-of-way of railroads, and along the shorelines of rivers and lakes. They need not be set for monuments established along business streets, in residential sections of cities, on the grounds of a school or a church, in cemeteries, in cultivated farmlands, or on bare mountain tops. For survey monuments established below grade or in cultivated fields, the post shall be set at a reference mark.