CHAPTER 6

CONSTRUCTION OF SEWER SYSTEMS

Section I. SEWER MATERIALS

6-1. Pipe

a. Sanitary Sewers. Vitrified-clay sewer pipe may be used in all sizes that are readily available. Bituminized-fiber sewer pipe of the 6-inch and 8-inch sizes may be used in house connections except in connections to boiler blowdown tanks and laundries. Concrete pipe, unlined asbestos-cement pipe, and cast iron soil pipe may be used except where the acid waste would be insufficiently diluted with akaline sewage to prevent corrosion and where unalterable conditions, such as high sulphate content, high temperature, and low velocity of the sewage, would be conducive to the formation and liberation of hydrogen sulphide. Asbestos-cement pipe may be used under these conditions if adequately lined with a corrosion-resisting plastic. In areas where sulphate concentrations in soil or water are in ranges of 0.10 to 0.20 percent as water soluble SO_4 in soil samples and of 150 to 1000 parts per million as SO_4 in water samples, the cement used in the manufacture of concrete pipe or construction of manholes or other structures will be type II portland cement; and where SO_4 concentrations exceed these maximum limits, the type V cement will be used. Asbestos-cement pipe used under either of these conditions will be type I or II and adequately protected with an outer coating. Where pressure pipe is required, as in force mains or inverted siphons, the pipe may be cast iron, steel or asbestos-cement pressure pipe adequately protected against interior and exterior corrosion as conditions indicate. Therefore, a study will be made of the soil and expected sewage conditions and specifications will be prepared accordingly. Pipe of any material will conform to the requirements of OCE guide specifications.

b. Industrial-Wade Sewers. As the mission of, or the processes used in military industrial installations are subject to change, pipe made of materials subject to attack by acids will not be included in specifications for industrial-waste sewers. Vitrified-clay pipe conforming to Federal Specifications SS-P-361 normally will be specified. Conditions seldom exist at military installations requiring discharge of acid in such concentrations that vitrified-clay pipe would not be suitable. Where it is known that such conditions will occur frequently, special acid-resistant pipe will be specified. In such cases the specifications will state the concentrations and type (nitric, sulfuric, etc.) of acids that will be encountered and whether the waste will contain mixtures of acids.

6-2. Joints

The joints of nonpressure bell-and-spigot sewer pipe normally should be made with hot poured bituminous material, poured in place or precast as rings inside the bells and as collars on the spigots. This type of joint reduces infiltration and the entrance of roots into the pipe. Portland cement mortar and certain cold-applied bituminous jointing compounds are satisfactory materials for sewer joints if the annular space is properly filled entirely around the pipe (fig 6-1). The problem with these materials is that the lower part of the joint is more difficult to fill and defects are more difficult to detect. It is primarily for this reason

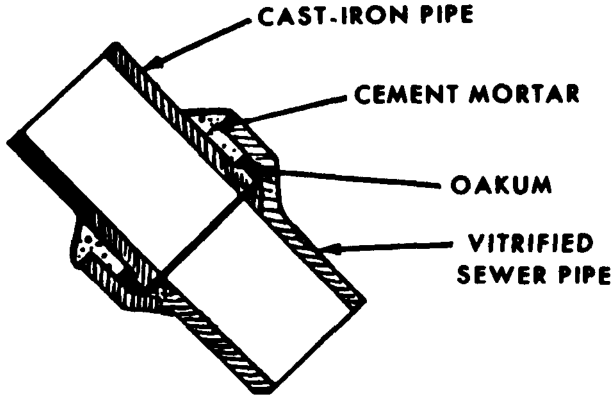


Figure 6–1. Cast-iron pipe and vitrified sewer pipe joint.

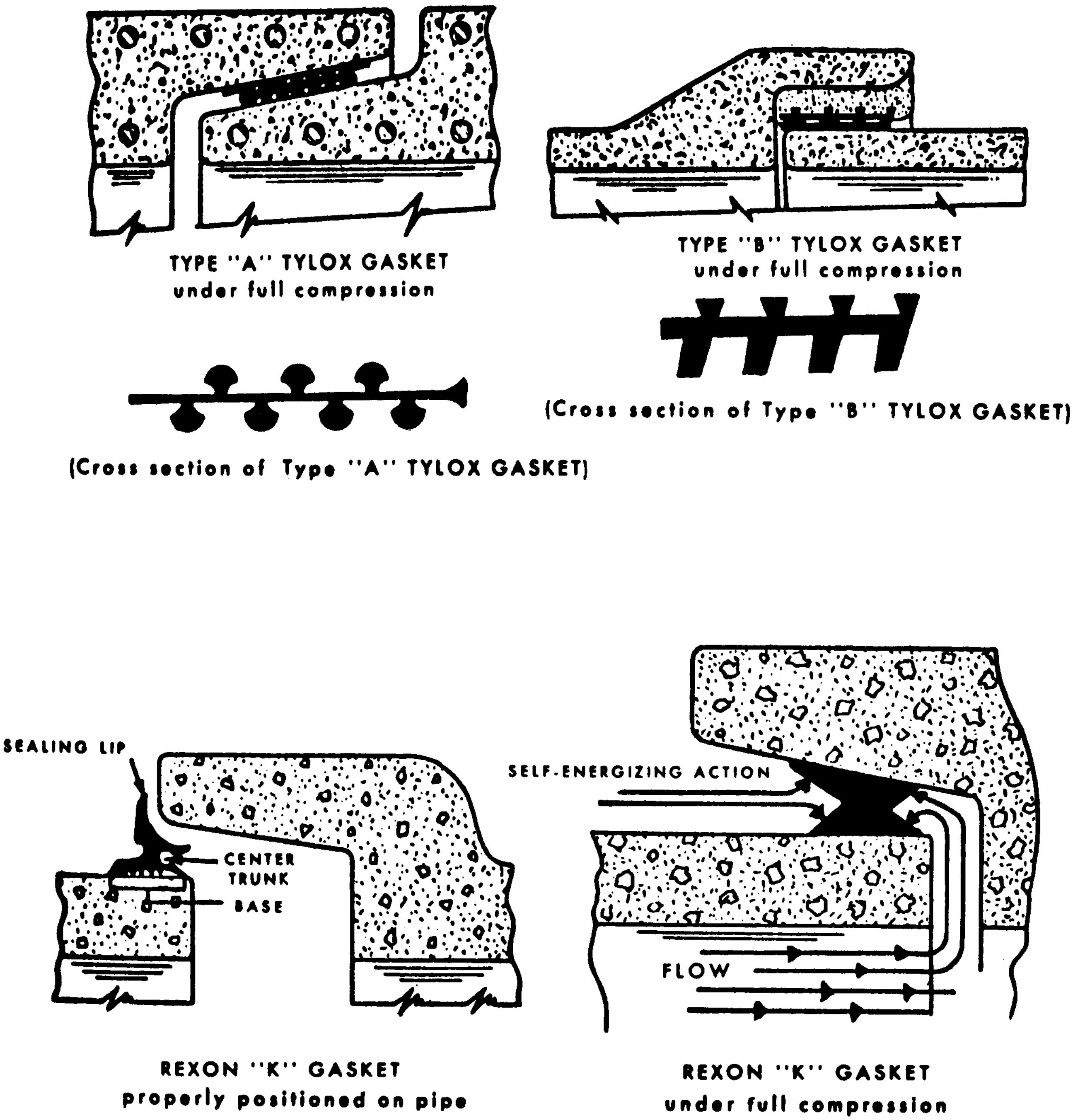


Figure 6–2. Tylox rubber gasket couplings.

that hot poured bituminous joints are preferred in bell-and-spigot pipe. Cement mortar or cold-applied compound would be required for the mortised or tongue-and-groove type of concrete pipe. Also, cement joints should be used in house connections to boiler blowdown tanks and laundries.

Slip joints with rubber gaskets are produced commercially and, because of the ease of installation, should be used when available. Figure 6-2 shows several types of slip joints with rubber gaskets. TM 5-551K and TM 5-814-1 provide additional information on sewer-pipe joints.

Section II. INSTALLATION

6-3. General

The construction of the sewerage system requires careful planning and organization. A thorough knowledge of existing conditions, careful scheduling of work, and use of men and machines will keep the actual length of sewer being worked on at any one time at a minimum. Local conditions influence the methods of construction, such as sheeting and bracing requirements and type of excavating equipment.

6-4. Line Location

a. Before staking out the sewer, a plan and profile view should be prepared to show—

(1) The horizontal location of each line in the system.

(2) The invert elevation of the upper and lower edge of each manhole.

(3) The slope of each line.

b. The stakeout consists of setting hubs and stakes to mark the alinement and indicate the depth of the sewer. The alinement may be marked by a row of offset hubs and a row of centerline stakes. Cuts may be shown on cut sheets (also called grade sheets or construction sheets) or may be marked on the stakes or both. The cuts shown on the centerline stakes guide the backhoe or ditcher operator; they are usually shown to tenths; they generally represent the cut from the surface of the existing ground to the bottom of the trench, taking into account the depth to the invert, the barrel thickness, and the depth of any sand or gravel bed. The cuts marked on the stakes next to the hubs are generally shown to hundredths and usually represent the distance from the top of the hub to the invert. Hubs and/or stakes are generally set at 25-foot intervals, though 50-foot and even 100-foot intervals are adequate. Sewer hubs are usually offset from 5 to 8 feet from the centerline. Figure 6-3 is a sewer stakeout plan view showing a line running through two manholes. The dotted lines are offsets (greatly exaggerated for clarity) to points where hubs will be set. Note that at stations 5 + 75 and 1 + 70.21 two hubs are set, one for the invert in and the other for the invert out. The invert elevations at the manholes are given on the profile.

c. An example of determining invert elevation is shown in figure 6-4.

d. One method of using these hubs to dig the trench to grade is to erect a batter board across the trench at each hub. The elevation of the batter board is at a set distance above the invert and a string line is laid parallel to the pipe along the centerline. The finished grade of the trench or the invert of the pipe may be checked by using a grade pole, as shown in figure 6-5.

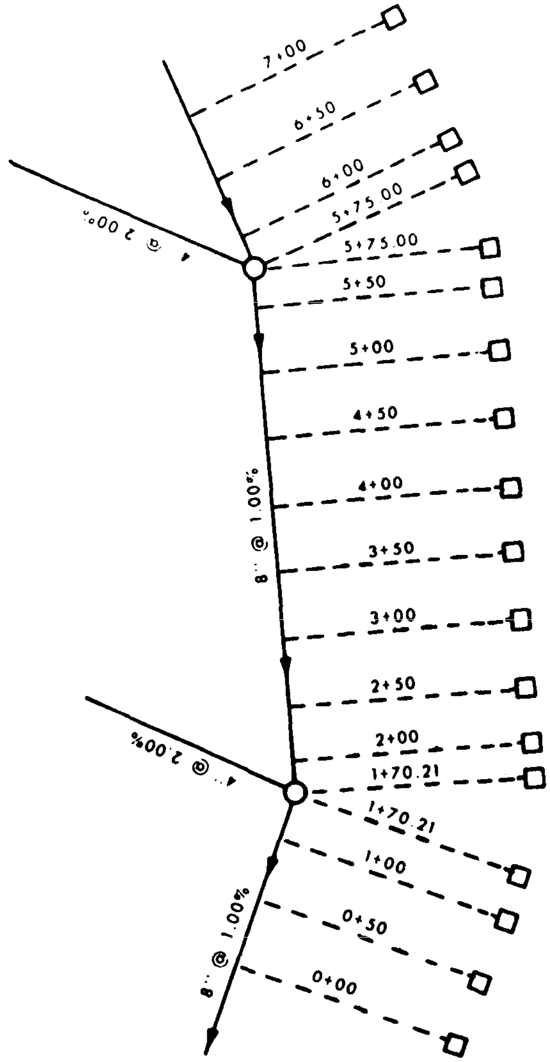
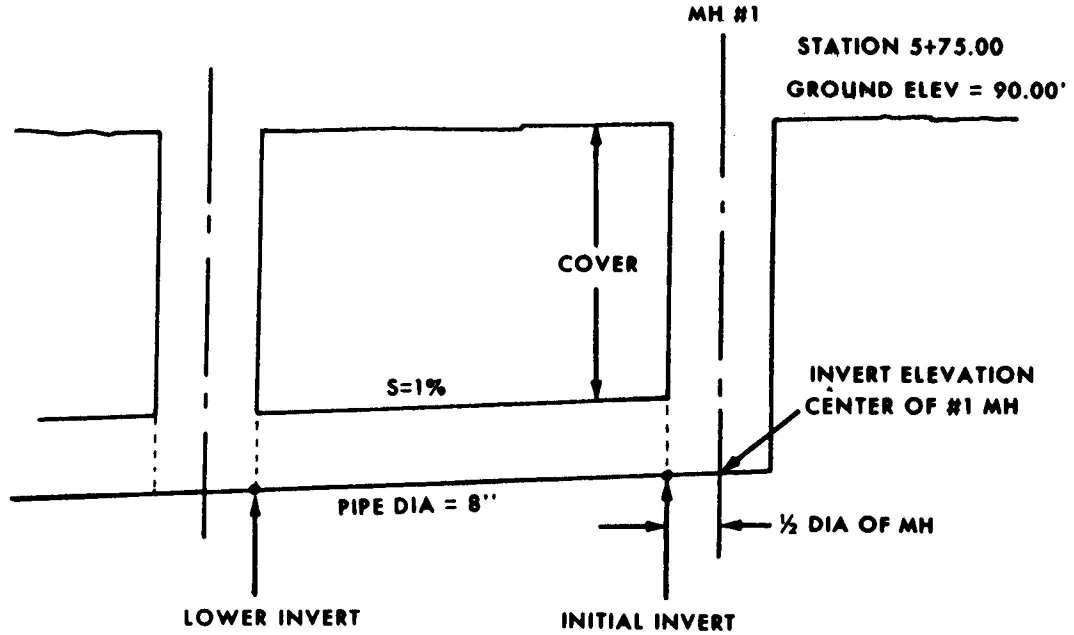


Figure 6-3. Sewer stakeout plan.

6-5. Excavation

a. Excavation may be done by hand labor or with equipment. Table 6-1 lists typical construction rates for hand labor.

b. Ditching equipment may be used to dig the trench to within inches of the final grade. The bottom of the trench is then shaped by hand labor as pipelaying progresses. Machine excavation is done by use of continuous bucket excavators, overhead



INVERT ELEVATION CENTER OF MH #1 = GROUND ELEVATION — COVER — DIAMETER OF PIPE

INITIAL PIPE INVERT = INVERT OF MH —(SLOPE OF LINE) (½ DIA OF MH)

SUBSEQUENT LOWER INVERT = UPPER INVERT ELEVATION —(SLOPE) (DISTANCE)

Figure 6–4. Determining invert elevation.

Table 6–1. Sewer Construction by Hand Labor (Man-Hours per 100 Feet)

Size of pipe	Depth to top of pipe								
	2 feet			4 feet			6 feet		
	Soft	Medium	Heavy	Soft	Medium	Heavy	Soft	Medium	Heavy
6 inch	50	76	94	80	125	158	110	176	224
8 inch	58	87	108	90	142	169	124	198	252
10 inch	69	103	129	106	163	206	141	221	282
12 inch	77	119	148	119	181	232	157	248	313
15 inch	94	138	171	137	208	262	182	278	347
18 inch	122	177	217	169	254	315	215	301	419

Note 1. Operation includes excavation to width of 16 inches plus pipe diameter, shaping bottom of trench, laying pipe, preparing joints, back fill, tamping to top of pipe, and back fill of trench. A normal method of determining trench width is to add 12 inches to 1.5 times the pipe diameter.

Note 2. Soil classifications are as follows: Soft-sandy silt or silt; medium—average solid; requiring some picking, gravelly; heavy—heavy clay or gravelly clay.

cableway excavators, track excavators, power shovels or boom and bucket excavators. Trapezoidal-shaped trenches help to keep the walls from caving in. However, the entire trench should be as narrow as possible with the bottom dimension equal to 1.5 times the pipe diameter plus 12 inches to permit proper bedding and construction of the joints.

c. Sheeting and bracing is used in trenches to prevent caving in of the wall and entrance of ground water. For shallow trenches where only limited support is needed, skeleton sheeting (fig 6-6) or poling boards may be used. These basically consist of wooden staves laid vertically against the face of the wall and braced to support the soil For deep trenches where greater support is required, box sheeting (horizontal staves) or vertical sheeting (fig 6-7) may be used. Vertical sheeting is the strongest since the staves are dug into the ground and braced. However, this sheeting is difficult and more time consuming to construct. Most sheeting is made of wood. However, metal is becoming more popular. The latter costs more but the sheeting can be used many more times than wood.

d. Proper embedment is essential in increasing the structural capacities of the sewer. When rock, shale and hard clay are encountered, the excavation should be carried to a minimum of 4 inches below the grade and a good granular material

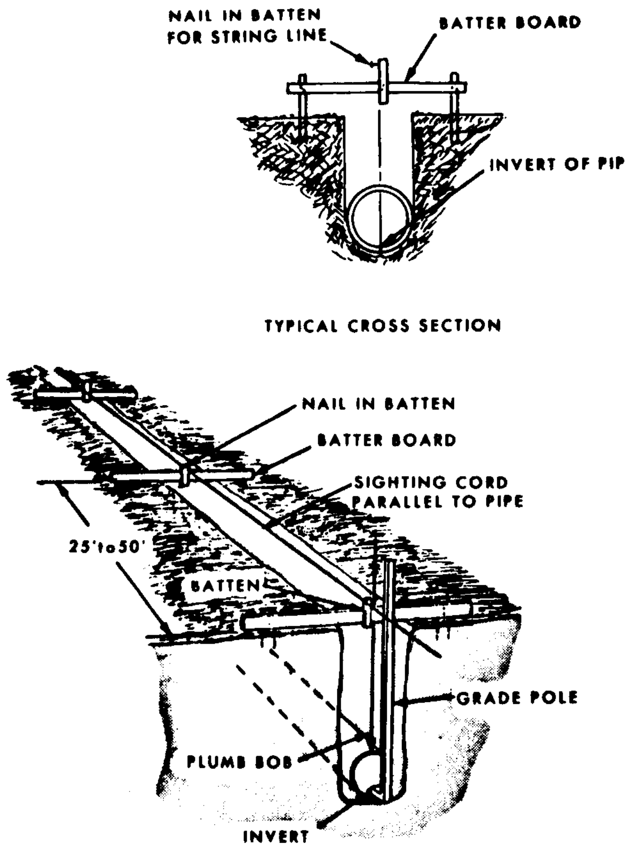


Figure 6–5. Setting sewer line to grade.

used as backfill. When the foundation for pipe sewers is in soft but stable clay soil, without excessive water, little attention will be required provided the trench width and bottom shape conform to the dimensions of the pipe. Careful trimming of the trench bottom to the shape of the pipe is

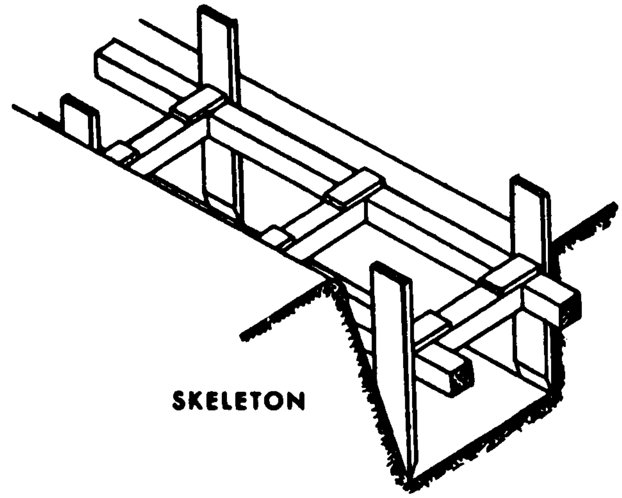


Figure 6–6. Skeleton sheeting.

however, costly in manpower and there is a growing (civilian) practice of overexcavation, followed by backfilling with granular material to provide uniform bedding of the pipe. Pea gravel or roofer's gravel is a good material for this purpose. In the theater of operations, construction on unstable soil should be avoided due to the requirement for additional effort in the form of concrete cradles or piling. In some cases, soft trench bottoms can be stabilized by overexcavating and adding coarse rock or gravel. Figure 6-8 shows four types of bedding.

e. Additional information may be found in TM 5-551K, Plumbing and Pipefitting.

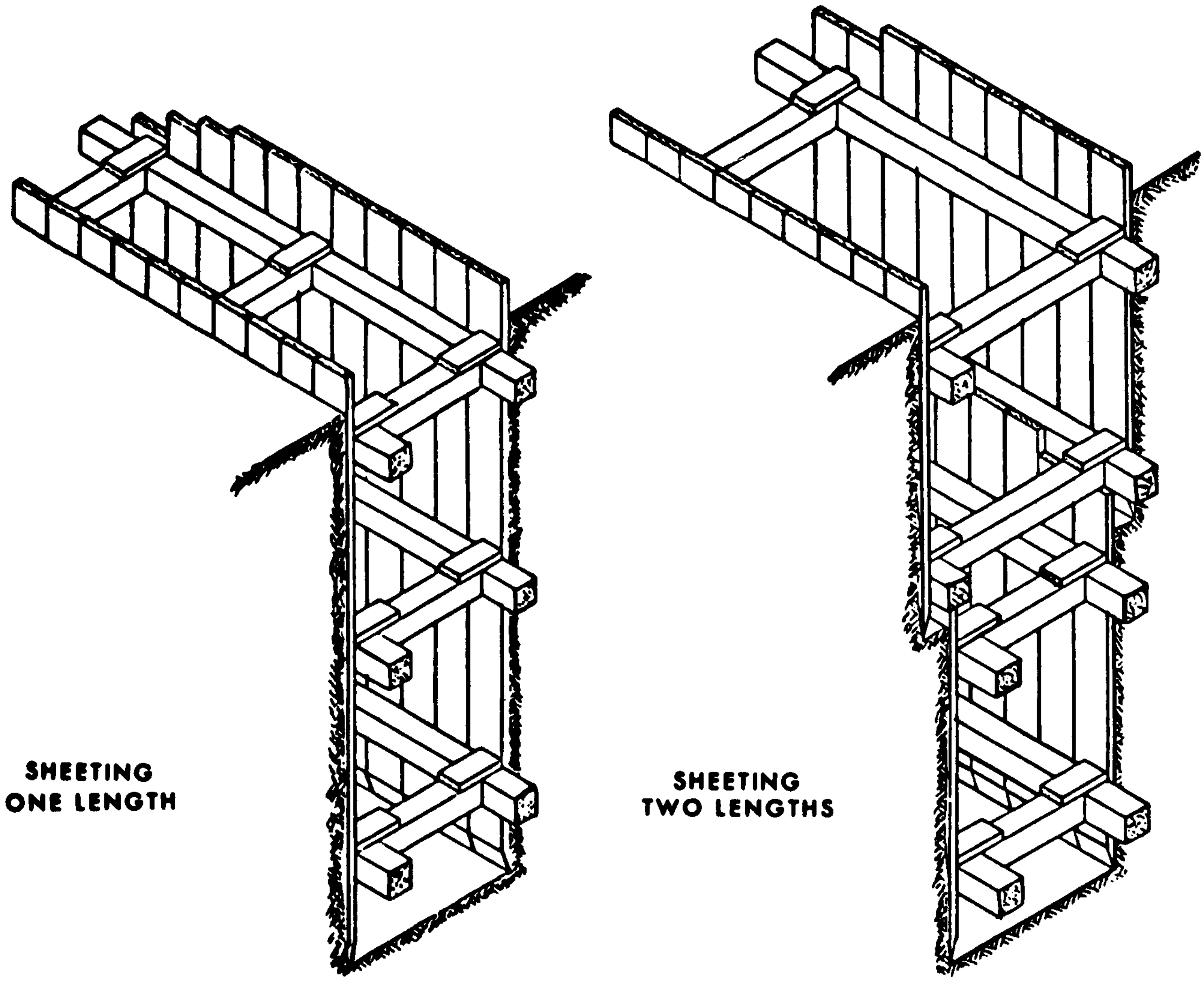


Figure 6–7. Typical vertical sheeting.

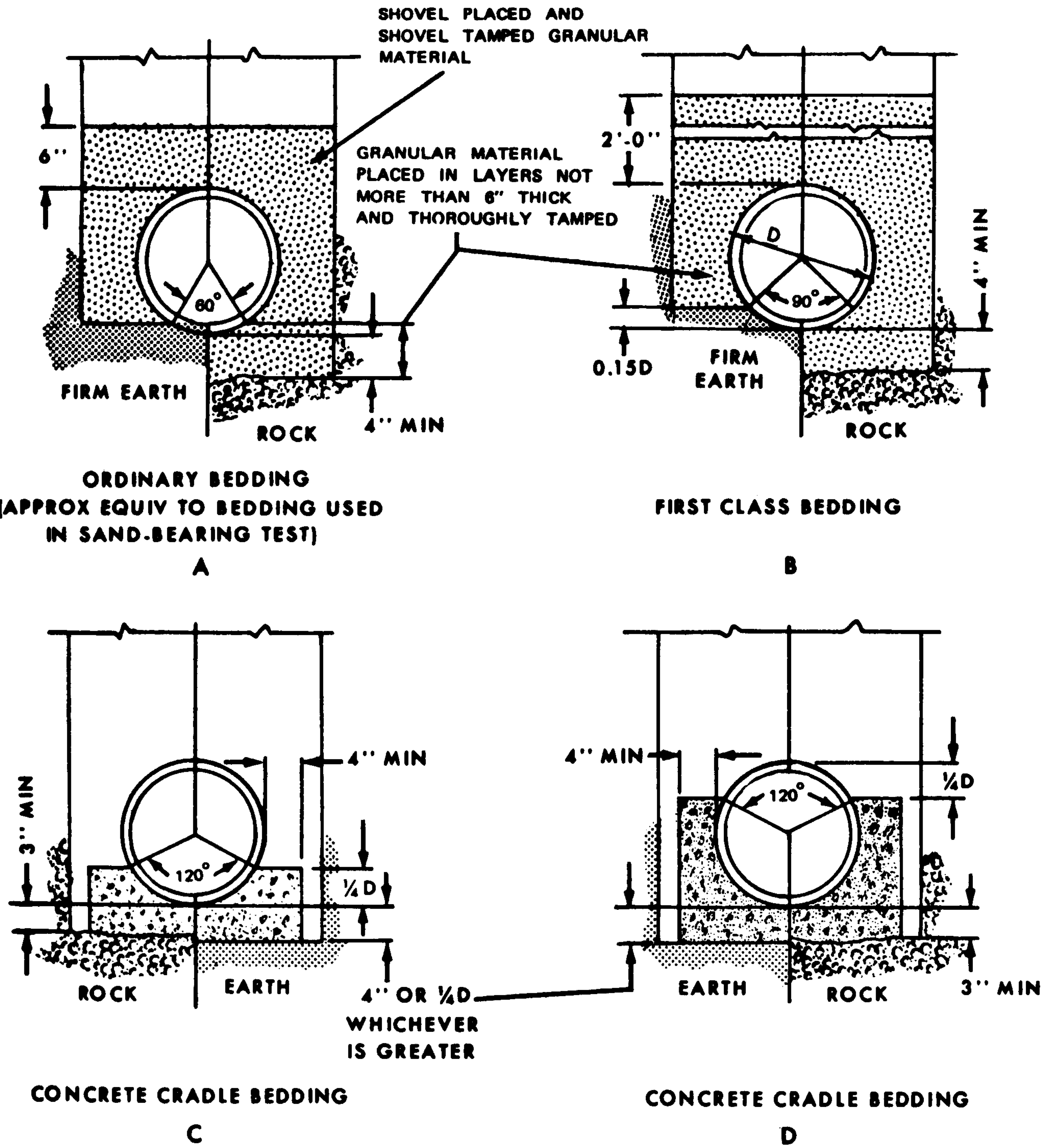


FIGURE	TYPE OF BEDDING	LOAD SUPPORTING RATIO*
(A)	ORDINARY	1.0
(B)	FIRST CLASS	1.25
(C)	CONCRETE CRADLE	1.5
(D)	CONCRETE CRADLE	2.0

*NOTE: THESE RATIOS ARE RELATIVE VALUES AND SHOULD NOT BE CONFUSED WITH FACTOR OF SAFETY

Figure 6–8. Four types of bedding for trenches.